BALLINA SHIRE COUNCIL

WARDELL & CABBAGE TREE ISLAND FLOODPLAIN RISK MANAGEMENT STUDY

Issue No. 5
FEBRUARY 2008

Patterson Britton
& Partners Pty Ltd
consulting engineers

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level 4
104 Mount Street
North Sydney 2060

PO Box 515
North Sydney 2059
Australia

telephone: (02) 9957 1619
facsimile: (02) 9957 1291
reception@patbrit.com.au
ABN 89 003 220 228

Newcastle Office
8 Telford Street
Newcastle East 2300

PO Box 668
Newcastle 2300
Australia

telephone: (02) 4928 7777
facsimile: (02) 4926 2111
mail@newcastle.patbrit.com.au

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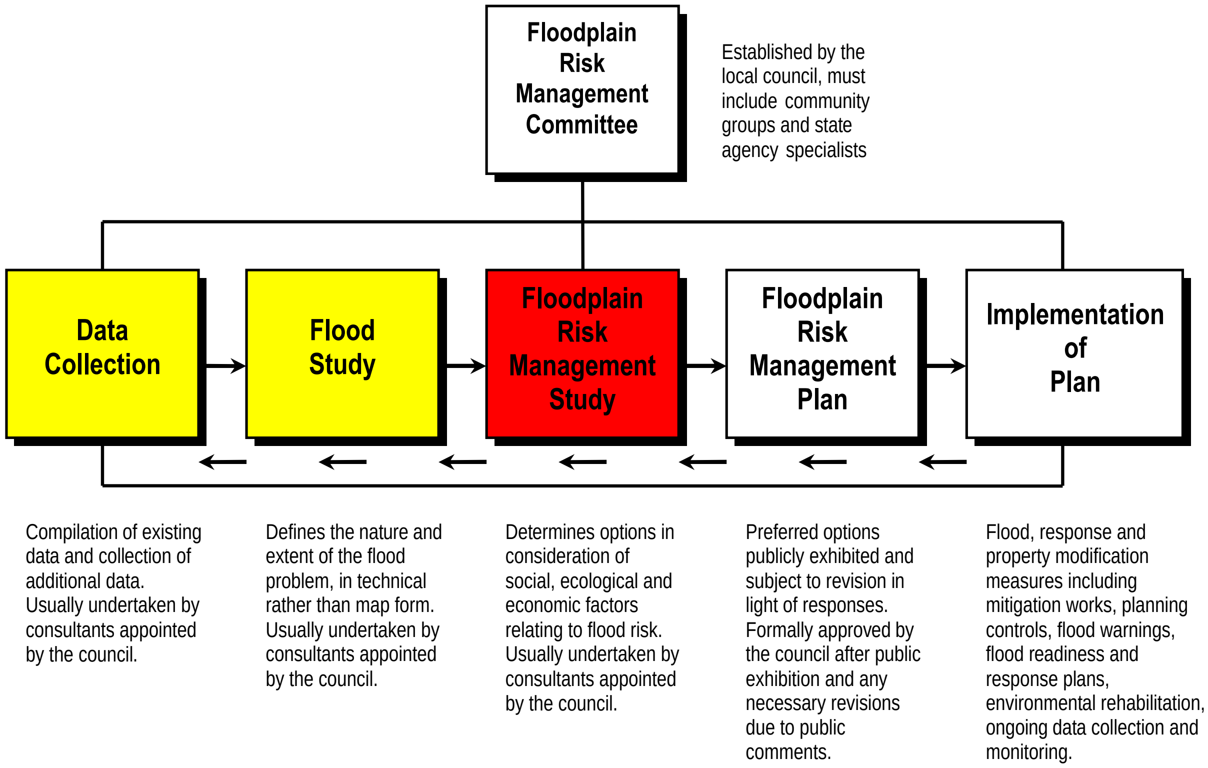
FOREWORD

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 and second stages of the process were completed in November 2007 with the publication of the *'Wardell & Cabbage Tree Island Flood Study'* (*refer boxes in flow chart highlighted in yellow*).

The *'Wardell & Cabbage Tree Island Floodplain Risk Management Study'* constitutes the third stage of the management process for the floodplain of the Richmond River between Broadwater and Pimlico Island. It has been prepared for Ballina Shire Council and provides the basis for the future management of flood liable lands around Wardell and East Wardell and on Cabbage Tree Island (*refer to box in flow chart that is highlighted in red*).

1 INTRODUCTION

Wardell and Cabbage Tree Island are 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. Both Wardell and Cabbage Tree Island are located along this reach of the Richmond River.

As shown in **Figure 2**, 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.

Cabbage Tree Island is located further upstream along the Richmond River, approximately midway between Wardell and the village of Broadwater (*refer* **Figure 2**). The Island has been inhabited by the Jali Aboriginal community for many years and contains a number of residential properties, an historic primary school, a workshop and a range of buildings that are used for recreation, administration and health services. The current population of the Island is about 170. The ***'Wardell and Cabbage Tree Island Flood Study'*** (*November 2007*) established that the island would begin to be flooded once flooding of the Richmond River reached an elevation corresponding to the 5 year recurrence flood.

In recent years, development applications in the region 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.

This report documents the findings of investigations undertaken to assess a range of potential flood damage reduction measures that could be implemented at Wardell and Cabbage Tree Island. It also documents measures to address emergency response management issues that are likely to exist at Cabbage Tree Island during major flooding of the Richmond River.

Source: Richmond Valley Floodplain Management Study (1980)

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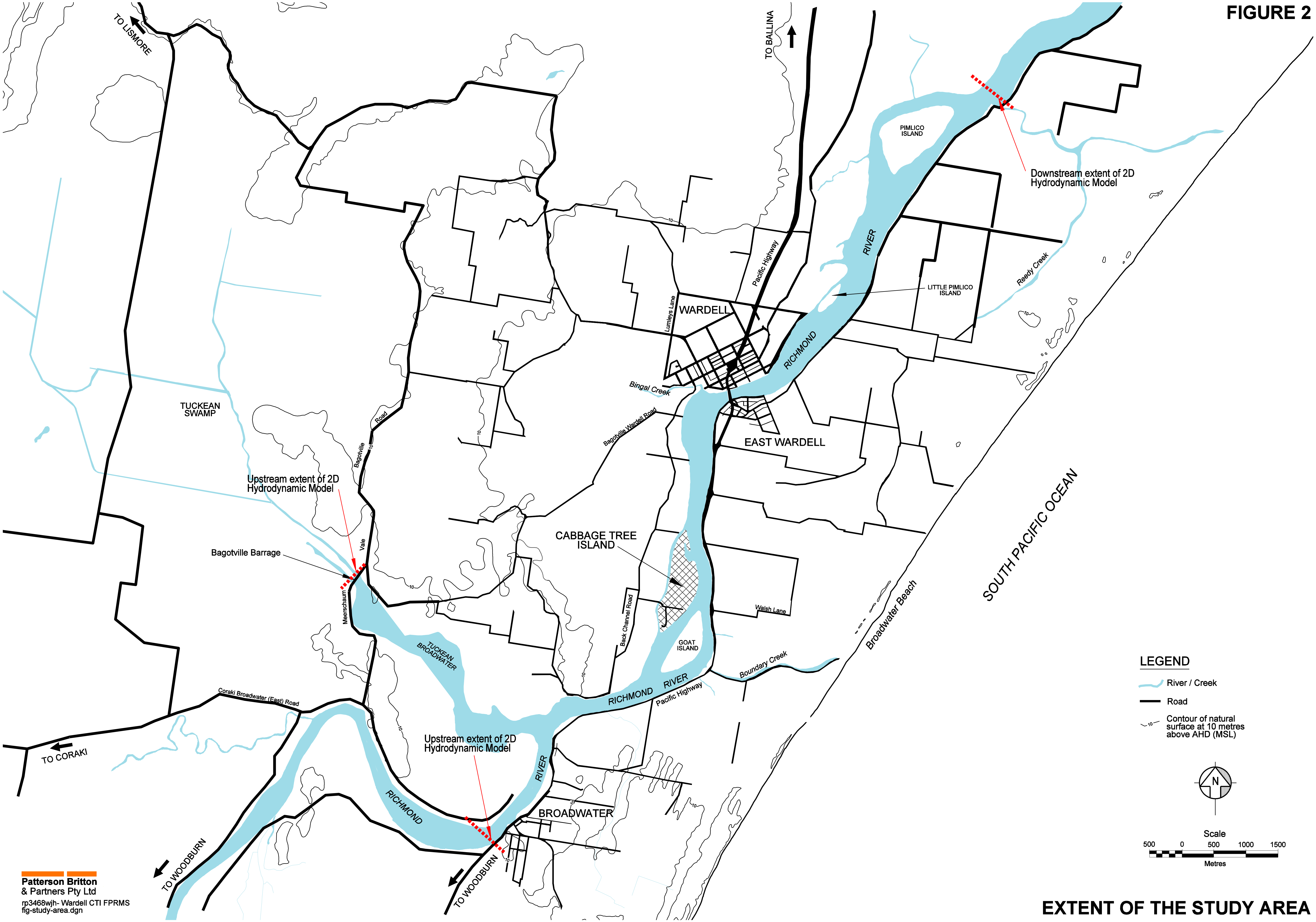
RICHMOND RIVER CATCHMENT

FIGURE 2



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EXTENT OF THE STUDY AREA

The existing flood problem at both Wardell and Cabbage Tree Island, 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 in both areas, and has increased the risk for loss of life among those who reside on Cabbage Tree Island.

Therefore, the existing flooding problem at both Wardell and Cabbage Tree Island is both real and potentially life threatening.

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 of both precincts and to reduce the risk for loss of life.

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

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

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

Therefore, this Floodplain Risk Management Study sets out to:

- identify and evaluate management options for the floodplain in terms of their capacity to reduce existing and potential future flooding problems;
- provide information on flood behaviour and flood hazard, so that community aspirations for future land use can be assessed; and,
- provide 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.

2 THE FLOODING PROBLEM

2.1 BACKGROUND

The contemporary flooding problem in the Lower Richmond River can be broken up into three major components, namely:

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

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

2.2 EXISTING FLOODING PROBLEM

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

As outlined in **Section 1**, the existing flooding problem at Wardell and Cabbage Tree Island is documented in a report titled, *'Wardell & Cabbage Tree Island Flood Study'* (*2007*). The Flood Study established the following:

(1) The majority of Cabbage Tree Island will be inundated once flood levels in the Richmond River reach an elevation corresponding to the 5 year recurrence flood.

However, the current awareness of the potential for flooding of Cabbage Tree Island is based on an expectation that inundation of the Island will not occur fully until water levels in the Richmond River reach the elevation of the 10 year recurrence flood. The higher frequency for flooding of the Island (*i.e., 5 year recurrence*) is partly attributed to the impact of the raising of the Pacific Highway between Broadwater and Wardell.

(2) Flood free access from Cabbage Tree Island is not possible during floods larger than the 5 year recurrence event. Back Channel Road would be impassable to vehicular traffic in an event of this magnitude making it impossible to gain road access to the bridge that links Back Channel Road to the Island.

(3) The 100 year recurrence flood level in the Richmond River at Cabbage Tree Island is predicted to be about 3.35 mAHD. Flooding of this magnitude will result in floodwater depths of up to 1.8 metres across those areas of the Island that have been developed for housing. Notwithstanding, most of the dwellings on the Island are constructed on stilts and habitable floor areas are typically above the 100 year recurrence flood level.

(4) Flooding at Wardell is less critical, but will lead to inundation of some of the commercial and residential areas of the town in 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. At least three existing dwellings are predicted to be inundated during the 20 year recurrence flood.

(5) 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. Most houses at East Wardell will experience some flood affectation during floods rarer than the 10 year recurrence event.

Hazard mapping for the 100 year recurrence flood is presented in **Figure 3** and shows the potential flood risk to which residents of Cabbage Tree Island, East Wardell and low lying areas of Wardell, could be exposed.

2.3 FUTURE FLOODING PROBLEM

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

As land resources for development become increasingly scarce, pressures mount to allow development within floodplain areas where it might otherwise be avoided. The future flooding problem has the greatest potential to cause large scale flood damages in the Lower Richmond River and presents the greatest potential risk to loss of life.

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

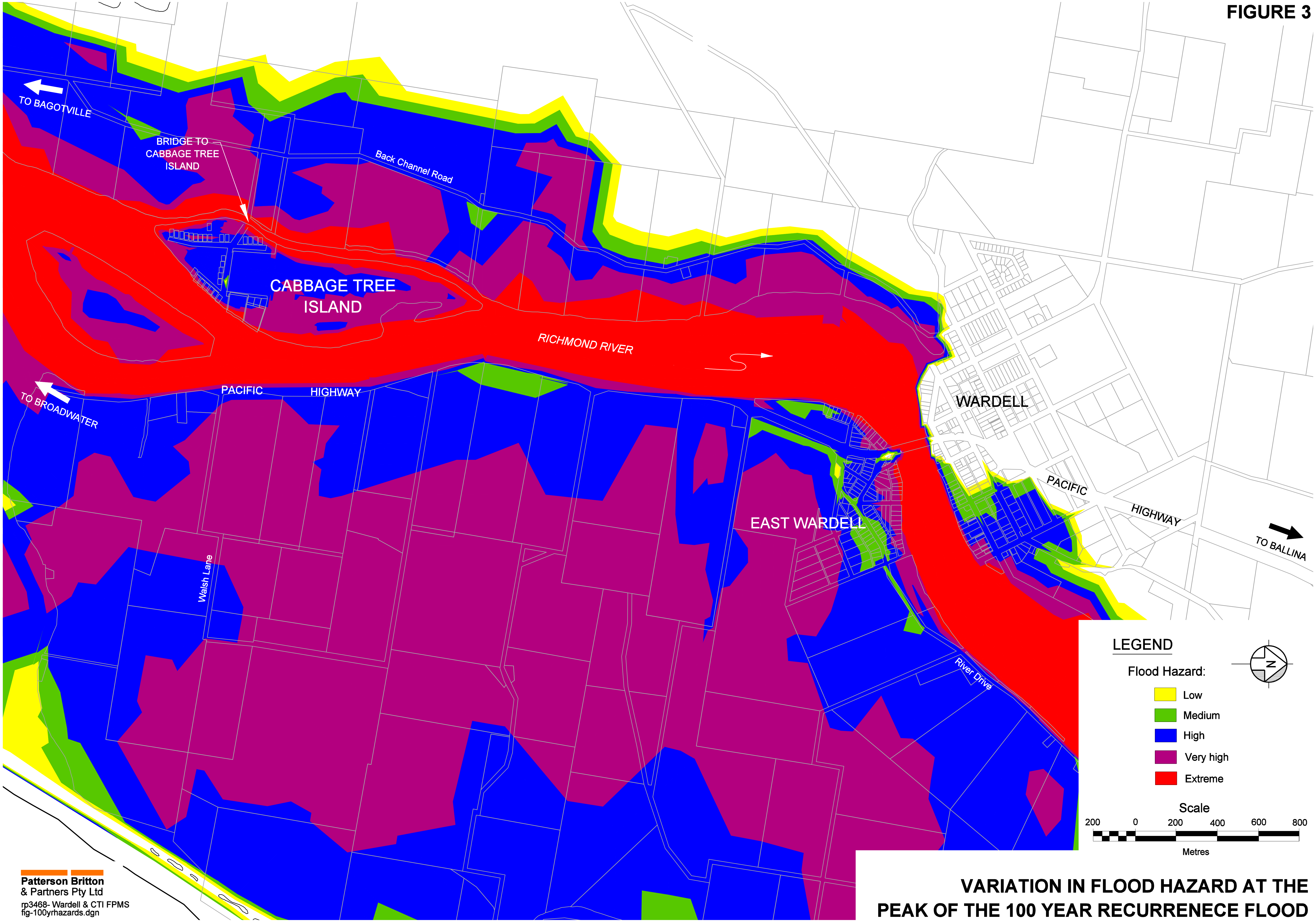
2.4 RESIDUAL FLOODING PROBLEM

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

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

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

FIGURE 3



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VARIATION IN FLOOD HAZARD AT THE PEAK OF THE 100 YEAR RECURRENECE FLOOD

3 FLOOD DAMAGE ASSESSMENT

3.1 WHAT ARE FLOOD DAMAGES?

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

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

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

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

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

3.1.1 Flood Damage Categories

Flood damage costs for Wardell and Cabbage Tree Island were determined based on consideration of the different types of land use within each village. The predominant land uses are:

- residential;
- light industrial; and,
- commercial.

There are also fringing areas of farmland which would experience agricultural flood damages. However, as this study is specific to the villages of Wardell and Cabbage Tree Island, no consideration of rural flood damages has been made.

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

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

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

The approach developed to calculate flood damages for the villages of Wardell and Cabbage Tree Island is based upon the development of a representative damage curve for a typical house in the Lower Richmond River floodplain. A damage curve is a numerical relationship that correlates the depth of flooding to the cost of damages that would result from that flooding. The cost of the damages associated with the flooding increases as the depth of flooding increases.

The approach employed applies procedures outlined in the Department of Natural Resources' Draft Guideline No 4 titled, *'Residential Flood Damage Calculation'*. It involves the application of the damage curves documented in the literature with flood data documented in the Flood Study Report (*2007*).

To account for the damages associated with the inundation of residential property and the costs associated with overfloor flooding of houses and their contents, the category for residential damages was further divided into:

§ the 'damages to property'; and,

§ the 'damages to dwellings (*including contents*)'.

Damage to dwellings includes the cost of structural damage and the damage to internal items such as furniture and floor coverings. Damage to property includes damage to fences, vehicles and landscaping.

As outlined in the Department of Natural Resource's Draft Guideline No 4, the data available on flood damages typically only applies to residential properties. Therefore, an estimate of the direct damages associated with the inundation of industrial and commercial premises (*such as at Wardell*) was based on recorded damage costs for similar premises reported in the literature. This literature includes a range of previous floodplain management studies and recorded data presented in intergovernmental reports.

It was not possible to calculate indirect damages for each individual lot or property. Therefore, the indirect damage costs were assumed to be 5% of the direct damage costs incurred by residential properties. This is in keeping with procedures adopted in other studies such as the *'Camden Haven Floodplain Management Study'* (*2001*), and is considered a reasonable approximation based on the relatively short duration of flooding.

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

There is no data available to define the extent of the public and corporate infrastructure that could be damaged as a result of flooding. Accordingly, infrastructure damages were determined to be 30% of the total direct and indirect residential (*including dwellings and property damages*) and industrial/commercial costs. This is in keeping with approaches employed for other areas of NSW.

3.1.2 Stage – Damage Relationships

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

The DNR's draft *'Floodplain Management Guideline No 4 – Residential Flood Damage Calculation'* outlines the method for determining stage-damage curves for residential dwellings. This procedure is recommended as the basis for derivation of average annual damages and net present values of damages to enable the comparison of management options. A copy of the spreadsheet version of this method is included within **Appendix B**.

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

Accordingly, stage-damage curves were developed for residential properties and commercial/industrial sites based on consideration of the available stage-damage relationships in the literature. The adopted stage-damage curves for the villages of Wardell and Cabbage Tree Island are included within **Appendix B**.

3.1.3 Average Annual Damage

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

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

The average annual damage is equivalent to the total damage caused by all floods over a long period of time divided by the number of years in that period (*DNR, 2004*). It provides a measure for comparing the economic benefits of potential flood damage reduction options.

3.2 FLOOD DAMAGES ANALYSIS FOR WARDELL AND CABBAGE TREE ISLAND

Data defining the floor levels of structures at Wardell and Cabbage Tree Island was provided by Ballina Shire Council (*refer* **Appendix C**). This data was used with peak flood levels generated from modelling completed for the *'Wardell and Cabbage Tree Island Flood Study'* (*November 2007*), 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 at Wardell and Cabbage Tree Island are identified in **Figures 4** and **5**, respectively.

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

Estimates of the tangible 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 **Tables 1** and **2** for Wardell and Cabbage Tree Island, respectively. The number of structures and properties predicted to be inundated in each flood are also listed. All damage costs are expressed in 2006 dollars.

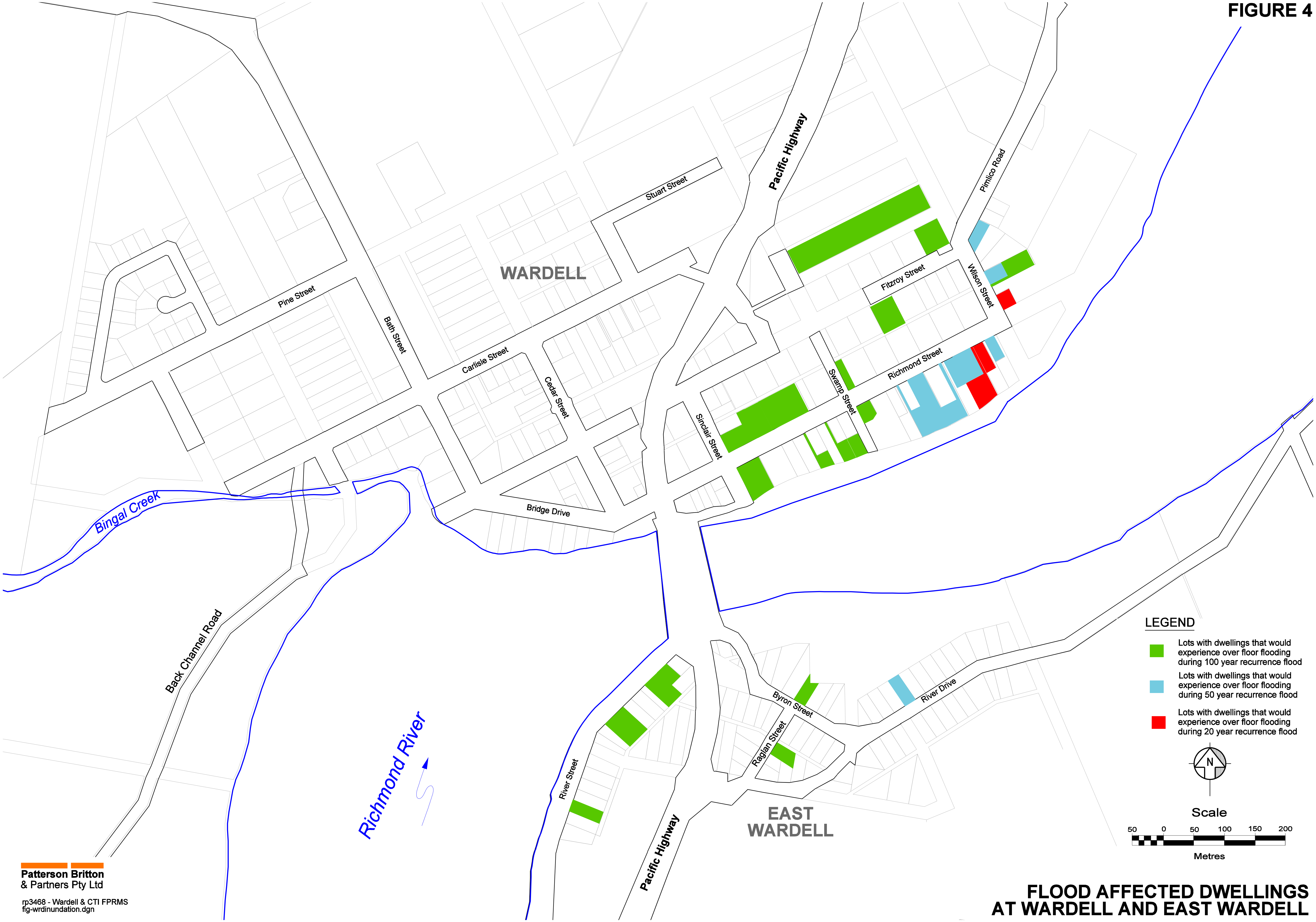
The results show that if the design 100 year recurrence flood occurred, the total tangible flood damages incurred at Wardell would be in the order of $3M. Based on principles applied in the Hawkesbury-Nepean (*Smith, 1992 and Warragamba Dam IDC, 1992*), it is conceivable that the intangible damages could be half as much again, thereby indicating that a total flood damage bill of **$4.5M** could be anticipated at Wardell if an event of this magnitude were to occur.

The tangible flood damages predicted at Cabbage Tree Island in a 100 year recurrence event are estimated to be in the order of $0.8M. However, it is likely that the intangible damages would be higher than for Wardell due to the fact that residents of Cabbage Tree Island would need to leave the island in an event of the magnitude of the 100 year recurrence flood. It is also possible that the location of the island centrally within the Richmond River could increase the recovery time and thereby increase the intangible damages experienced by the community.

Accordingly, it is considered appropriate for the intangible damage cost to be equivalent to the tangible damage cost. Hence, a total damage cost in the order of **$1.5M** is not an unreasonable expectation for the village in a flood of the magnitude of the 100 year recurrence event.

The results of the analysis also show that the bulk of the damages that would be incurred at both villages are those associated with over floor flooding of residential dwellings; viz., ~ 75% at Wardell and ~ 60% at Cabbage Tree Island. This reflects the primary land use within the villages and points to a real risk that small individual property owners would bear the brunt of any damages associated with flooding.

FIGURE 4



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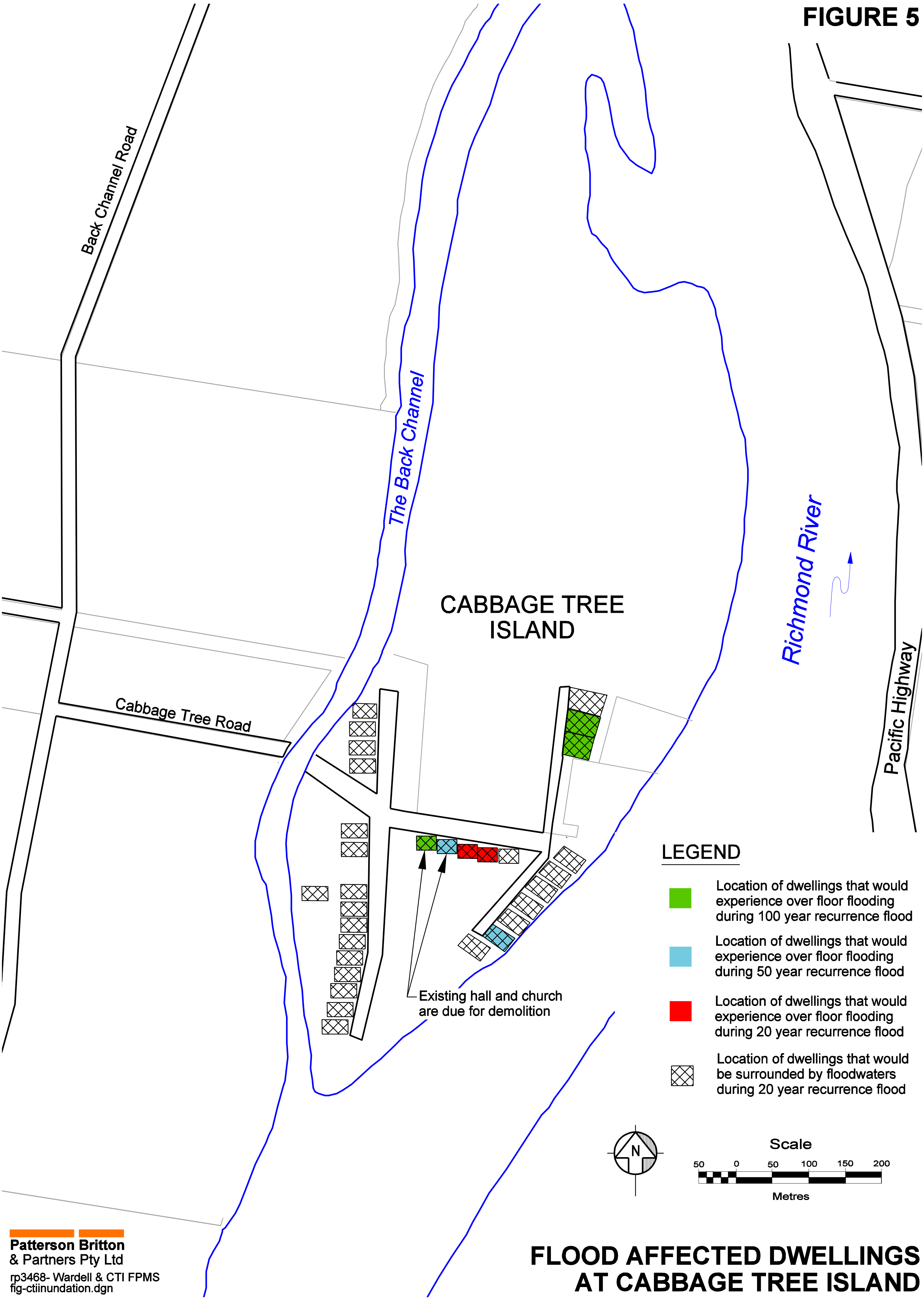
FLOOD AFFECTED DWELLINGS AT WARDELL AND EAST WARDELL

FIGURE 5



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FLOOD AFFECTED DWELLINGS AT CABBAGE TREE ISLAND

Table 1 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**

Table 2 EXISTING FLOOD DAMAGE COSTS FOR CABBAGE TREE ISLAND

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	10	$5,390	0	$0	$1,620	**$7,000**
10 Year	0	19	$90,190	1	$9,680	$29,960	**$130,000**
20 Year	0	26	$218,910	2	$54,200	$81,930	**$355,000**
50 Year	1	26	$362,250	3	$103,390	$139,690	**$605,000**
100 Year	3	26	$482,630	4	$150,640	$189,980	**$823,000**
Probable Maximum Flood	21	26	$1,624,900	6	$551,930	$653,050	**$2,830,000**

Based on the damages analysis presented in **Tables 1** and **2**, the Average Annual Damage (*AAD*) for Wardell and Cabbage Tree Island is estimated as follows:

- AAD for Wardell/East Wardell $145,000
- AAD for Cabbage Tree Island $60,000

These estimates of the AAD are 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 in 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.

Similarly, in the case of Cabbage Tree Island, if intangible damages corresponding to 100% of the corresponding tangible damages were adopted for events rarer than the 20 year recurrence flood, the AAD for Cabbage Tree Island would increase to about $110,000.

Accordingly, the intangible damages associated with flooding at both Cabbage Tree Island and Wardell are considered to be significant and an important component of the overall flood scenario.

4 FLOODPLAIN MANAGEMENT MEASURES

4.1 BACKGROUND

Information presented in the *'Wardell & Cabbage Tree Island Flood Study'* (*2007*) and the damages analysis outlined in **Section 3**, indicates that there is potential for substantial damages and loss to be incurred by the residents of Wardell and Cabbage Tree Island should major flooding of the lower Richmond River occur. These damages would include financial losses to individual property owners and losses to the overall community as a result of damage to infrastructure and disruption to everyday life.

Accordingly, it was considered appropriate to identify a range of measures that could potentially be implemented in both areas to reduce the flood damages that both communities could be exposed to in the future.

A list of measures was originally developed in consultation with representatives from Council and the Department of Natural Resources. The measures were devised with a view to reducing the existing flood damages that could be incurred by the community and with a view to providing a mechanism for ensuring that the risk faced by future development was minimised.

The potential floodplain management measures that were determined comprised a combination of 'flood damage reduction measures' (*structural measures*) and 'planning measures' (*non-structural measures*). The measures that were considered are listed in **Tables 3** and **4**.

Table 3 CONSIDERED FLOOD DAMAGE REDUCTION MEASURES

MEASURE	DESCRIPTION OF WORKS / ACTIONS ASSOCIATED WITH MEASURE
Wardell	
1A	Upgrade the levee along the western bank of the Richmond River downstream from Wardell bridge.
1B	Construction of a levee along the eastern bank of the Richmond River around East Wardell.
1C	Dredging of the Richmond River channel upstream and downstream of Wardell Bridge.
Cabbage Tree Island	
1A	Construction of a deflector levee along the upstream edge of Cabbage Tree Island to a crest elevation of 3.5 mAHD.
1B	Dredging sections of the river bed in the Back Channel..
1C	Dredging sections of the river bed in the Richmond River.
1D	Installation of additional culverts or enlargement of existing culverts beneath the Pacific Highway on the eastern bank of the Richmond River.

