WELLINGTON FLOODPLAIN RISK MANAGEMENT STUDY 2013 SUMMARY & FLOODPLAIN RISK MANAGEMENT PLAN

S1. BACKGROUND

S1.1. Status of Wellington Floodplain Management Plan

The Wellington Floodplain Management Study and Plan were originally prepared in 1996 by Lyall & Macoun Consulting Engineers and the Plan subsequently adopted by Wellington Council. The 1996 Study described the Wellington floodplain and defined flooding characteristics, quantified flood damages and determined flood hazard. Existing and potential floodplain management measures were described and appropriate measures for inclusion in the Floodplain Management Plan were identified and prioritised.

Subsequently, staff from Lyall & Macoun formed Evans & Peck. Wellington Council engaged Evans & Peck to carry out a review of the 1996 Plan and its implementation in light of the publication of the NSW Government's 2005 *Floodplain Development Manual* ('2005 FDM') and the time elapsed since the preparation of the original Plan.

This *Floodplain Risk Management Study* (FRMS) 2013 contains:

- an update of the out-of-date sections and appendices of the 1996 Study;
- a revised and updated *Floodplain Risk Management Plan* (FRMP) 2013 that takes into account:
    - the terminology and philosophy in the 2005 FDM;
    - the actions taken by Council to implement the 1996 FRMP;
    - the requirement for Council to incorporate new elements and revise existing elements in the FRMP.

This Summary presents the updated findings of the FRMS 2013, including the updated FRMP.

S1.2. NSW Flood Prone Land Policy & the Floodplain Development Manual

The primary objective of the NSW Government's Flood Prone Land Policy 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. At the same time, the policy recognises the benefits flowing from the use, occupation and development of flood prone land. The policy promotes the use of a merit approach which balances social, economic, environmental and flood risk factors to determine whether particular development or use of the floodplain is appropriate and sustainable.

The *Floodplain Development Manual* (NSW Government, 2005) ('2005 FDM') was prepared in accordance with the NSW Government's Flood Prone Land Policy. It guides councils in the development and implementation of detailed local floodplain risk management plans to produce robust and effective floodplain risk management outcomes. The 2005 FDM also outlines the technical assistance provided by the State Government throughout the floodplain risk management process.

The FRMS 2013 takes into account the changes in the 2005 FDM and updates the 1996 Study in keeping with the updated approach.

The steps involved in formulating and implementing a FRMP are shown in **Figure S1**, which depicts the Floodplain Risk Management Process as outlined in the 2005 FDM. The Floodplain Risk Management Process was developed in response to, and is consistent with, the NSW Flood Prone Lands Policy.

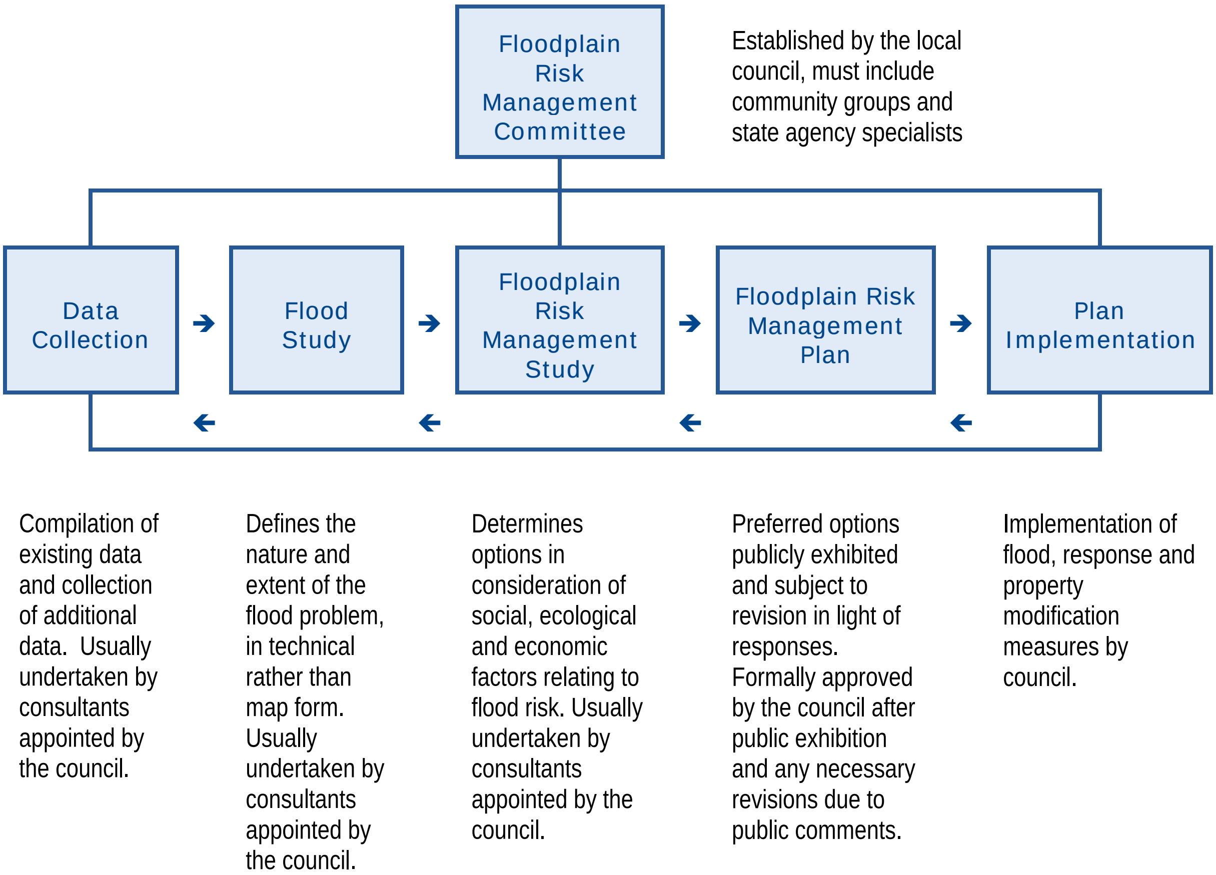


Figure S1: The Floodplain Risk Management Process

A Floodplain Risk Management Plan is an integrated mix of management measures for the floodplain that address existing, future and residual flood risks. These plans are based on a detailed analysis of the impact of floods on existing land-uses and infrastructure, together with an assessment of future needs and community expectations regarding uses of the floodplain. In addition to flooding behaviour Floodplain Risk Management Plans also consider the social, economic and environmental impacts of flooding, floodplain management measures and the development of flood-liable lands. In this way, a Floodplain Risk Management Plan represents a responsible and equitable compromise between the use of the floodplain for various purposes and the impact of flooding on adopted land-uses.

Such an approach will limit future flood losses to socially responsible levels whilst ensuring that floodplains are not unnecessarily sterilised, nor development unreasonably restricted - providing that development is adequately controlled and does not adversely affect flooding behaviour to an unacceptable degree, either at the development site or elsewhere.

S1.3. Definitions

There are a number of terms which have specific meaning in relation to floods and floodplain management. The following definitions, as provided by the 2005 FDM, reflect current government policies that are relevant to Wellington:

Flood liable land: The area of land which is subject to inundation by floods up to and including an extreme flood such as a probable maximum flood (PMF). Synonymous with *flood prone land* and *floodplain*.
***Flood mitigation work*:** Work designed and constructed for the express purpose of mitigating flood impacts. It involves changing the characteristics of flood behaviour to alter the level, location, volume, speed or timing of flood waters to mitigate flood impacts. Types of works may include excavation, construction or enlargement of any fill, wall, or levee that will alter riverine flood behaviour, local overland flooding, or tidal action so as to mitigate flood impacts.
Flood planning levels (FPL): The combinations of flood levels (derived from significant historical flood events or floods of specific AEPs) and freeboards selected for floodplain risk management purposes, as determined in management studies and incorporated in management plans.
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 typical residential uses). (See also Risk).
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.
***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.
Hazard: Flooding which has the potential to cause damage to the community. Definitions of high and low hazard categories are provided in Appendix L of the 2005 FPM.
High Flood Risk Precinct: Those parts of the floodplain where the depth and velocity of flood waters and evacuation difficulties would pose an unacceptable risk to types of development and activity. For Wellington, the High Flood Risk Precinct is the area of land subject to **high hydraulic hazard (floodway) in a 1% AEP flood event**. The flood hazard in this area cannot be reduced by methods such as filling without creating unacceptable flood hazard elsewhere on the floodplain. In comparison, the flood hazard in a high hydraulic flood fringe area can be managed by methods such as filling without adversely affecting flood hazard elsewhere on the floodplain.

Medium Flood Risk Precinct: Those parts of the floodplain where there would still be a significant risk of flood damage, but these damages can be minimised by the application of appropriate development controls. For Wellington, the Medium Flood Risk Precinct applies to land area **below the extent of the 1% AEP flood level +0.5 m, but above the high hazard 1% AEP extent.**
Low Flood Risk Precinct: Those parts of the floodplain where the risk of damages is low for most land uses and, therefore, most land uses would be permitted. Those uses considered critical or requiring maximum protection against risk from flooding should be identified as undesirable land uses in this precinct. For Wellington, the Low Flood Risk Precinct **applies to all land within the floodplain (i.e. within the extent of the PMF) not identified as being within either the High or Medium Flood Risk Precincts.**
Merit approach: The principles of the merit approach are embodied in the FDM (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 wellbeing of the State's rivers and floodplains.
Probable maximum flood (PMF): The largest flood that could conceivably occur at a particular location. The land inundated by this flood is '*flood liable land*'. For Wellington, the '*Extreme Flood*' (see below) has been adopted as a surrogate for the PMF.
Extreme flood: Because of the flood mitigation effect of Burrendong Dam and the complex interactions between floods on the Macquarie River and Bell River, a simple definition of the PMF is not possible for Wellington. For purposes of defining '*flood liable land*' two extreme flood scenarios (notionally 0.002% AEP) have been assessed: • Extreme Flood in the Macquarie River (EMAC) which has been defined as the flood levels arising from a combination of the flow at Wellington resulting from the PMP design flood inflow to Burrendong Dam with the dam full at the commencement of the flood and without dam failure (20,000 m^3/s) and the 1% AEP flow in the Bell River (2,140 m^3/s). • Extreme Flood in the Bell River (EBELL) which has been defined as the flood levels arising from a combination of an extreme flood in the Bell River (8,350 m^3/s) and a 1%AEP flood in the Macquarie River (2,800 m^3/s).
Reliable access: Reliable access during a flood means the ability for people to safely evacuate an area subject to imminent flooding to a defined regional evacuation route within effective warning time, having regard to the depth and velocity of flood waters, the suitability of the local evacuation route, and without a need to travel through areas where water depths increase.
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).

S1.3.1. Flood Frequency

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

Annual Exceedance Probability (AEP) %	Average Recurrence Interval (ARI) - years
0.2	500
0.5	200
1	100
5	19.5
20	4.5
50	1.4

The AEP of a flood represents the percentage chance of its being equalled or exceeded in any one year. Thus a 5% AEP flood has a 5% chance of being equalled or exceeded in any one year; a 1% AEP flood has a 1% chance, and so on. The larger the flood the smaller the chance of its being experienced. A 1% AEP flood is also equivalent to a 100 year ARI flood. Over a long period of, say 1000 years, 10 such floods would be expected to occur, at an average frequency of once in 100 years. This does not mean that a 100 year ARI flood will occur at regular intervals, or that only one 100 year ARI flood will be experienced in any 100 year period.

While a 1% AEP flood is a major flood event, it does not define the upper limit of possible flooding. Over the course of a human lifetime of, say 70 years, there is a 50% chance that a flood at least as big as a 1% AEP will be experienced. There is a 30% chance that a 0.5% AEP flood will be experienced over this period.

Reference is also made in this report to "extreme" flood events on the Macquarie and Bell Rivers. These floods approximate the upper limit of flooding on these two streams and are extremely rare floods. Such floods are analysed to determine the consequences of an event much greater than the floods on which the Flood Planning Levels are based, so that appropriate planning and response measures may be considered for inclusion in the FRMP. The definition of the extreme floods in Wellington is provided in Section S1.3 above.

S2. FLOOD CHARACTERISTICS

S2.1. Physical Setting

The town of Wellington is located at the confluence of the Macquarie and Bell Rivers in the north-west of NSW, about 350 km from Sydney, and has a population of 5,400. Upstream of the confluence, the Macquarie River has a catchment area of 14,250 km^2. The Bell River has a catchment of 1,860 km^2.

There are two major water storage dams upstream of Wellington. Burrendong Dam (completed in 1965) is located at the confluence of the Macquarie and Cudgegong Rivers approximately 30 km upstream of Wellington, and Windamere Dam (completed in 1984) is situated on the Cudgegong River approximately 30 km upstream of Mudgee.

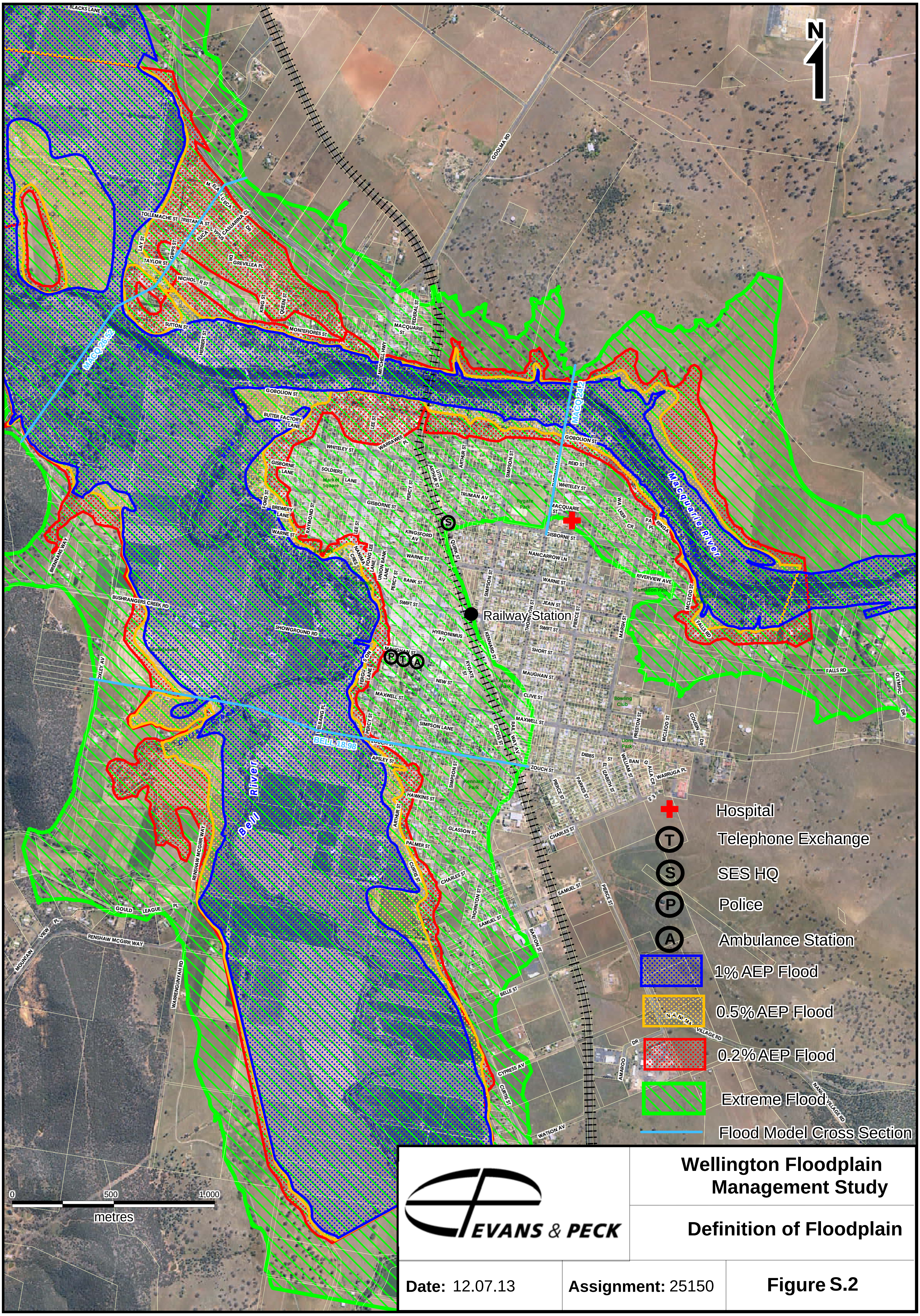
Burrendong Dam has a total catchment area of 13,900 km^2, which is approximately 86% of the catchment at Wellington. The dam has a total storage volume of 1,680 GL of which 480 GL is allocated to flood mitigation. This flood mitigation volume represents approximately half the volume of runoff which passed the dam site in the February 1955 flood. That flood resulted in the highest recorded flood level in the 19th century on the Macquarie River at Wellington.

Due to the high percentage of the catchment controlled by the dam, the large flood mitigation capacity and the planned operation of the spillway gates during floods, Burrendong Dam has a significant effect on the majority of flood events at Wellington. If the dam had been in existence at the time of the February 1955 flood, the flood peak at the Mitchell Highway bridge in Wellington would have been reduced by 8.4 m. A flood which had a peak inflow to the dam greater than the February 1955 flood occurred in August 1990. If the dam had not been in existence, the August 1990 flood would have been 3.5 m higher than the recorded peak at the Mitchell Highway bridge.

Windamere Dam has a total storage capacity of 368 GL and controls a catchment area of 1,070 km^2, which represents about 7% of the catchment area at Wellington. The reservoir has no reserved storage capacity or operating rules designed to reduce flood flows. The small proportion of the catchment controlled by the dam together with the absence of flood mitigation storage or operating rules mean that the dam has no significant effect on flood flows at Wellington.

As shown in **Figure S2**, most of the urban development including the main business and commercial area in Wellington is located in the wedge of land between the left bank of the Macquarie River and the right bank of the Bell River (looking downstream). Approximately 590 ha of land within the study area would be inundated in the event of a 1% AEP flood. Of this, about 40 ha is zoned as environmental management or for residential or business uses, with the remainder being zoned largely for open space or agriculture.

The 0.5% AEP flood would be about 1 m higher than 1% AEP flood and would inundate about 660 ha of which about 55 ha are zoned for residential or business purposes. The 0.2% AEP flood would be a further 1 m higher than the 0.5% flood and would inundate approximately 740 ha, including about 90 ha zoned for residential and business purposes.



N
Macquarie River
Bell River
Railway Station
MACQ292
MACQ212
BELL18.98
Hospital
Telephone Exchange
SES HQ
Police
Ambulance Station
1% AEP Flood
0.5% AEP Flood
0.2% AEP Flood
Extreme Flood
Flood Model Cross Section
0
500
1,000
metres
EVANS & PECK
Wellington Floodplain Management Study
Definition of Floodplain
Date: 12.07.13
Assignment: 25150
Figure S.2

Depending on location, the EMAC event would be around 12.5 m higher than the 1% AEP flood. In such a flood approximately 1,100 ha within the study area would be flooded.

S2.2. Floodplain Definition and Topography

Flooding in Wellington is influenced by the magnitude and synchronisation of flows in the Macquarie and Bell Rivers. Most of the town is considered to be flood free even for major floods of the order of 0.2% AEP, but parts of the commercial area near the Mitchell Highway - Warne Street intersection have been subject to flooding. Floodwaters enter this area by surcharging the banks of the Bell River either due to high flows in the Bell River alone, or in conjunction with backwater flooding from the Macquarie River. Properties along Ford Street and Gobolion Street, low lying rural properties on the Bell River floodplain and parts of Montefiores are also subject to inundation.

The Macquarie River upstream of the confluence has an incised channel about 15 m deep with a confined overbank area. For the 1% AEP flood, the width of flow would be 150 m and flow velocities in excess of 2 m/s. The difference in peak level between 5% and 1% AEP is about 3 m.

The Bell River, by comparison, has a much smaller channel, typically around 5 m deep and 50 m wide, but a much more extensive floodplain. The bank is overtopped in the event of minor floods of the order of 10% AEP, and the floodplain is inundated to a depth of about 2 m for floods of 5% AEP. For a 1% AEP flood the maximum depth of inundation on the left bank would be about 3 m and the width of flow in excess of 1 km. The difference in peak flood levels between 5% and 1% AEP floods is only about 1 m. For a 1% AEP flood, the flow velocity would be of the order of 1.0 - 1.2 m/s in the channel and 0.5 m/s on the floodplain. Backwater influences from the Macquarie River extend upstream as far as Maughan Street.

Downstream of the confluence of the Bell and Macquarie Rivers the floodplain of the Macquarie River becomes more extensive, with a width of around 800 m for a 1% AEP flood. The difference in peak levels between 5% and 1% AEP floods would be about 3.2 m. Flow velocities are generally higher than above the confluence, reflecting the increase in bed slope, which averages 1 m/km. The maximum velocity in the channel would be experienced at a narrow section about 1 km downstream of the confluence where the velocity would increase from 2.5 to 3.2 m/s between 5% and 1% AEP floods.

Two extreme flood conditions, which are designated EMAC and EBELL, have been adopted in this study for defining "extreme" flood conditions for planning purposes:

- Extreme Flood in the Macquarie River (EMAC) which has been defined as the flood levels arising from a combination of the flow at Wellington resulting from the PMP design flood inflow to Burrendong Dam with the dam full at the commencement of the flood and without dam failure (20,000 m^3/s) and the 1% AEP flow in the Bell River (2,140 m^3/s).
- Extreme Flood in the Bell River (EBELL) which has been defined as the flood levels arising from a combination of an extreme flood in the Bell River (8,350 m^3/s) and a 1% AEP flood in the Macquarie River (2,800 m^3/s).

The EMAC case gives the higher levels and has been adopted in this study for defining "extreme" flood conditions for planning purposes.

In 2001, State Water undertook safety studies of all major dams as part of the *24 Dams Portfolio Risk Assessment* (SKM, 2001). As part of these safety studies, the Burrendong risk analysis estimated the discharge from the dam as 20,000 m^3/s (probable maximum design flood without dam failure), compared to 15,700 m^3/s used in the 1996 Study. As part of this 2013 update, the EMAC was re-modelled with the revised estimate of the Macquarie River discharge at Wellington. The resulting increase in EMAC flood levels in the Macquarie River range between 2.5 m and 5 m, with an average increase of around 3.6 m, when compared with the 1996 EMAC results.

A rural flood mitigation scheme was implemented for the lower reaches of the Bell River in the 1980s, extending from the golf course to a location just upstream of the confluence with Curra Creek. The scheme aimed at confining minor flood flows, up to around the 30% AEP level, in the main channel and in defined floodways and depressions on the floodplain, thereby providing protection for up to 400 ha of river flats under cultivation outside these flooded areas.

S3. HOW FLOODING AFFECTS THE COMMUNITY

The numbers of flood affected properties and the resulting flood damages for various floods are summarised in **Tables S1** and **S2**. **Table S1** makes the distinction between flood "affected" properties where the water can be expected to be on the land around the house (to within the 0.5 m freeboard allowance) and flood "damaged" properties where the flood water would be above the floor of the property and cause some damage.

Table S1: Total Number of Properties Inundated

Flood Event (% AEP)	Number of Properties Inundated						
	Residential		Commercial / Industrial		Caravans	Public Buildings	
	A	B	A	B	A / B	A	B
5%	30	6	1	1	0	1	1
2%	36	25	4	4	0	1	1
1%	87	47	6	6	5	2	1
0.5%	164	102	20	14	10	2	2
0.2%	393	327	36	31	15	4	4
EMAC	1,134	1,131	73	73	38	18	18
EBELL	636	629	69	69	32	11	10

Note: A – flood-affected property (flooded to within 0.5 m freeboard allowance)
B – flood-damaged property

Table S2: Estimated Flood Damages (2012 Values)

Flood Event % AEP	Residential $ x 1,000	Commercial / Industrial $ x 1,000	Caravans $ x 1,000	Public Buildings $ x 1,000	Total $ x 1,000	Cum AAD $ x 1,000
5%	795	5	0	650	1,450	109
2%	1,799	74	0	650	2,523	168
1%	3,541	158	250	650	4,599	204
0.5%	8,070	323	500	685	9,578	239
0.2%	22,625	1,058	780	1,032	25,495	292
EMAC	122,455	25,383	1,961	9,317	159,116	475
EBELL	60,603	18,487	1,630	4,653	85,373	

The data in **Table S2** indicate that flood damage within Wellington could be as high as $159 million as a result of an extreme flood. Overall the average annual damages attributable to flooding in Wellington are modest and reflect the considerable flood protection already afforded to Wellington by Burrendong Dam.

The data in **Tables S1** and **S2** update the 1996 results. The numbers of residential properties impacted and the estimated value of damages has increased due to the following factors:

- additional properties have been included in the analysis as a result of the revised estimate of the extreme flood;
- residential damage estimates have been updated based on the DECC Guideline methodology;
- application of CPI to 1996 commercial and public damage estimates to update to 2012 values.

The use of the DECC's Guideline to calculate residential damages has substantially increased the value of estimated residential damages and the number of properties classified as flood affected, due to the change in methodology and assumptions made in the DECC Guideline method. It should be noted that there has been **no change in the depth of inundation of properties for any of the modelled flood events**, with the exception of the EMAC.

Tables S1 and **S2** do not include dwellings which may be impacted by overland flooding from the Aspley Drainage system (refer **Section S4.1.3** below). The investigation of the Aspley Drainage system did not include assessment of flood extents, identification of properties flooded, depths of flooding or damages. However, an indication of the numbers of properties which may be impacted by overland flooding caused by the 1% AEP event in this system includes:

- Railway Ave 8
- Zouch St/Cross St 8
- Zouch/Hawkins/Simpson 9
- Arthur St (East) 6
- Arthur St (West) 2
- Apsley St 4

The impact of flooding on infrastructure such as roads, bridges and electricity varies depending on the size of flood. **Table S3** provides a listing of effects of flooding on the infrastructure in Wellington.

Table S3: Qualitative Effects of Flooding on Infrastructure and Community Assets

Damage Sector	Flood Event (% AEP)						
	5	2	1	0.5	0.2	EMAC	EBELL
Electricity	0	3	3	3,8	3,8	3,8	3,8
Telephone	0	0	0	0	0	11	11
Roads	1	1	1	1	1	1	1
Bridges	0	4	4,7	4,7,9	4,7,9	4,7,9,12	4,7,9
Sewerage system	0	5	5	5	5	5,13	5,13
Water supply	0	0	0	0	10	10	10
Parks and showground	2	2,6	2,6	2,6	2,6	2,6	2,6
SES headquarters	0	0	0	0	0	14	0
Hospital (Gisborne St)	0	0	0	0	0	15	0

Notes relating to Table S3:

0. No significant damages likely to be incurred
1. Roads on Bell River floodplain flooded
2. Pioneer Park flooded
3. Power poles at Herbert St bridge and pole mounted transformer on Macquarie/Bell floodplain flooded
4. Herbert St and pedestrian suspension bridge in vicinity of Cameron Park flooded
5. Pump station in vicinity of Arthur and Gobolion Streets flooded
6. Cameron Park and Showground/Racecourse flooded
7. Maughan Street flooded
8. Pad mounted transformer on Maughan Street adjacent to Bowling Club flooded
9. Mitchell Highway flooded
10. Water treatment works flooded
11. Telephone exchange flooded
12. Railway bridge flooded
13. Sewage Treatment Plant flooded
14. SES HQ flood affected
15. Hospital in Gisborne St flood affected

EMAC = Extreme flood in the Macquarie River
EBELL = Extreme flood in the Bell River

Flooding of the Macquarie and Bell Rivers raises the following social implications for life in Wellington:

- Significant tracts of rural land within the study area are used for market gardens and other agricultural pursuits. These areas are contained within the fertile floodplain of both the Macquarie and Bell Rivers. Flooding of these areas has the potential for a significant impact on the economic viability of such activities and commensurate social impact both on the land owners and businesses which depend upon the viability of those activities.
- Main Road No. 233 (Maughan Street) passes through Wellington. Residents of rural areas to the west of Wellington are inconvenienced when that main road is severed by floodwaters near the Showground/Racecourse.

- Percy Street/Mitchell Highway is the "main" street of Wellington. This section of Wellington contains the majority of the business/commercial and retailing activity of Wellington. This area could be flooded for several days during the extreme flood event causing significant social disruption to the town and the surrounding rural areas.
- As expected, an extreme flood would also impact on significantly more residential property than the 1% AEP flood. In an extreme flood the area generally bounded by Whiteley Street, the Macquarie River, the Bell River and Percy Street would be subject to flooding, with varying degrees of inundation of structures. A significant section of residential land bound by the Mitchell Highway, Montefiores Street and Lay Street would also be inundated during the extreme event. The social disruption associated with such an event would be significant.
- During an extreme flood, the majority of shops, a number of schools, churches, the post office, motor registry, ambulance station, telephone exchange, police station, SES HQ and the Hospital in Gisborne Street would be inundated, with varying degrees of impact and social upheaval.

S4. FLOODPLAIN MANAGEMENT PLAN

The following sections set out the recommended elements of the Wellington Floodplain Risk Management Plan 2013, and provide information on funding and implementation. The FRMP is summarised on **Table S4**.

In accordance with the requirements of the 2005 FDM, this Plan identifies three broad categories of management actions:

- management of the existing flood risk faced by the existing development;
- management of future flood risk that might arise from new development or redevelopment of the existing housing stock;
- management of the continuing flood risk that remains after all floodplain management measures are implemented.

S4.1. Management of Existing Flood Risk

The management of existing flood risks is concerned with reducing flood impacts on the existing housing stock and community facilities. With the benefit of hindsight it can be seen that some buildings are located inappropriately or have floor levels that give rise to an unnecessarily high risk of flood damage. Management of the existing flood risk is concerned with correcting the worst of these existing problems.

It is recommended that following measures be incorporated in the updated FRMP:

- voluntary purchase;
- voluntary house raising;
- Apsley Drain overland flow investigations and works.

S4.1.1. Voluntary Purchase

Removal of housing is generally accepted as a cost effective means of correcting previous decisions to build in high hazard areas in the floodplain. The voluntary purchase of residential property in hazardous areas has been part of subsidised floodplain management programs in NSW for over 20 years.

Where a property is considered to qualify for a voluntary purchase scheme, the owner is notified that the body controlling the scheme (usually but not always Council) is prepared to purchase the property when the owner is ready to sell. There is no compulsion whatsoever to sell at any time. The price is determined by independent valuers and the Valuer General, and by negotiations between Council and the owners. Valuations are based on an equivalent residence which is not affected by flooding.

The timing of any agreed purchase is at the discretion of the landowner. Once the property is purchased, buildings are usually demolished. The land must then be used for flood compatible activities.

A voluntary purchase scheme could be adopted for houses exposed to hazardous conditions. Investigations by Council since the 1996 Study in conjunction with the updated hazard mapping indicates that 14 residential properties remain located in the high hazard area in 2013 and are considered candidates for inclusion in a voluntary purchase scheme, if it were to be pursued.

Council will need to reach consensus about the criteria to be applied in setting priorities for listing properties on a voluntary purchase program. The process for finalising the houses to be placed on the list is described in *Floodplain Management Guideline for Voluntary Purchase Schemes* and involve the following steps:

- As part of the process of Council's formal adoption of the FRMP, seek agreement in principle to establish a voluntary purchase program and determine the criteria to be applied in placing residences on the program. Such criteria would normally be based on factors such as severity of flooding, hazard and isolation.
- Seek funding subsidies from State and Federal Government.
- Analysis should then be undertaken by Council to determine the flood levels applicable to a particular residence using procedures specified in the Floodplain Management Study, which are to be used in conjunction with the Flood Maps that accompany the FRMS.
- Review and revise the list of candidate properties to be placed on the voluntary purchase scheme using the criteria adopted by Council in adopting the FRMP.
- Make personal approach to each resident concerned to explain the nature of the voluntary purchase program.
- Issue formal letters to residents concerned.

S4.1.2. Voluntary House Raising

House raising refers to raising existing structures by jacking up the house, constructing new supports, stairways and balconies and reconnecting services. It is generally not practical or economical to raise brick or masonry houses. The technique is therefore limited to dwellings of timber frame construction with fibro-cement or timber cladding. House raising is most applicable to dwellings which are not in high hazard areas.

Under the Voluntary House Raising Program, the NSW Government provides financial assistance to raise a dwelling to put the habitable floor level at the FPL, where it is shown to be cost effective.

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

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

Three residential dwellings in Wellington could be candidates for a house raising scheme. It will be necessary for Council to make further investigations regarding the final list of properties it wishes to include in a voluntary purchase scheme in accordance with the *Floodplain Management Guideline for Voluntary House Raising Schemes*.

S4.1.3. Apsley Drain Works

Council identified that the Apsley Drain was a potential source of overland flooding as defined by the 2005 FDM, as it occurs along a trunk system, involves depths of flow in excess of 0.3 m and has the potential to flood a number of properties.

Investigations into the Apsley Drain were carried out as part of the FRMS update. The results indicated that flow is above bank height along the majority of the trunk channel in the 1% AEP flood under existing conditions and that it is sufficiently high to threaten habitable buildings in a number of locations.

A number of mitigation measures to address the under capacity of the system were identified and assessed. Council's preferred option is the construction of a surface detention basin in Apex Park upstream of the railway, as it was found to the most advantageous flood mitigation option of all the options assessed, capable of substantially reducing flows and flood levels throughout the catchment. The benefits of this option include the reduction of both the depth of inundation and the risk of habitable flooding at the following locations:

- in the Railway Avenue area, in the 1% AEP event;
- downstream of Simpson Street;
- between Cross Street and Zouch Streets; and
- on the eastern side of Arthur Street..

Preliminary details of the required basin configuration have been provided as part of the FRMS.

In order to progress the basin option, it is recommended that the following steps be included in the FRMP:

1. Survey floor and ground levels of the properties potentially impacted by overland flooding of the Apsley drainage system and carry out a damages assessment in accordance with the *Residential Flood Damages Floodplain Risk Management Guideline* (DECC, 2007).
2. Investigate the invert levels and cover depths of the stormwater pipelines along Maxwell Street which currently discharge to the open channel downstream of Maxwell Street to determine if it is practicable to divert these pipelines into the detention basin in Apex Park.
3. Undertake concept design of the inlet structure for the diverted pipes, the low flow channel and the outlet at Maxwell Street to determine if the basin is can be constructed for a reasonable cost.
4. Carry out an assessment of Apex Park to determine if there are any current land uses, buildings, buried or above ground services, heritage objects or trees which would provide constraints on the construct or operation of the basin.
5. Consult with the local community to determine if they are amenable to the use of the Park as a detention basin, given the flood mitigation benefits to the catchment.
6. Undertake a costing of the basin and assess the cost:benefit ratio of the proposal, using the damages avoided (from Step 1) as the benefits of the proposal.
7. If the proposal is feasible, acceptable to the community and the cost:benefit analysis is favourable, detailed design followed by construction of the proposal should be carried out.
8. Determine extent of residual overland flow flooding and update LEP flood mapping to allow implementation of planning controls.

Regular maintenance of the drainage system, including the open channel, pipe inlets and outlets, would complement structural flood mitigation measures and provide cost-effective benefits. Inspection of the stormwater system in 2011 identified significant silting of the Apsley Drain stormwater system which has substantially reduced the capacity of the system. This is a relatively inexpensive option to improve conveyance.

S4.2. Management of Future Flood Risk

Management of future flood risk is concerned with ensuring that future development is not subject to unacceptable risk and that existing flood conditions are not exacerbated by unwise future development. The recommended floodplain planning measures are contained in several existing or proposed policy documents, as outlined below.

S4.2.1. Recommended FPL

The 1996 Study recommended that "the flood level corresponding with the 0.5% AEP flood should be used to define flood prone land which will be subject to flood related planning controls in Wellington." No freeboard was included.

In light of the 2005 FDM, the updated recommendation is for a range of FPLs that adopts the default 1% AEP event plus a freeboard of 500 mm for general residential development considerations but an extreme flood event for sensitive uses and critical facilities and emergency management considerations for all development. Other FPLs may be appropriate for specific development components such as non-habitable floors and robust structures such as park amenity buildings.

S4.2.2. Categories of Flood Prone Land

It is recommended that all land inundated by the extreme flood (EMAC) be classified into flood risk 'precincts' that reflect the characteristics of flooding on the land and the consequent hazard. Different flood-related development controls would apply depending on the precinct and the type of development. Three flood risk precincts are recommended for Wellington:

High Flood Risk Precinct	**This refers to land subject to a high hydraulic hazard in a 1% AEP flood.** The High Flood Risk Precinct is where major impacts on flood behaviour, high flood damages, potential risk to life or evacuation problems would be anticipated. Most development should be restricted in this precinct. Without compliance with flood related building and planning controls there would be a significant risk of flood damages and changes in flood behaviour in this precinct.
Medium Flood Risk Precinct	**This refers to the area below the 1% AEP flood level +0.5 m, but above the high hazard 1% AEP extent.** Development within the Medium Flood Risk Precinct would still be at significant risk of flood damage, but these damages can be minimised by the application of appropriate development controls.
Low Flood Risk Precinct	**This refers to all other land within the floodplain that is not in a High or Medium Flood Risk Precinct, that is land above the 1% AEP flood level + 0.5 m and below the level of the PMF.** In the Low Flood Risk Precinct the risk of damages is low for most land uses and, therefore, most land uses would be permitted without flood related development controls. Those uses considered critical or requiring maximum protection against risk from flooding should be identified as undesirable land uses in this precinct.

S4.2.3. Wellington LEP 2012

The 2012 LEP should be amended to incorporate the revised approach presented in the 2005 FDM (as amended by the *2007 Flood Planning Guideline*) as follows:

Flood Planning Clause and Mapping

The LEP flood planning clause provides for the mapping of any area as the "flood planning area" subject to the restrictions provided by the *Flood Planning Guideline*. It is recommended that the clause be amended to define 'flood liable land' consistent with the 2005 FDM as all land inundated up to the extreme flood and provide that the clause applies to all flood liable land. This would allow the terms 'flood planning area', 'flood planning level' (FPLs) and 'flood planning map' to be dispensed with, as the 2005 FDM definitions applying pursuant to the LEP flood planning clause would suffice. This would allow the DCP to be consistent with the LEP where the DCP imposes requirements on critical and sensitive uses above the 1% AEP flood plus freeboard, which are not subject to the restrictions in the Flood Planning Guideline.

These refinements to the LEP clause would retain consistency with the intent of the clause and provide greater simplicity and clearer information to the public.

Prohibition of Development in High Flood Risk Area

The LEP flood planning clause does not allow the introduction of prohibitions on flood sensitive developments generally or within certain parts of the floodplain (e.g. in a floodway). However, Council should consider the full risks of flooding when deciding upon the land use zone to apply to individual properties. If appropriate, Council should apply restrictive zones (such as an 'Environmental' zone) and development standards (such as a larger minimum lot size) available within LEP 2012 when undertaking future reviews.

Suitability of Land Use Zones in High Flood Risk Precinct

Council should review the suitability of the land use zones within the Wellington township based on consideration of planning issues, including flood risk. A preliminary review of the land use zones identified the following areas zoned Environmental Management (E3) within the High Flood Risk Precinct:

- the land immediately south of Montefiores Street;
- the vacant land at the eastern end of Gobolion Street;
- the residential sized lots surrounding Paringa Place;
- the vacant land at the western end of Apsley Street and Hawkins Street.

In these locations, any development or redevelopment currently permitted is unlikely to be acceptably achievable due to the location within the extent of the high flood risk precinct.

S4.2.4. Wellington DCP 2013

DCP 2013 should be amended to reflect the risk management approach to determine appropriate development within the floodplain. This will require an amendment of DCP 2013 to replace the existing flood related development controls contained in section C2 Flood Hazard. The new draft flood risk management DCP provisions should be ratified through the floodplain development management process and endorsed with the adoption of the FRMP, prior to being implemented by Council through the EP&A Act process.

The replacement chapter should generally be structured to conform to the style and level of detail of the overall DCP as far as possible. A recommended replacement chapter is provided in **Appendix E** which incorporates the following:

- Applies to all areas within the LGA affected by flooding (regardless of whether mapped or not).
- Definitions are consistent with the 2005 FDM where relevant.
- Objectives include the broader flood risk management issues such as emergency evacuation and climate change effects.
- Controls relating to:
  - a) Floor level
  - b) Building components and method
  - c) Structural soundness
  - d) Flood affectation
  - e) Car parking and driveway access
  - f) Evacuation
  - g) Management and design.
- Multiple flood planning levels are applied to different parts of a development (eg habitable and non-habitable floors, car parking etc) and different land uses, where appropriate.
- No controls are to apply to standard residential development on land above the 1% AEP (plus freeboard), except a requirement to consider emergency management issues (i.e. ability to safely evacuate or shelter in place during floods up to an extreme flood). This exception will invoke a requirement to apply for "exceptional circumstances" dispensation in accordance with the 2007 *Flood Planning Guideline*. To avoid delaying the implementation of the recommended DCP planning controls, the DCP could be amended in two stages. The second amendment could provide additional controls deferred until "exceptional circumstances" dispensation has been granted.
- Controls are to apply FPLs up to the EMAC to land uses considered more sensitive to flood hazards or which may be critical to emergency management operations or the recovery of the community post floods (eg Hospital, SES, Police, etc.).
- Special considerations for filling and fencing that have the potential to affect flood levels or redirect flow.
- General considerations recognise that compliance with the flood risk management controls is not authorisation for development that would be otherwise unacceptable due to other issues.
- Information requirements which specify the need and scope for a flood study where existing information is not available but flood hazards are suspected.

Flood compatible building materials and methods should be included in a "building code" that could be appended to or referred to in Council's DCP as a standard condition for building in parts of the floodplain.

Central to the recommended DCP controls is the flood planning control matrix. The principal controls contained within the matrix include:

- Minimum floor level of residential dwellings located within the Medium and Low Flood Risk Precinct must be the flood level corresponding to the 1% AEP flood plus 500 mm.
- Controls on the location of essential services such as hospitals and emergency services.
- Restrictions on buildings within the High Flood Risk Precinct - developments must be located outside the High Flood Risk Precinct.
- Strict controls on earthworks and fill that alter land surface levels within the High Flood Risk Precinct.

These controls are similar to those proposed in the 1996 Study and therefore do not result in any additional imposition for developers.

Exempt and Complying Development

The Codes SEPP provides that unless there is sufficient information to confirm that a site is not subject to high flood risks/hazards then the relevant Codes SEPP provisions cannot be applied. That is, unless there is certainty that a site is not high risk/hazard, it must be assumed that it is for the purposes of applying the Codes SEPP. Council advises that they do not have sufficient information to confidently advise that any land is not subject to high flood risk/hazard listed in clauses 3.36C and 3A.38 of the Codes SEPP. It is understood that even with the now available flood mapping in the township there remains some uncertainty as to some of categories listed in the SEPP.

It is recommended that the FRMP specify that at a minimum all areas with no flood risk mapping must be assumed to be a flood storage area, floodway area, flow path, high hazard area, or high risk area for the purposes of the Codes SEPP. Should Council consider that even in the areas where flood risk mapping is now available there remains some uncertainty as to whether some category such as a flow path may exist, Council should specify that these areas also are assumed to be subject to that category. This would have the effect of excluding the application of the Codes SEPP in areas where sufficient flood risk information is not currently available, which would consequently require the lodgement of a DA where flood risk management issues could be reviewed by Council.

S4.2.5. Section 149 Certificates

Council should review the form and content of Section 149 Certificates to consider the following:

- All properties known to be located within the extent of the EMAC should be notified that flood related planning controls apply. This would be subject to the full implementation of the recommended DCP controls recommended, until which time notifications should specify that flood related development controls do not apply to residential development other than specified sensitive uses. This would also have the effect of identifying that the property is a “flood control lot” for the purposes of complying development provisions.

- Inundation from stormwater and overland flow (except for 'local drainage') is 'flooding' under the 2005 FDM and should be recognised on Council's Section 149 certificates.
- Where Council is unsure of whether a property contains flood liable land (due to the lack of flood investigations and mapping in particular areas) a general notation to this effect could be provided with an explanation that a flood study may identify that the land is subject to flooding, in which case flood related controls could apply.
- Noting further flood risk information may be available upon enquiry to Council and/or (if a S149(2) Certificate is being issued) in a Section 149(5) Certificate.
- Provide information on a Section 149(5) certificate that reflects whether a property is known to be flood affected based on existing studies or Council cannot confirm whether a property is flood affected or not due to the absence of existing information.

Appropriate wording for the notifications should be determined based on legal advice. This should occur concurrently with the adoption of the recommended review of LEP 2013 and amendments to DCP 2013 or before. Ideally the revised notifications should reference the flood risk precinct category, if known, for a property and include its definition.

S4.3. Management of Continuing Flood Risk

Even if all flood risk management measures recommended in this study were implemented, there would still be a continuing risk associated with the extreme flood, as the recommended management measures only address flood mitigation at the 1% AEP flood or less. The continuing flood risk is the risk to lives and property from the extreme flood, even after all possible flood risk management measures have been implemented.

The management of continuing flood risk is concerned with ensuring that adverse effects on the community are minimised in the event of floods larger than those used to designate planning controls such as the FPL. This can be achieved through the SES's Local Flood Plan. The information provided in the updated FRMS should be used to update the SES's Local Flood Plan as an action under the FRMP.

Flood awareness, to increase community awareness of areas subject to flood risk and therefore preparedness, should be undertaken by preparing flood risk maps (showing high, medium and low precincts) and incorporating these into the planning controls available to the public and notified on S149 Planning Certificates.

S4.4. Funding

Broad funding requirements for the recommended flood risk management measures updated to 2012 values are provided in **Table S4**, along with a priority ranking in the overall plan.

The estimated costs are the total costs for each scheme, irrespective of where that funding may be obtained. The costs do not include costs for land acquisition, nor do they include compensation to landholders where drainage works are carried out on their land. Payment of compensation, in cases where works are carried out on private property for the assistance of the landholder, may render the scheme not cost effective.

S4.5. Implementation Program

The draft *Flood Risk Management Study and Plan* 2013 was endorsed by the Floodplain Risk Management Committee at its meeting dated 20 August 2013. It was exhibited by Wellington Council from 1 to 30 September 2013. No submissions were received.

The steps to progress the floodplain management process from this point onwards are:

- submit the final FRMP 2013 to Council;
- Council to adopt the FRMP 2013 and submit an application for funding assistance to the OEH;
- as funds become available from the OEH and/or Council's own resources, implement the recommended flood risk management measures in accordance with the ranking in **Table S4**.

The FRMP should be regarded as a dynamic instrument requiring review and modification over time. The catalysts for change could include new flood events and experiences, legislative change, alterations in the availability of funding, reviews of planning strategies and importantly, the outcome of some of the studies proposed in this report as part of the FRMP. In any event, a thorough review every 5 years is warranted to ensure the ongoing relevance of the FRMP.

The action program for implementing the FRMP is therefore:

- confirm the projects set out in **Table S4** and their priority ranking
- carry out design studies for schemes, liaise with residents and implement projects according to priority and funding constraints.

Table S4: Funding Requirements for Recommended Works and Measures

Project	Rank*	Indicative Cost ($)	Comment
Existing Flood Risk			
Voluntary Purchase	2	$1.8 million	Cost given is estimated capital cost of purchasing the 14 residences which are located within the 1% AEP High Hazard Precinct. The NSW Government may fund a portion of the capital cost.
House Raising	3	$195,000	Cost given is estimated cost of raising three timber framed residences at $65,000 each. The NSW Government may fund a portion of the capital cost.
Apsley Drainage Mitigation Measures	1	• Further investigation: Council staff Costs • Concept design & cost estimate: $30,000 • Construction cost (TBA)	Council to implement recommendations of the Apsley Drainage Study. Council to carry further investigations, consultation and costing for the construction of a detention basin at Apex Park.
Future Flood Risk			
Planning Measures	1	Council Costs	Amend LEP 2012, DCP 2013 and S149 certificate notifications.
Continuing Flood Risk			
Provide data for the SES's Local Flood Plan	1	Council/ SES costs	Council/SES to undertake this work using results of this current study.
Flood Awareness	1	Council costs	Council to prepare flood risk maps showing high, medium and low precincts and incorporate into planning controls available to the public and notified on S149 Planning Certificates.

