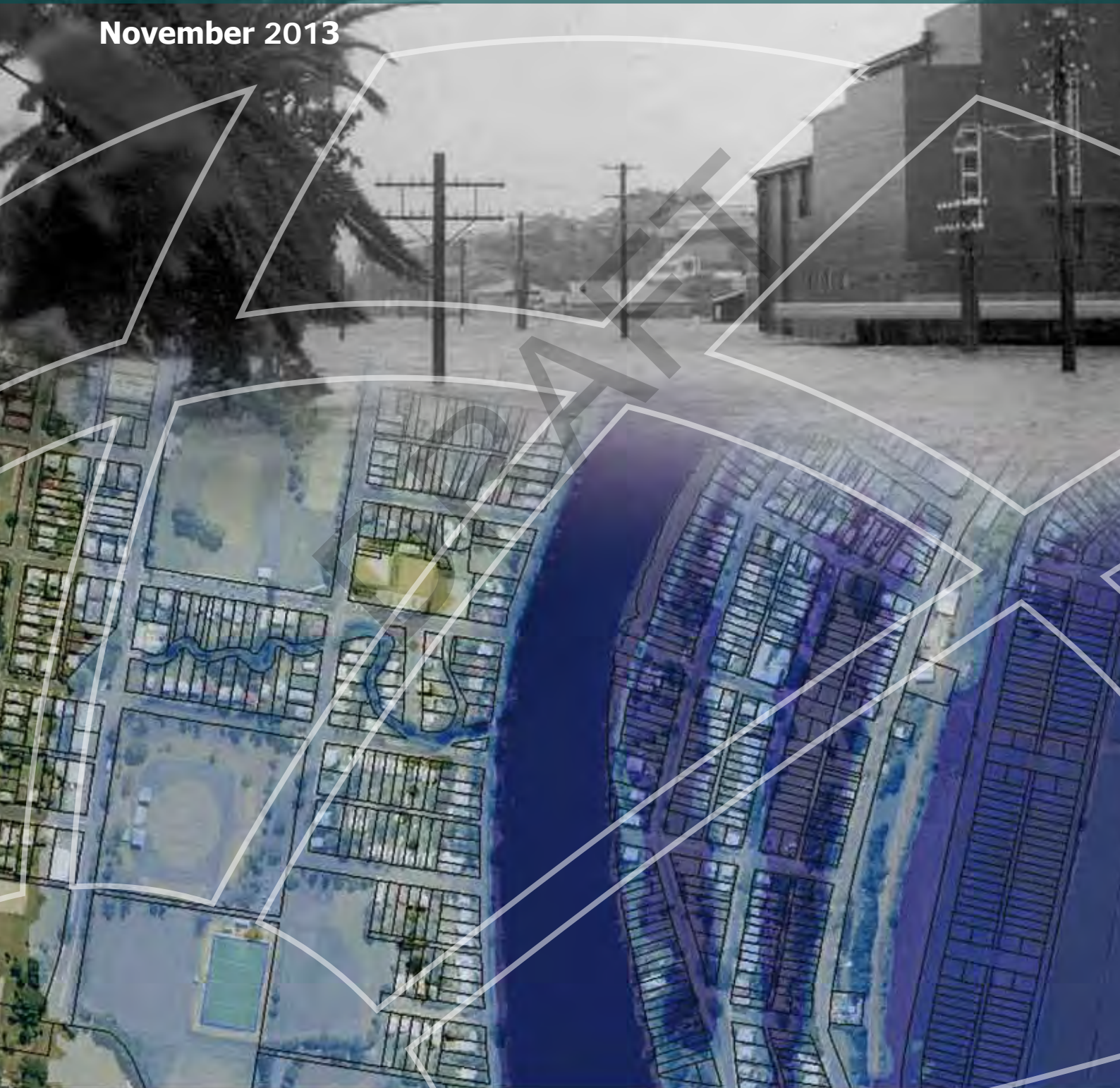


TWEED VALLEY FLOODPLAIN RISK MANAGEMENT PLAN

COMMITTEE ENDORSED DRAFT

November 2013



Tweed Valley Floodplain Risk Management Plan (COMMITTEE ENDORSED DRAFT)

DRAFT

Prepared For: Tweed Shire Council

Prepared By: BMT WBM Pty Ltd (Member of the BMT group of companies)

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| 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. |

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EXECUTIVE SUMMARY

The Tweed Valley Floodplain Risk Management Plan (FRMP) is the result of detailed investigation and consideration of flood risk across the study area in the Tweed Valley Floodplain Risk Management Study (FRMS). The Floodplain Risk Management Study and Plan are integrally linked. The Study provides for the assessment of options that form the basis for the considerations and decisions in the Plan. The process has been overseen by the Tweed Shire Council Floodplain Management Committee, with input from identified stakeholders and the broader community 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 measures recommended for implementation and / or further investigation is provided in Table ES- 1 below. Note that response modification measures have been subdivided into the following categories: flood awareness, flood intelligence, flood warning system, evacuation planning and evacuation centres. Further details of relative priorities, investment and key agency responsibilities are provided in the Implementation Plan in Section 12.

Table ES- 1 Summary of Measures

| FRMS No. | Description | Recommendation | Section |
|--|--|-----------------------|---------|
| Flood Modification Measures | | | |
| 1, 2 | Commission local drainage studies | Further investigation | 3.1 |
| 3 | Raise Tweed Heads South levee | Recommended | 3.2 |
| 5 | Extend Tweed Heads South levee | Further Investigation | 3.3 |
| 4, 7 | Commission levee overtopping studies | Further investigation | 3.3 |
| 6 | Preserve South Murwillumbah - Condong flowpath | Recommended | 3.5 |
| Response Modification Measures - Flood Awareness | | | |
| 8 | Support Community FloodSafe Program | Recommended | 4.1 |
| 9 | Educate residents about evacuation planning | Recommended | 4.2 |
| 10 | Provide personal flood risk information to community | Recommended | 4.3 |
| 18 | Educate residents in high risk areas | Recommended | 4.4 |
| Response Modification Measures - Flood Intelligence | | | |
| 11 | Update flood intelligence cards | Recommended | 5.1 |

| FRMS No. | Description | Recommendation | Section |
|--|---|-----------------------|---------|
| 12 | Develop flood information website | Recommended | 5.2 |
| 13 | Establish Flood Watch Network | Recommended | 5.3 |
| Response Modification Measures - Flood Warning System | | | |
| 14 | Review flood warning resources and plans | Recommended | 6.1 |
| 15 | Include Tumbulgum gauge in warning system | Recommended | 6.2 |
| 16 | Improve storm surge prediction capabilities | Recommended | 6.3 |
| Response Modification Measures - Evacuation Planning | | | |
| 17 | Commission detailed evacuation planning study | Further investigation | 7.1 |
| 19 | Establish plans for areas with insufficient warning | Further investigation | 7.2 |
| 20 | Establish plans if pedestrian evacuation required | Further investigation | 7.3 |
| 21 | Develop rural evacuation plans | Recommended | 7.4 |
| Response Modification Measures - Evacuation Centres | | | |
| 22, 23 | Review evacuation centres | Recommended | 8.1 |
| 24 | Identify alternative to Tweed Civic Centre | Recommended | 8.2 |
| Property Modification Measures | | | |
| 25 | Establish new voluntary house purchase scheme | Recommended | 9.1 |
| 26 | Establish new voluntary house raising scheme | Recommended | 9.2 |
| Climate Change Management Measures | | | |
| 27 | Implement climate change adaptation measures | Recommended | 10.1 |
| 28 | Implement climate change planning measures | Recommended | 10.2 |
| Planning and Future Development Management Measures | | | |
| 29 - 31 | Review and implement planning measures | Recommended | 11.1 |
| 32, 33 | Lower Tweed planning measures | Recommended | 11.2 |
| 34, 35 | Chinderah, Fingal Head, West Kingscliff planning measures | Recommended | 11.3 |
| 36, 37 | Murwillumbah, South Murwillumbah planning measures | Recommended | 11.4 |
| 38 | Riverside villages planning measures | Recommended | 11.5 |
| 39, 40 | Rural areas planning measures | Recommended | 11.6 |

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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 |
| DoPI | Department of Planning and Infrastructure |
| EP&A Act | Environmental Planning and Assessment Act |
| FESP | Flood Emergency Sub Plan |
| FIC | Flood Intelligence Card |
| FRMP | Floodplain Risk Management Plan |
| FRMS | Floodplain Risk Management Study |
| LEP | Local Environment 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) and should be read in conjunction with the FRMS. The plan provides practical information such as timing, priority, expense and responsibility for all of the measures recommended for implementation or further investigation.