Table 4 CONSIDERED FLOOD PLANNING MEASURES

MEASURE	DESCRIPTION OF WORKS / ACTIONS ASSOCIATED WITH MEASURE
Wardell	
2A	Revision to minimum fill levels and dwelling floor levels for Wardell and East Wardell.
2B	Development of flood emergency response protocols and promotion of community awareness.
Cabbage Tree Island	
2A	Review of minimum floor levels for future dwellings on Cabbage Tree Island.
2B	Revision and refinement of existing flood emergency response protocols and community awareness.

4.2 CONSULTATION

A consultation program was undertaken to determine the views of the community on the suitability of the floodplain management measures that were proposed for consideration. The consultation involved the preparation of information brochures and questionnaires that were distributed to all residents within both villages. Copies of the brochures and associated questionnaires are enclosed within **Appendix D**.

Responses to the questionnaires were compiled and processed to determine the most suitable combination of flood damage reduction measures. A total of 45 responses were received from the Wardell community. Three responses were received from the residents of Cabbage Tree Island.

A summary of the responses is enclosed within **Appendix E**.

4.2.1 Feedback on Measures for Wardell

The submissions indicated that the majority of people that responded to the questionnaire believe that dredging of the Richmond River in areas downstream of Wardell will reduce flood levels. Therefore, it was considered appropriate to proceed with the development of a suitable dredging scenario based on a cursory appraisal of channel morphology and bed levels in the area downstream of Wardell to the mouth of North Creek.

The least attractive measure was the proposal to upgrade the levee along the western bank of the river (*i.e., Measure 1A*). The responses indicated that there was a greater preference for consideration of Measure 1B, which involves the construction of a new levee along the southern bank of the river and which would provide greater protection to East Wardell.

A number of respondents (6) were concerned about the impact of a flood protection levee on the aesthetics of the area, while others (3) questioned the impact that construction of any new levees would have on the surrounding environment, particularly mangroves and the overall estuarine ecosystem.

Concern was also raised by three respondents regarding the impact that dredging activities could have on fish stocks as a result of turbid waters.

There was also some feedback on the existing planning controls for development. In particular, a number of respondents indicated their opposition to the requirement in Council's current Flood Policy for development sites to be filled before residential development can proceed. It was argued that this requirement actually increased the potential for adverse flood impacts.

4.2.2 Feedback on Measures for Cabbage Tree Island

The response from the Cabbage Tree Island community was disappointing. The small sample of responses made it difficult to justify consideration of any specific floodplain management measure. Notwithstanding, the limited response did indicate some support for the dredging measures put forward for the river and the Back Channel.

4.3 PREFERRED FLOODPLAIN MANAGEMENT MEASURES

4.3.1 Structural Measures

Representatives from Ballina Shire Council, the Department of Natural Resources and Patterson Britton & Partners reviewed the results of the community consultation and determined those measures that warranted more detailed investigation. The Flood Damage Reduction Measures that were adopted for investigation are listed in **Tables 5** and **6**. Each of the measures is identified graphically in **Figure 6** for Wardell and in **Figure 7** for Cabbage Tree Island. The Cabbage Tree Island deflector levee measure was further subdivided to assess the relative benefits of a high and low level deflector levee (*i.e., Options 1A (i) and 1A (ii) in* **Table 6**).

Wardell

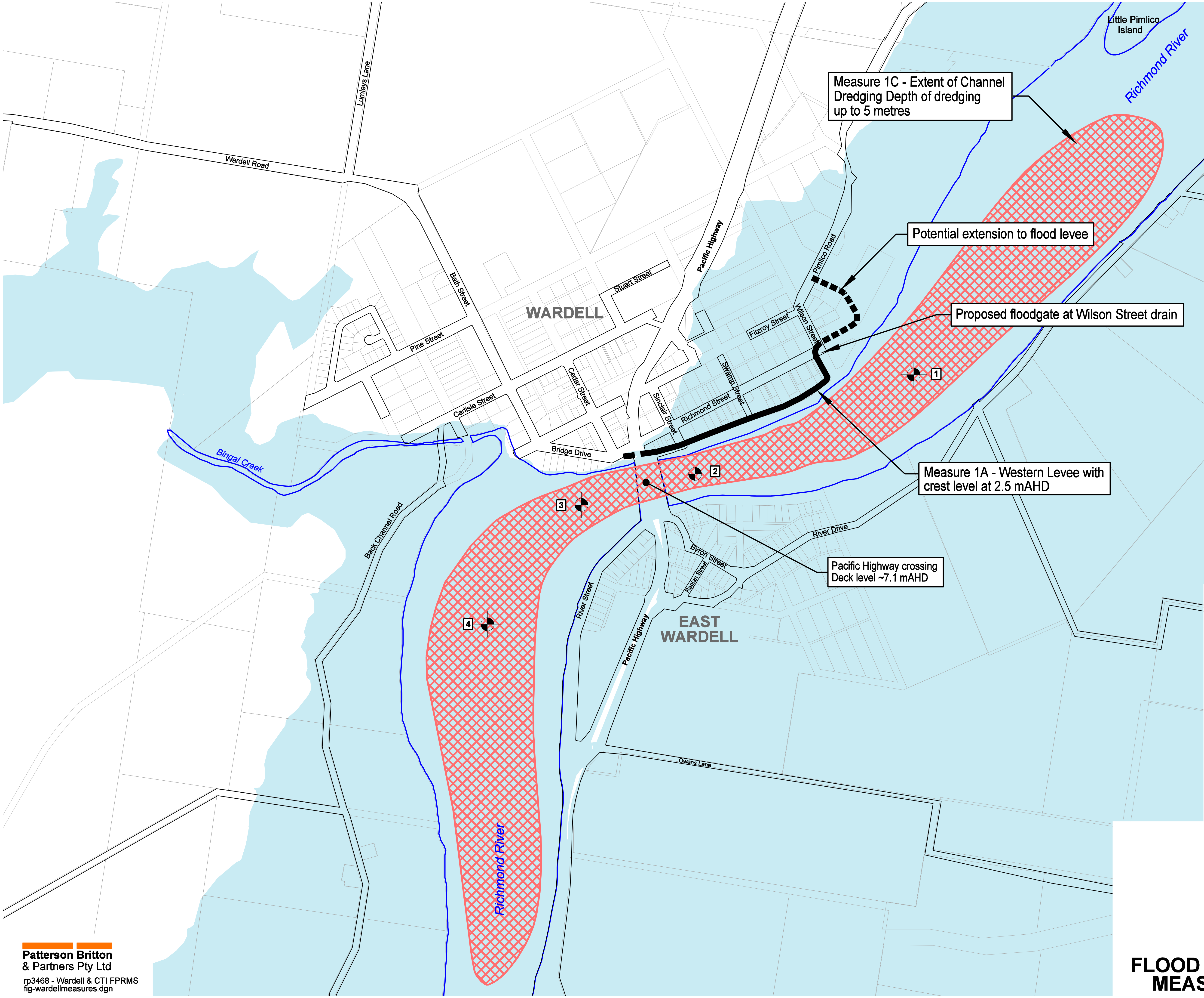
The measures selected for Wardell were generally based on the feedback provided by the community on each of the potential flood damage reduction measures as reported in the questionnaire responses (*refer* **Appendix E**).

The strong support for dredging of the Richmond River indicated the need for further investigation of a suitable dredging scenario. This scenario was based on a cursory appraisal of channel morphology and bed levels in the area downstream of Wardell to the mouth of North Creek.

The feedback also indicated support for the implementation of Measure 1B at Wardell, which involves construction of a levee along the eastern bank of the Richmond River to protect East Wardell. However, on closer inspection it was determined that this option would predominantly benefit currently undeveloped land and therefore did not technically constitute a flood damage reduction measure.

Department of Natural Resources policy stipulates that funding for floodplain management activities must be associated with works or actions that reduce the potential damage to existing buildings or infrastructure, or must reduce the potential for loss of life. A re-assessment of the results of the Flood Study established that the works associated with Measure 1B would not achieve this policy objective and that government funding for the associated works was unlikely to be secured. Accordingly, further investigation of Measure 1B was not pursued.

FIGURE 6



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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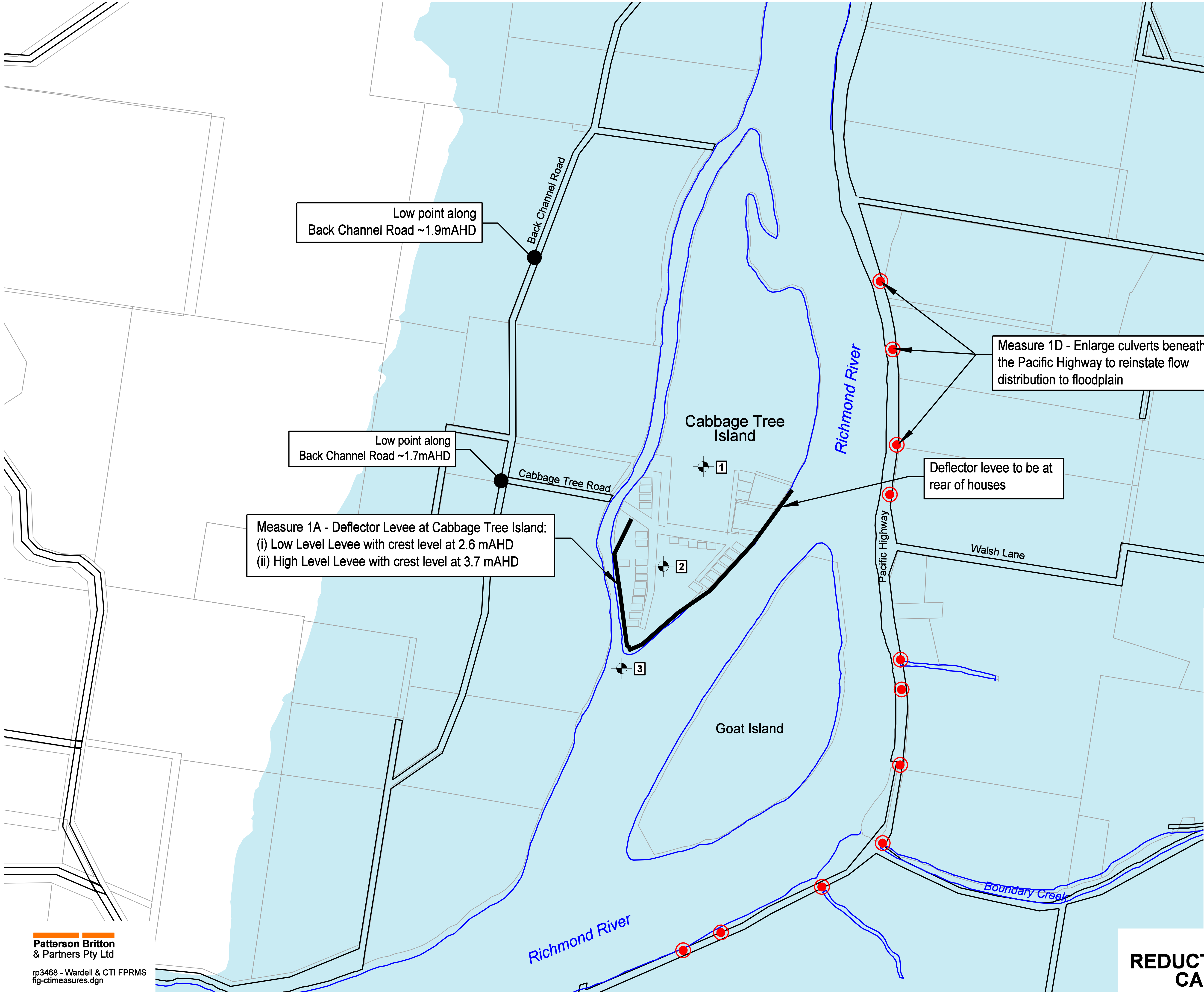
FLOOD DAMAGE REDUCTION MEASURES FOR WARDELL

FIGURE 7



Location	Peak Flood Level (mAHD)			
	PMF	100yr	50yr	20yr
1	4.90	3.30	2.98	2.53
2	4.92	3.34	3.04	2.60
3	4.95	3.38	3.07	2.64

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FLOOD DAMAGE REDUCTION MEASURES FOR CABBAGE TREE ISLAND

Table 5 PREFERRED FLOOD DAMAGE REDUCTION MEASURES FOR WARDELL

MEASURE	DESCRIPTION OF MEASURE
1A	**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**. The purpose of the levee is to provide a greater level of protection to those low lying properties at Wardell located east of the Pacific Highway.
1C	**Dredging of the Richmond River channel extending from Little Pimlico Island upstream to Meaneys Lane**. The aim of the dredging would be to increase the conveyance, or flow carrying capacity, of the river channel thereby reducing the proportion of flow discharged across the floodplain. It would involve deepening the river channel by up to 5 metres including the removal of approximately 1,200,000 m^3 of material.

Table 6 PREFERRED FLOOD DAMAGE REDUCTION MEASURES FOR CABBAGE TREE ISLAND

MEASURE	DESCRIPTION OF MEASURE
1A (i)	**Construction of a low level deflector levee with a nominal crest elevation of 2.6 mAHD extending around the southern end of Cabbage Tree Island**. The low level deflector levee will prevent floodwaters from discharging in a northerly direction across Cabbage Tree Island during floods up to and including the 10 year recurrence event.
1A (ii)	**Construction of a high level deflector levee with a nominal crest elevation of 3.7 mAHD extending around the southern end of Cabbage Tree Island**. The high level deflector levee will prevent floodwaters from discharging in a northerly direction across Cabbage Tree Island during floods up to and including the 100 year recurrence event.
1D	**Installation of additional culverts beneath the Pacific Highway**. The highway prevents the lateral movement of floodwaters from the Richmond River onto the eastern floodplain of the river, thereby increasing peak flood levels along the river in the vicinity of Cabbage Tree Island. The installation of additional culverts beneath the highway will allow flood flows to more readily move from the river onto the eastern floodplain, thereby potentially reducing peak flood levels at Cabbage Tree Island.

Cabbage Tree Island

The flood damage reduction measures selected for Cabbage Tree Island (*refer* **Table 6**) were determined by considering the limited feedback provided by the community and through discussion between representatives from Ballina Shire Council, the Department of Natural Resources and Patterson Britton & Partners.

The findings from the Flood Study indicate that those living on Cabbage Tree Island are exposed to a real flood risk and that there is potential for the loss of life and property damage in large floods. Accordingly, it was considered appropriate to investigate those measures that would afford the greatest benefit in terms of providing reduced hazard across the island.

It was recognised that the island will still be flooded in moderate to major events, so the impetus for any structural measures should be to reduce the hazard if possible and thereby provide a 'safer' platform for evacuation in times of flood.

Consideration was given to the two dredging measures (*Measures 1B and 1C in* **Table 3**), but it was felt that these measures were likely to have least impact in terms of a reduction in the flood hazard at Cabbage Tree Island. In addition, it was felt that the environmental impact of these two dredging scenarios was likely to be unacceptable and that this would override any minor benefit afforded by reduced flood levels on the island.

The assessment established that Measure 1A involving the construction of a deflector levee at the upstream end of the island, had the greatest potential to reduce the flood hazard on the island.

On ground investigations subsequently raised some concern regarding the practicality of constructing a deflector levee with a crest level equivalent to the peak 100 year recurrence flood level. Accordingly, it was decided that both a low level deflector levee (*to a crest elevation of 2.6 mAHD*) and a high level deflector levee (*to a crest elevation of 3.7 mAHD*) should be investigated (*refer* **Table 4**).

It was also considered that the installation of additional culverts beneath the section of the Pacific Highway that runs along the eastern bank of the Richmond River (*Measure 1D*) could reduce the frequency of flooding of Cabbage Tree Island and therefore warranted further investigation.

4.3.2 Non-Structural Measures

As outlined in **Table 3**, two potential non-structural or planning measures were identified during the community consultation program. These measures are targeted toward improving flood emergency response at both Wardell and Cabbage Tree Island, and toward addressing concerns raised by the community about existing flood related building controls.

However, in addition to these, concerns about the high flood hazard in some areas (*refer* **Figure 3**) led to an assessment of the current zoning of land within both villages and consideration of the suitability of that zoning relative to the potential flood risk.

In particular, some low lying areas of East Wardell that could be the subject of future development proposals would be exposed to very high or extreme flood hazard conditions in a design 100 year recurrence flood (*refer* **Figure 3**). In addition, all of Cabbage Tree Island would be exposed to high to extreme hazard conditions in an event of this magnitude and the majority of the island would be classified as a high hazard floodway.

The risks associated with flooding and the potential for isolation of residents within these areas was considered sufficient to warrant investigation of the suitability of the affected land for future residential development.

A discussion of the basis for determining non-structural or planning measures to be considered for detailed investigation is outlined in the following sections.

Wardell / East Wardell

Building Controls

The responses to the questionnaire and independent consultation with the community indicate that there are concerns, particularly at Wardell, regarding some of the existing flood related building controls that are enforced by Council. This concern is linked to increasing demand for development in the village and at East Wardell.

Council's existing *Flood Policy* is defined in *Policy Statement No.11 – Flood Levels* of Council's Development Control Plan No. 1 – Urban Land. This addresses the filling of sites in flood prone areas and states the following:

- minimum fill levels for areas within the study area covered by the *'Ballina Floodplain Management Study'* (*1997*) (*BFMS*) are to be based on the design 100 year recurrence flood level;
- minimum floor levels are to be based on the minimum fill level plus a freeboard of 300 mm in flood prone areas within the study area of the BMFS (*1997*).
- minimum fill levels are to be 300 mm above the highest recorded flood level for flood prone areas outside of the study area covered by the BFMS (*1997*); and,
- minimum floor levels are to be 600 mm above the highest recorded flood level for flood prone areas outside of the study area of the BFMS (*1997*).

A number of respondents to the questionnaire expressed their concern over the practicality of these flood related building controls, particularly in relation to land that is currently zoned residential, commercial or industrial, but which is below the minimum fill level.

Accordingly, it was considered appropriate to revisit the building controls and provide recommendations that could be considered as part of strategic planning for the village.

Development Restrictions at East Wardell

Figure 3 shows that areas adjacent to the river bank at East Wardell will be exposed to high to very high flood hazard conditions. This includes two 'strips' of land located upstream and downstream of the Pacific Highway bridge crossing.

The land located upstream of the bridge includes lots that front onto River Street. Some of these lots have been developed, with up to ten houses of varying ages sited on residential allotments within this strip of land. Some of these lots have been filled and the dwellings have been sited on an elevated pad, while others comprise dwellings that have been constructed at natural ground level.

The results of the flood modelling indicate that the unfilled lots could be exposed to floodwater depths of up to 1.75 metres and peak average flow velocities of about 0.6 m/s. These flood characteristics suggest that the strip of residential land fronting River Street fringes on being classified as a high hazard floodway. In normal circumstances, dwellings located on land within a floodway are typically recommended for voluntary purchase. In this circumstance, it appears that the dwellings at the eastern end of River Street would be exposed to the greatest threat.

The land located downstream from the bridge includes a large parcel located between the river bank and Byron Street / River Drive that is currently zoned *1(b) Rural – Secondary Agricultural Land*. A historical subdivision layout exists over this land and it has recently been mooted for future rezoning for residential development.

Similarly, land to the south of residential development that currently fronts River Drive has been subdivided and may be the subject of future rural residential development proposals. However, the flood hazard represented in **Figure 3** indicates that this area is subject to very high hazard conditions in the design 100 year recurrence flood. Accordingly, the potential for development of this land for residential purposes is considered to be limited.

Cabbage Tree Island

Flood Emergency Response

Flood emergency response protocols for Wardell and Cabbage Tree Island are covered by the Ballina Local Flood Plan. The Flood Plan was prepared by the State Emergency Services and was published in 2000. It is now due for review.

The plan covers preparedness measures, the conduct of response operations and the coordination of recovery measures for flood scenarios. It includes specific reference to the impact of flooding on communities at Cabbage Tree Island and Wardell, and contains a separate annexure detailing the *"special arrangements for the evacuation of Cabbage Tree Island"* (*refer Annexure G*). A copy of this Annexure is enclosed as **Appendix H**.

Accordingly, it was considered appropriate for a review of the Flood Plan to be undertaken and recommendations for amendments or changes arising from the work undertaken for this Floodplain Management Study to be incorporated into the proposed revision.

5 FLOODPLAIN MANAGEMENT OPTIONS

5.1 OPTIONS FOR INVESTIGATION

A floodplain risk management study is a multi-disciplinary process that needs to consider a number of different factors to develop an appropriate mix of management options to deal with the flood risk (*NSW Government, 2005*). Each floodplain risk management option will have both advantages and disadvantages. The purpose of the floodplain risk management study is to quantify the relative merits of each option, giving consideration to any flooding, social, economic and environmental consequences.

A range of <u>Flood Management Options</u> were developed for both Wardell and Cabbage Tree Island from the measures identified and presented during the community consultation program. Each of these options was then investigated in greater detail.

The <u>options</u> adopted for further investigation comprised a combination of the measures listed in **Table 5** and **6**. The measures that have been included within each option are identified in the matrix presented as **Table 7**.

Table 7 MATRIX SUMMARISING DETERMINATION OF OPTIONS

MEASURE	MODELLED AS PART OF FPRMS	OPTIONS						
		1	2	3	4	5	6	7
<u>Wardell</u>								
1A – Western Levee	YES	ü		ü				
1B – Eastern Levee	NO							
1C – River Dredging at Wardell	YES		ü	ü				ü
<u>Cabbage Tree Island</u>								
1A (i) – Low Level Deflector Levee	YES				ü			ü
1A (ii) – High Level Deflector Levee	YES					ü		
1B – Back Channel Dredging	NO							
1C – Richmond River Dredging	NO							
1D – Highway Culvert Upgrade	YES						ü	

5.2 STRUCTURAL OPTIONS

The Flood Management Options that were adopted for investigation are listed in **Table 8** for Wardell and **Table 9** for Cabbage Tree Island. Each of these options was investigated to assess their respective advantages and disadvantages considering issues associated with flood hydraulics, environmental constraints and economics.

Table 8 STRUCTURAL FLOOD MANAGEMENT OPTIONS FOR WARDELL

OPTION	FLOOD MANAGEMENT OPTIONS
1	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.
2	Dredging of the Richmond River channel extending from Little Pimlico Island upstream to Meaneys Lane.
3	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.

Table 9 STRUCTURAL FLOOD MANAGEMENT OPTIONS FOR CABBAGE TREE ISLAND

OPTION	FLOOD MANAGEMENT OPTIONS
4	Construction of a low level deflector levee with a nominal crest elevation of 2.6 mAHD extending around the southern end of Cabbage Tree Island
5	Construction of a high level deflector levee with a nominal crest elevation of 3.7 mAHD extending around the southern end of Cabbage Tree Island.
6	Installation of additional culverts beneath the Pacific Highway.
7	Construction of a low level deflector levee with a nominal crest elevation of 2.6 mAHD extending around the southern end of Cabbage Tree Island and dredging of the Richmond River channel extending from Little Pimlico Island upstream to Meaneys Lane near Wardell.

5.3 ASSESSMENT OF STRUCTURAL OPTIONS

5.3.1 Hydraulic Assessment

To enable the effectiveness of each of the suggested flood management options to be evaluated, each option was incorporated into the RMA-2 hydraulic model that was originally developed 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.

5.3.2 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 in **Section 3**. 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 'benefit' was calculated over a design life of 30 years as the summation of the reduction in AAD for each management option relative to the AAD that would be incurred under existing conditions.

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. A detailed breakdown of the cost estimates for each floodplain management option is provided in **Appendix G**.

5.3.3 Wardell

Option 1 – Western Levee

Description of Option

The township of Wardell is located on the western floodplain of the Richmond River and is generally sited on land above 5 mAHD. However, a small proportion of the township located east of the Pacific Highway is situated on lower-lying land that is generally located between 1.5 and 2.3 mAHD. Accordingly, during large floods along the Richmond River, this low lying section of the township has the potential to be inundated.

Option 1 would involve the construction of a levee along the western bank of the Richmond River at Wardell. The alignment and extent of the proposed levee is shown in **Figure 6**. The proposed levee would afford additional protection to those low-lying properties located on the western floodplain of the Richmond River.

As shown in **Figure 6**, 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.

Consideration was given to providing a higher level levee that would afford protection during events up to and including the 100 year recurrence flood. However, a levee of this height could not be accommodated in the available space between the western river embankment and the dwellings/infrastructure that currently front the river. Moreover, a levee at this height would also require approximately 2 metres of fill, thereby obstructing river views for existing dwellings on the lower lying section of the floodplain adjacent to the river.

Notwithstanding, the proposed 2.5 mAHD levee will prevent floodwaters discharging from the Richmond River in a north-easterly direction across the low-lying sections of the Wardell township during floods up to and including the 20 year recurrence event.

However, it should be noted that 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.

Hydraulic Assessment

The results of the RMA-2 modelling, incorporating the proposed western levee, indicate that the proposed levee will not be overtopped during all floods up to and including the 20 year recurrence flood. However, sections of the township are still predicted to be inundated during the 20 year recurrence flood by water backing up around the downstream end of the levee. The levee itself will begin to overtop during the 50 year recurrence flood (*overtopped by about 0.05 metres*). Although the levee will be overtopped during larger floods, the levee is still predicted to slow the movement of floodwaters through the township.

The following conclusions can be drawn from the results of the modelling (*refer* **Figures 8** *and* **9**):

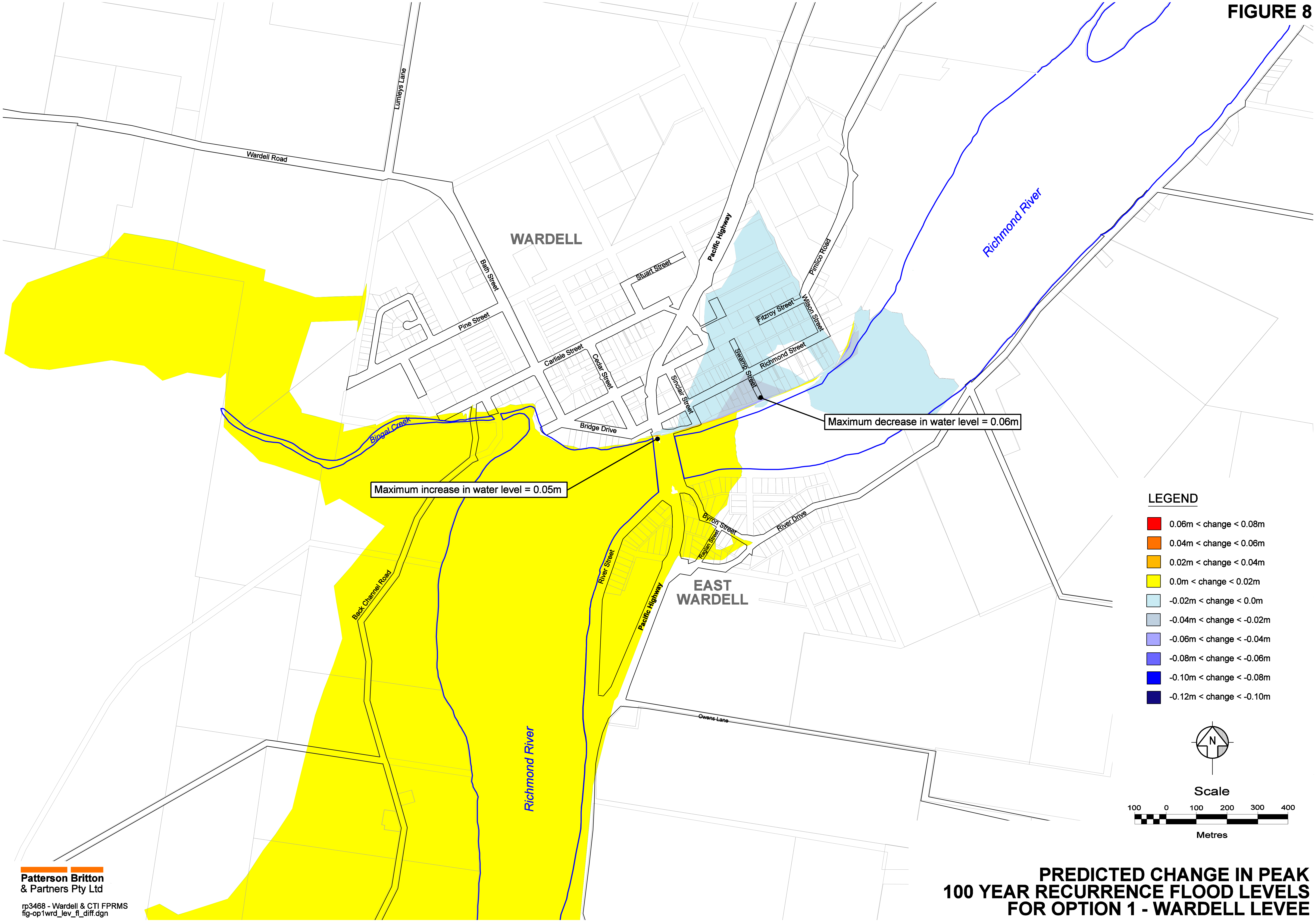
- The levee is predicted to generate a maximum increase in peak level during the 100 year recurrence flood of about 0.05 metres. This is predicted to occur immediately upstream of the Pacific Highway bridge crossing of the Richmond River. Generally the increases in peak level are predicted to be about 0.01 metres and are predicted to be contained to the river channel.

  Notwithstanding, small increases in peak flood level are predicted at East Wardell (*0.01 m*) and as far upstream as the northern end of Cabbage Tree Island (*refer* **Figure 8**).

- The maximum decrease in peak level is predicted to be about 0.06 metres and is predicted to occur near the eastern end of Swamp Street. Generally the decreases in peak flood level through Wardell are predicted to be less than 0.03 m and are generally contained between the proposed levee and Richmond Street (*refer* **Figure 8**).

- The proposed levee will effectively force a greater proportion of flood flows to be contained to the Richmond River channel. This is predicted to generate a maximum increase in peak flow velocity of about 0.18 m/s within the river channel.

FIGURE 8



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PREDICTED CHANGE IN PEAK 100 YEAR RECURRENCE FLOOD LEVELS FOR OPTION 1 - WARDELL LEVEE

Generally the increases in peak flow velocity occur over a localised area and are contained to the river channel. However, a small increase in flow velocity (*i.e., less than 0.05m/s*) is predicted to occur across an undeveloped section of the eastern floodplain of the Richmond River at East Wardell (*refer* **Figure 9**).

- Although it will be overtopped, the proposed levee will slow the movement of floodwaters through the township. The maximum decrease in peak flow velocity is predicted to be about 0.9 m/s and occur near the north side of the Wardell Bridge. Across areas in Wardell downstream from the bridge the decrease in peak velocity is expected to be up to 0.6 m/s. Small decreases in flow velocity are predicted across sections of East Wardell and the Richmond River channel, however, they are only in the order of 0.02 m/s (*refer* **Figure 9**).

Benefit - Cost Assessment

The results of the benefit-cost assessment for Option 1 indicate that:

§ Option 1 would cost about $300,000 to construct. This does not allow for life cycle costs including maintenance and repairs due to damage in a flood.

§ The average annual flood damage with Option 1 in place would be about $206,100. This compares to the average annual flood damage of $206,200 for existing conditions.

§ The present value of the benefits associated with implementing Option 1 would be about $1,300.

§ The benefit-cost ratio for Option 1 was determined to be less than 0.01.

