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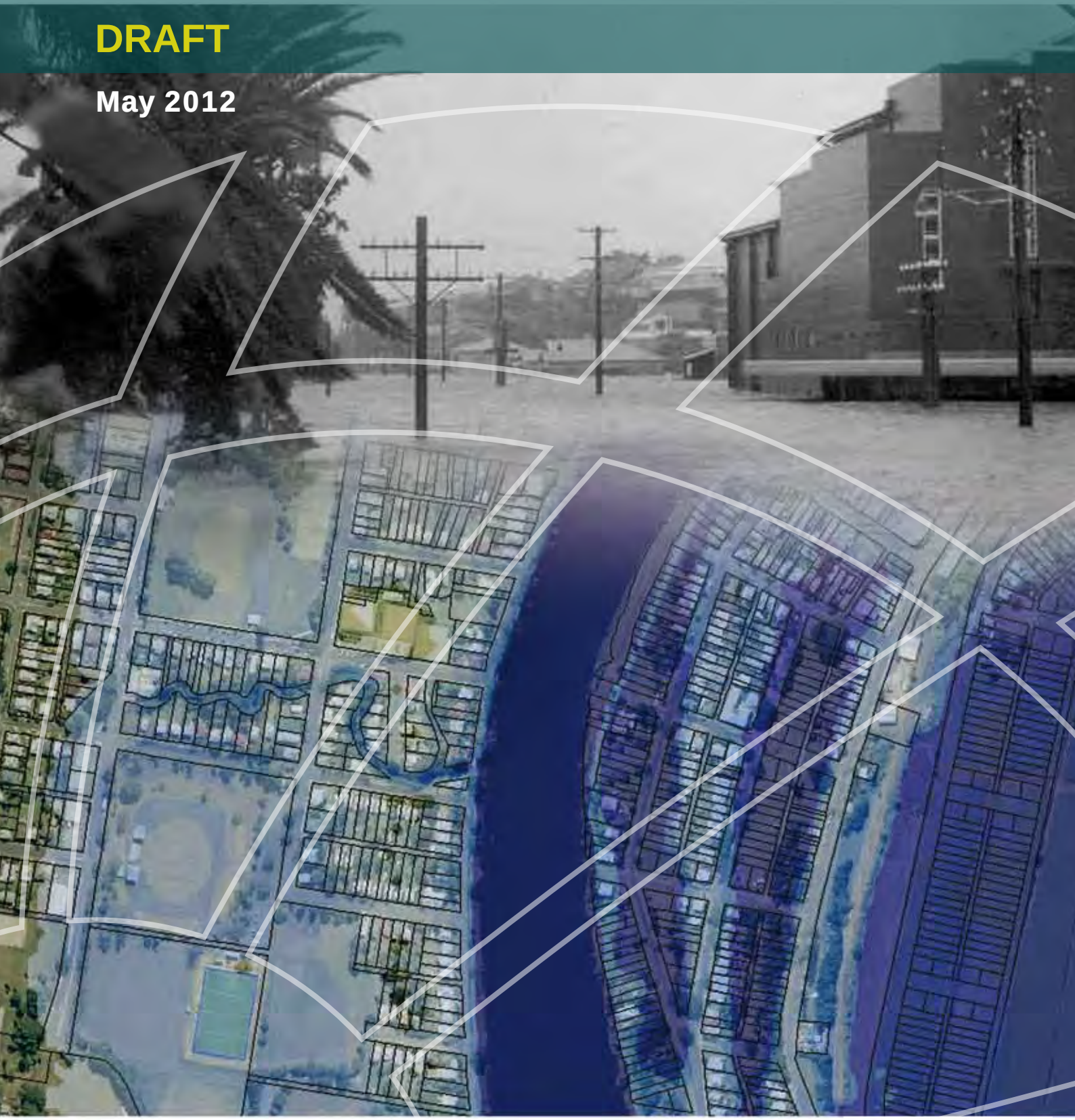
TWEED VALLEY FLOODPLAIN RISK MANAGEMENT PLAN

DRAFT

May 2012



TWEED SHIRE COUNCIL

Tweed Valley Floodplain Risk Management Plan (DRAFT)

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

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Title :	Tweed Valley Floodplain Risk Management Plan (DRAFT)
Author :	Carrie Dearnley, Sharon Wallace
Synopsis :	Draft plan outlining floodplain risk management measures for the Tweed Valley recommended by the Tweed Valley Floodplain Risk Management Study.

REVISION/CHECKING HISTORY

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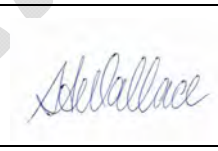
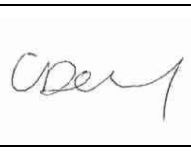
0	22 May 2012	SAW		CD	

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EXECUTIVE SUMMARY

The measures in this Plan are the result of detailed investigation and consideration of the Tweed Valley Floodplain Risk Management technical committee and its representatives. Input from the broader Floodplain Risk Management committee and stakeholder feedback has also been used to inform and guide the selection of measures.

Most of the recommended measures are non-structural, such as improved flood education, emergency planning and development planning. The major structural option recommended is raising the Tweed Heads South levee, which would provide increased protection to residents in the Dry Dock Road area. A number of properties have also been identified as suitable for voluntary house purchase or raising.

A summary of all recommended measures is provided in Table ES- 1 below. Note that response modification measures have been subdivided into the following categories: flood warning system, flood intelligence, Local Flood Plan, flood awareness, and evacuation planning. Further details of relative priorities, investment and key agency responsibilities are provided in the Implementation Plan in Section 11.

Table ES- 1 Summary of Measures

Description	Recommendation	Section
Flood Modification Measures		
Raise Tweed Heads South levee to provide 100 year ARI protection	Recommended	3.1
Extend Tweed Heads South levee to provide 100 year ARI protection to Philp Parade area	Further Investigation	3.2
Commission levee overtopping studies for Tweed Heads South levee and Murwillumbah levees (2 studies)	Further investigation	3.3
Commission local drainage studies	Further investigation	3.4
Preserve (and potentially enhance) South Murwillumbah / Condong flowpath	Recommended	3.5
Flood Awareness		
Continue / support Community FloodSafe Engagement Program	Recommended	4.1
Publish evacuation centres and routes	Recommended	4.2
Provide information to residents relating stream gauge heights to personal flood risk	Recommended	4.3

Description	Recommendation	Section
Provide targeted flood education to residents in high risk areas or who might have to pre-emptively evacuate	Recommended	4.4
Flood Intelligence		
Update flood intelligence cards	Recommended	5.1
Develop flood information website	Recommended	5.2
Flood Warning System		
Trial supplementary methods of warning dissemination	Recommended	6.1
Include Tumbulgum stream gauge in formal warning system	Recommended	6.2
Improve storm surge prediction tools	Recommended	6.3
Evacuation Planning		
Commission detailed evacuation planning study	Further investigation	7.1
Plan to pre-emptively evacuate residents who may not be able to evacuate under standard timeframes	Recommended	7.2
Include pedestrian evacuation in evacuation planning for high density areas	Recommended	7.3
Evacuation Centres		
Review capacity and resources of evacuation centres	Recommended	8.1
Identify alternative evacuation centres to Tweed Civic Centre	Recommended	8.2
Property Modification Measures		
Commence voluntary house purchase scheme	Recommended	9.1
Commence voluntary house raising scheme	Recommended	9.2
Planning Measures		
Review and implement detailed planning recommendations	Recommended	10.1

CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF ABBREVIATIONS

AAD	Average Annual Damages
mAHD	metres to Australian Height Datum
ARI	Average Recurrence Interval (of flood)
BoM	Bureau of Meteorology
DIPNR	(former) Department of Infrastructure, Planning and Natural Resources
DoCS	Department of Community Services
DoP	(former) Department of Planning
DPI	Department of Planning and Infrastructure
EP&A Act	Environmental Planning and Assessment Act
FIC	Flood Intelligence Card
FRMP	Floodplain Risk Management Plan
FRMS	Floodplain Risk Management Study
LEP	Local Environment Plan
LFP	Local Flood Plan
LGA	Local Government Area
m/s	metres per second
OEH	Office of Environment and Heritage
PMF	Probable Maximum Flood, also referred to as flood prone land
RMS	Roads and Maritime Services
SES	State Emergency Service
TSC	Tweed Shire Council
VHP	Voluntary House Purchase
VHR	Voluntary House Raising

1 OVERVIEW

This document outlines a plan to implement a range of floodplain management measures which were assessed as part of the Tweed Valley Floodplain Risk Management Study (FRMS). The plan provides practical information such as timing, priority, expense and responsibility for all of the measures recommended for implementation or further investigation.