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 to be undertaken by Council. |

Community consultation occurs throughout the process. This plan represents the third of the four stages for the Tweed Valley.

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>.

1.2 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 considering social, economic and ecological costs and benefits, to individuals as well as the community;
- Floodplain management matters are dealt with considering 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** (Council). The primary responsibilities of Council are:

- Commissioning a Floodplain Risk Management Study and implementing the Floodplain Risk Management Plan (this document);
- Preparation and application of Environmental Planning Instruments (LEP, DCP) which incorporate 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 Flood Emergency Sub Plan (FESP).

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** (DoPI) 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 the 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.

Future flood risk due to climate change is managed through a combination of the above measures to adapt existing development and infrastructure, and plan and design future development and infrastructure, for the predicted effects of climate change on flood risk.

2 BACKGROUND

2.1 Study Area

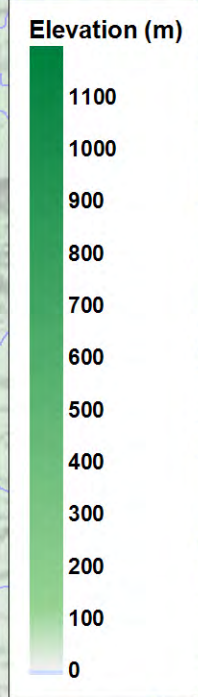
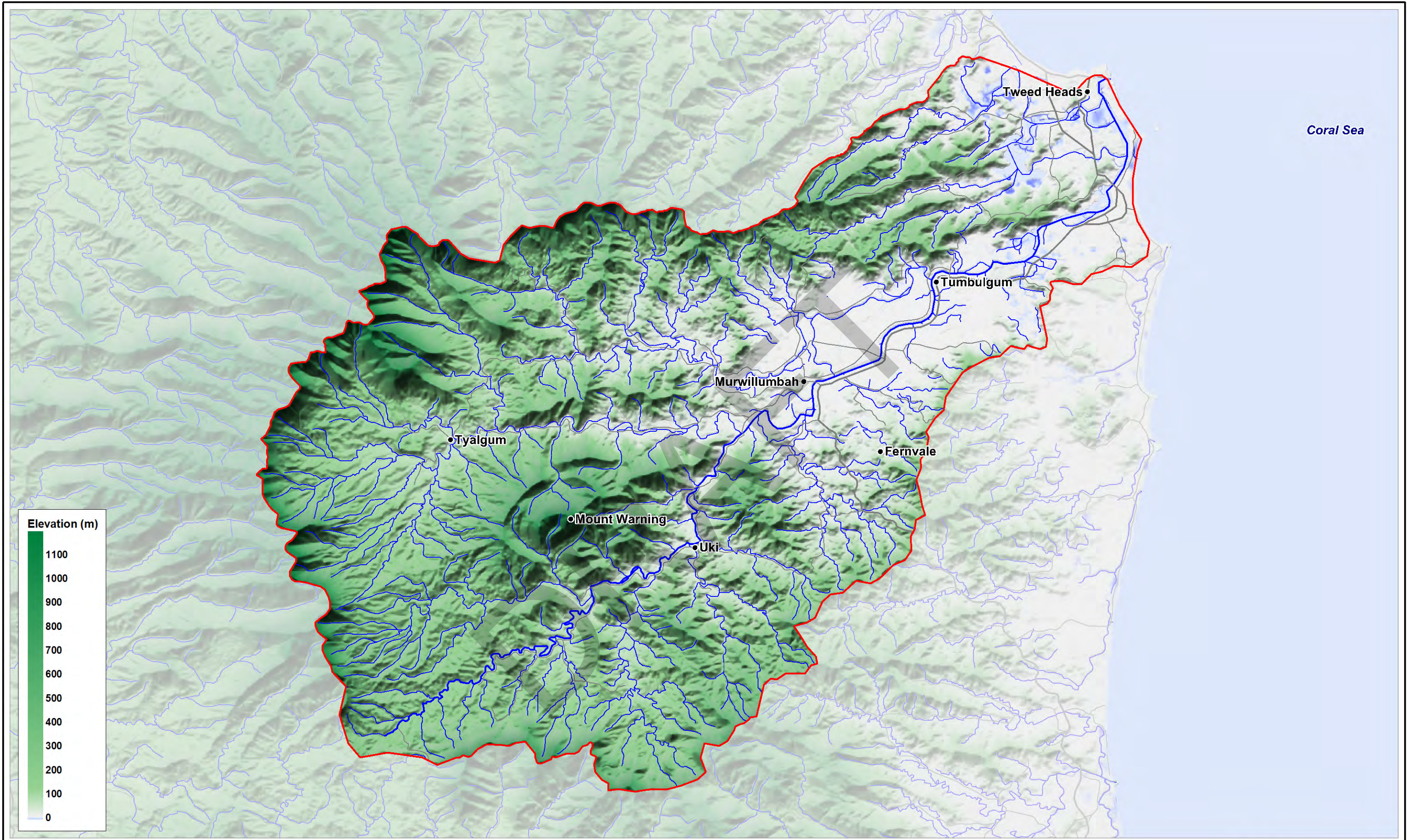
The Tweed River is located in Tweed Shire, the northern-most coastal region of New South Wales (see Figure 2-1). The main arm of the river has a length of about 50 km and a catchment area of about 1,100 km², including its various tributary systems. The main arm of the river flows in a general north-easterly 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. Most recently the catchment experienced moderate flood events in January 2008 and January 2012. 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.

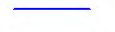


Regional flooding occurs via catchment rainfall, ocean storm surge or some combination of these events. The small tributaries in the Bilambil and Terranora regions and local areas can also experience flash flooding; however the focus of the Tweed Valley FRMS is catchment scale inundation. The critical 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'.



LEGEND

-  Tweed Catchment Boundary
-  Tweed River
-  Watercourse Line
-  Principal Road
-  Sealed Road

Title:
Tweed River and Surrounds

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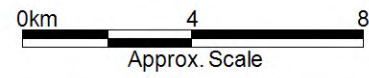


Figure:
2-1

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A



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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 within 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).