Option 2 – Channel Dredging

Description of Option

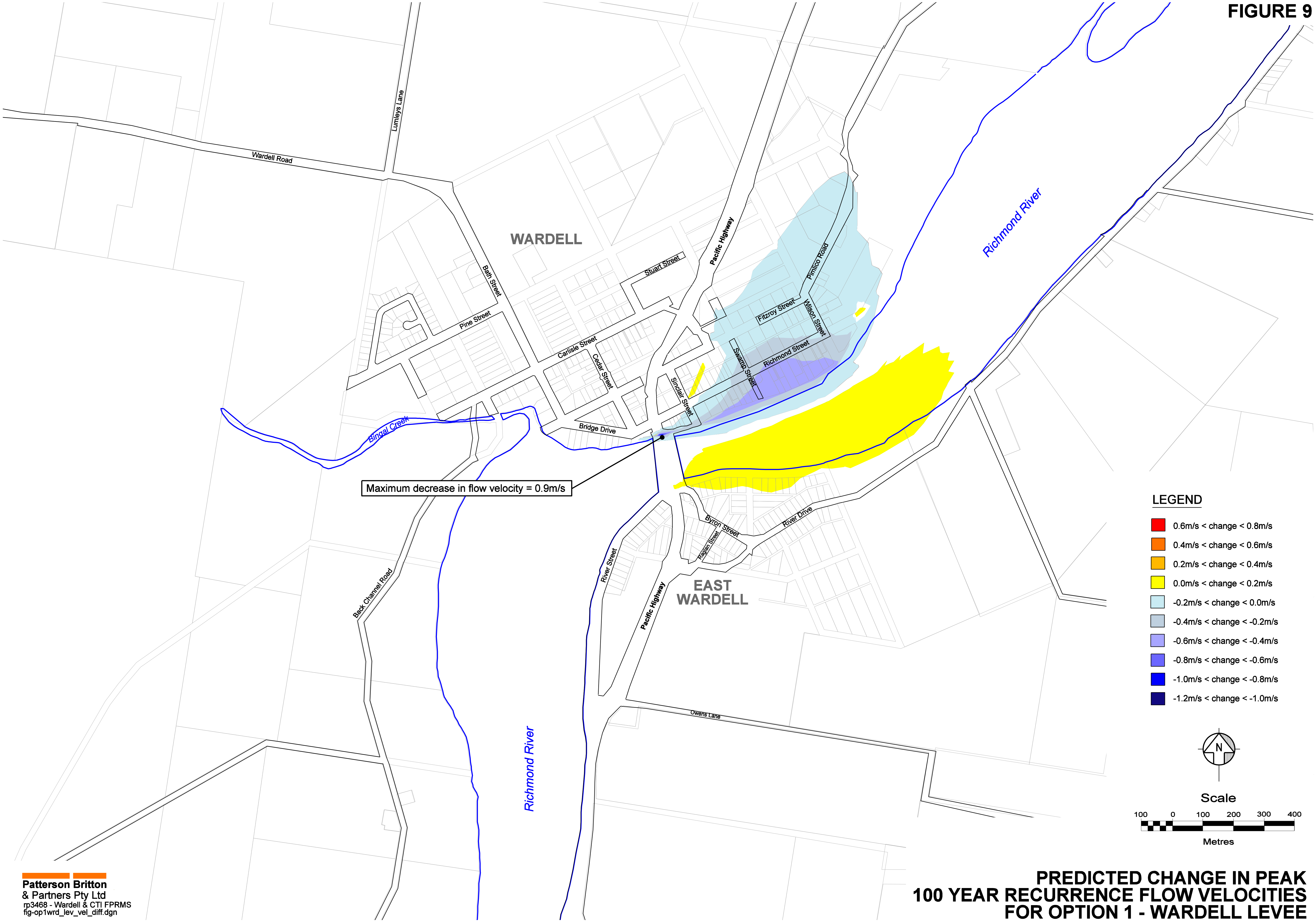
Recent hydrographic survey of the Richmond River channel in the vicinity of Wardell indicates significant variations in the geometry of the river bed. A longitudinal profile of the river bed is provided in **Figure 10**.

As shown in **Figure 10**, significant scouring of the river channel is evident around the Pacific Highway bridge crossing at Wardell where the channel invert approaches -15 mAHD. This indicates that high velocity flood flows through the bridge have, over time, removed sediment from this section of the river. However, **Figure 10** also indicates that as flow velocities in areas upstream and downstream of the bridge slow, the flood flows have insufficient energy to carry the suspended sediment. Therefore, sediment typically falls out of suspension and is deposited on the river bed. This has reduced the conveyance, or flow carrying capacity, of these sections of the river channel.

Option 2 will involve dredging of sections of the Richmond River channel in the vicinity of Wardell. The proposed dredging will extend from the southern end of Little Pimlico Island (*downstream of Wardell*) upstream to Meaneys Lane (*upstream of Wardell*). The extent of the proposed dredging is shown in **Figure 6**.

The dredging will include deepening the river channel by up to 5 metres and will involve the removal of about 1.2M m^3 of material from the river bed. A comparison between the existing channel invert and the ‘dredged’ channel invert is provided in **Figure 10**.

FIGURE 9



PREDICTED CHANGE IN PEAK 100 YEAR RECURRENCE FLOW VELOCITIES FOR OPTION 1 - WARDELL LEVEE

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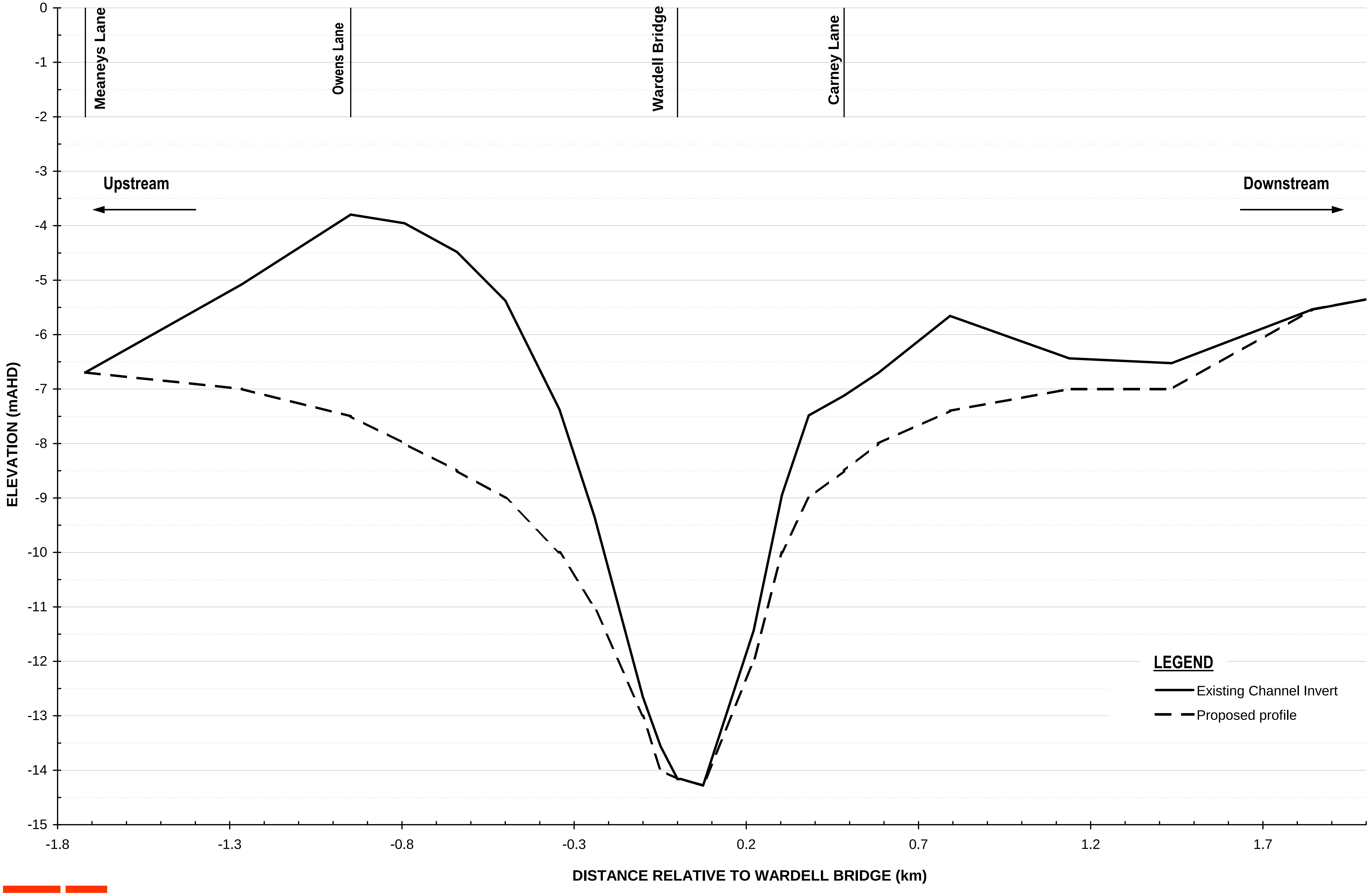
FIGURE 10



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Wardell & Cabbage Tree Island FRMS
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CHANNEL DREDGING PROFILE
FOR THE RICHMOND RIVER

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. The dredging also has the potential to reduce peak flood levels upstream at Cabbage Tree Island.

However, it should be noted that dredging of the Richmond River is likely to have significant environmental implications.

Hydraulic Assessment

The RMA-2 model was used to simulate the 100 year recurrence flood with the dredged Richmond River Channel. The following conclusions can be drawn from the results of the modelling (*refer* **Figures 11** *and* **12**):

- The dredging is predicted to generate a maximum decrease in peak level of about 0.08 metres. This is predicted to occur along the western bank of the Richmond River between Wardell and Cabbage Tree Island. Decreases in peak level in the vicinity of Wardell are predicted to be less than 0.02 metres. The channel dredging is also predicted to decrease peak flood levels as far upstream as Cabbage Tree Island, however the decreases are generally less than 0.02 metres (*refer* **Figure 11**).
- The maximum increase in peak level is predicted to be about 0.03 metres and occurs upstream of Little Pimlico Island. The maximum increase is contained to the Richmond River channel. Increases in peak flood level are predicted across isolated sections of Wardell, however, they are generally only 0.01 metres (*refer* **Figure 11**).
- The dredging is predicted to generate increases in peak flow velocity across isolated areas adjacent to the banks of the Richmond River. The magnitude of the increases is generally less than 0.05 m/s. Notwithstanding, an increase in peak flow velocity of up to 0.1 m/s is predicted across sections of East Wardell (*refer* **Figure 12**).
- The dredging is predicted to generate decreases in peak flow velocity of up to 0.4 m/s. However, the maximum decreases are predicted to occur within the main river channel. Decreases in flow velocity of up to 0.15 m/s are predicted across the lower-lying sections of Wardell (*refer* **Figure 12**).

Benefit - Cost Assessment

The results of the benefit-cost assessment for Option 2 indicate that:

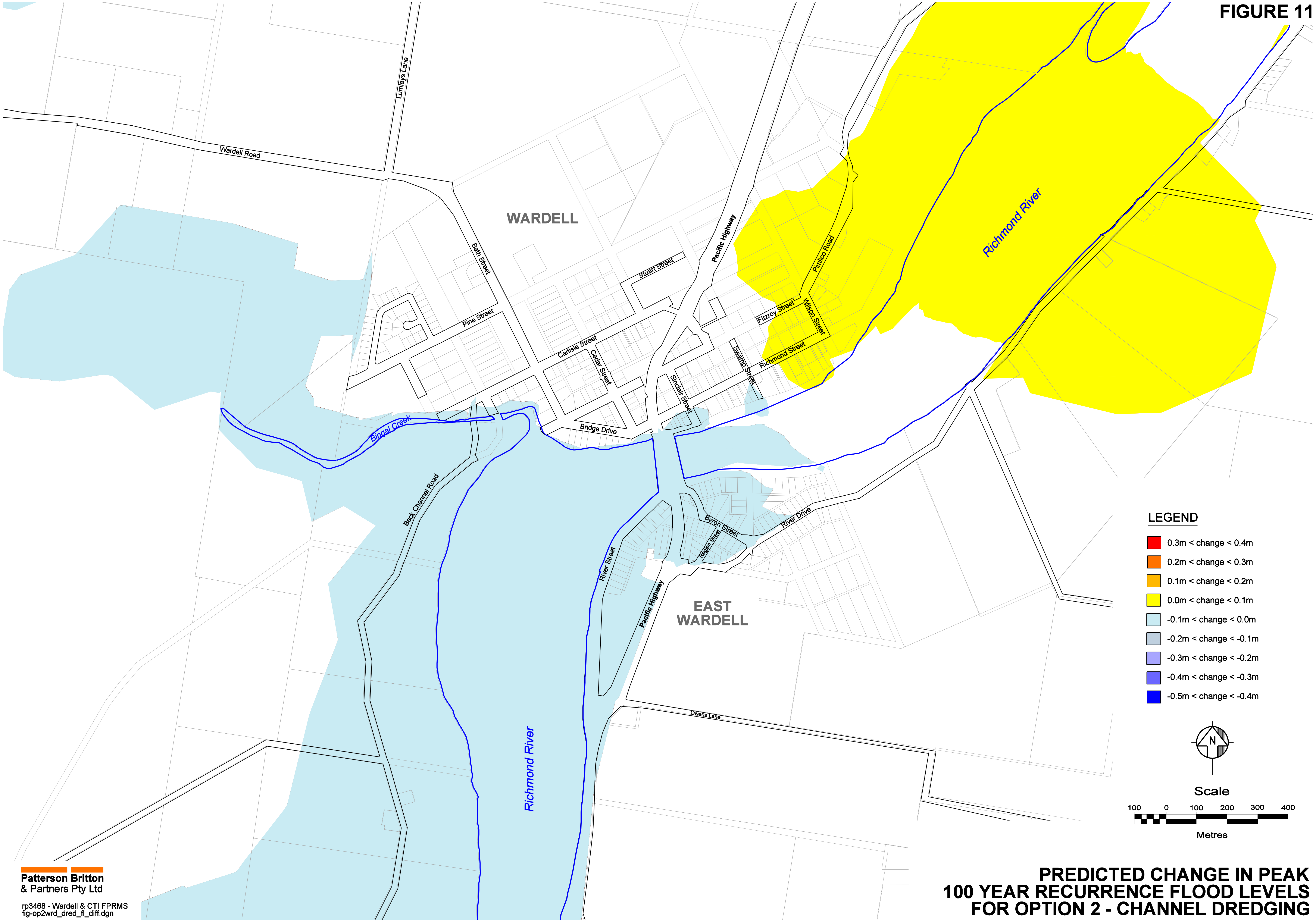
§ Option 2 would cost about $24.4M to implement. This does not allow for life cycle costs including the need to undertake follow-up dredging after a flood.

§ The average annual flood damage with Option 2 in place would be about $166,500. This compares to the average annual flood damage of $206,200 for existing conditions.

§ The present value of the benefits associated with implementing Option 2 would be about $609,900.

§ The benefit-cost ratio for Option 2 was determined to be about 0.02.

FIGURE 11



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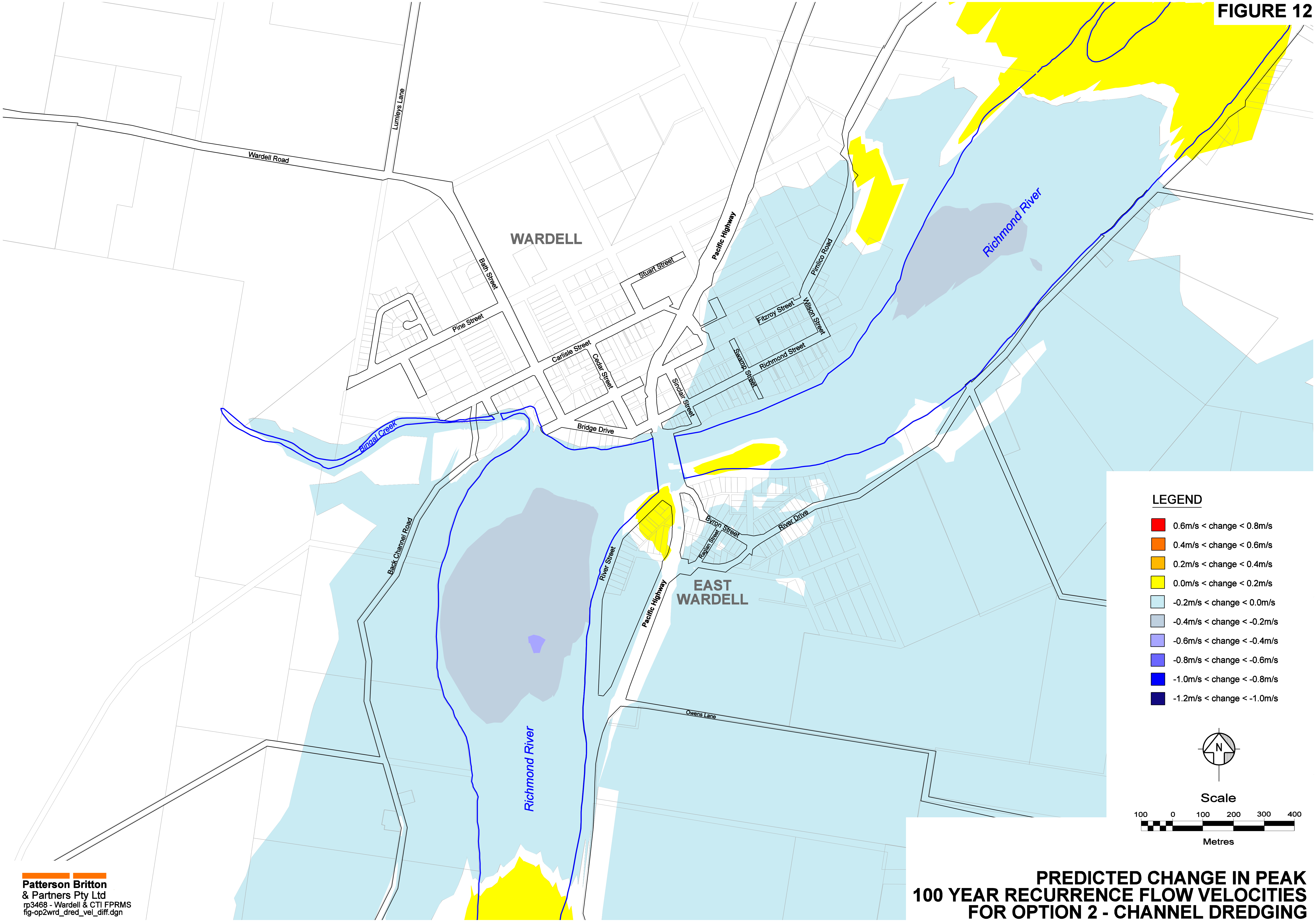
PREDICTED CHANGE IN PEAK 100 YEAR RECURRENCE FLOOD LEVELS FOR OPTION 2 - CHANNEL DREDGING

FIGURE 12



LEGEND

- 0.6m/s < change < 0.8m/s
- 0.4m/s < change < 0.6m/s
- 0.2m/s < change < 0.4m/s
- 0.0m/s < change < 0.2m/s
- -0.2m/s < change < 0.0m/s
- -0.4m/s < change < -0.2m/s
- -0.6m/s < change < -0.4m/s
- -0.8m/s < change < -0.6m/s
- -1.0m/s < change < -0.8m/s
- -1.2m/s < change < -1.0m/s

Scale

100 0 100 200 300 400

Metres

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fig-op2wrd_dred_vel_diff.dgn

PREDICTED CHANGE IN PEAK 100 YEAR RECURRENCE FLOW VELOCITIES FOR OPTION 2 - CHANNEL DREDGING

Option 3 – Western Levee and Channel Dredging

Description of Option

Option 3 would involve construction of a levee extending along the western bank of the Richmond River at Wardell <u>and</u> dredging of the Richmond River channel in the vicinity of Wardell (*refer* **Options 1** *and* **2**).

Hydraulic Assessment

The RMA-2 hydraulic model was used to simulate flood behaviour with the western levee at Wardell and dredging of the Richmond River channel in place. The following conclusions can be drawn from the results of the modelling (*refer* **Figures 13** *and* **14**):

- Option 3 is predicted to reduce peak flood levels in the vicinity of Wardell by between 0.02 to 0.05 metres. The maximum decrease in level in the vicinity of Wardell is predicted to occur near the eastern end of Swamp Street. More significant decreases (*i.e., about 0.07 metres*) are predicted along the river upstream of Wardell. A reduction in peak level of around 0.04 metres is also predicted upstream at Cabbage Tree Island (*refer* **Figure 13**).
- Option 3 is predicted to generate a small increase in peak flood level of about 0.02 metres in the vicinity of Little Pimlico Island (*refer* **Figure 13**).
- Option 3 will reduce peak flow velocities through the township by up to 0.9 m/s. However, decreases in velocities through the township are generally predicted to be between 0.2-0.5 m/s. Small decreases in flow velocity are also predicted across East Wardell, however, they are predicted to be less than 0.05 m/s (*refer* **Figure 14**).
- Option 3 is predicted to generate a maximum increase in peak flow velocity of about 0.18 m/s. The increases in flow velocity are predicted to be largely contained to the Richmond River channel although small increases of up to 0.1 m/s are predicted across East Wardell (*refer* **Figure 14**).

Benefit - Cost Assessment

The results of the benefit-cost assessment for Option 3 indicate that:

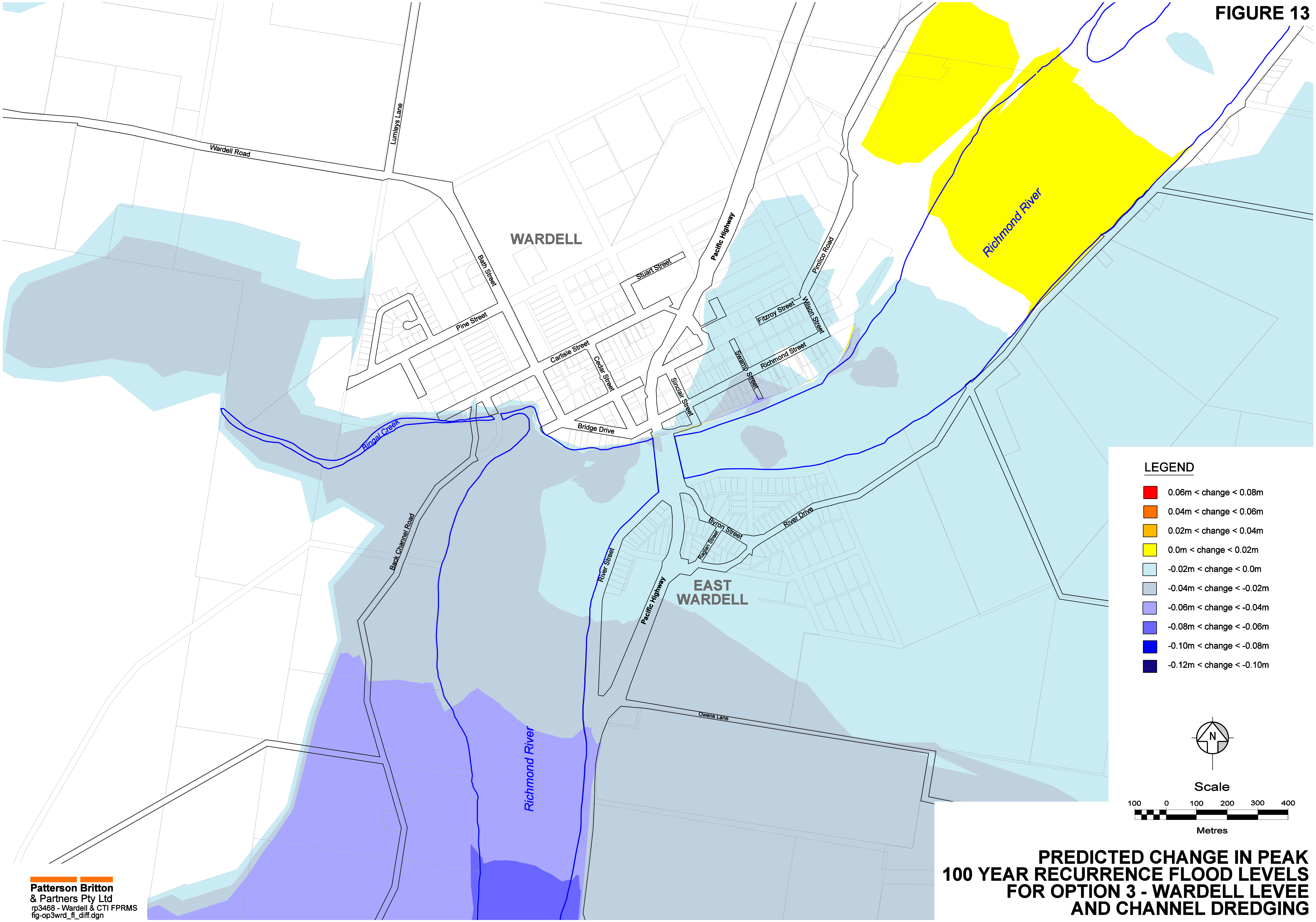
§ Option 3 would cost about $24.7M to implement. This does not allow for life cycle costs including the need to undertake follow-up dredging after a flood or to maintain or repair damaged sections of the levee.

§ The average annual flood damage with Option 3 in place would be about $195,300. This compares to the average annual flood damage of $206,200 for existing conditions.

§ The present value of the benefits associated with implementing Option 3 would be about $167,200.

§ The benefit-cost ratio for Option 3 was determined to be less than 0.01.

FIGURE 13



PREDICTED CHANGE IN PEAK 100 YEAR RECURRENCE FLOOD LEVELS FOR OPTION 3 - WARDELL LEVEE AND CHANNEL DREDGING

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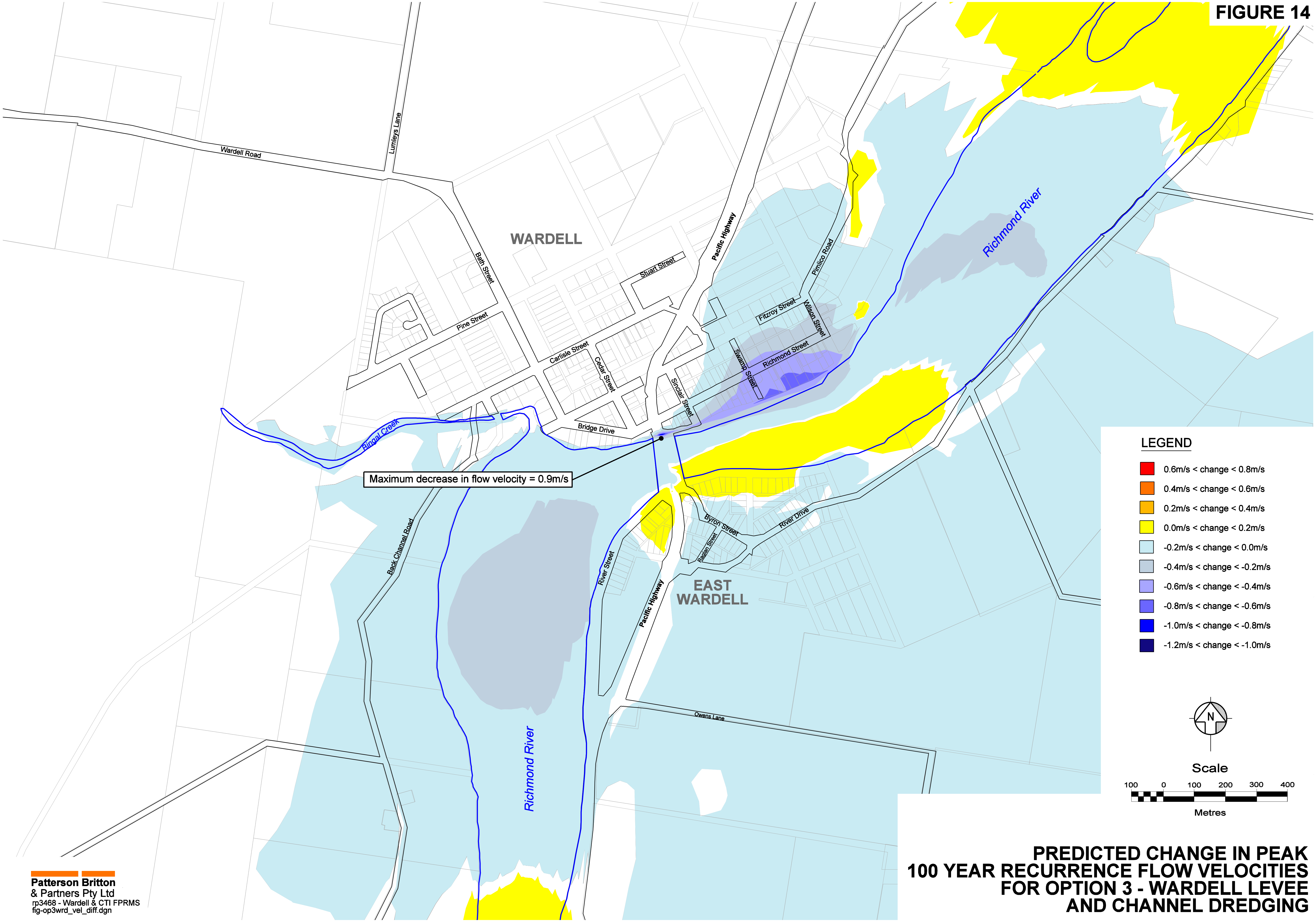
FIGURE 14



PREDICTED CHANGE IN PEAK
100 YEAR RECURRENCE FLOW VELOCITIES
FOR OPTION 3 - WARDELL LEVEE
AND CHANNEL DREDGING

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5.3.4 Cabbage Tree Island

Option 4 –Low Level Deflector Levee

Description of Option

Cabbage Tree Island is generally low lying with the majority of the island located between 1.5 mAHD and 2.5 mAHD. The low topography means that the habited sections of the island are subject to inundation during relatively frequent floods (*e.g., 5 year recurrence flood*). The low topography also means that during larger floods along the Richmond River (*e.g., the 100 year recurrence flood*), a large proportion of the flood flow is discharged across the island. This has the potential to generate significant floodwater depths and flow velocities across the island during large floods

Option 4 would involve the construction of a low level deflector levee around the upstream end of Cabbage Tree Island. The alignment and extent of the deflector levee is shown in **Figure 7**. The levee would be constructed with a nominal crest elevation of 2.6 mAHD (*peak 10 year recurrence flood level plus a freeboard of 300 mm*) and would be elevated up to 2 metres above the island. As the name suggests, the low level deflector levee would effectively ‘deflect’ flood flows around the southern end of Cabbage Tree Island during floods up to and including the 10 year recurrence flood. This would effectively prevent floodwaters from discharging in a northerly direction across the habited areas of the island during small floods (*i.e., up to and including the 10 year recurrence flood*). The levee would also serve to slow the progression of floodwaters during larger floods (*i.e., floods in excess of the 10 year recurrence event*).