* Note: Measures are ranked within each flood risk category (existing, future and continuing)

Wellington Council

WELLINGTON FLOODPLAIN RISK MANAGEMENT STUDY 2013

November 2013

Date: 26/11/2013

Table of Contents

Table of Contents (ctd)

Appendices

List of Tables

List of Figures

Abbreviations

AEP	Annual Exceedance Probability
AHD	Australian Height Datum
ARI	Average Recurrence Interval
CMA	Catchment Management Authority
Codes SEPP	State Environmental Planning Policy (Exempt and Complying Development Codes) 2008
CPI	Consumer Price Index
DCP	Development Control Plan
DECC	Department of Environment and Climate Change
DLWC	Department of Land and Water Conservation
DP&I	Department of Planning and Infrastructure
DWR	Department of Water Resources
EBELL	Bell River extreme flood
EMAC	Macquarie River extreme flood
EP&A Act	*Environmental Planning and Assessment Act 1979*
FDM	Floodplain Development Manual
FMM	Floodplain Management Manual
FPL	Flood planning level
FRM	Floodplain Risk management
FRMP	Floodplain Risk Management Plan
FRMS	Floodplain Risk Management Study
GIS	Geographic Information System
HNFMAC	Hawkesbury-Nepean Flood Management Strategy
LEP	Local Environmental Plan
LGA	Local Government Area
NOW	NSW Office of Water
OEH	Office of Environment and Heritage
PMF	Probable Maximum Flood
SES	State Emergency Service
WCIC	Water Conservation and Irrigation Commission
WM Act	Water Management Act 2000
WRC	Water Resources Commission

1 INTRODUCTION

1.1 Background

The *Wellington Floodplain Management Study and Plan* were originally prepared in 1996 by Lyall & Macoun Consulting Engineers. Wellington Council subsequently adopted the *Floodplain Management Plan*. The 1996 Study described the Wellington floodplain and defined flooding characteristics, quantified flood damages and determined flood hazard. Existing and potential floodplain management measures were described and appropriate measures for inclusion in the *Floodplain Management Plan* were identified and prioritised.

Subsequently the staff from Lyall & Macoun involved in the preparation of the 1996 Study and Plan joined Evans & Peck. Wellington Council has engaged Evans & Peck to carry out a review of the 1996 Plan and its implementation in light of the publication of the NSW Government's (2005) *Floodplain Development Manual* (the '2005 FDM') and the time elapsed since the preparation of the original Plan.

This *Floodplain Risk Management Study* (FRMS) 2013 contains:

- an update of the sections and appendices of the 1996 Study that are out of date;
- a revised and updated *Floodplain Risk Management Plan* (FRMP) 2013 that takes into account:
  - o the terminology and philosophy in the 2005 FDM;
  - o the actions taken by Council to implement the 1996 FRMP;
  - o the requirement for Council to incorporate new elements and revise existing elements in the FRMP.

1.2 Structure

The Wellington FRMS 2013 covers the following topics:

	The **Summary and Recommendations** preceding this report summarises this report and presents the recommended flood mitigation options for Wellington.
Chapter 2	The **Wellington Floodplain**, describes the existing situation in relation to the physical setting and flood producing mechanism, flood extents and resulting flood damages, transport linkages, planning instruments and the existing flood emergency system. It draws upon previous investigations including the Wellington Flood Study carried out by the Department of Land and Water Conservation (DLWC) in 1995, as well as data supplied by Council and a revised estimate of extreme flood conditions at Wellington.
Chapter 3	**Flood Planning Levels and Flood Risk Precincts**, details the issues which were evaluated in preparing recommendations for the Flood Planning Levels and Flood Risk Precincts.

Chapter 4 **Status of the 1996 Plan Implementation**, contains an assessment of the progress of the implementation of the 1996 FRMP.

Chapter 5 **Potential Floodplain Management Measures**, presents an appraisal of potential measures which may be incorporated in the FRMP.

Chapter 6 **Selection of Floodplain Management Measures**, outlines a range of considerations to be taken into account in the selection of the mix of measures recommended for inclusion in the FRMP.

Chapter 7 The updated **Flood Risk Management Plan 2013**, summarises the recommended elements for inclusion in the FRMP and provides information on funding and implementation.

Several technical appendices have been prepared which provide background information:

Appendix A A description of the flood conditions in the Macquarie and Bell Rivers, including review of the 1995 Flood Study and the results of additional hydraulic modelling undertaken for the 2013 study

Appendix B A review of the effects of Burrendong Dam in attenuating floods

Appendix C An assessment of urban flood damages in Wellington

Appendix D An appraisal of existing emergency management procedures

Appendix E Recommended amendments to Wellington LEP 2012 and DCP 2013

Appendix F Report on the Aspley Drainage Study

Appendix G Background to the selection of floodplain management measures

Appendix H Candidates for Voluntary Purchase and House Raising Schemes

1.3 NSW Flood Prone Land Policy & the Floodplain Development Manual

1.3.1 NSW Flood Prone Land Policy

The primary objective of the NSW Government's Flood Prone Land Policy 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. At the same time, the policy recognises the benefits flowing from the use, occupation and development of flood prone land.

The policy promotes the use of a merit approach which balances social, economic, environmental and flood risk factors to determine whether particular development or use of the floodplain is appropriate and sustainable.

In this way the policy avoids the unnecessary sterilisation of flood prone land. Equally it ensures that flood prone land is not the subject of uncontrolled development inconsistent with its exposure to flooding.

The policy highlights that primary responsibility for floodplain risk management rests with councils, which are provided with financial and technical support by the State

Government. The Commonwealth has also historically shown a willingness to be involved by providing financial assistance to local government in partnership with the State Government.

1.3.2 NSW Floodplain Development Manual

The *Floodplain Development Manual* (NSW Government, 2005) ('2005 FDM') was prepared in accordance with the NSW Government's *Flood Prone Land Policy*. It guides councils in the development and implementation of detailed local floodplain risk management plans to produce robust and effective floodplain risk management outcomes. The 2005 FDM also outlines the technical assistance provided by the State Government throughout the floodplain risk management process.

The 2005 FDM is concerned with the management of the consequences of flooding as they relate to the human occupation of the floodplain for both urban development and agricultural production. It addresses flood risk in recognition of the fact that management decisions taken in respect of the human occupation of the floodplain need to satisfy the social and economic needs of the community as well as being compatible with the maintenance or enhancement of the natural ecosystems that the floodplain sustains.

In 1986 the NSW Government released the first *Floodplain Development Manual* ('1986 FDM') to assist consent authorities to deal with flood liable land. It represented the practical expression of the Government's merit based Flood Prone Land Policy which had been introduced in 1984 to overcome the sterilisation of floodplains resulting from rigorous planning controls introduced in the 1977 Environment and Planning Circular No.15.

The 1986 FDM was very successful in assisting local councils in their management of the use and development of flood prone land. In 2001, a revised Floodplain Management Manual ('2001 FMM') was prepared to update the 1986 FDM to make it consistent with a series of improvements to both policy and practice which has been introduced in the intervening period. Specifically the 2001 FMM emphasised the need:

- to explicitly consider the full range of flood sizes up to and including the probable maximum flood (PMF) when developing a floodplain risk management plan;
- to recognise existing, future and continuing flood risk on a strategic rather than on an ad hoc individual proposal basis;
- for local councils, with support from State Government, to manage local overland flooding in a similar manner to riverine flooding; and
- to promote the preparation and adoption of local flood plans (prepared under the guidance of SES) that address flood readiness, response and recovery.

In 2003 major changes were made to the composition of agencies with responsibilities for floodplain risk management. This necessitated changes to the 2001 FMM and provided an opportunity, in light of experience with the 2001 FMM, to further clarify the intent of the policy. In particular, this clarification aimed to reduce the potential for inconsistent interpretation by consent authorities, particularly with respect to the interaction between the determination of flood planning levels and the consideration of rare floods up to the PMF.

The 2005 FDM replaces the 1986 FDM as the NSW Government's Manual relating to the management of flood liable land in accordance with Section 733 of the *Local Government Act 1993*.

The 1996 Wellington Floodplain Management Study and Plan were prepared in accordance with the 1986 FDM. The FRMS 2013 takes into account the changes in both the 2001 FMM and the 2005 FDM and updates the 1996 Study in keeping with the updated approach.

1.3.3 The Floodplain Risk Management Process

The steps involved in formulating and implementing a Floodplain Management Plan are shown in **Figure 1.1**, which depicts the Floodplain Risk Management Process as outlined in Figure 2.1 of the 2005 FDM.

With reference to **Figure 1.1**, Council has to date completed the following:

- established a Floodplain Management Committee. The Committee, which is composed of Local and State Government representatives, held its first meeting on 8 February 1995;
- carried out a Flood Study - prepared by the Department of Land and Water Conservation (DLWC) in June 1995;
- carried out a Floodplain Risk Management Study and prepared a Floodplain Risk Management Plan (Lyall & Macoun Consulting Engineers, 1996);
- implemented some of the items in the 1996 *Flood Risk Management Plan* (refer **Chapter 5**).

This FRMS 2013 updates the 1996 *Floodplain Management Study and Plan*.

The draft *Flood Risk Management Study and Plan* 2013 was endorsed by the Floodplain Risk Management Committee at its meeting dated 20 August 2013. It was exhibited by Wellington Council from 1 to 30 September 2013. No submissions were received.

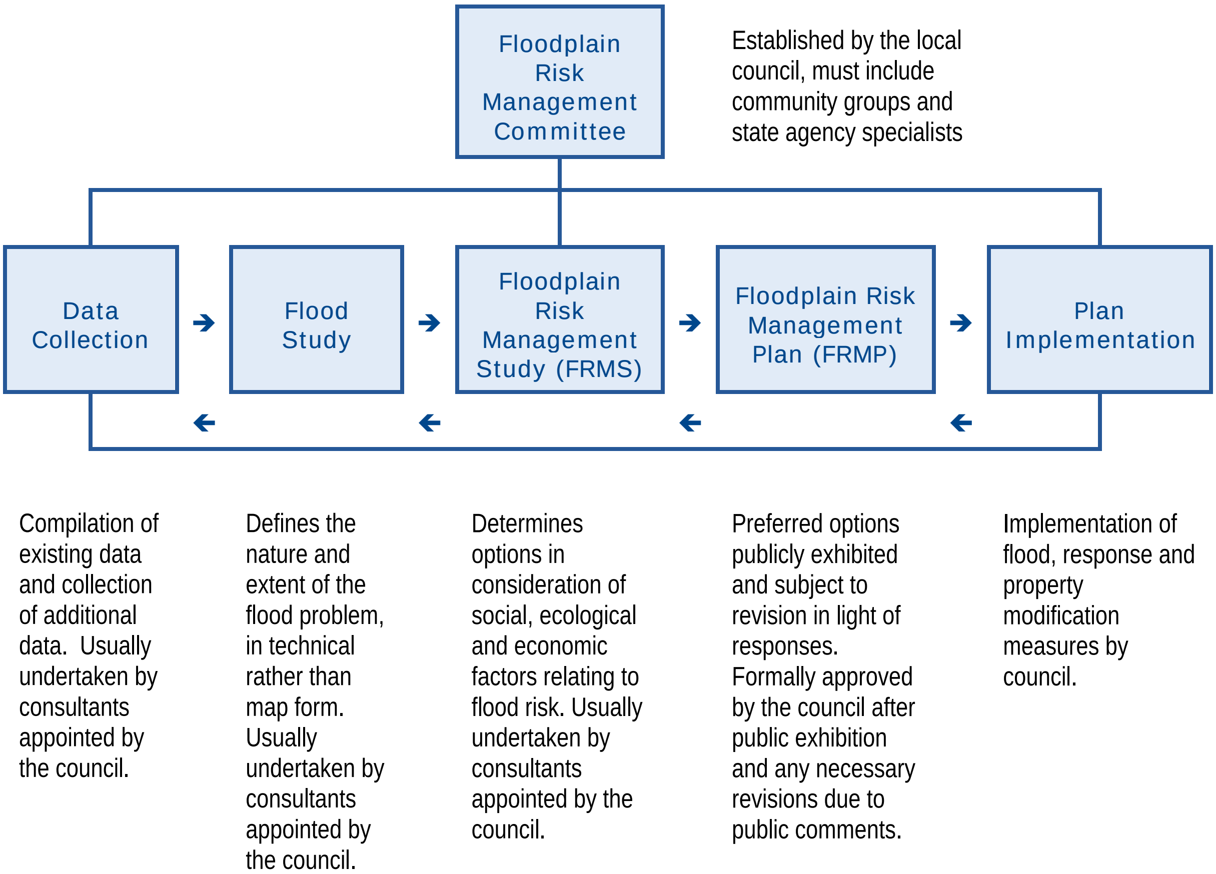


Figure 1.1: The Floodplain Risk Management Process

1.4 Definitions and Terminology

There are a number of terms which have specific meaning in relation to floods and floodplain management. The following definitions reflect current government policies and the definitions provided in the 2005 FDM.

Flood liable land	The area of land which is subject to inundation by floods up to and including an extreme flood such as a probable maximum flood (PMF). Synonymous with *flood prone land* and *floodplain*.
Flood mitigation work	Work designed and constructed for the express purpose of mitigating flood impacts. It involves changing the characteristics of flood behaviour to alter the level, location, volume, speed or timing of flood waters to mitigate flood impacts. Types of works may include excavation, construction or enlargement of any fill, wall, or levee that will alter riverine flood behaviour, local overland flooding, or tidal action so as to mitigate flood impacts.
Flood planning levels (FPL)	The combinations of flood levels (derived from significant historical flood events or floods of specific AEPs) and freeboards selected for floodplain risk management purposes, as determined in management studies and incorporated in management plans.

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 typical residential uses). (See also Risk).
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.
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.
Hazard	Flooding which has the potential to cause damage to the community. Definitions of high and low hazard categories are provided in Appendix L of the 2005 FPM.
High Flood Risk Precinct	Those parts of the floodplain where the depth and velocity of flood waters and evacuation difficulties would pose an unacceptable risk to types of development and activity. For Wellington, the High Flood Risk Precinct is the area of land subject to **high hydraulic hazard (floodway) in a 1% AEP flood event**. The flood hazard in this area cannot be reduced by methods such as filling without creating unacceptable flood hazard elsewhere on the floodplain. In comparison, the flood hazard in a high hydraulic flood fringe area can be managed by methods such as filling without adversely affecting flood hazard elsewhere on the floodplain.
Medium Flood Risk Precinct	Those parts of the floodplain where there would still be a significant risk of flood damage, but these damages can be minimised by the application of appropriate development controls. For Wellington, the Medium Flood Risk Precinct applies to land area **below the extent of the 1% AEP flood level +0.5 m, but above the high hazard 1% AEP extent.**
Low Flood Risk Precinct	Those parts of the floodplain where the risk of damages is low for most land uses and, therefore, most land uses would be permitted. Those uses considered critical or requiring maximum protection against risk from flooding should be identified as undesirable land uses in this precinct. For Wellington, the Low Flood Risk Precinct **applies to all land within the floodplain (i.e. within the extent of the PMF) not identified as being within either the High or Medium Flood Risk Precincts.**

Merit approach	The principles of the merit approach are embodied in the FDM (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 wellbeing of the State's rivers and floodplains.
Probable maximum flood (PMF)	The largest flood that could conceivably occur at a particular location. The land inundated by this flood is '*flood liable land*'. For Wellington, the '*Extreme Flood*' (see below) has been adopted as a surrogate for the PMF.
Extreme flood	Because of the flood mitigation effect of Burrendong Dam and the complex interactions between floods on the Macquarie River and Bell River, a simple definition of the PMF is not possible for Wellington. For purposes of defining '*flood liable land*' two extreme flood scenarios (notionally 0.002% AEP) have been assessed: • Extreme Flood in the Macquarie River (EMAC) which has been defined as the flood levels arising from a combination of the flow at Wellington resulting from the PMP design flood inflow to Burrendong Dam with the dam full at the commencement of the flood and without dam failure (20,000 m^3/s) and the 1% AEP flow in the Bell River (2,140 m^3/s). • Extreme Flood in the Bell River (EBELL) which has been defined as the flood levels arising from a combination of an extreme flood in the Bell River (8,350 m^3/s) and a 1%AEP flood in the Macquarie River (2,800 m^3/s).
Reliable access	Reliable access during a flood means the ability for people to safely evacuate an area subject to imminent flooding to a defined regional evacuation route within effective warning time, having regard to the depth and velocity of flood waters, the suitability of the local evacuation route, and without a need to travel through areas where water depths increase.
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).

1.5 Flood Frequency

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

Annual Exceedance Probability (AEP) %	**Average Recurrence Interval (ARI) - years**
0.2	500
0.5	200
1	100
5	19.5
20	4.5
50	1.4

The AEP of a flood represents the percentage chance of its being equalled or exceeded in any one year. Thus a 5% AEP flood has a 5% chance of being equalled or exceeded in any one year; a 1% AEP flood has a 1% chance, and so on. The larger the flood the smaller the chance of its being experienced. A 1% AEP flood is also equivalent to a 100 year ARI flood. Over a long period of, say 1000 years, 10 such floods would be expected to occur, at an average frequency of once in 100 years. This does not mean that a 100 year ARI flood will occur at regular intervals, or that only one 100 year ARI flood will be experienced in any 100 year period.

While a 1% AEP flood is a major flood event, it does not define the upper limit of possible flooding. Over the course of a human lifetime of, say 70 years, there is a 50% chance that a flood at least as big as a 1% AEP will be experienced. There is a 30% chance that a 0.5% AEP flood will be experienced over this period.

Reference is also made in this report to "extreme" flood events on the Macquarie and Bell Rivers. These floods approximate the upper limit of flooding on these two streams and are extremely rare floods. Such floods are analysed to determine the consequences of an event much greater than the floods on which the Flood Planning Levels are based, so that appropriate planning and response measures may be considered for inclusion in the FRMP.

2 THE WELLINGTON FLOODPLAIN

2.1 Physical Setting

The town of Wellington is located at the confluence of the Macquarie and Bell Rivers in the north-west of NSW, about 350 km from Sydney, and has a population of 5,400. Upstream of the confluence, the Macquarie River has a catchment area of 14,250 km^2. The Bell River has a catchment of 1,860 km^2.

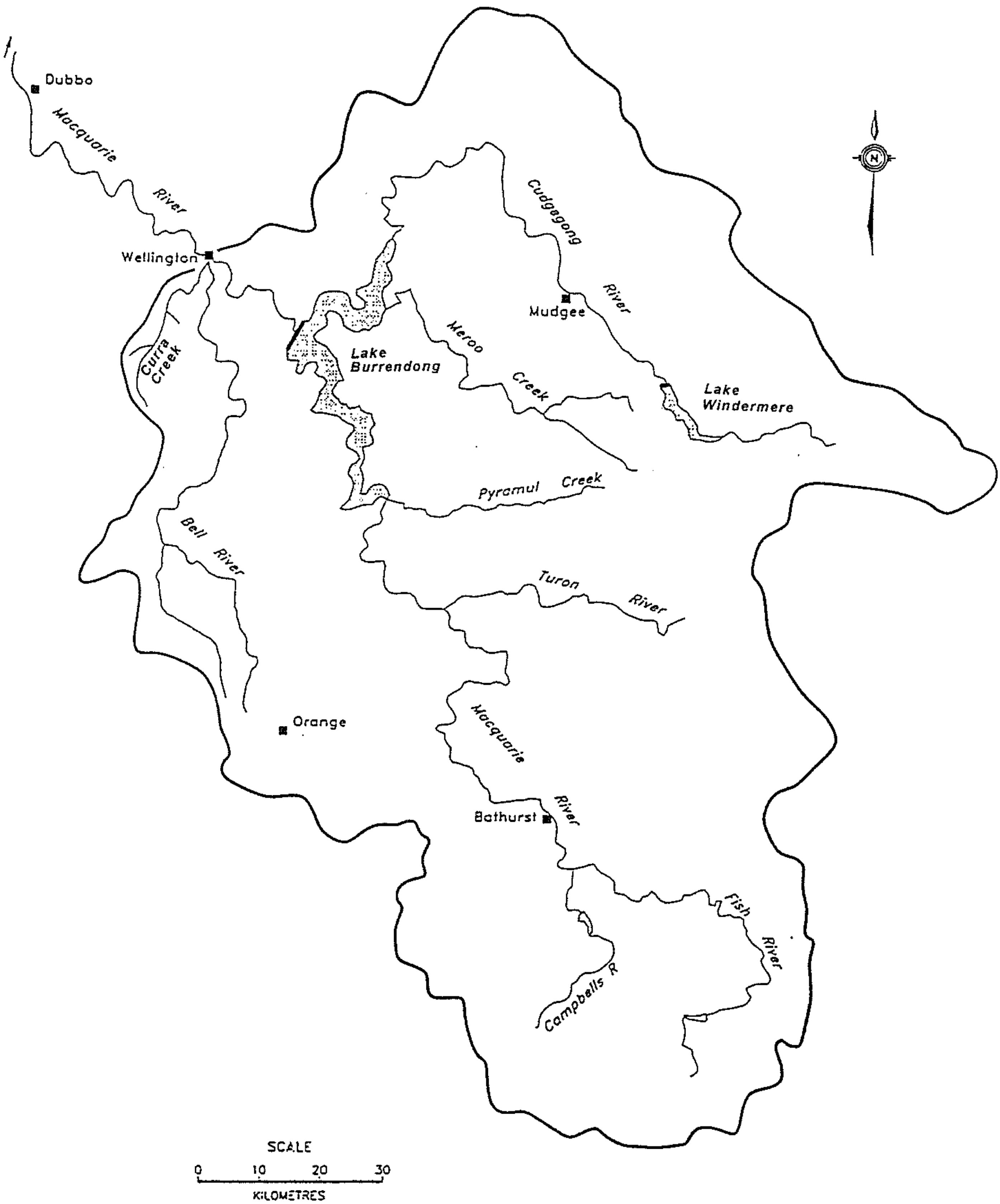
There are two major water storage dams upstream of Wellington. Burrendong Dam (completed in 1965) is located at the confluence of the Macquarie and Cudgegong Rivers approximately 30 km upstream of Wellington, and Windamere Dam (completed in 1984) is situated on the Cudgegong River approximately 30 km upstream of Mudgee (**Figure 2.1**).

Burrendong Dam has a total catchment area of 13,900 km^2, which is approximately 86% of the catchment at Wellington. The dam has a total storage volume of 1,680 GL of which 480 GL is allocated to flood mitigation. This flood mitigation volume represents approximately half the volume of runoff which passed the dam site in the February 1955 flood. That flood resulted in the highest recorded flood level in the 19^{th} century on the Macquarie River at Wellington.

Due to the high percentage of the catchment controlled by the dam, the large flood mitigation capacity and the planned operation of the spillway gates during floods, Burrendong Dam has a significant effect on the majority of flood events at Wellington. If the dam had been in existence at the time of the February 1955 flood, the flood peak at the Mitchell Highway bridge in Wellington would have been reduced by 8.4 m. A flood which had a peak inflow to the dam greater than the February 1955 flood occurred in August 1990. If the dam had not been in existence, the August 1990 flood would have been 3.5 m higher than the recorded peak at the Mitchell Highway bridge.

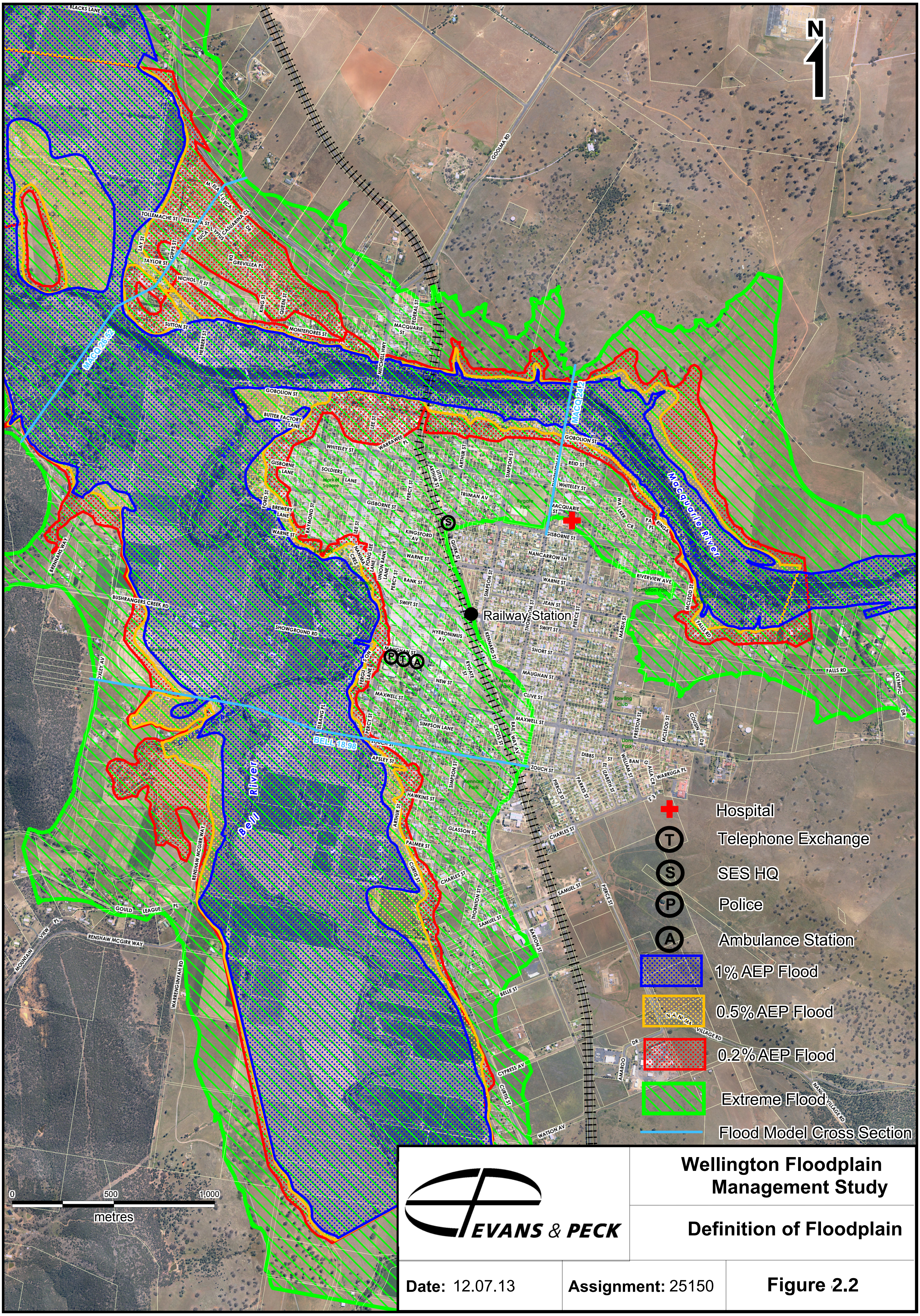
Windamere Dam has a total storage capacity of 368 GL and controls a catchment area of 1,070 km^2, which represents about 7% of the catchment area at Wellington. The reservoir has no reserved storage capacity or operating rules designed to reduce flood flows. The small proportion of the catchment controlled by the dam together with the absence of flood mitigation storage or operating rules mean that the dam has no significant effect on flood flows at Wellington.

Most of the urban development including the main business and commercial area in Wellington is located in the wedge of land between the left bank of the Macquarie River and the right bank of the Bell River (looking downstream). A plan of the town is shown on **Figure 2.2** which also shows the approximate extent of the 1% AEP flood as defined by the Flood Study (DLWC, 1995). The flood extent for three larger floods, 0.5%, 0.2% AEP and the Macquarie River extreme flood (EMAC), are also shown on **Figure 2.2**. The first two floods are respectively about 1 m and 2 m higher than the 1% AEP event. The "extreme" flood event, as the name suggests, is indicative of the upper limit of potential flooding in Wellington and, depending on location, is approximately 12.5 m higher than the 1% AEP flood.



(Source: Wellington Flood Study Report)

Figure 2.1: Locality Plan



EVANS & PECK

Wellington Floodplain Management Study

Definition of Floodplain

Date: 12.07.13 | **Assignment:** 25150 | **Figure 2.2**

2.2 Floodplain Definition and Topography

Flooding in Wellington is influenced by the magnitude and synchronisation of flows in the Macquarie and Bell Rivers. Most of the town is considered to be flood free even for major floods of the order of 0.2% AEP, but parts of the commercial area near the Mitchell Highway - Warne Street intersection have been subject to flooding. Floodwaters enter this area by surcharging the banks of the Bell River either due to high flows in the Bell River alone, or in conjunction with backwater flooding from the Macquarie River. Properties along Ford Street and Gobolion Street, low lying rural properties on the Bell River floodplain and parts of Montefiores are also subject to inundation.

Figure 2.3 shows typical cross sections of the floodplain. The Macquarie River upstream of the confluence has an incised channel about 15 m deep with a confined overbank area. For the 1% AEP flood the width of flow would be 150 m and flow velocities would be in excess of 2 m/s. The difference in peak levels between 5% and 1% AEP floods is about 3 m.

The Bell River, in comparison, has a much smaller channel, typically around 5 m deep and 50 m wide, but a much more extensive floodplain. The bank will be overtopped in the event of minor floods of about 10% AEP and the floodplain will be inundated to a depth of about 2 m for a 5% AEP flood. For the 1% AEP flood the maximum depth of inundation on the left bank would be 3 m and the width of flow in excess of 1 km. The difference in peak levels between 5% and 1% AEP floods is only about 1 m. For a 1% AEP flood flow velocity would be about 1.0 - 1.2 m/s in the channel and 0.5 m/s on the floodplain. Backwater influences from the Macquarie River extend upstream as far as Maughan Street.

Downstream of the confluence the floodplain of the Macquarie River becomes more extensive, with a width of around 800 m at 1% AEP. The difference in peak levels between 5% and 1% AEP floods is 3.2 m. Flow velocities are generally higher than above the confluence, reflecting the increase in bed slope, which averages 1 m/km. The maximum velocity in the channel would be experienced at a narrow section about 1 km downstream of the confluence and would increase from 2.5 to 3.2 m/s between 5% and 1% AEP floods.

In 2001, State Water undertook safety studies of all major dams as part of the *24 Dams Portfolio Risk Assessment* (SKM, 2001). As part of these safety studies, the Burrendong risk analysis estimated the discharge from the dam as 20,000 m^3/s (probable maximum design flood without dam failure), compared to 15,700 m^3/s used in the 1996 Study. As part of this 2013 update, the EMAC was remodelled with the revised estimate of the Macquarie River discharge at Wellington. The resulting increase in EMAC flood levels in the Macquarie River range between 2.5 m and 5 m, with an average increase of around 3.6 m, when compared with the 1996 results.

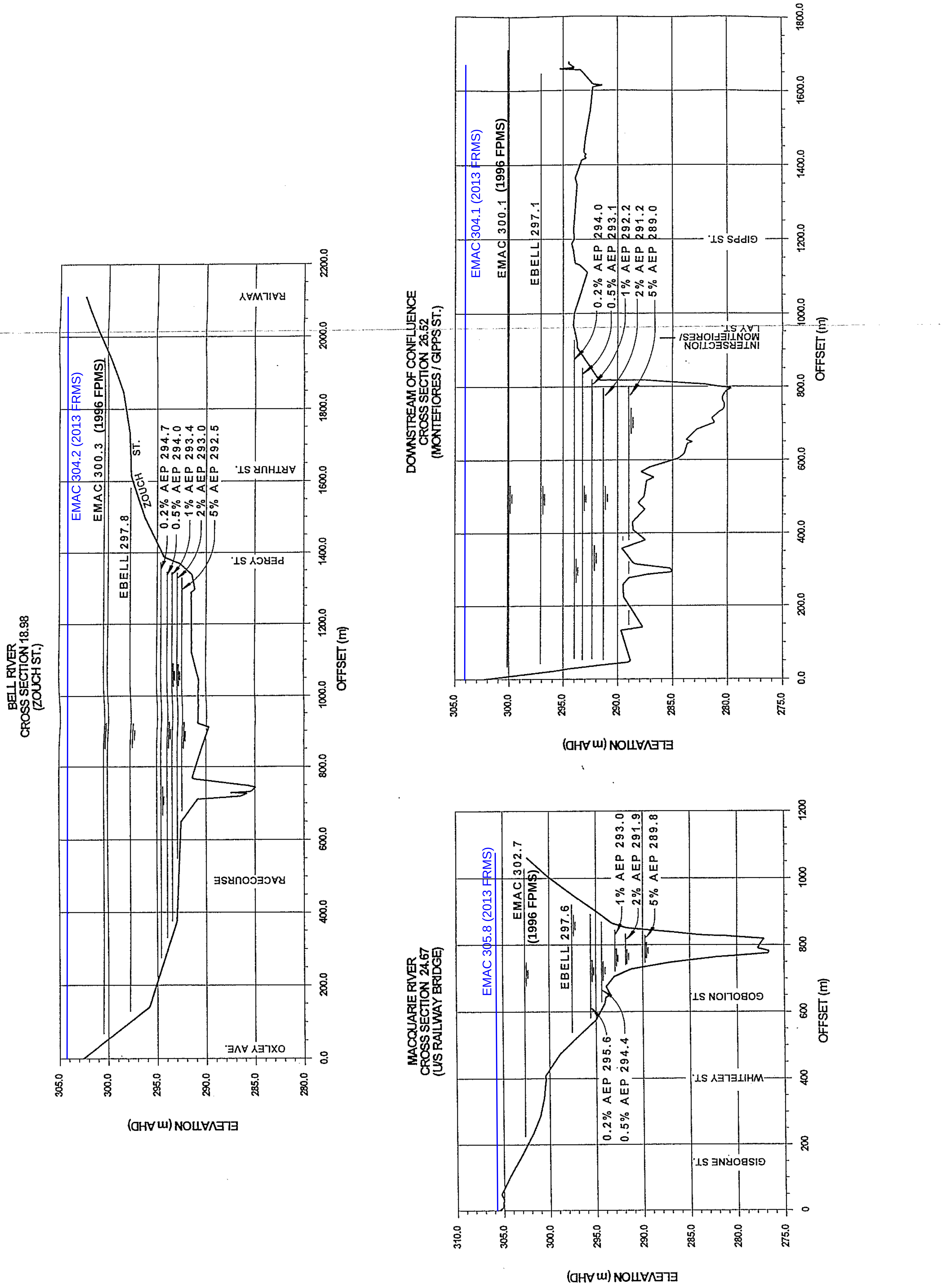


Figure 2.3: Typical Floodplain Cross Sections

Figure 2.3 also shows peak levels reached by several floods greater than 1% AEP, including two extreme floods which are labelled EMAC and EBELL which have been adopted in this study for defining "extreme" flood conditions for planning purposes:

- Extreme Flood in the Macquarie River (EMAC) which has been defined as the flood levels arising from a combination of the flow at Wellington resulting from the PMP design flood inflow to Burrendong Dam with the dam full at the commencement of the flood and without dam failure (20,000 m^3/s) and the 1% AEP flow in the Bell River (2,140 m^3/s).
- Extreme Flood in the Bell River (EBELL) which has been defined as the flood levels arising from a combination of an extreme flood in the Bell River (8,350 m^3/s) and a 1%AEP flood in the Macquarie River (2,800 m^3/s).

The revised flood extent for the EMAC is shown on **Figure 2.2**, together with the 1996 extents for the other modelled events. Detailed results, including flood profiles and tabulated flood levels, are contained in **Appendix A**. **Figure 2.3** has also been updated to reflect the revised peak levels reached by the EMAC.

A rural flood mitigation scheme was implemented for the lower reaches of the Bell River in the 1980s, extending from the golf course to a location just upstream of the confluence with Curra Creek. The scheme aimed at confining minor flood flows, up to around the 30% AEP level, in the main channel and in defined floodways and depressions on the floodplain, thereby providing protection for up to 400 ha of river flats under cultivation outside these flooded areas.

The scheme was designed to replace the uncoordinated levee banks which formerly existed, and aimed to restore the natural pattern of flood flows over the floodplain. The design flood was only 370 m^3/s, considerably smaller than a flow required to cause damaging flooding in the urban area of Wellington. In large floods, the levees bounding the floodways and the river banks will be overtopped. The leveed areas between the floodways and the river will then form part of the active floodplain and the scheme will have a progressively smaller effect on upstream and downstream flooding patterns.

2.3 Characteristics of Flooding

2.3.1 Critical Gauge Heights

The SES flood classifications for the Mitchell Highway and Maughan Street gauges, provided in the *Wellington Local Flood Plan* (SES, 2008), are as follows:

Flood Classification	Gauge Height (m) Macquarie R at Mitchell Hwy	Gauge Height (m) Bell R at Maughan St
Minor	4.0	3.4
Moderate	9.1	5.9
Major	12.2	8.4

The gauge height at which inhabitants in flood liable areas are warned of an impending flood is 9 m (287.6 m AHD) on the Macquarie River gauge at the Mitchell Highway.

This corresponds to a moderate flood as classified by SES. Only two floods have exceeded this level since construction of Burrendong Dam: in February 1971 and August 1990. The August 1990 flood was the third significant flood event which occurred in the period April-August 1990, and was the biggest post-Burrendong flood, reaching a peak of 13.1 m on the Mitchell Highway gauge. Four floods greater than the moderate flood gauge height would have been experienced between 1913, when records began, and 1965 if the dam had been in place and operated according to current procedures.

On the Bell River, flood heights have been recorded since 1913 at the Maughan Street gauge. It should be noted that in 1984 the gauge at the old Maughan Street bridge was removed and installed at the new bridge. The new gauge was incorrectly installed and the current staff gauge is 1 m higher than the old gauge. Therefore gauge readings taken after 1984 must incorporate the new gauge zero. When floods exceed the gauge height of 5 m on the new gauge (289.9 m AHD), overflow from the Bell River begins to affect nearby development. A total of 29 floods above this height have been experienced since 1913.

2.3.2 Synchronisation of Flows on Bell and Macquarie Rivers

Historically, the most severe flooding has occurred when high flows in the Bell River occurred concurrently with a major flood in the Macquarie River. This was the case in the March 1956 flood when the level of the Bell River at the town gauge on the old Maughan Street bridge reached 9.4 m (293.3 m AHD). By comparison, the February 1955 flood, which is the highest on record in the Macquarie River at Wellington, produced a level of only 6.6 m (290.5 m AHD) on the old Maughan Street gauge, as the Bell River did not simultaneously produce major flows.

In February 1955, the recorded level at the Maughan Street gauge was 290.5 m AHD but anecdotal evidence indicates that Cameron Park (approximately 292.5 m AHD) was flooded. The observation that Cameron Park was flooded is consistent with the peak flood level on the Macquarie River gauge at the Mitchell Highway (293.3 m AHD). It appears, therefore that the recorded level of 290.5 m AHD at the Maughan Street gauge may represent the peak which occurred due to flooding in the Bell River prior to the peak flood occurring on the Macquarie River.

The timing of Bell and Macquarie River flood peaks for the pre-1965 and post-1965 periods (ie post completion of Burrendong Dam) was examined in an investigation on the geomorphology of the Bell River (Thoms, 1995 draft). For the pre-1965 (unregulated period), most Macquarie River peaks occurred within 3 hours of the Bell River peak, with most Macquarie peaks occurring after the Bell peak. Since 1965, de-synchronisation of flood peaks has occurred. The Macquarie River peak is now less pronounced, with high flows occurring later and for a longer duration than under pre-dam conditions, due to the attenuating effect of the flood mitigation storage.

The hydrograph alteration has resulted in a reduction in flood levels in the Macquarie River at the time of occurrence of the Bell River peak, thereby increasing the flood slope in the lower reaches below the Maughan Street bridge. An analysis of the resulting increase in flow velocities in the lower Bell River is presented in **Appendix A**. The increased velocities in the Bell River are a major factor in the bank erosion which has occurred in recent years on the lower reaches of the Bell.

2.3.3 Rate of Rise and Duration

The flood of August 1990, which took place between 2 and 8 August, provides an example of flood behaviour under post-Burrendong Dam conditions. This flood was around a 2% AEP event on the Macquarie River upstream of the confluence and about 300 mm below a 2% AEP flood on the Bell River. Details of this flood are provided in the Flood Study report (DLWC, 1995) and other details were obtained by inspection of the stage and discharge hydrographs derived by the hydraulic model prepared for that investigation. Stage hydrographs summarising the event are presented on **Figure 2.4.**

On the Bell River at Neurea, the flood peaked at 318.3 m AHD at 1800 hours on 2 August, having risen from a low level over the preceding 12 hours. The flood peak arrived at Wellington about six hours later and reached 7.5 m (292.3 m AHD) at the Maughan Street gauge. Floodwaters at Maughan Street rose by 5 m to the peak over a period of 12 hours.

On the Macquarie River, significant releases from Burrendong Dam commenced on 2 August. The water level at the gauge immediately downstream of the dam increased from 295 m to 300 m AHD over the 12 hour period to 2400 hours on 2 August. Levels were maintained at around 300 m AHD until 0600 hours on 4 August and gradually reduced to 298 m AHD by 2400 hours on 4 August.

At the Wellington gauge (Mitchell Highway) the flood level rose by 7 m over the 12 hour period from 1200 to 2400 hours on 2 August (285 m to 292 m AHD) and was maintained above 290 m AHD until 1200 hours on 4 August. Subsequently, flood levels receded to 287.5 m AHD over the following 24 hours. On the Macquarie River, flood levels were maintained above the 5% AEP level for over 24 hours.

The data from the 1990 flood and other anecdotal data from the SES indicate that on the Bell River floodwaters generally have a travel time of about 16 hours from the headwaters around Molong and 6 - 8 hours from Nurea. On the Macquarie River flood peaks take 4 - 8 hours to travel the 30 km reach from Burrendong Dam to Wellington.

The operation of Burrendong Dam for flood mitigation leads to prolonged high flows in the Macquarie River which can also affect the lower reaches of the Bell River. For example, in August 1990 flood levels in the vicinity of the Maughan Street bridge inundated the approach road for two days.

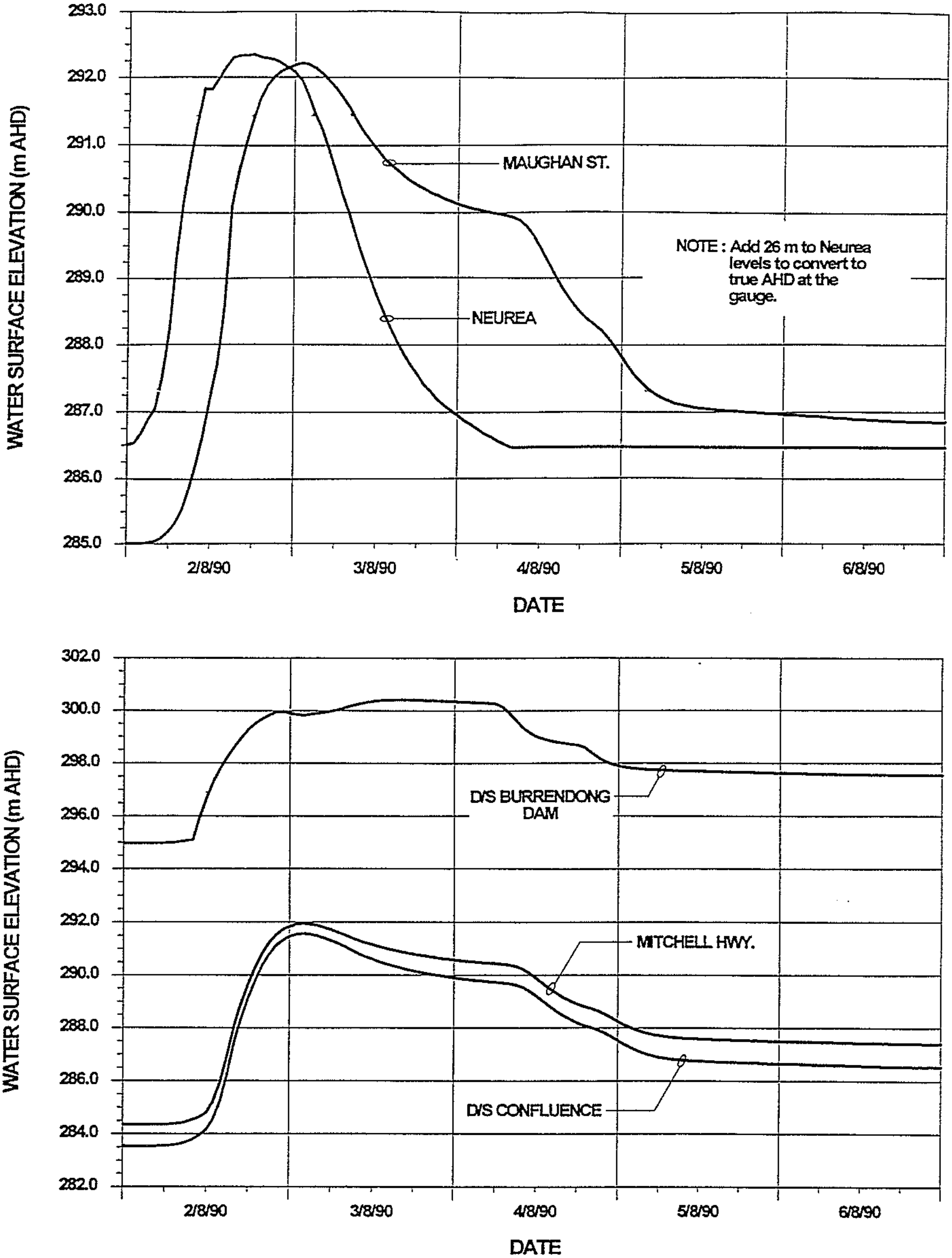


Figure 2.4: August 1990 Flood - Stage Hydrographs

2.3.4 Comparative Flood Levels

Comparative flood levels on the Macquarie River at the Mitchell Highway are shown on **Figure 2.5**. Both historic and design flood levels have been included as well as information pertaining to bridges. It should be noted that since 1965 the magnitude and timing of flood events on the Macquarie River have been altered due to the flood mitigation effect of Burrendong Dam. Flood levels pre-1965 would have been reduced significantly had the dam been constructed and estimates of these reductions are also given on **Figure 2.5**.

On the Bell River, Maughan Street acts as a transport link to areas to the east, principally Parkes. Historic and design flood levels for the Bell River at Maughan Street are shown on **Figure 2.6**. Ground levels at various locations along Maughan Street are also shown which indicate the low flood levels at which the road is inundated.

2.4 Floodplain Zoning

Land use planning within the Wellington Council area is regulated by way of the Wellington Local Environmental Plan (LEP) 2012. The total area of land lying within the extent of the 1% AEP flood within Wellington town boundaries is approximately 590 ha. **Table 2.1** shows the approximate breakdown of that land according to the various zonings set out in the Wellington LEP 2012. **Table 2.1** also indicates the approximate areas of land inundated by the 0.5% and 0.2% AEP floods.