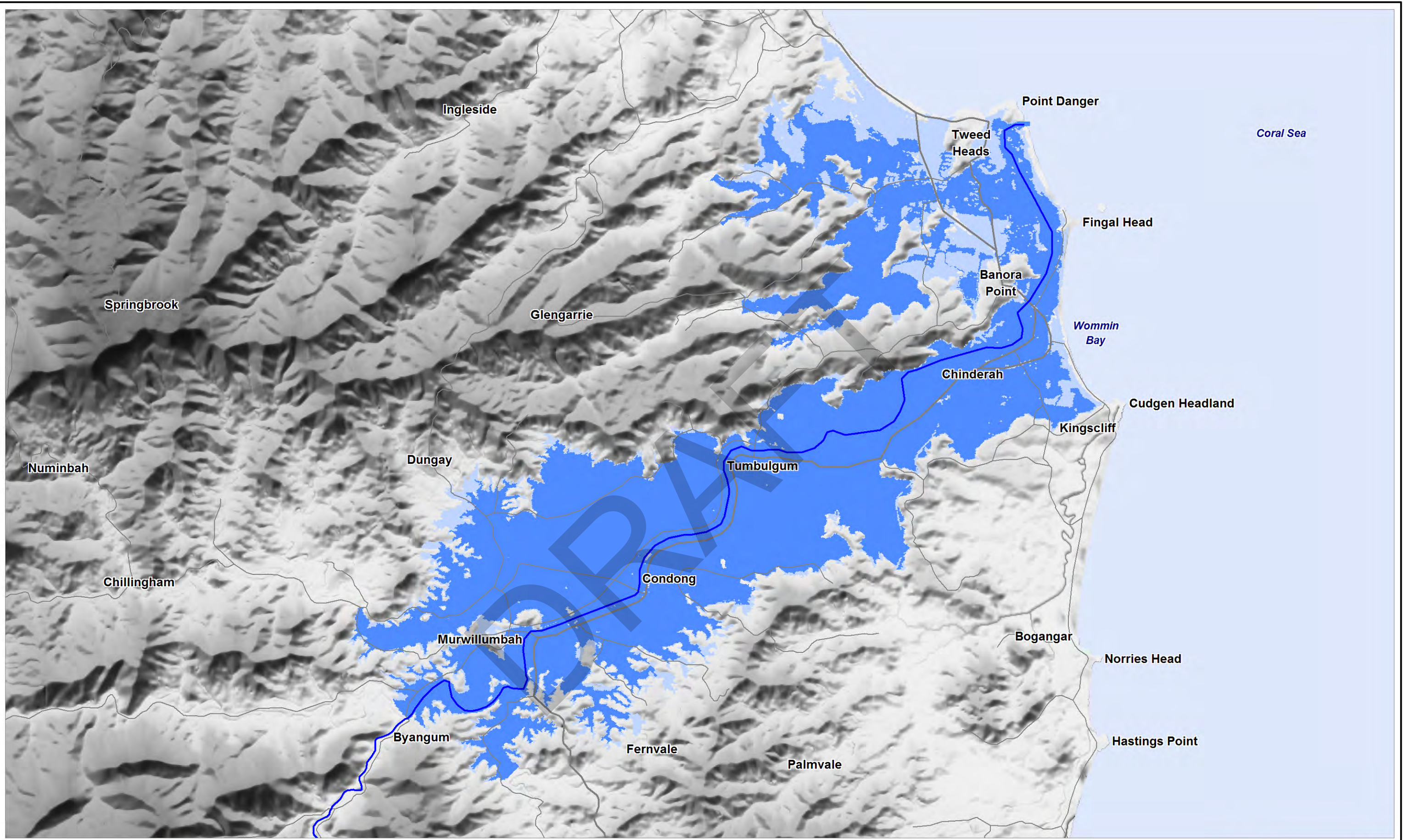
In a (theoretical) 100 year ARI flood event, there are major flowpaths in Murwillumbah through Bray Park, and from Blacks Drain to Condong Creek via the Murwillumbah airport. In the mid Tweed, there are large areas of floodplain conveying high flow between the Tweed and Rous Rivers, as well as from Condong 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, reaching 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 river mouth / entrance and the dunes between Kingscliff and Fingal Head.

Figure 2-2 shows the extent of catchment flooding in the Tweed Valley study area.



LEGEND

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

Title:
Existing Flood Extent

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| Figure: 2-2 | Rev: A |
|-----------------------|------------------|



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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 ¹

| 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 | 16 | 35 |
| 20 year ARI | 395 | 80 |
| 100 year ARI | 1,120 | 340 |
| 500 year ARI | 6,140 | 720 |
| Extreme flood | 14,360 | 970 |
| PMF | 14,760 | 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 \$22.5 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.

¹ Estimated based on dwellings located within the flood extent.

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 | \$7 | \$10 | \$82 |
| 100 year ARI | \$152 | \$46 | \$27 | \$225 |
| 500 year ARI | \$679 | \$187 | \$120 | \$986 |
| Extreme flood | \$2,380 | \$637 | \$419 | \$3,436 |
| PMF | \$2,638 | \$682 | \$463 | \$3,782 |
| AAD | \$16.2 | \$3.6 | \$2.8 | \$22.5 |

2.2.2 Future Flood Risk

The Tweed LGA's recent rapid growth is expected to continue based on State Planning Strategies, and the future risks to people and property of continued floodplain development need to be addressed. Furthermore, 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 ¹

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

3 FLOOD MODIFICATION MEASURES

3.1 Commission Local Drainage Studies

Local drainage issues, such as blocked and / or overflowing drains, were identified by the SES and Floodplain Management Committee (FMC) 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 and mitigating stormwater risks behind the town levee, to optimise the operation of the Lavender Creek pump station, and development planning purposes.

FRMS Recommendation 1 and 2: Commission Murwillumbah, lower Tweed and Chinderah local drainage studies

Priority: High – further investigation required

Estimated cost: Estimated \$50,000 to \$150,000 per study

3.1.1 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 mitigation and development planning.

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.

3.1.2 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 local areas, 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 local stormwater flooding for the full range of flood events up to and including the PMF;
- Assessment of the stormwater drainage system capacity, including flood pumping stations; 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 respective levee overtopping studies (Section 3.3). 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 potentially utilise the same model schematisation.

3.2 Raise Tweed Heads South Levee

The Tweed Heads South levee was constructed in the late 1960s / early 1970s and was designed to provide immunity from previously observed flood events, with a design crest of approximately 2.0m AHD, which equates to around a 20 year ARI event. The Tweed Valley Flood Study Update (BMT WBM, 2009) and the Tweed Shire Flood Emergency Sub 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.

FRMS Recommendation 3: Raise Tweed Heads South levee

Priority: Medium – further investigation required

Estimated capital cost: ~\$11.4 Million

Estimated maintenance cost: ~\$200,000 per annum

3.2.1 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. Significant stormwater infrastructure would also be required to ensure properties behind the levee are not at increased risk of stormwater damage from local catchment inundation.



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:
Tweed Heads South Levee

BMT WBM endeavours to ensure that the information provided in this map is correct at the time of publication. BMT WBM does not warrant, guarantee or make representations regarding the currency and accuracy of information contained in this map.

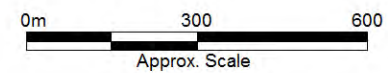


Figure:
3-1

Rev:
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Filepath : I:\B16879_I_BRH Tweed GJR\DRG\FRM Study\FLD_011_120501_Tweed Heads South Levee.WOR

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 | 51 | 18 |
| 100 year ARI | 185 | 38 |
| 500 year ARI | 191 | 2 |
| Extreme flood | 0 | 0 |
| PMF | 0 | 0 |

The associated reduction in average annual damages is approximately **\$2.6 million** per year. This results in a total benefit of approximately **\$35.4 million**, based on a levee design life of 50 years². 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. The cost estimate includes \$1 million for stormwater pumps.

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) | \$35.4m |
| Total Cost (\$2011) | \$11.4m |
| Monetary Benefit-Cost Ratio | 3.1 |

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.

3.2.2 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

² This benefit does not include intangible benefits associated with a reduction in floodplain risk to people and property.

- 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.

3.3 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 to established evacuation centres with support facilities.

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.

FRMS Recommendation 5: Extend Tweed Heads South levee

Priority: Medium – further investigation required

Estimated capital cost: Unknown – estimated >\$10 million

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

3.3.1 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 **\$10 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 with raising the existing Tweed Heads South levee, 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.

3.3.2 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.

3.4 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 Tweed Heads South. Levee overtopping studies are recommended for both locations.

FRMS Recommendations 4 and 7: Commission levee overtopping studies for Murwillumbah and Tweed Heads South

Priority: Medium – further investigation required

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

3.4.1 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.

3.4.2 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 the time and location of overtopping, and the 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 behind the levee.

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.

FRMS Recommendation 6: Preserve South Murwillumbah Condong flowpath

Priority: High – recommended (acquisition or planning controls), further investigation required (new hydraulic structure)

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.

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4 RESPONSE MODIFICATION MEASURES - FLOOD AWARENESS

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 existing 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.

