

Eastwood & Terrys Creek Floodplain Risk Management Study & Plan



Conditions in West Parade (and Eastwood Park in the background) during the November 1984 flood

Main Report

October 2009

CITY OF RYDE

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Report of City of Ryde's
Eastwood & Terrys Creek Floodplain Management Committee, prepared by

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FOREWORD

In New South Wales the prime responsibility for local planning and the management of flood liable land rests with local government. To assist local government with floodplain management, the NSW Government has adopted a Flood Prone land Policy in conjunction with the *Floodplain Development Manual*.

The Policy is directed at providing solutions to existing flood problems and to ensure that new development is compatible with the flood hazard and does not create additional flood problems.

The Policy sets out four sequential stages in the development of a floodplain management plan:

- 1 Flood Study - Assessment to define the nature and extent of flooding.
- 2 Floodplain Risk Management Study - Comprehensive evaluation of management options with respect to existing and proposed development.
- 3 Floodplain Risk Management Plan - Formal adoption by Council of a management plan for floodplain risks
- 4 Implementation of the Plan - Measures undertaken to reduce the impact of flooding on existing development, and implementing controls to ensure that new development is compatible with the flood hazard.

This Floodplain Risk Management Study and Plan constitutes the second and third stages of the management process for Eastwood & Terry's Creek and has been prepared for the City of Ryde by Bewsher Consulting Pty Ltd in association with Don Fox Planning Pty Ltd.

In broad terms, this Floodplain Risk Management Study has investigated what can be done to minimise the effects of flooding in the Eastwood & Terry's Creek catchment and has recommended a strategy in the form of a draft Floodplain Risk Management Plan.

The draft Floodplain Risk Management Study and Plan was placed on public exhibition between 4 February and 13 March 2009. Some changes to the draft were made following a review of submissions received. The next stage of the floodplain risk management process will be for the City of Ryde to formally adopt the Floodplain Risk Management Plan.

This project is being conducted under the Natural Disaster Mitigation Programme and has received Commonwealth and State financial and technical support.

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EXECUTIVE SUMMARY

Reasons for the Study and Plan

Flooding problems within the Eastwood town centre and other areas within the Terry's Creek catchment are well documented. Significant flooding problems have been experienced in 1967, 1984 and 1989. It is estimated that over 70 houses or commercial properties experienced above floor flooding in the November 1984 flood.

A range of flood mitigation options were investigated some 17 years ago, in the Terry's Creek Catchment Management Study that was prepared for the Water Board. Since that time, there have been a number of other studies with an emphasis largely on structural options, including tunnelling, as a means of reducing Eastwood's flood problem. There have also been various planning initiatives undertaken by Council which have imposed restrictions on development because of the flood problems.

In May 2006, Bewsher Consulting was commissioned by the City of Ryde to assist its Floodplain Management Committee in preparing a Floodplain Management Study and Plan for Eastwood and Terry's Creek.

Responsibilities

The prime responsibility for planning and management of flood prone lands in NSW rests with local government. The NSW Government provides assistance on state-wide policy issues and technical support. Financial assistance is also provided to undertake flood and floodplain risk management studies and for the implementation of works identified in any subsequent floodplain risk management plan.

The Eastwood and Terry's Creek Floodplain Management Committee oversaw the Study. This committee includes Councillors and staff from the City of Ryde, and staff from Parramatta City Council, Hornsby Shire Council, Department of Environment, Climate Change and Water (DECCW), Sydney Water Corporation and the State Emergency Service (SES). A number of community representatives were also represented on the committee.

The Study Area

The study area, shown on **Figure 1**, includes that portion of Terry's Creek within the City of Ryde, from Terry Road to the creek's confluence with the Lane Cove River.

The Eastwood town centre is located within the study area, and straddles the Main Northern Railway Line. In addition to the main creek, the study area includes all significant tributaries and many overland flow paths.

Some consideration has also been given to works that have previously been recommended within Parramatta City Council, where these works potentially impact on flooding within the City of Ryde. The potential for flooding of properties in Parramatta City Council and Hornsby Shire Council has also been considered immediately upstream and downstream of the railway crossing.

Reporting

The Study results have been presented in a number of reports as the study has progressed, including reports covering:

- i) the Flood Study (May 2008);
- ii) Town Planning Considerations (July 2008); and the
- iii) Floodplain Risk Management Study and Plan (this report).

**FIGURE 1
FLOOD PROBLEM
AREAS**

0 500m
Scale

LEGEND

- Location of Buildings Inundated
- 5yr Flood Event
 - 10yr Flood Event
 - 20yr Flood Event
 - 50yr Flood Event
 - 100yr Flood Event



Sub Area Regions



LGA Boundary

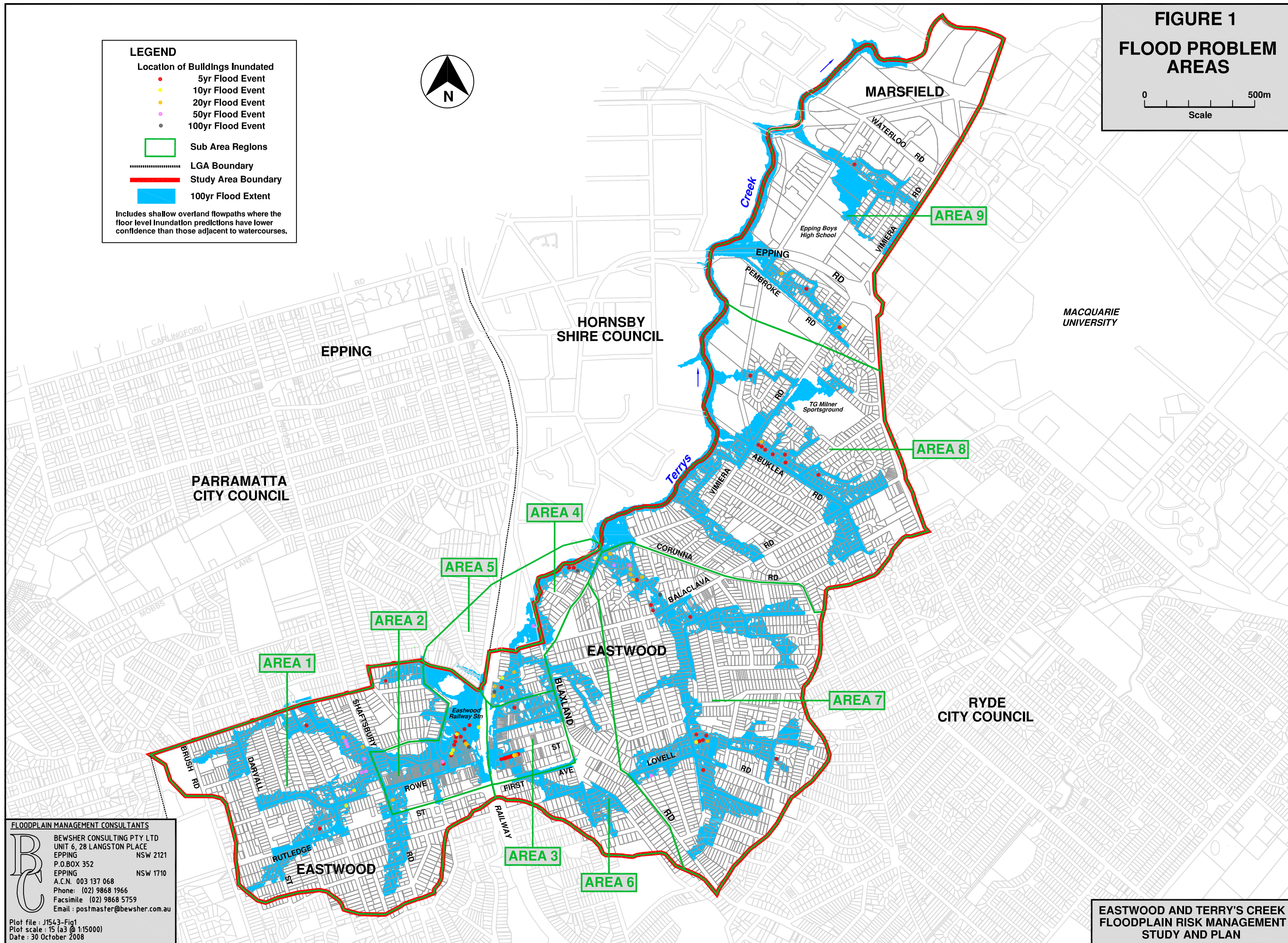


Study Area Boundary



100yr Flood Extent

Includes shallow overland flowpaths where the floor level inundation predictions have lower confidence than those adjacent to watercourses.



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**EASTWOOD AND TERRY'S CREEK
FLOODPLAIN RISK MANAGEMENT
STUDY AND PLAN**

Consultation

Community consultation has been an important component of the project. Key elements of the consultation process have been as follows:

- i) regular meetings of the Eastwood & Terry's Creek Floodplain Management Committee;
- ii) public review of the flood study results, including a public display during July and August 2007, an information day and feedback process; and
- iii) public exhibition of the draft floodplain risk management study and plan, prior to formal consideration by Council.

Modelling of Flood Behaviour

Flood behaviour has been assessed using computer models. The catchment area and stormwater pipe network within the study area was modelled using the DRAINS hydrologic model. Catchment flows from the Parramatta and Hornsby Council portion of the catchment were generated using a less detailed RAFTS model. Flows from these models were input to a two dimensional TUFLOW hydraulic model to estimate flood depths and the extent of flood inundation.

The flood models were calibrated to the November 1984 flood. They were then used to simulate flood behaviour for a range of flood events, including a 5 year, 10 year, 20 year, 50 year, 100 year and Probable Maximum Flood (PMF).

Flood Risk Mapping & Development Controls

The area subject to flooding (up to the PMF) has been divided into three flood risk precincts (high, medium and low). Different development controls are proposed for the catchment, depending on the type of development and the flood risk precinct in which the development is located. The flood risk precincts comprise:

- i) The high flood risk area – where high flood damages, potential risk to life, or evacuation problems are anticipated. It is recommended that most development is restricted within this area.
- ii) The medium flood risk area – where there is still a significant risk of flood damage, but where these damages can be minimised by the application of appropriate development controls.
- iii) The low flood risk area – where the risk of flood damage is low. Most land uses would be permitted within this area (subject to other planning considerations).

In addition to the flood risk precincts, an overland flow precinct has also been defined. This comprises shallow areas of inundation distant from major watercourses where less restrictive flood level and other controls apply.

The Flood Problem

A flood damages database has been prepared for the study area to quantify the flood problem and to assist in evaluating the economic merit of a range of flood mitigation measures.

The database includes details on 1,361 properties throughout the study area that could potentially be affected by flooding (up to a PMF flood). The database has further been divided into 9 geographical areas (shown on Figure 1) to help identify the spatial distribution of the flood problem over the study area.

Key results from the database are included in **Table 1** and **Table 2**.

Table 1
Summary of Buildings Inundated

Flood	Shallow Overland Flood Depth *			Remainder of Floodplain			TOTAL
	Residential	Commercial	Total	Residential	Commercial	Total	
5 year	16	16	32	13	11	24	56
10 year	20	17	37	14	15	29	66
20 year	27	19	46	22	17	39	85
50 year	31	16	47	27	19	46	93
100 year	34	20	54	29	21	50	104
PMF							338

* Shallow overland flood depth defined as depth of flooding < 0.3m in 100 year flood. Because of the shallow depth it is difficult to predict floor level inundation accurately. Therefore there is less confidence in these inundation estimates than in the remainder of the floodplain.

Table 2
Predicted Total Flood Damages under Existing Conditions

Location	Damage in Flood Event (\$M)				Average Annual Damage (\$M)	Present Value of Damage (\$M)
	5 Year	20 Year	100 Year	PMF		
Area 1 – Western Tribs	1.24	1.87	2.59	9.45	0.37	3.87
Area 2 – CBD West	1.76	2.76	3.88	33.54	0.61	6.43
Area 3 – CBD East	0.45	0.90	0.94	3.53	0.17	1.78
Area 4 – DS Railway	0.34	1.44	2.15	4.17	0.21	2.22
Area 5 – Other Councils	0.04	0.07	0.19	2.02	0.03	0.27
Area 6 – Southern Tribs	0.30	0.50	0.56	1.77	0.09	0.98
Area 7 – Central Tribs	1.96	3.08	4.12	10.16	0.58	6.10
Area 8 – Northern Tribs	1.25	1.66	1.96	4.92	0.31	3.33
Area 9 – Marsfield Tribs	0.34	0.65	0.74	1.40	0.10	1.09
TOTAL	7.7	12.9	17.1	71.0	2.5	26.1

Flood Mitigation Options Investigated

A total of 12 options were identified by the floodplain management committee for analysis. These options were initially assessed using performance in the 100 year flood and consideration of environmental and other factors. A short list of 6 options was identified for further economic assessment. An additional option for the Eastwood town centre was also investigated following the evaluation of these options. The options are shown in **Table 3**.

Table 3
Flood Mitigation Options Investigated

Option No.	Description	Committee Recommendation
1	Long Tunnel (Terry Rd to Forrester Park)	High costs & environmental concerns
2	Short Tunnel (Terry Rd to Eastwood Park)	Further consideration
3	Basin in Glen Reserve	Minimal impact on flood behaviour
4	Basin at Mobbs Lane	Further consideration
5	Enlarge Railway Culvert	High costs and practical difficulties
6	Basin in Eastwood Park	Minimal impact on flood behaviour
7	Upgrade Terry Road Culvert	Further consideration
8	Abuklea Road and Millner Park drainage	Further consideration
9	Debris control structures	Further consideration
10	Wood Street drainage upgrade	Has been upgraded since last flood
11	Divert flows to Parramatta River	High costs and practical difficulties
12	First Avenue Drainage Works (final stage)	Further consideration
13	Eastwood Town Centre Drainage Augmentation	Subsequently considered

The short tunnel option looked at diverting flow from upstream of Terry Road through a 3.8m diameter tunnel direct to a small basin in the lower part of Eastwood Park. The main objective was to reduce the flow carried by Terry's Creek through the town centre. This option reduces flood levels through the town centre by 0.4 to 0.6m in a 100 year flood, and reduces the present value of all flood damage by \$3.2M. However, flood levels downstream of the railway line increase marginally due to reduced travel times and results in an increase in flood damage of \$0.4M. The net benefit is \$2.8M and the estimated cost is \$13M. This option is not favoured due to its poor benefit/cost ratio of 0.2 and the increase in downstream flood levels.

The basin at Mobbs Lane and the culvert upgrade at Terry Road are two options that have been proposed in a report prepared for Parramatta City Council. Both options have been reviewed due to their potential impact on flood behaviour through the current study area. The basin is likely to reduce flood levels whilst the culvert upgrade could potentially increase flood levels. Model results indicate a reduction in flood levels of 0.1 to 0.2m through Eastwood in a 100 year flood due to the combined measures, but an increase of around 0.1m in more frequent floods (5 year and 10 year events). This is due to the basin becoming less effective in smaller floods whilst the impact of the culvert upgrade became more pronounced. It is recommended that a basin at Mobbs Lane be pursued with Parramatta City Council, with possible cost sharing arrangements between both Councils and the DECCW. Amplification of the Terry Road culvert can not be recommended without further consideration of the impacts in smaller floods.

Drainage improvements were investigated along Abuklea Road and in the vicinity of the TG Milner Sportsground. The initial scheme included doubling the size of the existing drainage pipeline behind properties in Abuklea Road, but provided limited benefits. Further stormwater drainage improvements have been proposed for this area (see Table 4 for potential drainage improvements in this area and others).

Debris control measures to prevent blockage of the railway culvert and the Progress Avenue culverts were investigated. The present value of all flood damage could be reduced by approximately \$0.5M if the potential for blockage of these structures is eliminated. The measures are envisaged to incorporate bollards around the perimeter of the railway culvert,

and structural fencing along the boundary of the open channel upstream of the Progress Avenue culverts. This measure has an estimated cost of the order of \$50,000 and a benefit/cost ratio considerably greater than 1.0. These works are recommended.

The final stage of a drainage augmentation scheme at First Avenue in the eastern town centre was included in the flood model. Results indicated that flooding of a number of commercial properties along Rowe Street could be alleviated by these works, with the present value of all flood damages reduced by approximately \$0.6M. The cost of the final stage of works has been estimated at \$1.3M, which provides a benefit/cost ratio of 0.5. As this is the final stage of a major drainage augmentation scheme, completion of this final stage is recommended.

The options recommended above only partially reduce flooding through the Eastwood town centre. Further evaluation of drainage augmentation measures in this area was subsequently undertaken. A scheme was identified including:

- i) modification of the existing drain upstream of Progress Avenue, including the option to cover this drain;
- ii) new twin box culverts from Glen Street Reserve to Eastwood Park, under Lakeside Road; and
- iii) an inlet headwall in Glen Street Reserve.

The drainage augmentation measures reduce the 100 year flood by up to 1.0 to 1.1m through the town centre, reducing the depth of flooding to less than 0.3m. The estimated cost is \$8.5M, and the present value of flood benefits estimated at \$4.6M. This provides a benefit/cost ratio of 0.5, which is a substantial improvement over the other tunnel options investigated. Given the reduced risk to personal safety this option could be considered more favourably. It would also remove many of the flooding constraints on future redevelopment of the town centre. The option has been included in the recommended Floodplain Management Plan.

Stormwater Drainage Problems

A large focus of the current study has been based on addressing the flood problems in the Eastwood town centre. However, the total flood damage from this area represents only 30% of the flood damage experienced throughout the wider study area (based on the present value of flood damage in Table 2). Most of the other flooding problems are related to stormwater drainage and overland flow problems along the tributaries that lead to Terry's Creek.

The majority of flooding problems are related to surface flows that are less than 0.5m in depth. Flood behaviour within these areas is very much influenced by local conditions, including fences, structures, the accuracy of the ALS survey, and assumed floor levels of potentially affected buildings. Further investigations will be required in several areas to determine the most appropriate stormwater drainage improvements.

Table 4 lists some provisional stormwater drainage improvement measures. These works are subject to detailed assessments, but are anticipated to include:

- i) formalisation of overland flow paths;
- ii) amplification of stormwater pipe lines; and
- iii) potential relocation of buildings that currently restrict overland flow paths.

Additional measures have been recommended for Area 7, including additional inlet pits in Brabyn Street, improvements to the culvert in Jim Walsh Park, and a feasibility study into a potential detention basin in Jim Walsh Park.

TABLE 4
Potential Drainage Improvements

Area No.	Address	Flood Regime	Formalise Overland Flow Path	Pipe Overland Flows	Relocate Buildings	Investigation Cost	Capital Works
1	33 Rutledge St	House located within overland flow regime			Investigate	\$20,000	\$200,000
	212-280 Rutledge St	School building within overland flow regime	Yes			\$15,000	\$20,000
	163 Shaftsbury Rd	House located below street level and flows spilling off street	Yes (difficult)			\$15,000	\$20,000
	298A Rowe St	Houses located within overland flow regime	Yes (difficult)			\$20,000	\$40,000
	2,3,4 Richards Ave	Houses located within overland flow regime	Yes (difficult)			\$20,000	\$30,000
	7-13 Auld Ave	Overbank flooding from Terry's Creek			Investigate	\$20,000	\$200,000
	9 Tarrants Ave	House located below street level and flows spilling off street	Yes (difficult)			\$15,000	\$20,000
	19A Clive Rd	House located within overland flow regime	Yes (difficult)			\$15,000	\$20,000
7	15 Milham Ave	House below road sag point, no overland flow path			Investigate	\$20,000	\$200,000
	36-40 Balaclava Rd	2 houses down slope of overland flow regime	Yes (difficult)			\$20,000	\$30,000
	6-11 Jupp Pl	6 houses located within overland flow regime	Yes (difficult)			\$30,000	\$90,000
	26-28 Virmiera Rd	House located within overland flow regime	Yes (difficult)			\$15,000	\$20,000
	12 Grove St	House located within overland flow regime	Yes (difficult)			\$15,000	\$20,000
	7-13 Pickford Ave	Series of houses with depression in backyards plus flow from street reserve	Yes (difficult)			\$30,000	\$80,000
	4 Russell St	House located below street level and flows spilling off street	Yes (difficult)			\$15,000	\$20,000
	5 Lovell Rd	House located within overland flow regime	Yes (difficult)			\$15,000	\$20,000

TABLE 4
Potential Drainage Improvements

Area No.	Address	Flood Regime	Formalise Overland Flow Path	Pipe Overland Flows	Relocate Buildings	Investigation Cost	Capital Works
8	38 Menzies Rd	House below road sag point, no overland flow path	Too difficult	Yes, pipe all 100 year flows off street. New 1200 pipe to supplement existing 900 pipe. Lay new pipe down opposite side of most floodprone property. Total pipe length about 60m)		\$25,000	\$120,000
	1-7 Abuklea Rd	Main depression in back yards of properties plus flow from street reserve	Cannot create much extra capacity, therefore not worthwhile	Yes, pipe all overland flow from Culloden Rd to Vimiera Rd culvert outlet. Estimate twin 1500 pipes laid in street, length of about 300m. Investigate extension upstream to Balaclava Rd & additional drainage inlet pits at Vimiera Rd/Raymond St.		\$70,000	\$1,600,000
	120 Vimiera Rd	Main depression in backyard of property		Yes (part of above Abuklea scheme)			
	30 Thelma St	House below road sag point, no overland flow path	Yes (difficult)			\$15,000	\$20,000
9	1 Torrington Dr	House below road sag point, no overland flow path	Yes (difficult)			\$15,000	\$20,000
	18 Brunton Pl	House below road sag point, no overland flow path	Too difficult to provide for flow from street but needed through Nos 16-20 because rear yard depression is inadequate	Yes, pipe all 100 year flows off street (replace 450 pipe with 1200 pipe, length about 40 metres with surcharge junction pit in upgraded flow path scheme)		\$25,000	\$110,000
	9 Towri Pl	House below road sag point, no overland flow path	Yes (difficult)			\$15,000	\$20,000
	2 Mawarra Pl	House below road sag point, no overland flow path	Yes (difficult)			\$15,000	\$20,000
	176-178 Balaclava Rd	2 houses located within overland flow regime	Yes (difficult)			\$15,000	\$20,000

Planning Issues

Existing planning controls related to flooding have been reviewed during the course of these investigations.

A number of flood related controls have been proposed for the study area, which would be implemented through a flood risk management chapter to be included in the City-wide DCP. The DCP chapter outlines a common preamble, principles and objectives that would apply to all catchments within the City of Ryde. Specific controls for Eastwood and Terry's Creek, as determined during the course of the floodplain management study, are included in a matrix of prescriptive controls (included as **Figure 2**). Other matrices would be developed and appended to the DCP chapter as studies and plans on other catchments are completed.

Many of the measures included in the proposed DCP chapter formalise procedures that are currently applied by officers from Council. Some changes that have been recommended include:

- i) increase of freeboard from 0.3m to 0.5m (except in the overland flow precinct);
- ii) limited controls on residential development above the 100 year flood, to satisfy freeboard allowance and vertical evacuation requirements;
- iii) more comprehensive car parking and driveway access requirements;
- iv) varying controls based on sensitivity of landuse to flood risk;
- v) providing concessions to encourage existing floodprone properties to redevelop in a flood-sensitive manner.

The study has also recognised that there may be locations beyond the limit of the 100 year flood (plus freeboard) where controls on residential development may be required in some rare circumstances (eg basement car parks, vertical evacuation). In accordance with the Department of Planning's January 2007 Guideline, Council will need to seek approval from the State Government to impose controls in this area.

The Recommended Floodplain Management Measures

The draft Eastwood and Terry's Creek Floodplain Risk Management Plan is shown on **Figure 3** and summarised in **Table 5**.

It is important to note that not all flooding problems in the study area have been alleviated. A complete solution to the flooding problem is not cost effective from a floodplain management perspective. However, problems can be reduced gradually over time as sensible redevelopment occurs. There may also be some scope to completely alter the drainage regime through the town centre in association with major redevelopment proposals.

Timing and Funding

The total cost of implementing all the recommended measures is approximately \$14.4M. This includes an amount of \$8.5M for drainage augmentation measures through the town centre. It is envisaged that the Plan would be implemented progressively over a 5 to 10 year time frame.

The timing of the proposed works will depend on the overall budgetary commitments of Council and the availability of funds from other sources (eg State Government, potential Section 94 contributions, private sector contributions etc).

Planning Consideration	Inundation Precincts																							
	Low Flood Risk						Medium Flood Risk						High Flood Risk						Overland Flow					
	Critical Uses & Facilities	Sensitive Uses & Facilities	Residential	Commercial & Industrial	Recreation & Non-Urban	Concessional Development	Critical Uses & Facilities	Sensitive Uses & Facilities	Residential	Commercial & Industrial	Recreation & Non-Urban	Concessional Development	Critical Uses & Facilities	Sensitive Uses & Facilities	Residential	Commercial & Industrial	Recreation & Non-Urban	Concessional Development	Critical Uses & Facilities	Sensitive Uses & Facilities	Residential	Commercial & Industrial	Recreation & Non-Urban	Concessional Development
Floor Level		3	2,6,7	5,6,7	1,6	4,7			2,6,7	5,6,7	1	4,7					1	4,7	3	3	2or8, 6or9, 7	5or8, 6or9, 7	1or8, 6or9	4,7
Building Components		2	1	1	1	1			1	1	1	1					1	1	2	2	1 or 3	1 or 3	1 or 3	1 or 3
Structural Soundness		3	2	2	2	2			2	2	2	2					1	1						
Inundation Effects		2	2	2	2	2			2	2	2	2					1	1	2	2	2	2	2	2
Car Parking & Driveway Access		1,3,5,6, 7	1,3,5,6, 7	1,3,5,6, 7	2,3,4,6, 7	6,7,8			1,3,5,6, 7	1,3,5,6, 7	2,3,4,6, 7	6,7,8					2,3,4,6, 7	6,7,8	1or9, 3,6	1or9, 3,6	1or9, 3,6	1or9, 3,6	2,3,6	6,8
Evacuation		2	2	1 or 2	3	2			2	1 or 2	3	2					3	2	2	2				
Management & Design		1,4,5	1	1,2,3,5	1,2,3,5	1,2,3,5			1	1,2,3,5	1,2,3,5	1,2,3,5					1,2,3,5	1,2,3,5	1,4,5	1,4,5	1	1,2, 3or6, 5	1,2, 3or6, 5	1,2, 3or6, 5

General Notes:

■ Unsuitable Land Use (refer to General Note b)

■ No Controls

- Freeboard* equals an additional height of 500mm. In *Overland Flow* precincts, the *freeboard* is 300mm.
- The relevant environmental planning instruments (generally the Local Environmental Plan) identify development permissible with consent in various zones in the LGA. Notwithstanding, constraints specific to individual sites may preclude Council granting consent for certain forms of development on all or part of a site.
- Filling of the site, where acceptable to Council, may change the FRP considered to determine the controls applied in the circumstances of individual applications.
- Refer to Section 2.3 of the DCP for planning considerations for proposals involving only the erection of a fence. Any fencing that forms part of a proposed development is subject to the relevant flood effects and structural soundness planning considerations of the applicable landuse category.
- Refer to Section 2.2 of the DCP for special considerations such as for house raising proposals and development of properties identified for voluntary acquisition.
- Terms in italics are defined in the glossary of this plan and Schedule 2 specifies development types included in each land use category. These development types are generally as defined within Environmental Planning Instruments applying to the LGA.

Floor Level

- All floor levels to be no lower than the 20 year flood level plus freeboard unless justified by site specific assessment.
- Habitable floor* levels to be no lower than the 100 year flood level plus freeboard.
- Habitable floor* levels to be no lower than the *PMF* level. *Non-habitable floor* levels to be no lower than the *PMF* level unless justified by a site specific assessment.
- Floor levels to be no lower than the *design floor level*. Where this is not *practical* due to compatibility with the height of adjacent buildings, or compatibility with the floor level of existing buildings, or the need for access for persons with disabilities, a lower floor level may be considered. In these circumstances, the floor level is to be as high as *practical*, and, when undertaking alterations or additions, no lower than the existing floor level.
- The level of *habitable floor areas* to be equal to or greater than the 100 year flood level plus freeboard. If this level is not *practical* for a development in a Business zone, the floor level should be as high as possible.
- Non-habitable floor* levels to be equal to or greater than the 100 year flood level plus freeboard where possible, or otherwise no lower than the 20 year flood level plus freeboard unless justified by site specific assessment.
- A restriction is to be placed on the title of the land, pursuant to S.88B of the Conveyancing Act, where the lowest *habitable floor area* is elevated above finished ground level, confirming that the undercroft area is not to be enclosed, where Council considers this may potentially occur.
- Habitable floor* levels to be minimum 500mm above adjacent ground levels.
- Non-habitable floor* levels to be minimum 300mm above adjacent ground levels.

Building Components & Method

- All structures to have *flood compatible building components* below the 100 year flood level plus freeboard.
- All structures to have *flood compatible building components* below the *PMF* level.
- All structures to have *flood compatible building components* up to 500mm above adjacent ground levels.

Structural Soundness

- Engineer's report to certify that the structure can withstand the forces of floodwater, debris and buoyancy up to and including a 100 year flood plus freeboard, or a *PMF* if required to satisfy evacuation criteria (see below). In the case of alterations or additions to an existing development, the structure to be certified is that which is proposed to be newly constructed or otherwise required to be of a specified standard to satisfy other controls.
- Applicant to demonstrate that the structure can withstand the forces of floodwater, debris and buoyancy up to and including a 100 year flood plus freeboard, or a *PMF* if required to satisfy evacuation criteria (see below). An engineer's report may be required.
- Applicant to demonstrate that any structure can withstand the forces of floodwater, debris and buoyancy up to and including a *PMF*. An engineer's report may be required.

Inundation Effects

- Engineer's report required to certify that the development will not increase effects elsewhere, having regard to: (i) loss of flood storage; (ii) changes in inundation levels and velocities caused by alterations to the conveyance of flood or overland flow waters; and (iii) the cumulative impact of multiple potential developments in the floodplain.
- The flood impact of the development to be considered to ensure that the development will not increase flood effects elsewhere, having regard to: (i) loss of flood storage; (ii) changes in flood levels and velocities caused by alterations to the flood conveyance; and (iii) the cumulative impact of multiple potential developments in the floodplain. An engineer's report may be required.

Car Parking and Driveway Access

- The minimum surface level of open car parking spaces or carports shall be as high as *practical*, and not below: (i) the 20 year flood level plus freeboard; or (ii) the level of the crest of the road at the location where the site has access; (which ever is the lower). In the case of garages, the minimum surface level shall be as high as *practical*, but no lower than the 20 year flood level plus freeboard.
- The minimum surface level of open car parking spaces, carports or garages, shall be as high as *practical*.
- Garages capable of accommodating more than 3 motor vehicles on land zoned for urban purposes, or *enclosed car parking*, must be protected from inundation by floods equal to or greater than the 100 year flood.
- The driveway providing access between the road and parking space shall be as high as *practical* and generally rising in the egress direction.
- Where the level of the driveway providing access between the road and parking space is lower than 0.3m below the 100 year flood, the following condition must be satisfied - the depth of inundation on the driveway during a 100 year flood shall not exceed: (i) the depth at the road; or (ii) the depth at the car parking space. (Refer to Schedule 3). A lesser standard may be accepted for single detached dwelling houses where it can be demonstrated that risk to human life would not be compromised.
- Enclosed car parking* and car parking areas accommodating more than 3 vehicles with a floor level below the 20 year flood level plus freeboard or more than 0.8m below the 100 year flood level, shall have adequate warning systems, signage and exits.
- Restraints or vehicle barriers to be provided to prevent floating vehicles leaving a site during a 100 year flood.
- Driveway and parking space levels to be no lower than the *design ground/floor levels*. Where this is not *practical*, a lower level may be considered. In these circumstances, the level is to be as high as *practical*, and, when undertaking alterations or additions, no lower than the existing level.
- The minimum surface level of open car parking spaces or carports shall be as high as *practical*, and not below: (i) the 20 year flood level plus freeboard; or (ii) the level of the crest of the road at the location where the site has access; or (iii) 300mm above adjacent ground level; (which ever is the lower). In the case of garages, the minimum surface level shall be as high as *practical*, but no lower than the 20 year flood level plus freeboard or 300mm above adjacent ground level.

Note: a. A flood depth of 0.3m is sufficient to cause a small vehicle to float.

b. *Enclosed car parking* is defined in the glossary and typically refers to carparks in basements.

Evacuation

- Reliable access for pedestrians or vehicles required during a 100 year flood.
- Reliable access for pedestrians or vehicles is required from the building, commencing at a minimum level equal to the lowest *habitable floor* level to an area of refuge above the *PMF* level, or a minimum of 20% of the gross floor area of the dwelling to be above the *PMF* level. In the case of alterations or additions to an existing development, this may require retro-fitting the existing structure if required to support a refuge above the *PMF*.
- The evacuation requirements of the development are to be considered. An engineer's report will be required if in the opinion of Council the evacuation of persons might not be achieved within the *effective warning time*.

Management and Design

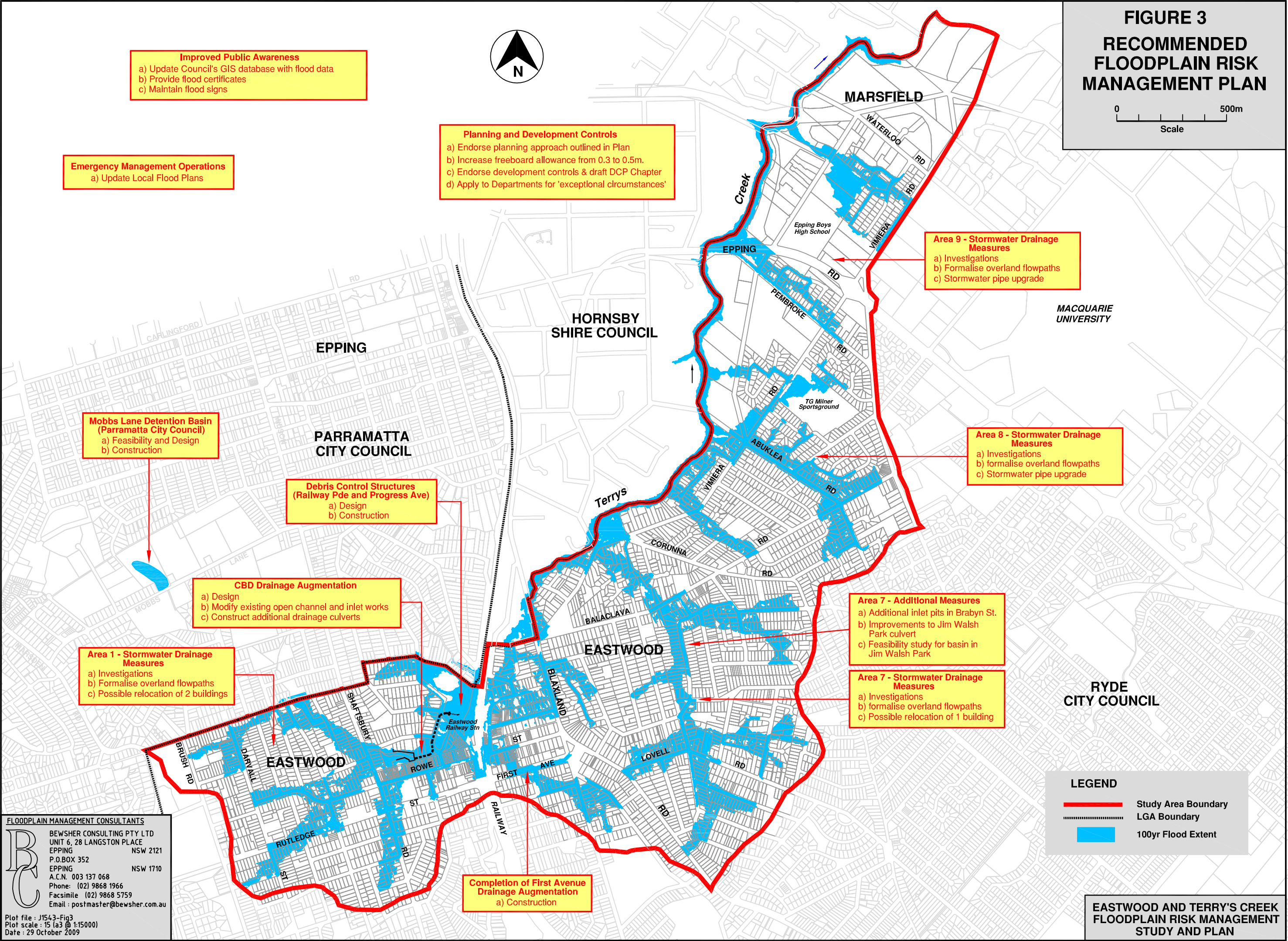
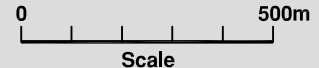
- If this application involves subdivision, the applicant is to demonstrate that potential development as a consequence of the subdivision, can be undertaken in accordance with this DCP
- Site Emergency Response Flood Plan* required where floor levels are below the *design floor level*, (except for single dwelling-houses).
- Applicant to demonstrate that an area is available to store goods above the 100 year flood level plus freeboard.
- Applicant to demonstrate that an area is available to store goods above the *PMF* level.
- No storage of materials below the *design floor level* which may cause pollution or be potentially hazardous during any flood.
- Applicant to demonstrate that an area is available to store goods at least 500mm above adjacent ground level.

TABLE 5
Recommended Floodplain Management Measures

Item	Description	Estimated Cost	B/C Ratio	Potential Funding Sources	Priority
1	Mobbs Lane Detention Basin (Parramatta City Council) a) Feasibility and Design b) Construction	\$50,000 \$800,000	>1.0	PCC, COR, DECCW	High
2	Debris Control Structures (Railway & Progress Avenue) a) Design b) Construction	\$5,000 \$50,000	>1.0	COR, DECCW	Medium
3	Completion of First Avenue Drainage Augmentation a) Construction	\$1,300,000	0.5	COR, DECCW	High
4	Area 1 – Stormwater Drainage Measures a) Investigations b) Formalise overland flow paths c) Possible relocation of 2 buildings	\$140,000 \$150,000 \$400,000	TBA	COR, DECCW	Low
5	Area 7 – Stormwater Drainage Measures a) Investigations b) Formalise overland flow paths c) Possible relocation of 1 building	\$160,000 \$280,000 \$200,000	TBA	COR, DECCW	Low
6	Area 8 – Stormwater Drainage Measures a) Investigations b) Formalise overland flow paths c) Stormwater pipe upgrade	\$125,000 \$40,000 \$1,720,000	TBA	COR, DECCW	Low
7	Area 9 – Stormwater Drainage Measures a) Investigations b) Formalise overland flow paths c) Stormwater pipe upgrade	\$70,000 \$60,000 \$110,000	TBA	COR, DECCW	Low
8	Additional Measures for Area 7 a) Additional inlet pits in Brabyn St b) Improvements to Jim Walsh Park Culvert c) Feasibility study for Jim Walsh Park detention basin	\$10,000 \$10,000 \$100,000	N/A N/A N/A	COR, DECCW	Low Medium Medium
9	Planning & Development Controls a) Endorse planning approach outlined in Plan b) Endorse adoption of Flood Management Areas c) Increase freeboard allowance from 0.3 to 0.5m d) Engage consultants to facilitate adoption of DCP chapter e) Apply to Departments for 'exceptional circumstances'	N/A N/A N/A \$30,000 N/A	>1.0	COR	High
10	Emergency Management Operations a) Update Local Flood Plans	\$20,000	>1.0	COR, SES	High
11	Improved Public Awareness a) Update Council's GIS database with flood data b) Provide Flood Certificates c) Maintain flood markers showing historic flood heights	\$20,000 \$20,000 \$20,000	>1.0	COR, DECCW	Medium
12	CBD Drainage Augmentation	\$8,500,000	0.5	COR, DECCW	Medium

Total: \$14,390,000

FIGURE 3
RECOMMENDED
FLOODPLAIN RISK
MANAGEMENT PLAN



Improved Public Awareness
a) Update Council's GIS database with flood data
b) Provide flood certificates
c) Maintain flood signs

Emergency Management Operations
a) Update Local Flood Plans

Planning and Development Controls
a) Endorse planning approach outlined in Plan
b) Increase freeboard allowance from 0.3 to 0.5m.
c) Endorse development controls & draft DCP Chapter
d) Apply to Departments for 'exceptional circumstances'

Area 9 - Stormwater Drainage Measures
a) Investigations
b) Formalise overland flowpaths
c) Stormwater pipe upgrade

Area 8 - Stormwater Drainage Measures
a) Investigations
b) formalise overland flowpaths
c) Stormwater pipe upgrade

Mobbs Lane Detention Basin (Parramatta City Council)
a) Feasibility and Design
b) Construction

Debris Control Structures (Railway Pde and Progress Ave)
a) Design
b) Construction

CBD Drainage Augmentation
a) Design
b) Modify existing open channel and inlet works
c) Construct additional drainage culverts

Area 1 - Stormwater Drainage Measures
a) Investigations
b) Formalise overland flowpaths
c) Possible relocation of 2 buildings

Area 7 - Additional Measures
a) Additional inlet pits in Brabyn St.
b) Improvements to Jim Walsh Park culvert
c) Feasibility study for basin in Jim Walsh Park

Area 7 - Stormwater Drainage Measures
a) Investigations
b) formalise overland flowpaths
c) Possible relocation of 1 building

Completion of First Avenue Drainage Augmentation
a) Construction

LEGEND

- Study Area Boundary
- LGA Boundary
- 100yr Flood Extent

FLOODPLAIN MANAGEMENT CONSULTANTS

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Plot file: J1543-Fig3
Plot scale: 1:5 (a3 @ 1:15000)
Date: 29 October 2009

1 INTRODUCTION

1.1 BACKGROUND

Terry's Creek is a tributary of the Lane Cove River, which drains an urban catchment in Sydney's north-west. The creek has a catchment area of 1,015 Ha and is located within three different local government areas: Parramatta City Council; the City of Ryde; and Hornsby Shire Council.

