WYONG SHIRE COUNCIL

Cardno
Shaping the Future

Porters Creek Floodplain Risk Management Study

Final Report

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Prepared for Wyong Shire Council

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Foreword

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

Under the Policy, the management of flood prone land is the responsibility of Local Government. The State Government subsidises floodplain management measures to alleviate existing flooding problems and provides specialist technical advice to assist Councils in their floodplain management responsibilities. The Commonwealth Government also assists with the subsidy of floodplain management measures.

The Policy identifies the following floodplain management 'process' for the identification and management of flood risks:

1. Formation of a Committee	Established by a Local Government Body (Local Council) and includes community group representatives and State agency specialists.
2. Data Collection	The collection of data such as historical flood levels, rainfall records, land use, soil types etc.
3. Flood Study	Determines the nature and extent of the floodplain.
4. Floodplain Risk Management Study	**Examines range of flood hazards and evaluates management options for the floodplain in respect of both existing and future development.**
5. Floodplain Risk Management Plan	Involves formal adoption by Council of a management plan for the floodplain.
6. Implementation of the Plan	Involves implementation of those measures recommended in the Plan, adopted by Council, which may include flood, property and emergency response modification measure.

This Floodplain Risk Management Study and Plan (FRMS&P) has been prepared for Wyong Shire Council and the Department of Environment, Climate Change and Water (DECCW) by Cardno.

The Floodplain Management Committee, which consists of representatives from Wyong Shire Council, DECCW, the SES and the community, has provided over sight and review of the project throughout its duration.

Executive Summary

Wyong Shire Council commissioned Cardno to prepare a Floodplain Risk Management Study and Plan for Porters Creek Catchment in November 2009. As part of this engagement it was requested that the 2009 Flood Study be updated to reflect current catchment conditions. This study, in the form of a Flood Study Addendum, was completed in July 2010. Results from the Addendum have been adopted for the purposes of undertaking the Floodplain Risk Management Study.

The flood behaviour for the existing catchment has been reviewed based on the findings of the Flood Study by Cardno in 2009 and 2010 (**Section 2.2** and **Section 6**). Flood hazard and hydraulic category maps have been prepared for the 20 year and 100 year ARIs as well as the PMF. An assessment of risk to motorists was also undertaken for the major road crossings in the catchment.

A preliminary desktop social and environmental review has been undertaken to identify potential constraints and social implications to and proposed flood management options (**Section 5**).

An economic damage assessment was undertaken for properties experiencing flooding in the catchment (**Section 7**). A summary of the findings from the assessment is included in the table below.

Flood	Properties with Over-floor flooding	Flood Damage
5 Year ARI	17	$2,363,385
10 Year ARI	17	$2,467,744
20 Year ARI	18	$2,654,260
50 Year ARI	19	$2,963,465
100 Year ARI	26	$3,763,148
200 Year ARI	29	$4,000,155
PMF	129	$25,181,731
Average Annual Damage		$934,376

A review of flood planning policy along with building and development controls is provided in **Section 9**. Recommendations for future review and modifications are also provided. Existing flood planning levels are also under review in order to select appropriate flood levels in the catchment that incorporate an allowance for the predicted impact of climate change. The flood planning level is recommended to be the 100 year ARI plus 15% rainfall intensity increase and 500mm freeboard. This takes into account the projected impacts of climate changed according to the latest available guidelines for the NSW central coast. The flood planning level is applied to building and development in the catchment through a flood planning matrix to be included in Council's Floodprone Land Development Control Plan (DCP no.113). Flood planning levels (**Figure 10.4**) and the flood planning matrix are currently being prepared and a draft version is included in **Appendix D**.

Using the merits-based approach advocated in the NSW State Government's Floodplain Development Manual (2005) and in consultation with the community, Council and state agency stakeholders, a number of potential options for the management of flooding were identified.

These options included:

- Flood modification measures;
- Property modification measures; and
- Emergency response measures.

An extensive list of options was assessed (**Section 11**) against a range of criteria (technical, economic, environmental and social). Hydraulic modelling of some of the flood modification options was undertaken to provide a comprehensive analysis of those options that would involve significant capital expenditure or likely strong positive benefits to the community. The assessment found that the highest scored flood modification options included:

- Option 2.1 – Lucca Road Levee Extension
- Option 1.5 – Raise Hue Hue Road Level at Buttonderry Creek Crossing
- Option 1.8 – Warnervale Road Culvert at Ebony Drive
- Option 1.9 – Bingarrah Creek crossing at Minnesota Road
- Option 1.10 – Natural Channel Maintenance

Property modification measures considered and recommended for the floodplain include:

- P1 – Planning controls
- P2 – Building and Development Controls
- P3 – House raising up to the 5 year ARI
- P7 – Flood Proofing Guidelines

Emergency response modification measures proposed for the floodplain include:

- Option EM1 – Information transfer to the SES
- Option EM2 – Revise the Wyong Local Flood Plan/DISPLAN
- Option EM3 – Flood Warning System for Wyong Community Christian School
- Option EM4 – Community Flood Awareness
- Option EM5 – Flood Warning Signs at Road Crossings

Data collection strategies proposed for the floodplain include:

- DC1 – Post Flood Data Collection Form

The above listed flood, emergency and property modification measures ranked highly using a multi-criteria matrix assessment (**Section 13**) and have been recommended for inclusion in the Floodplain Risk Management Plan. Those options selected for inclusion in the Plan are based upon both their likely benefit and the funding available from Council, SES and the State Government. Based on the options recommended above, the cost of implementing the Plan would be an estimated capital cost of approximately $11M and an annual recurrent cost of approximately $620,000.

Table of Contents

List of Tables

List of Figures

Appendices

Glossary

Annual Exceedence Probability (AEP)	Refers to the probability or risk of a flood of a given size occurring or being exceeded in any given year. A 90% AEP flood has a high probability of occurring or being exceeded each year; it would occur quite often and would be relatively small. A 1%AEP flood has a low probability of occurrence or being exceeded each year; it would be fairly rare but it would be relatively large.
Australian Height Datum (AHD)	A common national surface level datum approximately corresponding to mean sea level.
Cadastre, cadastral base	Information in map or digital form showing the extent land parcels, streets, water courses etc.
Catchment	The area draining to a site. It always relates to a particular location and may include the catchments of tributary streams as well as the main stream.
Creek Rehabilitation	Rehabilitating the natural 'biophysical' (i.e. geomorphic and ecological) functions of the creek.
Design flood	A significant event to be considered in the design process; various works within the floodplain may have different design events. E.g. some roads may be designed to be overtopped in the 1 in 1 year or 100%AEP flood event.
Development	The erection of a building or the carrying out of work; or the use of land or of a building or work; or the subdivision of land.
Discharge	The rate of flow of water measured in terms of volume over time. It is to be distinguished from the speed or velocity of flow, which is a measure of how fast the water is moving rather than how much is moving.
Flash flooding	Flooding which is sudden and often unexpected because it is caused by sudden local heavy rainfall or rainfall in another area. Often defined as flooding which occurs within 6 hours of the rain which causes it.
Flood	Relatively high stream flow which overtops the natural or artificial banks in any part of a stream, river, estuary, lake or dam, and/or overland runoff before entering a watercourse and/or coastal inundation resulting from super elevated sea levels and/or waves overtopping coastline defences.

Flood fringe	The remaining area of flood-prone land after floodway and flood storage areas have been defined.
Flood hazard	Potential risk to life and limb caused by flooding.
Flood-prone land	Land susceptible to inundation by the probable maximum flood (PMF) event, i.e. the maximum extent of flood liable land. Floodplain Risk Management Plans encompass all flood-prone land, rather than being restricted to land subject to designated flood events.
Floodplain	Area of land which is subject to inundation by floods up to the probable maximum flood event, i.e. flood prone land.
Floodplain management measures	The full range of techniques available to floodplain managers.
Floodplain management options	The measures which might be feasible for the management of flooding of a particular area.
Flood planning area	The area of land below the flood planning level and thus subject to flood related development controls.
Flood planning levels	Flood levels selected for planning purposes, as determined in floodplain management studies and incorporated in floodplain management plans. Selection should be based on an understanding of the full range of flood behaviour and the associated flood risk. It should also take into account the social, economic and ecological consequences associated with floods of different severities. Different FPLs may be appropriate for different categories of land use and for different flood plains. The concept of FPLs supersedes the "Standard flood event" of the first edition of the Manual. As FPLs do not necessarily extend to the limits of flood prone land (as defined by the probable maximum flood), floodplain management plans may apply to flood prone land beyond the defined FPLs.
Flood storages	Those parts of the floodplain that is important for the temporary storage of floodwaters during the passage of a flood.
Floodway areas	Those areas of the floodplain where a significant discharge of water occurs during floods. They are often, but not always, aligned with naturally defined channels. Floodways are areas which, even if only partially blocked, would cause a significant redistribution of flood flow, or significant increase in flood levels. Floodways

	are often, but not necessarily, areas of deeper flow or areas where higher velocities occur. As for flood storage areas, the extent and behaviour of floodways may change with flood severity. Areas that are benign for small floods may cater for much greater and more hazardous flows during larger floods. Hence, it is necessary to investigate a range of flood sizes before adopting a design flood event to define floodway areas.
Geographical Information Systems (GIS)	A system of software and procedures designed to support the management, manipulation, analysis and display of spatially referenced data.
High hazard	Flood conditions that pose a possible danger to personal safety; evacuation by trucks would be difficult; able-bodied adults would have difficulty wading to safety; potential for significant structural damage to buildings.
Hydraulics	The term given to the study of water flow in a river, channel or pipe, in particular, the evaluation of flow parameters such as stage and velocity.
Hydrograph	A graph that shows how the discharge changes with time at any particular location.
Hydrology	The term given to the study of the rainfall and runoff process as it relates to the derivation of hydrographs for given floods.
Low hazard	Flood conditions such that should it be necessary, people and their possessions could be evacuated by trucks; able-bodied adults would have little difficulty wading to safety.
Mainstream flooding	Inundation of normally dry land occurring when water overflows the natural or artificial banks of the principal watercourses in a catchment. Mainstream flooding generally excludes watercourses constructed with pipes or artificial channels considered as stormwater channels.
Management plan	A document including, as appropriate, both written and diagrammatic information describing how a particular area of land is to be used and managed to achieve defined objectives. It may also include description and discussion of various issues, special features and values of the area, the specific management measures which are to apply and the means and timing by which the plan will be implemented.

Mathematical/computer models	The mathematical representation of the physical processes involved in runoff and stream flow. These models are often run on computers due to the complexity of the mathematical relationships. In this report, the models referred to are mainly involved with rainfall, runoff, pipe and overland stream flow.
NPER	National Professional Engineers Register. Maintained by Engineers Australia.
Overland Flow	The term overland flow is used interchangeably in this report with “flooding”.
Peak discharge	The maximum discharge occurring during a flood event.
Probable maximum flood	The flood calculated to be the maximum that is likely to occur.
Probability	A statistical measure of the expected frequency or occurrence of flooding. For a fuller explanation see Annual Exceedence Probability.
Risk	Chance of something happening that will have an impact. It is measured in terms of consequences and likelihood. For this study, it is the likelihood of consequences arising from the interaction of floods, communities and the environment.
Runoff	The amount of rainfall that actually ends up as stream or pipe flow, also known as rainfall excess.
Stage	Equivalent to 'water level'. Both are measured with reference to a specified datum.
Stage hydrograph	A graph that shows how the water level changes with time. It must be referenced to a particular location and datum.
Stormwater flooding	Inundation by local runoff. Stormwater flooding can be caused by local runoff exceeding the capacity of an urban stormwater drainage system or by the backwater effects of mainstream flooding causing the urban stormwater drainage system to overflow.
Topography	A surface which defines the ground level of a chosen area.

* Terminology in this Glossary have been derived or adapted from the NSW Government *Floodplain Development Manual*, 2005, where available.

Abbreviations

AAD.	Average Annual Damages
AEP	Annual Exceedence Probability
AHD	Australian Height Datum
AHIMS	Aboriginal Heritage Information Management System (managed by DECCW).
ARI	Average Recurrence Interval
ASS	Acid Sulfate Soils
BoM	Bureau of Meteorology
DCP	Development Control Plan
DECCW	Department of Environment, Climate Change & Water
DHI	Danish Hydraulics Institute
DNR	Department of Natural Resources
EPI	Environmental Planning Instrument
ESD	Ecologically Sustainable Development
FPL	Flood Planning Level
FRMC	Floodplain Risk Management Committee
FRMP	Floodplain Risk Management Plan
FRMS	Floodplain Risk Management Study
GIS	Geographic Information System
GSDM	Generalised Short Duration Method
HAT	Highest Astronomical Tide
IEAust	Institution of Engineers, Australia (now referred to as Engineers Australia)
IFD	Intensity Frequency Duration
IWCM	Integrated Water Cycle Management

LEP	Local Environment Plan
LGA	Local Government Area
MCA	Multi Criteria Assessment
MHL	Manly Hydraulics Lab
MSL	Mean Sea Level
NPWS	National Parks and Wildlife Service (within DECCW)
NSW	New South Wales
PMF	Probable Maximum Flood
PMP	Probable Maximum Precipitation
REP	Regional Environmental Plan
RTA	Roads and Traffic Authority
SEPP	State Environmental Planning Policy
SES	State Emergency Service

1 Introduction

Cardno was commissioned by Wyong Shire Council to undertake a floodplain risk management study of the Porters Creek catchment in December 2009. As part of this project, Cardno undertook a review and update the Flood Study that was completed in July 2009. An addendum report, which details the updates, was completed in July 2010 and should be read in conjunction with the original Flood Study report (Cardno, 2009). This report includes the Floodplain Risk Management Study and draws on the findings of the Flood Study and associated Addendum in order to propose appropriate measures to mitigate and manage the flood risk in the Porters Creek catchment.

A detailed description of the study area can be found in **Section 2.1**.

1.1 Study Context

This study consists of stages 4 and 5 of the multiple stages of the Floodplain Management process which includes:

1. Formation of a Floodplain Management Committee
2. Data Collection
3. Flood Study
4. Floodplain Risk Management Study
5. Floodplain Risk Management Plan
6. Implementation of Floodplain Risk Management Plan

Stage 4 is detailed in this report, while Stage 3 is detailed in the Flood Study Addendum Report (Cardno, 2010). Stage 5 will follow Council review of this report. Stage 5 will also be put on exhibition to the public for comment prior to release of the final version.

The study was jointly funded by Council and the Department of Environment, Climate Change & Water (DECCW). DECCW also assists in the provision of specialist advice on flooding and related matters and has been directly involved in completion of this study.

The Floodplain Management Committee, which consists of representatives from Council, SES and DECCW has provided oversight and review of the project throughout its duration.

1.2 Study Objectives

The overall objective of this study is to develop a Flood Plain Risk Management Study where management issues are assessed, management options are investigated and recommendations are made. Thereafter a Flood Plain Risk Management Plan detailing how flood prone land within the study area is to be managed can be completed.

The objectives of the *Flood Risk Management Study* are to:

- Review Councils existing environmental planning policies and instruments including Councils long-term planning strategies for the study area;
- Identify works, measures and restrictions aimed at reducing the social, environmental and economic impacts of flooding and the losses caused by flooding on development and the community, both existing and future, over the full range of potential flood events;

- Assess the effectiveness of these works and measures for reducing the effects of flooding on the community and development, both existing and future;
- Consider whether the proposed works and measures might produce adverse effects (environmental, social, economic or worsened flooding) in the floodplain and whether they can be minimised;
- Examine the present flood warning system, community flood awareness and emergency response measures in the context of the NSW State Emergency Service's development and disaster planning requirements;
- Examine ways in which the creek and floodplain environment may be enhanced by exploring the possibility of a strategy for vegetation planning that may create a valuable corridor of vegetation without having a detrimental effect on flooding, and;
- Identify modifications that are required to current policies in light of the investigations.

The objectives of the *Flood Risk Management Plan* are to identify actions for implementation to:

- Reduce the flood hazard and risk to people and property in the existing community and to ensure future development is controlled in a manner consistent with the acceptable level of flood hazard and risk;
- Reduce private and public losses due to flooding and where possible enhance the creek and floodplain environment;
- Be consistent with the objectives of relevant state policies;
- Ensure that the floodplain management plan is fully integrated with Council's existing corporate, business and strategic plans, meets Councils obligations under relevant Acts and has the support of the local community;
- Ensure actions arising out of the management plan are sustainable in social, environmental, ecological and economic terms;
- Ensure that the floodplain management plan is fully integrated with the flood response procedure and is flexible to accommodate provisions from other relevant catchment management plans;
- Establish a program for implementation and a mechanism for the funding of the plan and should include priorities, staging, funding, responsibilities, constraints and monitoring.

1.3 Study Methodology

The report format follows the study methodology, which involved:

- Community consultation (Section 4)
- Preliminary review of Environmental and social characteristics of the catchment (Section 5)
- Discussion of the existing flood behaviour including the June 2007 and October 2004 storm events (Section 6)
- Assessment of economic impact of flooding (Section 7)
- Review of current emergency response arrangements (Section 8)
- Review of Policies and Planning (Section 9)
- Review of flood planning levels (Section 10)
- Assessment of floodplain risk management options (Section 11)
- Economic assessment of options (Section 12)
- Multi-criteria assessment of options (Section 13)

2 Background

2.1 The Study Area

The catchment area is approximately 5,500 hectares (55 km^2) and comprises a range of land uses including natural conservation areas, wetlands, residential, commercial and rural.

The eastern region of the study area covers a large proportion of the Warnervale region, which is drained towards the west via Woongarrah Creek. The Warnervale region currently represents the most developed portion of the catchment, comprising primarily residential subdivisions. Suburbs within this region are Hamlyn Terrace, Kanwal, Lake Haven, Wadalba and North Wyong.

The northern and western reaches of the catchment are currently less developed, with large regions of rural areas and land zoned as 'conservation'. The northern reaches are drained via two parallel creeks – Buttonderry Creek, and an unnamed tributary, referred to in this study as "Hue Hue Creek".

These three creeks (Woongarrah, Buttonderry and Hue Hue) find a confluence in the centre of the catchment at the Porters Creek Wetland to the west of the railway. Porters Creek is found to the south of the Porters Creek Wetland, and consists of an excavated channel that drains the wetland to the south until it finds a confluence with the Wyong River.

A locality plan can be found in **Figure 2.1.**

2.2 Previous Flood Studies

A number of previous flood studies that are relevant to the Porters Creek catchment were reviewed for this study. These studies are listed in **Section 2.2**. These previous flood studies can be broadly categorised as follows:

2.2.1 Flood studies of adjacent catchments

A comprehensive flood study of the Upper Wyong River was undertaken in 1988 by the Public Works Department. The lower limit of the study area was the Main Northern Railway Line and the upper limit was Woodburys Bridge on Yarramalong Road.

The Wyong River has a catchment area of 447 square kilometres to Tuggerah Lake. The lake is approximately 6 kilometres downstream of the railway line and was found to have an impact on flood levels within the study area. It was therefore necessary to carry out indicative modelling of the area downstream of the railway line to ensure that flood levels within the study area were properly represented.

The flood study was carried out using two mathematical models. A hydrologic model was used to convert rainfall to runoff and a quasi-two-dimensional hydraulic (CELL) model was used to convert runoff to flood levels. The models were calibrated and verified against historical floods. Sensitivity runs were also carried out to test the possible variations in design levels that could occur due to uncertainties in model calibration caused by data deficiencies.

Historical flood levels and observations within and adjoining the study area were generally sparse except for the major flood in June 1964. However, temporal rainfall data was not available for this event and flows had to be derived using a synthetic temporal pattern. Because of the good flood level record, this flood was chosen for calibrating the hydraulic model.

Design rainfall intensities and temporal patterns were taken from the 1987 version of AR&R. These were applied to the calibrated hydrologic model and the generated flows were then run through the hydraulic model. Design flood profiles, including the extreme flood, were plotted as were plans showing. Design flood levels, velocities and flows for the study area and flood contours for the 1%, 2% and 5% AEP floods were estimated.

Sensitivity runs were carried out to determine the impact on flood levels to variations in the model parameters. These showed that the assumptions that were necessary for model calibration would be unlikely to affect design values by more than ±0.2m.

The findings of this study were used to provide tail water levels for the Willing and Partners (1990) study of the Porters Creek catchment, discussed below.

2.2.2 Previous Flood study of the Porters Creek catchment

A flood study of the entire Porters Creek catchment was undertaken by Willing and Partners in 1990. For this flood study, modelling comprised a RAFTS hydrologic model of the entire catchment, with hydraulic routing achieved by application of the steady state HEC-2 model (for channel reaches) and a quasi-2D WILCELL model (for the Porters Creek Wetland region). This modelling was used to run 1%, 2% and 5% AEP flood in Porters Creek Wetland, and 1% AEP floods in the Warnervale region.

The investigation showed that the maximum flood levels in the Warnervale region were produced by a 2 hour storm event, and were independent of Wyong River tailwater levels. Design discharges and flood levels were calculated for the 1% AEP event, for both existing and fully urbanised conditions. The effects of urbanisation were represented in the RAFTS model by increasing the impervious areas and decreasing the loss rates and lag times in each sub-catchment as appropriate.

The analyses showed that flooding in Porters Creek Wetland is affected by both local runoff and by backwater from the Wyong River. At times of flood the local runoff is prevented from discharging by the high tail water level of Wyong River.

2.2.3 Porters Creek Flood Study - 2009

Since the 1990 study was completed there have been a number of developments that lead to the requirement for a revised flood study for this catchment. Urban development that has occurred has the potential to impact flood behaviour. There are also significant parcels of land to be released for urban development in this catchment. The ability of two-dimensional mathematical models has been remarkably improved since 1990 allowing for greater abilities in flood modelling through better definition of features such as the wetland. These factors have lead to the decision of Council to revise the flood study of this catchment.

For this flood study, modelling comprised a RAFTS hydrologic model of the entire catchment, with a hydraulic TUFLOW model including input hydrographs from the RAFTS model. The assumptions made in the RAFTS model were made to reflect the previous flood study and the

changes made in the catchment. Catchment topography was included in the TUFLOW model by creation of a terrain model using aerial laser survey data. Council supplied ALS data for the majority of the catchment and additional data was ordered from Fugro, who conducted further aerial surveying to complete the ALS data set for the catchment in 2006. Detail in the hydraulic model was delineated by the Northern Railway where a 15m grid cell was applied to the catchment as a whole that was refined for urbanised areas having a 4m grid. This allowed more efficient computation, with more detail in the urbanised area of the catchment where greater definition is required to define the flood behaviour.

The flood modelling results from this study was calibrated to achieve similar levels to previous studies in the catchment and to the observed flood levels. Two historical rainfall events in the catchment were investigated (October 2004 and June 2007) using rainfall data collected at local pluviographs. The estimated peak flood levels were compared to surveyed flood marks that were provided by Council for each event. The models were adjusted until a good agreement was achieved between observed and modelled flood levels.

It was confirmed in this study that the flood behaviour in the catchment is influenced by inundation of the Porters Creek wetland arriving from Wyong River. As such there are only minor variations in flood extent across a range of design storm events. This is in part due to the nature of the floodplain which has extensive areas of very flat land bounded by steeper slopes. In the upper tributary creeks, generally to the east and north-west of the study area, flood depths and velocities vary with ARI and are significantly influenced by local features such as road and railway crossings. The topography influences the critical event duration where 2 hour design storm duration generally produces peak flows for the upper tributary creek and a 9 hour duration producing the peak for Porters Creek Wetland.

2.2.4 Flood Study Addendum 2010

Cardno completed an addendum to the 2009 Flood Study as part of the Flood Plain Risk Management Study. The Addendum provides an update to the modelling of the flood study. This was achieved by reviewing the hydrology, roughness, terrain and hydraulic structures according to current conditions. The information used for the flood study to build the hydraulic model was derived from existing models and available data at the time that was found to be outdated in some cases. The existing condition model was reviewed and revised to ensure the most up to date information and data were used to refine the model. In addition various catchment changes were included into the model including:

1. Industrial sub-division fill, north of Lucca Road North Wyong
2. Warner Industrial Park, Hue Hue Road Warnervale
3. Mataram Road culvert upgrade, Woongarrah Creek
4. Natural revegetation of floodplain in cleared areas where it is expected that revegetation with thick low lying vegetation will occur in near future.

Further changes that were made to the hydraulic model were:

- The grid size was revised to model areas outside of the floodway in greater detail than the 15m grid size. As such the area to the east of the railway was allocated a 5m grid and the area to the west of the railway a 15m grid.
- It was found that the ALS did not accurately define topography for densely vegetated parts of the floodplain through comparison to recent ground survey supplied by Council.

A majority of the floodways in the catchment are dominated by the dense low lying vegetation that was giving an inaccurate estimation of the flood level in the model. Therefore the level of the ALS in densely vegetated areas was lowered by 0.3m.

Results were generated for the full range of design storm events together with a climate change assessment that included a 30% increase in rainfall intensity on the 100 year ARI. The 2009 flood study and results from the 2010 flood study addendum formed the basis for the Flood Risk Management Study and Plan documented in this report.

2.3 Flood History

Two significant flood events have occurred in recent history in the Porters Creek catchment that were addressed in the 2009 flood study. These are:

- 1st October 2004 (~100 year ARI), and;
- 7th to 12th June 2007 (~20 year ARI).

Reasonable records of flood levels were recorded for these two events and they have been used for calibration / verification of the flood models in the 2009 flood study. **Table 2.1** includes a comparison of observed flood levels at various location throughout the catchment and compares them with levels from design storm events to give an indication of what event may best describe the historic floods. It is not common that a historic flood will globally correlate to a specific design storm, however it is possible to make an approximation based on the design storm results and observed levels of the historic floods. The approximation of a design storm for the historic events of 2004 and 2007 are indicated above.

Earlier flood studies listed above make reference to historical flood events within the Porters Creek catchment. However, very limited observed flood levels were recorded and all models of Porters Creek catchment that were previously undertaken were not calibrated against observed flood levels. Events that are cited, but for which no flood data was found include the following:

- April 1974
- 5 December 1986
- 2 April 1989
- 31 August 1996

The 1988 PWD study of the Wyong River catchment lists a range of flood events relevant to the Wyong River catchment. Of key interest are recorded flood levels in the Wyong River at the confluence to Porters Creek, which are high enough to suggest flow reversal may occur in Porters Creek under these conditions (i.e. causing flood waters to flow north from Wyong River into Porters Creek Wetland). Council have reported anecdotal evidence of this flow reversal occurring in the past, and this behaviour was verified in the Willing and Partners 1990 modelling.

Table 2-1: Observed Flood Levels and Design Flood Levels from 2010 Flood Study Addendum in m AHD

Location	Oct 2004 'observed data'	June 2007 'observed data'	100 year ARI 'design storm'	20 year ARI 'design storm'
Northern Railway Culverts	3.65	4.2	6.32	5.68
Centre of Minnesota Road	7.18	6.9	6.80	6.70
Centre of Warnervale Road	10.16	8.82	9.53	9.48

3 Available Data

3.1 Previous Studies and Reports

A number of flood studies have been conducted for the locality. These studies have been reviewed as part of this study and relevant information incorporated into this report. Similarly, a range of data available for this investigation was reviewed and processed for use in this study.

Relevant flood studies and available data for the study are discussed in **Section 2.2** and summarised in **Table 3.1**

Table 3-1: Summary of Previous Studies and Reports

Study	Description
Upper Wyong River Flood Study	Upper Wyong River flood study was undertaken in 1988 by the Public Works Department. Key information from this study is flood levels at the confluence with Porters Creek.
Porters Creek Flood Study 1990	A flood study of the Porters Creek catchment was undertaken by Willing and Partners in 1990. Modelling comprised a RAFTS hydrologic model and steady state HEC-2 model (for channel reaches) and a quasi-2D WILCELL model (for the Porters Creek Wetland region).
Porters Creek Flood Study 2009	Flood study of the Porters Creek catchment with two-dimensional mathematical model (TUFLOW) using results from the previous flood studies and historic flood events of October 2004 and June 2007.
Porters Creek Flood Study Addendum 2010	The addendum revised the flood study 2009 model to include greater detail in roughness zones and inclusion of major urban developments within the catchment.

3.2 GIS Data

The following Geographic Information System (GIS) data was provided by Council:

- Airborne Laser Survey 2007
- 2m contours
- Cadastre
- Aerial photography 2007 and 2010.
- Land use zones
- Environmental and social characteristics (Acid Sulphate Soil, Aquatic vegetation, crown land, Heritage Items, Soil landscape).

3.3 Site Inspections

A site inspection was conducted in November 2009 to gain an appreciation of the topography, natural environment, built environment, proposed catchment changes and factors that influence flood behaviour.

3.4 Historic Flood Information

Historic events of October 2004 and June 2007 are recognised as causing significant flooding in the catchment. The following information was available for these events:

- Pluviograph data, recorded during the October 2004 and June 2007 storm events
- Records of flood levels from the October 2004 event and June 2007 event were provided by Council during the Flood Study.

Information from these events was used to calibrate the hydraulic model and details are included in the 2009 Flood Study.

3.5 Floor Level Survey

Cardno surveyors conducted a floor level survey in September 2010 to gather information regarding properties affected by the extent of design floods up to and including the 100 year ARI event, as per Council's instruction. The identification of the properties to be surveyed was determined by 100 year ARI flood extent over aerial photographs. Buildings that were located within or intersected by the 100 year ARI flood extent were listed for detail floor survey. Where the 100 year ARI extent affected areas of the property external to buildings they were not considered for the floor level survey.

In addition Council performed an assessment of these flood affected properties by interrogation of their development database to identify properties with a known floor level. These records are available for properties built within the last 20 years. Properties were only included in the final list to be surveyed if their floor level was unknown and was affected by the flood extent. As a result, the number of properties to be surveyed was reduced to 23 properties. Information was received from Council for properties with known floor levels.

The survey was performed by recording level at the lowest habitable floor level on the property as well as recording various details of the property that would be relevant to the damage that could be incurred in the event of flood inundation. Details such as the type of house construction, number of storeys, general size and condition were recorded.

Flood level information obtained from Council's database, in some cases, were lower than the ground terrain extracted from the ALS data. In these cases it is clear that the ALS is inaccurate which was also confirmed by ground survey undertaken in the Flood Study Addendum 2010. As the modelling was completed using the ALS to represent ground levels it was not realistic to use the floor levels provided by Council in cases where the level was below the ALS. It was agreed with Council that where the listed floor levels were below the ALS they should be artificially raised to a level of 0.3m above the ALS. This is considered as n average height of concrete slab on ground type floor. This would provide the best possible results when assessing overfloor flooding for the listed properties. It is however noted that this approach has obvious limitations.