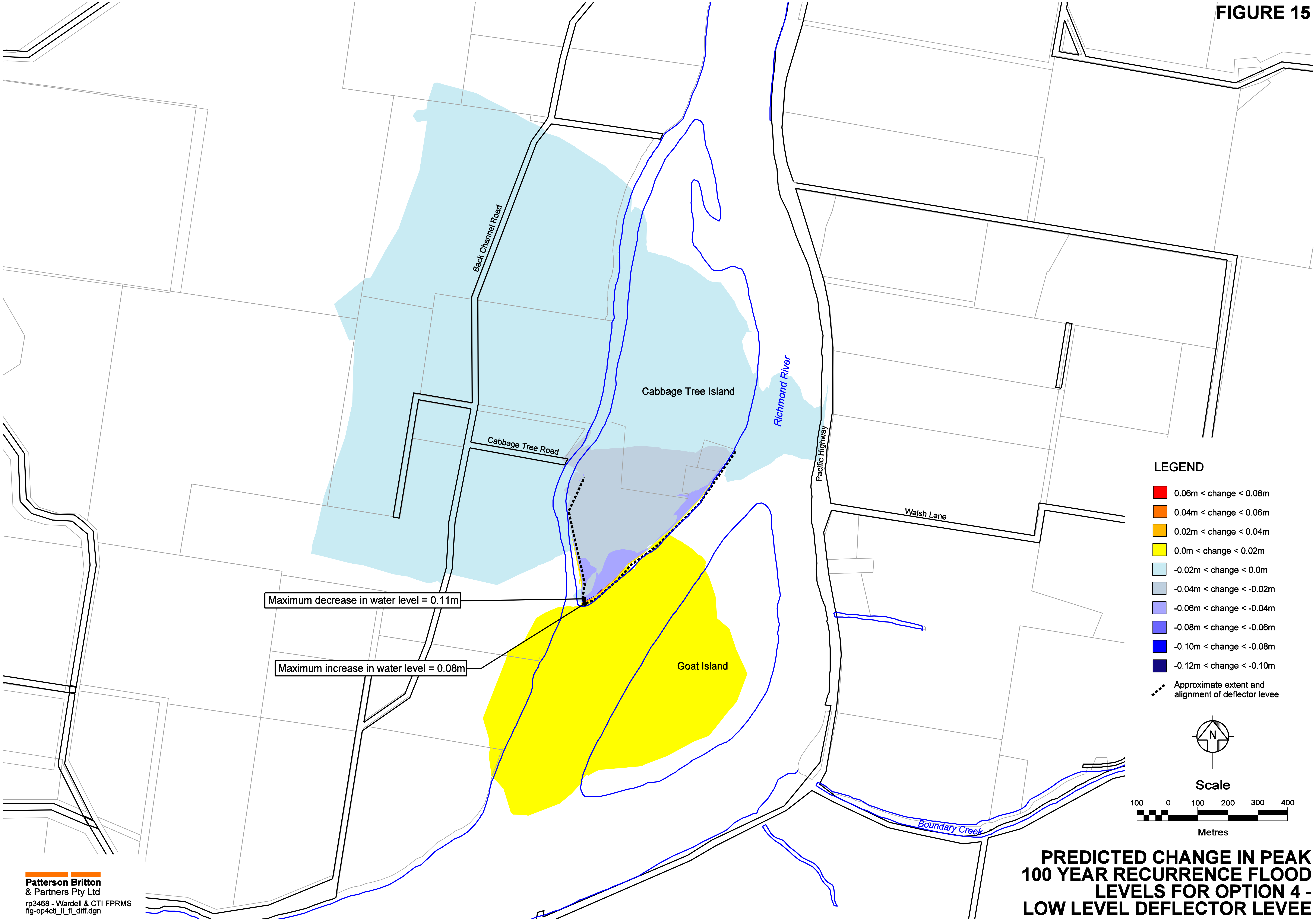
Hydraulic Assessment

The RMA-2 hydraulic model was used to simulate the 100 year recurrence flood with the low level deflector levee in place. The following conclusions can be drawn from the results of the modelling (*refer* **Figures 15** *and* **16**):

- **Figure 15** shows that Option 4 is predicted to generate small decreases in peak flood level north of the proposed levee. The maximum decrease in peak level is predicted to be about 0.11 metres but occurs across a small area. Generally, the decreases in peak level across the habited sections of the island are predicted to be less than 0.06 metres. A small decrease in peak level is also predicted across the western floodplain of the Richmond River, however, the decrease is generally only about 0.01 metres.
- **Figure 15** also shows that small increases in peak flood level are predicted immediately upstream of the proposed low level levee. The maximum increase in peak level is predicted to be about 0.08 metres, however, this occurs over a small, localised area. Generally the increases in peak level are predicted to be less than 0.02 metres. Increases in peak flood level are predicted as far upstream as the southern end of Goat Island.
- **Figure 16** shows that Option 4 is predicted to produce increases in peak flow velocity that are largely contained to the Richmond River and back channels. The maximum increase in peak velocity is predicted to be about 0.23 m/s and occurs immediately upstream of the Cabbage Tree Island Bridge.

  Increases in peak velocity are also predicted across sections of the western floodplain of the Richmond River, however, they are generally predicted to be less than 0.05 m/s.

FIGURE 15



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PREDICTED CHANGE IN PEAK 100 YEAR RECURRENCE FLOOD LEVELS FOR OPTION 4 - LOW LEVEL DEFLECTOR LEVEE

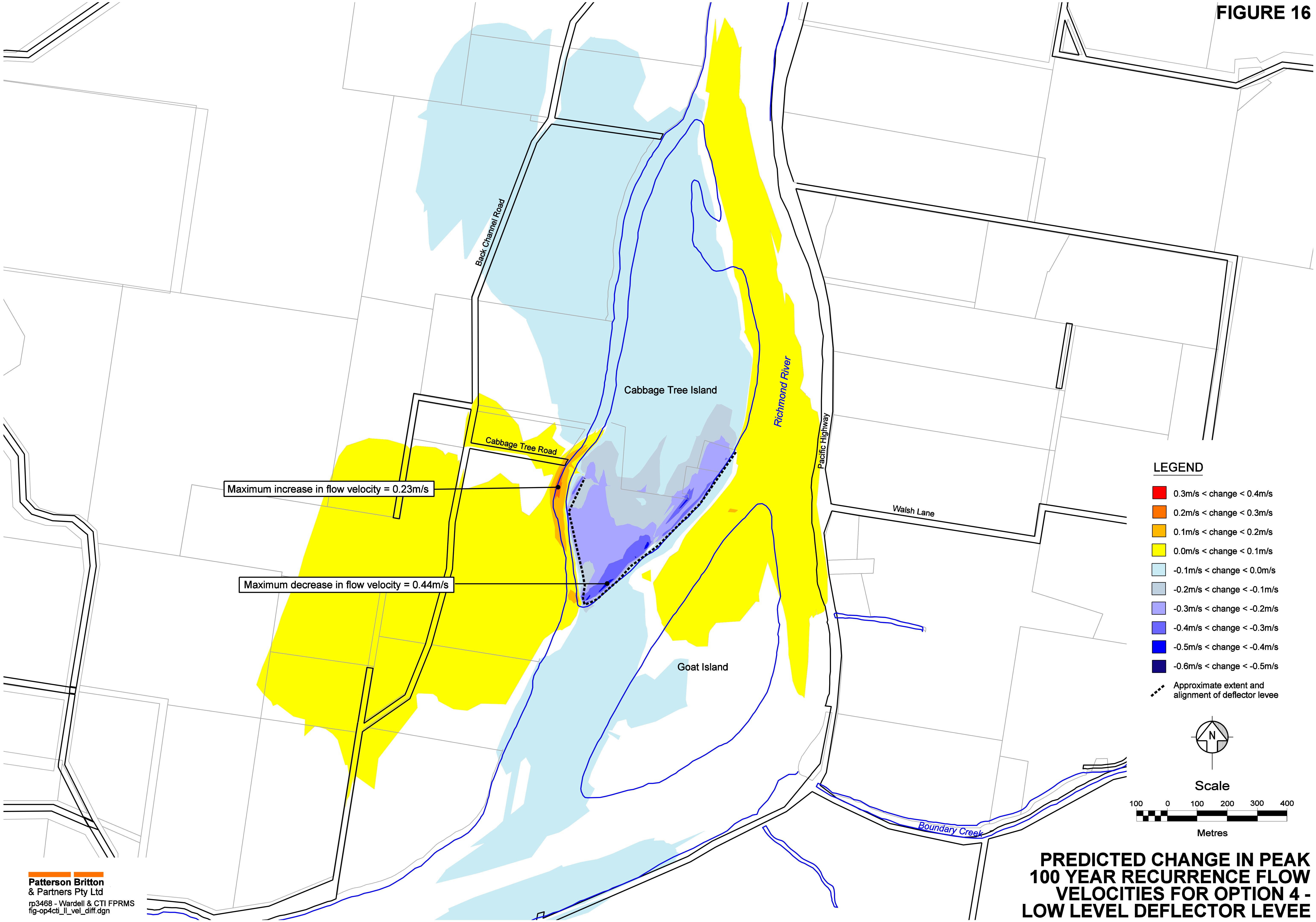


FIGURE 16

PREDICTED CHANGE IN PEAK 100 YEAR RECURRENCE FLOW VELOCITIES FOR OPTION 4 - LOW LEVEL DEFLECTOR LEVEE

- **Figure 16** also indicates that Option 4 is predicted to generate a significant reduction in peak flow velocities across Cabbage Tree Island during the 100 year recurrence flood. The maximum decrease in peak velocity is predicted to be about 0.44 m/s. Generally decreases in peak velocity of between 0.2 to 0.3 m/s are predicted across those sections of the island where dwellings are currently located. Small decreases in velocity are also predicted upstream and downstream of Cabbage Tree Island.

Benefit - Cost Assessment

The results of the benefit-cost assessment for Option 4 indicate that:

§ Option 4 would cost about $480,000 to construct. This does not allow for life cycle costs including maintenance and repairs due to damage in a flood.

§ The average annual flood damage with Option 4 in place would be about $197,300. This compares to the average annual flood damage of $206,200 for existing conditions.

§ The present value of the benefits associated with implementing Option 4 would be about $137,100.

§ The benefit-cost ratio for Option 4 was determined to be about 0.29.

Option 5 –High Level Deflector Levee

Description of Option

As discussed, the low level deflector would aim to prevent the discharge of floodwater in a northerly direction across Cabbage Tree Island during floods up to and including the 10 year recurrence flood. Option 5 would involve the construction of a high level deflector levee that would prevent the passage of floodwater across the island during floods up to and including the 100 year recurrence flood.

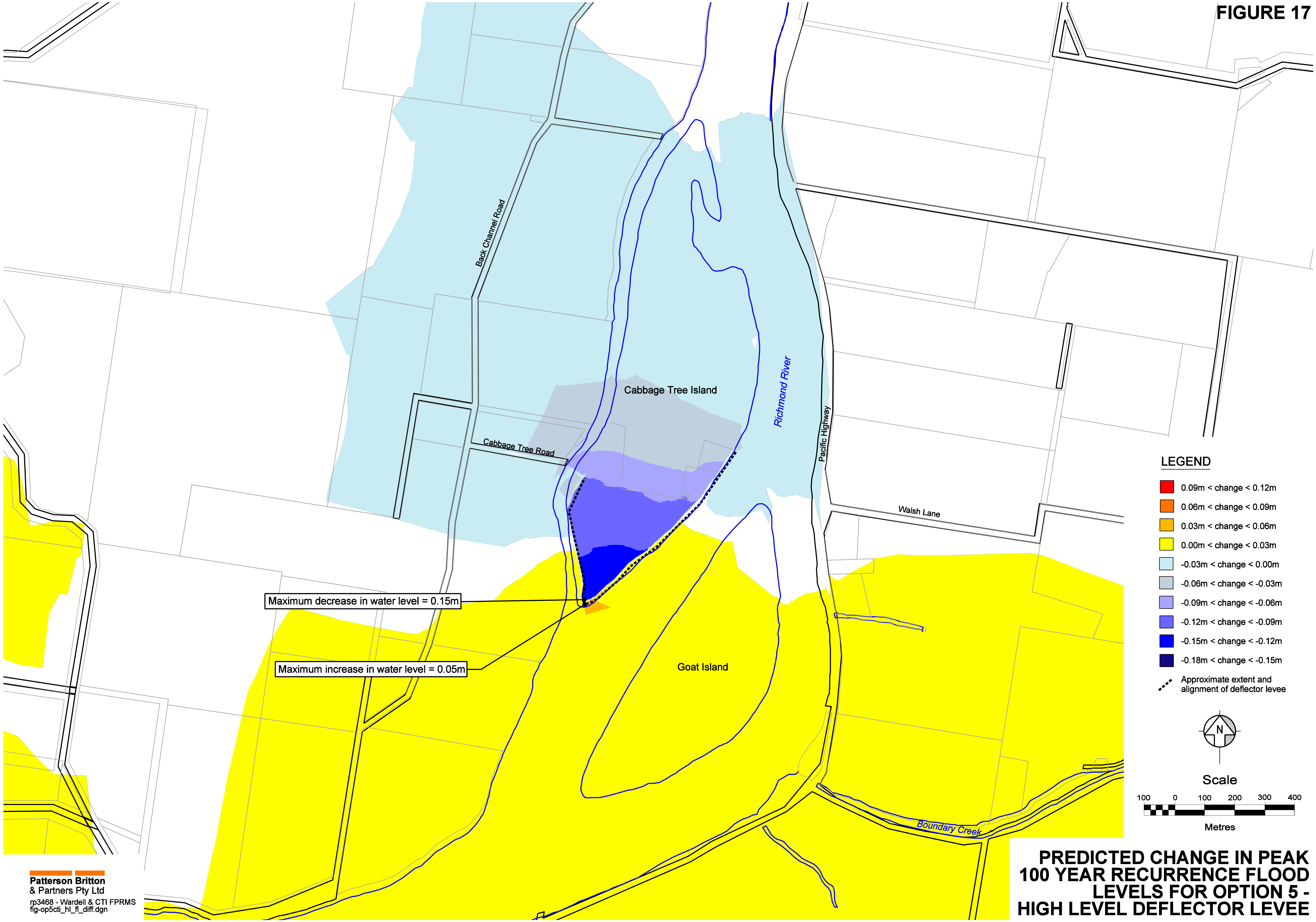
The levee would be constructed with a nominal crest elevation of about 3.7 mAHD (*peak 100 year recurrence flood level of 3.4 mAHD with a freeboard of 300 mm*). The levee would be elevated up to 3 metres above Cabbage Tree Island at some locations. The extent and alignment of the high level levee would be similar to that of the low level levee (*refer* **Figure 7**). However, because of the increased height of the levee, the levee footprint will occupy a greater area. As such, the high level levee is likely to intrude further into existing properties located along the eastern edge of Cabbage Tree Island.

Hydraulic Assessment

The RMA-2 hydraulic model was used to simulate flood behaviour during the 100 year recurrence event with the high level deflector levee in place. The following conclusions can be drawn from the results of the modelling (*refer* **Figures 17** *and* **18**):

- **Figure 17** shows that Option 5 is predicted to generate a significant reduction in peak flood levels across Cabbage Tree Island. The maximum decrease is predicted to be about 0.15 metres, but generally decreases of between 0.10 to 0.15 metres are predicted across those sections of Cabbage Tree Island where existing dwellings are located. Small decreases in peak level are also predicted across the western floodplain of the Richmond River.

FIGURE 17



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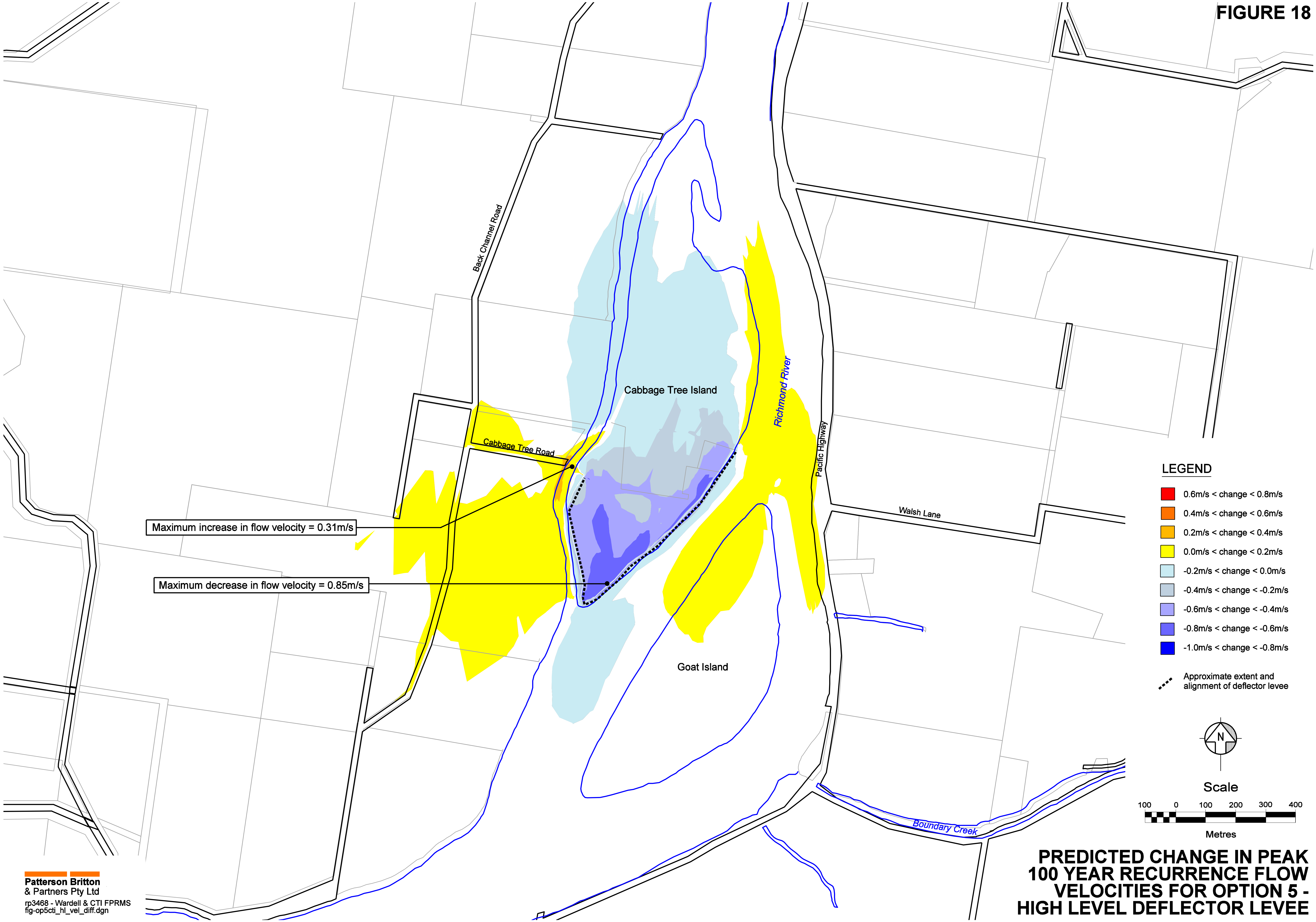
PREDICTED CHANGE IN PEAK 100 YEAR RECURRENCE FLOOD LEVELS FOR OPTION 5 - HIGH LEVEL DEFLECTOR LEVEE

FIGURE 18



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PREDICTED CHANGE IN PEAK 100 YEAR RECURRENCE FLOW VELOCITIES FOR OPTION 5 - HIGH LEVEL DEFLECTOR LEVEE

- **Figure 17** also shows that Option 5 is predicted to generate increases in peak flood level as far upstream as Bagotville Barrage and Broadwater. However, the magnitude of the increase in those areas upstream of Goat Island is only predicted be about 0.01 metres. The maximum increase in peak level is predicted to about 0.05 metres and occurs immediately upstream of the proposed levee.
- **Figure 18** shows that the maximum increase in peak flow velocity is predicted to be about 0.31 m/s and occurs through the Cabbage Tree Island Bridge. Generally the increases in flow velocity are contained to the waterways, however, small increase in peak velocity are also predicted across sections of the western floodplain of the Richmond River and the northern end of Goat Island. The magnitude of the increases across these areas is generally less than 0.1 m/s.
- **Figure 18** indicates that the maximum decrease in flow velocity is predicted to be about 0.85 m/s. Generally, decreases of between 0.5-0.7 m/s are predicted across those sections of the island where dwellings are located. Decreases in flow velocity are also predicted upstream and downstream of Cabbage Tree Island, however, they are generally predicted to be less than 0.05 m/s.

Benefit - Cost Assessment

The results of the benefit-cost assessment for Option 5 indicate that:

§ Option 5 would cost about $980,000 to construct. This does not allow for life cycle costs including maintenance and repairs due to damage in a flood.

§ The average annual flood damage with Option 5 in place would be about $196,100. This compares to the average annual flood damage of $206,200 for existing conditions.

§ The present value of the benefits associated with implementing Option 5 would be about $155,000.

§ The benefit-cost ratio for Option 5 was determined to be about 0.16.

Option 6 – Additional Culverts Beneath the Pacific Highway

Description of Option

The Pacific Highway between Wardell and Broadwater is generally located immediately east of Richmond River and is generally elevated above the level of the Richmond River floodplain. Accordingly, the highway embankment effectively constrains flow to the Richmond River channel during events that would have otherwise “spilt” on to the eastern floodplain of the river.

Notwithstanding, a number of culverts extend beneath the Pacific Highway that were originally implemented to drain water from the floodplain east of the Pacific Highway back into the river. Some of these culverts also allow a proportion of the total Richmond River flow to discharge in an easterly direction onto the floodplain.

Accordingly, Option 6 considered upgrading of these culverts so that a greater proportion of the Richmond River flow could discharge onto the floodplain, thereby reducing peak flood levels and velocities along the main river channel.

Hydraulic Assessment

A basic hydraulic assessment of the existing culvert system beneath the Pacific Highway was undertaken for the stretch of roadway between Wardell and Broadwater. Details of the existing culverts were gathered to assist with this process and are reproduced in **Appendix F**.

The capacity of the existing culvert system was determined assuming one-way flow from the Richmond River to the adjacent floodplain. The impact of existing floodgates was also considered in this assessment. The floodgates allow floodwater to escape from the floodplain and discharge to the river during times when the flood level in the river is lower than the floodgate. Conversely, during major floods (*i.e., times of high river flow*) the elevated water levels within the river force the floodgate closed, thereby preventing flow in either direction. Accordingly, during large Richmond River floods, any culverts with floodgates will not carry any flow from the river on to the floodplain.

It was determined that the peak flow through the non-floodgated culverts from the Richmond River onto the floodplain during the 100 year recurrence flood would be about 230 m^3/s for existing conditions. This represents only about 6% of the total flow within the Richmond River for this event. During the 10 year recurrence flood it was estimated that about 170m^3/s or 8% of flow would discharge to the floodplain via the existing culvert system.

An assessment was then undertaken assuming that the number of culverts along the Pacific Highway was doubled. If additional culverts with the same dimensions as the existing culverts were installed at the same invert level, then it is considered that the flow capacity of the system would be approximately doubled.

Hence, the capacity of the doubled culverts during the 100 year recurrence flood would be equivalent to approximately 12% of the total flow within the Richmond River. However, during an event of this magnitude, the peak flow remaining in the Richmond River would still be greater than the peak flow during the 50 year recurrence flood (*not including culvert effects*). The 50 year recurrence flood is the next smallest design event that was modelled as part of the flood study for Wardell and Cabbage Tree Island.

Previous flood modelling determined that peak 50 year recurrence flood levels between Cabbage Tree Island and Wardell are 200 to 300 mm lowering than for the 100 year recurrence flood (*Ballina Shire Council, 2007*). By comparison of the flows, it is predicted that the doubling of the culvert system capacity may reduce 100 year recurrence flood levels by a maximum of 100 mm. This estimate is based on additional considerations such as the potential for a high flood level on the floodplain to provide a backwater control for flow passing through the culverts, thereby reducing their capacity and potential for culvert blockage

Therefore, it was determined that the benefit of providing additional capacity to the culvert system beneath the Pacific Highway is limited in terms of lowering design flood levels within the Richmond River. Furthermore, the installation of additional culverts may prove a difficult task.

A significant proportion of the existing flow capacity is provided by five sets of 2 or 3 large culverts which have been installed at locations where flow can be concentrated in natural depressions at the entrance of small feeding tributaries. Each of the culverts in each set is typically larger than 1500mm in diameter.

Another consideration is the magnitude of the torrent of water that would be discharging to the floodplain at these locations. In addition to the potential damage to crops that may occur, this may also present a safety issue for properties along the frontage to the Pacific Highway.

Option 7 –Low Level Deflector Levee and Channel Dredging

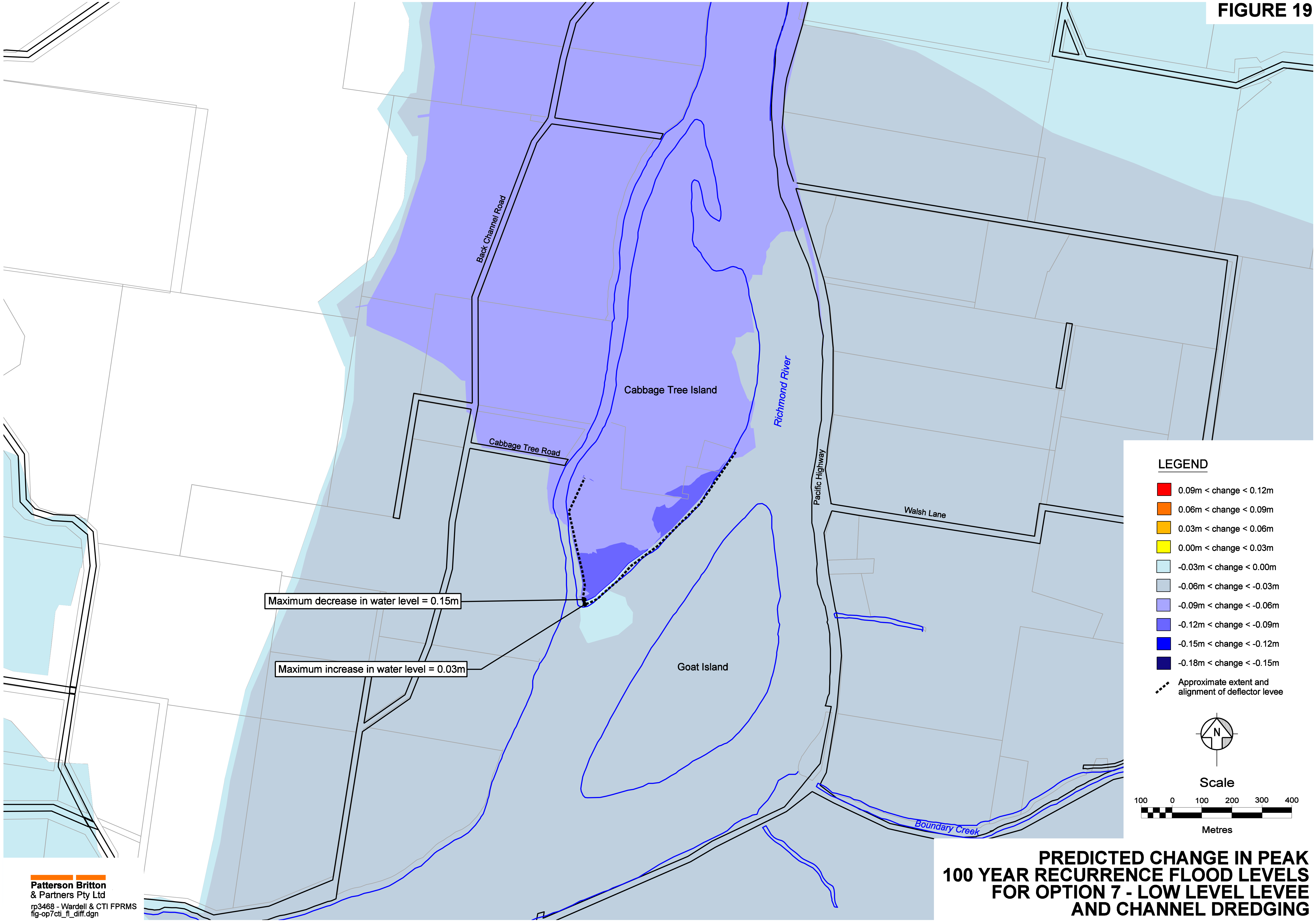
Description of Option

Option 7 involves the construction of a low level deflector levee around the southern end of Cabbage Tree Island and dredging of the Richmond River channel in the vicinity of Wardell (*refer* **Options 2** *and* **4**).

Hydraulic Assessment

The RMA-2 hydraulic model was used to simulate flood behaviour during the 100 year recurrence event with the low level deflector levee and channel dredging in place. The following conclusions can be drawn from the results of the modelling (*refer* **Figures 19** *and* **20**):

- **Figure 19** shows that Option 7 is predicted to reduce peak flood levels across Cabbage Tree Island by up to 0.15 metres. However, the reductions through the developed sections of the island are generally predicted to be between 0.08-0.10 metres. The most significant reductions in peak flood level occur around Cabbage Tree Island, however, Option 7 is also predicted to reduce peak flood levels upstream and downstream of Cabbage Tree Island. Decreases in level of around 0.03 metres are predicted as far upstream at Bagotville Barrage and Broadwater and decreases of around 0.02 metres are predicted at Wardell.
- Option 7 is only predicted to generate a small increase in peak level upstream of the proposed levee (*about 0.03 metres*) and downstream of Wardell (*about 0.02 metres*).
- **Figure 20** shows that Option 7 is predicted to increase peak flow velocities along the Richmond River and back channels. The maximum increase in flow velocity is predicted to be about 0.2 m/s and occurs through the Cabbage Tree Island Bridge. Small increases in flow velocity are also predicted across the western floodplain of the Richmond River, however, the increases are generally predicted to be less than 0.05 m/s.
- **Figure 20** also shows that Option 7 is predicted to generate significant reductions in flow velocity across Cabbage Tree Island. **Figure 20** shows that the maximum decrease in peak flow velocity is predicted to be about 0.43 m/s. Generally, the decreases in flow velocity across the habited sections of the island are predicted to vary between 0.1 to 0.3 m/s. Decrease in flow velocity are also predicted upstream and downstream of Cabbage Tree Island, however, the magnitude of the changes is generally less than 0.05 m/s.



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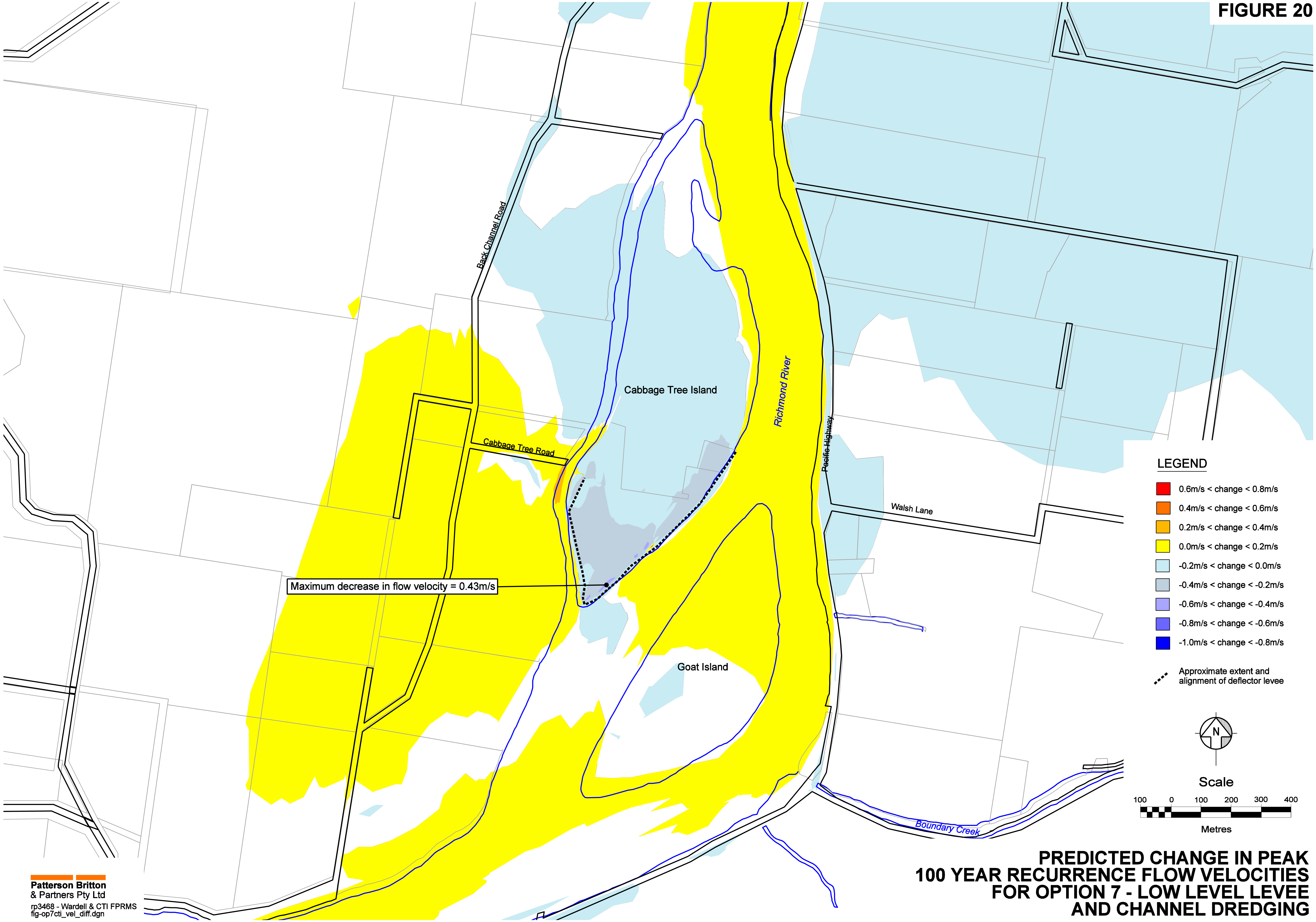
PREDICTED CHANGE IN PEAK 100 YEAR RECURRENCE FLOOD LEVELS FOR OPTION 7 - LOW LEVEL LEVEE AND CHANNEL DREDGING

FIGURE 20



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PREDICTED CHANGE IN PEAK 100 YEAR RECURRENCE FLOW VELOCITIES FOR OPTION 7 - LOW LEVEL LEVEE AND CHANNEL DREDGING

Benefit - Cost Assessment

The results of the benefit-cost assessment for Option 7 indicate that:

- Option 7 would cost about $24.9M to construct. This does not allow for life cycle costs including the need to undertake follow-up dredging after a flood or to maintain or repair damaged sections of the levee.
- The average annual flood damage with Option 7 in place would be about $187,800. This compares to the average annual flood damage of $206,200 for existing conditions.
- The present value of the benefits associated with implementing Option 7 would be about $282,900.
- The benefit-cost ratio for Option 7 was determined to be about 0.01.