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

1.1 Floodplain Risk Management Process

The New South Wales government's Flood Prone Land Policy is directed towards providing solutions to existing flooding problems in developed areas and ensuring that new development is compatible with the flood hazard and does not create additional flooding problems in other areas. Policy and practice are defined in the Floodplain Development Manual (DIPNR, 2005).

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

Table 1-1 Stages of Floodplain Risk Management Process

Stage	Description
1. Flood Study	Determines the nature and extent of the flood problem.
2. Floodplain Risk Management Study	Evaluates management options for the floodplain in consideration of social, ecological and economic factors.
3. Floodplain Risk Management Plan	Involves formal adoption by Council of a plan of management with preferred options for the floodplain.
4. Plan Implementation	Implementation of flood mitigation works, response and property modification measures by Council.

Community consultation occurs throughout the process.

This plan represents the third of the four stages for the Tweed Valley.

1.2 Aim of the Plan

The Plan aims to manage and minimise (where practical and possible) flood risk in the Tweed Valley, based on the outcomes of the broader Floodplain Risk Management Study. For the purposes of this study, flood risk can be broadly categorised as:

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

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

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

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

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

1.3 Responsibilities

The responsibility for land use planning in the Tweed Valley catchment, including flood prone land, lies primarily with **Tweed Shire Council**. The primary responsibilities of Council are:

- Commissioning a Floodplain Risk Management Study (this study) and implementing the Plan (this document);
- Preparation of a Local Environment Plan (LEP) which incorporates the planning provisions outlined in this document;
- Provide flood related information on planning certificates at time of property sale;
- Design, maintain and construct flood mitigation works;
- Promote flood readiness in the community via flood education; and
- Assist the SES in preparation of the Local Flood Plan (LFP).

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

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

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

The **State Emergency Service** (SES) provides specialist technical advice about emergency planning and development controls throughout the study process. The SES is responsible for implementing emergency planning and response measures recommended in the Plan.

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

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

1.4 Management Measures

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

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

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

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

2 BACKGROUND

2.1 Study Area

The Tweed River is located in Tweed Shire, the northern-most coastal region of New South Wales (see Figure 2-1). The main arm of the river has a length of about 50 km and a catchment area of about 1,100 km^2 including its various tributary systems. The main arm of the river flows in a general north-easterly direction through the towns of Murwillumbah (about 28 km upstream) and Tweed Heads (at the mouth) and past the villages of Condong, Tumbulgum, Chinderah and Fingal Head. The main tributaries include Oxley River, Rous River, Dunbible Creek and the Terranora and Cobaki Broadwaters. The river flows to the sea immediately south of Point Danger, close to the border with Queensland.

Regular flooding occurs, particularly in the low-lying cane regions of the valley. The most recent 'major' flood event was January 2008. The catchment has experienced larger flood events on a number of occasions, including in March 1974 and most severely in February 1954. This flood caused major inundation in all flood prone areas.

Regional flooding occurs via catchment inflows, ocean storm surge or some combination of these events. The small tributaries in the Bilambil and Terranora regions and local areas can also experience flash flooding; however the focus of the Tweed Valley FRMS is catchment scale inundation. The critical storm duration for catchment flooding at Murwillumbah was determined to be approximately 36 hours as part of previous flood studies.

Development in the catchment is centred on two major centres, Tweed Heads and Murwillumbah, with a number of smaller villages throughout the catchment. The Far North Coast Regional Strategy (DoP, 2006) was prepared to provide guidance in planning for the growth of the six North Coast Local Government Areas including Tweed Shire for a projected population growth of 26% over a 25 year period. Of this, the Strategy aims to focus 35% of new housing in the regional centres which includes Tweed Heads (to yield an additional 19,100 new dwellings).

The study area covers the Tweed Valley floodplain downstream of Byangum defined by the extent of the Probable Maximum Flood (PMF), also referred to as the extent of 'flood prone land'.

Coral Sea

Tweed Heads

Tumbulgum

Murwillumbah

Tyalgum

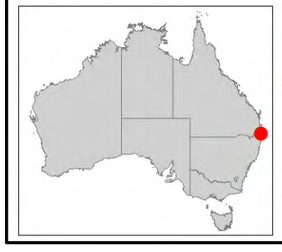
Fernvale

Mount Warning

Uki

Elevation (m)

1100
1000
900
800
700
600
500
400
300
200
100
0



LEGEND

Tweed Catchment Boundary

Tweed River

Watercourse Line

Principal Road

Sealed Road

Title:

Tweed River and Surrounds

Figure: **2-1**

Rev: **A**

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Approx. Scale

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2.2 Flood Risk

2.2.1 Existing Flood Risk

The Tweed Valley study area has a long history of flooding and will continue to flood in the future. There have been a number of major floods in the Tweed catchment in living memory, including the largest flood on record in 1954. During this flood, much of the floodplain was inundated with high velocities that caused significant damage to houses at South Murwillumbah. Calculations in the Murwillumbah Floodplain Management Plan (Tweed Shire Council, 1989) estimated the 1954 flood had a return period of 60 to 70 year Average Recurrence Interval (ARI).

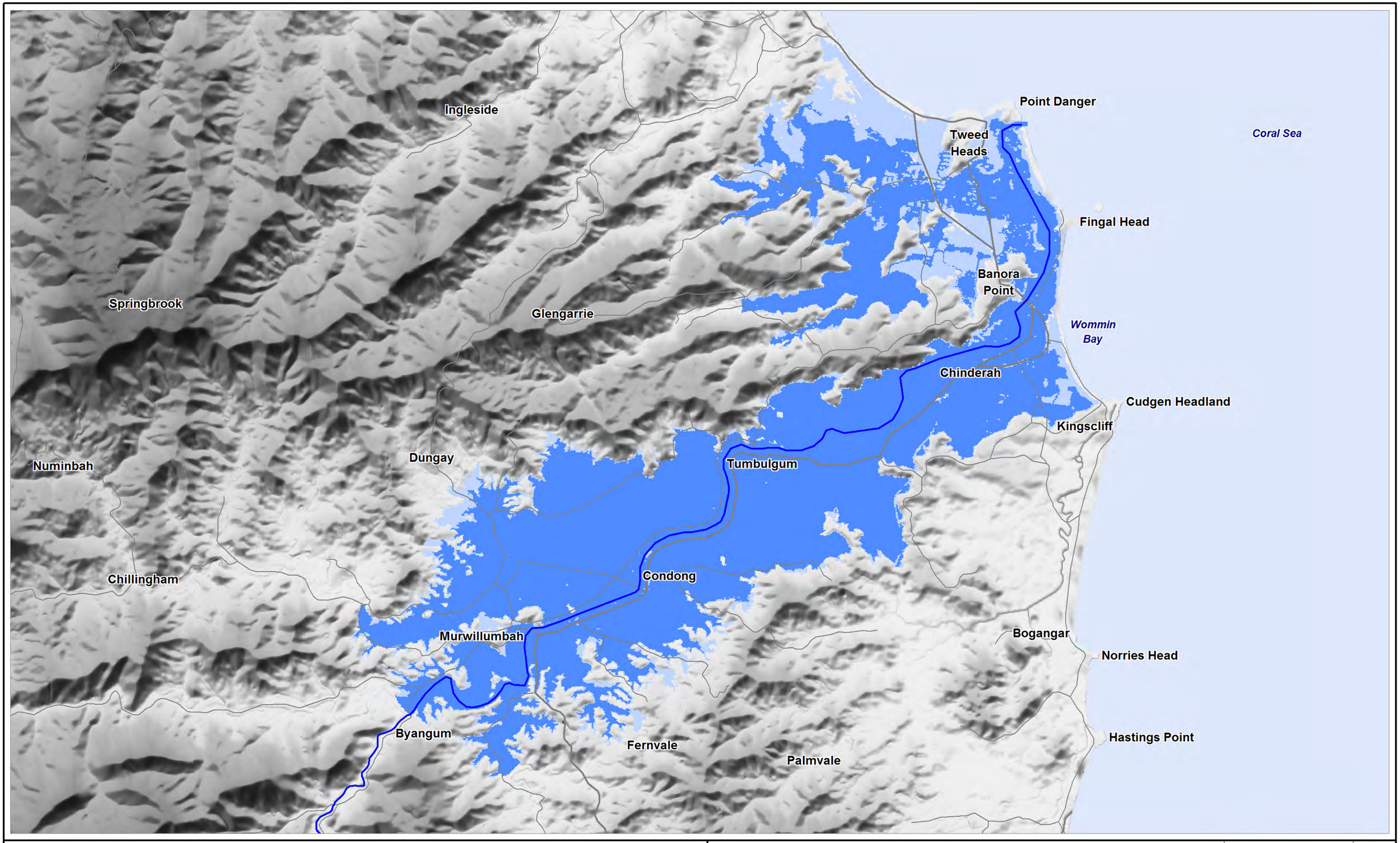
In a (theoretical) 100 year ARI flood event, there are major flowpaths in Murwillumbah through Bray Park, and from Blacks Drain to Condong Creek via the Murwillumbah airport. In the mid Tweed, there are large areas of floodplain conveying high flow between the Tweed and Rous Rivers, as well as from Condong to Stotts Island. In the lower Tweed, the valleys of the Broadwater tributaries (Cobaki, Piggabeen, Bilambil and Duroby Creeks) all convey high flows.