4 Consultation

4.1 Community Questionnaires

A resident questionnaire was delivered to approximately 5000 residents of the entire Porters Creek catchment in January 2010. The questionnaire was well received and approximately 700 responses were received, collected and tabulated. Residents generally provided detailed responses with 250 providing dates, comments and details of their experiences and the preferred floodplain risk management options.

Appendix A contains a copy of the brochure and questionnaire.

4.1.1 Respondent Details

Details of duration of residence in the catchment for the respondents are:

- 25% for 1-5 years;
- 35% for 5-10 years;
- 14% for 10-15 years;
- 7% for 15-20 years;
- 6% for 20-50 years, and;
- The remaining 14% of respondents have only lived in the area for a short period of less than 1 year.

Approximately 60% of respondents resided in the area for greater than 5 years, and would therefore have experiences at least the 2007 event and possibly the October 2004 event.

4.1.2 Flood Awareness & Information

The respondents had limited knowledge of flooding through information sources, however of those who are informed they did so via the following approaches:

- Discussion with locals (51 responses);
- Research of flood information on Council's webpage (39 responses); and
- Viewing the section 149 certificate (44 responses).

Approximately 50% of all respondents did not seek any information of flooding and believe there is no reason to do so.

40% of the respondents have experienced some form of flooding, including:

- 14% incurred building inundation;
- 43% experienced yard flooding; and
- 51% experienced road inundation.

The majority of events causing the flooding were recorded in October 2004, June 2007 or June 2008. It is interesting to note that 70% of the respondents do not expect their property to be affected by flooding in the future.

Preferred methods of flood information delivery are via mail out and on Council's webpage. Methods such as meetings were not preferred and information days/floodplain management committee has support of approximately 15% of residents.

4.1.3 Flood Management Options

Residents were questioned on their preferred methods of flood management measures. Natural channel maintenance and planning controls were ranked as the highest scoring flood mitigation options. Other options that were reasonably popular were culvert/bridge upgrades and retention of natural flowpaths (rather than converting to piped drainage systems). Less popular options are levees, flood education, and retarding/detention basins.

Each option has been given a rank based on the number of favourable responses from residents **(Table 4.1)**.

Table 4-1: Responses from Residents

Proposed Option	No. of Responses		Rank
	Most Preferred	Least Preferred	
Natural channel maintenance	415	63	1
Planning controls	390	56	2
Culvert/pipe/bridge enlargement	405	67	3
Natural Flowpath Retention	426	98	4
Flood forecasting and emergency response	329	87	5
Detention basins	324	88	6
Education	276	95	7
Levee Banks	215	149	8

Residents were invited to provide any further information on flooding in the catchment. The following provides an overview of some of the responses:

- There is a lack of maintenance for floodways, culverts and drains in the catchment.
- Wetlands should be preserved; there is a sentimental connection to the Porters Creek wetland that residents would like to continue enjoying.
- Confusion over Council's position over the whole area due to recent proposals for road works and water management have not been implemented (Warnervale Road, Minnesota Road, Porters Creek IWCM scheme, Section 94 plan).
- Old local road such as Warnervale Road, Sparks Road and Minnesota Road are now frequently used for through traffic due to increased development in the area. The service of these roads is limited due to regular flooding. Most residents would like road bridges to be constructed.
- Plans for public safety (warnings, traffic detours, evacuation to flood free zones) must be implemented in times of flood and communicated to residents. Of particular concern are schools and aged care facilities in the floodplain. Suggested method via local radio e.g. 2GO, Star FM.

4.2 Community Information Sessions

4.2.1 Watanobbi Warnervale Community Precinct Committee

Presentation was made to Watanobbi Warnervale Community Precinct Committee on 02 February 2010 to inform community about the flood risk management study, the processes

involved in preparing the risk management study and how community can help in preparing the study.

The Draft Risk Management Study was then presented to the same Committee on 01 February 2011. The intention of this presentation was to inform the committee that the Study would shortly be going to Council for approval for public exhibition. The presentation discussed the outcomes of the study and how the community can provide feedback to Council.

4.2.2 Tuggerah Lakes Estuary, Coastal and Floodplain Management Committee

The Draft Risk management Study was presented to the committee Tuggerah Lakes Estuary, Coastal and Floodplain Management Committee on 03 March 2011. The presentation informed the committee members of the outcomes of the study, the period it would be on public exhibition and where the broader community could find copies of the study for review. Committee members were requested to provide feedback on the study before the 13 May deadline.

4.3 Public Exhibition

The Council approved the public exhibition of the DRAFT Porters Creek Floodplain Risk management Study at the Council Meeting of 13 March 2011. Accordingly, copies of the draft study were made available to public on the 15 March 2011 via Council's website, Civic centre and libraries for a period of 8 weeks. Approximately 100 electronic copies were also sent on CD to residents who requested it. Residents were asked to review and provide written comments to Council. Approximately 4600 letters were sent to residents within the Porters Creek catchment to inform the public exhibition of the study. The Exhibition period closed on 13 May 2011.

4.4 Community Forum & Fact Sheet

A fact sheet was sent to the respondents of the community questionnaire, discussed in **Section 4.1**, prior to the meeting date for a Community Forum. The fact sheet formally invited them to the meeting and included some general information regarding the findings of the Floodplain Risk Management Study. Residents were also given the opportunity to rank the risk management options and return their response if they were unable to attend the meeting.

The Community Forum for the Porters Creek Floodplain Risk Management Study was held at Council's Civic Centre at 7pm on Wednesday 4 May 2011. The purpose of the session was to present the study to the community in a manner that was easy for the general public to understand. Residents were given the opportunity to ask questions in regards to the study and rank the flood risk management options according to their preference that they would like to see the options in the risk management plan.

A summary of the questions and answers discussed in the forum are listed below:

- Advice was sought regarding the possibility that the proposed Porters Creek IWCM scheme would alleviate flooding. It is evident that the stormwater re-use proposed in the IWCM scheme will not reduce the impact of flooding as it is intended to manage flows of a far lesser magnitude than those to be expected during a flood.
- The community questioned the likelihood that the upgrade of Warnervale and Minnesota roads would be constructed in the near future.
- The community do not support the inclusion of options to protect commercial and industrial properties from flooding. They would prefer for the funding to be spent protecting residents properties.

- On-site detention is considered an important development control for future development in the catchment.
- Concern was raised over the lack of maintenance in natural channels as there is often thick vegetation dominating flowpaths. Swales and natural channels in new sub-divisions were noted as particular concerns for the community.

The community ranked the risk management options according to the summary given in **Table 4-2**.

Table 4-2: Community ranking of risk management options

Option ID	Proposed Option	Rank
1.4	Natural channel maintenance	1
1.9	Minnesota Road Culvert	2
1.8	Warnervale Road Culvert	3
P1 & P2	Planning controls	4
1.7	Warnervale Road Raising	5
2.1	Lucca Road Levee Extension	6
1.6	Road Raising Hue Hue Road	7
P7	Flood Proofing Guidelines	8
EM3	Flood Warning System	9
P3	House Raising	10
P5	Voluntary purchase	11

5 Environmental and Social Characteristics

A description of the study area, comprising the Porters Creek catchment, is provided in **Section 2.1** and **Figure 2.1**.

5.1 Geology, Soils and Geomorphology

5.1.1 Creek Characteristics / Drainage Network

There is limited topographical relief in the catchment. The land is gently sloping on the northern portion of the catchment, draining down to large floodplain (**Figure 5.1**). The construction of the F3 Freeway and Northern Railway has modified historic drainage patterns (Andrews, 2007).

A number of sub-catchments have been identified within the Porters Creek catchment, each with the major discharge points located along Sparks, Hiawatha and Hakone Roads. The Porters Creek Catchment drains in a southerly direction towards Porters Creek and in a south-easterly direction to Porters Creek Wetland via the developed Woongarrah Creek catchment (Ecological Engineering, 2006).

The eastern region of the Porters Creek catchment covers a large proportion of the suburb of Warnervale, which drains west through Woongarrah Creek. The northern reaches of the catchment are located west of the northern railway line and drained by two parallel creeks – Buttonderry Creek, and an unnamed tributary, referred to in this report as Hue Hue Creek (Cardno, 2009). These three creeks (Woongarrah, Buttonderry and Hue Hue) form a confluence in the centre of the catchment at the region labelled Porters Creek Wetland. This is a wide region of flat low lying land at an approximate RL of 2-4 m AHD and an area of approximately 30 hectares.

Buttonderry Creek flows in a well-defined channel across the northwest region of the catchment. East of the existing Warnervale Airport, the creek spreads to form a wide, flat landform without an incised channel (Paterson Consultants, 1995).

Porters Creek, located to the south of the Porters Creek Wetland, drains an area of low lying land and flows south until it meets the Wyong River.

According to Wong and Breen (2009), several parts of the Porters Creek Wetland show evidence of past drainage works, most likely related to agricultural production. In general, these constructed drains are straight, have regular cross sections, and are often aligned with cadastral and fence boundaries. The drainage works include:

- Modified natural channels, including upstream portions of Porters Creek and Woongarrah Creek;
- Major artificial drains;
- Lateral drains off major drainage paths servicing individual fields, with occasional further finger drains off the lateral drains; and
- Minor artificial drains running into the wetland from concentrated inflow points, such as Buttonderry Creek culverts under Sparks Road (Wong and Breen, 2009).

The artificial drains are most noticeable in the southern portion of the catchment (upstream of the SEPP 14 wetland). The spoil for the drainage works appears to have been dumped on the

sides of the drain forming an embankment that impedes the passage of water flowing from upstream (Wong and Breen, 2009).

5.1.2 Geology and Soils

The interim 1:25 000 Geological Series Sheet for Wyong (Land and Property Information, 2002) indicates that the majority of the catchment area is underlain by Quaternary Alluvium, Tuggerah Formation and Patonga Claystone. Soil landscapes have been mapped for the study area based on mapping provided by Council in **Figure 5.2**. There is an area of disturbed land located in Halloran.

Watagan soils are found on rolling to steep hills on fine-grained Narrabeen Group sediments. It is characterised by convex crests and ridges, steep colluvial side slopes, occasional sandstone boulders and benches. Limitations include mass movement, soil erosion and foundation hazards, as well as rock outcropping and seasonal waterlogging (Murphy and Tille, 1993).

The Wyong soil landscape group is typically comprised of as clay loams overlying the silty clay associated with the Quaternary Alluvium. Limitations include waterlogging, streambank erosion, foundation hazard and localised acid sulfate potential (Murphy and Tille, 1993).

The Woodbury's Bridge soil landscape group has dominant soils described as sandy loam overlying clays weathered from Patonga Claystone Formation bedrock. Limitations are described as extreme erosion hazard, high foundation hazard, seasonal waterlogging (localised), and acid soils of very low fertility, low wet bearing strengths and high erodability (Murphy and Tille, 1993).

Tacoma Swamp soils consist of swampy floodplains and closed depressions on Quaternary sediments. They are generally highly saline, subject to permanent waterlogging, Potential Acid Sulfate Soils (PASS), foundation hazard and have very low fertility (Murphy and Tille, 1993).

The Gorokan soil landscape is an erosional soil landscape characterised by undulating low hills and rises on lithic sandstones of the Tuggerah Formation as well as broad crests and ridges, long gently inclined slopes and broad drainage lines. Gorokan soils have very high erosion hazard, foundation hazard, seasonal waterlogging, are hardsetting, are strongly acid, subject to rock outcropping, and have low fertility (Murphy and Tille, 1993).

Areas of known mine subsidence have also been mapped in **Figure 5.2**. The incidence of mine subsidence can add additional cost to potential construction projects, and also poses hazards associated with altered hydrological flow regimes.

5.1.3 Acid Sulfate Soils

Large areas of the southern portion of the Porters Creek catchment are mapped by DECCW as having the potential to be affected by Acid Sulfate Soils (ASS), as indicated in **Figure 5.3**. Where flood mitigation works are proposed in those areas identified as having a high or low probability of occurrence of ASS, the need for further investigation should be considered. It is noted that this mapping is predictive and that more detailed, site specific information may be available.

5.1.4 Contaminated Soils

Mapping provided by Council shows the location of previously identified contaminated sites within the LGA (**Figure 5.4**). There are a number of sites mapped as occurring within the Porters Creek catchment, although the current status of these sites is not clear.

A search of the EPA Contaminated Land Register conducted in October 2010 identified three contamination notices occurring within or near the catchment.

- Between 1998 and 2006, three Environmentally Hazardous Chemicals (EHC) Act Orders were issued for Lot 34 in DP9215 and Lots 1-3 in DP813908 at Aldenham Road and Railway Road, Warnervale NSW. These areas were deemed to be contaminated and environmentally degraded by the presence of a range of chemical wastes, including creosote, total petroleum hydrocarbons and polycyclic aromatic hydrocarbons as a result of the conducting of prescribed activities on the land, namely the dressing, treating and seasoning of timber.
- Between 1987 and 1998, two EHC Act Orders were issued for Lot 4 DP 568776 (Lakeside Resort Development 30 Boyce Ave, Wyong, NSW). The premises were deemed to be contaminated by reason of its being affected by industrial waste materials.
- One current and two former notices have been issued for the properties at 16-20 Lucca Road between 1991 and 1998. The current notice is a Maintenance of Remediation Notice stating that the notice recipient must maintain remediation action in accordance with the requirements set out in this notice. This notice is issued under section 28 of the Contaminated Land Management Act 1997. The two former EHC Act Orders were issued for the act of disposing of products and by-products of chemical manufactures including organochlorin pesticides and metabolites of these compounds.

It is important to note that the EPA Contaminated Land Record is not an exhaustive index, and there may be previously unreported contamination present in the catchment.

5.2 Water Quality

5.2.1 Catchment Water Quality

The Porters Creek catchment area has been under urban development for over 30 years and used for agricultural purposes prior to these activities. Currently, the land use within the catchment comprises a mix of residential and rural residential land uses, with some smaller areas of commercial/industrial development.

Sources of pollutants impacting upon water quality include:

- “Point” Sources, and
- “Non Point” Sources.

Point sources of pollutants can include, for example, discharges from premises licensed by the NSW EPA (within DECCW) within the catchment under the *Protection of the Environment Operations Act* (1997). A search of the register of licensed premises maintained by the EPA found two licences have been issued within the catchment:

- Buttonderry Composting Facility on Hue Hue Road (Warnervale), and
- Cheminova (MFG) Pty Ltd on Lucca Rd (Wyong).

The Buttonderry Composting facility holds a licence for composting of plant materials. Cheminova holds a licence for hazardous or industrial waste generation and storage of chemicals, pesticides or related products. Both of these activities are a potential source for water contamination in the catchment.

Sewer overflows are another common point source of water pollution. The points at which sewer overflows occur can often be identified by the presence of a sewage pumping station. However, exfiltration from the sewer system may also occur. In rural areas, septic tanks may also act as a point source of pollutants, particularly older septic systems that are no longer in use or are poorly maintained.

Contaminated lands may also act as a point source of pollution, either via direct runoff from the subject site or via infiltration to the groundwater. The presence of contaminated lands within the catchment is discussed in **Section 5.1.4**.

Non-point sources of pollution include discharges from diffuse sources, such as the build up of pollutants on road surfaces, runoff from fertilised gardens and the like. Diffuse sources of pollution are typically more difficult to identify and can be challenging to manage. Debris generated from urban development can also infiltrate the creeks in the catchment. Sources of debris can include organic materials such as leaf litter, garden clippings and animal droppings and anthropogenic materials such as litter (newspapers, plastic bags and cigarette butts) that become entrained in flows. Other sources of debris include illegally dumped waste and even rubbish bins (if a flood event occurs on a waste collection night). Essentially, any items that are not fixed, and lie within the flow path, can become debris.

Wong and Breen (2009) concluded that the inflow of pollutant concentrations into Porters Creek Wetland under existing conditions is significantly higher than they were under pre-development conditions. It is noted that developments in catchments upstream of natural wetlands need to meet urban water management objectives directed at preserving their supporting hydrology and maintaining sustainable pollutant loads discharged from the development (Ecological Engineering, 2005).

5.2.2 Receiving Waters – Wyong River and Tuggerah Lake

Porters Creek Wetland is where all overland flows from the upstream catchment converge. The wetland drains to the south via the main Porters Creek channel until the confluence with the larger Wyong River, which in turn flows into Tuggerah Lake.

Tidal flushing is said to contribute little to circulation and mixing within the Tuggerah Lakes estuary (Bioanalysis, 2005), which indicates that there is potential for localised water quality issues associated with tributary outlets. Symptoms of eutrophication are said to occur on occasion in particular locations near developed foreshores, as evidenced by small-scale blooms of drift macroalgae (Bioanalysis, 2005), although water quality in the estuary is generally thought to have improved significantly since the 1980's and 1990's. This is thought to be due in part to the implementation of a sewerage scheme in the catchment.

5.3 Land Use and Flooding

Land use zonings for the catchment have been mapped in **Figure 9.1** in accordance with the following planning instruments:

- Wyong Local Environment Plan (LEP) 1991, and
- Amendments to the State Environment Planning Policy (Major Projects) 2005 (the Major Projects SEPP).

The eastern region of the catchment covers a large section of the suburb of Warnervale. This suburb is currently the most developed area of the catchment, comprising primarily residential land uses. The northern sections of the catchment are less developed, with large regions of land zoned for conservation purposes (7a and 7b zonings). Special uses include the Warnervale Airport, which is located just north of the Porters Creek Wetland. Further details regarding the LEP or land uses are discussed in **Section 8.1**.

A spatial analysis of the land use within the extent of both the 100 year ARI and the Probable Maximum Flood (PMF) was conducted. The results of this analysis are provided in **Table 5.1**, which indicates the proportion of different land use categories (each comprising similar land use zones) falling within the flood extent.

Table 5-1: Land Use Categories Falling within the Flood Extents

Land Use Category	Proportion of the Flood Extent:	
	100 year ARI	PMF
Unzoned	0.1%	0.1%
Residential (zones: R1, 2a, 2b & 2e)	2.5%	3.8%
Industrial/Commercial (zones: 4a, 4b & IN1)	4.2%	8.7%
Infrastructure (zones: road, SP2, 5b, 5c & 5d)	3.1%	4.6%
Special Uses/Investigation (zones:5a, 10a)	7.2%	27.4%
Open Space / Scenic Protection (zones: RE1, 1c, 6a, 6b, 7b & 7c)	28.7%	47.7%
Conservation (zones: E2, 7a & 7g)	54.2%	7.7%

The results indicate that land use within the 100 year ARI flood and PMF extents is primarily low intensity land use categories for which significant disruption of human activities is unlikely to occur: 28.7% may be categorised open space/scenic protection and 54.2% categorised as conservation, summing to approximately 83% of the 100 year ARI flood extent. Residential and industrial/commercial land uses comprise a total of 6.7% of the 100 year ARI flood extent.

The proportion of low intensity land uses within the PMF extent is similarly high. The proportion of residential land uses increases from 2.5% to 3.8% when comparing the 100 year ARI and PMF extent, and the proportion of industrial/commercial land increases from 4.2% to 8.7%. This is due to the urbanisation of flood affected areas such as the Warnervale suburb centre, and indicates that there is a higher level of risk to both assets and human life during a PMF.

Schools, child care centres, hospitals and aged care facilities that are located within the PMF extent can be particularly vulnerable as these facilities represent higher risk assets in terms of evacuation.

Childcare centres and schools affected by flooding are identified in Annexure H and I of the *Local Flood Study* (WSC and SES, 2007). Two schools in Warnervale that lie in close proximity to the 100 year ARI flood extent fall within the flood extent of the more extreme PMF event. Wyong Christian Community School, located on Alison Road, Wyong, is located within the flood extent. Floor levels for the classrooms are set to provide a freeboard above the 100 year ARI flood level, however the school becomes isolated when flood water reaches 3.5 m AHD at Alison Road. Alison Road can be cut off by flood water from both Wyong River and Porters Creek.

Two aged care facilities located in Warnervale have the potential to be affected by flooding during the 100 year ARI and PMF events.

Portions of the cadastral parcel upon which Wyong Hospital is located fall within the flood extent for both the 100 year ARI and PMF, an assessment of the impact of road access to the hospital for these events is included in **Section 6.5**. However, no buildings are located with the flood extent.

5.4 Flora, Fauna and Riparian Areas

5.4.1 Riparian and Wetland Areas

The primary area of ecological interest within the Porters Creek catchment is the Porters Creek Wetland, which is a wetland of state significance gazetted under *State Environmental Planning Policy No. 14 - Coastal Wetlands* (SEPP 14).

Porters Creek Wetland is the largest remaining freshwater wetland on the Central Coast. The wetland contains several vegetation types, endangered swamp forest communities and several endangered plant and animal communities (DECCW, 2009). As a result of urban development and altered land uses, the wetland is showing signs of stress which is having adverse effects on the flora, fauna and riparian habitat (Wong and Breen, 2009; Sainty and Associates, 2003). Sainty and Associates (2003) have documented a number of indicators of habitat decline including:

- Swamp forest species such as Melaleuca linariifolia have been replaced by smaller more water-tolerant species, such as Melaleuca ericifolia, and weed infested open water zones.
    - A number of tree die-back sites in areas of the wetland that now receive increased “post development” flows, such as:
    - Below the stormwater drain at Fishburn Crescent, Watanobbi, where there has been significant loss to the ephemeral wetland Woollybutt (Eucalyptus longifolia) forest; and
- Southeast of Warnervale Airport, where past earthworks have created a pinch point in the wetland affecting the Eucalyptus robusta and Eucalyptus longifolia forest.
- Frequent collapse of healthy Melaleuca linariifolia trees has been observed within the swamp forest immediately downstream of the central railway culverts (near Railway Road, Watanobbi); and

- Serious weed infestations have been observed throughout the catchment from species including Blackberry, Pampas Grass, Sagittaria, privet, Eurasion Milfoil, and Crofton Weed.

Elsewhere in the catchment, significant wetland areas also exist within the floodplains located between Warnervale and Porters Creek Wetland. Woongarrah Creek, Kanwal Creek and the unnamed tributaries to the south of Warnervale are flat, wide waterways which contain wetland vegetation and habitat that is locally and regionally significant (Ecological Engineering, 2006).

These wetlands are essentially an extension of Porters Creek Wetland and contain a mix of riparian vegetation, Melaleuca sedge/swamp forest and are identified as ephemeral swamp forest. Groundcover is typical of frequent wetting comprising of numerous grasses, reeds and sedges species. The vegetation communities present in these wetlands are typical of areas that flood annually and remain wet and boggy over the winter months (Ecological Engineering, 2006).

5.4.2 Flora

The Porters Creek catchment is home to rare stands of vegetation communities that have evolved to specific hydrologic indices defined by inundation depth, inundation frequency and dry spell periods. The Porters Creek Wetland has been identified as a mosaic of Paperbark and Casuarina Wet Forest and Low Paperbark swamp forest communities with an isolated patch of Reed, Sedge and Herb Wetland (Wong and Breen, 2009).

A search of the EPBC threatened species and Bionet databases for the Wyong LGA identified records for 13 flora species listed under the *Threatened Species Conservation (TSC) Act 1995* and the *Environment Protection and Biodiversity Conservation (EPBC) Act 1999* (**Table 5.2**).

Table 5-2: Threatened Flora Species in the Wyong LGA

Scientific Name	Common Name	Legal Status EPBC Act	Legal Status TSC Act
Rutidosis heterogama	Heath Wrinklewort	Vulnerable	Vulnerable
Tetratheca juncea	Black-eyed Susan	Vulnerable	Vulnerable
Acacia bynoeana	Bynoe's Wattle	Vulnerable	Endangered
Maundia triglochinoides		-	Vulnerable
Prostanthera askania		Endangered	Endangered
Angophora inopina	Charmhaven Apple	Vulnerable	Vulnerable
Callistemon linearifolius	Netted Bottle Brush	-	Vulnerable
Eucalyptus camfieldii	Heart-leaved Stringybark	Vulnerable	Vulnerable
Melaleuca biconvexa	Biconvex Paperbark	Vulnerable	Vulnerable
Syzygium paniculatum	Magenta Lilly Pilly, Magenta Cherry, Pocket-less Brush, Cherry, Scrub Cherry, Creek Lilly Pilly, Brush Cherry	Vulnerable	Endangered
Cryptostylis hunteriana	Leafless Tongue Orchid	Vulnerable	Vulnerable

Scientific Name	Common Name	Legal Status EPBC Act	Legal Status TSC Act
Grevillea parviflora subsp. parviflora	Small-flower Grevillea	Vulnerable	Vulnerable
Tetratheca juncea	Black-eyed Susan	Vulnerable	Vulnerable

5.4.3 Fauna

A search of the EPBC threatened species and Bionet databases revealed 36 species as listed under the *TSC Act 1995* and the *EPBC Act* in the Wyong LGA (**Table 5.3**). It is important to note that not all species listed in the table will be found in Porters Creek Catchment.

Table 5-3: Threatened Fauna Species in the Wyong LGA

Scientific Name	Common Name	Legal Status EPBC Act	Legal Status TSC Act
Amphibia			
Litoria aurea	Green and Golden Bell Frog	Vulnerable	Endangered
Litoria brevipalmata	Green-thighed Frog	-	Vulnerable
Crinia tinnula	Wallum Froglet	-	Vulnerable
Mixophyes iteratus	Giant Barred Frog	Endangered	-
Aves		-	-
Botaurus poiciloptilus	Australasian Bittern	-	Vulnerable
Ixobrychus flavicollis	Black Bittern	-	Vulnerable
Ephippiorhynchus asiaticus	Black-necked Stork	-	Endangered
Ptilinopus superbus	Superb Fruit-Dove	Marine	Vulnerable
Grantiella picta	Painted Honeyeater	-	Vulnerable
Calyptorhynchus lathami	Glossy Black-Cockatoo	Endangered	Vulnerable
Lathamus discolor	Swift Parrot	Endangered	Endangered
Ninox connivens	Barking Owl	-	Vulnerable
Ninox strenua	Powerful Owl	-	Vulnerable
Tyto novaehollandiae	Masked Owl	Vulnerable	Vulnerable
Tyto tenebricosa	Sooty Owl	-	Vulnerable
Mammalia			
Saccolaimus flaviventris	Yellow-bellied Sheathtail-bat	-	Vulnerable
Mormopterus norfolkensis	Eastern Freetail-bat	-	Vulnerable
Pteropus poliocephalus	Grey-headed Flying-fox	Vulnerable	Vulnerable
Chalinolobus dwyeri	Large-eared Pied Bat	Vulnerable	Vulnerable
Falsistrellus tasmaniensis	Eastern False Pipistrelle	-	Vulnerable

Scientific Name	Common Name	Legal Status EPBC Act	Legal Status TSC Act
Kerivoula papuensis	Golden-tipped Bat	-	Vulnerable
Miniopterus australis	Little Bentwing-bat	-	Vulnerable
Miniopterus schreibersii oceanensis	Eastern Bentwing-bat	-	Vulnerable
Myotis macropus	Large-footed Myotis	-	Vulnerable
Scoteanax rueppellii	Greater Broad-nosed Bat	-	Vulnerable
Dasyurus maculatus	Spotted-tailed Quoll	Endangered	Vulnerable
Petaurus australis	Yellow-bellied Glider	Vulnerable	Vulnerable
Petaurus norfolcensis	Squirrel Glider	-	Vulnerable
Phascolarctos cinereus	Koala*	-	Vulnerable
Cercartetus nanus	Eastern Pygmy-possum	-	Vulnerable
Reptilia			
Chelonia mydas	Green Turtle	Vulnerable	-
Caretta caretta	Loggerhead Turtle	Endangered	-
Hoplocephalus bungaroides	Broad-headed Snake	Vulnerable	Endangered
Natator depressus	Flatback Turtle	Vulnerable	-

5.5 Recreational Activities

The catchment caters for a variety of human users. Recreational users can be categorised into 'active' users (those who require a vehicle, equipment or watercraft for their activity) and 'passive' users (those users not requiring a watercraft, vessel or specialised equipment). The majority of users of reserves and open space areas are passive users. No detailed studies of recreational uses were sited for the preparation of this report. However, recreational activities within the study area are likely to include:

- Passive use of reserves and open spaces;
- Picnicking;
- Walking and jogging;
- Dog exercising;
- Organised/team sports; and
- Golf driving range.

The types of recreational facilities within Porters Creek catchment are primarily reserves and parks, picnic areas, playing fields and walking tracks.

5.6 Cultural Heritage

5.6.1 Aboriginal Cultural Heritage

The study area is perceived to be the traditional lands of the Darkinjung people, whose land extends from the Hawkesbury River in the south, Lake Macquarie in the north, the McDonald

River and Wollombi up to Mt Yango to the west and the Pacific Ocean in the east. Wetland areas, such as those present within the study site, are considered to be of high importance to Aboriginal communities, due to the abundance of water, vegetation and fauna. As such, it is highly likely that the Darkinjung people consider this to be an area of significance.

A search of the NPWS Aboriginal Heritage Information Management System (AHIMS) database was undertaken (9 August 2010) for known or potential indigenous archaeological or cultural heritage sites within or surrounding the Porters Creek catchment. At the time of this search, 66 items and places were found in or near the study area. These include artefacts and open shelter areas with art and significant tool markings.

Due to the desire to respect and preserve these identified objects, mapping of these locations is not included within this report.

The following qualifications apply to an AHIMS search:

- AHIMS only includes information on Aboriginal objects and Aboriginal places that have been provided to DECCW;
- Large areas of New South Wales have not been the subject of systematic survey or recording of Aboriginal history. These areas may contain Aboriginal objects and other heritage values which are not recorded on AHIMS;
- Recordings are provided from a variety of sources and may be variable in their accuracy. When an AHIMS search identifies Aboriginal objects in or near the area it is recommended that the exact location of the Aboriginal object be determined by re-location on the ground; and
- The criteria used to search AHIMS are derived from the information provided by the client and DECCW assumes that this information is accurate.

A search of the National Native Title Tribunal for active Native Title claims within the Wyong Shire LGA was conducted to establish whether Native Title ownership would constrain future development of the proposed study area. There search did not find any Native Title claims in the study area.

5.6.2 Non-Aboriginal Heritage

A desktop review of non-Indigenous heritage was undertaken for the Wyong Shire LGA. Searches were undertaken of relevant databases including:

- Wyong Local Environment Plan 1991;
- NSW Heritage Office - NSW Heritage Register; and
- Australian Heritage Database (incorporates World Heritage List; National Heritage List; Commonwealth Heritage List; Register of the National Estate).

The NSW Heritage Register has three listings for cultural heritage items within the catchment. These listings are a Methodist Church along Warnervale Road, Warnies General Store/Café (also on Warnervale Road), and the Warnervale (Wallarah Creek) Underbridge located on Main North Line 110.32km Hiawatha Road, Warnervale (Heritage Branch, 2010).