5.4 ASSESSMENT OF NON-STRUCTURAL OPTIONS

5.4.1 Flood Emergency Response

As discussed in **Section 4.3.2**, there are areas of the floodplain that will experience flooding into the future irrespective of the outcomes of the analysis of potential structural options. This residual flood hazard needs to be considered as part of any Floodplain Risk Management Plan for the villages.

Due to their location on the floodplain, it is considered that the greatest risk to life as a result of the residual flood hazard will occur at Cabbage Tree Island and 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.

Cabbage Tree Island

As discussed in **Section 4.3.2**, the *Ballina Local Flood Plan* outlines special arrangements for the evacuation of Cabbage Tree Island. The SES has first hand experience of evacuation procedures for the Island. In the 1974 flood, the Island was inundated and residents were successfully evacuated.

The current protocols for evacuation from Cabbage Tree Island during a flood are specified in Annexure G of the Local Flood Plan, a copy of which is enclosed within **Appendix H**. These protocols indicate that evacuation would be initiated by the SES Local Controller and that the primary means for warning and instructing evacuation would occur via door knocking of dwellings by the Jali community. The residents would be evacuated by private vehicles and buses supplied by Blanches Bus Company. The current DISPLAN indicates that evacuation would occur via the Back Channel Road to Wardell and then via the Pacific Highway to Ballina.

The protocols for evacuation from Cabbage Tree Island at the onset of a major flood appear to be sufficiently detailed in the Ballina Local Flood Plan. However, the success of the evacuation is entirely dependent on the Back Channel Road not being cut by floodwaters. This is recognised in the Plan and typical elevations of the roadway are specified.

However, there is no information provided indicating the time from when floodwaters reach a particular level upstream (*say at Coraki or Broadwater*) and when overtopping of the Back Channel Road will occur. This of course will be dependent on the rate of rise of floodwaters, which may vary from flood to flood.

A profile of the road surface elevation of Back Channel Road is presented in **Figure 21**. Peak water surface profiles for a range of design floods are superimposed and show that Back Channel Road will begin to be overtopped once flood levels exceed the predicted peak level for the 5 year recurrence flood.

The profile also shows that the depths of inundation along Back Channel Road will be significant at six isolated sections of the roadway once floodwaters reach the level of the 10 year recurrence flood. Floodwater depths at these locations will be up to 600 mm in an event of this magnitude.

Accordingly, the section of Back Channel Road between Cabbage Tree Island and Wardell will become impassable in events rarer than a flood of somewhere between 5 and 10 year recurrence (*possibly in the order of a 7 year recurrence event*). This is of concern as the current perception is that the roadway will not be "cut" by floodwaters until flooding of the Richmond River of the magnitude of the 10 year recurrence flood occurs.

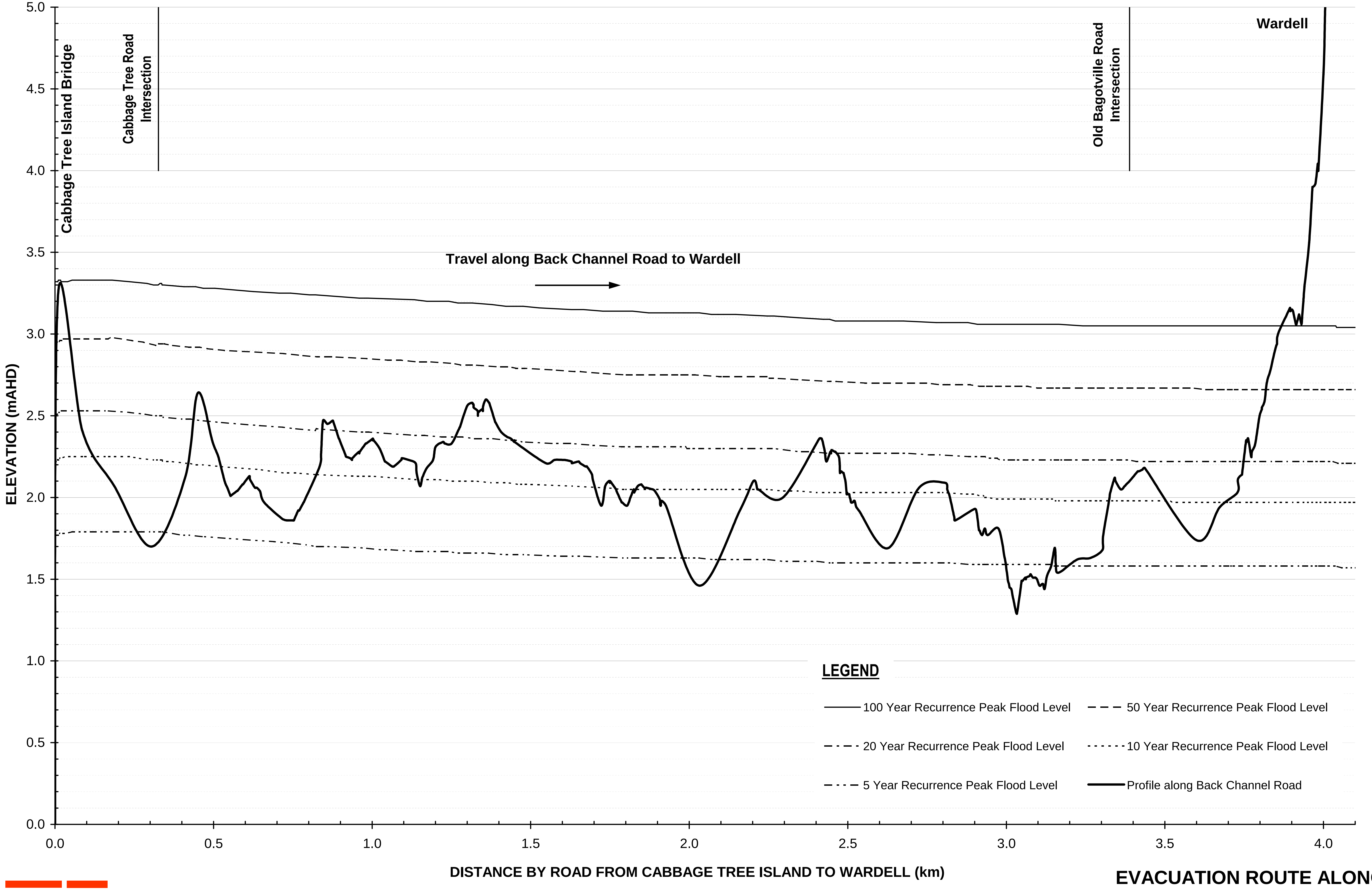
The profile presented in **Figure 21** indicates that localised road raising at selected locations along Back Channel Road could be undertaken to reduce the frequency of the flood at which this important evacuation route would be considered impassable. Road raising of up to 600 mm could occur at each of the six low points shown in **Figure 21**, thereby increasing the flood security of the evacuation route to a 10 year recurrence event.

In terms of flood warning, it is apparent that evacuation of the Island should commence as soon as there is evidence to suggest that a flood of 10 year recurrence will occur along the reach of the Richmond River downstream from Broadwater. Accordingly, an assessment of historical and design flood hydrographs for the Richmond River was undertaken to determine typical flood warning times.

The results of this assessment established that if a flood warning is issued 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 Cabbage Tree Island (*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 their 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 Cabbage Tree Island. In contrast, modelled hydrographs for the Woodburn gauge indicate that the flood warning time relative to Woodburn would be less than 1 hour which would be insufficient to allow evacuation to be implemented.

In addition, flood warnings are not typically issued by SES relative to gauges that are tidally affected like the Woodburn gauge.



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Wardell & Cabbage Tree Island FRMS
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EVACUATION ROUTE ALONG BACK CHANNEL ROAD FROM CABBAGE TREE ISLAND TO WARDELL

Accordingly, it is recommended that this information be incorporated into the revised Local Flood Plan for Ballina along with mapping similar to that presented in **Figure 22**, showing the location of the Back Channel Road evacuation route.

In this context, it is also noted that the current DISPLAN indicates that residents that are evacuated from the Island would be relocated to Ballina. 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. It is considered that the relocation of an additional 170 people from Cabbage Tree Island to Ballina would provide an additional burden on refuge centres that may already be stretched.

Therefore, it is recommended that the DISPLAN be amended to indicate that residents evacuated from Cabbage Tree Island be relocated to the entertainment centre at Alstonville.

East Wardell

The provision for evacuation of East Wardell appears to be 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 22**.

However, as the number of residents that would be affected is small, it may be more appropriate for residents to be evacuated to the Wardell Recreation Ground which is on relatively high ground. This would ensure 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. 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 a modification to the DISPLAN be made to reference the alternative option of relocating flood affected Wardell residents to Alstonville, particularly if the duration of flooding is expected to be more than a day or two.

In a similar fashion to the situation with Cabbage Tree Island, it is also considered appropriate to establish a typical warning time for inundation of trafficked streets within East Wardell relative to a particular flood level at Coraki. This warning time could be disseminated via the media and would assist in reducing the burden of SES in relation to door knocking and ensuring all residents are evacuated.

FIGURE 22

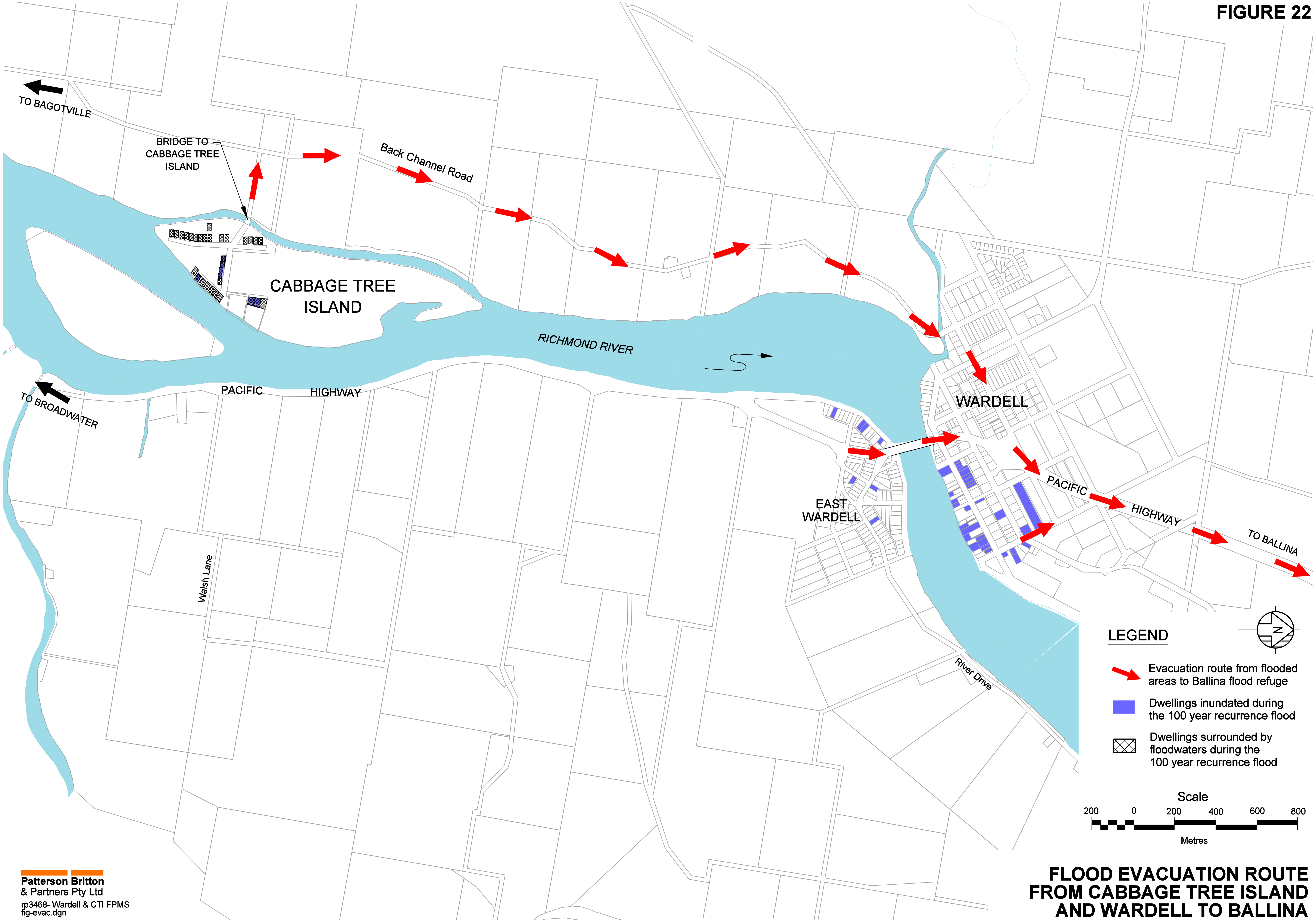

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fig-evac.dgn

FLOOD EVACUATION ROUTE FROM CABBAGE TREE ISLAND AND WARDELL TO BALLINA

5.4.2 Building Controls

Cabbage Tree Island

The variation in flood hazard across Cabbage Tree Island at the peak of the design 100 year recurrence flood is shown in detail in **Figure 24**. This indicates that the hydraulic flood hazard in the vicinity of residential areas of the Island would typically be classified as high in an event of this magnitude. This classification would normally be increased to very high or extreme in recognition of the location of the land on an island within a major river. That is, the potential for isolation and the associated risk to life would typically render the land as being an extreme flood hazard area.

In circumstances where residential development is located within a very high or extreme flood hazard area, it is common practice for government to look toward purchasing the properties in question via a voluntary purchase scheme under the NSW Government's Floodplain Management Program. In normal circumstances, voluntary purchase would be recommended for all of the residential dwellings located on Cabbage Tree Island.

However, during the course of this project, liaison with the Jali Aboriginal community has determined that it would not cooperate in such a scheme and that it would like to remain on the Island and retain all of the existing dwellings.

Notwithstanding, older residents recall the evacuation that occurred during the 1974 flood and Jali has acknowledged the potential flood risk to which the community could be exposed to.

Therefore, it is recommended that the Floodplain Management Plan for Cabbage Tree Island should include a recommendation for no further development of residential dwellings on the Island and that this restriction should be carried forward into Council's LEP.

Notwithstanding, it is recognised that there may be a need to construct new community buildings to service those who currently reside on the Island. Accordingly, it is considered appropriate for community related buildings to be allowed provided they are constructed with flood compatible materials.

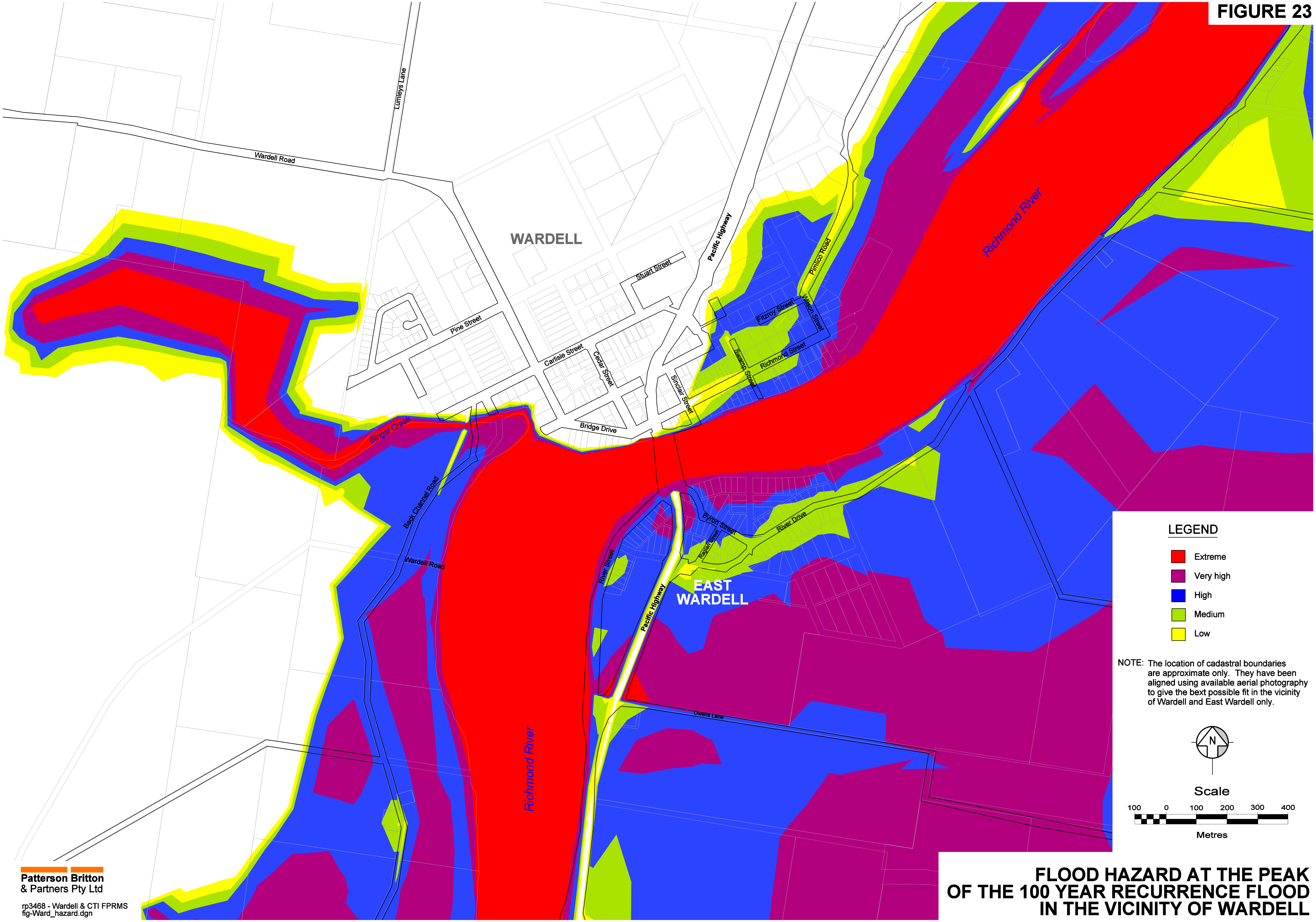
Wardell / East Wardell

Building Controls

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 the requirements of Council's existing Flood Policy.

The Flood Policy is outlined in Council's Development Control Plan No.1 – Urban Land under a section titled, *Policy Statement No.11 – Flood Levels*. This section addresses the filling of sites in flood prone areas and requires all sites that are to be developed to be filled to the level of the 100 year recurrence flood.

FIGURE 23



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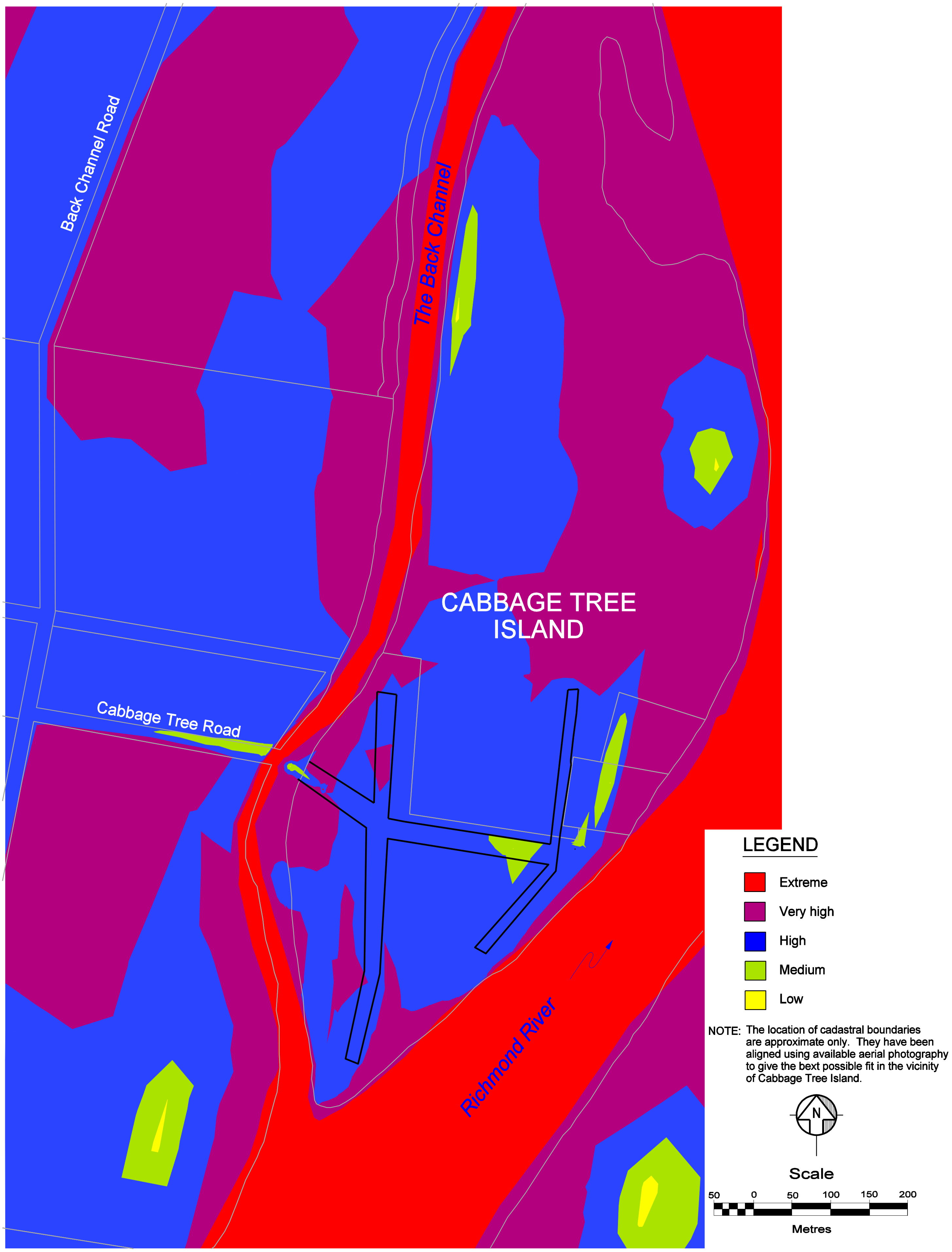
rp3468 - Wardell & CTI FPRMS
fig-Ward_hazard.dgn

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

FIGURE 24



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FLOOD HAZARD AT THE PEAK OF THE 100 YEAR RECURRENCE FLOOD IN THE VICINITY OF CABBAGE TREE ISLAND

Based on the nature of the flood hazard, it is considered that this requirement is onerous in some areas of the floodplain. In particular, it is considered unnecessary and will result in drainage and retaining wall issues in areas where the policy is enforced for infill development.

Accordingly, it is recommended that the requirement for filling of a lot to the predicted peal level of the 100 year recurrence flood be removed in both Wardell and East Wardell.

This does not mean that floor levels should be lowered. The existing minimum requirement for habitable floor levels is the 100 year recurrence flood level plus a specified freeboard of 300 mm. This requirement should be retained.

Accordingly, 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.

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 incorporate the following requirements:

- Building development on flood prone areas shall be restricted to single dwelling or non-residential development permissible within the zone, except where specifically permitted.
- Building development proposals on flood prone land for all sites provisionally classified as High Hazard/Floodway by the Manual 2005 or the relevant Floodplain Risk Management Plan should not be supported.

- Council will only support building developments on flood prone land provided the applicant can demonstrate to Council's satisfaction that the development will not adversely impact on flooding across adjoining properties. The applicant is also required to show that flooding will not adversely impact on the development proposal. Such applications are to be prepared by a suitably qualified civil engineer/surveyor/hydrologist with a demonstrated experience in flood assessment of land development proposals.
- The finished floor levels of habitable rooms shall be at least equal to the Flood Planning Level (*FPL*) where known, or where not known, 500 mm above the 100 year recurrence flood level advised at the time by Council.
- Renovations including re-cladding or re-roofing and floor extensions greater than 60 m^2 in flood prone sites are classified in accordance with the 2005 Manual as "major additions". Council will support applications provided the applicant can demonstrate to Council's satisfaction that flood proofing measures have been considered in accordance with guidelines presented in Appendix J of the 2005 Manual. Such applications are to be prepared by a suitably qualified civil engineer with demonstrated experience in floodplain management.
- Council will not support habitable floor extensions greater than 20 m^2 where the dwelling is located in a high hazard area.
- Council should only support residential or commercial 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 SES Local DISPLANS or any more recent strategies articulated in local floodplain management plans.
- Council will not support new building development on flood prone land where emergency evacuation can only occur through high hazard/floodway or high hazard flood storage areas.
- Developments that can demonstrate effective evacuation through low hazard conditions during the early warning phases of a flood may be supported. Applicants are to provide details of the evacuation route and likely flood conditions encountered during an effective evacuation.

Restrictions to Future Subdivision / Development

The variation in flood hazard at Wardell at the peak of the 100 year recurrence flood is shown graphically in **Figure 23**. This clearly shows that a number of areas of foreshore land, particularly downstream of the bridge at East Wardell, would be classified as either high hazard floodway or high hazard flood storage.

Irrespective of the classification, 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 4 properties in this area that would experience over floor flooding in the design 100 year recurrence event. 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 Natural Resources' experience that funding for voluntary house raising is difficult to obtain unless over floor flooding is predicted in more frequent events up to the 20 year recurrence flood.

In this context, although relaxation of the fill requirement in Council's existing Flood Policy is recommended, 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 23 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.

5.5 PREFERRED OPTIONS

5.5.1 Structural Measures

The results of the hydraulic, economic and environmental assessment outlined above, were used to determine appropriate floodplain management measures that could be included within the Floodplain Risk Management Plans that are proposed for both Wardell and Cabbage Tree Island.

The results of the economic assessment are summarised in **Tables 10** and **11**. **Table 10** lists the estimated flood damages that would arise after implementation of each option if a 100 year recurrence flood occurred. The economic benefit afforded by each option (*in $ terms*) can be established by determining the difference between the damage cost estimated with the option in place and the estimate of existing flood damage (*which is highlighted in the table*).

These results show that none of the options considered will have a substantial impact in terms of reducing the total damages in a 100 year recurrence flood.

However, expansion of the analysis to consider the full range of floods and the potential benefits afforded by reducing the flood risk (*as distinct from trying to remove the flood risk*), is summarised in **Table 11**. **Table 11** shows the benefit-cost ratio for each option.

As shown in **Table 11** and from the information presented in **Section 5.2**, the benefit-cost of all options is relatively low. The most favourable option is Option 4, which involves the construction of a low level deflector levee at the southern end of Cabbage Tree Island.

Based on consideration of tangible damages only (*i.e., indirect and direct damages*), Option 4 is estimated to have a benefit-cost ratio of about 0.3. A high level deflector levee is expected to cost about twice that for the low level levee (*refer* **Table 11**), while only providing about a 15% increase in benefit, thus reducing the benefit-cost ratio to 0.16.

If intangible damages were incorporated into the analysis, it is estimated that the B/C ratio for Option 4 would increase to 0.6. Due to the flood risk that the Cabbage Tree Island community may face, it is considered that there is sufficient justification for the funding for this option and that it should be recommended for inclusion within the Floodplain Risk Management Plan.

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

Table 10 PREDICTED FLOOD DAMAGE COSTS ASSOCIATED WITH THE 100 YEAR RECURRENCE FLOOD

FLOODPLAIN MANAGEMENT OPTION	RESIDENTIAL DAMAGES			INDUSTRIAL / COMMERCIAL DAMAGES		INFRASTRUCTURE DAMAGES	TOTAL DAMAGES
	Number of Dwellings Inundated	Number of Properties Inundated	Estimated Cost of Damages	Number of Sites Inundated	Estimated Cost of Damages	Estimated Cost of Damages	Estimated Cost of Damages
Existing						**TOTAL**	**$3,864,830**
Option 1 – Western Levee at Wardell						**TOTAL**	**$3,841,100**
Wardell	34	95	$2,273,230	5	$46,730	$695,990	$3,015,950
Cabbage Tree Island	3	26	$483,120	4	$151,610	$190,420	$825,150
Option 2 – Channel Dredging						**TOTAL**	**$3,006,720**
Wardell	22	89	$1,663,970	4	$38,630	$510,780	$2,213,380
Cabbage Tree Island	3	26	$474,490	3	$135,770	$183,080	$793,340
Option 3 – Western Levee and Channel Dredging						**TOTAL**	**$3,731,790**
Wardell	32	95	$2,171,370	5	$74,880	$673,870	$2,920,120
Cabbage Tree Island	3	26	$479,180	4	$145,180	$187,310	$811,670
Option 4 – Low Level Deflector Levee						**TOTAL**	**$3,760,250**
Wardell	32	95	$2,195,850	5	$80,510	$682,910	$2,959,270
Cabbage Tree Island	3	26	$477,200	3	$138,940	$184,840	$800,980
Option 5 – High Level Deflector Levee						**TOTAL**	**$3,744,200**
Wardell	32	95	$2,195,580	5	$80,510	$682,830	$2,958,920
Cabbage Tree Island	3	26	$473,750	3	$130,310	$181,220	$785,280
Option 7 – Low Level Deflector Levee and Channel Dredging						**TOTAL**	**$3,647,270**
Wardell	31	95	$2,127,650	5	$72,680	$660,100	$2,860,430
Cabbage Tree Island	3	26	$473,010	3	$132,250	$181,580	$786,840

Table 11 BENEFIT-COST RATIO FOR FLOODPLAIN MANAGEMENT OPTIONS

FLOODPLAIN MANAGEMENT OPTION	APPROXIMATE COST TO IMPLEMENT	AVERAGE ANNUAL DAMAGE■	PRESENT VALUE OF BENEFITS†	BENEFIT / COST RATIO
Existing Conditions	-	$206,200	-	-
Option 1 – Western Levee at Wardell	$300,000	$206,100	$1,300	<0.01
Option 2 – Channel Dredging	$24,410,000	$166,500	$609,900	0.02
Option 3 – Western Levee and Channel Dredging	$24,710,000	$195,300	$167,200	0.01
Option 4 – Low Level Deflector Levee	$480,000	$197,300	$137,100	0.29
Option 5 – High Level Deflector Levee	$980,000	$196,100	$155,000	0.16
Option 7 – Low Level Deflector Levee and Channel Dredging	$24,890,000	$187,800	$282,900	0.01

■ *Includes direct and indirect residential damages and infrastructure damages*

† *The present value of the benefits is determined over a 30 year design life assuming a flat 5% p.a. discount rate*

6 RECOMMENDATIONS

It is recommended that Ballina Shire Council proceed toward the development of separate specific Floodplain Risk Management Plans for Wardell and Cabbage Tree Island.

