SNOWY VALLEYS COUNCIL

ADELONG
FLOODPLAIN RISK MANAGEMENT
STUDY AND PLAN

JULY 2018

VOLUME 1 – REPORT

DRAFT REPORT FOR PUBLIC EXHIBITION

Job No: DP424 File: AFRMS_V1_Report_[Rev 1.2].doc	Date: August 2018 Rev No: 1.2	Principals: SAB Authors: SAB/DW

Document Set ID: 2012463
Version: 2, Version Date: 30/11/2018

FOREWORD

NSW Government's Flood Policy

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

Under the Policy, the management of flood liable land remains the responsibility of local government. The State subsidises flood mitigation works to alleviate existing problems and provides specialist technical advice to assist councils in the discharge of their floodplain management responsibilities. The Policy provides for technical and financial support by the State through the following four sequential stages:

1.	Data Collection and Flood Study	Collects flood related data and undertakes an investigation to determine the nature and extent of flooding.
2.	Floodplain Risk Management Study	Evaluates management measures for the floodplain in respect of both existing and proposed development.
3.	Floodplain Risk Management Plan	Involves formal adoption by Council of a plan of management for the floodplain.
4.	Implementation of the Plan	Construction of flood mitigation works to protect existing development. Use of Local Environmental Plans to ensure new development is compatible with the flood hazard. Improvements to flood emergency management procedures.

Presentation of Study Results

The results of the flood study investigations commissioned by Snowy Valleys Council have been presented in two separate reports:

- *Adelong Flood Study* dated September 2014.
- ***Adelong Floodplain Risk Management Study & Plan (this present report)***

The studies have been prepared under the guidance of the Floodplain Risk Management Committee comprising representatives from Snowy Valleys Council, the Office of Environment and Heritage and the NSW State Emergency Service.

ACKNOWLEDGEMENT

Snowy Valleys Council has prepared this document with financial assistance from the NSW Government through its Floodplain Management Program. This document does not necessarily represent the opinions of the NSW Government or the Office of Environment and Heritage.

NOTE ON NAMING CONVENSION

For the purpose of the following discussion the urbanised parts of Adelong are said to be located on the western overbank of Adelong Creek, with the creek said to flow in a northerly direction.

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ABBREVIATIONS

AEP	Annual Exceedance Probability (%)
AHD	Australian Height Datum
ARF	Areal Reduction Factor
ARI	Average Recurrence Interval (years)
ARR	Australian Rainfall and Runoff (1987 Edition)
BoM	Bureau of Meteorology
Council	Snowy Valleys Council
DECC	Department of Environment and Climate Change
FDM	Floodplain Development Manual, 2005
FFA	Flood Frequency Analysis
FRMC	Floodplain Risk Management Committee
FPL	Flood Planning Level (1% AEP flood level + freeboard)
FPA	Flood Planning Area
FRMS	Floodplain Risk Management Study
FRMP	Floodplain Risk Management Plan
FRMS&P	Floodplain Risk Management Study and Plan
IFC	Ideal Flow Conditions
LEP	Local Environmental Plan
LiDAR	Light Detection and Ranging
MFL	Minimum Floor Level
NSWG	New South Wales Government
NSW SES	New South Wales State Emergency Service
OEH	Office of Environment and Heritage
PBC	Partially Blocked Conditions
PMF	Probable Maximum Flood
PMP	Probable Maximum Precipitation
RMS	New South Wales Roads and Maritime Services
STP	Sewage Treatment Plant
VP	Voluntary Purchase
WTP	Water Treatment Plant

SUMMARY

S1 Study Objectives

Snowy Valleys Council (**Council**) commissioned the *Floodplain Risk Management Study and Plan* for the township of Adelong. The overall objectives of the *Floodplain Risk Management Study (**FRMS**)* were to assess the impacts of flooding, review existing Council policies as they relate to development of land in flood liable areas, consider measures for the management of flood affected land and to develop a *Floodplain Risk Management Plan (**FRMP**)* which:

i) Proposes modifications to existing Council policies to ensure that the development of flood affected land is undertaken so as to be compatible with the flood hazard and risk.

ii) Proposes *Flood Planning Levels* for the various land uses in the floodplain.

iii) Sets out the recommended program of works and measures aimed at reducing over time, the social, environmental and economic impacts of flooding.

iv) Provides a program for implementation of the proposed works and measures.

The *FRMS* focuses on *Main Stream Flooding* from Adelong Creek, Black Creek, Tanyard Creek, Golden Gully and an unnamed tributary that joins the creek opposite the extension of Gundagai Street, *Minor Tributary Flooding* which occurs as a result of the surcharge of the minor gullies that drain the rural areas which border the town, and *Major Overland Flow* which occurs in the developed parts of Adelong.

S2 Study Activities

The activities undertaken in this *FRMS* included:

1. Review of flooding patterns at Adelong for flood events up to the Probable Maximum Flood (**PMF**), as determined in the *Adelong Flood Study (*herein, referred to as the *Flood Study*), which was adopted by Council in 2014. (**Chapter 2**).
2. Undertaking a consultation program over the course of the study to ensure that the Adelong community was informed of its objectives, progress and outcomes (**Chapters 1** and **3**, as well as **Appendix A**).
3. Assessment of the economic impacts of flooding, including the numbers of affected properties and estimation of flood damages (**Chapter 2** and **Appendix B**).
4. Review of current flood related planning controls for Adelong and their compatibility with flooding conditions (**Chapter 2**).
5. Strategic review of potential floodplain management works and measures aimed at reducing flood damages, including an economic assessment of several measures (**Chapter 3** and **Appendix D**).
6. Definition of flooding behaviour at Adelong for a flood with an AEP of 5 per cent (**Appendix E**).
7. Ranking of works and measures using a multi-objective scoring system which took into account economic, financial, environmental and planning considerations (**Chapter 4**).
8. Preparation of a draft *FRMP* for Adelong (**Chapter 5**).

S3 Summary of Flood Impacts

The study area comprises the urban area of Adelong and its immediate environs. Flooding in the town is of a "flash flooding" nature, with water levels in Adelong Creek peaking about six hours, and those in the smaller tributaries about one hour after the commencement of heavy rainfall. On the smaller, urban catchments the time to peak on the Major Overland Flow paths will generally be less than one hour. **Figures 2.3** to **2.4** show the nature of both Main Stream and Minor Tributary Flooding, as well as Major Overland Flow at Adelong for the 1% annual exceedance probability (**AEP**) and PMF events, respectively assuming ideal flow conditions (i.e. no blockage of the bridges which cross Adelong Creek).

At the 1% AEP level of flooding under ideal flow conditions, 61 residential and 15 commercial/industrial properties would be flood affected (i.e. water has entered the allotment). Five of the affected residential properties and three of the affected commercial/industrial properties would experience above-floor inundation in a 1% AEP flood event. While two public buildings would be flood affected at the 1% AEP level of flooding, floodwater would not inundate their floors. The total flood damages at Adelong would amount to $0.87 Million in the event of a 1% AEP flood.

The "present worth value" of damages resulting from all floods up to the magnitude of the 1% AEP event at a seven per cent discount rate and 50 year economic life is $0.91 Million. This number represents the amount of capital spending that would be justified if a particular flood mitigation scheme prevented flooding for all properties up to the 1% AEP event.

A large amount of woody debris has historically been observed to lodge on the two road bridges which cross Adelong Creek at Adelong during major flood events. While both bridges have recently been upgraded which has reduced their blockage potential, the *Flood Study* demonstrated that the partial blockage of the bridge on the Snowy Mountain Highway (Highway No. 4) (named by NSW Roads and Maritime Services (**RMS**) as the "*Herb Feint Bridge*") has the potential to cause hazardous flooding conditions to arise in existing development that is located along Tumut Street.

Figure 2.10 shows the indicative depth and extent of inundation for a 1% AEP flood event assuming a partial blockage of both the Herb Feint Bridge and the recently upgraded bridge on Selwyn Street (Main Road 280) (known locally as "*Rimmers Bridge*") by floating debris, while **Figure 2.11** shows the impact a partial blockage of the two structures would have on flooding behaviour for an event of this magnitude.

While a partial blockage of Rimmers Bridge would result in an increase in peak 1% AEP flood levels of up to 300 mm, a partial blockage of the Herb Feint Bridge has the potential to increase peak 1% AEP flood levels by more than one metre. The increase in peak flood levels results in floodwater breaking out of Adelong Creek along its western bank upstream of the Herb Feint Bridge, where it flows in a northerly direction along Tumut Street. The resulting flooding patterns would be similar to what occurred in the recent October 2010 flood, when both the partially constructed Herb Feint Bridge and the partially demolished old wooden bridge which it replaced (referred to herein as the "*Adelong Bridge*") experienced a partial blockage by floating debris. **Plates 9**, **10**, **11**, **12**, **13** and **14** in **Appendix C** show the nature of flooding along the overland flow path which formed along Tumut Street when the partially demolished Adelong Bridge and partially constructed Herb Feint Bridge were partially blocked by floating debris during the October 2010 flood.

A partial blockage of the two road bridges by floating debris would result in an additional nine residential and three commercial/industrial properties experiencing above-floor inundation during a 1% AEP event, while no additional public buildings would be damaged. While the total flood damage at Adelong due to a partial blockage of the two bridges would double from $0.87 Million to $1.69 Million in a 1% AEP flood event, the "present worth value" of damages resulting from all floods up to this magnitude of flood would only increase from $0.98 Million to $0.95 Million. The minor increase in the "present worth value" of damages is a result of Adelong Creek only breaking its banks for relatively infrequent flood events.

S4 Flood Risk and Development Controls

A draft *Flood Policy* has been prepared to guide future development in flood prone areas in Adelong (refer **Appendix D**). The policy is based on the three types of flooding that are present at Adelong, those being Main Stream Flooding, Minor Tributary Flooding and Major Overland Flow. Controls over development are graded according to the flood risk. The delineation of flood risk zones is based on the impact a partial blockage of the two road bridges at Adelong will have on flooding behaviour, the proximity to flow paths, depths and velocities of flow, the rate of rise of floodwaters and ease of evacuation from the floodplain in the event of a flood emergency.

Figure D1.1 in the *Flood Policy* is an extract from the *Flood Planning Map* relating to Adelong and its immediate environs. The extent of the Flood Planning Area (**FPA**) (the area subject to flood related development controls) is shown in a solid red colour on the *Flood Planning Map* and has been defined as follows:

- In areas affected by Main Stream Flooding, the FPA is based on the traditional definition of the area which lies below the peak 100 year ARI flood level plus 500 mm freeboard.
- In areas affected by Minor Tributary Flooding, the FPA is defined as areas where the depth of inundation in a 1% AEP event exceeds 150 mm.
- In areas affected by Major Overland Flow, the FPA is defined as the extent of the High and Low Hazard Floodway zones, as well as areas where depths of inundation in a 1% AEP exceed 150 mm.

The illustration in **Section 5.9.1** of the *FRMP* (refer **Chapter 5** of this report) demonstrates the derivation of the FPA in areas affected by Main Stream and Minor Tributary Flooding, as well as Major Overland Flow. An Outer Floodplain has also been defined at Adelong comprising the additional land flooded between the extent of the FPA and the PMF, as shown on the *Flood Planning Map*.

Minimum floor level requirements would be imposed on future development in properties that are identified as lying either partially or wholly within the extent of the FPA shown on the *Flood Planning Map*. The minimum floor levels for all land use types affected by Main Stream Flooding is the level of the 1% AEP flood event plus 500 mm freeboard, while those for all land use types affected by Major Overland Flow is the level of the peak 1% AEP flood event plus 300 mm freeboard. The illustration in **Section 5.9.1** of the *FRMP* (refer **Chapter 5** of this report) demonstrates the minimum flood level requirements in areas subject to Main Stream and Minor Tributary Flooding, as well as Major Overland Flow.

S5 The Floodplain Risk Management Plan

The *FRMP* showing recommended flood management measures for Adelong is presented in **Chapter 5**, with the recommended works and measures summarised in **Table S1** at the end of this Summary. The recommended works and measures have been given a provisional priority ranking, confirmed by the Floodplain Risk Management Committee, according to a range of economic, social, environmental and other criteria set out in **Table 4.1** of the report.

The draft *FRMP* includes six management measures which could be implemented by Council with the assistance of New South Wales State Emergency Service (**NSW SES**), five of which would not require State Government funding. The six measures are as follows:

- **Measure 1** - The application of a graded set of planning controls for future development that recognise the location of the development within the floodplain; to be applied through the draft *Flood Policy* for Adelong, included in the report as **Appendix D**. Application of these controls by Council will ensure that future development in flood liable areas in Adelong is compatible with the flood risk.
- **Measure 2** – Minor amendment to the wording of clause 6.2 of the *Tumut Local Environmental Plan 2012* (***Tumut LEP 2012***) in order to support the implementation of the *Flood Policy*, as well as the inclusion of a new floodplain risk management clause which would apply to land identified as Outer Floodplain (i.e. to land which lies between the FPA and the extent of the PMF).
- **Measures 3** - Improvements in the NSW SES's emergency planning, including use of the flood related information contained in this study to update the *Tumut Local Flood Plan*.
- **Measure 4** – The development and implementation of a flood awareness and education program for residents and business owners located on the floodplain at Adelong. This could include the preparation of a *Flood Information Brochure* to be prepared by Council with the assistance of NSW SES containing both generic and site specific data and distributed with the rate notices.
- **Measure 5** – The installation of a telemetered stream gauge immediately upstream of the Herb Feint Bridge in combination with an automated broadcast system which will take the form of a loud speaker system. The flood warning system would alert residents and business owners located along Tumut Street of rising water levels in Adelong Creek, either due to increases in the rate of flow and/or as a result of a partial blockage of the Herb Feint Bridge by floating debris.
- **Measure 6** – The development and implementation of a program for monitoring and recording the possible accumulation of floating debris on both Rimmers Bridge and the Herb Feint Bridge during future flood events. The data gathered by the program would assist in the decision as to whether a debris control structure is required in Adelong Creek upstream of Adelong.

Two measures involve works within the inbank area of Adelong Creek and comprise the following:

- **Measure 7** – The development and implementation of a *Vegetation Management Plan* for the reach of Adelong Creek upstream of Herb Feint Bridge. The measure includes the removal of several large poplar trees that are at risk of being undermined during a flood event.

- **Measure 8** – The removal by RMS of a remnant section of the Adelong Bridge given its potential to capture floating debris and increase the scour potential beneath the Herb Feint Bridge.

The implementation of both of these measures would require State Government funding.

The final measure (**Measure 9**) involves the upgrade of the existing stormwater drainage system in Tumut Street and Lockhart Street. The measure will reduce the frequency of inundation in several residential and commercial properties that are located between the two roads. It will also reduce the duration of ponding in Tumut Street.

S6 Timing and Funding of FRMP Measures

The total estimated cost to implement the preferred floodplain management strategy is $160,000, exclusive of Council and NSW SES Staff Costs. The timing of the measures will depend on Council's overall budgetary commitments and the availability of both Local and State Government funds.

Assistance for funding qualifying projects included in the *FRMP* may be available upon application under the Commonwealth and State funded floodplain management programs, currently administered by the Office of Environment and Heritage.

S7 Council Action Plan

1. Council finalises the *FRMS* report and approves the draft *FRMP* according to the procedure recommended in **Section 5.15**.
2. Council and NSW SES commence work on the "non-structural" measures in the *FRMP* (**Measures 1**, **2**, **3**, **4** and **6**).
3. Council applies for Government Funding for:
    a. the installation of a telemetered stream gauge immediately upstream of the Herb Feint Bridge, in combination with an automated broadcast system in the form a loud speaker system (**Measure 5**); and
    b. the ongoing maintenance of vegetation along the reach of Adelong Creek upstream of Herb Feint Bridge, which is to include the cost of removing several large poplar trees that are located immediately upstream of the Herb Feint Bridge (**Measure 7**).
4. RMS to action the removal of the remnant section of the Adelong Bridge (**Measure 8**).
5. Council to undertake the upgrade of the existing stormwater drainage system in Tumut Street and Lockhart Street (**Measure 9**).

TABLE S1
RECOMMENDED MEASURES FOR INCLUSION IN THE ADELONG FLOODPLAIN RISK MANAGEMENT PLAN

Measure	Required Funding	Features of the Measure	Priority
1. Implement flood related controls over future development in flood prone areas in Adelong.	Council's staff costs	• Control development in floodplain as summarised in the draft *Flood Policy* (refer **Appendix D**). • *Flood Policy* caters for three types of flooding: Main Stream Flooding (Adelong Creek, Black Creek, Tanyard Creek, Golden Gully and the unnamed tributary which joins Adelong Creek east of Gundagai Street); Minor Tributary Flooding (minor gullies which drain the rural areas bordering Adelong) and Major Overland Flow principally through the urban parts of the town. • Graded set of flood controls based on location within the *Flood Planning Area* (**FPA**). For Main Stream Flooding, FPA is based on the traditional definition of the area which lies below the peak 100 year ARI flood level plus 500 mm freeboard. For Minor Tributary Flooding, FPA is defined as areas where the depth of inundation in a 1% AEP event exceeds 150 mm. For Major Overland Flow, FPA is defined as the extent of the High and Low Hazard Floodway zones, as well as areas where depths of inundation in a 1% AEP exceed 150 mm. • Minimum floor levels for residential development to be 1% AEP flood level plus 500 mm in areas subject to Main Stream and Minor Tributary Flooding; and 300 mm for areas affected by Major Overland Flow. Critical services and flood-vulnerable residential development (e.g. housing for aged persons and persons with disabilities) to be subject to more stringent controls than other land uses, especially in areas subject to Main Stream and Minor Tributary Flooding. • Council's evaluation of development proposals to use data presented in the *Flood Study* and in this *FRMS*.	**Priority 1**: this measure is designed to mitigate the flood risk to future development and has a high priority for inclusion in the *FRMP*. It does not require Government funding.
2. Update wording in *Tumut LEP 2012*	Council's staff costs	• Minor amendment is required to the wording of clause 6.2 in Tumut LEP 2012. • A new flood risk management clause should be incorporated in Tumut LEP 2012 which applies to land that lies between the FPA and the Probable Maximum Flood (**PMF**). The new clause relates to development with particular evacuation or emergency response issues (e.g. group homes, residential aged care facilities, etc). It is also aimed at protecting the operational capacity of emergency response facilities and critical infrastructure during extreme flood events.	**Priority 1**: this measure is required in order to implement the *Flood Policy*. It does not require State Government funding.
3. Ensure flood data in this *FRMS* are available to the NSW SES for improvement of flood emergency planning.	NSW SES costs	• NSW SES to update the *Tumut Local Flood Plan* using information on flooding patterns, times of rise of floodwaters and flood prone areas identified in the *Flood Study* and in this *FRMS*.	**Priority 1**: this measure would improve emergency response procedures and has a high priority. It does not require State Government funding.
4. Develop and implement flood awareness and education program for residents and business owners located on the floodplain.	Council staff and NSW SES costs	• Council to inform residents of the flood risk, based on the information presented in the *FRMS*. (e.g. displays of flood mapping at Council offices, preparation of *Flood Information Brochure* for distribution with rate notices, etc).	**Priority 1**: this measure would improve the flood awareness of the community and has a high priority. It does not require State Government funding.
5. Installation of an automated water level alert system	$80,000	• Installation of a telemetered stream gauge immediately upstream of the Herb Feint Bridge. • The linking to the telemetered stream gauge of an automated broadcast system in the form of a loud speaker system. • The flood warning system would alert residents and business owners located along Tumut Street of rising water levels in Adelong Creek, either due to increases in the rate of flow and/or as a result of a partial blockage of the Herb Feint Bridge by floating debris. • Key trigger levels are to be set based on the findings of the *Flood Study* and this *FRMS*. It is envisaged that the trigger levels would be set based on a ready-set-go type messaging system, as evacuation of residents and business owners located along Tumut Street may not be necessary during every flood event. Business owners will also require sufficient time to shift stock to a higher level prior to evacuating the premises.	**Priority 1**: this measure will manage risk of life and reduce flood damages along Tumut Street during either rare flood events and/or when the Herb Feint Bridge experiences a partial blockage by floating debris.
6. Develop and implement a blockage monitoring program	Council's staff costs	• Council to develop a program for monitoring and recording the possible accumulation of floating debris on both Rimmers Bridge and the Herb Feint Bridge during future flood events. • The recording of historic blockage at the two road bridges is to include both a written and date and time stamped photographic record.	**Priority 3**: this measure will assist in the assessment of whether a debris control structure is required in Adelong Creek upstream of the town

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TABLE S1 (Cont'd)
RECOMMENDED MEASURES FOR INCLUSION IN THE ADELONG FLOODPLAIN RISK MANAGEMENT PLAN

Measure	Required Funding	Features of the Measure	Priority
7. Develop and implement a *Vegetation Management Plan*	$80,000	• The *Vegetation Management Plan* will identify areas which require regular maintenance upstream of Herb Feint Bridge. It will also describe the scope of any rehabilitation works which would be required following the completion of any inbank works. • The measure includes the removal of several large poplar trees that are located immediately upstream of the Herb Feint Bridge given their potential to be undermined and increase the risk of blockage during a flood event. • The required funding would permit the development of the *Vegetation Management Plan*, the removal of the large poplar trees that are located immediately upstream of the Herb Feint Bridge and the implementation of a regular maintenance program over a five year period.	**Priority 2**: this measure will reduce the risk of the Herb Feint Bridge experiencing a partial blockage during a flood. It will also reduce peak flood levels along Adelong Creek.
8. Removal of remnant section of Adelong Bridge	RMS' costs	• RMS to demolish and remove a remnant section of Adelong Bridge.	**Priority 3**: this measure will reduce the risk of floating debris accumulating beneath the Herb Feint Bridge. It will also reduce the scour potential in Adelong Creek.
9. Upgrade of existing stormwater drainage system	Council's costs	• Upgrade of existing stormwater drainage system in Tumut Street and Lockhart Street. • Works comprise additional pit and pipe capacity in the road reserve. • The works would need to be funded by Council as the measure would not qualify for State Government funding under its Floodplain Management Program.	**Priority 3**: This measure will reduce the frequency of inundation in several residential and commercial properties that are located between the two roads. It will also reduce the duration of ponding in Tumut Street.
Total Estimated Costs	**$160,000**		

1 INTRODUCTION

1.1 Study Background

Snowy Valleys Council (**Council**) commissioned the preparation of the *Floodplain Risk Management Study and Plan* (***FRMS&P***) for the township of Adelong in accordance with the New South Wales Government's Flood Prone Land policy. This report sets out the findings of the *FRMS&P* investigation which utilises the flood models that were developed as part of the *Adelong Flood Study* (***Flood Study***) (Lyall & Associates, 2014). **Figure 1.1** shows the location of Adelong, which lies 15 km to the west of Tumut, in the Adelong Creek catchment.

The *Floodplain Risk Management Study* (***FRMS***) reviewed baseline flooding conditions, including an assessment of economic impacts and the feasibility of potential measures aimed at reducing the impact of flooding on both existing and future development. This process allowed the formulation of the *Floodplain Risk Management Plan* (***FRMP***) for Adelong.

1.2 Background Information

The following documents were used in the preparation of this report.

- *Floodplain Development Manual* (New South Wales Government (**NSWG**), 2005)
- *Tumut Development Control Plan,* 2011 (*Tumut DCP 2011*)
- *Flood Intelligence Collection and Review for Towns and Villages in the Murray and Murrumbidgee Regions Following the October 2010 Flood* (Bewsher, 2011)
- *Tumut Local Environmental Plan, 2012* (*Tumut LEP 2012*)
- *Flood Intelligence Collection and Review for 24 Towns and Villages in the Murray and Murrumbidgee Regions Following the March 2012 Flood* (Yeo, 2013)
- *Tumut Shire Council Growth Strategy Planning Report – Adelong Investigation Areas* (SP, 2013)
- *Adelong Flood Study* (Lyall & Associates, 2014)

1.3 Overview of FRMS Report

The results of the *FRMS* and the *FRMP* are set out in this report. Contents of each Chapter of the report are briefly outlined below:

- **Chapter 2**, **Baseline Flooding Conditions**. This Chapter includes a description of the drainage system and a review of existing flood behaviour at Adelong as derived by hydrologic and hydraulic models that were developed as part of the *Flood Study*. The Chapter also summarises the impact that a partial blockage of Rimmers Bridge and Herb Feint Bridge by floating debris has on flooding patterns, the economic impacts of flooding on existing urban development, reviews Council's existing flood planning controls and management measures and NSW State Emergency Service's (**NSW SES's**) flood emergency planning. The Chapter also assesses the impacts of future urbanisation in the catchments, as envisaged by *Tumut LEP 2012* and *SP, 2013*.
- **Chapter 3**, **Potential Floodplain Management Measures**. This Chapter reviews the feasibility of floodplain management measures for their possible inclusion in the *FRMP*. The list of measures considered is based on input from the Community Consultation process, which sought the views of residents and business owners in Adelong in regards to potential

flood management measures which could be included in the *FRMP*. The measures are investigated at the strategic level of detail, including indicative cost estimates of the most promising measures and benefit/cost analysis.

- **Chapter 4**, **Selection of Floodplain Management Measures**. This Chapter assesses the feasibility of potential floodplain management strategies using a multi-objective scoring procedure which was developed in consultation with the Floodplain Risk Management Committee (**FRMC**) and outlines the preferred strategy.
- **Chapter 5** presents the *FRMP* which comprises a number of structural and non-structural measures which are aimed at increasing the flood awareness of the community and ensuring that future development is undertaken in accordance with the local flood risk.
- **Chapter 6** contains a glossary of terms used in the study.
- **Chapter 7** contains a list of References.

Four appendices provide further information on the study results:

Appendix A – Community Consultation summarises residents' and business owners' views on potential flood management measures which could be incorporated in the *FRMP*.

Appendix B – **Flood Damages** is an assessment of the economic impacts of flooding to existing residential, commercial and industrial development, as well as public buildings in Adelong. The damages have been assessed using the results of the *Flood Study*, an estimate of floor levels and characteristics of affected development derived from a combination of a property survey conducted by a registered surveyor and a 'drive-by' survey to estimate floor heights above a natural surface level derived from Light Detecting and Ranging (**LiDAR**) survey data. A damages assessment was also carried out assuming the two road bridges at Adelong are subject to a partial blockage by floating debris.

Appendix C – Plates Showing Historic Flooding at Adelong contains a series of photos showing flooding that was experienced in Adelong during the January 1984, October 2010 and March 2012 flood events.

Appendix D – **Draft Flood Policy** presents guidelines for the control of future urban development in flood prone areas at Adelong. The guidelines cater for *Main Stream Flooding* of Adelong Creek, Black Creek, Tanyard Creek, Golden Gully and an unnamed tributary that joins the creek opposite the extension of Gundagai Street, *Minor Tributary Flooding* which occurs as a result of the surcharge of the minor gullies that drain the rural areas which border the town, and *Major Overland Flow* which occurs in the developed parts of Adelong.

Appendix E – **Additional Flood Mapping** contains two figures which show flooding behaviour at Adelong for the 5% AEP event.

1.4 Community Consultation

Following the Inception Meeting of the FRMC which included representatives from Council, NSW Office of Environment and Heritage (**OEH**), NSW SES and the community, a *Community Newsletter* was prepared by the Consultants and distributed by Council to residents and business owners in Adelong. The *Community Newsletter* contained a *Community Questionnaire* seeking details from the community of flood experience and attitudes to potential floodplain management

measures. The views of the community on potential flood management measures to be considered in the study were also taken into account in the assessment presented in **Chapter 3** of the report, with supporting information in **Appendix A.**

The FRMC reviewed the potential flood management measures developed in **Chapter 3** and assessed the measures using the proposed scoring system of **Chapter 4**. The *FRMS* and accompanying *FRMP* were also reviewed by the FRMC and amended prior to public exhibition.

1.5 Flood Frequency and Terminology

In this report, the frequency of floods is referred to in terms of their Annual Exceedance Probability (**AEP**). The frequency of floods may also be referred to in terms of their Average Recurrence Interval (**ARI**). The approximate correspondence between these two systems is:

Annual Exceedance Probability (AEP) – %	Average Recurrence Interval (ARI) – years
0.2	500
0.5	200
1	100
10	10
20	5

The AEP of a flood represents the percentage chance of its being equalled or exceeded in any one year. Thus a 1% AEP flood, which is equivalent to a 100 year ARI, has a 1% chance of being equalled or exceeded in any one year and would be experienced, on the average, once in 100 years; similarly, a 20 year ARI flood has a 5% chance of exceedance, and so on.

The 1% AEP flood (plus freeboard) is usually used to define the Flood Planning Level (**FPL**) and Flood Planning Area (**FPA**) for the application of flood related controls over residential and commercial/industrial development. While a 1% AEP flood is a major flood event, it does not define the upper limit of possible flooding. Over the course of a human lifetime of, say 70 years, there is a 50 per cent chance that a flood at least as big as a 1% AEP event will be experienced. Accordingly, a knowledge of flooding patterns in the event of larger flood events up to the Probable Maximum Flood (**PMF**), the largest flood that could reasonably be expected to occur, is required for land use and emergency management planning purposes. In the *Flood Study*, flooding patterns in Adelong were assessed for design floods ranging between a 20% AEP event and the PMF.

2 BASELINE FLOODING CONDITIONS

2.1 Physical Setting

Adelong has a population of about 900 and is located on the Snowy Mountains Highway about 15 km west of Tumut. **Figure 1.1** shows that Adelong is located on Adelong Creek, which has a catchment area of about 160 km^2 at Adelong. Adelong Creek flows in a northerly direction around the eastern side of the township, while Black Creek, a minor tributary of Adelong Creek, flows in an easterly direction around its southern side, as shown on **Figure 2.1**. Most of the developed parts of Adelong are situated on high ground above the floodplains of both Adelong Creek and Black Creek.

2.2 Drainage System

The headwaters of the Adelong Creek catchment are located near the township of Batlow, which lies approximately 25 km to the south of Adelong. Flow in the creek discharges to the Murrumbidgee River about 30 km downstream of Adelong. The Adelong Creek catchment is characterised by a mixture of steep heavily wooded slopes and pastoral land.

Adelong Creek is characterised by relatively rapid drops in bed level through locations of exposed rock, punctuated by level pools. Adelong Falls is located downstream of the township. While the bed of the creek is generally devoid of vegetation, trees and shrubs do encroach on the creek as it meanders through the township. The banks of the creek are generally vegetated by dense stands of poplar trees. Following the October 2010 flood, the banks of Adelong Creek adjacent to the Herb Feint Bridge were cleared of vegetation and other floodplain obstacles such as the swimming pool. The upstream reach of Adelong Creek between Selwyn Street and Herb Feint Bridge was also cleared of poplar trees and other vegetation following the October 2010 flood.

As shown on **Figure 2.1**, there are a number of minor named and unnamed gullies that discharge to Adelong Creek in the vicinity of the township. The aforementioned Black Creek also joins Adelong Creek a short distance upstream of Rimmers Bridge in the vicinity of Adelong Showground.

The stormwater drainage system at Adelong generally comprises roadside table drains, with piped crossings at road intersections. There are four piped drainage lines which discharge to Adelong Creek downstream of the Herb Feint Bridge. These drainage lines control overland flow which approaches Tumut Street from the south.

The WaterNSW operated Batlow Road stream gauge (GS 410061) is located on Adelong Creek, approximately 3 km (by river) upstream of Rimmers Bridge. The stream gauge was first installed in September 1947 and later shifted in 1980 a distance of approximately 200 m upstream to its current location. The relocated gauge is located on a rock bar and has a gauge zero of RL 351.52 m AHD. The highest recorded stream gauging was taken on 26 September 1983, when the water level rose to a peak height of 2.55 m. The recorded flow rate in Adelong Creek at this peak height was 105 m^3/s.

2.3 Bridges in Adelong

Four bridges cross Adelong Creek as it flows through the township. The most upstream of the three is located on Selwyn Street (Main Road 280) and is known locally as Rimmers Bridge. The new four span reinforced concrete bridge recently replaced a wooden bridge which had the same number of spans. Each span on the new bridge is 12 m in length. Construction of the new bridge was completed at the time of the October 2010 flood.

The Herb Feint Bridge, which is located on the Snowy Mountain Highway (Highway No. 4) crossing of Adelong Creek, replaced two in-series wooden bridges, one which spanned the low flow section, and the other the right (northern) inbank area of the creek (the older twin bridges are referred to herein as the *"Adelong Bridge"*). While the soffit and railing levels of the new Herb Feint Bridge are similar to those of the Adelong Bridge, the piers of the Adelong Bridge, whilst smaller in diameter than those of the Herb Feint Bridge, were spaced at between 4.6 m and 8.5 m centres, whilst those of the new bridge are spaced at 15.5 m centres. The Herb Feint Bridge was under construction at the time of the October 2010 flood, with the eastern (upstream) portion of the new bridge only just completed on the day of the event. As a result, the waterway area beneath the two bridges was obstructed by both the new and old sets of bridge piers, in addition to the old centrally located embankment. Further discussion on the impact that the build-up of floating woody debris on both bridges had on the flood behaviour during the October 2010 flood is contained in **Section 2.4**.

A three span steel truss type pedestrian bridge was constructed by Council a short distance downstream of the Herb Feint Bridge in about 2009. The central span of the pedestrian bridge where it crosses the low flow section of Adelong Creek is about 20 m in length and has a soffit level of RL 334.3 m AHD.

A fourth high level suspension bridge crosses Adelong Creek a short distance downstream of the aforementioned pedestrian bridge. The suspension bridge, which provides pedestrian access directly to the Golden Gully Caravan Park, has been denoted herein as the "*Caravan Park Suspension Bridge*". The left (southern) abutment of the bridge is located on the left overbank of Adelong Creek in an area which was subject to relatively shallow inundation during the October 2010 flood.

2.4 Recent Flood Experience

Table 2.1 over the page shows the highest ranked annual flood peaks at Adelong dating back to 1948.

The October 2010 flood, which is the largest recorded in the 70 years of gauge data and equivalent to about a 1% AEP flood event, reached a peak of 4.61 m on the Batlow Road stream gauge. Rainfall recorded in three hourly intervals by the Bureau of Meteorology (**BoM**) at its Batlow rainfall warning gauge (GS 72004.1) indicates that the rain fell in two discrete bursts, with the second burst resulting in the major flooding that was experienced in Adelong on the afternoon of 15 October 2010.

The damaging flooding that was experienced at Adelong on the afternoon of 15 October 2010 was primarily confined to commercial properties located along Tumut Street and at the northern end of Selwyn Street. Several residential properties located along Tumut Street also experienced above-floor flooding, as did a single residence in Havelock Street. A single residence located immediately upstream of the Herb Feint Bridge on the opposing bank of Adelong Creek was also inundated above its floor (Bewsher, 2011).

Damaging flooding in Adelong was principally a result of floodwater which surcharged Adelong Creek on the upstream side of the Herb Feint Bridge which was under construction at the time of the flood (refer *Flood Study* for details). The owner of the property which is located on the eastern bank of Adelong Creek immediately upstream of the Herb Feint Bridge advised that a large amount of floating woody debris lodged on the upstream side of two bridges during the

October 2010 flood event. This observation is supported by a number of photos that were sourced during the preparation of the *Flood Study* (refer **Appendix C** of this report). The owner also advised that a large amount of scour occurred beneath the two bridges, which included the partial erosion of the centrally located embankment on Adelong Bridge.

The January 1984 flood is the second largest flood to have been occurred at Adelong since the Batlow Road stream gauge was installed in 1948. The water at the gauge reached a peak gauge height of 3.52 m, which corresponds to a flood with an AEP of about 2 per cent. The January 1984 flood caused minor flooding in property located along Tumut Street, when floodwater surcharged the western bank of Adelong Creek upstream of Adelong Bridge. Again, a large amount of floating woody debris was observed to have built up on Adelong Bridge during the flood event, which would have exacerbated flooding conditions along Tumut Street.

The March 2012 flood reached a peak gauge height of 3.11 m and was equivalent to about a 5% AEP flood event. Floodwater was generally confined to the inbank area of Adelong Creek, with no reported occurrence of above-floor flooding (Yeo, 2013). Since the completion of the *Flood Study* in 2014, Adelong experienced another relatively minor flood on 30 October 2016. The October 2016 flood reached a peak height of 2.15 m on the Batlow Road stream gauge, indicating that it had an AEP of greater than 20 per cent.

TABLE 2.1
HIGHEST RANKED ANNUAL FLOOD PEAKS AT ADELONG
AS RECORDED BY THE BATLOW ROAD STREAM GUAGE
1948 TO 2014

Flood Event	Gauge Height[1] (m)	Discharge (m^3/s)	AEP[2] (%)
October 2010	4.61	382.8	0.9
January 1984	3.52	212.4	2
March 2012[3]	3.11	162.6	5
October 1974	-	147.2	7
October 1975	-	129.8	10
October 1955	-	122.4	10
August 1983	2.63	112.9	11
October 1993	2.59	108.6	13
September 1960	-	100.2	14
December 1988	2.47	98.3	14

1. Gauge heights not quoted for floods that occurred prior to the relocation of the stream gauge in 1980.
2. The frequency of the highest ranked historic floods is based on the findings of the flood frequency analysis which was undertaken as part of the *Flood Study*.
3. Note that a flood occurred in September 2010 which reached 3.03 m on the Batlow Road stream gauge, indicating the event was of similar magnitude to that which occurred in March 2012.

2.5 Design Flood Behaviour

2.5.1 Background

The *Flood Study* defined the nature of Main Stream Flooding, Minor Tributary Flooding and Major Overland Flow in the vicinity of Adelong for floods ranging between 20 and 0.5% AEP, as well as the PMF event. Flood behaviour was defined using a two-staged approach to flood modelling involving the running in series of:

1. The hydrologic models of the Adelong Creek catchment and the urbanised parts of Adelong, based on the RAFTS and ILSAX rainfall-runoff software, respectively.
2. The hydraulic model of Adelong Creek and the drainage system in Adelong based on the TUFLOW software.

The RAFTS and ILSAX models computed discharge hydrographs, which were then applied to the TUFLOW hydraulic model at corresponding sub-catchment outlets. Design storms were derived using procedures set out in *Australian Rainfall and Runoff* (IEAust, 1987) and then applied to the RAFTS and ILSAX models to generate discharge hydrographs. These hydrographs constituted input to the TUFLOW hydraulic model.

The TUFLOW model used a two-dimensional (in plan), grid-based representation of the natural surface based on a LiDAR survey of Adelong, as well as piped drainage data provided by Council. Field survey was used to derive cross sections (normal to the direction of flow) along the inbank area of Adelong Creek, which was modelled as a one-dimensional element within TUFLOW. Field survey was also used to confirm details of three of the four bridges which presently cross Adelong Creek at Adelong (i.e. Rimmers Bridge, Herb Feint Bridge and the adjacent pedestrian bridge).[1]

An "envelope" approach was adopted for defining design water surface elevations and flow patterns throughout the study area. The procedure involved running the model for a range of storm durations to define the upper limit (i.e. the envelope) of expected flooding for each design flood frequency.

2.5.2 Recent Updates to Flood Study TUFLOW Model

The TUFLOW hydraulic model was reviewed and updated as part of the present investigation to account for the slope of the Pedestrian Bridge, Herb Feint Bridge and Rimmers Bridge decks (previously modelled at constant elevation), as well as an improved representation of the form losses associated with each of these structures. The refinement of the three bridges resulted in a decrease in design peak flood levels by up to 250 mm immediately upstream of Herb Feint Bridge and by up to 100 mm immediately downstream of Rimmers Bridge.

Another significant change that has occurred since the completion of the *Flood Study* is the clearing of vegetation (namely poplar trees and associated understorey type vegetation) along the banks of Adelong Creek between Selwyn Street and Herb Feint Bridge. While the removal of the vegetation will increase the hydraulic capacity of the inbank area of Adelong Creek, this feature was not incorporated in the hydraulic model as the ongoing maintenance of the area cannot be guaranteed. **Figure 2.2** illustrates the impact the recent stream clearing has had on peak 1% AEP flood levels.

[1] The suspension bridge which crosses Adelong Creek downstream of Herb Feint Bridge and provides access to the Golden Gully Caravan Park is a high level structure which will not impact flood behaviour. Details of this structure were therefore not required for inclusion in the hydraulic model which was developed as part of the *Flood Study*.

The hydrologic model that was developed as part of the *Flood Study* was also used to undertake a comparative assessment of peak flow estimates that were derived based on the methodologies set out in the 1987 and 2016 versions of *Australian Rainfall and Runoff* (IEAUST, 1987 and GA, 2016).

Table 2.2 over the page sets out the design peak flow estimates that were derived from the Flood Frequency Analysis (**FFA**) that was undertaken as part of the *Flood Study*, as well those that were generated by the hydrologic model based on IEAust, 1987 and GA, 2016.