5.7 Visual Amenity

The Porters Creek catchment is dominated by grazing lands, floodplains and some natural vegetation / wetlands. It is considered that the cleared low-lying areas of the site were once wetlands that have since been drained by constructed open channels. The eastern and southern portions of the catchment contain urban development and industrial areas. Parts of the wetland have been modified over the last 100 years for agricultural purposes and as a result of the construction of roads and the main northern railway line. The modifications include clearing of vegetation, the formation of ditches and embankments, and introduction of structures such as culverts at upstream inflow points. Areas in the wetland are now showing visible signs of stress most likely as a result of these modifications and an altered hydrological regime due to development within the catchment.

5.8 Demographic Characteristics

The demographic characteristics provided in **Table 5.4** are derived from the Australian Bureau of Statistics 2006 Census results for the Wyong Shire LGA.

In summary census data revealed that:

- In the 2006 census, there were 3,116 persons usually resident in the catchment: 50.2% were males and 49.8% were females. Of the total population, 4.9% are Indigenous persons (comprises Aboriginal and Torres Strait Islanders).
- English is the primary language as it is spoken in at least 88.5% of homes in the catchment area. Of the non-English speaking homes, the most common languages are: Cantonese, Mandarin, Tagalog, Urdu, and Japanese.

Table 5-4: Demographic and Population Characteristics for Porters Creek Catchment (Source: ABS, 2010)

Demographic Characteristic	
Total population	3,116
Indigenous population	152
Australian born	1,491
Overseas born	256
Infants and children 0 to 14 years	507
Adults 15 to 64 years	1,634
Mature adults 65 years and over	665
Renting	191

This data is relevant to consideration of emergency response or evacuation procedures (i.e. information may need to be presented in a range of languages and special arrangements may need to be made for less mobile members of the community).

6 Existing Flood Behaviour

6.1 Overview

The characteristic of the Porters Creek floodplain is such that extensive areas of very flat land exist in the lower regions of the wetland areas which extend up into lower tributaries bounded by low relief slopes upstream. The floodplain upstream of the wetland generally consists of broad flowpath which experiences a high flow width to depth ratio. It is common that low depth flows spread across the floodplain for extended periods of time, encouraging dense low lying vegetation to dominate. It is expected that many grazing areas on the floodplain will change in their use as a result of land rezoning and cleared floodplain will naturally revegetate increasing surface roughness.

The flood depth in the Porters Creek Wetland is significantly influenced by flood waters from Wyong River and the nature of the topography. The shear expanse of the floodplain and steeper slopes on the periphery means that large variations in flood depth cause little variation in the flood extents. As a result there is often negligible difference in flood level/extent between the range of design flood events.

Two infrastructure corridors cross the catchment in a north south direction, being the F3 freeway and the Northern Railway. This infrastructure is built on raised earth platforms that act as barriers to flood flows and a number of large culverts are included at major crossings. In the upper tributary creeks, generally to the east of the railway and north-west of the catchment (upstream of the F3), flood depths and velocities vary with the size of the design flood events and are significantly influenced by physical barriers such as road crossings and land filling for urban development.

6.2 Properties with Overfloor Flooding

A detailed assessment of the flood damages and overfloor flooding is provided in **Section 7** of this report. **Table 6-1** provides a summary of the properties with overfloor flooding for each of the design events based on floor level survey and estimated floor levels discussed in **Section 3.5**. Single storey dwellings have also been included, as these have limited opportunity for vertical evacuation during a flood event.

Table 6-1: Properties with Overfloor Flooding

Flood Event (ARI)	Residential Properties		Commercial Properties	Industrial Properties
	Single and Double Storey Dwellings	Single Storey Dwellings		
PMF	97	93	1	31
200 year	25	21	-	4
100 year	22	18	-	4
50 year	15	11	-	4
20 year	14	10	-	4
10 year	13	9	-	4
5 year	13	9	-	4

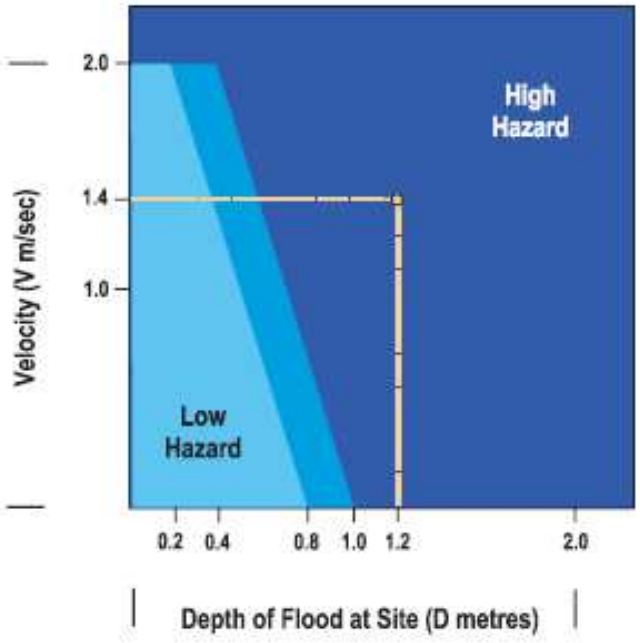
Considering there are approximately 5,000 dwellings in the catchment the number of properties experiencing overfloor flooding is considered to be fairly low. In addition much of the residential area in the catchment has been developed in the past 40 years where flood planning has played a greater role than in previous periods. As a result much of the residential areas remain flood free. However flood planning levels in this catchment are important for future development as there is currently rezoning studies underway for the Warnervale Region.

6.3 Flood Hazard

Flood hazard can be defined as the risk to life and limb caused by flood. The hazard caused by a flood varies both in time and place across a floodplain.

6.3.1 Provisional Flood Hazard

Experience from studies of floods throughout NSW and elsewhere has allowed authorities to develop methods of assessing the hazard of life and property on a floodplain. These guidelines are shown schematically below.



Provisional Hazard Ratings (after NSW Government, 2005)

To use the diagram, it is necessary to know the peak depth and velocity of floodwaters at a given location. If the combination of depth and velocity exceeds the critical limit (as shown by the white line on the diagram), the flood flow will create a High Hazard to life and property. There could possibly be danger to a person caught in the floodwaters, and possible structural damage. Evacuation of people from an area experiencing high flood hazard would be difficult.

By contrast, in low hazard areas people and their possessions can be evacuated safely by trucks. Between the two categories lies an intermediate zone in which the degree of hazard is dependent on site conditions and the nature of the proposed development.

For this study, the provisional flood hazard (High or Low) for Porters Creek Catchment for 20 year, 100 year ARI and PMF events are displayed in **Figures 6.1-6.3**. It is clear from the figures

that high provisional hazard extends throughout the lower parts of the floodplain of Porters Creek slightly into the tributaries. The characteristics of the catchment and floodplain result in low flow velocity, generally around 0.1m/s in the lower floodplain and less than 1m/s elsewhere. As a result areas of high hazard are limited to areas of the floodplain where depth is high and where localised high velocities are experienced.

6.3.2 True Flood Hazard

Provisional flood hazard categorisation based around the hydraulic parameters described above in **Section 6.3.1**, does not consider a range of other factors that influence the "true" flood hazard. In addition to water depth and velocity, other factors contributing to the true flood hazard include:

- Size of the flood,
- Effective warning time,
- Flood readiness,
- Rate of rise of floodwaters,
- Duration of flooding,
- Ease of evacuation,
- Effective flood access, and
- Type of development in the floodplain.

In the Porters Creek Catchment some of the above factors are not applicable in terms of affecting hazard definition. However, to provide a thorough assessment process, all of the above factors have been discussed in this report. These are discussed below. Figures of True Hazard for the PMF, 100 year ARI and 20 year ARI are shown in **Figure 6.4-6.6.**

Size of Flood

The size of a flood and the damage it causes varies from one event to another. For the purposes of this study, flood hazard has been assessed for the PMF, 100 year and 20 year ARI events. These events were determined to be the appropriate events to categorise the "true" hazard for the catchment for planning purpose.

Effective Warning Time

The effective warning time is the actual time available prior to a flood during which people may undertake appropriate mitigation actions (such as lift or transport belongings and/or evacuation). The effective warning time is always less than the total warning time available to emergency service agencies. This is related to the time needed to pass the flood warning to people located in the floodplain and for them to begin effective property protection and/or evacuation procedures.

The critical duration storm for the study area is generally the 2-9 hour duration event for the 20 year and 100 year ARI. An area where the 2 hour duration is critical is in tributary creeks to the east and northwest of the catchment. Areas in the lower floodplain have a 9 hour critical duration. The peak duration for the PMF event is approximately a 90 minute duration event.

Sufficient warning time has been selected as 6hrs from the beginning of the storm. Storms of a duration where flood levels begin to reach their peak within the 6hr period are nominated as being high risk storm durations. The 2 hour and 90 minute durations would not allow for

sufficient warning time for notification to residents that the catchment will soon experience flooding. However in areas where the 9 hour duration is the peak, there is approximately 6 hours warning time following the start of the storm to when the peak of the flood is expected. The recommended method for warning notification is via SMS, as indicated by several residents (**Section 4**), and through increase flood awareness that is discussed in more detail below.

Flood Readiness

Flood readiness or preparedness can greatly influence the time taken by flood-affected residents and visitors to respond in an efficient manner to flood warnings. In communities with a high degree of flood readiness, the response to flood warnings is prompt, efficient and effective.

Flood readiness is generally influenced by the time elapsed since the area last experienced severe flooding. The last major flood event occurred in Porters Creek Catchment in June 2007 which was roughly equivalent to a 50 year ARI event (Cardno 2009). This was a fairly wide spread event within the Wyong Shire LGA (and beyond). Based on the responses from the resident survey (**Section 4**), approximately 60% of respondents who have resided in the catchment for greater than 5 years would have been living in the catchment at the time of the 2007 flood event.

The responses from the resident survey suggest that approximately 50% of the residents are not concerned about flooding in the catchment. This can be both a function of the time the resident has lived in the catchment or also that they have not been affected by flooding in the past. Alternatively the respondent may reside outside of the floodplain.

It is assumed that flood awareness of larger floods is likely to be relatively low except for rural residential areas across the lower parts of the catchment where overfloor flooding is common in the 5 year ARI design flood events. Flood readiness is therefore considered to be relevant for this area only. These areas are fully located within the provisional high hazard flood extent and the ability to find as safe evacuation route is not available. Thus the true hazard would not change from the provisional in this case. Flood readiness for other residential areas in the catchment is not common due to the potential low frequency of flooding and has not been considered outside of this area. Flood awareness and readiness can be improved through community education via Council website, local newspaper and local information days run by the SES.

Rate of Rise of Floodwaters

The rate of rise of floodwater affects the magnitude of the consequences of a flood event. Situations where floodwaters rise rapidly are potentially far more dangerous and cause more damage than situations where flood water levels increase slowly. The rate of rise of floodwaters is affected by catchment and floodplain characteristics.

A rate of rise of 0.5 m/hr has been adopted as indicative of high hazard as it represents a rapid rise in flood waters over a short time period. However, it is important to note that if an area has a rate of rise greater than 0.5 m/hr this does not automatically result in the area being categorised as high hazard. For instance, if the rate of rise is very high but flood depths only reach 200 mm, this is not considered to pose any greater hazard than slowly rising waters. Therefore, peak flood depths were considered in conjunction with the rate of rise in defining areas affected by true high hazard.

A flood depth of 500 mm was selected as the trigger depth for high hazard where the rate of rise was equal to or greater than 0.5 m/hr.

In the study area, properties with such flow behaviour constraints are already identified in the provisional high hazard category.

Depth and Velocity of Floodwaters

As outlined above, provisional hazard mapping is determined from a relationship between velocity and depth. The provisional hazard mapping for the PMF, 100 year and 20 year ARI events were undertaken and presented in **Section 6.3.1** of this report. This provisional hazard mapping has been used as the base to determine true flood hazard.

Duration of Flooding

The duration of flooding or length of time a community, town or single dwelling is cut off by floodwaters can have a significant impact on the costs and disruption associated with flooding. Flooding durations in urban areas of the Porters Creek Catchment are generally less than two hours, for the upper regions of the eastern catchment and duration of flooding is not relevant for these areas.

Areas in the low lying floodplain are flooded for a critical duration of 9 hours for the local catchment and 36 hours for the Wyong River catchment. These durations are considered to be extensive and are included in the preparation of the true hazard.

Ease of Evacuation

The levels of damage and disruption caused by a flood are also influenced by the difficulty of evacuating flood affected people and property. Evacuation may be difficult due to a number of factors, including:

- The number of people requiring assistance,
- Mobility of those being evacuated,
- Time of day, and
- Lack of suitable evacuation equipment.

As noted above, the duration of flooding in the urban areas of the catchment is short. Therefore, evacuation issues for the majority of the catchment are not considered to be an issue. The exception is for properties that experience overfloor flooding in the 100 year ARI and PMF events that do not have a second level they could vertically evacuate to. There are a total of 18 of these residential properties in the 100 year ARI event and 93 in the PMF event.

Consideration of the properties experiencing overfloor flooding has been included in the true hazard maps.

Effective Flood Access

The availability of effective access routes to or from flood affected areas and emergency services such as Wyong Hospital can directly influence personal safety and potential damage reduction measures. Effective access implies that there is an exit route available that remains trafficable for sufficient time to evacuate people and possessions.

For the duration of the flooding experienced in the lower lying parts of the catchment evacuation is only recommended when access to property is safe. It is less of a risk to mobilise flood affected resident to places of refuge higher than the elevation of the PMF.

As such, effective flood access is considered in the True Hazard mapping and has been generally applied for residents that do not have safe flood access and for major road crossings assessed in Section 6.5.

Type of Development

The degree of hazard to be managed is a function of the type of development and resident demographic. This may alter the type of development considered appropriate in new development areas and may also change management strategies in existing development areas.

The majority of the land-use in the study area is generally residential with some commercial and industrial areas. There is however a number of child care facilities as well as Wyong Christian School located in the floodplain. This information has been included in preparation of the True Hazard Mapping.

6.4 Flood Categorisation

The damages and disruption caused by floodwaters depend on the extent and duration of flood inundation, and on the depth and the velocity of flow. The hydraulic categories (floodway, flood storage and flood fringe) are typically defined in accordance with the NSW Government's *Floodplain Development Manual (April 2005)* as follows:

- **Floodways** tend to be aligned with natural channels and carry the main volumes of water during floods, often at substantial flow velocities;
- **Flood storage** areas become filled with water for temporary storage during floods;
- **Flood fringe** areas are those remaining after floodways and storage areas have been defined.

Hydraulic Categories for the Porters Creek study area have been provided for the 20 year, 100 year and PMF design storms. The method of mapping the hydraulic categories is as follows:

- **Floodways** are mapped as the predicted 10 year ARI flood extent, with some manual adjustments to ensure that floodways are continuous (except at culverts) and that defined channels are categorised as floodways.
- **Flood storage** is the remaining area where flood depth is greater than 0.2 metres; and
- **Flood fringe** is the remaining area within the flood extent which is not either Floodway or Flood Fringe.

The spatial resolution of the mapping is limited by the cell size of the hydraulic model. The cell size is 15 m to the west of the railway and 5 m to the east of the railway. This was determined by the level of development in the catchment. Densely urban areas of the catchment exist to the east of the railway and rural areas exist to the west of the railway.

Please refer to **Figures 6.7-6.9** for hydraulic categories.

6.5 Major Access Road Flooding

Major access road flooding occurs periodically in many of the major road crossings in the eastern part of the catchment and is sustained over long periods across Hue Hue Road in the catchment's west. The existing level of service of collector roads such as Minnesota, Louisiana and Warnervale Roads is often less than the 20 year ARI causing inconvenience to local residents. These collector roads are used frequently by residents of Warnervale and Hamlyn Terrace and therefore can cause risk to residents in time of flood. Residents must use major roads such as Sparks Road and Pacific Highway as alternative routes during flooding.

A summary of peak flood depth over surface levels at major roads in the PMF, 100 year and 20 year ARI design flood events is presented in **Table 6-2** Locations where access roads were assessed is displayed in **Figure 6.10**.

Table 6-2: Major Access Road Flooding*

Location ID (Figure 6.7)	PMF		100 year ARI		20 year ARI	
	Flood Depth (m)	Duration where depth >0.2m (hr)	Flood Depth (m)	Duration where depth >0.2m (hr)	Flood Depth (m)	Duration where depth >0.2m (hr)
1	1.7	> 8hr	0.86	> 8 hr	0.73	> 8 hr
2	0.6	2hr	0.24	<0.5hr	0.21	<0.5hr
3	1.5	2hr	0.57	5hr	0.52	4hr
4	1.6	3hr	0.68	>8hr	0.61	5.8hr
5	0.9	<0.5hr	0.54	<0.5hr	0.49	<0.5hr
6	0.3	<0.5hr	0.19	<0.5hr	0.18	<0.5hr
7	0.6	2hr	0.37	2hr	0.31	1.2hr
8	1.7	4hr	0.61	5.4hr	0.53	4.8hr
9	0.5	1hr	0	0hr	0	0hr
10	0.9	1hr	0.6	<0.5hr	0.4	<0.5hr

*Indicative depths. Depths may vary across the road with changes in the road geometry and surface level.

According to the NSW Government Floodplain Development Manual (2005), the maximum depth at which roads are not considered safe to pass in a vehicle is 0.2 metres. An investigation into the depth and duration of inundation was undertaken for the road crossings that are utilised as major thoroughfares. Of particular importance is the ability to access Wyong Hospital in the case of flood. Road crossing number 5 is the major access route on Pacific Highway to the north of the hospital and number 6 is located on the Highway to the south. As shown in **Table 6-2** the inundation depth at point 6 only exceeds 0.2m during the PMF and the duration where depth is greater than 0.2m is less than half an hour. This indicated that the access to the hospital during flood is achievable for all design storm events. A similar case is estimated for location 5, therefore it is predicted that immediate access to and from the hospital would be possible during flood. Road thoroughfare further afield is achievable on Pacific Highway, Sparks Road and the F3 freeway.

It is emphasised, however, that motorists should be discouraged from driving through any flood waters due to the potential risk to life.

Road crossings that are impassable for an extended period during flood include Warnervale Road at the Woongarrah Creek crossing, Minnesota Road and Louisiana Road. Hue Hue Road is also impassable at the Buttonderry Creek crossing for all the design storm events assessed. Local residents have specifically voiced their concerns over the serviceability of Warnervale and Minnesota Roads during storms as described in **Section 4.1**. Council is considering methods to improve the serviceability of all roads that are impassable for the design storms assessed and options to improve the serviceability of the roads affected by flooding is discussed in **Section 11**.

7 Current Economic Impact of Flooding

7.1 Background

The economic impact of flooding can be defined by what is commonly referred to as flood damages. **Table 7.1** categorises various types of flood damages.

Table 7-1: Types of Flood Damages

Type	Description
Direct	Building contents (internal) Structural (building repair and clean) External items (vehicles, contents of sheds etc)
Indirect	Clean-up (immediate removal of debris) Financial (loss of revenue, extra expenditure) Opportunity (non-provision of public services)
Intangible	Social - increased levels of insecurity, depression, stress General inconvenience in post-flood stage

The direct damage costs, as indicated in **Table 7.1**, are just one component of the entire cost of a flood event. There are also indirect costs. Both direct and indirect costs are referred to as tangible costs. In addition to this there are also intangible costs such as social distress. The flood damage values discussed in this report are the tangible damages and do not include an assessment of the intangible costs which are difficult to calculate in economic terms.

Flood damages can be assessed by a number of methods including the use of computer programs such as FLDAMAGE or ANUFLOOD or via more generic methods using spreadsheets. For the purposes of this project, generic spreadsheets have been used with assistance from DECCW on the adoption of appropriate damage curves.

7.2 Floor Level and Property Survey

Floor level and property survey information is discussed in **Section 3.5.**

7.3 Damage Analysis

The flood damage assessment for the existing catchment conditions is based on damage curves that relate the depth of flooding on a property to the likely damage within the property. Ideally, the damage curves should be prepared for the particular catchment for which the study is being carried out. However, damage data in most catchments is not available and recourse is generally made to damage curves from other catchments.

DECCW has conducted research and prepared a methodology (draft) to develop damage curves based on state-wide historical data. This methodology is only for residential properties and does not cover industrial or commercial properties. The DECCW methodology is only a recommendation and there are currently no strict guidelines regarding the use of damage curves in NSW.

The following sections set out the methodology used for the determination of damages within the Porters Creek Catchment.

7.3.1 Residential Damage Curves

The draft DNR (now DECCW) Floodplain Management Guideline No. 4 *Residential Flood Damage Calculation* (2004) was used in the creation of the residential damage curves. These guidelines include a template spreadsheet program that determines damage curves for three types of residential buildings:

- Single Storey, slab on ground
- Two Storey, slab on ground
- Single Storey, high-set.

Two types of these properties were adopted for Porters Creek; the single storey slab on ground and the two storey slab on ground. No single storey high-set houses, apartment buildings or townhouses were identified in the survey therefore no additional costs were apportioned based on these land uses.

Damages are generally incurred on a property prior to any over floor flooding. The DECCW curves allow for a damage of $9,648 (February 2010 dollars) to be incurred when the water level reaches the base of the house (the base of the house is determined by 0.3m below the floor level for slab on ground). We have assumed that this remains constant until overfloor flooding occurs. A nominal value of $3,000 has been allowed to represent damage to gardens where the ground level of the property is overtopped by more than 0.3 metres of depth but only up to 0.3m below the floor of the house.

There are a number of input parameters required for the DECCW curves, such as floor area and level of flood awareness. The following parameters were adopted:

- Based on interrogation of the aerial photos a value of 200m^2 was adopted as a conservative estimate of the floor area for residential dwellings for the floodplain. With a floor area of 200m^2, the default contents value is $50,000 (November 2001 dollars).
- The Effective Warning Time has been assumed to be zero due to the absence of any flood warning systems in the catchment. A long Effective Warning Time allows residents to prepare for flooding by moving valuable household contents (e.g. the placement of valuables on top of tables and benches).
- The Porters Creek catchment is a small part of the Wyong Shire LGA and as such is not likely to cause any post flood inflation. These inflation costs are generally experienced in remote areas, where re-construction resources are limited and large floods can cause a strain on these resources.

The adopted residential damage curves are shown in **Figure 7.1**.

Average Weekly Earnings

The DECCW curves are derived for late 2001, and were updated to represent February 2010 dollars (shown in **Table 7-2**). General recommendations by DECCW are to adjust values in residential damage curves by Average Weekly Earnings (AWE), rather than by the inflation rate as measured by the Consumer Price Index (CPI). DECCW proposes that AWE is a better representation of societal wealth, and hence an indirect measure of the building and contents value of a home. The most recent data for AWE from the Australian Bureau of Statistics at the time of this study was for February 2010. Therefore all ordinates in the residential flood damage

curves were updated to February 2010 dollars. In addition, all damage curves include GST as per DECCW recommendations.

While not specified, we have assumed that the curves provided in DECCW guidelines were derived in 2007, which allows us to use the 2007 AWE statistics (issued quarterly) for comparison purposes. The 2007 AWE is shown in Table D1 of the Draft DNR guidelines, and February 2010 AWE were taken from the Australian Bureau of Statistics website (www.abs.gov.au).

Table 7-2: AWE Statistics

Month	Year	AWE
November	2001	$676.40
February	2010	$969.40

Consequently, damages have been increased by 43.0% and GST has been included compared to 2007 values.

7.3.2 Commercial Damage Curves

Commercial damage curves are adopted from the FLDamage Manual, Water Studies Pty Ltd (1992). FLDamage allows for three types of commercial properties:

- Low Value Commercial
- Medium Value Commercial
- High Value Commercial

In determining these damage curves, it has been assumed that the effective warning time is approximately zero, and the loss of trading days as a result of the flooding has been taken as 10. These curves are determined based on the floor area of the property. Estimation of floor area was completed through mapping of aerial photography for the individual properties. These have been used to factor these curves.

The Consumer Price Index (CPI) was used to bring the 1990 data to March 2010 dollars (this data was obtained from the Australian Bureau of Statistics website (www.abs.gov.au)). It was assumed that the Water Studies Pty Ltd data was in June 1990 dollars. The CPI data is shown in

Table 7-3.

Table 7-3: CPI Statistics

Month	Year	CPI
June	1990	102.50
March	2010	171.00

Consequently, damages have been increased by 66.8% and GST has been included compared to 1990 values.

7.3.3 Industrial Damage Curves

Cardno, as a part of the Allans Creek Floodplain Management Study, conducted a survey of industrial properties in 1998 for Wollongong City Council (Cardno Lawson Treloar, 2006). The damage curves derived from this survey are more recent than those presented in FLDamage and have been used in a number of previous studies. Therefore Cardno feels these damage curves are adequate for use in this study.

The curves were prepared for three categories:

- Low Value Industrial (e.g. small factories and workshops)
- Medium Value Industrial (e.g. large industrial properties on Lucca Rd, North Wyong)
- High Value Industrial (e.g. BHP steelworks in Wollongong).

Within the catchment, there are no properties considered to be representative of high value industrial properties, and hence these curves were not used.

The floor areas for the industrial properties were estimated from aerial photographs. To normalise the damages for property size, the curves have been factored to account for floor area.

The survey conducted only accounts for structural and contents damage to the property. Clean up costs and indirect financial costs were estimated based on FLDamage Manual. Actual internal damage could be estimated, along with potential internal damage, using various factors within FLDamage. Using both the actual and potential internal damages, estimation of both the cleanup costs and indirect financial costs could be made. The values were adjusted to March 2010 dollars using the CPI statistics shown in **Table 7-4**.

Table 7-4: CPI Statistics

Month	Year	CPI
June	1998	121.00
March	2009	171.00

Consequently, damages have been increased by 41.3% and GST has been included compared to 1998 values.

7.3.4 Adopted Damage Curves

The adopted damage curves are shown in **Figure 7.1**. The commercial and industrial damage curves are shown for a property with a nominal floor area of 100m^2.

7.4 Average Annual Damage

Annual Average Damage (AAD) is calculated on a probability approach, using the flood damages calculated for each design event.

Flood damages (for a design event) are calculated by using the 'damage curves' described in the sections above. These damage curves attempt to define the damage experienced on a property for varying depths of flooding. The total damage for a design event is determined by adding all the individual property damages for that event.

The AAD value attempts to quantify the flood damage that a floodplain would receive on average during a single year. It does this using a probability approach. A probability curve is drawn, based on the flood damages calculated for each design event (**Figure 7.2** below). For example, the 100 year ARI design event has a probability of occurring of 1% in any given year, and as such the 100 year ARI flood damage is plotted at this point on the AAD curve. AAD is then calculated by determining the area under this curve. Further information on the calculation of AAD is provided in Appendix M of the Floodplain Development Manual (2005).

For this study, the damage resulting from events more frequent than a 1 year ARI (100% AEP) was assumed to be zero for the AAD analysis.

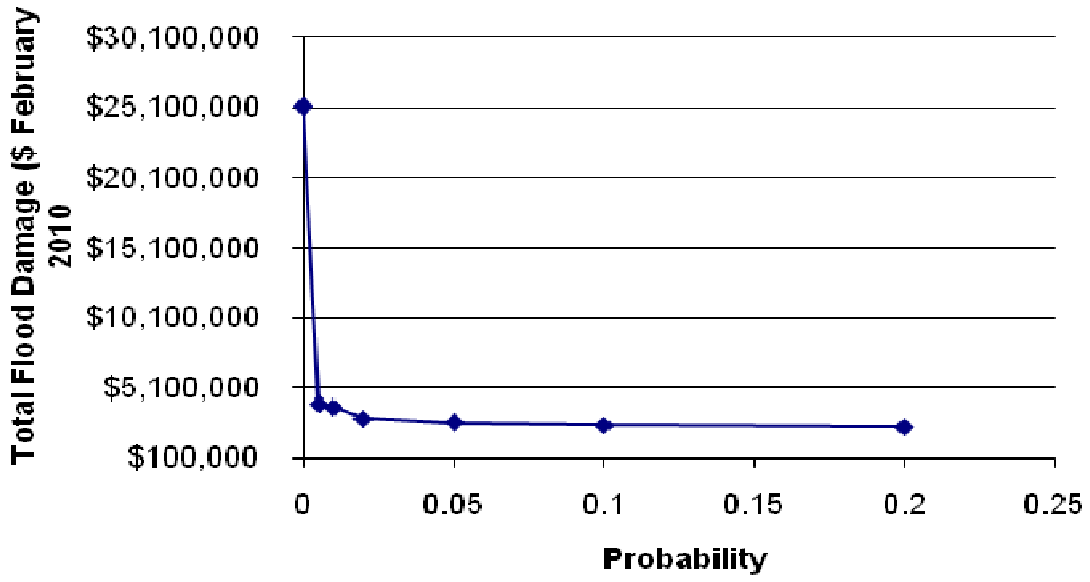


Figure 7.1: Annual Average Damage Curve for Porters Creek

7.5 Results

Table 7-5 shows the results of the flood damage assessments. Based on the analysis described in **Section 7.4** above, the average annual damage for the floodplain under existing conditions is approximately $934,400. Locations of the properties experiencing overfloor flooding have been kept confidential, and will be provided to Council separately.

Table 7-5: Flood Damage Assessment Summary

Event/Property Type	Number of Properties with overfloor flooding	Average Overfloor Flooding Depth (m)	Maximum Overfloor Flooding Depth (m)	Number of Properties with overground flooding	Total Damage ($March 2010)
PMF					
Residential	97	0.47	2.62	192	$ 6,244,398
Commercial	1	0.22	0.22	1	$ 1,862,992
Industrial	31	1.29	2.83	36	$ 17,074,342
PMF Total	129			229	$ 25,181,731

Event/Property Type	Number of Properties with overfloor flooding	Average Overfloor Flooding Depth (m)	Maximum Overfloor Flooding Depth (m)	Number of Properties with overground flooding	Total Damage ($March 2010)
200 year ARI					
Residential	25	0.47	2.01	47	$ 1,513,959
Commercial	-	-	-	-	$ -
Industrial	4	1.61	2.10	7	$ 2,486,196
200 Year ARI Total	29			54	$ 4,000,155
100 year ARI					
Residential	22	0.46	1.90	47	$ 1,366,701
Commercial	-	-	-	-	$ -
Industrial	4	1.47	1.96	6	$ 2,396,446
100 Year ARI Total	26			53	$ 3,763,148
50 year ARI					
Residential	15	0.48	1.59	45	$ 989,785
Commercial	-	-	-	-	$ -
Industrial	4	1.11	1.61	6	$ 1,973,681
50 Year ARI Total	19			51	$ 2,963,465
20 year ARI					
Residential	14	0.39	1.29	40	$ 864,635
Commercial	-	-	-	-	$ -
Industrial	4	0.97	0.68	5	$ 1,789,625
20 Year ARI Total	18			45	$ 2,654,260
10 year ARI					
Residential	13	0.36	1.19	35	$ 755,656
Commercial	-	-	-	-	$ -
Industrial	4	0.91	1.40	5	$ 1,712,088
10 Year ARI Total	17			40	$ 2,467,744
5 year ARI					
Residential	13	0.32	1.13	30	$ 730,963
Commercial	-	-	-	-	$ -
Industrial	4	0.84	1.33	5	$ 1,632,421
5 Year ARI Total	17			35	$ 2,363,385

While values are expressed to the nearest dollar, this does not reflect the accuracy of the values.