The creek and catchment has a history of flooding, with the worst flood experienced in November 1984. Over 70 houses and commercial properties were estimated to have been inundated above floor level in this flood. Most flooding problems were experienced throughout the City of Ryde, including the Eastwood town centre where some 50 commercial premises were estimated to have been inundated. Other floods are reported to have occurred in 1967 and 1989.

Bewsher Consulting was commissioned by the City of Ryde in May 2006 to prepare a Floodplain Risk Management Study and Plan for Eastwood and Terry's Creek (downstream of Terry Road). Don Fox Planning provided assistance to Bewsher Consulting on town planning issues.

The first step of the project was to establish a computer model to simulate flood behaviour throughout the study area. The model was calibrated to the November 1984 flood and used to determine flood behaviour for a range of design floods under existing conditions. Details of these investigations have been presented in a separate flood study report (Bewsher Consulting, May 2008).

The floodplain management study further identifies the flood problem, and investigates alternative options to reduce these flooding problems. A plan of recommended measures is also presented for Council to implement.

Funding for the study was jointly provided by the City of Ryde and the Department of Environment, Climate Change and Water (formerly Department of Natural Resources). Subsidised funding is also available through the Department for measures identified in the floodplain management plan. Funding assistance is usually provided on a 2:1 (State:Council) basis.

The Eastwood and Terry's Creek Floodplain Management Committee oversaw the study. This committee includes Councillors and staff from the City of Ryde, and staff from Parramatta City Council, Hornsby Shire Council, Department of Environment, Climate Change and Water (DECCW), Sydney Water Corporation and the State Emergency Service (SES). A number of community representatives were also represented on the Committee.

1.2 THE STUDY AREA

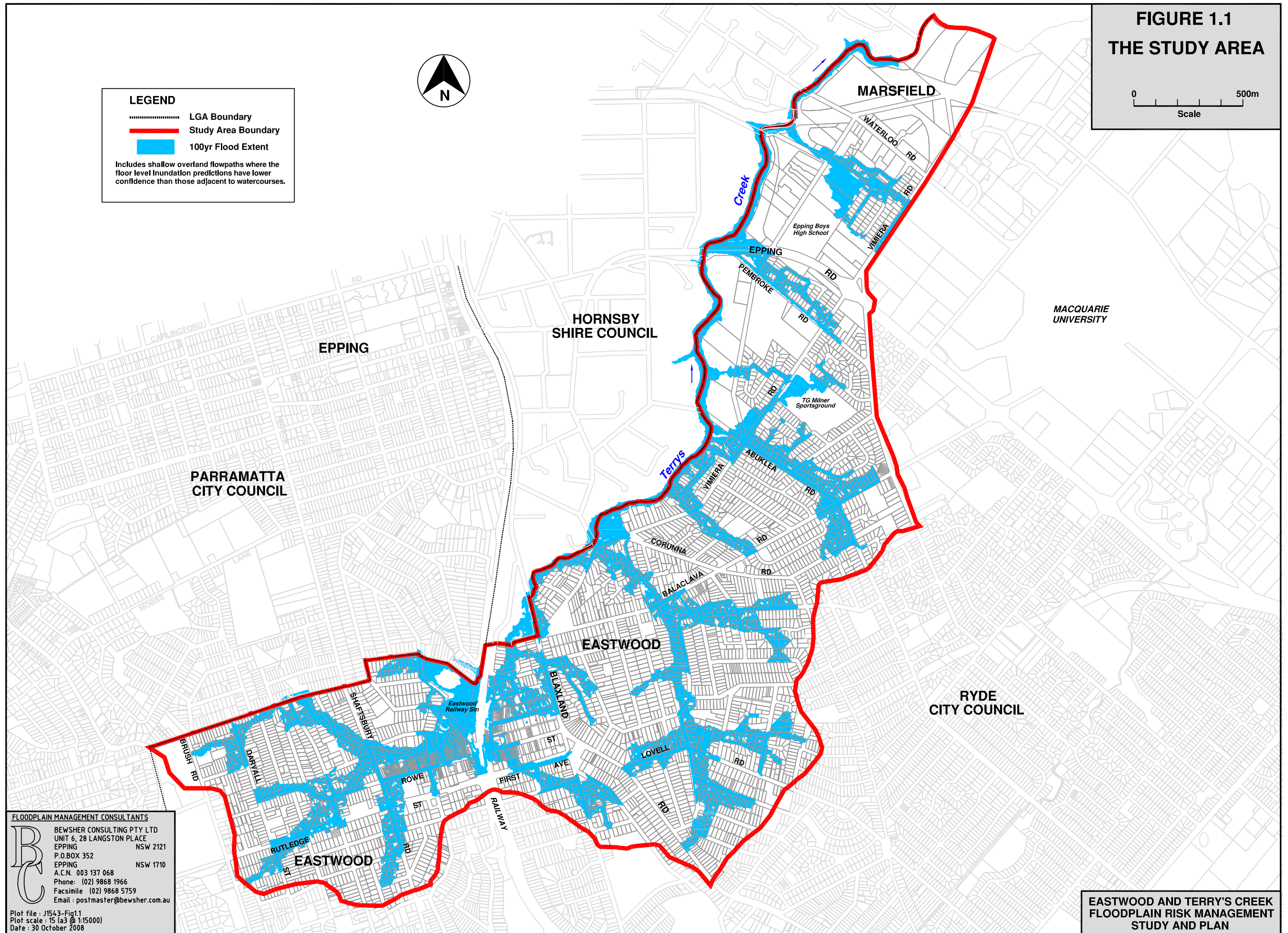
The study area includes that portion of Terry's Creek within the City of Ryde, from Terry Road to the creek's confluence with the Lane Cove River. It also includes all major tributaries and stormwater flow paths that are potentially affected by flooding within the City of Ryde. The Eastwood town centre is also a major focus of the current study.

The study area has been further divided into 9 sub-areas to facilitate the flood damage assessments, and to help identify the main problem areas within the catchment.

A map of the study area is included on **Figure 1.1**.

FIGURE 1.1

THE STUDY AREA



1.3 THE GOVERNMENT'S FLOODPLAIN MANAGEMENT PROCESS

The prime responsibility for planning and management of flood prone land in New South Wales rests with local government. The NSW Government provides assistance on state-wide policy issues and technical support. Financial assistance is also provided to undertake floodplain management studies and plans, such as the current project, and for the implementation of works identified in these studies.

A Flood Prone Land Policy and a *Floodplain Development Manual* (NSW Government, 2005) forms the basis of floodplain management in New South Wales.

The objectives of the Policy include:

- i) reducing the impact of flooding and flood liability on existing developed areas by flood mitigation works and measures, including ongoing emergency management measures, the raising of houses where appropriate, and development controls; and
- ii) reducing the potential for flood losses in new development areas by the application of ecologically sensitive planning and development controls.

The Policy provides some legal protection for Councils and other public authorities and their staff against claims for damages resulting from their issuing advice or granting approvals on floodplains, providing they have acted substantially in accordance with the principles contained in the *Floodplain Development Manual*.

The implementation of the Flood Prone Lands Policy, shown on **Figure 1.2**, generally culminates in the preparation and implementation of a Floodplain Management Plan. The Policy also provides for the Plan to be reviewed from time to time, for example on a regular basis or after a significant flood event.

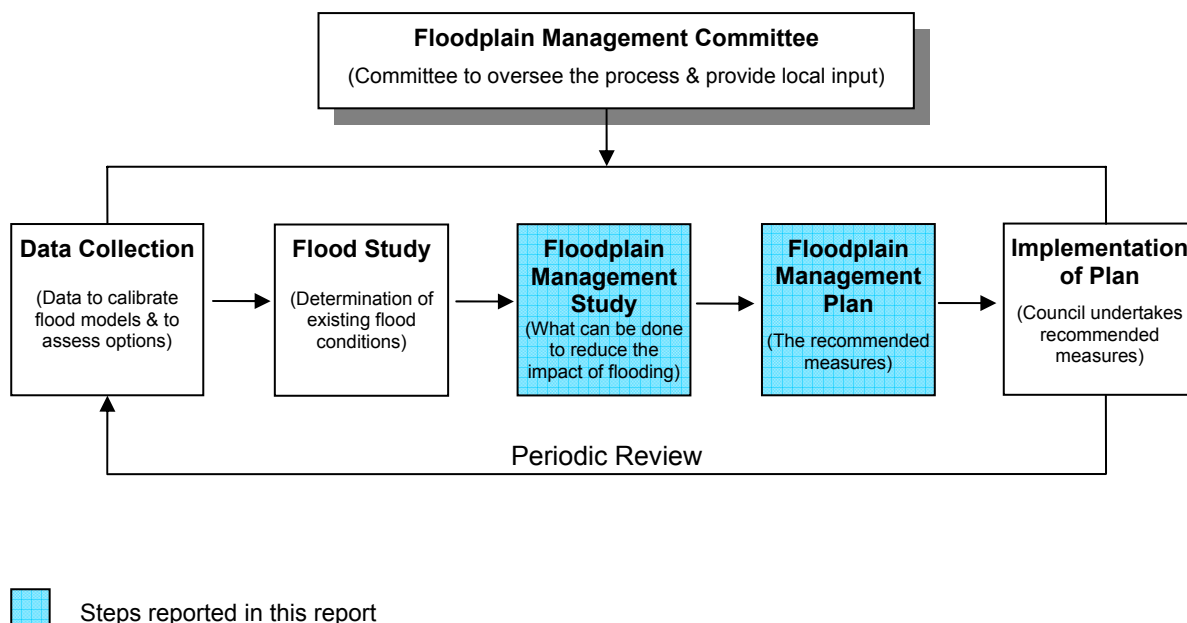


FIGURE 1.2
The Floodplain Management Process

1.4 STRUCTURE OF REPORT

This report is structured as follows:

- Chapter 1 – Introduction to the Study
- Chapter 2 – Background information, including a description of the catchment, history of flooding and previous investigations
- Chapter 3 – A review of consultation activities undertaken during the study
- Chapter 4 – Description of flood behaviour, including delineation of the catchment into different flood risk management areas and identification of properties potentially affected by flooding
- Chapter 5 – A flood damage assessment throughout the catchment for a range of flood events
- Chapter 6 – A review of floodplain management considerations, including adoption of flood planning levels and types of floodplain management measures that have been considered to alleviate flooding problems
- Chapter 7 – An assessment of potential flood mitigation options proposed by the committee
- Chapter 8 – Other floodplain management measures, including stormwater drainage problems, a review of planning and development controls and other potential measures
- Chapter 9 – The recommended floodplain management plan

2 BACKGROUND INFORMATION

2.1 DESCRIPTION OF THE CATCHMENT

Terry's Creek drains a heavily urbanised catchment, containing the suburbs of Carlingford, Epping, Eastwood, Marsfield and North Epping. The catchment contains a mix of normal residential, high density residential, and commercial premises throughout the catchment. The Eastwood town centre is a major feature in the catchment that is affected by flooding.

Terry's Creek has a catchment area of 1,015Ha which is divided between three different Local Government Areas:

- i) Parramatta City Council (230Ha);
- ii) City of Ryde (495 Ha); and
- iii) Hornsby Shire Council (290Ha).

The upper reaches of the catchment are located in Parramatta City Council, near Tomah Street in the Carlingford area. The main watercourse commences a short distance downstream, near Mobbs Lane, and flows in an easterly direction toward the LGA boundary at Terry Road.

The creek continues through the City of Ryde as a concrete trapezoidal channel, through Glen Reserve towards the Eastwood town centre. The creek is conveyed under the town centre through culverts under Progress Avenue and Eastwood Park. These culverts emerge into a short channel downstream of West Parade before passing under the Main Northern Railway embankment. A concrete trapezoidal channel continues on the eastern side of the railway embankment down to Somerville Park. Terry's Creek then meanders as a natural channel for approximately 3km in a north-easterly direction through the suburbs of Marsfield, and Epping, before joining the Lane Cover River at North Epping.

A short section of Terry's Creek downstream of the railway embankment is located wholly within Hornsby Shire Council. Terry's Creek forms the boundary between the City of Ryde and Hornsby Shire Council downstream of Blaxland Road.

Whilst Terry's creek is the predominant drainage feature of the catchment, there is also a substantial stormwater system comprising a network of stormwater pipes and overland flow paths. There are more than 1400 stormwater pits within the City of Ryde portion of the catchment alone.

The Main Northern Railway is also an important feature of the catchment, which divides the Eastwood town centre into two halves. The culvert under the railway embankment has an important influence on controlling flood levels on either side of the embankment.

2.2 HERITAGE

Heritage issues are important in forming an understanding of the social and cultural context of the floodplain and ensuring that flood mitigation measures do not unduly impact upon the heritage of the study area. Heritage items are classified as having either Local, Regional or State significance. Advice from the Heritage Council is required prior to any item of State Significance being demolished, defaced or damaged.

The Ryde Local Environmental Plan No. 105 provides a schedule of heritage items within the City of Ryde. Those heritage items that are within the proximity of the Eastwood and Terry's Creek study area have been listed in **Table 2.1**.

Table 2.1
Heritage Items within the Study Area

Item	Address	Type	Significance
101	53 Agincourt Rd, Marsfield – “Curzon Hall”	Restaurant	National & State
103	9 Orange St, Eastwood	Cottage	Local
104	495 Blaxland Rd, Denistone East – “Highbury House”	House	Local
123	12 Winbourne St, West Ryde – Ermington P School	School	Local
129	4 Auld Ave, Eastwood	House	Local
131	29 Clanalpine St, Eastwood – “St Phillip’s Church”	Church	Local
132	31 Trelawney St, Eastwood – “Womerah”	House	Local
136	1 Denistone Rd, Denistone – “Denistone House”	Hospital	National & State
136A	1 Denistone Rd, Denistone	Hospital	National & State
137	40 Hillview Rd, Eastwood – “Eastwood House”	School	National & State
139	45 West Pde, Eastwood – Eastwood Park	Grandstand	Local
139A	45 West Pde, Eastwood – Eastwood Park	Grandstand	Local
142	25 Clanalpine St, Eastwood – “The Rectory”	House	Local
170	45 West Pde, Eastwood – Eastwood Park	Pavilion	Local
171	269 Rowe St, Eastwood	Fire Station	Local
172	14 Auld Ave, Eastwood	House	Local
179	186 Rowe St, Eastwood	Hall	Local
180A	119-123&136 Rowe St, Eastwood – “Summerhayes”	Shops	Local
218	15-25 Railway Pde, Eastwood	Shops	Local
225	45 West Pde, Eastwood – Eastwood Park	Gates	Local
312	1 Coronation Ave, Eastwood	House	Local
329	24 Rutledge St, Eastwood – “Upna”	House	Local
330	2 Second Ave, Eastwood	House	Local

2.3 HISTORY OF FLOODING

A questionnaire was distributed to residents and business owners as part of previous flood investigations in the catchment (Water Board, 1991), which included questions concerning historical floods and other stormwater issues. Residents were asked to indicate whether or not they had experienced flooding on their property, the date of the largest flood experienced, and any other floods that were also experienced. Results of these questions are summarised in **Figure 2.1**.

The two dominant floods to stand out are the February 1990 and November 1984 floods. The 1990 flood was experienced by the most (174) number of residents, although the 1984 flood was noted as being the largest flood experienced by most (129) respondents. Of those residents who experienced both floods, 74% indicated that the 1984 flood was the largest. There also appears to have been two separate incidents of flooding in February 1990, occurring on the 7th and 10th of that month.

Some (11) residents also experienced a flood that occurred in 1967 or 1968, with all of these respondents noting that this was the largest flood that they had experienced. The actual date of this event is believed to be March 1967.

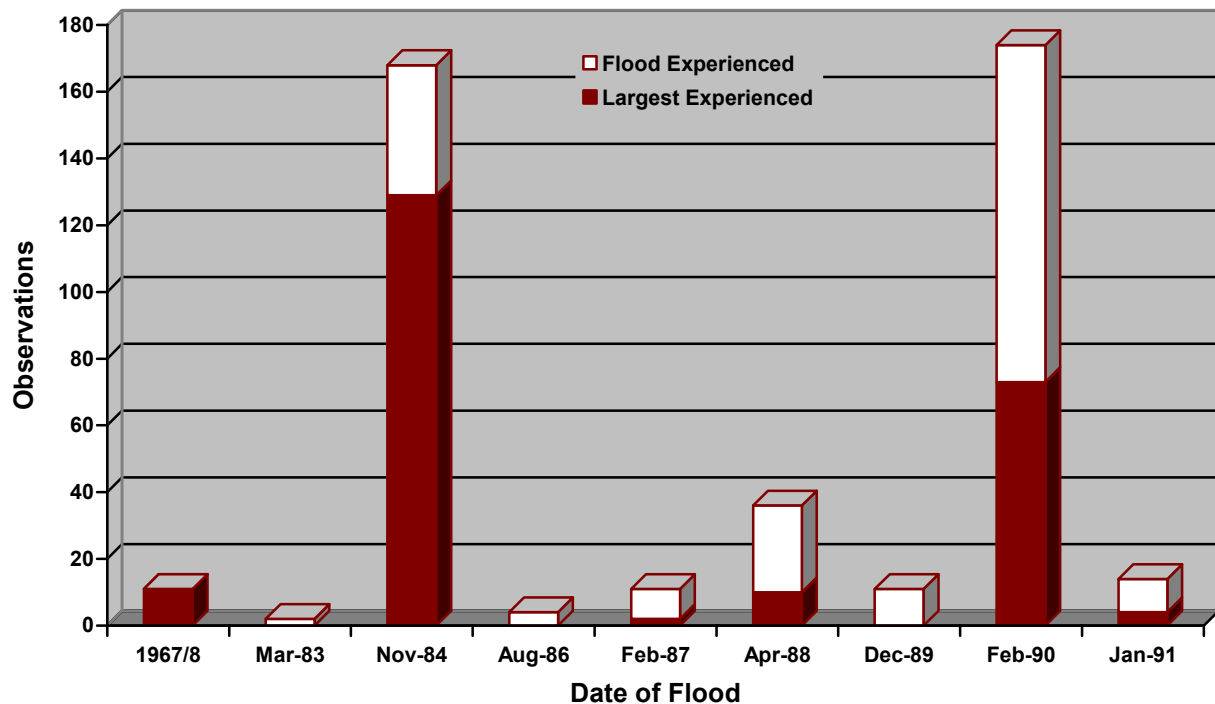


FIGURE 2.1
Floods Experienced in the Terry's Creek Catchment
 (Source: Community Questionnaire, Water Board, 1991)

Respondents to the questionnaire indicated the source of flooding to be from either:

- i) the open channel (32);
- ii) surcharge from street drains (63);
- iii) ponding in low areas (50); and
- iv) other sources (56).

Two types of flooding problems appear to be evident. The first involves stormwater flooding throughout various areas of the catchment, due to inadequate capacity of the stormwater pipe system and a lack of adequate overland flow paths. The second involves floodwater escaping from the main drainage channel (Terry's Creek) and flooding adjacent low lying property. The Eastwood town centre, which has been built above the main drainage channel, will flood when the capacity of this drain is exceeded. Flooding will also be exacerbated by inadequate stormwater drainage that diverts overland surface flows towards the town centre.

The 1984 flood resulted in flooding of a number of residential properties throughout the catchment, and also resulted in considerable damage and disruption in the Eastwood town centre. Photographs of flooding in Eastwood for this event are depicted in **Figure 2.2**.

The 1984 flood was selected to calibrate the flood models that have been established as part of the current floodplain management study. Further information concerning historical flood data is provided in the Flood Study Report (Bewsher Consulting, 2008).



Looking upstream across The Avenue



Looking west along Hillview Rd



Hillview Rd looking towards Progress Ave



Cars and debris threaten to block the Railway Culvert



Commuters (inc. school children) wading through floodwater



Looking South along Railway Pde

FIGURE 2.2
Flooding at Eastwood in November 1984

2.4 PREVIOUS FLOOD INVESTIGATIONS

A number of separate flood investigations have been undertaken within the Terry's Creek catchment in response to the floods that were experienced in 1984 and 1990. These investigations have been undertaken for different parts of the catchment, and for different authorities, including Parramatta City Council, City of Ryde and the Sydney Water Board.

A list of relevant reports and investigations that have been reviewed is provided in **Table 2.2**. A brief comment on the relevance of each report is also provided.

TABLE 2.2
List of Previous Investigations

No.	Date	Title	Author	Comment
1	Jan 1990	Ryde Stormwater Drainage Investigation	Willing & Partners	<p>Report prepared for Ryde Municipal Council.</p> <p>Stormwater drainage investigation for four catchments, including the Eastwood catchment. Included data collection and modelling of stormwater systems with pipe diameters of 600mm or more.</p> <p>Noted areas most affected by flooding in the Eastwood catchment as properties adjacent to Blaxland Rd, First Ave, Rowe St & Richards Ave.</p> <p>Noted that the commercial area of Eastwood is subject to severe flooding from Terry's Creek, but was outside the scope of the present study.</p>
2	June 1991	Terry's Creek Catchment Management Study	Bewsher Consulting	<p>Report prepared for the Sydney Water Board under the Special Environmental Programme.</p> <p>Volume 1 – Executive Summary Volume 2 – Main Report Volume 3 – Appendices</p> <p>Includes results of community questionnaire distributed to all residents within the catchment.</p> <p>Investigates existing flooding and water quality and recommends a strategy for reducing flooding and pollution of the creek.</p> <p>Main recommendations include:</p> <ul style="list-style-type: none"> < Basin at Mobbs Lane < Off-creek flood storage at Austral brickworks site < Various culvert & stormwater augmentation < Flood proofing & planning measures in town centre < Review impact of community building in Hillview Rd < Minor basin in Eastwood Park (lower field) < Uniform OSD policy for catchment <p>Notes that the best option to rectify the deficiency of the main trunk channel is through upper catchment retarding basins, particularly utilisation of the Austral Brickworks pit in Midson Road as an off-creek flood storage.</p> <p>Also notes the generally low standard of the tributary pipe systems and the difficulty of upgrading all drainage systems to even a 5 year capacity.</p>

TABLE 2.2
List of Previous Investigations

No.	Date	Title	Author	Comment
3	Oct 2001	Eastwood Tunnel Investigations Stage 1 – Feasibility & Concept Report	Robinson GRC	<p>Report prepared for Ryde City Council to investigate the effectiveness of a proposed stormwater tunnel on Terry's Creek to alleviate flooding of the Eastwood town centre.</p> <p>It was assumed that a tunnel (approx 3.9m diameter) could capture and divert all flows (estimated at 48m³/s) at Terry Road and divert this away from the town centre to a downstream outlet in Summerville Park. Flows through the Progress Avenue culverts were reduced from 73 to 35m³/s in the 100 year flood, but this still exceeded the capacity of the drain under the town centre and some flooding would still be evident. Relocating the intake tunnel to Braemar Park (downstream side of Terry Road) and increasing its size would be required to match the capacity of the drain under the town centre in the 100 year flood.</p> <p>It was also concluded that flooding downstream of the tunnel outlet would increase as a result of reduced travel times. It was suggested that downstream flooding problems could be largely alleviated if the outlet was moved further downstream to Forrester Park (where there are less properties at risk).</p>
4	Oct 2002	Eastwood Tunnel Investigations Stage 2 – Model Construction & Eastwood Flooding Assessment	Robinson GRC	<p>Report prepared for Ryde City Council describing further model investigations of the proposed stormwater tunnel to alleviate flooding in Eastwood.</p> <p>The report generally confirmed findings from the earlier (Stage 1) report. It also identified other stormwater limitations that would contribute to surface flows through the town centre. The report recommended a 1500mm pipeline to alleviate flooding at Rowe Street and Railway Pde on the eastern side of the railway, and a pipeline from the corner of Shaftsbury Road and Rowe Street to Terry's Creek to alleviate flooding on the western side of the railway.</p>
5	Dec 2005	Terry's Creek Subcatchment Management Study	Cardno Willing	<p>Report prepared for Parramatta City Council, which investigates stormwater problems within Terry's Creek, down to the end of the concrete channel at Forrester Park. The study did not include modelling of pipe drainage systems within Ryde or Hornsby Councils.</p> <p>Main recommendations include:</p> <ul style="list-style-type: none"> < Basin at Mobbs Lane < Culvert amplification (Valley Rd, Holway St, Terry Rd) < Further investigation of Eastwood CBD Tunnel < Pipe drainage amplification to the 5% flood (PCC only) < Development controls, including OSD requirements < Improved public awareness & flood response < Water quality measures to control sediment, litter and gross pollutants.

3 COMMUNITY CONSULTATION

3.1 CONSULTATION PROCESS

Community consultation is an important component in the development of a floodplain management plan. Consultation provides an opportunity to collect feedback and ideas from the community on problem areas and potential floodplain management measures. It also provides a mechanism to alert the community about the flood risk, and to improve their awareness and readiness for flooding.

Much of the community consultation for Eastwood & Terry's Creek has been coordinated through the floodplain management committee, including a public display of results from computer modelling of flood behaviour and a dedicated web page on the internet. An earlier community questionnaire distributed to every resident in the catchment (Water Board, 1991) has also provided valuable data on past flood behaviour and other flood related issues in the catchment. Public exhibition of the recommended floodplain management study and plan is also intended prior to formal consideration by Council.

Elements of the consultation process are discussed further below.

3.2 FLOODPLAIN MANAGEMENT COMMITTEE

The Eastwood & Terry's Creek Floodplain Management Committee has overseen the preparation of the floodplain management study and plan. The committee comprises representatives from:

- i) City of Ryde;
- ii) Parramatta City Council;
- iii) Hornsby Shire Council;
- iv) Sydney Water Corporation;
- v) State Emergency Service;
- vi) Department of Environment, Climate Change and Water;
- vii) RailCorp; and
- viii) a number of community representatives.

The Committee has played an active role in reviewing flood modelling results, selecting floodplain management options to be investigated, evaluating results for those options, reviewing planning controls and identifying the preferred floodplain management measures to be included in the final plan.

As many of the representatives on the Committee are themselves members of other associations or groups, the committee provides a valuable mechanism for the views of many interested parties to be represented.

3.3 INDIVIDUALLY ADDRESSED LETTERS TO RESIDENTS

All residents in the study area were sent an individually addressed letter at the start of the project to provide information about the study. Residents were advised of the risk of flooding in the catchment, the role of the floodplain management committee, information concerning the study, details of a public display of model results, and how to provide input to the study. Some 2,875 letters were issued during July 2007.

3.4 PUBLIC DISPLAY OF FLOOD MODELLING RESULTS

A computer flood model to simulate flood behaviour in the catchment was established as part of the first stage of the project. The computer model was calibrated to match flood heights that were observed during the November 1984 flood. Maps showing the extent of flooding for this event were also prepared and placed on public display during July and August 2007. Residents in the study area were formally invited to review the maps and to comment on how well these maps represented their own experience of this flood. Feedback forms were also available at the display to facilitate the collection of community comments.

The display occurred from 30 July to 13 August 2007, at three different venues:

- i) Eastwood Mall;
- ii) Eastwood Library; and
- iii) Council offices.

The display and feedback forms were provided in English, Chinese and Korean.

Despite considerable efforts in encouraging community review of the flood modelling results, only twelve feedback forms were completed. Of these, four indicated that the maps provided an “accurate” depiction of flooding for this event; three indicated “don’t know”; one indicated a “poor match”; and the remainder provided no response in regard to the flood modelling results.

During the afternoon and evening of 9 August 2007, the display was manned by officers from Council and the Department of Environment, Climate Change and Water. This provided an opportunity for the community to have the study explained to them and to receive answers to any questions that they had. A further 12 comments were received from the public during these meetings, which are summarised in **Table 3.1**.

Table 3.1
Comments from Public Meeting of 9 August 2007

Item	Location	Resident's Comments
1	Yangalla Place	Check drainage pipeline adjacent to Nos 7 & 12 Yangalla Place that discharges into TG Millner field as area ponds frequently
2	Abuklea Rd	Low point at intersection of Abuklea & Vimiera flood frequently. Would like the entire Abuklea Rd system reviewed to Balaclava.
3	Forrester Park	Forrester Park footbridge exacerbated flooding due to the blockage caused by the build up of debris.
4	Wood St	Overland flowpath from Wood St drains through property and under house. Suggest reviewing cross fall of the pathway to divert water.
5	Cassia Place	Severe erosion of creek bed and bank near termination of Sydney Water channel. Suggest inspection and rectification.
6	Pickleford Rd	Open watercourse adjacent to Nos 1,5&9 Pickleford Rd. Flood blocks access to and from property (battle axe subdivision isolated).
7	Abuklea Rd	Confluence of two pipes, pit surcharges frequently. Please review. Also check park on corner of Abuklea and Balaclava for performance.
8	Rutledge St	Questions accuracy of flood mapping along the side and front of the dwelling.
9	Wood St	Feels maps accurately represent the 1984 flood. Posts should be installed to stop trolleys being washed into waterway.
10	Bellamy Ave	Would like historical flood level data adjacent to house.
11	(general)	Advised that Northern District Times had pictures of a car washed into a culvert during the 1984 flood.
12	Wingate Ave	Floodwaters were one metre deep through the back of the property until the gate was opened.

3.5 WEB PAGE ON THE INTERNET

The City of Ryde has provided a dedicated web page on the internet for posting information about the study at www.ryde.nsw.gov.au/committees/eastwood_terryscrk.htm . An extract of the web page is illustrated on **Figure 3.1**.

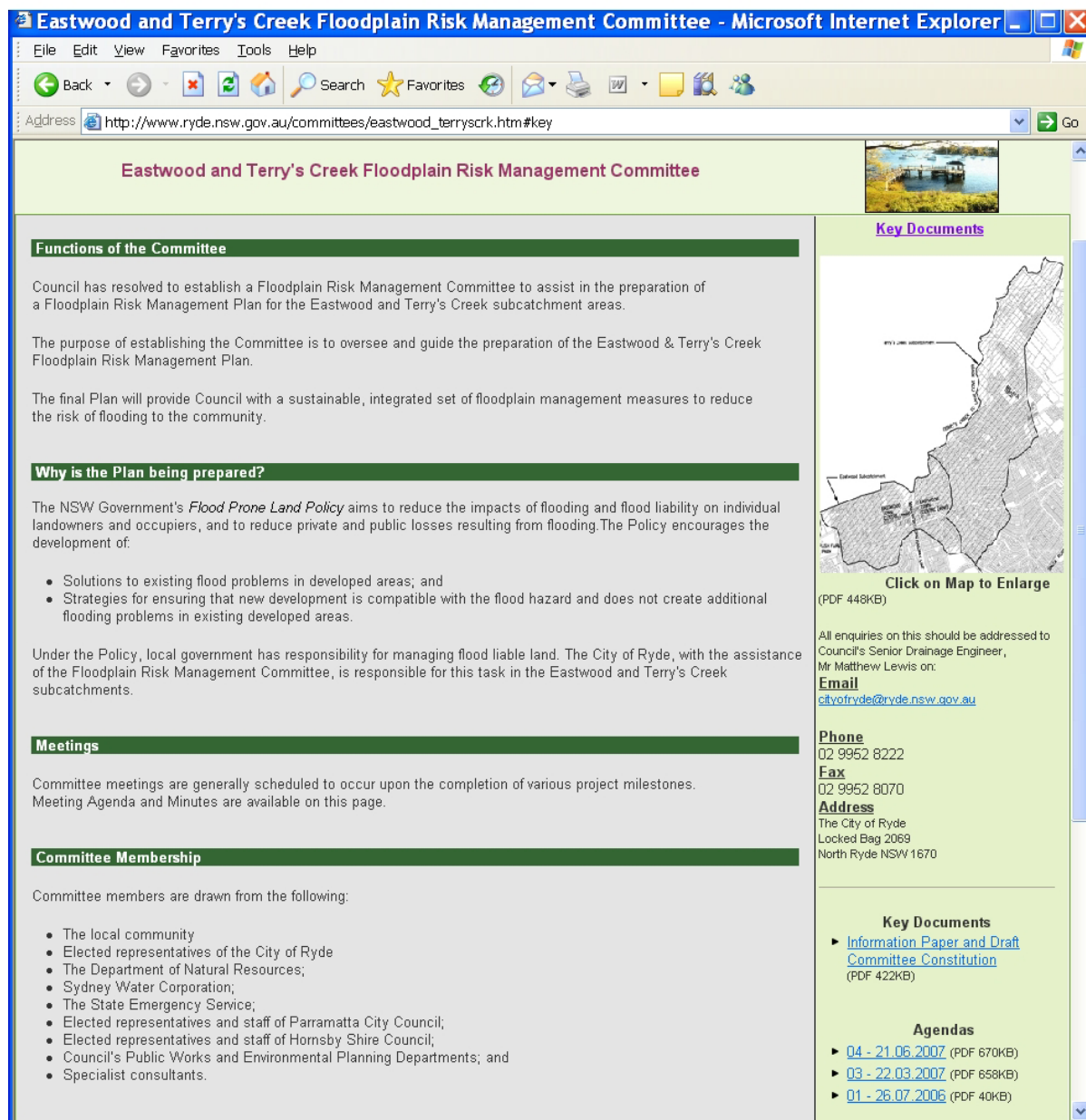


FIGURE 3.1
Eastwood & Terry's Creek Web Page

The web page provides details about the study, including:

- i) why the Plan is being prepared;
- ii) a map of the study area;
- iii) the function of the floodplain management committee;

- iv) members on the floodplain management committee;
- v) dates and agendas of upcoming committee meetings;
- vi) minutes of all meetings;
- vii) copies of presentations provided by the consultant; and
- viii) links to draft documents for public exhibition.

3.6 COMMUNITY QUESTIONNAIRE

Over 3,500 community questionnaires were distributed to residents within the catchment as part of an earlier investigation undertaken by Bewsher Consulting for Sydney Water (Water Board, 1991). The questionnaire sought information concerning the community's experience of flooding, the nature of flooding experienced; any stormwater or drainage concerns; and any other comments for the study to consider.

Some key results from the questionnaire are summarised in **Table 3.2**.

Table 3.2
Summary of Results from Earlier Questionnaire

Issue	Number*	Rate (%)
Experienced a flood on their property		
Yes	318	58%
No	231	42%
Nature of flooding		
Above floor level	44	8%
Under house	64	12%
Within yard area	199	39%
Street flooding	178	35%
Other	30	6%
Source of flooding		
From open channels	109	23%
Surcharge from street drains	146	31%
Ponding in low areas	111	24%
Other	106	22%
Pollution Concerns		
Rubbish	118	57%
Industrial waste	5	3%
Odours	11	5%
Oil and petrol	10	5%
Other	63	30%
Stormwater/Drainage concerns		
Safety	171	23%
Appearance	94	13%
Odours	47	7%
Maintenance	164	22%
Cleaning	173	24%
Other	83	11%

* Source: Water Board, 1991

3.7 PUBLIC EXHIBITION OF DRAFT REPORT

A draft copy of the Eastwood and Terry's Creek Floodplain Management Study and Plan was placed on public exhibition between 4th February and 13th March 2009. The exhibition was advertised in the *Ryde City View* and on Council's web site. All residents within the study area were also sent a letter advising of the exhibition and requesting feedback on the draft measures proposed. Reports were available for viewing at the Ryde Civic Centre, Eastwood Library, and Council's web site.

A total of 20 submissions were received following the exhibition. A public meeting was held with interested residents following the exhibition on 10th June 2009. A number of follow up meetings were also held with some residents, and six residents addressed Council's floodplain management committee meeting on 25th June 2009. A summary and response paper on those issues that were raised is provided in **Appendix E**.

A number of changes have been made to the draft study and plan following a review of the submissions received. These include:

- i) further sensitivity testing of the flood study model calibration within Area 7, which is reported in Appendix E;
- ii) areas of shallow inundation (in a 100 year flood) generally less than 0.3m to 0.5m, that are distant from watercourses, be re-classified as an 'overland flow' precinct and that areas of shallow inundation generally less than 0.1m to 0.2m receive no classification at all;
- iii) inclusion of additional drainage inlet pits in Brabyn Street and improvements to the culvert in Jim Walsh Park (Area 7) in the floodplain management plan;
- iv) inclusion of a feasibility study into a potential detention basin in Jim Walsh Park, to reduce flood damages downstream of Balaclava Road (Area 7) in the floodplain management plan;
- v) discussion of an alternate Eastwood CBD flood mitigation option, as suggested by one resident; and
- vi) consideration of an expanded drainage scheme in Abuklea Road.

4 DESCRIPTION OF FLOOD BEHAVIOUR

4.1 EASTWOOD & TERRY'S CREEK FLOOD STUDY

The Eastwood and Terry's Creek Flood Study was prepared as the first phase of investigations for this project (Bewsher Consulting, 2008). The flood study provides an assessment of flood behaviour under existing catchment conditions. Flood levels, flood velocities and the extent of flood inundation have been determined for floods with different probabilities of occurrence. This helps to determine the magnitude of the flood problem within the catchment, and to identify the main problem areas. It also provides the necessary flood models to examine the effectiveness of undertaking various floodplain management measures within the catchment, which is further examined in this report.

The flood study established computer models to simulate flood behaviour. A DRAINS hydrologic model was used to estimate catchment flows, which were then input to a second TUFLOW model to analyse flood behaviour. TUFLOW is a sophisticated two-dimensional computer model that simulates flood behaviour in creeks and channels. It also has the ability to model the stormwater pipe system and overland flow paths throughout the catchment. All stormwater pipes in the City or Ryde portion of the catchment were included in the model.

The models were calibrated to match flood behaviour observed from the November 1984 flood. This flood was selected on the basis that:

- i) it is the largest flood experienced within the catchment, since at least 1967;
- ii) various flood height observations are available (Table 3 of Flood Study Report) throughout the study area for this event; and
- iii) there is adequate rainfall data to describe the pattern of rainfall over the catchment.

Model parameters were adjusted until an acceptable fit was achieved between modelled flood heights and observed flood heights. Maps showing the extent and depth of flood inundation were prepared for this event and placed on public display between July and August 2007. Members from the public were invited to inspect the maps and to indicate whether or not the extent of flooding depicted matched their own recollections of the 1984 flood via a feedback form. The response from the community was limited, with four respondents indicating that the maps provided an 'accurate' representation of flooding; three respondents indicating that they 'did not know'; and one respondent indicating a 'poor match'. Based on the comparison of modelled and observed flood heights, and in the absence of any more detailed information from the community, it was concluded that the models were providing an adequate representation of flood behaviour.

The models were then used to generate design flood conditions for the 5 year, 10 year, 20 year, 50 year and 100 year average recurrence interval floods. A probable maximum flood (PMF) was also assessed to provide an upper limit of the potential magnitude of flooding.

The TUFLOW model produced a grid of results at 3m intervals over the study area. These results include flood levels, flood depths, and flood velocities at regular time intervals throughout the flood simulation. The peak values are also recorded and can be interrogated at any point within the study area using a GIS database, such as MAPINFO. The grid results can be depicted as colour-coded thematic maps of flood levels, depths and flood velocities for each design flood. The results can also be superimposed onto other base mapping, such as aerial photography and cadastral plans showing property boundaries.

Maps showing the extent of flood inundation and flood level contours have been produced for the different design floods. The flood level contours show the height of flooding likely to be experienced throughout the study area for each design flood. This provides Council with

the necessary information to specify minimum building floor levels and other controls for future development.

Flood levels were also extracted from the flood model for each property within the study area, and assembled within a geographical database. The database is intended to assist Council in releasing flood data to the community, either through issue of Section 149 Certificates, Flood Certificates, or other enquiries.