FRMS Recommendation 8: Support Community FloodSafe Program

Priority: High

Estimated cost: Normal operating budget

This program is relatively new 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 optimally utilised 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 Educate Residents about Evacuation Planning

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.

FRMS Recommendation 9: Educate residents about evacuation planning

Priority: Medium

Estimated cost: Include in Community FloodSafe Program

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 (enhanced awareness); and
- 2 The community will be better able to respond to evacuation advice due to familiarity with the evacuation process (enhanced readiness).

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 was provided to the community at the public open sessions held for this study.

4.3 Provide Personal Flood Risk Information

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. 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.

FRMS Recommendation 10: Provide personal flood risk information to community**Priority: High****Estimated cost: \$15,000 modelling, \$15,000 distribution / education****4.3.1 Benefits**

Provision of personalised flood risk information would enhance community flood awareness of the scale of flood classifications and large 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.

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.

FRMS Recommendation 18: Educate residents in high risk areas**Priority: High****Estimated cost: Include in Community FloodSafe Program****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 7.2); 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.

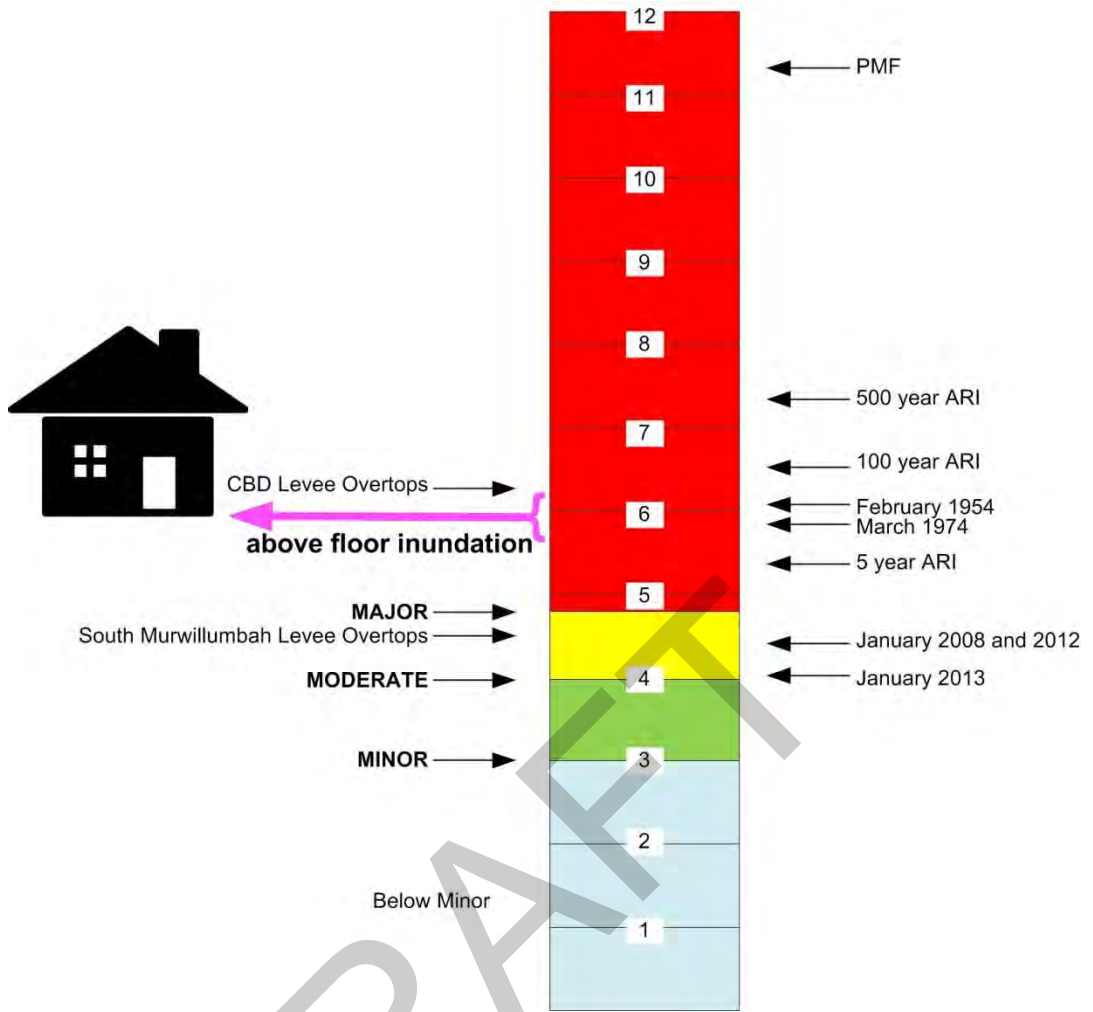


Figure 4-1 Floor Level to Gauge Relationship

5 RESPONSE MODIFICATION MEASURES - FLOOD INTELLIGENCE

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.

FRMS Recommendation 11: Update flood intelligence cards

Priority: High

Estimated cost: Normal operating budget

5.1.1 Benefits

Updating the FICs to include the review recommendations would improve emergency response and community safety by ensuring that the cards contain the latest available information.

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 such as flood warnings, predictions, evacuation information, road closures and interactive flood mapping.

FRMS Recommendation 12: Develop flood information website

Priority: High

Estimated cost: \$20,000 approx

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-alone 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.

5.3 Establish Flood Watch Network

Many residents in the Tweed Valley access their properties by rural roads which are not easily monitored by the SES during a flood event. In addition, a number of residents in these rural areas have extensive knowledge of historical flood behaviour in the region. These residents' knowledge can be utilised through a Flood Watch Network (FWN).

FWNs provide a formal mechanism for local residents to contribute real-time flood information and improve the SES's understanding of flooding and flood impacts across the entire study area. These types of networks have been successfully used in other areas and often exist informally.

FRMS Recommendation 13: Continue Flood Watch Network

Priority: Medium

Estimated cost: Normal operating budget

5.3.1 Benefits

Flood intelligence from community members in key locations can improve the SES's flood emergency response and assist the SES to provide more detailed advice to the broader community. An FWN is expected to improve safety of residents, particularly in rural areas.

5.3.2 Implementation

Establishment of a FWN has commenced and will likely require the following steps:

1. **Develop a system to receive and integrate information received from the FWN.** During a flood, the SES may receive a number of phone calls from the public requesting information or assistance. To ensure that information from the FWN is prioritised, it may be necessary to establish a dedicated phone number separate from the standard 132 500 number.
2. **Identify and recruit members of the public who are willing to participate.** The SES may wish to directly contact local residents who are known to collect flood information or who take an active interest in local flooding issues. Residents who have lived in the catchment for a long time with a good understanding of historic flood behaviour and are located in key locations (such as near major intersections, bridges etc.) will be able to make the most valuable contribution to the Network.
3. **Educate FWN members.** Residents who wish to participate in the FWN should be provided with education from the SES to ensure that members do not put themselves at risk in collecting information, understand what types of information might be helpful to the SES and how best to convey the information to the SES.

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6 RESPONSE MODIFICATION MEASURES - FLOOD WARNING

6.1 Review Flood Warning Resources and Plans

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. This method is also resource intensive and may not be solely practicable for warning large areas.

In practice, the SES uses a range of media to disseminate flood warnings including radio and TV, public address systems from emergency service vehicles, telephone, two-way radio, SES website, variable message signs and SES social media channels.

It is recommended that the SES review and update response plans based on the outcomes of this study, e.g. to include risk-based prioritisation of resources and plans to manage the warning process.

FRMS Recommendation 14: Review flood warning resources and plans

Priority: High

Estimated cost: Minimal cost to review, additional cost depends on whether it is identified that any new resources / systems are required

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 personnel 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 to review warning resources and plans in light of this most recent information.

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.

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).

6.2 Include Tumbulgum Gauge in Warning System

The automatic stream gauge at Tumbulgum is not currently included in BoM’s formal flood warning network. The BoM have a flood peak correlation relationship for the Tumbulgum gauge based on the Murwillumbah gauge, however this does not explicitly take account of the tide or Rous River inflow. 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 prediction, evacuation planning and warning.