8 Current Emergency Response Arrangements

Flood emergency measures are an effective means of reducing the costs of flooding and managing the continuing and residual risk to the area. Current flood emergency response arrangements for managing flooding in the Wyong Shire LGA are discussed below.

8.1 Wyong Shire Local Flood Plan (2007)

Flood emergency management for the Wyong Shire LGA is organised under Wyong Shire Local Flood Plan, a sub-plan of the Wyong Shire Local Disaster Plan (DISPLAN). The plan is consistent with similar plans prepared for areas across NSW and covers the following aspects:

- Preparedness measures;
- Conduct of response operations; and
- Co-ordination of immediate recovery measures.

The Flood Plan outlines the key responsibilities of the different response organisations. It is generally the responsibility of SES as the "combat" agency to respond to and coordinate the emergency response. It is the responsibility of Council and DECCW in the role of prevention through development controls, the floodplain management process and mitigation schemes.

The plan also consists of a series of appendices, which include details of flood sensitive areas, effects on the community, flood level and rainfall gauges in the area, SES bulletin dissemination, evacuation centres, evacuation methods and marshalling areas.

The Flood Plan covers the entire Wyong Shire LGA with a particular focus on Tuggerah Lakes and its three major estuaries Wyong River, Ourimbah Creek and Wallarah Creek. The plan describes specific risk areas in Annex B. Porters Creek is described as a wetland with inundation of the floodplain originating from Wyong River. Local events are relevant beyond the extent of inundation by Wyong River. Specific Risk areas in the Porters Creek Catchment are Wyong Christian School and properties downstream of the railway should a situation occur where the earth structure supporting the railway fails releasing detained flood waters on the upstream side.

8.2 SES/Emergency Service and Operations

The Porters Creek floodplain lies within the Sydney Northern Region within the Hunter and Central Coast Emergency Management District of the State Emergency Service (SES). The SES maintains a Local Headquarters Operations Centre at Levitt Street, Wyong. Should this not be operational, the alternative closest centre is the Wyong Shire Council Emergency Operations Centre on Arizona Road, Charmhaven.

The SES is listed as the "combat" agency for flooding in the Flood Plan, as well as the primary coordinator for evacuation and the initial welfare of affected communities.

The SES is primarily a volunteer organisation. In times of emergency, the SES operates a paging service for on-call volunteers. However, more experienced crew know when to mobilise based on their understanding of the local area. The role of the SES in flood events, as outlined in the Local Flood Plan (2007), is to:

- Preparedness
- Develop and operate a flood intelligence system;
- Develop and maintain emergency management arrangements; and
- Prepare, coordinate and deliver community awareness programs and educational material to ensure people located within the floodplain understand the threat and its management.
- Response
- Control flood operations, including directing SES units in the area as well as coordinating the activities of supporting agencies;
- Coordinate regular reconnaissance of key flood affected locations;
- Coordinate evacuation of people at risk; and
- Coordinate the protection of private properties (and contents) at risk from flooding.

The SES co-ordinates a number of support groups for flood response including:

- NSW Fire Brigade
- Energy Australia
- Ambulance Service NSW
- BoM
- NSW Police
- Schools and Child Care Centres
- Roads and Traffic Authority
- Wyong Shire Council
- Wyong Shire Local Emergency Management Committee

The locations of key emergency services for Porters Creek catchment are:

- Wyong Hospital on the Pacific Highway, Hamlyn Terrace;
- Police Station, 10 Alison Road, Wyong; and
- The NSW Fire Brigade, Minnesota Road, Hamlyn Terrace.

8.3 Flood Warning Systems

Due to the short timeframe of flooding for urban areas in the upper regions of the eastern area of the catchment it is not possible to deploy a flood warning system. The Bureau of Meteorology (BOM), however, may issue a 'severe thunderstorm warning' or a 'flash flooding warning'. Current forecasting and warning mechanisms for the Porters Creek catchment are based on predictions of severe rainfall, primarily from rainfall radar systems, and water level and rainfall for a number of gauges operated by Manly Hydraulics Laboratory and Council (listed in Annex C of the Local Flood Plan).

Flood warning systems would be appropriate for residents and community facilities on low lying areas of the floodplain, such as the Wyong Community Christian School, where the duration of flooding is in excess of 6 hours. The types of flood warnings that can be put in place are discussed in **Section 8.6**.

Systems to detect rainfall amounts for intense rainfall events (referred to as an ALERT system) are currently in place for the Central Coast area. This system draws upon the Bureau of Meteorology's rainfall gauge network and includes those gauges located as part of the network of Automatic Weather Stations (AWS) that report on a regular basis. Data from this network is

available in real-time at the Bureau of Meteorology Flood Forecasting Page for the 'Central Coast' at http://www.bom.gov.au/hydro/flood/nsw/greatersyd.shtml. Details available include 24 hour rainfall totals and rainfall from the last hour in graphical format. Details of depths of rainfall recorded at specific gauges are also available.

The value of the system to provide flood warnings followed by timely actions by residents themselves or combat agencies remains an issue due to the very short times to flood peak from the onset of rainfall in the Porters Creek Catchment.

The weather-based warnings (Severe Thunderstorm Warnings, Severe Weather Advices, and Gale Warnings etc.) from BoM are generally faxed to all of the local media outlets as well as the SES. Flood Watches (from the Hydrology Section of the Bureau) are only sent to the SES, who then disseminates the information to the local media (and other organisations as required).

8.4 Evacuation

The critical duration of flooding ranges from 2 hours in upper parts of the catchment to 9 hours in lower parts of the catchment fringing the floodplain for all design flood events. The decision and responsibility for evacuation is delegated to the SES Local Controller and should be undertaken in accordance with Annexure F of the Local Flood Plan (2007).

The Wyong Shire LGA is divided into several sectors for evacuation purposes, and three of these sectors appear to be roughly coincident with the Porters Creek catchment:

- Part of Section A, which (in the region of the Porters Creek catchment) is located between Tuggerah Lakes and the Pacific Highway;
- Sector B, which is located east of the F3, including Watanobbi and Warnervale; and
- Sector D, which is located west of the F3.

Specific trigger levels for evacuation and evacuation routes are provided for each of these sectors. The recommended approach for these sectors is generally to shelter in place, rather than to attempt to evacuate, with the exception of the Wyong Christian Community School. This school is identified as being completely inundated during even minor to moderate flood events. Wyong Community Christian School has a specific emergency management plan that is discussed in detail in **Section 8.6**. It is recommended that the school is evacuated before water levels reach to 2.2m AHD in Porters Creek, as recommended in the emergency management plan.

In general, the relatively fast response times for catchment flooding in Porters Creek mean that evacuation may not be feasible in many instances, and therefore the SES is not likely to play a significant role in evacuation during a flood event. Evacuation is generally not recommended as the response during the flood emergency is likely to be uncoordinated, which can expose the residents to a hazardous situation. As such, the preferred approach is to remain within the property and take refuge in a designated landmark above the level of the PMF or move to the upper level of the residence, where available.

8.5 Recovery

The Local Flood Plan (2007) provides details of the recovery operation in the aftermath of a flood event. In a major flood event, structural damage to flood-affected properties may occur and residents may need to be accommodated temporarily during the recovery operation. The

Department of Community Services is responsible for the long term welfare of the affected community. However, the immediate action is likely to be undertaken through the Wyong SES Local Controller, who assists the Wyong Shire Council Local Emergency Management Committee in establishing a Recovery Coordinating Committee.

8.6 Wyong Community Christian School

The school is located on Alison Road Wyong, adjacent to Wyong River and Porters Creek Wetland. The floor level of the school has been surveyed at 5.9m AHD that is slightly higher than the adjacent flood level of 5.82m AHD during the 100 year ARI. However the level of the PMF is 6.52m AHD, which would inundate the school. In addition there are no refuge points available in the vicinity of the school that would allow students and teachers to ensure their safety during flood.

The school is listed in the Wyong Shire Local Flood Plan under Annex I as a school that may require evacuation during flood. The school is also on a list of vulnerable communities in the DISPLAN that is held by the LEMO. As such the school would be contacted by either the SES or the LEMO if flood warnings are activated.

There is a requirement for the school to consider emergency evacuation in the event of flood should an event greater than a 100 year ARI design storm be experienced. The school does have a flood evacuation in place that relies on the adjacent Baptist church being the muster point for evacuation by vehicle to the west along Alison Road. Notification for the flood evacuation is to be triggered according to the following alerts:

- Yellow - Heavy rain for 6 hours and still raining including overnight. Porters Creek flowing strongly
- Orange - Water level is 1 metre over Wyong River Weir or Porters Creek alarm activated by Council or Porters Creek Swamp encroaches on School property
- Red - Water starting to flow over Alison Road Bridge or across property

The conditions for raising the alerts are subjective and reliant on external notification from Council and the SES. It is noted that there is a flood depth indicator in Porters Creek, upstream of the Alison road bridge, provided by Council that can be used for triggers to the alerts. For example, a yellow alert could be activated if the water level was to reach 2.2m AHD in Porters Creek. This would allow sufficient warning time for preparation to evacuate considering Alison Road is at a level of approximately 3.5m AHD. Words such as heavy rain and overnight rain are misleading and open to interpretation.

In addition it has been confirmed that the alarm for the flood level gauge at Wyong River Weir is no longer operational as they were decommissioned by MHL. However a new flood level gauge has been installed by Council on Porters Creek that can be upgraded to include an alarm via SMS to the SES, flood emergency officer at the school and Council. Thus it is recommended that the alarm be triggered when water levels reach a certain threshold to be confirmed by SES/Council to initiate alerts and evacuations. Considering that the route of evacuation is at a level of approximately 3.5m AHD then sufficient warning time would be required to ensure that evacuation could take place prior to the route becoming impassable. Safe egress for motorists from the muster point should be available until flood depth reaches 0.2 metres deep. The rate of flood level rise can vary significantly and is dependent on a number of conditions. Considering the location of the school and its in proximity to the confluence of the Porters Creek and Wyong

River catchments there are numerous scenarios, which could cause flood waters to rise rapidly, such as debris accumulation under bridges,

In addition the following risks have not been accounted for in the school's emergency management plan:

- Parents attempting to collect their children from the school in the case where it is unsafe to do so and vehicles become stranded in flood waters
- At present the emergency plan relies on evacuation taking place, if this does not occur then it is assumed that evacuation to Wyong High School will be possible. However the school is 800m to the east and involves crossing Porters Creek bridge that is likely to be overtopped at such a time.
- No procedures are documented for cases where it is not possible to evacuate by car or foot. In such a case a refuge point within the school grounds above the level of the PMF is recommended.
- Notification to parents to come and collect their children relies on phone calls made one by one and/or that they would be listening to 2GO radio at the time. It is suggested that notification via radio and SMS would be more efficient and effective. This recommendation is made on the assumption that road access to the school would not be in the high risk category as a result of regional flooding. A suitable hold point should be nominated for warning parents not to collect their children, i.e. flood levels begin to overtop Alison Road Bridge.

These are a guide for updating the flood evacuation plan for the Wyong Community Christian School. The plan should be updated in conjunction with the SES, the school and Council. It is noted at the time of reporting that a school hall is being developed under the Federal government's schools program. Once construction has been completed the floor level of the hall should be surveyed to confirm if it would be a suitable location for refuge during the PMF. No details of the floor level were available at the time of reporting.

9 Policies and Planning

9.1 Local Environmental Planning Instruments

9.1.1 Land Use Zoning

Land use within the Porters Creek catchment is generally controlled by the Wyong Local Environment Plan (LEP) 1991. There were, however, two amendments under the State Environment Planning Policy (Major Projects) 2005 that relate to land use zoning for two specific areas within the catchment. These include:

- Amendment No. 21 – Wyong Employment Zone; and
- Amendment No. 24 – Warnervale Town Centre.

Land use zoning for the study area has been indicated on **Figure 9.1**. The land use zonings designate the types of development that are permissible (either with or without consent) or not permissible in accordance with the objectives of each particular zone.

Flooding is referenced in one of the objectives for land zoned 1c (Non-Urban Constrained Lands) and includes "*limit development of land that may be affected by flooding*…". Further reference to flooding is contained within the LEP in relation to flood mitigation works, which are permitted only with development consent where such works are proposed for lands zoned as follows:

- 1c – Non-Urban Constrained Lands;
- 2a – Residential;
- 2b -Multiple Dwelling Residential;
- 2c -Medium Density Residential;
- 2d -High Density Residential;
- 2e -Urban Release Area;
- 7g -Wetlands Management; and
- 10a -Investigation Precinct.

It is noted, however, that the requirement for development consent for flood mitigation works would in some instances be superseded by the State Environmental Planning Policy (Infrastructure) 2007, which states that flood mitigation works may be carried out by or on behalf of a public authority without consent on any land.

There is also specific reference to development of flood prone land under Clause 23, which states that:

- (1) Notwithstanding any other provision of this plan a person shall not erect a building or carry out a work on land which, in the opinion of the Council is, within a flood prone area, other than on land within Zone No 2 (a), 2 (b), 2 (c), 2 (d) or 2 (g), without the consent of the Council.
- (2) The Council may, as a condition of its consent to the carrying out of development referred to in subclause (1), require the floor of the building or work to be erected at a height sufficient, in the opinion of the Council, to prevent or reduce the incidence of flooding of that building or work or of adjoining land.

- (3) The Council shall take into account as a matter for consideration in determining whether to grant consent as referred to in this clause the effect of the proposed development on flooding.

Additional development controls in relation to flood prone land are typically provided in Development Control Plans (**Section 9.2**) on policy documents.

Further discussion about land use zoning and compatibility with flood risk is provided in **Section 5.3**.

9.1.2 Future Land Use – Standard Instrument LEP

The New South Wales Planning Reforms, which are currently being implemented by the New South Wales Government, require all local governments to prepare their planning instruments in accordance with a new standard instrument LEP. The key features of these reforms are:

- An objective of reducing the number and layers of planning instruments;
- Provision of a standard LEP template for Councils to conform to;
- All mandatory controls to be included in the LEP;
- Mandatory timeframe for Council to prepare new LEP (3-5 years);
- Rationalise and clarify Development Control Plan (DCP) relationship to LEP
- Replace Master Plans with DCPs and staged development applications.

Under this process, Wyong Shire Council has been developing a draft LEP which is proposed to go on public exhibition in 2011. An important aspect of this process is that it provides opportunity for re-zoning of land and it is recommended that the preparation of the standard instrument LEP for Wyong Shire take into account the recommendations of this Floodplain Risk Management study.

The main changes in land use in the catchment are currently underway in relation to the:

- Warnervale Town Centre, which is proposed for retail, commercial and residential development;
- Wyong Employment Zone, which aims to provide additional commercial/industrial lands; and
- Precinct 7A, which is proposed for commercial, residential and a mix of education and sports related development.

9.2 Development Control Plans-2005

9.2.1 DCP Chapter No.113 – Flood Prone Land (Draft)

Wyong Shire Council are currently in the process of preparing a Development Control Plan Chapter for Flood Prone Land (DCP No. 113) and a review of the draft DCP has been provided below. The intention is for this DCP Chapter to replace the current policy (FS – Flood prone land development). This policy does not meet the standard of the NSW Government Floodplain Development Manual (2005).

The DCP objectives in relation to the management of flood prone land are:

- Inform the community of Council's Policy with regard to the use of flood prone land.

- Establish guidelines for the development of flood prone land that are consistent with the NSW Flood Policy and NSW Floodplain Development Manual (2005).
- To control development and activity within each of the individual floodplains within Wyong Shire having regard to the characteristics and level of information available for each of the floodplains, in particular the availability of Floodplain Risk Management Studies and Floodplain Risk Management Plans prepared in accordance with the Floodplain Development Manual.
- Minimise the risk to human life and damage to property by controlling development on flood prone land.
- Apply a merit based approach to all development decisions taking into account ecological, social and environmental considerations.
- To ensure that the development or use of floodplains and floodways does not adversely impact upon the aesthetic, recreational and ecological values of the waterway corridors.
- Improve riparian corridors during redevelopment and to ensure that the ecological values of the lake systems are enhanced.
- To ensure that all land uses and essential services are appropriately sited and designed in recognition of all potential floods.
- To ensure that all development on the floodplain complies with Ecological Sustainable Development (ESD) principles and guidelines.
- Prevent the introduction of unsuitable land uses on flood liable land.
- To ensure that the development of flood prone land does not result in significant impacts upon the amenity of an area.

The development of this FRMS&P for the Porter's Creek catchment is required to take into consideration the objectives of DCP No. 113. The outcome of this FRMS&P will be a series of prescriptive controls for flood affected land within the Porter's Creek catchment that will be tabulated in a matrix similar to Schedule D and attached to the DCP as currently indicated in the draft DCP. Proposals that meet the prescriptive controls schedule will be considered to have met the requirements of the DCP.

It is noted that the DRAFT DCP identifies that Council may relax some prescriptive requirements such as flood planning level requirements if the proposal can address either of the following issues:

- That building design is innovative in dealing with climate change such as addressing the adaptability of buildings to accommodate the impact of climate change and Council can be satisfied that in approving the development there will be no undue burden on future landowners or the community. This includes ensuring that issues such as site access can be addressed in the future as required.
- The projected life of the proposed development is limited and does not warrant the imposition of controls that consider impacts beyond the cessation of the proposed development.

The conditions detailed above are subject to change following further investigations of flood planning levels as they may include consideration of climate change.

General requirements for flood prone land as listed in Section 4 of the draft DCP are summarised in **Table 9.1**, along with a comment relevant to the Porters Creek catchment.

Table 9-1: Review of Requirements Relating to General Controls

Control	Comments
Requirements for fencing: ▪ Fencing is to be laid in such a manner that it will not modify the flow of floodwaters and cause damage to surrounding land.	This control is recommended.
Requirements for car parking: ▪ The proposed car park should not increase the risk of vehicle damage by flooding inundation. ▪ The proposed garage/car park should not increase the likelihood of flooding on other developments, properties or infrastructure. ▪ Any damage that may arise to the proposed garage/car park shall not be greater than that which can be reasonably managed by the property owner. ▪ Open car parking - The minimum surface level of open space car parking subject to inundation should be designed giving regard to vehicle stability in terms of depths and velocity during inundation by flood waters. Where this is not possible, it shall be demonstrated how the objectives will be met.	Reference is made to bunding to prevent inundation of basement car parks under the definitions (Section 1.4). However, it is recommended that these performance criteria be updated to include specific provisions relating to the need to prevent inundation of basement car parks up to the nominated flood planning level or the PMF whichever is the higher. Suggest removal of the clause referring to damages to carpark and garages.
Requirements for filling flood prone land: ▪ Unless a floodplain risk management plan for the catchment has been adopted, which allows filling to occur, filling in flood-prone areas is not permitted in areas designated as floodway or high hazard areas. In all other areas unless a report from a suitably qualified engineer is to be submitted and approved by Council that certifies that the development will not increase flood affectation elsewhere. ▪ Filling of individual sites in isolation, without consideration of the cumulative effects is not permitted. Any proposal to fill a site must be accompanied by an analysis of the effect on flood levels of similar filling of developable sites in the area. This analysis would form part of a flood study prepared by a suitable qualified professional.	This control is recommended.
Requirements for on-site sewer management: ▪ The treatment tank and holding device are to be located above the 1% AEP flood contour. ▪ The land application area is to be above that 5% AEP flood contour except in Wyong Shire's drinking water catchment where no component of the system will be permitted in any flood prone	This control is recommended. Freeboard is not considered to be necessary in this case.

Control	Comments
land below the 1% AEP flood contour. ▪ Refer to DCP 2005 Chapter 65 – On Site Effluent Disposal in Non-Sewered areas for guidance with regard to this form of application.	
Requirements on storage of hazardous substances: ▪ The storage of products which, in the opinion of Council, may be hazardous or pollute floodwaters, must be placed at a minimum of 500 mm above the height of the 1% AEP flood contours or placed within an area protected by bunds or levels such that no flood waters can enter the bunded area if the flood level rose to a level of 500 mm above the height of the 1% AEP flood.	This control is recommended and the recommended level should be revised for placement at the FPL.

9.2.2 DCP Chapter No. 97 – Water Sensitive Urban Design (Draft)

Council have also developed a DRAFT Water Sensitive Urban Design (WSUD) Development Control Plan No. 97 that aims to provide guidance on the development process and to facilitate WSUD in the LGA.

DCP Chapter No. 97 states that it is to be read in conjunction with Wyong Shire Councils Flood Prone Land Development Policy (the draft Chapter No.113 will replace this policy), and all WSUD elements implemented under this DCP Chapter should not contribute to increased flooding risk. Specific performance targets include:

- Incorporate WSUD elements into the stormwater drainage design such that the benefits of such measures are used to mitigate the impacts on flooding from urban development; and
- Post development peak flows are not to exceed pre development peak flows for the 1.5 year up to 100 year ARI events.

9.2.3 DCP Chapter No. 49 – Warnervale East and Wadalba North West Urban Release Area

The Warnervale/Wadalba Urban Release Area represents a significant expanse of land that is capable of supporting in excess of 10,000 dwellings. Wyong Shire Council wants to ensure that development of this area is well planned and to provide an efficient and attractive environment for future residents.

There is a general requirement that the ground floor level of all residential buildings shall have a minimum freeboard of 600mm above the designated 100 year ARI flood level. This freeboard includes a freeboard for flooding and a freeboard for mine subsidence. Freeboard for all other development is 300mm above the designated 100 year ARI flood level.

Section 4.13 contains provisions relating to flood prone land within the urban release area and specifies that development should comply with the requirements of the Wetlands DCP and Council's Flood Policy. The latter document will be replaced with DCP Chapter No. 113 – Flood Prone Land when it is adopted by Council, and this may result in a requirement to update (or

remove) the general requirement within DCP Chapter No. 49 in relation to floor levels for residential buildings.

9.2.4 DCP Chapter No. 36 – North Wyong Industrial Area (2005)

Section 3.4.2 of the *North Wyong Industrial Area Development Control Plan* (2005) includes provisions relating to a levee bank and pump system for land north of Lucca Road. It requires the following:

- Stormwater is to be managed in accordance with the Water Cycle Management Plan, Central Coast Business Park – Warnervale by Young Consulting Engineers (August 2003). A proposed levee bank is to be provided for the development site, designed to a minimum of RL 6.5m AHD. The levee bank is to provide protection from the 1% AEP flood with a minimum 300mm of freeboard for the subject land north of Lucca Road and existing properties in Pavitt Crescent.
- The construction of the levee bank, filling and associated works on the subject site and Lot 19 DP 250522 (Wyong Shire Council) will detain the local runoff should the water level in the receiving water (i.e. water in floodplain) be level with or higher than the local ponding level. In situations where the receiving water level is higher, a pump system is required to discharge the water.
- Water collected in the proposed storage pond is to be circulated through the constructed wetland system. Recirculation can be achieved by either:
- Pumping to the rock lined channel through use of a solar powered pump; and/or
- Recirculation through the wetland by the use of the discharge pumps.
- It is imperative that the pumps be maintained and operational at all times. One of the routine maintenance procedures would be monthly operation of the pumps. During this routine maintenance of the pumps, the water in the pond is recirculated through the wetland. Details of the maintenance of these pumps, including pumps and the required standby capacity of the pumps, are to be provided with any development application that is lodged for the land.
- The storage pond shall also be available for an adequate fire fighting water supply for the subject site and local area. The total minimum storage capacity required will be developed in accordance with Council and relevant fire authorities. Details are to be provided to ensure that water is available for fire fighting at all times including drought conditions.
- Any development application is to be supported by a suitable levee bank risk and failure analysis, including suitable ongoing monitoring and maintenance access arrangements.

The Concept Plan for these works were approved as part of a DA in 2010.

9.2.5 Warnervale Town Centre DCP (2008)

The *Warnervale Town Centre DCP* (DoP, 2008) applies to those lands subject to Amendment No. 24 of the Major Projects SEPP, as shown in **Figure 9.1**.

Section 8 of the DCP relates to environmental management for non-residential areas and includes information on Integrated Water Cycle Management (IWCM) and WSUD. Section 8.2 states that WSUD Strategy is required for each development, to be prepared in accordance with the Integrated Water Cycle Management Strategy for Warnervale Town Centre (Ecological Engineering, 2006). The IWCM strategy aims for the maintenance of flows for more regular

events, while managing flood flows discharging from the site so as to minimise the increase in flood flows further downstream. The target is to preserve the current peak flow exiting the site for the 5 to 100 year ARI events via storm water storage basins.

Section 10.5 of the DCP includes a list of other policies and plans relevant to the Warnervale Town Centre, including F5 – Flood Prone Land Policy, which will be replaced by DCP No. 113 – Flood Prone Land (currently in draft form). The Warnervale Town Centre DCP will need to be updated to reference DCP No. 113 once adopted.

In addition, it is recommended that it may be advisable to update the Warnervale Town Centre DCP to more explicitly draw out flood related issues in relation to other development controls discussed in that document. For example, within Section 9.15 on cut and fill, neither the objectives nor the controls include a reference to the need to consider the potential for filling of land to impact on flood behaviour. This section could benefit from a specific reference to DCP No. 113. It is recognised that the DCP for Warnervale Town Centre was developed and approved by the State Government Planning Department.

9.3 Recommended Policies to be Adopted

In order for Council to control development in the catchment in a consistent manner it is recommended that the existing flood policy be updated to a Chapter of DCP with a specific flood planning control specific to the Porters Creek Catchment. This will ensure requirements are adopted as per other areas in the Wyong LGA through the DCP and more specific requirements would be addressed by the matrix. This approach is considered most appropriate in the place of specific DCPs for specific areas within the catchment, as a Chapter of DCP, that can consolidate the Council's planning and development requirements for flooding. This streamlined approach also prevents confusion that may arise when numerous documents apply to a single lot that has conflicting requirements. Specific details of the content to be included in the DCP's Chapter are described in **Section 9.2.1** and details of the flood planning matrix can be found in **Section 10.**

9.4 Flood Policy, Planning and Modification Included in Other Studies

A number of developments are underway in the catchment, or are planned for development, that have not been included in this study. In order to raise awareness of the activity in the catchment a list of the existing, proposed and in-progress developments are included in **Table 9.2**.

Table 9-2: Catchment modification included in other studies

ID	Description
A.1 *	Wyong Employment Zone (WEZ) – Industrial development and business parks are proposed for the area bounded by Porters Creek wetland, the railway, sparks Road and the F3 freeway. A draft DCP has been prepared by Council for this area which has to be approved by DOP. This will be finalized in early 2011. Flood management recommendations for the development of this area are outlined in the WEZ DCP (as per study by DHI (2006) and subsequent addendums).
A.2 +	Warnervale Town Centre (WTC) - Development of a railway station, town centre and residential property on this site is regulated by DCP adopted by DoP.
A.3 *	Link Road Stage 1 & 2 across Porters Creek Wetland- Road link from Sparks Road Warnervale down to Watanobbi in Parallel to the Northern Railway. Stage 1 of the Link Road has been constructed. Stage 2 has been approved and construction is subject to the availability of funding.
A.4 +	Precinct 7A – A rezoning study is currently in progress for a 560ha parcel of land in the Warnervale area. Current land uses include conservation (wetlands), rural residential, grazing and residential. The rezoning is proposed to provide significant opportunity for residential housing in the region with associated community facilities including schools, sports grounds and a business park for employment generation. A considerable amount of the study area is constrained by flooding and EEC. A flood study is in progress as part of the rezoning study that is likely to revise flood extents in the study area.
A.5 +	Buttonderry Tip, north west of the Warner Industrial Park – Extension of the existing tip is approved and may be conducted at a future date on the western side of Buttonderry Creek. This will require the establishment of a new bridge crossing of Buttonderry Creek to access this portion of the site.
A.6 +	Jilliby Stage 2 – South West of Warner Industrial Park - Local residents have made enquiries about rezoning this area to rural residential
A.7 +	Wallarah 2 Coal Project, west of the Warner Industrial Park – A proposal has been prepared and is currently being considered under Part 3A by the Minister for Planning. It involves underground extraction of coal in the area of Jilliby and Wyong State Forest to the west of the F3 freeway. Construction of transport infrastructure is proposed in the north west of the Porters Creek catchment. Details are available at www.wallarah.com.au.
A.8 ^	There is an existing levee protection along the eastern boundary of Lots 20, 21, 22 and 23 DP 740438 near Carlyle Close, Jilliby NSW. This levee has not been recognised in Council records however it would provide flood protection for the aforementioned properties.
A.9 +	Raise the road crown level of Virginia Road at Woongarrah Creek crossing and provide an enlarged culvert to increase serviceability of road.
A.10 *	There is a sub-division under development for the Louisiana Road Infill Precinct. This is being controlled by a site specific DCP.

^ Denotes an existing flood modification measure

* Indicates a development that is in progress

+ A proposed development in the planning phase

10 Flood Planning Level Review

10.1 Background

The Flood Planning Level (FPL) for the majority of areas across New South Wales has been traditionally based on the 100 year ARI flood level plus a freeboard. The freeboard for habitable floor levels is generally set between 0.3 - 0.5 m for residential properties, and can vary for industrial and commercial properties.

A variety of factors are worthy of consideration in determining an appropriate FPL. Most importantly, the flood behaviour and the risk posed by the flood behaviour to life and property in different areas of the floodplain and different types of land use need to be accounted for in the setting of an FPL.

The Porters Creek catchment contains a mix of new developments built within the past 20 years and older development built in the past 50 years. In addition there is new land release areas such as Precinct 7A, Warnervale Industrial Park and the Louisiana Road precinct that will develop/urbanise much of the Warnervale Region. As such the setting of the FPL must consider both the impact on existing development and the planning issues related to new development.

The Floodplain Development Manual (2005) identifies the following issues to be considered:

- Risk to life
- Long term strategic plan for land use near and on the floodplain
- Existing and potential land use
- Current flood level used for planning purposes
- Land availability and its needs
- Changes in potential flood damages caused by selecting a particular flood planning level
- Consequences of floods larger than the flood planning level
- Potential impact of future development on flooding
- Duty of care.

These issues are dealt with collectively in the following sections.

10.2 Likelihood of Flooding

As a guide, **Table 10-1** has been reproduced from the Floodplain Development Manual (2005) to indicate the likelihood of the occurrence of an event in an average lifetime to indicate the potential risk to life.