The Wardell Floodplain Management Plan should incorporate the following:

- Recommendations for direct dialogue with the Local and Regional SES officers to modify the Ballina Local Flood Plan so that it incorporates provision for evacuation of flood affected residents of East Wardell and low lying areas of Wardell to a facility that is currently leased by Council and which is known as the "Wardell Access Space" and/or "Wardell Recreation Ground".

- Documentation of warning times for flooding of East Wardell relative to known flood levels at Coraki and Woodburn, and inclusion of this information within the proposed update to the Ballina Local Flood Plan. Calculations undertaken for this investigation have established that once flood levels reach the predicted peak level of the 10 year recurrence flood at Coraki, it will take about 10 hours for flooding of a similar magnitude to occur along the reach of the Richmond River downstream from Broadwater. Hence, there is typically 10 hours warning time relative to reported flood levels at the gauge at Coraki.

- Modification to Council's Flood Policy to allow the development of land currently zoned *2(b) – Residential Village Area* at Wardell and East Wardell so that development can occur without the need to fill to the level of the 100 year recurrence flood.

  At the same time, land currently zoned *1(a) - Rural* that may be the subject of a rezoning application, would need to be considered on a merits basis and in which the proponent would need to show that any rezoning and development of the land could proceed without inundation of lots proposed for development. That is, the relaxation of the policy should only apply to land currently zoned *2(a) – Residential, Village Area*.

- Prohibition of residential development along a 50 metre wide strip of land along the southern shoreline of the Richmond River extending downstream from the Pacific Highway bridge crossing to Carney Lane (*refer* **Figure 23**). This land is considered to be a high hazard floodway.

- Considering voluntary house raising of the 4 properties that would experience overfloor flooding in the design 100 year recurrence event in the area of East Wardell extending upstream from the Pacific Highway Bridge crossing. The likely cost of these works is estimated to be $70,000 per dwelling.

Notably, no structural options for reducing flood damages are proposed. This is due to their relatively low benefit-cost.

The Cabbage Tree Island Floodplain Management Plan should be worked up in close consultation with the Jali Aboriginal Land Council, the Cabbage Tree Island community and the local SES. It is recommended that the following be incorporated within the Plan:

- Construction of a low level deflector levee with a nominal crest elevation of 2.6 mAHD extending around the southern end of Cabbage Tree Island. The cost of the associated works is estimated at $480,000.
- Prohibition of any further residential development on Cabbage Tree Island. This is considered necessary due to the high to extreme flood hazard to which residents of the Island could be exposed in a major flood and an upper limiting number of individuals that the SES could conceivably evacuate in typical warning time scenarios.
- Documentation of warning times for flooding of Cabbage Tree Island relative to known flood levels at Coraki and Woodburn, and inclusion of this information within the proposed update to the Ballina Local Flood Plan.

  It is also recommended that a specific education program be undertaken with Jali to ensure that the potential flood risk is known across the full demographic of the community, and so that the role of SES in times of flood is clearly understood. This is considered to be important to ensure that smooth and efficient evacuation occurs when required.

- Upgrading of Back Channel Road to raise it by up to 600 mm at six localised low points where floodwaters would currently make the road impassable at some stage between the 5 and 10 year recurrence flood. These works are estimated to cost $250,000 and would lead to provision of a flood evacuation route from the Island that would be flood free in events up to the 10 year recurrence flood.

7 REFERENCES

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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*).

APPENDIX B
FLOOD DAMAGE CURVES

Table B1: RESIDENTIAL DWELLING DAMAGE CURVES

Floodplain Specific Damage/Aftermath Curves

Allowance for Waves 0 m
Steps in Curve 0.1 m

Single Storey Slab on Ground/Low Set			Single Storey High Set			2 Storey Houses		
Static AFD	AFD + Wave Action	Damage	Static AFD	AFD + Wave Action	Damage	Static AFD	AFD + Wave Action	Damage
-0.50	-0.50	$ 7,906	-1.50	-1.50	$ 7,906	-0.50	-0.50	$ 7,906
-0.40	-0.40	$ 7,906	-1.40	-1.40	$ 14,229	-0.40	-0.40	$ 7,906
-0.30	-0.30	$ 7,906	-1.30	-1.30	$ 14,996	-0.30	-0.30	$ 7,906
-0.20	-0.20	$ 7,906	-1.20	-1.20	$ 15,762	-0.20	-0.20	$ 7,906
-0.10	-0.10	$ 7,906	-1.10	-1.10	$ 16,528	-0.10	-0.10	$ 7,906
0.00	0.00	$ 21,439	-1.00	-1.00	$ 17,295	0.00	0.00	$ 17,379
0.10	0.10	$ 44,061	-0.90	-0.90	$ 18,061	0.10	0.10	$ 33,215
0.20	0.20	$ 46,073	-0.80	-0.80	$ 18,827	0.20	0.20	$ 34,623
0.30	0.30	$ 48,085	-0.70	-0.70	$ 19,593	0.30	0.30	$ 36,031
0.40	0.40	$ 50,097	-0.60	-0.60	$ 20,360	0.40	0.40	$ 37,439
0.50	0.50	$ 52,109	-0.50	-0.50	$ 21,126	0.50	0.50	$ 38,848
0.60	0.60	$ 54,120	-0.40	-0.40	$ 21,892	0.60	0.60	$ 40,256
0.70	0.70	$ 56,132	-0.30	-0.30	$ 22,659	0.70	0.70	$ 41,664
0.80	0.80	$ 58,144	-0.20	-0.20	$ 23,425	0.80	0.80	$ 43,073
0.90	0.90	$ 60,156	-0.10	-0.10	$ 24,191	0.90	0.90	$ 44,481
1.00	1.00	$ 65,946	0.00	0.00	$ 47,456	1.00	1.00	$ 48,534
1.10	1.10	$ 68,146	0.10	0.10	$ 49,923	1.10	1.10	$ 50,074
1.20	1.20	$ 70,347	0.20	0.20	$ 52,389	1.20	1.20	$ 51,615
1.30	1.30	$ 72,548	0.30	0.30	$ 54,855	1.30	1.30	$ 53,155
1.40	1.40	$ 74,749	0.40	0.40	$ 57,321	1.40	1.40	$ 54,696
1.50	1.50	$ 76,949	0.50	0.50	$ 59,788	1.50	1.50	$ 56,236
1.60	1.60	$ 79,150	0.60	0.60	$ 62,254	1.60	1.60	$ 57,777
1.70	1.70	$ 81,351	0.70	0.70	$ 64,720	1.70	1.70	$ 59,317
1.80	1.80	$ 83,552	0.80	0.80	$ 67,187	1.80	1.80	$ 60,858
1.90	1.90	$ 85,752	0.90	0.90	$ 69,653	1.90	1.90	$ 62,398
2.00	2.00	$ 87,953	1.00	1.00	$ 72,119	2.00	2.00	$ 63,939
2.10	2.10	$ 88,454	1.10	1.10	$ 74,585	2.10	2.10	$ 64,290
2.20	2.20	$ 88,955	1.20	1.20	$ 77,052	2.20	2.20	$ 64,640
2.30	2.30	$ 89,455	1.30	1.30	$ 79,518	2.30	2.30	$ 64,991
2.40	2.40	$ 89,956	1.40	1.40	$ 81,984	2.40	2.40	$ 65,341
2.50	2.50	$ 90,457	1.50	1.50	$ 84,451	2.50	2.50	$ 65,692
2.60	2.60	$ 90,958	1.60	1.60	$ 86,917	2.60	2.60	$ 66,042
2.70	2.70	$ 91,458	1.70	1.70	$ 89,383	2.70	2.70	$ 99,814
2.80	2.80	$ 91,959	1.80	1.80	$ 91,849	2.80	2.80	$ 100,365
2.90	2.90	$ 92,460	1.90	1.90	$ 94,316	2.90	2.90	$ 100,915
3.00	3.00	$ 92,961	2.00	2.00	$ 96,782	3.00	3.00	$ 101,466
3.10	3.10	$ 93,461	2.10	2.10	$ 97,548	3.10	3.10	$ 102,017
3.20	3.20	$ 93,962	2.20	2.20	$ 98,315	3.20	3.20	$ 102,568
3.30	3.30	$ 94,463	2.30	2.30	$ 99,081	3.30	3.30	$ 103,119

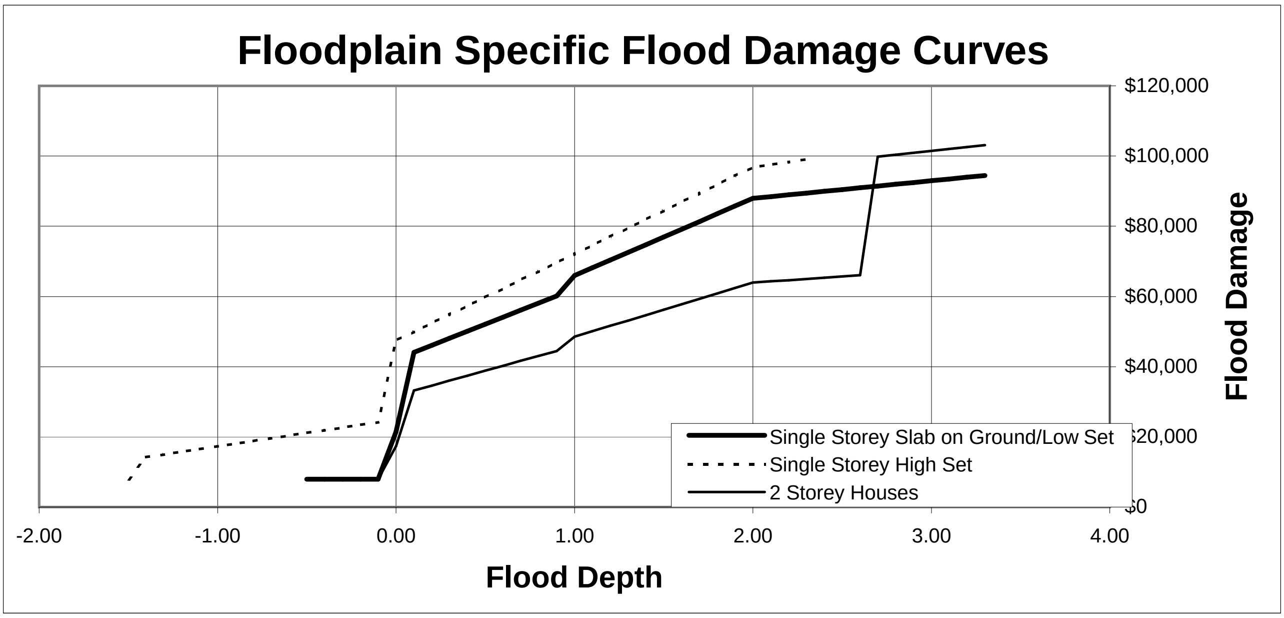


Table B2: RESIDENTIAL PROPERTY DAMAGES

Flood Depth (m)	Adopted Residential Damages ($)
0	0
0.3	1525
0.6	9386
0.6001	11732

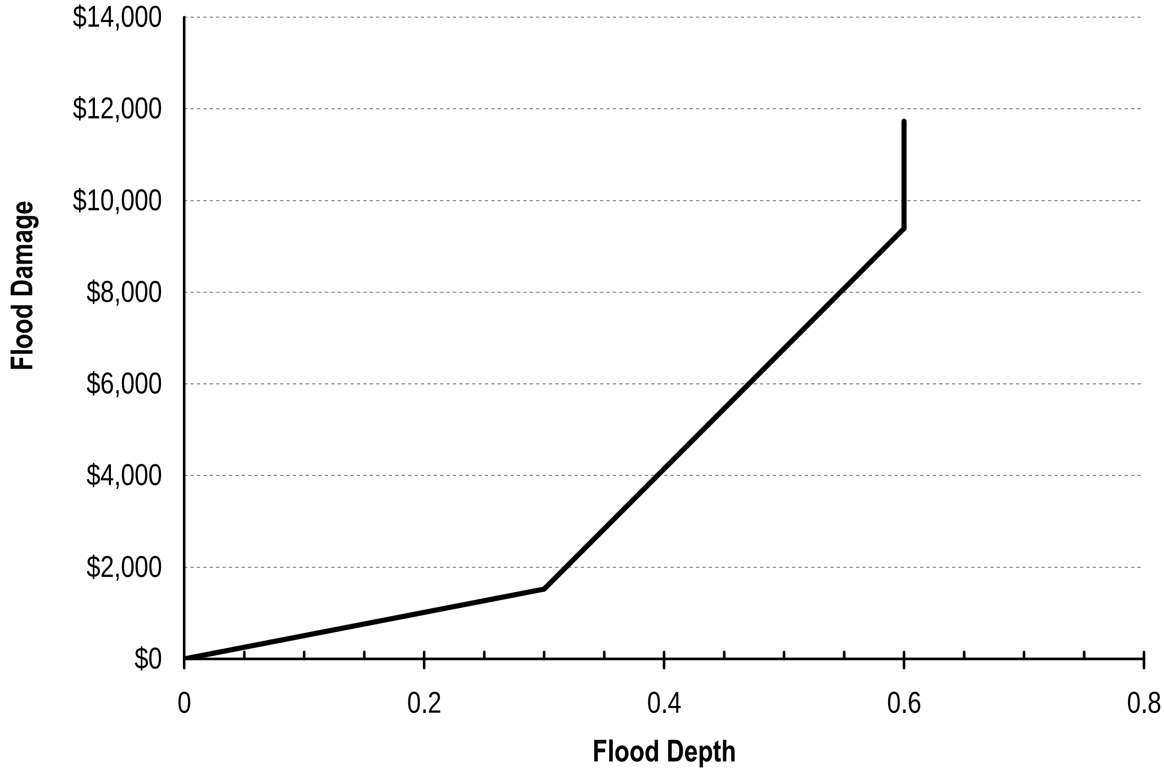
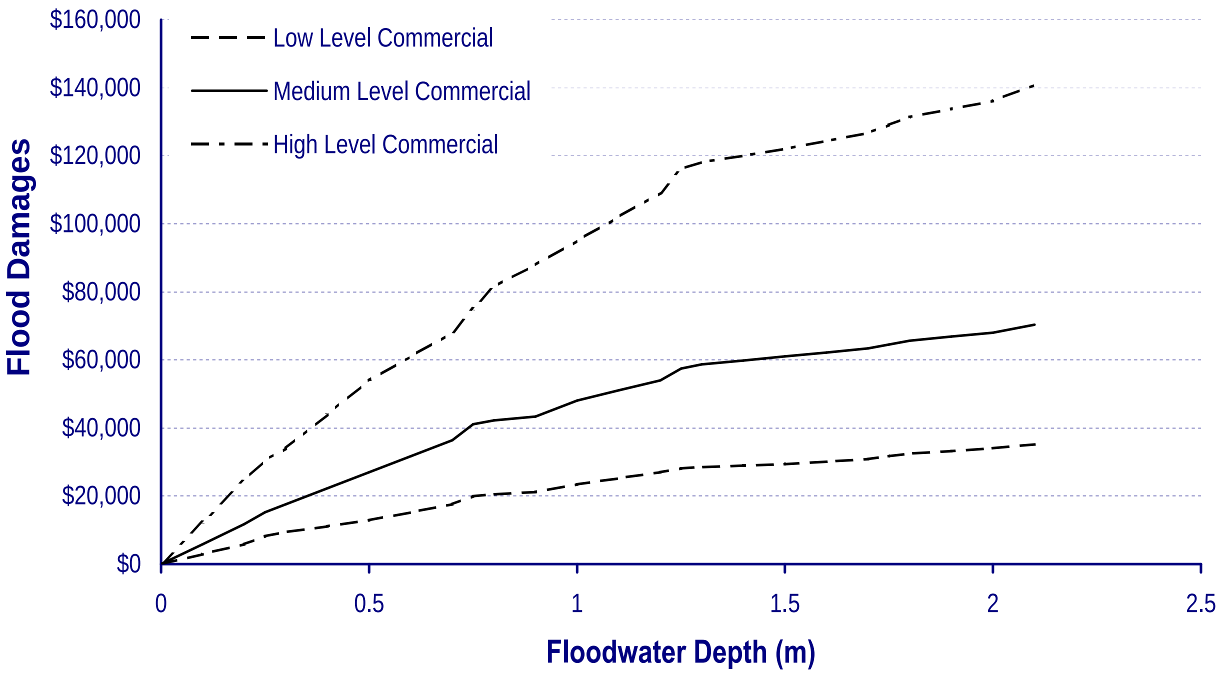


Table B3: COMMERCIAL PROPERTY DAMAGES

FLOODWATER DEPTH (m)	DAMAGES ($)		
	Low Level Commercial	Medium Level Commercial	High Level Commercial
0	0	0	0
0.1	2933	5866	12319
0.2	5866	11732	24637.2
0.25	8212	15252	30503
0.3	9386	17598	34023
0.4	11145	22291	43995
0.5	12905	26984	53967
0.6	15252	31676	61006
0.7	17598	36369	68046
0.75	19944	41062	75085
0.8	20531	42235	81537
0.9	21118	43408	87990
1	23464	48101	95029
1.1	25224	51034	102068
1.2	26984	53967	109108
1.25	28157	57487	116147
1.3	28548	58660	118102
1.4	28939	59833	120057
1.5	29330	61006	122013
1.6	30112	62180	124359
1.7	30894	63353	126706
1.75	31676	64526	129052
1.8	32459	65699	131398
1.9	33241	66872	133745
2	34023	68046	136091
2.1	35196	70392	140784



APPENDIX C
FLOOR LEVEL DATA FOR WARDELL AND CABBAGE TREE ISLAND

Table C1: FLOOR LEVEL AND PROPERTY DATA FOR WARDELL AND EAST WARDELL

WARDELL

BRIDGE STREET

ADDRESS	LAND USE	GRID REF ISG 56/2		ON/ABOVE GROUND		BUILDING TYPE	MATERIALS			Floor Level	Ground Level	SIZE	COND
		E	N				WALLS	ROOF	LEVELS				
2 BRIDGE STREET	RESIDENTIAL	345270	1795880	AG	0.6	RESIDENCE	W/B	GI	1	3.02	2.4	M	G
4 BRIDGE STREET	RESIDENTIAL	345250	1795880	AG	0.6	RESIDENCE	W/B	GI	1	3.14	2.55	M	F
6 BRIDGE STREET	VACANT	345240	1795870			VACANT					2.5		
8 BRIDGE STREET	RESIDENTIAL	345230	1795870	AG	0.5	RESIDENCE	BK/FIBRO	GI	1	3.16	2.65	M	F
10 BRIDGE STREET	RESIDENTIAL	345210	1795860	AG	0.8	RESIDENCE	CLAD	GI	1	3.45	2.65	M	F

RICHMOND STREET

ADDRESS	LAND USE	GRID REF ISG 56/2		ON/ABOVE GROUND		BUILDING TYPE	MATERIALS			Floor Level	Ground Level	SIZE	COND
		E	N				WALLS	ROOF	LEVELS				
01 RICHMOND ST	RESIDENTIAL	345730	1796090	AG	0.8	RESIDENCE	FIBRO	GI	1	2.96	1.4/2.15	S	G
03 RICHMOND ST	RESIDENTIAL	345710	1796120	AG	0.6	RESIDENCE	W/B	GI	1	2.27	1.65	S	G
05 RICHMOND ST	RESIDENTIAL	345720	1796070	OG		RESIDENCE	BRICK	GI	2	2.48/5.26	2.3	L	G
07 RICHMOND ST	RESIDENTIAL	345700	1796110	AG	0.4	RESIDENCE	W/B	GI	1	2.00	1.6	M	G
09 RICHMOND ST	RESIDENTIAL	345700	1796060	OG		RESIDENCE	BRICK	TILE	2	1.93/4.65	1.9	L	G
13 RICHMOND ST	RESIDENTIAL	345670	1796100	AG	0.7	RESIDENCE	FIBRO	GI	1	2.28	1.6	M	G
15A RICHMOND ST	RESIDENTIAL	345650	1796080	AG	0.3	RESIDENCE	W/B	TILE	1	2.4	2.05	M	G
15B RICHMOND ST	VACANT	345670	1796040			VACANT				-	1.8/2.0		
17 RICHMOND ST	RESIDENTIAL	345650	1796020	OG		RESIDENCE	BRICK	TILE	2	2.27/4.85	2.25	L	G
19 RICHMOND ST	RESIDENTIAL	345630	1796060	AG	0.6	UNITS	BK RENDER	TILE	1	2.85	2.2	M	G
19 RICHMOND ST	RESIDENTIAL	345630	1796060	OG		RESIDENCE	BRICK	TILE	1	2.58	2.4	M	G
20 RICHMOND ST	SCHOOL	345600	1796150	AG	0.5	OFFICE	BRICK	TILE	1	3.09	2.6	M	G
22-24 RICHMOND ST	CHURCH	345490	1796090	AG	0.6	ANGLICAN	BRICK	SHINGLE	1	3.05	2.1/2.4	M	G
22-24 RICHMOND ST	CHURCH	345490	1796090	AG	0.2	OLD CHURCH	W/B	GI	1	2.79	2.1/2.55	S	P
23 RICHMOND ST	RESIDENTIAL	345610	1796030	AG	0.5	RESIDENCE	W/B	GI	1	2.4	1.85	M	P
25 RICHMOND ST	RESIDENTIAL	345570	1796040	OG		RESIDENCE	BRICK	TILE	1	3.03	2.5	S	G
27 RICHMOND ST	RESIDENTIAL	345600	1796000	OG		RESIDENCE	BRICK	TILE	1	2.4	2.2	M	F
28 RICHMOND ST	RESIDENTIAL	345430	1796060	AG	0.7	RESIDENCE	BRICK	TILE	1	2.97	2.25	L	G
29 RICHMOND ST	RESIDENTIAL	345580	1796000	AG	1.2	RESIDENCE	W/B	GI	1	3.42	2.2	M	G
30 RICHMOND ST	RESIDENTIAL	345410	1796050	AG	0.4	RESIDENCE	W/B	GI	1	2.84	2.4	S	F
31 RICHMOND ST	RESIDENTIAL	345550	1796040	AG	0.6	RESIDENCE	FIBRO	GI	1	3.14	2.5	S	G
32 RICHMOND ST	RESIDENTIAL	345400	1796040	AG	0.6	RESIDENCE	BRICK	TILE	1	2.89	2.3	M	G
33 RICHMOND ST	RESIDENTIAL	345540	1795990	AG	0.3	RESIDENCE	BRICK	TILE	1	3.4	3.1	M	G

Table C1: FLOOR LEVEL AND PROPERTY DATA FOR WARDELL AND EAST WARDELL (continued)

WARDELL CONTINUED

RICHMOND STREET CONTINUED

ADDRESS	LAND USE	GRID REF ISG 56/2		ON/ABOVE GROUND		BUILDING TYPE	MATERIALS			Floor Level	Ground Level	SIZE	COND
		E	N				WALLS	ROOF	LEVELS				
34 RICHMOND ST	RESIDENTIAL	345380	1796030	AG	0.6	RESIDENCE	TIMBER	GI	1	2.74	2.10	M	G
35 RICHMOND ST	RESIDENTIAL	345500	1796020	AG	0.4	RESIDENCE	W/B	GI	1	2.59	2.20	M	P
36 RICHMOND ST	RESIDENTIAL	345370	1796030	AG	0.7	RESIDENCE	TIMBER	GI	1	2.78	2.10	M	G
37 RICHMOND ST	RESIDENTIAL	345470	1796000	AG	0.5	RESIDENCE	W/B FIBRO	GI		3.03	2.55	S	G
38 RICHMOND ST	RESIDENTIAL	345350	1796020	AG	0.5	RESIDENCE	TIMBER	GI	1	2.72	2.20	M	G
39 RICHMOND ST	RESIDENTIAL	345460	1795990	AG	0.4	RESIDENCE	STUCCO	GI	1	3.16	2.70	M	G
40 RICHMOND ST	COMMERCIAL	345330	1796010	OG		SHOPS	BRICK	GI	1	2.62	2.30	L	G
41 RICHMOND ST	RESIDENTIAL	345470	1795960	OG		RESIDENCE	BRICK	GI	1	2.77	2.55	M	G
42 RICHMOND ST	COMMERCIAL	345310	1796000	OG		SHOP	C/BLK/HP	GI	2	2.66/5.51	2.50	L	F
43 RICHMOND ST	RESIDENTIAL	345450	1795970	AG	0.4	RESIDENCE	W/B	GI	1	3.16	2.70	M	G
44 RICHMOND ST	RESIDENTIAL	345300	1795980	AG	0.3	RESIDENCE	WB	GI	1	2.79	2.50	S	F
45 RICHMOND ST	RESIDENTIAL	345420	1795970	AG	0.3	RESIDENCE	W/B	GI	1	3.12	2.80	M	F
46 RICHMOND ST	RESIDENTIAL	345290	1795980	AG	0.4	RESIDENCE	WB	GI	1	2.76	2.35	M	F
47 RICHMOND ST	RESIDENTIAL	345440	1795940	OG		RESIDENCE	BRICK	TILE	2	2.62/5.25	2.40	L	G
48 RICHMOND ST	RESIDENTIAL	345280	1795970	OG		RESIDENCE	S/S W/B	GI	2	2.74/5.28	2.70	M	G
49 RICHMOND ST	HALL	345410	1795950	AG	0.7	HALL	BK/TIM/GI	GI	1	3.05	2.30	L	F
51 RICHMOND ST	COMMERCIAL	345390	1795940	AG	0.5	OFFICE	BRICK	TILE	1	3.06	2.50	L	G
53-55 RICHMOND ST	RESIDENTIAL	345360	1795930	AG	0.9	UNIT A	HP	GI	1	3.30	2.40	S	G
53-55 RICHMOND ST	RESIDENTIAL	345360	1795930	AG	0.2	UNIT B	TIMBER	GI	1	2.84	2.60	M	G
53-55 RICHMOND ST	RESIDENTIAL	345360	1795930	AG	0.7	UNIT C	HP	GI	1	3.34	2.60	S	G
53-55 RICHMOND ST	RESIDENTIAL	345360	1795930	AG	0.8	UNIT D	HP	GI	1	3.18	2.40	S	G
53-55 RICHMOND ST	RESIDENTIAL	345360	1795930	AG	0.7	UNIT E	HP	GI	1	3.01	2.30	S	G
53-55 RICHMOND ST	RESIDENTIAL	345360	1795930	AG	0.7	UNIT F	HP	GI	1	2.96	2.25	S	G
53-55 RICHMOND ST	RESIDENTIAL	345360	1795930	AG	0.7	UNIT G	HP	GI	1	2.98	2.30	S	G
53-55 RICHMOND ST	RESIDENTIAL	345360	1795930	AG	0.8	UNIT H	HP	GI	1	3.04	2.25	S	G
59 RICHMOND ST	COMMERCIAL	345320	1795910	OG		HOTEL	BRICK	GI	2	2.70/6.4	2.1/2.5	L	F&G

SWAMP STREET

ADDRESS	LAND USE	GRID REF ISG 56/2		ON/ABOVE GROUND		BUILDING TYPE	MATERIALS			Floor Level	Ground Level	SIZE	COND
		E	N				WALLS	ROOF	LEVELS				
1 SWAMP ST	RESIDENTIAL	345490	1795960	OG		RESIDENCE	BRICK	GI	1	2.62	2.55	M	G
23 SWAMP ST	RESIDENTIAL	345430	1796210	OG		RESIDENCE	BRICK	TILE	1	2.79	1.80	L	F

Table C1: FLOOR LEVEL AND PROPERTY DATA FOR WARDELL AND EAST WARDELL (continued)

WARDELL CONTINUED

SINCLAIR STREET

ADDRESS	LAND USE	GRID REF ISG 56/2		ON/ABOVE GROUND		BUILDING TYPE	MATERIALS			Floor Level	Ground Level	SIZE	COND
		E	N				WALLS	ROOF	LEVELS				
3 SINCLAIR STREET	COMMERCIAL	345260	1795900	AG	0.5	OLD BANK	BRICK	GI	1	3.06	2.55	S	F

WILSON STREET

ADDRESS	LAND USE	GRID REF ISG 56/2		ON/ABOVE GROUND		BUILDING TYPE	MATERIALS			Floor Level	Ground Level	SIZE	COND
		E	N				WALLS	ROOF	LEVELS				
16 WILSON STREET	RESIDENTIAL	345730	1796200	AG	0.2	RESIDENCE	H/PLANK	GI	1	1.81	1.55	S	F
18 WILSON STREET	RESIDENTIAL	345780	1796230	OG		RESIDENCE	BRICK	TILE	1	2.65	1.2/2.5	M	G
20 WILSON STREET	RESIDENTIAL	345720	1796240	AG	0.8	RESIDENCE	W/B	TILE	1	2.41	1.55	M	F
22 WILSON STREET	VACANT	345720	1796280			VACANT							
24 WILSON STREET	RESIDENTIAL	345700	1796290	AG	1.4	RESIDENCE	H/PLANK	GI	1	3.02	1.60	M	G
26 WILSON STREET	CHURCH	345690	1796310	AG	0.8	CHURCH	W/B	GI	1	2.30	1.50	S	F

FITZROY STREET

ADDRESS	LAND USE	GRID REF ISG 56/2		ON/ABOVE GROUND		BUILDING TYPE	MATERIALS			Floor Level	Ground Level	SIZE	COND
		E	N				WALLS	ROOF	LEVELS				
1 FITZROY STREET	RESIDENTIAL	345650	1796240	AG	1.2	RESIDENCE	BRICK	TILE	1	3.00	2.20	M	G
2 FITZROY STREET	RESIDENTIAL	345610	1796300	AG	0.4	RESIDENCE	BK/FIBRO	METAL	1	2.69	1.6/2.3	M	F
3 FITZROY STREET	RESIDENTIAL	345640	1796230	OG		RESIDENCE	BRICK	TILE	1	2.99	2.0/2.7	M	G
5 FITZROY STREET	RESIDENTIAL	345620	1796220	OG		RESIDENCE	HP	METAL	1	2.84	2.55	M	F
7 FITZROY STREET	RESIDENTIAL	345600	1796210	AG	0.8	RESIDENCE	F/STUCCO	GI	1	3.32	2.45	M	G
9 FITZROY STREET	RESIDENTIAL	345570	1796200	OG		RESIDENCE	BRICK	GI	1	2.85	2.35	L	G
15 FITZROY STREET	RESIDENTIAL	345540	1796180	OG		RESIDENCE	BRICK	TILE	1	2.43	2.00	M	G
17 FITZROY STREET	RESIDENTIAL	345500	1796160	OG		RESIDENCE	BRICK	TILE	1	2.99	2.55	L	G
FITZROY STREET	SCHOOL	345460	1796140			P/GROUND				-	2.00		

PIMLICO ROAD

ADDRESS	LAND USE	GRID REF ISG 56/2		ON/ABOVE GROUND		BUILDING TYPE	MATERIALS			Floor Level	Ground Level	SIZE	COND
		E	N				WALLS	ROOF	LEVELS				
1047 PIMLICO ROAD	RESIDENTIAL	345770	1796480	AG	0.3	RESIDENCE	W/B FIBRO	GI	1	2.91	2.55	M	F
1061 PIMLICO ROAD	RESIDENTIAL	345720	1796350	OG		RESIDENCE	BRICK	GI	1	2.86	2.70	M	G
1063 PIMLICO ROAD	RESIDENTIAL	345710	1796330	AG	0.6	RESIDENCE	W/B	GI	1	3.31	2.70	S	F

Table C1: FLOOR LEVEL AND PROPERTY DATA FOR WARDELL AND EAST WARDELL (continued)