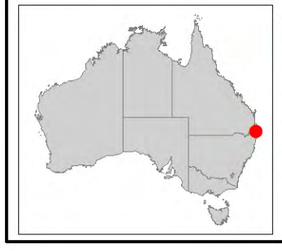
During smaller flood events, water is predicted to flow from the Rous River to the Tweed River via Mayal Creek. As the floodwaters rise, the Tweed River becomes the dominant flow and floodwater flows from the Tweed River to the Rous River. Most of the floodplain between the Tweed and Rous Rivers conveys high flows in the 100 year ARI flood event.

The Tweed Valley is generally quite wide and flat with few structures that significantly control the hydraulics of the floodplain. One exception is the constriction at Murwillumbah created by the town levees, the Murwillumbah Bridge and the sharp bend of the river immediately downstream of the bridge. This constriction causes high velocities in the river, over 2 m/s.

Low natural and man-made banks and levees are present along much of the Rous and Tweed Rivers but are generally exceeded in small flood events. In the lower Tweed, the embankment and drainage structures of the Pacific Highway and the constriction at Barneys Point influence flood behaviour in large events. In extreme events, flood levels in the lower Tweed area are controlled by the constriction at the rivermouth / entrance and the dunes between Kingscliff and Fingal Head.

Figure 2–2 shows the extent of catchment flooding in the Tweed Valley study area. All of the area within the PMF extent is at risk of flooding, or flood prone.





LEGEND

- 100 Year ARI Flood Extent
- Probable Maximum Flood Extent
- Tweed River
- Principal Road
- Sealed Road

Title:

Existing Flood Extent

Figure: **2-2**

Rev: **A**

N

0km 3 6

Approx. Scale

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The extent of the PMF is significant, with extremely high depths in some locations. There is a considerable number of people and properties located in flood prone land (within the PMF extent), including a large number at risk in the 100 year ARI flood, as shown in Table 2-1 and Table 2-2, below.

Table 2-1 Population at Risk

Numbers at Risk	5 year ARI	100 year ARI	PMF
People	1,600	11,700	41,500
Residential properties	600	4,300	16,800

Table 2-2 Estimated Number of Inundated Properties

Flood Event	Inundated Properties (Above Floor)	
	Residential	Commercial
5 year ARI	17	35
20 year ARI	390	80
100 year ARI	1,130	340
500 year ARI	6,080	720
Extreme flood	14,320	970
PMF	14,700	1,000

These figures provide an indication of the flood extent, however there are a number of other factors increasing the flood risk in the Tweed Valley. Flood depths and flows are of a dangerous magnitude in many locations and flood waters can rise quickly, often with short warning periods. Roads can become quickly cut and residents can become isolated.

The demographic in the Tweed Valley is also older than average. People in this demographic are likely to require assistance during evacuation and may be socially isolated, resulting in delayed awareness of evacuation warnings (SES, 2008). Furthermore, an estimated 1,200 people reside in aged care facilities, with up to 50% of these patients classified as 'high risk', requiring one-on-one assistance for evacuation purposes (SES, 2008).

A large proportion of the population are new residents, who are unfamiliar with the local flood risk and evacuation procedures.

All of these factors indicate that the Tweed Valley has a serious flood risk for both people and properties.

The economic consequences of flooding in the Tweed Valley are serious. The FRMS estimated an annual average damages (AAD) cost of **$22.3 million**. This value includes damages incurred by residential and commercial properties and approximated infrastructure damages. Results of this assessment for the entire study area are presented in Table 2-3, below.

Table 2-3 Flood Damage Estimates (millions of $)

Flood Event	Flood Damage Estimates (millions of $)			
	Residential	Commercial	Infrastructure	Total
5 year ARI	$7	$3	$1	$12
20 year ARI	$65	$6.7	$10	$82
100 year ARI	$151	$44	$27	$223
500 year ARI	$678	$182	$120	$980
Extreme flood	$2,374	$620	$417	$3,411
PMF	$2,621	$664	$458	$3,743
AAD	**$16.1**	**$3.5**	**$2.8**	**$22.3**

2.2.2 Future Flood Risk

Flood risk in the Tweed Valley is likely to increase in the future as a result of a changing climate. The effects of climate change will increase the risk for most properties which are already affected by flooding and increase the number of properties at risk. The number of people and properties within the 100 year ARI flood extent under both existing and future climates is presented in Table 2-4 below.

Table 2-4 Population at Risk, Climate Change

Numbers at Risk	100 Year ARI Existing Climate	100 Year ARI Future Climate	% Increase
People	11,700	18,200	55%
Residential properties	4,300	7,200	66%

3 FLOOD MODIFICATION MEASURES

3.1 Raise Tweed Heads South Levee

The Tweed Heads South levee was constructed in the late 1960s / early 1970s and was designed to provide immunity for a 20 year ARI flood, with a design crest of approximately 2.0 mAHD. The Tweed Valley Flood Study Update (BMT WBM, 2009) and the Tweed Shire Local Flood Plan identified that the levee has been poorly maintained and does not provide the level of protection it was designed for.

Raising the Tweed Heads South levee to approximately 2.8 mAHD to provide a 100 year ARI standard of flood protection (including 0.5 metre freeboard) has been assessed.

Priority: Medium – further investigation required

Estimated capital cost: ~$11.4 Million

Estimated maintenance cost: $200,000 per annum

3.1.1 Benefits

Hydraulic modelling of the proposed levee height indicated that the area immediately behind the levee would be protected from flooding for events up to and including the 100 year ARI event. Figure 3-1 shows the 100 year ARI flood extents with the current levee and for the proposed raised levee. Raising the levee would also reduce flood levels in the 500 year ARI event.

During extreme flood events, such as the PMF, the extent of flood inundation and flood levels are not changed by raising the levee. However, the time to the levee first overtopping is delayed which improves the safety of residents trying to evacuate along Dry Dock Road.

The hydraulic modelling indicates that raising the levee will not cause increased flood levels elsewhere in the catchment.

Tweed Heads West

Terranora Inlet

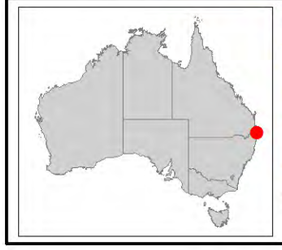
Ukerebagh Island

Terranora Creek

Tweed River

Tweed Heads South

Pacific Highway



LEGEND

- Tweed Heads South Levee
- Area Benefitting from Raising Levee
- Philp Parade Levee
- Area Benefitting from Philp Parade Levee
- Cadastral boundaries
- 100 Year ARI Flood Extent
- Probable Maximum Flood Extent

Title:

Raising Tweed Heads South Levee 100 Year ARI Extent

Figure: 3-1

Rev: A

N

0m 300 600

Approx. Scale

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Table 3-1 below shows the reduction in the number of properties inundated above floor for each magnitude event as a result of raising the levee.

Table 3-1 Reduction in Properties with Above Floor Flooding

Flood Event	Reduction in Properties Inundated above Floor Level	
	Residential	Commercial
5 year ARI	0	0
20 year ARI	58	18
100 year ARI	201	37
500 year ARI	229	4
Extreme flood	9	0
PMF	9	0

The associated reduction in average annual damages is approximately **$2.6 million** per year**.** This results in a total benefit of approximately **$36.1 million**, based on a levee design life of 50 years[1].

A preliminary cost estimate of the levee, summarised in Table 3-2 (in 2011 dollars), has been compiled to inform an initial monetary cost benefit assessment for the option.

Table 3-2 Preliminary Cost Estimate

Earthen Levee Capital Cost	$3,489,300
Concrete Levee Capital Cost	$7,725,900
Total Maintenance Cost	$207,000
Total Cost	**$11,422,200**

Comparing the economic costs and benefits of raising the levee, Table 3-3, indicates a benefit cost ratio in excess of 3. It is likely that this is over estimated based on the minimum cost estimate. However, sensitivity testing of construction costs indicates that the ratio is likely to remain above 1.