Analysis of the data presented in **Table 10-1** gives a perspective on the flood risk over an average lifetime. The data indicates that there is a 50% chance of a 1 in 100 year event occurring at least once in a 70 year period. Given this potential, it is reasonable from a risk management perspective to give further consideration to the adoption of the 1 in 100 year flood event as the basis for the flood planning level for residential, commercial and industrial uses. Given the social issues associated with a flood event and the non-tangible effects (such as stress and trauma), it is appropriate to limit the exposure of people and their properties to floods. Critical infrastructure and sensitive land uses are discussed in **Section 10.7**.

Table 10-1: Probability of Experiencing a Given Size Flood or Higher in an Average Lifetime (70 years)

Likelihood of Occurrence in any year (ARI)	Probability of experiencing at least one event in 70 years (%)	Probability of experiencing at least two events in 70 years (%)
1 in 10	99.9	99.3
1 in 20	97	86
1 in 50	75	41
1 in 100	50	16
1 in 200	30	5

Note that there still remains a 30% chance of exposure to at least one flood of a 1 in 200 year magnitude over a 70 year period. This gives rise to the consideration of the adoption of a rarer flood event (such as the PMF) as the flood planning level for some types of development.

10.3 Current FPL in Floodplain

Based on the existing Flood Prone Land Development Policy, F5, Council currently utilises the following flood planning levels:

- Habitable floor levels have a minimum of 300 mm freeboard above the 100 year ARI flood level for Residential, Industrial, Business, Open Space and Special Use zones.
- Industrial and Commercial properties are to be built with floor levels at a minimum of the 100 year ARI flood level for non-habitable properties.

The above flood planning levels refer to all land-uses in the LGA. This policy states that each new development will be assessed on its merits for adequate consideration of flood behaviour by complying with all relevant development controls, codes and policies. This is a non-prescriptive method of flood planning control and is not recommended as it is open to interpretation and will not stand as a firm policy should a proposed development be scrutinised in the Land and Environment court.

A DCP Chapter No.113- Flood Prone Land Development Policy (DRAFT) has been prepared by Council and is currently in DRAFT format. Recommendations in this study will be relevant to DCP no. 113.

10.4 Land Use and Planning

The hydrological regime of the catchment can change as a result of changes to the land use, particularly with an increase in the density of development. The removal of pervious areas in the catchment can increase the peak flow arriving at various locations, and hence the flood levels can be increased.

There is development in progress and plans for further development in the catchment. Effective planning for development is proposed through update of Council's flood policy to a DCP and preparation of a flood planning matrix specific to Porters Creek that imposes a range of controls dependent on the type of land use and the flood planning zone for which the site is located. Recommendations for flood planning zones are included in **Section 10.17**.

In general, it would be recommended to control development such that any increase in impervious area is countered by appropriate use of on-site detention. Council's DRAFT DCP

Chapter No. 97 Water Sensitive Urban Design currently incorporates on-site detention and other appropriate measures to minimise impacts on catchment runoff. Therefore, this is not considered to be a significant issue within the catchment if the DCP is adopted and measures recommended in DCP are enforced.

The other potential impact is through the intensity of development on the floodplain, which may either remove flood storage or impact on the conveyance of flows. DCP Chapter No. 97 and DCP Chapter No. 113, together with the recommendations in **Section 9**, address these key issues. As such, this is not expected to impact on flood levels or flood storage.

10.5 Damage Cost Differential between Events

Based on the existing flood behaviour and the assessment of flood damages, the incremental difference in Annual Average Damage for different recurrence intervals is shown in **Table 10-2**. This table represents the incremental increase in AAD attributed to each design event.

Table 10-2: Damage Differential Costs

Recurrence Period	Incremental AAD	Properties with Overfloor Flooding	Average AAD per Property
Up to 5 Year	$354,508	17	$20,853
5 Year to 10 Year	$241,556	17	$14,209
10 Year to 20 Year	$128,050	18	$7,114
20 Year to 50 Year	$84,266	19	$4,435
50 Year to 100 Year	$33,633	26	$1,294
100 Year to 200 Year	$19,408	29	$669
200 Year to PMF	$72,955	129	$566
AAD (Total)	$934,376		

Table 10.2 indicates that the largest incremental increases in the AAD per property occur up to the 5 year ARI event. This suggests that the largest benefit to the community would be if the 5 year event were utilised in the setting of the FPL, as the savings in AAD per property would be the greatest (assuming that existing properties were replaced with similar properties set at the FPL). However, there are other considerations as discussed in the following sections.

10.6 Incremental Height Difference between Events

Consideration of the average height difference between various design flood levels can provide another measure for selecting an appropriate FPL.

Based on the existing flood behaviour (**Section 6**) the incremental peak height difference between events is shown in **Table 10-3** for selected events. These are determined based on the flood levels determined at each of the reference points within the catchment identified as a part of the Flood Study Addendum (Cardno 2010).

Table 10-3 indicates a larger difference in flood level of the PMF event compared to other events. The adoption of the 100 year ARI event as the flood planning level is higher than that that of the 20 year ARI event (on average 0.16m higher). Therefore, the adoption of the 100

year ARI event would provide an increased level of risk reduction over the 20 year ARI event for a relatively small increase in height. The adoption of the PMF event as the flood planning level would result in more significant increases in levels over the 100 year ARI event (in the order of 0.72 metres) and may therefore potentially be too restrictive for the setting of flood planning levels in the catchment, particularly given the likelihood of this event.

Table 10-3: Relative Differences Between Design Flood Levels

Event	Diff PMF (m)		Diff 100yr + 15% (m)		Diff 100y (m)		Diff 20yr (m)	
	Avg	SD	Avg	SD	Avg	SD	Avg	SD
100 yr + 15%	0.69	0.45						
100 year	0.72	0.45	0.02	0.07				
20 year	0.88	0.54	0.18	0.13	0.16	0.16		
5 year	0.99	0.52	0.29	0.18	0.27	0.2	0.11	0.07

Avg = Average Difference; SD = Standard Deviation of Differences

In some cases the PMF can be more than 1m higher than the 100 year ARI (**Figure 10.1**). With regard to an appropriate freeboard, the maximum difference between the PMF event and the 100 year ARI event is 2.6m based on this analysis, but the average is approximately 0.72m. The difference between the 100 year ARI event and the PMF indicates that basing the flood planning level on the 100 year ARI level with a reasonable freeboard will result in reduction in building inundation for the PMF event for approximately 50% of the properties.

10.7 Consequence of Adopting the PMF as a Flood Planning Level

Analysis of the flood damages (**Section 7.3**) indicates that the choice of the PMF event over the 100 year ARI event as the FPL would result in limited economic benefits (in annualised terms) to the community. The difference in average flood levels between the 100 year event and the PMF event indicate that the use of the PMF as the FPL would result in much higher floor levels (0.72 metres on average), and as a result higher economic costs and visual impact as much higher new developments dwarf neighbouring properties built under current flood planning levels. The use of the PMF level as the FPL would also conflict with other development/building controls in Councils current flood policy and proposed DCP Chapter No.113.

Given the risk of exposure outlined in **Table 10-1**, it is recommended that emergency response facilities be located outside of the floodplain and any other likely critical facilities be limited to areas outside of the floodplain. Other critical facilities, such as schools, aged care and day care centres, are suggested to have a floor level at the PMF. These facilities commonly hold less mobile members of the community and therefore are faced with evacuation issues, and can also be used as evacuation shelters in an emergency.

10.8 Environmental and Social Issues

The FPL can result in housing being constructed at a higher level than it otherwise would be. This can lead to a reduction in visual amenity for surrounding property owners, and may lead to encroachment on neighbouring property rights. This may also lead to conflict with other development controls already present within the Council's development assessment process. Therefore nomination of the FPL is to achieve an acceptable level of flood related risk whilst observing practicalities of economics, visual amenity and social issues.

10.9 Climate Change – Sea Level Rise

The DECCW *Practical Consideration of Climate Change* (DECCW 2007b) provides guidance on expected ocean level rises. Three scenarios are recommended to be analysed:

- Low Level Rise (0.18 metres)
- Medium Level Rise (0.55 metres)
- High Level Rise (0.91 metres)

The impacts of ocean level rise were not directly assessed in the Flood Study. However, it is noted that not all flood affected properties in the catchment are above these levels with some properties in the vicinity of the Wyong River and Porters Creek confluence being affected under low hazard for a 100 year ARI event in the Tuggerah Lakes Flood Risk Management Study currently on public exhibition. As the majority of properties within the catchment are not impacted by sea level rise it has not been considered in the flood modelling.

10.10 Climate Change – Change in Rainfall Patterns

Current research indicates that while annual rainfalls will decrease as a result of climate change, storm intensities will actually increase in some areas. The DECCW guidelines (DECCW 2007b) provide recommended ranges for the assessment of increases in peak rainfall intensities. The guidelines recommend analysis of three scenarios:

- 10% increase in peak rainfall and volume
- 20% increase in peak rainfall and volume
- 30% increase in peak rainfall and volume.

Regional studies on the projected impact of climate change to rainfall were undertaken by the NSW Government and the CSIRO in 2007. For the Hunter-Central Coast region rainfall intensity was projected to increase by minus 10% to plus 12% by 2030 and minus 7% to plus 10% by 2070 in comparison to 1990 values for the 40 year ARI, 24 hour duration (CSIRO 2007). The projections were based on modelling provided by CSIRO and are considered to be a guide only.

The 30% increase is considered to be an upper limit based on DECCW guidelines; furthermore regional studies have concluded that change in runoff depths of -3 to 14% are projected for coastal regions in central NSW (DECCW 2008).

A climate change analysis was undertaken as a part of the flood study that included an increase in rainfall intensity of 15% and 30% for the 100 year ARI design storm, based on the DECCW guidelines.

Based on the sensitivity analysis, increases to the 100 year ARI levels can be up to 0.54 metres for 30% intensity increase and 0.29m for the 15% intensity increase. However, it is noted that this occurs primarily in localised areas such as those upstream of major culverts of the F3 freeway and Sparks Road. In the urban areas, the increase is generally lower than 0.2 metres; with some limited areas up to 0.3 metres (refer **Table 10.4**). See the Flood Study Addendum (Cardno 2010) for results of the flood level difference in map and tabular formats.

10.11 Climate Change – Use in FPL

The selection of appropriate FPLs based on climate change is challenging. Unlike traditional flood analysis, which has a probability of occurring at any given time, increases in ocean levels and rainfall will occur over a longer timeframe. Therefore, while increases in peak rainfalls are expected to occur over the next 100 years and further out, in the next 5 years there is unlikely to be any large change to the 100 year event.

This leads to challenges in the selection of FPLs which include climate change. It may be appropriate to select a FPL incorporating climate change based on the design life of a proposed structure or development. For example, a residential property may have a 50 year design life, and as such a 50 year outlook might be appropriate in the selection of a design storm event that includes predictions for climate change.

An alternative option is to investigate the potential for mitigation over time. For example, a property with a 50 year design life may be set at a 25 year outlook at present. However, it may be designed such that the floor level of the property can be raised to accommodate future climate change.

These are broader policy implications that need to investigate not only the setting of an FPL, but the adaptation of the community over time to the implications of climate change.

Climate change can be addressed during the approval phase of a development by undertaking a climate change assessment in the flood modelling of the proposed development. In this manner the various characteristics of the development and its relationship to the projected impacts of climate change can be addressed.

Nomination of a catchment wide control for climate change can be prescriptive and prone to issues with equity. For example, some areas of the catchment may be more prone to change in flood levels as a result of higher rainfall intensity than others. Setting a particular amount of freeboard or nomination of particular climate change flood extent can lead to flood controls that bring habitable floor levels close to the PMF. The economic cost of applying such controls can outweigh the risks. This is not the case for the Porters Creek catchment. It is shown in **Figure 10.2 and 10.3** that the extent and level of the PMF is greater than the 100 year + 15% climate change event.

Further discussion of the approach to incorporating controls to allow for climate change are discussed in **Section 10.16**.

10.12 Risk

The selection of an appropriate FPL also depends on the potential risk of different development types. For example, consideration should be given for different FPLs for industrial, commercial and residential properties, which have different implications should overfloor flooding occur.

Critical infrastructure, such as hospitals, fire stations, electricity sub-stations and other critical infrastructure, has wider spread implications should inundation occur. As such, FPLs are typically selected for these types of infrastructure that are higher than for residential, commercial or industrial properties. In the event of flood vulnerable members of the community can find it more difficult to cope with the stress and trauma of flood and require emergency access to

hospitals. Thus it is important that roads servicing the hospital and critical infrastructure be at a level such that flood will not prevent the ability for access.

10.13 Culvert Blockage

Culvert blockage has come to prominence with flooding in Wollongong in the late 1990s and other similar catchments where reasonably large culverts were blocked from debris floating down the creek. In the lower parts of the catchment, the debris is likely to be a mixture of anthropogenic and natural sources.

The Porters Creek catchment includes a number of large culverts below the F3 freeway, the Northern Railway, Sparks Road and the Pacific Highway. The sensitivity of flood levels to a 50% blockage factor was modelled as part of the Flood Study Addendum and results are shown in **Table 10-4.**

10.14 Revegetation of Natural Floodways

The Porters Creek catchment includes expansive floodways in the landscape that remain naturally vegetated with thick low lying scrub. Some parts of the floodways have been cleared and remain cleared for uses such as grazing. Over time it is predicted that the grazing uses will end and the floodways will naturally revegetate with similar vegetation and to the existing scrub. As a result the existing roughness will increase as a result of the revegetation. Sensitivity of flood levels to the increase in roughness was assessed in the Flood Study Addendum (Cardno 2010) and found the increases in roughness had little effect on the estimated flood levels. Refer to **Table 10-4** for details.

Table 10-4: Model Sensitivity with 100 year ARI benchmark*

Sensitivity Factor	100 year + 15%	100 year + 30%	50% Blockage	Roughness Increase
Overall Average level difference (m)	0.02	0.12	0.05	0.03
Maximum level difference (m)	0.29	0.54	0.81	0.23
Minimum level difference (m)	0.00	0.00	-0.13	-0.07
Area with land difference less than 0.1 metre	93%	48%	77%	88%
Area with land difference less than 0.2 metre	98%	94%	96%	99%
Area with land difference less than 0.3 metre	100%	96%	96%	100%

* Positive values represent an increase in levels based on results from the Reference Points identified in the Flood Study Addendum (Cardno 2010).

10.15 Freeboard Selection

As outlined in **Section 10.3**, a freeboard ranging from 0.3 - 0.5 metres is commonly adopted in determining the FPL. It should be realised that the freeboard accounts for uncertainties in deriving the design flood levels and as such should be used as a safety margin for all designed flood. This consideration may result in the adopted FPL being higher than the PMF in certain cases. However, given the inherent purpose of freeboard, the FPL should still be used in cases. The freeboard may account for factors such as:

- Accuracy of model inputs (e.g. accuracy of ground survey, accuracy of design rainfall inputs for the area)
- Model sensitivity (roughness and afflux)
- Local flood behaviour (e.g. due to local obstructions etc)
- Wave action (e.g. such wind-induced waves or wash from vehicles or boats)
- Culvert blockage
- Climate change (affecting rainfall and ocean water levels).

The accuracy of ground survey used in the modelling is generally of the order of +/-0.01 m for each point surveyed. The accuracy of the aerial survey has been found to be less accurate than ground survey as discussed in the flood study addendum. Accordingly the surface of the ALS was lowered by 0.3 m for densely vegetated areas of the floodplain (Cardno 2010). For areas external to those densely vegetated accuracy can be expected to be approximately +/- 0.15 m. The accuracy of the rainfall inputs is more difficult to translate to a level of accuracy.

The impact of various elements factored into a freeboard can be summarised as follows:

- Uncertainty in flood Modelling – difficult to estimate accurately however the sensitivity analysis indicates that variations of up to 0.23m could be expected as a result of roughness variations and 0.81m as a result of culvert blockage.
- Wave action as a result of heavy vehicles and/or boats passing through flood waters 0-0.1m
- Afflux (local increase in flood level due to a small local obstruction not accounted for in the modelling) (0.1m) (adopted from Gillespie (2005))
- Accuracy of ground/ aerial survey ~ +/-0.15m
- Climate change – Sea Level Rise – this generally does not impact on the properties within the catchment.
- Climate Change – rainfall increases – generally it would be recommended to incorporate climate change in the flood planning level, rather than through a freeboard.

These factors are not expected to be cumulative, i.e. it is unlikely that all factors would be relevant for a given location within the catchment at the same time. Based on this analysis, the likely variation of flood levels for Porters Creek Catchment is in the order of 500mm, excluding climate change. This would suggest that a freeboard allowance of 500mm would be appropriate for Porters Creek.

In addition to the standard 500mm freeboard, it may be appropriate to adopt a freeboard to account for climate change. Climate change is typically undertaken in a case by case assessment of specific locations throughout a catchment. However in the Porters Creek Catchment the increases in flood levels are generally less than 200mm for the case where rainfall intensity is increased by 30% and generally less than 100mm for the 15% intensity increase. Therefore the change to flood levels is minor and it is reasonable to include climate change in the planning level for the catchment as a whole.

10.16 Flood Planning Level Scenarios

A selected number of FPL scenarios have been assessed, to test the implications on the floodplain, in regards to the number of existing buildings which are below this level as well as the flood protection provided in various design events.

Table 10-5 summarises potential benefits for the setting of various flood planning levels (FPL) options with freeboards. Note that vacant lots are not included in floor level calculations and the results do not differentiate between the floor levels of residential properties compared to commercial or industrial buildings.

Table 10-5: Selected Flood Planning Level Scenarios & Impact on Properties

Description	100yr + 0.3m	100yr + 0.5m	100yr + 15% + 0.5m	PMF	20yr + 0.5m
Total number of properties evaluated (Non-Vacant Lots)	300	300	300	300	300
Number of properties which are below the FPL	65	292	292	129	289
Percentage of total number of properties	21.7%	97.3%	97.3%	43.0%	96.3%

Note – The assessment presented in this table is limited to the available floor level information used in the economic damage analysis

The results indicate that a reasonable proportion of properties within the catchment area have floor levels that would need to be raised, if they were redeveloped, to satisfy the five FPL scenarios above. Both the 100 year ARI plus 300mm freeboard and 500mm freeboard scenarios do assist in reducing the number of properties at risk during events larger than the 100 year ARI event.

10.17 Flood Planning Level Recommendations

Based on the preceding assessment, and following extensive discussions with Wyong Shire Council, it is recommended that the flood planning level (FPL) for residential, commercial and industrial areas be based on the 100 year + 15% climate change event. Some councils have adopted higher frequency ARIs (such as the 20 year ARI) for commercial or industrial properties, based on the perception of risk. However, the values reported in **Table 10-3** show that the 100 year ARI is on average 0.16m higher than the 20 year ARI. Therefore, it is recommended to adopt the 50 year ARI level for the additional risk protection for commercial and industrial properties.

The impact of climate change to flood levels is spread across the catchment at low levels. The management of risk as a result of climate change can be applied to the catchment globally with little change to the levels of the 100 year ARI. The 100 year + 15% event, for the most part, has an impact of 100mm to the 100 year ARI as shown in **Table 10-4**. The water level impacts of the 100 year + 30% are more extensive and local guidelines suggest that a rainfall intensity increase of 15% is more likely for the central coast.

It is therefore recommended that an allowance for climate change is included in the flood planning level. It is more appropriately incorporated in the flood planning level, rather than the freeboard, as it is variable across the catchment and would therefore unfairly penalise some

properties within the catchment if a freeboard were adopted. It is recommended that selection for the FPL be based on the extent for the 100 year ARI plus 15% rainfall intensity increase with 500mm freeboard. Nomination of this FPL will be defined in the specific flood planning matrix to be included in Council's Flood Policy, DCP chapter no. 113.

11 Floodplain Risk Management Options

11.1 Overview of Available Measures

Flood risk can be defined as being existing, future or residual risk:

- Existing flood risk - the existing problem refers to existing buildings and developments on flood prone land. Such buildings and development by virtue of their presence and location are exposed to an 'existing' risk of flooding.
- Future flood risk - the future problem refers to buildings and developments that may be built on flood prone land in the future. Such buildings and developments may be exposed to a 'future' flood risk, i.e. a risk would not materialise until the developments occur.
- Continuing risk of flooding - the continuing problem refers to the 'residual' risk associated with floods that exceed management measures already in place, i.e. unless a floodplain management measure is designed to withstand the Probable Maximum Flood, it will be exceeded by a sufficiently large flood at some time in the future.

The alternate approaches to managing risk are outlined in **Table 11-1**:

Table 11-1: Flood Risk Management Alternatives

Alternative	Description
Preventing/Avoiding risk	Setting the planning level at the Probable Maximum Flood or not allowing development to be within the floodplain
Reducing likelihood of risk	Relying on structural measures to reduce risk (possibly not viable for planning levels in the floodplain). The potential for implementation of flood modification options is limited by economic, social and environmental constraints.
Reducing consequences of risk	Using development controls - design of structures to withstand flooding, allows a floodplain to be developed in lower areas.
Transferring risk	Via insurance
Financing risk	Through natural disaster funding.
Accepting risk	Regardless of the options implemented, a continuing risk will be present.

Measures available for the management of flood risk can be categorised according to the way in which the risk is managed. As a result, there are three types of measures for the management of flooding:

- Flood Modification Measures (for the existing risk)
- Property Modification Measures and Flood Policy Modification (for the future risk)
- Emergency Response Modification Measures (for the residual risk).

11.1.1 Options Identified by the Community

A community survey was undertaken by delivering questionnaires to residents as discussed in **Section 4**. The survey provided an insight into the community's awareness of flooding and allowed the residents to provide comments and suggestions on proposed flood management

options. A summary of the responses to various management options is presented in **Section 4.1.3**.

11.2 Flood Modification Measures

Based on the community questionnaire, historical flood information, flood study results, and field inspections of the catchment, possible flood modification options (i.e. structural options) for various locations within the floodplain were identified and are listed in **Table 11-2**. Figures are provided for each option to provide further information.

It should be noted that the drainage network has not been incorporated into the modelling as discussed in the 2009 Flood Study (Cardno 2009). In addition the Aerial Laser Survey data was used to model the existing topography can be inaccurate in some areas as discussed in the Flood Study Addendum (Cardno, 2010). It is recommended that for any option that is considered additional investigations be undertaken into the topography, through detailed survey and consideration of the storm water pit and pipe network in that area.

Table 11-2: Flood Modification Options

ID	Location	Option Description	Figure No.
Floodplain Modification Options **These options primarily focus on increasing capacity of the floodplain and/or drainage system to mitigate flood risk to surrounding properties. The measures identified include detention basins, overland flowpaths, levees and increased capacity of road crossings. It was generally assumed that the existing culverts at crossings would be duplicated, or doubled in capacity.**			
1.1*	Alison Road and bridge over Porters Creek	Construct a levee in parallel to Alison Road at 6m AHD and provide a flood gate across Porters Creek approx 100m upstream of the Wyong River confluence. This will prevent backwater from Wyong River inundating the Porters Creek floodplain during storm events. A significant volume of flood storage will then become available for the Porters Creek catchment that would normally be inundated by flood water from Wyong River. The impact on flooding of Wyong River has not been considered for this option and should be investigated if this option is to be considered further.	11.1
1.2*	Kanwal Oval Detention Basin	Construct a detention bund around Kanwal Oval and undertake cut and fill across the oval to create a detention basin of approx 1.5m in depth and a volume of approximately 20,000m^3. The existing trunk drainage system runs under the oval and connects to the Pearce Road culvert. The drainage system can be utilised to provide hydraulic control of the basin to detain overland flows up to and including the 20 year ARI. It should be noted that there are already plans to upgrade the Pearce Road culvert to convey the 100 year ARI as part of Section 94 Plan.	11.2
1.3*	Skyhawke Ave Detention Basin ^	A subdivision has taken place in this location that involved development of a detention basin upstream of Skyhawke Avenue. In addition a 3.3 x 0.9m box culvert was constructed in conjunction with a sub-division from Georgia Drive to Cessna Place. These two existing catchment changes were	11.3

ID	Location	Option Description	Figure No.
		included to assess their impact on flood levels.	
1.4*	Pacific Highway at Kanwal Wetland	Construct a levee along eastern boundary of properties on Lomandra Terrace and provide greater capacity in the natural channel downstream of Kanwal Wetland. The channel capacity is increased to convey the 20 year ARI flow. This is proposed to reduce flood inundation of properties along Lomandra Terrace. A sub-division has been approved on the southern side of the channel that will involve filling within the 1% AEP flood extent. Increase of channel capacity should be investigated to compensate for the sub-division filling.	11.4
1.5*	Buttonderry Creek crossing at Hue Hue Road	Raise the road crown level of Hue Hue Road to the FPL in order to make the road crossing over Buttonderry Creek trafficable for the events up to the 100 year ARI. No additional hydraulic capacity under Hue Hue Road can be included in order to prevent potential flood impacts to the proposed Warnervale Industrial Park sub-division.	11.5
1.6*	Hue Hue Road culvert at Jilliby	Raise the road crown level of Hue Hue Road to the FPL in order to make the road crossing at Jilliby trafficable for the events up to the 100 year ARI.	11.6
1.7*	Warnervale Station culverts	Raise the road crown level of Warnervale Road in 2 locations to the east of the Railway and adjacent to Virginia Road. Existing culvert capacity has been nominally doubled to increase hydraulic capacity and the road crown has been raised to the level of the 100 year ARI in both locations.	11.7
1.8	Woongarrah Creek crossing at Warnervale Road	Raise the road crown level of Warnervale Road at the Woongarrah Creek crossing and provide a new culvert to increase serviceability of road and reduce flood risk to adjacent property. This option also includes some low level earth bunds upstream of Warnervale road to prevent flood water increase to adjacent property.	11.8
1.9	Bingarrah Creek crossing at Minnesota Road	The road in this location currently acts as a causeway in storm events and is not trafficable in frequent storm events. It is proposed to raise the road crown level at Bingarrah Creek crossing and provide a series of culverts to increase serviceability of road up to and including the 100 year ARI.	11.9
1.10	Natural Channel Maintenance	Floodways in the eastern part of the catchment are broad and do not commonly contain defined channels. As a result flows are likely to become retarded as they spread out into thickly vegetated floodways. Flood flows are attenuated by accumulation of sediment and debris at stormwater outlets and major road crossings such as the Pacific Highway, Warnervale, Louisiana and Minnesota Roads. Maintenance is a suitable method to remove the accumulation of sediment and debris to reduce flood flow attenuation. This option would also improve the water quality entering the floodplain through removal of introduced sediment from urban run-off. A plan of	n/a

ID	Location	Option Description	Figure No.
		management for each natural flowpath will also be required for 3 flowpaths including Woongarrah Creek, Bingarah Channel and the flowpath in parallel to Warnervale Road connecting to Woongarah Creek. The assumptions made for undertaking this option were to allow for sediment and weed removal from 10 locations where major culverts were located within residential areas. For each location clearing of and removal of 100m^3 to a general waste facility.	
Levee Banks **These options include construction of levee banks to protect fringes of the floodplain where over-floor flooding is experienced. It is not necessary to model these options as it they can be assessed without the need for numeric model assessment, and they are not expected to adversely affect flooding in these areas.**			
2.1	Lucca Road Levee extension	A levee exists surrounding several industrial properties to prevent flood ingress from the Porters Creek floodplain. It is proposed that the levee shall be extended to protect existing industrial properties along Lucca road. This will be completed by construction of an earth bund along the rear property boundary up to a level of 6.5m AHD to protect property from the 100yr ARI flood level of 6.2m AHD.	11.10

* Indicates detailed hydraulic modelling of this option to be undertaken

^ Denotes an existing flood modification measure

11.3 Property Modification Options

11.3.1 P1 - LEP Update

Local environmental plans prepared by councils guide planning decisions for local government areas. Through zoning and development controls, they allow councils to supervise the ways in which land is used. The Wyong LEP 1991 is discussed in detail in **Section 9**. Items for inclusion into the LEP for zoning purposes would be the extent of the 100 year ARI + 15%, hydraulic hazard and hydraulic categories.

11.3.2 P2 – Building and Development Controls

The key document for flood related controls is the draft Flood Management Policy - DCP no 113 (**Section 9.2.1**). This document recommends the adoption of policies for catchments once a floodplain risk management study and plan have been prepared.

Recommended controls have been provided in **Section 9** and the location of specific development areas is shown in **Figure 8.1**. It is recommended that these be adopted for general flood related requirements for the Porters Creek Catchment. The type of controls to be applied to a specific site will depend on the location of the land with respect to the Flood Hazard. Refer to **Figure 10.4** for the flood planning categories and the Flood Planning Matrix included in **Appendix D** for the controls that apply to the planning categories.

11.3.3 P3 – House Raising

House raising is a possible option to reduce the incidence of over-floor flooding in properties. In the Porters Creek catchment the majority of properties in the urban areas of the catchment have been constructed according to the Flood Planning Levels of the time and are free of flood inundation for events up to and including the 100 year ARI. However, there are several existing properties in rural and rural residential areas that experience over floor flooding during the 5 year ARI that could be candidates for house raising. Industrial properties that experience over floor flooding are located on Lucca Road North Wyong and management of flood risk for these has been recommended by Option 2.1. As a result house raising excludes industrial properties in the Porters Creek catchment.

Whilst house raising can reduce the occurrence of over-floor flooding, there are issues related to the practice including:

- Difficulties in raising some houses (such as slab on ground). In some slab on ground situations, it may be possible to install a false floor, although this is limited by the ceiling heights. Approximately 50% of the properties surveyed were slab on ground, the others were founded on piers.
- The potential for damage to items on a property other than the raised dwelling (such as gardens, sheds and their contents, garages, cars, etc).
- Unless a dwelling is raised above the level of the PMF, the potential for above floor flooding still exists (i.e. there will be a residual risk).
- Evacuation may be required (e.g. medical emergency during a flood event) even if no above floor flooding occurs. This evacuation is likely to be hampered by floodwaters surrounding a property.
- The need to ensure the new footings and piers can withstand flood-related forces.
- House raising is generally only suitable for low hazard areas, however all properties have been considered as part of this assessment.
- Potential conflict with height restrictions imposed for a specific zone or locality within the local government area (for properties to be raised a significant level, e.g. greater than 1m).

For a single storey, slab on ground property, the flooding damage that occurs for over-floor flooding of depths 0 to 0.5 metres is estimated as $45,000 based on recent house raising works undertaken by Pittwater Council.

Table 11.3 provides the approximate Annual Average Damage (excluding overground-only damage) for over-floor flooding commencing in different ARI events for individual residential properties.

Table 11.3 also demonstrates that properties with over-floor flooding in less frequent events are not exposed to flood damages as frequently, and hence the annualised damage for that property is not as significant.