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

FRMS Recommendation 15: Include Tumbulgum in warning system

Priority: Medium

Estimated cost: Minimal cost to progress to NSW FWCC

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 to include influences from the tide and Rous River 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 Consultative 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 Flood Emergency Sub Plan accordingly.

6.3 Improve Storm Surge Prediction Capabilities

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.

FRMS Recommendation 16: Improve storm surge prediction capabilities

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 Flood Emergency Sub Plan accordingly.

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7 RESPONSE MODIFICATION MEASURES - EVACUATION PLANNING

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.

FRMS Recommendation 17: Commission detailed evacuation planning study

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. 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 depths or stream gauge heights) that prompts evacuation actions; and
- Education program to inform residents of adopted evacuation measures.

7.2 Establish Plans for Areas with Insufficient Warning

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 may need 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.

FRMS Recommendation 19: Review plans for areas with insufficient warning

Priority: High

Estimated cost: Include in Community FloodSafe Program

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 need to 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, Section 7.1); 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 Establish Plans if Pedestrian Evacuation Required

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.

FRMS Recommendation 20: Establish plans if pedestrian evacuation required

Priority: Medium

Estimated cost: Include in Community FloodSafe Program

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, allowing more residents to reach evacuation centres safely.

7.3.2 Implementation

Based on the detailed evacuation planning study (Section 7.1), it is recommended that the SES review whether there are areas where pedestrian evacuation may be suitable and update the Flood Emergency Sub 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.

This should be undertaken in conjunction with providing targeted education to residents in areas which are identified as suitable for pedestrian evacuation.

7.4 Develop Rural Evacuation Plans

There may be some flood prone rural areas where there is more risk associated with evacuation to main centres. The rural floodplain is generally sparsely populated, and the ability to evacuate is limited given the low flood immunity of various rural roads. In extreme events, access can be cut before the SES is able to issue warnings. It is recommended that the SES review the latest information from the FRMS to update / develop evacuation plans for rural residents.

FRMS Recommendation 21: Develop rural evacuation plans

Priority: Medium

Estimated cost: Include in Community FloodSafe Program

7.4.1 Benefits

Having alternative evacuation strategies (e.g. to local high ground) may improve safety of rural residents cut off from main centres prior to warning and / or evacuation.

7.4.2 Implementation

It is recommended that based on the detailed evacuation planning study (Section 7.1) the SES review their plans to identify rural areas at risk of isolation prior to inundation. This can be informed by the detailed evacuation planning study, which is also recommended in this FRMP. The development of rural evacuation plans should be undertaken in conjunction with providing targeted education to residents in high risk areas.

8 RESPONSE MODIFICATION MEASURES - EVACUATION CENTRES

8.1 Review Evacuation Centres

Review of evacuation centres and evacuation protocol in the Tweed Valley area identified two potential issues:

- 1 A lack of space at many evacuation centres; and
- 2 Potential for miscommunication between the SES and DoCS (who are responsible for operation of evacuation centres).

These can be simultaneously tackled through a consultative review of evacuation centre capacity, operations and protocols by the SES and DoCS.

FRMS Recommendations 22 and 23: Review evacuation centres

Priority: Medium

Estimated cost: Minimal cost to review; additional cost depends on whether it is identified that any new resources are required

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 continue 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 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 Flood Emergency Sub Plan updated to reflect this information.

FRMS Recommendation 24: Identify alternative to Tweed Civic Centre

Priority: Medium

Estimated cost: Minimal cost to review; additional cost depends on whether it is identified that any new resources are required

8.2.1 Benefits

The Flood Emergency Sub Plan will no longer direct residents to an unsuitable flood 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 Flood Emergency Sub 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 Establish New Voluntary House Purchase Scheme

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. A VHP scheme is recommended for 8 properties in the highest hazard areas (referred to as VHP Option 3 in the FRMS). In addition it is recommended that this be followed by a review to consider the feasibility of a VHP scheme for an additional 21 properties identified in high hazard areas (referred to as VHP Option 2 in the FRMS).

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

FRMS Recommendation 25: Establish new voluntary house purchase scheme

Priority: Medium

Estimated cost: \$2.8 million approx.

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. The cost-benefit ratio to purchase the 8 priority properties (VHP Option 3) is 1.1 (see Table 9-1).

Table 9-1 VHP Cost Benefit Summary

| | Option 2 | Option 3 (Recommended) |
|------------------------|-----------------------|---------------------------|
| 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 |

9.1.2 Implementation

It will be necessary for Council and State Government to confirm the suitability of the specific properties and establish a program to commence the new VHP scheme.

9.2 Establish New Voluntary House Raising Scheme

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. A VHR scheme is recommended for 30 properties (referred to as VHR Option 3 in the FRMS).

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

FRMS Recommendation 26: Establish new voluntary house raising scheme

Priority: Medium

Estimated cost: \$2.1 million approx

Houses also had to be structurally suitable for raising (i.e. wooden, not slab on ground), which was 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. The cost-benefit ratio to raise the 30 properties (VHR Option 3) is 2.6 (see Table 9-2).

Table 9-2 Voluntary House Raising Summary

| | Option 2 | Option 3 (Recommended) |
|-----------------------------|-------------|---------------------------|
| 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 |

9.2.2 Implementation

It will be necessary for Council and State Government to confirm the suitability of the specific properties and establish a program to commence the new VHR scheme.

10 CLIMATE CHANGE MANAGEMENT MEASURES

10.1 Implement Climate Change Adaptation Measures

Tweed Shire Council developed a climate change adaptation plan (in conjunction with Byron Shire Council) in 2009 which outlines Council's plans to address climate change related risks. In relation to flood risk, the plan makes climate change adaptation recommendations for the design of infrastructure and flood defences, community awareness and education programs, and development planning. Information from the FRMS can be used to hydraulically assess the level of risk and quantify the actions required to meet the plan's recommendations.

FRMS Recommendation 27: Implement climate change adaptation measures

Priority: Low

Estimated cost: Depends on works; include in Community FloodSafe Program

10.1.1 Benefits

Climate change adaptation measures are necessary to manage future flood risks to existing development and infrastructure, as well as to increase awareness in residents of the potential future increase in flood risk.

10.1.2 Implementation

The implementation of the adaptation plan will occur over time via planning controls and an ongoing process of designing and upgrading infrastructure and flood defences to take into account predictions of the future effects of climate change on flood risk. The plan also recommends educating residents of the potential increases in flood risk associated with climate change which can be incorporated into the Community FloodSafe Program.

10.2 Implement Climate Change Planning Measures

The 2009 NSW Sea Level Rise Policy (since abandoned) recommended that strategic and statutory planning documents could respond to the projected flood risk by restricting the intensification of development in areas subject to predicted climate change flood risk or applying controls to manage the additional risk. The aim is to take a precautionary approach to contain flood risks where this can be practically achieved.

Some mechanisms are currently being applied by Council in respect of residential development, however it is recommended that climate change flood risks also be considered for rezoning for non-residential urban development (such as commercial and industrial uses) and design flood levels for new rural development. Introducing time-limited consents could also be beneficial for development types that have a shorter typical life span.

FRMS Recommendation 28: Implement climate change planning measures**Priority: Medium****Estimated cost: Normal operating budget****10.2.1 Benefits**

Climate change planning controls are necessary to manage flood risks to planned and future development and infrastructure. The aim is to ensure that development is located and designed to appropriately take account of both the nature of development and the flood risk predicted over the lifetime of the development.

10.2.2 Implementation

Climate change planning controls will need to be reviewed and implemented by Council via amendments to the Development Control Plan (DCP) including:

- Extending controls applied to the rezoning of greenfield land for residential use to apply to all urban development (such as commercial and industrial uses);
- The application of the 2100 climate change design flood level for habitable floors of new rural dwellings and an associated fill pad; and
- Imposing time-limited consents to provide the potential to remove, replace or adapt development in the future.