Table 2.1: Zoning of Land within 1%, 0.5% and 0.2% AEP Floods

Zone		Approximate Area (ha)		
		1% AEP	**0.5% AEP**	**0.2% AEP**
B2/B6	Local Centre/Enterprise Corridor	<1	2	5
E3	Environmental Management	38	52	85
R1/R2/R5	Residential	2	3	5
RE1/RE2	Public/Private Recreation	50	55	55
RU1/RU4	Primary Production	490	535	530
SP2	Infrastructure	10	15	15
Totals		**590**	**662**	**695**

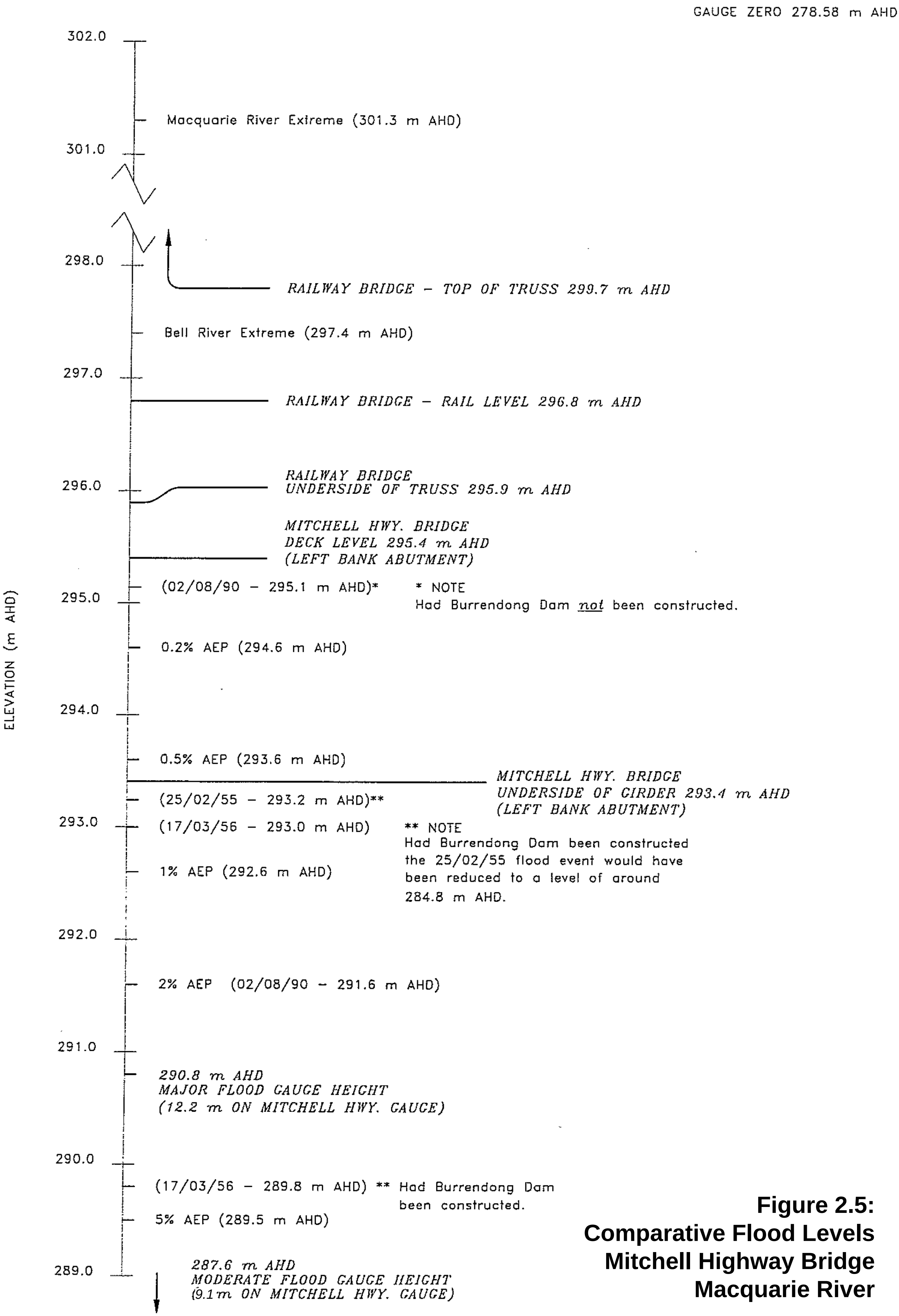


Figure 2.5: Comparative Flood Levels Mitchell Highway Bridge Macquarie River

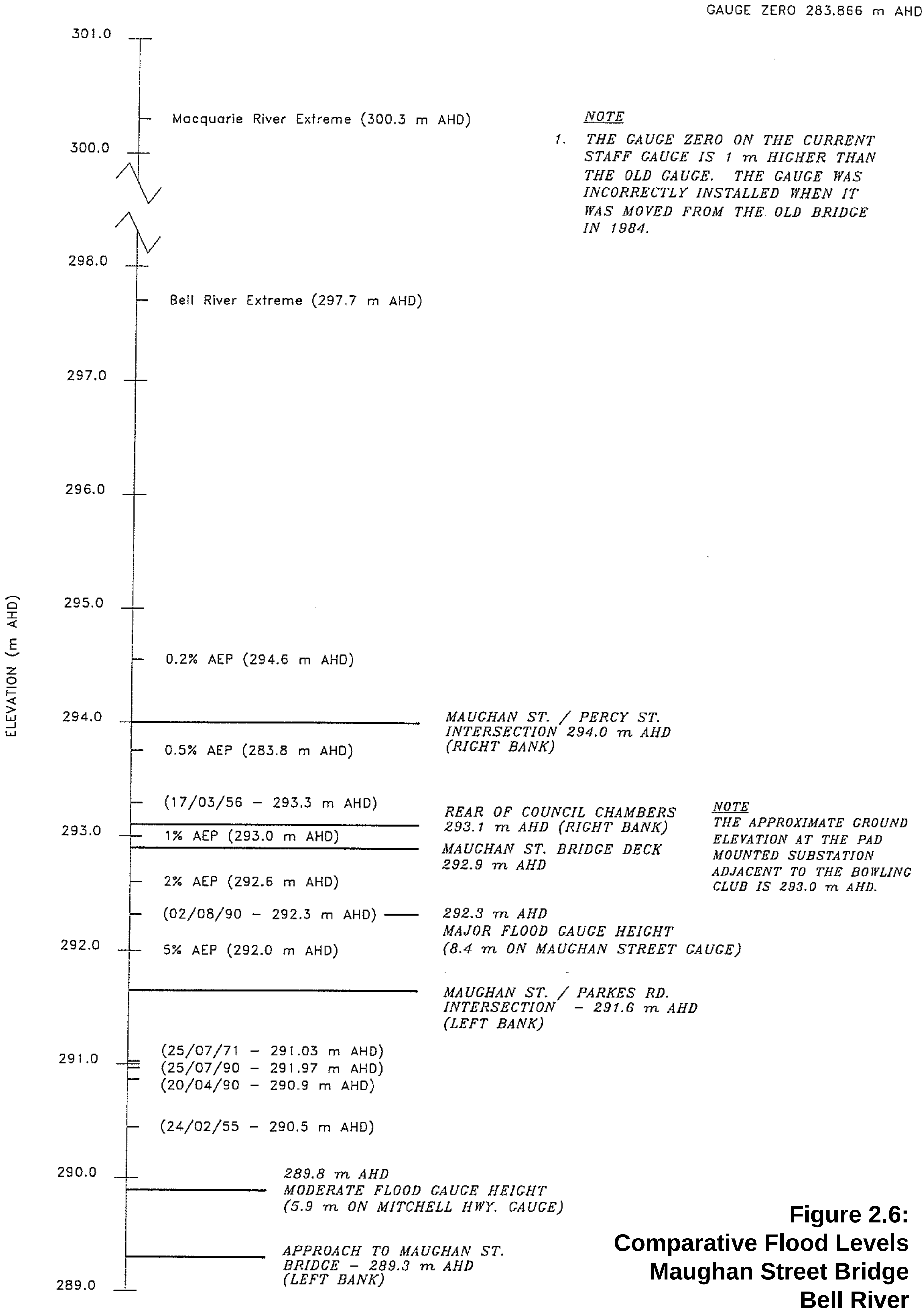


Figure 2.6: Comparative Flood Levels Maughan Street Bridge Bell River

2.5 Land Use

The indicative extent of the land use zones, based on LEP 2012, within the 1% AEP floodplain of the Macquarie and Bell Rivers are shown on **Figure 2.7**. The following discussion provides an overview of the land use types within the floodplain affected by the 1% AEP flood.

Primary Production (RU1) and Primary Production Small Lots (RU4)
The Primary Production zone within the floodplain is predominantly located within the the floodplain of the Bell River, north and south of Bushrangers Road and Showground Road.

Environmental Management (E3)
Prior to LEP 2012, around 40 ha of Residential zoned land lay within the 1% AEP floodplain, including land which backed onto both the north and south banks of the Macquarie River, generally upstream of the confluence of the Macquarie and Bell Rivers and an area in the vicinity of Apsley Street, Sutton Street, Lay Street, Butter Factory Lane and Whiteley Street.

LEP 2012 has resulted in the rezoning of most of this area as Environmental Management (E3). Only a small portion of land immediately west of the Mitchell Highway, bounded by Gobolion Street and the Macquarie River, remains zoned as Residential (R1).

The objectives of the Environmental Management zone (E3) include:

- To protect, manage and restore areas with special ecological, scientific, cultural or aesthetic values.
- To provide for a limited range of development that does not have an adverse effect on those values.
- To identify land along the Macquarie and Bell Rivers in proximity to the Town of Wellington suitable for low impact development that addresses the flood prone nature of this land.

Further discussion relating to this zoning is provided in **Section E5.3** in **Appendix E**.

Business (Local Centre / Enterprise Corridor) (B2 / B6)
There are few businesses located within the 1% AEP floodplain of the Macquarie and Bell Rivers in Wellington. The only identified land use within the Business zone was the Apsley Bowling Club located at the corner of Percy Street and Maughan Street. Other businesses located in the 1% AEP floodplain but in zones other than the Business zone include:

- the Visitor’s Centre in Cameron Park (Wellington Travel);
- the Riverside Caravan Park, Federal Street;
- the Bridge Motel, 5 Lee Street;
- structures associated with the Showground/Racecourse;
- greenhouses located in Bushrangers Creek Road and Showground Road.

The majority of businesses located in the Central Business District of Wellington would, however, be affected by the EMAC flood event.

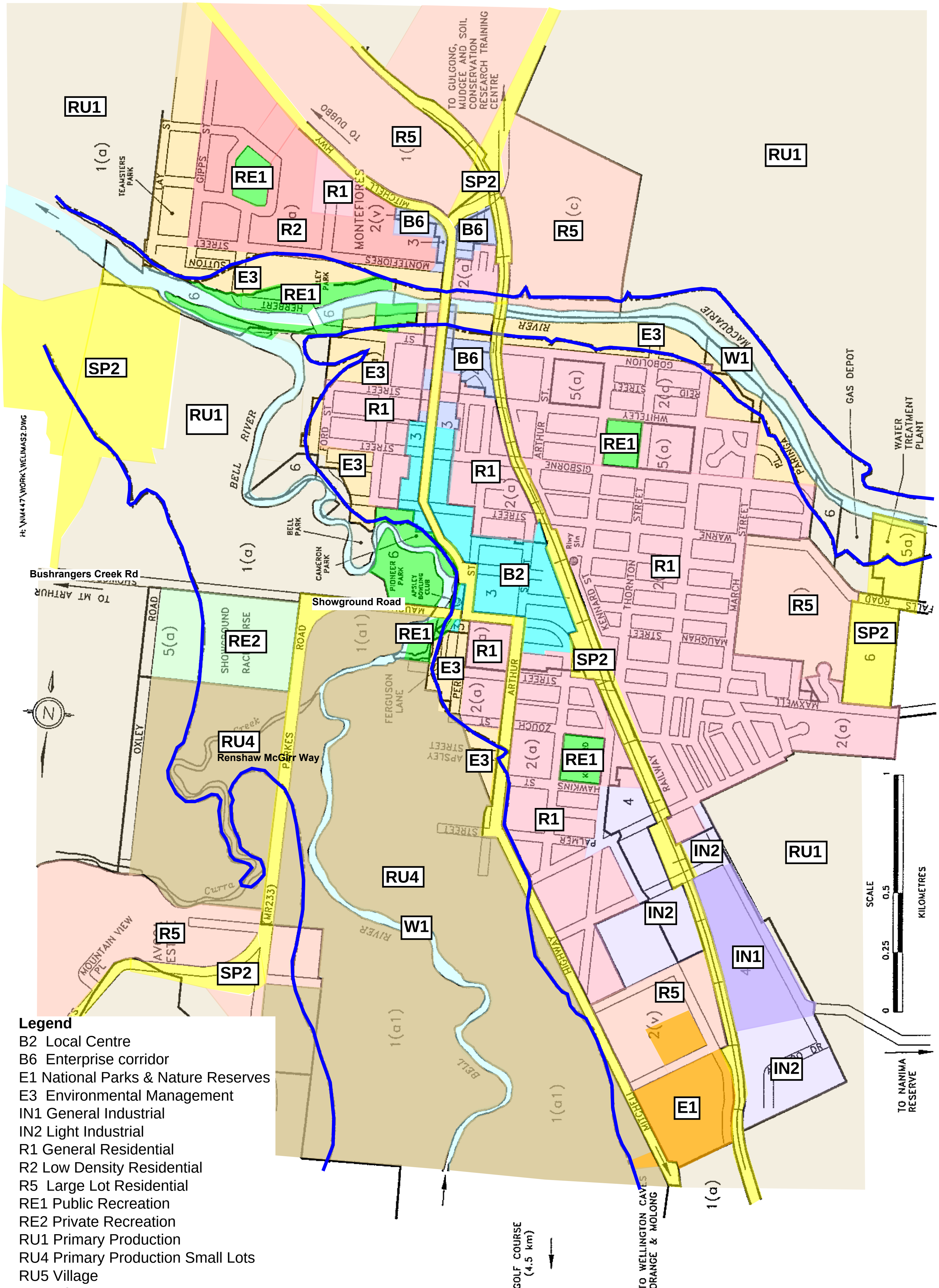


Figure 2.7
Floodplain Zoning (LEP 2012)

Infrastructure (SP2)

Land uses zoned Infrastructure within the 1% AEP floodplain are the Water Treatment Works and the Gas Depot in Falls Road, and the Sewage Treatment Plant in Brennans Way.

Public Recreation (RE1) and Private Recreation (RE2)

Areas zoned Public Recreation located within the 1% AEP floodplain include:

- John Oxley Park;
- Pioneer Park;
- Cameron Park.

The Showground/Racecourse in Showground Road was rezoned from Special Uses to Private Recreation (RE2) under LEP 2012.

Other park areas within the 1% AEP floodplain which are not zoned Public Recreation include Bell Park (zoned Primary Production (RU1)).

There are also a number of essential services located on land inundated by the EMAC including:

- SES facilities;
- Council Chambers;
- Police Station;
- Ambulance Station;
- Telephone Exchange;
- Hospital.

2.6 Flood Damages

2.6.1 Introduction

This section updates the damage assessment presented in the 1996 Study.

As noted in **Section 2.3**, flooding commences in the lower Bell River floodplain when the level at the new Maughan Street gauge reaches 5 m, but flooding does not have a significant effect until a 5% AEP flood (8.1 m gauge height) occurs. A detailed assessment of potential flood damages for floods from the 5% AEP event to the extreme event was carried out for this study and is reported in **Appendix C**. For this analysis, the depths of inundation for various floods were derived from the results of the hydraulic analysis presented in the Flood Study and the revised estimate of the EMAC extreme flood, details of building structure and state of repair were obtained from a drive-by survey, and floor levels were determined from a level survey undertaken by a local surveyor.

Damages were assessed using well recognised techniques developed and tested in numerous urban and rural flooding situations in NSW. Damages to residential, industrial, commercial and public buildings were included. There are no data available on historic flood damages to the residential and commercial/industrial sectors in Wellington. Accordingly, it was necessary to transpose data on damages experienced as a result of flooding in other centres. To that extent, the estimated values are "potential" damages rather than damages actually experienced. The estimated "potential" damages have been adjusted to allow for a reduction in the actual damages which would occur when residents move possessions to higher levels or take easily portable items to a safe location in event of a flood.

The assessment involved estimating the damages to residential, commercial and industrial and public buildings for various design floods. For the 2013 review, residential damages were re-calculated based on the *Floodplain Risk Management Guideline for Residential Flood Damages* (DECC, 2007).

For commercial/industrial and public properties damage estimates from the 1996 *Floodplain Management Study* were updated by applying CPI.

Potential and actual flood damages were estimated for floods from the 5% AEP event to the extreme event. Damages for the extreme flood on the Macquarie River (EMAC) were re-calculated based on the revised estimate of extreme flood levels and extent.

The numbers of flood-affected properties and the resulting flood damages are summarised in **Table 2.2** and **Table 2.3** respectively.

Table 2.2 makes the distinction between 'flood-affected' properties, where water is expected to be on the land around the house (to within the 0.5 m freeboard allowance), and 'flood-damaged' properties, where the flood water would be above the floor of the property and cause some damage. **Figure 2.8** shows the relationship between flood damages and flood frequency and **Figure 2.9** shows the cumulative average annual damages related to flood frequency.

Table 2.2: Estimated Number of Inundated Properties

Flood Event (% AEP)	Number of Properties Inundated						
	Residential		Commercial / Industrial		Caravans	Public Buildings	
	A	B	A	B	A / B	A	B
5%	30	6	1	1	0	1	1
2%	36	25	4	4	0	1	1
1%	87	47	6	6	5	2	1
0.5%	164	102	20	14	10	2	2
0.2%	393	327	36	31	15	4	4
EMAC	1,134	1,131	73	73	38	18	18
EBELL	636	629	69	69	32	11	10

Note: A – flood-affected property (flooded to within 0.5 m freeboard allowance)
B – flood-damaged property

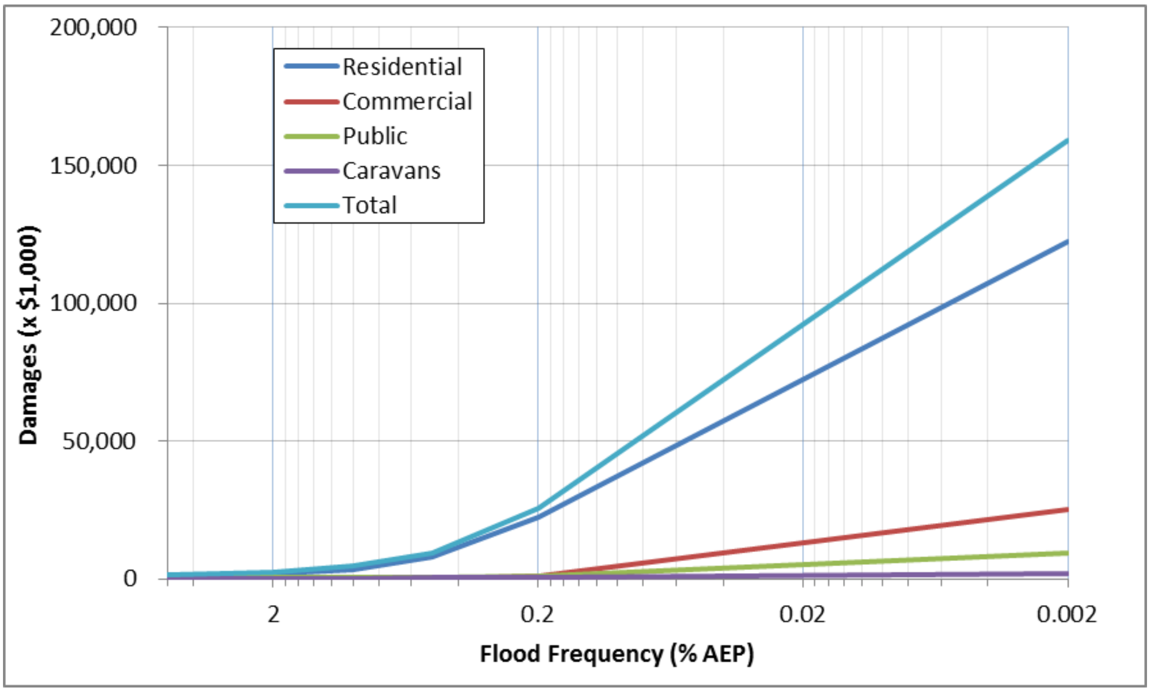


Figure 2.8: Total Damage Frequency Curve

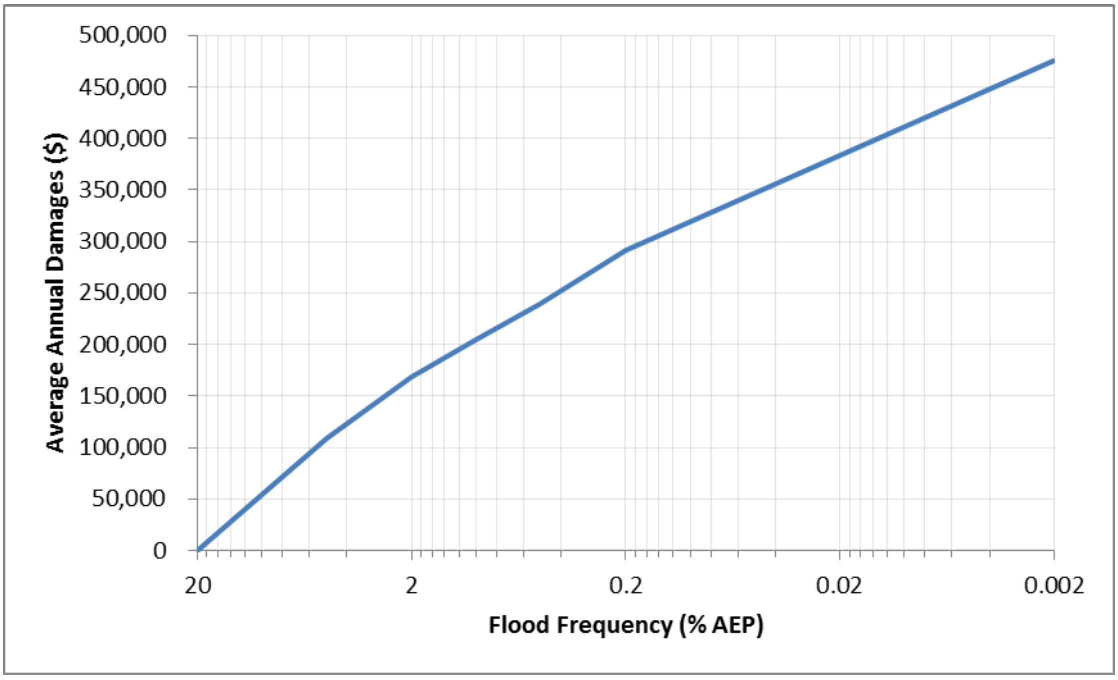


Figure 2.9: Cumulative Average Annual Damages

Table 2.3: Estimated Damages (2012 Values)

Flood Event % AEP	Residential $x1,000	Commercial / Industrial $x1,000	Caravans $x1,000	Public Buildings $x1,000	Total $x1,000	Cum AAD $x1,000
5%	795	5	0	650	1,450	109
2%	1,799	74	0	650	2,523	168
1%	3,541	158	250	650	4,599	204
0.5%	8,070	323	500	685	9,578	239
0.2%	22,625	1,058	780	1,032	25,495	292
EMAC	122,455	25,383	1,961	9,317	159,116	475
EBELL	60,603	18,487	1,630	4,653	85,373	

Table 2.3 indicates that flood damages increase progressively with the magnitude of the flood up to about $25.5 million at a 0.2% AEP flood. For an extreme flood, however, the damages could be up to $159 million. The average annual damages increase steadily up to the extreme flood. Overall the average annual damages in Wellington are modest and reflect the considerable flood mitigation protection afforded by Burrendong Dam.

The numbers of residential properties impacted and the estimated value of damages has increased when compared to the 1996 Study due to the following factors:

- additional properties have been included in the analysis as a result of the revised estimate of the extreme flood;
- residential damages have been updated based on the DECC Guideline methodology;
- application of CPI to 1996 commercial and public damage estimates to update to 2012 values.

The use of the DECC's Guideline to calculate residential damages has substantially increased the value of estimated residential damages and the number of properties classified as flood affected, due to the change in methodology and assumptions made in the DECC Guideline method. It should be noted that there has been **no change in the depth of inundation of properties for any of the modelled flood events**, with the exception of the EMAC.

Table 2.2 and **Table 2.3** do not include dwellings which may be impacted by overland flooding of the Aspley Drainage system (refer **Appendix F**). The investigation of the Aspley Drainage system did not include assessment of flood extents, identification of properties flooded, depths of flooding or damages. However, an indication of the numbers of properties which may be impacted by overland flooding caused by the 1% AEP event in this system includes:

- Railway Ave 8
- Zouch St/Cross St 8
- Zouch/Hawkins/Simpson 9
- Arthur St (East) 6
- Arthur St (West) 2
- Apsley St 4

Further investigation is required to confirm the numbers of properties impacted by overland flooding of the Apsley Drainage system and the resulting damages that would occur in the event of a flood.

The impact of flooding on infrastructure such as roads, bridges and electricity varies depending on the size of flood. **Table 2.4** provides a summary of indicative damages likely to be suffered by infrastructure in Wellington for various design flood events.

Table 2.4: Qualitative Effects of Flooding on Infrastructure and Community Assets

Damage Sector	Flood Event (AEP)						
	5%	2%	1%	0.5%	0.2%	EMAC	EBELL
Electricity	0	3	3	3,8	3,8	3,8	3,8
Telephone	0	0	0	0	0	11	11
Roads	1	1	1	1	1	1	1
Bridges	0	4	4,7	4,7,9	4,7,9	4,7,9,12	4,7,9
Sewerage system	0	5	5	5	5	5,13	5,13
Water supply	0	0	0	0	10	10	10
Parks and showground	2	2,6	2,6	2,6	2,6	2,6	2,6
SES headquarters	0	0	0	0	0	14	0
Hospital (Gisborne St)	0	0	0	0	0	15	0

Notes relating to **Table 2.4**:

0. No significant damages likely to be incurred
1. Roads on Bell River floodplain flooded
2. Pioneer Park flooded
3. Power poles at Herbert St bridge and pole mounted transformer on Macquarie/Bell floodplain flooded
4. Herbert St and pedestrian suspension bridge in vicinity of Cameron Park flooded
5. Pump station in vicinity of Arthur and Gobolion Streets flooded
6. Cameron Park and Showground/Racecourse flooded
7. Maughan Street flooded
8. Pad mounted transformer on Maughan Street adjacent to Bowling Club flooded
9. Mitchell Highway flooded
10. Water treatment works flooded
11. Telephone exchange flooded
12. Railway bridge flooded
13. Sewage Treatment Plant flooded
14. SES HQ flood affected
15. Hospital in Gisborne St flood affected

EMAC = Extreme flood in the Macquarie River
EBELL = Extreme flood in the Bell River

2.7 Flood Hazard

This section provides an update on the information relating to flood hazard which was contained in Section 2.7 of the 1996 Study.

The concept of flood hazard is discussed in Appendix L of the 2005 FDM. The 2005 FDM defines hazard as flooding which has the potential to cause damage to the community. The provisional hazard is related to a measure of the combination of depth and velocity at a particular location. Figure L2 from the FDM (reproduced below as **Figure 2.10**) shows the provisional hazard ratings, and the interface between High and Low hazard zones.

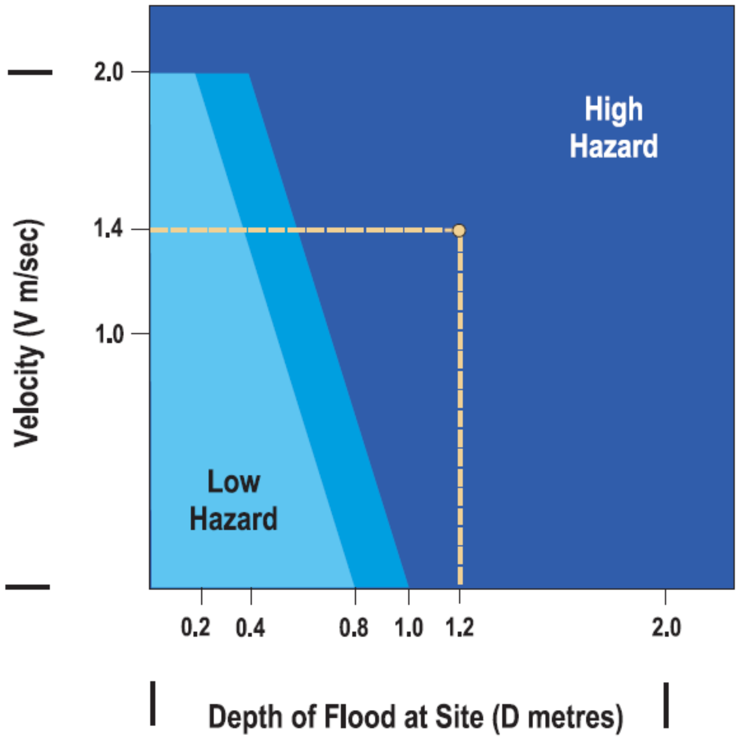


Figure 2.10: Provisional Hazard Rating

The provisional hazard can be increased or reduced after consideration of the following factors:

- effective warning time;
- flood awareness;
- rate of rise of floodwaters;
- duration of flooding;
- evacuation problems;
- access;
- potential flood damages.

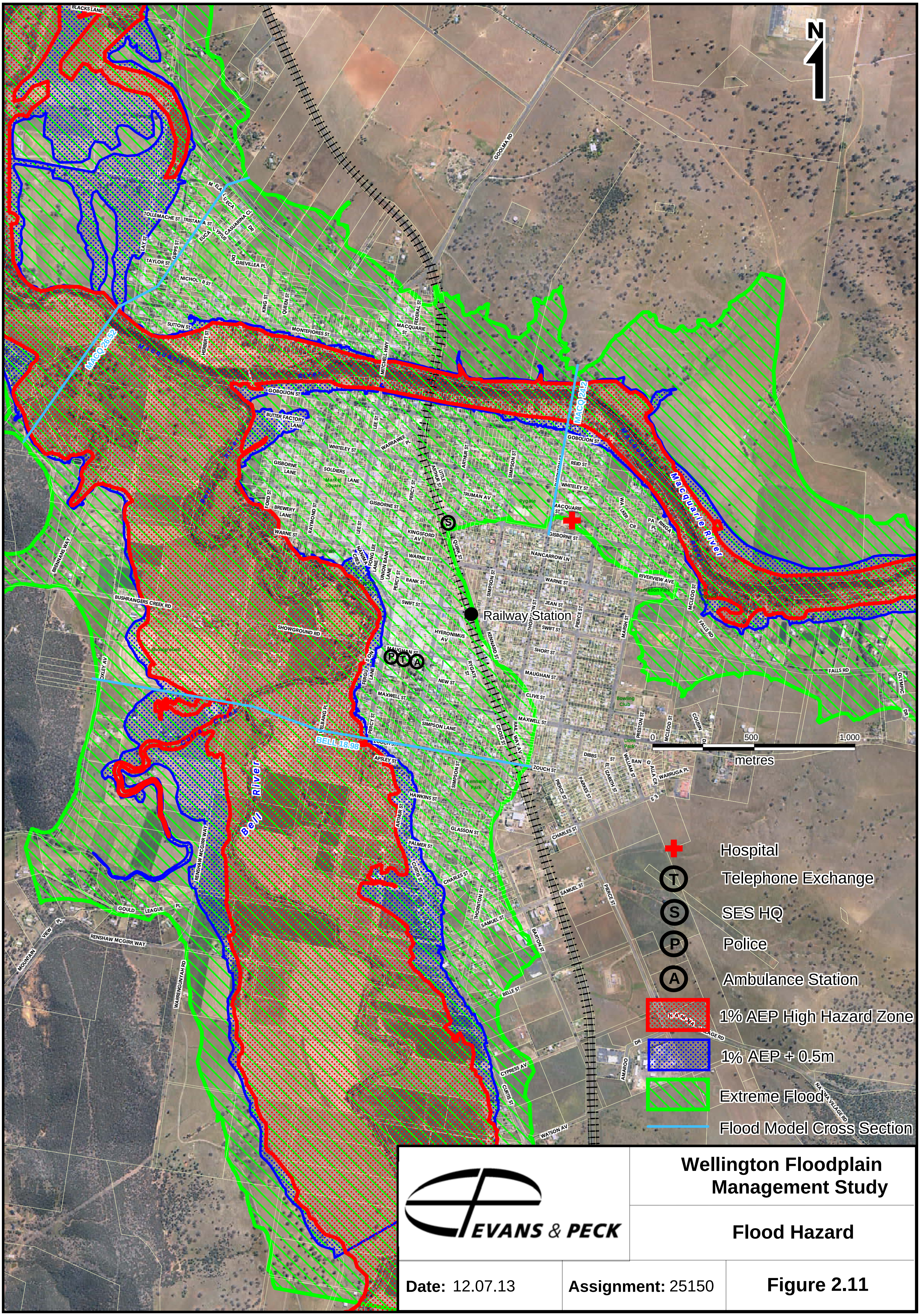
Wellington has a potential warning time of around 6-8 hours of flooding from the Bell River based on the travel time of the flood wave from the Neurea gauge and 6 hours warning from the Macquarie River as estimated by the time of travel of the flood wave from Burrendong Dam. (The effective warning time is, however, considerably longer due to the monitoring of the incoming flood peak by the gate operators). In addition the duration of peak flooding would usually be less than one day for a major event, although high flows may be prolonged on the Macquarie River due to releases from Burrendong Dam. These factors would suggest maintenance of, but not an increase in, the provisional hazard rating. Other factors, such as reasonable flood awareness in the town resulting from recent flood experience, absence of major evacuation problems or access problems due to the depth of flooding and relatively low potential damages would suggest that an increase in the hazard rating was not warranted. On balance, therefore, the provisional hazard rating should not be changed.

The hydraulic modelling results (see **Appendix A**), in conjunction with the damages model (**Appendix C**), were used to determine provisional hazard zones for the study area in the event of a 1% AEP flood, based on the guidelines provided in the 2005 FDM. These zones consist of:

- **high hazard**: possible danger to personal safety, evacuation by trucks difficult, able-bodied adults would have difficulty in wading to safety, potential for significant structural damage to buildings.
- **low hazard**: should it be necessary, trucks could evacuate people and their possessions, able-bodied adults would have little difficulty in wading to safety

For the 2013 review, the 2005 MIKE-11 hydraulic model was updated to a 1D geo-referenced MIKE-11 model based on an aerial photo and LiDAR data supplied by Council to produce the 1% AEP high hazard map.

Figure 2.11 shows the extent of the 1% AEP high hazard area, which is equivalent to the High Hazard Flood Risk Precinct (excluding evacuation issues) adopted for planning purposes. Based on the updated high hazard area definition, it is estimated that around 27 residential lots would have some portion of land located within the 1% AEP high hazard area. Of these, 13 residential dwellings within the high hazard area would experience above floor flooding. A list of these properties and a map showing their location is provided in **Appendix H** (supplied separately to Council).


N
Macquarie River
Bell River
MACQ 23.2
MACQ 25.2
BELL 18.98
Railway Station
0
500
1,000
metres
Hospital
Telephone Exchange
SES HQ
Police
Ambulance Station
1% AEP High Hazard Zone
1% AEP + 0.5m
Extreme Flood
Flood Model Cross Section
EVANS & PECK
Wellington Floodplain Management Study
Flood Hazard
Date: 12.07.13
Assignment: 25150
Figure 2.11

2.8 Social Effects

The 2005 FDM categorises flood damages as either tangible or intangible, with tangible damages further subdivided into direct and indirect. Essentially, tangible damages relate to the impact of flooding on the economic operation of Wellington while intangible damages or losses relate to the social impact of that flooding. Social impacts which could arise from flooding in Wellington include:

- inconvenience;
- isolation;
- disruption;
- psychological disturbances as a result of anxiety and trauma, and
- physical ill-health.

Flooding raises the following social implications for life in Wellington:

- Significant tracts of rural land within the study area are used for market gardens and other agricultural pursuits. These areas are contained within the fertile floodplain of both the Macquarie and Bell Rivers. Flooding of these areas has the potential for a significant impact on the economic viability of such activities and commensurate social impact both on the land owners and businesses which depend upon the viability of those activities.
- Main Road No. 233 (Maughan Street) passes through Wellington. Residents of rural areas to the west of Wellington are inconvenienced when that main road is severed by floodwaters near the Showground/Racecourse. As occurred in August 1990, this road can be inundated for two or more days in a major flood.
- Percy Street/Mitchell Highway is the main street of Wellington. This section of Wellington contains the majority of the business/commercial and retailing activity of Wellington. This area could be flooded for several days during the extreme flood event causing significant social disruption to the town and the surrounding rural areas.
- As expected, an extreme flood event would also impact on significantly more residential property than the 1% AEP event. In an extreme flood event the area generally bounded by Whiteley Street, the Macquarie River, the Bell River and Percy Street would be subject to flooding, with varying degrees of inundation of structures. A significant section of residential land bounded by the Mitchell Highway, Montefiores Street and Lay Street would also be inundated during the extreme flood event. The social disruption associated with such an event would be significant.
- During an extreme event, the majority of shops, a number of schools, churches, the post office, motor registry, ambulance station, telephone exchange, SES HQ, the hospital in Gisborne Street and police station would be inundated, which would contribute to the major social impact of such an event.

The above list is not exhaustive but provides an indication of the extent of the potential social impact of flooding in Wellington.

2.9 Environmental Considerations

The majority of the floodplain within the township of Wellington has been developed for agriculture or urban purposes. The only remaining "natural" areas lie within the river banks, particularly along the Macquarie River.

The Bell and Macquarie Rivers have different geomorphological forms within the township. The Bell River is characterised by having an incised channel which, over recent years, has been unstable and has started to undercut the deep alluvial floodplain deposits and to leave near vertical banks. The geomorphic behaviour of the Bell River within the town has been the subject of a geomorphological study (Thoms, 1995). In 1994, the then Department of Water Resources installed three weirs in the bed of the Bell in an attempt to provide a series of pools and to reduce the bank scour occurring.

The hydraulic analyses described in **Appendix A** show that releases from the flood mitigation storage component of Burrendong Dam at a rate of 460 m^3/s would result in tailwater levels at the Bell River confluence which would significantly reduce the flood slope and velocities on the lower reaches of the Bell River. This flow is equivalent to the 50% AEP peak discharge on the Macquarie River upstream of the confluence under pre-dam conditions. It amounts to a volume of 40 GL/day or 8% of the flood mitigation storage component of the dam.

The flood operation procedure of the dam (**Appendix B**) aims to maximise the flood mitigation potential of the storage and, if possible, take account of downstream flows, particularly on the Bell River. That is, releases are delayed, where possible, to follow and not compound the flood peaks from various downstream tributaries.

It may be practicable to maintain a release from the dam to cushion the effects of high flows on the Bell River, whilst maintaining the flood mitigation objectives. This may, in turn, reduce scour near the junction. However to investigate this matter further would require an operational study of the dam which is outside the scope of this present investigation.

The Macquarie River has a stable V shaped channel along much of its length through Wellington. The channel is generally 15 m deep and most of the floodwater is contained within its banks. The main river channel contains remnant vegetation including some large eucalypts but has also been subject to invasion by exotic species such as willows and weed species from domestic gardens. The invasion of exotic species along the river bank has the potential to increase the hydraulic roughness and raise flood levels. There does not appear to be any evidence that this has occurred yet, but monitoring of the vegetation along the Macquarie would be warranted to ensure that exotic species did not produce a significant increase in hydraulic roughness.

Council should consider a pro-active approach to the management of the vegetation along the riverine corridor of the Macquarie and prepare a vegetation management plan to maintain the original native vegetation and maintain a corridor for the movement of native birds and animals along the river.

2.10 Administrative / Political Considerations

The entire floodplain within the study area lies within the town of Wellington, the NSW State seat of Orange and the Federal electorate of Wellington.

Administrative interfaces on issues relating to this *Floodplain Risk Management Study* occur with respect to the following:

- Flood Warning — Bureau of Meteorology, Council and the State Emergency Service (SES).
- Planning Controls — DP&I, Council.
- Funding — Commonwealth Government, OEH, Council. Any request for funds to implement the recommendations of this report will be submitted through OEH with assistance sought from the Commonwealth.
- Floodplain crossings — Both the Roads and Maritime Services and Transport for NSW own bridge and approach embankment works on the floodplain and would be interested in any recommendation concerning these works.
- Welfare Management — Department of Family and Community Services, a range of service groups, Council, SES and Police. The arrangements under the State Emergency Management Organisation structure create numerous interfaces in the delivery of welfare services.
- Total Catchment Management — Central West Catchment Management Authority (CMA), whose Head Office is located in Wellington. On 1 January 2014, the functions of the CMA will be taken over by the Central West Local Land Services.

2.11 Transport Links

The Mitchell Highway bridge over the Macquarie River is the main access route between Wellington and Dubbo. The bridge is a comparatively recent structure with a deck level ranging between 295.4 and 295.9 m AHD and deep steel girders. The 1% AEP flood level is 292.6 m AHD, giving about 500 mm of freeboard between the peak water level and the underside of the girders. Longitudinal sections of the bridge approaches are not available. It appears that the bridge has been constructed at grade and therefore the route would remain flood free in the event of major flooding, at least in the vicinity of Wellington.

The Main Western Railway bridge is located 200 m upstream of the road bridge and is a high level structure above the 1% AEP flood peak.

Maughan Street, which is the main road link with Parkes (MR 233) has a bridge over the Bell River which has a deck level of 292.9 m AHD, slightly lower than the 1% AEP peak flood level (293 m AHD). While the bridge structure is set at a high level, the approaches on the Bell River floodplain are around 4 m lower (289.3 m AHD). This level is about 2.7 m below the peak level of a 5% AEP flood. Consequently, the approaches are impassable in a minor flood event. While floods originating from the

Bell River catchment are of relatively short duration, the bridge lies within the influence of backwater flooding from the Macquarie River, where flood peaks are prolonged by the attenuating effects of Burrendong Dam. The bridge approaches could be inundated for up to two days in a major flood such as the 1990 event.

A low level bridge across the Macquarie River has been constructed at Herbert Street linking the business district with the urban area of Montefiores. This bridge suffered damage in the August 1990 flood and can be expected to be flooded in floods smaller than the 5% AEP. However, there is alternative access between Montefiores and the town via the Mitchell Highway.

In summary, apart from the flooding of Maughan Street, there are no major issues relating to loss of access to and from Wellington during flood events.

3 FLOOD PLANNING LEVELS AND FLOOD RISK PRECINCTS

This section updates Section 3 of the 1996 Study. It has been updated to take account of the revised approach recommended in the 2005 FDM. **Sections 3.1** to **3.4** discuss the factors associated with the selection of FPLs.

3.1 General

The merit-based approach to floodplain management introduced by the 2005 FDM raises the need to select FPLs based on the particular local circumstances of flooding rather than adopting a state-wide standard. Key definitions provided in the 2005 FDM include:

- ***Flood planning area***: the area of land below the FPL and thus subject to flood related development controls.

  The concept of flood planning area generally supersedes the "flood liable land" concept in the 1986 FDM.

- ***Flood planning levels***: the combinations of flood levels (derived from significant historical flood events or floods of specific AEPs) and freeboards selected for floodplain risk management purposes, as determined in management studies and incorporated in management plans.

  FPLs supersede the "standard flood event" in the 1986 FDM.

Two important aspects of the adoption of FPLs are:

- Different FPLs may be set to reflect different flood hazards at different locations on the floodplain. In addition, FPLs may reflect the different consequences of flooding to different types of development on the floodplain.
- The FPL incorporates an adopted freeboard. The adopted freeboard is the difference between the flood event upon which the FPL is based and the FPL itself.

Various land uses are subject to different consequences (risks) from the flood hazard (e.g. the consequences of the flooding of a hospital are significantly different to the consequences of the flooding of an amenities block in parkland). Accordingly, there needs to be a simple approach reflecting the different flood risk to different land uses within the floodplain, while maintaining an understanding that flood risks still exist. The Flood Planning Control Matrix approach outlined in **Section 4.3.1** is an appropriate methodology to address these issues.

The merit approach is inherent in the selection of an FPL. It involves comparing social and economic considerations with the consequences of flooding, with a view to balancing the potential for property damage and danger to personal safety against the value of floodplain occupation. If the adopted FPL is too low for the type of development, new developments may be inundated relatively frequently, people may be subject to unnecessary danger and damage to associated public services will be greater. Alternatively, adoption of an excessively high FPL may subject land that is rarely flooded to unwarranted controls, reducing its productive usage to flood compatible activities.

Section 3.2 sets out the factors that influence the selection of an FPL and recommends an appropriate FPL for Wellington. **Section 3.3** provides information on the incorporation of selected FPLs within the Flood Planning Control Matrix.

3.2 FPL Factors

In accordance with the 2005 FDM, FPLs for new residential development will generally be based on the 1% AEP flood while the 2007 *Flood Planning Guideline*[1] explicitly restricts the adoption of a FPL greater than the 1% AEP flood (plus freeboard) for most residential development greater than the 1% AEP flood (plus freeboard). While there is potential to vary this, the 2005 FDM (as amended by the *Flood Planning Guideline*) states that this should only occur where it can be clearly demonstrated that the circumstances are exceptional. In proposing a case for exceptional circumstances, a Council would need to demonstrate that a different FPL was required for the management of residential development due to local flood behaviour, flood history, associated flood hazards or a particular historic flood.

There are a range of factors which are assessed in selecting the flood event upon which the FPL is based:

- risk to life
- social issues
- economic factors
- environmental issues
- cultural issues.

These factors are assessed in **Sections 3.2.1** to **3.2.3** in order to establish whether exceptional circumstances are present in Wellington that would warrant basing the FPL for residential development on a flood other than the 1% AEP flood.

3.2.1 Risk to Life

Consequences of the full range of floods

Risk to life issues relate to the consequences of the full range of floods including the flood used to derive the FPL and rarer floods.

A flood greater than that on which the FPL is based will eventually occur, and when it does, the potential exists for an increase in flood damages and hazard if the FPL has been set too low and has resulted in a large amount of unwise development. The occurrence of a flood greater than the FPL will always result in additional damages, unless the extreme flood is adopted as the basis for the FPL for all levels of development. Reference to **Table 2.3** shows that damages increase by about double

[1] See Department of Planning Circular dated January 31, 2007 (Reference PS 07-003). The *Flood Planning Guideline* issued by the Minister in effect relates to a package of directions and changes to the EPA Act, Regulation and Floodplain Development Manual.

between the 1% and 0.5% AEPs, and the 0.2% AEP is approximately 2.5 times that again.

Conclusion: The extreme flood should be the FPL for emergency management (risk to life) planning considerations. FPLs greater than the 1% AEP event could be applied to sensitive uses and critical facilities to minimise the consequences of an extreme event, which could be devastating to the sustainability of the town. Damages to residential properties in a 1% AEP event may have significant impacts on individuals but not on the sustainability of the town as a whole.

Emergency Response and Evacuation Issues

A flood runner would start to flow between the 1% and 0.5% AEP events in the vicinity of Montefiores and Gipps Streets and would isolate a high area of land near Teamsters Park **(Figure 2.2)**. Between the 0.5% and 0.2% AEP floods a second flood runner would start to flow in the vicinity of Montefiores and Queens Streets. This runner traverses low lying land to the north east of Montefiores and effectively severs access to the Montefiores area to the west of Queens Street. The flood runners create flood islands which result in a highly hazardous situation which could warrant an FPL based on a rarer event. However, all other areas have direct access to high ground.

Conclusion: The extreme flood should be the FPL for emergency management (risk to life) planning considerations. FPLs greater than the 1% AEP event could be applied to sensitive uses and critical facilities to minimise the consequences of an extreme event, which could be devastating to the sustainability of the town. Damages to residential properties in a 1% AEP event may have significant impacts on individuals but not but not on the sustainability of the town as a whole.

Flood Readiness

Does the flood history in Wellington suggest an FPL based on a particular flood? This involves a consideration of the magnitude and frequency of historic floods as well as the "flood awareness" of the population.

Flood levels in the Macquarie River at Wellington have been reduced by the operation of Burrendong Dam as a flood mitigation storage since its construction in 1965. The current 1% AEP flood level (post-dam) at the Mitchell Highway Bridge is 292.6 m AHD. The August 1990 flood reached a level about 1 m below the 1% AEP flood at this location and was generally around a 2% AEP flood along the frontage of the Macquarie and Bell Rivers in Wellington.

Experience in the August 1990 flood suggests that there is considerable flood awareness within the town which would support the adoption of an FPL based on no less than that particular event. On the other hand, the census data indicates that between successive censuses, typically 30% of the population of the town changed address. This suggests that, in a relatively short period after a major flood, there are likely to be a significant number of residents who have not experienced a flood.

Flood perception in the town is influenced by the attitude that the dam will provide protection from all future flood events. While it is true that the dam has a powerful attenuating effect on downstream flooding, the actual reduction in flood peaks for a particular flood will depend on the initial storage contents, the peak and volume of the inflow flood and the method of operation of the gate.

The results of the damages assessment described in **Section 2.6** have shown that damaging flooding may still be experienced under post-dam conditions for comparatively frequent flood events and there is therefore no room for complacency.

Conclusion: Appropriate basis for the FPL is no less than the 1% AEP flood.

3.2.2 Social Issues

Existing level of development

As land is developed, the options for changing its use and management are greatly reduced. This is due to the significant investment, both public and private, in existing development and associated infrastructure, such as buildings, roads, drainage, water supply, sewerage and electricity. The scale of existing investment is frequently such that the development cannot reasonably be abandoned, even if it is does have a high potential for flood damage.

In general, land within the 1% AEP floodplain in Wellington is zoned Primary Production, and flooding in urban zoned land is confined to areas on the flood fringe, mainly on the right bank of the Bell River. Several houses on urban land on the left bank of the Macquarie River will also be damaged in a 1% AEP flood. As shown in **Table 2.2**, 47 residential and six commercial properties could be damaged in a 1% AEP flood. For the same event, flood waters would encroach on an additional 40 residential properties. This suggests that the existing zoning is compatible with a 1% AEP event as the basis for the FPL. Adoption of a lower FPL, say a 5% AEP event, might result in a considerable increase in damages as a result of future encroachment into the floodplain. At present, the 5% AEP flood is around the threshold event at which significant damaging flooding commences and would damage six residential and one commercial property.

Floods larger than 1% AEP up to the 0.5% AEP result in a gradual increase in the extent of land inundated. The 0.5% AEP flood has a peak level generally about 1-1.4 m higher than the 1% AEP flood along the Macquarie River, while on the Bell River the difference in levels is around 900 mm. Beyond the 0.5% AEP event, there is a continuing gradual increase in flood extent on the Bell River and on the Macquarie River upstream of the Mitchell Highway. For a 0.5% AEP flood, there would be a significant increase in the extent of flooding in the Montefiores area, where a bench on the right floodplain would be inundated forming an island in the vicinity of Teamsters Park. It is estimated that 102 residences, 14 commercial premises and 2 public buildings would be damaged in the 0.5% AEP event.

The 0.2% AEP flood is generally around 1.3 m higher than the 1% AEP flood on the Bell River, 2.6 m higher on the Macquarie River upstream of the confluence and 1.8 m higher in the Montefiores area. The 0.2% AEP flood is a rare event having a probability of exceedance of 1 in 500 in any one year, (or an average recurrence interval of 500 years), and a probability of about 1 in 8 of being exceeded during a lifetime of 70 years. It is estimated that 327 residences, 31 commercial premises and 4 public buildings would be damaged in the 0.2% AEP event.

In the Montefiores area, access would be a problem during a 0.2% AEP flood due to the presence of two major flood runners which would isolate pockets of higher land. In this area it would be prudent to minimise development on land which does not have flood free access to high ground in major floods.

From the above discussion, it appears that the basis for the FPL should be at least the 1% AEP flood. Due to the topography of the floodplain, larger floods result in comparatively small increase in flood extent, although flood levels are higher. Consequently a slightly higher standard could reasonably be adopted.

Conclusion: Appropriate basis for the FPL is in the range of 1% - 0.5% AEP floods.

Current FPLs for planning purposes

The current FPL used for planning purposes has generally been set by a previous decision of council which may be based upon previous studies or historical precedent. It should therefore be an important consideration when determining FPLs for new development in the management study.