EAST WARDELL

RIVER STREET

ADDRESS	LAND USE	GRID REF ISG 56/2		ON/ABOVE GROUND		BUILDING TYPE	MATERIALS			Floor Level	Ground Level	SIZE	COND
		E	N				WALLS	ROOF	LEVELS				
1-5 RIVER STREET	RESIDENTIAL	345190	1795590	AG	1.0	RESIDENCE	H/PLANK	GI	1	2.67	1.65	S	P
7-9 RIVER STREET	RESIDENTIAL	345160	1795560	AG	1.1	RESIDENCE	W/BOARD	GI	1	2.95	1.8	M	F
11 RIVER STREET	RESIDENTIAL	345140	1795540	OG		RESIDENCE	BRICK	TILE	1	3.03	2.0/2.7	M	G
13 RIVER STREET	VACANT	345130	1795520			VACANT					1.7/2.65		
15 RIVER STREET	RESIDENTIAL	345120	1795510	OG		RESIDENCE	BRICK	TILE	1	2.99	1.75/2.6	M	G
17 RIVER STREET	RESIDENTIAL	345100	1795490	OG		RESIDENCE	FIBRO	GI	1	2.75	1.7/2.55	S	F
19 RIVER STREET	RESIDENTIAL	345090	1795480	OG		RESIDENCE	BRICK	TILE	1	3.04	1.85/2.8	M	G
21 RIVER STREET	RESIDENTIAL	345080	1795470	OG		RESIDENCE	BRICK	TILE	1	3.04	2.0/2.8	M	G
29 RIVER STREET	RESIDENTIAL	345050	1795390	AG	0.6	RESIDENCE	W/BOARD	GI	1	3.27	2.6	M	F
33 RIVER STREET	RESIDENTIAL	345040	1795360	OG		RESIDENCE	BRICK	TILE	3	2.91/4.23/5.58	2.75	L	G
LOT 1 RIVER STREET	RESIDENTIAL	345010	1795290	AG	0.8	RESIDENCE	W/BOARD	TILE	1	4.34	3.5	M	G

RAGLAN STREET

ADDRESS	LAND USE	GRID REF ISG 56/2		ON/ABOVE GROUND		BUILDING TYPE	MATERIALS			Floor Level	Ground Level	SIZE	COND
		E	N				WALLS	ROOF	LEVELS				
1 RAGLAN STREET	RESIDENTIAL	345290	1795430	OG		RESIDENCE	BRICK	TILE	1	3.00	1.9/2.75	M	G
3 RAGLAN STREET	RESIDENTIAL	345300	1795450	AG	0.9	RESIDENCE	W/BOARD	GI	1	3.48	1.7/2.6	M	F
4 RAGLAN STREET	RESIDENTIAL	345350	1795440	AG	0.7	RESIDENCE	FIBRO	GI	1	3.26	2.50	S	F
5 RAGLAN STREET	RESIDENTIAL	345310	1795470	AG	1.0	RESIDENCE	FIBRO	GI	1	3.97	1.5/3.1	M	F
6 RAGLAN STREET	RESIDENTIAL	345370	1795460	OG		RESIDENCE	BRICK	TILE	1	2.84	2.65	M	G
7 RAGLAN STREET	RESIDENTIAL	345320	1795490	OG		RESIDENCE	BRICK	TILE	1	3.17	1.8/3.05	S	G

BYRON STREET

ADDRESS	LAND USE	GRID REF ISG 56/2		ON/ABOVE GROUND		BUILDING TYPE	MATERIALS			Floor Level	Ground Level	SIZE	COND
		E	N				WALLS	ROOF	LEVELS				
01 BYRON STREET	RESIDENTIAL	345450	1795460	AG	0.4	RESIDENCE	W/BOARD	GI	1	3.38	2.95	M	F
03 BYRON STREET	RESIDENTIAL	345430	1795470	OG		RESIDENCE	BRICK	TILE	1	3.5	3.20	M	G
05 BYRON STREET	RESIDENTIAL	345420	1795480	OG		RESIDENCE	BRICK	TILE	1	2.95	2.75	M	G
07 BYRON STREET	RESIDENTIAL	345400	1795490	OG		RESIDENCE	BRICK	GI	1	2.87	2.4	M	G
09 BYRON STREET	VACANT	345380	1795500			VACANT					2.40		
11-19 BYRON STREET	RESIDENTIAL	345340	1795530	OG		RESIDENCE	BRICK	TILE	1	2.99	1.8/2.8	L	G
12 BYRON STREET	RESIDENTIAL	345400	1795550	AG	0.6	RESIDENCE	W/BOARD	GI	1	2.64	2.05	M	F
18 BYRON STREET	RESIDENTIAL	345340	1795600	AG	1.4	RESIDENCE	TIMBER	GI	1	2.99	1.65/2.25	M	F

Table C1: FLOOR LEVEL AND PROPERTY DATA FOR WARDELL AND EAST WARDELL (continued)

EAST WARDELL CONTINUED

RIVER DRIVE

ADDRESS	LAND USE	GRID REF ISG 56/2		ON/ABOVE GROUND		BUILDING TYPE	MATERIALS			Floor Level	Ground Level	SIZE	COND
		E	N				WALLS	ROOF	LEVELS				
7 RIVER DRIVE	RESIDENTIAL	345340	1795420	OG		RESIDENCE	BRICK	TILE	1	3.46	3.15	M	G
9 RIVER DRIVE	RESIDENTIAL	345370	1795430	OG		RESIDENCE	CONC BLK	GI	1	3.43	2.9/3.3	S	F
11 RIVER DRIVE	RESIDENTIAL	345390	1795430	OG		RESIDENCE	FIBRO	GI	1	3.35	3.00	S	G
13 RIVER DRIVE	RESIDENTIAL	345410	1795430	OG		RESIDENCE	CONC BLK	GI	1	3.18	2.7/3.0	S	G
20 RIVER DRIVE	VACANT	345460	1795400			VACANT					2.10		
21 RIVER DRIVE	RESIDENTIAL	345511	1795514	AG	0.5	RESIDENCE	BRICK	GI	1	3.5	3.00	M	G
22 RIVER DRIVE	VACANT	345470	1795420			VACANT					2.10		
23 RIVER DRIVE	RESIDENTIAL	345530	1795540	OG		RESIDENCE	BRICK	TILE	1	3.04	2.4/2.9	M	G
24 RIVER DRIVE	RESIDENTIAL	345500	1795420	OG		RESIDENCE	BK/HP	GI	1	3.08	2.50	M	G
25 RIVER DRIVE	RESIDENTIAL	345540	1795550	OG		DUPLEX	BRICK	TILE	1	3.21	2.8/3.0	L	G
26 RIVER DRIVE	RESIDENTIAL	345500	1795450	OG		RESIDENCE	BRICK	TILE	1	2.97	2.5/2.75	M	G
27 RIVER DRIVE	RESIDENTIAL	345560	1795560	OG		RESIDENCE	BRICK	TILE	1	3.34	1.8/3.15	M	G
28 RIVER DRIVE	RESIDENTIAL	345530	1795460	OG		RESIDENCE	BRICK	TILE	1	3.12	2.7/2.9	M	G
29 RIVER DRIVE	RESIDENTIAL	345580	1795570	AG	0.5	RESIDENCE	H/PLANK	GI	1	3.35	1.4/2.8	S	F
30 RIVER DRIVE	RESIDENTIAL	345540	1795470	AG	0.1	RESIDENCE	W/BOARD	GI	1	3.06	2.8/2.95	S	F
31 RIVER DRIVE	RESIDENTIAL	345590	1795580	OG		RESIDENCE	BRICK	GI	1	2.91	1.7/2.8	M	G
32 RIVER DRIVE	RESIDENTIAL	345560	1795480	AG	0.3	RESIDENCE	W/BOARD	GI	1	3.02	2.70	S	F
33 RIVER DRIVE	RESIDENTIAL	345610	1795590	AG	0.3	RESIDENCE	W/BOARD	GI	1	2.89	1.7/2.6	M	F
35 RIVER DRIVE	VACANT	345630	1795610			VACANT					1.8/2.2		
36 RIVER DRIVE	RESIDENTIAL	345590	1795500	AG	0.3	RESIDENCE	W/BOARD	GI	1	3.12	2.80	M	G
37 RIVER DRIVE	VACANT	345640	1795620			VACANT					1.8/2.2		
38 RIVER DRIVE	RESIDENTIAL	345610	1795510	AG	0.3	RESIDENCE	W/BOARD	GI	1	3.31	3.00	M	F
39 RIVER DRIVE	RESIDENTIAL	345660	1795630	OG		DUPLEX	BRICK	TILE	1	3.00	2.80	L	G
40 RIVER DRIVE	RESIDENTIAL	345630	1795520	AG	0.6	RESIDENCE	STUCCO	GI	1	3.62	3.00	M	G
41 RIVER DRIVE	RESIDENTIAL	345690	1795640	OG		RESIDENCE	BRICK	TILE	1	3.39	3.00	M	G
42 RIVER DRIVE	RESIDENTIAL	345650	1795530	AG	0.5	RESIDENCE	STUCCO	TILE	1	3.51	2.95	M	F
43 RIVER DRIVE	RESIDENTIAL	345710	1795628	AG	0.3	RESIDENCE	BRICK	TILE	1	3.5	3.20	M	G
44 RIVER DRIVE	RESIDENTIAL	345660	1795540	AG	0.5	RESIDENCE	W/BOARD	GI	1	3.29	2.80	M	G
46 RIVER DRIVE	RESIDENTIAL	345690	1795560	OG		RESIDENCE	BRICK	GI	1	3.11	3.00	M	G
50-52 RIVER DRIVE	RESIDENTIAL	345720	1795580	AG	0.6	RESIDENCE	W/BOARD	GI	1	3.29	2.65	M	G
54 RIVER DRIVE	RESIDENTIAL	345750	1795580	AG	0.5	RESIDENCE	W/BOARD	GI	1	3.12	2.60	M	G

Table C2: FLOOR LEVEL AND PROPERTY DATA FOR CABBAGE TREE ISLAND

ADDRESS	LAND USE	GRID REF ISG 56/2		ON/ABOVE GROUND		BUILDING TYPE	MATERIALS			Floor Level	Ground Level	SIZE	COND
		E	N				WALLS	ROOF	LEVELS				
A CABBAGE TREE ISL	RESIDENTIAL	344190	1792420	AG	2.6	RESIDENCE	BR/HP	GI	1	4.62	1.8/1.95	M	G
B CABBAGE TREE ISL	RESIDENTIAL	344190	1792390	AG	2.6	RESIDENCE	H/PLANK	GI	1	4.33	1.75	M	F
C CABBAGE TREE ISL	RESIDENTIAL	344190	1792320	AG	2.8	RESIDENCE	BR/HP	GI	1	4.42	1.65	M	G
D CABBAGE TREE ISL	RESIDENTIAL	344130	1792320	AG	2.7	RESIDENCE	BR/HP	GI	1	4.4	1.65	M	G
E CABBAGE TREE ISL	RESIDENTIAL	344190	1792300	AG	2.7	RESIDENCE	BR/HP	GI	1	4.44	1.7	M	G
F CABBAGE TREE ISL	RESIDENTIAL	344190	1792270	AG	2.8	RESIDENCE	W/BOARD	GI	1	4.31	1.55	S	P
G CABBAGE TREE ISL	RESIDENTIAL	344190	1792240	AG	2.6	RESIDENCE	W/BOARD	GI	1	4.31	1.7	S	P
H CABBAGE TREE ISL	RESIDENTIAL	344200	1792220	AG	2.6	RESIDENCE	FIBRO	GI	1	4.39	1.75	S	F
I CABBAGE TREE ISL	RESIDENTIAL	344190	1792190	AG	2.7	RESIDENCE	W/B FIBRO	GI	1	4.37	1.7	M	F
J CABBAGE TREE ISL	RESIDENTIAL	344180	1792170	AG	2.6	RESIDENCE	BRICK FIBRO	GI	1	4.66	2.1	M	F
K CABBAGE TREE ISL	RESIDENTIAL	344170	1792140	AG	2.7	RESIDENCE	W/B FIBRO	GI	1	4.48	1.8	S	P
L CABBAGE TREE ISL	RESIDENTIAL	344170	1792120	AG	2.7	RESIDENCE	W/B FIBRO	GI	2	4.7	1.95	S	P
M CABBAGE TREE ISL	RESIDENTIAL	344360	1792260	AG	2.6	RESIDENCE	BRICK FIBRO	GI	1	4.87	1.8/2.3	M	G
N CABBAGE TREE ISL	RESIDENTIAL	344380	1792270	AG	1.2	RESIDENCE	H/PLANK	GI	1	2.99	1.75	S	F
O CABBAGE TREE ISL	RESIDENTIAL	344400	1792300	AG	2.9	RESIDENCE	FIBRO	GI	1	4.86	2	M	F
P CABBAGE TREE ISL	RESIDENTIAL	344420	1792320	AG	2.8	RESIDENCE	BR/HP	GI	1	5.02	2.25	M	G
Q CABBAGE TREE ISL	RESIDENTIAL	344440	1792340	AG	2.8	RESIDENCE	BR/HP	GI	1	5.14	2.35	M	G
R CABBAGE TREE ISL	RESIDENTIAL	344450	1792360	AG	2.7	RESIDENCE	BR/HP	GI	1	5.14	2.45	M	G
S CABBAGE TREE ISL	RESIDENTIAL	344470	1792400	AG	2.7	RESIDENCE	H/PLANK	GI	1	5.19	2.0/2.5	M	G
CABBAGE TREE ISL	SCHOOL	344500	1792450	AG	0.7	RESIDENCE	W/BOARD	GI	1	4.14	2.1/3.4	M	G
T CABBAGE TREE ISL	RESIDENTIAL	344480	1792480	AG	1.0	RESIDENCE	W/B FIBRO	GI	1	3.18	2.2	S	P
U CABBAGE TREE ISL	RESIDENTIAL	344480	1792490	AG	1.0	RESIDENCE	W/B FIBRO	GI	1	3.13	2.1	S	P
V CABBAGE TREE ISL	RESIDENTIAL	344500	1792510	AG	2.7	RESIDENCE	BRICK FIBRO	GI	1	5.34	2.15/2.6	M	F
CABBAGE TREE ISL	OFFICE	344380	1792400	OG		HEALTH CTR	BRICK	GI	1	3.39	2.4/3.35	M	G
CABBAGE TREE ISL	OFFICE	344350	1792400	OG		OFFICE	BR/HP	GI	2	2.21/5.06	2.2	S	F
CABBAGE TREE ISL	OFFICE	344330	1792400	OG		SHOP	BRICK FIBRO	GI	2	2.06/4.84	2.05	S	F
CABBAGE TREE ISL	CHURCH	344310	1792410	AG	0.7	CHURCH	W/BOARD	GI	1	2.86	2.1	S	P
CABBAGE TREE ISL	HALL	344290	1792410	AG	1	HALL	W/BOARD	GI	1	3.3	2.3	M	F
W CABBAGE TREE ISL	RESIDENTIAL	344190	1792470	AG	2.6	RESIDENCE	H/PLANK	GI	1	4.33	1.5/1.7	S	F
X CABBAGE TREE ISL	RESIDENTIAL	344190	1792500	AG	2.7	RESIDENCE	BR/HP	GI	1	4.82	1.95/2.1	M	G
Y CABBAGE TREE ISL	RESIDENTIAL	344203	1792575	AG	2.6	RESIDENCE	BR/HP	BR/HP	1	4.5	1.9	M	G
Z CABBAGE TREE ISL	RESIDENTIAL	344203	1792595	AG	2.6	RESIDENCE	BR/HP	BR/HP	1	4.5	1.9	M	G

APPENDIX D

BROCHURES AND QUESTIONNAIRES DISTRIBUTED TO SEEK COMMENT ON FLOOD DAMAGE REDUCTION MEASURES

WARDELL & CABBAGE TREE ISLAND FLOODPLAIN RISK MANAGEMENT STUDY

Community Information Brochure

November 2004

Introduction

Much of the village of Wardell is located on relatively high ground and therefore is not typically flood affected. However, there are areas downstream from the Pacific Highway bridge crossing and at East Wardell, which would be inundated when floodwaters overtop the banks of the Richmond River.

The highest flood on record occurred in February 1954 and other major floods occurred in 1974 and 1981. The 1954 flood is considered to be equivalent to an 80 year recurrence flood.

Computer modelling has shown that about 13 dwellings at East Wardell are likely to be inundated to above the habitable floor level during floods of the magnitude of the 100 year recurrence event. A further 13 properties would be flood affected during less severe floods of the order of the 20 year recurrence flood.

In recognition of the flood hazard and increasing demand for urban development, Ballina Shire Council is developing Floodplain Risk Management Plans for Wardell and Cabbage Tree Island. The aim of each Plan is to determine and implement measures that will reduce flood damages. The Plans will also incorporate guidelines aimed at providing building and development controls for Wardell and will outline emergency response measures that could be implemented to manage the risks associated with future floods.

NSW Government Flood Policy

The State Government's *Flood Prone Lands Policy* is directed at providing solutions to existing flooding problems in developed areas, and ensuring that future development is compatible with the flood hazard and does not create additional flooding problems in other areas.

The management process for implementing the government's *Flood Policy* involves four sequential stages. These stages are:

1. Preparation of a Flood Study (*nearing completion*)
   - determines the nature and extent of the flooding problem.
   - provides data defining peak water levels, velocities and discharges for floods of varying severity.
2. Preparation of a Floodplain Risk Management Study
   - evaluates management strategies for the floodplain in terms of both existing and proposed development.
   - establishes and recommends a flood planning level and emergency response protocols.
3. Development of a Floodplain Risk Management Plan
   - involves formal adoption by Council of a plan of risk management for the floodplain.
4. Implementation of the Plan
   - involves identification of funding needs and preparation of a potential construction program.
   - involves construction of measures to reduce flood damages and protect existing development.
   - involves the inclusion of flood related planning controls within local environmental plans and development control plans to ensure new development is compatible with the flood hazard.
   - use of the Plan to identify and assess potential development areas.

Purpose of this Brochure

The purpose of this brochure is to provide sufficient information for residents of Wardell to understand the flooding issues that could affect them. The brochure also aims to identify a range of potential measures that could be implemented to reduce flood damages and / or reduce the risk of loss of life.

The brochure outlines a range of potential flood damage reduction measures that are being considered. These are shown overleaf and are discussed in the following sections.

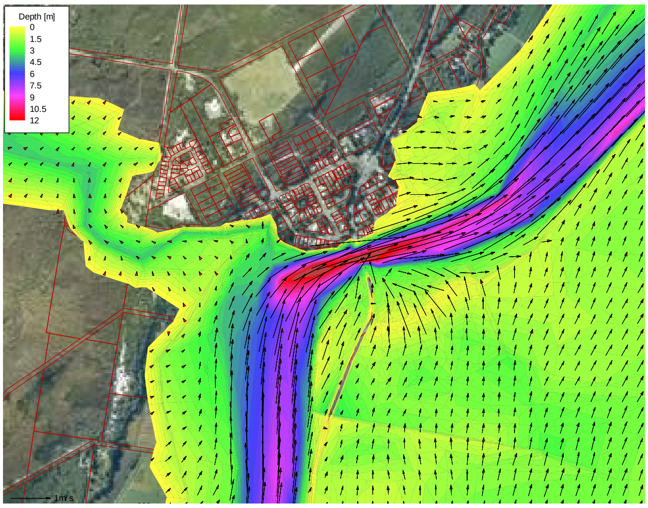
Ballina Shire Council welcomes your comments on the measures that are presented.

Alternatively, you may feel that there are other options that you believe need to be considered. Council welcomes your ideas on these also.

Progress to Date

The first stage in the floodplain management process has involved the preparation of a detailed Flood Study for the area between Broadwater and Pimlico Island. The report titled, ***Wardell & Cabbage Tree Island Flood Study***, can be viewed at Council's website: www.ballinacouncil.com.au.

The Flood Study details the extent of predicted inundation across the Island and shows the predicted depth of floodwaters and the flood hazard for floods of differing severity. A sample of the output generated by the Flood Study is shown below.



Where are We Now?

Council now wishes to move on to the next step in the floodplain management process. This involves taking the findings from the Flood Study and combining these with the results of investigations into potential flood damage reduction measures.

The findings of these investigations will form the basis of the Floodplain Risk Management Plan for Wardell, which will outline proposed works and strategies for implementation.

Similar investigations are being carried out for Cabbage Tree Island.

Ultimately the Floodplain Risk Management Study will determine which strategies are feasible.

WARDELL & CABBAGE TREE ISLAND FLOODPLAIN RISK MANAGEMENT STUDY

Potential Flood Damage Reduction Measures

Council has commissioned Consulting Engineers, Patterson Britton & Partners, to investigate potential flood damage reduction measure for Wardell. In consultation with Council, the Consultants have identified a number of measures that could potentially be implemented to reduce flood damages at Wardell.

These measures are outlined in the following table together with their principal objective. Their location is shown on the central pages of this brochure.
The flood damage reduction measures listed below are by no means an exhaustive list. Furthermore, at this stage, none are intended for implementation.

As part of the investigation process, Council wants to confirm that all potential measures have been considered. Due to your local knowledge of flooding in the area, you may know of other measures equally worthy of consideration. Council would be interested to hear of these.

Council is also interested to learn of your views on the measures presented in this brochure. Please feel free to answer the enclosed questionnaire and return it to Council.

Potential Structural Measures		Objectives
1A	Upgrade of the levee along the western bank of the Richmond River downstream from Wardell bridge.	This would protect property and dwellings in Wardell located east of the Pacific Highway from inundation during larger flood events.
1B	Construction of a levee along the eastern bank of the Richmond River around East Wardell.	This may protect property and dwellings in East Wardell from inundation during larger flood events.
1C	Dredging of the Richmond River channel upstream and downstream of Wardell Bridge.	This may increase the flow capacity through the channel constriction in the vicinity of Wardell Bridge and thus reduce flood levels at Wardell.

Potential Planning Measures

Apart from aiming to address existing flood problems, the State Government's *Flood Policy* also endeavours to prevent inappropriate development that could cause flooding problems in the future.

Although Council has an existing policy, the Committee wants to re-visit this and to consider any potential planning measures that could result in better management of floodplain lands.

A provisional list of potential planning measures is provided in the following table.

Council would welcome any comments you may have on these measures.

Potential Planning Measures		Potential Benefit
2A	Revision of minimum fill levels and dwelling floor levels for Wardell and East Wardell.	This may reduce the potential for flooding to cause damage to future dwellings.
2B	Development of flood emergency response protocols and community awareness.	Provide residents with an understanding of flood warning signs and potential flood impacts.

Where to from here?

Any comments or written submissions that you may have regarding these proposed strategies should be directed to:

Mr Paul Busmanis
Ballina Shire Council
Phone: 6686 1241
or
Mr Toong Chin
Department of Infrastructure, Planning and Natural Resources
Phone: 6627 0111
at
Ballina Shire Council
PO BOX 450
BALLINA NSW 2478
e-mail: frms@ballina.nsw.gov.au

They will be put before the Wardell & Cabbage Tree Island Floodplain Management Committee to assist in the preparation of the Floodplain Risk Management Study for the area.

The draft Floodplain Risk Management Study will be placed on public display and you will be invited to review and comment on its content.

Once finalised, the Floodplain Risk Management Study will provide an essential foundation for the development of a Floodplain Risk Management Plan for the Island. The Plan will ultimately be used to help protect existing development and ensure new development is compatible with the flood hazard.

A copy of the recently completed Flood Study Report, the Community Information Brochure and the questionnaire can be viewed at Council's website: www.ballinacouncil.com.au.

Have Your Say about Potential Flood Damage Reduction Measures for

Wardell

If you wish to register your views or outline alternative flood damage reduction measures for Wardell, please complete this form and return it to the address below.

PERSONAL DETAILS

Your Name: ____

Your Address: ____

Your Telephone Number: __________________________

....

QUESTIONS (please tick a box)	**YES**	**NO**	**NO VIEW**
(1) How many years have you lived at Wardell? _______			
(2) Are you aware of the risk of flooding of Wardell?	☐	☐	
(3) Are you concerned that you could be flooded and incur property damage?	☐	☐	
(4) Are you in favour of Flood Damage Reduction Measure 1A?	☐	☐	☐
(5) Are you in favour of Flood Damage Reduction Measure 1B?	☐	☐	☐
(6) Are you in favour of Flood Damage Reduction Measure 1C?	☐	☐	☐

Are there any other Flood Damage Reduction Measures that you believe should be considered?

If so, please list and describe:

(i) ____

____

(ii) ____

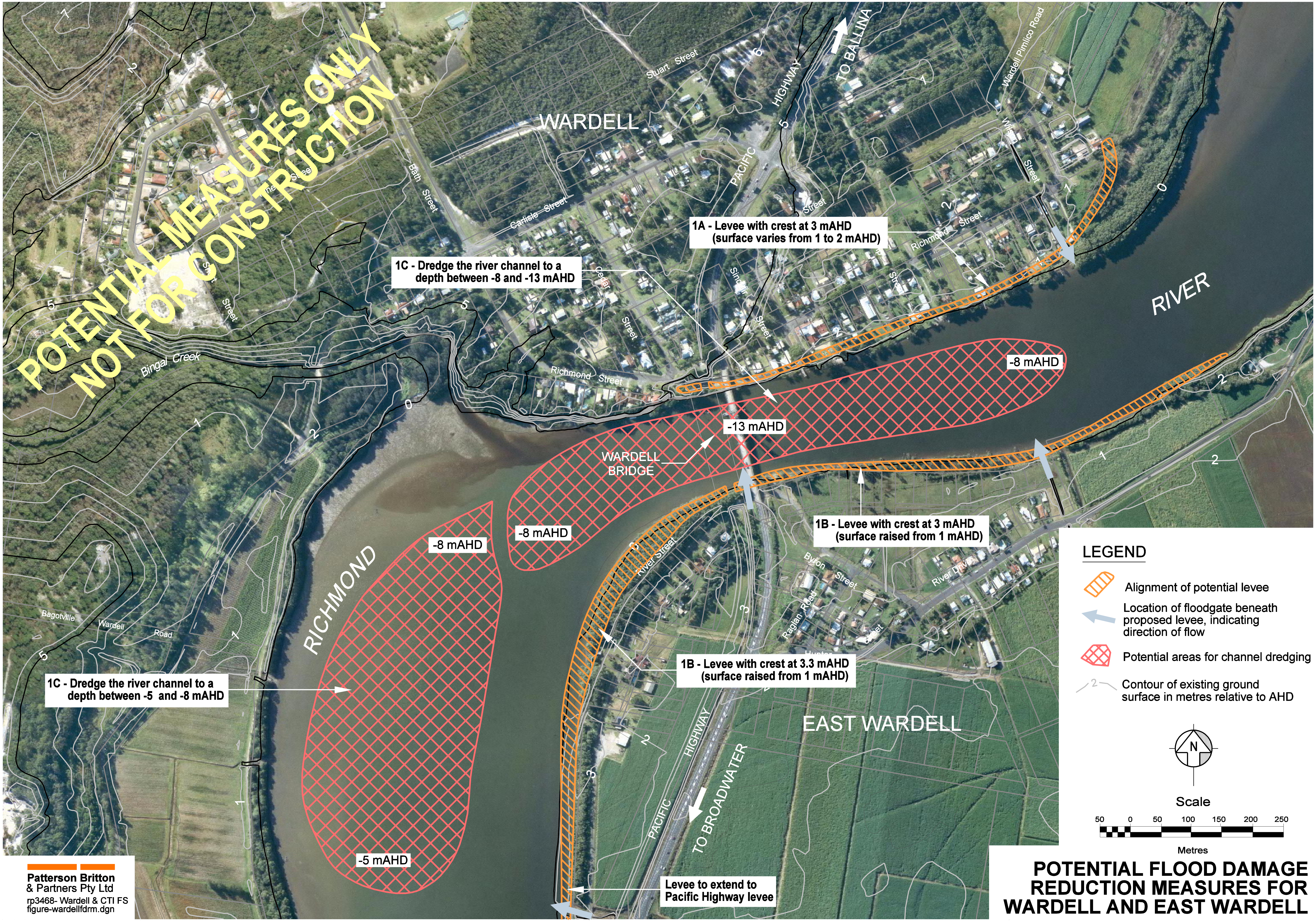
____

Please return to:

Mr Paul Busmanis
Engineering Works Manager
Ballina Shire Council
PO Box 450
BALLINA NSW 2478
Phone: (02) 6686 1241

Additional contact:

Mr Toong Chin
Senior Natural Resource Officer
Department of Infrastructure, Planning and Natural Resources-
Phone: (02) 6627 0111


POTENTIAL MEASURES ONLY
NOT FOR CONSTRUCTION
WARDELL
TO BALLINA
PACIFIC HIGHWAY
Stuart Street
Wardell Pimlico Road
Bath Street
Carlisle Street
Richmond Street
Bingal Creek
1A - Levee with crest at 3 mAHD
(surface varies from 1 to 2 mAHD)
1C - Dredge the river channel to a
depth between -8 and -13 mAHD
RIVER
-8 mAHD
-13 mAHD
WARDELL
BRIDGE
-8 mAHD
-8 mAHD
RICHMOND
1B - Levee with crest at 3 mAHD
(surface raised from 1 mAHD)
River Street
Byron Street
Raglan Road
River Drive
1B - Levee with crest at 3.3 mAHD
(surface raised from 1 mAHD)
Bagotville Wardell Road
1C - Dredge the river channel to a
depth between -5 and -8 mAHD
EAST WARDELL
TO BROADWATER
-5 mAHD
Levee to extend to
Pacific Highway levee
LEGEND
Alignment of potential levee
Location of floodgate beneath
proposed levee, indicating
direction of flow
Potential areas for channel dredging
Contour of existing ground
surface in metres relative to AHD
N
Scale
50 0 50 100 150 200 250
Metres
Patterson Britton
& Partners Pty Ltd
rp3468- Wardell & CTI FS
figure-wardellfdrm.dgn
POTENTIAL FLOOD DAMAGE
REDUCTION MEASURES FOR
WARDELL AND EAST WARDELL

WARDELL & CABBAGE TREE ISLAND
FLOODPLAIN RISK MANAGEMENT STUDY

Community Information Brochure

November 2004

Introduction

Cabbage Tree Island has experienced inundation on a number of occasions due to flooding of the Richmond River. The highest flood on record occurred in February 1954 and resulted in flooding to depths of up to 2 metres across the Island.

Recent computer modelling has shown that the majority of the Island would be inundated a flood of the magnitude of the 5 year recurrence event. Although most of the dwellings on Cabbage Tree Island are constructed with elevated floor levels, the safety of residents could be compromised in major floods.

The results of the computer modelling show that Back Channel Road would be inundated by floodwaters during floods larger than the 5 year recurrence event. Therefore, the only evacuation route from Cabbage Tree Island would be "cut" during floods of this magnitude. Some long time residents of the Island recall the 1974 and 1989 floods, when they had to evacuate to higher ground.

In recognition of the flood hazard and safety concern for residents, Ballina Shire Council is developing a Floodplain Risk Management Plan for Cabbage Tree Island (*and Wardell*). The aim of the Plan is to determine and implement measures that will reduce flood impacts and minimise flood damages. The Plan will also provide procedures for building and development controls on the island and will outline emergency response measures that could be put in place to manage the impacts and risks associated with future floods.

NSW Government Flood Policy

The State Government's *Flood Prone Lands Policy* is directed at providing solutions to existing flooding problems in developed areas, and ensuring that future development is compatible with the flood hazard and does not create additional flooding problems in other areas.

The management process for implementing the government's *Flood Policy* involves four sequential stages. These stages are:

1. Preparation of a Flood Study (*nearing completion*)
    - determines the nature and extent of the flooding problem.
    - provides data defining peak water levels, velocities and discharges for floods of varying severity.
2. Preparation of a Floodplain Risk Management Study
    - evaluates management strategies for the floodplain in terms of both existing and proposed development.
    - establishes and recommends a flood planning level and emergency response protocols.
3. Development of a Floodplain Risk Management Plan
    - involves formal adoption by Council of a plan of risk management for the floodplain.
4. Implementation of the Plan
    - involves identification of funding needs and preparation of a potential construction program.
    - involves construction of measures to reduce flood damages and protect existing development.
    - involves the inclusion of flood related planning controls within local environmental plans and development control plans to ensure new development is compatible with the flood hazard.
    - use of the Plan to identify and assess potential development areas.