Further information concerning the establishment and calibration of the flood models and design flood level results and mapping are provided in the Eastwood & Terry's Creek Flood Study Report (Bewsher Consulting, 2008). These maps can also be provided to Council in digital format for inclusion in Council's GIS computer system.

The flood models have been further utilised in the floodplain management study to quantify the extent of flood problems and to assess the merits for evaluating the impact of various floodplain management options on flood behaviour.

4.2 FLOOD RISK AND OVERLAND FLOW PRECINCTS

4.2.1 Introduction

Floodplain management is all about managing the risk of flooding across the floodplain. In doing so, it should be recognised that different parts of the floodplain are subject to different degrees of flood risk.

It is important not to confuse 'flood risk' with 'flood hazard' or 'provisional flood hazard'. The terms 'hazard' and 'provisional hazard' are defined in the 2005 *Floodplain Development Manual* and relate to the magnitude of a *specific* flood. For example, a site may experience high hazard conditions in a 100 year flood and low hazard conditions in a 5 year flood. On the other hand, flood risks (as used to define land use planning precincts) do not relate to a single flood, but rather to all floods.

4.2.2 Flood Risk Precincts

Flood risk precincts consider the probabilities and consequences of flooding over the full spectrum of flood frequencies that might occur at a site. When expressed in mathematical notation:

$$\text{Flood Risk} = \int_{\text{all floods}} \text{Probability} * \text{Consequence}$$

where probability is the chance of a flood occurring, and consequence is the property damage and personal danger resulting from the site's flood characteristics. Note that in carrying out this assessment, the existing land uses and any private warning/evacuation plans at the site are ignored, and typical residential land uses and the normal public warning/evacuation plans are assumed.

The parts of the study area subject to the most significant inundation have been categorised into three different grades of flood risk, namely 'high', 'medium' and 'low'. This same categorisation has been applied to a number of other catchments throughout NSW, and is consistent with the categorisation of other natural risks, such as bush fire risk. This risk categorisation allows different development controls to be applied in different parts of the floodplain, recognising both the type of development proposed and the flood risk where the

development is to be located. Further discussion on the approach to floodplain planning is provided in the Eastwood & Terry's Creek Floodplain Management Plan – Town Planning Considerations report (Don Fox Planning, 2008).

After a review of the probabilities and consequence of flooding over all flood frequencies, the 'high', 'medium' and 'low' flood risk precincts were mapped as described below, and are shown on **Figure 4.1**.

- ▶ **High Flood Risk Precinct** includes all areas of the floodplain which would be provisionally high hazard in a 100 year flood (based on Figure L2 of the *Floodplain Development Manual*). In addition to including the 100 year provisionally high hazard areas in the high flood risk precinct, other parts of the floodplain are also included where:
 - (a) in a 100 year event, significant evacuation difficulties exist (e.g. islands surrounded by provisionally high hazard conditions);
 - (b) in floods rarer than a 100 year event, the potential for significant or extreme consequences exist which are not otherwise apparent from consideration of only the 100 year flood or more frequent flood events. Some events that may result in these consequences (depending on their scale) include catchment diversions, areas subject to overtopping of levees and embankments, areas subject to severe bank or bed erosion, or other conditions that can lead to unusually high depths, velocities or otherwise produce very dangerous flood conditions. Whilst the probabilities of these events might be low, the consequences can in some cases be extreme and thus produce a high risk.
- ▶ **Medium Flood Risk Precinct** is the remaining area inundated in a 100 year flood event, not defined as the 'high' flood risk precinct. For reasons similar to those discussed above under (a) and (b), it is possible for some otherwise 'low' flood risk areas to be elevated to 'medium', when the flood conditions warrant it, though this is rarely required.
- ▶ **Low Flood Risk Precinct** comprises all remaining areas of the floodplain (defined as the limit of inundation in a PMF) but not identified as either a high flood risk or medium flood risk precinct, and where the risk of damages is low for most land uses.

4.2.3 Overland Flow Precinct

Areas of shallow overland flow that are distant from watercourses have been excluded from flood risk mapping described above. These properties have been identified in a separate **Overland Flow Precinct**.

The depth of inundation in these areas will typically be less than 0.3 to 0.5m but more than 0.1 to 0.2m in a 100 year flood. Velocities in these areas are mild and the combination of depth and velocity is unlikely to present a safety danger to able-bodied adults or to cause significant erosion problems. These areas would normally be classified as 'low' provisional hazard under the Floodplain Development Manual. Note that very shallow inundation may still occur in areas above the Overland Flow Precinct where depths would typically be less than 0.1 to 0.2m. These areas are not classified as either Overland Flow Precinct or a Flood Risk Precinct and would include areas referred to as 'Local Drainage' under the *Floodplain Development Manual*.

4.2.4 Floodway Mapping

The merit of mapping floodways on Terry's Creek has been considered. Floodways are defined as areas of significant flow that, even if partially blocked, would cause a significant redistribution of flood flow. In the previous Floodplain Development Manual, floodways were delineated on the basis of the product of flood depth and velocity being greater than 1.0 in the 100 year flood. In the case of the current study area, generally all such areas have been identified to be in the high provisional hazard area in the 100 year flood, and therefore have been incorporated into the high flood risk precinct. The proposed planning controls (i.e. those in Council's DCP) prohibit all new development (apart from recreational or non-urban uses) within the high flood risk precinct. Any 'concessional development' (for existing property) is permissible only upon the conditions that an engineer's report certifies that the development will not increase flood affectation elsewhere, and that safe evacuation is possible. For this reason, it was concluded that a separate exercise to control development within floodways would add little practical value.

**FIGURE 4.1
FLOOD RISK
MANAGEMENT
PRECINCTS**

0 500m
Scale

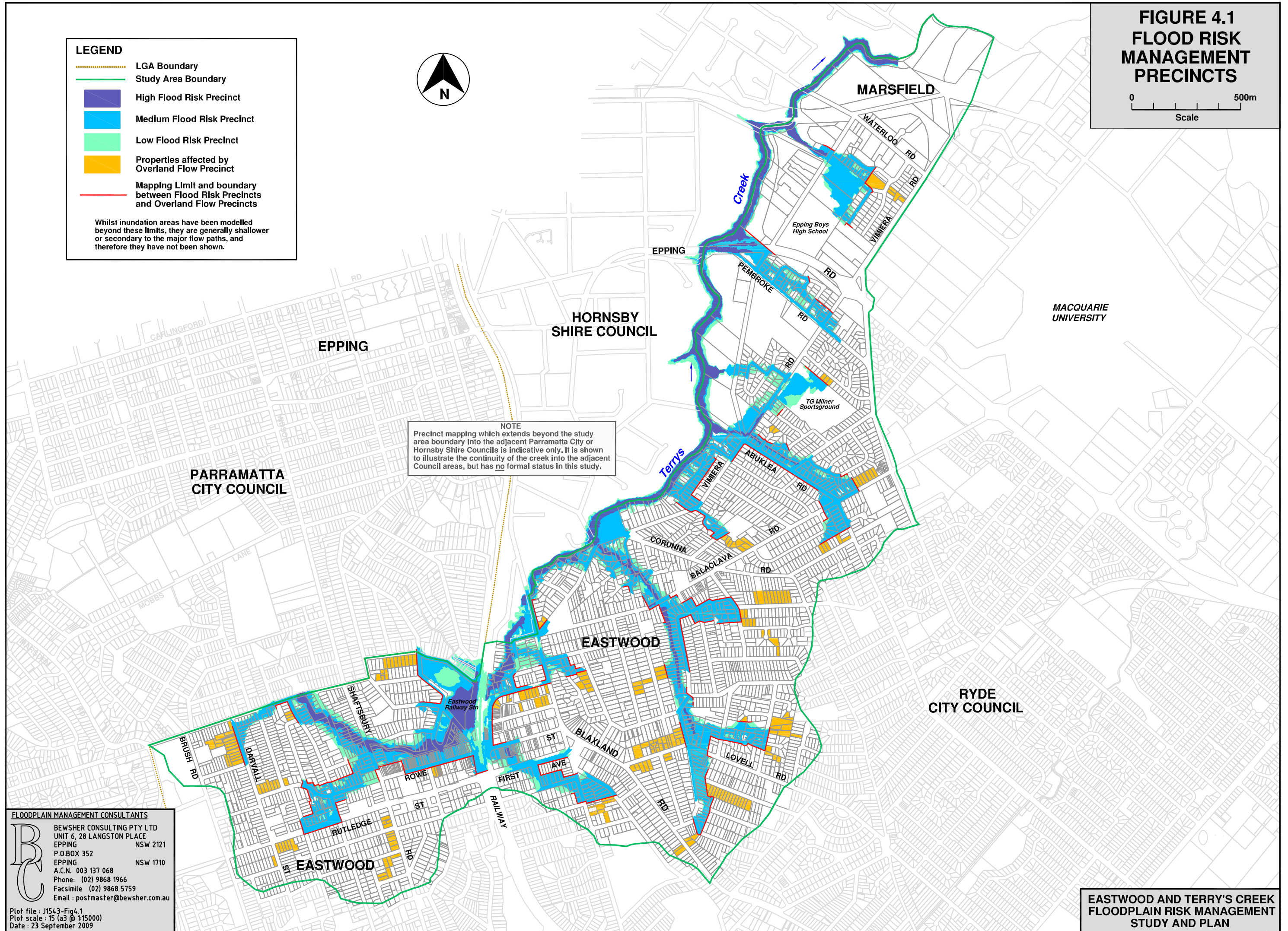
LEGEND

- LGA Boundary
- Study Area Boundary
- High Flood Risk Precinct
- Medium Flood Risk Precinct
- Low Flood Risk Precinct
- Properties affected by Overland Flow Precinct
- Mapping Limit and boundary between Flood Risk Precincts and Overland Flow Precincts

Whilst inundation areas have been modelled beyond these limits, they are generally shallower or secondary to the major flow paths, and therefore they have not been shown.



NOTE
Precinct mapping which extends beyond the study area boundary into the adjacent Parramatta City or Hornsby Shire Councils is indicative only. It is shown to illustrate the continuity of the creek into the adjacent Council areas, but has no formal status in this study.



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Plot file: J1543-Fig4.1
Plot scale: 15 (a3 @ 1:15000)
Date: 23 September 2009

**EASTWOOD AND TERRY'S CREEK
FLOODPLAIN RISK MANAGEMENT
STUDY AND PLAN**

4.3 SUMMARY OF PROPERTY INUNDATION

A flood damages database has been prepared for the study area. The database provides information on properties and buildings that are potentially affected by flooding up to the PMF event. The database has been used to estimate flood damages and to highlight problem areas within the catchment. It has also been used to evaluate the economic merit of various flood mitigation measures considered in this report.

A summary of homes and other buildings estimated to be inundated above floor level is included in **Table 4.1**. The majority of these buildings are affected by shallow overland flow paths where the depth of flooding is less than 0.3m. There is some uncertainty in predicting floor level inundation accurately for these properties, due to the shallow depth of flooding and the influence of local features such as fences, walls, landscaping, or other obstructions that may not be fully represented in the flood model.

The location of buildings potentially inundated above floor level in a 100 year flood is provided in **Table 4.2** and shown on **Figure 4.2**. It is evident that the main flood problems occur in the Eastwood business district (Progress Avenue, Lakeview Pde and Rowe Street), although many homes are also inundated and are scattered throughout the study area.

Table 4.1
Summary of Buildings Inundated

Flood	Shallow Overland Flood Depth *			Remainder of Floodplain			TOTAL
	Residential	Commercial	Total	Residential	Commercial	Total	
5 year	15	15	30	13	10	23	53
10 year	18	16	34	15	14	29	63
20 year	24	19	43	23	16	39	82
50 year	29	19	48	29	17	46	94
100 year	31	20	51	30	17	47	98
PMF							333

* Shallow overland flood depth defined as depth of flooding < 0.3m in 100 year flood. Because of the shallow depth it is difficult to predict floor level inundation accurately. Therefore there is less confidence in these inundation estimates than in the remainder of the floodplain.

Table 4.2
Buildings Inundated in 100 Year Flood (by Location)

Location	Total buildings inundated above floor level in 100 yr flood		
	Residential	Commercial	Total
Area 1 – Western Tribs	14	0	14
Area 2 – CBD West	0	21	21
Area 3 – CBD East	1	16	17
Area 4 – DS Railway	9	0	9
Area 5 – Other Councils	1	0	1
Area 6 – Southern Tribs	0	0	0
Area 7 – Central Tribs	22	0	22
Area 8 – Northern Tribs	9	0	9
Area 9 – Marsfield Tribs	5	0	5
TOTAL	61	37	98

FIGURE 4.2
BUILDINGS INUNDATED
IN EVENTS UP TO THE
100 YEAR FLOOD

0 500m
 Scale

LEGEND

Location of Buildings Inundated

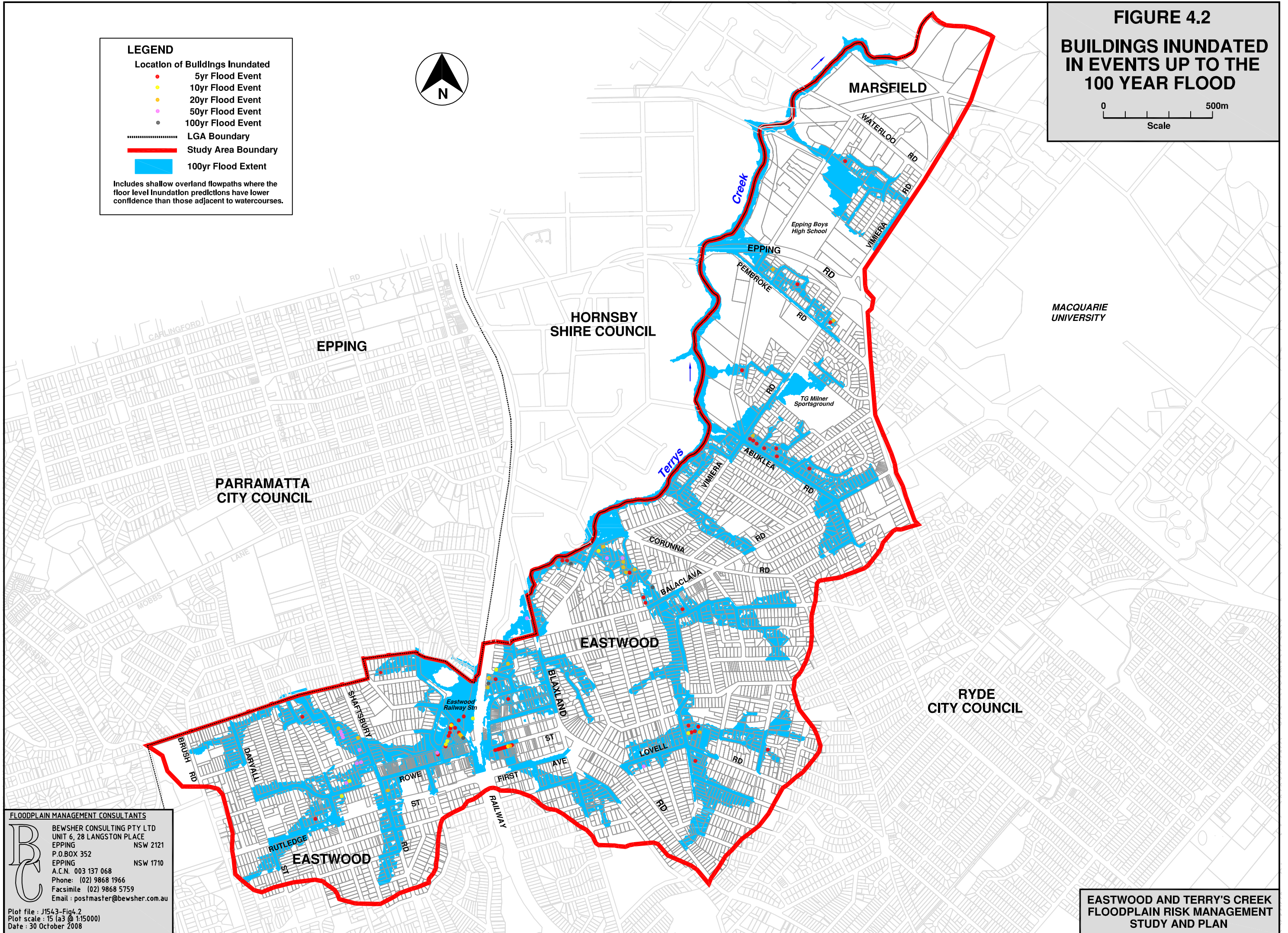
- 5yr Flood Event
- 10yr Flood Event
- 20yr Flood Event
- 50yr Flood Event
- 100yr Flood Event

..... LGA Boundary

Study Area Boundary

100yr Flood Extent

Includes shallow overland flowpaths where the floor level inundation predictions have lower confidence than those adjacent to watercourses.



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Plot file: J1543-Fig4.2
 Plot scale: 15 (a3 @ 1:15000)
 Date: 30 October 2008

5 FLOOD DAMAGE ASSESSMENT

5.1 FLOOD DAMAGES DATABASE

A flood damages database was assembled for the Eastwood and Terry's Creek study area. The database provides an estimate of the potential flood damage for each building in the study area for a range of flood events. These damage estimates are summed over the catchment to provide an economic assessment of the existing flood problem, and to assess the economic benefits of undertaking various flood mitigation measures.

The database includes information on:

- i) the type and location of each property;
- ii) the number and type of buildings within the property;
- iii) ground levels near each building, based on ALS survey;
- iv) surveyed floor levels for those buildings most susceptible to flooding (259 buildings);
- v) estimated floor levels for other buildings, based on the ground level near the building plus an average 'height above ground level' of 0.5m;
- vi) flood levels for the 5 year, 10 year, 20 year, 50 year, 100 year, and PMF floods; and
- vii) a damage code to select an appropriate stage-damage curve to be applied to each property.

The flood damages database essentially consists of a number of geographical points representing the location of residential and commercial/industrial buildings in the study area. These points were derived by digitising building footprints from aerial photography and assigning property details from Council's property cadastre and rates information. Flood levels were extracted from the TUFLOW model result grids and assigned to each building in the database.

Buildings most susceptible to flooding were identified and floor levels surveyed to provide accurate information on above floor flooding. These buildings were identified on the basis of a flood depth greater than 0.1m at the centre of the building footprint in the 100 year flood. The floor level survey provided accurate floor levels for 259 buildings. All other floor levels were estimated from the ground level at the centre of the building footprint (from Council's ALS survey) plus an average height difference between floor level and ground level. The average height difference was determined as 0.5m, based on the sample of buildings that were surveyed.

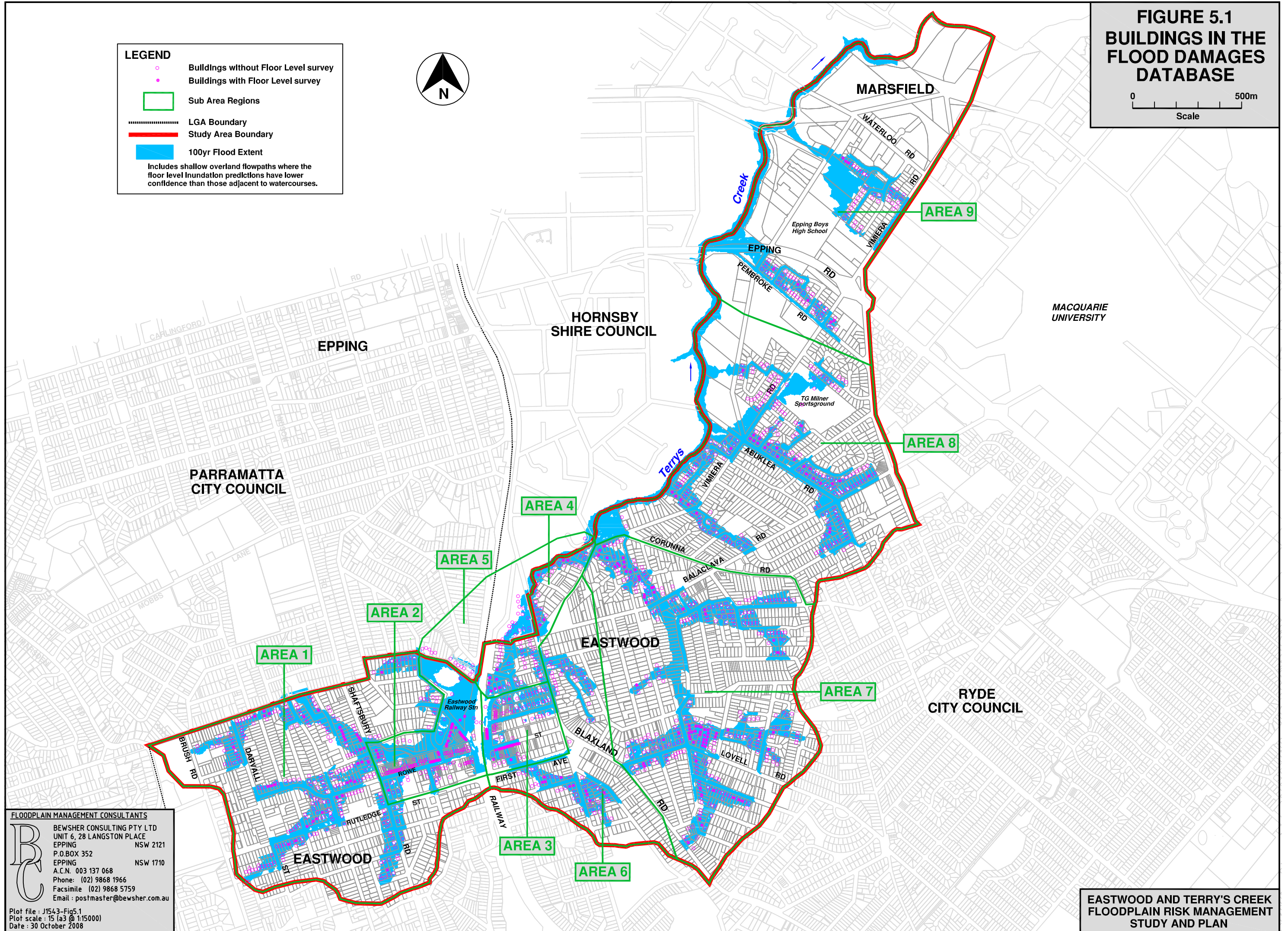
There are a total of 1,361 buildings in the database. These have been further grouped into 9 different areas, so that flood damage estimates can be provided in different parts of the catchment as well as over the whole study area. Buildings in the database, including those that have been surveyed, are shown on **Figure 5.1**.

A copy of the flood damages database is included in **Appendix B**.

**FIGURE 5.1
BUILDINGS IN THE
FLOOD DAMAGES
DATABASE**

0 500m
Scale

- LEGEND**
- Buildings without Floor Level survey
 - Buildings with Floor Level survey
 - Sub Area Regions
 - LGA Boundary
 - Study Area Boundary
 - 100yr Flood Extent
- Includes shallow overland flowpaths where the floor level inundation predictions have lower confidence than those adjacent to watercourses.



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Plot scale: 15 (a3 @ 1:15000)
Date: 30 October 2008

**EASTWOOD AND TERRY'S CREEK
FLOODPLAIN RISK MANAGEMENT
STUDY AND PLAN**

5.2 TYPES OF FLOOD DAMAGE

The types of flood damages examined in this study are summarised in **Figure 5.2**. The main categories include 'tangible' and 'intangible' flood damages. Tangible flood damages are those that can be more readily evaluated in monetary terms, while intangible damages relate to the social cost of flooding and therefore are much more difficult to quantify.

Tangible flood damages are further divided into direct and indirect damages. Direct flood damages relate to the loss or loss in value of an object or a piece of property caused by direct contact with floodwaters. Indirect flood damages relate to loss in production or revenue, loss of wages, additional accommodation and living expenses, and any extra outlay that occurs because of the flood.

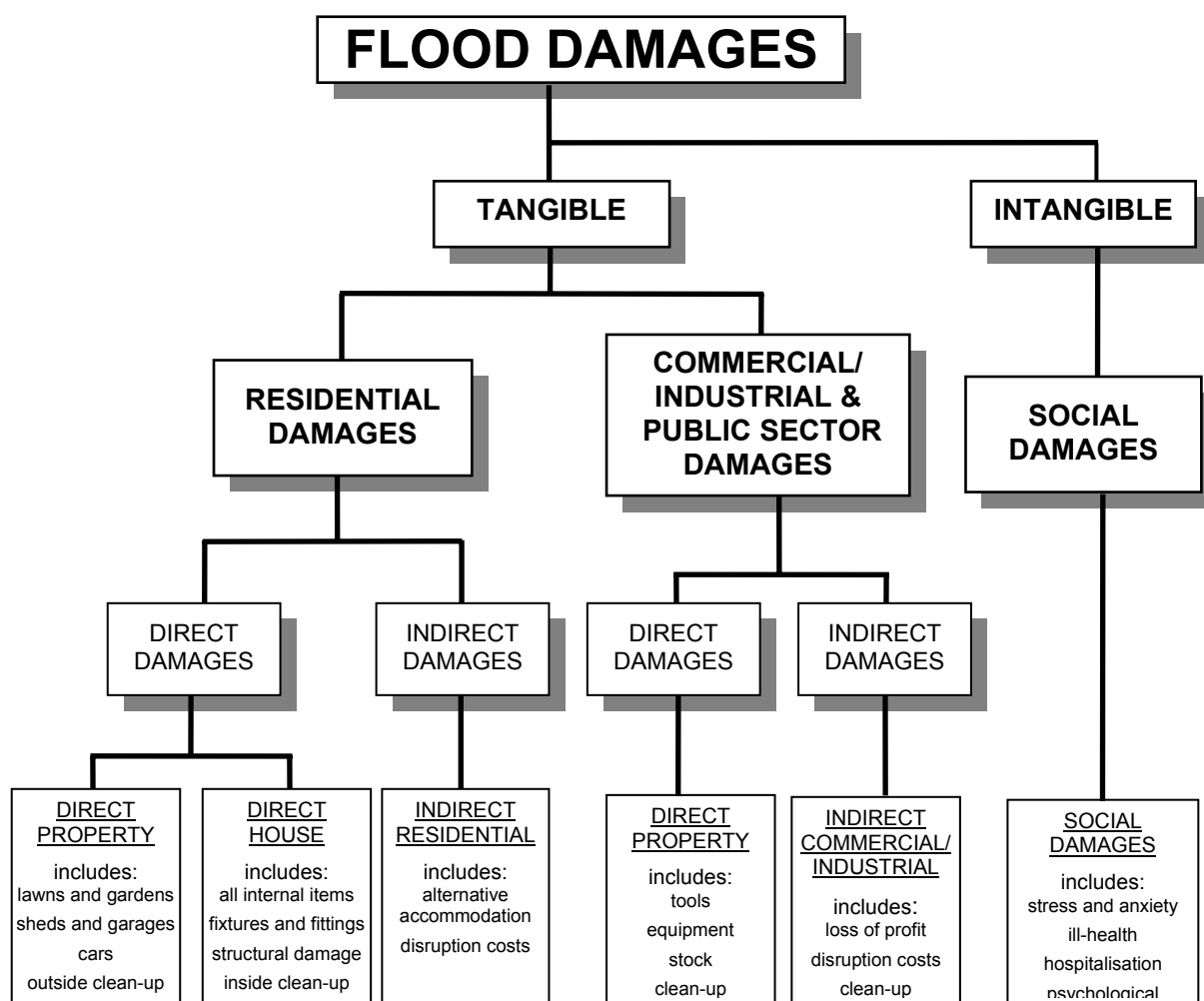


FIGURE 5.2
Types of Flood Damage

5.3 BASIS OF FLOOD DAMAGES CALCULATIONS

Potential flood damages have been calculated by applying a number of stage-damage curves to every property included in the database. These curves relate the amount of flood damage that would potentially occur at different depths of inundation, for a particular building type.

The Department of Environment, Climate Change and Water recently released guidelines for the preparation of site-specific *residential* stage-damage curves (DECCW, October 2007). The guidelines provide for the development of representative stage-damage curves for typical houses in different floodplains, based on work undertaken by the Risk Frontiers in the Natural Hazards Research Centre at Macquarie University. This approach is recommended by DECCW to ensure the consistent assessment of flood mitigation projects across NSW. The new procedures have been adopted for estimating residential flood damages within the Eastwood and Terry's Creek study area. Commercial and industrial flood damage estimates have been determined on the basis of previous flood damage surveys undertaken in NSW.

The different flood damage components are further discussed below.

5.3.1 Residential

Residential flood damages have been calculated in accordance with DECCW guidelines. This is based on standardized stage-damage curves representing low set buildings, high set buildings and two-storey buildings. The standard damage curves have been adjusted based on a number of parameters specific to the Eastwood and Terry's Creek catchment, including:

- i) regional cost variations (1.0);
- ii) average house size (240m²);
- iii) typical duration of immersion (6 hours);
- iv) average contents value (\$60,000);
- v) level of flood awareness (low);
- vi) effective warning time (1 hour); and
- vii) damage reduction factor (ratio of actual to potential losses) of 0.96 based on the flood awareness and effective warning time.

Damage estimates for ground floor units or villas were further reduced by 25% to account for the likely reduction in flood damages to these premises due to their smaller size.

It is noted that the DECCW residential stage-damage curves make allowance for both clean-up costs (\$4,000 per flooded house) and the cost of time in alternative accommodation. Nevertheless, a further measure of indirect damages has been estimated by taking 20% of the total direct damages, in keeping with advice received from DECCW.

5.3.2 Commercial/Industrial

No standard stage-damage curves were issued by DECCW for *commercial* and *industrial* damages. The stage-damage relationships used to estimate these damages in this study were based on specific consideration of the types of development within the catchment, information available from previous investigations, and flood damage surveys undertaken following major floods in Coffs Harbour (1996); Inverell (1991); Forbes (1990); Nyngan (1990); and the Georges River (1986). For consistency with the residential damages

assessment, predicted losses were estimated by applying a ratio of actual to potential damages of 0.96. Indirect commercial/industrial losses were estimated as 20% of direct actual commercial/industrial damages, in accordance with advice received from DECCW.

5.3.3 Infrastructure

The predicted value of damage to infrastructure (including roads and bridges, water supply and sewerage, electricity and telephone supplies, natural gas supplies) has been estimated at 15% of the 'total damages'. No allowance has been made for possible damage reduction in response to flood warnings.

5.3.4 Motor Vehicles

Losses to private motor vehicles have been modelled as a separate component of the process. This is to ensure that the assessment of flood mitigation measures is not unduly influenced by this component of damages. It has been assumed that there are on average 1.7 motor vehicles per residential household in the study area, based on data from the Australian Bureau of Statistics. Assuming that about 25% of these cars will be present during working hours (40 hours per week), and 90% will be present during non-working hours (128 hours per week), then the expected number of vehicles present at any given time that a flood may occur is estimated at about 1.3 per household.

Vehicles are assumed to be at the ground level assigned to each dwelling in the database. Based on insurance data from the Katherine flood (Jan 1998), Wollongong flood (Aug 1998) and Canberra bushfire (Jan 2003), it is assumed that the average cost of a written-off motor vehicle is of the order of \$12,000. Damage is expected to begin at a depth over the ground of 0.3m, and a write-off is assumed to occur at a depth of 0.6m over the ground.

For consistency with other components of the damages assessment, the same damage reduction factor of 0.96 has been applied to the estimation of predicted motor vehicle damages.

Damages to commercially owned vehicles are not assessed, since these may already be accounted for as part of direct commercial/industrial damages.

5.3.5 Social

Intangible, or social, flood damages are not readily quantifiable in monetary terms. Physical contact with floodwaters can cause residents to suffer physical and mental impacts to their health. Evacuation, the loss of personal property and cleaning up can trigger significant stress and trauma. While difficult to quantify, in keeping with advice received from DECCW, social damages have been estimated as 25% of 'total damages', which are interpreted as the sum of direct residential damages and direct commercial/industrial damages.

5.4 ECONOMIC ASSESSMENT

Flood damages under existing (2008) conditions have been calculated for each property in the flood damages database for the following floods:

- i) 5 Year flood ;
- ii) 10 Year flood;
- iii) 20 Year flood;
- iv) 50 year flood;

- v) 100 year flood; and
- vi) the PMF event.

Flood Damages are summed throughout the catchment to provide the total flood damage for each flood. The 'average annual damage' (AAD) and 'present value' of flood damage is also calculated. These are financial terms that are often used in the economic appraisal of flood damages and flood mitigation measures. The AAD is a measure of the cost of flood damage that could be expected each year, on average, by the community. The present value of flood damage is usually calculated to allow a direct comparison with the capital and on-going costs of proposed flood mitigation measures. This has been determined on the basis of a 7% discount rate and an expected life of 20 years, in accordance with guidelines provided by the NSW Treasury.

The flood damages database provides a valuable tool for assessing the economic merits of various flood mitigation options that may be considered for Eastwood and Terry's Creek. Flood level estimates within the flood damages database can be readily updated to reflect new conditions arising from proposed flood mitigation measures. The flood damages are then recalculated and the savings in flood damages can be calculated.

5.5 SUMMARY OF FLOOD DAMAGES

Flood damage calculations have been determined from the flood damages database for various areas within the study area. **Table 5.1** summarises the predicted flood damages for a range of floods, including estimates of the annual average flood damage and the present value of flood damage. **Figure 5.3** shows the total estimated flood damage for various floods, whilst **Figure 5.4** shows the different components of flood damage in the Eastwood and Terry's Creek floodplain.

TABLE 5.1
Predicted Total Flood Damages under Existing Conditions

Location	Damage in Flood Event (\$M)				Average Annual Damage (\$M)	Present Value of Damage (\$M)
	5 Year	20 Year	100 Year	PMF		
Area 1 – Western Tribs	1.24	1.87	2.59	9.45	0.37	3.87
Area 2 – CBD West	1.76	2.76	3.88	33.54	0.61	6.43
Area 3 – CBD East	0.45	0.90	0.94	3.53	0.17	1.78
Area 4 – DS Railway	0.34	1.44	2.15	4.17	0.21	2.22
Area 5 – Other Councils	0.04	0.07	0.19	2.02	0.03	0.27
Area 6 – Southern Tribs	0.30	0.50	0.56	1.77	0.09	0.98
Area 7 – Central Tribs	1.96	3.08	4.12	10.16	0.58	6.10
Area 8 – Northern Tribs	1.25	1.66	1.96	4.92	0.31	3.33
Area 9 – Marsfield Tribs	0.34	0.65	0.74	1.40	0.10	1.09
TOTAL	7.7	12.9	17.1	71.0	2.5	26.1

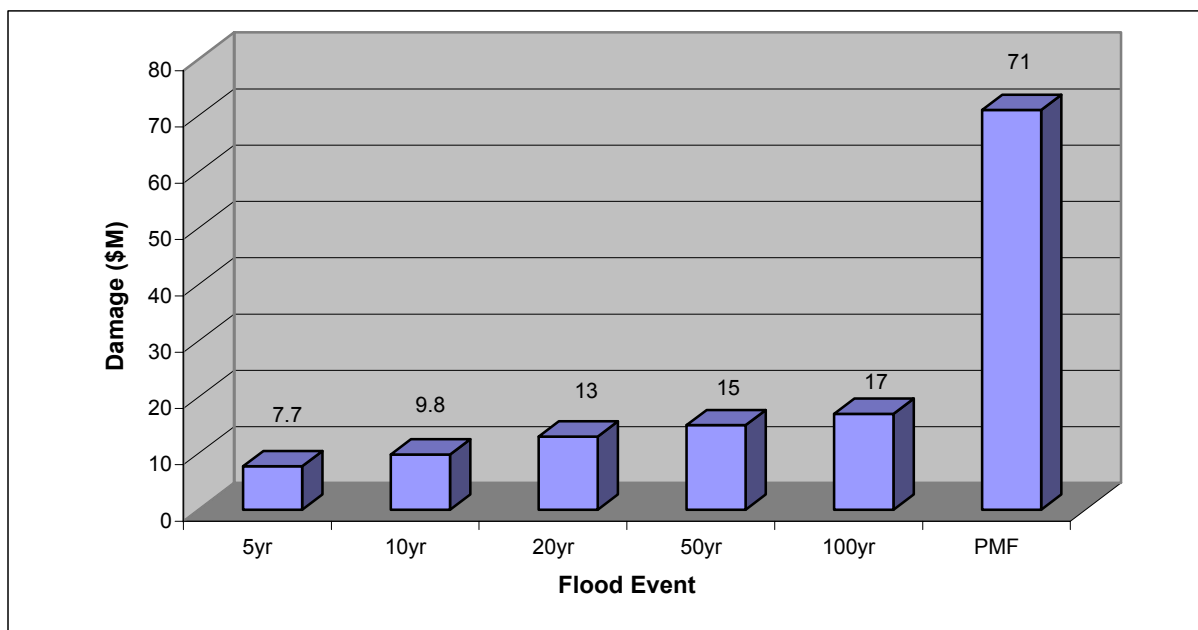


FIGURE 5.3
Total Estimated Flood Damage for Different Floods

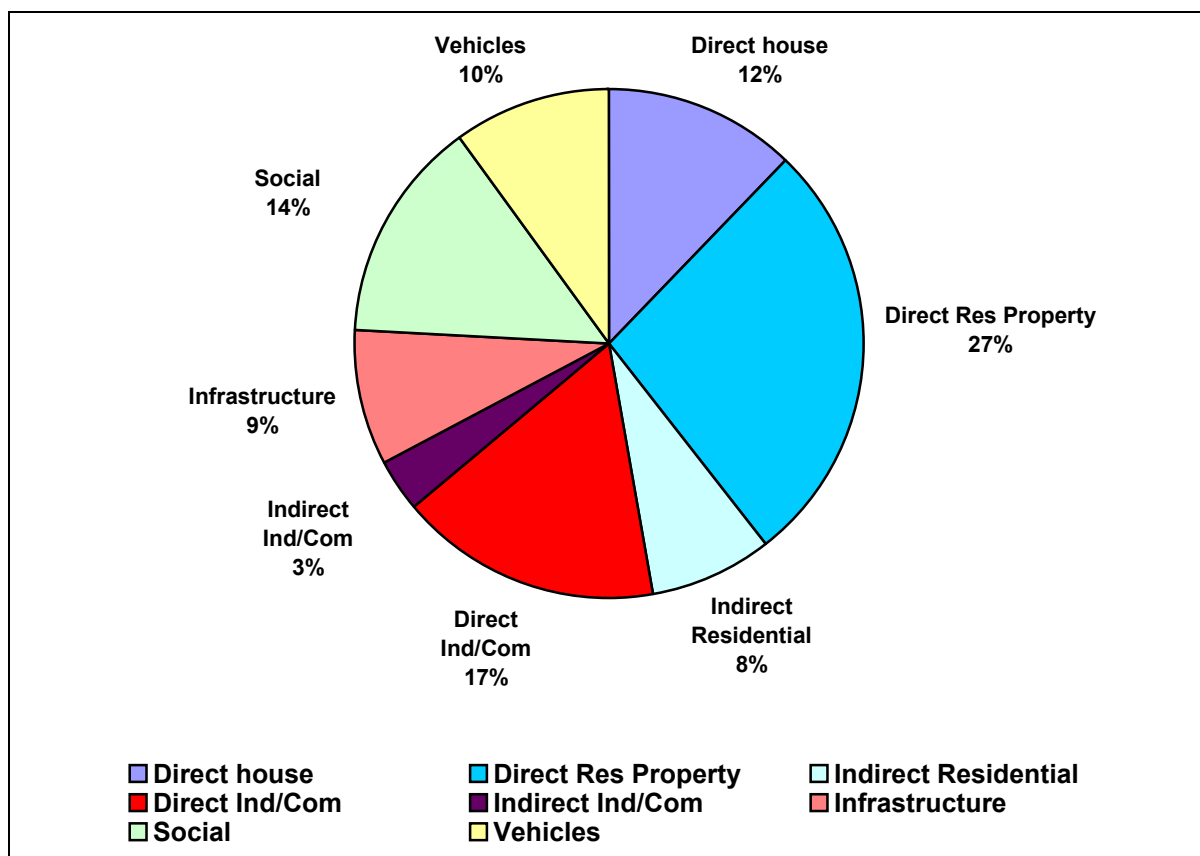


FIGURE 5.4
Components of Flood Damage
(Average Annual Damage)

The following points are relevant from the above results:

- ▶ Components of expected average annual flood damages within the study area are estimated as:

- Direct House Damage	\$ 300,000	(12%)
- Direct Property Damage	\$ 669,000	(27%)
- Indirect Residential Damage	\$ 194,000	(8%)
- Direct Industrial & Commercial	\$ 412,000	(17%)
- Indirect Industrial & Commercial	\$ 82,000	(3%)
- Infrastructure & Public Sector Damage	\$ 210,000	(9%)
- Vehicular damage (residential)	\$ 244,000	(10%)
- Social Damages	<u>\$ 349,000</u>	(14%)
- TOTAL	\$2,460,000	

- ▶ The estimated total flood damage in a 20 year flood is \$13M;
- ▶ The estimated total flood damage in a 100 year flood is \$17M;
- ▶ The present value of flood damage is estimated at \$26M.
- ▶ The estimated total average annual flood damage (from all floods) is \$2.5M per annum
- ▶ Significant flood damage is sustained in relatively minor floods (eg the 5 year event). There is only a modest increase in flood damage as the severity of flooding increases (up to the 100 year event).
- ▶ The highest damage costs throughout the study area are sustained by the residential sector. Most of this damage is incurred to property around homes (27%) rather than damage from above floor flooding of homes (12%).
- ▶ Flood damage is relatively distributed throughout the study area, and is not concentrated in any single area (apart from commercial damage which is concentrated around the Eastwood town centre).