LEP 2012 requires all new buildings within the 'Flood Planning Land' on the Flood Planning Map to have floor levels that are 500 mm above the 1% AEP flood level at that location.

Should a 1% AEP flood be used as a basis for minimum floor levels it would not affect existing residential areas and the business district, which are already subject to this minimum level. The economic impact on the town would, therefore, be nil and as such a 1% AEP would probably be supported by the community.

Any increase in the FPL would carry with it the burden of increased development costs, or of development opportunities foregone, which flow through to the community's cost of living. On the other hand, too low a standard would encourage unwise development and would increase average annual flood damages.

Conclusion: Appropriate basis for the FPL is no less than the 1% AEP flood.

Land values and social equity

Land values are influenced by the proximity of the land to natural features such as watercourses, employment and community facilities. Most of the community is aware that overbank flows from watercourses happen from time to time and land values incorporate this awareness. Some people have the perception that specific estimates of the likelihood of flooding have a much greater impact on land values than the general community awareness of flooding does. Therefore as FPLs are based on specific estimates of the likelihood of flooding, decisions about FPLs must recognise the associated social equity issues. This is particularly relevant if the decision about FPLs limits the type of development that may occur at a site.

Should a 1% AEP flood be used as a basis for minimum floor levels it would not affect existing residential areas and the business district which are already subject to this minimum level. The economic impact on the town would, therefore, be nil, and as such a 1% AEP would probably be supported by the community.

Adoption of a very rare flood as the basis for the FPL would carry with it the burden of increased development costs, or of development opportunities foregone, which would flow through to the community's cost of living. On the other hand, too low a standard would encourage unwise development and would increase average annual flood damages.

The social impacts of flooding on Wellington are small because of the flood mitigation effect of Burrendong Dam. The major social impacts associated with flooding are the inconvenience caused by flooding of roads and the stress and trauma associated with flooding of residences. Changing the FPL within a reasonable range will not have a significant social impact.

Conclusion: Appropriate basis for the FPL is at least the 1% AEP flood

3.2.3 Economic Factors

Future Development

A key consideration in new development cases is the ability of people to financially recover from severe flood events. This is an area where residents generally have less flexibility than businesses.

Most of the 1% AEP floodplain has been zoned for rural, agricultural or open space activities. The area zoned urban has some potential for more intense land use in the business zone as well as for infill of vacant residential lots and development of existing lots in the residential areas. However, the main pressure for residential development is in the Montefiores area, north of the Macquarie River. Development commenced in this area in the early 1980s and there are around 130 houses in the area, with the possibility of an additional 200. Around 10 new dwellings are being built each year.

In general, the existing development pattern does not impose a major constraint on the selection of an FPL based on the 1% AEP level. However, adoption of a significantly rarer event may constrain future development. Against this, it should be recognised that adoption of the 1% AEP as the basis for the FPL is likely to lead to a steepening of the damage-frequency curve (see **Figure 2.8**) for lower frequency (rarer) floods, as future development decisions would allow development to occur in that range. The overall effect would be to increase the average annual value of damages. Adoption of a somewhat rarer flood as the basis for the FPL would reduce that effect.

An additional consideration is that the flood runners in the Montefiores area operate at the 0.5% and 0.2% AEP events and would create flood islands which could result in a highly hazardous situation.

There are approximately 75 undeveloped residential properties and a commercial block that would be affected by the 0.5% AEP flood but which are not affected by the 1% AEP flood. The effect of adopting a FPL based on the 0.5% event would be to allow Council to impose minimum floor levels for new buildings on these blocks. It is unlikely that the adoption of a 0.5% AEP flood as the basis for the FPL would lead to prohibition of building on any of these blocks.

The demand for greenfield land for urban development in Wellington appears limited. The number of persons and dwellings within the Wellington township remained generally stable between the 2006 and 2011 censuses[2]. The most recent population projections from the Department of Planning and Infrastructure[3] indicate that the population of the LGA will decrease from about 8,600 to 7,100 persons over the next 25 years. Therefore, the maintaining of a higher FPL would not likely have the impact of constraining the orderly and economic expansion of the township to meet future housing needs.

Conclusion: Appropriate basis for the FPL is no less than the 1% AEP flood for habitable floor levels but an extreme flood for the purposes of assessing evacuation capability.

Potential Flood Damages

Does the nature or rate of increase of flood damages vary greatly within the feasible range of floods associated with the FPL?

Historic development has resulted in the potential for flood damages to commence with a 5% AEP flood, where flooding affects several properties on the floodplain of the Bell River. **Figure 2.8** shows the relationship between damages and flood frequency while **Figure 2.9** shows the cumulative average annual damages.

On the basis of the considerable potential for flood damages under present day conditions and the shape of the damages-frequency relationship, adopting the 1% AEP event as the minimum basis for the FPL appears reasonable. If such an FPL was adopted and appropriate policies implemented, then, in the long term, there should be minimal damage to new complying development associated with floods up to and including the 1% AEP flood. However, the cumulative average annual damages continue to increase up to the extreme flood. In order to minimise the long term average annual losses to the community, the 0.5% AEP flood would be an appropriate basis for the FPL.

Conclusion: Appropriate basis for the FPL is no less than 0.5% AEP flood.

Environmental Issues

It may be possible to choose an FPL to meet multiple objectives. For example, areas immediately adjacent to the watercourse (riparian zone) may also have a high conservation value and be below the proposed FPL. By ensuring this land is not developed inappropriately, valuable habitat areas may also be conserved. However, land use limits are a more appropriate tool for this purpose.

There would be no impact on the riverine environment as a result of adopting a particular flood to define the FPL.

[2] 'Place of usual residence' 2006 and 2011 census data for the 'Wellington urban centre' shows that the number of person decreased marginally from 4,660 to 4540 as did the number of occupied and unoccupied private dwellings which fell from 2,141 to 2,077. The decrease in dwelling numbers is questionable and may relate to minor changes to census collector districts but nonetheless reflect minimal growth rates.

[3] Department of Planning, 2010.

Cultural Issues

FPLs are unlikely to result in significant impacts on cultural issues. These are more likely to be affected by location of protection works or new development areas. However, the FPL of a protection work, such as a levee may impact on the views from a cultural site. Where this is a key issue for the site it may need consideration in balance with flood risk management objectives.

There would be no impact on cultural issues as a result of adopting a particular flood to define the FPL.

3.3 Recommended FPL

3.3.1 Selection of the flood upon which the FPL is based

Based on the assessment in **Sections 3.2.1** to **3.2.3**, there are no exceptional circumstances at Wellington that would provide adequate justification for adopting a residential FPL that is inconsistent with the 2005 FDM (as amended by the 2007 *Flood Planning Guideline*) other than for emergency management considerations. FPLs up to an extreme flood would be warranted generally for emergency management considerations and for sensitive uses and critical facilities.

3.3.2 Freeboard Selection

Freeboard is incorporated into FPLs. It is the difference between the flood upon which the FPL is based and the FPL itself. The purpose of freeboard is to provide reasonable certainty that the reduced risk exposure provided by selection of a particular flood as the basis of an FPL is actually provided.

The 2005 FDM states that, in the majority of circumstances, a freeboard of 0.5 m is acceptable for new residential development controls. There are no exceptional circumstances at Wellington that would justify a different freeboard.

3.3.3 Recommended FPL

The 1996 Study recommended that "the flood level corresponding with the 0.5% AEP flood should be used to define flood prone land which will be subject to flood related planning controls in Wellington." No freeboard was included.

This recommendation has changed in light of the 2005 FDM for the reasons outlined in the preceding sections. The updated recommendation is a range of FPLs that adopts the default 1% AEP event plus a freeboard of 0.5 m for general residential development considerations, and an extreme flood event for sensitive uses, critical facilities and emergency management considerations for all development. Other FPLs may be appropriate for specific development components such as non-habitable floors, robust structures and park amenity buildings.

3.3.4 Climate Change

The 2005 FDM recommends that the impacts of climate change be assessed in the Flood Study, however this was not done in the Wellington Flood Study. The potential adverse impacts of climate change on flooding behaviour include altered weather patterns which may intensify storms and so increase the severity of the resulting floods. Consideration of the associated impacts through sensitivity analyses may lead to:

- deciding to adopt a higher FPL now to provide a certain level of future protection; or
- deciding upon a particular level of flood protection now that will lead to a reduced level of flood protection in the future.

The 2005 FDM recommends that an appropriate FPL for residential development would still generally be the 1% AEP flood event plus 0.5 m freeboard. Freeboard could be expected to account for reasonable change in risk over time and therefore selection of a more conservative FPL is not generally necessary.

The *Floodplain Risk Management Guideline - Practical Consideration of Climate Change* (DECC, 2007) recommends that "*flood studies and associated reports should have a section that specifically addresses climate change. The scope of reporting should include an outline of the modelling and analyses undertaken and their limitations, discuss the impacts of climate change on flood behaviour and outline any associated conclusions and recommendations. Where the study also looks at ramifications of flooding and examines management options, these issues should also be addressed in the climate change section of the report.*

Where the project or decision making has progressed beyond this stage and climate change has not been considered, it is recommended that it be considered to ensure that decisions and options are robust and adaptive enough to deal with relevant climate change impacts for the locality. This may be undertaken as part of a review to the FRMP (required at least every 5 years under the 2005 FDM), as part of the preliminary concept design for a works project or as part of a review of works or development strategies that have been implemented."

It is recommended that future reviews of the FRMP address climate change impacts in accordance with the DECC *Guideline* and the 2005 FDM. This does not, however, change the FPLs recommended in **Section 3.3.3** above.

3.4 Categories of Flood Prone Land

The 2005 FDM promotes the appropriate use of flood liable land by breaking it down into areas based on:

- frequency of inundation
- hydraulic function comprising of:
  - floodways in which floodwaters are conveyed
  - flood storage areas where flood waters are temporarily stored during flood events
  - flood fringe areas
- flood hazard (a minimum of two categories: high and low).

It is proposed that all land inundated by the extreme flood (EMAC) be classified into flood risk 'precincts' that reflect the characteristics of flooding on the land and the consequent hazard. Different flood-related development controls would apply depending on the precinct and the type of development.

Three flood risk precincts are recommended for Wellington:

High Flood Risk Precinct	**This refers to land subject to a high hydraulic hazard in a 1% AEP flood.** The High Flood Risk Precinct is where major impacts on flood behaviour, high flood damages, potential risk to life or evacuation problems would be anticipated. Most development should be restricted in this precinct. Without compliance with flood related building and planning controls there would be a significant risk of flood damages and changes in flood behaviour in this precinct.
Medium Flood Risk Precinct	**This refers to the area below the 1% AEP flood level +0.5 m, but above the high hazard 1% AEP extent.** Development within the Medium Flood Risk Precinct would still be at significant risk of flood damage, but these damages can be minimised by the application of appropriate development controls.
Low Flood Risk Precinct	**This refers to all other land within the floodplain that is not in a High or Medium Flood Risk Precinct, that is, land above the 1% AEP flood level + 0.5 m and below the level of the extreme flood.** In the Low Flood Risk Precinct the risk of damages is low for most land uses and, therefore, most land uses would be permitted without flood related development controls. Those uses considered critical or requiring maximum protection against risk from flooding should be identified as undesirable land uses in this precinct.

These precincts have been formulated to provide a basis for strategic planning and development control having regard to the specific characteristics of the Wellington Floodplain. Recommendations for planning controls within these three precincts are presented in **Section 4.3** and **Appendix E**.

The other major purpose of the precincts is to identify and recognise the potential flood risk for all persons and properties affected by the EMAC extreme flood, regardless of whether any specific development controls are to be applied. This provides a basis for flood awareness programs, evacuation and emergency planning and to maximise the preparedness of the community.

The extent of inundation was defined as part of the 1996 Study on 1:5,000 scale GIS Flood Extent Maps with a 2 m contour spacing. As part of this update, the extent of inundation for the following events has been defined based on a 0.5 m contour spacing:

- 1% AEP High Hazard zone
- 1% AEP + 0.5 m
- Extreme flood (EMAC/EBELL).

These extents have been provided to Council as GIS layers for use in conjunction with the flood planning measures discussed in **Section 4.3.1**.

The Flood Extent Maps should be used as a guide only, with the final flood status determined by comparing the relevant FPL with ground survey.

4 POTENTIAL FLOODPLAIN MANAGEMENT MEASURES

This section supersedes **Section 5** of the 1996 Study and identifies measures to manage flood risk within Wellington.

The information has been re-organised and re-presented according to the revised approach outlined in the 2005 FDM, which requires a strategic approach to the assessment and consideration of the following three types of flood risk:

- *existing flood risk* - the management of flood damage and personal danger to the existing community and properties at risk to an acceptable level
- *future flood risk* - the management of flood damage and personal danger in areas yet to be developed to an acceptable level
- *continuing flood risk* - the management of personal danger, in particular (with flood damage a lesser consideration), associated with management measures being overwhelmed by a larger flood than used to design works or manage future development, and/or in areas not protected by measures, e.g. outside a levee.

Sections 4.1 to **4.4** provide information on potential floodplain management measures, including measures from the 1996 Plan and new measures that have since been identified. The management measures are reviewed for appropriateness and ranked according to various criteria in **Section 6** and **Appendix G.**

4.1 Flood Risk and Available Measures

The 1986 FDM dealt with both existing and future flood risks by considering flood mitigation and development controls. The 2005 FDM takes a more strategic approach, requiring assessment and consideration of existing, future and continuing risk.

The 1996 Study categorised potential floodplain management measures in terms of:

- property modification measures
- response modification measures
- flood modification measures.

Table 4.1 shows the relationship between these categories and the risk approach.

Table 4.1: Floodplain Risk Management Measures

Type of Flood Risk	Property Modification Measures	Response Modification Measures	Flood Modification Measures
Existing	• voluntary purchase • voluntary house raising • flood proofing buildings • flood access		• flood control dams • retarding basins • levees • bypass floodways • riverine management • flood gates

Table 4.1: Floodplain Risk Management Measures

Type of Flood Risk	Property Modification Measures	Response Modification Measures	Flood Modification Measures
Future	• zoning • building and development controls	• community awareness (indirectly by information derived from planning documents)	
Continuing		• community awareness • community readiness • flood prediction and warning • local flood plans • evacuation arrangements • recovery plans	

Sections 4.2 to **4.4** provide details on the various measures applicable to Wellington.

4.2 Measures to Alleviate Existing Flood Risk

4.2.1 Voluntary Purchase

In certain high hazard areas of the floodplain it may be impractical or uneconomic to mitigate flooding to existing properties at risk. In such circumstances it may be appropriate to cease occupation of such properties in order to free both residents and potential rescuers from the danger and cost of future floods.

Removal of flood affected housing is generally accepted as a cost effective means of correcting previous decisions to build in high hazard areas. These areas are those that would fall within a High Flood Risk Precinct. The voluntary purchase of residential property in high hazard areas has been part of subsidised floodplain management programs in NSW. After purchase, the property is removed or demolished and the site rezoned to a flood compatible use e.g. public open space.

A criterion applied by State Government agencies is that the property must be in a high hazard area where the depth of inundation and flow velocity are such that life could be threatened, damage of property is likely and evacuation difficult.

Where a property qualifies for voluntary purchase, the owner is notified that the body controlling the voluntary purchase scheme (the Council in the case of Wellington) is prepared to purchase the property when the owner is ready to sell. At no time is the property owner under any compulsion to sell. The price is determined by independent valuers and the Valuer General, and by negotiation between Council and the owners. Valuations are based on equivalent properties which are not affected by flooding.

The 1996 Study identified 16 residential and two commercial properties as being located in the high hazard area. The two commercial properties (the greenhouses and showground sheds on Maughan Street), which are located on the Bell River floodplain, do not qualify for inclusion in a voluntary purchase scheme due to their commercial nature.

Investigations by Council since the 1996 Study in conjunction with the updated hazard mapping indicates that 14 residential properties remain located in the high hazard area in 2013 and are considered candidates for inclusion in a voluntary purchase scheme, if it were to be pursued.

Council has provided an estimate of the valuation of the residential properties concerned, with a total indicative capital cost of a voluntary purchase scheme of around $1.8M. Assuming that this cost would be spread over a 20 year period, the net present cost of the scheme (for a 7% discount rate) would be about $950,000. The present worth of benefits, determined from the damages assessment, would amount to $770,000, resulting in a benefit-cost ratio of 0.8. The scheme is therefore not economically justifiable, but should be considered due to the position of the residential properties in the high hazard area and the difficulty of flood evacuations from these houses.

A list of properties for further consideration for inclusion in a voluntary purchase scheme has been supplied confidentially to Council (refer **Appendix H)**. It will be necessary for Council to make further investigations regarding the final list of properties it wishes to include in a voluntary purchase scheme in accordance with the *Floodplain Management Guideline for Voluntary Purchase Schemes* (provided in **Appendix H**).

4.2.2 Flood Proofing

This term refers to procedures undertaken, usually on a property by property basis, to protect structures from damage by floodwaters. The required floor level can be achieved in suitable existing structures by jacking up the house, constructing new supports, stairways and balconies and reconnecting services. It is generally not practical or economical to raise brick or masonry houses. The technique is therefore limited to dwellings of timber frame construction with fibro-cement or timber cladding. House raising is most applicable to dwellings which are not in high hazard areas.

Other procedures to flood proof properties include the construction of levees or diversion banks to deflect floodwaters away from individual residences. These banks could take the form of grass mounding or low block walls. Each situation should be evaluated separately and a site plan prepared showing the required works. In addition, the cumulative effects of such measures, which could exacerbate flooding, should be considered. Runoff from within protected areas must be catered for by temporary storage or drainage to downstream areas. On occasions, micro pump-out systems have been used to dispose of internal drainage. Waterproofing the outer skins of structures and providing floodgates/shutters on doorways and windows have also been used. This method is usually only applied to brick or masonry structures, is not common and not usually very aesthetically pleasing.

It is understood that flood proofing measures have been implemented by one householder on a property located in, or close to, the high hazard zone in Montefiores Street. Flood proofing is more applicable to areas which are not in high hazard zones. In high hazard areas removal of property is more applicable, although there would be some overlap between houses recommended for voluntary purchase and houses recommended for flood proofing. In practice, each area would have to be carefully evaluated to determine the best mix.

In accepting schemes for eligibility the Government has laid down the following conditions:

- house raising should be part of an adopted Floodplain Risk Management Plan
- the scheme should be administered by the local authority.

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

Under the Voluntary House Raising Program, where it is shown to be cost effective, the NSW Government may provide financial assistance to raise a dwelling to put the habitable floor level at the FPL.

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

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

Three residential dwellings in Wellington could be candidates for a house raising scheme. The approximate cost to raise a medium sized house is around $65,000 in 2012 values, based on experience in Kempsey. Therefore the capital cost of a house raising scheme could amount to $195,000. Assuming that this cost would be spread over a 20 year period, the net present cost of the scheme (for a 7% discount rate) would be about $105,000. The present worth of benefits, determined from the damages assessment, would amount to $70,000, resulting in a benefit-cost ratio of 0.7. The scheme is therefore approaching economic justification and could be considered.

Flood proofing of commercial premises could be achieved through the provision of floodgates/shutters on openings.

A list of properties for further consideration for inclusion in a voluntary house raising scheme has been supplied confidentially to Council (refer **Appendix H**). It will be necessary for Council to make further investigations regarding the final list of properties it wishes to include in a voluntary purchase scheme in accordance with the *Floodplain Management Guideline for Voluntary House Raising Schemes* (provided in **Appendix H**).

4.2.3 Channel Works

The hydraulic capacity of a river may be increased by widening, deepening or straightening the channel and by clearing the banks of obstructions. The scope of such improvements can vary from minor works such as de-snagging and bank clearing, which do not increase the waterway area but reduce hydraulic roughness, to major channel excavations.

Careful attention to design is required to ensure stability of the channel is maintained and scour or sediment build up is minimised. A degree of sinuosity is often provided in the channel route for these and aesthetic reasons. The potential for channel improvements to increase downstream flood peaks also needs to be considered. In general, channel improvements need to be carried out over a substantial stream length to have any significant effect on flood levels.

Stream Clearing and Vegetation Management

The existing channel of the Macquarie River upstream of the Bell River confluence is a deeply incised channel with a large hydraulic capacity. It is capable of containing flows up to the 1% AEP level without significant overbank flows.

The calibrated hydraulic model used in the *Flood Study* (DLWC, 1995) assigned values of hydraulic roughness of around 0.05. These values are characteristic of a hydraulically efficient channel which would not be significantly improved by minor clearing, which in any case would require a continuing program of maintenance to remain effective.

Downstream of the confluence, the channel is less incised but maintains a high hydraulic capacity. In this reach hydraulic roughness of the model was generally 0.04.

The Bell River has suffered considerable instability over the years which has resulted in significant costs incurred in efforts to control bed and bank erosion. An investigation by Thoms in 1995 suggests that erosion on the lower Bell River is mainly due to bank instability and that the bed of the river is relatively stable. The report also states that de-snagging of the river appears to have caused local scour of the banks due to channel smoothing and subsequent velocity increases.

Efforts at increasing channel capacity whether by minor clearing or channel enlargement would not be supported by the relevant Authorities as they may promote further instability.

Whilst significant stream clearing is not warranted, Council should consider being pro-active in managing vegetation in order to prevent the need arising in future, particularly along the incised section of the Macquarie River. Both rivers provide open space corridors through the town which offer the potential to provide a significant recreation and habitat resource whilst ensuring that hydraulic capacity is maintained:

- The vegetation along the riverine corridors should be managed to maintain hydraulic conveyance capacity. Invasion of exotic trees such as willows and shrubby vegetation on the higher banks will increase the hydraulic roughness compared to the original riverine vegetation. Whilst the effect of invasive exotic species is unlikely to have a significant effect because of the size of the channel, maintenance of hydraulic capacity should be an important consideration in the future management of these areas.
- The riverine corridor provides a natural pathway for the movement of native animals and birds through the urban area. Enhancement of the habitat value would also provide a haven and encourage native bird populations within the town. The Macquarie River corridor appears to have retained some of its original

vegetation which could form a basis for reintroduction of a wider diversity of native plants to the area.

- The river corridors have the potential to provide a valuable passive recreational resource for the town. The creation of a walking path along the river banks could provide a contrasting tranquil natural environment linking some of the other parks in town.

The 1996 Study recommended that Council be pro-active in managing riverine vegetation, particularly along the incised section of the Macquarie River. The main focus subsequent to the 1996 Study has been the management of Bell River erosion and bed stabilisation works.

Council is seeking funding to install the bank protection works listed in **Table 4.2** and shown on **Figure 4.1**.

Table 4.2: Bell River Bank Protection Works

Priority	Area on Figure 4.1		Length of Protection (m)
1	1	Bell River eastern bank at confluence of Bell and Macquarie Rivers	280
2	6 & 7	Bell River eastern bank	200
3	3	Bell River northern bank	170

These works are not eligible for funding under the Floodplain Management Program administered by OEH, as they are not located within the urban area, and are therefore not recommended for inclusion in the FRMP. Council applied for funding for these works under the NSW Environmental Trust in 2013 and has been placed on the reserve list.

Any riverine management works implemented as part of the FRMP would need to be carried out in accordance with the relevant legislation, including:

- *Water Management Act 2000;*
- *Native Vegetation Act 2003;*
- *Fisheries Management Act 1991.*

Water Management Act 2000

Instream works are regulated by the controlled activity provisions of the *Water Management Act 2000* (WM Act). The NSW Office of Water (NOW) administers the WM Act and is required to assess the impact of any proposed controlled activity to ensure that no more than minimal harm will be done to waterfront land as a consequence of carrying out the controlled activity. Instream works include modifications or enhancements to the watercourse, channel realignment, bed control structures, pipe laying and cable trenching etc.

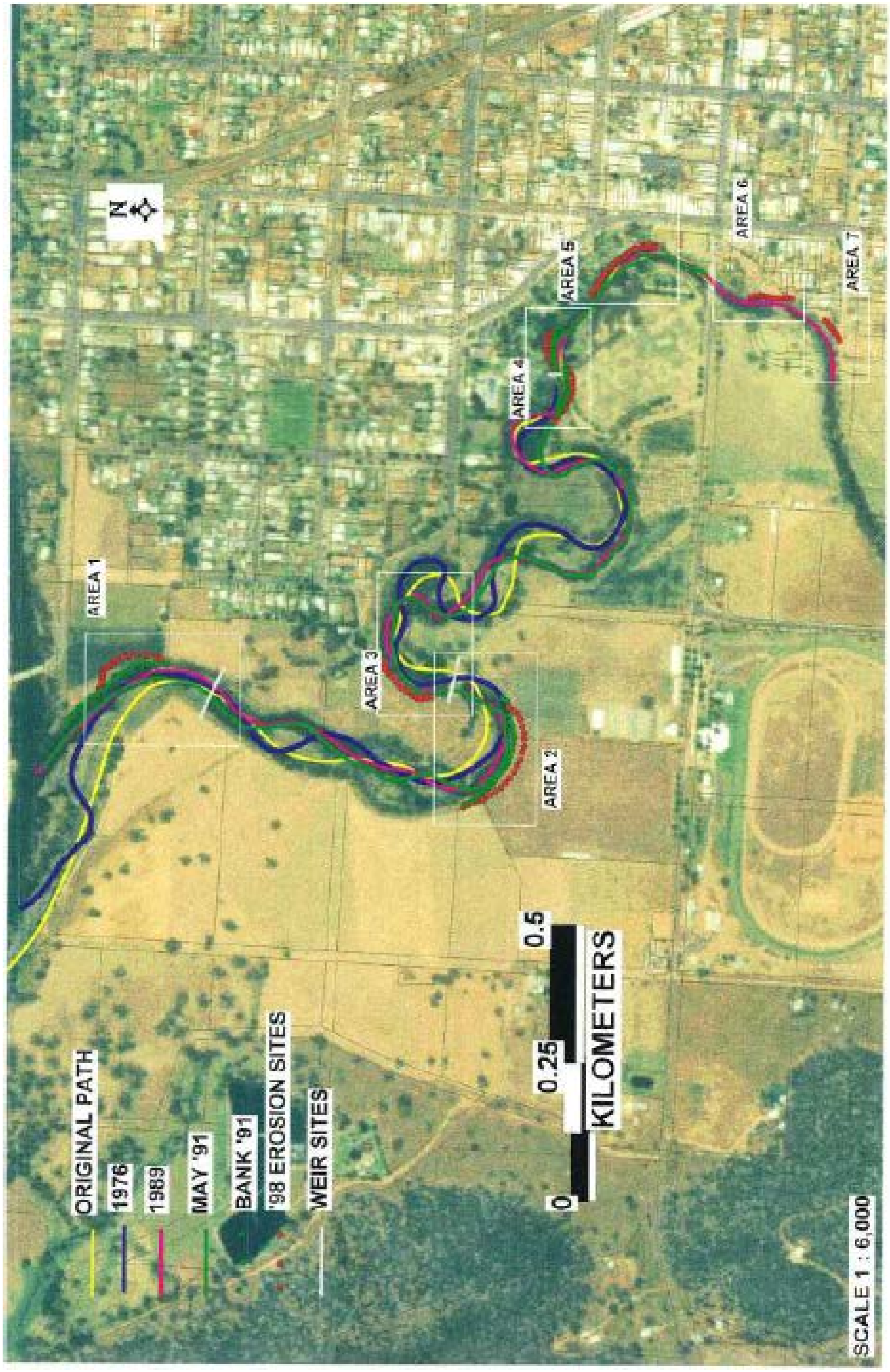


Figure 4.1: Bell River Channel Changes and Bank Erosion

Although Councils are exempt from NOW's controlled activity approvals, the NOW's *Guidelines for instream works on waterfront land* must still be followed.

The design and construction of works or activities within a watercourse or adjoining waterfront land should protect and enhance water flow, water quality, stream ecology and existing riparian vegetation. Impacts on the hydrologic, hydraulic and geomorphic functions of a watercourse should also be minimised. The design and construction footprint and the extent of disturbances within waterfront land should be minimised. Consultation with relevant government agencies at the concept stage of development and during the design phase is recommended.

All waterfront land disturbed by the construction or installation of a controlled activity should be rehabilitated in such a way that the integrity of the watercourse and its riparian corridor is restored or rehabilitated.

Considerations to be addressed in the design and construction of instream works are provided in the Guideline and include:

- Identify the width of the riparian corridor in accordance with the NSW Office of Water guidelines for riparian corridors.
- Consider the full width of the riparian corridor and its functions in the design and construction of any instream works. Where possible, the design should accommodate fully structured native vegetation.
- Identify alternative options and detail the reasons for selecting the preferred option/s.
- Minimise the design and construction footprint and proposed extent of disturbances to soil and vegetation within watercourse or waterfront land.
- Maintain or mimic existing or natural hydraulic, hydrologic, geomorphic and ecological functions of the watercourse. Demonstrate the instream works will not have a detrimental impact on these functions.
- Maintain the natural geomorphic processes.
- Maintain the natural hydrological regimes.
- Protect against scour by designing and providing necessary scour protection, for example, rock riprap and vegetation.
- Stabilise and rehabilitate all disturbed areas including topsoiling, revegetation, mulching, weed control and maintenance in order to adequately restore the integrity of the riparian corridor.
- Monitor and maintain all in-stream works until suitably stabilised.

Native Vegetation Act 2003

There is a range of measures available under the *Native Vegetation Act 2003* and certain provisions of the *Native Vegetation Conservation Act 1997* that may allow thinning of vegetation in flowpaths within the floodplain. Any proposals to undertake vegetation clearing to maintain flowpaths should be discussed with the Central West CMA (whose functions are to be taken over by Central West Local Land Services from 1 January 2014). The method of thinning should be one that minimises soil disturbance and reduces damage to non-target species. It is equally important that flowpaths be maintained and regularly inspected for damage, with identified problems promptly fixed. Such maintenance could include slashing and desilting.

4.2.4 Flood Mitigation Dams

Burrendong Dam, which was completed in 1965, controls 86% of the catchment above Wellington. As noted in **Sections 2.2** and **2.3**, studies by DLWC have shown that the dam reduces peak flood levels of major floods on the Macquarie River very significantly. A more detailed technical discussion of its influence on downstream flood flows is given in **Appendix B**.

Apart from the zone of backwater influence from the Macquarie River, which extends from the confluence upstream to Maughan Street, flooding along the Bell River is controlled by runoff from its own catchment which has an area of 1,860 km^2 at Wellington and is unregulated.

In 1973, the Department of Water Resources carried out an investigation into the feasibility of constructing a water conservation storage dam on the Bell River. In all, nine sites were investigated in the middle to upper reaches of the catchment. Site number 9, which is located downstream of Larras Lea and about 36 km upstream of Wellington, was considered the best dam site. This site controls about 960 km^2, equivalent to 50% of the catchment of the Bell River at Wellington.

Dams with a conservation storage ranging between 68 and 308 GL were investigated and preliminary layouts prepared. Details are shown in **Table 4.3**.

Table 4.3: Details of Conservation Storages on the Bell River (DWR, 1973)

Storage Volume (GL)	Full Supply Level (m)	Crest Level (m)	Width of Spillway (m)	Capital Cost $M (1973)
68	462	474.9	51.8	8.1
185	475	486	58.2	11.8
308	483.4	491.6	92.9	14.1

The study showed that none of the dams investigated was economically justified as a conservation storage. Possible flood mitigation benefits were not considered. Each dam was provided with an uncontrolled spillway designed to convey a flood with a peak discharge of 5,500 m^3/s and a 5 day volume of 470 GL, equivalent to about 490 mm of runoff from the catchment. The dams were not designed with a flood mitigation purpose in mind. However, it appears that due to the considerable volume of flood storage available above full supply level, a considerable reduction in the magnitude of the inflow peak would be achieved.

In the case of the 185 GL storage dam, and after allowing 1 m of freeboard between top water level and the crest of the dam, the inflow peak of 5500 m^3/s would be reduced to an outflow of 2,750 m^3/s.

These flows compare with the following Bell River discharges at Wellington, as given in the Flood Study (DLWC, 1995):

- 1% AEP 2,140 m^3/s

- 0.2% AEP 3,220 m^3/s
- 0.002% AEP 8,350 m^3/s
- PMF 12,800 m^3/s

Based on the assumption that peak flows increase according to the ratio of the catchment area raised to the power 0.7, the corresponding flows at the dam site are:

- 1% AEP 1,300 m^3/s
- 0.2% AEP 2,000 m^3/s
- 0.002% AEP 5,100 m^3/s
- PMF 7,800 m^3/s

Optimisation of the air space above full supply level by the provision of a gated spillway (at additional cost), together with implementation of a flood prediction system similar to that used for Burrendong Dam, could be expected to achieve additional reductions in peak outflow than could be obtained by the uncontrolled spillway adopted in the 1973 study. Consequently, the dam would be expected to have a significant effect in reducing flood peaks in the rural areas near the dam site. However, these effects would become progressively smaller as the area of uncontrolled catchment below the dam becomes larger. Flood routing studies, outside the scope of this present investigation, would be required to assess the reduction in the flood peak at Wellington.

In 2012 values the estimated capital cost of 185 GL or 308 GL dams are $90M and $106M respectively. Given the magnitude of urban damages at Wellington, which have a cumulative average annual value of about $239,000 for floods up to the 0.5% AEP flood, or a net present value of $3M at 7% discount rate, the dam would not be economically justified on the grounds of reduced flood damages in Wellington. The reduction in rural damages would increase the benefits of the dam, but there are no data presently available to quantify these effects. Even after including rural benefits, it is unlikely that the dam would be economically justified as a flood mitigation storage.

4.2.5 Levees and Road Raising

Levees are an effective means of protecting flood affected properties up to the chosen design flood level. In designing a levee it is necessary to take account of potential re-distribution of flood flows, the requirements for disposal of internal drainage from the protected area and the consequences of overtopping the levee in floods greater than the design event.

Levees are usually constructed of compacted soil won from local sources and carefully placed to strict engineering standards. NOW has issued criteria to provide a preliminary guide to a local authority in preparing specifications for levees which include the following recommendations:

- design and construction supervision to be undertaken by a professional engineer
- crest width sufficient to allow the passage of vehicles
- a freeboard for the crest level above the design flood of at least one metre (for urban levees)

- geotechnical investigation required to determine side slopes, assess material suitability and foundation conditions.

Reinforced concrete and concrete block walls are often used in situations where there is insufficient land available for earth banks. Such walls are provided with reinforced concrete footings of sufficient width to withstand overturning during flood events.

Damaging flooding occurs in flood fringe areas along the right bank of the Bell River and along both banks of the Macquarie River, for which levee schemes are considered in the following sections.

There are also several other properties located within the floodplain of the Bell River in the vicinity of Showground Road. However, to protect these particular houses a single or multiple ring levee scheme would be required which could result in isolation and the subsequent potential for evacuation problems. It is considered unwise to promote development in such areas and therefore ring levees are not recommended.

Bell River Levee

To protect the Bell River flood fringe where potential damages are the most highly concentrated, a levee would be required to run diagonally between the intersection of Palmer Street and the Mitchell Highway to the Zouch - Percy Street intersection. A short section of levee would be required which would extend eastwards along Palmer Street to tie into high ground. For preliminary planning purposes, a levee to protect against a 1% AEP flood has been examined. The levee would be approximately 600 m long and up to 2.7 m high and would protect both residential and commercial development along Apsley and Arthur Streets. In all, a total of 9 existing buildings would be protected which are currently flooded at the 1% AEP flood.

The total cost of earthworks and road repaving is estimated at $638,000 and there would be additional costs incurred in provision for temporary storage of internal runoff. The catchment draining to the protected area extends to the eastern boundary of the township and drains under the railway line towards the Bell River. It is about 110 ha in area. Storage of runoff from such a large area would cause major problems. The size of the storage basin required to contain local runoff could require removal of the houses which the levee is built to protect. Alternatively, it may be possible to direct the local runoff away from the protected area and hence reduce the requirements for storage.

Assuming that a storage basin could be provided to contain local runoff, the benefits of the scheme amount to the average annual damages currently incurred in the flooded properties up to the 1% AEP level in the protected area. In present worth terms, at a 7% p.a. discount rate, they amount to no greater than $60,000, giving a benefit cost ratio of 0.09. Accordingly, the scheme is clearly uneconomic and is not worthy of further consideration.

An alternative solution for the worst affected houses in the area which would be protected by a levee would be to implement a voluntary purchase scheme as outlined in **Section 5.2.1**.

Macquarie River Levee

On the Macquarie River flood fringe along Gobolion Street, there are 3 residential properties affected by the 1% AEP flood. The construction of a levee to protect these properties could not be economically justified. The levee would need to be located within the allotments and due to the steepness of the Macquarie River banks the amount of fill required would be large or a flood wall would have to be used instead of a levee.

Montefiores Levee and Road Raising

In the Montefiores area significant damages to properties commence for the 0.5% AEP flood event with 6 residential properties along Montefiores Street near Herbert Street being inundated. A further 23 properties would be inundated for the 0.2% AEP flood event, 16 of which are located in the south-western corner of the Montefiores area and the remainder located on Gipps Street near Tollemache Street. In addition, floodwater will tend to break out from the Macquarie River and flow in a north westerly direction forming two islands which will become isolated at the 0.5% AEP flood.

The SES Flood Plan (Annex B) identifies the risk of isolation of the area in a major flood and includes the need to closely monitor flood levels and assess whether evacuation is required.

The construction of a levee would need to ensure that obstruction of flows in the existing flood channels do not adversely affect flood levels elsewhere. The construction of a major levee scheme to protect the 23 residential properties would prevent the operation of the flood runners in rare flood events. However, hydraulic modelling showed that blocking the flood runners would cause only a small increase in flood levels. For the 0.2% AEP event the increase in peak levels in the Macquarie River was only 30 mm.

There are however practical difficulties associated with a riverside levee, as the construction of a levee to provide protection up to the 0.2% AEP flood level to properties fronting the Macquarie River on the southern side of Montefiores Street would require a levee of approximately 5 m height. The footprint of such a high levee would be large and its construction would be difficult without an extensive resumption of land. The construction of a levee scheme in the Montefiores area to give residential properties protection up to the 0.2% AEP flood level is not considered practicable, would involve significant capital works expenditure and is not worthy of further consideration.

4.2.6 Local Overland Flooding

The 2005 FDM requires that local overland flow flooding be considered within the same framework as ‘mainstream’ flooding. Council identified that the Apsley Drain was a potential source of overland flooding as defined by the FDM, as it occurs along a trunk system, involves depths of flow in excess of 0.3 m and has the potential to flood a number of properties. It was therefore assessed as part of this 2013 FRMS. The detailed assessment of the Apsley Drain is provided in **Appendix F**.

The primary objectives of the Aspley Drainage Study were to:

- define the existing overland flow flood behaviour of the catchment based on a hydrologic/hydraulic model of the trunk channel system;
- assess the effectiveness of a number of physical flood mitigation options; and
- determine, in collaboration with Wellington Council, the preferred flood mitigation option for the catchment.

Wellington Council requested that the assessment specifically examine the existing flood behaviour around the following properties:

- the single property on the railway side of the intersection between Kennard Street (Simpson Street) and Swift Street;
- several properties facing the railway line along Railway Avenue east of the culvert beneath the railway embankment;
- properties adjacent to and above the concrete channel in the residential block surrounded by Cross Street, Maxwell Street, Simpson Street and Zouch Street.
- several properties along the eastern side of Arthur Street between Zouch Street and Hawkins Street adjacent to the open channel to the north and south.

Council's concerns were based on the perceived potential for flooding to occur in these areas rather than confirmed reports of flooding at these properties in the past.

A DRAINS model was developed for the study as it was able to model both the catchment hydrology and the channel hydraulics to provide a basic assessment of potential flood levels and the ability to assess various flood mitigation options.

The DRAINS model was run for the 20%, 5% and 1% AEP flood events. The results indicated that flow would be above bank height along the majority of the trunk channel in the 1% AEP flood under existing conditions and that the flood level would be sufficiently high to threaten habitable buildings in a number of locations. The Drainage Study was not intended to definitively identify habitable properties that would be inundated in the various floods, as floor levels of residences were not surveyed and local flood extents were not produced. However, by comparing ground levels in each lot with the estimated flood level at the closest channel cross section, groups of properties that may be at risk of flooding were identified.

Under existing conditions, in a 20% AEP flood event the modelling indicated that the following properties are at risk of inundation:

- west side of Cross Street both north and south of the open channel;
- between Cross Street and Zouch Street adjacent to the open channel and above the covered channel;
- north and south of the open channel on the eastern side of Arthur Street.

In a 5% AEP flood event the properties located both north and south of the open channel immediately west of Simpson Street, between Zouch and Hawkins Streets would also be at risk of flooding. In a 1% AEP flood event 6 - 8 properties on the eastern side of Railway Avenue adjacent to the railway culvert would also be at risk of flooding, in addition to the properties identified above.

To address the limitations of the system the following mitigation options were assessed:

M1 - construction of a surface detention basin in Apex Park upstream of the railway;

M2 - construction of a surface detention basin in Apex Park upstream of the railway;

M3 - enlargement of the culvert beneath the Mitchell Highway (Arthur Street);

M4 - widening of the open channel immediately upstream of the Highway (Arthur Street); and

M5 - enlargement of the covered channel from the rear of Zouch Street to Kennard Park.

Each of these options was modelled in DRAINS to assess the impact on flood levels at all locations within the model.

Following review of the model results, Council indicated that its preferred option was Option M1 as it provided the best flood mitigation results, and was capable of substantially reducing flows and flood levels throughout the catchment. The benefits of Option M1 include the reduction of both the depth of inundation and the risk of habitable flooding at the following locations:

- in the Railway Avenue area, in the 1% AEP event;
- downstream of Simpson Street;
- between Cross Street and Zouch Streets; and
- on the eastern side of Arthur Street.

It should be noted that, following implementation of Option M1, there would still be a residual risk of habitable building flooding in the area between Cross Street and Zouch Street, and on the eastern side of Arthur Street.

The general configuration of the required basin is as follows:

- Base level 301.65 m AHD
- Top Water Level (TWL) 303.0 m AHD
- Surface Area at TWL 10,000 m^2
- Storage Volume at TWL 8,500 m^3
- Outlet Diameter 600 mm

A low flow channel would be required to convey low flows in a southerly direction along the western boundary adjacent to the rail corridor from Kennard Street to Maxwell Street. Diversion of major stormwater pipelines would also be necessary to divert runoff from Thornton and Pierce Streets which currently discharges into the open channel downstream of Maxwell Street. An inlet and energy dissipation structure would be required where this pipe flow is introduced to the basin to ensure flow would not spill out into the dry basin area in small flood events and to ensure the inflow would not cause erosion in larger events.

In order to progress the basin option, it is recommended that the following steps be included in the updated FRMP:

1. Survey floor and ground levels of the properties potentially impacted by overland flooding from the Apsley drainage system and carry out a damages assessment in accordance with the *Residential Flood Damages Floodplain Risk Management Guideline* (DECC, 2007).
2. Investigate the invert levels and cover depths of the stormwater pipelines along Maxwell Street which currently discharge to the open channel downstream of Maxwell Street to determine if it is practicable to divert these pipelines into the detention basin in Apex Park.
3. Undertake concept design of the inlet structure for the diverted pipes, the low flow channel and the outlet at Maxwell Street to determine if the basin is can be constructed for a reasonable cost.
4. Carry out an assessment of Apex Park to determine if there are any current land uses, buildings, buried or above ground services, heritage objects or trees which would provide constraints on the construct or operation of the basin.
5. Consult with the local community to determine if they are amenable to the use of the Park as a detention basin, given the flood mitigation benefits to the catchment. (Note that this arrangement is commonly used in new residential developments and the amenity of the park as open space would be retained.)
6. Undertake a costing of the basin and assess the cost:benefit ratio of the proposal, using the damages avoided (from Step 1) as the benefits of the proposal.
7. If the proposal is feasible, acceptable to the community and the cost:benefit analysis is favourable, detailed design followed by construction of the proposal should be carried out.
8. Determine extent of residual overland flow flooding and update the LEP flood mapping to allow implementation of planning controls.

Regular maintenance of the drainage system, including the open channel, pipe inlets and outlets, would complement structural flood mitigation measures and provide cost-effective benefits. Inspection of the stormwater system in 2011 identified significant silting of the Apsley Drain stormwater system which has substantially reduced the capacity of the system. This is a relatively inexpensive option to improve conveyance.

4.3 Measures to Alleviate Future Flood Risk

4.3.1 Planning Measures

One of the most effective future flood risk management measures for Council to adopt is strong floodplain management planning. **Appendix E** contains recommendations for updating Wellington Council's 2012 LEP and DCP 2013 to incorporate the revised approach presented in the 2005 FDM (as amended by the 2007 *Flood Planning Guideline* including Direction 4.3 issued by the Minister for Planning under Section 117(2) of the EP&A Act on 1 July 2009). A summary of these recommendations is provided below.

4.3.1.1 Wellington LEP

The 1996 Study reviewed the 1987 LEP and the draft 1995 LEP. Council has since adopted 1995 LEP, which has subsequently been replaced with LEP 2012.

Flood Planning Clause and Mapping

LEP 2012 contains the DP&I standard LEP flood planning clause, which is considered generally appropriate. The clause provides recognition of flood risk as a relevant consideration when assessing a development application. The clause does not prohibit development but identifies the specific matters to be addressed with a development application.

The issues with the LEP flood planning clause are whether the area to which the clause applies should also include the low flood risk precinct and whether the flood planning maps should differentiate between the medium and high flood risk precincts. The consequence of the LEP flood planning clause, and the outcome reflected in the LEP 2012 Flood Maps, is that only the residential flood planning area[4] is mapped and not the full flood planning area as defined in the 2005 FDM.

The LEP flood planning clause provides for the mapping of any area as the "flood planning area" subject to the restrictions provided by the *Flood Planning Guideline*. It is recommended that the clause be amended to define 'flood liable land' consistent with the 2005 FDM as all land inundated up to the extreme flood and provide that the clause applies to all flood liable land. This would allow the terms 'flood planning area', 'flood planning level' (FPLs) and 'flood planning map' to be dispensed with, as the 2005 FDM definitions applying pursuant to the LEP flood planning clause would suffice.

This would allow the DCP to be consistent with the LEP where the DCP imposes requirements on critical and sensitive uses above the 1% AEP flood plus freeboard, which are not subject to the restrictions in the *Flood Planning Guideline*. Where a DCP provision is inconsistent with an LEP, the DCP provision has no effect in accordance with clause 74C(5) of the EP&A Act.

It is considered that these refinements to the LEP clause would retain consistency with the intent of the clause and provide greater simplicity and clearer information to the public. This will be a matter for Council to discuss with the DP&I when reviewing LEP 2012 in the future.

Prohibition of Development in High Flood Risk Area

The LEP flood planning clause does not allow the introduction of prohibitions on flood sensitive developments generally or within certain parts of the floodplain (eg in a floodway). However, Council should consider the full risks of flooding when deciding upon the land use zones to apply to individual properties. If appropriate, Council should apply restrictive zones (such as an 'Environmental' zone) and development standards (such as a larger minimum lot size) available within LEP 2012 when undertaking future reviews.

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[4] The residential flood planning area in this context is a reference to the 1% AEP (plus 0.5m) FPL (medium and high flood risk precincts) and not the low flood risk precinct where emergency management measures are also relevant.

Review of Land Use Zones in High Flood Risk Precinct

A preliminary review of the appropriateness of the land use zones within the Wellington township with regard to flood risk was undertaken by overlaying the flood risk maps (summarised in **Figure 2.11**) with the LEP 2012 land use zone maps, minimum lot size maps and aerial photography.

Where the extent of the high flood risk precinct could potentially affect a property such that any development or redevelopment of the site currently permitted is unlikely to be acceptably achievable, the suitability of the land use was identified for review. The ability to acceptably develop the land was generally based on the DCP controls recommended in the 1996 FRMS. The review identified the following locations within the Environmental Management (E3) zone for consideration:

- the land immediately south of Montefiores Street, which is substantially within the High Flood Risk Precinct;
- the vacant land at the eastern end of Gobolion Street;
- the residential sized lots surrounding Paringa Place, which are substantially within the high flood risk precinct;
- the vacant land at the western end of Apsley Street and Hawkins Street.

A final determination of the suitability of the land use zone should involve a broader consideration of planning issues, not only flood risk, and the potential for structural engineering solutions (including land filling to a level above the 1% AEP flood) providing there are no unacceptable cumulative impacts.

4.3.1.2 Development Control

This 2013 review recommends that a risk management approach to the preparation of planning strategies and development controls to address flood risk be implemented. This will require an amendment to replace the existing flood related development controls contained in section C2 Flood Hazard of DCP 2013. New draft flood risk management DCP provisions would be ratified through the *Floodplain Development Manual* process and endorsed with the adoption of Wellington FRMP 2013, prior to being implemented by Council through the EP&A Act process.