11 PLANNING AND FUTURE DEVELOPMENT MANAGEMENT MEASURES

11.1 Review and Implement Planning Measures

Despite the presence of significant flood risks in the study area, future development can occur with well designed flood controls and appropriate assessment to determine and limit the impact of development. An extensive review of future development and planning considerations was undertaken as part of the FRMS and is summarised in Chapter 8 of the FRMS. Recommendations have been made to update Council's planning instruments with best-practice flood planning controls, together with specific flood risk management recommendations based on the latest available information about flood behaviour. On completion of the consultation phase, the committee should review these recommendations and implement as appropriate.

FRMS Recommendations 29, 30 and 31: Review and implement planning measures applicable to the whole study area

Priority: Medium

Estimated cost: Normal operating budget

11.1.1 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:

- The planning system will be informed by improved understanding of flood risk (based on outcomes from the Flood Study and FRMS); and
- The floodplain won't be unnecessarily closed to development.

11.1.2 Implementation

The majority of responsibility for review and implementation of the planning measures rests with Council as part of its normal planning process, in some cases in conjunction with the relevant State department. Ultimately the measures need to be reflected in planning instruments and policies via three mechanisms:

1. Strategic planning. Providing direction at a local and state strategic planning level to manage flood risks. Strategic planning measures include:

- Adoption of cumulative development scenario for the management of hydraulic impacts in the floodplain; and
- Application of evacuation risk classes (ERCs) in the strategic planning process.

2. Development controls and related policies. Recommending development controls and related policies to be incorporated in appropriate planning instruments to mitigate the risk to development where permitted in the floodplain. These include:

- Refinement of the flood related local provisions in the draft comprehensive Local Environment Plan.
- Updates and amendments to the Development Control Plan (DCP) including:
 - Updating controls to reflect hydraulic constraints to development fill including adoption of a cumulative development scenario, permissible rural development scenario and associated hydraulic assessment requirements;
 - Introduction of floor level controls on commercial and industrial development with sufficient flexibility when such controls cannot be practically met;
 - Review car parking and driveway controls to ensure consistency in particular for basement car parking across the study area;
 - Refinement of provisions relating to long term residents and hydraulic impact of caravan parks;
 - Additional detail as to what constitutes an acceptable on-site or communal refuge where proposed as a secondary emergency management measure; and
 - Controls for management of flood risks from stormwater and overland flow paths.
- Clarification of areas deemed to be high risk for the purposes of the Codes State Environmental Planning Policy.
- Establishment of Section 94 contributions plans where necessary or appropriate to fund flood mitigation works.
- Updates to Council's flood policies on finalisation of the FRMP.

3. Communication of flood risk. Ensuring that the planning controls and associated documents appropriately inform the community about the flood risk, including:

- Refinement of Section 149 notifications and notations; and
- Periodic reviews of protocols to release flood risk information to the public.

Additional planning measures referenced to provisions for specific localities are outlined in the following sections.

11.2 Lower Tweed Planning Measures

The Tweed City Centre Plan Vision 2011 indicates the majority of the future development in the lower Tweed area is to occur within Tweed Heads east of Razorback Hill (referred to as Tweed City Centre North). The City Centre Plan also includes proposals for Tweed Heads South (referred to as Tweed City Centre South). Flooding, climate change and evacuation considerations during the development of the City Centre Plan led to the deferral of Tweed City Centre South and part of North (east of Wharf Street) for due consideration in this FRMS.

The current strategic planning directions for Tweed Heads North (both east and west of Wharf Street) could be supportable on flood risk grounds given rising road access and multi-storey interconnected building forms with areas above PMF. This is subject to more detailed assessment, road access improvements where required and / or provision of necessary on site refuges and support facilities.

The presence of low flood islands and the lack of rising road access for Tweed Heads South present significant personal safety risks that are a serious impediment to any future expansion. It would appear that significant alterations to the proposed building form (e.g. to provide support facilities within elevated interconnected buildings as is being considered for Tweed Heads North) are required in order to reduce the risk to life. Areas where there may be sufficient time to evacuate via Fraser Drive may also be lesser risk, though still serious, requiring very detailed consideration when evaluating the appropriateness of any development in this area.

FRMS Recommendations 32 and 33: Review and implement planning measures specific to the lower Tweed area

Priority: Medium

Estimated cost: Normal operating budget

11.2.1 Benefits

Strategic planning and development controls are necessary to appropriately consider and manage flood risks associated with planned development in the lower Tweed area.

11.2.2 Implementation

Planning controls specific to Tweed City Centre will need to be reviewed and implemented by Council via amendments to the DCP including:

- The application of the 2100 climate change design flood level for habitable floors in Tweed City subject to variations in some circumstances;
- A preferential emphasis on providing for evacuation away from the floodplain in preference and sheltering on-site; and
- If the above cannot be practically achieved then specifying the nature of an on-site refuge that would be acceptable.

Current development plans for Tweed Heads North are supported by the FRMP subject to more detailed assessment, requirements and other planning criteria. Current development plans for Tweed Heads South are not supported by the FRMP but alternative forms of redevelopment that reduce flood risk could be reconsidered.

11.3 Chinderah, Fingal Head and West Kingscliff Planning Measures

Development in the Chinderah, Fingal Head and West Kingscliff region is guided by the Tweed Coast Strategy outlined in Section B9 of the Tweed DCP. The FRMS also assessed other large scale development options including some informal options.

Floodplain development in the area will generally require substantial filling. Hydraulic investigations show filling in Chinderah Village results in unacceptable impacts and limits development potential. Incremental development that leads to substantial cumulative expansion in the population could also result in unacceptable risks due to existing evacuation constraints.

Cumulative development assessment shows other potential development sites in Chinderah and West Kingscliff can be filled within limits. Evacuation risks should be manageable for those sites with

rising road access to Marine Parade or Kingscliff Street, however other areas are limited by existing evacuation constraints.

FRMS Recommendations 32 and 33: Review and implement planning measures specific to Chinderah, Fingal Head and West Kingscliff

Priority: Medium

Estimated cost: Normal operating budget

11.3.1 Benefits

Strategic planning and development controls are necessary to appropriately consider and manage flood risks associated with planned development in Chinderah, Fingal Head and West Kingscliff.

11.3.2 Implementation

Planning controls specific to Chinderah, Fingal Head and West Kingscliff will need to be reviewed and implemented by Council via amendments to the DCP including expanding the provisions of Section B9 to clarify the requirements for a detailed evacuation risk assessment prior to proceeding with areas identified for future urban development.

Current development plans under the Tweed Coast Strategy are supported by the FRMP subject to other planning criteria, as is other Chinderah / West Kingscliff development subject to evacuation and cumulative development constraints.

Stakeholder and community consultation identified strong support for filling and expansion in Chinderah Village which the FRMP does not recommend due to significant flood risk constraints. It is recommended that Council continue direct consultation with the relevant consultees regarding the flood risks, constraints and appropriate alternative redevelopment strategies.

11.4 Murwillumbah and South Murwillumbah Planning Measures

Future development in the Murwillumbah region is guided by Sections B22 and B6 of the Tweed DCP. This includes parts of the existing urban area of the town that have been identified to provide for intensification of residential development, as well as possible future expansion to industrial areas.

Areas both north and south of the river are currently protected by levees though South Murwillumbah has very low immunity (less than 5 year ARI) and very high hazard. The Murwillumbah CBD levee is overtopped in the 100 year ARI flood. Due to the constriction of the floodplain at Murwillumbah, there is a very large flood range in the river between the 100 year ARI and more extreme flood events, up to 5 metres in the PMF. The very high flood range results in significant evacuation constraints and safety risks, particularly for individuals who decide not to evacuate during a major flood.

A major flowpath for flood waters from the South Murwillumbah to Condong basins currently exists generally along the alignment of the airfield runway and hydraulic investigations show it is important to maintain and enlarge this where possible. Cumulative development assessment also indicates there are hydraulic constraints to filling in the South Murwillumbah basin.