6 FLOODPLAIN MANAGEMENT CONSIDERATIONS

6.1 SELECTION OF FLOOD PLANNING LEVELS

The flood planning levels are the flood levels selected for planning purposes, and will directly determine the area of land that should be subject to flood-related building and development controls.

Selection of the flood planning levels is one of the most critical decisions in floodplain management, and is not an easy one. It should be based on an understanding of the flood behaviour, together with the balancing of social, economic and environmental consequences of flooding, including the potential for property damage and the risk to human life. Traditionally, only one flood planning level has been selected for a particular area, but current thinking is to consider more than one level for different types of developments or locations within the floodplain.

The adoption of a singular flood planning level may be unduly restrictive for some types of land uses. For example, whilst it may be appropriate for some land uses, such as a hospital, to be located above a PMF flood, it could be argued that residential, industrial or recreational land uses do not require such restrictive control.

Also, the adoption of a single flood planning level causes misconceptions by the community regarding flood risk. Most importantly, residents within the floodplain (ie. the area below the PMF) but above the flood planning level, often mistakenly believe they are not at risk from flooding.

To overcome the shortcomings of a singular flood planning level, a graded set of controls that consider the variation of damage risk with flood frequency and land use, have been proposed for the Eastwood and Terry's Creek study area. These are contained in the *Planning Matrix* approach, which is discussed further in the Eastwood & Terry's Creek Floodplain Management Plan – Town Planning Considerations report (Don Fox Planning, 2008).

The planning matrix approach does not rely on the definition of a singular flood planning level. In essence, the approach makes use of a range of flood planning levels for various land uses within the flood prone land below the PMF, in relation to different ameliorative controls (eg. floor levels, evacuation routes, flood compatible materials, etc.).

Within the planning matrix, the selection of the controls and the various flood conditions at which the controls apply, has been based on:

- ▶ procedures and philosophy espoused in the Government's 2005 Floodplain Development Manual;
- ▶ investigations carried out within the current study;
- ▶ minimising Council's exposure to legal actions in relation to flooding;
- ▶ previous development policies applied by Council; and
- ▶ experience gained from the development of planning controls and flood policies for various communities across NSW in recent years.

The 100 year flood level (plus freeboard) has been retained as the principal floor level control for residential land uses in the study area. This is an important component of the proposed planning controls. The decision was based on a consideration of:

- ▶ the unacceptable increase in flood risks and damages, should a lower level be adopted;

- ▶ an unacceptable impost on future development, if a higher level was adopted;
- ▶ inconsistencies with recent development approvals if a level different from the 100 year flood was adopted;
- ▶ recognition that the community views the residential floor level control as the principal component of the Council floodplain controls, and that changes to this control should not be made unless very strong arguments exist.

6.2 TYPES OF FLOODPLAIN MANAGEMENT MEASURES

Floodplain management measures can be divided into three general groups:

- (i) those that modify flood behaviour;
- (ii) those that modify property in order to minimise flood damage; and
- (iii) those that modify people's response to flooding.

Measures that modify flood behaviour usually include structural or engineering works that attempt to lower flood levels, or to divert floodwaters away from areas that would otherwise flood. Examples include retarding basins, channel improvements, stormwater drainage improvements, bridge and culvert amplification, levee banks, dredging, and flow diversions. Many of the measures that have been considered for Eastwood & Terry's Creek are structural measures.

Measures that modify property in order to minimise flood damage include voluntary purchase, house raising and controls on new development. Voluntary purchase involves the acquisition and removal of flood affected homes by Council. It is an expensive flood mitigation measure that is usually only considered where the depth of inundation and flood velocity results in significant risk to life. Few, if any, residential homes in the study area would meet this criteria. House raising involves raising low-lying homes above a nominated level, usually the 100 year flood plus freeboard, to reduce flood damage. This is mainly suited to timber clad homes that are already on piers, or are otherwise easy to raise. Redevelopment, with appropriate minimum floor level controls, can often achieve the same objective as house raising whilst providing a more suitable (aesthetic) outcome. The application of appropriate development controls will ensure that the potential for flood damage is gradually reduced over time as future redevelopment occurs.

Measures that modify people's response to flooding usually includes measures that provide additional warning of flooding, improved public awareness of the flood risk and improvements to emergency management measures during floods. The rapid response to flooding in this catchment limits the effectiveness of a flood warning scheme. Nevertheless, improved community awareness of the flood risk and appropriate emergency management response plans will help residents and rescue personnel to take appropriate action in response to future flooding.

6.3 ASSESSMENT PROCEDURE

A total of 12 potential floodplain management options were identified by the floodplain management committee for preliminary assessment. These options were initially assessed using performance in the 100 year flood and preliminary consideration of economic, social and environmental factors. Based on these findings, the committee subsequently recommended that 6 of these options be assessed in more detail. This included analysis under a range of floods and an economic assessment of these options using the flood

damages database. An additional option for the Eastwood town centre was also investigated at the request of some committee members following the evaluation of these options.

Options that have been considered for Eastwood and Terry's Creek study area, including the recommendations from the floodplain management committee, are provided in **Table 6.1**. Further discussion of these options is presented in **Section 7**.

Table 6.1
Flood Mitigation Options Identified by the Committee

Option No.	Description	Committee Recommendation
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2	Short Tunnel (Terry Rd to Eastwood Park)	Further consideration
3	Basin in Glen Reserve	Minimal impact on flood behaviour
4	Basin at Mobbs Lane	Further consideration
5	Enlarge Railway Culvert	High costs and practical difficulties
6	Basin in Eastwood Park	Minimal impact on flood behaviour
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7 POTENTIAL FLOOD MITIGATION OPTIONS

7.1 LONG TUNNEL – TERRY ROAD TO FORRESTER PARK

Findings: Alternative tunnel options are preferable to reduce costs and minimise downstream impacts

The construction of an underground tunnel to divert flood flows away from the Eastwood town centre has been suggested as a possible solution to the flooding problems experienced in Eastwood.

The concept is similar to the West Ryde Stormwater Tunnel project, which was constructed from 1998-2003 by the City of Ryde to alleviate flooding problems in West Ryde. The West Ryde project involved the boring of a 2km long stormwater tunnel, 3.8m in diameter, between West Ryde and the Parramatta River. The total cost of that project was \$48M (indexed to 2008).

The stormwater tunnel was initially proposed to intercept floodwater on the upstream side of Terry Road in David Hamilton Reserve. Floodwater was to be conveyed under the Eastwood town centre and the Northern Railway line, before rejoining Terry's Creek at Somerville Park. Preliminary investigations (Robinson GRC, 2002) found that flows downstream of Somerville Park could increase by 4% to 9% due to reduced travel times. It was proposed to further extend the tunnel down to Forrester Park to avoid any increase in potential flooding of a number of homes located downstream of Somerville Park.

The location of the proposed tunnel is shown on **Figure 7.1**. The length of the tunnel, assuming a direct route between Terry Road and Forrester Park, is approximately 1.6km. The direct route passes under around 50 residential homes, 38 of which are located in Parramatta City Council and 12 of which are located within Hornsby Shire Council. This could present some political difficulties. An alternate route which better utilises available road reserves and minimises the number of homes directly over the tunnel is also shown on Figure 7.1. This results in an increased tunnel length of 1.75km. The final route of the tunnel would be dependent on the results of further geotechnical and other detailed investigations.

The current investigations have assumed a 3.8m diameter bored tunnel with shotcrete concrete lining, similar to the West Ryde tunnel. A longitudinal section of the tunnel is shown in **Figure 7.2**. The tunnel is typically 10-40m below ground level along much of the route, with an average grade of around 0.9%.

The impact of the proposed tunnel was assessed in the 100 year flood using the TUFLOW model. The tunnel intercepts up to 40m³/s of the total flow reaching Terry Road, reducing the flow that would otherwise travel through the Eastwood town centre. Peak flows downstream of Terry Road are reduced from 62 to 21m³/s. Peak flood levels are reduced by up to 1.3m between Terry Road and Shaftsbury Road, and most residential flooding problems would be alleviated in this area. The effectiveness of the tunnel is reduced further downstream as other tributary inflows add to the total flow carried in Terry's Creek. Flood levels are reduced by 0.5 to 0.8m through the town centre (western side of the railway only). Some flooding still persists in this area as the capacity of the culverts under Progress Avenue is still exceeded. Nevertheless, the flood hazard through the town centre is greatly improved. Smaller flood level reductions occur between the railway and Forrester Park. Below the tunnel exit at Forrester Park, flood levels increase by up to 0.2m due to reduced travel times.

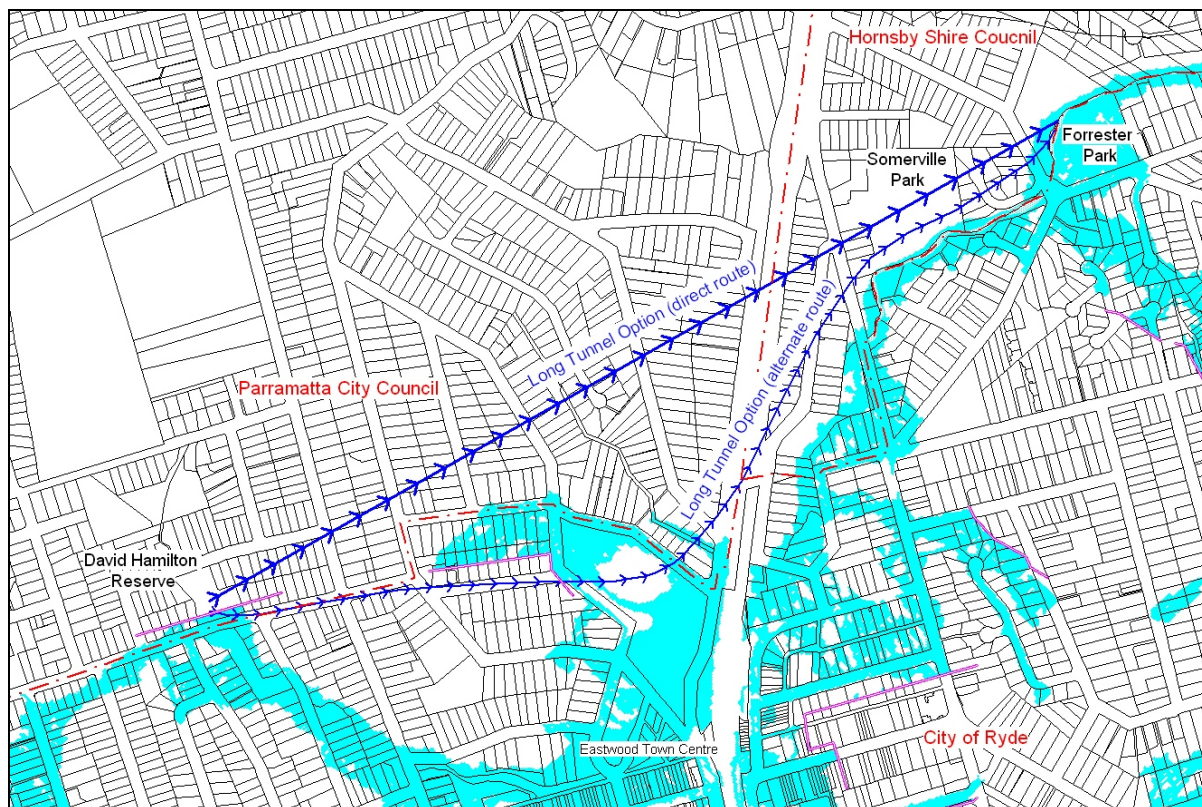


FIGURE 7.1
Long Tunnel Option Route

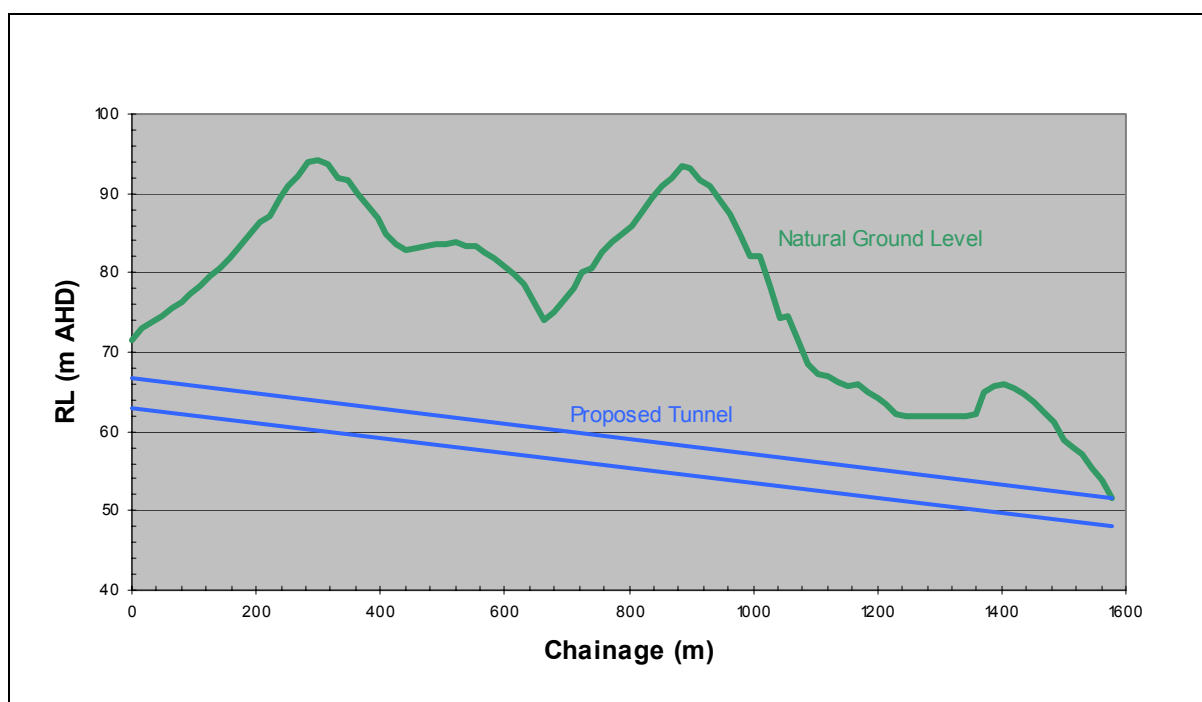


FIGURE 7.2
Long Tunnel (Direct Route) Longitudinal Profile

The tunnel has been estimated to cost of the order of \$26M, based on costs incurred on the West Ryde Tunnel and assuming the shortest direct route. Flooding to 7 residential buildings and 10 commercial properties would be alleviated in a 100 year flood. A consequence of this option is that flood flows downstream of the tunnel outlet will increase (by around 15% in the 100 year flood). Whilst it is unlikely that any additional dwellings will be affected by this increase, flood velocities will increase, and this could cause additional erosion problems throughout the lower creek and increased siltation in the Lane Cove River.

Given the high cost of this option, modest flood benefits, and the potential for adverse impacts downstream of the tunnel, it was concluded that alternative tunnel options should be investigated.

7.2 SHORT TUNNEL – TERRY ROAD TO EASTWOOD PARK

Findings: Not recommended as a flood mitigation strategy due to high costs and poor benefit/cost ratio

A shorter tunnel, from Terry Road in David Hamilton Reserve to a partly excavated detention basin in the lower section of Eastwood Park, was investigated. This proposal is based on a suggestion put forward by a committee member.

Proposed tunnel details are similar to the original proposal, but the length of the tunnel is reduced from 1.6km to 700m. The direct route for this proposal, shown on **Figure 7.3**, passes under approximately 23 residential homes. An alternative route, with a length of 760m, would keep the tunnel largely under existing road reserves and would avoid the majority of these homes. The final route will be subject to geotechnical and other detailed investigations. An advantage of this route is that it is located mostly within the City of Ryde, and there are likely to be less political difficulties in securing relevant approvals.

A longitudinal section of the tunnel is shown in **Figure 7.4**. The tunnel reaches a maximum depth 30m below ground level at its midpoint. The gradient is less than the earlier proposal, at approximately 0.7%, and the maximum capacity of the tunnel slightly reduced. The basin in Eastwood Park would be largely formed by constructing a 1.5m high embankment on the upstream side of West Parade, providing a storage volume of 10,000m³.

This option was selected by the committee for detailed analysis for the full range of floods investigated, and flood benefits calculated using the flood damages database.

This total cost of the short tunnel option, including associated basin works, is estimated at \$13M, based on costs incurred on the West Ryde Tunnel and assuming the shortest direct route. The option provides similar flood benefits upstream of the railway line as the long tunnel option, but results in marginally increased flood levels downstream of the railway line (by up to 0.05m in the 100 year flood). The present value of flood damage from all floods is reduced by \$3.2M upstream of the railway, and increased by \$0.4M downstream of the railway. The net benefit is estimated at \$2.8M, which provides a benefit/cost ratio of 0.2.

The short tunnel option is considered more attractive than the longer tunnel option, largely due to reduced costs and reduced political problems in securing approval for the project. The increase in downstream flood velocities is also reduced, providing more neutral environmental impacts. However costs are still relatively high and flooding through the town centre has not been totally eliminated. The benefit/cost ratio is particularly low, and it is unlikely that the project would qualify for subsidised assistance through the State Government as a flood mitigation project. This option is not recommended for inclusion in the floodplain management plan.

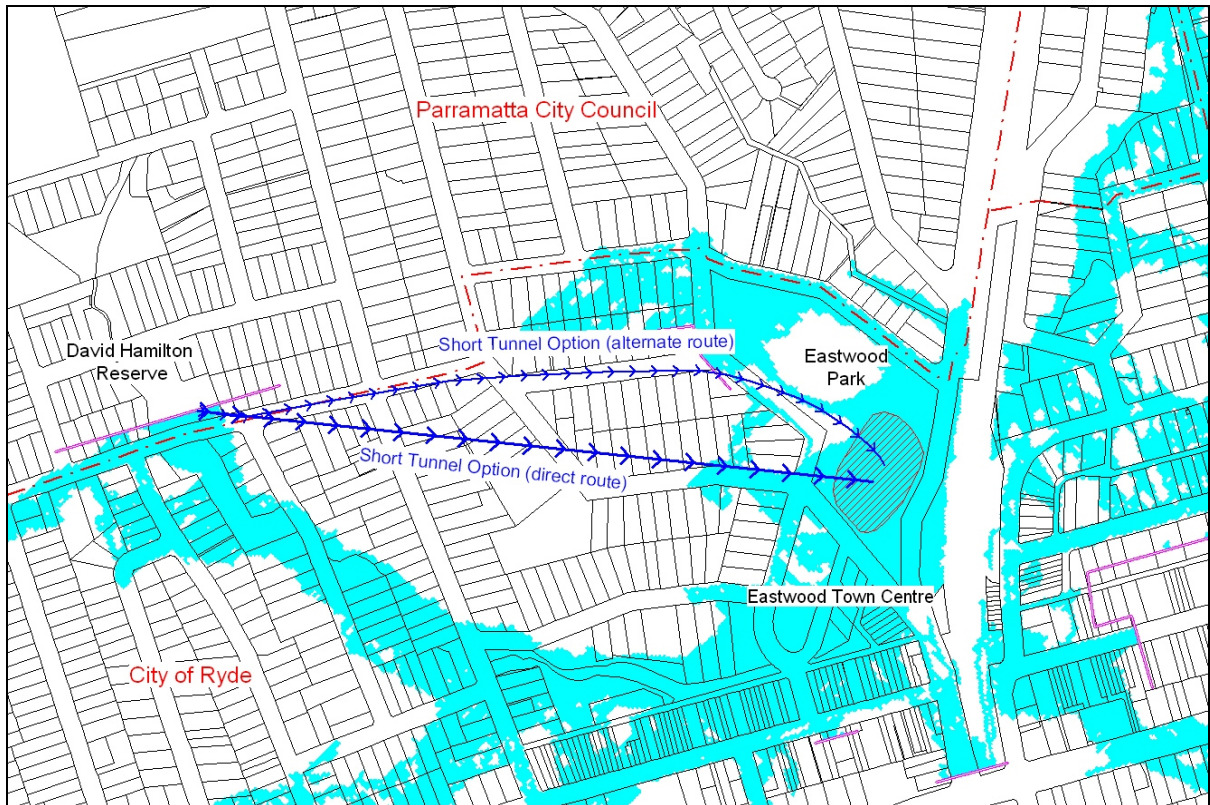


FIGURE 7.3
Short Tunnel Option Route

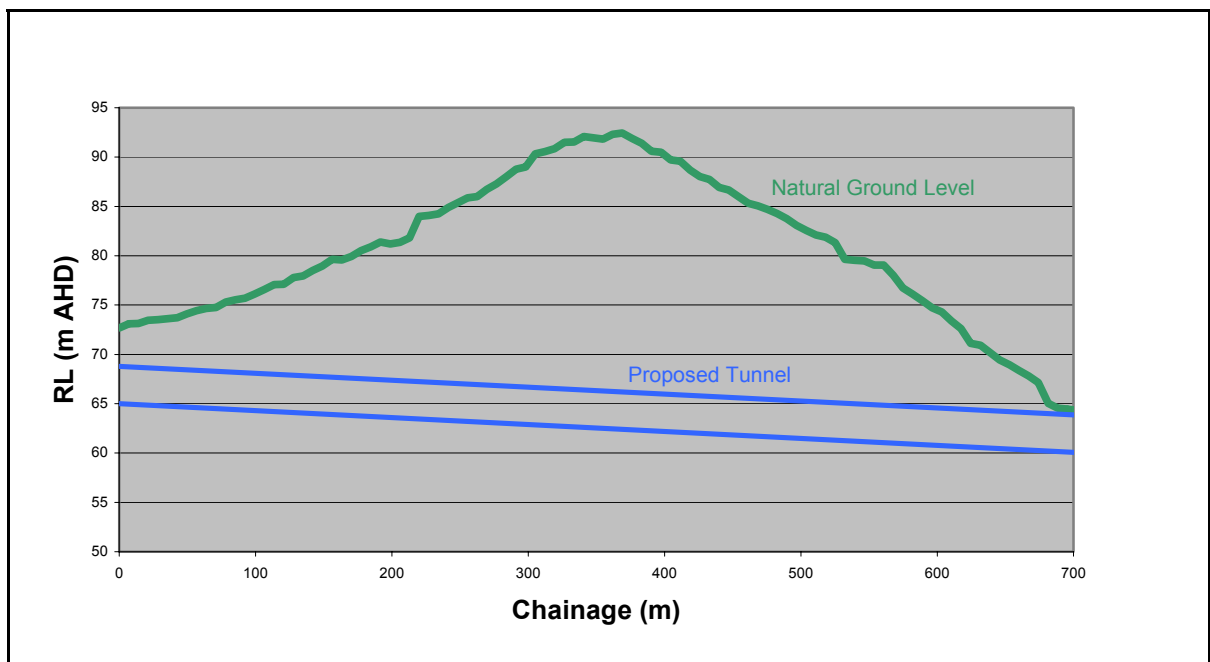


FIGURE 7.4
Short Tunnel (Direct Route) Longitudinal Profile

7.3 BASIN IN GLEN RESERVE

Findings: Not recommended due to limited flood benefits

A basin was proposed in Glen Reserve, a short distance upstream of the Eastwood town centre. The basin, shown on **Figure 7.5**, would be formed by constructing an embankment across the existing stormwater channel and around the perimeter of the car park in Hillview Parade and commercial buildings in Glen Street. An option to cover the stormwater channel between the basin outlet and the Progress Avenue culverts was also proposed.

The height of the embankment must be restricted to approximately RL 67.5m AHD to avoid increasing flood levels upstream of the basin, which would potentially impact on upstream houses. This limits the available flood storage that can be obtained from the site to 7,000m³. A significant portion of the basin site would already be inundated in a large flood, which reduces the effective storage volume of the basin to mitigate flooding. The effective storage volume is estimated to be reduced to as little as 3,000m³ in a 100 year flood.

The basin was included in the TUFLOW model and assessed under 100 year flood conditions. Covering the top of the stormwater channel and allowing for pressurised flow between down to the Progress Avenue culverts made little difference to the capacity of the downstream channel. This is largely due to the reduced waterway capacity of the covered channel compared with the larger waterway capacity of the Progress Avenue culverts.

The estimated cost of the basin is estimated to be of the order of \$1M. The flood level reduction downstream of the basin is less than 0.1m, and provides little benefit to existing floodprone property. The option of covering the downstream channel will further increase costs and provide little additional benefit. The committee concluded that further assessment of this option was not warranted.

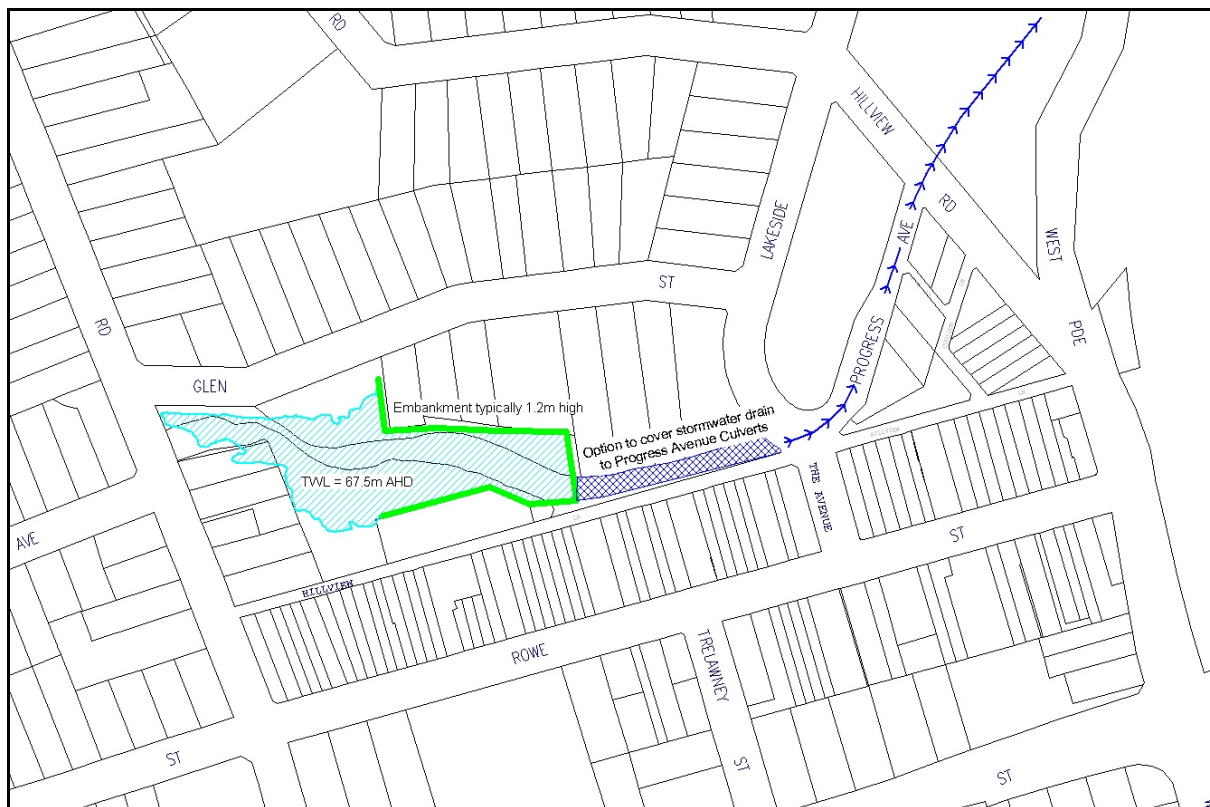


Figure 7.5
Glen Street Basin

7.4 BASIN AT MOBBS LANE

Findings: Recommended for inclusion in the floodplain management plan

A basin at Mobbs Lane, within Parramatta City Council, was included as an option due to its potential impact on flood behaviour through the current study area.

A basin at this location was recommended in both the Terry's Creek Catchment Management Study (Water Board, 1991) and the Terry's Creek Subcatchment Management Study (Cardno Willing, 2005). The 1991 study considered an excavated basin with a maximum storage volume of 45,000m³, whilst the latter study considered an unexcavated basin with a storage volume of 14,000m³. Results from both studies are summarised in Table 7.1.

Table 7.1
Mobbs Lane Basin Investigations

Details	Water Board (1991)	Cardno Willing (2005)
Type of Basin	Excavated	Natural
Maximum Storage Volume	45,000 m ³	14,300 m ³
Basin Inflow (100 yrs)	21 m ³ /s	19 m ³ /s
Basin outflow (100 yrs)	4 m ³ /s	7 m ³ /s
Peak flow at Terry Road (100 yrs, no Basin)	50 m ³ /s	45 m ³ /s
Peak flow at Terry Road (100 yrs, with Basin)	36 m ³ /s	33 m ³ /s

Despite different flood estimation methods and different flood storage volumes assumed for the basin, the results from both studies indicate similar peak flow reductions at Terry Road. The reduction in flood levels throughout the current study area was assessed using the TUFLOW model by adjusting the inflow hydrograph at Terry Road to represent the likely impacts of a basin at Mobbs Lane. This option was assessed together with a proposed culvert upgrade at Terry Road, which was another recommendation from the 2005 report.

Results from the modelling indicate that there is a 0.1 to 0.2m reduction in the 100 year flood level through the Eastwood town centre, and a smaller reduction of 0.05m downstream of the railway line. These reductions are mainly attributable to the basin at Mobbs Lane. Smaller impacts were evident in more frequent floods, such as the 5 year event, although this is most likely due to the inclusion of the culvert upgrade at Terry Road, which by itself would have a small detrimental impact on downstream flows. The present value from all floods is estimated to be reduced by about \$0.4M (in the current study area alone). Greater benefits are likely to be incurred immediately downstream of the basin, within Parramatta City Council. It is considered that this could be further improved by omitting the culvert upgrade at Terry Road and optimising the performance of the Mobbs Lane Basin in more frequent floods.

The most recent estimate provided for the basin is \$0.42M (Cardno Willing, 2005). This estimate is based on an unexcavated basin, and additional costs would be incurred if the basin was excavated to provide additional storage. Further feasibility studies are recommended to determine the optimal storage volume for the basin in terms of both site conditions and hydraulic performance.

It is recommended that a basin at Mobbs Lane be pursued with Parramatta City Council, with possible cost sharing arrangements between both Councils and the DECCW.

7.5 ENLARGE RAILWAY CULVERT

Findings: Not recommended due to high costs and detrimental downstream impacts

The culvert under the Northern Railway Line at Eastwood consists of a covered rectangular channel, 6.0m wide by 2.0m high on the entrance side, which opens into a brick arch covered channel. The option of increasing the capacity of this structure was investigated.

The railway culvert controls flooding on both sides of the railway line. Increasing the capacity of the culvert will allow more flow under the railway line and will reduce upstream flood levels, but it is also likely to increase flood levels downstream of the railway line. This could impact on commercial premises on the east side of the railway line, and a number of residential units and homes further downstream.

The option of increasing the capacity of the railway culverts by 25% was assessed using the TUFLOW model. Flood levels upstream of the railway line, in Eastwood Park, were reduced by up to 0.6m in a 100 year flood. Much smaller benefits were realised through the town centre. Hillview Road acts as a hydraulic control for overland flow through the town centre, which elevates flood levels above the height of ponding that occurs in Eastwood Park. The reduction in flood levels upstream of Hillview Road was limited to 0.2m. Flood levels downstream of the railway line were found to increase by between 0.1 to 0.2m in the 100 year flood.

There are a number of practical issues in enlarging the capacity of the railway culvert which will greatly add to the cost of this option, including:

- i) complete replacement of the existing structure may be required in order to increase the capacity of the existing structure without compromising the stability of the existing railway embankment;
- ii) all work and contractors will need to be approved and supervised by RailCorp; and
- iii) the track will need to be closed whilst work is undertaken, which will most likely need to be confined to several 48 hour 'windows' whilst other track maintenance is carried out.

A construction quote for a similar project south of Sydney was recently estimated at \$3.2M, and it is likely that a similar cost would apply to this project.

Given the high costs of this option, the modest reductions in flood levels through the town centre, and the increase in downstream flood levels, this option is not recommended for inclusion in the floodplain management plan.

7.6 BASIN IN EASTWOOD PARK

Findings: Not recommended due to negligible flood level reductions

A number of basin options have previously been investigated for Eastwood Park (Water Board, 1991), including an 'upper basin' where the formal playing field is located, and a 'lower basin' beside West Parade. These basins had storage volumes of 12,000m³ and 6,000m³ respectively. Both were estimated to have benefit/cost ratios less than 0.2 and neither basin was recommended.

The construction of a detention basin in the lower portion of Eastwood Park has been reviewed as a potential option to alleviate flooding in the Eastwood town centre. As the basin is downstream of the town centre, it can only be effective if it is able to lower flood levels that would otherwise occur within the park. The storage volume would largely be provided

through excavation of the site, which is limited to 3-4m in depth in order to maintain natural drainage to the culverts under the railway line. This provides a maximum storage volume of approximately 15,000m³.

The basin was included in the TUFLOW model and assessed for the 100 year flood. Flood levels within the basin were lowered by up to 0.3m due to the additional flood storage that has been provided through excavation. The reduction in upstream flood levels, through the town centre, is limited to just 0.05m due to the hydraulic control provided by Hillview Road. Similar flood level reductions of 0.05m occur downstream of the railway line.

The cost of the basin is likely to be of the order of \$1M. Given the negligible reduction in flood levels and the disturbance to the park, this option is not recommended for inclusion in the floodplain management plan.

7.7 UPGRADE TERRY ROAD CULVERT

Findings: Not recommended without further evaluation

Terry Road is at the boundary of Parramatta City Council and the City of Ryde. An earlier report for Parramatta City Council (Cardno Willing, 2005) recommended that the culvert at Terry Road be amplified to reduce upstream flooding. This has been further evaluated to determine the likely impact (if any) on downstream properties in the City of Ryde.

The 2005 report recommended upgrading the existing 3.1x1.6 box culvert at Terry Road with a 3.1x2.28 box culvert. This was noted as reducing flood levels upstream of Terry Road by 0.27m in the 100 year flood, with a slight (0.02m) increase in downstream flood levels. The report also recommended upgrading the Holway Street culvert (next upstream), which was estimated to have no impact on downstream flood levels.

The Terry Road Culvert upgrade was included in the TUFLOW model in conjunction with the proposed basin in Mobbs Lane, which was also recommended in the 2005 report. Results of modelling showed that proposed basin more than compensated for the slight increase from amplifying Terry Road, particularly in large floods. However, in more frequent events such as the 5 year flood, an increase in flood levels of up to 0.1m was predicted immediately downstream of Terry Road. This increase is mainly attributed to the culvert amplification, which appears to be more significant in minor floods.

Amplification of the Terry Road culvert can not be recommended without further consideration of the impacts in the full range of flood events. At a minimum, it would need to be contingent on the construction of the Mobbs Lane Basin.

7.8 ABUKLEA AND MILLNER PARK DRAINAGE

Findings: Further drainage augmentation investigations and measures are warranted

Drainage improvements were investigated along Abuklea Road, and in the vicinity of the TG Millner Sportsground, with the aim of reducing flooding problems that have been experienced to property in and adjacent to Abuklea Road. It is estimated that 5 homes in Abuklea Road, 1 home in Vimiera Road, 1 home in Gunyah Street and 1 home in Torrington Street is affected by above floor flooding on a relatively frequent basis.

The proposal, shown on **Figure 7.6**, includes the construction of an earthen embankment around the eastern and southern perimeter of the TG Millner Sports field to capture surface runoff, with an outlet pipeline discharging to Terry's Creek (via Pembroke Park). The

capacity of the existing stormwater pipeline behind properties on the north side of Abuklea Road was also doubled in an effort to reduce surface flows down Abuklea Road.

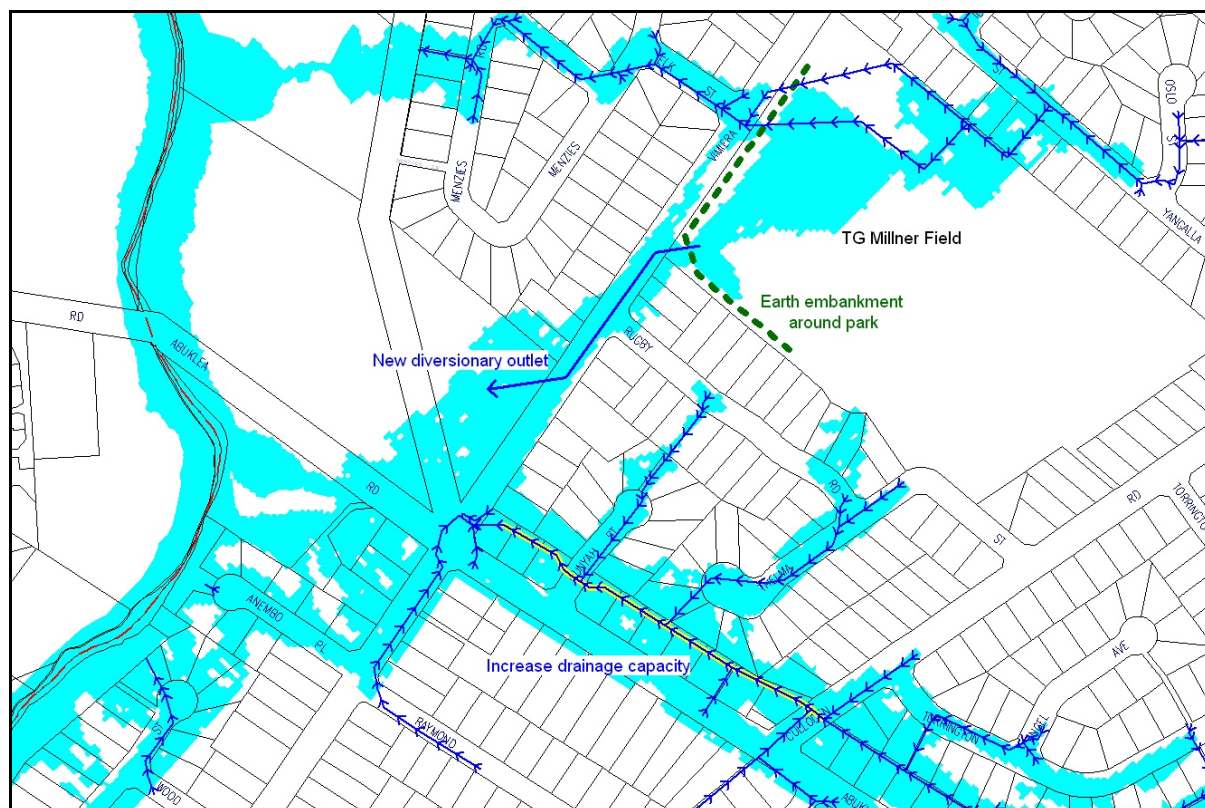


FIGURE 7.6
Abuklea Road and Millner Park Drainage Augmentation Measures

The proposed works were included in the TUFLOW model and assessed for a range of floods. The measures proposed in the TG Millner Sportsground were found to provide little benefit in reducing flood levels to those properties previously affected by flooding. Doubling the drainage capacity of the drain behind properties in Abuklea Road helped to reduce the extent of flooding, but significant overland flooding problems were still apparent.

Further increase to the drainage capacity of the stormwater pipes in the Abuklea Road area will be required to reduce the majority of the flooding problem in this area. Whilst local stormwater investigations will be required to establish the full extent of work necessary, it is anticipated that this could include the installation of additional twin 1500mm pipelines down Abuklea Road to supplement the existing pipeline running behind properties on the north side of this road. The merits of extending the pipeline further upstream to Balaclava Road, and additional drainage inlet pits on Vimiera Road near Raymond Street, should also be considered as part of the stormwater investigations. The total cost of these works is estimated at \$1.7M. Works in the TG Millner Sportsground do not appear to be warranted.

7.9 DEBRIS CONTROL STRUCTURES

Findings: Recommended for inclusion in the floodplain management plan

Debris control measures to prevent blockage of the railway culvert and the Progress Avenue culverts were investigated.