The recommended structure of the new FRM DCP chapter is as follows:

- The existing flood hazard section within clause C2 of DCP 2013 should be replaced.
- The replacement chapter should generally be structured to conform to the style and level of detail of the overall DCP as far as possible. However, due to the complex nature of flooding issues and the relative significance of the issue, the flood risk management provisions will unavoidably be more complex.
- The chapter should apply to all areas within the LGA affected by flooding (regardless of whether mapped or not).
- Definitions should be consistent with the 2005 FDM where relevant.
- Objectives are to include the broader flood risk management issues such as emergency evacuation and climate change effects.
- Controls are to relate to the following considerations:
    a) Floor level

b) Building components and method

c) Structural soundness

d) Flood affectation

e) Car parking and driveway access

f) Evacuation

g) Management and design.

- Multiple flood planning levels are to be applied to different parts of a development (eg habitable and non-habitable floors, car parking etc) and different land uses, where appropriate.
- No controls are to apply to standard residential development on land above the 1% AEP (plus freeboard), except a requirement to consider emergency management issues (i.e. ability to safely evacuate or shelter in place during floods up to an extreme flood). This exception will invoke a requirement to apply for "exceptional circumstances" dispensation in accordance with the 2007 *Flood Planning Guideline*. To avoid delaying the implementation of the recommended DCP planning controls, the DCP could be amended in two stages. The second amendment could provide additional controls deferred until "exceptional circumstances" dispensation has been granted.
- Controls are to apply FPLs up to the EMAC to land uses considered more sensitive to flood hazards or which may be critical to emergency management operations or the recovery of the community post floods (eg Hospital, SES, Police, etc.).
- Special considerations for filling and fencing that have the potential to affect flood levels or redirect flow.
- General considerations to recognise that compliance with the flood risk management controls is not authorisation for development that would be otherwise unacceptable due to other issues (e.g. excessive height leading to unacceptable streetscape and/or environmental and amenity impacts).
- Information requirements which specify the need and scope for a flood study where existing information is not available but flood hazards are suspected.

The use of flood compatible building materials and methods can be an important flood risk management measure. This matter is addressed in "*Reducing Vulnerability of Buildings to Flood Damage – Guidance on Building in Flood Prone Areas"* (HNFMAC June 2006). The relevant elements of this document require translation to a "building code" that could be appended to or referred to in Council's DCP as a standard condition for building in parts of the floodplain. In addition, a draft national standard is being prepared through the Australian Building Codes Board. Therefore, while a generalised definition of flood compatible materials and methods can be provided in the DCP, it is recommended that this be reviewed at a later date.

Draft recommended DCP provisions are provided in **Annexure E1**. These provisions should be considered by Council and adopted in accordance with the DCP making process specified by the EP&A Act. Central to the recommended DCP controls is the flood planning control matrix (**Table 5.4** below). The principal controls contained within the matrix include:

- Minimum floor level of residential dwellings located within the Medium and Low Flood Risk Precinct must be the flood level corresponding to the 1% AEP flood plus 500 mm.
- Controls on the location of essential services such as hospitals and emergency services.
- Restrictions on buildings within the High Flood Risk Precinct - developments must be located outside the High Flood Risk Precinct.
- Strict controls on earthworks and fill that alter land surface levels within the High Flood Risk Precinct.

These controls are similar to those proposed in the 1996 Study and therefore do not result in any additional imposition for developers.

Exempt and Complying Development

Exempt development (such as outbuildings, air conditioning units, fences, etc) is development for which no consent is required. Complying development (such as change of use, demolition, general housing, etc) is development for which a complying development certificate must be obtained from Council or a private certifier.

The specification of exempt and complying development is primarily governed by State Environmental Planning Policy (Exempt and Complying Development Codes) 2008 (the 'Codes SEPP'). Wellington LEP 2012 defaults to the Codes SEPP. The application of the Codes SEPP in relation to flood liable land is summarised on **Figure 4.2**.

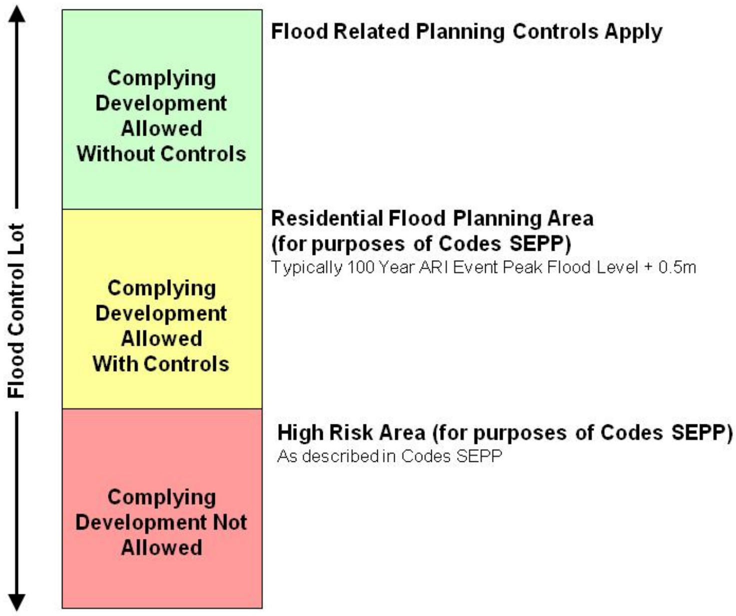

Figure 4.2: Application of the Codes SEPP to Flood Liable Land

The Codes SEPP provides that unless there is sufficient information to confirm that a site is not subject to high flood risks/hazards then the relevant Codes SEPP provisions cannot be applied. That is, unless there is certainty that a site is not high risk/hazard, it must be assumed that it is for the purposes of applying the Codes SEPP. Council advises that they do not have sufficient information to confidently advise that any land is not subject to high flood risk/hazard listed in clauses 3.36C and 3A.38 of the Codes SEPP. It is understood that even with the now available flood mapping in the township there remains some uncertainty regarding some of the categories listed in the SEPP.

It is recommended that the FRMP specify that at a minimum all areas with no flood risk mapping must be assumed to be a flood storage area, floodway area, flow path, high hazard area, or high risk area for the purposes of the Codes SEPP. Should Council consider that even in the areas where flood risk mapping is now available there remains some uncertainty as to whether some category such as a flow path may exist, Council should specify that these areas also are assumed to be subject to that category. This would have the effect of excluding the application of the Codes SEPP in areas where sufficient flood risk information is not currently available, which would consequently require the lodgement of a DA where flood risk management issues could be reviewed by Council.

The Codes SEPP provides different limitations on what could be permitted as exempt development. The primary issues for flood risk management would be the potential for exempt development to include the construction of non-rural fences that detrimentally obstruct the flow of flood waters as. The Codes SEPP excludes such fencing from being exempt development on a 'flood control lot' (see definition in **Section 4.3.1.3**), necessitating the lodgement of a development application. This is considered to provide adequate opportunity to address flood impact issues, subject to guidance being provided within DCP controls.

4.3.1.3 Section 149 Certificates

A Section 149 Planning Certificate is a zoning certificate issued under the provisions of the EP&A Act that is available to any person on request and must be attached to a contract prepared for the sale of property. The matters to be contained within the Section 149(2) Certificate are prescribed within Schedule 4 of the *Environmental Planning and Assessment Regulation*, 2000 and generally relate to whether planning controls (but not necessarily flood related risks) apply to a property.

A Section 149(5) Certificate requires councils to advise of "other relevant matters affecting the land of which it may be aware". These certificates are not mandatory for inclusion with property sale contracts. Where a Section 149(5) Certificate is obtained, this could require a council to notify of all flood risks of which it is aware.

As stated in the 2007 *Flood Planning Guideline*, the new Clause 7(A)(1) of Schedule 4 of the EP&A Regulation means that councils are not to 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) councils 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 assumed to be the same as that adopted for the purposes of this FRMS.

Wellington Council has advised that Section 149(2) Certificates may either respond with "No" or the following to the requirements of clause 7A of Schedule 4 of the Regulation:

> *Yes – The land is shown on Council's flood mapping as land that is above the 0.5% AEP flood event but below the 1% AEP flood event.*

No additional information in regard to flood risk is identified on a S149(5) Certificate.

The above S149(2) notification could more precisely respond to clause 7A of Schedule 4 of the EP&A Regulation by referring to the specific flood related planning controls and provide supplementary references to flood risk mapping where available. The notification could also note where Council has insufficient information to determine if a property is flood prone. If a flood study prepared at the DA stage identifies flood liability, it would be expected that the planning controls would then be applied.

Care is required to ensure that S149 certificates are not interpreted as confirmation that land is not flood affected when Council is directed not to provide this advice or does not have information to confirm whether or not a property is flood affected. The 2005 FDM defines flood liable land as all land potentially affected by inundation during a flood up to the PMF (in lieu of which the EMAC extreme flood has been adopted for Wellington). This includes both riverine flooding and flooding from major overland flow paths. Flood mapping (**Figure 2.2**) identifies the areas subject to major flooding but may not include all overland flow paths or riverine flooding beyond the modelled flood extents.

The recommended form and content of Section 149 Certificates should be reviewed to consider the following:

- All properties known to be located within the extent of the PMF (or extreme flood) should be notified that flood related planning controls apply. This would be subject to the full implementation of the DCP controls recommended in **Section 4.3.1.2** above, until which time notifications should specify that flood related development controls do not apply to residential development other than specified sensitive uses. This would also have the effect of identifying that the property is a “flood control lot” for the purposes of complying development provisions (refer **Section E5.4** in **Appendix E**).
- Inundation from stormwater and overland flow (except for ’local drainage’) is ’flooding’ under the 2005 FDM and should be recognised on Council’s Section 149 certificates. Inundation from the Apsley Drain is an example of this.
- Where Council is unsure of whether a property contains flood liable land (due to the lack of flood investigations and mapping in particular areas) a general notation to this effect could be provided with an explanation that a flood study may identify that the land is subject to flooding, in which case flood related controls could apply.
- Noting further flood risk information may be available upon enquiry to Council and/or (if a S149(2) Certificate is being issued) in a Section 149(5) Certificate.
- Provide information on a Section 149(5) certificate that reflects whether a property is known to be flood affected based on existing studies or Council cannot confirm whether a property is flood affected or not due to the absence of existing information.

Appropriate wording for the notifications should be determined based on legal advice. This should occur concurrently with the adoption of the recommended review of LEP 2013 and amendments to DCP 2013 or before. Ideally the revised notifications should reference the flood risk precinct category for a property and include its definition.

Table 4.4: Wellington Flood Planning Control Matrix

Planning Consideration	High Flood Risk						Medium Flood Risk						Low Flood Risk					
	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					1	4			2,6	1,5,6	1	4		3		1,5,6	2,6	4
Building Components and Method					1	1			1	1	1	1		1		1	1	1
Structural Soundness					1	1			1	1	1	1		3			2	
Flood Effects					1	1			2	2	2	2		2		2	2	
Car Parking and Driveway Access					2,4, 6,7	2,3, 4,6,7			1,3, 5,7	1,3, 5,7	2,4, 6,7	2,3, 4,6,7		1,3, 5,6,7		1,3, 5,7	1,3, 5,7	2,3, 4,6,7
Evacuation					4	2			2,3	1,3	4	2		2,3,4	2,3, 4,5	1,3	2,3	
Management and Design					1,2,3,5	2,3,5			1	1,2,3,5	1,2,3,5	2,3,5		4,5	1	1	1	

Notes: Controls to be deferred until 'exceptional circumstances' dispensation is obtained. Not Relevant Unsuitable Land Use

1 Freeboard equals an additional height of 500 mm.

2 The relevant environmental planning instruments (generally the Local Environmental Plan) identify development permissible with consent in various zones in the local government area. Notwithstanding, constraints specific to individual sites may preclude Council granting consent for certain forms of development on all or part of a site. The above matrix identifies where flood risks are likely to determine where certain development types will be considered 'unsuitable' due to flood related risks.

3 Filling of the site, where acceptable to Council, may change the flood risk precinct considered to determine the controls applied in the circumstances of individual applications.

Floor Level

1 All floor non-habitable levels to be equal to or greater than the 2% AEP flood level unless justified by site-specific assessment.

2 Habitable floor levels to be equal to or greater than the 1% AEP flood level plus freeboard.

3 All floor levels to be equal to or greater than the EMAC level plus freeboard.

4 Floor levels to be equal to or greater than the 1% AEP flood level plus freeboard. 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 Habitable floor levels to be equal to or greater than the 1% AEP flood level plus freeboard. If this level is impractical for a development in a Business zone, the floor level should be as high as possible.

6 A restriction is to be placed on the title of the land, pursuant to Section 88B of the *Conveyancing Act 1919*, where the lowest habitable floor area is elevated more than 1.5 metres above finished ground level, confirming that the undercroft area is not to be enclosed. Also, if the flood depth at the location is greater than 1.5 metres the restriction should also prevent site filling for slab on ground construction.

Building Components and Method

1 All structures to apply flood compatible building components and methods below the 1% AEP flood level plus freeboard.

Structural Soundness

1 Engineers report to certify that the structure can withstand the forces of floodwater, debris and buoyancy up to and including a 1% AEP flood plus freeboard.

2 Applicant to demonstrate that the structure can withstand the forces of floodwater, debris and buoyancy up to and including a 1% AEP flood plus freeboard. 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 an EMAC. An engineer's report may be required.

Flood Effects

1 Engineers report required to certify that the development will not increase flood effects elsewhere, having regard to: (i) loss of flood storage; (ii) changes in flood levels, flows and velocities caused by alterations to flood flows; and (iii) the cumulative impact of multiple similar developments in the vicinity.

2 The impact of the development on flooding elsewhere to be considered having regard to the three factors listed in consideration 1.

Car Parking and Driveway Access

1 The minimum surface level of a car parking space, which is not enclosed (e.g. open parking space or carport) shall be as high as practical, but no lower than the 5% AEP flood level or the level of the crest of the road at the location where the site has access.

2 The minimum surface level of a car parking space, which is not enclosed, shall be as high as practical.

3 Enclosed car parking or basement car parks capable of accommodating more than 3 motor vehicles on land zoned for urban purposes, must be protected from inundation by floods equal to or greater than the 1% AEP flood plus 0.1 m.

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 The level of the driveway providing access between the road and parking space shall be a minimum of 0.1m above the 1% AEP flood or such that depth of inundation during a 1% AEP flood is not greater than either the depth at the road or the depth at the car parking space. 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 three vehicles at a level below the 5% AEP flood level or at a level that is more than 0.8m below the 1% AEP 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 1% AEP flood. Note: A flood depth of 0.3m is sufficient to cause a typical vehicle to float.

Evacuation

1 Reliable access for pedestrians required during a 1% AEP flood.

2 Adequate flood warning is available to allow safe and orderly evacuation without increased reliance upon the SES or other authorised emergency services personnel.

3 The development is to be consistent with any relevant flood evacuation strategy or similar plan.

4 The evacuation requirements of the development are to be considered. An engineer's report will be required if circumstances are possible where the evacuation of persons might not be achieved within the effective warning time.

5 Reliable access for pedestrians or vehicles required during an EMAC to a publicly accessible location above the EMAC.

Management and Design

1 Applicant to demonstrate that potential development as a consequence of a subdivision proposal can be undertaken in accordance with this Plan.

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 area is available to store goods above the 1% AEP flood level plus freeboard.

4 Applicant to demonstrate that area is available to store goods above the EMAC level.

5 No storage of materials below the design floor level which may cause pollution or be potentially hazardous during any flood.

4.3.2 Mapping and GIS Data

As part of this FRMS 2013, the extreme flood extent, which delineates the extent of the floodplain and the Low Flood Risk Precinct for planning purposes, has been revised. The revised extent of the extreme flood is based on the latest GIS mapping with a 0.5 m contour spacing. In addition, the 1% AEP +0.5 m extent (Medium Flood Risk Precinct) and the 1% AEP High Hazard extent (High Flood Risk Precinct) have been mapped and provided to Council in the form of GIS layers. It is recommended that these maps be used in conjunction with the planning controls described in **Section 4.3.1** above.

The Flood Extent Maps should be used as a guide only. The following note should be attached to the maps (as recommended in the 1996 Study).

IMPORTANT NOTE

1. The lines on the Flood Extent Maps and labelled “indicative extent of inundation” must not be relied upon when determining whether or not any particular property is prone to inundation.
2. These lines are estimates only, which have been drawn after considering:
   - 2.1 flood levels **estimated** at cross sections;
   - 2.2 levels of the land as represented on contour maps;
   - 2.3 the combination of the information from 2.1 and 2.2 to interpolate the extent of inundation at points on the selected cross sections; and
   - 2.4 **interpolation** between the points identified in 2.3 to produce contour lines.
3. To determine the extent of inundation in the vicinity of a particular property, it is recommended that the following procedure be followed by a Registered Surveyor:
   - 3.1 Extract estimated flood levels at relevant cross sections from the Wellington Floodplain Risk Management Study 2013.
   - 3.2 Make appropriate interpolations to arrive at estimated flood levels in the vicinity of the subject property, taking account of the slope in the flood water surface profile down the valley.
   - 3.3 Survey along the ground to determine where those interpolated flood levels intersect the ground surface.
4. Even then, it must be accepted that such a determination is necessarily an estimate. If the ground surface has a small slope, the position of the line so determined to represent the extent of inundation could vary significantly on account of approximations inherent in the estimation and interpolation of flood levels, as well as the accuracy of surveying.

4.4 Measures to Alleviate Continuing Flood Risk

Measures to alleviate continuing flood risk refers to changing the response of flood prone communities to the flood risk by increasing flood awareness by the installation of flood warning systems and the development of contingency plans for property evacuation. These options are wholly non-structural.

Measures to alleviate continuing flood risk are outlined below. In order to prepare these sections consultation was carried out with SES State Headquarters and the Bureau of Meteorology.

4.4.1 Flood Warning System

Flood warning is an important means of mitigating flood damage. Flood warning may be considered as one element of a "Flood Preparedness and Response System" which consists of five separate processes:-

- identification of the areas at risk from flooding,
- forecasting the time of arrival and height of the flood peak,
- the dissemination of warnings to flood affected residents,
- the evacuation of people and possessions from flood threatened areas,
- the recovery of the community in the flood aftermath.

A flood forecasting and warning scheme is already in operation in Wellington. The scheme is reviewed in **Appendix D**.

The review of the Emergency Management System in Wellington carried out as part of this 2013 update indicated that the Bureau of Meteorology is satisfied with the Wellington flood warning system. The telemetered rainfall and river network system is adequate and flood watches and warnings are being issued more proactively and are becoming more accurate. Therefore, there are no recommendations for improvements to the flood warning system as part of this study.

4.4.2 SES Local Flood Plan

SES have advised that it is neither necessary nor appropriate to require consultants to review the emergency management arrangements described in the SES's *Local Flood Plan 2008*, as had been carried out in the 1996 Study.

Instead, a review of the underpinning flood behaviour/engineering information within the SES's Local Flood Plan has been undertaken. The information in Annex A to the SES's Local Flood Plan is generally acceptable, as it has been based on the information presented in the 1996 Study. Annex B to the SES's Local Flood Plan should be updated with the information provided in this study.

Annex A – The Flood Threat

Annex A to the SES's Local Flood Plan describes physical flood behaviour and the flood threat. The information presented in Annex A includes the information on flooding presented in the 1996 Study which is still current.

This 2013 study has modelled the impacts of a revised extreme flood on the Macquarie River (referred to as 'Case 2 Extreme' within the Local Flood Plan). However, Annex A to the Local Flood Plan does not discuss specific flood levels and velocities for this event and, therefore, no amendments are necessary.

Annex B – Effects of Flooding on the Community

Annex B of the SES's Local Flood Plan addresses 'Effects of Flooding on the Community' and identifies specific risk areas. The risk of isolation of the Montefiores area by floodwaters is identified including the need for close monitoring to establish whether the approximately 60 affected residents require evacuation.

Table B-2 in Annex B contains the total number of properties inundated and should be updated with the information presented in **Appendix C** of this study.

Essential services located on flood prone land could be included:

- SES facilities,
- Council Chambers,
- Police Station,
- Ambulance Station,
- Telephone Exchange,
- Hospital.

Table 4.5 provides a list of utilities and the frequency at which flooding commences. This table could be included in Annex B of the SES's Local Flood Plan.

Table 4.5: Utilities at Risk from Flooding

Facility / Damage Sector	Frequency at which flooding commences
Electricity	
Power poles at Herbert St bridge and pole mounted transformer on Macquarie/Bell floodplain	2% AEP
Pad mounted transformer on Maughan Street adjacent to Bowling Club	0.5% AEP
Telephone	
Telephone exchange	EMAC/EBELL
Sewerage Reticulation	
Pump station in vicinity of Arthur and Gobolion Streets	2% AEP
Sewage Treatment Plant	EMAC/EBELL
Water Supply	
Treatment works	0.2% AEP
Other	
SES Headquarters	EMAC
Hospital on Gisborne Street	EMAC

Residential and commercial properties located within the 1% AEP high and low hazard areas have been reviewed and updated as part of this 2013 study. This information should be incorporated into the SES's mapping.

4.4.3 Flood Intelligence

Information which could be provided to the SES for inclusion in their Local Flood Plan includes:

- plan indicating cross section and long section locations from the flood modelling
- river long sections and cross sections showing flood levels for design events at a readable scale on A3 plans

- a spreadsheet of ground levels, floor levels and flood levels for design events, to AHD based on the information used for the damage calculation
- maps showing flood extents, including the revised extreme flood event.

Appendix A to this study contains tabulated data and flood profiles which could be used as part of the SES's flood intelligence.

4.4.4 Flood Awareness Program

Current flood awareness in the town is reasonable due to past flood experience. However, flood awareness decreases with time and a flood awareness program should therefore form part of any *Floodplain Risk Management Plan*. The program should include:

- Information on the characteristics of flooding to be provided to the affected property owners. These characteristics should include information on the frequency of flooding and the depths in various floods at various locations. This information could be included in a flood information booklet containing both general and site specific data and distributed with the rate notices. Whilst the focus of this information should be land within the Flood Planning Area, information and advice should also be provided to owners of flood prone land. This information should assist landholders to realistically appraise the flood threat, make sensible decisions about flood compatible activities, be prepared for a flood when one eventually occurs and be aware of what to do should evacuation be necessary. The information should also highlight that the presence of Burrendong Dan will not prevent all flooding problems, as is the common perception.
- The *Floodplain Risk Management Plan* updated as a result of this study should be publicised and exhibited in Council offices, libraries and similar locations to make residents aware of the measures being proposed.
- Special commemorative events to publicise significant historic floods. Such events could include displays of photos and memorabilia, marking flood levels on buildings and publication of old newspaper articles.

4.4.5 Flood Data Collection

There is at present no formal system for collecting flood data for Wellington.

It is important that information from any future flooding be captured and collated for the whole of the area covered by the hydraulic model, especially if the flood warning system is to be maintained and further developed.

Council should file and index all flood related information in a "Compendium of Data" which should be upgraded after each significant flood event. The data would include:

- daily rainfalls and pluviographic traces (processed to give tabulated rainfall depths).
- stage and discharge hydrographs recorded at the Wellington gauges and at relevant upstream locations.
- observations made during a reconnaissance survey to be undertaken to identify and level flood marks, establish flooding patterns, conduct interviews with affected residents, etc.
- information on the cost of damages sustained by residential, commercial and public properties and to infrastructure.

4.5 Summary

Table 4.6 below summarises the potential flood risk management measures for Wellington.

Table 4.6: Summary of Potential Flood Risk Management Measures for Wellington

MEASURE	PURPOSE	COMMENT
EXISTING RISK		
Voluntary Purchase	Purchases of residential properties with dwellings in high hazard areas	Applies to 1% AEP high hazard area. Fourteen properties are candidates for a voluntary purchase scheme
Voluntary House Raising	Prevent flooding of individual buildings	Applies to wooden framed structures within the 1% AEP low hazard area. Three properties could be candidates for a house raising scheme.
Riverine Management	Prevent further erosion of the Bell River	Erosion protection works on the Bell River not eligible for inclusion in the FRMP so have not been considered further. Should Council receive funding under the NSW Environmental Trust the works should be carried out in accordance with the relevant legislation and guidelines identified in **Section 5.2.3.**
Road Raising – Montefiores Area	Provide access to flood free land during major flood events	1996 investigation using available survey indicates 1 m road raising required to allow egress from the area during 0.2% AEP flood. No funding available. Not justified. Current approach is for the SES to prioritise this area for evacuation rather than raise the road.
Apsley Drainage Mitigation Measures	Identify areas affected by overland flow for inclusion in planning documents and structures for upgrade.	Apsley Drainage Study Report (**Appendix F**) contains recommendations for addressing impacts of overland flow. Construction of a detention basin in Apex Park provides the best flood mitigation.
FUTURE RISK		
Planning Measures	Ensure flood risk to property and persons associated with future development is managed to acceptable levels.	Amend LEP 2012, DCP 2013 and Section 149 certificate notations in accordance with the recommendations in **Appendix E**. Applies to redevelopment of existing sites and future developments in the floodplain.
CONTINUING RISK		
Flood awareness	To increase community awareness of areas subject to flood risk and therefore preparedness.	Prepare flood risk maps (showing high, medium and low precincts) and incorporate into planning controls available to the public and notified on S149 Planning Certificates. Revised PMF has been estimated as part of this 2013 study update. The GIS has been updated to include extent of the revised PMF, 1% AEP high hazard and Flood Planning Area based on 0.5 m contour interval mapping.
Flood Warning System	Part of flood response emergency plan. Desirably, enables people to evacuate and/or move property to reduce actual flood damages	Current system is adequate according to the Bureau of Meteorology. No additional investigation or expenditure required.
SES's Local Flood Plan	Allow rapid appropriate actions to be taken during a flood	Supply findings, including mapping, from the FPM Study update to the SES to update their Local Flood Plan.

5 STATUS OF THE 1996 PLAN IMPLEMENTATION

This section provides a review of the status of the implementation of the measures adopted in the 1996 Plan. It supersedes **Section 4** of the 1996 Study, which identified existing floodplain management measures.

To assess the status of the 1996 Plan's implementation, the appropriate Council staff and SES members were requested to assess and provide written documentation regarding the implementation status of the relevant item/s within the Plan. In addition, the latest planning documents and the SES's Local Flood Plan were obtained.

A meeting was held with Officers from Council's Technical Services and Planning Departments as well as the SES and the then Department of Infrastructure, Planning and Natural Resources to discuss the progress made and what needed to be done to further the implementation of the Plan. Additional issues to be addressed were also identified.

Sections 5.1 to **5.7** outline the implementation status of each of the measures recommended within the 1996 Plan. Each section contains a summary of particular recommendations made in the 1996 Study, followed by the status of their implementation and some brief comments indicating the way in which the recommendation will be updated.

5.1 Planning Measures

The 1996 Study recommended that strong floodplain management planning measures be applied consistently by all branches of Wellington Council.

Council has undertaken the following actions relating to planning measures:

- The 1996 Study reviewed the 1987 Wellington Local Environmental Plan (LEP) and the draft 1995 LEP. Council subsequently adopted the 1995 LEP. The definition of 'flood liable land' was inserted into the 1995 LEP.
- Council applied the flood planning standard (0.5% AEP event) from the 1996 Plan since it was adopted in 1996. Council has relied on Section 79(c) of the *Environmental Planning and Assessment Act 1979* (EP&A Act) to apply the standard (and on the basis of precedence for consistency).
- On 31 March 2006, the NSW Government gazetted the Standard Instrument (LEPs) Order 2006. All Councils were required to produce an LEP in this format within 5 years. Wellington LEP 2012 is in the Standard Instrument format and adopts the model local flood planning clause and flood planning maps. The residential Flood Planning Level was adopted as the 1% AEP flood level plus 0.5 m.
- On 22 February 2006, Council resolved to amend Development Control Plan (DCP) No.1, which was the document reviewed in the 1996 Study. The amendment deleted everything from DCP No.1 except the provisions for exempt and complying development. Those matters that were deleted, including provisions relating to flood prone land, were revised and incorporated into DCP No.2, which became effective from 1 May 2006.
- Wellington DCP 2013 was adopted by Council on 22 May 2013 and became effective on 1 July 2013. DCP 2013 replaced DCP No.2 and reincorporated flood

related development controls. DCP 2013 now contains the provisions relating to flood prone land recommended in the 1996 FRMS, but not the provisions prepared as part of this 2013 update to the 1996 FRMS.

- Section 149(2) Certificates issued by Council respond either with "No" or "Yes – The land is shown on Council's flood mapping as land that is above the 0.5% AEP flood event but below the 1% AEP flood event". No additional information in regard to flood risk is currently identified on a S149(5) Certificates.

Updated recommendations relating to planning measures are contained in **Section 4.3.1** and **Appendix E**.

5.2 Voluntary Purchase Scheme

The 1996 Study recommended that a voluntary purchase scheme could be adopted for houses exposed to high hazard conditions. As part of the 1996 Study, a database summarising information on residential properties located in high hazard areas was prepared. At the time of the 1996 Study, 16 residential properties were located in such areas and were considered sufficiently flood affected to warrant inclusion in the scheme.

The 1996 Study noted that Council would need to reach consensus about the criteria to be applied in setting priorities for listing properties on a voluntary purchase scheme. The process for finalising the houses to be included on the property list was identified.

A draft report on a voluntary purchase scheme was prepared for Council which included a recommendation to allocate $15,000 per year into a reserve. Outstanding issues to be resolved include:

- clarifying precisely which properties are to be included on the property list; and
- developing a method to ensure notifications are placed on Section 149 certificates for the affected properties.

Updated recommendations relating to the voluntary purchase scheme are provided in **Section 4.2.1**.

5.3 Emergency Management

The 1996 Study identified an opportunity for improving the flood forecasting system by incorporating information from additional telemetered rain gauges and streamflow recorders in the Bell River catchment, along with implementation of modern rainfall runoff computer modelling. The 1996 Study also recommended that the Wellington Local Flood Plan be further developed by the SES so as to produce a graded response plan.

As part of this 2013 study, Evans & Peck has consulted with the SES and the Commonwealth Bureau of Meteorology. The SES provided a copy of the *Local Flood Plan* (September 2008).

More details on the status of the emergency management system in Wellington are provided in **Section 4.4** and **Appendix D**, including information on the consequences of a revised PMF estimate.

5.4 Local Overland Flooding

Local overland flooding was not assessed in the 1996 Study. As part of this 2013 study, a flood assessment for local overland flow has been carried out for the area known as the Apsley Drain. Further information relating to this assessment is contained in **Section 4.2.5** and **Appendix F**.

5.5 Riverine Management

The 1996 Study recommended that Council be proactive in managing riverine vegetation, particularly along the incised section of the Macquarie River. Both the Macquarie and Bell Rivers provide open space corridors through the town which offer the potential to provide a significant recreation and habitat resource whilst ensuring that hydraulic capacity is maintained.

The main focus subsequent to the 1996 Study has been the management of Bell River erosion and bed stabilisation works. Erosion of the Bell River, from the Parkes Road to the confluence with the Macquarie River, was being caused by low tailwater levels as a result of changes in the flow regime downstream of Burrendong Dam.

Major flood events in 1976, 1990, 1998, 2005 and 2010 resulted in major bank erosion in the Bell River, particularly in the section immediately upstream of where the river meets the Macquarie River.

The 2010 flood events further eroded a section of the Bell River bank on private property. Wellington Council considers there is a significant risk that the next major flood event will:

- cut a direct channel to the Macquarie River thus impinging on the existing road bridge across the Macquarie River and Oxley Park;
- create an unsatisfactory right angled entry to the Macquarie River with the potential to create further disturbed flow patterns in both rivers; and
- remove more soil from private property and further degrade the riverine environment with loss of significant landscape including significant trees.

Figure 4.1, reproduced from Figure 2.1 of Wellington Council's *Submission for Rehabilitation of Bell River Riverine Environment* (July 2011), shows the location of erosion on the Bell River. Protective riprap work undertaken adjacent to Cameron Park and the Polo fields (**Figure 4.1**) has been successful in stabilising the river banks at these locations. Large riprap rock was placed at the foot of the eroding bank to prevent further undercutting and collapsing of the bank. The riprap allows the development of a natural batter on which trees and vegetation can be established to further enhance the stabilisation of the bank.

As discussed in **Section 4.2.3** above, these works are not eligible for funding under the Floodplain Management Program administered by OEH, as they are not located within the urban area, and are therefore not recommended for inclusion in the FRMP. Council applied for funding for these works under the NSW Environmental Trust in 2013 and has been placed on the reserve list.

5.6 Road Raising / Levee – Montefiores Street

The 1996 Study recommended that consideration be given to construction of a levee and raising Montefiores Street and part of Queen Street to allow evacuation from this area during floods greater than the 1% AEP event. Raising the road by around 1 m would allow residents to evacuate to flood free land on the northern side of the river.

At the time of the 2013 review, Council had done no work to investigate this option further. Further information relating to this measure is contained in **Section 4.2.5**.

5.7 Flood Mapping

The 1996 Study recommended that, in order to implement the recommended planning policies, the flood extent should be defined more accurately than could be achieved with the 1996 standard of mapping, which was based on 2 m contour intervals.

At the time of this review, Council had updated its GIS to include 0.5 m contour interval mapping. Further information relating to this measure is contained in **Section 4.3.2**.

6 ASSESSMENT AND RANKING OF FLOODPLAIN MANAGEMENT MEASURES

The 2005 FDM highlights the need for flood mitigation measures proposed in flood risk management plans to address environmental, ecological, social and cultural issues and the principles of ecologically sustainable development. This approach was employed in the preparation of the 1996 Study. The ranking and weighting scheme adopted and described in detail in **Section 6** of the 1996 Study is provided in **Appendix G** of this 2013 update.

This section summarises the range of factors which need to be taken into consideration when selecting the mix of works and measures that should be included in the updated FRMP 2013.

The measures recommended in the 1996 Plan and the measures identified as part of this 2013 update have been ranked and weighted as shown in **Table 6.1**. An analysis is presented which assesses the performance of each available option against the factors to be considered.

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

6.1 Issues for Consideration

The issues which need to be considered in developing a FRMP typically fall under the following broad headings:

Community Expectations and Social Impacts

- Community Acceptance
- Strategic Planning Objectives
- Administrative/Political Issues

Natural Resource Management and Environmental Impact

- Total Catchment Management
- Other Relevant Government Policies
- Environmental Impact

Economic and Financial Feasibility

- Economic Feasibility
- Financial Feasibility

Technical Merit

- Engineering Feasibility
- Performance in Exceedance Floods.

Refer to **Appendix G** for more detail on these issues.

6.2 Ranking of Options

The 1996 Study presented a system for assessing and weighting the various options. The assessment system involved three steps:

1. Each issue to be considered for assessing the merits of various proposals is given a weighting according to how important each is for the town. The classification adopted in 1996 comprised:

'**Essentia**l' - (weight = 1.0)

- Gains community acceptance
- Meets planning objectives
- Positive or minimal environmental impacts

'**Desirable**' - (weight = 0.5)

- Economically justified
- Financially feasible
- Does not increase damage or risk in extreme floods

'**Considerations**' - (weight = 0.25)

- Consistent with Government policies
- Consistent with total catchment management (TCM) objectives
- Consistent with current administrative arrangements and responsibilities

2. Each option is given a score according to how well the option meets the considerations discussed in **Appendix G**. The following scoring system was adopted for the 1996 Study and is retained for this 2013 update:

   +2 Option rates very highly

   +1 Option rates well

   0 Option is neutral

   -1 Option rates poorly

   -2 Option rates very poorly

3. The score for each option is multiplied by the relevant weighting for the issue under consideration and the weighted scores are added to get a total for each option.

Table 6.1 presents a scoring matrix for the options for Wellington which were reviewed in **Section 5**. This scoring has been used as the basis for prioritising the components of the FRMP. The scoring shown in **Table 6.1** was reviewed and agreed to at the Floodplain Risk Management Committee Meeting held 20 August 2013.

Table 6.1: Floodplain Management Options Assessment

Option	Essential			Desirable			Considerations			Weighted Score	Rank*
	Community Acceptance	Planning Objectives	Env'tal Impacts	Economic Justification	Financial Feasibility	Extreme Flood	Govt Policies	TCM Objectives	Admin Arrang.		
Existing Risk											
Voluntary Purchase	1	2	1	1	1	2	2	0	1	6.75	2
Voluntary House Raising	1	1	1	1	2	1	2	0	1	5.75	3
Apsley Drainage Mitigation Measures	2	2	2	0	1	1	2	2	0	8	1
Future Risk											
Planning Measures	1	2	2	2	2	1	2	2	2	9	1
Continuing Risk											
Supply data for SES's Local Flood Plan	2	2	2	2	2	2	2	2	2	8.5	1
Flood Awareness	0	2	2	2	2	2	2	2	2	8.5	1

* Note: Measures are ranked within each flood risk category (existing, future and continuing)

7 FLOODPLAIN RISK MANAGEMENT PLAN 2013

The following sections set out the recommended updates to the Floodplain Risk Management Plan for Wellington based on the Floodplain Management Options Assessment presented in **Section 6** and **Appendix G**, and provides information on funding and implementation. A summary of the updated FRMP 2013 is shown on **Table 7.1**.

In accordance with the requirements of the 2005 FDM, this Plan identifies three broad categories of management actions:

- management of the existing flood risk faced by the existing development
- management of future flood risk that might arise from new development or redevelopment of the existing housing stock
- management of the continuing flood risk that remains after all floodplain management measures are implemented.

7.1 Management of Existing Flood Risk

The management of existing flood risks is concerned with reducing flood impacts on the existing housing stock and community facilities. With the benefit of hindsight it can be seen that some buildings are located inappropriately or have floor levels that give rise to an unnecessarily high risk of flood damage. Management of the existing flood risk is concerned with correcting the worst of these existing problems.

It is recommended that following measures be incorporated in the updated FRMP:

- voluntary purchase;
- voluntary house raising;
- Apsley Drain overland flow investigations and works.

7.2 Management of Future Flood Risk

Management of future flood risk is concerned with ensuring that future development is not subject to unacceptable risk and that existing flood conditions are not exacerbated by unwise future development. The recommended floodplain planning measures are contained in several existing or proposed policy documents, as outlined below.

7.2.1 LEP 2012

Appendix E contains recommendations for updating Wellington Council's 2012 LEP and DCP 2013 to incorporate the revised approach presented in the 2005 FDM (as amended by the 2007 *Flood Planning Guideline* including Direction 4.3 issued by the Minister for Planning under Section 117(2) of the EP&A Act on 1 July 2009). The 2012 LEP should be amended to incorporate the revised approach presented in the 2005 FDM (as amended by the *2007 Flood Planning Guideline*) as follows:

Flood Planning Clause and Mapping

The LEP flood planning clause provides for the mapping of any area as the "flood planning area" subject to the restrictions provided by the *Flood Planning Guideline*. It is recommended that the clause be amended to define 'flood liable land' consistent with the 2005 FDM as all land inundated up to the extreme flood and provide that the clause applies to all flood liable land. This would allow the terms 'flood planning area', 'flood planning level' (FPLs) and 'flood planning map' to be dispensed with, as the 2005 FDM definitions applying pursuant to the LEP flood planning clause would suffice. This would allow the DCP to be consistent with the LEP where the DCP imposes requirements on critical and sensitive uses above the 1% AEP flood plus freeboard, which are not subject to the restrictions in the Flood Planning Guideline.

These refinements to the LEP clause would retain consistency with the intent of the clause and provide greater simplicity and clearer information to the public.

Prohibition of Development in High Flood Risk Area

The LEP flood planning clause does not allow the introduction of prohibitions on flood sensitive developments generally or within certain parts of the floodplain (e.g. in a floodway). However, Council should consider the full risks of flooding when deciding upon the land use zone to apply to individual properties. If appropriate, Council should apply restrictive zones (such as an 'Environmental' zone) and development standards (such as a larger minimum lot size) available within LEP 2012 when undertaking future reviews.

Suitability of Land Use Zones in High Flood Risk Precinct

Council should review the suitability of the land use zones within the Wellington township based on consideration of planning issues, including flood risk. A preliminary review of the land use zones identified the following areas zoned Environmental Management (E3) within the High Flood Risk Precinct:

- the land immediately south of Montefiores Street;
- the vacant land at the eastern end of Gobolion Street;
- the residential sized lots surrounding Paringa Place;
- the vacant land at the western end of Apsley Street and Hawkins Street.

In these locations, any development or redevelopment currently permitted is unlikely to be acceptably achievable due to the location within the extent of the high flood risk precinct.

7.2.2 DCP 2013

DCP 2013 should be amended to reflect the concept of a risk management approach to determine appropriate development within the floodplain. This will require an amendment of DCP 2013 to replace the existing flood related development controls contained in section C2 Flood Hazard of DCP 2013. The new draft flood risk management DCP provisions should be ratified through the floodplain development management process and endorsed with the adoption of Wellington FRMP 2013, prior to being implemented by Council through the EP&A Act process.

The replacement chapter should generally be structured to conform to the style and level of detail of the overall DCP as far as possible. A recommended replacement chapter is provided in **Appendix E** which incorporates the following:

- Applies to all areas within the LGA affected by flooding (regardless of whether mapped or not).
- Definitions are consistent with the 2005 FDM where relevant.

- Objectives include the broader flood risk management issues such as emergency evacuation and climate change effects.
- Controls relating to:
  - a) Floor level
  - b) Building components and method
  - c) Structural soundness
  - d) Flood affectation
  - e) Car parking and driveway access
  - f) Evacuation
  - g) Management and design.
- Multiple flood planning levels are applied to different parts of a development (eg habitable and non-habitable floors, car parking etc) and different land uses, where appropriate.
- No controls are to apply to standard residential development on land above the 1% AEP (plus freeboard), except a requirement to consider emergency management issues (i.e. ability to safely evacuate or shelter in place during floods up to an extreme flood). This exception will invoke a requirement to apply for "exceptional circumstances" dispensation in accordance with the 2007 *Flood Planning Guideline*. To avoid delaying the implementation of the recommended DCP planning controls, the DCP could be amended in two stages. The second amendment could provide additional controls deferred until "exceptional circumstances" dispensation has been granted.
- Controls are to apply FPLs up to the EMAC to land uses considered more sensitive to flood hazards or which may be critical to emergency management operations or the recovery of the community post floods (eg Hospital, SES, Police, etc.).
- Special considerations for filling and fencing that have the potential to affect flood levels or redirect flow.
- General considerations recognise that compliance with the flood risk management controls is not authorisation for development that would be otherwise unacceptable due to other issues.
- Information requirements which specify the need and scope for a flood study where existing information is not available but flood hazards are suspected.

Flood compatible building materials and methods should be included in a "building code" that could be appended to or referred to in Council's DCP as a standard condition for building in parts of the floodplain.

Central to the recommended DCP controls is the flood planning control matrix. The principal controls contained within the matrix include:

- Minimum floor level of residential dwellings located within the Medium and Low Flood Risk Precinct must be the flood level corresponding to the 1% AEP flood plus 500 mm.
- Controls on the location of essential services such as hospitals and emergency services.

- Restrictions on buildings within the High Flood Risk Precinct - developments must be located outside the High Flood Risk Precinct.
- Strict controls on earthworks and fill that alter land surface levels within the High Flood Risk Precinct.

These controls are similar to those proposed in the 1996 Study and therefore do not result in any additional imposition for developers.

Exempt and Complying Development

The Codes SEPP provides that unless there is sufficient information to confirm that a site is not subject to high flood risks/hazards then the relevant Codes SEPP provisions cannot be applied. That is, unless there is certainty that a site is not high risk/hazard, it must be assumed that it is for the purposes of applying the Codes SEPP. Council advises that they do not have sufficient information to confidently advise that any land is not subject to high flood risk/hazard listed in clauses 3.36C and 3A.38 of the Codes SEPP. It is understood that even with the now available flood mapping in the township there remains some uncertainty as to some of categories listed in the SEPP.

It is recommended that the FRMP specify that at a minimum all areas with no flood risk mapping must be assumed to be a flood storage area, floodway area, flow path, high hazard area, or high risk area for the purposes of the Codes SEPP. Should Council consider that even in the areas where flood risk mapping is now available there remains some uncertainty as to whether some category such as a flow path may exist, Council should specify that these areas also are assumed to be subject to that category. This would have the effect of excluding the application of the Codes SEPP in areas where sufficient flood risk information is not currently available, which would consequently require the lodgement of a DA where flood risk management issues could be reviewed by Council.

7.2.3 Section 149 Certificates

Council should review the form and content of Section 149 Certificates to consider the following:

- All properties known to be located within the extent of the extreme flood should be notified that flood related planning controls apply. This would be subject to the full implementation of the DCP controls recommended in **Section 7.2.2** above, until which time notifications should specify that flood related development controls do not apply to residential development other than specified sensitive uses. This would also have the effect of identifying that the property is a “flood control lot” for the purposes of complying development provisions.
- Inundation from stormwater and overland flow (except for ’local drainage’) is ’flooding’ under the 2005 FDM and should be recognised on Council’s Section 149 certificates.
- Where Council is unsure of whether a property contains flood liable land (due to the lack of flood investigations and mapping in particular areas) a general notation to this effect could be provided with an explanation that a flood study may identify that the land is subject to flooding, in which case flood related controls could apply.

- Noting further flood risk information may be available upon enquiry to Council and/or (if a S149(2) Certificate is being issued) in a Section 149(5) Certificate.
- Provide information on a Section 149(5) certificate that reflects whether a property is known to be flood affected based on existing studies. Alternatively, whether Council cannot confirm whether a property is flood affected or not due to the absence of existing information.

Appropriate wording for the notifications should be determined based on legal advice. This should occur concurrently with the adoption of the recommended review of LEP 2013 and amendments to DCP 2013 or before. Ideally the revised notifications should reference the property's flood risk precinct category and include its definition.

7.3 Management of Continuing Flood Risk

Even if all flood risk management measures recommended in this study were implemented, there would still be a continuing risk associated with flooding at the extreme flood as the recommended management measures for new development only mitigate flood risk to residential properties at the 1% AEP flood (plus freeboard) with consideration of emergency management issues up to an extreme flood. The continuing flood risk associated with existing and new development is the risk to lives and property from the extreme flood, even after all possible flood risk management measures have been implemented.

The management of continuing flood risk is concerned with ensuring that adverse effects on the community are minimised in the event of floods larger than those used to designate planning controls such as the FPL. This can be achieved through the SES's Local Flood Plan.

The information provided in this report should be used to update the SES's Local Flood Plan as outlined in **Section 4.4.2** and **Appendix D**.

7.4 Funding

Broad funding requirements for the recommended flood risk management measures updated to 2012 values are provided in **Table 7.1**, along with a priority ranking in the overall plan.

The estimated costs are the total costs for each scheme, irrespective of the source of funding. The costs do not include costs for land acquisition, nor do they include compensation to landholders where drainage works are carried out on their land.

7.5 Implementation Program

The draft *Flood Risk Management Study and Plan* 2013 was endorsed by the Floodplain Risk Management Committee at its meeting dated 20 August 2013. It was exhibited by Wellington Council from 1 to 30 September 2013. No submissions were received.

The steps to progress the floodplain management process from this point onwards are:

- submit the final FRMP 2013 to Council;
- Council to formally adopt the FRMP 2013 and submit an application for funding assistance to the OEH; and
- as funds become available from the OEH and/or Council's own resources, implement the recommended flood risk management measures in accordance with the ranking in **Table 7.1**.

The FRMP should be regarded as a dynamic instrument requiring review and modification over time. The catalysts for change could include new flood events and experiences, legislative change, alterations in the availability of funding, reviews of planning strategies and importantly, the outcome of some of the studies proposed in this report as part of the FRMP. In any event, a thorough review every 5 years is warranted to ensure the ongoing relevance of the FRMP.

The action program for implementing the FRMP is therefore:

- confirm the projects set out in **Table 7.1** and their priority ranking; and
- carry out design studies for schemes, liaise with residents and implement projects according to priority and funding constraints.

Table 7.1: Indicative Funding Requirements for Recommended Works and Measures

Project	Rank*	Indicative Cost ($)	Comment
Existing Flood Risk			
Voluntary Purchase	2	$1.8 million	Cost given is estimated capital cost of purchasing the 14 worst affected residences which are located within the 1% AEP High Hazard Precinct. The NSW Government may fund a portion of the capital cost.
House Raising	3	$195,000	Cost given is estimated cost of raising three timber framed residences at $65,000 each. The NSW Government may fund a portion of the capital cost.
Apsley Drainage Mitigation Measures	1	• Further investigation: Council Costs • Concept design & cost estimate: $30,000 • Construction cost (TBA)	Council to implement recommendations of the Apsley Drainage Study. Council to carry further investigations, consultation and costing for the construction of a detention basin at Apex Park.
Future Flood Risk			
Planning Measures	1	Council Costs	Amend LEP 2012, DCP 2013 and S149 certificate notifications.
Continuing Flood Risk			
Provide data for the SES's Local Flood Plan	1	Council/ SES costs	Council/SES to undertake this work using results of this FRMS 2013.
Flood Awareness	1	Council costs	Council to prepare flood risk maps showing high, medium and low precincts and incorporate into planning controls available to the public and notified on S149 Planning Certificates.

* Note: Measures are ranked within each flood risk category (existing, future and continuing)

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Wellington Council

WELLINGTON FLOODPLAIN RISK MANAGEMENT STUDY 2013

Appendix A

Flood Conditions in the Macquarie and Bell Rivers

July 2013

Date: 21/07/2013

Table of Contents

Page No

Annexure

Hydraulic Modelling Results:

- Tabulated flood levels and velocities on the Macquarie and Bell Rivers

List of Tables

List of Figures

Note: Figures are located at the end of each section.