Column C of **Table 2.2** shows that the adoption of a BX factor of 1.0 and a catchment roughness of 0.08 in combination with the IEAust, 1987 methodology resulted in the hydrologic model generating peak flows that closely matched the FFA (refer Column B and C). Adoption of the same parameters without an Areal Reduction Factor (**ARF**), but using the GA, 2016 methodology resulted in the hydrologic model generating peak flows that were smaller for the rarer flood events than those derived by the FFA (refer Column D). When an ARF was adopted (as per EA, 2016), the difference became greater (refer Column J).

The hydrologic catchment parameters were then varied in an attempt to identify a set of model parameters which would produce peak flows which matched those derived by the FFA. Columns E through I, as well as K and L show the peak flows derived for a range of parameter combinations. With an ARF applied, it was found that a catchment roughness of 0.02 was required in order to give a peak flow for the 1% AEP which matched the FFA (refer Column L). A catchment roughness of 0.02 corresponds to hard concrete surface and is therefore not representative of the largely rural Adelong Creek catchment.

Based on the findings of the analysis, it was concluded that the hydrologic model developed as part of the *Flood Study* could not be used in combination with the EA, 2016 methodology without adjusting other parameters such as initial and continuing loss. Based on this finding, the hydrologic model that was relied on for the preparation of the *Flood Study* was adopted for use in the present study.

2.5.3 Design Flooding Patterns

There are three main types of flooding that are experienced at Adelong:

- **Main Stream Flooding** resulting from flows that surcharge the main channel of Adelong Creek, as well as Black Creek, Tanyard Creek, Golden Gully and the unnamed tributary which joins Adelong Creek opposite the extension of Gundagai Street. While the flows in Adelong Creek may be several metres deep in the channel and relatively fast moving with velocities of greater than 2 m/s, flow in the other watercourses are generally shallower and slower moving in nature.
- **Minor Tributary Flooding** resulting from overflows of the minor gully systems which drain the relatively steep hillsides bordering Adelong Creek. Watercourses that are included in this definition are Nuggety Gully, Curtis Gully and Currans Gully.
- **Major Overland Flow** is present along several flow paths that run through the urbanised parts of Adelong. It is also present in the undeveloped areas which border the township. Flows on the Major Overland Flow paths would typically be less than 300 mm deep, travelling over the surface at velocities less than 0.5 m/s.

Figures 2.3 and **2.4** show the indicative extent and depths of inundation at Adelong resulting from the three aforementioned types of flooding for the 1% AEP and PMF events, respectively, noting that the information shown on these figures is for ideal flow conditions (i.e. for the case where both Rimmers Bridge and the Herb Feint Bridge are free of any obstructions).

TABLE 2.2
COMPARISON OF PEAK FLOWS[1]

Annual Exceedance Probability (%)	Peak Flow (m^3/s)										
	Flood Frequency Analysis[2]	RAFTS (IEAust, 1987)[2]	RAFTS (EA, 2016) [No ARF applied][3]						RAFTS (EA, 2016) [ARF applied][3]		
BX[4]		1.0	1.0	0.9	0.8	1.0	1.0	0.8	1.0	0.8	0.8
Manning's n[4]		0.08	0.08	0.08	0.08	0.07	0.04	0.05	0.08	0.04	0.02
[A]	[B]	[C]	[D]	[E]	[F]	[G]	[H]	[I]	[J]	[K]	[L]
20	84	80 [6hr]	76 [6hr]	82 [6hr]	89 [6hr]	83 [6hr]	105 [6hr]	107 [6hr]	-	-	-
10	120	117 [6hr]	122 [9hr]	129 [9hr]	136 [9hr]	130 [9hr]	154 [9hr]	157 [9hr]	-	-	-
2	270	270 [6hr]	248 [6hr]	257 [6hr]	269 [6hr]	258 [6hr]	302 [6hr]	308 [6hr]	195 [6hr]	282 [6hr]	302 [6hr]
1	375	366 [6hr]	299 [6hr]	313 [6hr]	327 [6hr]	315 [6hr]	369 [6hr]	379 [6hr]	235 [6hr]	319 [6hr]	367 [6hr]
0.5	500	432 [4.5hr]	-	-	-	-	-	-	-	-	-

1. Peak flows are given in m^3/s. Critical durations in hours are shown in square brackets
2. Derived as part of the *Flood Study*
3. ARF = Areal Reduction Factor
4. RAFTS model parameters

Main Stream Flooding – Adelong Creek

Floodwater is generally confined to the inbank area of Adelong Creek for floods up to about 5% AEP,[2] with surcharge of the overbank area occurring at the following locations for floods of lesser AEP:

- Floodwater commences to surcharge the western bank of Adelong Creek at the northern end of Selwyn Street for a flood with an AEP between 10 and 5 per cent.[3] Commercial development located adjacent to the bend in the creek is impacted by floodwater which surcharges the creek and flows across Selwyn Street in a 2% AEP flood.
- Floodwater commences to inundate low lying areas that are located on both the western and eastern overbank areas of Adelong Creek immediately upstream of Rimmers Bridge in a 2% AEP flood. Floodwater also commences to inundate Cromwell Street near its intersection with Selwyn Street. Floodwater begins to backwater toward the extension of Gundagai Street on the western overbank of Adelong Creek in a 2% AEP flood event. Floodwater which backs up into this area is joined by floodwater which surcharges the western bank of Adelong Creek upstream of Gundagai Street in a 1% AEP flood event. Three residential properties along Selwyn Street are at risk due to the breakout of floodwaters upstream of Gundagai Street.
- Floodwater surcharges Cromwell Street near its intersection with Selwyn Street in a 1% AEP flood, where it follows the line of a natural overbank flood runner north to Oberne Street. Several residences located along the western side of Selwyn Street north of Cromwell Street are affected by floodwater which breaks out of Adelong Creek at this location. One of these residences was observed to comprise slab-on-ground type construction. Floodwater also extends to the rear of several buildings which are located along the northern side of Tumut Street between Wyndam Street and Neill Street in a 1% AEP flood event. Floodwater would extend out to Tumut Street within several of these properties in a 0.5% AEP flood event.
- Floodwater commences to surcharge the western bank of Adelong Creek upstream of the Herb Feint Bridge for floods greater than 0.5% AEP. Floodwater which surcharges Adelong Creek at this location generally flows in a northerly direction along Tumut Street, where it discharges between several buildings before re-joining flow in the creek.

There is about 0.5 m freeboard to the soffit level of Rimmers Bridge, and zero freeboard to that of the Herb Feint Bridge in a 1% AEP flood.

The Golden Gully Caravan Park, which is located on the eastern bank of Adelong Creek a short distance downstream of the Herb Feint Bridge is located above the 1% AEP flood.

A common feature in areas where there are incised valleys with narrow floodplains (as is the case in Adelong), is a relatively large flood range, especially for the more extreme flood events. For example, the flood range at Adelong between the 20% and 1% AEP events is about 2 m, increasing to about 5 m between the 1% AEP and PMF events (refer **Figure 2.5**). Whilst the relatively large flood range does not translate into a large increase in the extent of flood affected

[2] Based on modelling of the March 2012 flood, which was equivalent to about a 5% AEP flood event (refer Figure 4.5 of the *Flood Study* for TUFLOW model results).

[3] By inspection of Figure E1.1 in **Appendix E** of this report, surcharge of the southern bank of Adelong Creek at this location is likely to occur during floods with AEP's of between 10 and 5 per cent.

land (i.e. because of the steep sided nature of the floodplain), this characteristic of flooding at Adelong needs to be taken into consideration when formulating appropriate flood related planning controls for vulnerable type development such as aged care, the locating of critical infrastructure and identifying appropriate flood evacuation routes.

Main Stream Flooding – Black Creek

Black Creek has limited capacity upstream of Todds Road and floodwater surcharges both its eastern and western bank during relatively frequent storm events. Depths of overbank flow are relatively shallow, in the range 0-300 mm for floods up to 1% AEP, with isolated areas of deeper flooding generally centred on the creek.

Floodwater surcharges the culverts under Adelong Cemetery Road for events as frequent as 20% AEP. Floodwater which surcharges the eastern bank of the creek at this location flows in an easterly direction along the upstream side of Oberne Street before crossing the road west of Neill Street. Depths of flow across the low point in the road increase from between 100-200 mm in a 20% AEP event to 300-400 mm in a 1% AEP event.

Floodwater also surcharges the eastern bank of Black Creek immediately upstream of the Todds Road culvert for events as frequent as 20% AEP. Floodwater which surcharges the creek at this location ponds along the northern (upstream) side of the road east of the creek, before surcharging Todds Road during storms larger than about 10% AEP. Floodwater which surcharges Todds Road east of Black Creek contributes to flooding in the Adelong Showground and in the rear of several residential properties which are located along the western side of Cromwell Street. While there is no existing residential development impacted by floodwater which surcharges Black Creek, consideration will need to be given to flooding behaviour during the rezoning and subdivision of land as part of the Adelong South-West Future Growth Area (refer **Section 2.13** for further details).

Main Stream Flooding – Tanyard Creek and Golden Gully

Floodwaters are generally confined to the immediate overbank area of both Tanyard Creek and Golden Gully near their confluence with Adelong Creek for events up to 0.2% AEP.

Minor Tributary Flooding

Floodwaters are generally confined to the immediate overbank area of the minor gullies which drain the rural areas which lie on the eastern side of Adelong Creek for events up to 0.2% AEP.

Major Overland Flow

Surcharge of the existing piped drainage system occurs for flows as frequent as 20% AEP. While depths of overland flow are generally no greater than 300 mm, greater depths do occur in property located along the western side of Wyndham Street north of Lockhart Street and between Neill and Havelock Streets north of Lockhart Street.

Flow velocities associated with Major Overland Flow at Adelong are relatively mild and generally do not exceed 0.5 m/s.

2.6 Hydrologic Standard of Existing Road Network

Both major and minor roads around Adelong are vulnerable to inundation during flood events. Identification of such roads is important to providing knowledge to NSW SES, identifying hazardous areas during floods, and evacuation planning.

The results of the hydraulic model show that Snowy Mountains Highway and Tumut Street become inundated in a 0.5% AEP flood event under ideal flow conditions. However, the accumulation of floating woody debris on the Herb Feint Bridge can cause floodwater to break out of Adelong Creek along its western bank for floods larger than a 2% AEP event.

While Rimmers Bridge remains flood free in all events up to the 0.2% AEP, its approaches via Cromwell Street and Selwyn Street commence to become inundated at the 2% and 1% level of flooding, respectively. Selwyn Street is also inundated at its northern end in a 2% AEP which prevents access to the commercial buildings that are located in this area.

While Bleak Street is a minor road, it is important in that it provides vehicular access to the electricity substation, as well as the Adelong Sewage Treatment Plant (**STP**). While flow in Nuggety Gully inundates Bleak Street in a 2% AEP event and prevents vehicular access to the STP, access to the electricity substation will only be prevented in a PMF flood event when flow in Adelong Creek will inundate a large section of the road.

The southern end of Campbell Street will be inundated in a 10% AEP event due to flow in Black Creek surcharging the culvert which is located adjacent to the Adelong Showground. At this time vehicular access to the Adelong Water Treatment Plant (**WTP**) will be prevented.

2.7 Existing Flood Mitigation Measures

Mitigation measures that have been undertaken by Council in recent years are limited to the stream clearing activities that took place following the October 2010 flood. This involved the removal of large stands of poplar trees and other vegetation along the creek banks between Herb Feint Bridge and the extension of Selwyn Street. The impact that this clearing has had on a flood with an AEP of 1 per cent (which approximates the October 2010 flood) is shown on **Figure 2.2**. It should be noted that this mitigation measure requires ongoing maintenance if its effectiveness as a flood mitigation measure is to be maintained.

The replacement of the Adelong Bridge with the Herb Feint Bridge by the NSW Roads and Maritime (**RMS**) can also be considered a flood mitigation measure, as it has increased the waterway area beneath the bridge deck and also reduced the risk of blockage by floating woody debris given the reduced number and increased spacing of the bridge piers.

2.8 Economic Impacts of Flooding

The economic consequences of floods are discussed in **Appendix B**, which assesses flood damages to residential, commercial / industrial property and public buildings in areas affected by Main Stream Flooding, Minor Tributary Flooding and Major Overland Flow. There are limited data available on historic flood damages to the urban sectors in the study area. Accordingly, it was necessary to use data on damages experienced as a result of historic flooding in other urban centres. The residential flood damages were based on the publication *Floodplain Risk Management Guideline No. 4, 2007* (***Guideline No. 4***) published by the Department of Environment and Climate Change (**DECC**) (now OEH). Damages to industrial and commercial development, as well as public buildings were evaluated using data from previous floodplain management investigations in NSW.

It is to be noted that the principal objectives of the damages assessment were to gauge the severity of urban flooding likely to be experienced at Adelong and also to provide data to allow the comparative economic benefits of various flood modification measures to be evaluated in **Chapter 3** of the report. As explained in **Appendix B**, it is not the intention to determine the depths of inundation or the damages accruing to *individual properties*, but rather to obtain a reasonable estimate of damages experienced over the extent of the urban area in the town for the various design flood events. The estimation of damages using *Guideline No. 4* (in lieu of site specific data determined by a loss adjustor) also allows a uniform approach to be adopted by Government when assessing the relative merits of measures competing for financial assistance in flood prone centres in NSW.

Damages were estimated for the design flood levels determined from the hydraulic modelling undertaken as part of the present study. The floor levels of 80 properties that are located on land which is affected by the 1% AEP flood event were surveyed by a registered surveyor, while the floor levels of properties located elsewhere on the floodplain were estimated by a "drive-by" survey which assessed the height of the floor above local natural surface elevations. These natural surface elevations were derived from the LiDAR survey used to construct the hydraulic model. The number of properties predicted to experience "above-floor" inundation as a result of Main Stream Flooding, Minor Tributary Flooding and Major Overland Flow, together with estimated flood damages are set out in **Table 2.3** over the page.

At the 1% AEP level of flooding under ideal flow conditions, 61 residential properties would be flood affected (i.e. water inundates the allotment to a depth of 100 mm or greater), five of which would experience above-floor inundation. Similarly, 15 commercial buildings would be flood affected, three of which would be inundated above floor level. Only two public buildings would be flood affected, of which none would be inundated above floor level. The total cost of flood damages in Adelong would be approximately $0.87 Million for a 1% AEP event under ideal flow conditions.

Flood damage in the 1% AEP event occurs primarily due to Major Overland Flow, which is responsible for four residential and two commercial properties becoming inundated above floor level. Main Stream Flooding accounts for above-floor inundation in one residential property that is located along Selwyn Street.

The "present worth value" of damages in Adelong resulting from all floods up to the 1% AEP event at a seven per cent discount rate under ideal flow conditions is $0.91 Million. This value represents the amount of capital spending that would be justified if a particular flood mitigation measure prevented flooding for all properties up to the 1% AEP event. **Section 2.12** provides further details on the impact a partial blockage of Rimmers Bridge and Herb Feint Bridge by floating woody debris would have on flood damages in Adelong.

2.9 Impact of Flooding on Critical Infrastructure

Figure 2.7 shows the location of critical infrastructure relative to the extent of inundation resulting from floods with AEP's of 10, 2 and 1 per cent, as well as the PMF, while **Table 2.4** over the page summarises the impact that flooding has on critical infrastructure in Adelong.[4]

[4] Critical infrastructure has been split into three categories; community assets, emergency services and vulnerable infrastructure, the locations of which were taken from data provided by NSW SES or as identified by visual surveys.

TABLE 2.3
FLOOD DAMAGES[1]

Design Flood Event (% AEP)	Number of Properties												Total Damage ($ Million)	
	Residential				Commercial/Industrial				Public					
	Flood Affected		Flood Above Floor Level		Flood Affected		Flood Above Floor Level		Flood Affected		Flood Above Floor Level			
	IFC	PBC	IFC	PBC	IFC	PBC	IFC	PBC	IFC	PBC	IFC	PBC	IFC	PBC
20	41	41	0	0	6	6	1	1	2	2	0	0	0.11	0.11
10	43	43	0	0	10	10	2	2	2	2	0	0	0.19	0.19
2	45	47	2	2	13	12	2	2	2	2	0	0	0.37	0.37
5	54	54	3	3	14	14	2	2	2	2	0	0	0.52	0.52
1	61	70	5	14	15	24	3	6	2	3	0	0	0.87	1.69
0.5	71	74	9	23	17	28	5	16	3	4	0	0	1.29	3.05
0.2	75	76	19	31	28	28	16	27	4	4	0	2	2.94	4.78
PMF	174	176	158	160	28	28	28	28	8	8	7	8	42.34	42.72

1. IFC – Ideal Flow Conditions PBC – Partially Blocked Conditions

TABLE 2.4
IMPACT OF FLOODING ON CRITICAL INFRASTRUCTURE

Type	Structure	10% AEP	2% AEP	1% AEP	PMF
Vulnerable Infrastructure	Hospital	O	O	O	X
	Educational Facility (Adelong Public School)	O	O	O	O
	Child Care Facility	O	O	O	O
	Caravan Park / Camping Ground	O	O	O	X
	Aged Care Facilities	-	-	-	-
Emergency Services	SES Headquarters	-	-	-	-
	RFS Brigade	O	O	O	X
	Police Station	O	O	O	X
	Fire & Rescue NSW Station	-	-	-	-
	Ambulance	-	-	-	-
	Evacuation Centre (Adelong & District Bowling Club)	O	O	O	O
Community Assets	Electricity Substation	O	O	O	X
	Telephone Exchange	O	O	O	X
	Sewage Pump Station / Treatment Plant	O	O	O	X
	Water Supply Dam / Bore	O	O	O	X
	Major Road Crossing	O	O	O	X

"O" = Infrastructure not impacted by flooding.
"X" = Infrastructure impacted by flooding.
"-" = No such infrastructure in Adelong.

All critical infrastructure in Adelong is located in areas that are not affected by flooding up to the 1% AEP event. In addition to this, the two main road bridges in Adelong remain flood free for all floods up to the 1% AEP event.

Accessibility to some critical or vulnerable infrastructure may be disrupted due to local catchment tributary flows cutting off road access. This is the case with Black Creek which would prevent vehicular access to the Adelong WTP which is located on Campbell Street in a 10% AEP storm event. Flow surcharging Nuggety Creek would also prevent vehicular access to the Adelong STP on Bleak Street during a 2% AEP storm event. Vehicular access to the Golden Gully Caravan Park would be prevented during a 20% AEP storm event due to flow in Golden Gully inundating Victoria Hill Road. The telephone exchange located on Tumut Street would also become inaccessible should Herb Feint Bridge experience a partial blockage during a 1% AEP flood event.

In a PMF event, much of the infrastructure in Adelong would become inundated. Both the Adelong WTP and STP would be completely inundated, along with the Golden Gully Caravan Park and telephone exchange. While emergency facilities in Adelong, those namely being the Adelong Medical Centre, the Rural Fire Service station and the police station would become inoperable due to partial inundation and inaccessibility of these facilities, the evacuation centre at the Adelong and District Bowling Club would remain operational. The electricity substation would become inaccessible due to floodwater inundating parts of Bleak Street. Herb Feint Bridge and Rimmers Bridge would also be overtopped in a PMF event, thereby preventing vehicular movements across Adelong Creek.

2.10 Flood Hazard and Hydraulic Categorisation of the Floodplain

2.10.1 General

According to Appendix L of *NSWG, 2005*, in order to achieve effective and responsible floodplain risk management, it is necessary to divide the floodplain into areas that reflect:

1. The impact of flooding on existing and future development and people. To examine this impact it is necessary to divide the floodplain into *"flood hazard"* categories, which are provisionally assessed on the basis of the velocity and depth of flow. This task was undertaken in the *Flood Study* where the floodplain was divided into *Low Hazard* and *High Hazard* zones. In this present report, a *final determination* of hazard was undertaken which involved consideration of a number of additional factors which are site specific to Adelong. **Section 2.10.2** below provides details of the procedure adopted.
2. The impact of future development activity on flood behaviour. Development in active flow paths (i.e. *"floodways"*) has the potential to adversely re-direct flows towards adjacent properties. Examination of this impact requires the division of flood prone land into various *"hydraulic categories"* to assess those parts which are effective for the conveyance of flow, where development may affect local flooding patterns. Hydraulic categorisation of the floodplain was also undertaken in the *Flood Study* and was reviewed in this present investigation. **Section 2.10.3** below summarises the procedure adopted.

2.10.2 Flood Hazard Categorisation

As mentioned above, flood prone areas may be *provisionally* categorised into *Low Hazard* and *High Hazard* areas depending on the depth of inundation and flow velocity. A flood depth of 1 m in the absence of significant flow velocity represents the boundary between *Low Hazard* and *High Hazard* conditions. Similarly, a flow velocity of 2.0 m/s but with a small flood depth around 200 mm also represents the boundary between these two conditions. Interpolation may be used to assess the hazard for intermediate values of depth and velocity. Flood hazards categorised on the basis of depth and velocity only are *provisional*. They do not reflect the effects of other factors that influence hazard.

These other factors include:

1. Size of flood – major floods though rare can cause extensive damage and disruption.
2. Effective warning time – flood hazard and flood damage can be reduced by sandbagging entrances, raising contents above floor level and also by evacuation if adequate warning time is available.

3. Flood awareness of the population – flood awareness greatly influences the time taken by flood affected residents to respond effectively to flood warnings. The preparation and promotion by Council of Flood Studies and Floodplain Risk Management Studies and Plans increases flood awareness, as does the formulation and implementation of response plans by NSW SES (Local Flood Plans) for the evacuation of people and possessions.
4. Rate of rise of floodwaters – situations where floodwaters rise rapidly are potentially more dangerous and cause more damage than situations in which flood levels increase slowly.
5. Duration of flooding – the duration of flooding (or length of time a community is cut off) can have a significant impact on costs associated with flooding. This duration is shorter in smaller, steeper catchments.
6. Evacuation problems and access routes – the availability of effective access routes from flood prone areas directly influences flood hazard and potential damage reduction measures.

Provisional hazard categories may be reduced or increased after consideration of the above factors in arriving at a final determination. A qualitative assessment of the influence of the above factors on the *provisional flood hazard* (i.e. the hazard based on velocity and depth considerations only) is presented in **Table 2.5** over the page. Based on the scoring system set out in **Table 2.5**, areas affected by Main Stream Flooding and Minor Tributary Flooding that were provisionally classified as low hazard could be reclassified as high hazard. The major contributing factors to the reclassification of the floodplain are the rapid rise and flash flooding nature of the flow in Adelong Creek and its minor tributaries, in combination with the potential for floods slightly larger than the 1% AEP event or a partial blockage of either the Herb Feint Bridge or Rimmers Bridge to cause dangerous flooding conditions in parts of Adelong. **Figure 2.8** shows the division of the floodplain into high and low hazard areas based on ideal flow conditions following consideration of the factors set out in **Table 2.5**.

2.10.3 Hydraulic Categorisation of the Floodplain

According to the *NSWG, 2005*, the floodplain may be subdivided into the following zones:

- ***Floodways*** are those areas where a significant volume of water flows during floods and are often aligned with obvious natural channels. They are areas that, even if partially blocked, would cause a significant increase in flood level and/or a significant re-distribution of flow, which may in turn adversely affect other areas. They are often, but not necessarily, areas with deeper flow or areas where higher velocities occur.
- ***Flood Storage*** areas are those parts of the floodplain that are important for the temporary storage of floodwaters during the passage of a flood. If the capacity of a flood storage area is substantially reduced by, for example, the construction of levees or by landfill, flood levels in nearby areas may rise and the peak discharge downstream may be increased. Substantial reduction of the capacity of a flood storage area can also cause a significant redistribution of flood flows.
- ***Flood Fringe*** is the remaining area of land affected by flooding, after floodway and flood storage areas have been defined. Development in flood fringe areas would not have any significant effect on the pattern of flood flows and/or flood levels.

TABLE 2.5
INFLUENCE OF FLOOD RELATED PARAMETERS ON PROVISIONAL FLOOD HAZARD

Parameter	Flood Characteristics	Influence on Provisional Hazard	
		Main Stream / Minor Tributary Flooding Affected Areas	Urban Areas Affected by Major Overland Flow
Size of flood	The effects of flooding in Adelong are relatively minor in events less than a 1% AEP flood. Damages from more frequent events is mostly due to Major Overland Flow, and any above-floor inundation that occurs would be very shallow. Impacts due to flooding become very significant for events larger than a 1% AEP flood under partially blocked conditions, or under ideal flow conditions for a 0.5% AEP flood, when floodwaters break out of Adelong Creek and begin to flow along Tumut Street. A number of residential and commercial properties along Tumut Street would be at risk of flooding and the hazardous nature of flooding in this area also creates serious safety concerns. A new flood runner develops when floodwaters break out of Adelong Creek along its western bank immediately upstream of Rimmers Bridge and discharge along Selwyn Street before rejoining Adelong Creek at a distance of about 300 metres downstream of its point of origin during a flood slightly larger than the 2% AEP event. The development of this flow path in rare flood events poses a risk to properties at the southern end of Selwyn Street.	+1	0
Effective warning time	The potential for flooding along Adelong Creek occurs approximately five hours after the onset of heavy rain. The minor tributaries around Adelong Creek have response times of about one hour, while flood levels along Major Overland Flow paths can peak in much shorter times. BoM maintains a storm warning service which would provide some warning for short-duration 'flash flooding'. Two properties which would become flood damaged in a 1% AEP flood under ideal flow conditions would have some warning time. There are four residential and two commercial properties which are susceptible to above-floor flooding under ideal flow conditions in a 1% AEP event due to Major Overland Flow. These properties would receive little or no warning time.	+1	+1
Flood awareness	Flood awareness appears to be quite high due to recent floods. The community may be less aware of Minor Tributary Flooding and Major Overland Flow.	-1	0
Rate of rise and velocity of floodwaters	Floodwaters rise very quickly after the onset of heavy rain, particularly along Minor Tributaries and Major Overland Flow paths. However, the depth and velocities associated with these flows are low hazard in nature. While floodwaters would rise more slowly along Adelong Creek, the depth and velocity associated with Main Steam Flooding is more hazardous. Under partially blocked conditions for a 1% AEP flood, or under ideal flow conditions for a 0.5% AEP flood, floodwaters break out of Adelong Creek and begin to flow along Tumut Street, where the depth and velocity of flow will become hazardous very quickly.	+1	0

Refer over for Legend

Continued Over

TABLE 2.5 (Cont'd)
INFLUENCE OF FLOOD RELATED PARAMETERS ON PROVISIONAL FLOOD HAZARD

Parameter	Flood Characteristics	Influence on Provisional Hazard	
		Main Stream / Minor Tributary Flooding Affected Areas	Urban Areas Affected by Major Overland Flow
Duration of flooding	Flood levels along Adelong Creek will remain elevated for a relatively short time – between 2 and 4 hours. In areas affected by Minor Tributary Flooding and Major Overland Flow, the duration of inundation will be much shorter – typically less than an hour.	-1	-1
Evacuation problems	Under partially blocked conditions for a 1% AEP flood, or under ideal flow conditions for a 0.5% AEP flood, floodwaters will break out from Adelong Creek and flow along Tumut Street. This presents a serious problem for evacuation as access to the Snowy Mountains Highway, particularly towards Tumut, will be prevented. Minor roads will become cut by flow which surcharges the numerous gullies and creeks which surround Adelong.	+1	0
	OVERALL SCORE	+2	0

Legend 0 = neutral impact on provisional hazard
+ 1 = tendency to increase provisional hazard
– 1 = tendency to reduce provisional hazard

The *Flood Study* identified that flood storage effects are not significant in Adelong Creek as there is very little storage on its overbank areas. For this reason, the floodplain was only sub-divided into floodway and flood fringe areas. **Figure 2.8** shows the division of the floodplain into floodway and flood fringe areas at the 1% AEP level of flooding under ideal flow conditions.

While the floodway area is generally confined to the inbank area of Adelong Creek due to the relatively high hydraulic capacity of the channel, it does extend onto the immediate overbank of Adelong Creek at several locations along its length. Most of the areas in Adelong subject to shallow overland flow are "Flood Fringe" zones.

The *Flood Study* found that the velocity-depth based high hazard floodway area closely correlates with the extent of the 2% AEP flood, the peak flow of which is about 74 per cent that of the 1% AEP event, whilst the corresponding low hazard floodway generally comprised areas where major break outs of flow occur due to the higher flow rate (e.g. at the northern and southern ends of Selwyn Street and on the eastern overbank of Adelong Creek upstream of Rimmers Bridge).

Further discussion on the impact a partial blockage of Rimmers Bridge and the Herb Feint Bridge by floating woody debris has on the extent of high and low floodway areas is contained in **Section 2.12**.

2.11 Council's Existing Planning Instruments and Policies

2.11.1 General

The *Tumut Local Environmental Plan, 2012* (***Tumut LEP 2012***) is the principal statutory planning document used by Council for controlling development by defining zoning provisions, establishing permissibility of land use and regulating the extent of development in Adelong.

The *Tumut Development Control Plan 2011* (***Tumut DCP 2011***) supplements *Tumut LEP 2012* by providing general information and detailed guidelines and controls which relate to the decision making process.

2.11.2 Land Use Zoning – Tumut Local Environmental Plan 2012

Figure 2.9 shows the zonings incorporated in *Tumut LEP 2012* at Adelong. The urban area of Adelong is zoned *RU5 Village*, with a portion of land zoned *R5 Large Lot Residential* located to the north-east of the township along the Snowy Mountain Highway.

2.11.3 Future Growth Areas

The *Tumut Shire Council Growth Strategy Planning Report – Adelong Investigation Areas* (SP, 2013) investigated land identified as potential growth areas for the purpose of residential development in Adelong. The land was highlighted within the outcomes of the *Tumut Shire Rural Land Use Strategy 2008*. **Figure 2.9** shows the extent of the two growth areas that have been denoted the *"Adelong South-West Growth Area"* and the *"Adelong South-East Growth Area"*.

The *Adelong South-West Growth Area* (SP, 2013) identifies the significant impact flooding has had on parts of Adelong (namely along Tumut Street), and notes that Adelong Cemetery Road is inundated by floodwater which surcharges Black Creek during heavy rainfall events. The report also notes that inundation of the roadway is typically of a shallow and short duration nature. Reference to a new culvert being required under Todds Road is also contained in the report.

The *Adelong South-East Growth Area* (SP, 2013) notes that flooding from Adelong Creek will impact only a small portion of the land identified for future residential development. The report also notes that access to the area was cut for a period of about one hour during the October 2010 flood due to the inundation of Selwyn Road. Reference to the same road being cut in the January 1984 flood event is also contained in the report. The report states that several culverts under Wondalga Road and Rimmers Lane will need to be upgraded to service future development.

It is noted that the findings of the *Flood Study* generally confirm the statements made in SP, 2013 regarding the characteristics of flooding in the two growth area.

2.11.4 Flood Provisions – Tumut LEP 2012

Clause 6.2 of *Tumut LEP 2012* entitled "Flood planning" outlines its objectives in regard to development of land that is at or below the FPL. It is similar to the standard Flood Planning Clause used in recently adopted LEPs in other NSW country centres and applies to land at or below the FPL.

The FPL referred to is the 1:100 ARI (or 1% AEP) flood plus an allowance for freeboard of 500 mm. The area encompassed by the FPL (i.e. the FPA) denotes the area subject to flood related development controls, such as locating development outside high hazard areas and setting minimum floor levels for future residential development. It is now standard practice for the residential FPL to be based on the 1% AEP flood plus an appropriate freeboard unless exceptional circumstances apply.

Clause 6.2 also applies to land identified as the FPA on the "*Flood Planning Map*" which is attached to *Tumut LEP 2012*. A review of the *Flood Planning Map* shows that the extent of the FPA is based on data presented in a flood study which was undertaken by the Water Resources Commission (**WRC**) (now OEH) in 1986. It is not clear from the *Flood Planning Map* whether the extent of the FPA includes the 500 mm freeboard allowance, as the FPL would not have been presented in WRC, 1986. It also only covers the main arm of Adelong Creek and not its minor tributaries.

Whilst appropriate for Main Stream Flooding, the present clause 6.2 would result in a large part of the urban areas of Adelong which are affected by shallow overland flow being subject to flood affectation notification on Planning Certificates issued under S10.7 of the EP&A Act. It would also result in flood related development controls being applied to land which is presently rural in nature where the flood risk is very low.

For the *Flood Planning Map* to be modified, a formal amendment would need to be made to *Tumut LEP 2012*, which would take considerable time. It is therefore recommended that the *Flood Planning Map* not be attached to *Tumut LEP 2012*, as this way it can be updated without the need to update the LEP. Recommended amendments to the wording of clause 6.2 are set out in **Section 3.5.1.4** of the report.

Tumut LEP 2012 would need to be supported by the *Flood Policy* in **Appendix D** which sets out specific requirements for development in flood liable areas based on the flood extent and hazard mapping for Adelong. **Figure D1.1** in **Appendix D** is an extract from the *Flood Planning Map* (as defined by this study) referred to in clause 6.2 and relates to Adelong.

It is also recommended that a new Floodplain Risk Management clause be incorporated in *Tumut LEP 2012*. The objectives of the new clause are as follows:

- in relation to development with particular evacuation or emergency response issues (e.g. schools, group homes, residential care facilities, hospitals, etc.) to enable evacuation of land which lies above the FPL; and
- to protect the operational capacity of emergency response facilities and critical infrastructure during extreme flood events.

The new clause would apply to land which lies between the FPL and the level of the PMF, but would not apply to land at or below the FPL. As per the Direction of the Minister, this clause cannot apply to standard residential development. Suggested wording in relation to this new clause is given in **Section 3.5.1.4**.

2.11.5 Flooding and Stormwater Controls – Tumut DCP 2011

Tumut DCP 2011 contains two chapters which are relevant to flooding and stormwater in Adelong.

Chapter 23 titled '*Flood Plain Management*' outlines its purpose as, among others, to alert the community to the extent and hazard of flood liable land, to encourage development and construction which is compatible with flood hazard, and to reduce the risk and implications of flooding.

In order to achieve these objectives a number of policy statements are made. Regarding development in floodways, only non-habitable buildings ancillary to agriculture, recreational areas and sporting grounds may be developed in floodways, as identified by Council. New development or additions/alterations to existing buildings located on flood liable land (incorrectly defined in *Tumut DCP 2011* as land inundated in the 1% AEP flood event) must demonstrate within the development application that there are no adverse flood impacts on other properties, that evacuation can be safely carried out, that the development can withstand the forces of flooding, and that any habitable room has a minimum floor level above the 1% AEP flood level plus 500 mm.

Chapter 30 titled '*Stormwater Drainage Construction and Maintenance*' states the purpose of the chapter is to provide guidelines for the construction and maintenance of stormwater drainage systems, and to provide guidance for the selection of stormwater improvements.

The chapter lists a number of guidelines which are aimed at ensuring effective stormwater design. Some of these measures include preventing stormwater to flow into habitable rooms in flood events up to the 1% AEP, retaining trunk drainage routes as natural water courses where practical, sizing piped minor drainage systems to a 5% AEP standard, and requiring new developments to make necessary provisions for stormwater drainage. Chapter 30 also includes a list of guidelines titled '*Principles for the selection of town works programs*' which provides guidelines for determining the area where flood mitigation or stormwater works should be undertaken, the manner in which they should be designed, and other considerations relating to works programs.

2.12 Potential Impact of a Partial Blockage of Major Hydraulic Structures

Parts of Adelong are susceptible to increased flood affectation due to blockage of the major hydraulic structure in the township, namely Herb Feint Bridge and Rimmers Bridge. Given the high debris load which has been observed during major floods in Adelong Creek, it is likely that Rimmers Bridge and the Herb Feint Bridge will experience a partial blockage during future flood events. Whilst the degree of blockage experienced during the October 2010 flood at Herb Feint Bridge is considered atypical (i.e. because the central embankment of the partially demolished Adelong Bridge acted to trap debris beneath the partially constructed Herb Feint Bridge), debris is likely to accumulate on the upstream side of the bridge piers during a flood. If the flood is of sufficient magnitude, floating woody debris could also accumulate on the upstream side of the bridge deck, with a partial reduction in waterway area experienced below the soffit level of the structure.

The partial blockage of both Herb Feint Bridge and Rimmers Bridge was modelled and the results of a 1% AEP flood event presented in **Figure 2.10**. An afflux was then generated comparing the flood levels in Adelong under partially blocked conditions against those under ideal flow conditions (**Figure 2.11**). The partial blockage of the hydraulic structures in Adelong was carried out assuming a 1 m thick raft of floating woody debris lodges beneath the underside of the bridge decks and a 4 m wide raft of debris lodges on the upstream side of each bridge pier over the full height of the clear openings.

Figure 2.11 shows the increases in water level under partially blocked conditions for a 1% AEP flood event. Immediately upstream of Rimmers Bridge the water level would increase by between 300-500 mm, with the resulting impacts extending upstream to a location adjacent to the Adelong WTP. The blockage of Rimmers Bridge would also increase the magnitude of flow which surcharges the western bank of Adelong Creek, where it would flow north along Selwyn Street. Peak 1% AEP flood levels would be increased in the range 50 to 200 mm along this flow path and would result in:

i. an increase in the depth of above-floor inundation in an existing dwelling from 200 mm under ideal flow conditions to 300 mm under partially blocked conditions; and

ii. the above-floor inundation of a second dwelling, albeit to a relatively shallow depth of less than 10 mm.

The blockage of Herb Feint Bridge would result in a maximum increase in peak 1% AEP flood levels of 1.1 m, with the effects of the partial blockage extending upstream to Currans Creek. The partial blockage of Herb Feint Bridge by debris would result in the surcharge of Adelong Creek along its western bank, with the resulting flow discharging in a northerly direction along Tumut Street, as occurred during the October 2010 flood. Floodwater which traverses Tumut Street flows back into Adelong Creek adjacent to the petrol station which is located opposite Havelock Street. Based on the provisional hazard categorisation that is presented in NSWG, 2005, the flow in Tumut Street under these conditions is of a low hazard nature (refer **Figure 2.12**).

The number of properties predicted to experience "above-floor" inundation as a result of Main Stream Flooding, Minor Tributary Flooding and Major Overland Flow, together with estimated flood damages under partially blocked conditions are set out in **Table 2.3**.

As a result of a partial blockage of Herb Feint Bridge in a 1% AEP flood event, eleven additional buildings (comprising eight dwellings and three commercial buildings) would be inundated above floor level, while two buildings which were inundated above floor level under ideal flow conditions would experience a greater depth of inundation. Of the eight additional flood damaged dwellings, six are located immediately upstream of Herb Feint Bridge and lie in areas which are not flooded under ideal flow conditions. The remaining five buildings which are not damaged under ideal flow conditions and the two which would experience greater depths of above floor inundation are all located along the new flow path which forms along Tumut Street under partially blocked conditions. While most of the flood damaged buildings would be inundated above their floor level to depths up to 200 mm, two buildings would experience depths of above-floor inundation of between 300 and 400 mm, while another would experience a depth of above-floor inundation of approximately 780 mm.

In addition to the increased property damage which would be incurred by a partial blockage of Herb Feint Bridge during a major flood event, numerous properties along Tumut Street would be isolated and unable to evacuate due to the formation of the new flow path. Given the high probability of some blockage occurring during a major flood event, the impacts of a partial blockage need to be taken into consideration when developing emergency management procedures (NSW SES) and flood related development controls (Council) for Adelong.

Overall, at the 1% AEP level of flooding under partially blocked conditions, 70 dwellings would be flood affected (i.e. water inundates the allotment to a depth of 100 mm or greater), 14 of which would experience above-floor inundation. Similarly, 24 commercial buildings would be flood affected, six of which would be inundated above floor level. Only three public buildings would be flood affected, of which none would be inundated above floor level. The total cost of flood

damages in Adelong would be approximately $1.7 Million for a 1% AEP event under partially blocked conditions (this is compared to $0.87 Million under ideal flow conditions).

The "present worth value" of damages in Adelong resulting from all floods up to the 1% AEP event at a seven per cent discount rate under partially blocked conditions is $0.95 Million (this is compared to $0.89 Million under ideal flow conditions). This value represents the amount of capital spending which would be justified if a particular flood mitigation measure prevented flooding for all properties up to the 1% AEP event.

A number of measures which would reduce the risk of blockage of the two road bridges are discussed in **Section 3.4.5**.

2.13 Potential Impacts of Future Urbanisation

Future urbanisation has the potential to increase the rate and volume of runoff conveyed along the various overland flow paths at Adelong, as well as increase the frequency of surcharge of the local stormwater drainage system. It is also likely to result in changes in the existing drainage system. While existing minor watercourses are likely to be retained and formalised in drainage reserves, piped drainage systems associated with urban subdivisions will result in significant amendments to existing overland flow paths leading to the watercourses.

The impact of future urbanisation could have on flooding and drainage patterns in Adelong was assessed by increasing the fraction impervious values of twelve sub-catchments in the hydrologic model. The fraction impervious of these sub-catchments was increased from zero to 40% to reflect future urbanisation in the designated future growth areas which are located to the south-west and south-east of Adelong.