There is potential for culvert and other hydraulic structures to become blocked by debris during floods. Fallen trees and other creek-side vegetation, shopping trolleys, garbage bins and floating cars can all potentially become trapped on the upstream side of culverts. **Figure 2.2** shows a photo of a car and other debris threatening to block the railway culvert during the November 1984 flood. When this happens, the capacity of the structure can be significantly reduced and upstream flood levels increased.

The potential for culvert blockage in the Eastwood catchment was considered by the floodplain management committee. It was concluded that a variable blockage allowance should be included for all structures when modelling flood behaviour, depending on the opening width of the structure. The blockage allowance assumed for the railway and Progress Avenue culverts was 25% and 35% respectively.

Constructing debris control structures around the opening of these two structures will reduce the likelihood of these structures becoming blocked, and will potentially lower flood levels. The increased capacity by avoiding blockage is similar to enlarging the size of the structure, but at a much reduced cost. The debris control structure around the railway culvert is anticipated to include bollards or vertical posts around the perimeter of the open channel leading to the railway culvert, on the downstream side of West Parade. The structure for the Progress Avenue Culvert is anticipated to be tubular fencing along the perimeter of the open drain, between Shaftsbury Road and The Avenue, sufficient to avoid shopping trolleys, bins and cars from being washed into the drain.

Modelling results indicate that flood levels can be reduced by up to 0.6m in Eastwood Park, and by 0.2 to 0.3m through the town centre in the 100 year flood. The present value of all flood damage could be reduced by approximately \$0.5M if the potential for blockage of these structures is eliminated. This debris control measures are estimated to cost of the order of \$50,000 with a benefit/cost ratio considerably greater than 1.0.

These works are recommended for inclusion in the floodplain management plan due to the low costs and high benefit/cost ratio.

7.10 WOOD STREET DRAINAGE UPGRADE

Findings: Recent measures have largely addressed the flooding problem at this location

Flooding problems had been noted during the November 1984 flood at the end of the cul-de-sac in Wood Street. Measures to address these flooding problems have been investigated.

The southern end of Wood Street is potentially affected by floodwater in Terry's Creek. It is also potentially affected by stormwater runoff from a small catchment area that drains to Terry's Creek at this location. It was reported that floodwater broke the banks of Terry's Creek in the 1984 flood, with floodwater coming to 'within 10 feet of the back of fences' of property in Wood Street. Significant inundation from stormwater runoff was also noted through several properties at the end of Wood Street. This appears to be the major cause of flooding at this location.

The stormwater drainage system starts at Balaclava Road, passes down Deborah Place to Vimiera Road, and finally discharges to Terry's Creek below Wood Street. The stormwater pipeline between Vimiera Road and Terry's Creek consists of a 900mm diameter pipeline. Flows in excess of the pipe's capacity will flow overland through the three properties at the end of Wood Street.

It is understood that additional drainage improvements have been implemented following the 1984 flood. These improvements, which may have reduced the magnitude of previous flooding problems, include:

- i) A series of three drop pits were replaced by a single drop pit to reduce hydraulic losses;
- ii) An abrupt bend in the pipeline upstream of Wood Street was removed; and
- iii) Local drainage improvements were included at the end of the Wood Street cul-de-sac.

An upgraded drainage scheme was investigated with the capacity of the pipeline between Vimiera Road and Terry's Creek doubled, at an estimated cost of \$200,000. Results from the TUFLOW analysis indicated a maximum reduction in the 100 year flood of just 0.1m.

Whilst flooding problems have been reported around a number of properties in this area, there have been no reports of above floor flooding. Inspection of the flood damages database indicates that buildings most at risk are substantially elevated above natural ground level. The floor level of the house on the property that is most susceptible to flooding is 1.27m above natural ground and 0.1m above the 100 year flood level.

Given that the floor level of all existing buildings are above the current estimate for the 100 year flood, and the drainage measures recently undertaken, additional flood mitigation measures are difficult to justify.

7.11 DIVERT FLOW TO PARRAMATTA RIVER

Findings: Not recommended due to high costs

It was proposed to intercept floodwater upstream of the Eastwood town centre, and to divert these flows through a pipeline running along the railway corridor to the Parramatta River.

The proposed scheme, shown on **Figure 7.7**, includes a diversion structure upstream of the Progress Avenue culverts and a 3.8km long pipeline running beside the railway embankment down to the Parramatta River. The route provides an average 1.6% fall towards the Parramatta River. The pipeline would be mostly located just below natural ground level, although some sections may need to be up to 10m below natural ground to maintain a constant grade. The pipeline could deviate from the railway line about 700m north of the Parramatta River and discharge to the Parramatta River via Charity Creek.

A single 2100mm pipeline was originally considered for this proposal. The capacity of the pipeline was estimated at 14m³/s, which was considered to provide insufficient capacity to significantly reduce flooding through Eastwood. Twin 2100mm pipelines were subsequently considered. Some thought was also given to connecting the pipeline directly to the West Ryde tunnel scheme, which would reduce its length to 1.5km. This option was not pursued due to the risk of flooding occurring at Eastwood and West Ryde at the same time.

The pipeline diverts 28m³/s away from the Eastwood town centre. The impact on flooding is relatively similar to the short tunnel option, with the present value of flood damage from all floods reducing by around \$3.2M. The cost of the scheme is estimated at \$44M, providing a benefit/cost ratio of less than 0.1. There could also be some technical difficulties with this scheme, including stability issues associated with the railway embankment during construction and conditions that may be imposed by RailCorp during construction.

The proposal is not recommended due to high costs and potential technical difficulties.

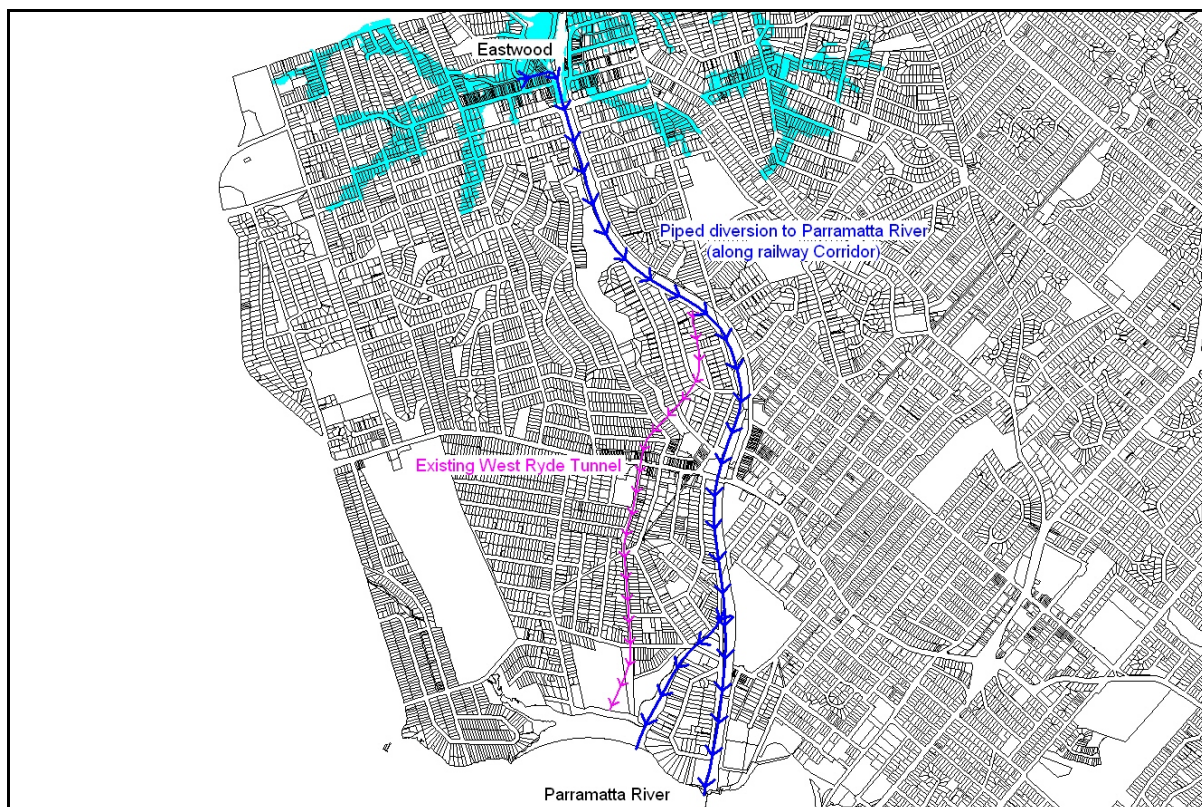


FIGURE 7.7
Proposed Diversion Pipeline to Parramatta River

7.12 FIRST AVENUE DRAINAGE WORKS (FINAL STAGE)

Findings: Recommended for inclusion in the floodplain management plan

The First Avenue Drainage Reconstruction Scheme was developed by the City of Ryde to alleviate flooding problems to a number of residential and commercial properties in Eastwood, between First Avenue and Railway Parade on the eastern side of the railway. The scheme has been largely constructed except for the final stage, which involves the construction of an 1800mm pipeline between First Avenue and Rowe Street.

The First Avenue Drainage Works that have been constructed to date are included in the flood model as existing conditions, and much of the merits of the scheme have already been realised. The final stage of the First Avenue Drainage Scheme was included in the TUFLOW model to assess the merits of the final stage of the work.

Model results indicate that the final stage of work would reduce flood depths by up to 0.9m between First Avenue and Rowe Street in the 100 year flood. Flooding of up to 8 commercial premises would be prevented in this flood. The present value of all of all flood damages was reduced by approximately \$0.6M. The cost of the remaining work has been estimated by the City of Ryde as \$1.3M, which provides a benefit/cost ratio of 0.5.

These measures are considered to have a reasonable benefit/cost ratio, and given that they are required to complete an overall scheme which has realised other benefits already, completion of the final stage of work is recommended for inclusion in the floodplain management plan.

7.13 CBD DRAINAGE AUGMENTATION

Findings: Recommended for inclusion in the floodplain management plan

Of the options that have been recommended above, only the Mobbs Lane detention basin and the debris control structures at the Progress Avenue and railway culverts provide limited flood benefits to the Eastwood town centre. Options that provide a significant reduction in flooding, such as the two tunnel options, were not recommended due to their high cost and poor benefit/cost ratio.

The continuing risk to public safety posed by flooding in the town centre was raised by some committee members, and a review of other options to alleviate flooding through the town centre was subsequently requested by Council.

The major cause of flooding through the town centre is due to the limited capacity of the underground culverts under Progress Avenue and Eastwood Park. This drainage line is capable of carrying only half of the estimated flow in a 100 year flood, with the balance of floodwater flowing overland through the town centre.

Options to augment the existing drainage line were investigated, including additional culverts down Lakeside Road, Progress Avenue, or the small laneway behind Progress Avenue. Lakeside Road was considered the most feasible route due to the required width of the culverts and the available space under existing road reserves. A concept plan for the preferred option is shown on **Figure 7.8**, with a longitudinal profile provided on **Figure 7.9**. The scheme includes:

- i) modification of the existing drain upstream of Progress Avenue, including the option to cover this drain;
- ii) new twin box culverts (approximately 2x3000Wx2400H) from Glen Street Reserve to Eastwood Park, under Lakeside Road to supplement the existing culverts down Progress Avenue; and
- iii) an inlet headwall in Glen Street Reserve.

The new drainage augmentation scheme was investigated using the TUFLOW model. It was assumed that debris control measures recommended for Progress Avenue and the railway culverts would be included, and a blockage allowance for these structures (including the new culverts) would not be required. A small (existing) wall along the northern fence of the Eastwood Public School, which helps to reduce overland flow down Rowe Street, was also included in the modelling of this option.

The drainage augmentation measures reduce the 100 year flood by up to 1.0 to 1.1m through the town centre, reducing the depth of flooding to less than 0.3m. The present value of benefits from all floods is estimated at \$4.6M. The cost of the scheme is estimated at \$8.5M (City of Ryde). This provides a benefit/cost ratio of 0.5, which is a substantial improvement over the other tunnel options investigated. Given the reduced risk to personal safety this option could be considered more favourably. It would also remove many of the flooding constraints on future redevelopment of the town centre. The option has been recommended for inclusion in the Floodplain Management Plan.

An alternative option for the CBD drainage upgrade was proposed by a member of the local community following exhibition of the draft plan. The alternative option involves additional culverts from Lakeside Road to the railway line (via Coolgun Lane), deepening the culverts under the railway line, and other downstream improvements. The alternate option is not favoured due to higher construction costs and a potential increase in flood flows downstream of the railway line.

**FIGURE 7.8
EASTWOOD VILLAGE
DRAINAGE IMPROVEMENTS
CONCEPT PLAN**

0 10 20 30 40 50m
Scale

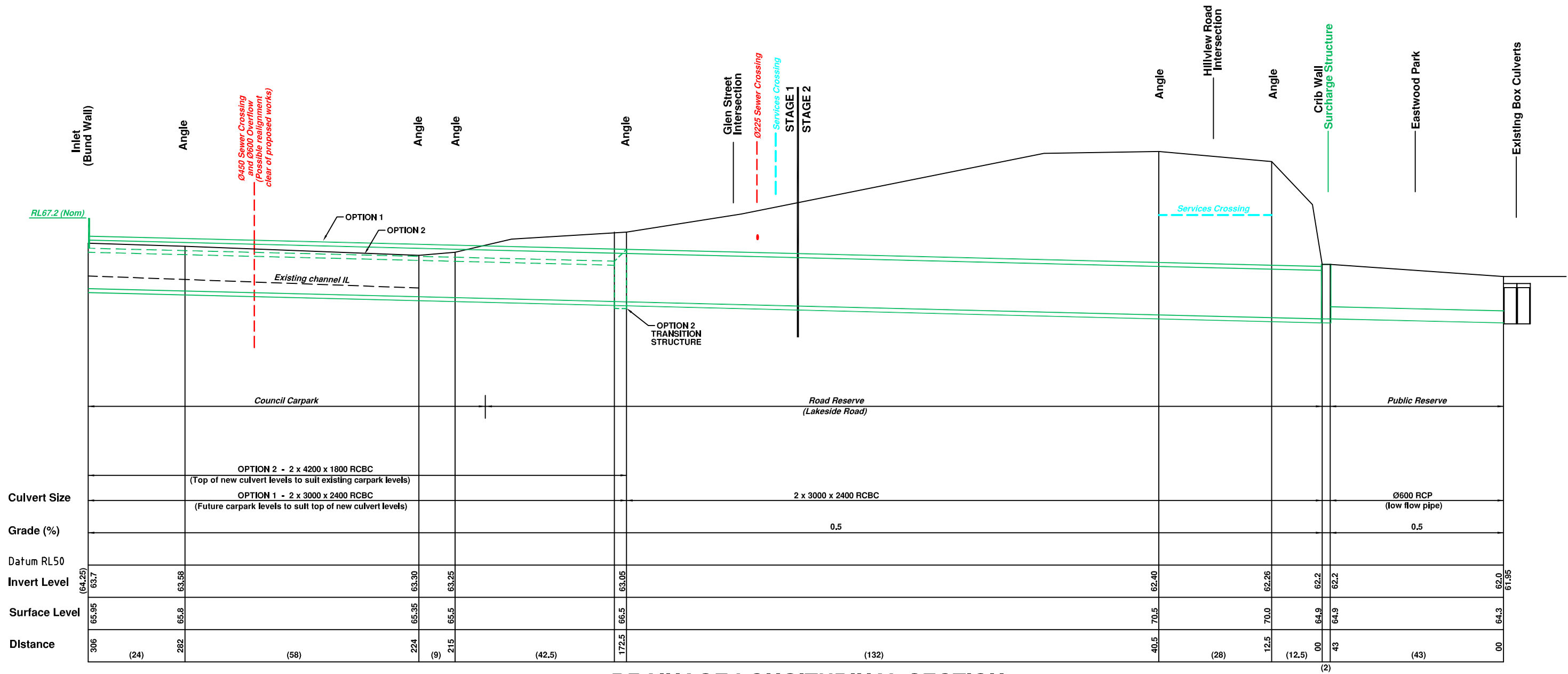


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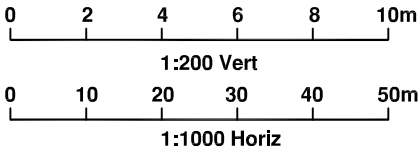
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 Date: 30 October 2008

**EASTWOOD AND TERRY'S CREEK
FLOODPLAIN RISK MANAGEMENT
STUDY AND PLAN**

FIGURE 7.9
EASTWOOD VILLAGE
DRAINAGE IMPROVEMENTS
CONCEPT LONGITUDINAL
PROFILE



DRAINAGE LONGITUDINAL SECTION



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EASTWOOD AND TERRY'S CREEK
FLOODPLAIN RISK MANAGEMENT
STUDY AND PLAN

8 OTHER FLOODPLAIN MANAGEMENT MEASURES

8.1 STORMWATER DRAINAGE PROBLEMS

A large focus of the current study has been based on addressing the flood problems in the Eastwood town centre. However, the total flood damage from this area represents only 30% of the flood damage experienced throughout the wider study area (based on the present value of flood damage in **Table 5.1**). Most of the other flood problems are related to stormwater drainage and overland flow problems along the tributaries that lead to Terry's Creek.

The majority of flooding problems are related to surface flows that are less than 0.3m in depth. Flood behaviour within these areas is very much influenced by local conditions, including fences, structures, the accuracy of the ALS survey, and assumed floor levels of potentially affected buildings. Further investigations will be required in several areas to determine the most appropriate stormwater drainage improvements.

Stormwater drainage problems are distributed throughout the study area, however, there are four areas where the majority of stormwater problems are concentrated. These include:

Area 1 – Upstream of Shaftsbury Road, where stormwater flooding has been estimated to inundate at least five dwellings between Rutledge Street and Shaftsbury Road in floods up to the 100 year event.

Area 7 – Downstream of the railway, in a stormwater flow path between Lovell Road and Balaclava Road. Six dwellings are estimated to be affected by inundation in the vicinity of Lovell Road and another nine dwellings affected by inundation downstream of Balaclava Road.

Area 8 – A stormwater flow path behind properties in Abuklea Road, which is estimated to inundate five dwellings in Abuklea Road, one dwelling in Vimiera Road, one dwelling in Thelma Street, and one dwelling in Torrington Drive.

Area 9 – A stormwater flow path at the downstream end of the study area, on the southern side of Epping Road, which is estimated to inundate up to four dwellings.

Table 8.1 lists some provisional stormwater drainage improvement measures. These works are subject to detailed assessments, but are anticipated to include:

- i) formalisation of overland flow paths;
- ii) amplification of stormwater pipe lines; and
- iii) potential relocation of buildings that currently restrict overland flow paths.

TABLE 8.1
Potential Drainage Improvements

Area No.	Address	Flood Regime	Formalise Overland Flow Path	Pipe Overland Flows	Relocate Buildings	Investigation Cost	Capital Works
1	33 Rutledge St	House located within overland flow regime			Investigate	\$20,000	\$200,000
	212-280 Rutledge St	School building within overland flow regime	Yes			\$15,000	\$20,000
	163 Shaftsbury Rd	House located below street level and flows spilling off street	Yes (difficult)			\$15,000	\$20,000
	298A Rowe St	Houses located within overland flow regime	Yes (difficult)			\$20,000	\$40,000
	2,3,4 Richards Ave	Houses located within overland flow regime	Yes (difficult)			\$20,000	\$30,000
	7-13 Auld Ave	Overbank flooding from Terry's Creek			Investigate	\$20,000	\$200,000
	9 Tarrants Ave	House located below street level and flows spilling off street	Yes (difficult)			\$15,000	\$20,000
	19A Clive Rd	House located within overland flow regime	Yes (difficult)			\$15,000	\$20,000
7	15 Milham Ave	House below road sag point, no overland flow path			Investigate	\$20,000	\$200,000
	36-40 Balaclava Rd	2 houses down slope of overland flow regime	Yes (difficult)			\$20,000	\$30,000
	6-11 Jupp Pl	6 houses located within overland flow regime	Yes (difficult)			\$30,000	\$90,000
	26-28 Virmiera Rd	House located within overland flow regime	Yes (difficult)			\$15,000	\$20,000
	12 Grove St	House located within overland flow regime	Yes (difficult)			\$15,000	\$20,000
	7-13 Pickford Ave	Series of houses with depression in backyards plus flow from street reserve	Yes (difficult)			\$30,000	\$80,000
	4 Russell St	House located below street level and flows spilling off street	Yes (difficult)			\$15,000	\$20,000
	5 Lovell Rd	House located within overland flow regime	Yes (difficult)			\$15,000	\$20,000

TABLE 8.1
Potential Drainage Improvements

Area No.	Address	Flood Regime	Formalise Overland Flow Path	Pipe Overland Flows	Relocate Buildings	Investigation Cost	Capital Works
8	38 Menzies Rd	House below road sag point, no overland flow path	Too difficult	Yes, pipe all 100 year flows off street. New 1200 pipe to supplement existing 900 pipe. Lay new pipe down opposite side of most floodprone property. Total pipe length about 60m)		\$25,000	\$120,000
	1-7 Abuklea Rd	Main depression in back yards of properties plus flow from street reserve	Cannot create much extra capacity, therefore not worthwhile	Yes, pipe all overland flow from Culloden Rd to Vimiera Rd culvert outlet. Estimate twin 1500 pipes laid in street, length of about 300m. Investigate extension upstream to Balaclava Rd & additional drainage inlet pits at Vimiera Rd/Raymond St.		\$70,000	\$1,600,000
	120 Vimiera Rd	Main depression in backyard of property		Yes (part of above Abuklea scheme)			
	30 Thelma St	House below road sag point, no overland flow path	Yes (difficult)			\$15,000	\$20,000
9	1 Torrington Dr	House below road sag point, no overland flow path	Yes (difficult)			\$15,000	\$20,000
	18 Brunton Pl	House below road sag point, no overland flow path	Too difficult to provide for flow from street but needed through Nos 16-20 because rear yard depression is inadequate	Yes, pipe all 100 year flows off street (replace 450 pipe with 1200 pipe, length about 40 metres with surcharge junction pit in upgraded flow path scheme)		\$25,000	\$110,000
	9 Towri Pl	House below road sag point, no overland flow path	Yes (difficult)			\$15,000	\$20,000
	2 Mawarra Pl	House below road sag point, no overland flow path	Yes (difficult)			\$15,000	\$20,000
	176-178 Balaclava Rd	2 houses located within overland flow regime	Yes (difficult)			\$15,000	\$20,000

8.2 ADDITIONAL MEASURES FOR AREA 7

A number of residents made submissions regarding the flood problem in Area 7 following the exhibition of the draft floodplain management study and plan. A number of additional measures have been reviewed for this area, and are discussed further below.

8.2.1 Additional Inlet Pits in Brabyn Street

A submission from one resident referred to stormwater problems along Brabyn Street due to insufficient stormwater inlet pits along the road.

Some minor stormwater flooding occurs along the southern side of Brabyn Street, over a distance of approximately 200m. Inundation depths are typically less than 200mm. No homes are predicted to be flooded above floor level in a 100 year flood.

Providing one or two additional inlet pits along Brabyn Street may help to reduce nuisance flooding along the road and neighbouring properties, particularly in more frequent floods. Whilst the economic benefits are low, this measure could be implemented for minor costs only. As such, this measure is recommended for further consideration as part of the floodplain management plan, with a nominal allowance of \$10,000.

8.2.2 Improvements to Culvert in Jim Walsh Park

One resident submission recommended consideration of improving the efficiency of the culvert under Balaclava Road, by providing a tapered edge to the headwall structure in Jim Walsh Park, removing existing vegetation around this structure, and providing an improved debris structure to minimise blockage problems.

The works are relatively minor and are anticipated to provide a small improvement in the capacity of the existing culvert structure. The proposed measure warrants further consideration, and has been included in the proposed floodplain management plan with a nominal allowance of \$10,000.

8.2.3 Amplification of Drainage Pipeline downstream of Jim Walsh Park

Many of the flood problems experienced within Area 7 are located downstream of Jim Walsh Park, between Balaclava Road and Vimiera Road. There are some 58 properties potentially affected by flooding in this area, with 12 homes estimated to be inundated above floor level in the 100 year flood.

The existing drainage regime downstream of Jim Walsh Park consists of twin 1800mm diameter pipes that discharge to Terry's Creek below Vimiera Road. A supplementary 1800mm pipeline was investigated to reduce flooding within this area. The additional pipeline, shown on **Figure 8.1**, commences at the culvert in Jim Walsh Park and generally follows the alignment of the existing pipes. Some deviation is likely to be required at the southern end of Jupp Place due to constraints with existing buildings. Easements and possible property acquisition may also be required, which significantly adds to the cost of the proposal. Alternative routes may need to be investigated to reduce these costs, for example down Munroe Street and west along Corruna Road, although significant savings are not anticipated.

The performance of the scheme and the level of protection afforded will need to be confirmed through further computer modelling, but is expected to be in the range of 20 to

100 years. The present value of flood damages is estimated to be reduced by approximately \$1.0M. The estimated cost of the scheme is \$5M, with a benefit/cost ratio estimated at 0.2.

The drainage amplification measures are not recommended due to high costs and the relatively low benefit/cost ratio.

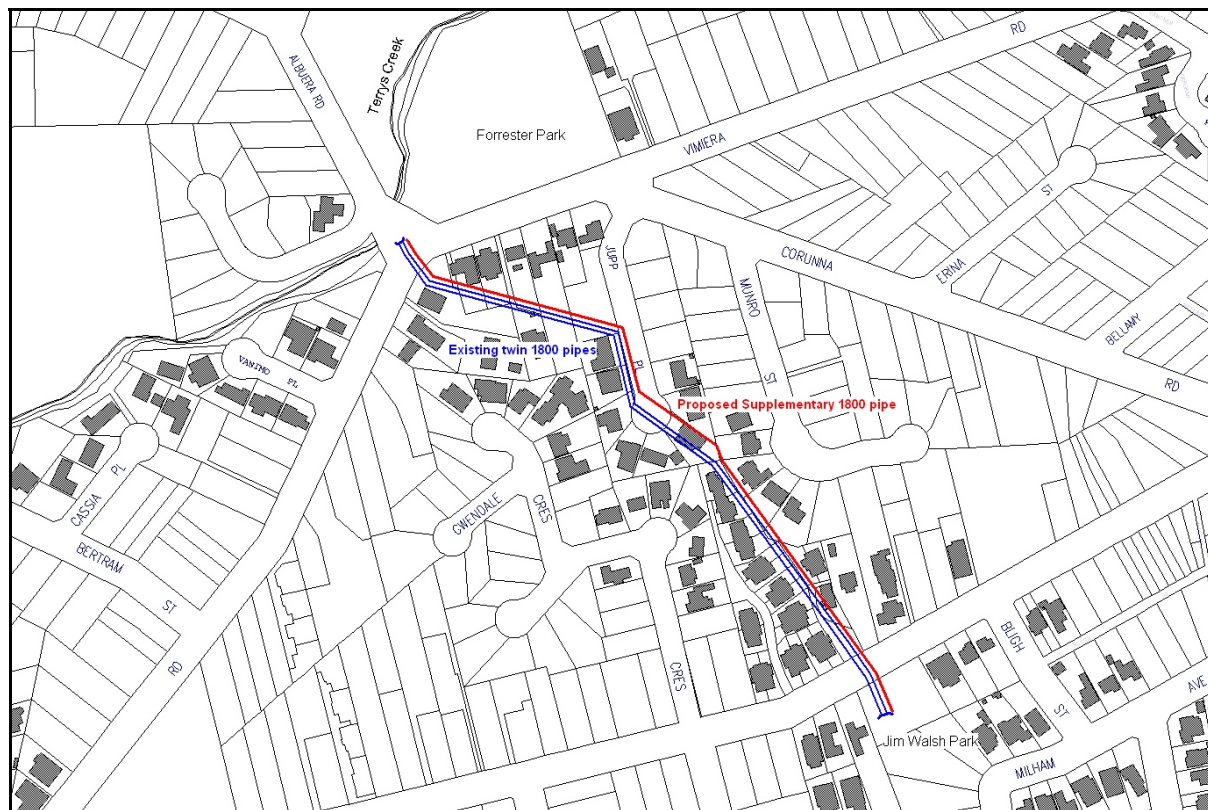


FIGURE 8.1
Amplification of Pipeline downstream of Jim Walsh Park

8.2.4 Potential Detention Basin in Jim Walsh Park

A potential detention basin in Jim Walsh Park was investigated to alleviate flooding problems in Area 7, downstream of Balaclava Road. The basin, shown conceptually on **Figure 8.2**, would occupy a surface area of about 18,000m², and would largely be formed through excavation and some limited height embankments. The total storage volume in the basin would need to be of the order of 20,000m³ to effectively reduce downstream flood problems. The average storage depth within the basin will be slightly greater than 1.0m. Some additional excavation may be required to maximise the potential storage volume or to provide a permanent water feature within the park should this be desirable.

A major constraint to a basin at this location is the environmental and aesthetic impact that excavation will have on the existing park landscape. There are a number of trees that will be lost when undertaking the excavation and the aesthetic qualities of the park may be impacted. Nevertheless, the basin would occupy around half of the existing park area, and there may be some opportunity to provide an enhanced amenity around a permanent water feature. Further studies will be required, including consultation with the community, to determine whether or not a basin within the park will be socially acceptable and technically viable.

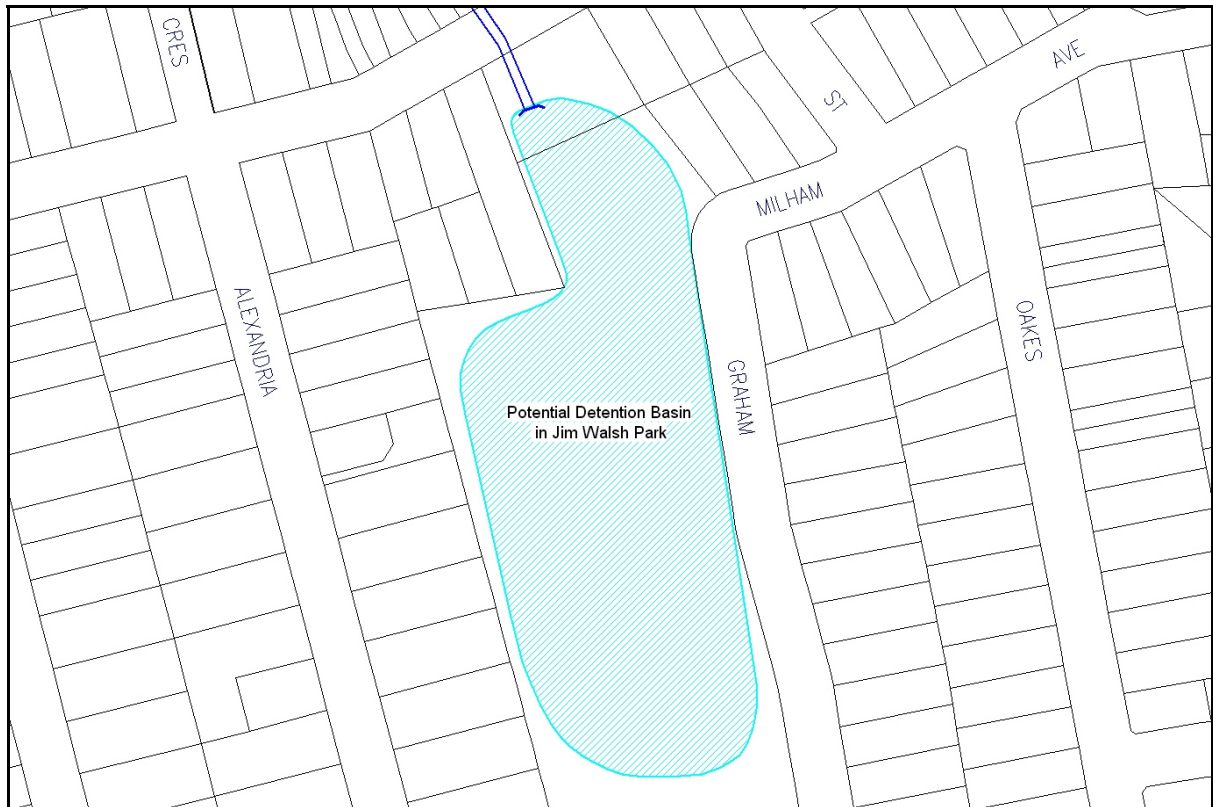


FIGURE 8.2
Potential Detention Basin in Jim Walsh Park

The proposed basin could provide protection for up to 58 downstream properties that are affected by flooding in the 100 year flood, including the 12 homes that are estimated to be flooded above floor level. The present value of flood damages is estimated to be reduced by approximately \$1.4M.

The cost of the basin is anticipated to be of the order of \$2M, although this will be dependent on further technical studies, geotechnical investigations, and additional landscaping requirements. This would provide a benefit cost ratio of the order of 0.7, which from an economic perspective is quite reasonable.

Further detailed investigations are recommended to determine the feasibility of constructing a basin at this location. The study would include community consultation, review of landscaping opportunities, geotechnical investigations, and further flood modelling. The cost of the feasibility study is estimated at \$100,000.

Schedule 4

Eastwood & Terrys Creek
Planning & Development Controls

Template: V5.2

Planning Consideration	Flood Risk and Overland Flow Precincts																							
	Low Flood Risk						Medium Flood Risk						High Flood Risk						Overland Flow					
	Critical Uses & Facilities	Sensitive Uses & Facilities	Residential	Commercial & Industrial	Recreation & Non-Urban	Concessional Development	Critical Uses & Facilities	Sensitive Uses & Facilities	Residential	Commercial & Industrial	Recreation & Non-Urban	Concessional Development	Critical Uses & Facilities	Sensitive Uses & Facilities	Residential	Commercial & Industrial	Recreation & Non-Urban	Concessional Development	Critical Uses & Facilities	Sensitive Uses & Facilities	Residential	Commercial & Industrial	Recreation & Non-Urban	Concessional Development
Floor Level		3	2,6,7	5,6,7	1,6	4,7			2,6,7	5,6,7	1	4,7					1	4,7	3	3	2or8, 6or9, 7	5or8, 6or9, 7	1or8, 6or9	4,7
Building Components		2	1	1	1	1			1	1	1	1					1	1	2	2	1 or 3	1 or 3	1 or 3	1 or 3
Structural Soundness		3	2	2	2	2			2	2	2	2					1	1						
Flood Effects		2	2	2	2	2			2	2	2	2					1	1	2	2	2	2	2	2
Car Parking & Driveway Access		1,3,5,6, 7	1,3,5,6, 7	1,3,5,6, 7	2,3,4,6, 7	6,7,8			1,3,5,6, 7	1,3,5,6, 7	2,3,4,6, 7	6,7,8					2,3,4,6, 7	6,7,8	1or9, 3, 6	1or9, 3, 6	1or9, 3, 6	1or9, 3, 6	2,3,6	6,8
Evacuation		2	2	1 or 2	3	2			2	1 or 2	3	2					3	2	2	2				
Management & Design		1,4,5	1	1,2,3,5	1,2,3,5	1,2,3,5			1	1,2,3,5	1,2,3,5	1,2,3,5					1,2,3,5	1,2,3,5	1,4,5	1,4,5	1	1,2, 3or6, 5	1,2, 3or6, 5	1,2, 3or6, 5

General Notes:

- Unsuitable Land Use (refer to General Note b)
- No Controls
- a *Freeboard* equals an additional height of 500mm. In *Overland Flow* precincts, the *freeboard* is 300mm.
 - b The relevant environmental planning instruments (generally the Local Environmental Plan) identify development permissible with consent in various zones in the LGA. Notwithstanding, constraints specific to individual sites may preclude Council granting consent for certain forms of development on all or part of a site.
 - c Filling of the site, where acceptable to Council, may change the FRP considered to determine the controls applied in the circumstances of individual applications.
 - d Refer to Section 2.3 of the DCP for planning considerations for proposals involving only the erection of a fence. Any fencing that forms part of a proposed development is subject to the relevant flood effects and structural soundness planning considerations of the applicable landuse category.
 - e Refer to Section 2.2 of the DCP for special considerations such as for house raising proposals and development of properties identified for voluntary acquisition.
 - f Terms in italics are defined in the glossary of this plan and Schedule 2 specifies development types included in each land use category. These development types are generally as defined within Environmental Planning Instruments applying to the LGA.

Floor Level

- All floor levels to be no lower than the 20 year flood level plus freeboard unless justified by site specific assessment.
- Habitable floor* levels to be no lower than the 100 year flood level plus *freeboard*.
- Habitable floor* levels to be no lower than the *PMF* level. *Non-habitable floor* levels to be no lower than the *PMF* level unless justified by a site specific assessment.
- Floor levels to be no lower than the *design floor level*. Where this is not *practical* due to compatibility with the height of adjacent buildings, or compatibility with the floor level of existing buildings, or the need for access for persons with disabilities, a lower floor level may be considered. In these circumstances, the floor level is to be as high as *practical*, and, when undertaking alterations or additions, no lower than the existing floor level.
- The level of *habitable floor areas* to be equal to or greater than the 100 year *flood* level plus *freeboard*. If this level is not *practical* for a development in a Business zone, the floor level should be as high as possible.
- Non-habitable floor* levels to be equal to or greater than the 100 year flood level plus *freeboard* where possible, or otherwise no lower than the 20 year flood level plus *freeboard* unless justified by site specific assessment.
- A restriction is to be placed on the title of the land, pursuant to S.88B of the Conveyancing Act, where the lowest *habitable floor area* is elevated above finished ground level, confirming that the undercroft area is not to be enclosed, where Council considers this may potentially occur.
- Habitable floor* levels to be minimum 500mm above adjacent ground levels.
- Non-habitable floor* levels to be minimum 300mm above adjacent ground levels.

Building Components & Method

- All structures to have *flood compatible building components* below the 100 year flood level plus *freeboard*.
- All structures to have *flood compatible building components* below the *PMF* level.
- All structures to have *flood compatible building components* up to 500mm above adjacent ground levels.

Structural Soundness

- Engineer's report to certify that the structure can withstand the forces of floodwater, debris and buoyancy up to and including a 100 year flood plus *freeboard*, or a *PMF* if required to satisfy evacuation criteria (see below). In the case of alterations or additions to an existing development, the structure to be certified is that which is proposed to be newly constructed or otherwise required to be of a specified standard to satisfy other controls.
- Applicant to demonstrate that the structure can withstand the forces of floodwater, debris and buoyancy up to and including a 100 year flood plus *freeboard*, or a *PMF* if required to satisfy evacuation criteria (see below). An engineer's report may be required.
- Applicant to demonstrate that any structure can withstand the forces of floodwater, debris and buoyancy up to and including a *PMF*. An engineers report may be required.

Flood Effects

- Engineer's report required to certify that the development will not increase effects elsewhere, having regard to: (i) loss of flood storage; (ii) changes in flood levels and velocities caused by alterations to the conveyance of flood or overland flow waters; and (iii) the cumulative impact of multiple potential developments in the floodplain.
- The flood impact of the development to be considered to ensure that the development will not increase flood effects elsewhere, having regard to: (i) loss of flood storage; (ii) changes in flood levels and velocities caused by alterations to the flood *conveyance*; and (iii) the cumulative impact of multiple potential developments in the floodplain. An engineer's report may be required.

Car Parking and Driveway Access

- The minimum surface level of open car parking spaces or carports shall be as high as *practical*, and not below: (i) the 20 year flood level plus freeboard; or (ii) the level of the crest of the road at the location where the site has access; (which ever is the lower). In the case of garages, the minimum surface level shall be as high as *practical*, but no lower than the 20 year flood level plus freeboard.
- The minimum surface level of open car parking spaces, carports or garages, shall be as high as *practical*.
- Garages capable of accommodating more than 3 motor vehicles on land zoned for urban purposes, or *enclosed car parking*, must be protected from inundation by floods equal to or greater than the 100 year flood.
- The driveway providing access between the road and parking space shall be as high as *practical* and generally rising in the egress direction.
- Where the level of the driveway providing access between the road and parking space is lower than 0.3m below the 100 year flood, the following condition must be satisfied - the depth of inundation on the driveway during a 100 year flood shall not exceed: (i) the depth at the road; or (ii) the depth at the car parking space. (Refer to Schedule 3). A lesser standard may be accepted for single detached dwelling houses where it can be demonstrated that risk to human life would not be compromised.
- Enclosed car parking* and car parking areas accommodating more than 3 vehicles with a floor level below the 20 year flood level plus *freeboard* or more than 0.8m below the 100 year flood level, shall have *adequate warning systems, signage and exits*.
- Restraints or vehicle barriers to be provided to prevent floating vehicles leaving a site during a 100 year flood.
- Driveway and parking space levels to be no lower than the *design ground/floor levels*. Where this is not *practical*, a lower level may be considered. In these circumstances, the level is to be as high as *practical*, and, when undertaking alterations or additions, no lower than the existing level.
- The minimum surface level of open car parking spaces or carports shall be as high as *practical*, and not below: (i) the 20 year flood level plus freeboard; or (ii) the level of the crest of the road at the location where the site has access; or (iii) 300mm above adjacent ground level. (which ever is the lower). In the case of garages, the minimum surface level shall be as high as *practical*, but no lower than the 20 year flood level plus freeboard or 300mm above adjacent ground level.