Table 3-3 Cost Benefit Ratio

Total Benefit ($2011)	$36.1m
Total Cost ($2011)	$11.4m
Monetary Benefit-Cost Ratio	**3.2**

Raising the Tweed Heads South levee to the proposed height of 2.8 mAHD will bring significant benefit to the residents living behind the levee. Safety will be improved for all flood events – either through protection from inundation, or delayed inundation – and property damage will be significantly reduced. Although raising the levee requires a large capital investment, the economic benefits far outweigh these costs over the design lifetime of the levee.

[1] This benefit does not include intangible benefits associated with a reduction in floodplain risk to people and property.

3.1.2 Implementation

This assessment considered the hydraulic implications of raising the Tweed Heads South levee, however there are many other issues which must be considered. A number of investigations / consultations should be undertaken prior to construction, including:

- A levee overtopping study to improve understanding of hydraulic behaviour around the levee (discussed further in Section 3.3);
- A detailed costing by a quantity surveyor; and
- Community consultation to discuss issues such as improved safety, economic costs and benefits, negative impact on visual amenity, and other social and environmental impacts.

If the outcomes of these studies continue to support raising the Tweed Heads South levee, it is recommended that Council proceed with design and construction of the raised levee.

3.2 Extend Tweed Heads South Levee

The FRMS highlighted that the Philp Parade area of South Tweed Heads has a high evacuation risk due to early inundation during flood events. Residents in this area quickly become isolated and are unable to evacuate.

Extending the existing Tweed Heads South levee (westwards) to protect the Philp Parade area has been assessed as a preliminary option to estimate the benefits and identify whether additional investigations are warranted.

Priority: Medium – further investigation required

Estimated capital cost: Unknown – estimated >$10 million

Estimated maintenance cost: Unknown – estimated $100,000 per annum

3.2.1 Benefits

Preliminary hydraulic assessment of the levee extension modelled the levee crest at 2.8 mAHD, consistent with the raised Tweed Heads South levee option. Results from the hydraulic assessment indicate that extension of the levee will protect approximately 60 properties from inundation in flood events up to and including the 100 year ARI event. The total economic benefit is estimated at **$8 million**, based on an associated reduction in average annual damages for flood events up to and including the 100 year ARI. A cost estimation has not been completed at this stage.

Furthermore, as for option 3.1, above, there is also expected to be some benefits in larger flood events due to a delay in levee overtopping. This measure will significantly improve the safety of residents in the Philp Parade area. Residents and properties will be protected from smaller flood events and have more time to evacuate during larger events.

3.2.2 Implementation

This assessment was preliminary and will need to be supported by further investigations.

It is recommended that advice is sought from Council regarding land use and land resumption requirements in the potential levee extension area. If the levee extension proves feasible at this stage, it is recommended that the following investigations / consultations be undertaken:

- Community consultation to discuss issues of safety, visual amenity and Tweed River access requirements with the Philp Parade community;
- A levee overtopping study to improve understanding of hydraulic behaviour around the levee (discussed further in Section 3.3); and
- A detailed costing by a quantity surveyor.

If the outcomes of these studies continue to support extending the Tweed Heads South levee to the Philp Parade area, it is recommended that Council proceed with design and construction of the levee extension.

3.3 Commission Levee Overtopping Studies

Levees are effective flood modification structures for small to medium sized floods, however a detailed understanding of flood behaviour for larger floods (when levees overtop) can help to improve the safety of people living behind the levee.

There are two major levee locations in the Tweed Valley study area: Murwillumbah (five locations) and South Tweed Heads. Levee overtopping studies are recommended for both locations.

Priority: Medium – further investigation required

Estimated cost: Estimated $30,000 per study (two studies)

3.3.1 Benefits

Flood behaviour around levees can be complex: a detailed hydraulic assessment, focused on the levee, will provide a greater level of detail than the broader Tweed Valley Flood Study model. An informed understanding of the levee overtopping process can improve community safety and reduce property damage through the following mechanisms:

- Enhanced emergency response planning to better plan and execute flood evacuations;
- Improved community awareness of levee overtopping behaviour;
- Appropriate design (or retrofit) of the levee to avoid uncontrolled high velocity flows when the levee is overtopped (such as inclusion of a spillway);
- Appropriate building standards for houses behind the levee to be able to withstand high velocity flows;
- Appropriate design (or retrofit) of the levee to minimise risk of failure or design for controlled failure;
- Appropriate design of supporting drainage structures to enhance the function of the levee; and
- Informed decisions about use of levees (or retrofit) as a flood modification measure.

3.3.2 Implementation

Project briefs should be prepared for two separate levee overtopping studies:

1 The Tweed Heads South Levee Overtopping Study, which would compare the relative overtopping risks for the levee at the current height and at the proposed raised height; and

2 The Murwillumbah Levee Overtopping Study, to better understand the levee overtopping behaviour of the Murwillumbah levees, particularly in the town area, and identify if further measures are required to minimise flood risk behind the levee.

Although two different briefs will be required, it is anticipated that both studies would include the following requirements:

- Improved detail in the flood model in the levee area through the use of one or more nested grids in the Tweed Valley Flood Study hydraulic model;
- Inclusion of the raised levee height (for Tweed Heads South levee);
- Consideration and assessment of controlled overtopping locations;
- Assessment of time of overtopping, location of overtopping, relationship to stream gauge levels;
- Assessment of hazard behind the levee, including time of inundation following overtopping, high flow hazards, road closures;
- Assessment of impact to personal safety, properties and infrastructure following levee overtopping;
- Sensitivity analysis comparing levee overtopping for floods of different behaviour (specifically a range of storm patterns, durations and onset) and / or combinations with storm surges;
- Recommendations for the SES to improve flood response and emergency planning in the event of levee overtopping; and
- Recommendations for Council regarding land use and building design in the area behind the levee.

3.4 Commission Local Drainage Studies

Local drainage issues, such as blocked and / or overflowing drains, were identified by the SES and FRMS committee as key impediments to evacuation in the past. Local drainage studies would provide more information about flooding from this source.

It is recommended that hydraulic models are developed which include drainage infrastructure, such as pipes and pits. Based on anecdotal evidence from past flooding events (particularly 2005), local drainage studies are recommended for the lower Tweed area (including Tweed Heads, Tweed Heads South and Banora Point), and Chinderah. A local drainage study for Murwillumbah town is also needed for the purposes of quantifying stormwater risks and development planning purposes.

Priority: High – further investigation required

Estimated cost: Estimated $75,000 to $150,000 per study

3.4.1 Benefits

Development of a local drainage flood model will improve understanding of flood behaviour in key locations of the Tweed Valley and subsequently inform decisions about floodplain management in these locations.

The flood model developed for the Tweed Valley Flood Study (and used in the FRMS) was a 'catchment scale' model which did not include local drainage infrastructure and could not be used to provide information about local drainage issues. The local drainage model will include all drainage infrastructure and connect overland flows (above ground) with piped flow (below ground) to better represent the movement of flood waters. In addition, the local drainage models will have a higher resolution than the catchment scale model and provide information at a finer scale.

Greater understanding of the local flood behaviour can lead to improved floodplain management, including the selection of flood, response, and property modification measures, and inform future development issues.

Review of the existing infrastructure can also highlight whether the system is capable of containing the increased flows which are likely to result from climate change.

3.4.2 Implementation

Project briefs should be prepared for the local drainage studies. The briefs will vary by scale, but are likely to include the following requirements:

- Development of detailed hydraulic models for the local area, using drainage infrastructure supplied by Council and boundary conditions from the Tweed Valley Flood Study hydraulic model;
- Sensitivity analysis to determine critical storm durations and appropriate boundary conditions;
- Sensitivity analysis to determine conservative 'blockage' conditions of drainage infrastructure;
- Identification of the nature and extent of the flood problem for the full range of flood events up to and including the PMF;
- Assessment of the stormwater drainage system capacity; and
- Recommendations for improvements to the drainage system, based on the system capacity and other factors identified in the FRMS such as evacuation constraints.

There may be efficiencies in combining the lower Tweed and Murwillumbah local drainage studies with the levee overtopping studies (option 3.3 above). Although the flooding mechanism and design events will differ, the extent and scale of the hydraulic model are likely to be similar (e.g. 5 metre grid) and could utilise the same model schematisation.