Table 11-3: Estimates of AAD and NPV for Different Over-floor Flooding Scenarios

Event in which Over-floor Flooding Commences	Number of Properties with Over-floor Flooding*	Annual Average Damage per Property	NPV (50 years) per Property
5 year	13	$8,434	$116,395
10 year	13	$5,718	$78,913
20 year	14	$2,893	$39,926
50 year	15	$1,854	$25,587
100 year	22	$536	$7,397
200 year	25	$288	$3,975
PMF	97	$200	$2,760

*based on number of residential properties, discussed in Economic Damage Analysis (**Section 7**). This excludes the industrial properties

In order for the house raising scheme to be equitable, the house raising should only occur by raising floor levels up to a suitable level so that overfloor flooding does not occur for the intended design storm level. If house raising were to occur for a higher level, then it is arguable that the properties experiencing over-floor flooding in the next ARI storm would be disadvantaged. For example, if only those properties in the 10 year ARI event were raised to the 100 year ARI event, this would disadvantage properties who have over-floor flooding in the 20 year ARI event as they would not be included in the house raising but still experience over-floor flooding in more frequent events than the 100 year ARI. As such it is considered appropriate for the properties experiencing overfloor flooding up to and including the 5 year ARI level to be raised 110mm higher than the 5yr ARI. 110mm is considered an appropriate amount of freeboard over the 5yr ARI level to ensure the property does not incur overfloor flooding.

The estimated cost of raising for these properties is estimated at $80,000 per house (based on recent work undertaken by Pittwater Council).

Funding for this option may occur jointly between Council, NSW Government and residents.

11.3.4 P4 - House Rebuilding

Under a re-building scheme, the property owner would have the option of utilising the subsidy for house raising described above for re-construction instead. In a number of cases, the ability to raise properties can be difficult and therefore rebuilding may be the only option. The advantage of this option is that the new structure can also be built in a flood compatible way (such as including a second storey for flood refuge).

One of the issues associated with this option is that there is still a significant cost for the property owner to redevelop their land. In addition, this provides an inequitable situation for those properties that are subject to the subsidy and those that are not. It can have the effect of skewing the property redevelopment market, where those properties subject to the subsidy are more attractive for development than those properties that are not.

11.3.5 P5 – Voluntary Purchase

An alternative to the construction of flood modification options and for properties where house raising is not possible is the use of voluntary purchase (VP) of existing properties. This option would free both residents and emergency service personnel and volunteers from the hazard of future floods. This can be achieved by the purchase of properties and the removal and demolition of buildings. Properties could be purchased by Council at an equitable price and only when voluntarily offered. Such areas would then need to be rezoned to a flood compatible use, such as recreation or parkland or possibly redeveloped in a manner that is consistent with the flood hazard. However, this option should be considered after other, more economical options have been investigated and exhausted.

The recommended criteria to determine properties that are eligible for voluntary purchase are:

- Property located in high hazard area for the 100 year ARI flood,
- Occurrence of above floor flooding in the 5 year ARI flood event, and
- Economic value of damages for a particular property is comparable to the property market value.

There are a total of 17 properties located in the high hazard area of the 100 year ARI and a total of 17 properties that have over floor flooding during the 5 year ARI design storm event.

The damages to a property which experiences overfloor flooding in a 5 year ARI is equivalent to approximately $116,395 in NPV terms (from **Table 11.3**). Typical prices of residential properties in the suburb of Warnervale are in the order of $478,000 (based on median property prices listed for the area through www.realestate.com.au as at November 2010). Voluntary purchase is not considered a viable option for commercial and industrial properties. Alternative methods such as Flood Proofing are more appropriate and are discussed below as option P7.

Table 11-4: Estimates of Property Value for voluntary purchase

Overfloor flooding event	TOTAL Over-floor Flooding*	# Residential Properties	Residential purchase value	Average price per property	AAD in NPV (50 years)
5 year	17	13	$6,214,000	$478,000	$116,395
10 year	17	13	$6,214,000	$478,000	$78,913
20 year	18	14	$6,692,000	$478,000	$39,926
50 year	19	15	$7,170,000	$478,000	$25,587
100 year	26	22	$10,516,000	$478,000	$7,397

Therefore, the cost of voluntary purchase of the one house with overfloor flooding in a 5 year ARI event is higher than the cost of annual average damages as shown in **Table 11-4**.

It is therefore recommended that this option focus on properties which experience overfloor flooding in a 5 year ARI event. While the savings are still lower than the costs, additional benefits (such as risk to life and flooding benefits to neighbouring properties) should also be considered. It is noted that properties experiencing overfloor flooding in the 5 year ARI are located in clusters such as those on Alison Road Wyong and Rolfe Avenue, Kanwal.

It should be noted that voluntary purchase only benefits a few properties, and not the wider floodplain. This effectively results in an inequitable distribution of Council funds. By comparison, some of the flood modification options may in fact be less expensive and benefit the wider floodplain.

11.3.6 P6 – Land Swap

An alternative to voluntary purchase is the consideration of a land swap program, whereby Council swaps a parcel of land in a non-flood prone area for the flood prone land. After the land swap, Council would then arrange for demolition of the building and have the land rezoned to open space, or similar, undergoing studies to enable for rezoning. This may be a possibility within the Porters Creek catchment considering the areas to the north and east of the catchment i.e. Warnervale Town Centre and Precinct 7A. An allowance would be provided for rebuilding on a suitable lot of Council owned property. There is not considered to be a cost incurred to Council as a result of the land exchange alone considering Council would demolish the existing flood affected property and convert to open space.

This option would be suitable for residential property considering the availability of existing and future residential lots in the area. The construction of a 3 bedroom dwelling is estimated to be $220,000 based on research of current project home value (www.realestate.com.au). Demolition and materials disposal/recycling of the flood affected house and materials is estimated to be $20,000.

Table 11-5: Estimates of Land Swap Cost

Overfloor flooding event	Residential Properties Affected	Land Swap Cost	AAD in NPV (50 years)	Total AAD in NPV
5 year	13	$ 3,120,000	$ 767,446	$9,976,804
10 year	13	$ 3,120,000	$ 196,098	$2,549,269
20 year	14	$ 3,360,000	$ 97,507	$1,365,097
50 year	15	$ 3,600,000	$ 60,826	$912,390
100 year	22	$ 5,280,000	$ 17,760	$390,711

11.3.7 P7 – Flood Proofing

Flood proofing involves undertaking structural changes and other procedures in order to reduce or eliminate the risk to life and property (and thus the damage caused by flooding). Flood proofing of buildings can be undertaken through a combination of measures incorporated in the design, construction and alteration of individual buildings or structures subject to flooding. These include modifications or adjustments to building design, site location or placement of contents. Measures range from elevating or relocating structures to the intentional flooding of parts of the building during a flood in order to equalise pressure on walls and prevent them from collapsing. There is also the opportunity to control extent of flood inundation on some of the larger rural residential properties in the western side of the catchment through bunding and levees. An example of this option is at Carlyle Close Jilliby where subtle bunding at the rear of the rural residential properties provides flood protection to a certain degree in a flood event.

Examples of flood proofing measures include:

- All structural elements below the Flood Planning Level shall be constructed from flood compatible materials;
- All structures must be designed and constructed to ensure structural integrity for immersion and impact of velocity and debris up to the level of the FPL event. If the structure is to be relied upon for 'shelter-in-place' evacuation then structural integrity must be ensured up to the level of the Probable Maximum Flood; and
- All electrical equipment, wiring, fuel lines or any other service pipes and connections must be waterproofed to the Flood Planning Level.

In addition to flood proofing measures that are implemented to protect a building, temporary/emergency flood proofing measures may be undertaken prior to or during a flood to protect the contents of a building. These measures are generally best applied to commercial or industrial properties as the availability of staff on-site to implement the measures makes them more viable. It is noted that there are 4 industrial properties which experience overfloor flooding in a 5 year ARI storm or greater on Lucca Road, North Wyong.

These measures should be carried out according to a pre-arranged plan. These measures may include:

- Raising belongings by stacking them on shelves or taking them to a second storey of the building.
- Secure objects that are likely to float and cause damage.
- Re-locate waste containers, chemicals and poisons well above the flood planning level.
- Install any available flood proofing devices (such as temporary levees and emergency water sealing of openings).

These measures may be provided as an alternative to structural option 2.1 described in **Table 11-2**.

The SES business *Flash Flood Tool Kit* provides business with a template to create a floodsafe plan and to be prepared to implement flood proofing measures. It is recommended that this tool kit is distributed to the flood affected businesses and community facilities within the Porters Creek floodplain and followed by Council/SES as part of ongoing flood awareness program.

11.4 Emergency Response Modification Options

The following emergency response modification options are suitable for consideration in the floodplain:

- Information transfer to SES (EM1)
- Preparation of Local Flood Plan & Update of DISPLAN (EM2)
- Flood warning system (EM3)
- Public Awareness and Education (EM4)
- Flood Warning Signs at Critical Locations (EM5)

11.4.1 EM1 - Information Transfer to SES

The findings of the flood study and the flood risk management study and plan provide an extremely useful data source for the State Emergency Service. Information could be provided from the findings of the study in two forms:

- Electronic information (in GIS format where applicable), including:
- Flood extent mapping ;
- Flood hazard mapping;
- Major access road overtopping and flooding, as per **Table 6-2**;
- Tables relating design storm ARIs with rainfall depths and intensities, to assist in predictions. Tables should also be prepared showing recent historical events and their approximate ARI. This will assist the SES in relating the size of a flood prediction to previous events when providing warnings to the community;
- Information on over-floor flooding in the catchment, and single storey properties with over-floor flooding; and
- Laminated plans (hard copies of flood extent and hazard mapping in laminated plan format) for use in the operations centre to assist with directing teams to the most likely affected localities. This can also help to overcome any issues associated with power loss or difficulty with accessing information in an emergency.

It would also be recommended that flood intelligence tables be prepared, providing details on response actions to be taken at different stages of flooding. These should be prepared together with the SES, and would result in a more efficient response from the SES during a flood.

11.4.2 EM2 –Update of DISPLAN and local flood plan

This option would provide more detail in the Wyong Local Flood Plan in light of the information provided in this report. Once warnings are triggered for one of the major systems then it would be prudent to consider neighbouring catchments and the likely impacts that may occur as a result.

11.4.3 EM3 - Flood Warning System

Residential areas of the Porters Creek catchment upstream of the lower floodplain have relatively short critical durations of 2 hours that make it difficult for emergency management staff to respond to warning systems. However the Porters Creek floodplain and Wyong River systems have much longer critical durations for design storms that would allow effective response time. An effective warning system could be achieved with the use of flood level and rainfall gauges connected to a telemetry system to send an alarm once flood levels reach a certain point or rainfall intensity has been sustained for a nominated duration. A flood level gauge has been installed by Council north of the Alison Road bridge over Porters Creek upstream of confluence with Wyong River and nearby rainfall gauges exists in Warnervale (Warnervale Road) and on Jilliby Jilliby Creek. These could be co-ordinated to disseminate alarms at the appropriate time to warn emergency management staff that flooding is imminent.

11.4.3.1 Wyong Community Christian School

Of particular concern is the warning system for Wyong Community Christian School, which is discussed in further in **Section 8.6**. The system requires update in light of the findings of this study and the following recommendations are made for inclusion in the update:

1. It is the responsibility of the school to update the flood plan and this should be completed in conjunction with Council and the SES. It is understood that new buildings of the school under construction are to be built above the level of the PMF. This is to be confirmed with the results of the Flood Study Addendum in communication with council.

2. The current flood warning system is to be replaced. The system is to be linked to available water level and rainfall gauges on both Wyong River and Porters Creek to warn the school in the case of the flood from both catchments

3. A demonstration of a flood evacuation is to be held at the school at least once per year. This is to be held in partnership with the SES and parents to improve flood preparedness. Parents are to be made fully aware that they must follow the orders of the school's flood warden and the SES at all times.

11.4.4 EM4 - Public Awareness and Education

Flood awareness is an essential component of flood risk management for people residing in the floodplain. The affected community must be made aware, and remain aware, of their role in the overall floodplain management strategy for their area. This includes the defence of their property and their evacuation in the flooding event, if required.

Flood awareness campaign should be an ongoing process and requires continuous effort of related organisations (e.g. Council and SES). The major factor determining the degree of awareness within the community is the frequency of moderate to large floods which have occurred recently. The more recent and more frequent the flooding, the greater the awareness. The majority of events causing the flooding in Porters Creek were recorded in October 2004, June 2007. The resident questionnaire described in **Section 4.1** indicates a moderate awareness of flooding amongst respondents (approximately 51%).

For effective flood emergency planning, it is important to maintain an adequate level of flood awareness during the extended periods when flooding does not occur. A continuous awareness program needs to be undertaken to ensure new residents are informed, the level of awareness of long-term residents is maintained, and to cater for changing circumstances of flood behaviour and new developments. An effective awareness program requires ongoing commitment.

It is recommended that the following awareness campaigns be considered for the floodplain. These should be prepared together with the SES, as they have a responsibility for community awareness under the DISPLAN:

- Preparation of a FloodSafe brochure. Such a brochure with a fridge magnet may prove to be a more effective means of ensuring people retain information
- Development of a Schools Package from existing materials developed by the SES and distribution to schools accordingly. Education at schools is not only useful in educating the students, but can be useful in the dissemination of information to the wider community.
- SES information day where the SES setup an information booth for the public to visit and inquire about the emergency related services in their area. Often the day is co-ordinated with Council with advertising in the local paper and on local radio.

A meeting of local Community groups could be used to arrange flood awareness programs on regular intervals.

Information dissemination is recommended to be included in Council rates notices for all affected properties on a regular basis.

Once prepared, the FloodSafe brochure can then be uploaded to the SES website (www.ses.nsw.gov.au) in portable document format (PDF) where it is available to everyone.

11.4.5 EM5 - Flood Warning Signs at Critical Locations

A number of public places in the catchment experience high hazard flooding in the 100 year ARI event. It is therefore important that appropriate flood warning signs are posted at these locations. The following locations have been identified for flood signs

- Alison Road Bridge over Porters Creek
- Alison Road, Western side of entry to Wyong Community Christian School.
- Minnesota Road Crossing/Causeway at Bingarrah Creek
- Warnervale Road Crossing at Woongarrah Creek

The signs will read “Do Not Drive Through Flood Water” and are currently being prepared through an agreement between the SES, Wyong Shire Council and Gosford Council.

Of particular importance are signs for the western and eastern approach to the Wyong Community Christian School. It is expected that evacuation during flood will occur by vehicle from Alison Road according to the Flood Evacuation Plan (**Section 8.6**) and effective notification to drivers needs to be provided to prevent crossing during flood.

11.5 Data Collection Strategies

DC1 – Post Flood Data Collection Form

This would involve the preparation of a flood data collection form and use of this form following a flood event. This would allow for more information to be gathered concerning the nature of flooding within the catchment, building on the knowledge included in the Flood Study.

12 Economic Assessment of Options

12.1 Hydraulic Impact of Options

The hydraulic impact of the structural options assessed is important to note and is displayed for the 100 year ARI in **Figures 12.1-12.7**. For structural options that were not modelled and non-structural options hydraulic impact is not available and it is necessary to assess their viability in relation to all the options identified. It is possible to quantitatively assess the economic benefit of most of the options (i.e. those which are hydraulically modelled and those with known benefits such as house raising). For those options, a benefit-cost ratio can be calculated. Further assessment of the options that can be assessed economically and those that cannot is completed in the multi criteria assessment in **Section 13.**

Table 12-1: Hydraulic Impact of Structural Options Modelled

Option	Reasoning	100 year ARI Water Level Impact
1.1	Porters Creek is a tributary of Wyong River and is subject to backwater from the river in the event of flood. Control of backwater ingress would allow for significant flood storage to become available that may have the potential to reduce flood risk for the catchment. A detention bund along Alison Road and flood gate on Porters Creek is required to control the ingress of backwater.	Increase of up to 50mm upstream of the flood gate. Increase of up to 20mm across the Porters Creek wetland. Decrease of approximately 160mm upstream of the railway. Nil impact in areas of catchment upstream of the floodplain.
1.2	A detention basin was chosen in this location to provide flood storage that may potentially alleviate flood risk to surrounding properties and increase serviceability of the Pearce Road crossing. Sports fields such as Kanwal Oval can easily be converted to basins by construction of a peripheral bund.	Decrease of 200mm downstream of Kanwal Oval. Reduced level by 100mm over the crown Pearce Road and as a result a flood depth of up to 200mm. Decrease of 25mm over the Pacific Hwy, flood depth 130mm as a result.
1.3	Existing development included in the structural options to assess the hydraulic impacts.	Increase of up to 0.9m in the detention basin. Decrease downstream of basin of approx 10mm. Decrease in level of up to 200mm along cosmos place with a depth of up to 150mm as a result.
1.4	A levee is proposed at the rear of flood affected properties of Lomandra Terrace along with augmentation of the natural channel. These structural options were chosen in place of others for their ease in construction, other options such as modifications to the Pacific Highway or the pedestrian bridge would be expensive.	Relief of flooding for properties along Lomandra Terrace. No impact over Pacific Hwy, flood depth is 250mm. General reduction in water level of 200mm in the natural channel except for an increase in level of 120mm upstream of the pedestrian bridge.
1.5	Hue Hue Road is flood affected and serviceability of the road is to be improved by inclusion of a	Level increased upstream by 1.6m. The road is still flood affected to a depth

Option	Reasoning	100 year ARI Water Level Impact
	bund on the upstream side of the road. Culvert capacity is not increased to reduce likely flood impact to the proposed industrial development downstream.	of up to 250mm as a result. Level decreased downstream by 300mm with some localised increases of up to 150mm along the road verge.
1.6	The inundation of Hue Hue Road in this location is controlled by raising the road level and increasing culvert capacity. This is considered the most economical option for increasing the serviceability of the road.	Level increased up to 520mm upstream. No road flooding as a result. Level decreased downstream by up to 120mm with some localised increases of 50mm.
1.7	The inundation of Warnervale Road is controlled in 2 locations to the east of Warnervale Station by raising the road level and increasing culvert capacity. This is considered the most economical option for increasing the serviceability of the road.	For the crossing adjacent to Warnervale Station the level is increased by 330mm upstream, no flooding over the road and decrease of 50mm downstream. For the crossing to the east of Virginia Rd level reduced upstream by 300mm, no flooding over road and increase of 50mm downstream.

For further details of the structural option see Table 11-2.

12.2 Preliminary Costing of Options

A summary of the estimated capital costs for those options which have been quantitatively assessed is provided below in **Table 12.1**. Details of these costings are provided in **Appendix B**. These cost estimates have been based on experience and Cordells Building Cost Guide.

For other options, broad estimates were made for the purpose of comparison in the multi-criteria assessment. These are detailed in **Section 13**.

Prior to an option proceeding, it is recommended that in addition to detailed analysis and design of the options, these costs be revised prior to budget allocation to allow for a more accurate assessment of the overall cost. Detailed rates and quantities will also be required at the detailed design phase.

Table 12-2: Costs of Quantitatively Assessed Options

Option ID	Capital Cost Estimate	*Recurrent Cost Estimate	Details
1.1	$3,919,100	$100,000	Alison Road Levee and Porters Creek Flood Gate
1.2	$279,100	$5,000	Kanwal Oval Detention Basin
1.4	$725,600	$12,000	Pacific Highway at Kanwal Wetland
1.5	$595,200	$5,000	Buttonderry Creek crossing at Hue Hue Road
1.6	$419,100	$7,500	Hue Hue Road Culvert at Jilliby
1.7	$689,600	$15,000	Warnervale Road Culverts

Option ID	Capital Cost Estimate	*Recurrent Cost Estimate	Details
2.1	$545,000	$10,000	Luca Rd Levee Extension
P3	$640,000	$35,000	House Raising of 8 properties - up to 5 year ARI
P5	$6,214,000	N/A	Voluntary Purchase - Council Redevelopment
P6	$3,120,000	N/A	Land Swap

*An example of recurrent cost includes inspections and clearing of debris on an annual basis

12.3 Average Annual Damage for Quantitatively Assessed Options

In a similar fashion to that discussed in **Section 7**, the total damage costs were evaluated for each of the options assessed by hydraulic modelling (quantitative assessment). The average annual damage (AAD) after the option is constructed is shown comparatively against the existing case in **Table 12-3**.

Table 12-3: Average Annual Damage for Quantitatively Assessed Options

Option ID	Details	Design AAD	Existing AAD	Reduction in AAD (Existing AAD – Design AAD)
1.1	Alison Road Levee and Porters Creek Flood Gate	$890,619	$934,376	$43,757
1.2	Kanwal Oval Detention Basin	$930,508	$934,376	$3,868
1.4	Pacific Highway at Kanwal Wetland	$924,769	$934,376	$9,607
1.5	Buttonderry Creek crossing at Hue Hue Road	$925,725	$934,376	$8,651
1.6	Hue Hue Road Culvert at Jilliby	$933,084	$934,376	$1,292
1.7	Warnervale Road Culverts	$933,236	$934,376	$1,140
2.1	Luca Rd Levee Extension	$330,274	$934,376	$604,102
P3	House Raising up to 5 year ARI	$799,091	$934,376	$135,285
P5	Voluntary Purchase - Council Redevelopment for 5 year ARI	$697,835	$934,376	$236,541
P6	Land Swap for properties up to 5 year ARI	$697,835	$934,376	$236,541

The results shown in **Table 12-3** indicate that the maximum reduction in average annual damage (AAD) is approximately $840,269 (compared with an existing case with an AAD of $934,376 (90%)). This reduction, for Option P5 (Voluntary Purchase – Council redevelopment) provides a significant decrease in damage. The Lucca Road Levee and Voluntary Purchase options (Option 2.1 and P5) also provide a significant reduction in damages. This is primarily the result of the 4 large industrial properties experiencing overfloor flooding in a 5 year ARI on Lucca Road North Wyong that incur a high damage value as a result.

Whilst the AAD is reduced to various degrees for different options, this reduction needs to be offset against the capital and recurrent costs of the option. This is described below.

12.4 Benefit Cost Ratio of Options

The economic evaluation of each modelled option was assessed by considering the reduction in the amount of flood damage incurred by various events and comparing this value with the cost of implementing the option.

The existing condition (or the 'do nothing' option) was used as the base case to compare the performance of modelled options. Inputs for the assessment include those data reported in **Section 7** derived from a floor level and property survey along with damage curves derived for other, similar areas. The PMF, 100 year, 50 year, 20 year, 10 year, and 5 year ARI events were considered for this evaluation. Preliminary costs of each option were prepared **(Table 12-2)** and a benefit-cost analysis of each option was undertaken on a purely economic basis.

Table 12-4 summarises the overall economics for each option that was able to be economically assessed. The indicator adopted to rank options on economic merit is the benefit-cost ratio (B/C).

- Where the B/C is greater than 1 the economic benefits are greater than the cost of implementing the option.
- Where the B/C is less than 1 but greater than 0, there is still an economic benefit from implementing the option but the cost of implementing the option is greater than the economic benefit.
- Where the B/C is equal to zero, there is no economic benefit from implementing the option.
- Where the B/C is less than zero, there is a negative economic impact of implementing the option.

Table 12-4: Summary of Economic Assessment of Management Options

Option ID	AAD	Reduction in AAD due to Option	NPW of Benefit	Capital Cost Estimate	Recurrent Cost Estimate	NPW of Option	B/C Ratio
1.1	$890,619	$43,757	$603,879	$3,919,100	$100,000	$5,299,175	0.11
1.2	$930,508	$3,868	$53,381	$279,100	$5,000	$348,104	0.15
1.4	$924,769	$9,607	$132,584	$725,600	$12,000	$891,209	0.15
1.5	$925,725	$8,651	$119,390	$595,200	$5,000	$664,204	0.18
1.6	$933,084	$1,292	$17,831	$419,100	$7,500	$522,606	0.03
1.7	$933,236	$1,140	$15,733	$689,600	$15,000	$896,611	0.02
2.1	$330,274	$604,102	$8,337,058	$545,000	$10,000	$683,007	12.21
P3	$799,091	$135,285	$1,867,034	$640,000	$35,000	$1,123,026	1.66
P5	$697,835	$236,541	$3,264,442	$6,214,000	N/A	$6,214,000	0.53
P6	$697,835	$236,541	$3,264,442	$3,120,000	N/A	$3,120,000	1.05

NPW – Net Present Worth is calculated using 7% interest over 50 years.

The benefit-cost analysis shown in **Table 12-4** indicates that the following options have a benefit cost ratio of greater than 1:

- Option 2.1 – Extension of existing levee at Lucca Road North Wyong
- Option P3 – House Raising (Residential only) – up to 5 year ARI
- Option P6 – land swap for residential properties affected by the 5 year ARI

It is important to note that Option P3 may not be feasible in all situations. For example, there are limited options for house raising for slab on ground properties, of which there are a number in Porters Creek. As a result the house raising has only been considered for non-slab on ground properties according to the information provided by the floor level survey.

The remaining options listed in **Table 12-4** show varied levels of economic benefit, but all have benefit-cost ratios less than 1. However, these options may provide other social and environmental benefits, which are accounted for in the multi-criteria matrix assessment in **Section 13**.

Further, those options listed above that have a benefit-cost ratio greater than 1, may have other limitations, such as minor flood level increases, environmental impacts and lack of community support. These have been taken into account in the multi-criteria assessment.

12.5 Economic Assessment of Desktop Assessed Options

Given the overall benefits of those options where a desktop assessment was utilised (as opposed to hydraulic modelling), a detailed economic analysis was not undertaken. Instead, a judgement on the economic benefits of the options was made. This is described in **Section 13**.

13 Multi-Criteria Matrix Assessment

13.1 Overview

A multi-criteria matrix assessment approach was adopted for the comparative assessment of all options identified using a similar approach to that recommended in the *Floodplain Development Manual* (2005). This approach to assessing the merits of various options uses a subjective scoring system. The principle merits of such a system are that it allows comparisons to be made between alternatives using a common index. In addition, it makes the assessment of alternatives "transparent" (i.e. all important factors are included in the analysis). However, this approach does not provide an absolute "right" answer as to what should be included in the plan and what should be omitted. Rather, it provides a method by which stakeholders can re-examine options and, if necessary, debate the relative scoring assigned.

13.2 Scoring System

A scoring system was devised to subjectively rank each option against a range of criteria given the background information on the nature of the catchment and floodplain outlined in **Section 6** as well as the community preferences outlined in **Section 4**. The scoring is based on a triple bottom line approach, incorporating economic, social and environmental criterion.

The criterion adopted includes:

Economic	Benefit Cost Ratio
	Capital and Operating Costs
	Reduction in Risk to Property
Social	Reduction in Social Disruption
	Reduction in Risk to Life
	Community Acceptance
	Compatible with Policy and Plan
Environmental	Meeting of Flow and Water Quality Objectives
	Fauna/ Flora

The scoring system is shown in **Table 13-1** for the above criteria.

Table 13-1: Details of Adopted Scoring System

Category	Category Weighting	Criteria	Criteria Weighting	Score				
				-2	-1	0	1	2
Economic	1	Benefit Cost Ratio	0.5	0 to 0.5	0.5 to 1	1	1 to 1.5	>1.5
		Capital and Operating Costs	0.25	>$2 million	$500,000 - $2 million	$200,000 - $500,000	$50,000 - $200,000	$10,000 - $50,000
		Reduction in Risk to Property*	0.25	Major increase in AAD	Slight increase in AAD	No Improvement	Slight decrease in AAD	Major decrease in AAD
Social	1	Risk to Life	0.3	Major increase in risk to life	Slight increase in risk to life	No change in risk to life	Slight reduction of risk to life	Major reduction of risk to life
		Serviceability of major road crossing	0.3	Major decrease in road serviceability	Slight decrease in road serviceability	No change to road serviceability	Slight increase in road serviceability	Major increase in road serviceability
		Community support	0.2	Strong disagreement	Disagreement	Neutral/No response	Support	Strong support
		Compatible with Policies and Plans	0.2	Completely incompatible	Slightly incompatible	Neutral	Compatible	Completely Compatible
Environment	1	Compatible with Water Quality and Flow Objectives	0.5	Completely incompatible	Slightly incompatible	Neutral	Compatible	Completely Compatible
		Fauna/Flora Impact	0.5	High negative impact	Slight negative impact	No impact	Some benefit	Considerable benefit

*Values of likely AAD reduction assumed where actual assessment not undertaken

13.2.1 Economic Assessment Overview

The economic assessment involved an appreciation of:

- Benefit Cost Ratio;
- Capital and Operating Costs; and
- Reduction in Risk to Property.

Capital and operating costs for options were hydraulically assessed as described in **Section 12.1**, whilst a judgement of the likely capital and recurrent costs was made for the remaining options by experienced engineers.

It is noted that the Benefit Cost Ratio incorporates both the capital & operating costs, and the reduction in the Risk to Property. However, these are included to provide an overall measure of both the affordability of an option (the magnitude of the cost) as well as the overall benefit of the option. The Benefit Cost Ratio, while providing a representation of the economic efficiency of the option, does not provide this information.

13.2.2 Social Impact Assessment

The social impact assessment involved an appreciation, based on the information collated in **Section 4**, of:

- Road Serviceability;
- Reduction in Risk to Life;
- Compatibility with Policy and Plans; and
- Community Support.

In general, there is a moderate level of flood awareness in the community. The nature of the population in the area is such that the population is growing steadily with further growth expected. In the 2006 census a growth of 1.6% was recorded for the Wyong Shire LGA. The Warnervale and Hamlyn Terrace regions represent growth areas for the LGA that hold available land for continuous growth into the future in areas such as Precinct 7A and the Louisiana Road Infill Precinct (**Table 9.2**). However, regardless of the awareness in the area, the social disruption due to flooding (via the effects of property inundation, loss of access and inability to cross roads such as Warnervale and Minnesota Roads) remains present. Similarly, while there is an understanding of the potential for flooding, the reduction in the risk to life is an important criterion to be taken into account. This criterion is highly subjective as it is difficult to assess the behaviour of persons under extreme conditions such as flooding.

The community support for a particular option was derived by converting the community responses received in the consultation period **(Appendix A)** discussed in **Section 4** into a numerical score.

Wyong Shire Councils support of the different options was subjectively assessed through comparison with councils policy and plans.

[Both the Council and community support criteria will be updated following the exhibition period]

13.2.3 Environmental Assessment

The environmental impact assessment involved an appreciation, based on the information collated in **Section 5**, of both:

- Compatibility of the option with Water Quality and Flow Objectives, and
- Fauna/flora impact.

It is important to recognise that the watercourses and wetlands of the area need to be managed in a sustainable way, in recognition of the modified nature of the system. There is a regional IWCM strategy under design by Council. The strategy aims to protect the health of the Porters Creek wetland by emulating the pre-development hydrology. This is achieved with the implementation of constructed wetlands that incorporate both water quality and treated stormwater storage and re-use functions. The treated stormwater is reticulated in a pressure pipeline that is ultimately connected to Wyong River to supplement environmental flows (EDAW 2009). The flood management options were assessed for their compatibility with the IWCM strategy.