- Note:**
- a. A flood depth of 0.3m is sufficient to cause a small vehicle to float.
 - b. *Enclosed car parking* is defined in the glossary and typically refers to carparks in basements.

Evacuation

- Reliable access for pedestrians or vehicles required during a 100 year flood.
- Reliable access for pedestrians or vehicles is required from the building, commencing at a minimum level equal to the lowest *habitable floor* level to an area of refuge above the *PMF level*, or a minimum of 20% of the gross floor area of the dwelling to be above the *PMF* level. In the case of alterations or additions to an existing development, this may require retro-fitting the existing structure if required to support a refuge above the PMF.
- The evacuation requirements of the development are to be considered. An engineers report will be required if in the opinion of Council the evacuation of persons might not be achieved within the *effective warning time*.

Management and Design

- If this application involves subdivision, the applicant is to demonstrate that potential development as a consequence of the subdivision, can be undertaken in accordance with this DCP.
- Site Emergency Response Flood Plan* required where floor levels are below the *design floor level*, (except for single dwelling-houses).
- Applicant to demonstrate that an area is available to store goods above the 100 year flood level plus *freeboard*.
- Applicant to demonstrate that an area is available to store goods above the *PMF* level.
- No storage of materials below the *design floor level* which may cause pollution or be potentially hazardous during any flood.
- Applicant to demonstrate that an area is available to store goods at least 500mm above adjacent ground level.

8.3 TOWN PLANNING ISSUES

8.3.1 Review of Planning Controls

Land use planning and development controls are key mechanisms by which Council can manage flood-affected areas within the catchment. Such mechanisms will influence future development (and redevelopment) and therefore the benefits will accrue gradually over time. Without comprehensive floodplain planning, existing problems may be exacerbated and opportunities to reduce flood risks may be lost.

A comprehensive review of planning controls and flood risk management policies was undertaken as part of this study, which is outlined in the Eastwood & Terry's Creek Floodplain Risk Management Plan – Town Planning Considerations (Don Fox Planning, July 2008).

The appropriate mechanism for stipulating flood related development controls is through a Development Control Plan (DCP). A Local Environmental Plan (LEP) should also provide some reference to floodplain management, including key definitions in relation to the floodplain and other flood related clauses that specifically identify the matters for consideration in the assessment of development applications of flood liable land. Recommended inclusions to the LEP template are provided in **Appendix C**.

The proposed floodplain risk management controls would form a chapter in Council's consolidated DCP 2008. The recommended DCP provisions are provided in **Appendix D**. These provisions have been prepared in a generic form to allow application across the entire LGA. A matrix of planning controls for use in the assessment of individual development applications has been formulated specifically for Eastwood & Terry's Creek. A second matrix of planning controls was also formulated for application to other floodplains within the LGA pending the development of specific matrices for other areas through other floodplain management studies. These would be appended to the DCP chapter as additional matrices once the other studies have been completed.

The matrices provide a graded set of planning controls that vary dependent upon the relevant flood risk or overland flow precinct and individual land use categories. The matrix of planning controls for Eastwood & Terry's Creek is shown on **Figure 8.3**. There are six areas of development control considerations in the flood planning matrix. These include controls related to:

- i) minimum floor levels;
- ii) the use of flood compatible building components below a certain level;
- iii) that structure located in high flood risk precincts are structurally sound;
- iv) that development does not increase flood behaviour elsewhere;
- v) maximising opportunities for people to safely evacuate; and
- vi) other specific considerations regarding the use of the property.

8.3.2 Flood Planning Guidelines

On 31st January, 2007 the NSW Planning Minister announced a new guideline for development controls on floodplains (the “2007 Flood Planning Guideline”). An overview of the new guideline and associated changes to the Environmental Planning and Assessment Act and Regulation was issued by the Department of Planning in a Circular dated 31st January, 2007 (Reference PS 07-003). The new guideline issued by the Minister in effect relate to a package of directions and changes to the EPA Act, Regulation and Floodplain Development Manual, the implications of which are summarised as follows:

a) Guideline on Development Controls in Low Flood Risk Areas – Floodplain Development Manual

A discreet Guideline has been issued to provide additional guidance on matters dealt with in the Floodplain Development Manual. This Guideline effectively provides an amendment to the Manual. The Guideline confirms that unless there are “exceptional circumstances”, Councils are to adopt the 100 year flood as the flood planning level (FPL) for residential development, with the exception of some sensitive forms of residential development such as seniors living housing. The Guideline does provide that controls on residential development above the 100 year flood may be imposed subject to an “exceptional circumstances” justification being agreed to by the Department of Natural Resources (now Department of Environment, Climate Change and Water) and the Department of Planning prior to the exhibition of a Draft LEP or Draft DCP.

The Guideline provides conflicting statements in regard to what is the residential flood planning level for the purpose of applying the directions in the Guideline. Despite noting the flood planning level for typical residential development would generally be based around the 100 year flood plus a freeboard of typically 0.5m, the Guideline “confirms” that “unless there are exceptional circumstances, Councils should adopt the 100 year flood as the flood planning level for residential development.” Senior officers of the Department of Planning have subsequently advised that the flood planning level is inclusive of freeboard, and this has been included in a draft Q&A document issued to the Floodplain Management Authorities of NSW in a letter dated 28th March 2008 from the Department of Planning.

b) Amendment to Regulation on Section 149 Certificates

Schedule 4 of the Environmental Planning and Assessment Regulation was amended, commencing on 16th February, 2007, to specify flood related information that can be shown on Section 149(2) Certificates. The amendment will require Councils to distinguish between the situation where there are flood related development controls on nominated types of “residential development” and all other development. More sensitive land uses such as group homes or seniors living is excluded from the limitation of notations for residential development.

Clause 7(A)(1) of the Regulation means that Council should not include a notation for residential development on Section 149(2) Certificates in “low risk areas” if no flood related development controls apply to the land. Under Clause 7(A)(2) Council can include a notation for critical infrastructure or more flood sensitive development on Section 149(2) Certificates in low flood risk areas if flood related development controls apply. Low flood risk areas are undefined, but in the context of the Circular it is assumed to be a reference to that part of the floodplain between the 100 year flood (plus freeboard) and the PMF extents.

c) *Section 117 Ministerial Direction No. 4.3 – Flood Prone Land*

Section 117 Direction No. 15 – Flood Prone Land was revised on 31st January, 2007 and is now known as Section 117 Direction No. 4.3. The principal implication of the revision of the Direction was to introduce provisions to limit the imposition of LEP controls on residential development within that part of the floodplain above the 100 year flood level. This limitation is specifically set out in Clauses (4) and (5) of the Direction as follows:

“(4) A draft LEP must not impose flood related development controls above the residential flood planning level for residential development on land, unless a council provides adequate justification for those controls to the satisfaction of the Director-General (or an officer of the Department nominated by the Director-General).”

“(5) For the purposes of a draft LEP, council must not determine a flood planning level that is inconsistent with the Floodplain Development Manual 2005 (including the Guideline on Development Controls on Low Flood Risk Areas) unless a council provides adequate justification for the proposed departure from that Manual to the satisfaction of the Director-General (or an officer of the Department nominated by the Director-General).”

Clause (6) of the Direction specifies circumstances which must be satisfied in order for the Director-General or nominee to allow for a variation to the Direction, as follows:

“(6) A draft LEP may be inconsistent with this Direction only if council can satisfy the Director-General (or an officer of the Department nominated by the Director-General) that any particular provision or area should be varied or excluded having regard to the provisions of section 5 of the Environmental Planning and Assessment Act, and

(a) the rezoning is in accordance with a floodplain risk management plan prepared in accordance with the principles and guidelines of the Floodplain Development Manual, 2005, or

(b) the rezoning, in the opinion of the Director-General (or an officer of the Department nominated by the Director-General) or minor significance.”

The flood risk precinct maps and proposed matrix of development controls prepared during the floodplain management study are potentially in conflict with the 2007 Flood Planning Guideline. The DCP provisions allow for controls on residential land within the “low flood risk” precinct, although the main intent of these controls is to include minimum floor level and other controls that would apply up to the 100 year flood level plus freeboard. The main discrepancy lies in the different definitions of the “low flood risk” precinct in the DCP provisions (defined as the 100 year flood) and the definition of “low risk area” in the 2007 Flood Planning Guideline (which we presume is defined as the 100 year flood plus freeboard).

Bewsher Consulting and Don Fox Planning have liaised with the Department of Planning in regard to issues associated with the new flood planning Guideline. It is understood that the Department is in the process of preparing further clarification. The Guideline, the specific exemption provisions of the Section 117 Direction, and our understanding of the further clarification to be provided by the Department of Planning, are all directed towards establishing a basis for Councils to seek variations to the restrictions of the Guideline and the Direction on the basis of ‘exceptional circumstances’. The basis for the variations required for the recommended LEP provisions would equally apply to the variations sought in regard to the recommended DCP controls. The relevant grounds to justify ‘exceptional circumstances’ in this case could be summarised as:

- i) Preparation of the Floodplain Management Plan commenced before the introduction of the new Guideline, and substantial effort and involvement from government departments, Council and the community have provided for the ultimate adoption of the floodplain management plan in a manner which now creates some limited inconsistency with the new Guideline.
- ii) There is a history of significant flooding in the area, particularly in the Eastwood town centre.
- iii) Council's existing planning controls (Section 8.2 of DCP 2006) currently place restrictions on development in the floodplain and require consideration of floods up to the PMF in certain circumstances.
- iv) The intent of the Floodplain Management Plan is to facilitate further development subject to managing risk within the package of measures not to unreasonably restrict development. The risk management measures include increasing awareness of all flood hazard and consequent risk to property and the safety of persons.
- v) The form of development planned for the Eastwood town centre will generally incorporate residential dwellings within mixed use development where a differentiation between flood risk conveyed to the public in planning controls and Section 149 zoning certificates will be inappropriate and confusing.
- vi) Those controls to be imposed upon residential development is that relatively small portion of the floodplain between the 100 year extent and PMF primarily relate to the setting of floor levels at the 100 year plus freeboard level; requiring flood compatible building components below that level; ensuring the structure is sound and impacts on other development in the floodplain are considered; and most importantly to address emergency evacuation issues. These controls are materially the same as what Council could impose in accordance with the provisions of DCP 2008.
- vii) The exclusion of controls on residential development between the 100 year flood and PMF extents would principally have the effect of not requiring floor level and similar controls on residential development in the 'shadow zone' (ie in that part of the floodplain between the extent of the 100 year and the 100 year plus freeboard) which would apply in exactly the same manner to residential development within the 100 year flood extent. More critically, there would be an absence of consideration on an integrated and comprehensive basis of evacuation issues for all residential development across the floodplain.
- viii) There is little horizontal variation between the 100 year flood and the PMF extents, so it is practical to adopt the PMF as the upper limit for the definition of the floodplain consistently for all land uses, without any major consequence in limiting development potential above the 100 year flood. In some cases the 100 year flood level plus a 0.5m freeboard extends beyond the PMF.

8.4 FLOOD WARNING MEASURES

Flood warning is an important component of floodplain management. It provides advice on impending flooding so relevant agencies and residents can take action to minimise property damage and personal risk.

Flood warning systems usually monitor rainfall and river gauges in the upper catchment in real time and, through hydrologic and hydraulic models, predict the resulting flow and flood levels at some time in the future in the lower catchment.

The Bureau of Meteorology is the government agency responsible for issuing flood warnings throughout Australia. Dissemination of the flood warning and action to evacuate or otherwise

assist people in the event of flooding is the responsibility of the State Emergency Service. As a general rule, the Bureau only provides a flood warning service where there is likely to be at least 6 hours warning of impending flooding.

The Eastwood catchment is a small urban catchment, where the response to flooding is rapid (often within an hour of heavy rainfall). This provides little opportunity to provide a warning of flooding based on rainfall that has already occurred; to disseminate that warning to the public; and for the public to take appropriate action to reduce their exposure to the flood threat.

The development of formal flood warning scheme in the Terry's Creek catchment is considered to be of little value.

8.5 PUBLIC AWARENESS

Raising and maintaining flood awareness provides residents with an appreciation of the flood problem and what measures can be taken to reduce potential flood damage and to minimise personal risk during future floods.

The City of Ryde has taken some steps to raise community awareness of the risks of flooding throughout the study area. The process of undertaking the floodplain management study and plan, and its intended public exhibition, is in itself an excellent means of raising community awareness. Other campaigns, including the installation of flood markers at various locations to indicate the height of past floods, act as a constant reminder of the threat of flooding.

An ongoing public awareness campaign is recommended, that includes:

- i) Consolidation of the recent flood risk mapping, flood data and flood damages database prepared during the floodplain management study into Council's computer based GIS system. This will provide Council with valuable flood information that can be easily retrieved, and which will form the basis of information that can be supplied to the public when requests are made, or on a periodic basis.
- ii) Consideration could also be given to providing information on the flood risk and the flood levels that apply to a particular property on a special flood certificate. These certificates could be appended to the Section 149(5) certificates; provided whenever flood information is requested for a property; or provided on a regular basis to all residents in the study area.
- iii) Maintaining flood markers indicating the height of past floods throughout the study area.

The cost of the public awareness campaign is relatively low. Initial costs to set up the information and procedures are estimated to be of the order of \$60,000.

8.6 EMERGENCY MANAGEMENT

The State Emergency Service (SES) has formal responsibility for emergency management operations in response to flooding. Other organisations normally provide assistance, including the Bureau of Meteorology, council, police, fire brigade, ambulance and community groups. Emergency management operations are usually outlined in a Local Flood Plan.

Information from the current floodplain management study and flood damages database will provide valuable data on which to base a Local Flood Plan for Eastwood and the Terry's

Creek catchment. Whilst this is normally the responsibility of the SES, assistance could be offered through the floodplain management committee to assist in the development and review of the Local Flood Plan.

A nominal allowance of say \$20,000 could be provided in the Floodplain Management Plan to assist with this review.

8.7 CLIMATE CHANGE CONSIDERATIONS

There is increasing evidence that the earth's atmospheric and ocean temperatures have increased over the last century, and that the accumulation of greenhouse gases in the earth's environment will accelerate this process in future years. Current estimates indicate that the annual average temperature for Australia could increase by about 1.0°C by 2030 (relative to 1990) and by between 1.8°C to 3.4°C by 2070 (Climate Change in Australia, CSIRO, 2007).

Future climate change can potentially affect flood behaviour through:

- i) increased sea levels; and
- ii) increased severity of flood producing storms or other weather systems.

A global increase in mean sea level of between 0.18 and 0.79m has been predicted by 2100 (IPCC, 2007). The impact of climate change on rainfall is less certain. Evidence to date suggests that whilst mean annual rainfall over Australia is likely to reduce, the intensity of extreme daily rainfall could increase.

The downstream limit of Terry's Creek is located about 25m above mean sea level. An increase in sea level is therefore unlikely to have any impact on flood behaviour within the Terry's Creek catchment. The impact of increased rainfall intensities, however, could have a more significant affect on flood behaviour.

A freeboard allowance is added to design flood levels when determining floor level controls for future development. The freeboard allowance caters for a range of uncertainties in the estimation procedure, including changes in rainfall patterns and ocean water levels as a result of climate change. The freeboard level currently applied by the City of Ryde is 0.3m. Whilst there still remains a high degree of uncertainty regarding the impact of climate change on increased storm intensities, the current freeboard allowance may not be adequate to fully cater for changes that may occur in the future. The majority of Councils in NSW adopt a minimum 0.5m freeboard. The Floodplain Development Manual also refers to the freeboard allowance being 'typically 0.5m'. Given these trends, there is a strong case for increasing the freeboard allowance applied by the City of Ryde from 0.3m to 0.5m.

9 RECOMMENDED FLOODPLAIN MANAGEMENT PLAN

9.1 THE RECOMMENDED MEASURES

The floodplain management measures that are recommended for inclusion in the Eastwood & Terry's Creek Floodplain Management Plan are summarised in **Table 9.1** and are shown on **Figure 9.1**. The recommended measures are discussed briefly below.

9.1.1 Mobbs Lane Detention Basin

A basin on the upstream side of Mobbs Lane, within the Parramatta City Council area, was recommended in two previous studies.

Results from the current investigations indicate that the basin could reduce flood levels by between 0.1 to 0.2m through the Eastwood town centre in the 100 year flood. The present value from all floods is estimated to be reduced by about \$0.4M through the current study area alone. Greater benefits are likely to be incurred immediately downstream of the basin, within Parramatta City Council. The estimated cost of the basin is approximately \$800,000, although this will be subject to further detailed investigations and the feasibility of providing additional storage volume through excavation. The benefit/cost of the basin, accounting for benefits within Parramatta City Council, is estimated to be greater than 1.0.

It is recommended that a basin at Mobbs Lane be pursued with Parramatta City Council, with possible cost sharing arrangements between both Councils and the DECCW.

9.1.2 Debris Control Structures

Constructing debris control structures around the opening of the railway culvert and the Progress Avenue culverts will reduce the likelihood of these structures becoming blocked, and will potentially lower flood levels. The increased capacity by avoiding blockage is similar to enlarging the size of the structure, but at a much reduced cost. The debris control structure around the railway culvert is anticipated to include bollards or vertical posts around the perimeter of the open channel leading to the railway culvert, on the downstream side of West Parade. The structure for the Progress Avenue Culvert is anticipated to be tubular fencing along the perimeter of the open drain, between Shaftsbury Road and The Avenue, sufficient to avoid shopping trolleys, bins and cars from being washed into the drain.

Modelling results indicate that flood levels can be reduced by up to 0.6m in Eastwood Park, and by 0.2 to 0.3m through the town centre in the 100 year flood. The present value of all flood damage could be reduced by approximately \$0.5M if the potential for blockage of these structures is eliminated. This debris control measures are estimated to cost of the order of \$50,000 with a benefit/cost ratio considerably greater than 1.0.

It is recommended that debris control measures are included at the railway culvert and Progress Avenue culverts in the floodplain management plan.

9.1.3 Completion of First Avenue Drainage augmentation

The First Avenue Drainage Reconstruction Scheme was developed by the City of Ryde to alleviate flooding problems to a number of residential and commercial properties in Eastwood, between First Avenue and Railway Parade on the eastern side of the railway. The scheme has been largely constructed except for the final stage, which involves the construction of an 1800mm pipeline between First Avenue and Rowe Street.

Model results indicate that the final stage of work would further reduce flood depths by up to 0.9m between First Avenue and Rowe Street in the 100 year flood, with the present value of all of all flood damages reduced by approximately \$0.6M. The cost of the remaining work has been estimated by the City of Ryde as \$1.3M, which provides a benefit/cost ratio of 0.5.

Completion of the First Avenue Drainage Reconstruction Scheme is recommended for inclusion in the floodplain management plan.

9.1.4 Area 1 – Stormwater Drainage Measures

Stormwater drainage measures are recommended upstream of Shaftsbury Road, where at least five dwellings are subject to stormwater inundation in the 100 year flood.

Recommended measures are subject to further detailed drainage investigations, but are anticipated to include formalising overland flow paths and the possible relocation of one or more buildings, at an estimated cost of approximately \$0.69M.

9.1.5 Area 7 – Stormwater Drainage Measures

Stormwater drainage measures are recommended downstream of the railway, between Lovell Road and Balaclava Road. Six dwellings are estimated to be affected by stormwater inundation in the vicinity of Lovell Road and another nine dwellings affected by inundation downstream of Balaclava Road.

Recommended measures are subject to further detailed drainage investigations, but are anticipated to largely include formalising overland flow paths and the possible relocation of one building, at an estimated cost of \$0.64M.

9.1.6 Area 8 – Stormwater Drainage Measures

Stormwater drainage measures are recommended for a flow path along and behind properties at Abuklea Road. Five dwellings are estimated to be inundated by stormwater in the 100 year flood in Abuklea Road, one dwelling in Vimiera Road, one dwelling in Thelma Street, and one dwelling in Torrington Drive.

Recommended measures are subject to further detailed drainage investigations, but are anticipated to include twin pipelines up to 1500mm diameter along Abuklea Road and some formalisation of overland flow paths, at an estimated cost of approximately \$1.9M.

9.1.7 Area 9 – Stormwater Drainage Measures

Stormwater drainage measures are recommended for a flow path on the upstream side of Epping Road, where up to four dwellings are estimated to be inundated by stormwater in the 100 year flood.

Recommended measures are subject to further detailed drainage investigations, but are anticipated to include formalising overland flow paths and some additional stormwater pipe drains, at an estimated cost of approximately \$0.24M.

9.1.8 Additional Measures for Area 7

Additional measures for Area 7 are recommended, including:

- a) Additional inlet pits to the stormwater pipe in Brabyn Street to reduce nuisance flooding, at an estimated cost of \$10,000;
- b) Improvements to the Culvert in Jim Walsh Park, including a tapered edge to the headwall structure, removing existing vegetation around the structure, and providing an improved debris structure to minimise blockage problems, at an estimated cost of \$10,000; and
- c) A feasibility study for a detention basin in Jim Walsh Park, including community consultation, a review of landscaping opportunities, geotechnical investigations and further flood modelling, at an estimated cost of \$100,000.

9.1.9 Planning & Development Controls

Land use planning and development controls are key mechanisms by which Council can manage flood-affected areas within the Terry's Creek catchment. This will ensure that new development is compatible with the flood risk, and allows for existing problems to be gradually reduced over time through sensible redevelopment.

The following planning measures are recommended:

- a) The Floodplain Management Committee and Council endorse the planning approach outlined in the floodplain management study. This approach basically requires a graded set of planning controls for different land uses relative to different levels of flood risk in the study area, consistent with the requirements of the Floodplain Development Manual.
- b) That the Committee and Council formally endorse the defining of the three flood risk precincts within the floodplain (High, Medium and Low) and an overland flow precinct, and that Council finalise and adopt the flood maps which delineate these precincts. These maps are to effectively form a referenced component of the DCP.
- c) That Council increases the freeboard allowance (added to design flood levels when stipulating minimum floor level controls) from 0.3m to 0.5m, except for development in the overland flow precinct. This is to provide for consistency with most other Councils in NSW and in recognition of potential uncertainties in the magnitude of future storm intensities due to climate change factors.
- d) That the Committee and Council endorse the recommended inclusions with Council's future LEPs as outlined in **Appendix C**, and the model DCP provisions that provide the detailed controls relating to floodplain management that are provided in **Appendix D**. Formal preparation of the LEP and DCP will require further exhibition and refinement of these provisions in accordance with the EPA Act. Council may wish to engage a consultant to help facilitate this process.
- e) In areas subject to local drainage (ie areas of shallow inundation beyond the flood risk and overland flow precincts defined in this study), Council consider reviewing Section 8.2 of DCP 2008 and other controls to ensure that habitable floors are built a minimum of 300mm above finished ground levels unless a site-specific drainage assessment has shown a lower level will not result in inundation of the floor.
- f) That Council refer a copy of the adopted Floodplain Management Study and Plan to the Department of Planning and Department of Environment, Climate Change and Water to seek their endorsement to the recommendations for the preparation of DCP and LEP controls, and to vary the prescriptive provisions of the new flood planning guidelines on the basis of 'exceptional circumstances'. The grounds that could be

included within a submission to the Departments to justify the variations are provided in **Section 8.3.2.**

9.1.10 Emergency Management Operations

Information from the current floodplain management study and flood damages database will provide valuable data on which to base a Local Flood Plan for Eastwood and the Terry's Creek catchment. Whilst this is normally the responsibility of the SES, assistance could be offered through the floodplain management committee to assist in the development and review of the Local Flood Plan.

A nominal allowance of say \$20,000 could be provided in the Floodplain Management Plan to assist with this review.

9.1.11 Improved Public Awareness

Raising and maintaining flood awareness provides residents with an appreciation of the flood problem and what measures can be taken to reduce potential flood damage and to minimise personal risk during future floods.

An ongoing public awareness campaign is recommended, that includes:

- i) Consolidation of the recent flood risk mapping, flood level data and flood damages database prepared during the floodplain management study into Council's computer based GIS system.
- ii) Providing information concerning the flood risk and flood levels for properties on a flood certificate, which could be appended to Section 149(5) certificates or provided when requests about flooding are made?
- iii) Maintaining flood markers indicating the height of past floods throughout the study area.

A nominal amount of \$60,000 has been provided for these initiatives.

9.1.12 CBD Drainage Augmentation

A scheme to largely alleviate flooding through the Eastwood town centre was investigated. The scheme includes:

- i) modification of the existing drain upstream of Progress Avenue, including the option to cover this drain;
- ii) new twin box culverts (approximately 2x3000Wx2400H) from Glen Street Reserve to Eastwood Park, under Lakeside Road to supplement the existing culverts down Progress Avenue; and
- iii) an inlet headwall in Glen Street Reserve.

The drainage augmentation measures reduce the 100 year flood by up to 1.0 to 1.1m through the town centre, reducing the depth of flooding to less than 0.3m. The present value of benefits from all floods is estimated at \$4.6M. The cost of the scheme is estimated at \$8.5M (City of Ryde). This provides a benefit/cost ratio of 0.5, which is a substantial improvement over the other tunnel options that were investigated.

Given the reduced risk to personal safety this option could be considered favourably. It would also remove many of the flooding constraints on future redevelopment of the town

centre. The CBD drainage augmentation scheme is recommended for inclusion in the Floodplain Management Plan.

9.2 FUNDING AND IMPLEMENTATION

The total estimated cost of implementing the Floodplain Management Plan is estimated at \$14.4M (2008). This includes an amount of \$8.5M for drainage augmentation measures through the Eastwood town centre.

The timing of proposed works will depend on overall budgetary commitments of Council and the availability of funds from other sources. It is envisaged that the Plan would be implemented progressively over a 5 to 10 year time frame.

There are a variety of sources of potential funding that could be considered to implement the Plan. These include:

- i) Council funds;
- ii) Section 94 contributions;
- iii) State funding for flood risk management measures through the Department of Environment, Climate Change and Water;
- iv) State Emergency Service, either through volunteered time or funding assistance for emergency management measures;

Council can expect to receive the majority of financial assistance through the Department of Environment, Climate Change and Water. These funds are available to implement measures that contribute to reducing existing flood problems. Funding assistance is likely to be available on a 2:1 (State:Council) basis.

Although much of the Plan may be eligible for Government assistance, funding can not be guaranteed. Government funds are allocated on an annual basis to competing projects throughout the State. Measures that receive Government funding must be of significant benefit to the community. Funding is usually available for the investigation, design and construction of flood mitigation works included in the floodplain management plan.

9.3 ON-GOING REVIEW OF PLAN

The Plan should be regarded as a dynamic instrument requiring review and modification over time. The catalyst for change could include new flood events and experiences, legislative change, alterations in the availability of funding, or changes to the area's planning strategies.

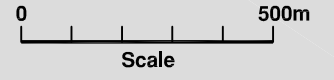
A thorough review every 5 years is warranted to ensure the ongoing relevance of the Plan.

TABLE 9.1
Recommended Floodplain Management Measures

Item	Description	Estimated Cost	B/C Ratio	Potential Funding Sources	Priority
1	Mobbs Lane Detention Basin (Parramatta City Council) a) Feasibility and Design b) Construction	\$50,000 \$800,000	>1.0	PCC, COR, DECCW	High
2	Debris Control Structures (Railway & Progress Avenue) a) Design b) Construction	\$5,000 \$50,000	>1.0	COR, DECCW	Medium
3	Completion of First Avenue Drainage Augmentation a) Construction	\$1,300,000	0.5	COR, DECCW	High
4	Area 1 – Stormwater Drainage Measures a) Investigations b) Formalise overland flow paths c) Possible relocation of 2 buildings	\$140,000 \$150,000 \$400,000	TBA	COR, DECCW	Low
5	Area 7 – Stormwater Drainage Measures a) Investigations b) Formalise overland flow paths c) Possible relocation of 1 building	\$160,000 \$280,000 \$200,000	TBA	COR, DECCW	Low
6	Area 8 – Stormwater Drainage Measures a) Investigations b) Formalise overland flow paths c) Stormwater pipe upgrade	\$125,000 \$40,000 \$1,720,000	TBA	COR, DECCW	Low
7	Area 9 – Stormwater Drainage Measures a) Investigations b) Formalise overland flow paths c) Stormwater pipe upgrade	\$70,000 \$60,000 \$110,000	TBA	COR, DECCW	Low
8	Additional Measures for Area 7 a) Additional inlet pits in Brabyn St b) Improvements to Jim Walsh Park Culvert c) Feasibility study for Jim Walsh Park detention basin	\$10,000 \$10,000 \$100,000	N/A N/A N/A	COR, DECCW	Low Medium Medium
9	Planning & Development Controls a) Endorse planning approach outlined in Plan b) Endorse adoption of Flood Management Areas c) Increase freeboard allowance from 0.3 to 0.5m d) Engage consultants to facilitate adoption of DCP chapter e) Apply to Departments for 'exceptional circumstances'	N/A N/A N/A \$30,000 N/A	>1.0	COR	High
10	Emergency Management Operations a) Update Local Flood Plans	\$20,000	>1.0	COR, SES	High
11	Improved Public Awareness a) Update Council's GIS database with flood data b) Provide Flood Certificates c) Maintain flood markers showing historic flood heights	\$20,000 \$20,000 \$20,000	>1.0	COR, DECCW	Medium
12	CBD Drainage Augmentation	\$8,500,000	0.5	COR, DECCW	Medium

Total: \$14,390,000

FIGURE 9.1
RECOMMENDED
FLOODPLAIN RISK
MANAGEMENT PLAN



Improved Public Awareness
a) Update Council's GIS database with flood data
b) Provide flood certificates
c) Maintain flood signs

Emergency Management Operations
a) Update Local Flood Plans

Planning and Development Controls
a) Endorse planning approach outlined in Plan
b) Increase freeboard allowance from 0.3 to 0.5m.
c) Endorse development controls & draft DCP Chapter
d) Apply to Departments for 'exceptional circumstances'

Area 9 - Stormwater Drainage Measures
a) Investigations
b) Formalise overland flowpaths
c) Stormwater pipe upgrade

Area 8 - Stormwater Drainage Measures
a) Investigations
b) formalise overland flowpaths
c) Stormwater pipe upgrade

Area 7 - Additional Measures
a) Additional inlet pits in Brabyn St.
b) Improvements to Jim Walsh Park culvert
c) Feasibility study for basin in Jim Walsh Park

Area 7 - Stormwater Drainage Measures
a) Investigations
b) formalise overland flowpaths
c) Possible relocation of 1 building

Completion of First Avenue Drainage Augmentation
a) Construction

CBD Drainage Augmentation
a) Design
b) Modify existing open channel and inlet works
c) Construct additional drainage culverts

Debris Control Structures (Railway Pde and Progress Ave)
a) Design
b) Construction

Mobbs Lane Detention Basin (Parramatta City Council)
a) Feasibility and Design
b) Construction

Area 1 - Stormwater Drainage Measures
a) Investigations
b) Formalise overland flowpaths
c) Possible relocation of 2 buildings

LEGEND

- Study Area Boundary
- LGA Boundary
- 100yr Flood Extent

FLOODPLAIN MANAGEMENT CONSULTANTS

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Plot file : J1543-Fig9.1
Plot scale : 15 (a3 @ 1:15000)
Date : 29 October 2009

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- ▶ residents of the study area;
- ▶ Councillors and Council staff from the City of Ryde;
- ▶ Hornsby Shire Council;
- ▶ Parramatta City Council;
- ▶ Department of Environment, Climate Change and Water;
- ▶ State Emergency Service;
- ▶ RailCorp
- ▶ Sydney Water Corporation;
- ▶ the Floodplain Risk Management Committee;
- ▶ the NSW State Government; and
- ▶ the Commonwealth Government.

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12 GLOSSARY

Note that terms shown in bold are described elsewhere in this Glossary.

100 year flood	A flood that occurs on average once every 100 years. Also known as a 1% flood. See annual exceedance probability (AEP) and average recurrence interval (ARI) .
50 year flood	A flood that occurs on average once every 50 years. Also known as a 2% flood. See annual exceedance probability (AEP) and average recurrence interval (ARI) .
20 year flood	A flood that occurs on average once every 20 years. Also known as a 5% flood. See annual exceedance probability (AEP) and average recurrence interval (ARI) .
afflux	The increase in flood level upstream of a constriction of flood flows. A road culvert, a pipe or a narrowing of the stream channel could cause the constriction.
annual exceedance probability (AEP)	AEP (measured as a percentage) is a term used to describe flood size. It is a means of describing how likely a flood is to occur in a given year. For example, a 1% AEP flood is a flood that has a 1% chance of occurring, or being exceeded, in any one year. It is also referred to as the '100 year flood' or 1 in 100 year flood'. The terms 100 year flood , 50 year flood , 20 year flood etc, have been used in this study. See also average recurrence interval (ARI) .
Australian Height Datum (AHD)	A common national plane of level approximately equivalent to the height above sea level. All flood levels , floor levels and ground levels in this study have been provided in metres AHD.
average annual damage (AAD)	Average annual damage is the average flood damage per year that would occur in a nominated development situation over a long period of time.
average recurrence interval (ARI)	ARI (measured in years) is a term used to describe flood size. It is the long-term average number of years between floods of a certain magnitude. For example, a 100 year ARI flood is a flood that occurs or is exceeded on average once every 100 years. The terms 100 year flood , 50 year flood , 20 year flood etc, have been used in this study. See also annual exceedance probability (AEP) .
catchment	The land draining through the main stream, as well as tributary streams.
Development Control Plan (DCP)	A DCP is a plan prepared in accordance with Section 72 of the <i>Environmental Planning and Assessment Act, 1979</i> that provides detailed guidelines for the assessment of development applications.
DNR	Department of Natural Resources, formerly the Department of Infrastructure, Planning & Natural Resources (DIPNR).
discharge	The rate of flow of water measured in terms of volume per unit time, for example, cubic metres per second (m³/s) . Discharge is different from the speed or velocity of flow, which is a measure of how fast the water is moving.
ecologically sustainable development (ESD)	Using, conserving and enhancing natural resources so that ecological processes, on which life depends, are maintained, and the total quality of life, now and in the future, can be maintained or increased. A more detailed definition is included in the <i>Local Government Act 1993</i> .

effective warning time	The time available after receiving advice of an impending flood and before the floodwaters prevent appropriate flood response actions being undertaken. The effective warning time is typically used to move farm equipment, move stock, raise furniture, evacuate people and transport their possessions.
emergency management	A range of measures to manage risks to communities and the environment. In the flood context it may include measures to prevent, prepare for, respond to and recover from flooding.
EP&A Act	<i>Environmental Planning and Assessment Act, 1979.</i>
extreme flood	An estimate of the probable maximum flood (PMF) , which is the largest flood likely to occur.
flood	A relatively high stream flow that overtops the natural or artificial banks in any part of a stream, river, estuary, lake or dam, and/or local overland flooding associated with major drainage before entering a watercourse, and/or coastal inundation resulting from super-elevated sea levels and/or waves overtopping coastline defences excluding tsunامي.
flood awareness	An appreciation of the likely effects of flooding and a knowledge of the relevant flood warning, response and evacuation procedures.
flood hazard	The potential for damage to property or risk to persons during a flood . Flood hazard is a key tool used to determine flood severity and is used for assessing the suitability of future types of land use.
flood level	The height of the flood described either as a depth of water above a particular location (eg. 1m above a floor, yard or road) or as a depth of water related to a standard level such as Australian Height Datum (eg the flood level was 7.8m AHD). Terms also used include flood stage and water level .
flood liable land	Land susceptible to flooding up to the probable maximum flood (PMF) . Also called flood prone land . Note that the term flood liable land now covers the whole of the floodplain , not just that part below the flood planning level .
flood planning levels (FPLs)	The combination of flood levels and freeboards selected for planning purposes, as determined in floodplain management studies and incorporated in floodplain management plans . The concept of flood planning levels supersedes the designated flood or the flood standard used in earlier studies.
flood prone land	Land susceptible to flooding up to the probable maximum flood (PMF) . Also called flood liable land .
flood proofing	A combination of measures incorporated in the design, construction and alteration of individual buildings or structures subject to flooding, to reduce or eliminate damages during a flood .
Flood risk precinct	An area of land with similar flood risks and where similar development controls may be applied by a council to manage the flood risk . (The flood risk is determined based on the existing development in the precinct or assuming the precinct is developed with normal residential uses). Usually the floodplain is categorised into three flood risk precincts – ‘low’, ‘medium’ and ‘high’ – although other classifications can sometimes be used. (See also risk).
Flood Study	A study that investigates flood behaviour, including identification of flood extents, flood levels and flood velocities for a range of flood sizes.

floodplain	The area of land that is subject to inundation by floods up to and including the probable maximum flood event, that is, flood prone land or flood liable land .
Floodplain Risk Management Plan	The outcome of a Floodplain Risk Management Study . (Note that the term 'risk' is often dropped in common usage.
Floodplain Risk Management Study	Studies carried out in accordance with the <i>Floodplain Development Manual</i> (NSW Government, 2005) that assesses options for minimising the danger to life and property during floods . These measures, referred to as 'floodplain management measures/options', aim to achieve an equitable balance between environmental, social, economic, financial and engineering considerations. The outcome of a Floodplain Risk Management Study is a Floodplain Risk Management Plan .
floodway	Those areas of the floodplain where a significant discharge of water occurs during floods . Floodways are often aligned with naturally defined channels. Floodways are areas that, even if only partially blocked, would cause a significant redistribution of flood flow, or a significant increase in flood levels .
flow	see discharge
foreshore building line	A line fixed by resolution of Council in respect of land fronting any bay, river, creek, lagoon, harbour or ocean, which provides a setback distance where buildings or other structures would normally be prohibited.
freeboard	A factor of safety expressed as the height above the design flood level . Freeboard provides a factor of safety to compensate for uncertainties in the estimation of flood levels across the floodplain , such as wave action, localised hydraulic behaviour and impacts that are specific event related, such as levee and embankment settlement, and other effects such as "greenhouse" and climate change.
high flood hazard	For a particular size flood , there would be a possible danger to personal safety, able-bodied adults would have difficulty wading to safety, evacuation by trucks would be difficult and there would be a potential for significant structural damage to buildings.
hydraulics	Term given to the study of water flow in waterways; in particular, the evaluation of flow parameters such as water level and velocity .
hydrology	Term given to the study of the rainfall and runoff process; in particular, the evaluation of peak discharges , flow volumes and the derivation of hydrographs (graphs that show how the discharge or stage/flood level at any particular location varies with time during a flood).
Local Environmental Plan (LEP)	A Local Environmental Plan is a plan prepared in accordance with the <i>Environmental Planning and Assessment Act</i> , 1979, that defines zones, permissible uses within those zones and specifies development standards and other special matters for consideration with regard to the use or development of land.
low flood hazard	For a particular size flood, able-bodied adults would generally have little difficulty wading and trucks could be used to evacuate people and their possessions should it be necessary.
m AHD	metres Australian Height Datum (AHD) .
m/s	metres per second. Unit used to describe the velocity of floodwaters.

m³/s	Cubic metres per second or 'cumecs'. A unit of measurement for creek or river flows or discharges . It the rate of flow of water measured in terms of volume per unit time.
merit approach	The principles of the merit approach are embodied in the <i>Floodplain Development Manual</i> (NSW Government, 2005) and weigh up social, economic, ecological and cultural impacts of land use options for different flood prone areas together with flood damage, hazard and behaviour implications, and environmental protection and well being of the State's rivers and floodplains .
overland flow path	The path that floodwaters can follow if they leave the confines of the main flow channel. Overland flow paths can occur through private property or along roads. Floodwaters travelling along overland flow paths, often referred to as 'overland flows', may or may not re-enter the main channel from which they left — they may be diverted to another water course.
peak discharge	The maximum flow or discharge during a flood.
present value	In relation to flood damage, is the sum of all future flood damages that can be expected over a fixed period (usually 20 years) expressed as a cost in today's value.
probable maximum flood (PMF)	The largest flood likely to ever occur. The PMF defines the extent of flood prone land or flood liable land , that is, the floodplain . The extent, nature and potential consequences of flooding associated with the PMF event are addressed in the current study.
reliable access	During a flood , reliable access means the ability for people to safely evacuate an area subject to imminent flooding within effective warning time , having regard to the depth and velocity of floodwaters, the suitability of the evacuation route, and other relevant factors.
risk	Risk is measured in terms of consequences and likelihood. In the context of floodplain management, it is the likelihood and consequences arising from the interaction of floods, communities and the environment. For example, the potential inundation of an aged person's facility presents a greater flood risk than the potential inundation of a sports ground amenities block (if both buildings were to experience the same type and probability of flooding). Reducing the probability of flooding reduces the risk, increasing the consequences increases risk. (See also flood risk precinct).
runoff	The amount of rainfall that ends up as flow in a stream, also known as rainfall excess.
SES	State Emergency Service of New South Wales.
stage–damage curve	A relationship between different water depths and the predicted flood damage at that depth.
velocity	the term used to describe the speed of floodwaters, usually in m/s .
water level	see flood level .
water surface profile	A graph showing the height of the flood (flood stage , water level or flood level) at any given location along a watercourse at a particular time.