While future urbanisation in the future growth areas would have only a minor impact on flooding behaviour at Adelong at the 1% AEP level of flooding, it is likely to increase the frequency of surcharge of the existing piped drainage system. It will therefore be necessary to upgrade existing drainage infrastructure to cater for the increase that will occur in the rate of flow in the receiving drainage lines and to also set out development which takes into account the flood hazard. Measures which are aimed at controlling future development on the floodplain at Adelong are set out in the draft *Flood Policy* which is contained in **Appendix D**.

2.14 Potential Impacts of Climate Change

Consideration was given to the impacts on design flood levels of future climate change when estimating freeboard requirements on minimum floor levels in future development at Adelong.

OEH recommends that its guideline *Practical Consideration of Climate Change, 2007* be used as the basis for examining climate change in projects undertaken under the State Floodplain Management program and the *FDM, 2005*. The guideline recommends that until more work is completed in relation to the climate change impacts on rainfall intensities, sensitivity analyses should be undertaken based on increases in rainfall intensities ranging between 10 and 30 per cent.

On current projections the increase in rainfalls within the service life of developments or flood management measures is likely to be around 10 per cent, with the higher value of 30 per cent representing an upper limit which may apply near the end of the century. Under present day climatic conditions, increasing the 1% AEP design rainfall intensities by 10 per cent would produce about a 0.5% AEP flood; and increasing those rainfalls by 30 per cent would produce about a 0.2% AEP event.

For the purpose of the present investigation, the impact 10% and 30% increases in design 1% AEP rainfall intensities would have on flooding behaviour was assessed by comparing the peak flood levels which were derived from the flood modelling for design events with AEP's of 1, 0.5 and 0.2 per cent.

Figure 2.14 shows the afflux data (i.e. increase in peak flood levels compared with present day conditions) derived from the hydraulic modelling that was undertaken as part of the present investigation for the 1 and 0.5% AEP events under ideal flow conditions. The potential impact of a 10% increase in rainfall intensity on flooding patterns at Adelong may be summarised as follows:

- Depths of Major Overland Flow would generally be increased in the range 10-50 mm, with increases in the range 50-100 mm shown to occur in several areas.
- It was found that the impacts of a 10% increase in rainfall intensities to Minor Tributary Flooding would be varied. For example, peak flood levels along Black Creek and Golden Gully would increase by between 20-100 mm, while along Tanyard Creek and the unnamed flow path which joins Adelong Creek east of Gundagai and Selwyn Streets they would be increased by between 50-200 mm.
- While there were isolated pockets along Adelong Creek where peak flood levels would be increased by between 100-200 mm, elsewhere depths would be increased by between 200-500 mm. Areas of importance which would experience the largest increase of 300-500 mm are located upstream of Rimmers Bridge and Herb Feint Bridge, and near the Adelong Showground.
- There would be an increase in the area of land inundated by floodwater in the vicinity of Herb Feint Bridge (as indicated by the purple shaded areas on **Figure 2.14**), particularly in properties that are located immediately upstream of the bridge on the western overbank of Adelong Creek.
- Additional land which lies to the east of the intersection of Selwyn and Gilmore streets would become inundated by floodwater which breaks out of Adelong Creek along its western bank.

Figure 2.15 shows the afflux data derived from the hydraulic modelling that was undertaken as part of the present investigation for the 1 and 0.2% AEP events under ideal flow conditions. The potential impact of a 30% increase in rainfall intensity on flooding patterns at Adelong may be summarised as follows:

- Depths of inundation along Major Overland Flow paths and along the minor watercourses which join Adelong Creek would typically be increased by between 20-200 mm, while peak flood levels along Adelong Creek would generally be increased by more than 500 mm.
- A greater extent of land would be inundated by floodwater to the east of the intersection of Selwyn and Gilmore streets.
- A major break out of floodwater would occur on the western bank of Adelong Creek immediately upstream of Herb Feint Bridge, with the resulting flooding patterns similar to those that would be experienced in a 1% AEP flood under partially blocked conditions.

2.15 Flood Warning and Flood Preparedness

The NSW SES is nominated as the principal combat and response agency for flood emergencies in NSW. NSW SES is responsible for the issuing of relevant warnings (in collaboration with BoM), as well as ensuring that the community is aware of the flood threat and how to mitigate its impact.

The *Tumut Local Flood Plan*, 2013 (herein referred to as the ***Flood Plan***) published by NSW SES covers preparedness measures, the conduct of response operations and the coordination of immediate recovery measures for all levels of flooding within the Tumut Shire area. The *Flood Plan* is administered by the Tumut Shire NSW SES Local Controller who controls flood operations within the Tumut Shire area. The NSW SES Tumut Shire Unit, which is responsible for the Adelong area, has its headquarters based in Tumut; there is no operations centre in Adelong.

The *Flood Plan* is divided into three volumes: Volume 1 – '*Tumut Shire Flood Emergency Sub Plan*' was completed in 2013 and includes sections on flood preparedness, response, and recovery; Volume 2 – '*Hazard and Risk in Tumut Shire*', was completed in 2004 and includes information on the flood threat and the effects of flooding; Volume 3 – *'SES response arrangements for Tumut Shire'* includes specific details concerning information dissemination and evacuations.

Volume 1 of the current Flood Plan follows the standard NSW SES template and is divided into the following sections:

- ***Introduction****;* this section of the *Tumut Local Flood Plan* identifies the responsibilities of the NSW SES Local Controller and NSW SES members and supporting services such as the Police, BoM, Ambulance, Country Energy, Fire Brigades, Department of Community Services, Snowy Valleys Council, etc. The *Tumut Local Flood Plan* identifies the importance for NSW SES and Council to coordinate the development and implementation of a public education program to advise the population of the flood risk.
- ***Preparedness****;* this section deals with activities required to ensure the *Local Flood Plan* functions during the occurrence of the flood emergency. The Plan will devote considerable attention to flood alert and emergency response.
- ***Response***. The NSW SES maintains an operation centre at the Local NSW SES Headquarters at Adelong Road in Tumut. Response operations will commence: on receipt of a severe weather warning for flash flooding from BoM or when other evidence leads to an expectation of flooding within the Adelong area. Sources of Flood Intelligence identified will include the BoM, Tumut Region headquarters and Council.

  Volume 2 of the Flood Plan notes that there is only a small amount of warning time prior to flood events, with the potential for flooding to begin within six hours after the onset of heavy rain. Adelong lacks a formal warning system which contributes to the limited time which is available for evacuation of occupiers of the floodplain by NSW SES. *[The FRMP includes a recommendation to install a telemetered stream gauge on Herb Feint Bridge linked to a loud speaker type alert system to provide more lead time in this respect.]*

  The *Flood Plan* notes that Adelong can experience flooding along its main street and that a number of properties and shops are at risk, including the public swimming pool (which since the time of writing has been demolished). Potential road closures are identified in the document as being the Snowy Mountains Highway (Tumut Street) at

Adelong and Wondalga-Adelong Road (Wondalga Road). *[The list of affected properties, roads, and other critical infrastructure which are flood affected should be updated based on the findings of the FRMS.]*

The *Flood Plan* identifies suitable flood evacuation centres in the region. In Adelong, the Adelong & District Bowling Club on Campbell Street is to be used as a flood evacuation centre. As shown on **Figure 2.4**, the bowling club is located on land which lies above the PMF, so is therefore suitably located to operate as an evacuation centre during a flood event.

- ***Recovery***, involving measures to ensure the long term welfare for people who have been evacuated, recovery operations to restore services and clean up and de-briefing of emergency management personnel to review the effectiveness of the *Tumut Local Flood Plan*.

2.16 Environmental Considerations

While the bed of Adelong Creek at Adelong is largely in its natural state, its banks have generally been cleared of native vegetation. While Council has recently removed large stands of poplar trees and associated undergrowth which lined the creek between the Herb Feint Bridge and the extension of Selwyn Street, there is limited opportunity to undertake further broad-scale stream clearing at Adelong. **Section 3.4.4** presents the findings of an investigation which was undertaken to assess the mitigating benefits that could be achieved by removing vegetation along the reach of Adelong Creek between the extension of Selwyn Street and Gundagai Street.

While there is limited benefit in undertaking further broad-scale clearing of vegetation in Adelong Creek, there is merit in the ongoing maintenance of vegetation. Several members of the FRMC identified that there are also a number of poplar trees located on the banks of Adelong Creek immediately upstream of Herb Feint Bridge which are currently being undermined and their removal is recommended given the potential for them to exacerbate blockage of the bridge opening should they be uprooted during a flood event.

While localised widening of Adelong Creek is also considered in **Chapter 3**, it has the potential to cause significant erosion to the banks of the channel, thereby degrading the land adjacent to the creek, as well as water quality. Channel widening can also have an impact on the biodiversity in the creek. Localised channel widening was found to be an ineffective means of mitigating the flood effects in Adelong and is therefore not a recommended flood mitigation measure.

The land surrounding Adelong has been largely cleared, as too have the various minor watercourses which drain to Adelong Creek adjacent to the town. Despite this, effort should be made to prevent further clearing of these tributaries, especially as part of any future development in order to prevent erosion or impacts on water quality, and to protect the biodiversity in these areas.

3 POTENTIAL FLOODPLAIN MANAGEMENT MEASURES

3.1 Range of Available Measures

A variety of floodplain management measures can be implemented to reduce flood damages. They may be divided into three categories, as follows:

Flood modification measures change the behaviour of floods in regard to discharges and water surface levels to reduce flood risk. This can be done by the construction of levees, detention basins, channel improvements and upgrades of piped drainage systems in urban areas. Such measures are also known as "structural" measures as they involve the construction of engineering works. Vegetation management is also classified as a flood modification measure.

Property modification measures reduce risk to properties through appropriate land use zoning, specifying minimum floor levels for new developments, voluntary purchase of residential property in high hazard areas, or raising existing residences in the less hazardous areas. Such measures are largely planning (i.e. "non-structural") measures, as they are aimed at ensuring that the use of floodplains and the design of buildings are consistent with flood risk. Property modification measures could comprise a mix of structural and non-structural methods of damage minimisation to individual properties.

Response modification measures change the response of flood affected communities to the flood risk by increasing flood awareness, implementation of flood warning and broadcast systems and the development of emergency response plans for property evacuation. These measures are entirely non-structural.

3.2 Community Views

Comments on potential flood management measures were sought from the Adelong community by way of the *Community Questionnaire* which was distributed at the commencement of the study. The responses are summarised in **Appendix A** of this report. Question 14 in the *Community Questionnaire* outlined a range of potential flood management measures. The responses are shown on **Table 3.1** over the page together with initial comments on the feasibility of each measure. The measures are discussed in more detail in later sections of this Chapter.

The Community favoured the following measures:

- Management of vegetation along creek corridors.
- Removal of floodplain obstructions.
- Improvements in the stormwater system in the urban parts of Adelong.
- Flood related controls over future development in flood liable areas.
- Improved flood warning, evacuation and flood response procedures.
- Community education to promote flood awareness.
- Advice of flood affectation via Planning Certificates for properties located within the *Flood Planning Area*.

TABLE 3.1
COMMUNITY VIEWS ON POTENTIAL FLOOD MANAGEMENT MEASURES

Flood Management Measure		Classification[1]	Respondent's Views			Comments
			Yes	No	No Response	
a)	Management of vegetation along creek corridors to provide flood mitigation, stability, aesthetic and habitat benefits.	FM	32	1	5	The community is strongly in favour of this measure, which is an essential part of the *FRMP*. The present investigation shows that benefits in terms of reduced flood levels have been achieved by reducing the density of vegetation (namely poplar trees) along Adelong Creek, particularly for properties located at the northern end of Selwyn Street. While the benefits achieved from this measure cannot be relied upon for reducing the FPL (i.e. because they rely on ongoing and regular maintenance), it does nonetheless reduce the impacts of flooding on existing development.
b)	Widening of watercourses	FM	5	18	15	The community is not in favour of this measure. The present investigation shows that it has little application at Adelong where the majority of the flow is conveyed in the inbank area of the creek. Nonetheless, the technical requirements associated with channel improvements are discussed in **Section 3.4.3**.
c)	Removal of floodplain obstructions	FM	29	2	7	This measure is strongly supported by the community and needs to be considered as part of the *FRMP*, as it is aimed at ensuring that the existing drainage system functions at maximum capacity during floods. While one respondent noted the need to remove a large block of concrete that is present beneath Herb Feint Bridge, it is noted that apart from ongoing vegetation management, the recent demolition of the Adelong swimming pool and the replacement of the Adelong Bridge with the Herb Feint Bridge has led to the removal of the major obstructions that have historically influenced flooding behaviour in the urbanised parts of Adelong.
d)	Improvements in the stormwater system in the urban parts of Adelong.	FM	25	5	8	This measure is supported by the community and needs to be considered as part of the *FRMP*. The present investigation shows that the severity of flooding due to a Major Overland Flow path which runs along Havelock Street, before cutting across Lockhart and Tumut Streets could be significantly reduced in minor storm events if the inlet capacity of the existing stormwater system is increased. This flood management measure and the technical requirements associated with an upgrade of the existing stormwater system are discussed in **Section 3.4.5**.
e)	Construct permanent levees along the creek to contain floodwater.	FM	10	18	10	The community is not in favour of this measure. The results of the present investigation show that there are a limited number of residential and commercial properties that are affected by Main Stream Flooding at Adelong. However, this measure may be applicable where Adelong Creek breaks its western bank immediately upstream of Herb Feint Bridge, as well as on the western side of the creek immediately upstream of Rimmers Bridge as suggested by one respondent. The technical requirements associated with flood protection levees are discussed in **Section 3.4.1**.
f)	Voluntary purchase of residential property in **high hazard** areas.	PM	8	14	16	The community is not in favour of this measure, which is often adopted to remove residential property in high hazard areas of the floodplain. As there is one existing dwelling located in the High Hazard Floodway area, this measure was assessed, the findings of which are set out in **Section 3.5.2**.
g)	Provide funding or subsidies to raise houses above 1% AEP flood level in **low hazard** areas.	PM	9	15	14	The community is not in favour of this measure. Nonetheless, this measure would have application for timber framed houses located in low hazard zones on the floodplain and is reviewed in **Section 3.5.3**.
h)	Controls over future development in flood-liable areas (e.g. controls on location in the floodplain, minimum floor levels, etc.).	PM	22	6	10	The community supports this measure, which is an essential part of the *FRMP*. The issue is covered in the draft *Flood Policy*, referenced in **Section 3.5.1** and presented in **Appendix D**.
i)	Improve flood warning and evacuation procedures both before and during a flood.	RM	29	2	7	Flooding in Adelong is of a "flash flooding" nature. Flash flooding results in a sudden rise in water levels after the onset of heavy rainfall. While BoM provides notice if flood producing rainfall is likely to occur, no other formal warning system exists at Adelong. NSW SES responds to flood occurrences in Adelong in accordance with the *Tumut Local Flood Plan*. This document should be updated in response to the completion of the *FRMS&P*. Improvements to flood warning and flood emergency response planning (using information contained in this study, as well as the *Flood Study*) are strongly supported by the community and are considered in **Section 3.6.1** and **3.6.2**.
j)	Community education, participation and flood awareness programs.	RM	17	5	16	Ensuring the community is aware of the flood risk in Adelong is favoured by the questionnaire respondents. This measure is reviewed in **Section 3.6.3**.
k)	Provide a Planning Certificate to purchasers in flood prone areas stating that the property is flood affected.	PM	28	3	7	Provision of information on flood affection of properties is strongly favoured by the community. This may be achieved by not ation of flood affectation of allotments on Section 10.7 Planning Certificates. This measure is discussed in **Section 3.5.1.3**.

1. FM = Flood Modification Measure
PM = Property Modification Measure
RM = Response Modification Measure

3.3 Outline of Chapter

The measures set out in **Table 3.1** were examined at the strategic level of detail in **Chapter 3** and where appropriate, tested for feasibility on a range of assessment criteria in **Chapter 4**. Following consideration of the results by the FRMC, selected measures were included in the *FRMP* in **Chapter 5**.

A number of flood modification measures were considered at Adelong. Three flood modification schemes were aimed at preventing property damage and inundation of Tumut Street which occur due to Main Stream Flooding, while a fourth was aimed at reducing damage in a number of properties from Major Overland Flow. The assessed measures consisted of a block levee, channel widening, a blockage prevention scheme and the upgrade of the existing stormwater system.

In the economic analysis, the damages prevented by a flood mitigation scheme represent its benefits. The damages were computed for present day and post-scheme conditions for a range of floods up to the 1% AEP event. By integrating the area beneath the damage–frequency curve up to the "design standard" of the scheme (in this case the 1% AEP), the long term "average annual" value of benefits were calculated (by subtraction of post-scheme from present day damages). These average annual benefits were then converted to an equivalent present worth value for each of the three discount rates nominated by NSW Treasury Guidelines for the economic analysis of public works (i.e. 4, 7 and 11 per cent), over an economic life of 50 years. These present worth values of benefits were then divided by the capital costs of the schemes to give benefit/cost ratios for the three discount rates.

The property modification measures considered as part of the present study include controls over future development, voluntary purchase of residential properties and house raising. Response modification measures such as improvements to the flood warning system, improvements to emergency planning and responses, and public awareness programs have been considered for Adelong.

3.4 Flood Modification Measures

3.4.1 Levees

Levees are an effective means of protecting flood affected properties up to the design flood level. In designing a levee, it is necessary to take account of three important factors: potential re-distribution of flood flows, the requirements for the collection and disposal of internal drainage from the protected area and the consequences of overtopping the levee in floods greater than the design event. A freeboard between the design flood level and the crest level of between 0.5 and 1 m would be required, based on an assessment of site specific flooding conditions.

Reinforced concrete and concrete block walls are often used in situations where there is insufficient land available for earth banks. Such walls are provided with reinforced concrete footings of sufficient width to withstand overturning during flood events. These footings may also need to be founded on sheet or reinforced concrete piles where bank stability is of concern.

A potential flood protection levee was assessed which ran along the rear of several residential properties that are located on the western bank of Adelong Creek upstream of Herb Feint Bridge.

The assessed levee, which would be about 200 m in length and comprise reinforced block wall type construction, commences adjacent to 30 Tumut Street and ties into the abutment of Herb Feint Bridge. The objective of the levee is to prevent floodwater from breaking out of Adelong Creek and flowing along Tumut Street for the case where Herb Feint Bridge is subject to a partial blockage during a 1% AEP flood, or during a 0.2% AEP flood under ideal flow conditions.[5]

The impact the potential flood protection levee would have on peak 1% AEP flood levels under ideal flow and partially blocked conditions is shown on **Figure 3.1**. It can be seen that under partially blocked conditions the residential properties that are located immediately behind the levee are no longer subject to Main Stream Flooding. Moreover, under partially blocked conditions the levee prevents floodwater from breaking out of the creek and flowing along Tumut Street. As a consequence, damages incurred along Tumut Street for floods up to 1% AEP under partially blocked conditions or for floods up to 0.2% AEP under ideal flow conditions would be significantly reduced as shown in **Table 3.2**.

TABLE 3.2
ECONOMIC ANALYSIS
OF POTENTIAL FLOOD PROTECTION LEVEE

Discount Rate %	Nominal Flood Level Case under Ideal Flow Conditions			Nominal Flood Level Case under Partially Blocked Conditions		
	4	7	11	4	7	11
Present Worth Value of Benefits (Damages Prevented) $ Million	0.00	0.00	0.00	0.09	0.05	0.03
Cost of scheme $ Million(1)	0.80	0.80	0.80	0.80	0.80	0.80
Benefit/Cost Ratio	-	-	-	0.11	0.06	0.04

1. Derived based on a unit rate of $4,000/linear metre and does not include the cost of sheet or reinforced concrete piling.

The potential levee would result in third-party related impacts due to it preventing the breakout of floodwater onto Tumut Street. Peak flood levels in 20 and 22 Tumut St, and 6 Snowy Mountains Highway would be increased in the range 100-200 mm under partially blocked conditions, while those in the large commercial property that is located at the northern end of Selwyn Street would be increased in the range 50-100 mm. Additional measures would likely be required in these properties in order to mitigate the resulting third-party related impacts.

The present worth value of damages prevented (benefits) of the proposed flood protection levee for floods up to the 1% AEP is presented in **Table 3.2**. Also shown is the estimated cost of scheme and the benefit cost ratio using three different discount rates. There are no economic benefits of the scheme under ideal flow conditions for floods up to the 1% AEP event. While flood damages are prevented under partially blocked conditions, the present worth value of the average annual benefits is much less than the cost of the scheme. This is because the damages prevented occur only in large flood events which are less frequent, whereas there are no damages prevented in smaller, more frequent events. The benefit cost ratio under partially blocked conditions shows that the scheme is also not economically justifiable.

[5] Note that flooding patterns under pre-levee conditions are similar under these two scenarios.

Practical considerations also reduce the merits of a flood protection levee at this location. For example, its proposed alignment would require the acquisition of multiple easements through private property. The land in which the levee could feasibly be constructed is also constrained between the creek bank and the existing dwellings. As a result, the levee would need to be of reinforced block wall type construction rather than an earthen embankment which would add significantly to its cost. The wall would also likely need to be founded on sheet or reinforced concrete piling along part of its length due to possible bank stability issues. The location of the block wall along the creek bank would also detract from the visual amenity of the creek and may be rejected by the owners of the land upon which the levee would need to be built.

Based on the above findings, the inclusion of a levee along the western bank of Adelong Creek immediately upstream of the Herb Feint Bridge in the *FRMP* is not recommended.

3.4.2 Hydraulic Structure Upgrades

Upgrading hydraulic structures by increasing their waterway area has the potential to reduce the impact of flooding on existing development within the study area. However, care must be taken when assessing the merits of such upgrades as changes in flooding patterns and the removal of temporary flood storage can under certain circumstances increase downstream flood peaks. The risk of a blockage of hydraulic structures by debris also needs to be taken into consideration when determining appropriate dimensions for an upgraded structure.

There are only a small number of hydraulic structures that span waterways at Adelong. These include the two main road bridges and the two pedestrian bridges across Adelong Creek, as well as a number of minor culvert crossings on minor tributaries. While increasing the waterway area of the bridges within Adelong Creek may result in a minor reduction in peak flood levels within the creek, the costs associated with the replacement of these structures would be prohibitive.

Culverts under Bleak Street, Rimmers Lane, Campbell Street and Adelong Cemetery Road could be upgraded to improve the hydrologic standard of the road crossings. While the upgrade of these culverts would reduce nuisance flooding, their economic feasibility cannot be justified given their surcharge does not result in any flood damages (other than possible minor damage to the adjacent road surface).

While Council may consider upgrading certain culverts in order to maintain access to critical infrastructure such as the Adelong WTP and STP, as well as the Golden Gully Caravan Park, these facilities would generally be inaccessible for a very short period of time given the relatively small size of the catchments which contribute to flow in the associated watercourses.

Given the relatively large costs and minimal benefits associated with replacing hydraulic structures along the minor waterways in Adelong, their upgrade was not included in the *FRMP*.

3.4.3 Channel Widening

The hydraulic capacity of a stream may be increased by widening, deepening or straightening the channel and clearing the banks of obstructions. The scope of such improvements can vary from: schemes which do not increase the waterway area but ensure the creek is maintained in a condition which maximises hydraulic capacity; to major channel excavations. Careful attention to design is required to ensure stability of the channel is maintained and scour or sediment build-up

is minimised. The potential for large scale improvements to increase downstream flood peaks also needs to be considered. In general, channel improvements need to be carried out over a substantial stream length to have any significant effect on flood levels. Proposals also need to conform with Government Policies in regard to retention of native vegetation, maintenance of fish habitat and other environmental considerations.

A flood mitigation scheme was considered in which Adelong Creek is widened downstream of Herb Feint Bridge in the vicinity of the pedestrian bridge. Widening the watercourse at this location would theoretically allow greater conveyance of floodwater and lessen flood impacts in its immediate vicinity. The channel widening would involve excavation on the western bank behind 60-64 Tumut Street to remove the natural bend in the creek.

By inspection, the scheme would have limited benefits as damages in this area for floods up to 1% AEP event under ideal flow conditions are mostly associated with Major Overland Flow. Based on this finding, this scheme was not considered further.

3.4.4 Vegetation Management

Management programs in creeks typically involve maintenance of batters, the removal of sediment, removal of dense vegetation and the clearance of flood debris after significant flow events. Clearance of debris within the stream corridor reduces the potential for future capture by the flow and blockage of culverts.

In Adelong, significant stream clearing took place in response to the October 2010 flood, when large stands of poplar trees which lined the banks of Adelong Creek upstream of Herb Feint Bridge and their associated undergrowth were cleared. The impact of the recent stream clearing can be seen on **Figure 2.2**, with reductions in peak flood levels having been achieved at the northern end of Selwyn Street.

Analysis was undertaken to assess the merits of further removing vegetation along Adelong Creek as far upstream as the extension of Gundagai Street, the results of which are shown on **Figure 3.2**. It can be seen that only a minor reduction in peak flood levels would be achieved along the cleared reach of Adelong Creek, with only small areas of land rendered flood free as a result of this measure.

Overall, the measure was found to have very minor positive impacts and would not reduce the amount of flood damage that occurs in Adelong for floods up to the 1% AEP event. Based on this finding, apart from ongoing maintenance of the reach of Adelong Creek between Herb Feint Bridge and Selwyn Street and the removal of the large polar trees that are at risk of being undermined immediately upstream of the bridge crossing, further broad scale stream clearing is not recommended for inclusion in the *FRMP*.

3.4.5 Upgrade of Stormwater Drainage System

Stormwater drainage systems are an effective means of preventing frequent flooding of urban areas by local catchment runoff. Stormwater drainage systems are usually designed to convey flows associated with more frequent rainfall events. Flows resulting from rarer events will usually exceed the capacity of the stormwater drainage system and travel along flow paths as local overland flow. While upgrading key elements of a stormwater drainage system may prevent

nuisance flooding in low lying properties or inundation of low points in roads due to small storms that occur frequently, it is generally not a cost effective or practical way to mitigate damaging flooding that results from intense, rare storm events.

An option for upgrading the existing stormwater drainage system at Adelong was assessed, whereby the inlet capacity in Lockhart Street and Tumut Street was increased in order to reduce the rate and frequency of overland flow entering properties between 68 and 86 Lockhart Street. **Figure 3.3** shows the location and impact the proposed upgrade of the stormwater drainage system along Lockhart Street and Tumut Street for the 10% and 1% AEP events under ideal flow conditions.

A number of alternative schemes to that shown in **Figure 3.3** were assessed which consisted of increased inlet capacity in combination with increasing the capacity of the pipe network along Lockhart Street and along the easement through 70 Lockhart Street. The benefits of these alternative schemes have not been presented as it was found that they provide only marginal improvements in the damages prevented compared to the scheme presented in **Figure 3.3** while being significantly more expensive to construct.

Figure 3.3 shows an increase in inlet pit capacity would render a significant area of land flood free, particularly around Tumut Street during a 10% AEP event. The impacts along the flow path which runs between Lockhart and Tumut Streets would also be significantly reduced. **Figure 3.3** also shows that the benefits of the scheme would reduce with increasing storm intensity.

Implementation of the flood mitigation scheme would prevent frequent flooding being experienced in a number of residential properties. A commercial property which would be flood damaged in a 10% AEP event would instead be damaged in a 2% AEP event. A second commercial property which was flood affected in a 10% AEP event would also not become flood affected until a 2% AEP event. The economic costs and benefits (damages prevented) of the scheme are summarised in **Table 3.3**.

TABLE 3.3
ECONOMIC ANALYSIS
POTENTIAL STORMWATER UPGRADE SCHEME

Discount Rate %	Nominal Flood Level Case under Ideal Flow Conditions		
	4	7	11
Present Worth Value of Benefits (Damages Prevented) $ Million	0.29	0.18	0.12
Cost of scheme $ Million	0.33	0.33	0.33
Benefit/Cost Ratio	0.88	0.55	0.36

While increasing the inlet capacity of the stormwater drainage system along Lockhart and Tumut Streets cannot be justified on economic grounds, the scheme does provide social benefits in that it would prevent nuisance flooding in a number of residential and commercial properties, as well as preventing inundation of roadways. While this scheme has not been included in the *FRMP*, Council may wish to implement this scheme as part of its general works and improvements programme.

3.4.6 Blockage Prevention

The risk of blockage to major hydraulic structures in Adelong is of serious concern, giving that historically the accumulation of floating woody debris on the two main road bridges has exacerbated flooding conditions in parts of Adelong. For example, in both the January 1984 and October 2010 floods, the accumulation of debris on the Snowy Valley Highway bridge crossing caused floodwater to break out of Adelong Creek where it flowed down Tumut Street. While the old Adelong Bridge with its closer pier spacing was present as the time of the January 1984 flood and both the Adelong Bridge and the partially constructed Herb Feint Bridge were present at the time of the October 2010 flood which increased the potential for blockage by debris, the presence of bridge piers in the water column (albeit at a larger spacing) still poses a risk in terms of potential blockage.

The increased risk of blockage at Adelong compared to other locations is principally due to the presence of dense forested areas which lie in the upper reaches of the Adelong Creek catchment. Logging activities in these areas may also be responsible for an increased debris load that is washed into the creek system during intense rainfall events.

There are a number of ways in which the flood risk due to blockage of the two main road bridges in Adelong can be reduced:

- **Planning controls**, which provide a non-structure means of preventing damage and minimising risk to life in large flood events, which may or may not be exacerbated by blockage.
- **Vegetation management**, which would reduce the amount of vegetation which could potentially be swept into the creek during a flood event. The removal of poplar trees which are present along the banks of the creek would also reduce the opportunity for debris to become trapped adjacent to developed areas where it would adversely impact flooding behaviour. It is noted that vegetation management is unlikely to reduce the debris load generated by the upper portion of the catchment given its more heavily forested nature.
- **Debris control measures**, which would act to intercept floating debris prior to it reaching the two main road bridges. A number of papers have been written which review different methods of debris mitigation (e.g. Wipf et al, 2012; Tyler, 2011). Options presented in these papers include debris fins, sweepers, deflectors, booms and racks.

The feasibility of constructing a debris control structure in Adelong Creek was investigated as part of the present investigation. The assessed structure comprised a line of reinforced concrete piers similar those of a bridge that would be installed across Adelong Creek at six metres centres. The line of piers would be aligned at 45 degrees to the direction of flow, so as to deflect debris toward an offline containment area.

A location upstream of the Adelong STP was chosen as the preferred site for the debris control structure. This location was chosen for a number of reasons including accessibility, isolation from existing development and the presence of a natural containment area on the western bank where debris could be directed.

Figure 3.4 shows the impact the debris control structure would have on flooding behaviour for the case where no debris has accumulated across the piers during a 1% AEP flood event. Peak 1% AEP flood levels immediately upstream the structure would be increased between 100-200 mm, with the impact reducing in the upstream direction over a distance of about one kilometre. The structure would also increase the magnitude of flow which presently surcharges the eastern bank of Adelong Creek at its location.

Figure 3.5 shows the impact a partial blockage of the debris control structure would have on flooding behaviour.[6] Peak 1% AEP flood levels would be increased by up to a metre immediately upstream of the structure, reducing in the upstream direction.

The magnitude of flow surcharging the eastern bank of Adelong Creek would increase significantly and result in high hazard flooding conditions being experienced along the flow path. While there is no existing development located in the affected area, the flow path is located on privately owned land.

While peak 1% AEP flood levels would also be increased by up to 50 mm downstream of the structure as a result of the short circuiting of flow that occurs on the eastern overbank of the creek, only the commercial property that is located at the northern end of Selwyn Street would be adversely impacted under partially blocked conditions.[7] It is noted that the increase in peak 1% AEP flood levels attributable to the debris control structure in this property is less than the increase that would occur should the Herb Feint Bridge experience a similar degree of blockage (refer **Figures 2.11** and **3.5** which show the impact a partial blockage of the two structures would have on flooding behaviour).

As the difference between the *present worth value* of flood damages for all floods up to the 1% AEP under ideal flow and partially blocked conditions is only $0.06 Million, the construction of a debris control structure upstream of Adelong cannot be justified on economic grounds (i.e. because its cost would be well in excess of $0.06 Million and therefore its benefit/cost ratio would be much less than 1). That said, the reduction in the risk of blockage of the main road bridges would have a significant social benefit as it would reduce the risk of hazardous flooding conditions developing in parts of Adelong, namely along Tumut Street for floods which would otherwise be confined to the inbank area of Adelong Creek.

Given that blockage has historically occurred on road bridges that have recently been replaced by structures which incorporate a reduced number of piers at larger spacings, the likelihood of a blockage by debris is significantly reduced. It is therefore recommended that the potential for these new structures to experience a blockage during future flood events be monitored prior to a decision being made as to whether to construct a debris control structure in Adelong Creek upstream of the town. The need to set up and maintain such a monitoring programme has been incorporated in the *FRMP*.

[6] Similar to the blockage scenario adopted for assessing the impact a partial blockage of both Rimmers Bridge and Herb Feint Bridge would have on flooding behaviour, a 4 m wide raft of debris was assumed to lodge on each pier to their full height (which was assumed to exceed the peak 1% AEP flood level at its location).

[7] The maximum increase in peak 1% AEP flood levels at the location of the existing building is 19 mm.

3.4.7 Removal of Floodplain Obstructions

The possibility of removing floodplain obstructions from Adelong Creek was raised by the community as a possible measure for inclusion in the *FRMP*. In particular, concerns were raised that an existing block of concrete that is located beneath the recently constructed Herb Feint Bridge is creating an impediment to flow.

The existing block of concrete, which was inspected during the preparation of the *FRMS,* appears to be a remnant section of the old Adelong Bridge. While the concrete block would not cause a large impediment to flow, its removal by RMS has merit as it would reduce the potential for woody debris to build up on its upstream side. It would also reduce turbulence in the flow which would otherwise increase the scour potential beneath the new bridge. Based on these findings, its removal by NSW Road and Maritime has been included in the *FRMP* for Adelong.

3.5 Property Modification Measures

3.5.1 Controls over Future Development

3.5.1.1 Considerations for Setting Flood Planning Level

Selection of the FPL for an area is an important and fundamental decision as the standard is the reference point for the preparation of floodplain risk management plans. It is based on adoption of the peak level reached by a particular flood plus an appropriate allowance for freeboard. It involves balancing social, economic and ecological considerations against the consequences of flooding, with a view to minimising the potential for property damage and the risk to life and limb. If the adopted FPL is too low, new development in areas outside the FPA (particularly where the difference in level is not great) may be inundated relatively frequently and damage to associated public services will be greater. Alternatively, adoption of an excessively high FPL will subject land that is rarely flooded to unwarranted controls.

Councils are responsible for determining the appropriate FPL's within their local government area. *Tumut LEP 2012* nominates the "*1:100 ARI (average recurrence interval) flood event plus 0.5 m freeboard*" as the FPL. However, the LEP does not presently distinguish between the different flood producing mechanisms at Adelong; namely Main Stream and Minor Tributary Flooding along Adelong Creek and several of its tributaries, and the slow moving and shallow Major Overland Flow which is generated by the local catchments which draining to the creek system at Adelong.

3.5.1.2 Current Government Policy

The circular issued by the Department of Planning on 31 January 2007 contained a package of changes clarifying flood related development controls to be applied on land in low flood risk areas (land above the 1% AEP flood). The package included an amendment to the Environmental Planning and Assessment Regulation 2000 in relation to the questions about flooding to be answered in Section 149 planning certificates (now referred to as Section 10.7 planning certificates), a revised ministerial direction (Direction 15 – now Direction 4.3 issued of 1 July 2009) regarding flood prone land (issued under Section 117 of the EP&A Act, 1979) and a new Guideline concerning flood-related development controls in low flood risk areas. The Circular advised that councils will need to follow NSWG, 2005, as well as the Guideline to gain the legal protection given by Section 733 of the Local Government Act.

The Department of Planning Guideline confirmed that unless exceptional circumstances applied, councils should adopt the 1% AEP flood with appropriate freeboard as the FPL for residential development. In proposing a case for exceptional circumstances, a council would need to demonstrate that a different FPL was required for the management of residential development due to local flood behaviour, flood history, associated flood hazards or a particular historic flood. Unless there were exceptional circumstances, Council should not impose flood-related development controls on residential development on land with a low probability of flooding, that is land above the residential FPL.

Nevertheless, the safety of people and associated emergency response management needs to be considered in low flood risk areas, which may result in:

- Restrictions on types of development which are particularly vulnerable to emergency response, for example, developments for aged care and schools.
- Restrictions on critical emergency response and recovery facilities and infrastructure. These aim to ensure that these facilities and the infrastructure can fulfil their emergency response and recovery functions during and after a flood event. Examples include evacuation centres and routes, hospitals and major utility facilities. Specific issues relating to Adelong include the medical centre which may be inaccessible and would be flood affected in a PMF event. Access along Tumut Street, which is a major evacuation route, would also be prevented in a 1% AEP event under partially blocked conditions, or a 0.5% AEP event under ideal flow conditions. These issues should be considered in emergency response planning.

3.5.1.3 Proposed Planning Controls for Adelong

As mentioned in **Section 2.12**, consideration needs to be given to the impact a partial blockage of the two road bridges at Adelong has on flooding behaviour and whether planning controls should take this mechanism of flooding into account.

While a partial blockage of Rimmers Bridge would result in a relatively minor increase in the depth of flow traversing the western overbank of Adelong Creek, the partial blockage of Herb Feint Bridge would result in a new hazardous floodway forming along Tumut Street for floods larger than 2% AEP.

Figure 3.6 shows the depth and extent of inundation, as well as the available freeboard to the floor level of existing dwellings and commercial buildings that are located along Tumut Street for a 1% AEP flood event under both ideal flow and partially blocked conditions. Also shown on **Figure 3.6** is the extent of the FPA under both ideal flow and partially blocked conditions.

While the adoption of partially blocked conditions would result in the floor level or mezzanine area of any future development needing to be set at a higher level, **Figure 3.6** shows that the number of properties to which flood related development controls would apply is only increased slightly. The reason for this is the relatively steep sided nature of the floodplain at Adelong.

Figure 3.7 shows that if the floor level or mezzanine area of any future development is derived based on ideal flow conditions, then those developments could potentially be subject to above-floor inundation should the Herb Feint Bridge experience a partial blockage during a major flood event (i.e. because the FPL based on ideal flow conditions lies below the peak 1% AEP flood level based on partially blockage conditions at several locations).

Given the characteristically high woody debris load in Adelong Creek and the limited experience which has been gained of how the two new road bridges at Adelong will perform from a blockage point of view, it is considered prudent that Council adopt a set of planning controls which take into account the potential for the two structures to experience a partial blockage during major flood events.

Based on the above, the draft *Flood Policy* (**Appendix D**) used the concepts of *flood hazard* and *hydraulic categorisation* outlined in the previous sections based on the envelope of ideal flow and partially blockage conditions to develop flood related controls for future development at Adelong. The *Flood Policy* caters for the three types of flooding:

- **Main Stream Flooding** resulting from flows that surcharge the main channel of Adelong Creek, as well as Black Creek, Tanyard Creek, Golden Gully and the unnamed tributary which joins Adelong Creek opposite the extension of Gundagai Street. While the flows in Adelong Creek may be several metres deep in the channel and relatively fast moving with velocities of greater than 2 m/s, flow in the other watercourses are generally shallower and slower moving.
- **Minor Tributary Flooding** resulting from overflows of the minor gully systems which drain the relatively steep hillsides bordering Adelong Creek. Watercourses that are included in this definition are Nuggety Gully, Curtis Gully and Currans Gully.
- **Major Overland Flow** is present along several flow paths that run through the urbanised parts of Adelong. It is also present in the undeveloped areas which border the township. Flows on the Major Overland Flow paths would typically be less than 300 mm deep, travelling over the surface at velocities less than 0.5 m/s.

Considerable reduction in the number of properties in Major Overland Flow areas classified as "flood affected" would result by the adoption of a threshold depth of inundation under 1% AEP conditions of 150 mm as the criterion for flood affectation, compared with the traditional approach. Properties with depths of inundation 150 mm or greater, or in a floodway (i.e. traversed by significant overland flows) would be considered to be flood affected and lie within the FPA. Properties with depths of inundation under 1% AEP conditions of less than 150 mm would be classified as "Local Drainage" and, as such would be subject to controls such as the Building Code of Australia (**BCA**) requirements, rather than attracting a flood affectation notice. This approach is supported by NSWG, 2005 and would not adversely impact on Council's duty of care in regard to management of flood prone lands. The proposed categorisation of the floodplain, terminology and controls are shown on **Table 3.4** over the page.

Figure D1.1 in **Appendix D** is an extract from the *Flood Planning Map* at Adelong. The figure includes areas subject to both Main Stream Flooding, Minor Tributary Flooding and Major Overland Flow in the town. The extent of the FPA (the area subject to flood related development controls) is shown in a solid red colour in **Figure D1.1** and has been defined as follows:

- In areas subject to Main Stream Flooding, the FPA is based on the traditional definition of the area inundated by the 1% AEP plus 500 mm freeboard.
- In areas affected by Minor Tributary Flooding, the FPA is defined as areas where depths of inundation in a 1% AEP event exceed 150 mm.
- In areas subject to Major Overland Flow, the FPA is defined as the extent of the High and Low Hazard Floodway zones, as well as areas where depths of inundation in a 1% AEP event exceed 150 mm.