Purpose of this Brochure

The purpose of this brochure is to provide sufficient information for residents of Cabbage Tree Island to understand the flooding issues that could affect them. The brochure also aims to identify a range of <u>potential</u> measures that could be implemented to reduce flood damages and / or reduce the risk of loss of life.

The brochure outlines a range of potential flood damage reduction measures that are being considered. These are shown overleaf and are discussed in the following sections.

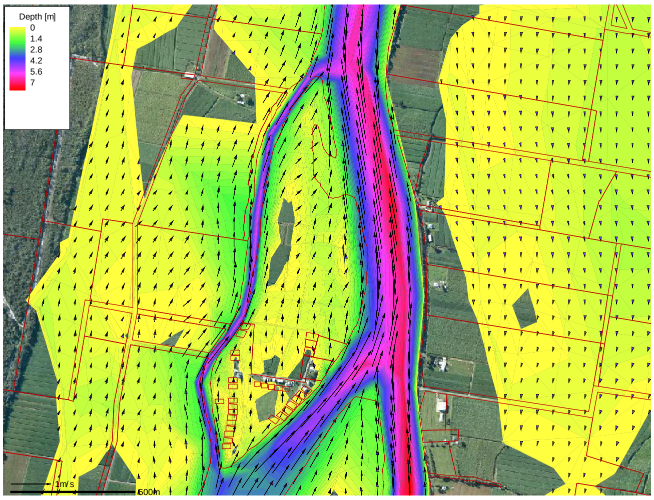
Ballina Shire Council welcomes your comments on the measures that are presented.

Alternatively, you may feel that there are other options that you believe need to be considered. Council welcomes your ideas on these also.

Progress to Date

The first stage in the floodplain management process has involved the preparation of a detailed Flood Study for the area between Broadwater and Pimlico Island. The report titled, *Wardell & Cabbage Tree Island Flood Study*, can be viewed at Council's website: www.ballinacouncil.com.au.

The Flood Study details the extent of predicted inundation across the Island and shows the predicted depth of floodwaters and the flood hazard for floods of differing severity. A sample of the output generated by the Flood Study is shown below.



Where are We Now?

Council now wishes to move on to the next step in the floodplain management process. This involves taking the findings from the Flood Study and combining these with the results of investigations into potential flood damage reduction measures.

The findings of these investigations will form the basis of the Floodplain Risk Management Plan for the Island, which will outline proposed works and strategies for implementation.

Similar investigations are being carried out for Wardell and East Wardell.

Ultimately the Floodplain Risk Management Study will determine which strategies are feasible.

Potential Flood Damage Reduction Measures

Council has commissioned Consulting Engineers, Patterson Britton & Partners, to investigate potential flood damage reduction measure for Cabbage Tree Island. In consultation with Council, the Consultants have identified a number of measures that could potentially be implemented to reduce flood damages on the Island.

These measures are outlined in the following table together with their principal objective. Their location is shown on the central pages of this brochure.

The flood damage reduction measures listed below are by no means an exhaustive list. Furthermore, at this stage, none are intended for implementation.

As part of the investigation process, Council wants to confirm that all potential measures have been considered. Due to your local knowledge of flooding in the area, you may know of other measures equally worthy of consideration. Council would be interested to hear of these.

Council is also interested to learn of your views on the measures presented in this brochure. Please feel free to answer the enclosed questionnaire and return it to Council.

	Potential Structural Measures	Objectives
1A	Construction of a deflector levee along the upstream edge of Cabbage Tree Island to a crest elevation of 3.5 mAHD.	This would direct flow around the island and reduce the velocity of floodwaters, thereby reducing the flood hazard in the areas where dwellings are situated.
1B	Dredging sections of the river bed in the Richmond River.	This would increase the channel capacity and potentially decrease flood levels in the vicinity of Cabbage Tree Island.
1C	Dredging sections of the river bed in the Back Channel.	This would increase the channel capacity and potentially decrease flood levels in the vicinity of Cabbage Tree Island.
1D	Installation of additional culverts or enlargement of existing culverts beneath the Pacific Highway on the eastern bank of the Richmond River.	This would allow floodwaters to more easily disperse onto the eastern floodplain and may reduce flood levels in the vicinity of Cabbage Tree Island during minor to moderate floods.

Potential Planning Measures

Apart from aiming to address existing flood problems, the State Government's *Flood Policy* also endeavours to prevent inappropriate development that could cause flooding problems in the future.

Although Council has an existing policy, the Committee wants to re-visit this and to consider any potential planning measures that could result in better management of floodplain lands.

A provisional list of potential planning measures is provided in the following table.

Council would welcome any comments you may have on these measures.

	Potential Planning Measures	Potential Benefit
2A	Revision of minimum floor levels for future dwellings on Cabbage Tree Island.	This may reduce the potential for flooding to cause damage to future dwellings.
2B	Development of flood emergency response protocols and community awareness.	This could provide residents with a better understanding of the flood risk to which they may be exposed and SES protocols for evacuation during floods.

Where to from here?

Any comments or written submissions that you may have regarding these proposed measures should be directed to:

Mr Paul Busmanis
Ballina Shire Council
Phone: 6686 1241
or
Mr Toong Chin
Department of Infrastructure, Planning and Natural Resources
Phone: 6627 0111
at
Ballina Shire Council
PO BOX 450
BALLINA NSW 2478
e-mail: frms@ballina.nsw.gov.au

They will be put before the Wardell & Cabbage Tree Island Floodplain Management Committee to assist in the preparation of the Floodplain Risk Management Study for the area.

The draft Floodplain Risk Management Study will be placed on public display and you will be invited to review and comment on its content.

Once finalised, the Floodplain Risk Management Study will provide an essential foundation for the development of a Floodplain Risk Management Plan for the Island. The Plan will ultimately be used to help protect existing development and ensure new development is compatible with the flood hazard.

A copy of the recently completed Flood Study Report, the Community Information Brochure and the questionnaire can be viewed at Council's website: www.ballinacouncil.com.au.

Have Your Say about
Potential Flood Damage Reduction Measures for

Cabbage Tree Island

If you wish to register your views or outline alternative flood damage reduction measures for Cabbage Tree Island, please complete this form and return it to the address below.

PERSONAL DETAILS

Your Name: ____

Your Address: ____

Your Telephone Number: ___________________________

....

QUESTIONS (please tick a box)	**YES**	**NO**	**NO VIEW**
(1) How many years have you lived at Cabbage Tree Island? _______			
(2) Are you aware of the risk of flooding of Cabbage Tree Island?	☐	☐	
(3) Are you concerned that you could be flooded and incur property damage?	☐	☐	
(4) Are you in favour of Flood Damage Reduction Measure 1A?	☐	☐	☐
(5) Are you in favour of Flood Damage Reduction Measure 1B?	☐	☐	☐
(6) Are you in favour of Flood Damage Reduction Measure 1C?	☐	☐	☐
(7) Are you in favour of Flood Damage Reduction Measure 1D?	☐	☐	☐

Are there any other Flood Damage Reduction Measures that you believe should be considered?

If so, please list and describe:

(i) ____

____

(ii) ____

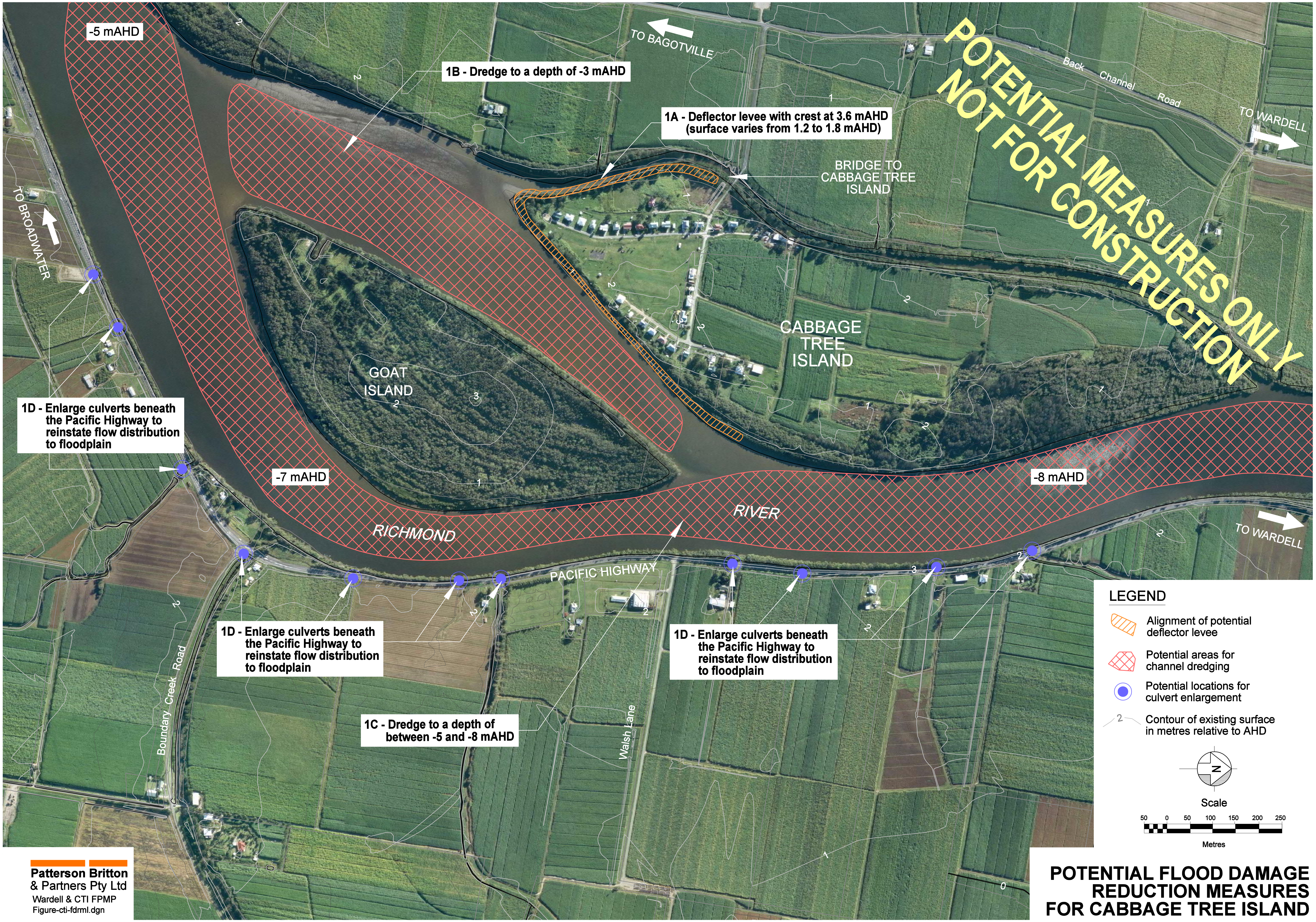
____

Please return to:

Mr Paul Busmanis
Engineering Works Manager
Ballina Shire Council
PO Box 450
BALLINA NSW 2478
Phone: (02) 6686 1241

Additional contact:

Mr Toong Chin
Senior Natural Resource Officer
Department of Infrastructure, Planning and Natural Resources
Phone: (02) 6627 0111



-5 mAHD
1B - Dredge to a depth of -3 mAHD
TO BAGOTVILLE
POTENTIAL MEASURES ONLY NOT FOR CONSTRUCTION
Back Channel Road
TO WARDELL
1A - Deflector levee with crest at 3.6 mAHD (surface varies from 1.2 to 1.8 mAHD)
BRIDGE TO CABBAGE TREE ISLAND
TO BROADWATER
GOAT ISLAND
CABBAGE TREE ISLAND
1D - Enlarge culverts beneath the Pacific Highway to reinstate flow distribution to floodplain
-7 mAHD
-8 mAHD
RICHMOND
RIVER
TO WARDELL
PACIFIC HIGHWAY
1D - Enlarge culverts beneath the Pacific Highway to reinstate flow distribution to floodplain
1D - Enlarge culverts beneath the Pacific Highway to reinstate flow distribution to floodplain
Boundary Creek Road
Walsh Lane
1C - Dredge to a depth of between -5 and -8 mAHD
LEGEND
Alignment of potential deflector levee
Potential areas for channel dredging
Potential locations for culvert enlargement
Contour of existing surface in metres relative to AHD
N
Scale
50 0 50 100 150 200 250
Metres
Patterson Britton & Partners Pty Ltd
Wardell & CTI FPMP
Figure-cti-fdrml.dgn
POTENTIAL FLOOD DAMAGE REDUCTION MEASURES FOR CABBAGE TREE ISLAND

APPENDIX E

RESULTS OF COMMUNITY CONSULTATION ON FLOOD DAMAGE REDUCTION MEASURES

Wardell and Cabbage Tree Island Floodplain Risk Management Study

Summary of Responses to Questionnaires

Wardell

A total of 45 responses were received for the questionnaire regarding management options for floodplain management in Wardell. All but one respondent are aware of the risk of flooding at Wardell. Only 9 respondents (20%) were concerned that they could be flooded and incur property damage.

In addition to this, three phone calls were received by Paul Busmanis regarding the proposed flood damage reduction measures. These have been dealt with separately in analyzing and discussing the results as they did not respond to the specific questions detailed in the questionnaire.

The distribution of the length of time respondents have resided in the Wardell area and their responses to the questionnaire are as follows:

TABLE C1 SUMMARY OF RESPONSES FOR WARDELL QUESTIONNAIRE

No. of Years in Area	No. of Respondents	% age of Total	Support Option 1A	Support Option 1B	Support Option 1C	Support All Options	Opposed to all options
1 – 5	15	33.3	5	5	7	2	3
6 – 10	4	8.9	1	2	3	1	
11 – 15	1	2.2					1
16 – 20	1	2.2	1	1	1	1	
21 – 25	9	20.0	3	3	5	2	2
26 – 30	3	6.7					3
31 – 35	2	4.4	1	1	2	1	
36 – 40	2	4.4	2	2	2	2	
41 – 45	1	2.2					1
46 – 50	Nil						
51 – 55	Nil						
56 – 60	5	11.1	2	4	5	3	
61 or more	2	2.2	1		1		1
Totals	**45**		**16**	**18**	**26**	**12**	**11**
%age of total			**35.6%**	**40.0%**	**57.8%**	**26.7%**	**24.4%**

The greatest number of respondents (33.3%) have lived in the area for 5 years or less, followed by those that have been in the area for between 21 – 25 years (20.0%). In comparison, only 13.3% of respondents were longer term residents (i.e., > 40 years).

The following is a summary of the responses received:

§ 16 respondents (35.6%) were in favour of flood damage reduction measure 1A (levee eastern bank).

- 18 respondents (40.0%) were in favour of flood damage reduction measure 1B (levee western bank).

- 26 respondents (57.8%) were in favour of flood damage reduction measure 1C (dredging of river channels)

- 12 (25.0%) respondents were in favour of all three damage reduction measures.

- 2 respondents (6.4%) had no specific view on any of the damage reduction measures.

- 11 respondents (24.4%) did not favour of any of the suggested measures, however, only 4 of these gave suggestions for alternative flood reduction measures. Alternative measures suggested included:
    - i) building on stilts such that the river can run its natural course
    - ii) closing the ditch at the junction of Richmond and Wilson Streets
    - iii) designing buildings such that the living areas are above the flood level
    - iv) dredging of waters in Ballina, in particular, North Creek (x2)
    - v) all development should be built on the high side (Wardell side) of the river
    - vi) maintenance of drains
    - vii) construct a levee in Ballina for the park at the Ferry Boat Motel area
    - viii) allocate funds to flood affected properties to raise their homes
    - ix) build lots of small dams in the catchment areas
    - x) encourage all homes to install rainwater tanks
    - xi) folding gates (?) at Tuckimbol escape at Woodburn (this response was quite difficult to read)
    - xii) divert water and Woodburn through the existing canal to the Evans River
    - xiii) dredge more extensively and rebuild the riverbanks and islands, sports grounds etc

- The majority (6 out of a total of 7) of longer term residents were in favour of option 1C - dredging. Whereas only about half (10 out of 19) of the shorter term residents (10 years of less) were in favour of this option. Similarly, of those that have lived in the area for between 11 and 39 years, 50% (9 out of 18) are in favour of option 1C – dredging.

- Those that were in favour of dredging suggested the following locations:
    - (i) Ballina, in particular North Creek
    - (ii) From mouth of river to south of Burns Point Ferry
    - (iii) The whole of the Richmond River, especially around the bridge to the sailing club, and North Creek
    - (iv) Eastern channel at Pimlico Island
    - (v) Richmond River around Goat Island

- A number of respondents (6) were concerned about the impact of the levees on the aesthetics of the area, while others (3) questioned the impact that the construction of the levees would have on the surrounding environment, particularly the mangrove ecosystem.

Concern was also raised by three (3) respondents with regards to the impact that dredging activities would have on fish stocks as a result of turbid waters.

- Two (2) respondents suggested that the requirement to infill sites prior to development should be removed as this increases the risk of flooding elsewhere.
- Two (2) respondents suggested using the fill from dredging activities to infill low lying land.
- Three (3) respondents expressed their concern about the loss of river access due to construction of the levees

Of the three phone calls that were received by Paul Busmanis, only one indicated their support for any of the suggested measures. This caller was in favour of dredging the Richmond River around Goat Island (Option 1C). One of the other callers indicated that they were opposed to a levee on the western bank. The third caller gave no specific view on any of the suggested damage reduction measures, but questioned the impact of the Lismore levee system and suggested that siltation downstream of Wardell was contributing to the flooding problem.

Cabbage Tree Island

Only 3 responses were received for the Cabbage Tree Island questionnaire. The responses are summarized in the Table 2 below:

TABLE 2 SUMMARY OF RESPONSES FOR CABBAGE TREE ISLAND QUESTIONNAIRE

	Support Option 1A	Support Option 1B	Support Option 1C	Support Option 1D	Support All Options	Opposed to all options
Totals	1	3	2	1	0	0

One of the respondents had lived in the local area for 11 years, and favoured the two dredging options (1B and 1C). Of the other two respondents, one had family that lived on the island and the other did not indicate how long they had lived in the area.

All respondents were aware of the risk of flooding at Cabbage Tree Island and 2 out of the 3 respondents were concerned about flooding and the subsequent damage of property. The most favoured option was Option 1B (dredge west of Goat Island), with all respondents in support of this action. This was followed by Option 1C (dredge east of Goat Island) with 2 out of the 3 respondents favouring this action. Options 1A and 1D were only favoured by 1 of the respondents each. There were no respondents that were opposed to all of the options.

There were no other suggestions for any other flood reduction measures.

APPENDIX F

SURVEY OF CULVERTS
BENEATH PACIFIC HIGHWAY

Table F1: SURVEY OF CULVERTS BENEATH PACIFIC HIGHWAY

CULVERT SURVEY ON SH 10 FROM SOUTHERN ABUTUMENT WARDELL BRIDGE TO 9.675 KM SOUTH (START OF SEGMENT 6410)

Date 13/06/2003	PC (Pipe Culvert)				RBC (Reinforced Box Culvert)
				Approx Invert	
Chainage	**Type**	**Number**	**Size**	**Below C.L.(m)**	**Comments**
0.100	PC	1	600 mm	2.40	No Floodgate
0.230	PC	2	600 mm	2.40	No Floodgate
0.390	PC	3	600 mm	2.00	No Floodgate
0.710	PC	3	1500 mm	4.40	No Floodgate
0.910	PC	1	900 mm	3.60	Floodgate working
1.080	PC	1	450 mm	3.50	Floodgate blocked open
1.350	RBC	2	3000x2000	4.00	No Floodgates (RTA No 9277)
1.510	PC	1	900 mm	2.60	Floodgate blocked open
1.540	PC	1	350 mm	2.30	No Floodgate
1.640	PC	1	800 mm	3.00	No Floodgate
1.740	PC	1	450 mm	2.00	No Floodgate
1.880	PC	1	800 mm	2.50	Floodgate blocked open
2.020	PC	1	350 mm	2.40	No Floodgate
2.910	PC	1	700 mm	3.00	No Floodgate
2.540	PC	3	1800 mm	3.00	Floodgate working
2.750	PC	1	900 mm	3.30	Floodgate working
3.060	PC	1	800 mm	2.70	Floodgate working
3.200	PC	1	900 mm	3.00	No Floodgate
3.260	PC	1	450 mm	2.60	No Floodgate
3.480	PC	1	450 mm	3.10	Floodgate blocked open
3.730	RBC	2	1400/2400	3.00	No Floodgate
3.810	PC	1	600 mm	2.00	Floodgate blocked open
3.970	PC	1	450 mm	1.50	Floodgate blocked open
4.040	PC	1	450 mm	2.50	Floodgate working
4.280	PC	3	1500 mm	2.00	No Floodgate
4.510	RBC	2	3000/2400	3.00	No Floodgate (Andersons Creek)
4.830	PC	1	400 mm	1.60	No Floodgate
5.010	PC	1	450 mm	2.10	Floodgate blocked open
5.310	PC	1	450 mm	2.60	Floodgate working (Hole in top of pipe)
5.430	PC	1	450 mm	2.60	No Floodgate
5.630	PC	1	600 mm	3.30	Floodgate blocked open
6.090	PC	1	1500 mm	3.30	Floodgates OK(Eversons Ck RTA No 9278)
6.240	PC	2	600 mm	2.00	1 Floodgate blocked open,1 Working
6.440	PC	1	900 mm	2.70	Floodgate working
6.840	PC	1	600 mm	2.50	Floodgate working
7.020	RBC	1	500 x 900	1.50	Floodgate blocked open
7.260	PC	1	300 mm	1.80	Floodgate working
7.410	RBC	3	2000/2000	3.50	Floodgates OK (Rattle Crk RTA No2164)
8.040	PC	1	400 mm	1.20	No Floodgate
8.580	PC	1	400 mm	1.40	No Floodgate
8.670	PC	1	1500 mm	3.00	Floodgate blocked open
8.970	PC	1	450 mm	1.00	Floodgate blocked open
9.170	PC	4	1500 mm	2.50	Floodgates OK (Montis Crk RTA No9282)
9.620	PC	1	600 mm	1.00	No Floodgate

APPENDIX G
COST ESTIMATES FOR
FLOODPLAIN MANAGEMENT OPTIONS

Table G1: COST ESTIMATE FOR LEVEE AT WARDELL

Project No.: 3468
Project Name: Wardell & Cabbage Tree Island FPMS
Date: 27-Apr-06

Patterson Britton
& Partners Pty Ltd

Disclaimer
This cost estimate is based on Patterson Britton's experience and judgement as a firm of practising professional engineers familiar with the construction industry. This cost estimate can NOT be guaranteed as we have no control over Contractor's prices, market forces and competitive bids from tenderers. This cost estimate excludes design fees, project management fees and authority approval fees.

Note: Wherever possible, cost estimates are based on Rawlinsons Australian Construction Handbook Edition 22, 2004

Item	Description	Quantity	Rate	Unit	Total
1	**Site Preparation**				
	- remove top soil and vegetation	8664	1.76	sqm	15,249
3	**Levee Core Construction**				
	- excavate clay from borrow site, deposit as fill & compact to 90%	4981	15.55	cum	77,459
	- shaping of batter slopes	6102	2.40	sqm	14,644
4	**Levee Landscaping**				
	- topsoil placement, raking and levelling	6102	14.25	sqm	86,951
	- turf layed, rolled and watered for 2 weeks	6102	7.15	sqm	43,628
	- dish drain construction along town-side toe of levee	731	10.00	m	7,308
				TOTAL (SYDNEY)	$245,239
				TOTAL (Ballina, +2.5%)	$251,370
				TOTAL (+20% CONTINGENCY)	**$300,000**

Table G2: COST ESTIMATE FOR CHANNEL DREDGING OPTION

Project No.: 3468
Project Name: Wardell & Cabbage Tree Island FPMS
Date: 27-Apr-06

Patterson Britton
& Partners Pty Ltd

Disclaimer
This cost estimate is based on Patterson Britton's experience and judgement as a firm of practising professional engineers familiar with the construction industry. This cost estimate can NOT be guaranteed as we have no control over Contractor's prices, market forces and competitive bids from tenderers. This cost estimate excludes design fees, project management fees and authority approval fees.

Item	Description	Quantity	Rate	Unit	Total
PRELIMINARY ACTIVITIES					
1	**Site Establishment**		Item	Lump sum	$250,000
2	**Deploy and Maintain Environmental Control Provisions**				
	Deploy and maintain turbidity curtain		Item	Lumpsum	$50,000
	Turbidity monitoring		Item	Lumpsum	$50,000
REMOVAL AND HANDLING OF MATERIALS					
1	**Dredging of Richmond River along 2.5km stretch in vicinity of Wardell**				
	Mobilise plant		Item	Lump sum	$25,000
	Mobilise plant		Item	Lump sum	$100,000
	Mobilise Plant		Item	Lump sum	$200,000
	Removal of material	1,200,146	m^3	$5.00	$6,000,728
	Transfer from barges to truck	1,200,146	m^3	$5.00	$6,000,728
	Truck material from Wardell to disposal	1,200,146	m^3	$5.00	$6,000,728
	Demobilise barges and tug		Item	Lump sum	$100,000
				Subtotal	**$18,427,183**
				TOTAL	**$18,777,183**
				Miscellaneous 10% Additional investigations Engineering design Contract supervision Project management	**$1,877,718**
				Contingencies 20%	**$3,755,437**
				GRAND TOTAL	**$24,400,000**

Table G3: COST ESTIMATE FOR LOW LEVEL LEVEE AT CABBAGE TREE ISLAND

Project No.: 3468
Project Name: Wardell & Cabbage Tree Island FPMS
Date: 27-Apr-06

Patterson Britton
& Partners Pty Ltd

Disclaimer
This cost estimate is based on Patterson Britton's experience and judgement as a firm of practising professional engineers familiar with the construction industry. This cost estimate can NOT be guaranteed as we have no control over Contractor's prices, market forces and competitive bids from tenderers. This cost estimate excludes design fees, project management fees and authority approval fees.

Note: Wherever possible, cost estimates are based on Rawlinsons Australian Construction Handbook Edition 22, 2004

Item	Description	Quantity	Rate	Unit	Total
1	**Site Preparation**				
	- remove top soil and vegetation	14371	1.76	sqm	25,293
3	**Levee Core Construction**				
	- excavate clay from borrow site, deposit as fill & compact to 90%	7384	15.55	cum	114,813
	- shaping of batter slopes	10160	2.40	sqm	24,383
4	**Levee Landscaping**				
	- topsoil placement, raking and levelling	10160	14.25	sqm	144,776
	- turf layed, rolled and watered for 2 weeks	10160	7.15	sqm	72,642
	- dish drain construction along town-side toe of levee	1196	10.00	m	11,961
				TOTAL (SYDNEY)	$393,868
				TOTAL (Ballina, +2.5%)	$403,715
				TOTAL (+20% CONTINGENCY)	**$484,000**

Table G4: COST ESTIMATE FOR HIGH LEVEL LEVEE AT CABBAGE TREE ISLAND

Project No.: 3468
Project Name: Wardell & Cabbage Tree Island FPMS
Date: 27-Apr-06

Patterson Britton & Partners Pty Ltd

Disclaimer
This cost estimate is based on Patterson Britton's experience and judgement as a firm of practising professional engineers familiar with the construction industry. This cost estimate can NOT be guaranteed as we have no control over Contractor's prices, market forces and competitive bids from tenderers. This cost estimate excludes design fees, project management fees and authority approval fees.

Note: Wherever possible, cost estimates are based on Rawlinsons Australian Construction Handbook Edition 22, 2004

Item	Description	Quantity	Rate	Unit	Total
1	**Site Preparation**				
	- remove top soil and vegetation	20949	1.76	sqm	36,871
3	**Levee Core Construction**				
	- excavate clay from borrow site, deposit as fill & compact to 90%	21547	15.55	cum	335,054
	- shaping of batter slopes	17262	2.40	sqm	41,430
4	**Levee Landscaping**				
	- topsoil placement, raking and levelling	17262	14.25	sqm	245,988
	- turf layed, rolled and watered for 2 weeks	17262	7.15	sqm	123,426
	- dish drain construction along town-side toe of levee	1196	10.00	m	11,961
				TOTAL (SYDNEY)	$794,729
				TOTAL (Ballina, +2.5%)	$814,597
				TOTAL (+20% CONTINGENCY)	**$978,000**

APPENDIX H
COPY OF ANNEXURE G OF BALLINA LOCAL FLOOD PLAN

ANNEX G - SPECIAL ARRANGEMENTS FOR THE EVACUATION OF CABBAGE TREE ISLAND

GENERAL

1. This area includes the Jali Community on Cabbage Tree Island and low lying areas along the Western Bank of the Richmond River North from the island to Bingal Creek.

2. The Back Channel Road accesses the Jali Community on the Western bank of the Richmond River with a single lane bridge across to the island and a bridge across Bingal Creek.

3. The population of the community is approximately 160 to 170.

NATURE OF FLOOD THREAT

4. Cabbage Tree Island is located in a high hazard floodway. In a 1% AEP flood it is expected that approximately 1 metre of water flowing at 1 m/s will be experienced across the island.

5. There are 24 residences, a School, Shop, Church, Hall, Health Centre and Office on the island. All of which are located on land that is likely to experience flooding as a result of a 10% AEP flood (approximately 2.4 m AHD at the Broadwater Gauge). All but three residences, the Office, Health Centre, Shop, Church and Hall are raised with floor levels above the approximate 1 % AEP flood level (approximately 3.8 m AHD on the Broadwater Gauge). An approximate plan of locations of buildings on Cabbage Tree Island is at Map 4.

6. The only road access to the island is via the Back Channel Road from Wardell. It is a low-level road with a general level of 1.8 m to 2.1 m AHD. The lowest point on the road is 1.3m AHD. The Bingal Creek Bridge has a deck height of 2.6m AHD and the bridge to the island has a deck height of 3.1m AHD. As a result the evacuation route is likely to be closed to light traffic by 1.4m AHD on the Broadwater gauge and closed to all traffic by 1.6m AHD.

OPERATIONAL CONTROL

7. The BALLINA SES Local Headquarters will control operations in the Cabbage Tree Island area.

OPERATIONAL RESOURCES

8 Operational resources likely to be available for evacuation tasks are:

a. Ballina SES Unit – 15 personnel, 1 4WD vehicle, 2 flood boats.

b. Broadwater SES Unit – 5 personnel, 1 flood boat.

c. NSW Police (Wardell, Alstonville & Ballina Stations) – 4 personnel, two cars.

d. NSW RFS (Wardell & Meerschaum Vale Brigades) – 8 personnel, 2 high clearance vehicles.

e. NSW Ambulance Service (Ballina Station) – 2 personnel, 1 ambulance.

f. Jali Community Land Council – 4 personnel.

g. Ballina Shire Council – 10 personnel, 2 high clearance vehicles.

8. Helicopters could operate from :

a. Ballina Airport,

b. Lismore Rescue Helicopter Base, and

c. Wardell Sports Grounds.

DECISION TO EVACUATE

9 The decision to evacuate will be made by the Ballina SES Local Controller. The decision to evacuate part or all of the community will be based on advice from the Bureau of Meteorology and in consultation with the Jali Community Land Council and Richmond Tweed SES Division Controller.

WARNING SYSTEM

10 The primary means of warning for the Jali Community will be by door knock by the Jali Land Council. The Richmond Tweed SES Division Headquarters will also broadcast a warning over local radio stations.

ASSEMBLY AREA

11 The community's Main Hall will be the evacuation assembly area.

EVACUATION CENTRE

12 The Uniting Church Conference Centre Cherry Street, Ballina.

EVACUATION ROUTE

13 The Back Channel Road to Wardell then the Pacific Highway to Ballina.

TRANSPORT

14 The primary means will be by private vehicle. Blanches Bus Company is available to assist for those residents without private transport. Emergency Services high clearance vehicles are available if required.

SECURITY

15 The Jali Land Council is responsible to provide security.