APPENDIX A

FREQUENTLY ASKED QUESTIONS

FREQUENTLY ASKED QUESTIONS

Why do flood levels change over time?

There is a chance that floods of various magnitudes will occur in the future. As the size of a flood increases, the chance that it will occur becomes rarer. Because some of these rare floods have never been experienced or accurately recorded since European settlement, the height of future floodwaters is normally predicted using computer models. These computer models simulate flood levels and velocities for a range of flood sizes and flood probabilities. Given the importance of estimating flood levels accurately, councils and the NSW Department of Environment, Climate Change and Water (DECCW) engage experts to establish and operate the computer models.

From time to time the computer models are revised and predicted flood levels can change. The resultant change in flood levels however is normally very small. The reasons why the computer models are revised can include:

- ▶ new rainfall or ground topography information becomes available;
- ▶ new floods occur which provide additional data from which to fine-tune the models;
- ▶ better computer models become available as the science of flood modelling improves and computer capabilities increase; or
- ▶ flood mitigation works may have been carried out, or development within the catchment may have occurred, that was not previously simulated in the models.

How are these studies funded?

Flood studies and floodplain risk management studies are often carried out under State Government guidelines and are funded on a 1:1:1 basis among the Federal and State Governments, and councils. This funding arrangement is also available for the construction of flood mitigation works.

My property is in a Low Flood Risk Precinct. What does this mean?

The classification of a 'Low Flood Risk Precinct' can differ slightly between councils. Generally it means that your property would not be inundated in a 100 year flood but still has a very slight chance of inundation from larger (i.e. rarer) floods.

If you are a residential property owner, there will be virtually no change to how you may develop your property. However, there may be controls on the location of essential services such as hospitals, evacuation centres, nursing homes and emergency services.

My property is in a Medium Flood Risk Precinct. What does this mean?

The classification of a 'Medium Flood Risk Precinct' can differ slightly between councils. Often it means that your property is inundated in a 100 year flood, however conditions are not likely to be hazardous during such a flood. If you are a residential property owner development controls will probably be similar to those that currently exist.

My property is in a High Flood Risk Precinct. What does this mean?

The classification of a 'High Flood Risk Precinct' can differ slightly between councils. Often it means that your property will be inundated in a 100 year flood and that hazardous conditions may occur. This could mean that there would be a possible danger to personal safety, able bodied adults may have difficulty wading to safety, evacuation by trucks may be difficult, or there may be a potential for significant structural damage to buildings. This is an area of higher hazard where stricter controls may be applied.

Will my property value be altered if I am in a Flood Risk Precinct?

Any change in a council's classification of properties can have some impact on property values. Nevertheless, councils normally give due consideration to such impacts before introducing a system of flood risk classifications or any other classification system (e.g. bushfire risks, acid sulphate soil risk, etc). If your property is now classified as being in a Flood Risk Precinct, the real flood risks on your property have not changed, only its classification has altered. A prospective purchaser of your property could have previously discovered this risk if they had made enquiries themselves.

If you are in a Low Flood Risk Precinct, generally there will be no controls on normal residential type development. Previous valuation studies have shown that under these circumstances, your property values will not alter significantly over the long term. Certainly, when a new system of classifying flood risks is introduced, there may be some short-term effect, particularly if the development implications of the precinct classification are not understood properly. This should only be a short-term effect however until the property market understands that over the long-term, the Low Flood Risk Precinct classification will not change the way you use or develop your property.

Ultimately, however, the market determines the value of any residential property. Individual owners should seek their own valuation advice if they are concerned that the flood risk precinct categorisation may influence their property value.

My property was never classified as 'flood prone' or 'flood liable' before. Now it is in a Low Flood Risk Precinct. Why?

The State Government changed the meaning of the terms 'flood prone', 'flood liable' and 'floodplain' in 2001. Prior to this time, these terms generally related to land below the 100 year flood level. Now it is different. These terms now relate to all land that could possibly be inundated, up to an extreme flood known as the probable maximum flood (PMF). This is a very rare flood.

The reason the Government changed the definition of these terms was because there was always some land above the 100 year flood level that was at risk of being inundated in rarer and more extreme flood events. History has shown that these rarer flood events can and do happen (e.g. the 1990 flood in Nyngan, the November 1996 flood in Coffs Harbour, the January 1998 flood in Katherine, the August 1998 flood in Wollongong, the 2002 floods in Europe, Hurricane Katrina in 2005, etc).

Will I be able to get house and contents insurance if my house is in a Flood Risk Precinct?

In contrast to the USA and many European countries, flood insurance has generally not been available in Australia for residential property. Following the disastrous floods in Coffs Harbour in November 1996 and in Wollongong in August 1998, very limited flood cover began to be offered by some insurance companies. From 2008, many insurance companies started offering wider cover although the extent of the cover particularly for very flood prone properties is still not well known and may differ between insurers. The most likely situation is that your insurer will now offer you some flood cover although this will be dependent of the flood level information that the insurer has for your property. (This may not necessarily be the same as that available from Council). If flood cover is offered, the classification of your property within a Flood Risk Precinct per se, is unlikely to alter the availability of cover. Obviously insurance policies and conditions may change over time or between insurance companies, and you should confirm the specific details of your situation with your insurer.

Will I be able to get a home loan if my land is in a Flood Risk Precinct?

Most banks and lending institutions do not account for flood risks when assessing home loan applications unless there is a very significant risk of flooding at your property. The system of Flood Risk Precinct classification will make it clear to all concerned, the nature of the flood risks. Under the previous system, if a prospective lending authority made appropriate enquiries, they could have identified the nature of the flood risk during assessment of home loan applications. As a result, it is not likely that the classification of your property within a Flood Risk Precinct will alter your ability to obtain a home loan. Nevertheless, property owners who are concerned about their ability to obtain a loan should clarify the situation with their own lending authority.

How have the flood risk maps been prepared?

Because some large and rare floods have often not been experienced or accurately recorded since European settlement commenced, computer models are used to simulate the depths and velocities of major floods. These computer models are normally established and operated by flooding experts employed by local and state government authorities. Because of the critical importance of the flood level estimates produced by the models, such modelling is subjected to very close scrutiny before flood information is formally adopted by a council. Maps of flood risks (e.g. 'low', 'medium' and 'high') are prepared after consideration of such issues as:

- ▶ flood levels and velocities for a range of possible floods;
- ▶ ground levels;

- ▶ flood warning time and duration of flooding;
- ▶ suitability of evacuation and access routes; and
- ▶ emergency management during major floods.

What is the probable maximum flood (PMF)?

The PMF is the largest flood that could possibly occur. It is a very rare and improbable flood. Despite this, a number of historical floods in Australia have approached the magnitude of a PMF. Every property potentially inundated by a PMF will have some flood risk, even if it is very small. Under the State Government's Floodplain Development Manual (2005), councils must consider all flood risks, even these potentially small ones, when managing floodplains. As part of the State Government's Manual, the definitions of the terms 'flood liable', 'flood prone' and 'floodplain' refer to land inundated by the PMF.

What is the 100 year flood?

A 100 year flood is the flood that will occur or be exceeded on average once every 100 years. It has a probability of 1% of occurring in any given year. If your area has had a 100 year flood, it is a fallacy to think you will need to wait another 99 years before the next flood arrives. Floods do not happen like that. Some parts of Australia have received a couple of 100 year floods in one decade. On average, if you live to be 70 years old, you have a better than even chance of experiencing a 100 year flood.

Why do councils prepare floodplain management studies and plans?

Under NSW legislation, councils have the primary responsibility for management of development within floodplains. To appropriately manage development, councils need a strategic plan which considers the potential flood risks and balances these against the beneficial use of the floodplain by development. To do this, councils have to consider a range of environmental, social, economic, financial and engineering issues. This is what happens in a floodplain risk management study. The outcome of the study is the floodplain risk management plan, which details how best to manage flood risks in the floodplain for the foreseeable future.

Floodplain risk management plans normally comprise a range of works and measures such as:

- ▶ improvements to flood warning and emergency management;
- ▶ works (e.g. levees or detention basins) to protect existing development;
- ▶ voluntary purchase or house raising of severely flood-affected houses;
- ▶ planning and building controls to ensure future development is compatible with the flood risks; and
- ▶ measures to raise the community's awareness of flooding so that they are better able to deal with the flood risks they face.

Will the Flood Risk Precinct maps be changed?

Yes. All mapping undertaken by council is subjected to ongoing review. As these reviews take place, it is conceivable that changes to the mapping will occur, particularly if new flood level information or ground topography information becomes available. However, this is not expected to occur very often and the intervals between revisions to the maps would normally be many years. Many councils have a policy of reviewing and updating floodplain management studies and plans about every five to ten years. This is the likely frequency at which the maps may be amended.

APPENDIX B

FLOOD DAMAGES DATABASE

Confidential

APPENDIX C

Standard Recommended LEP Inclusions

DEFINITIONS

[To be inserted into the Dictionary of the Template LEP in alphabetical order]

Flood liable land (being synonymous with **flood prone land** and **floodplain**) is the area of land which is subject to inundation by floods up to and including a probable maximum flood (PMF).

Consideration could be given to expanding the definition to refer to flood liable land"as identified on a map held in the office of Council as may be amended from time to time" or "as identified on a development control plan adopted by Council"

Probable maximum flood (PMF) is the largest flood that could conceivably occur at a particular location.

STANDARD CLAUSE

[To be inserted as Clause 5.13 in the LEP Template]

5.13 Development on Flood Liable Land

- (1) The objective of this clause is to ensure that the risk to human life and damage to property due to flooding is appropriately managed by controlling development.
- (2) When undertaking an assessment required by this clause, Council must take into consideration the impact of the development in combination with the cumulative impact of development which is likely to occur within the future, within the same floodplain. Such cumulative impact assessments should be undertaken in accordance with the requirements of any relevant Manual as published by the State Government.
- (3) Consent must not be granted to development on flood liable land unless the development:
 - (a) is consistent with any floodplain risk management plan adopted by Council in accordance with any relevant Manual as published by the State Government;
 - (b) is consistent with any development control plan adopted by Council to manage flood risks;
 - (c) does not detrimentally increase the potential flood effect on other development or property;
 - (d) will not result, to a substantial degree, in an increased risk to human life; and
 - (e) is unlikely to result in additional economic and social cost which could not reasonably be managed by potentially affected persons and the general community.

APPENDIX D

DRAFT FLOODPLAIN MANAGEMENT DCP PROVISIONS

(For inclusion in DCP 2008)

8.3

Floodplain Management



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Schedules

Section 1.0

Introduction

1 Floodplain Management

1.1 Land to which this Part applies

This part applies to all land within the City of Ryde that is affected by flooding and overland flow.

The part also includes provisions and controls for specific floodplains within the City.

1.2 Development covered by this Part

This part applies to any development for which consent is required that is located on land affected by flooding and overland flow.

1.3 Purpose of this Part

The purpose of this Part is to guide development to ensure danger to life and property damage associated with flooding and overland flow are minimised in a manner consistent with the Policies of Council formulated under the NSW Flood Policy and Floodplain Development Manual (FDM).

In 1984, the State Government introduced its flood prone land policy applicable to New South Wales. The first FDM was published in 1986, providing guidelines for the implementation of the government's flood prone land policy and the merit approach that underpins its application.

In 2005, the State Government released revised guidelines under the *Floodplain Development Manual* (FDM April 2005) to support the Flood Prone Land Policy, the primary objective of which is:

“to reduce the impact of flooding and flood liability on individual owners and occupiers of flood prone property, and to reduce private and public losses resulting from floods, utilising ecologically positive methods wherever possible.”

Local Government is the primary authority responsible for both flood risk management and land use planning New South Wales. The State Government's flood policy provides for a flexible merit based approach to be followed by local government when preparing controls for planning, development and building matters on flood prone land. For Council to fully carry out its responsibilities for management of flood prone land, it is necessary to prepare a local *“Floodplain Risk Management Plan”* (FRMP).

The FDM requires that Councils prepare *Floodplain Risk Management Studies* (FRMS) as a prelude to the formulation of a FRMP that, among other things, would control development and other activity within the floodplain. The process for preparing a FRMS and FRMP is depicted by **Figure 1**.

The following controls are consistent with the State Government's “Flood Prone Land Policy” and the FDM. The controls in this chapter, represent an application of the State Policy that reflects local circumstances as identified for some floodplains, through the preparation of FRMSs and FRMPs.

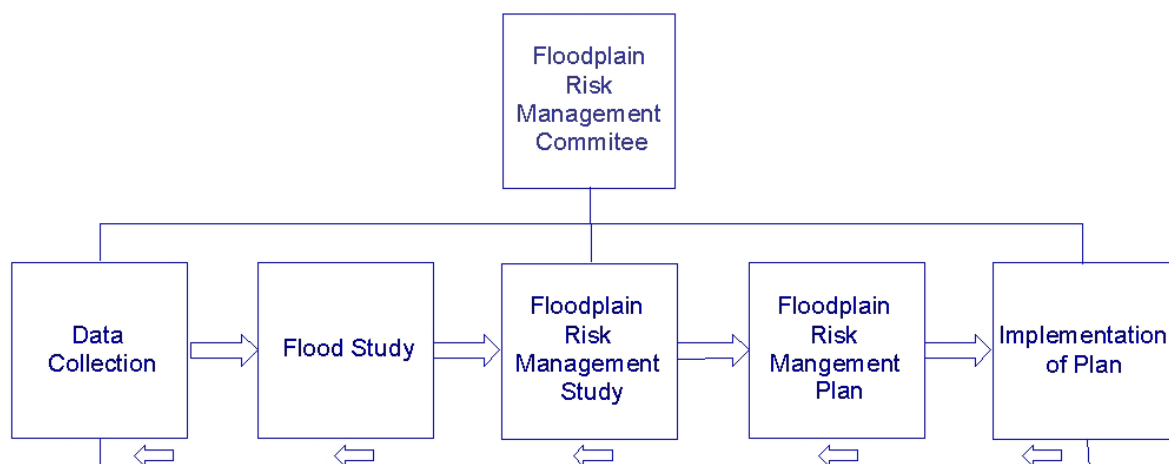


Figure 1 - Floodplain Risk Management Process (FDM, 2005)

1.4 Objectives of this Part

The objectives of this Part are:

- To increase public awareness of the hazard and extent of land affected by all potential floods, including floods greater than the 100 year average recurrence interval (ARI) flood
- To ensure essential services and land uses are planned in recognition of all potential floods.
- To manage the danger to human life and damage to property caused by flooding and inundation through controlling development on land affected by potential floods and overland flow.
- To apply a merit based approach to proposals that relate to flood or overland flow affected land – taking into account flooding, social, economic, ecological and design considerations
- To provide detailed controls for the assessment of applications lodged on land affected by potential floods and overland flow.
- To reduce the risk associated with flooding and overland flow to existing development within the City

1.5 Relationship with other Instruments and Documents

The following documents should be considered in relation to the provisions of this Part:

- Draft Local Environmental plan 2008
- Part 8.2 Stormwater Management of this DCP
- Part 10 - Dictionary
- Draft City of Ryde Floodplain Management Technical Manual

1.6 How to Use this Part

The following is a summary of the major steps to be followed in applying this part of the DCP:

- (a) Determine the relevant floodplain (eg. Eastwood and Terrys Creek Floodplain).
- (b) Determine the Flood Risk and/or Overland Flow Precinct within which your site is situated. Note that the floodplain is divided into four precincts, i.e. High Flood Risk Precinct, Medium Flood Risk Precinct, Low Flood Risk Precinct and the Overland Flow Precinct.
- (c) Enquire with Council regarding existing flood mapping or whether a site-specific assessment may be warranted in your case. Where a property is located in more than one Precinct, the assessment must consider the controls relative to each Precinct.
- (d) Determine the land use category relevant to your proposal.
(Note: Some minor forms of development may be classified as either exempt or complying development subject to satisfying certain criteria. In such cases, this DCP may not need to be applied).
- (e) Check if the proposal will satisfy controls for the relevant land use category in the applicable Precinct, in accordance with this Part.

The assistance of Council staff or an experienced floodplain management consultant may be required at various steps in the process to ensure that the requirements of this Plan are fully and satisfactorily addressed.

1.7 Lodging an Application

Refer to Council's information sheets regarding Council's development assessment process and pre – lodgement services.

The Draft City of Ryde Floodplain Management Technical Manual outlines the information requirements to be submitted with a development proposal on flood liable land.

Section 2.0

Requirements and Controls

2 Requirements and Controls

2.1 Assessment Criteria

In formulating development proposals on land that is affected by flooding and overland flow it is important to recognise that different controls will apply to different land uses, depending on the flood hazard applying to the land. The controls in this part of the DCP comprise:

- **The objectives** which represent the outcomes that the Council wishes to achieve from each control.
- **The performance criteria** which represent a means of assessing whether the desired outcomes will be achieved.
- **The prescriptive controls** which are preferred ways of achieving the outcome. While adherence to the prescriptive controls may be important, it is paramount that the objectives and the performance criteria are clearly satisfied.

The steps to determine whether the proposal complies with the controls are:

- Identify the applicable land use category of the development (see 2.1.1 and Schedule 2)
- Determine the floodplain and precinct in which the property is located
- Assess whether the proposal complies with the performance criteria
- Assess whether the proposal complies with the prescriptive controls
- If the proposal does not comply with any prescriptive controls, any variations must be justified by demonstrating compliance with the performance criteria having regard to the overall objectives.

2.1.1 Land Use Categories

The range of potential development types listed within the Draft LEP 2009 have been grouped into 6 major land use categories based on the sensitivity to flood risks. The 6 land use categories are

- Critical uses and facilities
- Sensitive uses and facilities
- Residential
- Commercial or industrial
- Recreation and non urban
- Concessional development

The land use categories are outlined **Schedule 2**.

2.1.2 Flood Risk and Overland Flow Precincts

Each of the floodplains within the local government area can be divided into precincts based on different levels of potential risk. The precincts provide a basis to assign controls on a development. The relevant Precincts are outlined below.

- **High Flood Risk Precinct**

The high flood risk precinct is where high flood damages, potential risk to life and/or evacuation problems would be anticipated or where development would significantly or adversely alter flood behaviour. Most development should be restricted in this precinct. In this precinct, there would be a significant likelihood of flood damages or danger to life without compliance with flood related building and planning controls.

- **Medium Flood Risk Precinct**

In this precinct there would still be a significant likelihood of flood damage or danger to life, but these damages or dangers to life can be minimised by the application of appropriate development controls.

- **Low Flood Risk Precinct**

This has been defined as all other land within the floodplain (ie. within the extent of the probable maximum flood) but not identified within either the High Flood Risk Medium Flood Risk Precinct or the Overland Flow Precinct, where the likelihood of damages is low for most land uses.

- **Overland Flow Precinct**

The Overland Flow Precinct comprises areas distant from watercourses where shallow inundation occurs following heavy rain. Typically the depth of inundation will be less than 0.3m to 0.5m but more than 0.1m to 0.2m in a 100 year ARI event. Velocities in these areas are mild and the combination of depth and velocity is unlikely to present a safety danger to able-bodied adults or to cause significant erosion problems. These areas would normally be classified as 'low' provisional hazard under the Floodplain Development Manual.

Note, very shallow inundation may still occur in areas above the Overland Flow Precinct where depths would typically be less than 0.1m to 0.2m. These areas are not classified as in either an Overland Flow Precinct or any Flood Risk Precinct and would include areas referred to as 'Local Drainage' under the Floodplain Development Manual.

2.2 General Development Controls

This section outlines the development controls that apply to land within a flood risk or overland flow precinct. The development controls are graded relative to the severity and frequency of potential floods, based on the findings of a floodplain study and management plan or council's interim considerations when a study or plan does not yet exist.

The controls applicable to each floodplain are outlined within the planning matrix contained in following schedules

Schedule 4 - Eastwood and Terrys Creek

Schedule 5 - All Other floodplains (interim controls)

It is intended that development controls and a planning matrix for other floodplains within the City be included in the Schedules of this Part following the completion of floodplain studies and plans.

Objectives

1. To require development with high sensitivity to flood damages or danger to life to be sited and designed so that it is subject to minimal flood hazard.
2. To allow development with low sensitivity to flood damages or danger to life to be located within a floodplain - subject to design and siting controls and provided the chance of personal harm and damage to property is minimised.
3. To ensure that the design and siting controls and built form outcomes required to address the flood hazard do not result in unreasonable impacts on the:
 - amenity and character of an area;

- streetscape and the relationship of the building to the street;
 - social and economic outcomes; and the
 - environment and ecology.
4. To ensure the flood risk associated with development, comprising danger to life and damage to property, is minimised and not increased beyond the level acceptable to the community.
 5. To ensure that the proposed development does not exacerbate flooding on other properties.

Performance Criteria

- (a) The risk associated with the flooding of development comprising danger to life and damage to property is minimised and not increased beyond the level acceptable to the community.
- (b) The additional economic and social cost which may arise from damage to property from flooding is not greater than that which can reasonably be managed by the property owner and general community. The cost of damages that may be incurred over the expected life of a development should be no greater than that which could be reasonably expected to be met by the occupants and/or the developer without Government assistance.
- (c) Effective warning time and reliable access is available for evacuation from an area potentially affected by flooding to an area free of risk from flooding and overland flow.
- (d) Appropriate procedures (such as warning systems, signage or evacuation drills) for land use categories of “critical uses and facilities” and “sensitive uses and facilities” be in place, if necessary, so that people are aware of the need to evacuate personnel and relocate goods and motor vehicles during a flood, and are capable of identifying an appropriate evacuation route.
- (e) Development does not detrimentally increase the potential flood effects on other development or properties either individually or in combination with the cumulative impact of development that is likely to occur in the same floodplain. Development should not change the height or behaviour of flood waters elsewhere in the floodplain in a manner which is likely to affect other property. The assessment of these effects must include the potential for similar impacts that would arise as a consequence of other development in the floodplain that has the potential to occur in the future under current zoning and planning controls.
- (f) Motor vehicles associated with the development are able to be relocated, undamaged, to an area with substantially less likelihood from flooding, within the effective warning time.
- (g) Development does not result in significant impacts upon the amenity of an area (eg. by way of unacceptable overshadowing of adjoining properties) or privacy impacts (eg. by unsympathetic house-raising).
- (h) Development must be compatible with the existing and planned streetscape and character of the locality.
- (i) The design of car parking (enclosed or uncovered) and associated driveways should not result in unacceptable environmental or amenity impacts such as visual intrusion from elevated driveways and parking structures and overshadowing of adjoining residential properties.
- (j) The proposal must not have an unacceptable adverse impact upon the ecological value of the waterway corridors, and where possible, should provide for their enhancement.
- (k) Development does not prejudice the economic viability of any Voluntary Acquisition Scheme, by significantly increasing the value of property above the existing or likely future funds available in the scheme.

Prescriptive Controls

- (a) Compliance with the requirements of the planning matrix for the relevant floodplain within the City as contained in Schedules 4 and 5.
- (b) Development within the commercial centres of the City must ensure that design solutions address flood risk management objectives as well as providing appropriate urban design outcomes, particularly in regard to:
 - (i) ground floor levels that are consistent with existing adjoining commercial development or form part of an integrated design which incorporate the frontage of a whole street block. (Note: design solutions could include, flood proofed shop front windows at street level and confined active spaces (such as eating areas) at the street level which are substantially constructed of flood compatible materials and building components or able to be closed off with flood proof doors. Ground floor areas away from the street interface may vary subject to being adequately integrated.)
 - (ii) acceptable access for persons with disabilities; and
 - (iii) an overall building height that is compatible with the existing and planned streetscape.
- (c) Proposals involving collecting and piping overland flow through the subject property or upgrading a section of Council's existing pipe-infrastructure, will generally not be acceptable for the following reasons:
 - (i) this is a substantial potential for system blockage due to the limited number of inlets available;
 - (ii) the natural detention storage available within the catchment is reduced and flow velocities are increased; and
 - (ii) due to greater rates of flow, it may cause localised increases in hazard at the system outlet and greater scour of natural creeks and/or disturbance of the downstream river bed.
- (d) Proposed land subdivisions of lots affected by overland flow will not be approved unless the applicant can demonstrate to Council that it is possible to provide a development on the newly created lot that realises the full floor space ratio (FSR) potential of the lot and provides suitable private open space while meeting the overland flow management criteria outlined in this document.
- (e) Proposals for house raising must provide appropriate documentation including:
 - (i) a report from a suitably qualified engineer to demonstrate that the raised structure will not fail from the forces of floodwaters in a 100 year ARI flood; and
 - (ii) the provision of details such as landscaping and architectural enhancements which ensure that the resultant structure will not result in significant adverse impacts upon the amenity and character of an area.
- (f) Notwithstanding any other provision where a property is identified within a Voluntary Acquisition Scheme area, Council will only consent to further development being "concessional development"; provided:
 - (i) the development is for only minor works such as small awnings over existing balconies or in-ground swimming pools; and
 - (ii) capital investment intended for the property is, in the opinion of Council, not greater than the minimum required to satisfy acceptable standards.

2.3 Fencing

Fencing can have a significant influence on the distribution of flood waters, particularly in a built up urban area such as the City of Ryde. The implications of fencing are greater where flood waters are deeper and faster moving such as is expected in a high flood risk precinct.

Objectives

To ensure that development involving fencing has fencing constructed:

1. in a manner that does not affect the flow of flood waters so as to result in additional flood impacts on surrounding land; and
2. so as to withstand the forces of flood waters, or collapse in a controlled manner to prevent the undesirable impediment of flood waters.

Performance Criteria

- (a) Fencing is to be constructed in a manner that does not affect the flow of flood waters so as to detrimentally change flood behaviour or increase flood levels on surrounding land.
- (b) Ability to be certified by a suitably qualified engineer, that the proposed fencing is adequately constructed so as to withstand the forces of flood waters, or collapse in a controlled manner to prevent the undesirable impediment of flood waters.

Prescriptive Controls

- (a) Fencing within a High Flood Risk Precinct must be security/ permeable/ open type/safety fences. Council may require such fencing to be able to be opened at the bottom with the force of floodwaters. (This requirement may be secured by a Section 88B instrument burdening the title of the land).
- (b) An applicant will need to demonstrate that any fence would create no impediment to the flow of flood waters. Appropriate fences must satisfy the following:-
 - (i) An open collapsible hinged fence structure or pool type fence;
 - (ii) Other than a brick or other masonry type fence (which will generally not be permitted); or
 - (iii) A fence type and siting criteria as prescribed by Council.

2.4 Local Drainage

The effects of local drainage are invariably minor (with inundation depths typically less than 0.1m to 0.2m) and may be addressed as part of structural design process. The Building Code of Australia (BCA) sets site drainage and minimum levels for slab-on-ground construction for Class 1 buildings which would generally address local drainage issues. Less specific controls are set by the BCA for Class 2 to 9 buildings (which include most development other than single dwelling houses, attached dwellings separated by firewalls or small scale boarding houses or hostels).

Where Class 2 to 9 buildings require development consent and Council is aware of the potential for the site to be affected by local drainage, Council may impose controls in addition to the requirements of the BCA. Section 8.2 of this DCP sets out various requirements that must be read in addition to those outlined below. The provisions of section 8.2 of the DCP prevails where there is an inconsistency.

Objectives

1. To ensure that the impacts of inundation from local drainage are addressed when assessing all development proposals.

Performance Criteria

- (a) Habitable floor levels are not inundated by local drainage.

Prescriptive Controls

- (a) Habitable floor levels of buildings affected by local drainage are to be a minimum of 300mm above the external finished surface of the building.
- (b) The external finished surface level surrounding the slab must be drained to move surface water away from the building.
- (c) The ground beneath suspended floors must be graded so that the area beneath the building is above the adjacent external finished level.

Note: The prescriptive controls may be varied where a site specific drainage study demonstrates that the performance control can be achieved. This may be a relevant approach for various forms of development such as shops within a street shopping centre where it is important to achieve direct and easy access from the footpath into a shop.

Section 3.0

Information Requirements

3 Information Requirements

Applications must include the following matters, as applicable.

1. Applications for Concessional Development (which includes alterations and additions to existing developments or minor development – see **Schedule 2**) to an existing dwelling on Flood Liable Land shall be accompanied by documentation from a registered surveyor confirming existing floor levels.
2. A survey plan showing:
 - (a) The position of the existing building/s or proposed building/s;
 - (b) The existing ground levels to Australian Height Datum around the perimeter of the building and contours of the site; and
 - (c) The existing or proposed floor levels to Australian Height Datum.
3. Applications for earthworks, filling of land and subdivision shall be accompanied by a survey plan (with a contour interval of 0.5m) showing relative levels to Australian Height Datum.
4. For large scale developments, or developments in critical situations, particularly where an existing catchment based flood study is not available, a flood study using a fully dynamic one or two dimensional computer model may be required. For smaller developments the existing flood study may be used if available and suitable (eg it contains sufficient local detail), or otherwise a flood study prepared in a manner consistent with the “Australian Rainfall and Runoff” publication, any relevant Council Drainage Design Code and the Floodplain Development Manual, will be required. From this study, the following information shall be submitted in plan form:
 - (a) water surface contours (including the 100 year flood and PMF extents)
 - (b) velocity vectors;
 - (c) velocity and depth product contours;
 - (d) delineation of flood risk and overland flow precincts relevant to individual floodplains;

and

 - (e) show both existing and proposed flood profiles for the full range of events for total development including all structures and works (such as revegetation/ enhancements).

This information is required for the pre-developed and post-developed scenarios.
5. Where the controls for a particular development proposal require an assessment of structural soundness during potential floods, the following impacts must be addressed:
 - (a) hydrostatic pressure;
 - (b) hydrodynamic pressure;
 - (c) impact of debris; and
 - (d) buoyancy forces.

Foundations need to be included in the structural analysis.
6. Where computer modelling is used for either hydrological or hydraulic analysis, an electronic copy of the input and output files shall be submitted to Council in a form compatible with Council’s computer software along with the plans and a hard copy of the input and output data.

Section 4.0

Dictionary

(To be inserted in alphabetical order into Part
10 Dictionary DCP 2008)

DICTIONARY

Adequate Warning Systems, Signage and Exits is where the following is provided:

- (a) an audible and visual alarm system which alerts occupants to the need to evacuate, sufficiently prior to likely inundation to allow for the safe evacuation of pedestrians and vehicles;
- (b) signage to identify the appropriate procedure and route to evacuate; and
- (c) exits which are located such that pedestrians evacuating any location during any flood do not have to travel through deeper water to reach a place of refuge above the 100 year flood, away from the enclosed car parking.

Australian Height Datum (AHD) is a common national plain of level corresponding approximately to mean sea level.

Average Recurrence Interval (ARI) means the long-term average number of years between the occurrence of a flood as big as, or larger than, the selected event. For example, floods with a discharge as great as, or greater than, the 20 year ARI flood event will occur on average once every 20 years. ARI is another way of expressing the likelihood of occurrence of a flood event.

Compensatory Works refers to earthworks where material is excavated (or “cut”) from one location in the floodplain and placed (or “filled”) at another location in the floodplain, with no net importation of fill material, such that the volume available for storage of flood waters is not altered for all floods.

Conveyance is a direct measure of the flow carrying capacity of a particular cross-section of a stream or stormwater channel. (For example, if the conveyance of a channel cross-section is reduced by half, then the flow carrying capacity of that channel cross-section will also be halved).

Design floor level or ground level means the minimum floor level that applies to the development. If the development is concessional development, this level is determined based on what land use category would apply if it was not categorised as Concessional Development.

Ecologically Sustainable Development (ESD) is using, conserving and enhancing natural resources so that ecological processes, on which life depends, are maintained, and the total quality of life, now and in the future, can be maintained or increased.

Effective warning time is the time available after receiving advice of an impending flood and before the floodwaters prevent appropriate flood response actions being undertaken. The effective warning time is typically used to move farm equipment, move stock, raise furniture, evacuate people and transport their possessions.

Enclosed car parking means car parking which is potentially subject to rapid inundation, which consequently increases danger to human life and property damage (such as basement of bunded car parking areas). The following criteria apply for the purposes of determining what is enclosed car parking:

- (a) Flooding of surrounding areas may raise water levels above the perimeter which encloses the car park (normally the entrance), resulting in rapid inundation of the car park to depths greater than 0.8m, and
- (b) Drainage of accumulated water in the car park has an outflow discharge capacity significantly less than the potential inflow capacity.

Flood is a relatively high stream flow which overtops the natural or artificial banks in any part of a stream, river, estuary, lake or dam, and/or local overland flow associated with major drainage as defined by the FDM before entering a watercourse.

Flood awareness is an appreciation of the likely effects of flooding and a knowledge of the relevant flood warning and evacuation procedures.

Flood compatible building components means a combination of measures incorporated in the design and/or construction and alteration of individual buildings or structures subject to flooding, and the use of flood compatible materials for the reduction or elimination of flood damage.

Note: A list of typical flood compatible building components is provided in Schedule 1.

Flood compatible materials include those materials used in building which are resistant to damage when inundated.

Note: A list of typical flood compatible materials is provided in Schedule 1.

Flood evacuation strategy means the proposed strategy for the evacuation of areas within effective warning time during periods of flood as specified within any policy of Council, the FRMP, the relevant SES Flood Plan, by advices received from the State Emergency Services (SES) or as determined in the assessment of individual proposals.

Flood prone land (being synonymous with flood liable and floodplain) is the area of land which is subject to inundation by the probable maximum flood (PMF).

Floodplain Development Manual (FDM) refers to the document dated April 2005, published by the New South Wales Government and entitled "Floodplain Development Manual: the management of flood liable land".

Floodplain Risk Management Plan (FRMP) means a plan prepared for one or more floodplains in accordance with the requirements of the Floodplain Development Manual or its predecessors.

Floodplain Risk Management Study (FRMS) means a study prepared for one or more floodplains in accordance with the requirements of the Floodplain Development Manual or its predecessors.

Freeboard provides reasonable certainty that the risk exposure selected in deciding on a particular flood chosen as the basis for a FPL is actually provided. It is a factor of safety typically used in relation to the setting of flood levels, levee crest levels, etc. (as specified at Section K5 of the FDM). Freeboard is included in the flood planning level.

Habitable floor area means:

- in a residential situation: a living or working area, such as a lounge room, dining room, rumpus room, kitchen, bedroom or workroom;
- in an industrial or commercial situation: an area used for offices or to store valuable possessions susceptible to flood damage in the event of a flood.

Note: Separate considerations are specified for the car parking area of a development irrespective of the land use with which it is associated.

Hazard is a source of potential harm or a situation with a potential to cause loss. In relation to this plan, the hazard is flooding which has the potential to cause harm or loss to the community.

Infill development is development which is proposed within established existing urban area and usually involves the development of a vacant residential site, or the removal of an existing residential or retail/commercial building to provide a replacement building for a similar use.

Local drainage means small scale inundation in urban areas outside the definition of flooding or overland flow (major drainage) as defined in the Floodplain Development Manual. Local drainage problems invariably involve shallow depths (less than 0.1m to 0.2m) with generally little danger to personal safety.

Merit approach is an approach, the principles of which are embodied in the Floodplain Development Manual which weighs social, economic, ecological and cultural impacts of land use options for different flood prone areas together with flood damage, hazard and behaviour implications, and environmental protection and well being of the State's rivers and floodplains.

Outbuilding means a building that is ancillary to a principal residential building and includes sheds, garages, carports and similar buildings but does not include granny flats.

Overland Flow means inundation by local runoff rather than overbank discharge from a stream, river, estuary, lake or dam.

Performance criteria represent a means of assessing whether the desired outcomes will be achieved.

Practical means that which in the opinion of Council can be achieved within the design of the development, while not necessitating:

- (a) floor levels to be raised in a way that would unreasonably hinder access to and from existing floor levels or ground levels on the same site or adjacent public areas; and
- (b) the raising of a structure to a height that would result in unacceptable impacts on the amenity of adjacent residential properties; and
- (c) the height or presentation of a building that would be inconsistent with the existing or planned streetscape.

Note: Examples of where the preferred design may not be practical include:

Example 1: A minor extension to an existing dwelling (falling within the “Concessional Development” land use category) where an additional room would require a floor level higher than what otherwise exists within the dwelling constraining internal movements or resulting in an unusual external appearance to the building.

Example 2: The rebuilding or refitting of a singular shop in a traditional street shopping centre where existing ground floor levels of the site and adjoining sites relate closely to the footpath level. In this case the width of the site would not be sufficient to allow for a redevelopment that could incorporate a podium level or colonnade along the street frontage at the preferred design floor flood level while remaining compatible with the existing or planned streetscape. The site would have insufficient frontage to the road to enable the creation of a site specific streetscape presentation that was compatible with, but not consistent with that otherwise prevailing in the shopping centre (eg. the site does not occupy a whole street block).

Example 3: The topographical site constraints of a site would require a driveway to be elevated more than 1 metre above natural ground in a location that would not allow the driveway to be incorporated in the final landscape or visually and acoustically screened from habitable rooms associated with dwellings on the site or adjacent properties. The resultant garage design and driveway levels may also be unable to meet Australian Standards. In this case the development of the site for the proposed residential purposes would otherwise be a reasonable expectation having regard to the planning controls and existing development in the locality.

Prescriptive controls are preferred ways of achieving the outcome. While adherence to the prescriptive controls may be important, it is paramount that the objectives and the performance criteria are clearly satisfied.

Probable maximum flood (PMF) is the largest flood that could conceivably occur at a particular location, usually estimated from probable maximum precipitation.

Primary habitable floor area means the majority of habitable floor area and in a residential situation includes the majority of bedrooms, main living area, kitchen and first bathroom.

Probable maximum precipitation (PMP) is the greatest depth of precipitation for a given duration meteorologically possible over a given size storm area at a particular location at a particular time of the year, with no allowance made for long-term climatic trends (World Meteorological Organisation, 1986). It is often the primary input to the estimation of the probable maximum flood.

Probability is a statistical measure of the expected chance of flooding (see ARI).

Rebuilt dwelling refers to the construction of a new dwelling on an allotment where an existing dwelling is demolished.

Reliable access during a flood means the ability for people to safely evacuate an area subject to flooding, having regard to the depth and velocity of flood waters and the suitability of the evacuation route, without a need to travel through areas where water depths increase.

Risk means the chance of something happening that will have an impact. It is measured in terms of consequences and probability (likelihood). In the context of this plan, it is the likelihood of consequences arising from the interaction of floods, communities and the environment.

Site Emergency Response Flood Plan (not being an SES Flood Plan) is a management plan that demonstrates the ability to safely evacuate persons and include a strategy to move goods above the flood level within the available warning time. This Plan must be consistent with any relevant flood evacuation strategy, flood plan or similar plan.

Survey plan is a plan prepared by a registered surveyor which shows the information required for the assessment of an application in accordance with the provisions of this Plan.

Section 5.0

Schedules

SCHEDULE 1
FLOOD COMPATIBLE MATERIALS & BUILDING COMPONENTS

BUILDING COMPONENT	FLOOD COMPATIBLE MATERIAL	BUILDING COMPONENT	FLOOD COMPATIBLE MATERIAL
Flooring and Sub-floor Structure	<ul style="list-style-type: none"> concrete slab-on-ground monolith construction suspension reinforced concrete slab. 	Doors	<ul style="list-style-type: none"> solid panel with water proof adhesives flush door with marine ply filled with closed cell foam painted metal construction aluminium or galvanised steel frame
Floor Covering	<ul style="list-style-type: none"> clay tiles concrete, precast or in situ concrete tiles epoxy, formed-in-place mastic flooring, formed-in-place rubber sheets or tiles with chemical-set adhesives silicone floors formed-in-place vinyl sheets or tiles with chemical-set adhesive ceramic tiles, fixed with mortar or chemical-set adhesive asphalt tiles, fixed with water resistant adhesive 	Wall and Ceiling Linings	<ul style="list-style-type: none"> fibro-cement board brick, face or glazed clay tile glazed in waterproof mortar concrete concrete block steel with waterproof applications stone, natural solid or veneer, waterproof grout glass blocks glass plastic sheeting or wall with waterproof adhesive
Wall Structure	<ul style="list-style-type: none"> solid brickwork, blockwork, reinforced, concrete or mass concrete 	Insulation Windows	<ul style="list-style-type: none"> foam (closed cell types) aluminium frame with stainless steel rollers or similar corrosion and water resistant material.
Roofing Structure (for Situations Where the Relevant Flood Level is Above the Ceiling)	<ul style="list-style-type: none"> reinforced concrete construction galvanised metal construction 	Nails, Bolts, Hinges and Fittings	<ul style="list-style-type: none"> brass, nylon or stainless steel removable pin hinges hot dipped galvanised steel wire, nails or similar.