The illustration in **Section 5.9.1** of the draft *FRMP* (refer **Chapter 5** of this report) demonstrates the derivation of the FPA in areas affected by Main Stream Flooding, Minor Tributary Flooding and Major Overland Flow.

TABLE 3.4
PROPOSED CATEGORISATION OF THE FLOODPLAIN

Category (FDM, 2005)	Proposed Terminology used to define inundation in *FRMS&P* report	Are Development Controls Required?	Is Section 10.7 Notification Warranted?
Main Stream Flooding	"Main Stream Flooding"	Yes	Yes
Minor Tributary Flooding	"Minor Tributary Flooding"	Yes	Yes
Local Overland Flooding - Local Drainage - Major Drainage	 "Local Drainage" "Major Overland Flow"	 No (ref. footnote 1). Yes (ref. footnote 2).	 No (ref footnote 1) Yes (ref footnote 3)

Footnotes

1. Inundation in Local Drainage areas is accommodated by the minimum floor level requirement of 150 mm above finished surface level contained in the BCA and does not warrant a flood affectation notice in S10.7 Planning Certificates.
2. These are the deeper flooded areas with higher flow velocities. Development controls are specified in the draft *Flood Policy* of **Appendix D**.
3. Depth and velocity of inundation in Major Overland Flow areas are sufficient to warrant a flood affectation notice in S10.7 Planning Certificates. Inundation is classified as "flooding".

It is proposed that properties intersected by the extent of the FPA would be subject to S10.7 flood affectation notification and planning controls graded according to flood. NSWG, 2005 suggests wording on S10.7 (2) Planning Certificates along the following lines:

> *"Council considers the land in question to be within the Flood Planning Area and therefore subject to flood related development controls. Information relating to this flood risk may be obtained from Council. Restrictions on development in relation to flooding apply to this land as set out in Council's Flood Policy which is available for inspection at Council offices or website."*

Annexures 2.1 and **2.2** in **Appendix D** set out the graded set of flood related planning controls which have been developed for Adelong. **Annexure 2.1** deals with areas subject to Main Stream Flooding and Minor Tributary Flooding, while **Annexure 2.2** deals with areas subject to Major Overland Flow. **Figure D1.2** in **Appendix D** is the *Development Controls Matrix Map* for Adelong showing the areas over which both **Annexures 2.1** and **2.2** apply.

Minimum floor level requirements would be imposed on future development in properties that are identified as lying either partially or wholly within the extent of the FPA shown on the *Flood Planning Map*. The minimum floor levels for all land use types affected by Main Stream Flooding and Minor Tributary Flooding is the level of the 1% AEP flood event plus 500 mm freeboard, while those for all land use types affected by Major Overland Flow is the level of the 1% AEP flood event plus 300 mm freeboard.

The exception to the above set of criteria relates to commercial development located along Tumut Street, whereby the floor levels in these properties may be built at street level, provided a mezzanine area where goods can be temporarily stored is provided at the peak 1% AEP flood

level on Adelong Creek plus 500 mm freeboard. This will assist in maintaining connectivity to the footpath of Tumut Street, while reducing flood damages that would otherwise occur if a storage area is not provided above the 1% AEP flood level.

The illustration in **Section 5.9.1** of the draft *FRMP* (refer **Chapter 5** of this report) demonstrates the minimum floor level requirements in areas affected by Main Stream Flooding, Minor Tributary Flooding and Major Overland Flow.

Figure D1.3 in **Appendix D** is the *Flood Hazard Map* for Adelong which shows the subdivision of the floodplain into a number of categories which have been used as the basis for developing the graded set of planning controls.

The floodplain has been divided into the following four categories in areas that are affected by Main Stream Flooding and Minor Tributary Flooding:

- The **Inner Floodplain (Hazard Category 1A)** zone (shown as a solid red colour) comprises areas where factors such as the depth and velocity of flow, time of rise, isolation on Low Flood Islands and evacuation problems mean that the land is unsuitable for most types of development. It principally comprises High and Low Hazard Floodway areas. Erection of buildings and carrying out of work; use of land, subdivision of land and demolition subject to State Environmental Planning Policies and Local Environmental Plan provisions are not permitted in this zone.
- The **Inner Floodplain (Hazard Category 1B)** zone (shown as a solid orange colour) comprises an area on the western overbank of Adelong Creek centred on Tumut Street. This area is affected by hazardous flooding as a result of a partial blockage of the Herb Feint Bridge or during a flood slightly larger than the 1% AEP event. Only commercial/industrial development and minor additions to existing residential development is permitted in this zone.
- The **Inner Floodplain (Hazard Category 2)** zone (shown as a solid yellow colour) comprises Low Hazard Floodway areas, where development other than Essential Community Facilities, Critical Utilities, Schools and Flood Vulnerable development is permitted provided it is capable of withstanding hydraulic forces and sited on the allotment to minimise adverse redirections of flow toward adjacent properties. Council may require a *Flood Risk Report* if it considers that the proposal has the potential to significantly affect flooding behaviour in adjacent properties.
- The **Intermediate Floodplain** zone (shown as a solid blue colour) is the remaining land lying outside the extent of the Inner Floodplain zones, but within the FPA. Within this zone, there would only be the requirement for minimum floor levels to be set at the 1% AEP flood levels plus 500 mm. While land use permissibility would be as specified by State Environmental Planning Policies or the Local Environmental Plan, Essential Community Facilities, Critical Utilities and Flood Vulnerable Residential development are not permitted in this zone.
- The **Outer Floodplain** zone is the area outside the Intermediate Floodplain where the depth of inundation will exceed 150 mm in the PMF (shown as a solid cyan colour). This area is outside the extent of the FPA and hence controls on residential, commercial and industrial development do not apply.

The floodplain has been divided into the following two additional categories in areas that are affected by Major Overland Flow:

- **High Hazard Floodway**, which is shown in solid orange colour. Future development in this area is not permitted under the *Flood Policy*.
- **Low Hazard Floodway / Flood Fringe**, which is shown in solid green colour. Residential, commercial and industrial type development can occur in this zone subject to compliance with a prescribed set of flood related development controls.

The **Intermediate Floodplain** zone in areas subject to Major Overland Flow is the remaining land lying outside the extent of the Floodway and Flood Fringe areas where the depth of inundation during a 1% AEP storm event depths will exceed 150 mm, while the **Outer Floodplain** zone represents the area outside the aforementioned zones where the depth of inundation will exceed 150 mm during the PMF. Flood related planning controls in these two areas are similar to those that apply to development in areas subject to Main Stream Flooding and Minor Tributary Flooding, with the following exceptions:

- the adoption of a reduced freeboard of 300 mm for defining minimum floor levels in the **Intermediate Floodplain**; and
- the potential for Essential Community Facilities, Critical Utilities and Flood Vulnerable Residential type development to take place in both the **Intermediate Floodplain** and **Outer Floodplain** zones subject to compliance with the flood related development controls set out in **Annexure 2.2** of the *Flood Policy*.

3.5.1.4 Revision of Tumut LEP 2012 by Council

To implement the recommended approach set out in the *FRMS&P*, clause 6.2 of *Tumut LEP 2012* would require minor amendments, namely in regards the wording of sub clause (2) and (5). It is recommended that the following clause replaces the existing clause 6.2 of *Tumut LEP 2012*:

"6.2 Flood planning

(1) The objectives of this clause are as follows:

(a) to minimise the flood risk to life and property associated with the use of land,

(b) to allow development on land that is compatible with the land's flood hazard, taking into account projected changes as a result of climate change,

(c) to avoid significant adverse impacts on flood behaviour and the environment.

(2) This clause applies to land at or below the flood planning level.

(3) Development consent must not be granted for development on land to which this clause applies unless the consent authority is satisfied that the development:

(a) is compatible with the flood hazard of the land, and

(b) will not significantly adversely affect flood behaviour resulting in detrimental increases in the potential flood affectation of other development or properties, and

(c) incorporates appropriate measures to manage risk to life from flood, and

(d) will not significantly adversely affect the environment or cause avoidable erosion, siltation, destruction of riparian vegetation or a reduction in the stability of river banks or watercourses, and

(e) is not likely to result in unsustainable social and economic costs to the community as a consequence of flooding.

(4) A word or expression used in this clause has the same meaning as it has in the Floodplain Development Manual, unless it is otherwise defined in this Plan."

In order to support the proposed changes to clause 6.2 of *Tumut LEP 2012*, it will be necessary to include the following definitions in the Dictionary:

- ***Flood planning level*** means the level of a 1% AEP (annual exceedance probability) flood event plus 0.5 metre freeboard, or other freeboard as determined by any floodplain risk management plan adopted by the Council in accordance with the Floodplain Development Manual.
- ***Floodplain Development Manual*** means Floodplain Development Manual (ISBN 0 7347 5476 0) published by the NSW Government in April 2005.

It is also recommended that a new floodplain risk management clause be added to *Tumut LEP 2012* as follows:

"Floodplain risk management

(1) The objectives of this clause are as follows:

(a) in relation to development with particular evacuation or emergency response issues, to enable evacuation of land subject to flooding in events exceeding the flood planning level,

(b) to protect the operational capacity of emergency response facilities and critical infrastructure during extreme flood events.

(2) This clause applies to land which lies between the flood planning level and the level of the probable maximum flood, but does not apply to land at or below the flood planning level.

(3) Development consent must not be granted to development for the following purposes on land to which this clause applies unless the consent authority is satisfied that the development will not, in flood events exceeding the flood planning level, affect the safe occupation of, and evacuation from, the land:

(a) child-based child care facility

(b) correctional centre

(c) educational establishment

(d) emergency services facility

(e) extractive industry

(f) group homes

(g) mining

(h) place of public worship

(i) residential care facilities

(j) respite day care centre

(k) senior housing

(l) tourist and visitor accommodation

(m) waste or resource management facility

(4) A word or expression used in this clause has the same meaning as it has in the Floodplain Development Manual, unless it is otherwise defined in this Plan."

In order to support the inclusion of the new clause in *Tumut LEP 2012*, it will be necessary to include the following definitions in the Dictionary:

- ***probable maximum flood*** means the largest flood that could conceivably occur at a particular location, usually estimated from probable maximum precipitation.

The steps involved in Council's amending *Tumut LEP 2012* following the finalisation and adoption of the *FRMS&P* are:

1. Council Planning Staff consider the conclusions of the *FRMS&P* and suggested amendments to *Tumut LEP 2012*.
2. Council resolves to amend *Tumut LEP 2012* in accordance with the *FRMS&P*.
3. Council prepares a Planning Proposal in accordance with NSW Planning and Environment Guidelines. Planning Proposal submitted to NSW Planning and Environment in accordance with section 3.33 of the EP&A Act, 1979.
4. Planning Proposal considered by NSW Planning and Environment and determination made in accordance with section 3.34 of the EP&A Act, 1979 as follows:
   (a) whether the matter should proceed (with or without variation),
   (b) whether the matter should be resubmitted for any reason (including for further studies or other information, or for the revision of the planning proposal),
   (c) community consultation required before consideration is given to the making of the proposed instrument (the community consultation requirements),
   (d) any consultation required with State or Commonwealth public authorities that will or may be adversely affected by the proposed instrument,
   (e) whether a public hearing is to be held into the matter by the Planning Assessment Commission or other specified person or body,
   (f) the times within which the various stages of the procedure for the making of the proposed instrument are to be completed.

5. Planning Proposal exhibited for public comment.
6. Planning Proposal reviewed following public submissions and submissions from relevant State and Commonwealth authorities.
7. Final Local Environmental Plan with proposed amendments drafted.
8. Amending Local Environmental Plan made by the Minister and gazetted.

3.5.2 Voluntary Purchase of Residential Properties

Removal of housing from high hazard floodway areas in the floodplain is generally accepted as a cost-effective means of correcting previous decisions to build in such areas. The Voluntary Purchase (**VP**) of residential property in hazardous areas has been part of subsidised floodplain management programs in NSW for over 20 years. After purchase, land is subsequently cleared and the site re-developed and re-zoned for public open space or some other flood compatible use. A further criterion applied by State Government agencies in assessing eligibility for funding is that the property must be in a high hazard floodway area, that is, in the path of flowing floodwaters where the depth and velocity at the peak of the flood are such that life could be threatened, damage of property is likely and evacuation difficult.

Under a VP scheme the owner is notified that the body controlling the scheme, Council in the present case, is prepared to purchase the property when the owner is ready to sell. There is no compulsion whatsoever to sell at any time. The price is determined by independent valuers and the Valuer General, and by negotiation between Council and the owners. Valuations are not reduced due to the flood affected nature of the site.

While there are no residential properties that lie within the high hazard floodway area for the 1% AEP flood event under ideal flow conditions, hazardous conditions can develop rapidly in six properties that are located along Tumut Street as a result of either a partial blockage of Herb Feint Bridge or in the event of a flood that is slightly larger than the 1% AEP event.[8] **Plates 9**, **10**, **11**, **12**, **13** and **14** in **Appendix C** show the nature of flooding along the overland flow path which formed along Tumut Street when the partially demolished Adelong Bridge and partially constructed Herb Feint Bridge were partially blocked by debris during the October 2010 flood. While flow conditions in these properties would not be classified as high hazard based on a velocity and depth criteria, the rapid rise in water levels and the sudden break out of flow along Tumut Street leads to the true hazard of this area being of a high hazard nature.

In addition to the above six dwellings, there is also a single dwelling that is located on the western side of Selwyn Street, immediately downstream of Rimmers Bridge that is located in a floodway that develops for the case where a flood slightly larger than the 1% AEP event occurs, or where the bridge experiences a partial blockage during a 1% AEP flood event. While the warning time would be relatively short, the depth of above-ground and above-floor inundation under partially blocked conditions would generally be limited to about 0.25 m and 0.04 m, respectively, while for a 0.2% AEP event it would be limited to 0.4 m and 0.19 m respectively. Given the relatively shallow depth of inundation of this property, its inclusion in a VP scheme could not be justified.

[8] Five of the six properties are located on the upstream side of Herb Feint Bridge, while the remaining property is located at the northern end of the overland flow path that forms along Tumut Street. All six properties are located on the western overbank of Adelong Creek.

While the purchase of the six properties that are located along Tumut Street could not be justified on economic grounds (i.e. because flooding in these properties does not occur on a frequent basis, resulting in a very low present worth value of flood damages), there is merit in removing residential development from an area which functions as a high hazard floodway under certain hydraulic and climatic conditions. At an estimated cost of $400,000 per property, a VP scheme comprising the seven affected residential properties along Tumut Street would cost an estimated $2.8 Million.

It is noted that if the five properties that are located upstream of Herb Feint Bridge were to be acquired, then it would be feasible to construct a much cheaper earthen type levee than the reinforced block wall arrangement that is outlined in **Section 3.4.1**. Given the large cost associated with acquiring these properties, it would be more cost effective to manage risk of life through the implementation of an effective flood warning system in combination with ongoing consultation with the affected land owners. This approach is discussed further in **Section 3.6**

3.5.3 Raising Floor Levels of Residential Properties

The term "house raising" refers to procedures undertaken, usually on a property by property basis, to protect structures from damage by floodwaters. The most common process is to raise the affected house by a convenient amount so that the floor level is at or above the minimum floor level. For weatherboard and similar buildings this can be achieved by jacking up the house, constructing new supports, stairways and balconies and reconnecting services. Alternatively, where the house contains high ceilings, floor levels can be raised within rooms without actually raising the house. It is usually not practical to raise brick or masonry houses. Most of the costs associated with this measure relate to the disconnection and reconnection of services. Accordingly, houses may be raised a considerable elevation without incurring large incremental costs.

State and Federal Governments have agreed that flood mitigation funds will be available for house raising, subject to the same economic evaluation and subsidy arrangements that apply to other structural and non-structural flood mitigation measures. In accepting schemes for eligibility, the State Government has laid down the following conditions:

- House raising should be part of the adopted *FRMP*.
- The scheme should be administered by the local authority.

The State Government also requires that councils carry out ongoing monitoring in areas where subsidised voluntary house raising has occurred to ensure that redevelopment does not occur to re-establish habitable areas below the design floor level. In addition, it is expected that councils will provide documentation during the conveyancing process so that subsequent owners are made aware of restrictions on development below the design floor level.

Council's principal role in subsidised voluntary house raising would be to:

- Define a habitable floor level, which it will have already done in exercising controls over new house building in the area.
- Guarantee a payment to the builder after satisfactory completion of the agreed work.
- Monitor the area of voluntary house raising to ensure that redevelopment does not occur to re-establish habitable areas below the design floor level.

The current cost to raise a medium sized (150 m^2) house is about $100,000 based on recent experience in other centres.

While there are five dwellings which experience above-floor inundation at the 1% AEP flood event under ideal flow conditions (refer **Figure 2.3** for their location), all but one are affected by Major Overland Flow. Given the relatively shallow, slow moving and short duration nature of the Major Overland Flow, adoption of a house raising scheme for the five affected properties cannot be justified on both social and economic grounds. As the one dwelling that is affected by Main Stream Flooding is of slab-on-ground and brick veneer type construction, it would not be possible to raise its floor level.

While there are several dwellings that are located along Tumut Street that would experience above-floor inundation under certain hydraulic and climatic conditions, given the high hazard nature of the resulting flow it is recommended that the floor level of these properties not be raised, and rather an effective flood warning system be implemented to manage risk of life.

While there is scope to raise the floor level of one weatherboard type dwelling that is located on the western side of Selwyn Street, immediately downstream of Rimmers Bridge, the depth of above-floor inundation only reaches 0.04 m in a 1% AEP event under partially blocked conditions. Given the relatively shallow and infrequent nature of the inundation of the dwelling, its inclusion in a voluntary house raining scheme could also not be justified.

Based on the above findings, a voluntary house raising scheme is not recommended for Adelong.

3.6 Response Modification Measures

3.6.1 Improvements to Flood Warning System

Improvements to the flood warning and response procedures were strongly favoured by the community during the consultation process. An effective flood warning system has three key components, i.e. a flood forecasting system, a flood warning broadcast system and a response/evacuation plan. All systems need to be underpinned by an appropriate public flood awareness program.

As mentioned in **Section 2.15**, BoM currently operates a well-established and proven flood warning system which provides advance warning of potential flood producing storms in the region surrounding Adelong. While this service provides both a means of forecasting and flood warning to NSW SES and other management authorities, as well as residents, it is important that 'flood watches' issued by BoM are relayed to residents via radio, TV, social media and other mediums. Establishing an automated warning services could be considered by Council which would send text messages containing important information to all mobile devices in the region. However, given the cost of such systems, the small population of Adelong and that flood risk areas are known, it would be more effective for NSW SES to contact residents directly.

While the Batlow Road stream gauge provides information on flooding in Adelong Creek, it is located too close to town to give any useful warning time.

To improve flood response in Adelong it is therefore recommended that:

a) The *Local Flood Plan* be updated (see **Section 3.6.2**) to provide the most up to date information on the nature of flooding in Adelong.

b) Ongoing consultation with residents and business owners along Tumut Street to ensure they are aware of the existing flood risk and the need to respond to announcements made by the loudspeaker system. Consideration should also be given to linking the trigger levels to the dissemination of flood warnings via SMS on the newly installed stream gauge to mobile phones.

c) A telemetered stream gauge be installed on the upstream side of Herb Feint Bridge and trigger levels set which are linked to a loud speaker system which warns residents and business owners along Tumut Street of rapidly rising water levels in Adelong Creek.

3.6.2 Improved Emergency Planning and Response

As mentioned in **Section 2.15**, the *Local Flood Plan* provides detailed information regarding preparedness measures, conduct of response operations and coordination of immediate recovery measures for all levels of flooding.

NSW SES should ensure information contained in this report on the impacts of flooding on urban development, as well as recommendations regarding flood warning and community education are used to update Volume 2 of the *Tumut Local Flood Plan*. Volume 2 should include the following sections:

1 – The Flood Threat includes the following sub-sections:

1.1 Land Forms and River Systems – ref. **Sections 2.1** and **2.2** of the report for information on these topics.

1.4 Characteristics of Flooding – Indicative extents of inundation for the 1% AEP and PMF events and the typical times of rise of floodwaters at key locations on both the major watercourses and Major Overland Flow paths under ideal flow conditions are shown on **Figures 2.3**, **2.4** and **2.6**. Indicative extents of inundation for the 1% AEP event under partially blocked conditions is presented on **Figure 2.10**. **Table 2.4** summarises the impact flooding has on the critical infrastructure at Adelong. The location of critical infrastructure relative to the flood extents is shown on **Figure 2.7**.

1.5 Flood History – Recent flood experience at Adelong is discussed in **Section 2.4** of the report.

1.6 Flood Mitigation Systems – There are no significant flood mitigation systems in Adelong, other than recent stream clearing which is discussed in **Section 2.7**, and the replacement of the Adelong Bridge with the Herb Feint Bridge and the upgrade of Rimmers Bridge.

1.7 Extreme Flood Events – The Probable Maximum Flood was modelled and the indicative extent and depth of inundation under ideal flow conditions is presented on **Figure 2.4** and in the *Flood Study*.

2 – Effects on the Community

Information on the properties affected by the 1% AEP design flood under ideal flow and partially blocked conditions are included in this report (**Figure 2.3** and **2.10**). While the floor levels of eighty properties that are affected at the 1% AEP level of flooding were surveyed by a registered surveyor, the floor levels of properties located elsewhere on the floodplain were estimated by a "drive-by" survey which assessed the height of the floor above local natural surface elevations. While fit for

use in estimating the economic impacts of design floods, the data for the properties that are not affected at the 1% AEP level of flooding should not be used to provide specific details of the degree of flood affectation of individual properties.

Figure 2.6 shows stage hydrographs at locations along Adelong Creek. The figure contains information such as the assessed minimum road/bridge level, times to peak flood levels, times to overtopping of the road crossing, and maximum depth of inundation.

Figure 2.7 shows the location of critical infrastructure in Adelong relative to the flood extents of the 10%, 2% and 1% AEP flood events, as well as the PMF. Refer **Section 2.9** and **Table 2.4** for details of affected infrastructure.

Figures 3.8 and **3.9** show the flood emergency response planning classifications for the 1% AEP and PMF events, respectively, based on the definitions set out in the *Floodplain Risk Management Guideline – Flood Emergency Response Classification of Communities* (DECC, 2007).[9]

While areas classified as High Hydraulic Hazard Flooding are generally confined to the main stream areas, there are a number of Low Flood Islands that are present adjacent to Adelong Creek and the minor tributaries for a 1% AEP event.

3.6.3 Public Awareness Programs

Community awareness and appreciation of the existing flood hazards in the floodplain would promote proper land use and development in flood affected areas. A well informed community would be more receptive to requirements for flood proofing of buildings and general building and development controls imposed by Council. Council should also take advantage of the information on flooding presented in this report, including the flood mapping, to inform occupiers of the floodplains of the flood risk.

One aspect of a community's preparedness for flooding is the "flood awareness" of individuals. This includes awareness of the flood threat in their area and how to protect themselves against it. The overall level of flood awareness within the community tends to reduce with time, as memories fade and as residents move into and out of the floodplain. The improvements to flood warning arrangements described above, as well as the process of disseminating this information to the community, would represent a major opportunity for increasing flood awareness in Adelong.

Means by which community awareness of flood risks can be maintained or may be increased include:

- displays at Council offices using the information contained in the present study and photographs of historic flooding in the area; and
- talks by NSW SES officers with participation by Council and longstanding residents with first-hand experience of flooding in the area.

[9] Note that the flood emergency response planning classifications for the 1% AEP flood event are based on the envelope of ideal flow and partially blocked conditions, since either condition may arise during a major flood event.

- preparation of a *Flood Information Brochure* which could be prepared by Council with the assistance of NSW SES containing both general and site specific data and distributed with rate notices.

The community should also be made aware that a flood greater than historic levels or the planning level can, and will, occur at some time in the future.

As mentioned in **Section 3.6.1**, it is recommended that a community awareness programme be developed which specifically targets residents and business owners that are located along the overland flow path that would develop during either a partial blockage of Herb Feint Bridge during a flood larger than 2% AEP, or during a 0.2% AEP flood event under ideal flow conditions. The community awareness program would be aimed at ensuring that the affected residents and business owners are aware of the existing flood risk and the need to respond to announcements made over the loud speaker system which forms part of the recommended flood warning system for Adelong.

4 SELECTION OF FLOODPLAIN MANAGEMENT MEASURES

4.1 Background

NSWG, 2005 requires a Council to develop a *FRMP* based on balancing the merits of social, environmental and economic considerations which are relevant to the community. This chapter sets out a range of factors which need to be taken into consideration when selecting the mix of works and measures that should be included in the *FRMP*.

The community will have different priorities and, therefore, each needs to establish its own set of considerations used to assess the merits of different measures. The considerations adopted by a community must, however, recognise the State Government's requirements for floodplain management as set out in NSWG, 2005 and other relevant policies. A further consideration is that some elements of the *FRMP* may be eligible for subsidy from State and Federal Government sources and the requirements for such funding must, therefore, be taken into account.

Typically, State and Federal Government funding is given on the basis of merit, as judged by a range of criteria:

- The magnitude of damage to property caused by flooding and the effectiveness of the measure in mitigating damage and reducing the flood risk to the community.
- Community involvement in the preparation of the *FRMP* and acceptance of the measure.
- The technical feasibility of the measure (relevant to structural works).
- Conformance of the measure with Council's planning objectives.
- Impacts of the measure on the environment.
- The economic justification, as measured by the benefit/cost ratio of the measure.
- The financial feasibility as gauged by Council's ability to meet its commitment to fund its part of the cost.
- The performance of the measure in the event of a flood greater than the design event.
- Conformance of the measure with Government Policies (e.g. NSWG, 2005 and Catchment Management objectives).

4.2 Ranking of Measures

A suggested approach to assessing the merits of various measures is to use a subjective scoring system. The chief merits of such a system are that it allows comparisons to be made between alternatives using a common "currency". In addition, it makes the assessment of alternatives "transparent" (i.e. all important factors are included in the analysis). The system does not, however, provide an absolute "right" answer as to what should be included in the *FRMP* and what should be left out. Rather, it provides a method by which Council can re-examine the measures and if necessary, debate the relative scoring given to aspects of the *FRMP*.

Each measure is given a score according to how well the measure meets the considerations discussed above. In order to keep the scoring simple, the following system is proposed:

+2 Measure rates very highly

+1 Measure rates well

0 Measure is neutral

- 1 Measure rates poorly

- 2 Measure rates very poorly

The scores are added to get a total for each measure.

Based on considerations outlined in this chapter, **Table 4.1** presents a suggested scoring matrix for the measures reviewed in **Chapter 3** at Adelong. This scoring has been used as the basis for prioritising the components of the *FRMP*.

4.3 Summary

Table 4.1 indicates that there are good reasons to consider including the following elements into the draft *FRMP*:

- Planning Controls via a Flood Policy for future development in Adelong.
- An update of the *Tumut LEP 2012* to allow better management of the floodplain
- Incorporation of the catchment specific information on flooding impacts contained in this Study in NSW SES Response Planning and Flood Awareness documentation for the study area.
- Improvements to the Flood Warning System at Adelong
- Improved public awareness of flood risk in the community.
- Ongoing vegetation management along Adelong Creek upstream of the Herb Feint Bridge
- Removal of remnant section of the Adelong Bridge from beneath the Herb Feint Bridge.

TABLE 4.1
ASSESSMENT OF POTENTIAL FLOODPLAIN MANAGEMENT MEASURES FOR INCLUSION IN THE FLOODPLAIN RISK MANAGEMENT PLAN

Measure	Impact on Flooding/ Reduction in Flood Risk	Community Acceptance	Technical Feasibility	Planning Objectives	Environ. Impacts	Economic Justification	Financial Feasibility	Extreme Flood	Government Policies and TCM Objectives	Score
Flood Modification										
Construction of flood protection levee on western bank of Adelong Creek immediately upstream of Herb Feint Bridge	+1	-1	-1	+2	-1	-2	-1	0	+1	-2
Upgrade of existing stormwater drainage system	+1	+2	+2	+1	0	-1	-1	0	0	+4
Channel widening works on western bank of Adelong Creek immediately downstream of Herb Feint Bridge	0	-1	-2	0	-2	-2	-1	0	0	-8
Construction of debris capture structure upstream of Rimmers Bridge	+1	+2	+1	0	-1	-2	-1	0	+2	+2
Removal of remnant section of Adelong Bridge from beneath Herb Feint Bridge	+1	+2	+2	0	+1	0	0	0	+2	+8
Property Modification										
Controls over Future Development (via draft Flood Policy)	+2	+2	+2	+2	0	0	0	+1	+2	+11
Voluntary Purchase of Residential Property	+2	-1	+2	+2	+1	-2	-2	+2	+1	+5
House Raising in High and Low Hazard Floodway Areas	+1	-1	+2	+1	0	-1	-1	0	+1	+3
Response Modification										
Improvements to Flood Warning System	+2	+2	+2	+1	0	0	0	+2	+2	+11
Improved Emergency Planning and Response	+2	+2	+2	+1	0	0	0	+2	+2	+11
Public Awareness Programs	+1	+2	+2	+1	0	0	0	+1	+2	+9

5 DRAFT FLOODPLAIN RISK MANAGEMENT PLAN

5.1 The Floodplain Risk Management Process

The *Floodplain Risk Management Study* (***FRMS***) and draft *Floodplain Risk Management Plan* (***FRMP***) have been prepared for Adelong as part of a Government program to mitigate the impacts of major floods and reduce the hazards in the floodplain. The *FRMP* which is set out in this Chapter has been prepared as part of the Floodplain Risk Management Process in accordance with NSW Government's Flood Prone Land Policy.

The first steps in the process of preparing the *FRMP* were the collection of flood data and the review of the *Adelong Flood Study* (***Flood Study***). The *Flood Study* was the formal starting process of defining management measures for flood liable land and represented a detailed technical investigation of flood behaviour for Adelong.

5.2 Purpose of the Plan

The overall objectives of the *FRMS* were to assess the impacts of flooding, review policies and measures for management of flood affected land and to develop a *FRMP* which:

- Sets out the recommended program of works and measures aimed at reducing over time, the social, environmental and economic impacts of flooding and establishes a program and funding mechanism for the *FRMP*.
- Proposes amendments to Snowy Valleys Council's (**Council's**) existing policies to ensure that the future development of flood affected land at Adelong is undertaken so as to be compatible with the flood hazard and risk.
- Ensures the *FRMP* is consistent with NSW SES's local emergency response planning procedures.
- Ensures that the *FRMP* has the support of the community.

5.3 The Study Area

The study area for this *FRMP* comprises the town of Adelong and its immediate environs. The *FRMP* applies in areas affected by the three flood producing mechanisms that occur at the town: ***Main Stream Flooding*** along Adelong Creek, Black Creek, Tanyard Creek, Golden Gully and the unnamed tributary which joins Adelong Creek opposite the extension of Gundagai Street, ***Minor Tributary Flooding*** along the various minor gullys which drain the rural hillsides which surround Adelong and the shallow and slower moving ***Major Overland Flow*** which is present mainly in the urbanised parts of the town.

5.4 Community Consultation

The Community Consultation process provided valuable direction over the course of the investigations, bringing together views from key Council staff, other departments and agencies, and importantly, the views of the community gained through:

- the delivery of a *Community Newsletter* and *Community Questionnaire* to property occupiers located in the floodplain which allowed the wider community to gain an understanding of the issues being addressed as part of the study; and
- meetings of the Floodplain Risk Management Committee to discuss results as they became available.

5.5 Indicative Flood Extents

Figures 2.3 and **2.4** show the indicative extent and depths of inundation at Adelong for the 1% AEP and PMF events, respectively, noting that the information shown on these figures is for the case where both Rimmers Bridge and the Herb Feint Bridge are free of any obstructions (i.e. ideal flow conditions). **Figures 2.3** and **2.4** also show the buildings that would experience above-floor inundation under ideal flow conditions.[10]

The 1% AEP design flood which has been adopted as the "planning flood" for the purposes of specifying flood related controls over future development. The extent of flooding is indicative only, being based on hydrologic and hydraulic models that were developed both as part of the *Flood Study* and the present study.

To allow Council to assess individual development proposals for the purposes of the draft *Flood Policy* (ref. **Section 5.9** below), a detailed site survey would be required to allow the extent of flooding and the flood hazard to be evaluated using the results of the *Flood Study*. For this reason, proponents will be required to submit a detailed survey plan of the site for which development is proposed.

5.6 Impact of a Partial Blockage on Flooding Behaviour

A high woody debris load has historically been associated with flood flows in Adelong Creek. Furthermore, woody debris has historically been observed to build up on the two road bridges at Adelong, which in turn has exacerbated flooding conditions in parts of the town, especially along Tumut Street.

While the recent upgrade of both road bridges has reduced their blockage potential, consideration has been given to the impacts a partial blockage of the new structures would have on flooding behaviour. **Figure 2.11** shows the impact a partial blockage of both Rimmers Bridge and the Herb Feint Bridge would have on flooding behaviour, while **Figure 3.6** shows the indicative depth and extent of inundation along Tumut Street under both ideal flow and partially blocked conditions for the 1% AEP flood event. Also shown on **Figure 3.6** is the available freeboard to the floor levels of the buildings that are located along Tumut Street for the two flow conditions.

While a partial blockage of Rimmers Bridge would result in an increase in peak 1% AEP flood levels of up to 300 mm, a partial blockage of the Herb Feint bridge has the potential to increase peak 1% AEP flood levels by more than one metre.

Given the characteristically high woody debris load in Adelong Creek and the limited experience which has been gained of how the two new road bridges at Adelong will perform from a blockage point of view, it is considered prudent that Council adopt a set of planning controls which take into account the potential for the two structures to experience a partial blockage during major flood events.

[10] The floor levels of eighty properties that are affected at the 1% AEP level of flooding were surveyed by a registered surveyor, while the floor levels of properties located elsewhere on the floodplain were estimated by a "drive-by" survey which assessed the height of the floor above local natural surface elevations.

5.7 Economic Impacts of Flooding

Tables 5.1 and **5.2** show the number of properties that would be flooded to above-floor level and the damages experienced for the various classes of property in Adelong under ideal flow (i.e. zero blockage) and partially blocked road bridge conditions, respectively.

By inspection of the values set out in **Tables 5.1** and **5.2**, a partial blockage of the two road bridges would increase the number of residential and commercial/industrial properties which experience above-floor inundation during floods larger than 2% AEP. Apart from one residential property located on the western overbank of Adelong Creek immediately downstream of Rimmers Bridge, the remainder of the affected properties are located along Tumut Street. Damages in Adelong for a range of design flood events are evaluated in **Appendix B** of the *FRMS*.

5.8 Structure of Floodplain Risk Management Study and Plan

The *FRMS* and *FRMP* are supported by Appendices which provide additional details of the investigations. A summary of the *FRMP* proposed for the study area along with broad funding requirements for the recommended measures are shown in **Table S1** at the commencement of the *FRMS* report. These measures comprise preparation of planning documentation by Council, improvements to the flood warning system and community education on flooding by Council and NSW SES to improve flood awareness and response, the development of a debris monitoring programme for Adelong, ongoing vegetation management along Adelong Creek by Council and the removal of a remanent section of Adelong Bridge from beneath the Herb Feint Bridge by RMS. The measures will over time achieve the objectives of reducing the flood risk to existing and future development for the full range of floods.

The *FRMP* is based on the following mix of measures which have been given a provisional priority ranking according to a range of economic, social, environmental and other criteria set out in **Table 4.1** of the report:

- **Measure 1** – Planning and development controls for future development in flood prone areas
- **Measure 2** – Update wording in *Tumut LEP 2012*
- **Measure 3** – Improvements to emergency response planning
- **Measure 4** – Increase public awareness of the risks of flooding in the community
- **Measure 5** – Installation of an automated water level alert system
- **Measure 6** – Development of Debris Monitoring Programme for Adelong
- **Measure 7** – Development and implementation of a *Vegetation Management Plan* for Adelong Creek upstream of the Herb Feint Bridge
- **Measure 8** – Removal of a remnant section of the Adelong Bridge from beneath the Herb Feint Bridge.

TABLE 5.1
ECONOMIC IMPACTS OF FLOODING AT ADELONG
IDEAL FLOW CONDITIONS

Design Flood Event (% AEP)	Properties Flooded Above-Floor Level						Total Flood Damages
	Residential		Commercial/Industrial		Public Buildings		
	No.	$ Million	No.	$ Million	No.	$ Million	$ Million
20	0	0.08	1	0.03	0	0.00	0.11
10	0	0.09	2	0.08	0	0.02	0.19
5	2	0.19	2	0.16	0	0.02	0.37
2	3	0.31	2	0.19	0	0.02	0.52
1	5	0.50	3	0.35	0	0.02	0.87
0.5	9	0.80	5	0.45	0	0.03	1.28
0.2	19	1.59	16	1.27	0	0.06	2.92
PMF	158	17.85	28	22.06	7	2.45	42.36

TABLE 5.2
ECONOMIC IMPACTS OF FLOODING AT ADELONG
PARTIALLY BLOCKED CONDITIONS

Design Flood Event (% AEP)	Properties Flooded Above-Floor Level						Total Flood Damages
	Residential		Commercial/Industrial		Public Buildings		
	No.	$ Million	No.	$ Million	No.	$ Million	$ Million
20	0	0.08	1	0.03	0	0.00	0.11
10	0	0.09	2	0.08	0	0.02	0.19
5	2	0.20	2	0.15	0	0.02	0.37
2	3	0.31	2	0.19	0	0.02	0.52
1	14	1.11	6	0.55	0	0.03	1.69
0.5	23	1.70	16	1.29	0	0.06	3.05
0.2	31	2.42	27	2.28	2	0.08	4.78
PMF	160	18.09	28	22.16	8	2.47	42.72

5.9 Planning and Development Controls

The results of the *FRMS* indicate that an important measure (**Measure 1**) for Council to adopt in the floodplain would be strong floodplain management planning applied consistently by all branches of Council.

5.9.1 Flood Policy

The draft *Flood Policy* proposed for Adelong (**Appendix D**) used the concepts of *flood hazard* and *hydraulic categorisation* outlined in **Section 2.10** of the report based on the envelope of ideal flow and partially blockage conditions to develop flood related controls for future development in flood prone land. The *Flood Policy* caters for three types of flooding in Adelong:

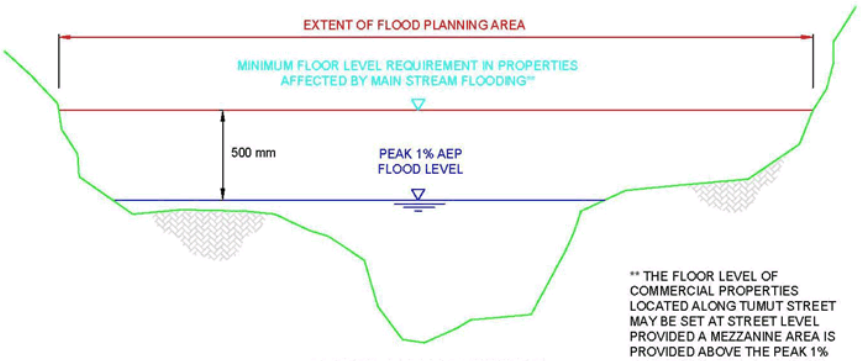
- **Main Stream Flooding** resulting from flows that surcharge the main channel of Adelong Creek, as well as Black Creek, Tanyard Creek, Golden Gully and the unnamed tributary which joins Adelong Creek opposite the extension of Gundagai Street. While the flows in Adelong Creek may be several metres deep in the channel and relatively fast moving with velocities of greater than 2 m/s, flow in the other watercourses are generally shallower and slower moving.
- **Minor Tributary Flooding** resulting from overflows of the minor gully systems which drain the relatively steep hillsides bordering Adelong Creek. Watercourses that are included in this definition are Nuggety Gully, Curtis Gully and Currans Gully.
- **Major Overland Flow** is present along several flow paths that run through the urbanised parts of Adelong. It is also present in the undeveloped areas which border the township. Flows on the Major Overland Flow paths would typically be less than 300 mm deep, travelling over the surface at velocities less than 0.5 m/s.

To implement the recommended approach set out in the *FRMS&P*, clause 6.2 of *Tumut LEP 2012* would require minor amendment. A new clause aimed at addressing potential flood evacuation issues in parts of Adelong would also need to be inserted into *Tumut LEP 2012* (ref. **Section 5.9.2** below).