3.5 Preserve South Murwillumbah Condong Flowpath

It was identified that the hydraulic connection between the South Murwillumbah and Condong basins at Lot 4 Quarry Road is a critical flowpath that should be preserved to ensure no worsening of flooding in South Murwillumbah. Mechanisms for achieving this via either acquisition or planning controls have been identified as part of the review of planning considerations.

There is also potential to alleviate flooding in the South Murwillumbah basin by improving this flowpath. Initial assessment indicated that lowering Lot 4 Quarry Road to the levels of the upstream airstrip could reduce 100 year ARI flood levels in the South Murwillumbah basin by approximately 50 mm. Construction of a new hydraulic structure at Quarry Road could further reduce levels.

Priority: Medium – further investigation required

Estimated cost: Depends on option (estimated land value $428,000)

3.5.1 Benefits

The key benefit of preserving the flowpath is to ensure no worsening of flooding for approximately 50 houses in the South Murwillumbah basin that are already likely to be inundated in a 100 year ARI flood.

Enhancing the flowpath via the acquisition and lowering of Lot 4 Quarry Road, together with a new hydraulic structure at Quarry Road, could reduce flood levels in the South Murwillumbah basin by approximately 50 to 100 mm in a 100 year ARI flood.

3.5.2 Implementation

There are three potential options with the latter option requiring further investigation prior to implementation:

- Introduction of planning controls for Lot 4 Quarry Road to preserve the hydraulic connection (no worsening of flood levels):
- Acquire and lower Lot 4 Quarry Road to improve the flowpath (reduce flood levels in South Murwillumbah basin by approximately 50 mm); or
- Acquire and lower Lot 4 Quarry Road together with construction of a new hydraulic structure at Quarry Road (reduce flood levels in South Murwillumbah basin by approximately 100mm).

This latter option would require more detailed assessment to confirm the estimated hydraulic (and in turn economic) benefit of upgrading the flowpath at Quarry Road. Preliminary design will also need to consider the nature and extent of associated works (if any) affecting the property immediately downstream.

4 FLOOD AWARENESS MEASURES

4.1 Support Community FloodSafe Program

General flood awareness in the Tweed Valley is likely to be low, particularly in coastal areas with a higher proportion of new residents and tourists. Increased flood education is required, and the best way to do this is to support the SES Community FloodSafe Program.

The stated aims of this program are to:

- Increase community awareness of flood risk;
- Increase community understanding of what to do before / during / after floods;
- Increase awareness of SES role and SES phone number; and
- Build partnerships with local community / business / local and state government.

Priority: High

Estimated cost: Unknown, depends on strategies employed

This program is in its infancy and has yet to secure funding for all of the planned programs and strategies.

4.1.1 Benefits

Community flood education will improve community safety through greater awareness of flood risk and knowledge of how to respond during flood events.

Undertaking flood education through an existing program will ensure that funds are utilised optimally and program strategies are cohesive.

4.1.2 Implementation

It is planned that the program would be overseen by a Flood Education Advisory Committee, which would include representatives from:

- SES / police / fire service;
- Aged care / carers / North Coast Health;
- Chamber of Commerce and Industry / Council;
- Tourism / caravan parks / RMS;
- Schools / child care / family day care / universities; and
- Media (ABC).

Planned strategies in the FloodSafe program include media releases, SES community education training, additional brochures targeting other sectors of the community, flood risk workshops with retirement village managers and business breakfasts.

A number of target groups have been identified as being at increased flood risk and requiring specialised materials or education. These groups include the elderly and/or disabled, businesses, caravan park residents, tourists and school/child care facilities. Identification of these target groups is essential to assist in prioritisation of limited resources.

In addition to the existing measures under the FloodSafe Program, it is recommended that the SES review the program in light of information provided in this FRMS and update the strategies accordingly.

4.2 Publish Evacuation Centres and Routes

Feedback from stakeholder submissions indicates that the community would like to know more about the evacuation planning process. It is recommended that the SES provide more evacuation planning information to the community.

Priority: Medium

Estimated cost: Low cost

4.2.1 Benefits

Providing evacuation information to the community prior to flood events has two major benefits:

1 The community will have a better understanding of the process and is more likely to respond to evacuation advice; and

2 The community will be better able to respond to evacuation advice due to familiarity with the evacuation process.

4.2.2 Implementation

It is recommended the SES publish and publicise the locations of major evacuation routes and evacuation centres. This information would be best supported by informal consultation or information booths to discuss individual evacuation requirements with interested residents. Publication of this information may occur as one of the strategies in the FloodSafe Program (see Section 4.1).

Some information about evacuation planning, issues and proposed response management measures will be provided to the community at the public open sessions held for this study.

4.3 Provide Personal Flood Risk Information to Community

It has been identified in previous flood events that residents have difficulty relating broad scale flood warnings (e.g. 'major' flood predicted) or predicted gauge heights to their personal level of flood risk.

Although the predicted gauge height is generally given with the flood warning, most residents are unable to translate this into a personal flood risk. Very few residents know the absolute height (i.e. in mAHD) of their property or local roads. Even if residents are aware of their property level, flood slope

and local flood behaviour means that it is not a simple translational exercise to estimate flood levels at specific locations.

Providing personalised information relating flood warnings to flood risk at specific locations (e.g. houses, major evacuation routes) would improve residents' understanding of flood warnings.

Priority: Medium

Estimated modelling cost: $15,000

Estimated information distribution cost: $15,000

4.3.1 Benefits

Provision of personalised flood risk information would enhance community flood awareness of the scale of flood classifications and large to extreme flood events in excess of those previously experienced.

4.3.2 Implementation

This option would require some modelling of additional flood events (e.g. durations, magnitudes, spatial and temporal patterns) to maximise the robustness of estimates, as every flood is different. It would also be necessary to ensure the community understood and was correctly interpreting individual prediction information. A potential product from this process might be a figure showing the local stream gauge in relation to the resident's property. An example is provided in Figure 4–1.

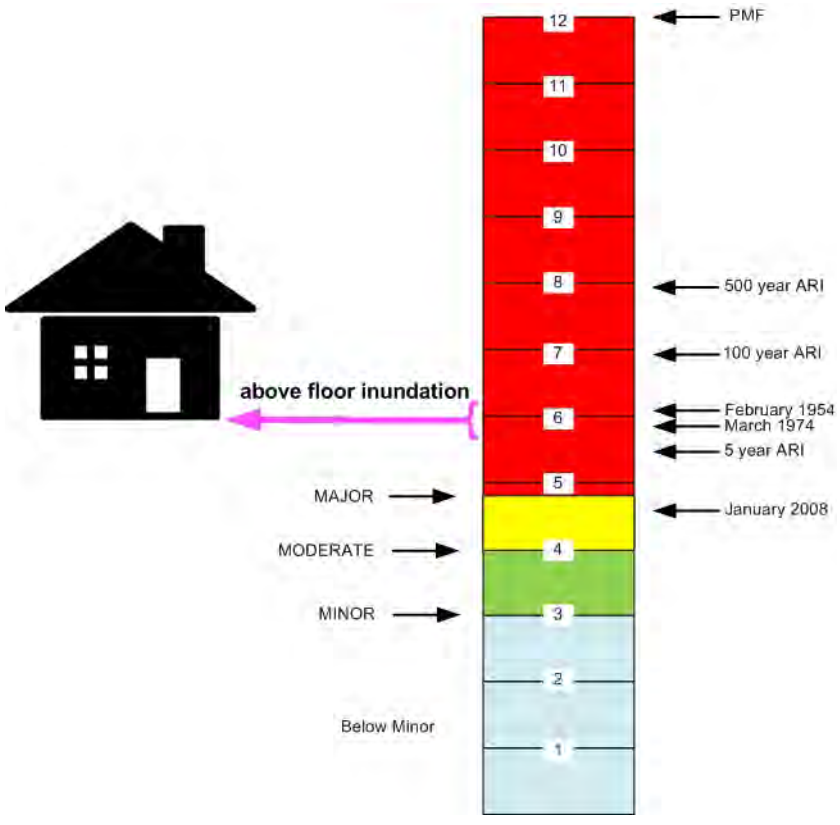

Figure 4–1 Floor Level to Gauge Relationship

4.4 Educate Residents in High Risk Areas

The SES FloodSafe Program targets vulnerable groups of the community, such as the elderly, however, it is also important to provide targeted education to residents who live in high flood risk areas.

Priority: High

Estimated cost: Unknown, depends on strategies employed

4.4.1 Benefits

Residents who are aware of their increased flood risk:

- Have a better understanding of local flood risk and are more likely to respond to evacuation advice (such as pre-emptive evacuation, see Section 7.1); and
- Are able to make informed decisions regarding living in a high risk area.