<p>Electrical and Mechanical Equipment</p> <p>For dwellings constructed on land to which this Plan applies, the electrical and mechanical materials, equipment and installation should conform to the following requirements.</p>	<p>Heating and Air Conditioning Systems</p> <p>Heating and air conditioning systems should, to the maximum extent possible, be installed in areas and spaces of the house above the relevant flood level. When this is not feasible every precaution should be taken to minimise the damage caused by submersion according to the following guidelines.</p>
<p>Main power supply -</p> <p>Subject to the approval of the relevant authority the incoming main commercial power service equipment, including all metering equipment, shall be located above the relevant flood level. Means shall be available to easily disconnect the dwelling from the main power supply.</p>	<p>Fuel -</p> <p>Heating systems using gas or oil as a fuel should have a manually operated valve located in the fuel supply line to enable fuel cut-off.</p>
<p>Wiring -</p> <p>All wiring, power outlets, switches, etc., should, to the maximum extent possible, be located above the relevant flood level. All electrical wiring installed below the relevant flood level should be suitable for continuous submergence in water and should contain no fibrous components. Earth core linkage systems (or safety switches) are to be installed. Only submersible-type splices should be used below the relevant flood level. All conduits located below the relevant designated flood level should be so installed that they will be self-draining if subjected to flooding.</p>	<p>Installation -</p> <p>The heating equipment and fuel storage tanks should be mounted on and securely anchored to a foundation pad of sufficient mass to overcome buoyancy and prevent movement that could damage the fuel supply line. All storage tanks should be vented to an elevation of 600 millimetres above the relevant flood level.</p>
<p>Equipment -</p> <p>All equipment installed below or partially below the relevant flood level should be capable of disconnection by a single plug and socket assembly.</p>	<p>Ducting -</p> <p>All ductwork located below the relevant flood level should be provided with openings for drainage and cleaning. Self draining may be achieved by constructing the ductwork on a suitable grade. Where ductwork must pass through a water-tight wall or floor below the relevant flood level, the ductwork should be protected by a closure assembly operated from above relevant flood level.</p>
<p>Reconnection -</p> <p>Should any electrical device and/or part of the wiring be flooded it should be thoroughly cleaned or replaced and checked by an approved electrical contractor before reconnection.</p>	<p>Ancillary Structures (steps, pergolas, etc) -</p> <p>Suitable water tolerant materials should be used such as masonry sealed hardwood and corrosive resistant metals. Copper Chrome Arsenate (CCA) treated timber is <u>not</u> a suitable material.</p>

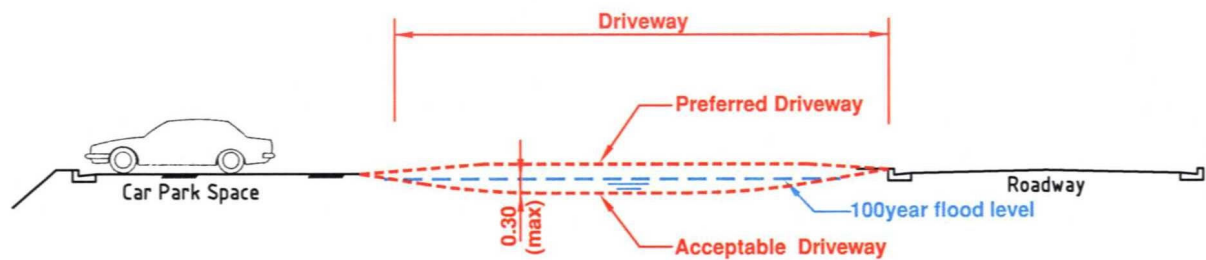
SCHEDULE 2

LAND USE CATEGORIES

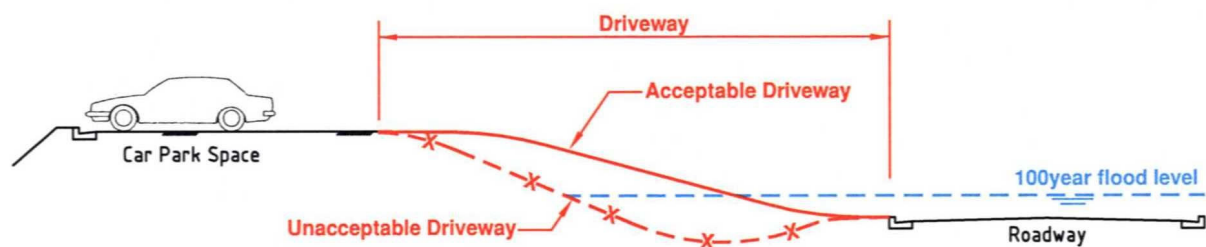
Critical Uses and Facilities	Sensitive Uses and Facilities	Residential
Emergency services facilities; administration building or public administration building that may provide an important contribution to the notification or evacuation of the community during flood events (e.g. SES Headquarters and Police Stations); Hospitals.	Community facility; telecommunications facility; Institutions; Educational establishments; Liquid fuel depot; Public utility undertaking (including electricity generating works and utility installations) which are essential to evacuation during periods of flood or if affected would unreasonably affect the ability of the community to return to normal activities after flood events, residential care facility, school and seniors housing.	Attached dwelling, backpackers' accommodation; bed and breakfast accommodation; boarding house; caravan park (with permanent occupants); child care centre; dual occupancy; dwelling; dwelling house; exhibition home; group home; home-based child care centre; home business; home industry; home occupancy; home occupation (sex services); hostel; hotel or motel accommodation; moveable dwelling; multi dwelling housing; neighbourhood shop; permanent group home; residential accommodation; residential flat building; secondary dwelling; semi-detached dwelling; serviced apartments; tourist and visitor accommodation and transitional group home.

Commercial or Industrial	Recreation and Non-Urban	Concessional Development
<p>Air transport facility; airport; amusement centre; brothel; bulky goods premises; business premises; caravan park; community facility (other than critical and sensitive uses and facilities); correctional centre; crematorium; depot; entertainment facility; exhibition village; food and drink premises; freight transport facility; function centre; funeral chapel; funeral home; hazardous industry; hazardous storage establishment; health care professional; health consulting rooms; health services facility; heavy industry; heliport; highway service centre; industrial retail outlet; industry; liquid fuel depot; light industry; market; medical centre; mixed use development; mortuary; night club; offensive industry; offensive storage establishment; office premises; passenger transport facility; place of public entertainment; place of public worship; pub; public administration building (other than critical uses and facilities); recreation facility (major); registered club; restaurant; restricted premises; retail premises; self-storage units; service station; sex services premises; shop top housing; storage premises; take away food or drink premises; timber and building supplies; transport depot; truck depot; vehicle body repair workshop; vehicle repair station; vehicle sales or hire premises; veterinary hospital; warehouse or distribution centre; waste disposal facility; waste management facility; waste or resource management facility; waste or resource transfer stations; and wholesale supplies.</p>	<p>Animal boarding or training establishment; biosolid waste application; biosolids treatment facility; boat launching ramp; boat repair facility; boat shed; caravan park (with non-permanent occupants); charter and tourism boating facility; environmental facility; environmental protection works; extensive agriculture; extractive industry; information and education facility; horticulture; kiosk; landscape and garden supplies; marina; mine; mining; moveable dwelling; port facilities; public utility undertaking (other than critical uses or facilities); recreation area; recreation facility (indoor); recreational facility (outdoor); research station; resource recovery facility; restriction facilities; utility installations (other than critical uses and facilities); water recreation structure; water recycling facility; and water storage facility.</p>	<p>(a) In the case of residential development:</p> <ul style="list-style-type: none"> (i) an addition or alteration to an existing dwelling of not more than 10% or 30m² (whichever is the lesser) of the habitable floor area which existed at the date of commencement of this Plan; (ii) the construction of an outbuilding with a maximum floor area of 30m²; or (iii) rebuilt dwellings which substantially reduce the extent of flood risks compared with the existing situation. <p>(b) In the case of other development:</p> <ul style="list-style-type: none"> (i) an addition to existing buildings of not more than additional 100m² or 10% of the floor area which existed at the date of commencement of this DCP (whichever is the lesser); (ii) rebuilding of a development which substantially reduces the extent of flood risks to the existing development; (iii) a change of use which does not increase flood risk having regard to property damage and personal safety; or (iv) subdivision that does not involve the creation of new allotments with potential for further development.

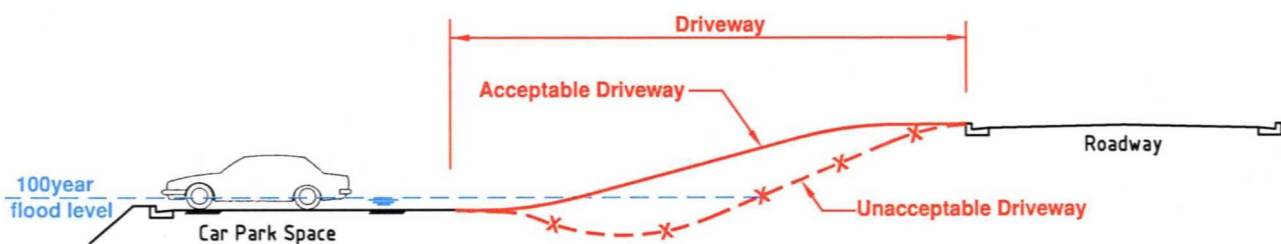
Schedule 3 – Car Parking and Driveway Access Examples



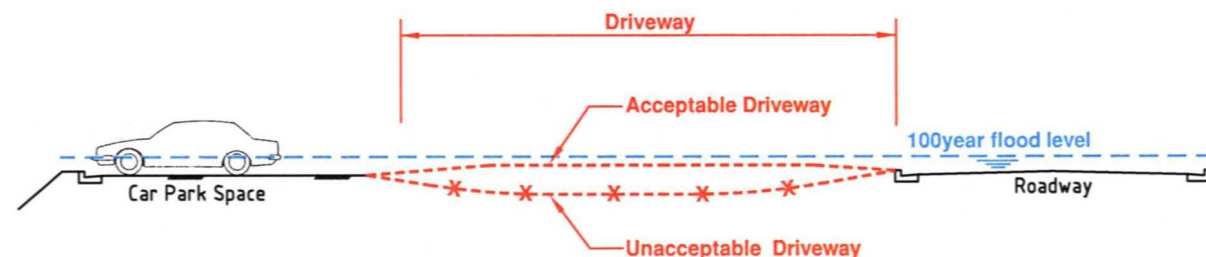
HIGH ROADWAY AND CAR PARK SPACE
(No part of driveway more than 0.3m below 100 year flood level)



LOW ROADWAY
(Driveway inundation depth not greater than roadway inundation depth)



LOW CAR PARK SPACE
(Driveway inundation depth not greater than car park inundation depth)



LOW ROADWAY AND CAR PARK SPACE
(Driveway inundation depth not greater than car park or roadway inundation depth)

Schedule 4

Eastwood & Terrys Creek
Planning & Development Controls

Template: V5.2

Planning Consideration	Flood Risk and Overland Flow Precincts																							
	Low Flood Risk						Medium Flood Risk						High Flood Risk						Overland Flow					
	Critical Uses & Facilities	Sensitive Uses & Facilities	Residential	Commercial & Industrial	Recreation & Non-Urban	Concessional Development	Critical Uses & Facilities	Sensitive Uses & Facilities	Residential	Commercial & Industrial	Recreation & Non-Urban	Concessional Development	Critical Uses & Facilities	Sensitive Uses & Facilities	Residential	Commercial & Industrial	Recreation & Non-Urban	Concessional Development	Critical Uses & Facilities	Sensitive Uses & Facilities	Residential	Commercial & Industrial	Recreation & Non-Urban	Concessional Development
Floor Level		3	2,6,7	5,6,7	1,6	4,7			2,6,7	5,6,7	1	4,7					1	4,7	3	3	2or8, 6or9, 7	5or8, 6or9, 7	1or8, 6or9	4,7
Building Components		2	1	1	1	1			1	1	1	1					1	1	2	2	1 or 3	1 or 3	1 or 3	1 or 3
Structural Soundness		3	2	2	2	2			2	2	2	2					1	1						
Flood Effects		2	2	2	2	2			2	2	2	2					1	1	2	2	2	2	2	2
Car Parking & Driveway Access		1,3,5,6, 7	1,3,5,6, 7	1,3,5,6, 7	2,3,4,6, 7	6,7,8			1,3,5,6, 7	1,3,5,6, 7	2,3,4,6, 7	6,7,8					2,3,4,6, 7	6,7,8	1or9, 3, 6	1or9, 3, 6	1or9, 3, 6	1or9, 3, 6	2,3,6	6,8
Evacuation		2	2	1 or 2	3	2			2	1 or 2	3	2					3	2	2	2				
Management & Design		1,4,5	1	1,2,3,5	1,2,3,5	1,2,3,5			1	1,2,3,5	1,2,3,5	1,2,3,5					1,2,3,5	1,2,3,5	1,4,5	1,4,5	1	1,2, 3or6, 5	1,2, 3or6, 5	1,2, 3or6, 5

General Notes:

- Unsuitable Land Use (refer to General Note b)
- No Controls
- a *Freeboard* equals an additional height of 500mm. In *Overland Flow* precincts, the *freeboard* is 300mm.
 - b The relevant environmental planning instruments (generally the Local Environmental Plan) identify development permissible with consent in various zones in the LGA. Notwithstanding, constraints specific to individual sites may preclude Council granting consent for certain forms of development on all or part of a site.
 - c Filling of the site, where acceptable to Council, may change the FRP considered to determine the controls applied in the circumstances of individual applications.
 - d Refer to Section 2.3 of the DCP for planning considerations for proposals involving only the erection of a fence. Any fencing that forms part of a proposed development is subject to the relevant flood effects and structural soundness planning considerations of the applicable landuse category.
 - e Refer to Section 2.2 of the DCP for special considerations such as for house raising proposals and development of properties identified for voluntary acquisition.
 - f Terms in italics are defined in the glossary of this plan and Schedule 2 specifies development types included in each land use category. These development types are generally as defined within Environmental Planning Instruments applying to the LGA.

Floor Level

- All floor levels to be no lower than the 20 year flood level plus freeboard unless justified by site specific assessment.
- Habitable floor* levels to be no lower than the 100 year flood level plus *freeboard*.
- Habitable floor* levels to be no lower than the *PMF* level. *Non-habitable floor* levels to be no lower than the *PMF* level unless justified by a site specific assessment.
- Floor levels to be no lower than the *design floor level*. Where this is not *practical* due to compatibility with the height of adjacent buildings, or compatibility with the floor level of existing buildings, or the need for access for persons with disabilities, a lower floor level may be considered. In these circumstances, the floor level is to be as high as *practical*, and, when undertaking alterations or additions, no lower than the existing floor level.
- The level of *habitable floor areas* to be equal to or greater than the 100 year *flood* level plus *freeboard*. If this level is not *practical* for a development in a Business zone, the floor level should be as high as possible.
- Non-habitable floor* levels to be equal to or greater than the 100 year flood level plus *freeboard* where possible, or otherwise no lower than the 20 year flood level plus *freeboard* unless justified by site specific assessment.
- A restriction is to be placed on the title of the land, pursuant to S.88B of the Conveyancing Act, where the lowest *habitable floor area* is elevated above finished ground level, confirming that the undercroft area is not to be enclosed, where Council considers this may potentially occur.
- Habitable floor* levels to be minimum 500mm above adjacent ground levels.
- Non-habitable floor* levels to be minimum 300mm above adjacent ground levels.

Building Components & Method

- All structures to have *flood compatible building components* below the 100 year flood level plus *freeboard*.
- All structures to have *flood compatible building components* below the *PMF* level.
- All structures to have *flood compatible building components* up to 500mm above adjacent ground levels.

Structural Soundness

- Engineer's report to certify that the structure can withstand the forces of floodwater, debris and buoyancy up to and including a 100 year flood plus *freeboard*, or a *PMF* if required to satisfy evacuation criteria (see below). In the case of alterations or additions to an existing development, the structure to be certified is that which is proposed to be newly constructed or otherwise required to be of a specified standard to satisfy other controls.
- Applicant to demonstrate that the structure can withstand the forces of floodwater, debris and buoyancy up to and including a 100 year flood plus *freeboard*, or a *PMF* if required to satisfy evacuation criteria (see below). An engineer's report may be required.
- Applicant to demonstrate that any structure can withstand the forces of floodwater, debris and buoyancy up to and including a *PMF*. An engineers report may be required.

Flood Effects

- Engineer's report required to certify that the development will not increase effects elsewhere, having regard to: (i) loss of flood storage; (ii) changes in flood levels and velocities caused by alterations to the conveyance of flood or overland flow waters; and (iii) the cumulative impact of multiple potential developments in the floodplain.
- The flood impact of the development to be considered to ensure that the development will not increase flood effects elsewhere, having regard to: (i) loss of flood storage; (ii) changes in flood levels and velocities caused by alterations to the flood *conveyance*; and (iii) the cumulative impact of multiple potential developments in the floodplain. An engineer's report may be required.

Car Parking and Driveway Access

- The minimum surface level of open car parking spaces or carports shall be as high as *practical*, and not below: (i) the 20 year flood level plus freeboard; or (ii) the level of the crest of the road at the location where the site has access; (which ever is the lower). In the case of garages, the minimum surface level shall be as high as *practical*, but no lower than the 20 year flood level plus freeboard.
- The minimum surface level of open car parking spaces, carports or garages, shall be as high as *practical*.
- Garages capable of accommodating more than 3 motor vehicles on land zoned for urban purposes, or *enclosed car parking*, must be protected from inundation by floods equal to or greater than the 100 year flood.
- The driveway providing access between the road and parking space shall be as high as *practical* and generally rising in the egress direction.
- Where the level of the driveway providing access between the road and parking space is lower than 0.3m below the 100 year flood, the following condition must be satisfied - the depth of inundation on the driveway during a 100 year flood shall not exceed: (i) the depth at the road; or (ii) the depth at the car parking space. (Refer to Schedule 3). A lesser standard may be accepted for single detached dwelling houses where it can be demonstrated that risk to human life would not be compromised.
- Enclosed car parking* and car parking areas accommodating more than 3 vehicles with a floor level below the 20 year flood level plus *freeboard* or more than 0.8m below the 100 year flood level, shall have *adequate warning systems, signage and exits*.
- Restraints or vehicle barriers to be provided to prevent floating vehicles leaving a site during a 100 year flood.
- Driveway and parking space levels to be no lower than the *design ground/floor levels*. Where this is not *practical*, a lower level may be considered. In these circumstances, the level is to be as high as *practical*, and, when undertaking alterations or additions, no lower than the existing level.
- The minimum surface level of open car parking spaces or carports shall be as high as *practical*, and not below: (i) the 20 year flood level plus freeboard; or (ii) the level of the crest of the road at the location where the site has access; or (iii) 300mm above adjacent ground level. (which ever is the lower). In the case of garages, the minimum surface level shall be as high as *practical*, but no lower than the 20 year flood level plus freeboard or 300mm above adjacent ground level.

- Note:**
- a. A flood depth of 0.3m is sufficient to cause a small vehicle to float.
 - b. *Enclosed car parking* is defined in the glossary and typically refers to carparks in basements.

Evacuation

- Reliable access for pedestrians or vehicles required during a 100 year flood.
- Reliable access for pedestrians or vehicles is required from the building, commencing at a minimum level equal to the lowest *habitable floor* level to an area of refuge above the *PMF level*, or a minimum of 20% of the gross floor area of the dwelling to be above the *PMF* level. In the case of alterations or additions to an existing development, this may require retro-fitting the existing structure if required to support a refuge above the PMF.
- The evacuation requirements of the development are to be considered. An engineers report will be required if in the opinion of Council the evacuation of persons might not be achieved within the *effective warning time*.

Management and Design

- If this application involves subdivision, the applicant is to demonstrate that potential development as a consequence of the subdivision, can be undertaken in accordance with this DCP.
- Site Emergency Response Flood Plan* required where floor levels are below the *design floor level*, (except for single dwelling-houses).
- Applicant to demonstrate that an area is available to store goods above the 100 year flood level plus *freeboard*.
- Applicant to demonstrate that an area is available to store goods above the *PMF* level.
- No storage of materials below the *design floor level* which may cause pollution or be potentially hazardous during any flood.
- Applicant to demonstrate that an area is available to store goods at least 500mm above adjacent ground level.

Planning Consideration	Flood Risk and Overland Flow Precincts																							
	Low Flood Risk						Medium Flood Risk						High Flood Risk						Overland Flow					
	Critical Uses & Facilities	Sensitive Uses & Facilities	Residential	Commercial & Industrial	Recreation & Non-Urban	Concessional Development	Critical Uses & Facilities	Sensitive Uses & Facilities	Residential	Commercial & Industrial	Recreation & Non-Urban	Concessional Development	Critical Uses & Facilities	Sensitive Uses & Facilities	Residential	Commercial & Industrial	Recreation & Non-Urban	Concessional Development	Critical Uses & Facilities	Sensitive Uses & Facilities	Residential	Commercial & Industrial	Recreation & Non-Urban	Concessional Development
Floor Level		3	2,6,7	5,6,7	1,6	4,7			2,6,7	5,6,7	1	4,7					1	4,7	3	3	2or8, 6or9, 7	5or8, 6or9, 7	1or8, 6or9	4,7
Building Components		2	1	1	1	1			1	1	1	1					1	1	2	2	1 or 3	1 or 3	1 or 3	1 or 3
Structural Soundness		3	2	2	2	2			2	2	2	2					1	1						
Flood Effects		2	2	2	2	2			2	2	2	2					1	1	2	2	2	2	2	2
Car Parking & Driveway Access		1,3,5,6,7	1,3,5,6,7	1,3,5,6,7	2,3,4,6,7	6,7,8			1,3,5,6,7	1,3,5,6,7	2,3,4,6,7	6,7,8					2,3,4,6,7	6,7,8	1or9, 3, 6	1or9, 3, 6	1or9, 3, 6	1or9, 3, 6	2,3,6	6,8
Evacuation		2	2	1 or 2	3	2			2	1 or 2	3	2					3	2	2	2				
Management & Design		1,4,5	1	1,2,3,5	1,2,3,5	1,2,3,5			1	1,2,3,5	1,2,3,5	1,2,3,5					1,2,3,5	1,2,3,5	1,4,5	1,4,5	1	1,2, 3or6, 5	1,2, 3or6, 5	1,2, 3or6, 5

General Notes:

- Unsuitable Land Use (refer to General Note b)
- No Controls
- a

Freeboard equals an additional height of 500mm. In Overland Flow precincts, the freeboard is 300mm.
- b

The relevant environmental planning instruments (generally the Local Environmental Plan) identify development permissible with consent in various zones in the LGA. Notwithstanding, constraints specific to individual sites may preclude Council granting consent for certain forms of development on all or part of a site.
- c

Filling of the site, where acceptable to Council, may change the FRP considered to determine the controls applied in the circumstances of individual applications.
- d

Refer to Section 2.3 of the DCP for planning considerations for proposals involving only the erection of a fence. Any fencing that forms part of a proposed development is subject to the relevant flood effects and structural soundness planning considerations of the applicable landuse category.
- e

Refer to Section 2.2 of the DCP for special considerations such as for house raising proposals and development of properties identified for voluntary acquisition.
- f

Terms in italics are defined in the glossary of this plan and Schedule 2 specifies development types included in each land use category. These development types are generally as defined within Environmental Planning Instruments applying to the LGA.

Floor Level

- 1 All floor levels to be no lower than the 20 year flood level plus freeboard unless justified by site specific assessment
- 2 Habitable floor levels to be no lower than the 100 year flood level plus freeboard .
- 3 Habitable floor levels to be no lower than the PMF level. Non-habitable floor levels to be no lower than the PMF level unless justified by a site specific assessment
- 4 Floor levels to be no lower than the design floor level. Where this is not practical due to compatibility with the height of adjacent buildings, or compatibility with the floor level of existing buildings, or the need for access for persons with disabilities, a lower floor level may be considered. In these circumstances, the floor level is to be as high as practical , and, when undertaking alterations or additions, no lower than the existing floor level.
- 5 The level of habitable floor areas to be equal to or greater than the 100 year flood level plus freeboard . If this level is not practical for a development in a Business zone, the floor level should be as high as
- 6 Non-habitable floor levels to be equal to or greater than the 100 year flood level plus freeboard where possible, or otherwise no lower than the 20 year flood level plus freeboard unless justified by site specific assessment.
- 7 A restriction is to be placed on the title of the land, pursuant to S.88B of the Conveyancing Act, where the lowest habitable floor area is elevated above finished ground level, confirming that the undercroft area is not to be enclosed, where Council considers this may potentially occur.
- 8 Habitable floor levels to be minimum 500mm above adjacent ground levels
- 9 Non-habitable floor levels to be minimum 300mm above adjacent ground levels

Building Components & Method

- 1 All structures to have flood compatible building components below the 100 year flood level plus freeboard.
- 2 All structures to have flood compatible building components below the PMF level.
- 3 All structures to have flood compatible building components up to 500mm above adjacent ground levels

Structural Soundness

- 1 Engineer's report to certify that the structure can withstand the forces of floodwater, debris and buoyancy up to and including a 100 year flood plus freeboard, or a PMF if required to satisfy evacuation criteria (see below). In the case of alterations or additions to an existing development, the structure to be certified is that which is proposed to be newly constructed or otherwise required to be of a specified standard to satisfy other controls.
- 2 Applicant to demonstrate that the structure can withstand the forces of floodwater, debris and buoyancy up to and including a 100 year flood plus freeboard, or a PMF if required to satisfy evacuation criteria (see below). An engineer's report may be required.
- 3 Applicant to demonstrate that any structure can withstand the forces of floodwater, debris and buoyancy up to and including a PMF An engineers report may be required.

Flood Effects

- 1 Engineer's report required to certify that the development will not increase effects elsewhere, having regard to: (i) loss of flood storage; (ii) changes in flood levels and velocities caused by alterations to conveyance of flood or overland flow waters; and (iii) the cumulative impact of multiple potential developments in the floodplain.
- 2 The flood impact of the development to be considered to ensure that the development will not increase flood effects elsewhere, having regard to: (i) loss of flood storage; (ii) changes in flood levels and velocities caused by alterations to the flood conveyance ; and (iii) the cumulative impact of multiple potential developments in the floodplain. An engineer's report may be required.

Car Parking and Driveway Access

- 1 The minimum surface level of open car parking spaces or carports shall be as high as practical , and not below: (i) the 20 year flood level plus freeboard; or (ii) the level of the crest of the road at the location where the site has access; (which ever is the lower). In the case of garages, the minimum surface level shall be as high as practical , but no lower than the 20 year flood level plus freeboard.
- 2 The minimum surface level of open car parking spaces, carports or garages, shall be as high as practical .
- 3 Garages capable of accommodating more than 3 motor vehicles on land zoned for urban purposes, or enclosed car parking, must be protected from inundation by floods equal to or greater than the 100 year flood.
- 4 The driveway providing access between the road and parking space shall be as high as practical and generally rising in the egress direction
- 5 Where the level of the driveway providing access between the road and parking space is lower than 0.3m below the 100 year flood, the following condition must be satisfied - the depth of inundation on the driveway during a 100 year flood shall not exceed: (i) the depth at the road; or (ii) the depth at the car parking space. (Refer to Schedule 3). A lesser standard may be accepted for single detached dwelling houses where it can be demonstrated that risk to human life would not be compromised.
- 6 Enclosed car parking and car parking areas accommodating more than 3 vehicles with a floor level below the 20 year flood level plus freeboard or more than 0.8m below the 100 year flood level, shall have adequate warning systems, signage and exits.
- 7 Restraints or vehicle barriers to be provided to prevent floating vehicles leaving a site during a 100 year flood
- 8 Driveway and parking space levels to be no lower than the design ground/floor levels. Where this is not practical , a lower level may be considered. In these circumstances, the level is to be as high as practical , and, when undertaking alterations or additions, no lower than the existing level.
- 9 The minimum surface level of open car parking spaces or carports shall be as high as practical , and not below: (i) the 20 year flood level plus freeboard; or (ii) the level of the crest of the road at the location where the site has access; or (iii) 300mm above adjacent ground level; (which ever is the lower). In the case of garages, the minimum surface level shall be as high as practical , but no lower than the 20 year flood level plus freeboard or 300mm above adjacent ground level.

- Note:
- a. A flood depth of 0.3m is sufficient to cause a small vehicle to float.
- b. Enclosed car parking is defined in the glossary and typically refers to carparks in basements.

Evacuation

- 1 Reliable access for pedestrians or vehicles required during a 100 year flood
- 2 Reliable access for pedestrians or vehicles is required from the building, commencing at a minimum level equal to the lowest habitable floor level to an area of refuge above the PMF level , or a minimum of 20% of the gross floor area of the dwelling to be above the PMF level. In the case of alterations or additions to an existing development, this may require retro-fitting the existing structure if required to support a refuge above the PMF.
- 3 The evacuation requirements of the development are to be considered. An engineers report will be required if in the opinion of Council the evacuation of persons might not be achieved within the effective warning time .

Management and Design

- 1 If this application involves subdivision, the applicant is to demonstrate that potential development as a consequence of the subdivision, can be undertaken in accordance with this DC
- 2 Site Emergency Response Flood Plan required where floor levels are below the design floor level, (except for single dwelling-houses).
- 3 Applicant to demonstrate that an area is available to store goods above the 100 year flood level plus freeboard.
- 4 Applicant to demonstrate that an area is available to store goods above the PMF level.
- 5 No storage of materials below the design floor level which may cause pollution or be potentially hazardous during any flood
- 6 Applicant to demonstrate that an area is available to store goods at least 500mm above adjacent ground leve

APPENDIX E

PUBLIC RESPONSE FROM DRAFT PLAN

Eastwood & Terrys Creek Floodplain Risk Management Study & Plan SUBMISSIONS FROM PUBLIC EXHIBITION HELD MARCH 2009

A total of 20 submissions were received following the exhibition. Subsequent to the public meeting held 10 June 2009 and Council's Committee Meeting held 25 June 2009, additional submissions from a few of the original respondents have also been received.

Approximately one quarter of the submissions were critical of the flood study model despite the community's endorsement of the model through the previous public display of the 1984 flood simulation. These submissions were generally from the Vimiera Road area and were prepared by residents who had previously made representations concerning the accuracy of the flood model. A main issue appears to be the perceived impact on property values that might occur if the flood mapping was accepted by Council. The respondents seem to be unaware that Council already has estimates of flood prone land in the study area and that these maps already show many of their properties to be flood prone. (These maps have been derived based on local knowledge, numerical assessments and the extensive experience of Council drainage officers over many years). A small petition was also included with one of the submissions, calling for a new flood model to be established.

Consultation

There has been extensive consultation with the local community both prior to and after the public exhibition of the draft report. The consultation has included:

- (a) exhibition of the 1984 flood simulation in August 2007. This was provided in three languages. All landowners were invited by letter to attend and comment on the exhibition. As a result of the feedback, the Council's Committee subsequently adopted the model and proceeded to investigate options and to prepare the draft plan which was exhibited in March this year;
- (b) in late 2008, three Vimiera Road residents (lower part of Area 7), made representations to Council concerning the accuracy of the model. Three site meetings were held with the residents and additional information was provided. (A copy of the model files had previously been provided to one of these residents). They also requested that some additional inlet pits be simulated in the model. Council arranged for this modelling to be carried out although the pits were small and made no significant difference to flood behaviour;
- (c) the three residents were also given an opportunity to put their concerns to the Committee meeting in November 2008. A major issue raised related to the location of anecdotal depth observations from the 1984 flood and recorded in Council's data-base. Although none of the residents was living in Vimiera Road in 1984, they collected further information from previous owners and requested the Committee to reposition the depth observation locations. The residents believed that there were significant errors in the model and that the repositioning of the flood observation locations would demonstrate this error. Nevertheless the repositioned observations only further verified the model and the committee decided to exhibit the draft report and plan (with the modified locations);

- (d) after the exhibition, these residents provided Submissions 6, 18 and 19 and a number of other residents from Area 7, also provided submissions;
- (e) all respondents were invited to the public meeting held on 10 June 2009;
- (f) after this, three follow-up meetings were held at residences in Jupp Place and Milham Avenue, and also at Council's Depot offices, which were attended by five respondents (in total);
- (g) attendees at the public meeting were also given the opportunity to attend (and speak to) the Committee meeting on 25 June 2009. Residents who spoke at the committee meeting were requested to put their comments in writing and this material has been received by Council. Copies of the computer models were also requested by some residents and these computer files were subsequently provided by Council.

Prior to reviewing the submissions in detail, some background to modelling accuracies and use of the 1984 flood model simulation may be beneficial.

Model Accuracies for FRMS&Ps

- (a) The model used for this study is one of the most sophisticated currently available in Australia. The study area totals some 5.2 million m² of which Area 7 comprises 1.1 million m². The model calculates flood levels over a 3m by 3m grid and is therefore of enormous complexity. Its accuracy and its ability to model flowpaths in urban networks far exceed those of other models previously used by Council.
- (b) Council's study is one of many flood studies in urban environments that are funded under the State's flood mitigation program and managed by the Department of Environment and Climate Change (DECC). DECC have overseen the selection, calibration and operation of the model used for this study, as they have for numerous other studies across the state. DECC would not be continuing to support and fund the study if it had concerns over the accuracy of the model or its application within the current study.
- (c) As can be seen from the flood maps that have been prepared, in many areas the aerial extent of inundation doesn't change much between floods of different magnitudes and therefore refinement of the model would be unlikely to alter flood affection of properties to any significant extent. The prediction of some flood depths within properties would change if extra ground levels and features are included, but changes in the flood levels would be expected to be minor.
- (d) There has been a mammoth effort involved in the collection of data used in the model to date. This has far exceeded the effort on previous modelling exercises in Council's area and resulted in the production of a very detailed model. Nevertheless it is recognised that the model can be improved with the addition of finer scale information. It has always been the case that when new developments are being considered on particular properties, applicants can carry out additional field survey and prepare refinements to Council's model, should the circumstances warrant it. Council will always use the best available information when assessing developments.

Use of the November 1984 Flood Simulation in Area 7

- (a) A number of the submissions referred to inaccuracies in the 1984 flood simulation. Some writers of these submissions maintain an inappropriate view of the use of the 1984 flood simulation in the study process, despite various meetings with Council staff and the Consultants during which the proper use of the 1984 flood simulation was explained.
- (b) Some residents continue to point out known inaccuracies in the 1984 flood in some specific areas, which are of no consequence in the simulation of the design floods (such as the 100 year ARI event) which are the primary outcomes of the flood study.
- (c) The 1984 flood simulation provided a useful reference point against which to check the model by comparing the model results at key locations where recorded information was available. The comparison presented in Table 5 of the Flood Study report indicates that the model performed well at these locations. Further, the public exhibition held in August 2007 also gave the community an opportunity to confirm that the model was adequately reproducing the historical behaviour.
- (d) In respect of Area 7 and Vimiera Road, whilst there were some anecdotal information about flooding in 1984, there were no flood marks surveyed following the 1984 event. As surveyed flood marks were the primary means of calibrating the model, no calibration of the Area 7 section of the model was carried out but rather typical model parameters were adopted. The flood behaviour in this area is largely dominated by overland flows travelling through private yards where yard features such as fences and other obstructions may significantly influence local flood behaviour. Such features can vary with time and may not be subject to a DA, and therefore design floods were simulated using model parameters which reflected typical yard conditions.
- (e) Nevertheless the 1984 simulation was presented for Area 7 in the draft report and there have been numerous submissions raised about it. Further the original 1984 simulation that was reported, only coarsely represented 1984 conditions because the additional effort required to more accurately model it was not considered warranted, given that there were no surveyed flood marks available for use in calibration.
- (f) Following the June 2009 public meeting, and at the request of some Vimiera Road residents, Council commissioned further model refinements to better incorporate the 1984 conditions into the simulation of this flood for Area 7. This information was reported at the June 2009 Committee meeting.
- (g) There is anecdotal flood information in Area 7 which could be used to provide an overall check of the model performance. This comprises information in the Oakes Avenue to Balaclava Road area, Jupp Place, and Vimiera Road. This included the previous flood depth observations for the 1984 flood in Vimiera Road which were subsequently repositioned following the November 2008 Committee meeting.

- (h) The revised 1984 simulation will now be more accurate than that presented in the draft report that was exhibited. Nevertheless given the difficulties in determining conditions some 25 years ago, the simulation will remain an estimate. (These conditions include ground levels, the extent of built development, stormwater infrastructure, blockage, rainfall intensity and both the temporal and spatial distribution of rainfall).
- (i) Comparing the revised simulation with the anecdotal information indicates that simulated 1984 flood levels were typically between 0.0 and 0.2m of the observed levels. This confirms that the model is reasonably reproducing the observed 1984 flood behaviour, but nonetheless given the uncertainties in modelling such an event and the uncertainties in the anecdotal information to which it is compared, there is insufficient basis to deviate from the model parameters that were adopted.
- (j) In summary, and as explained to residents on numerous previous occasions, the model parameters for Area 7 which are proposed for adoption by Council are regional parameters typical for overland flow areas such as Area 7, and are not the result of direct model calibration using the 1984 simulation. Nevertheless the anecdotal information for this flood is reasonably consistent with the model.

Response to Written Submissions

A summary of the submissions together with responses to each of the issues raised, was prepared for consideration by Council's Committee.

One of the most significant responses concerns the possible changes to the proposed flood risk precinct system to either remove or rename the precinct applying to inundation caused by shallow overland flow. This is discussed further in the following section.

Amendments to the Flood Risk Precinct System in Shallow Overland Flow Areas

- (a) There have been previous discussions with the Committee concerning the classification of shallower overland flow areas into the flood risk precinct system (refer Section 4.2 of the Main Report). There was a view at the time which has been echoed in some of the submissions, that to classify inundation from overland flow as "flooding" in areas distant from the main watercourse, may lead to misunderstandings in the community.
- (b) There would appear merit to applying a different classification system in shallow overland flow areas as this may alleviate unnecessary perceptions associated with the term "flooding". Further, in these overland flow areas, having regard to the generally limited flood range experienced when compared with watercourses and creeks, the likely risk (as defined in Section 4.2 of the Main Report) would also be less than for comparable inundation depths adjacent to creeks. In some very shallow inundation areas, it may not be appropriate to have a classification system at all.
- (c) Consequently it is suggested that the Committee recommend that after adoption of the draft report by Council, areas subject to shallow overland flow and

currently mapped in the draft medium flood risk precinct, be re-classified to remove the flood connotation. The revised classification then be referred back to Council for approval prior to any substantial implementation of the proposed Plan.

Summary of Suggested Outcomes from Public Submissions

- (a) Council officers be advised of the requirements of the RTA and Sydney Water;
- (b) resident suggestions (for expansion of the scheme) be considered when investigations of the 1-7 Abuklea Road drainage upgrades commence;
- (c) resident concerns relating to creek vegetation, debris, siltation, water quality and protection of the Blue Gum High Forest in Vimiera Reserve be referred to the appropriate sections within Council;
- (d) extended inlet pits be provided in Brabyn Street and a hooded inlet be provided in Jim Walsh Park;
- (e) Council's Committee consider the views of a number of Area 7 residents including the respondents from Vimiera Road, that greater priority be given to works to alleviate Area 7 problems in lieu of those associated with the Eastwood CBD;
- (f) Council's Committee consider the merits of a large detention basin in Jim Walsh. This would need to be investigated further through a feasibility study looking at geotechnical, landscaping, vegetation, flood mitigation and recreational issues. The study's objectives would be to refine the impacts, benefits and costs of the basin and to make a recommendation to Council;
- (g) Council's Committee recommend that following adoption of the draft report, areas of shallow inundation that are distant from current or past watercourses, be re-classified as an 'overland flow risk precinct' (or similar wording), or be given no inundation classification at all;
- (h) the residents' petition be received and considered;
- (i) Hornsby Shire Council be informed of a resident request for a similar FRMS&P to be prepared for the portion of Terrys Creek catchment which lies within their LGA;
- (j) advice be provided to residents and business owners on the use of temporary flood proofing measures including flood gates and barriers, as part of the proposed community education program;
- (k) the respondent who developed a revised Eastwood CBD drainage option be advised that his option has not been endorsed by the Committee; and
- (l) a summary of the resident's submissions and the Committee's responses be included in the draft report.