A1. INTRODUCTION

This Appendix updates the hydraulic modelling of flooding from the Macquarie and Bell Rivers that was presented in the 1996 *Floodplain Management Study*. As part of this update, the impacts of the revised estimate of the extreme flood discharge from Burrendong Dam, identified in the *24 Dams Portfolio Risk Assessment*, has been modelled. The assessment, which was carried out for State Water by SKM, included a risk analysis for several extreme flood scenarios for Burrendong Dam.

State Water's estimate of the flow at Wellington resulting from the PMP design flood inflow to the dam (assuming the dam was initially full) was input to the MIKE-11 hydraulic model set up for the 1996 Study. As part of this process it was necessary to convert the 1996 MIKE-11 model (version 3.2B) to MIKE-11 version 2005.

Subsequent to the modelling of the revised extreme flood discharge, the extent of the 1% AEP high hazard zone was required to be mapped for planning purposes. This required the 2005 MIKE-11 model to be updated to a 1D geo-referenced MIKE-11 model based on aerial photography and LiDAR data supplied by Council.

This Appendix reproduces the relevant material from the 1996 *Floodplain Management Study* and presents the updated flood levels, velocities and flood extent for the extreme flood event and the 1% AEP high hazard zone.

As part of the 2013 update of the *Wellington Floodplain Risk Management Study*, an analysis was undertaken into overland flow flooding along the Apsley Drain. Details of that analysis are presented separately in **Appendix F**.

A2. FLOOD HYDROLOGY

A2.1 1995 Flood Study

A2.1.1 Methodology

The Department of Land and Water Conservation (DLWC) completed a detailed flood study for Wellington in 1995 (*Flood Study Report - Wellington*, DLWC, 1995). Design discharges, levels and velocities were computed for the 5, 2 and 1% AEP events, as well as for an extreme flood which was assigned a frequency of 0.002% AEP. Data contained in the DLWC report superseded the 1979 Flood Map prepared by the Department of Water Resources.

The study involved a hydrologic component to assess design discharges, and a hydraulic component to convert design flows to levels and velocities and to define of the extent of flooding.

Burrendong Dam has a significant effect on flood flows in the Macquarie River and as post-dam flood records were only available for the 29 years at the time of the Flood Study, it was not possible to use direct flood frequency analysis to estimate design discharges with confidence. The situation is further complicated by the location of the town at the confluence of two rivers, and therefore any analysis of flood frequencies must take into account their interaction under post-dam conditions. **Figure A2.1** is a locality plan showing the setting of the town of Wellington within the Macquarie River basin. **Figure A2.2** shows the locations of the various flow gauging stations.

To be able to use the longer periods of records on the Macquarie River pre-Burrendong Dam, it was necessary to adjust them so that they represented what would have occurred if all historical events occurred under present day conditions with the dam in place.

The approach adopted in the flood study was similar to that described by Laurenson (1973, 1974) and follows work carried out by that author in an investigation of the usage of Burrendong Dam (IESC, 1971). The approach recognised that the post-dam flood discharges and their frequency of occurrence at Wellington depended on four factors:

1. The inflow flood to Burrendong Dam;
2. The storage contents at the onset of the flood;
3. The attenuating effects of the floodplain storage between the dam and Wellington;
4. Flood flows from the Bell River catchment.

Hydraulic modelling confirmed that there was negligible attenuation of the flood peak between the dam and Wellington as outflow hydrographs tended to be flat and of long duration. The effects of item 3 above were therefore ignored.

The flood frequency analysis for the Macquarie River at Wellington was undertaken in two stages:

a) Estimation of the probability distribution of Burrendong Dam outflow peaks.

b) Estimation of post-Burrendong flood frequencies downstream of the Bell River confluence.

The probability distribution of outflows from the dam was assessed using a joint probability approach relating dam inflows and storage contents at the commencement of the flood. The frequency distribution of inflows to the dam was computed from the full historic flood record since it is unaffected by the presence of the dam. The distribution of storage contents was determined from a monthly behaviour analysis of the dam operated in response to the demands from the various water consumers in the Macquarie Valley as well as other established operating criteria.

As there is little flood attenuation between dam and the confluence with the Bell River, the post-dam flood frequency relationship for the Macquarie River upstream of the confluence was assumed to be the same as for downstream of Burrendong Dam.

Floods in the Bell and Macquarie Rivers are generally not independent of each other as they usually originate from the same storm. A conditional probability method was therefore required to estimate the flood frequency curve downstream of the confluence of the two rivers. In this method, the probability of the flow downstream of the confluence being within a particular range is computed as the sum of the probabilities of all the combinations of Bell and Macquarie River flows which result in the flow downstream of the confluence being within that class of flow.

A2.1.2 Review

The approach used in the hydrologic analysis involved the combined modelling of the stochastic and deterministic aspects of the system and has seen widespread application since its introduction by Laurenson in the early 1970s.

Most hydrologic systems have both stochastic and deterministic components. The stochastic components are parameters defined by probability distributions whereas the deterministic components are processes that can be modelled mathematically or graphically without probabilistic statements.

System modelling determines the value of some output resulting from one or more sources of input. If any of the input are stochastic then the output must also be stochastic and the object of modelling is to determine its probability distribution from the distribution of the inputs and the deterministic operation of the system.

The flood study for Wellington was carried out in two phases:

1. Estimation of a flood frequency relationship for post-dam conditions downstream of Burrendong Dam. In this case, the inputs were the frequency distribution of inflow flood peaks and the distribution of prior storage contents. The distribution of peak outflows was the output. The deterministic components comprised the monthly behavioural analysis which gave the distribution of storage contents, and the routing of recorded discharge hydrographs through the dam storage for various assumed values of initial storage.

2. The second phase involved assessment of the flood frequency relationship for post-dam conditions on the Macquarie River downstream of the Bell River confluence. In this case, the inputs were the flood frequency relationship on the Macquarie River upstream of the confluence (the output from phase 1) and

the frequency of peak flows on the Bell River derived from the records at Neurea gauging station. The deterministic component involved development of an empirical graphical relationship between the Bell peak, Macquarie (upstream) peak and Macquarie (downstream) peak based on recorded flood data.

The approach is complex, makes numerous assumptions and involves the processing of large amounts of data. However, the accuracy of the method is supported by the close agreement between the developed flood frequency curve downstream of the confluence and the flood frequency curve at Dubbo for the post-dam years 1965-1991.

A2.2 Burrendong Dam Risk Assessment (2001)

A risk assessment for Burrendong Dam was carried out by SKM for State Water in 2001as part of the *24 Dams Portfolio Risk Assessment*.

Due to the sensitive nature of the report contents, State Water could not supply Council with the entire report. However, an excerpt was provided to assist with the preparation of this *Floodplain Risk Management Study*. As the information was supplied on a commercial-in-confidence basis it is not reproduced in this Appendix, however the relevant features are discussed below. The information provided by State Water included:

- graphs of peak flood levels for the 170 km reach of the Macquarie River modelled downstream of Burrendong Dam for four extreme flood scenarios and two non-flood scenarios;
- tables of peak flood levels and velocities for the first 47 km of river downstream of the dam for the same six events;
- time series graphs of peak flood levels, velocities and discharge at a particular cross section at Wellington (corresponding to a distance of 30.4 km downstream of the dam) for the same events;
- a plot of the cross section details at CH 30.4 km;
- a full size plot of the inundated areas in question overlaid on the Wellington 1:50,000 topographic map.

The scenarios for which the information was supplied comprised:

- dam crest flood with reservoir initially at Full Supply Level without dam failure;
- dam crest flood with reservoir initially at Full Supply Level with dam failure;
- PMP Design Flood with reservoir initially at Full Supply Level without dam failure;
- PMP Design Flood with reservoir initially at Full Supply Level with dam failure;
- Sunny day dam failure with the reservoir initially at Full Supply Level;
- Sunny day dam rapid (1 hour) failure with the reservoir initially at Full Supply Level;

Of the six scenarios for which information was provided, the scenario of relevance to the Floodplain Risk Management Study is the PMP Design Flood without dam failure, corresponding to the map of the extent of flooding provided by State Water (see below). The flood levels, velocities and flood extent associated with this event were extracted from the State Water information. At Wellington (chainage 30.4 km) the peak flood level for this event is 304.2 m AHD and the peak flood velocity is 3.0 m/s. Based on the discharge hydrograph supplied by State Water the discharge at CH 30.4 km for this event is about 20,000 m^3/s (an exact tabulated value was not provided). The frequency of this extreme event could not be ascertained from State Water's information. For purposes of this *Floodplain Risk Management Study* it has been assumed that the extreme flood for Wellington has an AEP of 0.002%, as for the original study.

A2.3 Adopted Flood Flows

Table A1.1 summarises the results of the frequency analysis and the Burrendong flood risk analysis.

Table A2.1: Results of flood frequency analysis (values in m^3/s)

Frequency	Macquarie River			Bell River
% AEP	Inflow to Burrendong Dam	Upstream of Bell River Confluence	Upstream of Bell River Confluence	
(1)	(2)	(3)	(4)	(5)
10	2,600	950	1,200	NA
5	3,600	1,500	1,800	1,330
2	5,000	2,200	2,700	1,850
1	5,900	2,800	3,400	2,140
0.5	7,200	3,500	4,200	2,600
0.2	8,700	4,500	5,300	3,200
0.002	NA	20,000	NA	8,350

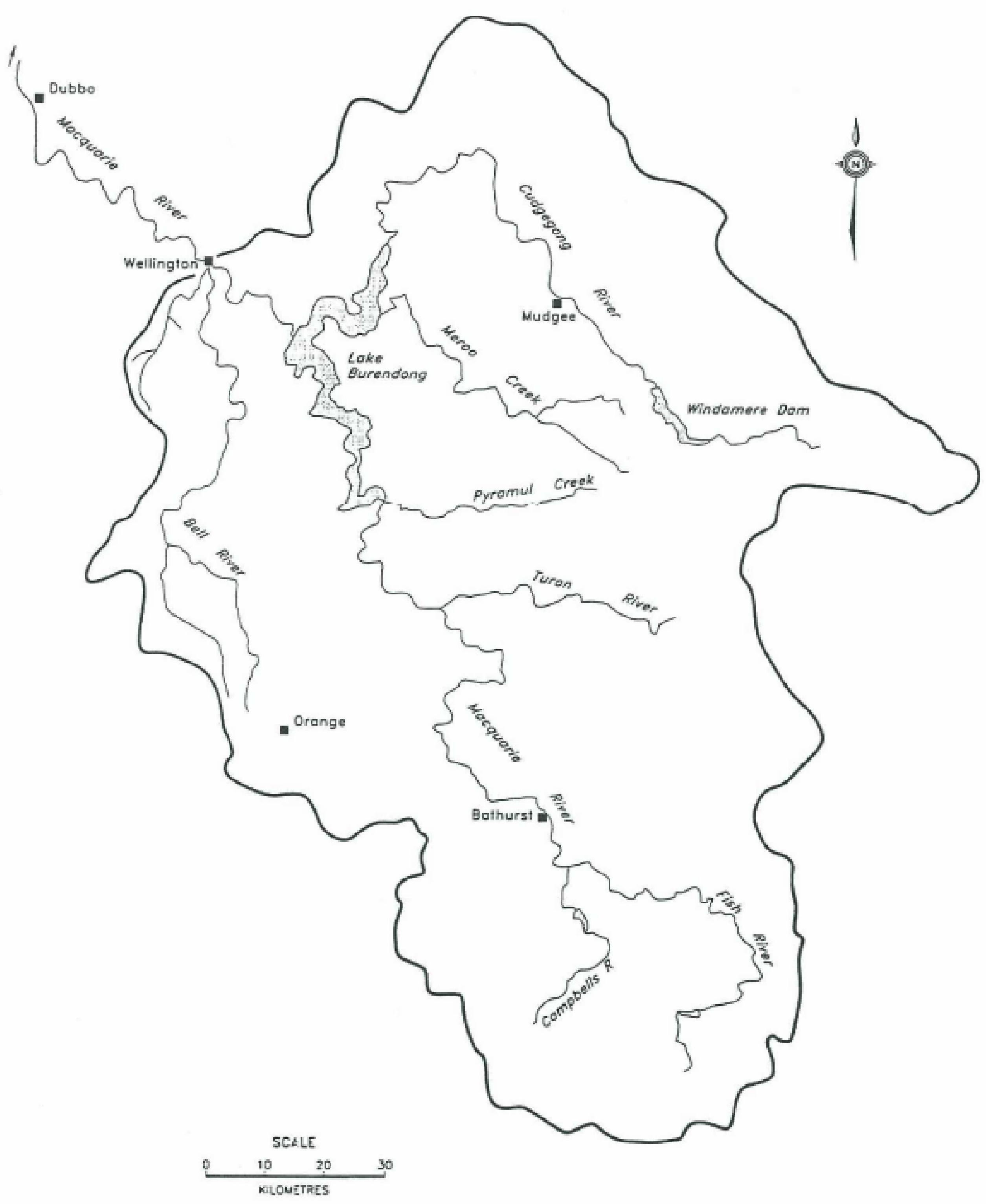


Figure A2.1: Locality Plan

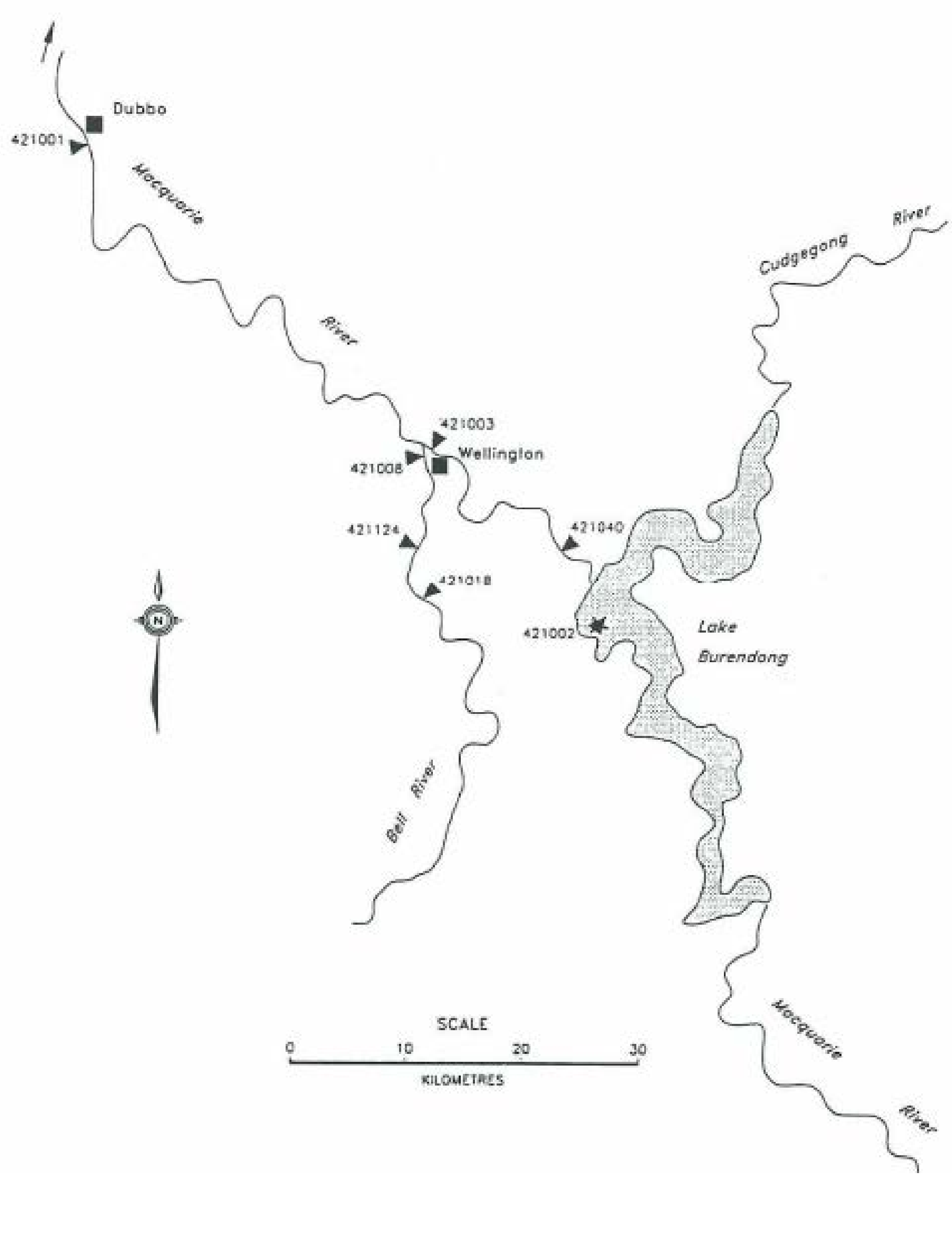


Figure A2.2: Locations of Gauging Stations

A3. HYDRAULIC ANALYSIS

A3.1 1995 Hydraulic Model

A3.1.1 Overview

For the 1995 Flood Study, hydraulic modelling was carried out using the MIKE-11 software package. The model includes two major flowpaths, the Macquarie and the Bell River, and two minor flowpaths through Montefiores. **Figure A3.1** (reproduced from the *Flood Study Report - Wellington*) shows the model layout. Surveyed cross sections were used to describe the channels. They extended upstream of the town to include the Nanima Aboriginal Reserve on the Macquarie River and all the residential development near the Bell River floodplain. The model extended approximately 9 km downstream of the confluence of the Bell and Macquarie Rivers.

A3.1.2 Model Calibration

For calibrating the model, hydrographs recorded at the gauging stations on the Macquarie River downstream of Burrendong Dam and the Bell River at Neurea were adopted as the upstream boundary conditions. The downstream boundary condition comprised a rating curve which was computed using the slope-area method. The August 1990 flood was adopted for calibrating purposes as it is the only major post-dam flood for which extensive good quality level data were available.

In order to use recorded hydrographs at the gauging stations as boundary conditions, it was necessary to extend the model upstream of Wellington. Cross sections on the Bell River were derived from available contour plans and on the Macquarie River by interpolating between the cross section at the gauging station and the most upstream, surveyed sections.

Successful reproduction of recorded flood levels to within ± 100 mm was achieved using realistic values of hydraulic roughness, which is the main calibrating parameter of the model. The model also reproduced the observed travel time of flood peaks on the two rivers.

A3.1.3 Modelling Design Floods

Steady state runs of the hydraulic model were undertaken to produce design flood levels and velocities for floods from 10% to 1% AEP and 0.002% AEP.

In the zone upstream of the Macquarie/Bell confluence where flood levels are dependent on the discharge in each river, a range of flood levels and velocities is possible for any given probability. A given design AEP discharge downstream of the confluence can made be up of contributions from both streams in varying proportions. The flood levels and velocities upstream of the confluence will depend on the relative proportions of the total flow carried by each of the two streams. In addition, for a given design AEP discharge in the Bell River or the Macquarie River upstream of the confluence, the flood levels and velocities will depend on the total flow downstream of the confluence.

Consequently, for the backwater zone of the Macquarie and Bell Rivers, an upper and lower limit of flood levels was provided in the Flood Study. Water surface profiles shown on **Figure A3.2** and **Figure A3.3** illustrate the range of flood levels. For the Bell River, the upper limit was obtained assuming the design AEP discharge in the Bell River and the design AEP discharge in the Macquarie downstream of the Bell. The lower limit for the Bell River is the higher of the levels resulting from:

- The design AEP discharge in the Bell and negligible discharge in the Macquarie upstream of the Bell.
- Negligible discharge in the Bell and the design AEP discharge in the Macquarie downstream of the Bell.

Similarly, for the Macquarie River, the upper limit was obtained assuming the design AEP discharge in the Macquarie River upstream of the Bell and the design AEP discharge in the Macquarie downstream of the Bell. The lower limit for the Macquarie River is higher of the levels resulting from:

- The design AEP discharge in the Macquarie upstream of the Bell confluence and negligible discharge in the Bell.
- Negligible discharge in the Macquarie upstream of the Bell confluence and the design AEP discharge in the Macquarie downstream of the Bell.

Discharges, velocities and levels were provided upstream of the town for the full extent of the surveyed cross-sections. However, calibration data upstream of cross-section 22.6 on the Macquarie and cross-section 18.53 on the Bell were not available and therefore design flood data in those reaches have a lesser degree of reliability than further downstream.

A3.1.4 Review of 1995 Hydraulic Modelling

Hydraulic modelling required the implementation of an unsteady flow model which was capable of modelling branched streams. Model calibration was undertaken using all available level data and the model parameters lie within the expected range of values.

It would normally be expected that for design purposes the model would run in unsteady mode using design discharge hydrographs as input. In the present case, the model was run in steady state mode using peak discharges derived from the frequency analysis. This is considered a reasonable approach, bearing in mind the attenuated shape of the post-dam hydrographs on the Macquarie River and the steepness of the Bell River channel. On the Bell River, the magnitude of the unsteady flow terms in the momentum equation would be trivial and the effects of floodplain storage would be relatively small.

It is considered from this review that the MIKE-11 model results may therefore be adopted for computing flood damages and assessing the extent of flooding under present day conditions. The model may also be used for assessing the implications of alternative flood management strategies.

A3.2 Hydraulic Modelling of Floods Between 1% AEP and Extreme Flood

By inspection of **Figure A3.2** it can be seen that there is a difference of 8-12 m between the water surface profiles of the extreme flood event (0.002% AEP) and the 1% AEP event along the length of the Macquarie River. From **Figure A3.3**, it can be seen that on the Bell River the extreme flood is about 6-8 m higher than the 1% AEP flood.

In order to provide definition of intermediate flood events, hydraulic modelling was undertaken for 0.5% and 0.2% AEP floods. The procedure used to define the peak flow combinations on the two rivers was similar to that used in the DLWC flood study. Peak flows adopted are given in **Table A3.1**.

Water surface profiles are shown on **Figure A3.4** and **Figure A3.5** and tabulated flood levels for the 5%, 1 %, 0.5% and 0.2% AEP events are contained in **Attachment A**. The approximate extent of flooding is shown on **Figure A3.6**. This figure also shows the location of important infrastructure and emergency service operation locations.

Table A3.1: Peak Flows Adopted for Modelling 0.5% and 0.2% AEP Events

For Defining Flow Profiles on:	Peak Flows In Hydraulic Model (m^3/s)		
	Macquarie River Upstream Bell River	Macquarie River Downstream Bell River	Bell River
Peak Flows Adopted for Modelling 0.5% AEP Event:			
Macquarie River	3,500[1]	4,160[2]	660[4]
Bell River	1,560[4]	4,160[2]	2,600[3]
Peak Flows Adopted for Modelling 0.2% AEP Event:			
Macquarie River	4,500[1]	5,300[2]	800[4]
Bell River	2,100[4]	5,300[2]	3,200[3]

Notes on derivation of peak flows:

(1) From Figure 5.4 of DLWC, 1995.
(2) From Figure 5.7 DLWC, 1995.
(3) By extrapolation of Bell River Peak Flows Table A3.1 to A3.8 of DLWC, 1995.
(4) By subtraction to maintain continuity in model.

A3.3 Modelling Extreme Floods

A3.3.1 Methodology

For purposes of determining the extent of 'flood liable land' (as defined in the 2005 *Floodplain Development Manual*) defining it is necessary to assess the extent of flooding that would occur in extreme conditions. For many locations, the Probable Maximum Flood (PMF) is adopted for this purpose. However in the case of Wellington, because of the flood detention effect of Burrendong Dam and the interaction between the Macquarie and Bell Rivers, it has been necessary to define two extreme flood scenarios which have been given a notional AEP of 0.002% (as per the 1996 *Floodplain Management Study*):

- An extreme flood (0.002% AEP) in the Macquarie River upstream of the Macquarie/Bell confluence in conjunction with a 1% AEP discharge in the Bell, (for simplicity this scenario is referred to as EMAC) and,
- A 0.002% AEP discharge in the Bell with a 1% AEP discharge in the Macquarie upstream of the confluence (for simplicity this scenario is referred to as EBELL).

For purposes of the 1996 *Floodplain Management Study*, the EMAC scenario was defined in terms of the estimate at that time of the Burrendong Dam Imminent Failure Flood (15,700 m^3/s). However, as a result of the *24 Dams Portfolio Risk Assessment,* the extreme flood flow in the Macquarie River upstream of the Macquarie/Bell confluence has been taken to be the flow resulting from the PMP design flood inflow to the dam with the dam full at the commencement of the flood and without dam failure (20,000 m^3/s).

Information provided by State Water in relation the effects of extreme floods on Burrendong Dam (see **Section A2.2**) also included mapping indicating the extent of flooding associated with the six scenarios. State Water's estimates of the extent of flooding were compared with the results from the 1996 *Floodplain Management Study*. Notwithstanding the differences in flows in the Macquarie River used in the two sets of analysis, inconsistencies flood levels and extents occurred because State Water's estimates were based on model cross sections defined using 1:50,000 scale topographic mapping.

It was therefore agreed with Council that State Water's estimate of the extreme flood discharge at Wellington (20,000 m^3/s – see **Table A1.1**) would be input to the MIKE-11 model set up for the original *Floodplain Management Study* in 1996. As part of this process (undertaken by DHI Water and Environment) it was necessary to convert the existing Wellington MIKE-11 model version 3.2B to MIKE-11 version 2005.

The MIKE-11 model was re-run for the revised extreme flood discharge in the Macquarie River. The model layout was not changed and is shown on **Figure A3.1**. Subsequently, the model was updated to a 1D geo-referenced MIKE-11 model based on aerial photography and LiDAR data supplied by Council to enable identification of the 1% AEP high hazard zone.

The flows used to assess flood levels and flow velocities for extreme events are summarised in **Table A3.2**.

Table A3.2: Modelled Discharges (m^3/s)

	Bell R	Macquarie R U/S	Macquarie R D/S
EMAC (0.002%)	2,140	20,000	22,140
EBELL (0.002%)	8,350	2,800	11,150

In these extreme floods, flow would be occurring over a considerable length of the right bank of the Macquarie River and just downstream of Montefiores. Conceptual lateral flow branches linking main flow paths were placed at discrete spatial intervals in the hydraulic model to represent continuous cross flow between the Macquarie River and Montefiores floodplain. The lateral branches represent the exchange of flow over a certain width of creek bank and not at a discrete location. As such, design discharges, velocities and flood levels were quoted for main flow paths only.

Similarly, water would be flowing over the left bank of the Bell River into Curra Creek. The design discharges, velocities and flood levels calculated for Curra Creek assume that there is no discharge from the Curra Creek catchment and ignore the effects of the culvert under Main Road No 233.

A3.3.2 Model Results

The modelling of the extreme event with the revised discharge on the Macquarie River resulted in an average increase in flood level of 3.6 m.

The annexure to this appendix contains the updated modelling results in terms of:

- plots of the extreme flood profile for the Macquarie River;
- tabulated flood levels and velocities on the Macquarie and Bell Rivers for the extreme flood event on the Macquarie River.

Figure A3.8 shows the revised flood extent for the extreme event on the Macquarie River, together with the extent of the 1% AEP high hazard zone (see below).

The flood extents have been provided to Council as GIS layers.

A3.4 Flood Hazard Assessment

A3.4.1 Methodology

As noted above, the 2005 MIKE-11 hydraulic model was updated to a 1D geo-referenced MIKE-11 model based on an aerial photo and LiDAR data supplied by Council to produce the 1% AEP high hazard map (necessary for floodplain planning). The methodology used was as follows:

1. The existing model cross-sections were not changed.
2. A 10 m Digital Elevation Model (DEM) was created based on the LiDAR data. This DEM was then used to produce the inundation and hazard maps.
3. The geo-referenced MIKE-11model was run for the 1% AEP flood event with the Macquarie River flow of 2,800 m^3/s and Bell River flow of 0.015 m^3/s (as per 1996 model).
4. The flood level results of the geo-referenced model were compared with the previous and found to be consistent.

The model was then operated to generate the 1% AEP inundation, velocity and high hazard maps. The 1% AEP high hazard zone was determined using the relationship shown in L2 in the FDM (reproduced **Figure A3.2** below).

A3.4.2 Model Results

Figure A3.8 shows the extent of the 1% AEP high hazard zone together with the revised flood extent for the extreme flood event on the Macquarie River.

The flood extents have been provided to Council as GIS layers.

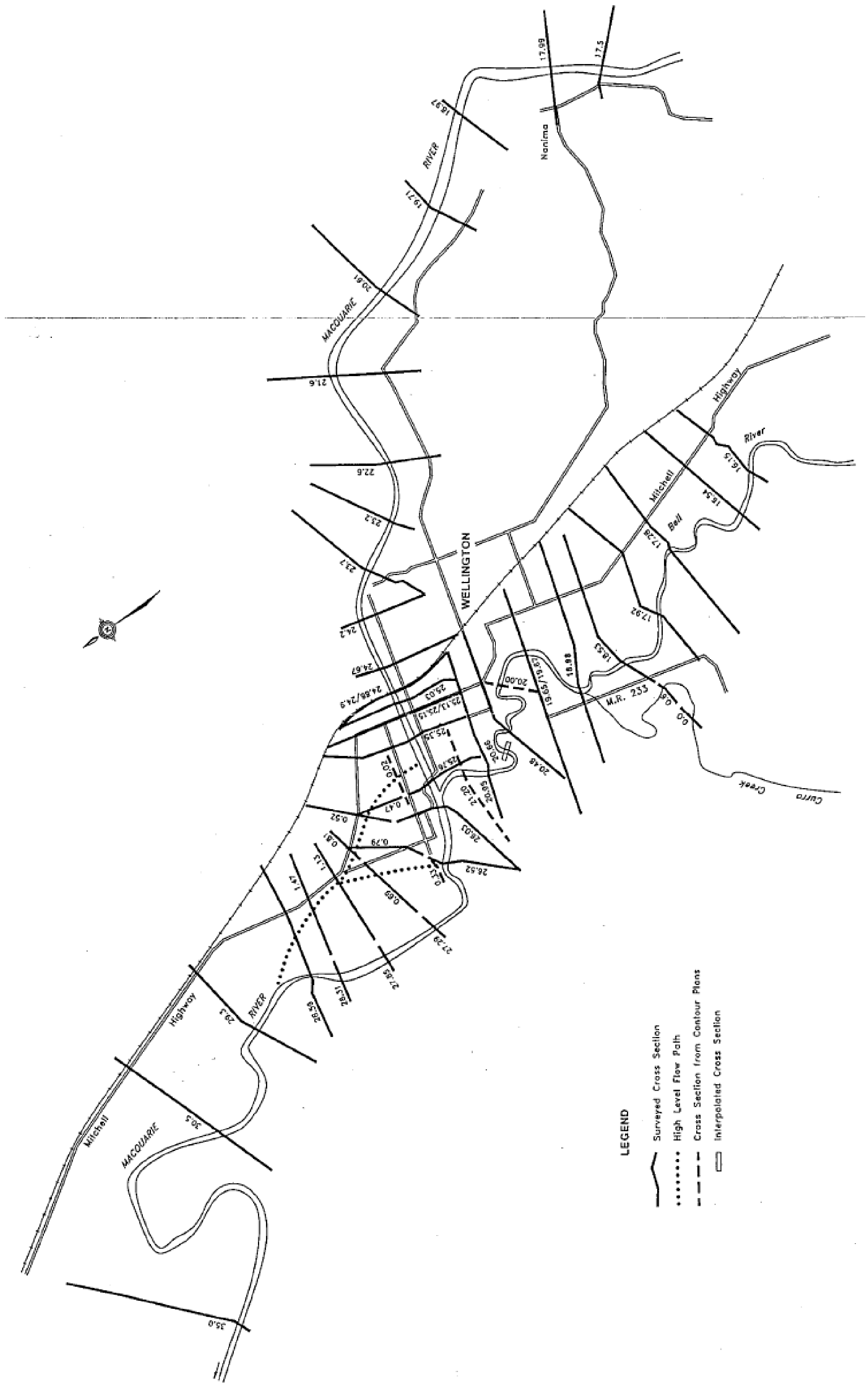


Figure A3.1: Hydraulic Model Layout

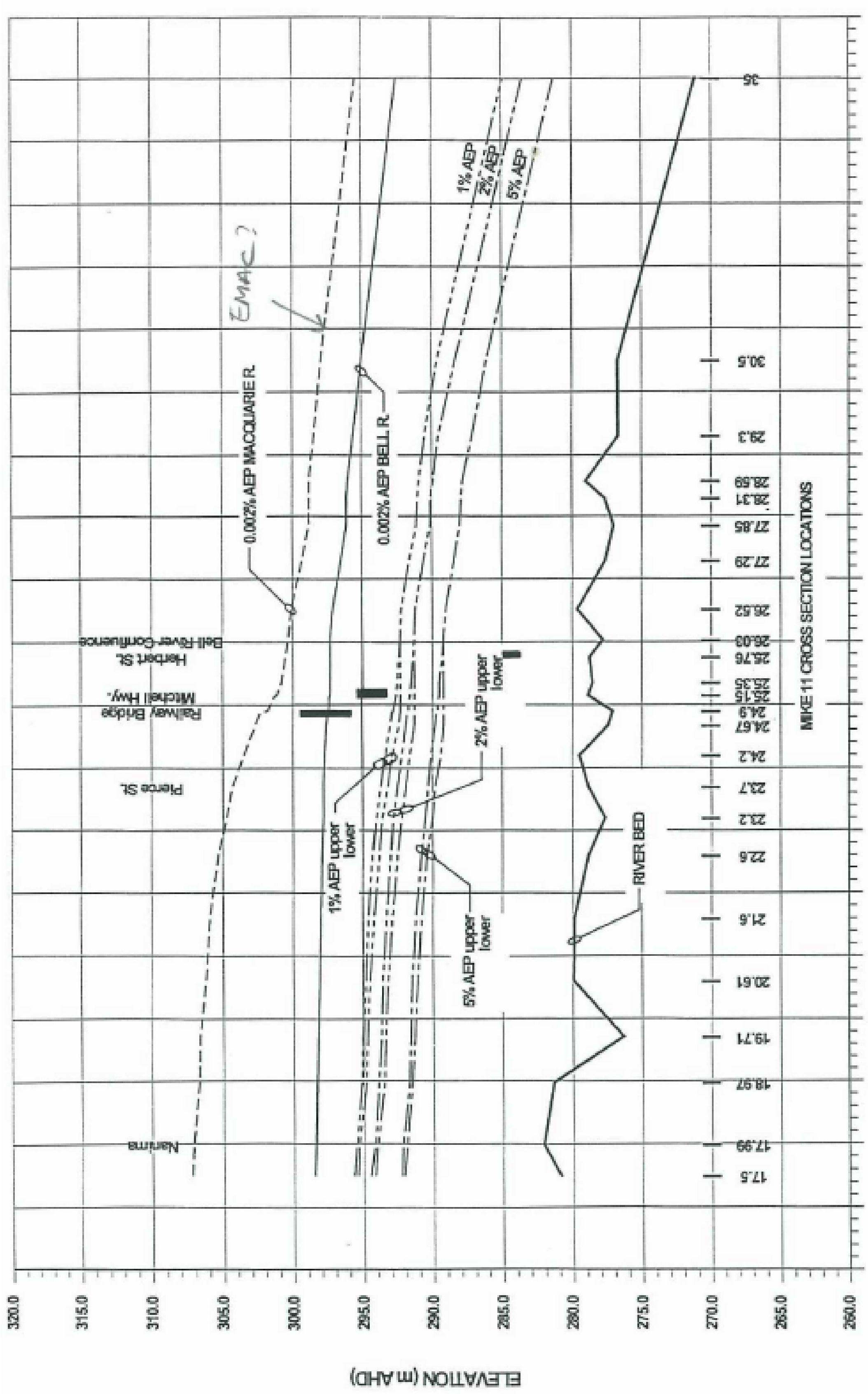


Figure A3.2: Water Surface Profiles – Macquarie River

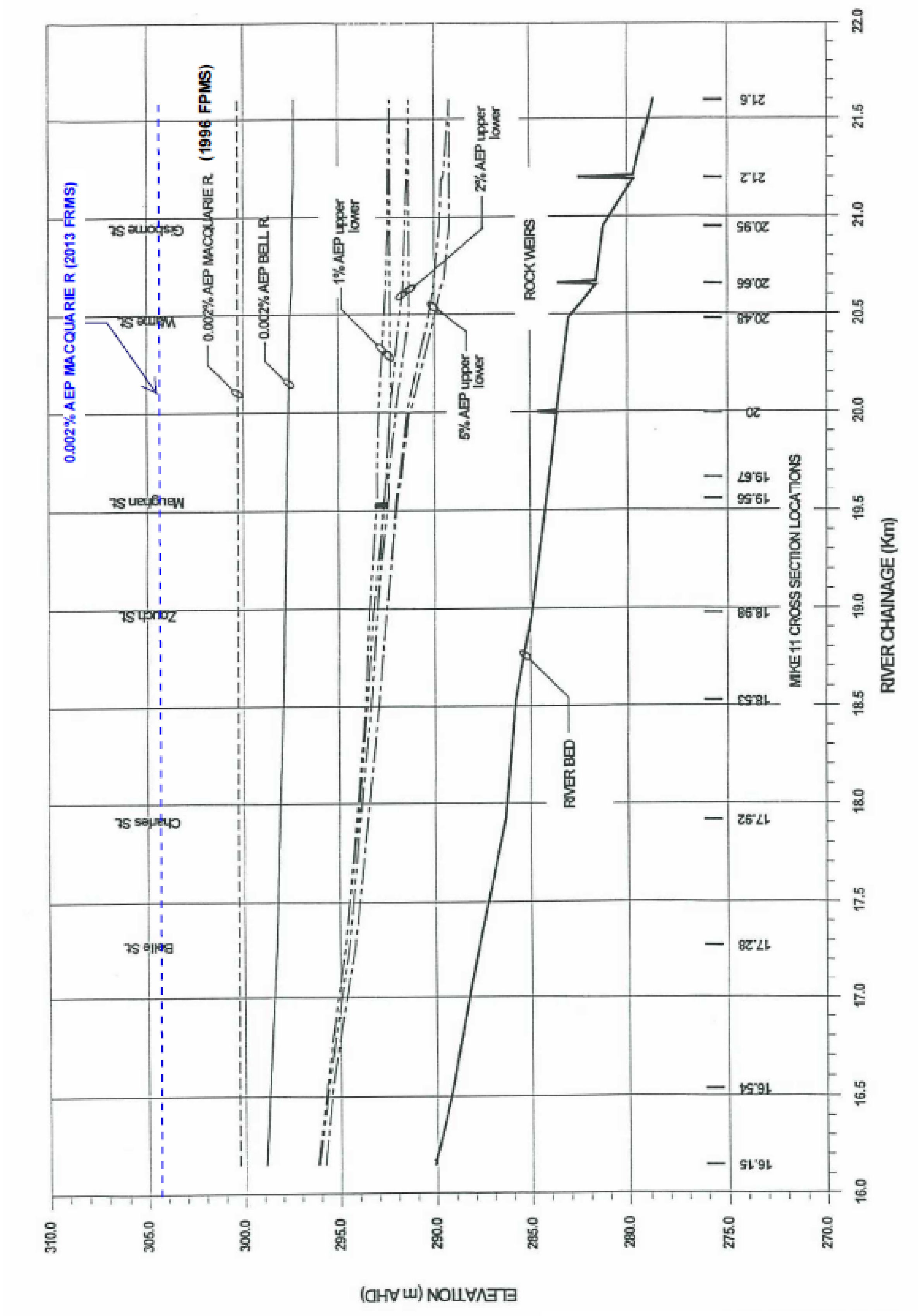


Figure A3.3: Water Surface Profiles – Bell River

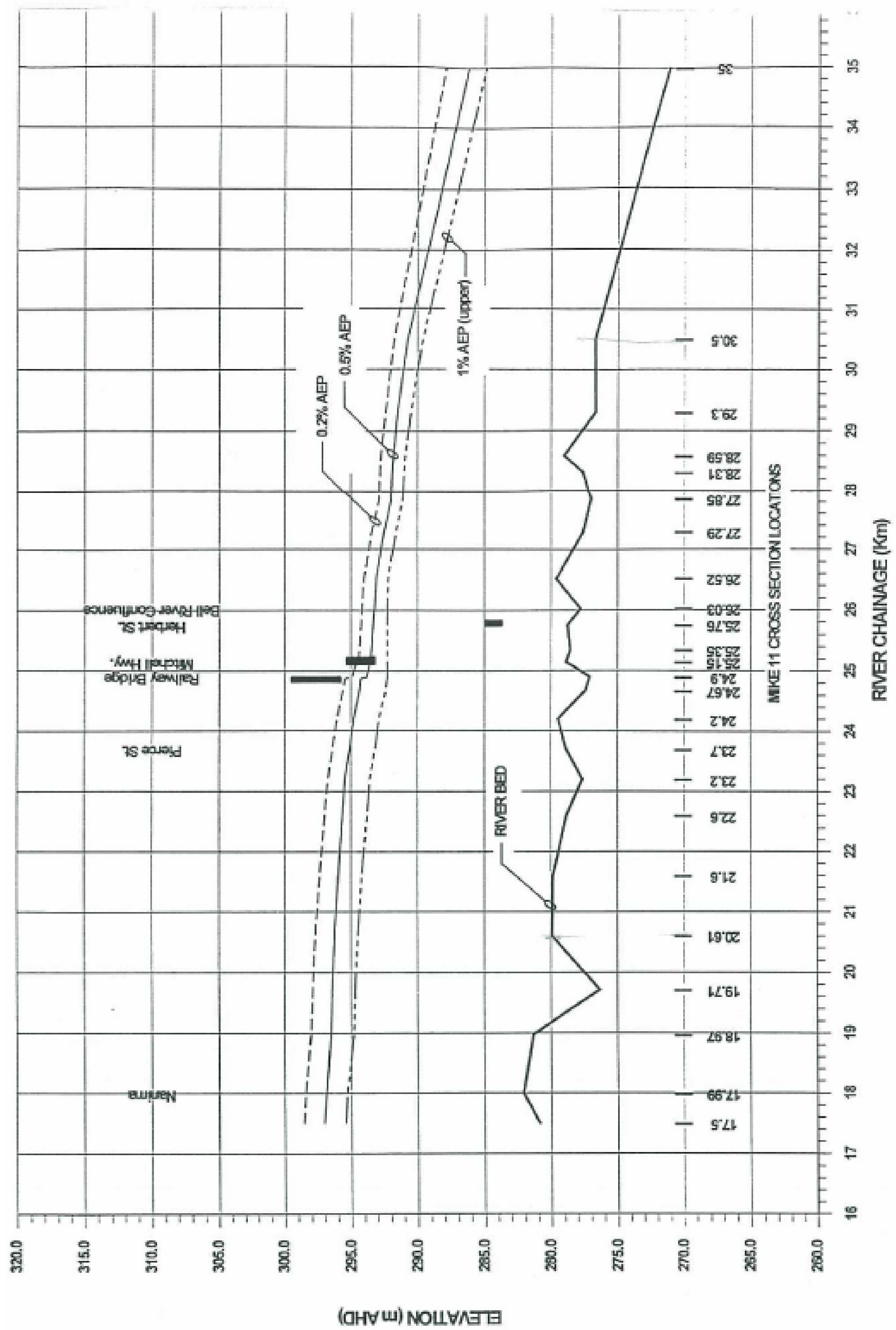


Figure A3.4: Water Surface Profiles – Macquarie River – 1, 0.5 and 2 % AEP

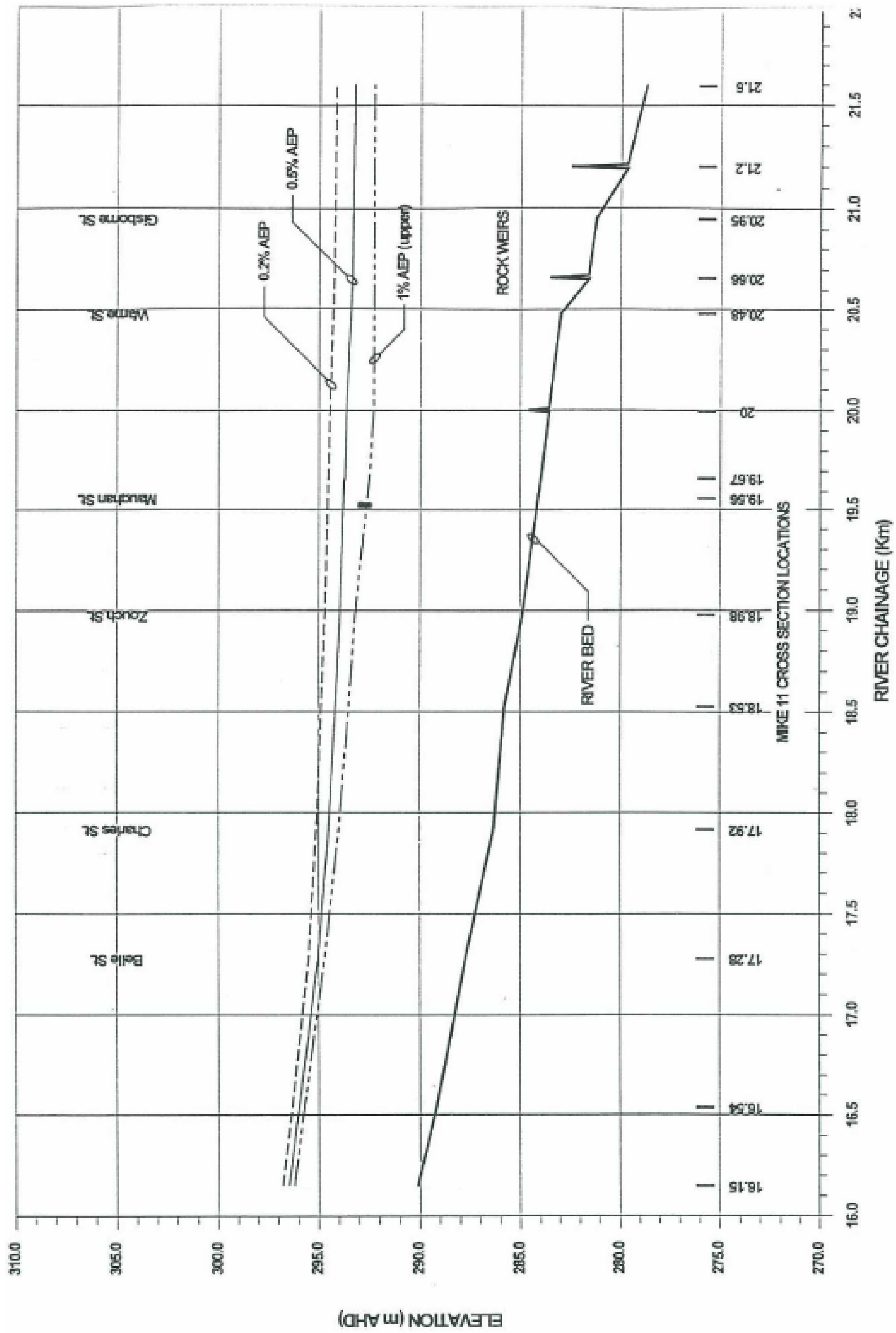


Figure A3.5: Water Surface Profiles – Bell River – 1, 0.5 and 2% AEP

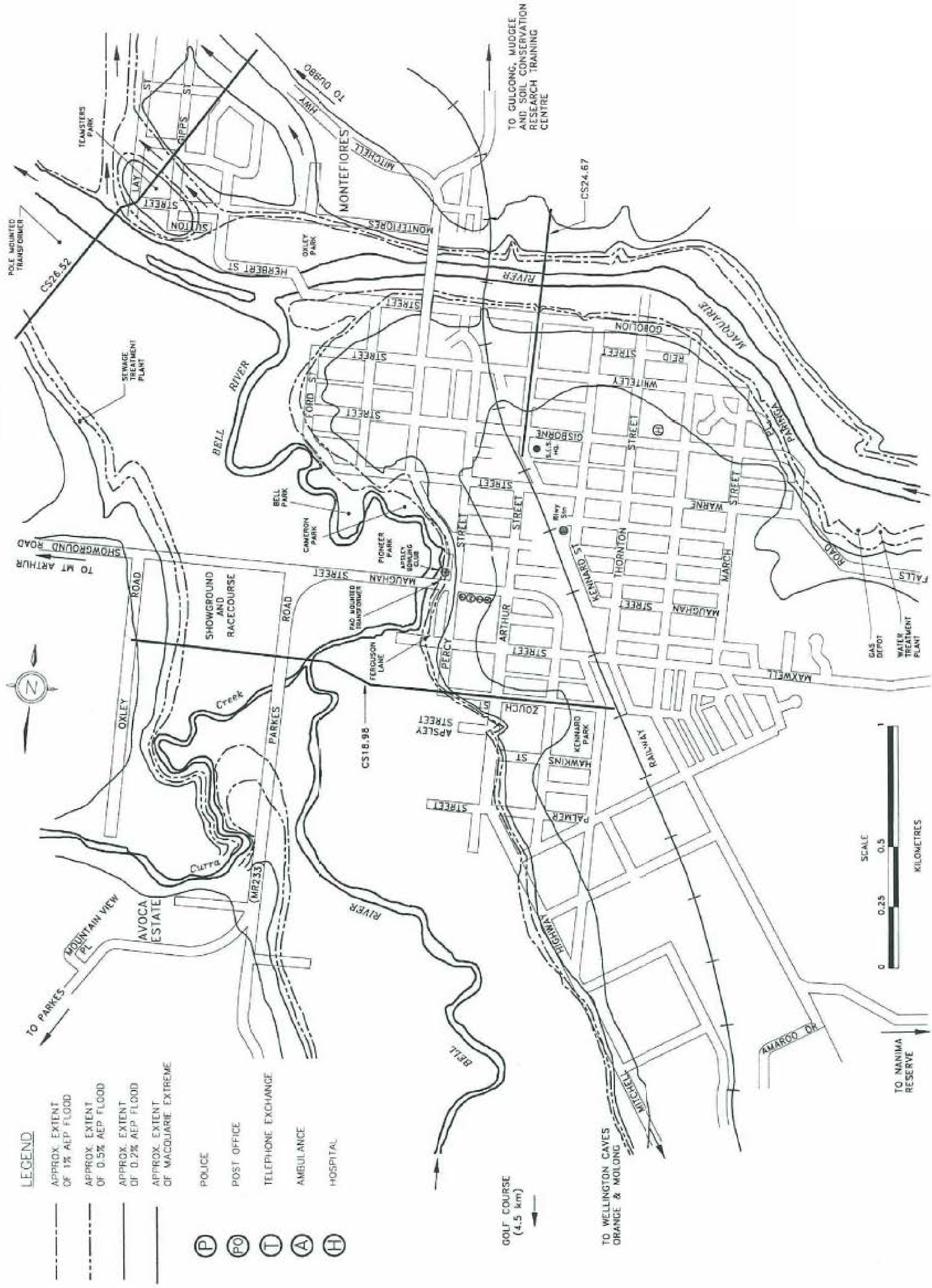


Figure A3.6: Extent of Flooding 1, 0.5 and 2% AEP

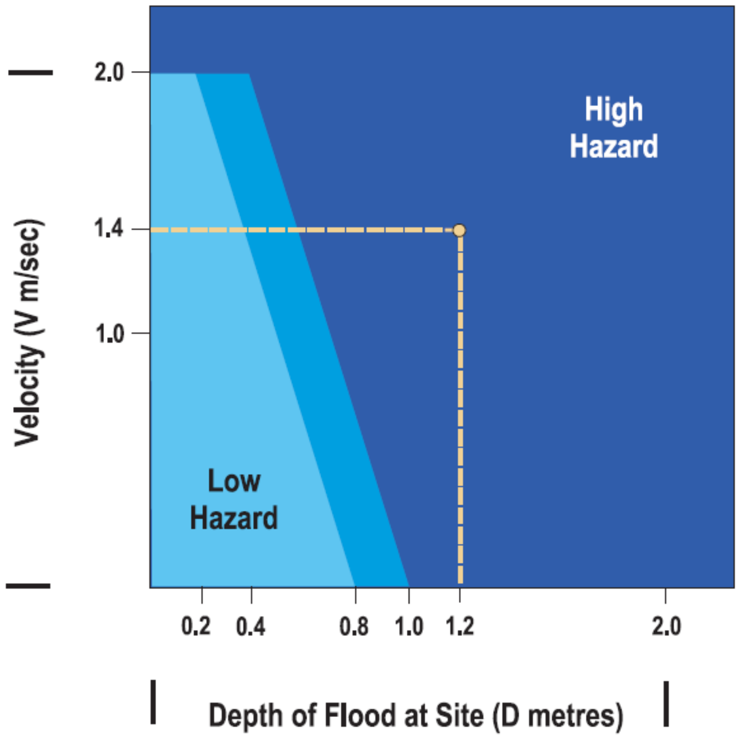
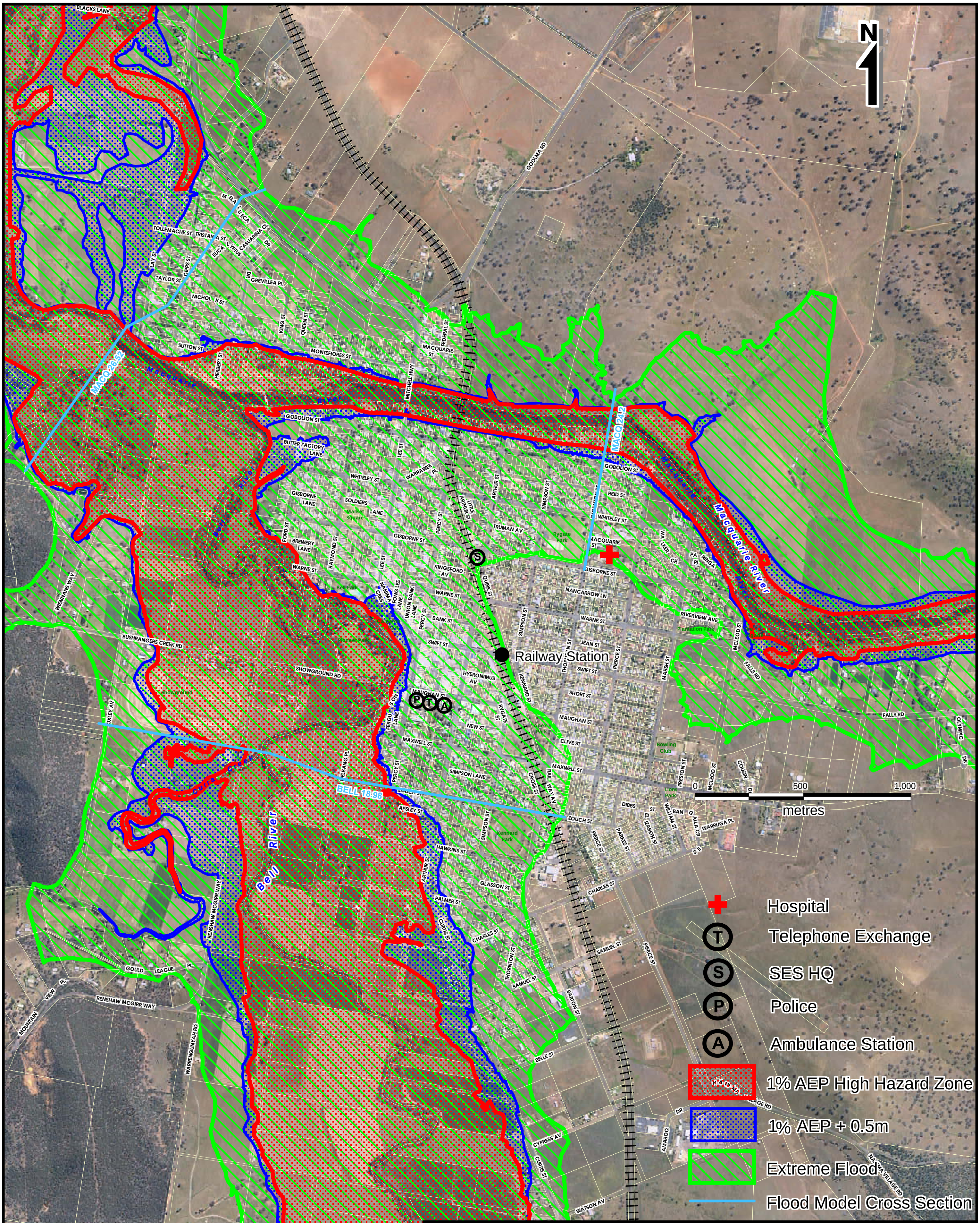