13.3 Multi-Criteria Matrix Assessment

The assignment of each option with a score for each criterion is shown in its entirety in **Appendix C**. The score for each category (i.e. economic, environment and social) is determined by the score for each criterion, factored by a weighting as shown in **Table 13-1**. The overall score for the option is then calculated by the weights for each of the categories.

Economic, social and environmental categories are given equal score weightings for the Porters Creek catchment.

A rank based on the total score was calculated to identify those options with the greatest potential for implementation. The total scores and ranks are also shown in **Appendix C**.

This ranking is proposed to be used as the basis for prioritising the components of the *Floodplain Risk Management Plan*. It must be emphasised that the scoring shown in **Appendix C** is not “absolute” and the proposed scoring and weighting should be reviewed carefully as part of the process of finalising the overall *Floodplain Risk Management Study and Plan*.

13.3.1 MCA Results and Discussion

It is clear from the ranking of the scores for the Multi Criteria Assessment that the options which have a high economic benefit for a relatively low capital cost outlay are the best performing options. This is evident for option 1.10 Natural Channel Maintenance receiving the highest ranking along with property modification options P1 Planning Controls – LEP update and P2 Development Controls. Option 1.10 achieved a high result due to the environmental value and support from the community as being the most preferred. Structural option 2.1, Lucca Road Levee, is the highest ranking of the structural options as it provides a high damage reduction through prevention of overfloor flooding for large industrial properties. Other high ranking options was P3 house raising as it is relatively economical to provide prevention of overfloor flooding for low level houses in the floodplain that are not slab on ground.

Structural options, other than 2.1, did not rank highly as they did not achieve high damage reduction figures in comparison to more economical property modification options such as House Raising (P3) and Land Swap (P6). Land Swap is not considered a viable option as it would require Council provision of developable, flood free land that is a valued resource that would not readily be swapped for a flood prone lot. As such Land Swap has been left out of the recommendations for inclusion in the Flood Risk Management Plan.

It is noted however that many of the structural options (1.5, 1.6, 1.7, 1.8 and 1.9) improve road serviceability and the benefit of their implementation did not perform well in the cost benefit analysis as they were not intended to relieve overfloor flooding. To balance out this inequity high scores for road serviceability were allocated, however this did not improve their ranking considerably. One of the key challenges in the catchment is the serviceability of roads such as Warnervale Road and Minnesota Road. This has been supported by outcomes of the resident questionnaire (**Section 4.1**) and the road risk assessment (**Section 6.5**). Options 1.8 and 1.9 are on the capital works program for Council and have been left out of the recommendations as a result. Option 1.5 is recommended as it will allow greater road serviceability for an alternate north-south access to the F3 Freeway during flood.

All of the emergency management options ranked in the mid range as they are relatively economical to implement and have high scores for reduction in risk to life. The community was less supportive of emergency management options, however this may be in response to lack of experience. Many residents would not be aware of the importance of the emergency response measures as they have not experienced an event greater than the 100 year ARI in recent history. The most significant event to occur recently was in June 2007 event was estimated to be similar to that of a 20 year ARI, see **Table 2-1,** and the October 2004 event had observed levels similar to a 100 year ARI in urban areas in the east of the catchment.

The following list of options is ranked for inclusion into the Flood Risk Management Plan:

1. Option P1 – Planning Controls
2. Option P2 – Development Controls
3. Option 1.10 - Natural Channel Maintenance
4. Option EM1 - Information Transfer to SES
5. Option EM2 – Revise the Wyong Local Flood Plan
6. Option EM3 –Wyong Community Christian School Emergency Management Plan Update
7. Option EM4 – Community Flood Awareness
8. Option EM5 – Signage at road crossings
9. Option DC1 – Data Collection Strategy
10. Option 1.5 – Raise Road Levels of Hue Hue Road at Buttonderry Creek Crossing
11. Option 1.8 - Warnervale Road Upgrade at Ebony Drive
12. Option 1.9 - Bingarrah Channel Crossing at Minnesota Road
13. Option P7 – Flood Proofing Controls
14. Option P3 – House Raising for non-slab on ground houses up to the 5 year ARI
15. Option 2.1 – Lucca Road Levee Extension

14 Qualifications

The following qualifications apply to this report:

- This report has been prepared by Cardno for Wyong Shire Council and as such should not be used by a third party without proper reference.
- The investigation and modelling procedures adopted for this study follow industry standards and considerable care has been applied to the preparation of the results. However, model set-up and calibration depends on the quality of data available. The flow regime and the flow control structures are complicated and can only be represented by schematised model layouts. Hence there will be a level of uncertainty in the results and this should be borne in mind in their application.
- The terrain used in the modelling has been based on ALS data supplied by Council. The accuracy of the data is not of an acceptable standard for detailed studies as per finding in the Flood Study Addendum (Cardno 2010). It is recommended that ground survey should be undertaken to support any further modelling.
- The modelling of pits and pipes in this study has not been included. It is recommended additional modelling be undertaken for future detailed studies and for structural option design.
- All options presented in this report are at a concept level only.
- Study results should not be used for purposes other than those for which they were prepared.
- All cost estimates prepared in this study are at a preliminary concept level only. These should be verified prior to undertaking detailed design.

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Figures

Appendix A

Resident Survey

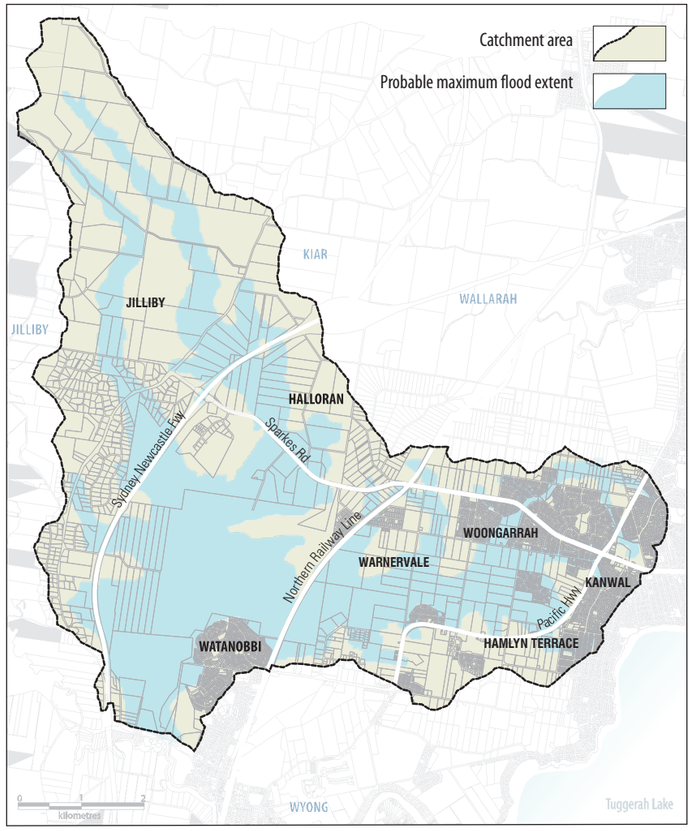
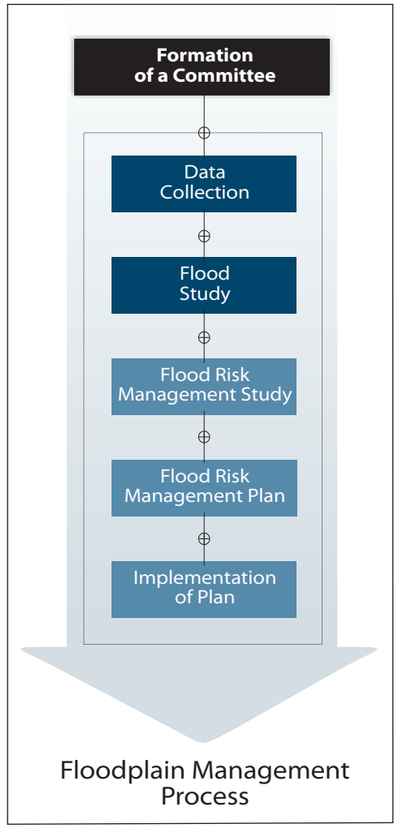


Figure: The Study Area



Floodplain Management Process

If you have any further comments that relate to the Porters Creek Floodplain Risk Management Study and Plan, please provide them in the space below (or attach any additional pages):

Please return this questionnaire page in the enclosed 'reply paid' envelope by Friday, 29 Jan

Contact Us

YOUR PERSONAL INFORMATION WILL REMAIN CONFIDENTIAL

If you have any queries, please contact:

Wyong Shire Council
Shah Alam
P: (02) 4350 5710
F: (02) 4351 2098
E: SAlam@wyong.nsw.gov.au

Cardno
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Gordon NSW 2072
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F: (02) 9499 3033
E: louise.collier@cardno.com.au
E: rhys.thomson@cardno.com.au

Wyong Shire Council CENTRAL COAST

Department of Environment & Climate Change NSW

Cardno Shaping the Future

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Porters Creek

Floodplain Risk Mangement Study and Plan

Concept Options | **December 2009**

Flooding is a nature driven event that poses risk to human lives, services, goods and properties. Wyong Shire experienced significant floods in 2007, 2004, 1964 and 1949. Flood risk can be mitigated through flood study and flood risk management plan.

Porters Creek Catchment includes suburbs: Kanwal, Hamlyn Terrace, Woongarrah, Warnervale, Watanobbi, Halloran and Jilliby (see Figure overleaf). Council completed a flood study for the catchment in July 2009. Cardno, on behalf of Council, is currently carrying out Floodplain Risk Management Study and Plan for the catchment.

The community's flood information, thoughts and ideas are considered important and essential part for preparing the study and plan.

Do you or your family member/s live, work or play in the Porters Creek catchment area (see figure overleaf)? Do you have thoughts and suggestions of what Council can do to help manage flood risk in this area?

Council would like you to participate in this survey and request you to fill in and return this questionnaire form in the enclosed 'reply paid' envelope by Friday, 29 January 2010.

All returned questionnaires will be put in a draw to win a $50 gift voucher.

Wyong Shire Council CENTRAL COAST

Department of Environment & Climate Change NSW

Cardno Shaping the Future

Local Resident/Land Owner Survey

Q 1. Could you please provide us with the following details (optional)? We may wish to contact you to discuss some of the information you have provided us.

Name: .....

Address .....

.....

Daytime Ph: .....

Email: .....

Q 2. Is your property (please tick).

☐ Owner occupied ☐ Occupied by a tenant ☐ A business ☐ School/Aged Care

Q 3. How long have you lived, worked and/or owned your property?

..... Months ..... Years

Q 4. Have you ever experienced flooding since living/working/owning your property? (please tick relevant boxes).

- ☐ Yes, floodwaters entered my house/business/school/aged care (date/location...../.....)
- ☐ Yes, floodwaters entered my yard/surrounding property (date/location...../.....)
- ☐ Yes, the road was flooded (date/location...../.....)
- ☐ Yes, the creek broke is banks (date:.....)
- ☐ Yes, other parts of my neighborhood were flooded (date:.....)
- ☐ No, I haven't experienced a flood (go to Q.6)

Q 5. If you have experienced a flood, how did the flooding affect you and your family/business? (please tick relevant boxes).

- ☐ Parts of my house/business/school/aged care building were damaged
- ☐ The contents of my house/business/school/aged care were damaged
- ☐ My garden, yard, and/or surrounding property were damaged
- ☐ My car was damaged
- ☐ Other property was damaged (specify .....)
- ☐ I couldn't leave my house/business/school/aged care
- ☐ Family members/work mates couldn't return to the house/business
- ☐ My family had to evacuate the house/business/school/aged care
- ☐ The flood disrupted my daily routine
- ☐ The flood affected me in other ways (specify .....)
- ☐ No, the flood didn't affect me

Q 6. Do you think your property would be flooded sometime in the future? (please tick relevant boxes).

- ☐ No
- ☐ Yes, but only a small part of my yard
- ☐ Yes, most of my yard
- ☐ Yes, my house/office/business could flood over the floor

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Q 7. Have you looked for information about flooding on your property? (please tick relevant boxes).

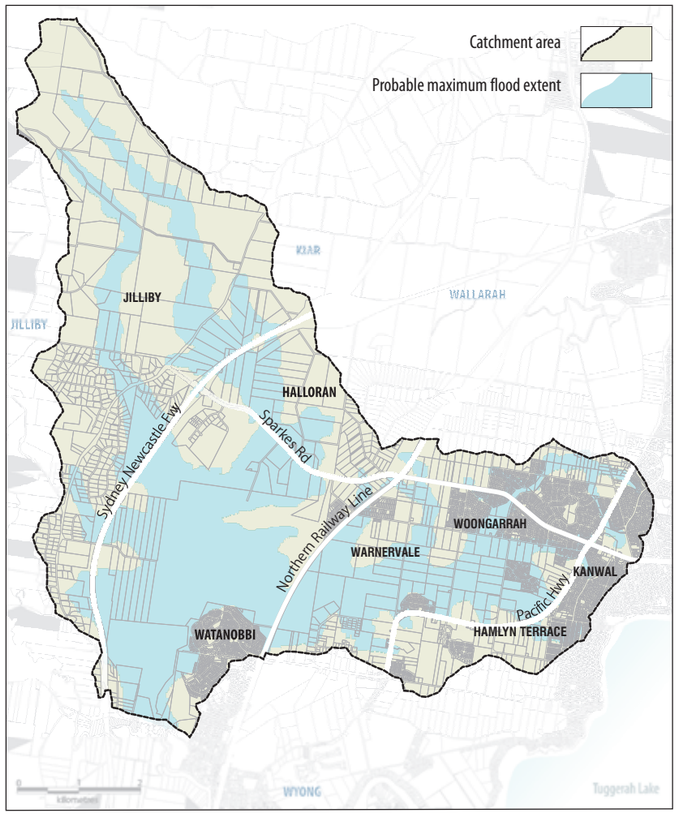
- ☐ Council's customer service centre
- ☐ Other information from Council (specify .....)
- ☐ Viewed a Property Planning (Section 149) Certificate
- ☐ Information from a real estate agent
- ☐ Information from relatives, friends, neighbours, or the previous owner
- ☐ Other information (specify .....)
- ☐ No information has been sought
- ☐ I do not believe my property is affected by flooding

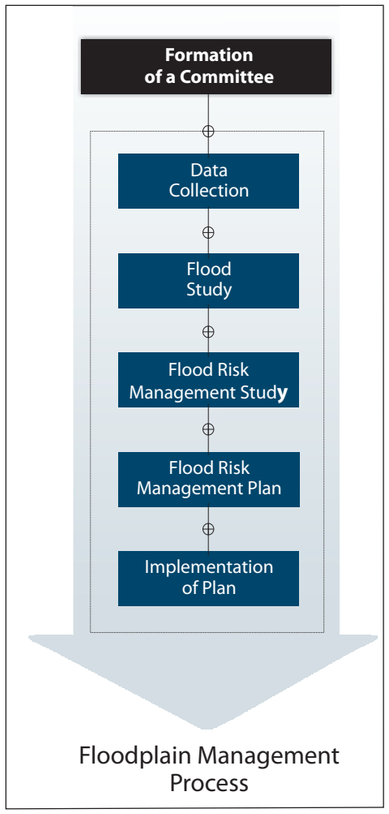
Q 8. What do you think are the best ways to get input and feedback from the local community about the options being considered to manage flooding and the results fo this project? (please tick relevant boxes).

- ☐ Council's website
- ☐ Emails from Council
- ☐ Council's Floodplain Management Committee
- ☐ Formal Council meetings
- ☐ Council's information page in the local paper
- ☐ Other articles in the local paper
- ☐ Information days in the local area
- ☐ Community meetings
- ☐ Mail outs to all residents/business owners in the study area

Q 9. As a local resident and (probably) having witnessed a number of flooding/drainage problems, you may have your own ideas on how to reduce flood risks. Which of the following management options would you prefer for Porters Creek (1=least preferred, 5=most preferred)? Please also provide comments as to the location where you think the option might be suitable.

Proposed Option	Preference (please circle)	Location/Other Comments?
Recognition of natural flow path	1 2 3 4 5	
Environmental channel improvements, including removal of weeds & bank stabilisation	1 2 3 4 5	
Planning and flood-related development controls	1 2 3 4 5	
Education of community, providing greater awareness of flood hazards	1 2 3 4 5	
Flood forecasting, flood warning, evacuation planning and emergency response	1 2 3 4 5	
Retarding or detention basins; these temporarily hold water and reduce peak flood flows	1 2 3 4 5	
Culvert/ bridge/pipe enlarging	1 2 3 4 5	
Levee banks	1 2 3 4 5	
Other (please specify any options you believe are suitable). Please attach extra pages for other suggestions		





Floodplain Management Process

Figure: The Study Area and the Floopplain Management Process

Could you please provide us with the following details (optional)? We may wish to contact you to discuss some of the information you have provided us.

Name: .....

Address .....

.....

Daytime Ph: .....

Email: .....

If you are unable to attend the community information session on **Wednesday 4 May 2011**, you can submit your completed feedback form to the study team by posting your completed form in the enclosed reply paid envelope, or via the contact details provided below.

Contact Us

YOUR PERSONAL INFORMATION WILL REMAIN CONFIDENTIAL

If you have any queries, please contact:

Wyong Shire Council

Shah Alam

P: (02) 4350 5710

F: (02) 4351 2098

E: salam@wyong.nsw.gov.au

Wyong Shire Council CENTRAL COAST

Cardno Shaping the Future

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Flooded timber yard near Wyong River | 2007

Porters Creek

Floodplain Risk Management Study and Plan

Preliminary Flood Risk Management Options | **April 2011**

Wyong Shire Council and Cardno have been working to prepare a Floodplain Risk Management Study and Plan for the Porters Creek Catchment. The Study and Plan is being prepared in accordance with the NSW Government Floodplain Risk Management Process, as illustrated on the final page of this brochure.

The Porters Creek Floodplain Risk Management Study and Plan has identified a series of preferred management options to reduce flood risk based on consideration of the potential economic, social and environmental impacts associated with each option.

Wyong Shire Council would like to advise that the draft Porters Creek Floodplain Risk Management Study has been prepared is now on public exhibition. Copies of the Study and Plan can be viewed on Council's website, at Council chambers or in the Council Libraries at Lake Haven and Tuggerah.

Council would like to invite you to participate in a community information session where you can find additional information on the Study and Plan, ask the study team questions, and provide feedback on your preferred options.

Date and Time: **Wednesday 4 May 2011 from 7pm to 8pm**

Location: **Committee Room, Wyong Shire Council, 16 Hely Street, Wyong.**

RSVP Required: **SAlam@wyong.nsw.au** or **(02)4350 5710**

Please bring this form along so that you can provide your feedback on the proposed options. Alternatively please send your completed feedback form to the study team via the contact details provided overleaf.

Wyong Shire Council CENTRAL COAST

Cardno Shaping the Future

Preliminary Flood Risk Management Options

There are four general types of option available for managing flood risk:

Flood modification options can include structural works such as levees, culvert enlargement, detention basins or creek works that modify flood behaviour.

Property modification options relate to individual properties and may include floor raising, flood proofing, voluntary purchase (for residences affected by high flood hazard), or planning controls.

Emergency response options may recommend changes to the way flood emergencies are handled by the emergency management authorities (e.g. the SES) via, for example, the use of early warning systems or providing evacuation routes.

Cardno has worked with Council, the SES and the State Government to develop a range of flood management options for the Porters Creek catchment. Council would like to seek your input on your preferred flood mitigation options. The eleven preferred management options are described below.

1. Lucca Road Levee Extension - There is currently a levee surrounding several industrial properties on Lucca Road. This option provides for an extension of the levee to prevent inundation by floodwaters from the catchment.

2. Road Raising, Hue Hue Road - This option provides for the raising of Hue Hue Road where it crosses Buttonderry Creek so that it provides safe flood access for cars during rare flood events (i.e. for the 100 year flood).

3. Natural Channel Maintenance - Flood flows can be impeded by the accumulation of sediment, debris or organic matter in stormwater outlets. This option provides for regular cleaning of stormwater outlets, particularly at major road crossings such as the Pacific Highway at Kanwal, and at Warnervale, Louisianna and Minnesota Roads. An added benefit of this option is that it can improve water quality.

4. Road Raising, Warnervale Road - This option provides for the raising of Warnervale Road in two locations, one to the east of the railway line, and one location adjacent to Virginia Road. This would provide safe flood access for cars during rare flood events.

5. Road Raising and Culvert, Warnervale Road, Wongarrah Creek Crossing - This option provides a new, larger culvert and raising of the road where Warnervale Road crosses Wongarrah Creek. This would reduce flood risk to adjacent properties and would also provide safe flood access.

6. Road Raising and Culvert Works, Minnesota Road, Bingarrah Creek Crossing - This section of Minnesota Road currently acts as a causeway during a storm event and is not trafficable during frequent storm events. It is proposed to provide a series of culverts at this location and to raise the road level to provide access during a rare flood event.

Wyong Shire Council CENTRAL COAST

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7. Flood Warning System, Wyong Community Christian School - The school is affected by flooding in large storm events. There is currently a flood emergency management plan in place for the school, but it requires updating to take advantage of new flood warning technology.

8. Housing Raising - This option proposes house raising (where feasible) to prevent over-floor flooding where properties are currently affected by flooding in smaller flood events (i.e. occurring on average once every five years).

9. Voluntary Purchase - Where house raising is not possible, an alternative is to undertake voluntary purchase of residences that are significantly flood affected (i.e. located in high hazard zone).

10. Flood Proofing - There are a range of options available to residents and developers with respect to flood proofing their properties. This may include structural or other works. This option provides for the preparation of guidelines on how to flood proof your property.

11. Planning & Development Controls - Planning and development controls may include land re-zoning or setting floor levels for properties. These are effective means by which development can be managed so as to reduce flood risks to an acceptable level, or to avoid development in locations where flood risk is unacceptably high.

Council would like to invite you to provide your input on which of these 11 flood mitigation options you would prefer to see implemented. Please rank each option from 1 (most preferred) to 11(least preferred). Space has been provided for you to include a comment. Please feel free to attached additional pages if required. Each option has a specific Option ID in the Porters Creek Floodplain Management Study & Plan.

Flood Management Option	Option ID.	Rank	Comments
1. Lucca Road Levee Extension	2.1		
2. Road Raising, Hue Hue Road	1.5		
3. Natural Channel Maintenance	1.1		
4. Road Raising, Warnervale Road	1.7		
5. Road Raising & Culvert, Warnervale Road, Wongarrah Creek Crossing	1.8		
6. Road Raising & Culvert Works, Minnesota Road, Bingarrah Creek Crossing	1.9		
7. Flood Warning System, Wyong Community Christian School	Em3		
8. House Raising	P3		
9. Voluntary Purchase	P5		
10. Flood Proofing	P7		
11. Planning & Development Controls	P1		

Appendix B

Cost Estimates

W4822 Porters Creek

Opt 1.1 - Alison Rd Levee plus flood gate
Cost Estimate

v1

ITEM NO.	DESCRIPTION OF WORK	QUANTITY	UNIT	RATE	COST
1.0	**GENERAL AND PRELIMINARIES**				
1.1	Site establishment, security fencing, facilities & disestablishment	1	item	20000	20,000
1.2	Provision of sediment & erosion control	1	item	10000	10,000
1.3	Construction setout & survey	1	item	25000	25,000
1.4	Work as executed survey & documentation	1	item	25000	25,000
1.5	Geotechnical supervision, testing & certification	1	item	3500	3,500
	SUBTOTAL				**83,500**
2.0	**DEMOLITION, CLEARING AND GRUBBING**				
2.1	Clearing & grubbing	4,500	sq. m	10	45,000
2.2	Strip topsoil & stockpile for re-use (assuming 150mm depth)	675	cu. m	20	13,500
2.3	Dispose of excess topsoil (nominal 10% allowance)	70	cu. m	50	3,500
2.4	Minor works around bridge	1	item	25000	25,000
	SUBTOTAL				**87,000**
3.0	**EARTHWORKS**				
3.1	Minor Earthworks - regrade to suit new design levels, including disposal / provision of cut / fill	3600	cu. m	60	216,000
	SUBTOTAL				**216,000**
4.0	**DRAINAGE**				
4.1	Make adjustements for bridge to accomodate flood gate	1	item	10000	10,000
4.2	Make concrete additions to control water ingress around flood gate	1	item	20000	20,000
4.3	Supply and install 20m wide flood gate with shut down valve mechanism	1	each	2000000	2,000,000
4.3	Supply and install concrete dam wall	1	each	500000	500,000
	SUBTOTAL				**2,530,000**
5.0	**PAVEMENTS**				
5.1	Reinstate disturbed road pavement, including demolition and disposal of additional material to provide good jointing	150	sq. m	50	7,500
	SUBTOTAL				**7,500**
6.0	**MINOR LANDSCAPING**				
6.1	Repair disturbed areas in accordance with landscape architects requirements (nominal allowance)	4,500	sq. m	10	45,000
	SUBTOTAL				**45,000**
	CONSTRUCTION SUB-TOTAL				**2,969,000**
7.0	**CONTINGENCIES**				
7.1	20% construction cost				**593,800**
	CONSTRUCTION TOTAL, excluding GST				**3,562,800**
	GST				**356,280**
	CONSTRUCTION TOTAL, including GST				**3,919,080**
	CONSTRUCTION TOTAL, rounded				**3,919,100**

DISCLAIMER:

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NOTES:

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2. Estimate / rates in 2010 dollars and does not allow for inflation

W4822 Porters Creek FPRMS&P

Opt 1.2 - Kanwal Detention Basin
Cost Estimate

v1

ITEM NO.	DESCRIPTION OF WORK	QUANTITY	UNIT	RATE	COST
1.0	**GENERAL AND PRELIMINARIES**				
1.1	Site establishment, security fencing, facilities & disestablishment	1	item	10000	10,000
1.2	Provision of sediment & erosion control	1	item	7500	7,500
1.3	Construction setout & survey	1	item	5000	5,000
1.4	Work as executed survey & documentation	1	item	5000	5,000
1.5	Geotechnical supervision, testing & certification	1	item	3500	3,500
	SUBTOTAL				**31,000**
2.0	**DEMOLITION, CLEARING AND GRUBBING**				
2.1	Clearing & grubbing	1,000	sq. m	10	10,000
2.2	Strip topsoil & stockpile for re-use (assuming 150mm depth)	150	cu. m	20	3,000
2.3	Dispose of excess topsoil (nominal 10% allowance)	15	cu. m	50	750
2.4	Break into exisitng pit to modify for detention basin drainage	1	item	2500	2,500
	SUBTOTAL				**16,250**
3.0	**DRAINAGE**				
3.1	Provide new 1.5m sq pit with grated inlet and orifice plate	1	item	5200	5,200
3.2	Supply and install rock amour spillway	20	cu. m	110	2,200
3.3	Earthworks for spillway	75	cu. m	60	4,500
3.4			each		0
	SUBTOTAL				**11,900**
4.0	**Civil Works**				
4.1	Cut and fill across detention basin to required levels	2000	cu. m	35	70,000
	SUBTOTAL				**70,000**
5.0	**MINOR LANDSCAPING**				
5.1	Cut existing turf and relay across field, infill with new turf as needed	4,000	sq. m	10	40,000
	SUBTOTAL				**40,000**
	CONSTRUCTION SUB-TOTAL				**169,150**
6.0	**CONTINGENCIES**				
6.1	50% construction cost				**84,575**
	CONSTRUCTION TOTAL, excluding GST				**253,725**
	GST				**25,373**
	CONSTRUCTION TOTAL, including GST				**279,098**
	CONSTRUCTION TOTAL, rounded				**279,100**

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NOTES:

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Opt 1.3 - ALREADY CONSTRUCTED
Cost Estimate

v1

ITEM NO.	DESCRIPTION OF WORK	QUANTITY	UNIT	RATE	COST
1.0	**GENERAL AND PRELIMINARIES**				
1.1	Site establishment, security fencing, facilities & disestablishment		item	10000	0
1.2	Provision of sediment & erosion control		item	7500	0
1.3	Construction setout & survey		item	5000	0
1.4	Work as executed survey & documentation		item	5000	0
1.5	Geotechnical supervision, testing & certification		item	3500	0
	SUBTOTAL				**0**
2.0	**DEMOLITION, CLEARING AND GRUBBING**				
2.1	Clearing & grubbing		sq. m	10	0
2.2	Strip topsoil & stockpile for re-use (assuming 150mm depth)		cu. m	20	0
2.3	Dispose of excess topsoil (nominal 10% allowance)		cu. m	50	0
2.4	Pull up and dispose existing road surface		sq.m	35	0
	SUBTOTAL				**0**
3.0	**DRAINAGE**				
3.1	Supply, excavate, bed, lay, joint, backfill and provide connections for 0.6m dia. Pipe, including demolition and disposal of existing pipe		lin.m	1900	0
3.2	Supply, excavate, bed, lay, joint, backfill and provide connections for 0.75m dia. Pipe, including demolition and disposal of existing pipe		each	2100	0
3.3	Install new 2.4m pre-cast drainage pit		each	5000	0
3.4	Install new 1.8m pre-cast drainage pit		each	4000	0
3.5	Install new 2.4m precast drainage pit, including demolition and disposal of existing 0.95m pits		each	8000	0
	SUBTOTAL				**0**
4.0	**PAVEMENTS**				
4.1	Reinstate disturbed road pavement, including demolition and disposal of additional material to provide good jointing		sq. m	50	0
	SUBTOTAL				**0**
6.0	**MINOR LANDSCAPING**				
6.2	Repair disturbed areas in accordance with landscape architects requirements (nominal allowance)		sq. m	10	0
	SUBTOTAL				**0**
	CONSTRUCTION SUB-TOTAL				**0**
7.0	**CONTINGENCIES**				
7.1	50% construction cost				**0**
	CONSTRUCTION TOTAL, excluding GST				**0**
	GST				**0**
	CONSTRUCTION TOTAL, including GST				**0**
	CONSTRUCTION TOTAL, rounded				**0**