Figure D1.1 in the draft *Flood Policy* is an extract from the *Flood Planning Map* relating to Adelong. The extent of the Flood Planning Area (**FPA**) (the area subject to flood related development controls) is shown in a solid red colour on the *Flood Planning Map* and has been defined as follows:

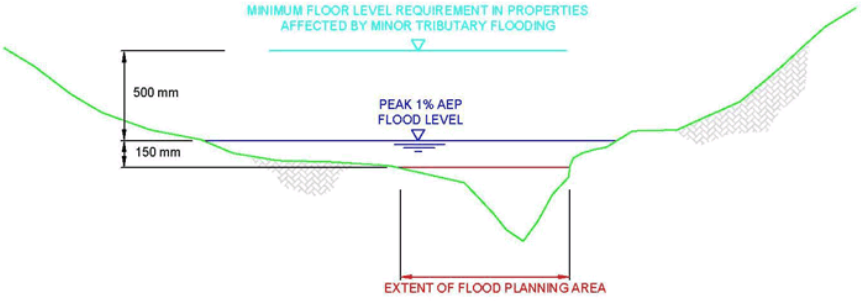
- In areas affected by Main Stream Flooding, the FPA is based on the traditional definition of the area inundated by the 1% AEP plus 500 mm freeboard.
- In areas subject to Minor Tributary Flooding, the FPA is defined as areas where depths of inundation in a 1% AEP event exceed 150 mm.
- In areas affected by Major Overland Flow, the FPA is defined as the extent of the High and Low Hazard Floodway zones, as well as areas where depths of inundation in a 1% AEP event exceed 150 mm.

The illustration over the page demonstrates the derivation of the FPA in areas subject to Main Stream and Minor Tributary Flooding, as well as Major Overland Flow.

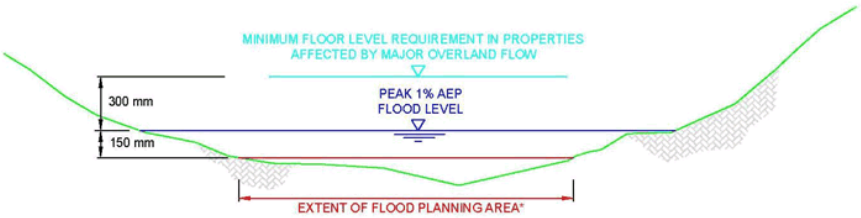


** THE FLOOR LEVEL OF COMMERCIAL PROPERTIES LOCATED ALONG TUMUT STREET MAY BE SET AT STREET LEVEL PROVIDED A MEZZANINE AREA IS PROVIDED ABOVE THE PEAK 1% AEP FLOOD LEVEL IN ADELONG CREEK PLUS 500 mm FREEBOARD

MAIN STREAM FLOODING



MINOR TRIBUTARY FLOODING



* INCLUDES AREAS OF FLOODWAY WHERE DEPTHS OF INUNDATION MAY BE LESS THAN 150 mm IN A 100 YEAR ARI EVENT

MAJOR OVERLAND FLOW

TYPE OF FLOODING	FREEBOARD (mm) ON PEAK 1% AEP FLOOD LEVEL	
	FLOOD PLANNING LEVEL (FPL)	MINIMUM FLOOR LEVEL (MFL)
MAIN STREAM FLOODING	+ 500	+ 500
MINOR TRIBUTARY FLOODING	- 150	+ 500
MAJOR OVERLAND FLOW (MOF)	- 150	+ 300

Illustration showing the approach that has been used to derive the extent of the Flood Planning Area and the Minimum Floor Levels (MFL) requirements in areas affected by Main Stream and Minor Tributary Flooding, as well as Major Overland Flow at Adelong

It is proposed that properties intersected by the extent of the FPA would be subject to S10.7 flood affectation notification and planning controls graded according to flood hazard. **Annexures 2.1** and **2.2** in the *Flood Policy* set out the graded set of flood related planning controls which have been developed for Adelong. **Annexure 2.1** deals with areas subject to Main Stream and Minor Tributary Flooding, while **Annexure 2.2** deals with areas affects by Major Overland Flow. **Figure D1.2** in the *Flood Policy* is the *Development Controls Matrix Map* and shows the area over which both **Annexures 2.1** and **2.2** apply.

Minimum floor level requirements would be imposed on future development in properties that are identified as lying either partially or wholly within the extent of the FPA shown on the *Flood Planning Map*. The minimum floor levels for all land use types affected by Main Stream and Minor Tributary Flooding is the level of the 1% AEP flood event plus 500 mm freeboard, while those for all land use types affected by Major Overland Flow is the level of the 1% AEP flood event plus 300 mm freeboard. For areas outside the FPA shown on the *Flood Planning Map*, the minimum floor level for all land use types is the level of the 1% AEP flood event plus 500 mm freeboard. The illustration on the previous page demonstrates the application of the variable freeboard approach in the derivation of the minimum floor level requirements in areas subject to Main Stream Flooding and Minor Tributary Flooding, as well as Major Overland Flow.

The exception to the above set of criteria relates to commercial development located along Tumut Street, whereby the floor levels in these properties may be built at street level, provided a mezzanine area where goods can be temporarily stored is provided at the peak 1% AEP flood level on Adelong Creek plus 500 mm freeboard. This will assist in maintaining connectivity to the footpath of Tumut Street, while reducing flood damages that would otherwise occur if a storage area is not provided above the 1% AEP flood level.

The adoption of a reduced freeboard in areas subject to Major Overland Flow is justified by the fact that the flow is relatively shallow and slow moving in nature, with water levels unlikely to rise above this level during a 1% AEP storm event due to say obstructions to flow and wave action. **Figure D1.3** in the *Flood Policy* is the *Flood Hazard Map*. The figure shows the subdivision of the floodplain into a number of categories which have been used as the basis for developing the graded set of planning controls.

The floodplain has been divided into the following four categories in areas that are affected by both Main Stream and Minor Tributary Flooding:

- The **Inner Floodplain (Hazard Category 1A)** zone (shown as a solid red colour) comprises areas where factors such as the depth and velocity of flow, time of rise, isolation on Low Flood Islands and evacuation problems mean that the land is unsuitable for most types of development. It principally comprises High and Low Hazard Floodway areas. Erection of buildings and carrying out of work; use of land, subdivision of land and demolition subject to State Environmental Planning Policies and Local Environmental Plan provisions are not permitted in this zone.
- The **Inner Floodplain (Hazard Category 1B)** zone (shown as a solid orange colour) comprises an area on the western overbank of Adelong Creek centred on Tumut Street. This area is affected by hazardous flooding as a result of a partial blockage of the Herb Feint Bridge or during a flood slightly larger than the 1% AEP event. Only commercial/industrial type development and minor additions to existing residential development is permitted in this zone.

- The **Inner Floodplain (Hazard Category 2)** zone (shown as a solid yellow colour) comprises High and Low Flood Storage areas, as well as areas where isolation on Low Flood Islands and evacuation problems mean development other than Essential Community Facilities, Critical Utilities, Schools and Flood Vulnerable development is permitted provided it is capable of withstanding hydraulic forces and sited on the allotment to minimise adverse redirections of flow toward adjacent properties. Council may require a *Flood Risk Report* if it considers that the proposal has the potential to significantly affect flooding behaviour in adjacent properties.
- The **Intermediate Floodplain** zone (shown as a solid blue colour) is the remaining land lying outside the extent of the Inner Floodplain zones, but within the FPA (defined as land which lies below the 1% AEP flood level plus 500 mm freeboard). Within this zone, there would only be the requirement for minimum floor levels to be set at the 1% AEP flood levels plus 500 mm. While land use permissibility would be as specified by State Environmental Planning Policies or the Local Environmental Plan, Essential Community Facilities, Critical Utilities and Flood Vulnerable Residential development is not permitted in this zone.
- The **Outer Floodplain** zone is the area outside the Intermediate Floodplain where the depth of inundation will exceed 150 mm in the Extreme Flood (shown as a solid cyan colour). This area is outside the extent of the FPA and hence controls on residential, commercial and industrial development do not apply. However, Essential Community Facilities, Critical Utilities and Flood Vulnerable development is not permitted in this zone.

A full list of prescriptive controls that apply to areas subject to Main Stream and Minor Tributary Flooding are set out in **Annexure 2.1** of **Appendix D**.

The floodplain has been divided into the following two additional categories in areas that are affected by Major Overland Flow:

- **High Hazard Floodway**, which is shown in solid orange colour. Future development in this area is not permitted under the *Flood Policy*.
- **Low Hazard Floodway / Flood Fringe**, which is shown in solid green colour. Residential, commercial and industrial type development can occur in this zone subject to compliance with a prescribed set of flood related development controls.

The **Intermediate Floodplain** zone in areas subject to Major Overland Flow is the remaining land lying outside the extent of the Floodway and Flood Fringe areas where the depth of inundation during a 1% AEP storm event depths will exceed 150 mm, while the **Outer Floodplain** zone represents the area outside the aforementioned zones where the depth of inundation will exceed 150 mm during the PMF. Flood related planning controls in these two areas are similar to those that apply to development in areas subject to Main Stream and Minor Tributary Flooding, with the following exceptions:

- the adoption of a reduced freeboard of 300 mm for defining minimum floor levels; and
- the potential for Essential Community Facilities, Critical Utilities and Flood Vulnerable Residential type development to take place subject to compliance with the flood related development controls set out in **Annexure 2.2** of the Flood Policy.

5.9.2 Revision to Tumut LEP 2012

Measure 2 recommends that the wording in the *Tumut LEP 2012* concerning flood planning be updated.

Clause 6.2 of *Tumut LEP 2012* entitled "Flood planning" outlines its objectives in regard to development of flood prone land. It is similar to the standard Flood Planning Clause used in recently adopted LEPs in other NSW country centres and applies to land at or below the Flood Planning Level (**FPL**). The FPL referred to is the 1% AEP flood plus an allowance for freeboard of 500 mm. The area encompassed by the FPL is known as the FPA and denotes the area subject to flood related development controls, such as locating development outside high hazard areas and setting minimum floor levels for future residential development.

Whilst appropriate for Main Stream Flooding, the present clause 6.2 would have resulted in a large part of the urban area which is affected by shallow overland flow being subject to flood affectation notification on Planning Certificates issued under S10.7 of the EP&A act. Similarly, the adoption of this approach in the rural areas bordering Adelong that are subject to Minor Tributary Flooding would have resulted in areas located remote from the incised gullies being subject to flood related development controls.

To implement the *Flood Policy* set out in **Appendix D**, clause 6.2 of *Tumut LEP 2012* would require minor amendment. Suggested amendments are given in **Section 3.5.1.4**.

It is also recommended that a new floodplain risk management clause be included in *Tumut LEP 2012*. The objectives of the new clause are as follows:

- in relation to development with particular evacuation or emergency response issues (e.g. group homes, residential care facilities, etc.) to enable evacuation of land subject to flooding in events exceeding the flood planning level; and
- to protect the operational capacity of emergency response facilities and critical infrastructure during extreme flood events.

The new clause would apply to land identified as Outer Floodplain (i.e. land which lies between the FPA and the extent of the PMF). Suggested wording in relation to this new clause is given in **Section 3.5.1.4**.

5.10 Improvements to Flood Warning, Emergency Response Planning and Community Awareness

Three measures are proposed in the *FRMP* to improve flood warning, emergency response planning and community awareness to the threat posed by flooding.

Measure 3 involves the update by NSW SES of the *Tumut Local Flood Plan* using information on flooding patterns, times of rise of floodwaters and flood prone areas identified in this report. Figures have been prepared showing indicative extents of flooding, high hazard areas, expected rates of rise of floodwaters in key areas and locations where flooding problems would be expected. **Section 3.6.2** references the locations of key data within this report.

Council should also take advantage of the information on flooding presented in this report, including the flood mapping, to inform occupiers of the floodplains of the flood risk (included as

Measure 4 of the *FRMP*). This information could be included in a *Flood Information Brochure* to be prepared by Council with the assistance of NSW SES containing both general and site specific data and distributed with the rate notices. The community should also be made aware that a flood greater than historic levels or the planning level can, and will, occur at some time in the future. The *FRMP* should be publicised and exhibited at community gathering places to make residents aware of the measures being proposed.

Measure 5 involves potential reviews and improvements that should be undertaken to ensure the flood warning system in Adelong is adequate. A flood warning system has three components; a flood forecasting system, a flood warning broadcast system and a response/evacuation plan. It is recommended that all three components by reviewed and improvements made where necessary.

BoM operates a flood warning system based on potential flood producing storms in the region. This provides both a means of forecasting and flood warning to NSW SES and other management authorities, as well as residents. However, it is important that 'flood watches' issued by BoM are relayed to residents via radio, TV, social media and other mediums. Establishment of an automated warning services could be considered by Council which would send text messages containing important information to all mobile devices in the region. Given the cost of such systems, the small population of Adelong and that flood risk areas are known, it would be more effective for NSW SES to contact residents directly.

While the Batlow Road stream gauge provides information on flooding in Adelong Creek, it is located too close to the township to provide any meaningful advance warning time of impending flooding, especially in relation to the rapid rise in water levels which would be associated with a partial blockage of the Herb Feint Bridge. To improve flood response for those residents and business owners that are located along the floodway that develops along Tumut Street under certain hydraulic and climatic conditions, it is recommended that a telemetered stream gauge be installed upstream of the Herb Feint Bridge to which an automated broadcasting system in the form of a loud speaker system is to be linked. Pre-defined trigger levels could then be set based on the findings of the *Flood Study* and the *FRMS* which warn residents and business owners of rising water levels in Adelong Creek. It is envisaged that the trigger levels would be set based on a ready-set-go type messaging system, as not every flood event would require the evacuation of residents and business owners from potentially flood effected areas. Business owners would also need time to shift stock to higher levels prior to evacuating the premises.

5.11 Flood Modification Works

Due to the relatively small flood damages that are experienced at Adelong for floods with AEP's up to 1 per cent, the inclusion of flood modifications measures such as flood protection levees, channel widening works, stormwater drainage upgrades and debris control structures cannot be justified on economic grounds.

That said, the reduction in the risk of blockage that the construction of a debris control structure would provide is of significant social benefit as it would reduce the risk of hazardous flooding conditions developing in parts of Adelong, namely along Tumut Street for floods which would otherwise be confined to the inbank area of Adelong Creek.

Given that blockage has historically occurred on the two road bridges that have recently been replaced by structures which incorporate a reduced number of piers at larger spacings, the likelihood of a blockage being experienced during a flood event is significantly reduced. It is

therefore recommended that the potential for these new structures to experience a blockage during future flood events be monitored prior to a decision being made as to whether to construct a debris control structure in Adelong Creek upstream of the town. The need to set up and maintain such a monitoring programme has been incorporated in the *FRMP* as **Measure 6**.

While Council removed a large amount of vegetation from Adelong Creek upstream of the Herb Feint Bridge following the October 2010 flood (namely a number of poplar trees and their associated undergrowth) and the present study has shown that there is limited flood mitigation benefits associated with conducting similar activities upstream of the extension of Selwyn Street, there is merit in the ongoing maintenance of Adelong Creek from a vegetation management point of view. There is also merit in the removal of several large poplar trees which still remain on the banks of Adelong Creek immediately upstream of the Herb Feint Bridge given the potential for them to exacerbate flooding conditions should they be uprooted during future flood events. On this basis, the development and implementation of a *Vegetation Management Plan* for Adelong Creek at Adelong forms **Measure 7** of the *FRMP*.

While the removal of a remnant section of Adelong Bridge which is located beneath the Herb Feint Bridge will not have a significant impact on flooding behaviour, it has merit in that it will:

a) reduce the likelihood of debris building up on its upstream side; and

b) reduce turbulence in the flow which in turn will reduce the scour potential in the creek.

Based on the above, the removal of the remnant section of bridge by RMS has been included in the *FRMP* as **Measure 8**.

Improvements to the inlet capacity of the existing stormwater drainage system in Tumut Street and Lockhart Street between their intersections with Neil Street and Havelock Street would prevent frequent flooding being experienced in a number of residential and commercial properties. The measure would also reduce the duration stormwater ponds in Tumut Street following heavy rain. While the upgrade of the existing stormwater drainage system would not qualify for State Government funding under its Floodplain Management Program (and hence would need to be wholly funded by Council), it has been included in the *FRMP* as **Measure 9**.

5.12 Mitigating Effects of Future Development

Under the zoning associated with the *Adelong LEP 2012*, future development is envisaged in the currently rural areas zoned *RU1 Primary Production*. While hydrologic and hydraulic analyses undertaken as part of the present study showed that the resulting urbanisation would result in only minor increases in peak flood levels along the minor gullies and tributaries which drain to Adelong Creek, there is the potential for the more frequent surcharge of existing drainage structures.

It is therefore recommended that Council ensure that existing drainage structures that are located downstream of any future development be upgraded to prevent the increased frequency of surcharge.

5.13 Voluntary Purchase of Residential Property

Removal of housing is a means of correcting previous decisions to allow buildings in high hazard areas in the floodplain. The voluntary purchase of residential property in hazardous areas has been part of subsidised floodplain management programs in NSW.

While there is merit in including six residential properties that are located along the hazardous flow path that develops along Tumut Street during floods slightly larger than the 1% AEP, or as a result of a partial blockage of the Herb Feint Bridge in a Voluntary Purchase scheme, given the low probability of such an occurrence it is recommended that the risk of blockage be assessed on an ongoing basis as part of **Measure 6** and that risk of life in these properties be managed through **Measures 1** and **5**.

5.14 Raising Floor Levels of Residential Property

As the one dwelling that is subject to above-floor Main Stream Flooding in a 1% AEP under ideal flow conditions is of slab-on-ground and brick veneer type construction, its inclusion in a voluntary house raising scheme is not feasible.

While there are several other dwellings that are located along Tumut Street that would experience above-floor inundation under certain hydraulic and climatic conditions, given the relative infrequent nature of such an event it is recommended that risk of life be managed through the implementation of **Measures 1** and **5**.

While there is scope to raise the floor level of one weatherboard type dwelling that is located on the western side of Selwyn Street immediately downstream of Rimmers Bridge, the depth of above-floor inundation is only 0.04 m in a 1% AEP event under partially blocked conditions. Given the relatively shallow and infrequent nature of the inundation of the dwelling, its inclusion in a voluntary house raising scheme could not be justified.

Based on the above, a voluntary house raising scheme is not recommended for inclusion in the *FRMP*.

5.15 Implementation Program

The steps in progressing the floodplain management process from this point onwards are:

1. Floodplain Risk Management Committee to consider and adopt recommendations of this study. In particular, the Committee should review the basis for ranking floodplain management measures (as set out in **Table 4.1** of the *FRMS* and the proposed works and measures to be included in the *FRMP* as set out in **Table S1**); exhibit the *draft FRMS* and *FRMP* and seek community comment.
2. Consider public comment, modify the document if and as required, and submit to Council.
3. Council adopts the *FRMP* and submits application(s) for funding assistance in the next funding round for qualifying projects. Assistance for funding qualifying projects included in the *FRMP* may be available upon application under the Commonwealth and State funded floodplain management programs, currently administered by NSW Office of Environment and Heritage.
4. As funds become available from Government agencies and/or Council's own resources, implement the measures in accordance with the established priorities.

The *FRMP* should be regarded as a dynamic instrument requiring review and modification over time. The catalysts for change could include new flood events and experiences, legislative change, alterations in the availability of funding, reviews of Council's planning strategies and importantly, the outcome of some of the studies proposed in this report as part of the *FRMP*. In any event, a thorough review every five years is warranted to ensure the ongoing relevance of the *FRMP*.

6 GLOSSARY OF TERMS

Note: For expanded list of definitions, refer to Glossary contained within the NSW Government Floodplain Development Manual, 2005.

TERM	DEFINITION
Average Recurrence Interval (ARI)	The average return period between the occurrence of a particular flood event. For example, a 100 year ARI flood has an average recurrence interval of 100 years.
Australian Height Datum (AHD)	A common national surface level datum corresponding approximately to mean sea level.
Areal Reduction Factor	A factor applied in hydrological models to large catchments to reduce the intensity of rainfall across the catchment. This is because design rainfall intensities which are calculated for a point location are not representative of the areal average rainfall intensity across the catchment.
Extreme Flood	An extremely rare event analogous to the PMF, which in the case of the present study is assumed to have a peak flow 3 times the 1% AEP flood event.
Flood Affected Properties	Properties that are either encompassed or intersected by the Flood Planning Area.
Flood Frequency Analysis	A statistical methodology to estimate peak flood levels and discharge of design flood events based on a record of historic flood data.
Floodplain	Area of land which is subject to inundation by floods up to and including the Probable Maximum Flood (**PMF**) event, that is, flood prone land.
Flood Planning Area	The area of land that is shown to be in the Flood Planning Area on the *Flood Planning Map*. The Flood Planning Area is the area of land which lies at or below the Flood Planning Level.
Flood Planning Map	The *Flood Planning Map* referred to in the Tumut Local Environmental Plan 2012, an extract of which is shown on **Figure D1.1** in **Appendix D**.
Flood Planning Level (FPL) (General Definition)	The combinations of flood levels and freeboards selected for planning purposes, as determined in floodplain risk management studies and incorporated in floodplain risk management plans.
Flood Planning Level (FPL)	For land within the Flood Planning Area subject to Main Stream Flooding in Adelong, the Flood Planning Level (**FPL**) is the level of the 1% Annual Exceedance Probability (**AEP**) flood event plus 500 mm freeboard. For land within the Flood Planning Area subject to Minor Tributary Flooding and Major Overland Flow in Adelong, the FPL is the level of the 1% AEP flood event minus 150 mm freeboard. For areas outside the Flood Planning Area shown on the *Flood Planning Map*, the FPL is the level of the 1% AEP flood event plus 500 mm freeboard.
Flood Prone/Flood Liable Land	Land susceptible to flooding by either the Extreme Flood in the case of Main Stream Flooding and the PMF in the case of Major Overland Flow. Flood Prone land is synonymous with Flood Liable land.

TERM	DEFINITION
Floodway	Those areas of the floodplain where a significant discharge of water occurs during floods. They are often aligned with naturally defined channels. Floodways are areas that, even if only partially blocked, would cause a significant redistribution of flood flow, or a significant increase in flood levels.
Flood Storage Area	Those parts of the floodplain that may be important for the temporary storage of floodwaters during the passage of a flood. Loss of flood storage can increase the severity of flood impacts by reducing natural flood attenuation.
Freeboard	Provides reasonable certainty that the risk exposure selected in deciding a particular flood chosen as the basis for the FPL and setting minimum floor level requirements is actually provided. It is a factor of safety typically used in relation to the setting of floor levels, levee crest levels, etc. Freeboard is included in the derivation of the FPL and the setting of minimum floor level requirements.
Habitable Room	In a residential situation: a living or working area, such as a lounge room, dining room, kitchen, bedroom or workroom. In an industrial or commercial situation: an area used for offices or to store valuable possessions susceptible to flood damage in the event of a flood.
Inner Floodplain (Hazard Category 1A)	Comprises areas where factors such as the depth and velocity of flow, time of rise, isolation and evacuation difficulties mean that the land is unsuitable for future development. It includes areas of High and Low Hazard Floodway, Flood Storage, Flood Fringe, Intermediate Floodplain and Outer Floodplain areas. It also includes land which may become isolated during a flood event. Future development is not permitted in this zone.
Inner Floodplain (Hazard Category 1B)	Comprises an area on the western overbank of Adelong Creek centred on Tumut Street. This area is affected by hazardous flooding as a result of a partial blockage of the Herb Feint Bridge or during a flood slightly larger than the 1% AEP event. Only commercial/industrial development and minor additions to existing residential development is permitted in this zone.
Inner Floodplain (Hazard Category 2)	Comprises areas of Low Hazard Floodway and Flood Storage areas where development other than Essential Community Facilities, Critical Utilities, Schools and Flood Vulnerable is permitted provided it is capable of withstanding hydraulic forces and sited on the allotment to minimise adverse redirections of flow towards adjacent properties. It also includes land which may become isolated during a flood event. Council may require a *Flood Risk Report* if it considers that the proposal has the potential to significantly affect flooding behaviour in adjacent properties.
Intermediate Floodplain	For Main Stream Flooding it is the strip of land on each side of the two Inner Floodplain zones and the line defining the indicative extent of flooding resulting from the occurrence of the 1% AEP flood plus 500 mm (i.e. the FPA). For Major Overland Flow it is the land outside the High Hazard Floodway and Low Hazard Floodway / Flood Storage zones where the depth of inundation during the 1% AEP storm event is greater than 150 mm.
Local Drainage	Land on an overland flow path where the depth of inundation during the 1% AEP storm event is less than 150 mm.

TERM	DEFINITION
Main Stream Flooding	The inundation of normally dry land occurring when water overflows the natural or artificial banks of a major stream; for the study area, the main streams are Adelong Creek and Black Creek.
Major Overland Flow	Where the depth of overland flow during the 1% AEP storm event is greater than 150 mm.
Minimum Floor Level (General Definition)	The combinations of flood levels and freeboards selected for setting the minimum floor levels of future development located in properties subject to flood related planning controls.
Main Stream and Minor Tributary Flooding Minimum Floor Level	For properties subject to Main Stream and Minor Tributary Flooding in Adelong, the MFL is the level of the 1% AEP flood event plus 500 mm freeboard. Note that for areas outside the FPA shown on the *Flood Planning Map*, the MFL is the level of the 1% AEP flood event plus 500 mm freeboard.
Major Overland Flow Minimum Floor Level	For properties subject to Major Overland Flow in Adelong, the MFL is the level of the 1% AEP flood event plus 300 mm freeboard. Note that for areas outside the FPA shown on the *Flood Planning Map*, the MFL is the level of the 1% AEP flood event plus 500 mm freeboard.
Outer Floodplain	This is defined as the land between the FPA and the extent of the PMF event.
Probable Maximum Flood (PMF)	The largest flood that could conceivably occur at a particular location. Generally, it is not physically or economically possible to provide complete protection against this event. The PMF defines the extent of flood prone land, that is, the floodplain. For the study area, the extent of the PMF has been trimmed to include depths greater than 100 mm.

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APPENDIX A

COMMUNITY CONSULTATION

Document Set ID: 2012463
Version: 2, Version Date: 30/11/2018

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A1. INTRODUCTION

At the commencement of the *FRMS,* the Consultants prepared a *Community Newsletter* and a *Community Questionnaire*, both of which were distributed by Council to the residents and business owners in Adelong (refer to **Attachment 1**). A media release was also prepared that introduced the project and encouraged the community to provide input to the study by responding to the *Community Questionnaire*. The media release was placed on Council's website and advertised in the local newspaper and radio station.

The purpose of the *Community Newsletter* was to introduce the objectives of the study and set the scene on flooding conditions so that the community would be better able to respond to the *Community Questionnaire* and contribute to the study process.

The *Newsletter* contained the following information:

- A plan showing the extent of the study area.
- A statement of the objectives of the *FRMS&P*; namely the development of a strategy for reducing the flood risk and minimising the long-term impact of flooding on the community.

The *Community Questionnaire* was structured with the objectives of:

- Obtaining local information on flood experience and behaviour at residents' and business owners' properties.
- Determining residents' and business owners' attitudes to controls over future development in flood liable areas.
- Inviting community views on possible flood management options which could be considered for further investigation in the *FRMS* and possible inclusion in the resulting *FRMP*.
- Obtaining feedback on any other flood related issues and concerns which the residents and business owners cared to raise.

This **Appendix** to the *FRMS&P* report discusses the responses to the fifteen questions that were included in the *Community Questionnaire* and comments made by respondents.

Chapter A2 deals with the residents' and business owners' experience with historic flooding, as well as determining their views on the relative importance of classes of development over which flood-related controls should be imposed by Council.

Chapter A3 identifies residents' and business owners' views on the suitability of the various options which could be considered in more detail in the *FRMS*.

Chapter A4 discusses the best methods by which the community could provide feedback to the consultants over the course of the study.

Chapter A5 summarises the findings of the community consultation process.

A2 RESIDENT PROFILE AND FLOOD AWARENESS

A2.1 General

Residents were requested to complete the *Community Questionnaire* and return it to the Consultants by 28 July 2017. The deadline was extended to include any submissions that were received after this date. The Consultants received 39 responses in total out of the 550 that had been distributed.[1]

The Consultants have collated the responses, which are shown in graphical format in **Attachment 2**.

A2.2 Experiences of Flooding

The first ten questions of the *Community Questionnaire* canvassed resident information such as length of time at the property, the type of property (e.g. house, unit/flat), whether the respondent had any experience of flooding and if so which particular flood and whether they had experienced above-floor inundation. Of those who replied to the question, 18 respondents had lived in Adelong for between five and 20 years and 17 for more than 20 years (**Question 2**). Thirty-six respondents occupied a house, one respondent occupied a unit/flat and four respondents owned vacant land (**Question 3**).

Eighteen respondents reported that they had information about flooding on their property (**Question 4**), with 15 respondents citing their own experience and seven reported having photographs of flooding.

In response to **Question 5**, 17 respondents reported that they had experienced flooding on their property either as a result of main stream flooding (11) or shallow overland flow (six). Twelve respondents reported flooding on their property as a result of the October 2010 flood, ten reported flooding as a result of the March 2012 flood and four reported flooding as a result of the October 2016 flood. Only one of the respondents advised that they had experienced above-floor inundation in the largest flood which they had experienced (**Question 6**), while nine residents experienced damage to either their garden, yard, shed, fencing, equipment, stock or premises (**Question 7**). In response to **Question 8**, seven residents incurred damage to their property of less than $5000, while one resident reported a damage bill of $250,000. Two of the respondents experienced higher insurance premiums as a result of flooding (**Question 9**).

As far as the source of flood warnings to the population of Adelong is concerned (**Question 10**), ten respondents claimed they had no warning of the flood, one was warned by TV, four by radio, twelve by their own observations, three by NSW SES and seven by neighbours. These results are characteristic of situations where flooding is of a "flash flooding" nature with little warning time being available for the dissemination of warnings by the authorities.

A2.3 Controls over Development in Flood Prone Areas

The respondents were also asked to rank from 1 to 4 the classes of development which they consider should receive protection from flooding (**Question 11**). Rank 1 was the most important and rank 4 the least.

[1] Note that one of the respondents was both a resident and business owner in Adelong.

The classes in decreasing order of importance to respondents, ranged from vulnerable residential (e.g. aged persons accommodation), residential property, commercial/business and lastly, essential community facilities (e.g. schools, evacuation centres).

These results gave a guide to the Consultants as to the appropriate location of future development of the various classes within the floodplain. For example, on the basis of community views, vulnerable residential would receive the highest level of protection by locating future development of this nature outside the floodplain.[2]

In **Question 12**, respondents were asked what notifications Council should give about the flood affectation of individual properties. The community was strongly in favour of advising existing residents and prospective purchasers of the known potential flood threat, with only two residents not in favour of providing flood related notifications.

Respondents were also asked in **Question 13** about the level of control Council should place on new development to minimise flood-related risks. The most popular response was to advise of the flood risks, but allow the individual the choice as to whether they develop or not provided they take steps to minimise the potential flood risks. The next most favoured response was placing restrictions on developments to reduce the potential for flood damage (e.g. minimum floor level controls or the use of compatible building materials). Nine respondents felt that Council should prohibit all development on land with any potential to flood.

[2] The community view that essential services is of least importance may be a reflection of the fact that these types of development are located on land which has historically not been flooded. For example, both the Adelong Public School and the Adelong and District Bowling Club, the latter which functions as the evacuation centre during a flood event, are located on flood free land.

A3 POTENTIAL FLOOD MANAGEMENT MEASURES

The respondents were asked for their opinion on potential flood management measures which could be evaluated in the *FRMS* (and if found to be feasible included in the *FRMP*), by ticking a "yes" or "no" to the eleven potential options identified in **Question 14**.

The options comprised a range of *structural flood management measures* (e.g. programs by Council to manage vegetation in the creek system to maintain hydraulic capacity; improving the stormwater system; levees to contain floodwaters; widening of watercourses; removal of floodplain obstructions), as well as various *non-structural management measures* (e.g. voluntary purchase of residential properties in high hazard areas; raising floor levels of houses in low hazard areas; flood related controls over new developments; improvements to flood warning and evacuation procedures; community education on flooding; flood advice certificates). The options were not mutually exclusive, as the adopted *FRMP* could, in theory, include all of the options set out in the *Community Questionnaire*, or indeed, other measures nominated by the respondents or the FRMC.

The most popular measure was the management of vegetation along the creek corridor[3]. Other popular structural measures included the removal of floodplain obstructions and improving the stormwater system in the town.

Of the non-structural measures, improvement of flood warning and evacuation procedures received the strongest support, followed by provision of a Planning Certificate to purchasers in flood prone areas. Other popular measures included specifying controls on future development in flood-prone areas and community flood-awareness programs.

A mostly negative response was given to the widening of watercourses and the construction of permanent levees. Providing subsidies for raising the floor level of properties and the implementation of a residential Voluntary Purchase scheme were also unpopular.

[3] It is noted that since completion of the *Flood Study*, Council has cleared built-up debris, as well as a large number of poplar trees which were present on both banks of Adelong Creek between Selwyn Street and Herb Feint Bridge.

A4 INPUT TO THE STUDY AND FEEDBACK FROM THE COMMUNITY

In **Question 15,** residents were asked for their view on the best methods of their providing input to the Study and feedback to the Consultants over the course of the investigation. Articles in the local newspaper was the most popular method, followed by communication via the FRMC and website. Other suggestions raised by respondents suggested a letter drop (similar to the *Community Newsletter* and *Community Questionnaire* distributed as part of the present study) and announcements on local radio as methods of community engagement.

A5 SUMMARY

Thirty-nine responses were received to the *Community Questionnaire* which was distributed by Council to residents and business owners in Adelong. The responses amounted to about seven per cent of the total distributed. Respondents provided anecdotal and photographic evidence of the nature and cause of previous flooding in Adelong. One respondent indicated that debris (e.g. felled trees) built up on the upstream face of Rimmers Bridge during the October 2010 flood. Another respondent also indicated that the seriousness of the October 2010 flood in Adelong was exacerbated by the presence of the Adelong Bridge alongside the new Herb Feint Bridge (which was still under construction at the time). Two respondents indicated that previous flooding in Adelong could be attributed to the lack of vegetation management along Adelong Creek, while two other respondents identified a lack of available resources (e.g. sandbags) and a lack of assistance from authorities to prevent damage to some properties during previous floods.

A5.1 Issues

The issues identified by the responses to the *Community Questionnaire* support the objectives of the study as nominated in the attached *Community Newsletter,* and the activities nominated in the Study Brief. No new issues were identified in regard to Main Stream Flooding, Minor Tributary Flooding and Major Overland Flow.

A5.2 Flood Management Measures

Of the *structural measures* which could be incorporated in the *FRMP*, the most popular were management of vegetation along creek corridors, removal of floodplain obstructions and improving the capacity of the stormwater system. The construction of permanent levees along the banks of Adelong Creek and the widening of the watercourse received a mostly negative response.

Improvements to flood warning and emergency management measures appeared to be the most popular of the potential *non-structural measures* set out in the *Community Questionnaire*. Planning controls and providing Planning Certificates were also widely popular. Community education and flood awareness programs received support from the community as well. There does not appear to be any new measures raised by the respondents.

ATTACHMENT 1

COMMUNITY NEWSLETTER AND QUESTIONNAIRE

Adelong Floodplain Risk Management Study & Draft Plan

To Residents and Business Owners of Adelong:

Snowy Valleys Council has engaged consultants to undertake a Floodplain Risk Management Study for the township of Adelong. The Floodplain Risk Management Study will assess options which are aimed at reducing the impacts of flooding on existing development and the establishment of a framework to manage flood liable land in accordance with current best floodplain management principles.

The consultants have also been engaged to prepare a Floodplain Risk Management Draft Plan which will set out a recommended program of works and measures which will over time reduce the social, environmental and economic impacts of flooding at Adelong.

The studies are jointly funded by Council and the NSW Office of Environment & Heritage and aim to build community resilience towards flooding through informing better planning of development, emergency management and community awareness. Council has established a Floodplain Risk Management Committee which is comprised of relevant council members, state government agencies and community representatives.

The studies will build on the results of the *Adelong Flood Study* (completed in 2014) which defined flooding patterns and flood levels in Adelong under present day conditions.

The attached figure shows the indicative extent of flood prone land as a result of main stream flooding along Adelong Creek and Black Creek (defined by the extent of the Probable Maximum Flood), as well as land subject to depths of overland flow greater than 100 mm in a 1 in 100 year ARI flood.

Have Your Say on Floodplain Management

An important first step in the preparation of a Floodplain Risk Management Study and Draft Plan is to determine the flood issues which are important to the community. The attached **questionnaire** has been provided to residents and businesses to assist the Consultants in gathering this important information. All information provided will remain confidential and for use in this study only. Please return the completed questionnaire in the reply paid envelope provided by **Friday 28 July 2017**.

Contact: Snowy Valleys Council

Paul Mullins | Director of Compliance – Environmental Services
Phone: (02) 6941 2530
Email: pmullins@snowyvalleys.nsw.gov.au

Office of Environment & Heritage

Adelong Floodplain Risk Management Study & Draft Plan

Snowy Valleys Council

Community Questionnaire

This Questionnaire is part of the *Adelong Floodplain Risk Management Study and Draft Plan*, which is currently being prepared by Snowy Valleys Council with the financial and technical support of the NSW Office of Environment & Heritage. Your responses to the questionnaire will help us determine the flood issues that are important to you.

Please return your completed Questionnaire in the reply paid envelope provided by **Friday 28 July 2017**. No postage stamp is required. If you have misplaced the supplied envelope or wish to send an additional submission the address is:

Lyall & Associates Consulting Water Engineers
Reply Paid 85163
NORTH SYDNEY NSW 2060

Your name (optional):_____

Address:_____

About your property

1. Please tick as appropriate:

- ☐ I am a resident
- ☐ I am a business owner
- ☐ Other (please specify_____)

2. How long have you been at this address?

- ☐ 1 year to 5 years
- ☐ 5 years to 20 years
- ☐ More than 20 years (… years)

3. What is your property?

- ☐ House
- ☐ Villa/Townhouse
- ☐ Unit/Flat/Apartment
- ☐ Vacant land
- ☐ Industrial unit in larger complex
- ☐ Stand alone warehouse or factory
- ☐ Shop
- ☐ Community building
- ☐ Other (_____)

Your flood experience

(If you have experienced a flood, please answer Questions 4 to 10, otherwise go to Question 11)

4. Do you have any information about flooding at the property?

- ☐ Yes
- ☐ No

If yes, what information do you have?

- ☐ Own experience
- ☐ Flood levels from Council
- ☐ Information from State Emergency Service (SES)
- ☐ Photographs
- ☐ Other (_____)

5. Have you ever experienced flooding, either as a result of the river breaking its banks or due to shallow overland flow through the property?

- ☐ Yes - River break out
- ☐ Yes - Shallow overland flow
- ☐ No

If yes, which floods?

- ☐ October 2010
- ☐ March 2012
- ☐ October 2016
- ☐ Other (_____)

6. In the biggest flood you have experienced, was the property flooded above floor level of the main building?

☐ No ☐ Yes

If yes, what was the depth of water over the floor?

_____

What year? _____

7. During the biggest flood, what was damaged by floodwaters?
(Tick one or more boxes)

- ☐ No damage occurred
- ☐ Vehicles
- ☐ Garden, yard, paddocks
- ☐ Garage, shed
- ☐ Electrical equipment, machinery, tools
- ☐ Stock and other goods
- ☐ Carpet, furniture, fittings and/or office equipment
- ☐ Your premises (paint, structurally, etc)
- ☐ Other part of your property

Please specify _____

8. During the biggest flood, what was the approximate cost to you (at the time) from the damage caused by the flood?

$_____

9. As a result of the biggest flood, did you experience any problems during or after the flood?
(Tick one or more boxes)

- ☐ No problems experienced
- ☐ Loss of business / trade
- ☐ Higher insurance premiums
- ☐ Considered selling/moving

10. In this biggest flood, did you receive any warning, and if so, from where?
(Tick one or more boxes)

- ☐ No warning whatsoever
- ☐ TV
- ☐ Radio
- ☐ Own observations
- ☐ Police
- ☐ State Emergency Service (SES)
- ☐ Neighbours, relatives or friends
- ☐ Other (_____)

Your attitudes to Council's development controls

11. Please rank the following development types according to which you think are the most important to protect from floods (1=highest priority to 4=least priority)

Development Type	Rank
Commercial/Business	
Residential	
Vulnerable residential development (e.g. aged persons accommodation)	
Essential community facilities (e.g. schools, evacuation centres)	

12. What notifications do you consider Council should give about the potential flood affectation of individual properties?
(Tick one or more boxes)

- ☐ Advise every resident and property owner on a regular basis of the known potential flood threat
- ☐ Advise only those who enquire to Council about the known potential flood threat
- ☐ Advise prospective purchasers of property of the known potential flood threat.
- ☐ Provide no notifications
- ☐ Other (_____)

13. What level of control do you consider Council should place on new development to minimise flood-related risks?

(Tick only one box)

(In addition to being favoured by the Community, these options would also need to comply with legislation)

- ☐ Prohibit all new development on land with any potential to flood
- ☐ Prohibit all new development only in those locations that would be extremely hazardous to persons or property due to the depth and/or velocity of floodwaters, or evacuation difficulties
- ☐ Place restrictions on developments which reduce the potential for flood damage (e.g. minimum floor level controls or the use of flood compatible building materials)
- ☐ Advise of the flood risks, but allow the individual a choice as to whether they develop or not, provided steps are taken to minimise potential flood risks
- ☐ Provide no advice regarding the potential flood risks or measures that could minimise those risks

Your opinions on floodplain risk management measures

14. Below is a list of possible options that may be looked at to try to minimise the effects of flooding in the study area (see plan at page 5).