Figure A3.7: Provisional Hazard Rating



Wellington Floodplain Risk Management Study

Extent of 1% AEP High Hazard and Extreme Flood

Date: 12.07.13 | **Assignment:** 25150 | **Figure A3.8**

A4. STABILITY OF THE LOWER BELL RIVER

An investigation of the geomorphology of the Bell River was carried out for the DLWC (Thoms, 1995). The aims of that study were:

- to review the historic pattern of river changes, particularly on the lower Bell River;
- to assess the likely stability of the channel; and
- to provide management options for the Bell River near Wellington.

Analysis of pre- and post- Burrendong Dam hydrographs showed that there has been a de-synchronisation of flood peaks on the Bell and Macquarie Rivers as a result of the attenuating effects of the dam. Before 1965, the typical flood pattern was for the two rivers to peak at around the same time and for the flood hydrographs to have a similar shape. Under post-dam conditions, floods in the Macquarie River have lagged behind those in the Bell River and have been reduced in level.

The de-synchronisation and lowering of Macquarie River flood levels due to the attenuating effects of the dam has led to a decrease in the flood levels on the lower Bell River which can be seen on **Figure A4.1**. For the 50% AEP event the construction of the dam has led to a 1 m drop in flood levels while for the 20% AEP event the reduction is more pronounced with a drop of approximately 4 m.

The reduction in downstream flood levels has resulted in a higher flood slope in the Bell River at the time of occurrence of its flood peak. According to Thoms, 1995, the stream power of floods has increased and they have a greater ability to erode and modify the river channel. This has resulted in lateral instability leading to cutoffs and channel shortening which has the effect of further steepening the energy slopes.

Previous management techniques include structural management techniques such as bank protection works and river training. The most recently employed management strategy has involved the construction of three rock weirs between the Macquarie River and the Maughan Street bridge. These rock weirs were designed to promote upstream ponding and hence cushion incoming flows.

For the 1996 *Floodplain Management Study*, analyses were carried out to assess flow velocities and levels in the Bell River under pre- and post- Burrendong conditions. The hydraulic model prepared by DLWC for the Wellington Flood Study was used for these purposes and it included the three rock weirs. **Tables A4.1** and **A4.2** give adopted flows, obtained from the Flood Study, for the relatively frequent 50 and 20% AEP events modelled and the corresponding average velocities in the Bell River for pre- and post- dam conditions.

The impacts on the Bell River will be more pronounced for the smaller, more frequent, floods as illustrated by the above examples. They will be expressed by tendencies towards geomorphological changes occurring over many years, probably in an episodic manner. This is really a river channel management subject. However this and geomorphological investigations, are outside the scope of the present floodplain management study. For the larger floods that are of major interest for this study the geomorphological changes cannot be expected to have any significant effect on peak flood levels, and any such effects are likely to take a very long time to emerge.

Table A4.1: Peak Flows - 50% and 20% AEP (values m^3/s)

Condition	Bell River	Macquarie River	
		U/S Confluence	D/S Confluence
50% AEP			
Pre-Dam	150	460	610
Post-Dam	150	140	290
20% AEP			
Pre-Dam	230	1,700	1,930
Post-Dam	230	490	720

Table A4.2: Typical Flow Velocities - 50% and 20% AEP (values m/s)

Condition	Reach			
	D/S Weir 1	Weir 1 – Weir 2	Weir 2 – Weir 3	U/S Weir 3 (Maughan St)
50% AEP				
Pre-Dam	0.7	0.5	1.0	1.2
Post-Dam	1.1	0.7	1.1	1.2
20% AEP				
Pre-Dam	0.3	0.3	0.7	1.0
Post-Dam	1.0	0.7	1.3	1.4

Source of flows: *Flood Study Report*, (DLWC 1995)

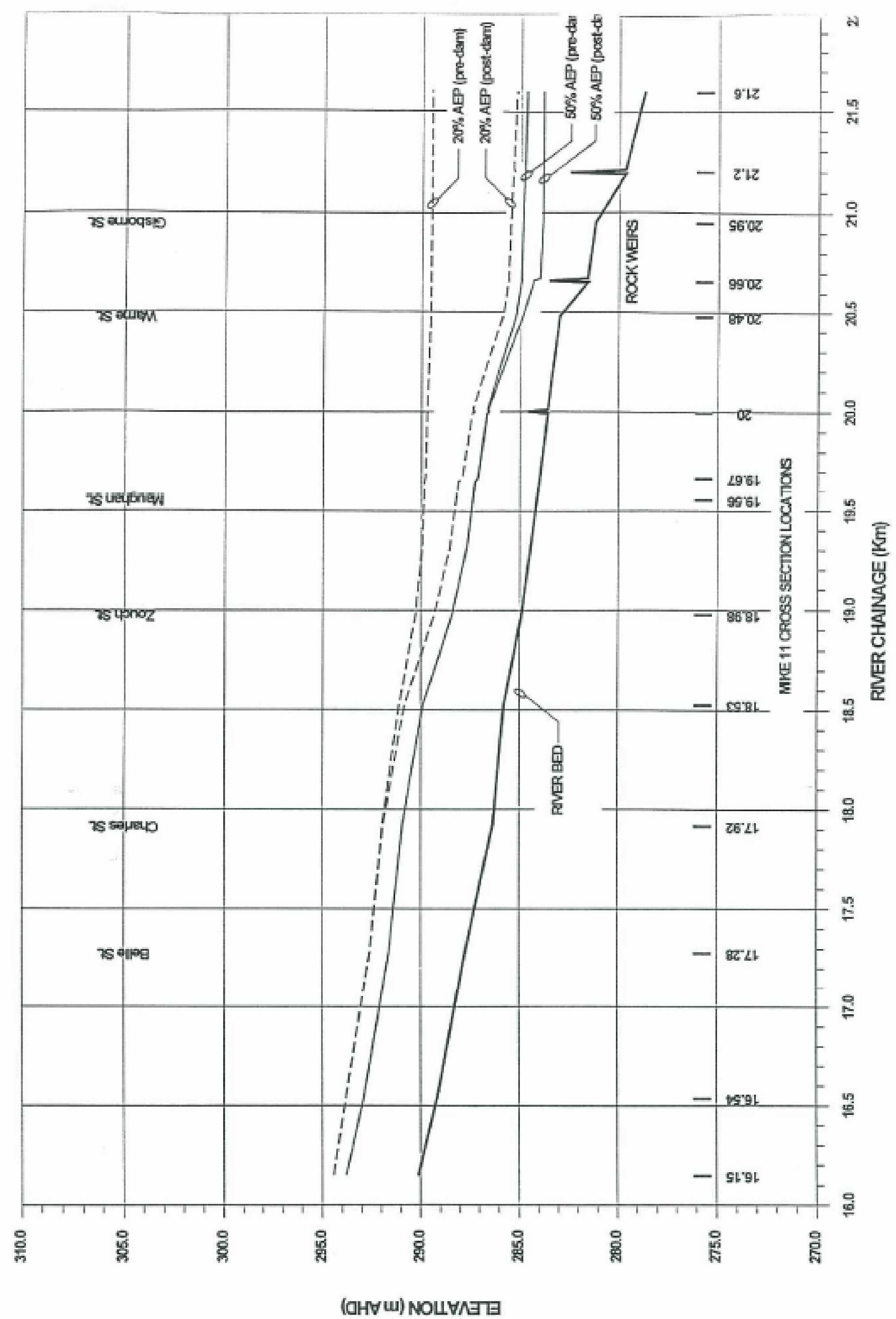


Figure A4.1: Water Surface Profiles: Bell River – Pre and Post Burrendong Dam

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Annexure: Hydraulic Modelling Results

SECTION	FLOOD LEVEL (mAHD)						PEAK VELOCITY (m/s)					
	5% AEP	2% AEP	1% AEP	0.5% AEP	0.2% AEP	Extreme (0.002%)	5% AEP	2% AEP	1% AEP	0.5% AEP	0.2% AEP	Extreme (0.002%)
Macquarie River												
17500	292.1	294.2	295.4	296.9	298.4	309.7	2.11	2.28	2.36	2.38	2.44	2.96
17990	292.0	294.0	295.2	296.8	298.3	309.6	1.33	1.62	1.82	1.80	1.84	2.34
18970	291.5	293.6	294.8	296.4	297.9	309.3	1.90	1.92	1.97	1.99	2.00	2.61
19710	291.4	293.4	294.7	296.3	297.7	309.1	0.91	1.12	1.20	1.20	1.24	1.68
20610	291.2	293.2	294.5	296.1	297.5	308.9	1.15	1.23	1.30	1.30	1.34	1.88
21600	290.9	293.0	294.2	295.8	297.2	308.6	1.59	1.57	1.59	1.61	1.70	1.95
22600	290.4	292.6	293.8	295.5	296.8	308.1	1.56	1.81	1.83	1.78	1.84	2.14
23200	290.1	292.4	293.6	295.2	296.5	307.5	1.83	1.90	1.91	1.87	1.94	2.45
23700	289.8	292.1	293.3	294.9	296.1	307.2	1.42	1.74	2.02	2.24	2.43	2.82
24200	289.5	291.7	292.9	294.5	295.7	306.5	1.71	1.85	1.97	1.88	2.03	2.91
24670	289.1	291.4	292.5	294.1	295.3	305.8	1.76	1.92	2.07	2.19	2.48	2.96
24880	289.0	291.3	292.4	294.0	295.0	305.6	1.55	1.74	1.91	2.06	2.42	2.87
24900	288.9	291.2	292.2	293.8	294.8	305.6	1.58	1.77	1.95	2.09	2.47	3.39
25030	288.9	291.1	292.1	293.7	294.7	305.3	1.72	1.93	2.13	2.29	2.58	3.44
25130	288.8	291.0	292.0	293.6	294.5	305.2	1.88	2.06	2.23	2.36	2.78	3.80
25150	288.7	291.0	292.0	293.5	294.4	305.1	1.89	2.07	2.24	2.36	2.80	4.10
25350	288.7	290.9	291.9	293.5	294.3	304.9	1.60	1.66	1.79	1.85	2.19	3.30
25760	288.5	290.7	291.7	293.3	294.2	304.8	1.61	1.63	1.62	1.61	1.61	2.09
26030	288.4	290.7	291.7	293.3	294.2	304.2	1.07	1.19	1.23	1.22	1.26	1.31
26520	288.1	290.5	291.5	293.2	294.0	304.1	1.12	1.14	1.15	1.14	1.18	1.34
27290	287.6	290.0	291.0	292.6	293.5	303.5	2.25	2.46	2.84	3.24	3.37	4.03
27850	287.2	289.6	290.6	292.1	292.9	303.1	2.15	2.40	2.64	3.06	3.22	3.64
28310	287.1	289.6	290.5	292.0	292.9	303.2	1.65	1.70	1.72	1.75	1.77	2.60
28590	287.0	289.5	290.4	291.9	292.8	303.3	1.05	1.13	1.28	1.35	1.38	1.98
29300	286.4	289.1	290.1	291.6	292.5	303.1	1.87	2.07	2.10	2.13	2.17	2.45
30500	285.6	288.3	289.3	291.0	291.8	302.9	1.50	1.68	1.77	1.82	1.84	2.03
35000	282.5	286.3	286.8	287.9	288.8	302.0	3.31	3.31	3.31	3.31	3.31	3.31
Montiefiores (west of Lay St)												
330	291.6	291.6	291.6	293.1	293.9	303.3	0.06	0.06	0.06	0.98	1.36	1.53
690	289.9	289.9	290.5	292.3	293.3	303.3	0.03	0.03	0.03	0.62	0.83	1.17
1130	288.5	289.5	290.4	292.0	292.9	303.3	0.09	0.09	0.09	0.51	0.90	1.75
1470	287.6	289.5	290.4	292.0	292.8	303.3	0.01	0.01	0.01	0.24	0.54	1.03
Montiefiores (Lay St to Mitchell Hwy)												
20	293.4	293.4	293.4	293.4	294.2	303.8	0.03	0.03	0.03	0.03	0.12	0.28
470	292.5	292.5	292.5	292.5	294.1	303.8	0.02	0.02	0.03	0.06	0.02	0.05
520	292.4	292.4	292.4	292.5	294.1	303.8	0.14	0.12	0.23	0.65	0.11	0.10
790	290.1	290.1	290.4	292.0	293.6	303.7	0.03	0.03	0.05	0.14	0.33	0.93
810	290.1	290.0	290.4	292.0	293.4	303.6	0.03	0.06	0.06	0.15	0.39	1.49
Bell River												
16150	295.8	296.1	296.2	296.5	296.8	299.0	1.50	1.65	1.75	1.58	1.49	1.89
16540	295.4	295.6	295.7	296.0	296.3	298.7	1.74	1.73	1.75	1.96	1.71	1.77
17280	294.2	294.5	294.7	295.0	295.5	298.4	1.16	1.14	1.16	1.23	1.19	1.49
17920	293.5	293.9	294.1	294.5	295.1	298.2	1.20	1.21	1.21	1.25	1.27	1.46
18530	292.9	293.4	293.6	294.2	294.9	298.1	1.52	1.63	1.54	1.53	1.71	1.61
18980	292.6	293.1	293.3	294.0	294.7	297.9	2.14	2.20	1.79	2.00	1.74	1.94
19650	292.0	292.7	292.8	293.8	294.5	297.8	1.84	1.88	2.02	1.70	2.02	1.52
19670	291.7	292.3	292.6	293.8	294.5	297.8	1.91	1.92	2.17	1.74	2.12	1.55
19990	291.2	292.0	292.3	293.7	294.5	297.8	1.91	2.00	1.92	1.85	1.72	1.85
20010	291.2	292.0	292.3	293.7	294.5	297.8	2.05	2.02	2.04	1.97	1.74	1.92
20480	289.8	291.0	291.5	293.5	294.3	297.6	2.63	2.69	2.73	2.31	2.21	2.64
20650	289.3	290.6	291.2	293.4	294.3	297.6	1.62	2.01	2.19	1.63	1.58	2.26
20670	289.3	290.5	291.1	293.4	294.3	297.6	1.62	2.03	2.20	1.65	1.58	2.31
20950	288.9	290.3	291.0	293.4	294.2	297.5	2.21	2.40	2.50	1.53	1.42	1.93
21190	288.6	290.1	290.8	293.3	294.2	297.5	3.23	3.45	3.49	1.76	1.51	2.09
21210	288.6	290.1	290.8	293.3	294.2	297.5	3.47	3.53	3.57	1.76	1.55	2.19

Wellington Council

WELLINGTON FLOODPLAIN RISK MANAGEMENT STUDY

Appendix B

Burrendong Dam

July 2013

Date: 18/07/2013

Table of Contents

Tables

Figures

B1. INTRODUCTION

Burrendong Dam, which was constructed in 1965, is situated below the junction of the Macquarie and Cudgegong Rivers 32 km above the town of Wellington and controls a catchment area of 13,900 km^2. Just downstream of Wellington, the Macquarie River is joined by the Bell River. A further 11 km downstream another tributary, the Little River, joins the main stream. The city of Dubbo is located 78 km below Wellington.

Catchment areas are shown in **Table B1.1**.

Table B1.1: Catchment Area (km^2)

Location	Catchment Area (km^2)
Burrendong Dam	13,900
Wellington upstream of confluence with Bell River	14,250
Bell River at Wellington	1,860
Dubbo	19,950

Burrendong Dam has a total storage volume of 1680 GL, of which 480 GL is allocated to flood mitigation. This flood mitigation storage can greatly reduce the peaks of floods flowing through the dam. Because the dam controls 86% of the combined catchment at Wellington, this effect is carried downstream and significantly reduces flood peaks there. It also has a significant effect at Dubbo.

Previous investigations on the effects of the dam in mitigating downstream flooding were carried out by I.E.S.C. in 1971 and by the then Water Resources Commission in 1978. Those studies were updated in the Wellington Flood Study (DLWC, 1995).

B2. BURRENDONG DAM FLOOD OPERATION

B2.1 Procedure

The flood operation procedure for Burrendong Dam is based on the following:

- the principle that outflows from the dam are not permitted to exceed inflows to storage until after the rate of inflow into storage has begun to subside
- an operation procedure which is designed to obtain maximum benefit from the use of available surcharge storage in reducing the intensity of peak outflows from the dam. The flood operation procedure involves:

  1. The estimation of the likely flood inflow rate up to four hours in advance, together with adoption of a flood recession assuming the estimated inflow is a flood peak. The estimation of the flood inflow is based on rainfall information and river levels recorded at three upstream telemetric stations: the Macquarie River at Bruinbun, the Cudgegong River at Yamble Bridge and the Turon River at Sofala. These upstream levels also indicate the trend of the inflow hydrograph to the storage. An important result of this step is to give the minimum volume that will flow into the storage after the time of the estimation.

  2. Based on this predicted inflow hydrograph, the procedure determines a constant outflow so as to make maximum use of available surcharge storage. During the rising stages of a flood the actual rate of inflow (based upon the change in storage level measured at the dam) is monitored, and the above estimation procedure is usually revised at hourly intervals.

Staff at the dam are responsible for transmitting information on the dam storage level, rainfall and recorded upstream flows to the Parramatta office. There, the staff in the Operations Division are responsible for calculating the required outflow and gate openings, and for relaying this information to the dam officers. The procedure aims at maximising the flood mitigation potential of the storage and, if possible, also takes account of downstream tributary flows, particularly on the Bell River. That is, releases are delayed where possible to follow, and not compound, the flood peaks from the various downstream tributaries.

During operation of the gates a minimum gate freeboard of 0.3 m should be maintained until the storage reaches a surcharge level of RL 353.8 m. After this the gates are to be gradually withdrawn at such a rate that when RL 356.9 m is reached, the gates will be clear of the water.

Burrendong Dam has a huge lake surface area (some 8900 ha at RL 350.8 m), so that any raising of the storage level behind the radial gates represents a significant additional volume of flood water that can be stored.

Thus, raising of the gates not only increases the spillway discharge but also allows a greater storage potential. This means that for major flood inflows, when the storage level is likely to exceed RL 350.8 m, additional flood mitigation storage is obtained for each incremental raising of the gates.

Close contact is maintained with the Bureau of Meteorology which is the agency responsible for issuing the warning of likely flooding along the river. The State Emergency Services (SES) is then responsible for evaluating and acting upon that warning. Details of the flood warning system for Wellington are given in **Appendix D**.

B2.2 Attenuation of Flood Peaks Through Burrendong Dam

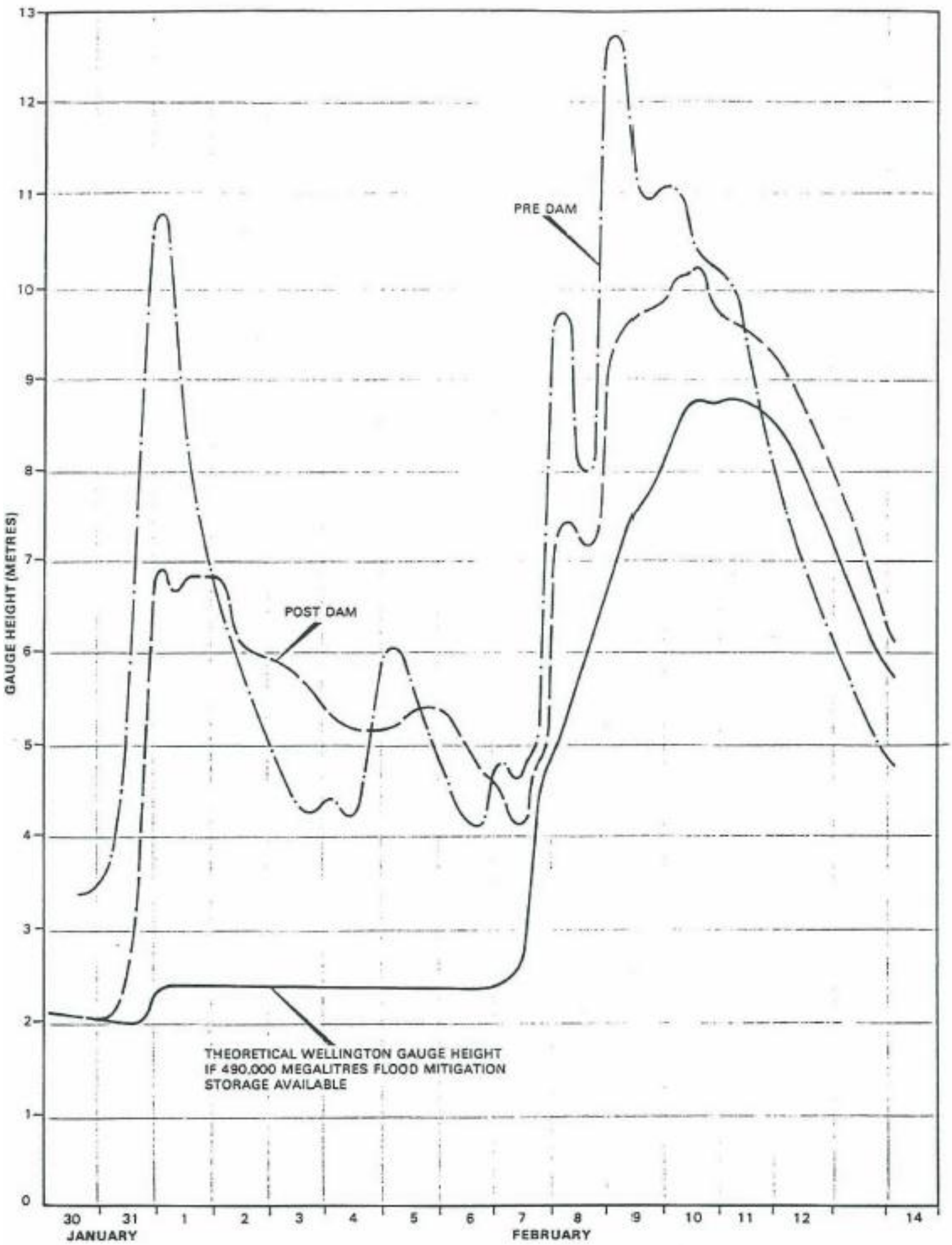
An example of the performance of the dam in attenuating floods is illustrated by **Figure B2.1**, which is for the double peaked flood of January-February 1971.

The first peak occurred at the dam on 31 January, where the peak inflow of 1,920 m^3/s was reduced to a peak outflow of 730 m^3/s. Flow in the Bell River was not significant during this peak. As shown on **Figure B2.1**, under pre-dam conditions, the flood peak would have reached about 10.8 m on the Wellington (Mitchell Highway) gauge early on 1 February, but actually reached 6.8 m.

At the dam, the second flood inflow peak of 2,550 m^3/s was reduced to an outflow of 1,300 m3/s, which occurred at 20:00 hours on 10 February. By this time, the Bell River was in flood, with a peak discharge of 760 m^3/s recorded at Neurea at 22:00 hours on 9 February. Allowing for 6 hours travel time to Wellington, the Bell River peak arrived in the early morning of 10 February. The peak level recorded on the Macquarie River at the Mitchell Highway gauge was 10.2 m. However under pre-dam conditions it would have reached 12.6 m.

The flooding of July-August 1990 also illustrates the attenuating effects of the dam. Three separate floods were experienced, with the last being the most severe and occurring over the three days 2 to 4 August. The peak inflow to the dam was 6,500 m3/s, the highest experienced over the life of the structure. The flood mitigation storage had been emptied at the time of arrival of the flood and attenuated the peak to an outflow of 2,100 m^3/s. At the Mitchell Highway gauge the recorded peak height was 13.1 m, which is equivalent to the 2% AEP level under post-dam conditions (DLWC, 1995). Under pre-dam conditions, the flood peak would have been 3.5 m higher. On the Bell River the peak level at the Maughan Street gauge was slightly less than a 2% AEP level on that stream. The peak discharge was about 1,400 m^3/s.

The 1971 and 1990 floods are the only two events to have reached the critical level of 9 m on the Mitchell Highway gauge at Wellington over the life of Burrendong Dam. OEH has carried out behavioural analyses which investigated the potential of the dam to attenuate historic floods that occurred prior to its construction. If the dam had been in existence since 1909, when records commenced, only 6 floods would have reached 9 m on the gauge (including the 1971 and 1990 events), whereas 30 floods would have reached this height if the dam had not been built.



(Source: SKP, 1984)

Figure B2.1: Stage Hydrographs at Wellington Jan – Feb 1971

B3. ATTENUATION EFFECTS OF FLOOD MITIGATION STORAGE

The ability of the dam to reduce flood heights at Wellington depends partly on the storage contents at the time of arrival of the flood.

Data presented in the Wellington Flood Study (DLWC, 1995) may be used to evaluate the performance of the dam in attenuating flows with various initial storage contents (**Table B3.1**). Values shown in columns (2) to (5) were derived by DLWC by routing recorded floods through the dam using the current gate operation procedures. Column (6) shows the probability distribution of post-dam flood peaks on the Macquarie River at Wellington (upstream of the Bell River confluence). These last results were obtained from a joint probability analysis (**Appendix A**) and apply for the current operation of Burrendong Dam as a conservation-flood mitigation storage.

Under current operating procedures, the dam will be at conservation storage level, or less, at the onset of a flood, except in the extremely rare event of a closely spaced double peak flood when some of the flood mitigation storage may be occupied at the time of the second peak. Column (4) shows the range of peak outflows that would occur if the dam was at the conservation storage level at the onset of all floods. Because the dam will often be at a lower level, the actual peaks will usually be lower, and column (5) illustrates what the situation would be if it was at the level corresponding to 50% of the conservation storage.

If the policy were to be changed so that the dam was operated solely as a conservation storage, ie with the flood mitigation storage (airspace) used for additional conservation storage, then the peak outflows at the dam would be higher. Column (3) shows the range of peak outflows that would occur if the dam was full at the onset of all floods. A considerable attenuation of the inflow peaks would still be achieved; for example the 1% AEP flood peak would be reduced from 5,900 m^3/s to 3,200 m^3/s. As under current operating conditions, the dam would not actually be full at the onset of all floods, and so there would be greater reduction in outflow peaks in most cases. However estimation of the resulting discharge frequency relationship is outside the scope of this review.

The MIKE 11 model was run for the deterministic cases where the dam was either full or at conservation level at the time of the 1% AEP inflow, so as to estimate the effects at Wellington. Columns (3) and (4) of **Table B3.1** show that for this frequency the peak discharges at Burrendong Dam would be 3,200 m^3/s for the dam full case and 1,500 m^3/s when the dam is at conservation level. The results of the analysis showed that at the Mitchell Highway, the flood level would be 3 m lower if the dam was at conservation storage level instead of being full. Note however, that these discharges and their corresponding levels do not correspond with the 1% AEP flow downstream of the dam because the flood frequency distribution there is changed by the presence of the dam, as discussed in **Appendix A**. Compared with the 1% AEP peak discharge of 2,800 m^3/s at the Mitchell Highway (column 6), the peak levels for these two cases are 0.6 m higher and 2.4 m lower, respectively.

Table B3.1: Results of Routing Floods Through Burrendong Dam

Frequency (% AEP)	Peak Inflow to Dam (m^3/s)	Peak Outflow (m3/s) For dam condition at onset of flood inflow as follows:			Peak Discharge at Wellington (u/s Bell River) (m^3/s)
		Dam Full (No Air-Space)	Dam at Conservation Storage Level	Dam at 50% Conservation Storage Levels	
(1)	(2)	(3)	(4)	(5)	(6)
5	3,600	1,700	350	-	1,500
2	5,000	2,400	900	-	2,200
1	5,900	3,200	1,500	-	2,800
0.5	7,200	3,900	2,200	350	3,500

Source: DLWC, 1995

B4. REFERENCES

McCormick R M (1978), *"Report on Flood Frequency Studies for Macquarie River at Wellington and Dubbo"*.

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Wellington Council

WELLINGTON FLOODPLAIN RISK MANAGEMENT STUDY

Appendix C

Assessment of Flood Damages

July 2013

Date: 18/07/2013

Table of Contents

Annexures

1 Surveyed Floor Levels

2 DECC *Floodplain Risk Management Guideline* (2007)

Tables

Figures

C1. INTRODUCTION AND SCOPE

C1.1 Introduction

This appendix updates the damage assessment provided in the 1996 Study.

Residential damages have been re-assessed in accordance with the NSW DECC's (2007) *Residential Flood Damages Floodplain Risk Management Guideline*, which was developed to provide a method of calculating flood damage across NSW. This method was developed exclusively for residential properties, and does not address non-residential damage.

The method used to assess commercial and public property damages is the same as that in the 1996 study with the results updated from 1996 values to 2012 values by applying CPI, as supplied by the ABS website (a rate of 1.52).

The depths of inundation were determined from the results of the hydraulic modelling described in **Appendix A**. Property characteristics used to determine damage were obtained from site inspections carried out for the 1996 Study. Google Maps with Street View was used to acquire additional information on property characteristics required for this update.

C1.2 Background

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

Generally, tangible damages are measurable in dollar values using survey procedures, interpretation, and research of government files.

The various factors included in the intangible damages category may be significant. However, these effects are difficult to quantify due to lack of data and the absence of an accepted methodology and therefore have not been separately assessed in this study. Such factors may include:

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

C2. DESCRIPTION OF NUMERICAL MODEL

C2.1 Residential Damages

The NSW DECC (2007) *Residential Flood Damages Floodplain Risk Management Guideline* and spreadsheet tool was used to estimate the damages to residential property within the study area. The guideline is contained in **Attachment 2** to this Appendix. Flood levels at individual properties were estimated as part of the 1996 Study using the URBLOSS program.

To determine the depth of inundation at each property, URBLOSS requires input of water surface elevations within the study area for a range of flood events. Flood level data was derived from hydraulic modelling, as described in Appendix A, and processed in URBLOSS as part of the 1996 study. In URBLOSS the flood liable area is divided into triangular cells, the vertices of which are defined by a set of coordinates. A water surface elevation is calculated for each of the vertices, and a water surface plane between these points defines the water surface elevation for all points within the triangle. The depth of inundation at each property is then computed as the difference between the water surface elevation and an appropriate base level. In the case of most buildings the base level will be the floor level, or a level slightly lower at which structural damage may commence.

The flood depths calculated in URBLOSS was then integrated into the DECC spreadsheet tool to derive average residential damage curves for three types of dwellings: single storey high set, single storey low set and 2 storey houses. The curves quantify an average relationship between depth of inundation and damage costs for each type of dwelling. They are based on a range of location specific input data and include adjustments for factors such as flood awareness and warning time. The curves also include the cost of some indirect damages for example alternate accommodation and clean-up costs.

Table C4.1 below outlines the input factors required to develop the damage curves, and provides further detail of inherent assumptions.

It should be noted that the calculations do not provide an accurate assessment of flood damage to **individual** properties. The reason for this caveat lies in the various assumptions commonly made in the calculations, which include:

- the assumption that computed water levels are accurate and without any error;
- the assumption that the water surfaces between computational points are planar, not curved;
- the use of "average" depth-damage relationships rather than a relationship for each property;
- the uncertainty associated with assessing an accurate factor to convert potential to actual flood damages for each property;
- the uncertainty associated with determining location specific input factors; assumption that floor levels can be accurately determined on the basis of local ground levels shown on topographic plans together with visual estimates of floor height above ground level.

To reduce errors from the last source floor levels were surveyed for properties lying within the influence of the 1% AEP flood. Floor levels for properties above this flood were estimated from mapping supplied by Council.

C2.2 Commercial and Industrial Damages

Damages to commercial and industrial properties were estimated using a combination of the URBLOSS model to estimate flood depths at individual properties and a spreadsheet approach to calculate damages, based on floor area. Damages have been have been adjusted from the 1996 results to present day values by applying CPI.

Using this method, property damage calculations are based on the floor area of the property and a corresponding depth-damage function which assigns a damage cost per square metre of floor area.

Three damage relationships are used: one each for low, medium and high value properties. The damage costs assigned to each category are based on the results of the *Nyngan April 1990 Flood Investigation* (DWR, 1990).

The surface water elevations and corresponding depths of inundation used in this model are the same as those described in the above section on Residential Damage.

C3. SOURCES OF DATA

To estimate average annual flood damages for a specific town it is necessary to estimate the damages for several floods of different magnitudes, i.e. of different frequencies, and then to integrate the damages over the whole range of frequencies. To do this it is necessary to have data on the damages sustained by all types of property over the likely range of inundation. There are several ways of doing this, as follows:

- The ideal way is to conduct specific surveys in the aftermath of a range of floods, preferably immediately after each. Obviously this is seldom practicable, and it cannot be used in the present case. An example approaching this ideal is the case of Nyngan where surveys were conducted in May 1990 following the disastrous flood of a month earlier.
- The second best way is for experienced loss adjusters to conduct a survey to estimate likely losses that would arise due to various depths of inundation. This approach is used from time to time, but it can add significantly to the cost of a floodplain management study. It was not used for Wellington.
- The third way is to use generalised data such as that published by CRES (Centre for Resource & Economic Studies, Canberra). This kind of data is considered to be suitable for generalised studies, such as broad regional studies. It is not considered to be suitable for use in specific towns, unless none of the other approaches can be satisfactorily applied.
- The fourth way, which was used in this study, is to adapt or transpose data from another town:
  - calculation of commercial and public property damages was based on the data collected for the Nyngan study (DWR, 1990), with adjustments made to account for inflation and to account for differences in the nature of developments in Nyngan and Wellington;
  - calculation of residential damages was undertaken using the DECC Residential Flood Damage assessment model is based on data collected from flooding in Katherine in 1998 and Brisbane in 1974, adjusted using a range of location specific input factors and inflation factors.

An important source of data for this study was a drive-by inspection of properties considered as likely to be affected by flooding events up to and including the 1% AEP flood, undertaken as part of the 1996 Study. Floor levels of these properties were then surveyed. The surveyed floor levels are contained in **Attachment 1** to this appendix.

Data obtained from the drive-by inspection for residential properties included:

- the location/address of each property;
- a general description of the residence;
- an estimate of the residence's value;
- an estimate of the construction type and foundations;
- a general description of any external buildings/structures; and

- an estimate of the height of floor level above the ground level.

Data obtained from the drive-by inspection for commercial/industrial properties and public buildings included:

- the location of each property;
- the nature of each enterprise;
- an estimate of the floor area;
- an estimate the construction type and foundations of the property; and
- an estimate of the height of floor level above the ground level.

Vacant blocks and car parks (except for underfloor car parks) were not included in the modelling. It was assumed that vehicles would be removed to flood free areas prior to the arrival of a flood.

Flood levels and the extent of the extreme flood event were revised as part of this 2013 update, based on the PMF discharge determined from the dambreak analysis carried out for Burrendong Dam by SKM for State Water as part of the *24 Dams Portfolio Risk Assessment* (refer Appendix A). The number of properties in the flood fringe between the 1% AEP and the extreme flood (0.002% AEP) and their approximate floor levels were assessed from GIS maps with 2 m contour spacing, supplied by Council. These properties were assessed in blocks, rather than on an individual basis, and defined by a representative set of characteristics.

In cases where further information about a property was required for the 2013 update, e.g. to check if a dwelling was single or double storey, Google Maps with Street View was used.

The following assumptions were made:

- data collected in the surveys for the 1996 Study is still an appropriate representation;
- if data was unavailable on property type, then the conservative assumption of single storey, non-raiseable was adopted; and
- all properties in a ‘block’ were represented by the same property type and representative floor level. If identifiable, the type representing the majority was used, otherwise the conservative assumption of single storey, non-raiseable dwelling was adopted.

C4. RESIDENTIAL DAMAGES

C4.1 Method

The study area was subdivided into damage cells, with the cell layout generally following the same orientation as that of the MIKE 11 hydraulic model. Properties assessed as being flood prone up to the extreme flood level were included in the analysis.

C4.2 Damage Functions

A depth-damage curve relates flood damage to depth of flooding above floor level. The NSW DECC (2007) *Residential Flood Damages Floodplain Risk Management Guideline* and spreadsheet tool was used to developing representative damage curves for a 'typical' house on the floodplain.

The damage relationships in the DECC tool are based on data from flood events in Katherine and Brisbane. These relationships are adjusted through a range of location specific adjustment factors. The factors are calculated using a range of site specific input values, which are summarised in **Table C4.1** below. The inclusion of factors such as warning time and flood awareness means the resultant damage values represent actual, rather than potential, damages.

Table C4.1: Adopted Input Factors for Residential Damages Calculations

Input Factor	Adopted value	Reference / Comment
Regional Cost Variation Factor	1.08	Rawlinsons Construction Handbook (2012)
Post Late 2001 Adjustment	1.55	Calculated using Average Weekly Earnings statistics from Bureau of Statistics
Post Flood Inflation Factor	1.50	As per the DECC Guideline for a Regional Town with more than 50 houses affected by a 1%AEP event.
Typical Duration of Immersion	36 hours	Wellington Local Flood Plan 2008: page 4 of Annexe A indicates water levels remained within 2 m of the peak for 36 hours at the Wellington gauge during the 1990 flood event; page 3 Annex B indicates some properties would be "flooded for several days in an extreme event".
Building Damage Repair Limitation Factor	0.85	DECC Guideline recommended factor for longer duration immersion (greater than 12 hours).
Typical House Size	150 m^2	Assumed average from drive-by survey: • 85 dwellings <130 m^2, • 103 dwellings 130-200 m^2 • 10 dwellings >200 m^2

Input Factor	Adopted value	Reference/Comment
Average Contents Relative to Site	$37, 500	DECC Guideline recommended value.
Contents Damage Repair Limitation Factor	0.85	DECC Guidelines indicative range, based on inundation duration (long duration 0.9 - short duration (<12h) 0.75).
Level of Flood Awareness	Low	DECC Guideline recommendation is to assume low, unless a high level can be justified. Wellington FPMS Supporting Document states that "*despite high levels of awareness being exhibited in the 1990 floods, high population turnover and a sense of security due to the dam make a lower level of awareness a more appropriate assumption.*"
Effective Warning Time	1.5 hours	Wellington Local Flood Plan 2008 Annexe F: "*flood evacuation warning time could be as little as 90 mins in a dam failure event.*"
Typical Table/Bench Height	0.9 m	DECC Guideline recommended value for single storey dwellings
Protection Level	0.5 m	Freeboard necessary to give desired protection. Standard recommended in the 2005 FDM.
External Damage	$6,700	DECC Guideline recommended value
Clean Up Costs	$4,000	DECC Guideline recommended value
Likely Time in Alternate Accommodation	3 weeks	Wellington Flood Management Plan, Appendix C, October 2007, page 6, states a time of 21-28 days for Nyngan residents based on the Nyngan Study (DWR, 1990) and 12 days for Georges River residents in 1986.
Additional Accommodation Costs	$220 per week	DECC Guideline recommended value

Indirect residential damages comprise the costs of evacuating people and contents, providing temporary accommodation, cash grants to welfare and relief agencies, clean-up costs after the flood, and loss of wages. The DECC Guideline model includes allowance for some indirect damage costs, e.g. alternate accommodation and clean-up costs, as shown above in **Table C4.1**.

C4.3 Residential Damages

Table C4.2 summarises residential damages for a range of floods. The damage estimates were carried out for floods between the 5% AEP flood level, which is approximately the threshold flood at which significant damages commence, and the extreme event.

The numbers of properties that would be flood "affected" and "damaged" are shown in **Table C4.2**. Flood affected properties have water within the allotment. In the 1996 analysis damages were assumed to commence a level 0.04 m below floor level. This approach has been replaced in the *DECC Guideline* by adopting the freeboard necessary to give desired protection, which has been assumed to be 0.5 m. This has resulted in additional residential properties now being included as been flood affected.

The properties affected by the revised extreme event on the Macquarie have been estimated based on the cadastral mapping. The properties were identified in blocks, as described in **Section C2** above. The discharge of the extreme event on the Macquarie River was estimated by State Water as part of its *24 Dams Portfolio Risk Assessment*, which included Burrendong Dam. The frequency of this event has been assumed to be 0.002% AEP. The frequency of the extreme event on the Bell River is also 0.002% AEP.

Table C4.2: Estimated Actual Residential Damages (2012 Values)

Flood Event AEP %	Number of Properties: Flood Affected	Number of Properties: Damaged	Damage x $1,000
5	30	6	795
2	36	25	1,799
1	87	47	3,541
0.5	164	102	8,070
0.2	393	327	22,625
EMAC	1134	1131	122,455
EBELL	636	629	60,603

Residential properties flooded in the 1% AEP flood are located in the following streets:

- Apsley Street
- Arthur Street
- Curtis Street
- Ferguson Lane
- Gobolion Street
- Maxwell Street
- Montefiores Street
- Percy Street
- Renshaw McGirr Way
- Showground Road
- Welbang Street

C5. COMMERCIAL AND INDUSTRIAL DAMAGES

C5.1 Direct Commercial and Industrial Damages

Direct damages up to the extreme event were estimated using the URBLOSS program outlined previously. Each enterprise was included in the database.

Each commercial and industrial property was categorised in terms its damage category, floor area and floor level.

The damage category assigned to each enterprise was either "low", "medium" or "high", depending on the nature of the enterprise and the likely effects of flooding. Damages were then determined on the basis of floor area.

Commercial damages have been updated from 1996 values to 2012 values by adjusting by the CPI rate (1.52). The following damage functions (2012 values) were adopted for potential internal damages for commercial and industrial properties:

- Low value enterprise $243/m^2$
- Medium value enterprise $631/m^2$
- High value enterprise $958/m^2$

These values were based on results presented in the Nyngan Study (DWR, 1990). The values are indexed to a depth of inundation of 2 m. The depth-damage function adopts zero loss at floor level, and 70% of the above values at a depth of inundation of 1.2 m. The resulting depth-damage relationship is similar to that used in the ANUFLOOD computer model (SKM, 1994).

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

For the present study, the approach of relating the potential to actual conversion factors to the depth of inundation was adopted. Potential damages were converted to actual damages using factors which were 0.14 at zero inundation, increasing to 0.36 for an inundation of 400 mm, and 0.9 at 1.6 m, at which depth it remained constant.