Plans to increase residential densities in the Prospero Street, South Murwillumbah Riverfront and South-Side Residential Precincts are not supported due to low flood immunity, very high hydraulic hazard and unacceptable evacuation risks. Development plans for Wardrop Valley / Fernvale and industrial development in South Murwillumbah are limited by hydraulic constraints (and subject to detailed consideration of evacuation risk).

FRMS Recommendations 36 and 37: Review and implement planning measures specific to Murwillumbah and South Murwillumbah

Priority: Medium

Estimated cost: Normal operating budget

11.4.1 Benefits

Strategic planning and development controls are necessary to appropriately consider and manage flood risks associated with planned development in Murwillumbah and South Murwillumbah.

11.4.2 Implementation

Planning controls specific to Murwillumbah and South Murwillumbah will need to be reviewed and implemented by Council via amendments to the DCP including:

- Any further consideration of the large development options would necessitate detailed planning of evacuation routes;
- It would be desirable from a flood risk perspective for the whole of the River Front precinct to form a continuous river front park; and
- Consider concessions to allow lower storey habitable floor levels subject to more detailed studies and requirements.

In addition, the flowpath through the industrial zoned land in South Murwillumbah should be secured via purchase/acquisition or imposition of planning controls.

The following are recommended for review on completion of the more detailed evacuation, local drainage and levee overtopping studies:

- Increasing residential development within parts of the Town Centre Core Precinct and the Medium Density Housing Precinct with rising road access; and
- Fill of allotments behind levee.

Current development plans for West Murwillumbah are supported by the FRMP subject to other planning criteria, as is commercial redevelopment that reduces flood risk (subject to the above).

Stakeholder and community consultation identified strong support for increased residential development in South Murwillumbah which the FRMP does not recommend due to significant flood risk constraints. It is recommended that Council continue direct consultation with the relevant consultees regarding the flood risks, constraints and appropriate alternative redevelopment strategies. The SES could also be included in the direct consultation process if appropriate.

11.5 Riverside Villages Planning Measures

The riverside villages of Condong and Tumbulgum generally have minimal further development potential and no formal planning proposals. Remaining urban zoned land in Kielvale is identified in the Tweed Urban and Employment Land Release Strategy.

The riverside villages area can experience major flooding from rainfall events over the Tweed River catchment including the Rous River. There are significant constraints to evacuation of Condong and Tumbulgum in an extreme event. The provision of on-site refuges will reduce the risk to development and should be viewed as a secondary but necessary emergency management strategy.

FRMS Recommendation 38: Review and implement planning measures specific to the riverside villages

Priority: Low

Estimated cost: Normal operating budget

11.5.1 Benefits

Strategic planning and development controls are necessary to appropriately consider and manage flood risks associated with planned development in the riverside villages including Condong, Tumbulgum and Kielvale.

11.5.2 Implementation

Planning controls specific to the riverside villages will need to be reviewed and implemented by Council via amendments to the DCP including amendment to limit subdivision or intensification of development in Condong / Tumbulgum.

Current development plans for Kielvale are supported by the FRMP subject to other planning criteria, as is redevelopment in Condong / Tumbulgum that reduces flood risk (subject to the above).

11.6 Rural Areas Planning Measures

Due to prevailing topography, the rural floodplain consists of large areas of high hazard floodway, significant flood storage areas, and limited flood fringe around the steep sided river valleys. The rural floodplain is prone to rapid inundation even in minor flood events.

To streamline applications for future rural development, Council aimed to identify permissible filling / bunding thresholds below which cumulative development assessment would not be required. As the large scale urban development scenarios were already approaching predetermined acceptable limits of hydraulic impacts, only 1% of suitable rural zoned land could be filled in addition without adverse hydraulic impacts around Tumbulgum and Chinderah. Many rural areas are also subject to significant evacuation constraints.

FRMS Recommendations 39 and 40: Review and implement planning measures specific to rural areas

Priority: Medium

Estimated cost: Normal operating budget

11.6.1 Benefits

Strategic planning and development controls are necessary to appropriately consider and manage flood risks associated with future rural development.

11.6.2 Implementation

Planning controls for rural areas will need to be reviewed and implemented by Council via amendments to the DCP including:

- Adoption as a development control a maximum filling threshold of 1% of flood prone land (excluding floodways) without cumulative development re-assessment;
- The application of the 2100 climate change design flood level for habitable floors of new rural dwellings and an associated fill pad (also included in Section 10.2 Climate Change Planning Measures); and
- A requirement for high level vehicular or pedestrian access to a refuge for additional dwelling subdivisions or other land uses.

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12 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 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 12-1, below.

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

Table 12-1 Implementation Plan

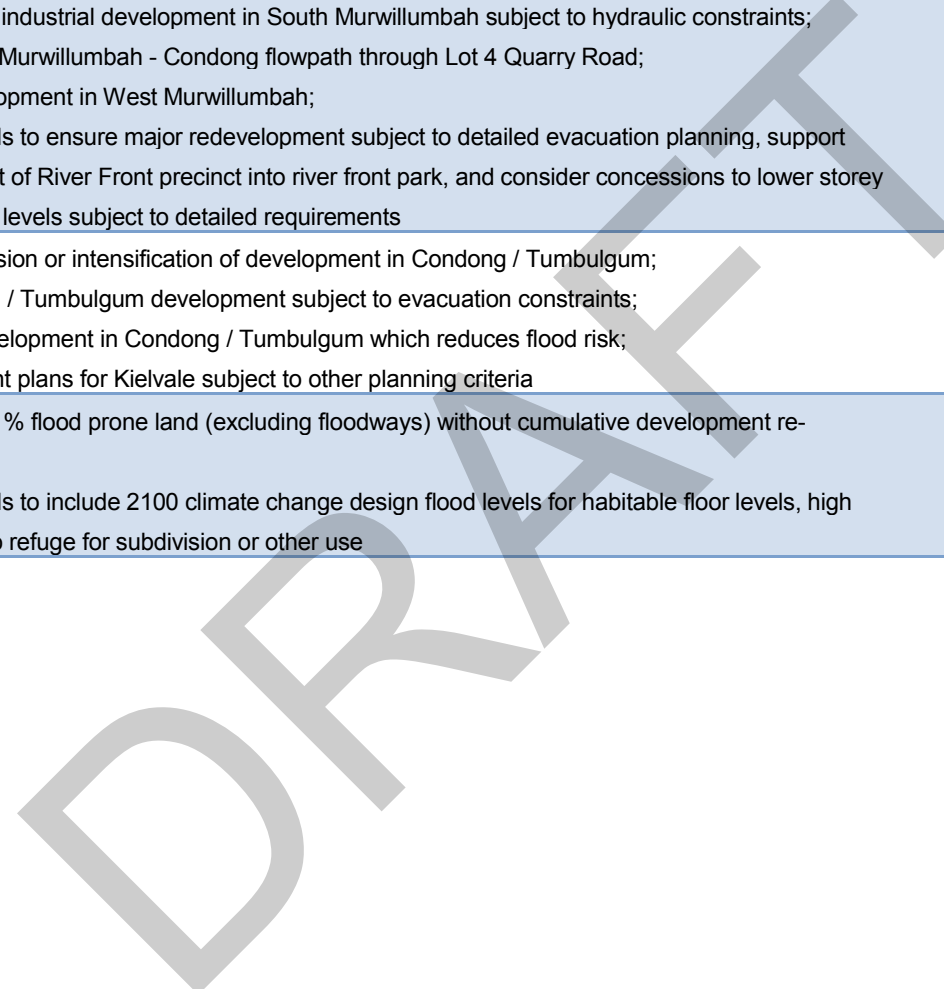
| FRMS Option | Measure | Required Actions | Responsibility | Estimated Cost | Priority |
|-------------|--|---|----------------|---|----------|
| 1, 2 | Commission local drainage studies | Scope and commission local drainage studies for Lower Tweed, Chinderah and Murwillumbah | TSC / OEH | \$50,000 to \$150,000 approx. per study (x 3 studies) | High |
| 3 | Raise Tweed Heads South levee | Commission levee overtopping study (see 4); Commission detailed costing by quantity surveyor; Undertake community consultation | TSC / OEH | ~\$11 million capital costs; \$200,000 pa maintenance costs | Medium |
| 5 | Extend Tweed Heads South levee | Review land zoning, land resumption etc.; Commission levee overtopping study (see 4); Commission detailed costing by quantity surveyor; Undertake community consultation | TSC / OEH | >\$10 million capital costs; \$100,000 pa maintenance costs | Medium |
| 4, 7 | Commission levee overtopping studies | Scope and commission levee overtopping study for Tweed Heads South and Murwillumbah | TSC / OEH | \$30,000 approx. per study (x 2 studies) | Medium |
| 6 | Preserve 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 | High |
| 8 | Support Community FloodSafe Program | Update FloodSafe Program strategies to include information from FRMS; Continue to support program as primary means of community flood education | SES | Normal operating budget | High |
| 9 | Educate residents about evacuation planning | Include evacuation planning information in FloodSafe Program (see 8) | SES | Include in Community FloodSafe Program (see 8) | Medium |
| 10 | 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 | \$30,000 approx. | High |
| 18 | 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 / TSC | Include in Community FloodSafe Program (see 8) | High |
| 11 | Update flood intelligence cards | Verify recommendations about datums from 2008 flood intelligence review; Update flood intelligence cards | SES / TSC | Normal operating budget | High |
| 12 | 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 approx. | High |
| 13 | Continue Flood Watch Network | Develop system to receive / integrate information; Identify / recruit members for FWN; Educate FWN members | SES | Normal operating budget | Medium |
| 14 | Review flood warning resources and plans | Review and update response plans based on FRMS information; Include risk-based prioritisation of resources and plans for warning; Consult residents about preferred warning methods | SES | Minimal cost to review; Additional cost depends on any new resources / systems required | High |
| 15 | Include Tumbulgum gauge in warning system | Put forward recommendation to NSW Flood Warning Committee; Update FESP if required | BoM / SES | Minimal cost to progress to NSW FWCC | Medium |
| 16 | Improve storm surge prediction capabilities | Advise local SES when storm surge prediction products upgraded; Update FESP accordingly | BoM / SES | Minimal cost | Medium |
| 17 | Commission detailed evacuation planning study | Commission study to inform SES evacuation planning | TSC / SES | \$25,000 per region | High |
| 19 | Review plans for areas with insufficient warning | Identify areas where pre-emptive evacuation may be required; Update FESP accordingly; Educate residents in these areas about the local risks, plans and implications | SES | Include in Community FloodSafe Program (see 8) | High |
| 20 | Include pedestrian evacuation in planning | Identify areas where pedestrian evacuation may be required, from detailed evacuation planning study; Update FESP accordingly; Educate residents in these areas about the local risks, plans and implications | SES | Include in Community FloodSafe Program (see 8) | Medium |