This list is not in any order of importance and there may be other options that you think should be considered. For each of the options listed, please indicate "yes" or "no" to indicate if you favour the option. Please leave blank if undecided.

Option	Yes	No
Management of vegetation along creek corridors to provide flood mitigation, stability, aesthetic and habitat benefits.		
Widening of watercourses.		
Removal of floodplain obstructions.		
Improve the stormwater system within the town area.		
Construct permanent levees along the river to contain floodwaters.		
Voluntary scheme to purchase residential property in high hazard areas.		
Provide funding or subsidies to raise houses above major flood level in low hazard areas.		
Specify controls on future development in flood-liable areas (eg. controls on extent of filling, minimum floor levels.)		
Improve flood warning and evacuation procedures both before and during a flood.		
Community education, participation and flood awareness programs.		
Provide a Planning Certificate to purchasers in flood prone areas, stating that the property is flood affected.		

Other Information

15. What do you think is the best way for us to get input and feedback from the local community about the results and proposals from this study? (Tick one or more boxes)

- ☐ Council's website
- ☐ Articles in local newspaper
- ☐ Through Council's Floodplain Management Committee
- ☐ Other (please specify) _____

16. If you wish us to contact you so you can provide further information, please provide your details below:

Name: _____

Address: _____

_____

Phone: _____

Best time to call is _____

Fax No: _____

Email: _____

Who can I contact for further information?

Snowy Valleys Council
Paul Mullins | Director of Compliance – Environmental Services
Phone: (02) 6941 2530
Email: pmullins@snowyvalleys.nsw.gov.au

Copies of this Questionnaire can be obtained from: www.snowyvalleys.nsw.gov.au

COMMENTS

Please write any additional comments here:

_____

_____

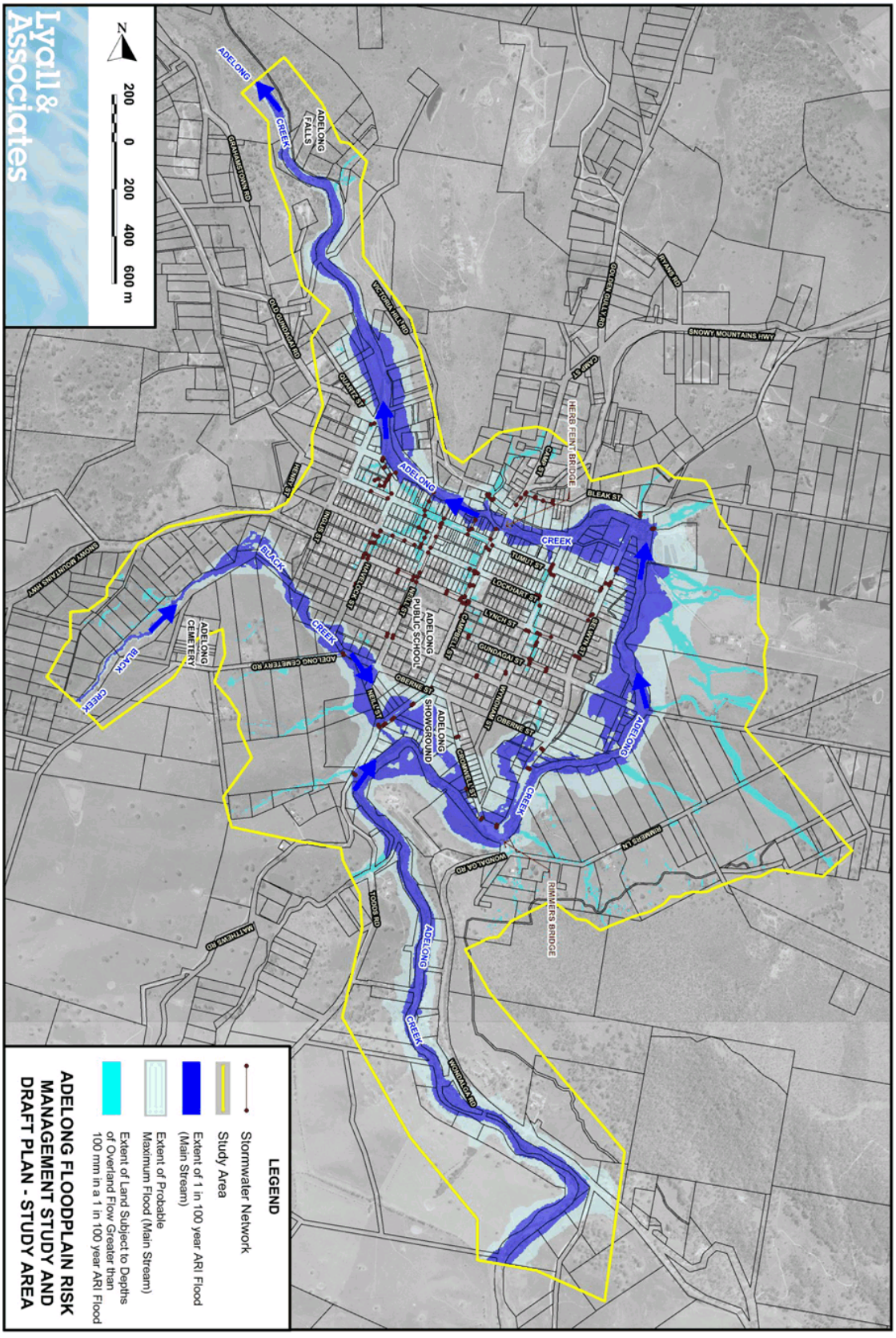
_____

_____

_____

_____

_____



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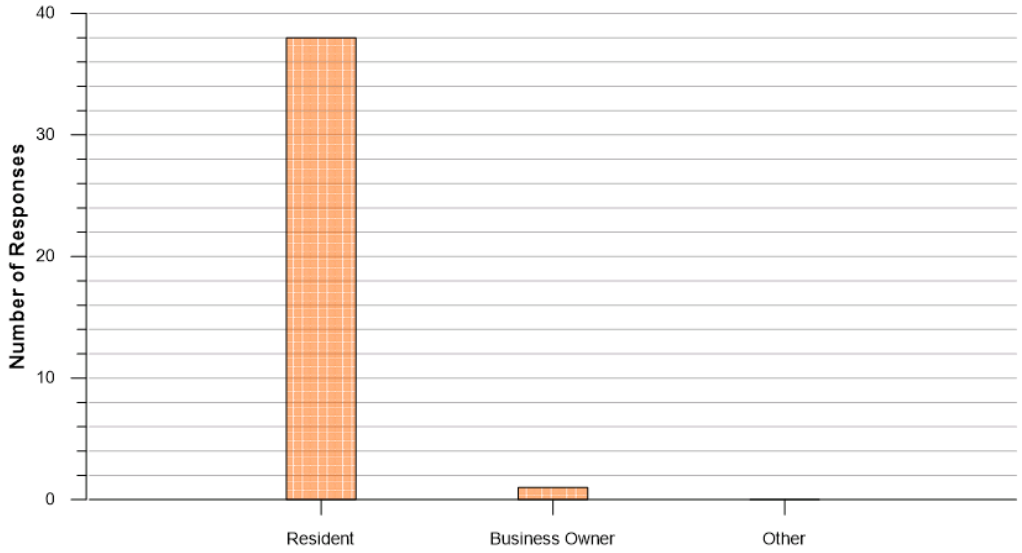
Version: 2, Version Date: 30/11/2018

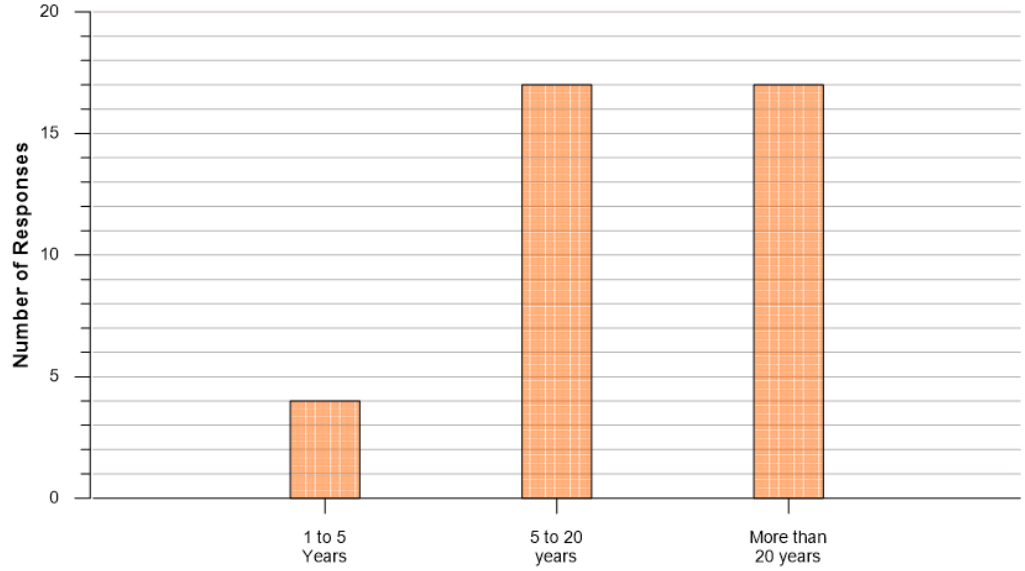
ATTACHMENT 2

RESPONSES TO COMMUNITY QUESTIONNAIRE

Q1. Residential Status

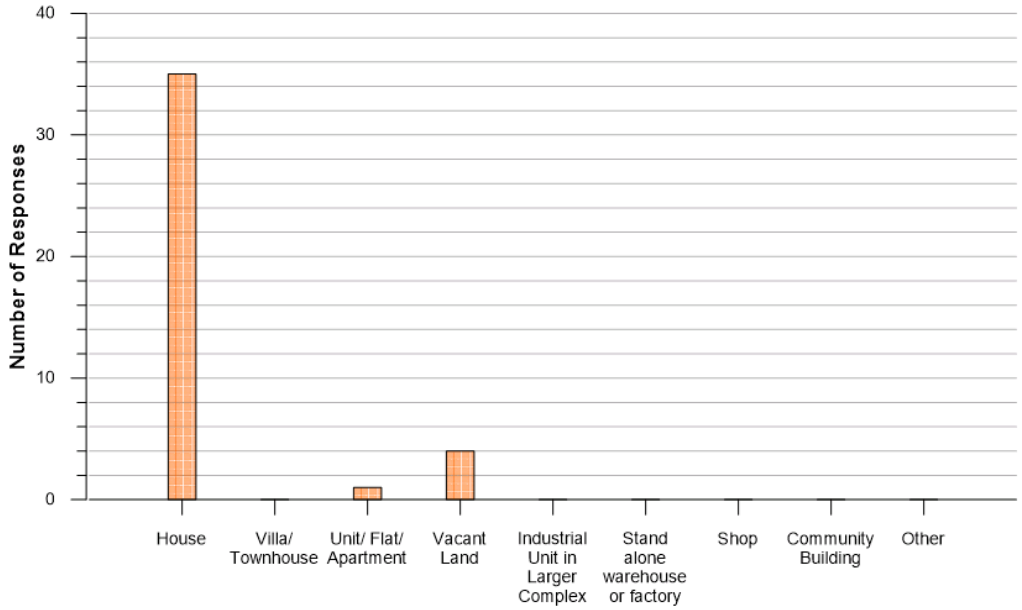


Q2. How long have you owned or lived at this address?

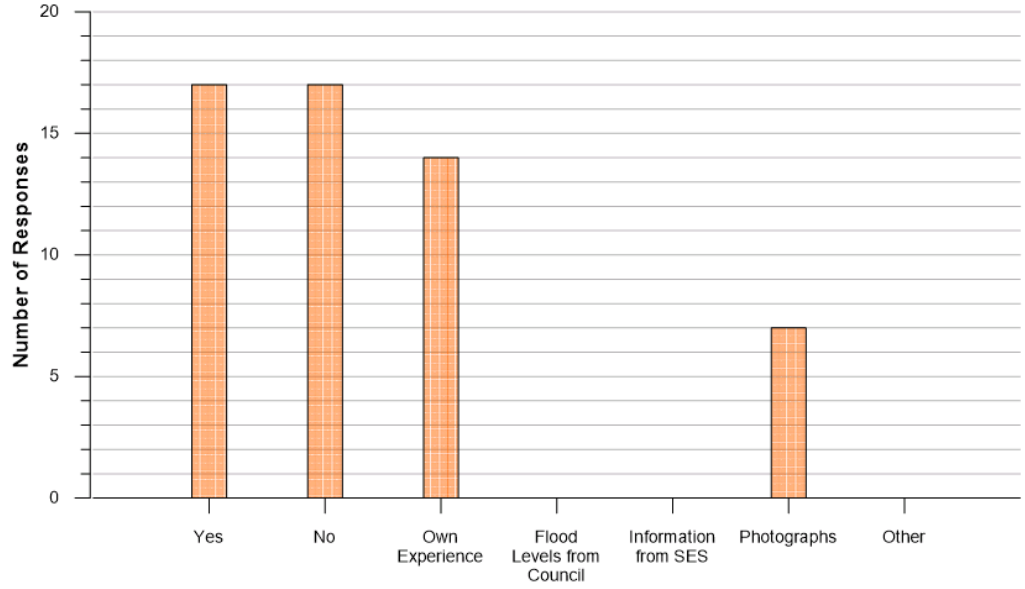


RESPONSE TO COMMUNITY QUESTIONNAIRE

Q3. Type of Property?



Q4. Do you have any information about flooding at your property?



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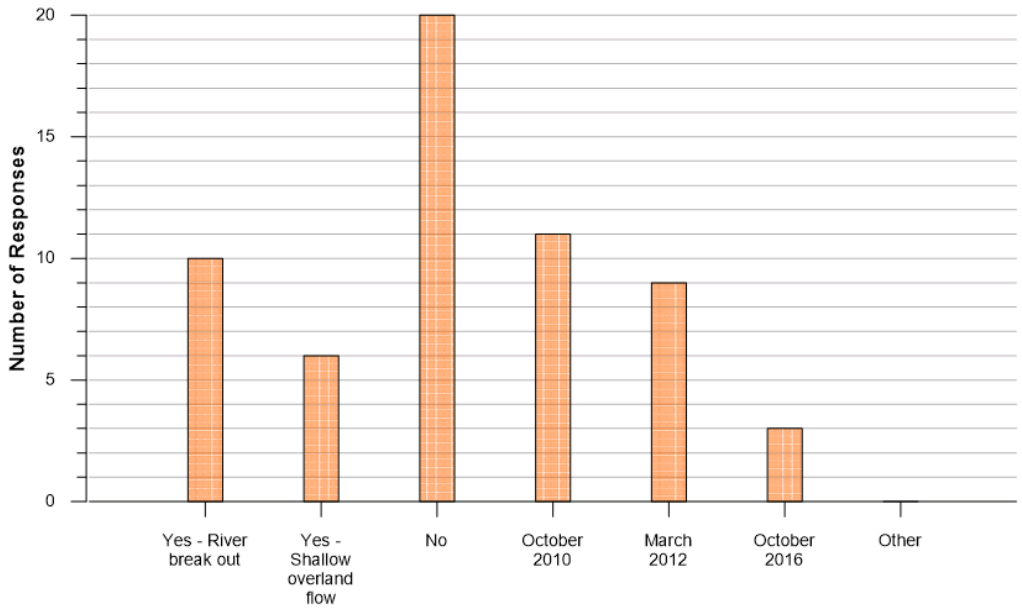
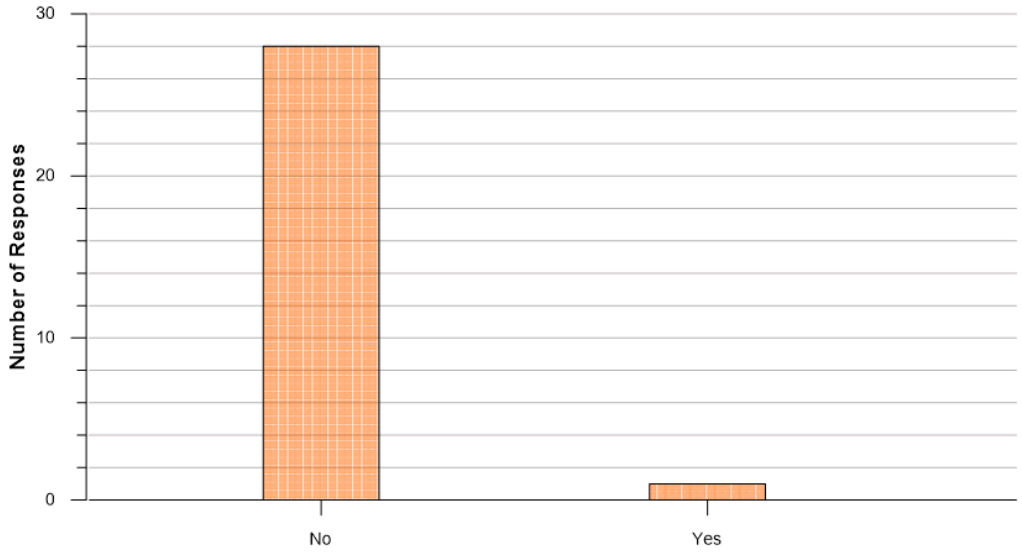
Version: 2, Version Date: 30/11/2018

Q5. Have you experienced flooding?

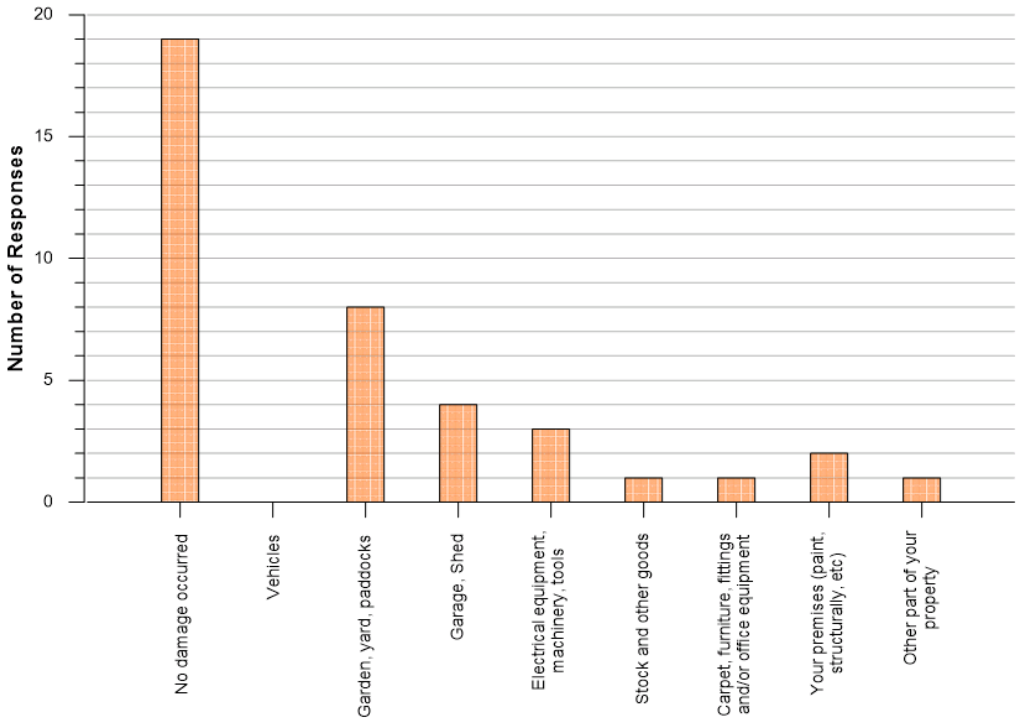


Q6. Was the main building of your property flooded above floor level?

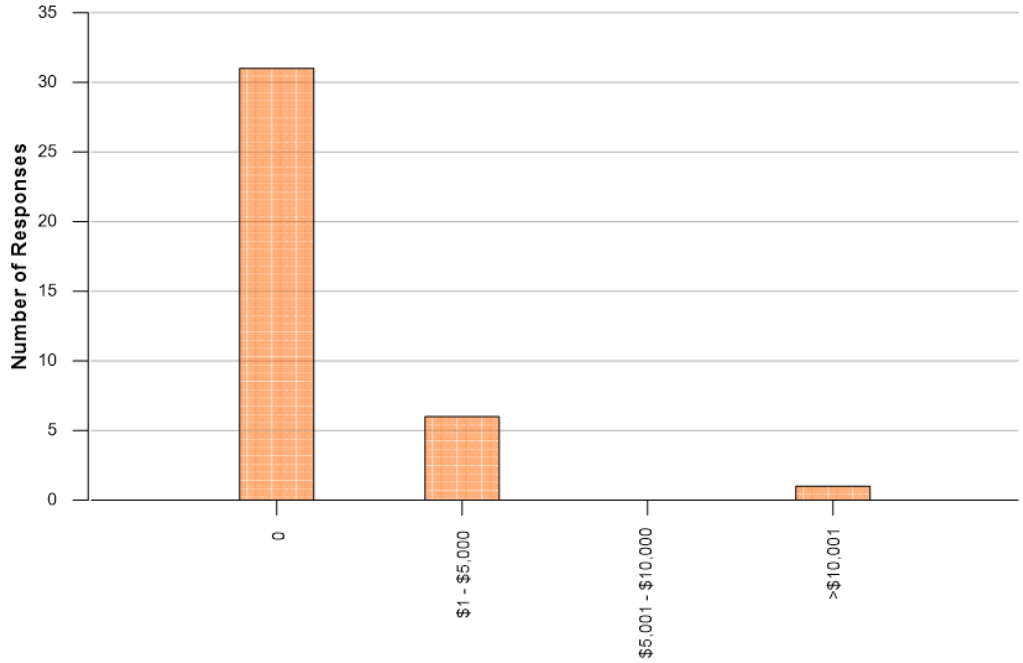


RESPONSE TO COMMUNITY QUESTIONNAIRE

Q7. What was damaged by floodwaters?

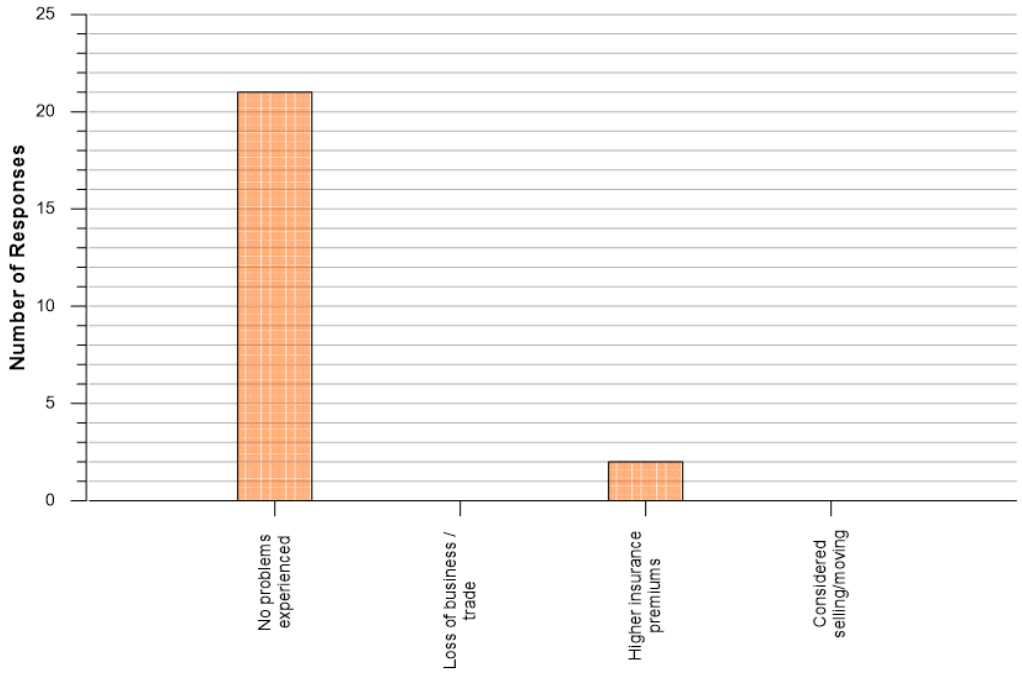


Q8. What was the cost of damage caused by flooding?

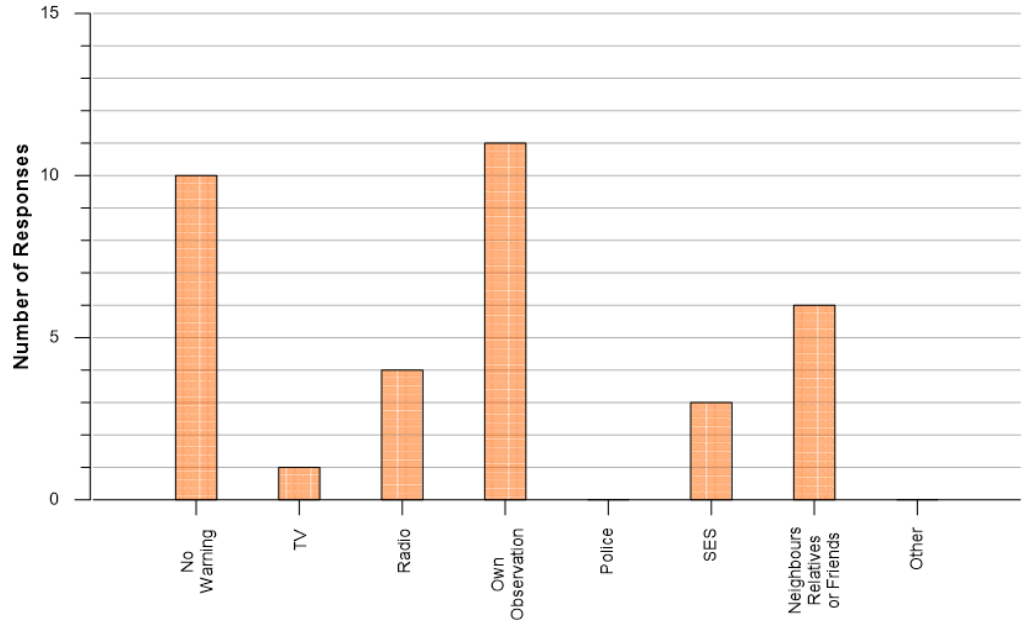


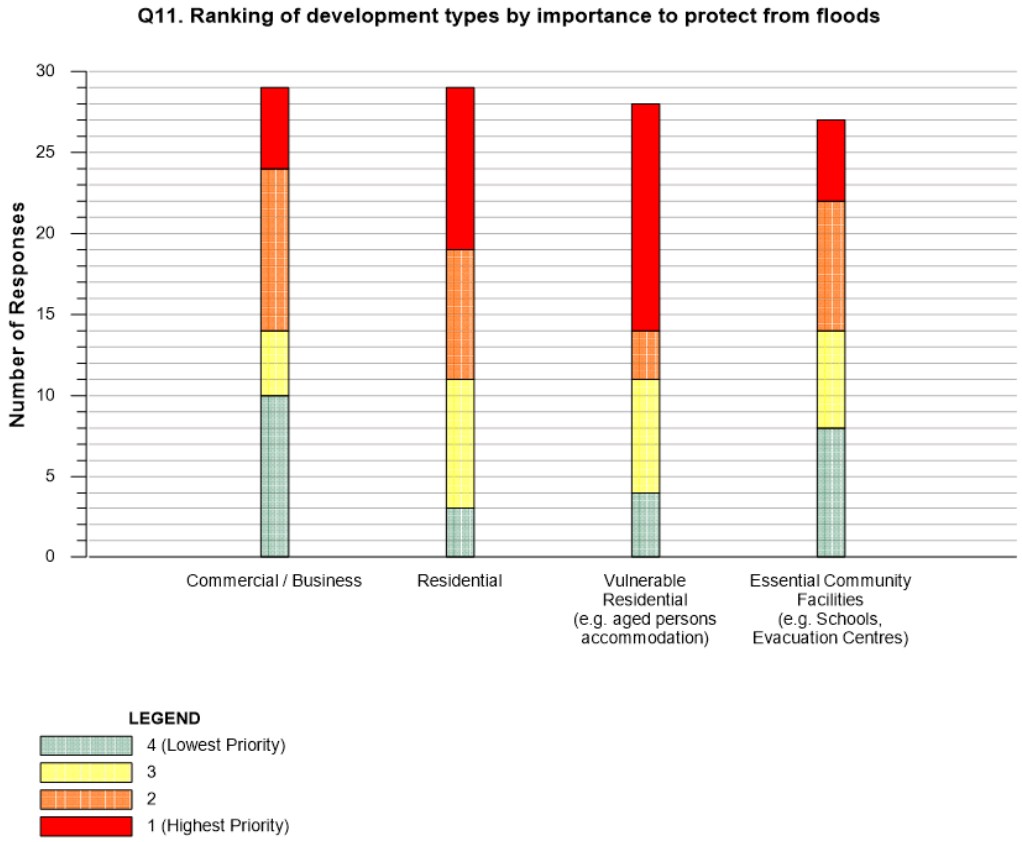
RESPONSE TO COMMUNITY QUESTIONNAIRE

Q9. What problems were experienced as a result of flooding?

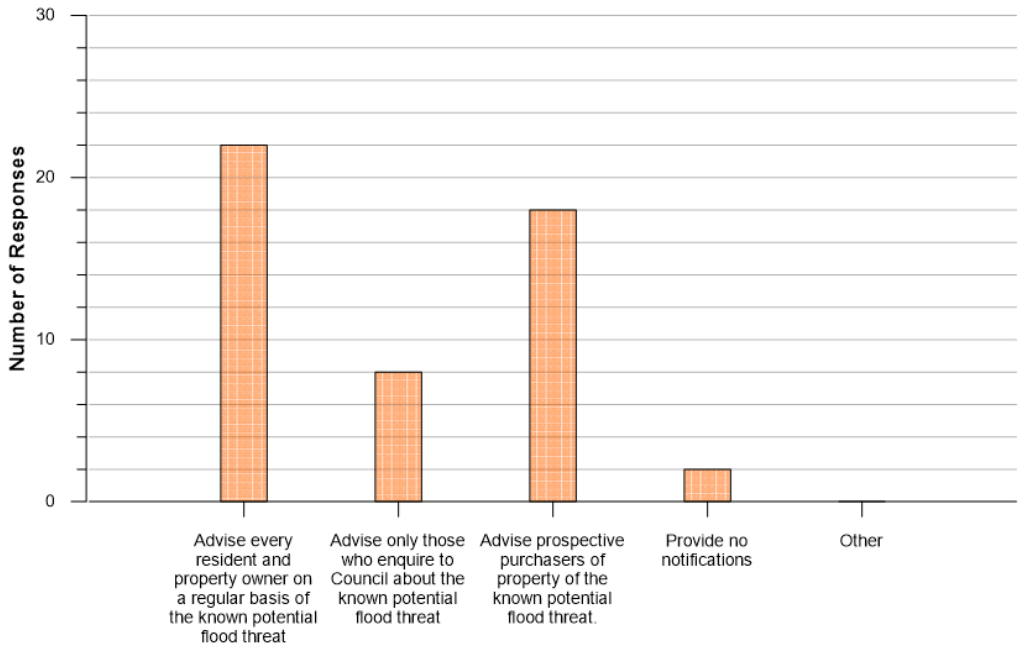


Q10. In this biggest flood, did you receive any warning, and if so, from where?

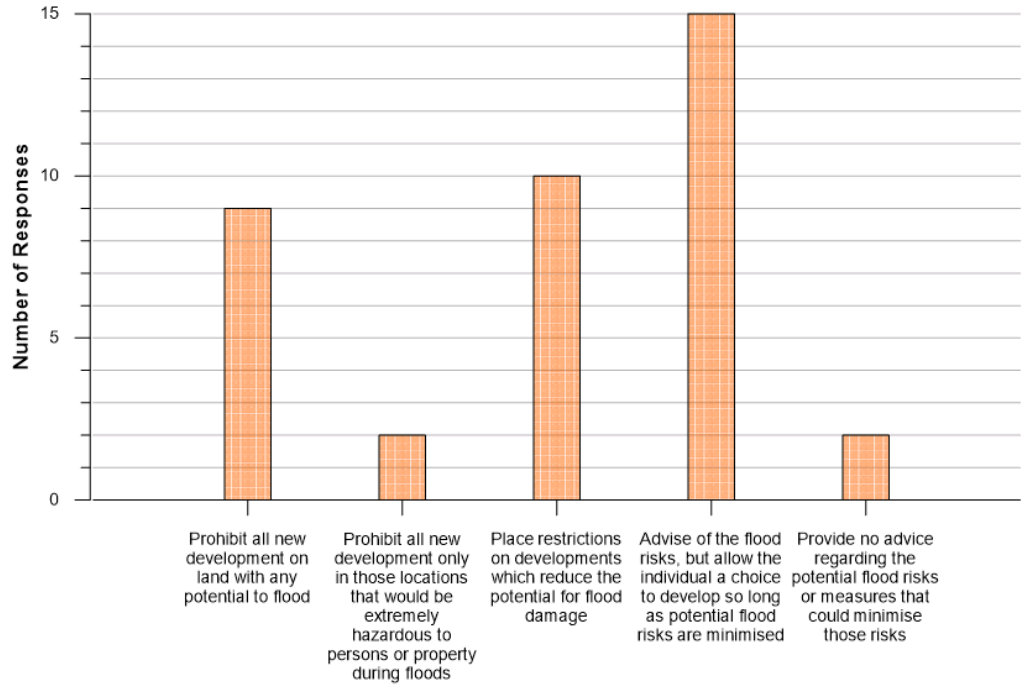




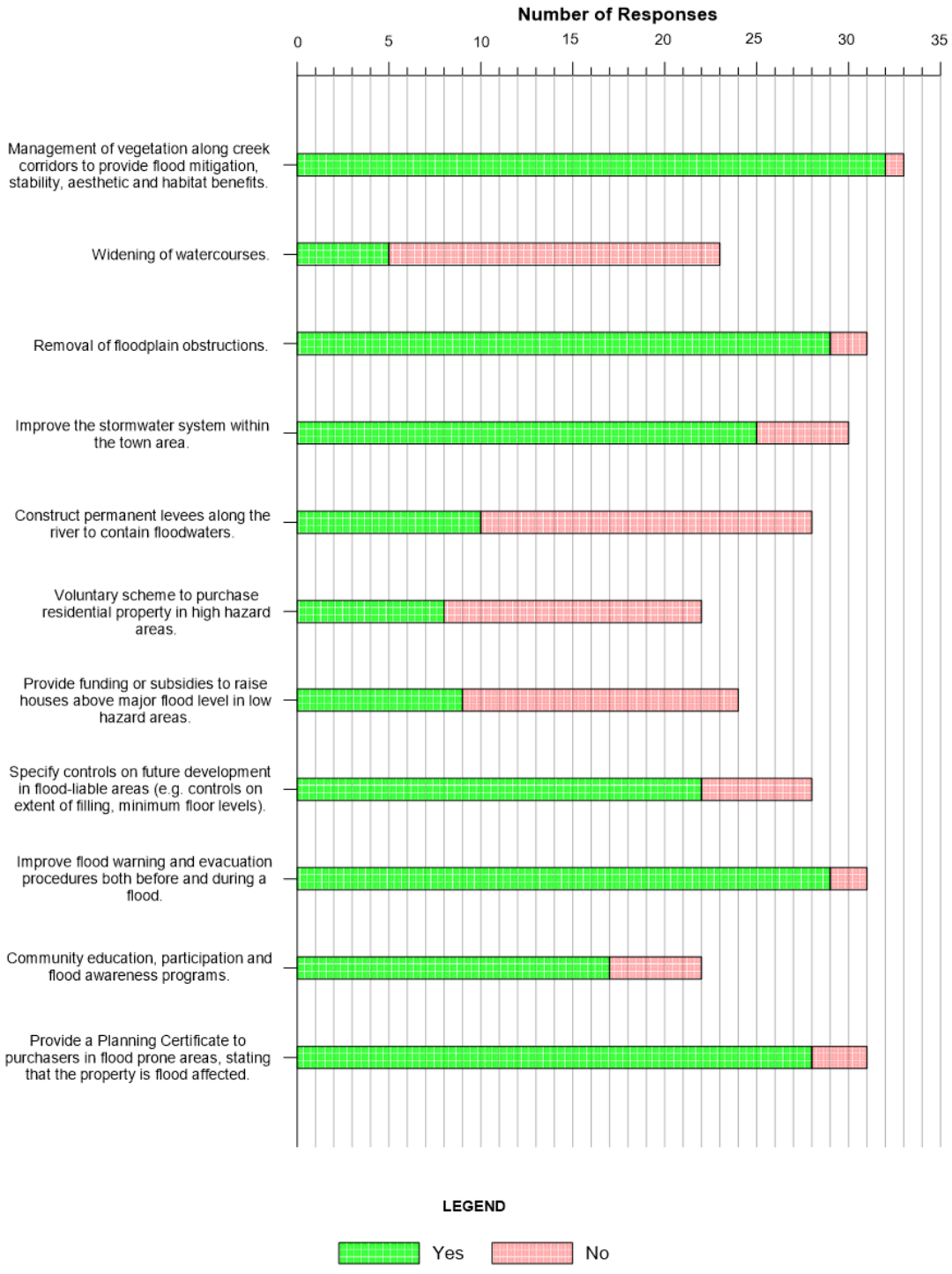
Q12. What notifications should Council give about the potential flood affectation of properties?



Q13. What level of control should Council place on new development to minimise flood-related risks?

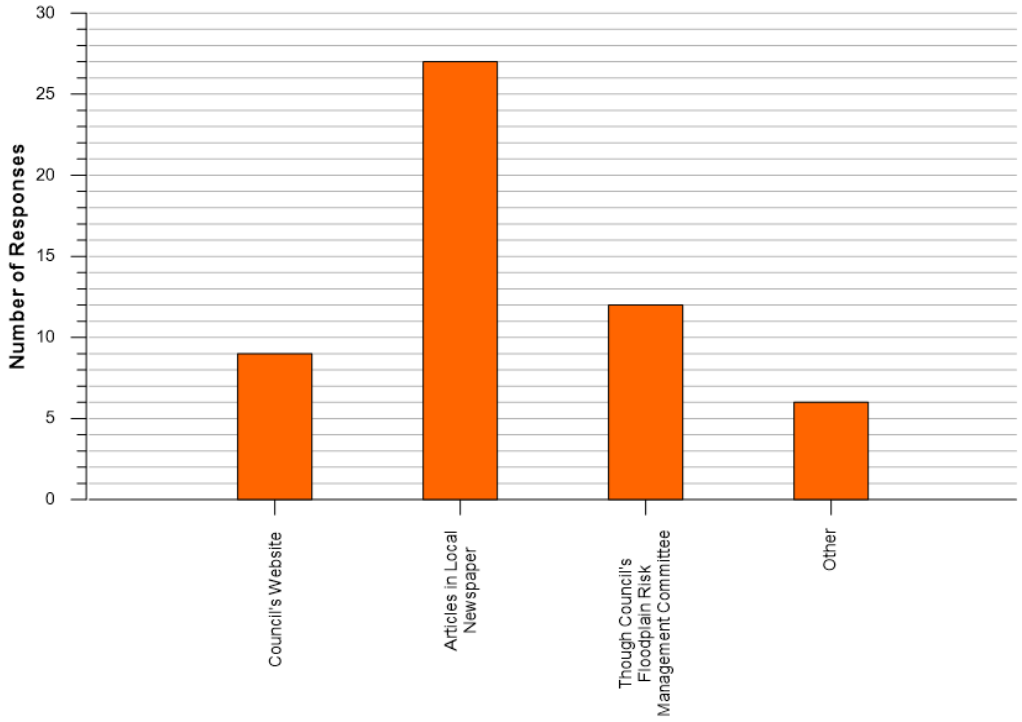


Q14. Possible Flood Management Options



RESPONSE TO COMMUNITY QUESTIONNAIRE

Q15. Best methods to get input and feedback from the local community



APPENDIX B

FLOOD DAMAGES

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(BOUND IN VOLUME 2)

B8.1 Damage - Frequency Curves and Cumulative Flooded Properties versus Depth of Inundation Diagram - 1% AEP

SYNOPSIS

Estimation of flood damages to urban development was carried out to assess the impact of flooding on the community. The objective was to allow an economic assessment of various flood management measures to be carried out at the strategic level of detail. Damages were assessed for floods ranging between the 20% AEP and PMF events. Assessment of urban flood damages was carried out for the two categories of development on the floodplain: "Residential" and "Commercial and Industrial". A third category of development, "Public Buildings", was also included in the damages model.