4.4.2 Implementation

It is recommended that residents in high risk areas should be warned about the increased flood risk in their location and made aware that they may be evacuated more frequently than other areas. Residents behind levees should also be the subject of targeted education campaigns to highlight the limits of protection provided by the levee.

5 FLOOD INTELLIGENCE MEASURES

5.1 Update Flood Intelligence Cards

The flood intelligence cards (FICs) used for flood planning in the Tweed were reviewed by Bewsher Consulting following the major flood event in 2008. Recommendations included updates to the FICs and advice regarding ambiguous flood datums.

The SES has advised that recommendations provided in the review have not yet been implemented.

Priority: High

Estimated cost: Low cost

5.1.1 Benefits

Updating the FICs to include the review recommendations would improve emergency response and community safety by ensuring that the cards are accurate and comprehensive.

5.1.2 Implementation

It is recommended that SES headquarters update the FICs for Murwillumbah, Tumbulgum and Chinderah. It is understood that this process has been delayed in the past due to the need to verify recommendations made about flood datums in the review. It is recommended that this verification process be undertaken by the local SES and Council.

5.2 Develop Flood Information Website

The public generally look online for information during a flood, however residents in the Tweed Valley do not have a single location where all of the vital information can be found:

- Council's website provides information on flood modelling and reports;
- The SES website provides generic information about flood risk and evacuation;
- The BoM website provides real-time information about rainfall and stream gauge levels; and
- MyRoadInfo provides information about road closures.

A flood information website would provide all of this information (or links to information) in a single location.

Priority: High

Estimated cost: $20,000

5.2.1 Benefits

The public will be able to develop a greater understanding of flood risk, evacuation procedures, and real time flood information, if the information is easily accessible.

It is recommended that a cut-down 'mirror' of the site be constructed which diverts web-traffic during high volume events (such as during a flood). This will prevent the site from crashing during critical times and ensure that important information is available when the community needs it most.

5.2.2 Implementation

The following steps will need to be taken by Council to prepare a flood information website:

- Identify what information is required before, during and after flood events;
- Update Council website (or create a separate, stand-along flood information website) to include important flood information;
- Build functionality in the website to ensure it is robust enough to withstand high volume web traffic; and
- Publicise the existence and features of the website to the public.

These steps may be done in conjunction with other agencies (such as the SES) or by an external consultant.

6 FLOOD WARNING MEASURES

6.1 Trial Supplementary Flood Warning Methods

Flood evacuation warnings are issued through a variety of mediums, depending on the number of properties to be warned, urgency of warning, and available warning time. The most reliable warning method is doorknocking. Unfortunately, this method is also the most resource intensive and may not be solely practicable for warning large areas.

It is recommended that the SES consider and potentially trial / adopt a range of flood warning methods to supplement doorknocking.

[Note: It is understood that the SES wish to continue to rely upon doorknocking as their primary means of flood warning.]

Priority: Medium

Estimated cost: Depends on method

6.1.1 Benefits

Although doorknocking is the most reliable flood warning method, the scale of the flood problem in Tweed Valley indicates that it cannot be the only method. Use of a range of evacuation warning methods will have the following benefits:

- Ensure that a greater number of residents receive flood warnings;
- Reduce resource pressure on the SES, freeing up staff for other tasks;
- Help to distribute flood warnings to more remote residents, who may not have been feasibly contacted by doorknocking; and
- Reducing risk by bolstering the range of warning capabilities and mechanisms that can be employed.

6.1.2 Implementation

The FRMS highlights the scale and extent of the flooding and evacuation problem in the Tweed Valley area. It is recommended that the SES use this information to undertake (or commission) a short study assessing the cost, geographical reach, and effectiveness of various flood warning methods.

Community questionnaires conducted by BMT WBM in Tweed Valley and other catchments, indicate that the community would welcome SMS alerts. It is therefore recommended that the SES (potentially in conjunction with Council) investigate establishing an SMS alert system such as via Emergency Alert (http://www.emergencyalert.gov.au/). Once established it will be necessary to advertise the system to the community and encourage residents to 'opt in' to receive flood warning and / or evacuation messages via SMS, in addition to traditional means.

It is recommended that other methods are also investigated and trialled. A range of methods is provided in Figure 6–1, below.

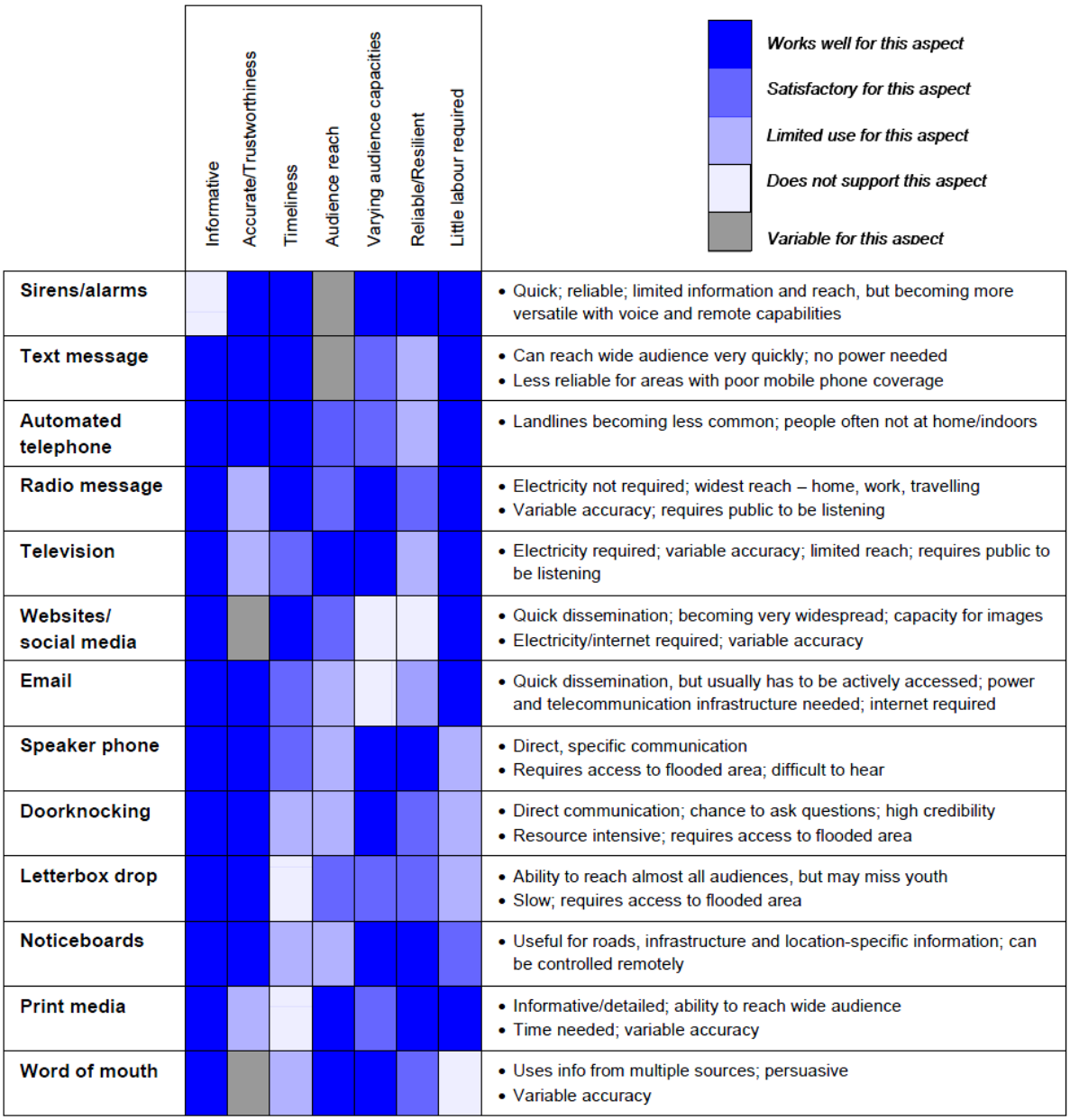

Figure 6–1 Comparison of Flood Warning Communication Methods [2]

Residents in Fingal Head have indicated that mobile phone reception is poor in some areas and that SMS alerts would not be suitable. As an alternative, the SES should consult residents in this area (and other areas known to be affected) to determine the best warning solution. For the Fingal Head area, this may be the development of a 'neighbourhood warning tree' where particular residents receive direct warnings from the SES and are then responsible for passing the warning to their neighbours (and so on).