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W4822 Porters Creek FPRMS&P

Opt 1.4 - Lomandra Terrace Levee & Natural Channel
Cost Estimate

v1

ITEM NO.	DESCRIPTION OF WORK	QUANTITY	UNIT	RATE	COST
1.0	**GENERAL AND PRELIMINARIES**				
1.1	Site establishment, security fencing, facilities & disestablishment	1	item	10000	10,000
1.2	Provision of sediment & erosion control	1	item	7500	7,500
1.3	Construction setout & survey	1	item	5000	5,000
1.4	Work as executed survey & documentation	1	item	5000	5,000
1.5	Geotechnical supervision, testing & certification	1	item	3500	3,500
	SUBTOTAL				**31,000**
2.0	**DEMOLITION, CLEARING AND GRUBBING**				
2.1	Clearing & grubbing	6,150	sq. m	10	61,500
2.2	Strip topsoil & stockpile for re-use (assuming 150mm depth)	930	cu. m	20	18,600
2.3	Dispose of excess topsoil (nominal 10% allowance)	100	cu. m	50	5,000
2.4	Pull up and dispose existing road surface	20	sq.m	35	700
	SUBTOTAL				**85,800**
3.0	**EARTHWORKS**				
3.1	Minor Earthworks - regrade to suit new design levels, including disposal / provision of cut / fill	4340	cu. m	60	260,400
	SUBTOTAL				**260,400**
4.0	**DRAINAGE**				
4.1			lin.m	2600	0
4.2			each	5000	0
4.3			each	7000	0
4.4			lin.m	500	0
	SUBTOTAL				**0**
5.0	**PAVEMENTS**				
5.1	Reinstate disturbed road pavement, including demolition and disposal of additional material to provide good jointing	20	sq. m	50	1,000
	SUBTOTAL				**1,000**
6.0	**MINOR LANDSCAPING**				
6.1	Repair disturbed areas in accordance with landscape architects requirements (nominal allowance)	6,150	sq. m	10	61,500
	SUBTOTAL				**61,500**
	CONSTRUCTION SUB-TOTAL				**439,700**
7.0	**CONTINGENCIES**				
7.1	50% construction cost				**219,850**
	CONSTRUCTION TOTAL, excluding GST				**659,550**
	GST				**65,955**
	CONSTRUCTION TOTAL, including GST				**725,505**
	CONSTRUCTION TOTAL, rounded				**725,600**

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NOTES:

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W4822 Porters Creek FPRMS&P

Opt 1.5 - Hue Hue Road Raising at WIP
Cost Estimate

v1

ITEM NO.	DESCRIPTION OF WORK	QUANTITY	UNIT	RATE	COST
1.0	**GENERAL AND PRELIMINARIES**				
1.1	Site establishment, security fencing, facilities & disestablishment	1	item	10000	10,000
1.2	Provision of sediment & erosion control	1	item	7500	7,500
1.3	Construction setout & survey	1	item	5000	5,000
1.4	Work as executed survey & documentation	1	item	5000	5,000
1.5	Geotechnical supervision, testing & certification	1	item	3500	3,500
	SUBTOTAL				**31,000**
2.0	**DEMOLITION, CLEARING AND GRUBBING**				
2.1	Clearing & grubbing	2,400	sq. m	10	24,000
2.2	Strip topsoil & stockpile for re-use (assuming 150mm depth)	360	cu. m	20	7,200
2.3	Dispose of excess topsoil (nominal 10% allowance)	50	cu. m	50	2,500
2.4	Pull up and dispose existing road surface	2400	sq.m	35	84,000
	SUBTOTAL				**117,700**
3.0	**EARTHWORKS**				
3.1	Minor Earthworks - regrade to suit new design levels, including disposal / provision of cut / fill	1200	cu. m	60	72,000
	SUBTOTAL				**72,000**
4.0	**DRAINAGE**				
4.1			lin.m	2600	0
4.2			each	5000	0
4.3			each	8000	0
4.3			each	7000	0
	SUBTOTAL				**0**
5.0	**PAVEMENTS**				
5.1	Reinstate disturbed road pavement, including demolition and disposal of additional material to provide good jointing	2800	sq. m	50	140,000
	SUBTOTAL				**140,000**
6.0	**MINOR LANDSCAPING**				
6.1	Repair disturbed areas in accordance with landscape architects requirements (nominal allowance)		sq. m	10	0
	SUBTOTAL				**0**
	CONSTRUCTION SUB-TOTAL				**360,700**
7.0	**CONTINGENCIES**				
7.1	50% construction cost				**180,350**
	CONSTRUCTION TOTAL, excluding GST				**541,050**
	GST				**54,105**
	CONSTRUCTION TOTAL, including GST				**595,155**
	CONSTRUCTION TOTAL, rounded				**595,200**

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NOTES:

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W4822 - Porters Ck FPRMS&P

Opt 1.6 - Hue Hue Rd upgrade at Jilliby
Cost Estimate

v1

ITEM NO.	DESCRIPTION OF WORK	QUANTITY	UNIT	RATE	COST
1.0	**GENERAL AND PRELIMINARIES**				
1.1	Site establishment, security fencing, facilities & disestablishment	1	item	10000	10,000
1.2	Provision of sediment & erosion control	1	item	7500	7,500
1.3	Construction setout & survey	1	item	5000	5,000
1.4	Work as executed survey & documentation	1	item	5000	5,000
1.5	Geotechnical supervision, testing & certification	1	item	3500	3,500
	SUBTOTAL				**31,000**
2.0	**DEMOLITION, CLEARING AND GRUBBING**				
2.1	Clearing & grubbing	1,200	sq. m	10	12,000
2.2	Strip topsoil & stockpile for re-use (assuming 150mm depth)	180	cu. m	20	3,600
2.3	Dispose of excess topsoil (nominal 10% allowance)	20	cu. m	50	1,000
2.4	Pull up and dispose existing road surface	1400	sq.m	35	49,000
	SUBTOTAL				**65,600**
3.0	**DRAINAGE**				
3.1	Supply, excavate, bed, lay, joint, backfill and provide connections for twin 1.2 by 0.8m culvert	12	lin.m	3200	38,400
3.2	Supply and install rock/concrete apron	2	each	5000	10,000
3.3	Supply and install concrete headwall	2	each	7500	15,000
3.4			Each		0
	SUBTOTAL				**63,400**
4.0	**PAVEMENTS**				
4.1	Reinstate disturbed road pavement, including demolition and disposal of additional material to provide good jointing	1400	sq. m	50	70,000
	SUBTOTAL				**70,000**
5.0	**MINOR LANDSCAPING**				
5.1	Repair disturbed areas in accordance with landscape architects requirements (nominal allowance)	2400	sq. m	10	24,000
	SUBTOTAL				**24,000**
	CONSTRUCTION SUB-TOTAL				**254,000**
6.0	**CONTINGENCIES**				
6.1	50% construction cost				**127,000**
	CONSTRUCTION TOTAL, excluding GST				**381,000**
	GST				**38,100**
	CONSTRUCTION TOTAL, including GST				**419,100**
	CONSTRUCTION TOTAL, rounded				**419,100**

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NOTES:

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W4822 - Porters Ck

Opt 1.7 -
Cost Estimate

v1

ITEM NO.	DESCRIPTION OF WORK	QUANTITY	UNIT	RATE	COST
1.0	**GENERAL AND PRELIMINARIES**				
1.1	Site establishment, security fencing, facilities & disestablishment	1	item	10000	10,000
1.2	Provision of sediment & erosion control	1	item	7500	7,500
1.3	Construction setout & survey	1	item	5000	5,000
1.4	Work as executed survey & documentation	1	item	5000	5,000
1.5	Geotechnical supervision, testing & certification	1	item	3500	3,500
	SUBTOTAL				**31,000**
2.0	**DEMOLITION, CLEARING AND GRUBBING**				
2.1	Clearing & grubbing	1,500	sq. m	10	15,000
2.2	Strip topsoil & stockpile for re-use (assuming 150mm depth)	225	cu. m	20	4,500
2.3	Dispose of excess topsoil (nominal 10% allowance)	25	cu. m	50	1,250
2.4	Pull up and dispose existing road surface	1750	sq.m	35	61,250
	SUBTOTAL				**82,000**
3.0	**EARTHWORKS**				
3.1	Minor Earthworks - regrade to suit new design levels, including disposal / provision of cut / fill	940	cu. m	60	56,400
	SUBTOTAL				**56,400**
4.0	**DRAINAGE**				
4.1	Supply, excavate, bed, lay, joint, backfill and provide connections for 4 x 1.2 dia. culvert, including demolition and disposal of existing material	40	lin.m	2400	96,000
4.2	Supply and install rcok/concrete apron	4	each	5000	20,000
4.3	Supply and install concrete headwall	4	each	7500	30,000
4.3			each		0
	SUBTOTAL				**146,000**
5.0	**PAVEMENTS**				
5.1	Reinstate disturbed road pavement, including demolition and disposal of additional material to provide good jointing	1750	sq. m	50	87,500
	SUBTOTAL				**87,500**
6.0	**MINOR LANDSCAPING**				
6.1	Repair disturbed areas in accordance with landscape architects requirements (nominal allowance)	1,500	sq. m	10	15,000
	SUBTOTAL				**15,000**
	CONSTRUCTION SUB-TOTAL				**417,900**
7.0	**CONTINGENCIES**				
7.1	50% construction cost				**208,950**
	CONSTRUCTION TOTAL, excluding GST				**626,850**
	GST				**62,685**
	CONSTRUCTION TOTAL, including GST				**689,535**
	CONSTRUCTION TOTAL, rounded				**689,600**

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NOTES:

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W4822 - Porters Ck FRMS&P

Opt 1.8 - Warnervale Rd Upgrade at Ebony Drive
Cost Estimate

v1

ITEM NO.	DESCRIPTION OF WORK	QUANTITY	UNIT	RATE	COST
1.0	**GENERAL AND PRELIMINARIES**				
1.1	Site establishment, security fencing, facilities & disestablishment	1	item	10000	10,000
1.2	Provision of sediment & erosion control	1	item	7500	7,500
1.3	Construction setout & survey	1	item	5000	5,000
1.4	Work as executed survey & documentation	1	item	5000	5,000
1.5	Geotechnical supervision, testing & certification	1	item	3500	3,500
	SUBTOTAL				**31,000**
2.0	**DEMOLITION, CLEARING AND GRUBBING**				
2.1	Clearing & grubbing	2,100	sq. m	15	31,500
2.2	Strip topsoil & stockpile for re-use (assuming 150mm depth)	315	cu. m	25	7,875
2.3	Dispose of excess topsoil (nominal 10% allowance)	35	cu. m	60	2,100
2.4	Pull up and dispose existing road surface	2450	sq.m	60	147,000
	SUBTOTAL				**188,475**
3.0	**EARTHWORKS**				
3.1	Minor Earthworks - regrade to suit new design levels, including disposal / provision of cut / fill	1300	cu. m	90	117,000
	SUBTOTAL				**117,000**
4.0	**DRAINAGE**				
4.1	Supply, excavate, bed, lay, joint, backfill and provide connections for 7 x 3.6m x 0.9m BC, including demolition and disposal of existing material	28	lin.m	5700	159,600
4.2	Supply and install rock/concrete apron	4	each	40000	160,000
4.3	Supply and install concrete headwall	4	each	25000	100,000
4.3			each		0
	SUBTOTAL				**419,600**
5.0	**PAVEMENTS**				
5.1	Reinstate disturbed road pavement, including demolition and disposal of additional material to provide good jointing	2450	sq. m	80	196,000
	SUBTOTAL				**196,000**
6.0	**MINOR LANDSCAPING**				
6.1	Repair disturbed areas in accordance with landscape architects requirements (nominal allowance)	1,500	sq. m	30	45,000
	SUBTOTAL				**45,000**
	CONSTRUCTION SUB-TOTAL				**997,075**
7.0	**CONTINGENCIES**				
7.1	50% construction cost				**498,538**
	CONSTRUCTION TOTAL, excluding GST				**1,495,613**
	GST				**149,561**
	CONSTRUCTION TOTAL, including GST				**1,645,174**
	CONSTRUCTION TOTAL, rounded				**1,645,200**

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NOTES:

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2. Estimate / rates in 2010 dollars and does not allow for inflation

W4822 - Porters Ck FRMS&P

Opt 1.9 - Minnesota Rd Upgrade
Cost Estimate

v1

ITEM NO.	DESCRIPTION OF WORK	QUANTITY	UNIT	RATE	COST
1.0	**GENERAL AND PRELIMINARIES**				
1.1	Site establishment, security fencing, facilities & disestablishment	1	item	50000	50,000
1.2	Provision of sediment & erosion control	1	item	50000	50,000
1.3	Construction setout & survey	1	item	20000	20,000
1.4	Work as executed survey & documentation	1	item	30000	30,000
1.5	Geotechnical supervision, testing & certification	1	item	150000	150,000
	SUBTOTAL				**300,000**
2.0	**DEMOLITION, CLEARING AND GRUBBING**				
2.1	Clearing & grubbing	3,720	sq. m	15	55,800
2.2	Strip topsoil & stockpile for re-use (assuming 150mm depth)	558	cu. m	25	13,950
2.3	Dispose of excess topsoil (nominal 10% allowance)	60	cu. m	60	3,600
2.4	Pull up and dispose existing road surface	4340	sq.m	60	260,400
	SUBTOTAL				**333,750**
3.0	**EARTHWORKS**				
3.1	Minor Earthworks - regrade to suit new design levels, including disposal / provision of cut / fill	9300	cu. m	90	837,000
	SUBTOTAL				**837,000**
4.0	**DRAINAGE**				
4.1	Supply, excavate, bed, lay, joint, backfill and provide connections for 20 x 3.6m x 0.9m BC, including demolition and disposal of existing material	20	each	32000	640,000
4.2	Supply and install rcok/concrete apron	4	each	80000	320,000
4.3	Supply and install concrete headwall	4	each	12500	50,000
4.3			each		0
	SUBTOTAL				**1,010,000**
5.0	**PAVEMENTS**				
5.1	Reinstate disturbed road pavement, including demolition and disposal of additional material to provide good jointing	8680	sq. m	60	520,800
	SUBTOTAL				**520,800**
6.0	**MINOR LANDSCAPING**				
6.1	Repair disturbed areas in accordance with landscape architects requirements (nominal allowance)	6,000	sq. m	60	360,000
	SUBTOTAL				**360,000**
	CONSTRUCTION SUB-TOTAL				**3,361,550**
7.0	**CONTINGENCIES**				
7.1	50% construction cost				**1,680,775**
	CONSTRUCTION TOTAL, excluding GST				**5,042,325**
	GST				**504,233**
	CONSTRUCTION TOTAL, including GST				**5,546,558**
	CONSTRUCTION TOTAL, rounded				**5,546,600**

DISCLAIMER:

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Cardno (NSW) will not accept liability in the event that actual costs exceed the estimate.

NOTES:

1. Estimate does not include Consultant's fees, including design or project management

2. Estimate / rates in 2010 dollars and does not allow for inflation

W4822 - Porters Ck FRMS&P

Opt 1.10 - Natural Channel Maintenance
Cost Estimate

v1

ITEM NO.	DESCRIPTION OF WORK	QUANTITY	UNIT	RATE	COST
1.0	**GENERAL AND PRELIMINARIES**				
1.1	Development of maintenance plan	3	item	12000	36,000
1.2	Identifying maintenance access	3	item	7500	22,500
1.3	Identifying disposal method and location	1	item	1200	1,200
	SUBTOTAL				**59,700**
2.0	**CLEARING EXOTIC VEGETATION**				
2.1	Clearing of exotic veg	10,000	sq. m	20	200,000
2.2	Stockpile debris and load for removal	10000	sq. m	10	100,000
2.3	Apply herbicide to control future growth	1000	sq. m	20	20,000
	SUBTOTAL				**320,000**
3.0	**EXCAVATION AND REMOVAL OF ACCUMILATED SEDIMENT**				
3.1	Remove accumilated sediment with bobcat and load into truck	1000	cu. m	60	60,000
	SUBTOTAL				**60,000**
4.0	**DISPOSAL OF MATERIAL**				
4.1	Cartage to disposal facility	1000	cu. m	20	20,000
4.2	Disposal Cost	1000	cu. m	25	25,000
	SUBTOTAL				**45,000**
5.0	**Access Roads**				
5.1	Formalise existing 4WD tracks or Fire Roads for access	100	m	25	2,500
	SUBTOTAL				**2,500**
	CONSTRUCTION SUB-TOTAL				**487,200**
7.0	**CONTINGENCIES**				
7.1	20% construction cost				**97,440**
	CONSTRUCTION TOTAL, excluding GST				**584,640**
	GST				**58,464**
	CONSTRUCTION TOTAL, including GST				**643,104**
	CONSTRUCTION TOTAL, rounded				**643,200**

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NOTES:

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2. Estimate / rates in 2010 dollars and does not allow for inflation

W4822 Porters Creek FPRMS&P

Opt 2.1 - Luca Rd Levee extension
Cost Estimate

v1

ITEM NO.	DESCRIPTION OF WORK	QUANTITY	UNIT	RATE	COST
1.0	**GENERAL AND PRELIMINARIES**				
1.1	Site establishment, security fencing, facilities & disestablishment	1	item	10000	10,000
1.2	Provision of sediment & erosion control	1	item	7500	7,500
1.3	Construction setout & survey	1	item	5000	5,000
1.4	Work as executed survey & documentation	1	item	5000	5,000
1.5	Geotechnical supervision, testing & certification	1	item	3500	3,500
	SUBTOTAL				**31,000**
2.0	**DEMOLITION, CLEARING AND GRUBBING**				
2.1	Clearing & grubbing	2,500	sq. m	10	25,000
2.2	Strip topsoil & stockpile for re-use (assuming 150mm depth)	375	cu. m	20	7,500
2.3	Dispose of excess topsoil (nominal 10% allowance)	35	cu. m	50	1,750
	SUBTOTAL				**34,250**
3.0	**EARTHWORKS**				
3.1	Minor Earthworks - regrade to suit wall footings, including disposal / provision of excess cut / fill	4000	cu. m	60	240,000
	SUBTOTAL				**240,000**
5.0	**MINOR LANDSCAPING**				
5.1	Repair disturbed areas in accordance with landscape architects requirements (nominal allowance)	2,500	sq. m	10	25,000
	SUBTOTAL				**25,000**
	CONSTRUCTION SUB-TOTAL				**330,250**
6.0	**CONTINGENCIES**				
6.1	50% construction cost				**165,125**
	CONSTRUCTION TOTAL, excluding GST				**495,375**
	GST				**49,538**
	CONSTRUCTION TOTAL, including GST				**544,913**
	CONSTRUCTION TOTAL, rounded				**545,000**

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NOTES:

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2. Estimate / rates in 2010 dollars and does not allow for inflation

Appendix C

Multi-Criteria Matrix

Plan No.	ID	Category of Measure	Description	Estimate of Capital Cost	Estimate of Recurrent Cost	Net Present Value (7%, 50 years)	Reduction in AAD	% reduction in c.f. to base case	NPV of Reduction in AAD	Benefit - Cost Ratio	Score on Benefit Cost Ratio	Capital and Operating Costs	Reduction in Risk to Property	Economic Score	Reduction in Risk to Life	Disruption to major road crossing	Community Criteria	Compatible with Policies and Plans	Social Score	Water Quality and Flow	Fauna & Flora	Environmental Score	TOTAL SCORE	RANK on TOTAL SCORE	To be included in Plan	Capital Cost	Recurrent Cost
1	P1	Planning Control	Wyong LEP Update	$5,000	$1,000	$18,801	NC	N/A	N/A	N/A	0	2	2	**1.0**	2	0	2	2	**1.4**	1		**0.5**	**2.9**	**2**	YES	$5,000	$1,000
2	P2	Building and Development Control	DCP chapter 113 - Flooding	$15,000	$1,000	$28,801	NC	N/A	N/A	N/A	0	2	2	**1.0**	2	0	2	2	**1.4**	1	1	**1.0**	**3.4**	**1**	YES	$15,000	$1,000
3	P3	Property Modification	House raising - up to 5yr	$640,000	$35,000	$1,123,026	$135,285	14.5%	$1,867,034	1.66	2	-1	2	**1.3**	1	0	-2	0	**-0.1**	0	0	**0.0**	**1.2**	**9**	YES	$640,000	$35,000
4	P4	Property Modification	House Rebuilding	An option considered in P6 Land Swap																							
5	P5	Property Modification	Voluntary purchase	$6,214,000	$0	$6,214,000	$236,541	25.3%	$3,264,442	0.53	0	-2	2	**0.0**	1	0	-2	2	**0.3**	0	0	**0.0**	**0.3**	**17**	NO	$0	$0
6	P6	Property Modification	Land swap	$3,120,000	$0	$3,120,000	$236,541	25.3%	$3,264,442	1.05	1	-2	2	**0.5**	1	0	0	-2	**-0.1**	0	0	**0.0**	**0.4**	**16**	NO	$0	$0
4	P7	Property Modification	Flood proofing guidelines	$15,000	$1,000	$28,801	NC	N/A	N/A	N/A	0	2	1	**0.8**	0	0	1	2	**0.6**	0	0	**0.0**	**1.4**	**8**	YES	$15,000	$1,000
5	EM1	Emergency Response Modification	Information Transfer to SES	$3,000	$0	$3,000	NC	N/A	N/A	N/A	0	2	0	**0.5**	2	0	0	2	**1.0**	0	0	**0.0**	**1.5**	**6**	YES	$3,000	$0
6	EM2	Emergency Response Modification	Revisal of SES Local Flood Plan	$30,000	$2,000	$57,601	NC	N/A	N/A	N/A	0	2	0	**0.5**	2	0	0	2	**1.0**	0	0	**0.0**	**1.5**	**6**	YES	$30,000	$2,000
7	EM3	Emergency Response Modification	Flood Warning System (Wyong Christian School)	$0	$0	$0	NC	N/A	N/A	N/A	0	1	0	**0.3**	2	0	-1	2	**0.8**	0	0	**0.0**	**1.1**	**11**	YES	$0	$0
8	EM4	Emergency Response Modification	Community Flood Awareness	$20,000	$5,000	$89,004	NC	N/A	N/A	N/A	0	1	1	**0.5**	2	0	-2	2	**0.6**	0	0	**0.0**	**1.1**	**10**	YES	$20,000	$5,000
9	EM5	Emergency Response Modification	Signage at road Crossings	$10,000	$200	$12,760	NC	N/A	N/A	N/A	0	2	0	**0.5**	2	1	-1	2	**1.1**	0	0	**0.0**	**1.6**	**5**	YES	$10,000	$200
10	1.1	Flood Modification	Alison Road Levee and Porters Creek Flood Gate	$3,919,100	$100,000	$5,299,175	$43,757	4.7%	$603,879	0.11	-2	-2	2	**-1.0**	1	0	-2	-2	**-0.5**	-1	-1	**-1.0**	**-2.5**	**22**	NO	$0	$0
11	1.2	Flood Modification	Kanwal Oval Detention Basin	$279,100	$5,000	$348,104	$3,868	0.4%	$53,381	0.15	-2	0	1	**-0.8**	1	0	-1	1	**0.3**	-1	-1	**-1.0**	**-1.5**	**21**	NO	$0	$0
12	1.4	Flood Modification	Levee and Natural Channel upgrade at Lomandra Tce Kanwal	$725,600	$12,000	$891,209	$9,607	1.0%	$132,584	0.15	-2	-1	1	**-1.0**	1	1	0	2	**1.0**	0	0	**0.0**	**0.0**	**19**	NO	$0	$0
10	1.5	Flood Modification	Buttonderry Creek crossing at Hue Hue Road	$595,200	$5,000	$664,204	$8,651	0.9%	$119,390	0.18	-2	-1	0	**-1.3**	2	1	2	2	**1.7**	0	0	**0.0**	**0.5**	**15**	YES	$595,200	$5,000
11	1.6	Flood Modification	Hue Hue Road Culvert at Jilliby	$419,100	$7,500	$522,606	$1,292	0.1%	$17,831	0.03	-2	0	1	**-0.8**	2	1	1	1	**1.3**	-1	0	**-0.5**	**0.0**	**18**	NO	$0	$0
11	1.7	Flood Modification	Warnervale Road Culverts	$689,600	$15,000	$896,611	$1,140	0.1%	$15,733	0.02	-2	-2	1	**-1.3**	2	2	0	0	**1.2**	0	0	**0.0**	**-0.1**	**20**	NO	$0	$0
12	1.8	Flood Modification	Warnervale Road Upgrade at Ebony Drive	$3,500,000	$20,000	$3,776,015	NC	N/A	N/A	N/A	-2	-1	0	**-1.3**	2	2	2	2	**2.0**	0	0	**0.0**	**0.8**	**12**	YES	$3,500,000	$20,000
13	1.9	Flood Modification	Bingarrah Creek Crossing at Minnesota Road	$5,000,000	$50,000	$5,690,037	NC	N/A	N/A	N/A	-2	-1	0	**-1.3**	2	2	2	2	**2.0**	0	0	**0.0**	**0.8**	**12**	YES	$5,000,000	$50,000
14	1.10	Natural Channel Maintenance	Woongarrah Creek, Bingarrah Creek and Kanwal Channel	$643,200	$480,000	$7,267,558	NC	N/A	N/A	N/A	0	-1	1	**0.0**	0	0	2	1	**0.6**	2	2	**2.0**	**2.6**	**3**	YES	$643,200	$480,000
15	2.1	Flood Modification	Luca Rd Levee Extension	$545,000	$10,000	$683,007	$604,102	64.7%	$8,337,058	12.21	2	-1	2	**1.3**	2	0	-2	2	**0.6**	0	0	**0.0**	**1.9**	**4**	YES	$545,000	$10,000
16	DC1	Data Collection Strategies		$5,000	$3,000	$46,402	NC	N/A	N/A	N/A	0	2	0	**0.5**	0	0	-1	2	**0.2**	0	0	**0.0**	**0.7**	**14**	YES	$5,000	$3,000
																									TOTAL	**$11,026,400**	**$613,200**

Appendix D

Flood Planning Matrix

	Flood Planning Area 1										Flood Planning Area 2										Flood Planning Area 3									
	Critical Infrastructure	Sensitive Uses and Facilities	Land Subdivision	Low Density Residential	Medium to High Density Res.	Commercial and Industrial	Sheds/Garages/ancillary residential	Tourist Development	Agricultural and Recreation	Earthworks	Critical Infrastructure	Sensitive Uses and Facilities	Land Subdivision	Low Density Residential	Medium to High Density Res.	Commercial and Industrial Uses	Sheds/Garages/ancillary residential	Tourist Development	Agricultural and Recreation	Earthworks	Critical Infrastructure and Facilities	Sensitive Uses and Facilities	Land Subdivision	Low Density Residential	Medium to High Density Residential	Commercial and Industrial Uses	Sheds/Garages/ancillary residential	Tourist Development	Agricultural and Recreation	Earthworks
Floor Level	3,5	3,5												1,5		2,5	5,6	1,5	4										4	
Building Components	1,3	1,3												1		1,2,3	1	1,2,3	1										1	
Structural Soundness	1	1												1		1	1	1	1	1									1	1
Flood Affectation	1	1								1,2			1,2	1		1		1	1	1,2									1,2	1,2
Evacuation	1	1												1,2		1,2		1,2,3	1,2										1,2	
Access	1	1											1,2	1,2		1,2		1,2	1										1	
Other	1	1											2			1	3	1											1	

Colour Legend

Unsuitable land use- requires performance based assessment

Not Relevant

1 Flood related controls apply

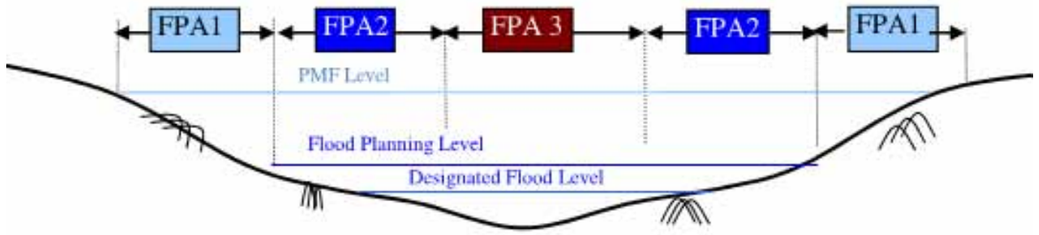

Figure: Flood Planning Area (FPA)

Floor Level

1 = Flood Planning Level (FPL) for residential development Designated flood level plus 500mm freeboard

2 = FPL for commercial and industrial development = Designated flood level plus 0mm freeboard

3 = FPL is PMF level plus 0mm freeboard

4 = FPL for non habitable floor is 20% AEP flood level with 0mm freeboard

5 = Mine subsidence allowance to be added to flood level to determine flood planning level, if applicable. Information is to be obtained by applicant from Mine Subsidence Board.

6 = Ground level. Absolute minimal filling will be permitted to provide vehicular access to sheds and other residential ancillary structures such as pools and gazebos, where required

Building Components

1 = Any part of the building located below the FPL to be constructed of flood compatible materials.

2 = Basement carpark entry level to be the designated flood level plus 500mm or the PMF, whichever is the higher.

3 = Above ground carparks are to be at a minimum level of 150mm below the designated flood. Flood Affectation rules 1 and 2 below apply where filling is proposed.

Structural Soundness

1 = Engineering report - the structures can withstand floodwater forces including debris and buoyancy up to the FPL.

Flood Affectation

1 = Engineering report to certify that the development will not increase flood affectation elsewhere, having regard to a) loss of flood storage, b) changes in flood levels, flows and velocities upstream, downstream and adjacent to the site, c) cumulative impact of multiple development in the vicinity, d) negligible impact to flood hazard as a result of development

2 = There must be no loss in floodplain storage or floodway capacity as a result of earthworks i.e. filling will only be permitted with the equivalent level-for-level excavation in the same floodplain, provided that the fundamental flow patterns are not significantly altered.

Evacuation

1 = Engineers report demonstrating that permanent, failsafe, maintenance free measures are incorporated in to the development for timely and safe evacuation of people without significant cost added to the development.

2 = Where flood evacuation from the property cannot be provided, flood refuge above the level of the PMF is required on the property for a minimum of 1 day during a flood event

3 = Effective evacuation plan is to be developed by the park manager, in conjunction with the SES, with adequate documentation (signs) of the plan to be displayed around the park. Plan is to be updated every 2 years.

Access

1 = Emergency vehicle access for ambulance, SES and fire trucks for all floods up to and including the designated flood level.

2 = Access for pedestrians or vehicles required during the designated flood event to an appropriate area of refuge located above the PMF level.

Other

1 = Provision of adequate flood liability information and advice to residents, attendants, guests and /or visitors

2 = Creation of fully flood affected lots (in flood planning area 3) through subdivision of parent lots that are partially flood prone will not be permissible.

3 = Maximum size of enclosed shed/garage/ancillary structure is $50m^2$

Definitions

Designated Flood = 1% AEP design storm event plus 15% rainfall intensity increase

Floodway = Those areas, often aligned with obvious naturally defined channels, where a significant discharge of water occurs during floods. They are also areas where, if only partially blocked, will cause a significant redistribution of flood flow or significant increase in flood levels, which many impact on other properties.

PMF – Probable Maximum Flood

ARI – Average Recurrence Interval

SES – State Emergency Services

Figure 2: Floodplain Development Matrix