There was only limited quantitative data available on historic flood damages in Adelong (refer **Appendix A**). Therefore the analysis was carried out using the residential flood damages model attached to *"Floodplain Risk Management Guideline No. 4 - Residential Flood Damages"* (DECC, 2007) (**Guideline No. 4**). This publication was prepared by DECC (now OEH) to allow a consistent assessment of residential damages across NSW for the economic comparison of flood management projects.

In *Guideline No. 4*, damage assessments undertaken after major flooding in other urban centres were adjusted and used to estimate damages likely to be experienced to typical residential development in NSW. Data for the flood damages models comprised the peak water surface elevations over the extent of the study area as determined from the hydraulic models developed as part of the *Flood Study*, as well as information on the unit values of damages to residential property. The depths of above-floor inundation of properties were determined from the difference between the hydraulic model results and the floor levels of each residence. The floor levels of 80 buildings that are affected at the 1% AEP level of flooding were surveyed by a registered surveyor, while those located elsewhere on the floodplain were calculated by adding the height of the floor above a representative natural surface within the allotment (as estimated by visual inspection) to the natural surface elevation determined from the LiDAR survey data. The type of structure and potential for property damage was also assessed from a visual inspection.

The procedures in *Guideline No. 4* allow for the estimation of structural damage to the building, damage to internals and contents, external damages and clean-up costs. The level of flood awareness and available warning time are taken into account by factors which are used to reduce "potential" damages to contents to "actual" damages. "Potential" damages represent losses likely to be experienced if no action were taken by residents to mitigate impacts. A reduction in the potential damages to "actual" damages is usually made to allow for property evacuation and raising valuables above floor level, which would reduce the damages actually experienced. Any action taken by residents to reduce flood losses is mainly limited to a reduction in the damage to contents, as damages to the structure and clean-up costs are not usually capable of significant mitigation.

No specific information is given in *Guideline No. 4* in relation to commercial and industrial properties. Damages to the non-residential sectors depend on the nature of the enterprise, the depth of inundation over the floor area and the time available for owners to take action to mitigate damage to contents. A spreadsheet was used to assess flood damages which was similar to the residential model in terms of both surveyed and estimated floor levels and estimation of depths of inundation, but used typical unit damage data which had been adopted in similar floodplain risk management studies in NSW in recent years.

The number of flood affected properties and the estimated damages which could occur for various flood events in Adelong are summarised in **Table BS1** over the page.

Calculation of the estimated damages at Adelong was conducted under ideal flow conditions, as well as a scenario whereby Rimmers Bridge and Herb Feint Bridge were assumed to be partially blocked by debris (as has occurred historically to now replaced bridge structures during major flood events at Adelong).[1] While the piped stormwater drainage network was assumed to be operating at optimal capacity under partially blocked conditions, the two bridges were assumed to have a 1 m thick raft of debris lodged beneath the underside of their decks and a 4 m wide raft of debris lodged against each pier over their full height. The flood damages that would arise under both ideal flow and partially blocked conditions are presented in this Appendix.

At the 1% AEP level of flooding under ideal flow conditions, 61 residential properties would be flood affected (i.e. water inundates the allotment to a depth of 100 mm or greater), five of which would experience above-floor inundation. Similarly, 15 commercial buildings would be flood affected, three of which would be inundated above floor level. Only two public buildings would be flood affected, of which none would be inundated above floor level. The total cost of flood damages in Adelong would be approximately $0.87 Million for a 1% AEP event.

At the 1% AEP level of flooding under partially blocked conditions, 70 residential properties would be flood affected, while a total of 14 dwellings would experience above-floor inundation (i.e. an additional nine properties where compared to ideal flow conditions). Similarly, a total of 24 commercial buildings would be flood affected, with a total of six inundated above floor level (i.e. an additional three properties when compared to ideal flow conditions). While one additional public building would be flood affected, none would be inundated above floor level as a result of a partial blockage of the two road bridges. The total cost of flood damages in Adelong under partially blocked conditions would be approximately $1.69 Million for a 1% AEP event.

The "present worth value" of damages in Adelong resulting from all floods up to the 1% AEP event at a seven per cent discount rate under ideal flow and partially blocked conditions is $910,000 and $980,000, respectively (refer **Section B8** for more detail). These values represent the amount of capital spending which would be justified if a particular flood mitigation measure prevented flooding for all properties up to the 1% AEP event.

Additional information on the damages is presented in the tables attached to **Section B8** and in **Figure B8.1** which is referred to in this Appendix but bound in Volume 2 of the *FRMS&P* report.

[1] While historically blockage has been observed on the Adelong Bridge, there is the potential for a partial blockage to occur to the new Herb Feint Bridge, albeit less likely given the reduced number and larger spacing of the bridge piers.

TABLE BS1
FLOOD DAMAGES (1)

Design Flood Event (% AEP)	Number of Properties												Total Damage ($ Million)	
	Residential				Commercial/Industrial				Public					
	Flood Affected		Flood Above Floor Level		Flood Affected		Flood Above Floor Level		Flood Affected		Flood Above Floor Level			
	IFC	PBC	IFC	PBC	IFC	PBC	IFC	PBC	IFC	PBC	IFC	PBC	IFC	PBC
20	41	41	0	0	6	6	1	1	2	2	0	0	0.11	0.11
10	43	43	0	0	10	10	2	2	2	2	0	0	0.19	0.19
2	45	47	2	2	13	12	2	2	2	2	0	0	0.37	0.37
5	54	54	3	3	14	14	2	2	2	2	0	0	0.52	0.52
1	61	70	5	14	15	24	3	6	2	3	0	0	0.87	1.69
0.5	71	74	9	23	17	28	5	16	3	4	0	0	1.29	3.05
0.2	75	76	19	31	28	28	16	27	4	4	0	2	2.94	4.78
PMF	174	176	158	160	28	28	28	28	8	8	7	8	42.34	42.72

1. IFC – Ideal Flow Conditions PBC – Partially Blocked Conditions

B1 INTRODUCTION AND SCOPE

B1.1 Introduction

Damages from flooding belong to two categories:

- **Tangible Damages**
- **Intangible Damages**

Tangible damages are defined as those to which monetary values may be assigned, and may be subdivided into direct and indirect damages. Direct damages are those caused by physical contact of floodwater with damageable property. They include damages to commercial / industrial and residential building structures and contents, as well as damages to infrastructure services such as electricity and water supply. Indirect damages result from the interruption of community activities, including traffic flows, trade, industrial production, costs to relief agencies, evacuation of people and contents and clean up after the flood.

Generally, tangible damages are estimated in dollar values using survey procedures, interpretation of data from actual floods and research of government files.

The various factors included in the **intangible damage** category may be significant. However, these effects are difficult to quantify due to lack of data and the absence of an accepted method. Such factors may include:

- inconvenience
- isolation
- disruption of family and social activities
- anxiety, pain and suffering, trauma
- physical ill-health
- psychological ill-health.

B1.2 Scope of Investigation

In the following sections, tangible damages to residential, commercial / industrial and public properties have been estimated resulting from flooding at Adelong. Intangible damages have not been quantified. The threshold floods at which damages may commence to infrastructure and community assets have also been estimated, mainly from site inspection and interpretation of flood level data. However, there is no data available to allow a quantitative assessment of damages to be made to this category.

B1.3 Terminology

Definitions of the terms used in this Appendix are presented in **Chapter B8** which also summarises the value of Tangible Flood Damages.

B2 DESCRIPTION OF APPROACH

The damage caused by a flood to a particular property is a function of the depth of inundation above floor level and the value of the property and its contents. The warning time available for residents to take action to lift property above floor level also influences damages actually experienced. A spreadsheet model which has been developed by OEH for estimating residential damages and an in house spreadsheet model which has been developed for previous investigations of this nature for estimating commercial, industrial and public building damages were used to estimate damages on a property by property basis according to the type of development, the location of the property and the depth of inundation.

Using the results of the flood modelling, a peak flood elevation for each event was interpolated at each property. The interpolated property flood levels were input to the spreadsheet models which also contained property characteristics and depth-damage relationships. The depth of above-floor inundation was computed as the difference between the interpolated flood level and the floor elevation at each property. The floor levels of the 50 buildings which lie within the extent of the 1% AEP flood were surveyed by a registered surveyor, while the elevations of building floors located elsewhere on the floodplain were assessed by adding the height of floor above a representative natural surface within the allotment (as estimated by visual inspection) to the natural surface elevation determined from LiDAR survey data. The type of structure and potential for property damage was also assessed during the visual inspection.

The depth-damage curves for residential damages were determined using procedures described in *Guideline No. 4*. Damage curves for other categories of development (commercial and industrial, public buildings) were derived from previous floodplain management investigations.

Damages to the non-residential sector depend on the nature of the enterprise, the depth of inundation over the floor area and the time available for owners to take action to mitigate losses to contents. A spreadsheet model was used which was similar to the residential model in terms of both surveyed and estimated floor level and estimation of depths of inundation, but used typical unit damage data which had been adopted in similar studies in NSW in recent years.

It should be understood that this approach is not intended to identify individual properties liable to flood damages and the value of damages in individual properties, even though it appears to be capable of doing so. The reason for this caveat lies in the various assumptions used in the procedure, the main ones being:

- the assumption that computed water levels and topographic data used to define flood extents are exact and without any error;
- the assumption that the water levels as computed by the hydraulic model are not subject to localised influences;
- the estimation of property floor levels by visual inspection rather than by formal field survey;
- the use of "average" stage-damage relationships, rather than a unique relationship for each property;
- the uncertainties associated with assessing appropriate factors to convert *potential damages* to *actual flood damages* experienced for each property after residents have taken action to mitigate damages to contents.

The consequence of these assumptions is that some individual properties may be inappropriately classified as flood liable, while others may be excluded. Nevertheless, when applied over a broad area these effects would tend to cancel, and the resulting estimates of overall damages, would be expected to be reasonably accurate.

For the above reasons, the information contained in the spreadsheets used to prepare the estimates of flood damages for the catchments should not be used to provide information on the depths of above-floor inundation of individual properties.

B3 SOURCES OF DATA

B3.1 General

To estimate A*verage Annual Flood Damages* for a specific area it is necessary to estimate the damages for several floods of different magnitudes, i.e. of different frequencies, and then to integrate the area beneath the damage – frequency curve computed over the whole range of frequencies up to the PMF. To do this, it is necessary to have data on the damages sustained by all types of property over the likely range of inundation. There are several ways of doing this:

- The ideal way would be to conduct specific damage surveys in the aftermath of a range of floods, preferably immediately after each. An example approaching this ideal is the case of Nyngan where surveys were conducted in May 1990 following the disastrous flood of a month earlier (DWR, 1990). In Adelong, the most recent occurrence of major flooding which caused significant damage was the October 2010 flood, with only one respondent to the *Community Questionnaire* advising both the depth of above-floor inundation and the resulting flood damage. Given the inability to develop a depth-damage relationship from site specific data, this approach cannot be implemented at Adelong.
- The second best way is for experienced loss adjusters to conduct a survey to estimate likely losses that would arise due to various depths of inundation. This approach is used from time to time, but it can add significantly to the cost of a floodplain management study (LMJ, 1985). It was not used for the present investigation.
- The third way is to use generalised data such as that published by CRES (Centre for Resource & Economic Studies, Canberra) and used in the Floodplain Management Study for Forbes (SKM, 1994). These kinds of data are considered to be suitable for generalised studies, such as broad regional studies. They are not considered to be suitable for use in specific areas, unless none of the other approaches can be satisfactorily applied.
- The fourth way is to adapt or transpose data from other flood liable areas. This was the approach used for the present study. As mentioned, the *Guideline No 4* procedure was adopted for the assessment of residential damages. The approach was based on data collected following major flooding in Katherine in 1998, with adjustments to account for changes in values due to inflation, and after taking into account the nature of development and flooding patterns in the study area. The data collected during site inspection in the flood liable areas assisted in providing the necessary adjustments. Commercial and industrial damages were assessed via reference to recent floodplain management investigations undertaken by Lyall and Associates of a similar nature to the present study.

B3.2 Property Data

The properties were divided into three categories: residential, commercial/industrial and public buildings.

For residential properties, the data used in the damages estimation included:

- the location/address of each property
- an assessment of the type of structure
- natural surface level
- floor level

For commercial/industrial and public properties, the required data included:

- the location of each property
- the nature of each enterprise
- an estimation of the floor area
- natural surface level
- floor level

The property information was used to classify the commercial and public developments into categories (i.e. high, medium or low value properties) which relate to the magnitude of likely flood damages.

Properties lying along the Major Overland Flow paths were included in the database. The total number of residential, commercial, industrial and public properties is shown in **Table B3.1**.

TABLE B3.1
NUMBER OF PROPERTIES INCLUDED IN DAMAGES DATABASE

Development Type	Number of Properties
Residential	205
Commercial / Industrial	28
Public	8
Total	241

B3.3 Flood Levels Used in the Analysis

Damages were computed for the design flood levels determined from the hydraulic model that was set up for the *Flood Study* under ideal flow conditions. The design levels assume that the piped stormwater drainage system in Adelong is operating at optimum capacity and that no debris builds up on either the Herb Feint Bridge or Rimmers Bridge during a flood event.

Damages were also assessed for flood levels under partially blocked conditions. While the piped stormwater drainage system was assumed to operate at optimum capacity, this scenario assumed that a 1 m thick raft of debris lodges beneath the underside of the two bridge decks and that a 4 m wide raft of debris lodges across each bridge pier to their full height.

B4 RESIDENTIAL DAMAGES

B4.1 Damage Functions

The procedures identified in *Guideline No 4* allow for the preparation of a depth versus damage relationship which incorporates structural damage to the building, damage to internals and contents, external damages and clean-up costs. In addition, there is the facility for including allowance for accommodation costs and loss of rent. Separate curves are computed for three residential categories:

- Single storey slab on ground construction
- Single storey elevated floor
- Two storey residence

The level of flood awareness and available warning time are taken into account by factors which are used to reduce "potential" damages to contents to "actual" damages. "Potential" damages represent losses likely to be experienced if no action were taken by residents to mitigate impacts. A reduction in the potential damages to "actual" damages is usually made to allow for property evacuation and raising valuables above floor level, which would reduce the damages actually experienced. The ability of residents to take action to reduce flood losses is mainly limited to reductions in damages to contents, as damages to the structure and clean-up costs are not usually capable of significant mitigation.

The reduction in damages to contents is site specific, being dependent on a number of factors related to the time of rise of floodwaters, the recent flood history and flood awareness of residents and emergency planning by the various Government Agencies (BoM and NSW SES).

As illustrated in the *Flood Study*, flood levels will peak at Adelong approximately 5 hours after the onset of flood producing rainfall, which is considered 'flash flooding' according to the *Floodplain Development Manual*. The Batlow Road stream gauge (GS 410061) located 3 km upstream of Adelong provides the town with approximately 30 minutes warning time of rising water levels in Adelong Creek. These factors illustrate that Adelong has limited warning time of damaging flooding. As a result, there is currently limited time for damage reducing measures to be taken by residents.

Measures which increase awareness and response time include BoM's flood warning system which alerts NSW SES of flood producing rain. Additionally, detailed flood response procedures have been incorporated in the *Tumut Shire Local Flood Plan* which are implemented during flood alerts. While these factors would assist with the timely evacuation of residents and business owners, they are unlikely to reduce flood damages.

House contents may be raised above floor level to about 0.9 m, which corresponds with the height of a typical table/bench height. The spreadsheet provides two factors for assessing damages to contents, one for above and one for below the typical bench height. The reduction in damages is also dependent on the likely duration of inundation of contents, which would only be a few hours for most flooded properties.

Flooding on the overland flow paths is of a short duration nature with the catchment response time limited to less than an hour in the urbanised parts of town. The duration of inundation is similarly

quite short. While the flood warning system operated by BoM provides limited warning of potential "flash flooding" at Adelong, no specific response procedures have been developed by NSW SES for flooding along the Major Overland Flow paths. Consequently, there would be very limited time in advance of a flood event in which to warn residents and for them to take action to mitigate flood losses.

Table B4.1 sets out the parameters and resulting factors that were adopted for converting potential to actual damages.

TABLE B4.1
DAMAGE ADJUSTMENT FACTORS/PARAMETERS FOR RESIDENTIAL DEVELOPMENT SUBJECT TO FLOODING

Property Damage	Parameter/Factor	Value
Building	Typical Duration of Immersion (hours)	2
	Building Damage Repair Limitation Factor	0.85
	Total Building Adjustment Factor	1.36
Contents	Contents Damage Repair Limitation Factor	0.75
	Level of Flood Awareness	Low
	Effective Warning Time	0
	Typical Table/Bench Height (TTBH) (m)	0.9
	Total Contents Adjustment Factor (Above-Floor Depth <= TTBH)	1.31
	Total Contents Adjustment Factor (Above-Floor Depth > TTBH)	1.31

Table B4.2 shows total flood damages estimated for the three classes of residential property using the procedures identified in *Guideline No. 4*, for typical depths of above-floor inundation of 0.1 m and 0.4 m (the maximum depth of above-floor inundation in Adelong is about 800 mm at the 1% AEP level of flooding under partially blocked conditions). A typical ground floor area of 200 m^2 was adopted for the assessment. The values in **Table B4.2** allow for damages to buildings and contents, as well as external damages and provision for alternative accommodation.

TABLE B4.2
DAMAGES TO RESIDENTIAL PROPERTIES

Type of Residential Construction	0.1 m Depth of Inundation Above Floor Level	0.4 m Depth of Inundation Above Floor Level
Single Storey Slab on Ground (190)	$54,765	$64,321
Single Storey High Set (0)	$49,775	$58,281
Double Storey (4)	$34,842	$40,797

Note: These values allow for damages to buildings and contents, as well as external damages and provision for alternative accommodation.

B4.2 Total Residential Damages

Table B4.3 summarises residential damages in Adelong for the range of assessed flood events. The damage estimates were carried out for floods between the 20% AEP and the PMF. The location of dwellings which would experience above-floor inundation during a 1% AEP and PMF event under ideal flow conditions), and a 1% AEP under partially blocked conditions are shown on **Figures 2.3**, **2.4** and **2.10**, respectively.

TABLE B4.3
RESIDENTIAL FLOOD DAMAGES

Design Flood Event (% AEP)	Ideal Flow Conditions			Partially Blocked Conditions		
	Number of Properties		Total Damages ($ Million)	Number of Properties		Total Damages ($ Million)
	Flood Affected	Flood Damaged		Flood Affected	Flood Damaged	
20	41	0	0.08	41	0	0.08
10	43	0	0.09	43	0	0.09
2	45	2	0.19	47	2	0.2
5	54	3	0.31	54	3	0.31
1	61	5	0.50	70	14	1.11
0.5	71	9	0.81	74	23	1.70
0.2	75	19	1.61	76	31	2.42
PMF	174	158	17.83	176	160	18.09

At the 1% AEP level of flooding under ideal flow conditions, above-floor inundation would be experienced in five dwellings. Four of these dwellings are located near the northern end of Tumut Street, downstream of the Herb Feint Bridge and are affected by Major Overland Flow. All four dwellings would experience above-floor flooding of less than 100 mm in a 1% AEP flood event. The other remaining dwelling is located at the southern end of Selwyn Street and is inundated to a depth of 230 mm in a 1% AEP flood event. This dwelling is impacted by floodwater which breaks out of Adelong Creek upstream of Rimmers Bridge

At the 1% AEP level of flooding under partially blocked conditions, nine additional dwellings would experience above-floor inundation. The depth of above-floor inundation in the affected dwellings varies, with one inundated to a depth of 800 mm, two to a depth less than 400 mm, and the remainder to depths less than 200 mm. Eight of the nine affected dwellings are located along Tumut Street, with the remaining property located at the southern end of Selwyn Street. In total, 17 dwellings are flooded above floor level in a 1% AEP flood event under partially blocked conditions.

The total residential damages at the 1% AEP level of flooding is about $0.5 Million under ideal flow conditions, increasing to $1.1 Million under partially blocked conditions. The portion of the total residential damages attributable to Major Overland Flow is relatively minor, with the majority of damage resulting from floodwater that surcharges Adelong Creek.

A PMF event would result in a significant number of dwellings experiencing above-floor inundation in Adelong, with the majority of these concentrated along Tumut and Lockhart Streets. The upper limit of potential flood damage in Adelong is estimated to be about $18 million, when about 174 residential properties would be affected by floodwater.

B5 COMMERCIAL / INDUSTRIAL DAMAGES

B5.1 Direct Commercial / Industrial Damages

The method used to calculate damages requires each property to be categorised in terms of the following:

- damage category
- floor area
- floor elevation

The damage category assigned to each enterprise may vary between "low", "medium" or "high", depending on the nature of the enterprise and the likely effects of flooding. Damages also depend on the floor area.

It has recently been recognised following the 1998 flood in Katherine that previous investigations using stage-damage curves contained in proprietary software tends to seriously underestimate true damage costs. OEH are currently researching appropriate damage functions which could be adopted in the estimation of commercial and industrial categories as they have already done with residential damages. However, these data were not available for the present study.

On the basis of previous investigations, the following typical damage rates are considered appropriate for potential external and internal damages and clean-up costs for both commercial and industrial properties. They are indexed to a depth of inundation of 2 metres. At floor level and 1.2 m inundation, zero and 70% of these values respectively were assumed to occur:

Low value enterprise	$280/m^2	(e.g. Commercial: small shops, cafes, joinery, public halls. Industrial: auto workshop with concrete floor and minimal goods at floor level, Council or Government Depots, storage areas.)
Medium value enterprise	$420/m^2	(e.g. Commercial: food shops, hardware, banks, professional offices, retail enterprises, with furniture/fixtures at floor level which would suffer damage if inundated. Industrial: warehouses, equipment hire.)
High value enterprise	$650/m^2	(e.g. Commercial: electrical shops, clothing stores, bookshops, newsagents, restaurants, schools, showrooms and retailers with goods and furniture, or other high value items at ground or lower floor level. Industrial: service stations, vehicle showrooms, smash repairs.)

The factor for converting potential to actual damages depends on a range of variables such as the available warning time, flood awareness and the depth of inundation. Given sufficient warning time, a well prepared business will be able to temporarily lift property above floor level. However, unless property is actually moved to flood free areas, floods which result in a large depth of inundation, will cause considerable damage to stock and contents.

For the present study, the above-floor potential damages were converted to actual damages using a multiplier which ranged between 0.5 and 0.8 depending on the depth of inundation above the floor. The multiplier of 0.5 was adopted to convert potential to actual damages for depths of inundation up to 1.2 m, increasing to 0.8 for greater depths.

B5.2 Indirect Commercial and Industrial Damages

Indirect commercial and industrial damages comprise costs of removal of goods and storage, loss of trading profit and loss of business confidence.

Disruption to trade takes the following forms:

- The loss through isolation at the time of the flood when water is in the business premises or separating clients and customers. The total loss of trade is influenced by the opportunity for trade to divert to an alternative source. There may be significant local loss but due to the trade transfer this may be considerably reduced at the regional or state level.
- In the case of major flooding, a downturn in business can occur within the flood affected region due to the cancellation of contracts and loss of business confidence. This is in addition to the actual loss of trading caused by closure of the business by flooding.

Loss of trading profit is a difficult value to assess and the magnitude of damages can vary depending on whether the assessment is made at the local, regional or national level. Differences between regional and national economic effects arise because of transfers between the sectors, such as taxes, and subsidies such as flood relief returned to the region.

Some investigations have lumped this loss with indirect damages and have adopted total damage as a percentage of the direct damage. In other cases, loss of profit has been related to the gross margin of the business, i.e. turnover less average wages. The former approach has been adopted in this present study. Indirect damages have been taken as 50% of direct actual damages. A clean-up cost of \$15/metre^2 of floor area of each flooded property was also included.

B5.3 Total Commercial and Industrial Damages

Table B5.1 over summarises estimated commercial and industrial damages in Adelong.

While 15 commercial and industrial properties would be affected by floodwater during a 1% AEP flood event under ideal flow conditions, only three would experience above-floor inundation. The total flood damages for this event would amount to \$0.35 Million. Under partially blocked conditions, the number of flood affected properties would increase to 24, of which six would experience above-floor inundation. The total flood damages under these conditions would increase to \$0.55 Million.

A significant increase in the number of commercial / industrial buildings that would experience above-floor inundation occurs at the 0.2% AEP level of flooding under ideal flow conditions and at the 0.5% AEP level of flooding under partially blocked conditions, with 16 commercial properties becoming flood damaged under each scenario.

All 28 commercial properties comprising the property database would be damaged by floodwater during the PMF event. This is largely due to the significant depth of inundation which would be experienced along Tumut Street during an extreme flood event.

TABLE B5.1
COMMERCIAL AND INDUSTRIAL FLOOD DAMAGES

Design Flood Event (% AEP)	Ideal Flow Conditions			Partially Blocked Conditions		
	Number of Properties		Total Damages ($ Million)	Number of Properties		Total Damages ($ Million)
	Flood Affected	Flood Damaged		Flood Affected	Flood Damaged	
20	6	1	0.03	6	1	0.03
10	10	2	0.08	10	2	0.08
5	13	2	0.16	12	2	0.15
2	14	2	0.19	14	2	0.19
1	15	3	0.35	24	6	0.55
0.5	17	5	0.45	28	16	1.29
0.2	28	16	1.27	28	27	2.28
PMF	28	28	22.06	28	28	22.16

B6 DAMAGES TO PUBLIC BUILDINGS

B6.1 Direct Damages – Public Buildings

Included under this heading are government buildings, churches, swimming pools and parks. Damages were estimated individually on an area basis according to the perceived value of the property. Potential internal damages were indexed to a depth of above-floor inundation of 2 metres as shown below. At floor level and 1.2 metres depth of inundation, zero and 70% of these values respectively were assumed to occur.

Low value	$280/m^2	
Medium value	$420/m^2	(e.g. council buildings, NSW SES HQ, fire station)
High value	$650/m^2	(e.g. schools)

These values were obtained from the Nyngan Study (DWR, 1990), as well as commercial data presented in the Forbes Water Studies report (WS, 1992). External and structural damages were taken as 4 and 10% of internal damages respectively.

B6.2 Indirect Damages – Public Buildings

A value of $15/metre^2 was adopted for the clean-up of each property. This value is based on results presented in the Nyngan Study and adjusted for inflation. Total "welfare and disaster" relief costs were assessed as 50% of the actual direct costs.

B6.3 Total Damages – Public Buildings

Table B6.1 over summarises estimated damages to public buildings in Adelong. Generally there is very minor damage to public property as a result of flooding in the town.

Of the eight public buildings comprising the property database, two are affected by a 20% AEP flood event, while one additional building is affected at the 0.5% AEP level of flooding under ideal flow conditions and at the 1% AEP level of flooding under partially blocked conditions.

Above-floor inundation in public buildings only occurs in a PMF event under ideal flow conditions and at the 0.2% AEP level of flooding under partially blocked conditions.

The cost of damage to public buildings from flooding in a 1% AEP event is relatively low at between $0.02 Million and $0.03 Million.

TABLE B6.1
PUBLIC FLOOD DAMAGES

Design Flood Event (% AEP)	Ideal Flow Conditions			Partially Blocked Conditions		
	Number of Properties		Total Damages ($ Million)	Number of Properties		Total Damages ($ Million)
	Flood Affected	Flood Damaged		Flood Affected	Flood Damaged	
20	2	0	0	2	0	0
10	2	0	0.02	2	0	0.02
5	2	0	0.02	2	0	0.02
2	2	0	0.02	2	0	0.02
1	2	0	0.02	3	0	0.03
0.5	3	0	0.03	4	0	0.06
0.2	4	0	0.06	4	2	0.08
PMF	8	7	2.45	8	8	2.47

B7 DAMAGES TO INFRASTUCTURE AND COMMUNITY ASSETS

No data were available regarding damage of community infrastructure during historic flood events. However, a qualitative matrix of the effects of flooding on important assets in Adelong is presented in **Table B7.1**.

TABLE B7.1
QUALITATIVE EFFECTS OF FLOODING ON INFRASTRUCTURE AND COMMUNITY ASSETS

Damage Sector	Design Flood Event (% AEP)							
	20	10	5	2	1	0.5	0.2	PMF
Electricity	O	O	O	O	O	O	O	X
Telephone	O	O	O	O	O	X	X	X
Roads	X##	X##	X	X	X	X	X	X
Bridges	O	O	O	O	O	O	X	X
Sewerage	O	O	O	O	O	X	X	X
Water Supply	O	O	O	O	O	O	X	X
Parks and Gardens	X	X	X	X	X	X	X	X

Notes: O = No significant damages likely to be incurred.
X = Some damages likely to be incurred.
= Roads subject to inundation due to Minor Tributary Flooding and Major Overland Flow, as Adelong Creek does not surcharge it banks for floods more frequent than about 5% AEP.

B8 SUMMARY OF TANGIBLE DAMAGES

B8.1 Tangible Damages

Floods have been computed for a range of flood frequencies from 20% AEP up to the PMF. For the purposes of assessing damages, the 50% AEP was adopted as the "threshold" flood at which damages commence in Adelong. From **Table B8.1** at the end of this chapter, considerable flood damages would only be expected in Adelong during extreme flood events, and only then in residential and commercial/industrial properties. The relatively large increase in flood damages is a function of the confined nature of flooding at Adelong.

Figure B8.1 shows the damage-frequency curves and cumulative distribution of above-floor depths of inundation at the 1% AEP flood level for residential, commercial/industrial and public buildings in Adelong.

B8.2 Definition of Terms

Average Annual Damages (also termed "expected damages") are determined by integrating the area under the damage-frequency curve. They represent the time stream of annual damages, which would be expected to occur on a year by year basis over a long duration.

Using an appropriate discount rate, average annual damages may be expressed as an equivalent "*Present Worth Value*" of damages and used in the economic analysis of potential flood management measures.

A flood management scheme which has a design 1% AEP level of protection, by definition, will eliminate damages up to this level of flooding. If the scheme has no mitigating effect on larger floods, then these damages represent the benefits of the scheme expressed on an average annual basis and converted to the *Present Worth Value* via the discount rate.

Under current NSW Treasury guidelines, economic analyses are carried out assuming a 50 year economic life for projects and discount rates of 7% pa. (best estimate) and 11% and 4% pa. (sensitivity analyses).

B8.3 Average Annual Damages

The *Average Annual Damages* in Adelong for all flood events up to the PMF are shown in **Table B8.2**. Note that values have been quoted to two decimal places to highlight the relatively small recurring damages in the town.

B8.4 Present Worth of Damages

The *Present Worth Value* of damages likely to be experienced in Adelong for all flood events up to the 1% AEP and PMF events, a 50 year economic life and discount rates of 4, 7 and 11 per cent are shown in **Table B8.3**.

For a discount rate of 7% pa and an economic life of 50 years, the *Present Worth Value* of damages for all flood events up to the 1% AEP flood at Adelong is about $0.91 Million under ideal flow conditions, increasing to about $0.98 Million under partially blocked conditions. Therefore, one or more schemes costing up to these amounts could be economically justified if they eliminated

damages in Adelong for all flood events up to this level. While schemes costing more than these values would have a benefit/cost ratio less than 1, they may still be justified according to a multi-objective approach which considers other criteria in addition to economic feasibility. Flood management measures are considered on a multi-objective basis in **Chapter 4** of the Main Report.

TABLE B8.1
TOTAL FLOOD DAMAGES - $ MILLION

Design Flood Event (%AEP)	Ideal Flow Conditions				Partially Blocked Conditions			
	Residential	Commercial	Public	Total	Residential	Commercial	Public	Total
20	0.08	0.03	0	0.11	0.08	0.03	0	0.11
10	0.09	0.08	0.02	0.19	0.09	0.08	0.02	0.19
5	0.19	0.16	0.02	0.37	0.20	0.15	0.02	0.37
2	0.31	0.19	0.02	0.52	0.31	0.19	0.02	0.52
1	0.50	0.35	0.02	0.87	1.11	0.55	0.03	1.69
0.5	0.81	0.45	0.03	1.29	1.70	1.29	0.06	3.05
0.2	1.61	1.27	0.06	2.94	2.42	2.28	0.08	4.78
PMF	17.83	22.06	2.45	42.34	18.09	22.16	2.47	42.72

TABLE B8.2
AVERAGE ANNUAL DAMAGES - $ MILLION

Design Flood Event (%AEP)	Ideal Flow Conditions				Partially Blocked Conditions			
	Residential	Commercial	Public	Total	Residential	Commercial	Public	Total
20	0.012	0.005	0	0.017	0.012	0.005	0	0.012
10	0.021	0.01	0.001	0.032	0.021	0.01	0.001	0.021
5	0.028	0.016	0.002	0.046	0.028	0.016	0.002	0.028
2	0.035	0.021	0.003	0.059	0.035	0.021	0.003	0.035
1	0.039	0.024	0.003	0.066	0.043	0.025	0.003	0.043
0.5	0.042	0.026	0.003	0.071	0.05	0.029	0.003	0.05
0.2	0.046	0.029	0.003	0.078	0.056	0.035	0.003	0.056
PMF	0.064	0.051	0.005	0.12	0.075	0.058	0.006	0.075

TABLE B8.3
PRESENT WORTH VALUE OF DAMAGES
$ MILLION

Discount Rate (%)	Ideal Flow Conditions		Partially Blocked Conditions	
	All Floods Up to 1% AEP	All Floods Up to PMF	All Floods Up to 1% AEP	All Floods Up to PMF
4	1.42	2.58	1.53	2.99
7	0.91	1.66	0.98	1.92
11	0.59	1.08	0.64	1.25

B9 REFERENCES

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APPENDIX C

PLATES SHOWING HISTORIC FLOODING AT ADELONG

PHOTOGRAPHS SHOWING FLOODING BEHAVIOUR IN ADELONG – JANUARY 1984 FLOOD

(Source: Bewsher, 2011)

Plate 1 - Adelong Pool kiosk

Plate 2 - View across Snowy Mountains Highway towards No. 46 Tumut Street

Plate 3 - View across Snowy Mountains Highway towards No. 46 Tumut Street

Plate 4 - View from Adelong Bridge towards Royal Hotel, No. 45 Tumut Street

Plate 5 - Old Pharmacy, No.88 Tumut Street

Plate 6 - Inundation at Broadhurst Motors, No. 96 Tumut Street

Plate 7 - Looking west along Tumut Street towards Broadhurst Motors

Plate 8 - Adelong Falls

PHOTOGRAPHS SHOWING FLOODING BEHAVIOUR IN ADELONG – OCTOBER 2010 FLOOD

(Source: Bewsher, 2011)

Plate 9 - Flooded garages at rear of Nos. 38 and 40 Tumut Street, with damaged fences.

Plate 10 - View of No. 46 Tumut Street from Tumut Street.

Plate 11 - View of No. 46 Tumut Street from Adelong Bridge.

Plate 12 - View northwest from corner of Tumut and Campbell Streets towards Bendigo Bank.

Plate 13 - View southeast up Tumut Street.

Plate 14 - View northwest down Tumut Street towards Adelonia Theatre.

Plate 15 - View south across partially constructed section of Herb Feint Bridge, showing creek capacity was exceeded at 13:04 hours on Friday 15th October.

Plate 16 - View south across partially constructed section of Herb Feint Bridge, showing inundation of the bridge deck and debris trapped on upstream side.

Plate 17 - View from No. 46 Tumut Street north towards partially constructed section of Herb Feint Bridge as flood recedes, shows accumulation of debris and influence in elevating water levels.

Plate 18 - Middle section of the remaining downstream half-width of Adelong Bridge collapsed.

Plate 19 - Evidence of debris blockage on partially constructed section of Herb Feint Bridge, looking downstream.

Plate 20 - Evidence of debris blockage on partially constructed section of Herb Feint Bridge, looking downstream.

Plate 21 - Evidence of debris blockage on partially constructed section of Herb Feint Bridge, looking downstream.

Plate 22 - Evidence of debris blockage on partially constructed section of Herb Feint Bridge, looking downstream.

Plate 23 - Evidence of debris blockage on partially constructed section of Herb Feint Bridge, looking downstream.

Plate 24 - Evidence of debris blockage at Adelong Flood Channel at Adelong Bridge, looking upstream.

Plate 25 - Evidence of debris blockage at Adelong Bridge, looking upstream.

Plate 26 - Evidence of debris deposited on downstream side of southern abutment of Caravan Park Suspension Bridge, looking upstream.

PHOTOGRAPHS SHOWING FLOODING BEHAVIOUR IN ADELONG – MARCH 2012 FLOOD

(Source: Yeo, 2013)

Plate 27 - View south across Adelong Creek with Herb Feint Bridge on left, Thursday 1 March 2012.

Plate 28 - View downstream of Herb Feint Bridge with floodwater on the point of surcharging the left (western) bank of Adelong Creek, Thursday 1 March 2012.

APPENDIX D

DRAFT FLOOD POLICY

Document Set ID: 2012463
Version: 2, Version Date: 30/11/2018

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D1.1 Extract of Flood Planning Map Showing Extent of Flood Planning Area at Adelong
D1.2 Development Controls Matrix Map
D1.3 Flood Hazard Map

ABBREVIATIONS

AHD	Australian Height Datum
AEP	Annual Exceedance Probability (%)
Council	Snowy Valleys Council
EP&A	Environmental Planning and Assessment
FPL	Flood Planning Level (1% AEP flood level + freeboard)
FPA	Flood Planning Area (area inundated at the FPL)
FRMS&P	Floodplain Risk Management Study and Plan
LEP	Local Environmental Plan
MFL	Minimum Floor Level (1% AEP flood level + freeboard)
NSW SES	New South Wales State Emergency Service
PMF	Probable Maximum Flood

D1. INTRODUCTION

This Flood Policy has been prepared to provide specific controls to guide development of land in flood prone areas in Adelong.

The Flood Policy incorporates the findings of the *Adelong Floodplain Risk Management Study & Plan, 2017* and the procedures set out in the NSW Floodplain Development Manual (NSWG, 2005).

Adelong Floodplain Risk Management Study & Plan, 2017 identified the occurrence of three types of flooding in Adelong:

- **Main Stream Flooding** resulting from flows that surcharge the main channel of Adelong Creek, as well as Black Creek, Tanyard Creek, Golden Gully and the unnamed tributary which joins Adelong Creek opposite the extension of Gundagai Street. While the flows in Adelong Creek may be several metres deep in the channel and relatively fast moving with velocities of greater than 2 m/s, flow in the other watercourses are generally shallower and slower moving.
- **Minor Tributary Flooding** resulting from overflows of the minor gully systems which drain the relatively steep hillsides bordering Adelong Creek. Watercourses that are included in this definition are Nuggety Gully, Curtis Gully and Currans Gully.
- **Major Overland Flow** is present along several flow paths that run through the urbanised parts of Adelong. It is also present in the undeveloped areas which border the township. Flows on the Major Overland Flow paths would typically be less than 300 mm deep, travelling over the surface at velocities less than 0.5 m/s.

The Flood Policy takes into account the impacts a potential partial blockage of the Herb Feint Bridge and Rimmers Bridge by floating woody debris would have on flooding behaviour at Adelong.

The Flood Policy also takes into account the "*Guideline on Development Controls on Low Flood Risk Areas*" and Ministerial Direction No 4.3 issued by the then Department of Planning on 1 July 2009. As a consequence, residential areas within the extent of the **Flood Planning Area** (**FPA**) shown on the **Flood Planning Map** are subject to flood related development controls in this Flood Policy. **Figure D1.1** is an extract from the *Flood Planning Map* showing the extent of the FPA at Adelong. Within the FPA, the controls over residential development reflect the nature of the flood risk. The division of the floodplain into hazard areas is shown on the **Flood Hazard Map** for Adelong (refer **Figures D1.3**).

The Policy recognises the need for controls over commercial and industrial development within the FPA to balance the flood risk against the requirement for continuing the long term viability of this sector in the town. The Policy also recognises that the safety of people and associated emergency response planning need to be considered and imposes restrictions on vulnerable development (for example education and aged care facilities) and critical emergency response and recovery facilities and infrastructure (evacuation centres, hospitals and utilities).

D1.1 What does the Policy do?

The Flood Policy provides information to assist people who want to develop or use land affected by potential flooding in Adelong. Development may include, among other things:

- dwelling construction, including additions to existing dwellings;
- filling land to provide building platforms above flood level;
- commercial and industrial development; and
- subdividing land.

D1.2 Objectives

The objectives of this Flood Policy are:

(a) To provide detailed flood related development controls for the assessment of applications on land affected by floods in accordance with the provisions of the Tumut Local Environmental Plan 2012 (*Tumut LEP 2012*) and the findings of the *Adelong Floodplain Risk Management Study and Plan, 2017*.

(b) To alert the community to the hazard and extent of land affected by floods.

(c) To inform the community of Snowy Valley Council's (**Council's**) policy in relation to the use and development of land affected by the potential flooding in Adelong.

(d) To reduce the risk to human life and damage to property caused by flooding through controlling development on land affected by floods.