[2] (Office of the Queensland Chief Scientist, 2011)

6.2 Include Tumbulgum in Warning System

The automatic stream gauge at Tumbulgum is not currently included in BoM's formal flood warning network. As this gauge is immediately downstream of the confluence of the Tweed and Rous Rivers, the gauge provides important flood information which can be used in real-time evacuation planning and warning.

It is recommended that the gauge be included in BoM's flood warning network.

Priority: Medium

Estimated cost: Low cost

6.2.1 Benefits

Inclusion of the Tumbulgum gauge in BoM's formal flood warning network will improve predictions of flood height in the mid catchment area and improve flood warnings and real-time evacuation planning.

6.2.2 Implementation

It is recommended that this issue be discussed with the NSW Flood Warning Committee to determine whether it is feasible to expand the formal flood warning system to include predictions for the Tumbulgum gauge.

If BoM decides to include Tumbulgum gauge in its warning network, the SES will need to update the Local Flood Plan accordingly.

6.3 Improve Storm Surge Prediction

Storm surge predictions are currently issued on the peak prior to the storm, i.e. 12 hours prior to peak. This may not be sufficient time to prepare, warn and evacuate the public.

BoM's research centre is developing storm surge predictions products that should extend this warning lead time, even to the extent of flagging this in Flood Watches.

Priority: Medium – waiting for BoM product to become available

Estimated cost: Minimal cost

6.3.1 Benefits

Increased storm surge prediction time will improve community safety by providing more time for flood warning and evacuation.

6.3.2 Implementation

It is likely that experimental coverage for the Tweed River will be available within the next 12 months. BoM should alert the SES when the product becomes available and the SES should update the Local Flood Plan accordingly.

7 EVACUATION PLANNING MEASURES

7.1 Commission Detailed Evacuation Planning Study

The FRMS highlighted a number of areas in the catchment which have a constrained evacuation capability and require measures to reduce the evacuation risk. Highlighted constraints included early road closures, lack of evacuation centre capacity and insufficient warning time. A more detailed evacuation planning study is required to investigate trouble spots more closely and plan strategies for reducing evacuation risk in these areas.

Priority: High

Estimated cost: $25,000 per region

7.1.1 Benefits

A detailed evacuation planning study is able to take broad scale recommendations from the FRMS and apply them at the local level. This will ensure that all factors in the local evacuation situation are considered, including inundation of local roads (not just primary evacuation routes). Outcomes from the study will ensure that the individual risks faced by different areas of the catchment area are addressed in the most effective way possible, thereby improving the safety of residents and reducing SES resourcing requirements.

7.1.2 Implementation

It will be necessary for the committee to determine the agency best suited to preparing the detailed evacuation planning study. The SES may have sufficient resources to undertake this study on their own, or may require the assistance of external consultants. It is recommended that the study cover the following:

- Identification and prioritisation of the areas with the highest evacuation risk (can be informed from the FRMS);
- Identification of locations where further information is required (e.g. from a flood model that includes local drainage);
- Recommendations for suitable mitigation measures, such as alternative procedures, pre-emptive evacuation and / or pedestrian evacuation;
- Consultation with local residents, if appropriate;
- Development of detailed plan with clear triggers (such as rainfall or stream gauge height) that prompts evacuation actions; and
- Education program to inform residents of adopted evacuation measures.

7.2 Plan to Pre-Emptively Evacuate

During a large (or rapid onset) flood event, some areas of the Tweed Valley may become inundated before the SES is able to issue flood warnings (according to standard warning time frames). In these

locations, the SES should plan to pre-emptively warn residents in key locations. Pre-emptive evacuation may result in unnecessary evacuation, however this should be weighed against the risk of isolation or inundation if pre-emptive evacuation were not undertaken.

Priority: Medium

Estimated cost: Minimal cost

7.2.1 Benefits

The primary benefit of pre-emptive evacuation is the improved safety of residents who are evacuated early.

A positive flow on effect is that the evacuation capability of the surrounding residents (who are not evacuated early) may also improve: fewer cars on the road results in less congestion and a better evacuation process.

7.2.2 Implementation

There are two key stages which the SES must undertake to implement this measure:

1 Identify the areas which will be warned pre-emptively (this can be informed by the evacuation capability assessments in the FRMS and / or a detailed Evacuation Planning Study where required, see option 7.1 above); and

2 Educate the residents in these areas that they may be evacuated pre-emptively.

Education of residents will need to highlight why pre-emptive evacuation is necessary for that particular area. It will also be necessary to indicate that residents in the targeted areas may be required to evacuate more often than the rest of the community due to greater uncertainty at time of evacuation.

7.3 Include Pedestrian Evacuation in Planning

Results of the evacuation capability assessment indicate that there are some locations where there may be less risk associated with pedestrian evacuation than by car. Locations which may be suitable include those with:

- Rising road access;
- High density development; and
- Close to evacuation centres.

Priority: Medium

Estimated cost: Minimal cost

It is recognised that evacuation on foot will not be suitable for some sections of the community, such as the elderly, those with mobility impairments or young children. Pedestrian evacuation is

recommended as an alternative to vehicular evacuation for situations where it is safe and within residents' capabilities.

7.3.1 Benefits

Pedestrian evacuation may improve safety by reducing traffic congestion and associated delays, and allowing more residents to reach evacuation centres safely.

7.3.2 Implementation

It is recommended that the SES identify areas where pedestrian evacuation may be suitable and update the Local Flood Plan accordingly. During flood evacuations, flood warnings for the identified areas should remind residents of the option to evacuate on foot rather than by car, particularly if the area is experiencing high congestion.

The SES should also consider providing targeted education to residents in areas which are identified as suitable for pedestrian evacuation.

8 EVACUATION CENTRE MEASURES

8.1 Review Evacuation Centres

Review of evacuation centres and evacuation protocol in the Tweed Valley area identified two significant problems:

1 A lack of communication and consultation between the SES and DoCS (who are responsible for operation of evacuation centres); and

2 A lack of space at many evacuation centres.

These two issues can be simultaneously tackled through a consultative review of evacuation centres by the SES and DoCS.

Priority: Medium

Estimated cost: Normal operating budget

Poor management of evacuation centres was identified by stakeholders as a major floodplain management concern.

8.1.1 Benefits

Improved and formalised communication channels between the SES and DoCS will ensure that evacuation planning is holistic and includes all key players. During flood evacuations, this will result in more efficient and successful evacuations, and lead to increased community safety.

8.1.2 Implementation

It is recommended that the SES establish communication with DoCS and that a consultative review is commenced. Issues that may be addressed as part of the review include:

- Determining current evacuation centre capacity;
- Reviewing capacity requirements (this can be informed by information included in the FRMS) and identifying additional evacuation centre facilities where they are insufficient;
- Developing communication protocol between SES and DoCS for times of emergency planning (pre flood), evacuation (during flood), and flood recovery;
- Reviewing current procedures for management of evacuation centres and highlighting areas which can be improved;
- Establishing a time frame to implement the recommendations of the review; and
- Establishing a monitoring protocol to ensure that communication is maintained between the SES and DoCS after the review is complete, and into the future.

8.2 Identify Alternative Evacuation Centre to Tweed Civic Centre

The Tweed Civic Centre is within the 100 year ARI flood extent and is not suitable for use as a flood evacuation centre. An alternative or new centre needs to be identified and the Local Flood Plan updated to reflect this information.

Priority: Medium

Estimated cost: Minimal cost

8.2.1 Benefits

The Local Flood Plan will no longer direct residents to an unsafe evacuation centre.

8.2.2 Implementation

It is recommended that the SES and DoCS identify an alternative evacuation centre to service the area; possibly including consideration of options across the border in Queensland. The Local Flood Plan should then be updated accordingly. It will be necessary to review broader evacuation plans to ensure that there is sufficient evacuation centre space in this area depending on the required receiving capacity (see Section 8.1).

9 PROPERTY MODIFICATION MEASURES

9.1 Commence Voluntary House Purchase

The primary objective of voluntary house purchase (VHP) is to reduce risks to personal safety by purchasing houses located in areas subject to excessive hazard. Such measures can only be undertaken on a voluntary basis with the property owner. Post-purchase, the property should be rezoned for flood compatible use.

A range of criteria for VHP were assessed as part of this study.

Voluntary house purchase is co-funded by Council and the State Government.

Priority: Medium

Estimated cost: $2.8 - $10.3 million, depending on scheme

Properties which may be eligible for VHP have the highest hydraulic hazard in the study area.

9.1.1 Benefits

VHP improves the safety of residents in the purchased houses and reduces the economic and social burden of flooding by avoiding property damage.

9.1.2 Implementation

The floodplain management committee must select one of the two VHP scenarios put forward in the FRMS, based on the summary in Table 9-1, below.