IMPLEMENTATION PLAN

| FRMS Option | Measure | Required Actions | Responsibility | Estimated Cost | Priority |
|-------------|--|--|------------------|--|----------|
| 21 | Develop rural evacuation plans | Identify rural areas where evacuation may not be possible, from detailed evacuation planning study; Establish evacuation plans; Update FESP accordingly; Educate residents in these areas about the local risks, plans and implications | SES | Include in Community FloodSafe Program (see 8) | Medium |
| 22, 23 | Review evacuation centres | Prompt to review communications between SES, TSC and DoCS for future evacuations; Continue consultative review of evacuation centre capacities and planning issues | SES / DoCS / TSC | Minimal cost to review; Additional cost depends on any new resources required | Medium |
| 24 | Identify alternative to Tweed Civic Centre | Identify alternative evacuation centre and check capacity requirements; Update FESP | SES / DoCS | Minimal cost to review; Additional cost depends on any new resources required | Medium |
| 25 | Establish new voluntary house purchase scheme | Confirm suitability of properties for inclusion; Commence new scheme | TSC / OEH | \$2.8 million approx. | Medium |
| 26 | Establish new voluntary house raising scheme | Confirm suitability of properties for inclusion; Commence new scheme | TSC / OEH | \$2.1 million approx. | Medium |
| 27 | Implement climate change adaptation measures | Include climate change considerations in design and upgrade of infrastructure and flood defences; Educate residents of increase in flood risk due to climate change | TSC | Depends on works; Include in Community FloodSafe Program (see 8) | Low |
| 28 | Implement climate change planning measures | Retain controls for greenfield subdivision; Introduce controls for commercial / industrial rezoning, new rural development and time-limited consents | TSC | Normal operating budget | Medium |
| 29, 30, 31 | Review and implement planning measures – whole study area | Refine LEP flood related local provisions; Update controls to include hydraulic constraints, floor level controls on commercial and industrial development, consistent car parking / driveway controls, detailed definition of acceptable flood refuges, provision of guidance for assessing climate change effects, flood risk stormwater and overland flow; Clarification of Codes SEPP; Establishment of S94 contributions plans; Updates to Council's flood policies; Refinement of Section 149 notification and notations; Periodic reviews of protocols to release flood risk information to public; Adopt cumulative development scenario for management of hydraulic impacts; Apply evacuation risk classes (ERCs) in the strategic planning process | TSC | Normal operating budget | Medium |
| 32, 33 | Implement planning measures – Lower Tweed | Support plans for Tweed Heads North subject to detailed assessment / requirements; Reject plans for Tweed Heads South in current form; Update controls to include 2100 climate change design flood level for Tweed City habitable floor level, preferential emphasis on evacuation over refuge, detailed definition of acceptable flood refuges as secondary evacuation measure | TSC | Normal operating budget | Medium |
| 34, 35 | Review and implement planning measures – Chinderah, Fingal Head, West Kingscliff | Support plans for Tweed Coast Strategy subject to other planning criteria; Reject plans for Chinderah Village expansion; Further stakeholder consultation regarding flood risk constraints to Chinderah Village expansion; Support plans for other Chinderah / West Kingscliff development subject to evacuation and cumulative development constraints; Update controls to clarify requirements for detailed evacuation assessment of future urban development, limit incremental intensification of development | TSC | Normal operating budget | Medium |

IMPLEMENTATION PLAN

| FRMS Option | Measure | Required Actions | Responsibility | Estimated Cost | Priority |
|-------------|---|---|----------------|-------------------------|----------|
| 36, 37 | Review and implement planning measures – Murwillumbah, South Murwillumbah | Review plans to increase CBD residential development subject to evacuation constraints; Review plans to fill allotments behind levee subject to local drainage and levee overtopping studies; Reject plans to increase residential densities in the Prospero Street, South Murwillumbah Riverfront and South-Side Residential Precincts; Further stakeholder consultation regarding flood risk constraints to residential development in South Murwillumbah; Support commercial redevelopment which reduces flood risk; Limit plans for Wardrop Valley / Fernvale development subject to hydraulic and evacuation constraints; Limit plans for industrial development in South Murwillumbah subject to hydraulic constraints; Secure South Murwillumbah - Condong flowpath through Lot 4 Quarry Road; Support development in West Murwillumbah; Update controls to ensure major redevelopment subject to detailed evacuation planning, support redevelopment of River Front precinct into river front park, and consider concessions to lower storey habitable floor levels subject to detailed requirements | TSC | Normal operating budget | Medium |
| 38 | Review and implement planning measures – Riverside Villages | Reject subdivision or intensification of development in Condong / Tumbulgum; Limit Condong / Tumbulgum development subject to evacuation constraints; Support redevelopment in Condong / Tumbulgum which reduces flood risk; Support current plans for Kielvale subject to other planning criteria | TSC | Normal operating budget | Low |
| 39, 40 | Review and implement planning measures – Rural Areas | Limit filling to 1% flood prone land (excluding floodways) without cumulative development re-assessment; Update controls to include 2100 climate change design flood levels for habitable floor levels, high level access to refuge for subdivision or other use | TSC | Normal operating budget | Medium |



13 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.

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14 REFERENCES

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