(e) To ensure new development is consistent with the flood response strategies adopted by the NSW State Emergency Service (**NSW SES**) and does not impose additional burdens on, or risk to its personnel during flood emergencies.

Definitions of flood related terms used herein are provided in the **Glossary** in **Section D3** of this document.

D1.3 Will the Policy affect my Property?

The Policy applies to all development permitted with the consent of Council on land:

i) to which the *Tumut LEP 2012* applies,

ii) that lies within the extent of the FPA, as shown in **Figure D1.1**; and

iii) that lies on the floodplain but outside the extent of the FPA (refer area identified as "Outer Floodplain" in **Figure D1.1**).

D1.4 How to use this Policy

The Policy provides criteria which Council will use for the determination of development applications in areas within the extent of the FPA in Adelong. The criteria recognise that different controls apply to different land uses and levels of potential flood inundation or hazard.

The procedure Council will apply for determining the specific controls applying to proposed development within the FPA is set out below. Upon enquiry by a prospective applicant, Council will make an initial assessment of the flood affectation and flood levels at the site using the following procedure:

i) Determine which part of the floodplain the development is located in from **Figure D1.1**.

ii) Determine which Development Controls Matrix applies to the development from **Figure D1.2** (i.e. either Main Stream Flooding, Minor Tributary Flooding or Major Overland Flow)

iii) Determine the flood hazard zone(s) that applies to the development from **Figures D1.3**.

iv) Identify the category of the development from **Annexure 1: Land Use Category**.

v) Determine the flood level at the site using information contained in *Adelong Floodplain Risk Management Study and Plan, 2017,* as well as the appropriate freeboard for defining the Minimum Floor Level (**MFL**) and flood related development controls for the category of development from **Figure D1.3** and **Annexure 2: Development Controls Matrices**.

vi) Confirm that the development conforms with the controls in **Annexure 2**.

With the benefit of this initial information from Council, the Applicant will prepare the documentation to support the development application according to **Annexures 2** and **4**.

A survey plan showing natural surface levels over the site will be required as part of the Development Application documentation. Provision of this plan by the applicant at the initial enquiry stage will assist Council in providing flood related information relevant to the site.

Further information on flooding in Adelong and the controls over development imposed by this Policy are available by discussion with and upon written application to Council.

D1.5 Other Documents Which May Need to be Read in Conjunction with this Policy

- New South Wales Government (NSWG) Floodplain Development Manual (NSWG, 2005); and associated Guideline on Development Controls on Low Flood Risk Areas; and Ministerial Direction No. 4.3, 1 July 2009;
- Tumut LEP 2012;
- Adelong Flood Study (Lyall & Associates, 2014);
- *Adelong Floodplain Risk Management Study and Plan* (Lyall & Associates, 2017); and
- Relevant Council policies, development control plans and specifications.

D2. WHAT ARE THE CRITERIA FOR DETERMINING APPLICATIONS?

D2.1 General

Development controls on flood prone land are set out in **Annexure 2** of this Flood Policy. The controls recognise that different controls are applicable to different land uses, the location within the floodplain, levels of potential flood inundation and flood hazard.

The controls applicable to proposed development depend upon:

- The type of development.
- The part(s) of the floodplain where the development is located.
- Peak flood levels at the site of the development.

D2.2 Division of the Floodplain into Hazard Zones

D2.2.1 General

Figure D1.3 is the *Flood Hazard Map* for Adelong. The figure shows the subdivision of the floodplain into a number of categories which have been used as the basis for developing the graded set of planning controls.

D2.2.2 Main Stream and Minor Tributary Flooding

The floodplain has been divided into the following four categories in areas that are affected by both Main Stream and Minor Tributary Flooding:

- **Inner Floodplain (Hazard Category 1A)**, which is shown in solid red colour. This zone comprises areas where factors such as the depth and velocity of flow, time of rise, isolation on Low Flood Islands and evacuation problems mean that the land is unsuitable for some types of development. It includes areas of High and Low Hazard Floodway, Flood Storage, Flood Fringe, Intermediate Floodplain and Outer Floodplain areas. Erection of buildings and carrying out of work; use of land, subdivision of land and demolition subject to State Environmental Planning Policies and Local Environmental Plan provisions are not permitted in this zone.
- The **Inner Floodplain (Hazard Category 1B)** zone (shown as a solid orange colour) comprises an area on the western overbank of Adelong Creek centred on Tumut Street. This area is affected by hazardous flooding as a result of a partial blockage of the Herb Feint Bridge or during a flood slightly larger than the 1% AEP event. Only commercial/industrial type development and minor additions to existing residential development is permitted in this zone.
- **Inner Floodplain (Hazard Category 2)**, which is shown in solid yellow colour. This zone comprises Low Hazard Floodway and Flood Storage areas where development other than Essential Community Facilities, Critical Utilities, Schools and Flood Vulnerable development is permitted provided it is capable of withstanding hydraulic forces and sited on the allotment to minimise adverse redirections of flow towards adjacent properties. Council may require a *Flood Risk Report* if it considers that the proposal has the potential to significantly affect flooding behaviour in adjacent properties.

- **Intermediate Floodplain**, which is shown in solid blue colour. This area is the remaining land lying outside the extent of the Inner Floodplain zones, but within the FPA. Within this zone, there would only be the requirement for MFL's to be set at the 1% AEP flood levels plus 500 mm. While land use permissibility would be as specified by State Environmental Planning Policies or the Local Environmental Plan, Essential Community Facilities, Critical Utilities and Flood Vulnerable Residential development is not permitted in this zone.
- **Outer Floodplain**, which is shown in solid cyan colour. This area represents the remainder of the floodplain between the Intermediate Floodplain and the extent of the Probable Maximum Flood (PMF) (that is, the extent of the floodplain). This area is outside the extent of the FPA and hence controls on residential, commercial and industrial development do not apply. However, Essential Community Facilities, Critical Utilities and Flood Vulnerable development is not permitted in this zone.

D2.2.3 Major Overland Flow

The floodplain has been divided into the following categories in areas that are affected by Major Overland Flow:

- **High Hazard Floodway**, which is shown in solid orange colour. This zone comprises areas where significant depths of overland flow of a high hazard nature occur in Adelong. This type of flow is typically limited to reaches of engineered channel. Future development in this area is not permitted under the *Flood Policy*.
- **Low Hazard Floodway / Flood Storage**, which is shown in solid green colour. This zone comprises areas where significant overland flow or excessive depths of ponding of a low hazard nature occur in Adelong. Council may permit residential, commercial and industrial development in this zone, provided it is capable of withstanding hydraulic forces and is sited within the allotment to minimise adverse redirection of flow towards adjacent properties. There would also be the requirement for MFL's to be set at the 1% AEP flood levels plus 300 mm in this zone, as well as restrictions on site filling to prevent blockage of flows (ref. **Section D2.15**). Similar controls exist for commercial and industrial development. Council may require a *Flood Risk Report* for development proposals in this zone (typically for larger scale commercial or industrial developments).
- **Intermediate Floodplain**, which is shown in solid blue colour. This zone is defined by the area outside the High Hazard Floodway and Low Hazard Floodway / Flood Storage zones where depths of flow would exceed 150 mm in a 1% AEP storm event. Within this zone, there would only be the requirement for MFL's to be set at the 1% AEP flood level plus 300 mm. Land use permissibility would be as specified by State Environmental Planning Policies or the Local Environmental Plan.
- **Outer Floodplain**, which is shown in solid cyan colour. This zone is the area outside the Intermediate Floodplain zone where depths of flow would exceed 150 mm in a PMF event (shown as a solid cyan colour). This area is outside the extent of the FPA and hence controls on residential, commercial and industrial development would not apply. While Essential Community Facilities, Critical Utilities and Flood Vulnerable Residential development would be permitted in this zone, the flood related development controls identified in **Annexure 2.2** would apply to these types of development.

D2.6 Local Drainage

At the lower end of the scale, drainage problems are typically caused by direct surface runoff, surcharges and overflows from low points in kerbs, or overflows from the smaller pipes in the stormwater drainage system. They typically involve depths of inundation up to 300 mm. In the Floodplain Development Manual (NSWG, 2005), these situations are categorised as **Local Drainage**.

NSWG, 2005 recognises that Local Drainage problems are not always amenable to rigorous analysis and therefore Council is **not** obliged to convey information on Planning Certificates under Section 10.7 of the EP&A Act. Local Drainage problems involve shallow depths of inundation with generally little danger to personal safety. Problems due to property inundation generally arise because of deficiencies in stormwater management controls or building practice where floor levels are near finished ground levels.

In Adelong, the threshold between Major Overland Flow and Local Drainage has been reduced to 150 mm in recognition that depths of flow greater than this value could result in above-floor inundation if appropriate controls are not imposed on new development.

D2.7 Land Use Categories and Minimum Floor Level Requirements

Eight land use categories have been adopted. The specific land use in each category is listed in **Annexure 1**. The MFL's for the various land use types are:

- For new residential development, the MFL is the peak 1% AEP flood level at the particular development site, plus an allowance for freeboard. Within the Main Stream and Minor Tributary Flooding FPA's, the freeboard is 500 mm. For residential allotments in the FPA of the Major Overland Flow paths, the freeboard is 300 mm.
- For commercial and industrial development, the MFL is the peak 1% AEP flood level plus freeboard. Within the Main Stream and Minor Tributary Flooding FPA's, the freeboard is 500 mm. For allotments in the FPA of the Major Overland Flow paths, the freeboard is 300 mm. Council may at its discretion allow variation to this MFL, subject to local conditions (refer **Section D2.8**).
- For Essential Community Facilities, Critical Utilities and Flood Vulnerable Residential Development (nursing homes, aged care facilities and the like), the MFL is the peak 1% AEP flood level plus freeboard, noting that these types of development are not permitted in areas subject to Main Stream and Major Tributary Flooding. For areas subject to Major Overland Flow, the freeboard is 300 mm. Council will require an area at a higher level (to be determined by Council) for the storage of valuable equipment and will also require the applicant to demonstrate that there is safe access to and from the site in the event of a flood emergency (refer **Sections D2.9** and **D2.10**).

D2.8 Assessing Commercial and Industrial Development Proposals

The *Flood Policy* nominates the same MFL as for residential development. However, where it is not practicable to achieve this level, Council may approve a lesser level commensurate with the local streetscape. In this eventuality, the applicant is to provide an area within the development for the storage of goods at a minimum level equal to the MFL. This area should be at least 20% of the gross floor area, or as determined by Council.

D2.9 Essential Community Facilities and Critical Utilities

The *Flood Policy* nominates the same MFL as for residential development in areas subject to Major Overland Flow, noting that these types of development are not permitted in areas subject to Main Stream and Major Tributary Flooding. It also recognises that critical utilities and essential services necessary for emergency management need to be designed to be capable of operating during extreme flood events and constructed of flood resistant materials so as to suffer minimal damages at a higher level of flooding than the MFL. Development proposals are to ensure that valuable equipment necessary for the operation of the facility is located at or above the PMF, or otherwise protected from extreme flooding. Council will also require development proposals to provide safe and reliable access to facilities during major flooding.

D2.10 Vulnerable Residential Development

The *Flood Policy* nominates the same MFL for Flood Vulnerable Residential Development (which includes nursing homes, aged care facilities and the like) as for residential development in areas subject to Major Overland Flow, noting that these types of development are not permitted in areas subject to Main Stream and Major Tributary Flooding. The applicant is also to ensure that valuable equipment necessary for the operation of the facility is located above the MFL *(at a level determined by Council)*. Council will also require development proposals to provide safe and reliable access during major flooding.

D2.11 Minor Additions (Residential)

Council has nominated the floor levels of minor additions to residences to be no lower than the MFL. However, where it can be demonstrated by the applicant that this is not practicable, Council at its discretion may allow a reduction in minimum floor levels, provided that the level is at least 300 mm above natural ground level, or as otherwise determined by Council so as to be above the level of frequent flooding.

D2.12 Checking of Completed Finished Floor Height

After the building has been built to the relevant MFL, Council officers will check compliance with this requirement at the relevant inspection stage. The applicant is to provide a benchmark on the site, levelled to Australian Height Datum (**AHD**). Alternatively, Council officers may require surveyor's certification as the finished floor height(s).

D2.13 Fencing

Any proposed fencing is to be shown on the plans accompanying a development application to allow Council to assess the likely effect of such fencing on flood behaviour.

In the Inner Floodplain (Hazard Categories 1 and 2), High Hazard Floodway and Low Hazard Floodway / Flood Storage zones where flow velocities may be significant, fences which minimise obstructions to flow are to be adopted. Where impermeable fences such as Colorbond, galvanised metal, timber or brush are proposed, fencing panels should be either:

a) removable so that panels can be laid flat; or

b) horizontally hinged where a portion of at least 1 m high is capable of swinging open to allow floodwater to pass. Trees/landscaping and other structures are not to impede the ability of a hinged fence to open.

D2.14 Other Uses and Works

All other development, building or other works within any of the categories that require Council's consent will be considered on their merits. In consideration of such applications, Council must determine that the proposed development is in compliance with the objectives of this Policy.

D2.15 Land Filling and Obstructions to Flow

No filling or alteration of the land surface is permissible in the Inner Floodplain (Hazard Category 1) and High Hazard Floodway zones due to the potential for filling or obstructions to flow to adversely redirect flows. Any minor extensions or repairs permitted by Council should be located on piers to minimise obstructions to the passage of flow, with the underside of any structure supporting the buildings to be above the 1% AEP flood level.

Council may permit building pads for residential blocks in the Inner Floodplain (Hazard Category 2) and Low Hazard Floodway / Flood Storage zones, provided it is satisfied that the proposal will not significantly obstruct or adversely re-direct flows towards adjacent developments. In order not to significantly obstruct flows, Council may require part of the development to be located on piers to minimise obstructions to the passage of flow, with the underside of any structure supporting the buildings to be above the 1% AEP flood level. Sub-surface drainage of building pads is required.

D2.16 Flood Related Information to be Submitted to Council

D2.16.1 Survey Details – Existing Site and Proposed Development

A Survey Plan prepared by a Registered Surveyor is required to be lodged with the Development Application for properties located on flood affected land as shown on the Flood Planning Map. The Survey Plan will enable Council to assess the extent and depth of inundation over the site (at existing natural surface levels) and must indicate the following:

- the location of existing building or structures;
- the floor levels and ceiling heights of all existing buildings or structures to be retained;
- existing and/or proposed drainage easements and watercourses or other means of conveying flood flows that are relevant to the flood characteristics of the site;
- 1% AEP flood level(s) over the site (to be provided by Council); and flood extents; and
- 0.2 metre natural surface contour intervals across the entire property (existing and proposed). Note: All levels must be relative to AHD.

Annexure 4 outlines requirements for survey data required by Council.

D2.16.2 Evaluation of Development Proposals

The Applicant will need to demonstrate, using Council supplied flood information, that:

1. **The development conforms with the requirements of this Policy for the particular Flood Hazard zone in which it is located.**
2. **Depending on the nature and extent of the development and its location within the floodplain, Council may request the Applicant to prepare a *Flood Risk Report* to demonstrate that the proposal does not increase the flood hazard to existing and future occupiers of the floodplain (see Section D2.16.3).**

   Council will make its evaluation and confirm requirements regarding the proposed site development, based on the Survey Plan and accompanying data on the proposed development (see Annexure 4); and according to the conformance of the proposal with the performance requirements of the Development Controls Matrices – Annexures 2.1 and 2.2 and Chapter D2.

D2.16.3 Flood Risk Report – Inner Floodplain (Hazard Category 2), High Hazard Floodway and Low Hazard Floodway / Flood Storage Zones

A. Scope of Work – General

Council will require a *Flood Risk Report* for any (minor) residential development located in the High Hazard Floodway zone. Depending on its nature and scale, Council may also require a *Flood Risk Report* for a development situated in the Inner Floodplain (Hazard Category 2) and Low Hazard Floodway / Flood Storage zones where lesser but still significant flow velocities may be expected and/or where depths of inundation may be significant and a partial filling may restrict flow.

Typically, such a report may be required for a large commercial or industrial development which Council considers has the potential to adversely redirect flows. This report is to be prepared by a suitably qualified Consulting Engineer and must address the following:

a) Confirm the MFL for the particular category of development (MFL to be determined through enquiries of Council).

b) Specify proposed floor levels (and existing floor levels where they are to be retained) of habitable and non-habitable structures.

c) Include a site-specific flood assessment that may require flood modelling to demonstrate that there will be no adverse impact on surrounding properties as a result of the development, up to the 1% AEP flood.

d) Propose measures to minimise risk to personal safety of occupants and the risk of property damage, addressing the flood impacts on the site of the 1% AEP flood. These measures shall include but are not limited to the following:

   - Types of materials to be used, up to the MFL to ensure the structural integrity for immersion and impact of velocity and debris.
   - Waterproofing methods, including but not limited to electrical equipment, wiring, fuel lines or any other service pipes and connections.

e) Confirm the structural adequacy of the development, taking into account the following:

- all piers and all other parts of the structure which are subject to the force of flowing waters or debris have been designed to resist the stresses thereby induced.
- all forces transmitted by supports to the ground can be adequately withstood by the foundations and ground conditions existing on the site.
- the structure will be able to withstand stream flow pressure, force exerted by debris, and buoyancy and sliding forces caused by the full range of flooding up to the MFL.

f) All electrical connections must be located above the MFL. Council will also require all electrical circuit connections to be automatically isolated in the event of flood waters having the potential to gain access to exposed electrical circuits, either internal or external of the building (see also **Annexure 3A**).

g) All materials used in the construction are to be flood compatible to a minimum level equivalent to the MFL (**Annexure 3B**).

B. Additional Items (Commercial and Industrial Development)

h) For commercial and industrial development (in the Inner Floodplain (Hazard Category 2) and Low Hazard Floodway / Flood Storage zones), include flood warning signs/depth indicators for areas that may be inundated, such as open car parking areas.

D3. GLOSSARY OF TERMS

Note: For expanded list of definitions, refer to Glossary contained within the NSW Government Floodplain Development Manual, 2005.

TERM	DEFINITION
Annual Exceedance Probability (AEP)	The chance of a flood of a given or larger size occurring in any one year, usually expressed as a percentage. For example, for a flood magnitude having five per cent AEP, there is a five per cent probability that there would be floods of greater magnitude each year.
Australian Height Datum (AHD)	A common national surface level datum corresponding approximately to mean sea level.
Flood Affected Properties	Properties that are either encompassed or intersected by the **Flood Planning Area (FPA)**.
Floodplain	Area of land which is subject to inundation by floods up to and including the Probable Maximum Flood (**PMF**) event, that is, flood prone land.
Flood Planning Area	The area of land that is shown to be in the Flood Planning Area on the *Flood Planning Map*.
Flood Planning Map	The *Flood Planning Map* shows the extent of land on which flood related development controls apply, an extract of which is shown on **Figure D1.1**.
Flood Planning Level (FPL) (General Definition)	The combinations of flood levels and freeboards selected for planning purposes, as determined in floodplain risk management studies and incorporated in floodplain risk management plans.
Flood Planning Level (FPL)	For land within the Flood Planning Area subject to Main Stream Flooding in Adelong, the Flood Planning Level (FPL) is the level of the 1% Annual Exceedance Probability (AEP) flood event plus 500 mm freeboard. For land within the Flood Planning Area subject to Minor Tributary Flooding in Adelong, the FPL is the level of the 1% AEP flood event minus 150 mm freeboard. For land within the Flood Planning Area subject to Major Overland Flow in Adelong, the FPL is the level of the 1% AEP flood event minus 150 mm freeboard. For areas outside the Flood Planning Area shown on the *Flood Planning Map*, the FPL is the level of the 1% AEP flood event plus 500 mm freeboard.
Flood Prone/Flood Liable Land	Land susceptible to flooding by the PMF. Flood Prone land is synonymous with Flood Liable land.
Floodway	Those areas of the floodplain where a significant discharge of water occurs during floods. They are often aligned with naturally defined channels. Floodways are areas that, even if only partially blocked, would cause a significant redistribution of flood flow, or a significant increase in flood levels.
Flood Storage Area	Those parts of the floodplain that may be important for the temporary storage of floodwaters during the passage of a flood. Loss of flood storage can increase the severity of flood impacts by reducing natural flood attenuation.

TERM	DEFINITION
Freeboard	Provides reasonable certainty that the risk exposure selected in deciding a particular flood chosen as the basis for the FPL and MFL is actually provided. It is a factor of safety typically used in relation to the setting of floor levels, levee crest levels, etc. Freeboard is included in the FPL and MFL.
Habitable Room	In a residential situation: a living or working area, such as a lounge room, dining room, kitchen, bedroom or workroom. In an industrial or commercial situation: an area used for offices or to store valuable possessions susceptible to flood damage in the event of a flood.
Inner Floodplain (Hazard Category 1)	Comprises areas where factors such as the depth and velocity of flow, time of rise, isolation and evacuation difficulties mean that the land is unsuitable for future development. It includes areas of High and Low Hazard Floodway, Flood Storage, Flood Fringe, Intermediate Floodplain and Outer Floodplain areas subject to Main Stream and Minor Tributary Flooding. It also includes land which may become isolated during a flood event. Future development is not permitted in this zone subject to Main Stream and Minor Tributary Flooding.
Inner Floodplain (Hazard Category 2)	Comprises areas of Low Hazard Floodway and Flood Storage areas where development other than Essential Community Facilities, Critical Utilities, Schools and Flood Vulnerable is permitted provided it is capable of withstanding hydraulic forces and sited on the allotment to minimise adverse redirections of flow towards adjacent properties. It also includes land which may become isolated during a flood event. Council may require a *Flood Risk Report* if it considers that the proposal has the potential to significantly affect flooding behaviour in adjacent properties.
Intermediate Floodplain	For Main Stream and Minor Tributary Flooding it is land within the indicative extent of flooding resulting from the occurrence of the 1% AEP flood plus 500 mm (i.e. the FPA), but not classified as Inner Floodplain. For Major Overland Flow, it is the land outside the High Hazard Floodway and Low Hazard Floodway / Flood Storage zones where the depth of inundation during the 1% AEP storm event is greater than 150 mm.
Local Drainage	Land on an overland flow path where the depth of inundation during the 1% AEP storm event is less than 150 mm.
Main Stream Flooding	Inundation of normally dry land occurring when water overflows the natural or artificial banks of a stream, river, estuary, lake or dam. In Adelong, Main Stream Flooding is confined to Adelong Creek.
Minor Tributary Flooding	The inundation of normally dry land occurring when water overflows the natural or artificial banks of a minor stream. In the study area, these are located along Black Creek, Tanyard Creek, Golden Creek, and the unnamed flowpath which joins Adelong Creek east of Gundagai and Selwyn Streets.
Major Overland Flow	Where the depth of overland flow during the 1% AEP storm event is greater than 150 mm.
Minimum Floor Level (MFL) (General Definition)	The combinations of flood levels and freeboards selected for setting the Minimum Floor Levels (MFL's) of future development located in properties subject to flood related planning controls.

TERM	DEFINITION
Main Stream and Minor Tributary Minimum Floor Level	For properties subject to Main Stream and Minor Tributary Flooding, the Minimum Floor Level (MFL) is the level of the 1% AEP flood event plus 500 mm freeboard. Note that for areas outside the Flood Planning Area shown on the Flood Planning Map, the Main Stream and Minor Tributary Flooding MFL is the level of the 1% AEP flood event plus 500 mm freeboard.
Major Overland Flow Minimum Floor Level	For properties subject to Major Overland Flow, the MFL is the level of the 1% AEP flood event plus 300 mm freeboard. Note that for areas outside the Flood Planning Area shown on the *Flood Planning Map*, the Major Overland Flow MFL is the level of the 1% AEP flood event plus 500 mm freeboard.
Outer Floodplain	This is defined as the land between the FPA and the extent of the PMF.
Probable Maximum Flood (PMF)	The largest flood that could conceivably occur at a particular location. Generally, it is not physically or economically possible to provide complete protection against this event. The PMF defines the extent of flood prone land, that is, the floodplain. For the study area, the extent of the PMF has been trimmed to include depths greater than 150 mm.

D4. REFERENCES

Lyall and Associates (2014) ***"Adelong Flood Study"***.

Lyall and Associates (2017) "***Adelong Floodplain Risk Management Study and Plan***".

New South Wales Government (2005) ***"Floodplain Development Manual – The Management of Flood Liable Land"***.

ANNEXURE 1
LAND USE CATEGORIES

Essential Community Facilities	Critical Utilities and Uses	Flood Vulnerable Residential	Residential	Business, Commercial/Industrial & Rural Industry	Non-Urban and Outbuildings	Residential Subdivision	Minor Additions (Residential)
Development that may provide an important contribution to the notification and evacuation of the community during flood events; Hospitals; Institutions; Child care centres; Educational establishments.	Telecommunication facilities; Public Utility Installation that may cause pollution of waterways during flooding, or if affected during flood events would significantly affect the ability of the community to return to normal activities after the flood events. Hazardous industry; Hazardous storage establishments.	Group home; Housing for aged or disabled persons; and Units for aged persons.	Dwelling; Residential flat building; Home industry; Boarding house; Professional consulting rooms;	Bulk Store; Bus depot; Bus station; Car repair stations; Club; Commercial premises (other than where referred to elsewhere); General store; Health care professional; Hotel; Intensive livestock keeping; Junkyard; Liquid fuel depot; Motel; Motor showroom; Place of Assembly (other than essential community facilities; Place of public worship; Public building (other than essential community facilities); Recreation facility; Refreshment room; Road transport terminal; Rural industry; Service station; Shop; Tourist facilities; Warehouse.	Retail nursery; Recreation area; Roadside stall; Outbuildings (Sheds, Garages) up to 40 m^2 area.	Subdivision of land involving the creation of new allotments for residential purposes; Earthworks or filling operations covering 100 m^2 or more than 0.3 m deep.	An addition to an existing dwelling of not more than 30 m^2 (habitable floor area)

ANNEXURE 2.1
DEVELOPMENT CONTROLS MATRIX - MAIN STREAM AND MINOR TRIBUTARY FLOODING

	Outer Floodplain							
	Essential Community Facilities	Critical Utilities and Uses	Flood Vulnerable Residential	Residential	Business & Commercial/Industrial	Non-Urban and Outbuildings	Residential Sub-Division	Minor Additions (Residential)
Floor Level				1	1		1	1
Building Components								
Structural Soundness								
Flood Affectation								
Evacuation / Access								
Management and Design								

	Intermediate Floodplain							
	Essential Community Facilities	Critical Utilities and Uses	Flood Vulnerable Residential	Residential	Business & Commercial/Industrial	Non-Urban and Outbuildings	Residential Sub-Division	Minor Additions (Residential)
Floor Level				1	1,2		1	1
Building Components				1	1		1	1
Structural Soundness				1	1		1	1
Flood Affectation								
Evacuation / Access								
Management and Design					3		1	5

	Inner Floodplain (Hazard Category 2)							
	Essential Community Facilities	Critical Utilities and Uses	Flood Vulnerable Residential	Residential	Business & Commercial/Industrial	Non-Urban and Outbuildings	Residential Sub-Division	Minor Additions (Residential)
Floor Level				1	1,2		1	1
Building Components				1	1		1	1
Structural Soundness				1	1		1	1
Flood Affectation				1	1	1	1	1
Evacuation / Access				1	1	1	1	1
Management and Design				6	3,6	2,6	1,6	5

	Inner Floodplain (Hazard Category 1B)							
	Essential Community Facilities	Critical Utilities and Uses	Flood Vulnerable Residential	Residential	Business & Commercial/Industrial	Non-Urban and Outbuildings	Residential Sub-Division	Minor Additions (Residential)
Floor Level					1,2			1
Building Components					1			1
Structural Soundness					1			1
Flood Affectation					1	1		1
Evacuation / Access					1			1
Management and Design					3,6	2,6		5

	Inner Floodplain (Hazard Category 1A)							
	Essential Community Facilities	Critical Utilities and Uses	Flood Vulnerable Residential	Residential	Business & Commercial/Industrial	Non-Urban and Outbuildings	Residential Sub-Division	Minor Additions (Residential)
Floor Level								
Building Components								
Structural Soundness								
Flood Affectation						1		
Evacuation / Access								
Management and Design						2,6		

Not Relevant   Unsuitable Land Use

Main Stream Flooding applies for inundation of land bordering Adelong Creek, Black Creek, Tanyard Creek, Golden Gully and the unnamed tributary which joins Adelong Creek east of Gundagai Street, while Minor Tributary Flooding applies to inundation of land along the minor gullies which drain the rural areas bordering Adelong (See Section D1).

The Intermediate Floodplain is defined by the area between the two Inner Floodplain zones and the Flood Planning Area (FPA). The Outer Floodplain is the area between the FPA and the Probable Maximum Flood (PMF).

See Notes over page:

ANNEXURE 2.1 (CONT'D)
DEVELOPMENT CONTROLS MATRIX - MAIN STREAM AND MINOR TRIBUTARY FLOODING

Floor Level

1. Floor levels to be equal to or greater than the 1% AEP flood level plus 500 mm freeboard.

Building Components

1. All structures to have flood compatible building components below the 1% AEP flood level plus 500 mm freeboard.

Structural Soundness

1. Structure to be designed to withstand the forces of floodwater, debris and buoyancy up to the 1% AEP flood level plus 500 mm freeboard.

Flood Affection in Adjacent Areas

1. A Flood Risk Report may be required to demonstrate that the development will not increase flood hazard (see Item 7 Management and Design below).
   Note: When assessing Flood Affectation the following must be considered:
   i. Loss of conveyance capacity in the floodway or areas where there is significant flow velocity.
   ii. Changes in flood levels and flow velocities caused by the alteration of conveyance of floodwaters.

Evacuation/ Access

1. Reliable access for pedestrians or vehicles required in the event of 1% AEP flood.

Management and Design

1. Applicant to demonstrate that potential developments as a consequence of a subdivision proposal can be undertaken in accordance with this Policy and the Plan.
2. No external storage of materials which may cause pollution or be potentially hazardous during PMF.
3. Where it is not practicable to provide floor levels to the 1% AEP flood level plus 500 mm freeboard, applicant is to provide an area to store goods at that level.
4. Applicant is to provide an area to store valuable equipment above the 1% AEP flood level plus 500 mm freeboard (level to be advised by Council) – see **Section D2.8**.
5. Where it is not practicable to provide floor levels to the 1% AEP flood level plus 500 mm freeboard, Council may allow a reduction for minor additions to habitable areas - see **Section D2.11.**
6. Flood Risk Report may be required prior to development of this area – see **Sections D2.16.2** and **D2.16.3.**

NOTE: THESE NOTES ARE TO BE READ IN CONJUNCTION WITH REMAINDER OF THE FLOOD POLICY, IN PARTICULAR CHAPTER D2.

ANNEXURE 2.2
DEVELOPMENT CONTROLS MATRIX – MAJOR OVERLAND FLOW

	Outer Floodplain							
	Essential Community Facilities	Critical Utilities and Uses	Flood Vulnerable Residential	Residential	Business & Commercial/Industrial	Non-Urban and Outbuildings	Residential Sub-Division	Minor Additions (Residential)
Floor Level	2	2	2	2	2		2	2
Building Components	2	2						
Structural Soundness	2	2						
Flood Affectation								
Evacuation / Access	1	1	1					
Management and Design	2,3	2,3	5					

	Intermediate Floodplain							
	Essential Community Facilities	Critical Utilities and Uses	Flood Vulnerable Residential	Residential	Business & Commercial/Industrial	Non-Urban and Outbuildings	Residential Sub-Division	Minor Additions (Residential)
Floor Level	2	2	2	2	2		2	2
Building Components	2	2	1	1	1		1	1
Structural Soundness	2	2	1	1	1		1	1
Flood Affectation								
Evacuation / Access	1	1	1					
Management and Design	2,3	2,3	5		4		1	6

	Low Hazard Floodway / Flood Storage							
	Essential Community Facilities	Critical Utilities and Uses	Flood Vulnerable Residential	Residential	Business & Commercial/Industrial	Non-Urban and Outbuildings	Residential Sub-Division	Minor Additions (Residential)
Floor Level				1	1		1	1
Building Components				1	1		1	1
Structural Soundness				1	1		1	1
Flood Affectation				1	1		1	1
Evacuation / Access								
Management and Design				7	4,7		1,7	6

	High Hazard Floodway							
	Essential Community Facilities	Critical Utilities and Uses	Flood Vulnerable Residential	Residential	Business & Commercial/Industrial	Non-Urban and Outbuildings	Residential Sub-Division	Minor Additions (Residential)
Floor Level								1
Building Components								1
Structural Soundness								1
Flood Affectation						1		1
Evacuation / Access								
Management and Design						3,7		6,7

Not Relevant   Unsuitable Land Use

Major Overland Flow applies for inundation of land along the various flow paths which are present in Adelong.

The Intermediate Floodplain is defined by the area between the High Hazard Floodway and Low Hazard Floodway / Flood Storage zones and the Flood Planning Area (FPA). The Outer Floodplain is the area between the FPA and where depths exceed 150 mm during the Probable Maximum Flood (PMF).

See Notes over page:

ANNEXURE 2.2 (CONT'D)
DEVELOPMENT CONTROLS MATRIX - MAJOR OVERLAND FLOW

Floor Level

1. Floor levels to be equal to or greater than the 1% AEP flood level plus 300 mm freeboard.
2. Floor levels to be equal to or greater than the 1% AEP flood level plus 300 mm freeboard or 300 mm above natural surface levels, whichever is the higher.

Building Components

1. All structures to have flood compatible building components below 1% AEP flood level plus 300 mm freeboard.
2. All structures to have flood compatible building components below PMF flood level (where PMF level is higher than the 1% AEP flood level plus 300 mm freeboard).

Structural Soundness

1. Structure to be designed to withstand the forces of floodwater, debris and buoyancy up to 1% AEP flood level plus 300 mm freeboard.
2. Structure to be designed to withstand forces of floodwater, debris and buoyancy up to PMF flood (where PMF level is higher than the 1% AEP flood level plus 300 mm freeboard).

Flood Affection in Adjacent Areas

1. Residential development may be "deemed to comply" provided it conforms with the requirements of **Section D2.15**. A Flood Risk Report may be required to demonstrate that the development will not increase flood hazard (see Item 7 Management and Design below).

   Note: When assessing Flood Affectation the following must be considered:
   - i. Loss of conveyance capacity in the floodway or areas where there is significant flow velocity.
   - ii. Changes in flood levels and flow velocities caused by the alteration of conveyance of floodwaters.

Evacuation/ Access

1. Reliable access for pedestrians or vehicles required in the event of 1% AEP flood.

Management and Design

1. Applicant to demonstrate that potential developments as a consequence of a subdivision proposal can be undertaken in accordance with this Policy and the Plan.
2. Applicant to demonstrate that facility is able to continue to function in event of PMF.
3. No external storage of materials which may cause pollution or be potentially hazardous during PMF.
4. Where it is not practicable to provide floor levels to 1% AEP flood level plus 300 mm freeboard, applicant is to provide an area to store goods at that level.
5. Applicant is to provide an area to store valuable equipment above 1% AEP flood level plus 300 mm freeboard (level to be advised by Council) – see **Section D2.8**.
6. Where it is not practicable to provide floor levels to 1% AEP flood level plus 300 mm freeboard, Council may allow a reduction for minor additions to habitable areas – see **Section D2.11.**
7. Flood Risk Report may be required prior to development of this nature in this area – see **Sections D2.16.2** and **D2.16.3.**

NOTE: THESE NOTES ARE TO BE READ IN CONJUNCTION WITH REMAINDER OF THE FLOOD POLICY, IN PARTICULAR CHAPTER D2.

ANNEXURE 3A

GENERAL BUILDING MATTERS

Electrical and Mechanical Equipment

For dwellings constructed on land to which this policy applies, the electrical and mechanical materials, equipment and installation should conform to the following requirements.

Main Power Supply

Subject to the approval of the relevant authority the incoming main commercial power service equipment, including all metering equipment, shall be located above the MFL. Means shall be available to easily isolate the dwelling from the main power supply.

Wiring

All wiring, power outlets, switches, etc, should be, to the maximum extent possible, located above the MFL. All electrical wiring installed below this level should be suitable for continuous underwater immersion and should contain no fibrous components. Earth leakage circuit breakers (core balance relays) must be installed. Only submersible type splices should be used below the MFL. All conduits located below the relevant designated flood level should be so installed that they will be self-draining if subjected to flooding.

Equipment

All equipment installed below or partially below the MFL should be capable of disconnection by a single plug and socket assembly.

Reconnection

Should any electrical device and/or part of the wiring be flooded it should be thoroughly cleaned or replaced and checked by an approved electrical contractor before reconnection.

Heating and Air Conditioning Systems

Where viable, heating and air conditioning systems should be installed in areas and spaces of the house above the MFL. When this is not feasible, every precaution should be taken to minimise the damage caused by submersion according to the following guidelines:

i) Fuel

Heating systems using gas or oil as a fuel should have a manually operated valve located in the fuel supply line to enable fuel cut-off.

ii) Installation

The heating equipment and fuel storage tanks should be mounted on and securely anchored to a foundation pad of sufficient mass to overcome buoyancy and prevent movement that could damage the fuel supply line. All storage tanks should be vented to the MFL.

iii) Ducting

All ductwork located below the MFL should be provided with openings for drainage and cleaning. Self-draining may be achieved by constructing the ductwork on a suitable grade. Where ductwork must pass through a watertight wall or floor below the relevant flood level, a closure assembly operated from above the MFL should protect the ductwork.

Sewer

All sewer connections to properties in flood prone areas are to be fitted with reflux valves.

ANNEXURE 3B

FLOOD COMPATIBLE MATERIALS

Building Component	Flood Compatible Material	Building Component	Flood Compatible Material
Flooring and Sub Floor Structure	• Concrete slab-on-ground monolith construction. Note: clay filling is not permitted beneath slab-on-ground construction which could be inundated. • Pier and beam construction or • Suspended reinforced concrete slab	**Doors**	• Solid panel with waterproof adhesives • Flush door with marine ply filled with closed cell foam • Painted material construction • Aluminium or galvanised steel frame
Floor Covering	• Clay tiles • Concrete, precast or in situ • Concrete tiles • Epoxy formed-in-place • Mastic flooring, formed-in-place • Rubber sheets or tiles with chemical set adhesive • Silicone floors formed-in-place • Vinyl sheets or tiles with chemical-set adhesive • Ceramic tiles, fixed with mortar or chemical set adhesive • Asphalt tiles, fixed with water resistant adhesive • Removable rubber-backed carpet	**Wall and Ceiling Linings**	• Brick, face or glazed • Clay tile glazed in waterproof mortar • Concrete • Concrete block • Steel with waterproof applications • Stone natural solid or veneer, waterproof grout • Glass blocks • Glass • Plastic sheeting or wall with waterproof adhesive
Wall Structure	Solid brickwork, blockwork, reinforced, concrete or mass concrete	**Insulation**	• Foam or closed cell types
Windows	Aluminium frame with stainless steel or brass rollers	**Nails, Bolts, Hinges and Fittings**	• Galvanised • Removable pin hinges

ANNEXURE 4
DEVELOPMENT APPLICATION REQUIREMENTS

Step 1

Check with Council staff to see whether or not the proposal:

- Is located on *Flood Prone Land* (Based on initial assessment of the extent of flood affectation and flood levels (refer from **Section D1.4** for details)).
- Is permissible in the Flood Hazard zone and determine the MFL for the particular category of land use.
- Note: an existing site survey (see **Section D2.16.1** of the Policy) is to accompany development proposals to confirm the flood affectation of the allotment and its location within the flood risk zoning system.

Step 2

Plans – A Development Application should include the following plans showing the nature of the proposed development and its extent within the allotment:

- A locality plan identifying the location of the property.
- Plan of the existing site layout including the site dimensions (in metric), site area, contours (0.20 m intervals), existing trees, other natural features, existing structures, north point, location of building on adjoining properties (if development involves a building), floor plans located on a site plan, roof plan, elevations and sections of the proposed building, finished levels of floors, paving and landscaped areas, vehicular access and parking.
- Plans should indicate:
  a) The existing ground levels to Australian Height Datum around the perimeter of the proposed building; and
  b) The existing or proposed floor levels to Australian Height Datum.
- Minor additions to an existing dwelling must be accompanied by documentation from a registered surveyor confirming existing floor levels.
- In the case of subdivision, four (4) copies of the proposed site layout showing the number of lots to be created (numbered as proposed lot 1, 2, 3 etc), the proposed areas of each lot in square metres, a north point, nearest roads and the like.

Council require plans presented on A3 sheets as a minimum

A scale of 1:200 is recommended for site plans

Extent of Cut and Fill – All areas subject to cut and fill require the depths of both to be shown as well as the measures proposed to retain both. Applications shall be accompanied by a survey plan (with existing and finished contours at 0.20 m intervals) showing relative levels to Australian height datum.

Vegetation Clearing – Landscaping details including a description of trees to be removed existing and proposed planting, retaining walls, detention basins, fences and paving.

Stormwater Drainage – Any existing and all proposed stormwater drainage to be indicated on the site plan.