Table 9-1 VHP Cost Benefit Summary

	Option 2	Option 3
Properties Purchased	29	8
Mean Property Price	$350,000 - $400,000	
Total Cost	$10,300,000	$2,800,000
Annual Average Benefit	$407,000	$220,000
Total Benefit	$5,619,000	$3,039,500
Benefit Cost Ratio	0.6	1.1

It is recommended that the committee use the following (competing) considerations when selecting an option:

- Option 3 has a significantly better cost benefit ratio than Option 2;
- Option 2 removes far more houses than Option 3 and hence improves the safety of a greater number of residents;

- Option 2 will cost 3.5 times more than Option 3 to implement;
- Personal safety should be the overriding goal of the VHP scheme, with cost benefit a secondary consideration; and
- The scheme must be affordable over a reasonable timeframe to be practicable.

When a VHP scheme has been selected, it will be necessary for Council and State Government to confirm the suitability of the specific properties and establish a program to commence the VHP scheme.

9.2 Commence Voluntary House Raising

Voluntary house raising (VHR) is aimed at reducing the flood damage to houses by raising the habitable floor level of individual buildings. Such measures can only be undertaken on a voluntary basis. VHR is a suitable management measure for houses in low hazard areas of the floodplain; houses identified for voluntary house purchase will not also be identified for VHR.

A range of criteria for VHR were assessed as part of this study.

Voluntary house purchase is co-funded by Council and the State Government.

Priority: Medium

Estimated cost: $1.7 - $2.1 million, depending on scheme

Houses also had to be structurally suitable for raising (i.e. wooden, not slab on ground) confirmed from the property survey.

9.2.1 Benefits

The VHR process targets properties in low hazard areas of the floodplain which are likely to incur major property damage but not pose a significant risk to human life (properties in these high hazard areas will fall under the voluntary house purchase scheme). Therefore, the primary aim of the VHR scheme is to reduce the economic and social burden of flooding by avoiding property damage. Improved safety of residents may also result, as a positive, secondary outcome.

9.2.2 Implementation

The floodplain management committee must select one of the two VHP scenarios put forward in the FRMS, based on the summary in Table 9-2, below.

Table 9-2 Voluntary House Raising Summary

	Option 2	Option 3
Properties Raised	25	30
Mean Property Raising Price	$70,000	
Total Cost	$1,750,000	$2,100,000
Annual Average Benefit	$223,000	$389,000
Total Benefit	$3,079,000	$5,368,000
Benefit Cost Ratio	1.8	2.6

It is recommended that the committee use the following (competing) considerations when selecting an option:

- Option 3 has a higher benefit cost ratio than Option 2;
- The benefit cost ratio of both schemes is high (above 1);
- Option 3 reduces the flood risk for a greater number of properties than Option 2;
- Option 2 costs less to implement than Option 3; and
- The scheme must be affordable over a reasonable timeframe to be practicable.

When a VHR scheme has been selected, it will be necessary for Council and State Government to confirm the suitability of the specific properties and establish a program to commence the VHR scheme.

10 PLANNING MEASURES

10.1 Implement Planning Recommendations

An intensive review of future development and planning considerations was undertaken as part of the FRMS and is documented in Supplementary Report 1. The resultant recommendations with respect to planning and flood risk in the Tweed Valley are summarised in Section 9 of the FRMS, including recommendations relating to:

- Strategic planning;
- Development controls and related policies; and
- Communication of flood risk.

On completion of the consultation phase, the committee should review these recommendations and implement as appropriate.

Priority: Medium

Estimated cost: Normal operating budget

10.1.1 Benefits

Strategic planning and flood-related development controls are designed to appropriately manage flood risk and future development. Updating the relevant planning instruments will have two main benefits:

1 The planning system will be informed by improved understanding of flood risk (based on outcomes from the Flood Study and FRMS); and

2 The floodplain won't be unnecessarily closed to development.

10.1.2 Implementation

The floodplain management committee should review the full set of recommendations arising from the detailed planning review and associated consultation feedback, and confirm those for implementation and / or amendment. The majority of responsibility for the various recommendations rest with Council as part of its normal planning process, in some cases in conjunction with the relevant State department.

11 IMPLEMENTATION PLAN

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

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

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

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

An implementation plan has been developed, summarising the required actions, responsibilities, estimated costs and priorities for each of the recommended measures. This plan is provided in Table 11-1, below.

Note that recommendations should be checked for consistency against Council's statutory powers and obligations prior to adoption.

Table 11-1 Implementation Plan

Measure	Required Actions	Responsibility	Estimated Cost	Priority
Raise Tweed Heads South levee	Commission levee overtopping study Commission detailed costing by quantity surveyor Undertake community consultation	TSC / OEH	~$11 million capital costs $200,000 pa maintenance costs	Medium
Extend Tweed Heads South levee	Seek advice from TSC re land zoning, land resumption etc. Commission levee overtopping study Commission detailed costing by quantity surveyor Undertake community consultation	TSC / OEH	>$10 million capital costs $100,000 pa maintenance costs	Medium
Commission levee overtopping studies	Commission studies for Murwillumbah and Tweed Heads South levees	TSC / OEH	$30,000 per study (2 studies)	Medium
Commission local drainage studies	Commission local drainage studies for Lower Tweed, Chinderah and Murwillumbah	TSC / OEH	$50,000 to $150,000 per study (3 studies)	High
Preserve / enhance South Murwillumbah / Condong flowpath	Introduce planning controls or proceed with land acquisition (and lowering) Further investigation required for Quarry Road hydraulic structure	TSC / OEH	Depends on option Estimated land value $428,000	Medium
Continue / support Community FloodSafe Program	Update FloodSafe Program strategies to include information from FRMS. Continue to support Program as primary means of community flood education.	TSC / SES	Depends on strategies employed	High
Publish evacuation centres and routes	Update FloodSafe Program strategy to include publication of evacuation centres and routes	SES / TSC	Minimal cost	High
Provide personal flood risk information to community	Commission additional flood modelling to link stream gauge heights to floor levels. Provide personalised flood information to residents based on modelling.	TSC / SES	$30,000	Medium

Measure	Required Actions	Responsibility	Estimated Cost	Priority
Educate residents in high risk areas	Identify high risk areas using information in FRMS. Create education strategy through FloodSafe Program targeted at residents in these areas.	SES	Depends on strategies employed	High
Update flood intelligence cards	Verify recommendations about datums from 2008 flood intelligence review. Update flood intelligence cards.	SES	Minimal cost	High
Develop flood information website	Upgrade Council's website to encompass a comprehensive Flood Information website Provide measures to ensure website is robust enough to handle high volume web traffic	TSC	$20,000	High
Trial supplementary methods of warning dissemination	Investigate and trial alternative methods of flood warning (especially SMS) Consult with Fingal Head residents about preferred warning methods	SES	Depends on method	Medium
Include Tumbulgum in warning system	Put forward recommendation to NSW Flood Warning Committee Update LFP if required	BoM / SES	Minimal cost	Medium
Improve storm surge prediction	Advise local SES when storm surge prediction products upgraded. Update LFP accordingly	BoM / SES	Minimal cost	Medium
Commission detailed evacuation planning study	Commission study or undertake internally by SES	SES	$25,000 per region	High
Plan to pre-emptively evacuate	Identify areas suitable for pre-emptive evacuation. Update LFP accordingly. Educate residents in these areas about likely pre-emptive evacuation.	SES	Minimal cost	Medium

Measure	Required Actions	Responsibility	Estimated Cost	Priority
Include pedestrian evacuation in planning	Identify areas suitable for pedestrian evacuation. Update LFP accordingly. Educate residents in these areas about possible pedestrian evacuation.	SES	Minimal cost	Medium
Review evacuation centres	Establish line of communication between SES and DoCS. Commence consultative review of evacuation centre capacities and planning issues.	SES / DoCS	Normal operating budget	Medium
Identify alternative evacuation centres to Tweed Civic Centre	Identify alternative evacuation centre and check capacity requirements. Update LFP.	SES / DoCS	Minimal cost	Medium
Commence voluntary house purchase scheme	Select appropriate VHP scheme. Confirm suitability of properties for inclusion.	TSC / OEH	$2.8 - $10.3 million, depending on selected scheme	Medium
Commence voluntary house raising scheme	Select appropriate VHR scheme. Confirm suitability of properties for inclusion.	TSC / OEH	$1.7 - $2.1 million, depending on selected scheme	Medium
Review and implement detailed planning recommendations	Review and update the relevant planning instruments as appropriate	TSC / DPI	Normal operating budget	Medium

12 MONITORING AND REVIEW

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

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

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

13 REFERENCES

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