Other investigators have used similar approaches or have based the conversion factors on warning time and preparedness only, not depth. In the study for Forbes (SKM. 1994) a factor of 0.15 was adopted to convert potential to actual damages. That community would have an extremely high degree of preparedness given the history of flooding in the town and accordingly the conversion factor would be low.

External and structural damages were assessed as 1% and 3% of the actual internal damages respectively.

The cost for flood damages to caravans was assessed at $50,000 each, based on 2012 values, independent of the depth of inundation. Once damaged by flooding a caravan generally cannot be repaired. The flood damage cost per caravan is therefore the cost of replacement.

C5.2 Indirect Commercial and Industrial Damages

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

Disruption to trade takes the following forms:

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

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

Some investigations have lumped this loss with indirect damages and have adopted total indirect damage as a percentage of the direct damage. In other cases, loss of profit has been related to the gross margin of the business, ie turnover less average wages. The former approach has been adopted in this present study. Indirect damages have been taken as 15% of direct actual damages.

For caravan parks, indirect damages were taken as 3% of actual direct damages. This reduced factor was adopted because of the high actual direct damages associated with the flooding and replacement of caravans.

The total indirect damage is then the sum of the clean-up costs, a value of $23/m^2 was adopted, and the loss of trading profit.

C5.3 Total Commercial and Industrial Damages

Table C5.1 summarises actual commercial and industrial damages for the study area affected properties are mainly confined to the Bell River on both the floodplain and right bank.

Table C5.1: Estimated Actual Commercial and Industrial Damages Wellington (2012 Values)

Flood Event AEP %	Number of Properties Flood Affected	Number of Properties Damaged	Damage x $1,000
5	1	1	5
2	4	4	74
1	6	6	158
0.5	20	14	323
0.2	36	31	1,058
EMAC	73	73	25,383
EBELL	69	69	18,487

The number of caravans damaged was based on an estimated average occupancy rate within the two caravan parks in Wellington. They are located on the right bank of the Macquarie River immediately upstream of the Mitchell Highway, and on the Bell River on the eastern side of the Mitchell Highway between Charles and Palmer Streets. **Tables C5.2** shows the estimated damages.

Table C5.2: Estimated Actual Damages to Caravan/Caravan Parks at Wellington (2012 Values)

Flood Event AEP %	Number of Properties Flood Affected	Number of Properties Damaged	Damage x $1,000
5	0	0	0
2	0	0	0
1	5	213	250
0.5	10	426	500
0.2	15	638	780
EMAC	38	1,611	1,961
EBELL	32	1,368	1,630

C6. DAMAGES TO PUBLIC BUILDINGS

C6.1 Direct Damages - Public Buildings

Included under this heading are government buildings, churches, swimming pools and parks. Damages were estimated individually on an areal basis according to the perceived value of the property. These values were obtained from the Nyngan Study (DWR, 1990), then adjusted for CPI to update from 1996 values to 2012 values. Potential internal damages (2012 values) were assigned as follows:

- Very low value $58/m^2$ (eg. park buildings)
- Low value $243/m^2$ (eg. pools)
- Medium value $631/m^2$ (eg. council buildings)
- High value $958/ m^2$ (eg. schools)

Structural damages were taken as 15% of internal damages. An allowance was also made for damages to external buildings. It was estimated that 50% of public properties had external buildings, and for each of these, damages were taken as 25% of internal damages to the main building.

C6.2 Indirect Damages - Public Buildings

Similar values were used to those given previously in **Section C4.2**, except that a value of $11,100 was adopted for the clean-up of the property. This value is based on results presented in the Nyngan Study (DWR, 1990), adjusted for inflation. Total "welfare and disaster" relief costs were assessed as 15% of the actual direct costs, as for the residential properties.

C6.3 Total Damages - Public Buildings

Table C6.1 summarises damages to public buildings in Wellington.

Table C6.1: Estimated Actual Damages - Public Buildings in Wellington (2012 Values)

Flood Event	Number of Properties		Damage $ x 10^3
AEP %	Flood Affected	Damaged	
5	1	1	650
2	1	1	650
1	2	1	650
0.5	2	2	685
0.2	4	4	1,032
Macquarie Extreme	18	18	9,317
Bell Extreme	11	10	4,653

C7. DAMAGES TO INFRASTRUCTURE AND COMMUNITY ASSETS

Infrastructure in the area, such as the electrical supply and telephone connections, sewerage and water supply systems, and road network, are prone to damage as a result of flooding. Community assets such as parks and other recreation amenities also suffer damage. Council and relevant authorities provided some data on damages experienced in the floods of April and August 1990, which are reviewed below. The latter flood approximated a 2% AEP event. The data are not sufficiently detailed to allow a quantitative estimate of damages for the design flood events. However, a qualitative matrix of the effects of flooding on these categories is presented in **Table C7.1**.

C7.1 Infrastructure

Table C7.1: Qualitative Effects of Flooding on Infrastructure and Community Assets

Damage Sector	Flood Event (AEP)					EMAC	EBELL
	5%	2%	1%	0.5%	0.2%	0.002%	0.002%
Electricity	0	3	3	3,8	3,8	3,8	3,8
Telephone	0	0	0	0	0	11	11
Roads	1	1	1	1	1	1	1
Bridges	0	4	4,7	4,7,9	4,7,9	4,7,9,12	4,7,9
Sewerage Reticulation/Treatment	0	5	5	5	5	5,13	5,13
Water Supply	0	0	0	0	10	10	10
Parks & Showground	2	2,6	2,6	2,6	2,6	2,6	2,6
SES HQ	0	0	0	0	0	14	0
Hospital (Gisborne St)	0	0	0	0	0	15	0

Notes:

0 = No significant damages likely to be incurred
1 = Roads on Bell River floodplain flooded
2 = Pioneer Park flooded
3 = Power poles at Herbert St bridge and pole mounted transformer on Macquarie/Bell floodplain flooded
4 = Herbert St and pedestrian suspension bridge in vicinity of Cameron Park flooded
5 = Pump station in vicinity of Arthur and Gobolion Streets flooded
6 = Cameron Park and Showground/Racecourse flooded
7 = Maughan Street flooded
8 = Pad mounted transformer on Maughan Street adjacent to Bowling Club flooded
9 = Mitchell Highway flooded
10 = Treatment works flooded
11 = Telephone exchange flooded
12 = Railway bridge flooded
13 = Sewage Treatment Plant flooded
14 = SES HQ flooded
15 = Hospital in Gisborne St flooded
EMAC = PMF in the Macquarie River
EBELL = PMF in the Bell River

Electricity

All electrical facilities are pole mounted and hence are not at high risk. However, Western Power has some concerns about live power on the Bell River floodplain. In a flood situation, power is cut to this area when the river rises to such a level which is deemed dangerous by the local superintendent. In the August 1990 flood, two transformers were de-energised (shut down). The first was a pole mounted transformer located on the left floodplain of the Macquarie River downstream of its confluence with the Bell River. This transformer was inundated by flood flows and required replacing. The second was a pad mounted (on-grade) transformer located near the Maughan Street bridge on the right bank of the Bell River. This transformer, although not flooded, was de-energised due to its high voltage feeder being inundated. This transformer is located on the flood fringe of the 1% AEP event and could be expected to be inundated for larger flood events.

Additional to the damaged transformer, 5 light poles were lost at the low level crossing at Herbert Street due to instability of the road embankment. Western Power has a policy of setting new poles in concrete footings if knocked down by flooding, therefore there is less chance of the same poles being removed by an equivalent flood in the future.

At present, Western Power in conjunction with Wellington Council is laying power lines underground in the vicinity of the main road through the town as part of the Council's beautification program. This area is flood free for events up to the 0.2% AEP event, thus the probability of damage to the underground cables is small.

Telstra

Telstra received damage to infrastructure in the August 1990 flood outside Wellington's town limits, with around 6 poles being knocked over and needing replacement. Cables at several creek crossings were also uncovered and damaged during the flood.

Telstra's inland Single Mode Optic Fibre line is located between Dubbo and Wellington. This line is located underground and will cross the Bell River at the Maughan Street bridge. The line is laid at such a depth that erosion of the river bed and banks is unlikely to uncover the poly pipe in which it is placed.

The telephone exchange is located on Maughan Street outside the extent of the 0.2% AEP flood but within the area affected by an extreme flood.

Roads, Bridges and Railway

In 1990, damage to roads occurred in both the April and August floods. Some of the roads which were damaged in the April flood were Oxley Avenue, Old Sydney Road, Caves Road and Spillsbury Lane. The total cost for the restoration of roads in Wellington Shire as a result of this flood was approximately $400,000. In the August flood, damage to the road infrastructure was more severe. Most of the remedial works undertaken after the April flood were destroyed. The total cost for the restoration of Shire roads was approximately $7,000,000 (not all within the area covered in this assessment).

Floodwaters reach the underside of the Mitchell Highway bridge in the event of a 0.5% AEP flood. The deck is overtopped for events in excess of 0.2% AEP. Local scouring of the bridge abutments may occur for events greater than the 1% AEP flood event.

The railway crossing over the Macquarie River and its approaches is flood free for all flood events, excluding an extreme flood in the Macquarie River.

As a result of the August 1990 flood, damages were incurred to the small suspension bridge located on the Bell River in the vicinity of Cameron Park. Both the bridge decking and stays were damaged. Some minor scouring occurred to the river bank in the vicinity of the bridge. The cost of repairs to the bridge was around $46,000.

Sewerage Reticulation/Treatment

Wellington Council maintains the sewerage system in the area. One pumping station along the Macquarie River in the vicinity of Gobolion and Arthur Streets was inundated in the August 1990 event. Another pumping station is located on the bank of the Bell River in the vicinity of Ford Street and there is concern that an embankment on which the station is situated could be eroded by a large flood event. The Sewage Treatment Plant is located south of the Macquarie River, downstream of the confluence with the Bell River. It is located within the extent of the 1% AEP event.

Water Supply

The Wellington water treatment plant, located on the left bank of the Macquarie River several kilometres upstream of the Bell River confluence, is flood free up to and including the 1% AEP. In a larger event the plant's settling tanks would be inundated and thus incur damage. The water supply in Wellington would be unfit for direct consumption and alternative sources of drinking water would need to be provided.

Gas

There is no reticulated gas supply in Wellington.

C7.2 Community Assets

This category comprises damages to recreational amenities, such as the racecourse and showground, and to certain parks, all of which are located on the Bell River floodplain.

Racecourse and Showground

These recreational amenities are located on the left bank of the Bell River along Showground Road. The August 1990 flood (about 2% AEP) caused substantial damage to both the track and amenity buildings. Works undertaken after the flood include:

- resheet trotting track with crushed granite,
- replace sand on training track,
- turf track,
- clean up carpark of silt and regrade,
- excavate polluted sand from sand roll,
- replace 300 m of security fencing,
- clean out buildings, plumbing and replace electrical fittings.

Total cost of works was around $51,000.

Damages can be expected to increase for larger events as depths of inundation and flow magnitude and velocities increase.

Pioneer Park

The park is located on the left bank of the Bell River, immediately downstream of Maughan Street. The park consists of a sports field and a landscaped area. Its locality in a low lying area makes it susceptible to damage by relatively small events which surcharge the river. As a result of the April 1990 flood, damage to the park required the following works:

- renewal of 600 m of fencing,
- replacement of around 300 shrubs,
- resheeting of granite roadway,
- supply loam and level field,
- removal of stones and debris.

The cost of the above works was estimated at $34,000 not including damages to the electrical supply and 200 hours of voluntary labour by school children.

The larger August 1990 flood (about 2% AEP) incurred damages to the park generally as above, but on a larger scale. Some additional works undertaken due to damages to the park as a result of the larger flow and increased depth of inundation were the need to:

- clean up kiosk and shed,
- repair seats and signs,
- supply and sow kikuyu grass over 8000 m^2 of parkland.

The total cost of the above works was estimated at $39,000.

In the event that a flood occurs which is larger than that which occurred in August 1990, damages could be expected to increase.

Cameron Park

This park is located downstream of Maughan Street on the right bank of the Bell River. The park extends from the Bowling club to the Swimming Centre, and covers an area of around 26,000 m^2. The Bell River in the vicinity of the park generally contains flood flows up to the 2% AEP event. Damages to the park incurred by the August 1990 flood were therefore confined mainly to the river banks. The total expenditure for repairs to the park was around $4,000.

For floods larger than 2% AEP a steadily increasing area of park is inundated. In the event of a 1% AEP flood an area of the park outside the Council chambers of around 7,500 m^2 would be inundated. For the 0.5% AEP flood the whole park would be inundated. Damages to the park between the 2% and 0.5% AEP events could be expected to increase significantly. For events greater than 0.5 % AEP damages would increase at a reduced rate.

Bell Park

The park is located downstream of the Swimming Centre on the right bank of the Bell River. The park is low lying and is inundated by relatively minor floods. The park is susceptible to erosion from these lesser events. No data was available on value of damages incurred by the 1990 floods.

C8. SUMMARY OF TANGIBLE DAMAGES

The number of flooded and flood affected properties and total estimated damages for each flood event are shown in **Table C8.1**. **Figure C8.1** shows the resulting damages versus frequency curve.

Table C8.1: Total Estimated Damages – Wellington (2012 Values)

Flood Event	Number of Properties Flooded							Total Damages	Cum AAD
	Residential		Commercial / Industrial		Caravans	Public Buildings			
AEP %	A[1]	B	A[2]	B		A[2]	B	$ x 1000	
5	30	6	1	1	0	1	1	1,450	109
2	36	25	4	4	0	1	1	2,523	168
1	87	47	6	6	5	2	1	4,599	204
0.5	164	102	20	14	10	2	2	9,578	239
0.2	393	327	36	31	15	4	4	25,495	292
EMAC	1134	1131	73	73	38	18	18	159,116	475
EBELL	636	629	69	69	32	11	10	85,373	

Notes: A - flood affected property (flooded to within 0.5 m freeboard allowance)
B - flood damaged property
Cum ADD - Cumulative Average Annual Damages

Comparison with the 1996 values shows an increase in the flood damages estimation. This is due mainly to the revised calculation method and the assumptions made for that assessment.

Cumulative average annual damages are included in **Table C8.1** and are shown on **Figure C8.2**. Average annual damages (also known as expected damages) are determined by integrating the damage-frequency curve (**Figure C8.1**). They represent the time stream of average damages which would be experienced year by year. Using an appropriate discount rate, average annual damages may be expressed as an equivalent present worth value of damages and used in the economic analysis of potential flood management measures.

For example, the cumulative average annual value of damages for all floods up to the 1% AEP level is around $204,000 per year. A flood management scheme which has a 1% AEP design flood would eliminate damages up to this level of flooding. If the scheme has no mitigating effect on larger floods, then these damages represent the benefits of the scheme.

Under the *NSW Government Guidelines for Economic Appraisal* (2007), economic analyses are carried out assuming a 30 year economic life for the project and discount rates of 7% pa (best estimate) and 11% and 4% pa (sensitivity analysis).

For a discount rate of 7% pa, the present worth value of damages up to the 1% AEP level is approximately $2.5M. Therefore, a scheme costing up to $2.5M which eliminates damages up to the 1% AEP level could economically be justified. More expensive schemes would have a benefit/cost ratio less than 1, but may still be justified based on a multi-objective assessment which considers other criteria in addition to economic feasibility (see **Section 4** of the FRMS 2013).

Unless the scheme is designed to give protection against all flood events up to the probable maximum flood (PMF), there will be a residual value of damages which will still be experienced under post-scheme conditions. In this study the extreme flood considered has an AEP of 0.002%. The cumulative average annual value of damages for floods up to the 0.002% AEP would be of the order of $475,000. The present worth value for floods up to the 0.002% AEP is about $5.9M for the 7% pa discount rate. This value therefore represents the upper limit cost of a flood management scheme which could be economically justified in Wellington. Therefore the residual damages for a scheme with a 1% AEP design flood is $475,000 - $204,000 = $271,000 per annum. These annual damages have a present worth value of approximately $3.4M at a 7% discount rate.

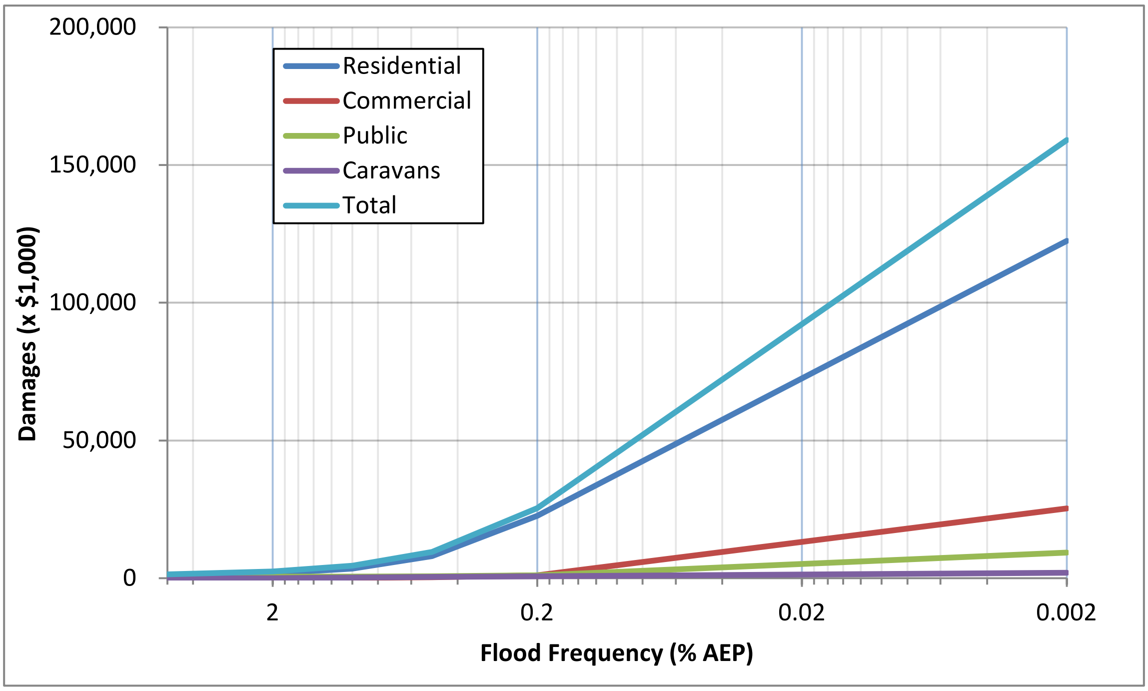

Figure C8.1: Total Damage-Frequency Curves

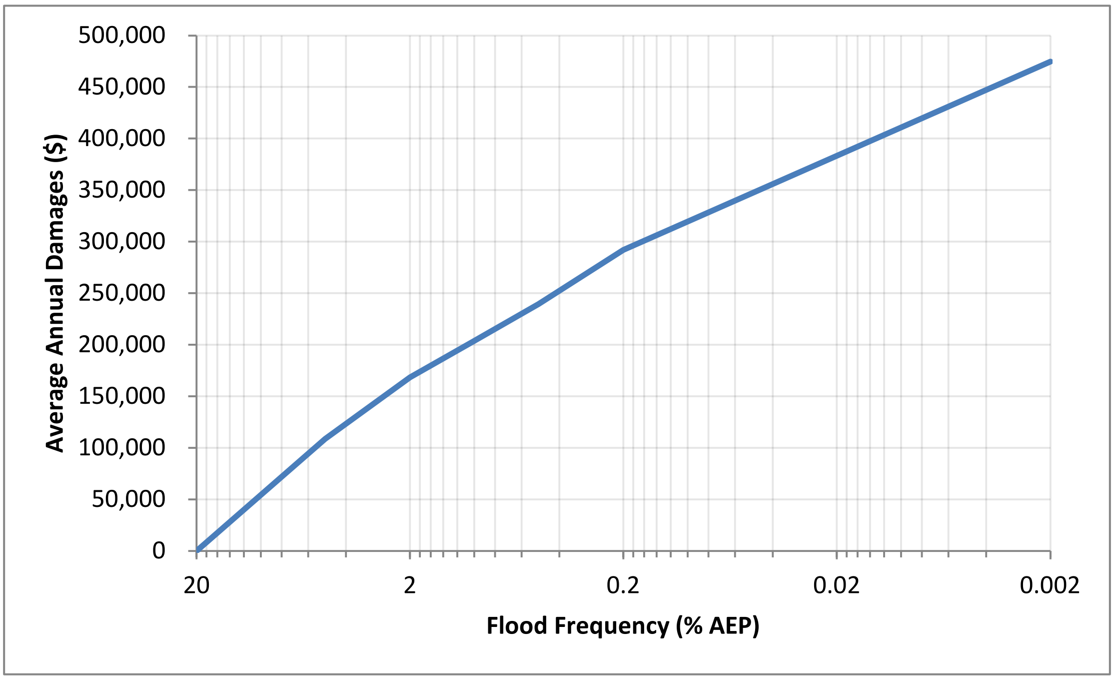

Figure C8.2: Cumulative Average Annual Damages

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Annexure 1 Surveyed Floor Levels

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IN REPLY PLEASE QUOTE: 95/050

24th August, 1995

Lyall & Macoun Consulting Engineers
Level 2, 4 Help Street,
Chatswood.
NSW 2067

ATTENTION: DR. STEPHEN J. PERRENS

Dear Sir,

RE: WELLINGTON FLOODPLAIN MANAGEMENT STUDY

Please find enclosed the representative floor levels for the properties as requested by you. The levels were taken on the front step of the building and should not be used as an absolute value for the level of the existing floor as the floor may be higher or lower than this value in some cases. I have enclosed a computer disk with a copy of my files on it. You may be able to convert it to a format that will save you typing the level information into your existing files. My files are from a Microsoft Works word data base file. I have changed the numbers of some of the street addresses to agree with the number on the door. I have also included a level for the Club House Hotel on the North Western corner of Lee and Warne Streets.

Please find enclosed the account for the survey.

If you have any queries please contact me.

Yours faithfully,

Neil Doherty,
Surveyor Registered Under
The Surveyors' Act, 1929.

WELLINGTON FLOODPLAIN MANAGEMENT STUDY
RESIDENTIAL PROPERTY DATA

ID No.	Map No.	Address	Damage Category	Floor Level
1	8	7 Sutton Street	1310	293.31
2	8	9 Sutton St	1300	293.5
3	8	13 Sutton St	1310	294.05
4	8	6 Sutton St	1310	293.79
5	8	15 Sutton St	1310	294.1
6	8	4 Sutton Street	1310	294
7	8	17 Sutton Street	1300	294.02
8	8	2 Sutton Street	1310	294.03
9	8	19 Sutton Street	1300	294.24
10	8	21 Sutton Street	1300	294.34
11	8	2 Lay Street	1310	293.97
12	8	1 Lay Street	1300	293.43
13	8	99 Montefiores Street	1300	294.15
14	8	97 Montefiores Street	1300	294.16
15	8	95 Montefiores Street	1300	294.29
16	8	92 Montefiores Street	1310	293.06
17	8	91 Montefiores Street	1310	294.05
18	8	88 Montefiores Street	1310	293.18
19	8	89 Montefiores Street	1310	293.34
20	8	86 Montefiores Street	1310	293.45
21	8	82 Montefiores Street	1310	293.94
22	8	80 Montefiores Street	1300	294.02
23	8	78 Montefiores Street	1310	294.3
24	8	79 Montefiores Street	1320	292.48
25	8	75 Montefiores Street	1320	294.22
26	8	76 Montefiores Street	1300	294.32
27	8	74 Montefiores Street	1310	294.47
28	8	72 Montefiores Street	1310	294.46
29	8	73 Montefiores Street	1310	293.32
30	8	70 Montefiores Street	1310	294.72
31	8	69 Montefiores Street	1310	292.49
32	8	68 Montefiores Street	1310	294.76
33	8	66 Montefiores Street	1310	294.81
34	8	65-67 Montefiores Street	1310	292.98
35	8	64 Montefiores Street	1310	294.73
36	8	62 Montefiores Street	1310	294.67
37	8	56 Montefiores Street	1300	294.89
38	8	57-61 Montefiores Street	1310	290.56
39	8	54 Montefiores Street	1310	294.71
40	8	52 Montefiores Street	1310	294.85
41	8	48 Montefiores Street	1300	294.38
42	8	43 Montefiores Street	1300	294.45
43	8	41 Montefiores Street	1310	294.53
44	8	46 Montefiores Street	1300	294.61
45	8	39 Montefiores Street	1310	295.4
46	8	42 Montefiores Street	1300	295.15
47	8	37 Montefiores Street	1310	295.28
48	8	40 Montefiores Street	1300	294.98

NOTE: ALL LEVELS WERE TAKEN ON FRONT STEP OF BUILDING.

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WELLINGTON FLOODPLAIN MANAGEMENT STUDY
RESIDENTIAL PROPERTY DATA

ID No.	Map No.	Address	Damage Category	Floor Level
49	8	35 Montefiores Street	1310	295.19
50	8	38 Montefiores Street	1300	295.56
51	8	33 Montefiores Street	1300	295.22
52	8	36 Montefiores Street	1300	295.51
53	8	31 Montefiores Street	1310	295.17
54	8	34 Montefiores Street	1310	295.21
55	8	32 Montefiores Street	1310	295.61
56	8	27 Montefiores Street	1300	295.31
57	8	28 Montefiores Street	1310	295.54
58	8	25 Montefiores Street	1310	295.24
59	8	22 Montefiores Street	1310	295.08
60	8	21 Montefiores Street	1300	295.07
61	8	20 Montefiores Street	1310	295.07
62	8	19 Montefiores Street	1310	295.12
63	8	18 Montefiores Street	1310	295.29
64	8	17 Montefiores Street	1310	295.2
65	8	16 Montefiores Street	1310	295.37
66	8	15 Montefiores Street	1310	295.64
67	8	14 Montefiores Street	1310	295.21
68	8	13 Montefiores Street	1300	295
69	8	12 Montefiores Street	1310	295.18
70	8	9 Montefiores Street	1310	295.18
71	8	10 Montefiores Street	1300	295.13
72	8	7 Montefiores Street	1300	295.32
73	8	8 Montefiores Street	1310	295.6
74	8	5 Montefiores Street	1310	295.54
75	8	6 Montefiores Street	1300	295.68
76	8	3 Montefiores Street	1300	295.25
77	8	4 Montefiores Street	1310	295.89
78	3	1 Montefiores Street	1300	295.51
79	3	2 Montefiores Street	1310	296.11
80	3	1 Mitchell Hwy	1300	295.68
81	3	1A Mitchell Hwy	1300	295.1
82	3	44 Gobolion Street	1300	294.97
83	3	46 Gobolion Street	1300	294.74
84	3	48 Gobolion Street	1310	295.26
85	3	48A Gobolion Street	1300	295.32
86	3	50 Gobolion Street	1300	295.11
87	3	52 Gobolion Street	1310	295.29
88	3	58 Gobolion Street	1310	295.11
89	3	60 Gobolion Street	1300	295.3
90	3	62 Gobolion Street	1300	295.34
91	3	38 Gobolion Street	1310	294.99
92	3	36 Gobolion Street	1300	294.64
93	3	34 Gobolion Street	1310	295.11
94	3	32 Gobolion Street	1300	294.92
95	3	30 Gobolion Street	1300	294.97
96	3	28 Gobolion Street	1310	294.68
97	3	26 Gobolion Street	1310	294.7

NOTE: ALL LEVELS WERE TAKEN ON FRONT STEP OF BUILDING.

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WELLINGTON FLOODPLAIN MANAGEMENT STUDY
RESIDENTIAL PROPERTY DATA

ID No.	Map No.	Address	Damage Category	Floor Level
98	3	12 Gobolion Street	1310	293.07
99	3	2 Gobolion Street	1300	293.2
100	3	9 Raymond Street	1320	295.94
101	3	3 Butterfactory Lane	1310	294
102	3	1 Butterfactory Lane	1310	294.09
103	3	15 Raymond Street	1300	295.28
104	3	17 Raymond Street	1300	295.41
105	3	19 Raymond Street	1300	295.38
106	3	20 Whiteley Street	1310	295.49
107	3	18 Whiteley Street	1310	295.07
108	3	16 Whiteley Street	1300	295.33
109	3	14 Whiteley Street	1310	295.15
110	3	12 Whiteley Street	1310	295.03
111	3	10 Whiteley Street	1300	295.03
112	3	6 Whiteley Street	1300	294.29
113	3	4 Whiteley Street	1310	293.84
114	8	1 Ford Street	1310	294.47
115	3	3 Ford Street	1300	294.56
116	9	5 Ford Street	1310	294.46
117	9	7 Ford Street	1310	294.48
118	9	9 Ford Street	1300	294.42
119	9	11 Ford Street	1310	294.37
120	9	13 Ford Street	1310	294.36
121	9	15 Ford Street	1300	294.3
122	9	17 Ford Street	1310	294.15
123	9	19 Ford Street	1310	293.75
124	9	19A Ford Street	1300	293.71
125	9	14 Ford Street	1310	293.73
126	9	12 Ford Street	1310	293.69
127	9	1 Gisborne Street	1310	294.24
128	9	16 Ford Street	1300	293.43
129	9	3 Warne Street	1310	293.41
130	9	4 Warne Street	1310	293.54
131	9	6 Warne Street	1310	293.94
132	9	8 Warne Street	1310	294.18
133	9	5-7 Warne Street	1310	293.2
134	9	9 Warne Street	1310	293.38
135	9	10 Warne Street	1310	294.36
136	9	12 Warne Street	1310	293.8
137	9	13 Warne Street	1310	294.1
138	9	16 Warne Street	1310	294.43
139	9	18 Warne Street	1310	294.27
140	9	20 Warne Street	1300	294.27
141	9	22 Warne Street	1310	293.93
142	9	24 Warne Street	1310	293.81
143	9	26 Warne Street	1300	293.77
144	4	1 Ferguson Lane	1300	292.97
145	4	3 Ferguson Lane	1300	293.12
146	4	5 Ferguson Lane	130	293.08

NOTE: ALL LEVELS WERE TAKEN ON FRONT STEP OF BUILDING.

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WELLINGTON FLOODPLAIN MANAGEMENT STUDY
RESIDENTIAL PROPERTY DATA

ID No.	Map No.	Address	Damage Category	Floor Level
147	4	9 Ferguson Lane	1300	293.11
148	4	11 Ferguson Lane	1300	293.39
149	4	4 Maxwell Street	1300	293.5
150	4	2 Maxwell Street	1300	293.13
151	4	2A Maxwell Street	1300	292.92
152	4	5 Maxwell Street	1300	290.77
153	4	9 Maxwell Street	1300	294.11
154	4	11 Maxwell Street	1300	294.88
155	4	13 Maxwell Street	1300	295.63
156	4	15-17 Maxwell Street	1300	296.21
157	4	113 Percy Street	1300	293.74
158	4	115 Percy Street	1310	294.14
159	4	123 Percy Street	1300	294.56
160	4	125 Percy Street	1300	294.14
161	4	127 Percy Street	1300	294.52
162	4	129 Percy Street	1300	294.79
163	4	131 Percy Street	1300	294.79
164	4	133 Percy Street	1300	294.88
165	4	137 Percy Street	1300	294.81
166	4	139 Percy Street	1300	295.35
167	4	Maughan Street	130	292.57
168	9	Montena Maughan Stre	1310	293.04
169	9	Ambleside Maughan St	1310	291.89
170	9	Y Maughan Street	1300	291.77
171	9	Maughan Street	1300	291.25
172	3	64 Gobolion Street	1300	295.37
173	3	66 Gobolion Street	1310	295.34
174	3	68 Gobolion Street	1300	295.04
175	3	70 Gobolion Street	1300	294.89
176	3	72 Gobolion Street	1300	294.9
177	3	74 Gobolion Street	1310	294.79
178	3	76 Gobolion Street	1310	294.66
179	3	78 Gobolion Street	1310	294.63
180	3	80 Gobolion Street	1310	294.5
181	3	82 Gobolion Street	1300	294.1
182	3	84 Gobolion Street	1310	294.09
183	3	86-88 Gobolion Street	1310	294.09
184	3	90 Gobolion Street	1310	293.63
185	3	92 Gobolion Street	1310	294.21
186	3	94 Gobolion Street	1300	293.49
187	3	100 Gobolion Street	1300	293.91
188	3	102 Gobolion Street	1300	294.01
189	3	104 Gobolion Street	1300	293.8
190	3	106 Gobolion Street	1300	294.02
191	3	110 Gobolion Street	1310	293.75
192	3	110A Gobolion Street	1300	294.05
193	3	112 Gobolion Street	1300	294.13
194	3	114 Gobolion Street	1300	294.09
195	3	116 Gobolion Street	1310	293.77

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NOTE: ALL LEVELS WERE TAKEN ON FRONT STEP OF BUILDING.

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WELLINGTON FLOODPLAIN MANAGEMENT STUDY
RESIDENTIAL PROPERTY DATA

ID No.	Map No.	Address	Damage Category	Floor Level
196	3	118 Gobolion Street	1300	294.27
197	3	120 Gobolion Street	1310	294.11
198	3	120 Gobolion Street	1310	293.18
199	3	124 Gobolion Street	1300	293.76
200	3	128 Gobolion Street	1300	293.39
201	3	130 Gobolion Street	1300	293.75
202	3	132 Gobolion Street	1310	293.43
203	3	134 Gobolion Street	1310	293.61
204	3	121 Gobolion Street	1300	295.08
205	4	144 Whitely Street	1310	297.84
206	4	146 Whitely Street	1310	296.57
207	4	148 Whitely Street	1300	296.25
208	4	150 Whitely Street	1310	296.06
209	4	152 Whitely Street	1300	295.74
210	4	2 Marsh Street	1300	295.74
211	4	6 Marsh Street	1310	296.89
212	4	8 Marsh Street	1310	298.5
213	4	1 Paringa Place	1310	296.29
214	4	3 Paringa Place	1310	294.38
215	4	5 Paringa Place-top flo	1320	296.29
216	4	5A Paringa Place_bottc	1310	293.35
217	4	7 Paringa Place	1320	299.15
218	2	132 Gisborne Street	1310	297.6
219	2	A ~~Gisborne Street~~ Falls Rd	1310	295.91
220	2	B ~~Gisborne Street~~ Falls Rd.	1310	295.78
221	8	45 Gipps Street	1310	293.77
222	8	47 Gipps Street	1300	293.59
223	8	52 Gipps Street	1310	293.54
224	8	56 Gipps Street	1300	293.43
225	8	58 Gipps Street	1310	293.63
226	8	60 Gipps Street	1300	293.29
227	7	61 Gipps Street	1310	293.52
228	7	62 Gipps Street	1310	293.2
229	7	63 Gipps Street	1310	293.01
230	7	65 Gipps Street	1300	292.99
231	7	64 Gipps Street	1310	293.03
232	7	66 Gipps Street	1320	292.89
233	5	169 Percy Street	1300	293.51
234	5	167 Percy Street	1300	294.16
235	5	165 Percy Street	1300	294.32
236	5	163 Percy Street	1300	294.55
237	5	161 Percy Street	1300	294.95
238	5	159 Percy Street	1300	295.37
239	5	157 Percy Street	1300	295.63
240	5	155 Percy Street	1310	295.53
241	5	153 Percy Street	1310	296.03
242	5	151 Percy Street	1300	296.09
243	5	149 Percy Street	1300	296.15
244	5	147 Percy Street	1300	296.22

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NOTE: ALL LEVELS WERE TAKEN ON FRONT STEP OF BUILDING.

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WELLINGTON FLOODPLAIN MANAGEMENT STUDY
RESIDENTIAL PROPERTY DATA

ID No.	Map No.	Address	Damage Category	Floor Level
245	5	145 Percy Street	1310	296.29
246	5	A Percy Street	1300	291.77
247	5	25 Zouch Street	1300	294.6
248	5	27 Zouch Street	1300	294.9
249	5	29 Zouch Street	1300	294.98
250	5	33 Zouch Street	1300	295.58
251	5	35 Zouch Street	1300	295.25
252	5	37 Zouch Street	1300	295.62
253	5	39 Zouch Street	1300	295.71
254	5	41 Zouch Street	1300	296.19
255	5	135 Arthur Street	1310	294.6
256	5	133 Arthur Street	1300	295.53
257	5	6 Apsley Street	1300	293.4
258	5	8 Apsley Street	1310	293.9
259	5	3 Apsley Street	1300	291.95
260	5	5 Apsley Street	1310	292.5
261	5	10 Apsley Street	1310	293.43
262	5	7 Apsley Street	1310	293.54
263	5	139 Arthur Street	1300	293.85
264	5	141 Arthur Street	1300	293.82
265	5	156 Arthur Street	1310	294.1
266	5	154 Arthur Street	1310	294.16
267	5	160 Arthur Street	1310	293.8
268	5	162 Arthur Street	1310	293.79
269	5	164 Arthur Street	1300	294.58
270	5	174 Arthur Street	1300	293.19
271	5	B Arthur Street	1300	293.51
272	5	C Arthur Street	1310	294.74
273	5	D Arthur Street	1310	294.49
271	5	E Arthur Street	1310	294.62
275	5	F Arthur Street	1310	294.17

NOTE: ALL LEVELS WERE TAKEN ON FRONT STEP OF BUILDING.

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WELLINGTON FLOODPLAIN MANAGEMENT STUDY
COMMERCIAL/INDUSTRIAL PROPERTY DATA

ID No.	Map No.	Address	Description	Floor Level
1	8	93 Montefiores Street	Lion of Waterloo - Pub	293.82
2	4	Warne Street	Payless Supermarket	293.71
3	4	Nanima Crescent	Natural Gas Showroom	293.66
4	4	Nanima Crescent	Commonwealth Bank	293.59
5	4	Nanima Crescent	Wellington Travel	293.06
6	4	Nanima Crescent	Laruma Gift Centre	293.35
7	4	Nanima Crescent	Wellington Fruit Supply	293.17
8	4	Nanima Crescent	Crescent Shoes	293.25
9	4	Nanima Crescent	Kel's School Uniforms	293.31
10	4	Nanima Crescent	Gillin's Butchery	293.16
11	4	Nanima Crescent	vacant shop	293.23
12	4	Nanima Crescent	Kellee's Place Cafe	293.32
13	4	Nanima Crescent	St George Building Soc	293.34
14	4	Nanima Crescent	Town & Country Real Est	293.34
15	4	Nanima Crescent	Chemart Chemist	293.07
16	4	Nanima Crescent	Supermarket	293.22
17	4	Nanima Crescent	Coffee Lounge	293.44
18	4	Nanima Crescent	Central Hotel	294.23
19	4	Nanima Crescent	Takeaway Shop	294.18
20	4	Nanima Crescent	vacant shop	294.37
21	4	Nanima Crescent	Parkside Jewellers	294.71
22	4	Nanima Crescent	Solicitors	295.05
23	4	Nanima Crescent	ANZ Bank	295.25
24	4	Nanima Crescent	Takeaway	295.14
25	4	Nanima Crescent	Peter Milling	295.81
26	4	Nanima Crescent	Amcal Chemist	295.31
27	4	Nanima Crescent	Clancy's Supermarket	295.16
28	4	Nanima Crescent	Coffee Shop vacant	295.05
29	4	1 Swift Street	Westpac Bank	296.09
30	4	Percy Street	Real Estate Agent	295.21
31	4	Percy Street	Westfund Health Fund	295.15
32	4	Percy Street	Golden Key Cafe	295.11
33	4	Percy Street	Newsagent	295.12
34	4	Percy Street	Fossey's	295.08
35	4	Percy Street	Real Estate	294.98
35	4	Percy Street	Hardware	294.91
37	4	Percy Street	vacant	294.94
38	4	Percy Street	vacant	294.92
39	4	Percy Street	Pub	294.94
40	4	Percy Street	Hairdresser	295.05
41	4	Percy Street	Haberdashery	294.68
42	4	Percy Street	Fashion Centre	294.82
43	4	Percy Street	Hardware & Giftware	294.48
44	4	Percy Street	State Bank	294.74
45	4	Percy Street	Toys & Bikes	294.24
46	4	Percy Street	Takeaway	294.23
47	4	Percy Street	2nd Hand Furniture	294.41

NOTE: ALL LEVELS WERE TAKEN ON FRONT STEP OF BUILDING

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WELLINGTON FLOODPLAIN MANAGEMENT STUDY
COMMERCIAL/INDUSTRIAL PROPERTY DATA

ID No.	Map No.	Address	Description	Floor Level
48	4	Percy St cnr Maughan	Apsley Bowling Club	293.53
49	4	101 Percy Street	Beaurepaires Tyres	293.89
50	4	Percy Street	Soil Con Office	295.42
51	4	Warne Street	Kimbell's Bakery	293.64
52	3	Mitchell Hwy	Riverside C'van Park	296.59
53	3	44 Gobolion Street	Corner Store	295.02
54	3	Gobolion st cnr Hwy	Bridge Motel	294.97
55	9	Maughan Street	Showground-club house	291.77
56	9	Maughan Street	Greenhouses x 3	291.09
57	5	139 Arthur Street	Corner Shop	293.68
58	5	141 Arthur Street	Caltex	293.34
59	5	158 Arthur Street	Wood Turning Shop	293.65
60	5	166 Arthur Street	Wellington Nursery	293.72
61	5	Arthur Street	Shell Garage	293.36
62	5	Arthur Street	Caravan Park	294.32
63	5	Lee Street	Club House Hotel	293.46

NOTE: ALL LEVELS WERE TAKEN ON FRONT STEP OF BUILDING

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WELLINGTON FLOODPLAIN MANAGEMENT STUDY
PUBLIC PROPERTY DATA

ID No.	Map No.	Address	Description	FLOOR LEVEL
1	4	Warne Street	Swimming Pool	293.88
2	4	Nanima Cres	Council Chambers	293.64
3	4	Nanima Cres	Library/Tourist Info	293.06
4	4	Percy St	Police Station	295.52

NOTE: ALL LEVELS WERE TAKEN ON FRONT STEP OF BUILDING

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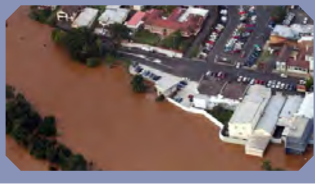
Annexure 2 DECC Floodplain Risk Management Guideline



Residential Flood Damages

Summary

This guideline has been developed to provide both a more appropriate level of flood damage (adjustable with time) and more consistent residential flood damage calculations, whilst allowing for variability between floodplains. The guideline does not address either house failure or non-residential damages.

Introduction

Whilst no definitive data exists on flood damages, consistent assessment across NSW is necessary for fair comparison of projects.

This guideline outlines an approach to the development of a representative damage curve for a typical house in the floodplain using a residential flood damage spreadsheet developed by DECC that is based upon work undertaken for it by Risk Frontiers in the Natural Hazards Research Centre at Macquarie University. This approach uses a typical damage curve rather than approaches (such as FLDAMAGE) which allow damages to be estimated for individual dwellings on the basis of their size (small, medium and large) and age (new, old).

This guideline outlines the process and use of the typical damages curve to enable assessment of mitigation options in the following sections and provides an outline and examples of how to do annual average damage (AAD) and net present value (NPV) calculations:

Section 1. Discusses derivation of a damage curve for a typical house in the floodplain using DECC's spreadsheet.

Section 2. Compares DECC and Risk Frontiers work with other historic work.

Section 3. Discusses specific issues with other approaches or curves that have been used.

Section 4. Discusses AAD and NPV calculations.

Impacts on Assessments Using Other Methods and for Other Types of Development

Section 3 provides an adjustment for FLDAMAGE calculations on top of the inclusion of GST (where applicable) and average weekly earning (AWE) adjustments to bring damages more in line with those calculated using the approach outlined in this guideline.

No specific advice is provided in relation to commercial or industrial properties or multi-unit residential developments. However, no matter the model used the base data should be adjusted to current day by using AWE and including GST, where applicable.

Recommendations

It is recommended that flood damage calculations for studies undertaken with either technical or financial assistance from DECC be undertaken in accordance with this guideline. Reports should include a specific` section of flood damages to document the assumptions made and findings of the damages assessment.

References

Department of Infrastructure Planning and Natural Resources. "Floodplain Development Manual: the management of flood liable land", gazetted May 2005.

Blong, R McAneney, J. Risk Frontiers (for DECC). "Residential Flood Damage" November 2002.

FRM Guidelines are prepared to assist Councils in the preparation and implementation of their FRM plans
Queries can be directed to your local DECC floodplain risk management contact or duncan.mcluckie@dnr.nsw.gov.au
Version No: 1.0 Status: Final Issue date 25/10/2007 Authorisation: Director Coast & Floodplain Management

Section 1 Derivation of a Typical Curve for House on a Floodplain

This approach does not purport to provide a definitive assessment of damages but instead provides consistent basis for calculation of flood damage between different projects across NSW whilst allowing consideration for local variation through the scale of a typical house and the value of its contents.

This information can be used to derive total damages across the floodplain for specific events, and for derivation of average annual damages (AAD) and net present values (NPV) of damages to enable comparisons of management options in management studies. A consistent approach to damage calculations helps ensure a level playing field when projects are being prioritised for funding purposes.

This section describes a spreadsheet tool developed by and available from DECC which assists in deriving average residential damage curves for slab on ground, low set and high set houses for a specific floodplain. The background to the development of the spreadsheet is outlined in Section 2.

The spreadsheet also provides an example of the linkage between generation of flood damage curves and tables for houses discussed below and typical residential flood damage, AAD and NPV of damages calculations, as discussed in Section 4.

Developing Location Specific Residential Damage Curves

When using the spreadsheet the following should be noted:

- All input cells are highlighted with red text.
- All other cells are locked and cannot be altered.
- Blue text is typically descriptive/informative or relevant to iterative calculations.
- Black text is to do with outcomes of calculations or descriptions.

The spreadsheet including a number of worksheets as follows:

- ***Typical Curve Input:*** provides the base input for curve development. This involves location specific factors for buildings, contents, additional factors and two storey house adjustments and provides the Risk Frontiers base curves upon which variations are based. The required input is outlined below:

Buildings

- ***Regional Cost Variation Factor.*** This can be derived from Rawlinsons.
- ***Post Late 2001 Adjustments.*** This can be derived from changes in AWE from the "AWE stats" worksheet in the damage calculation spreadsheet. More up to date figures may be able to be sourced from the Australian Bureau of Statistics web site (www.abs.gov.au).
- ***Post Flood Inflation Factor.*** This is a real factor resulting from the cost of house repairs (not contents) being significantly higher than predicted by insurance assessors. Judgement is required here so indicative rather than definitive guidance is provided. The factor should be considered on the basis of what happens in a 1% AEP event.
- ***Typical Duration of Immersion.*** This is for input information only for later reference.
- ***Building Damage Repair Limitation Factor.*** A typical reduction factor for longer duration immersion is 0.85, whilst 0.75 is used for short duration immersion (<12 hours) as some materials recover from short periods of inundation and do not need replacement.
- ***Typical Building Size.*** An indicative figure can be used for adjustment of total building damage and value of contents (this can be directly overridden). To estimate this figure it may be expedient to note the relative sizes of dwellings (small, medium, large) during the "drive-by" survey and use the relative proportions of each to estimate the "typical" or average building size.
- ***Total Building Adjustment Factor***. The above figures combine to give a total building adjustment factor which is used to adjust the base curves on this worksheet to derive the revised curves on the equations worksheet.

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Contents

- *Average Contents Relevant to Location.* This is adjusted on the basis of $60,000 for a 240sqm house reducing to a minimum of $30,000 for a 120sqm house. This figure can be overridden, if better information is available or is considered more valid for the location.
- *Post Late 2001 Adjustments.* This is automatically transferred from the entry under "Buildings" above.
- *Contents Damage Repair Limitation Factor.* A typical reduction factor for longer duration immersion would be 0.90, with 0.75 used for short duration immersion (<12 hours) as some materials can recover from short periods of inundation and may not need replacement.
- *Level of Flood Awareness.* Indicates whether the community's flood awareness is likely to be high or low. Low should be used as a default unless a level of high can be justified.
- *Effective Warning Time.* The minimum warning time available for the community to react.
- *Interpolated DRF adjustment.* A damage reduction factor (DRF) adjustment derived from the effective warning time in conjunction with the level of flood awareness automatically from the table in the spreadsheet.
- *Typical Table/Bench Height.* The height above which the Interpolated DRF is negated as goods are raised onsite rather than removed. a height of 0.9m should be used unless another height can be justified. If houses are typically 2 storey then 2.6m can be used where contents can be removed to the second floor.
- *Total Contents Adjustment Factors.* Two factors are given, one for above and one for below the typical table/bench height which considers all the above factors in deriving the floodplain specific equations on the equations worksheet from the base curve.

Additional Factors

- *Post Late 2001 Adjustments.* This is directly obtained from the entry under "Buildings" above.
- *External Damage.* A figure of $6,700 is acceptable without justification, where above floor flooding occurs. Any extra amount needs significant justification.
- *Clean up Costs.* A figure of $4,000 is acceptable without justification, where above floor flooding occurs. Any extra amount needs significant justification.
- *Likely Time for Alternate Accommodation.* This needs to be estimated based upon the immersion, clean up and recovery times i.e. the estimated time for houses to be rehabitable.
- Extra *Accommodation Costs/Loss of Rent.* This relates to extra not total costs. The default figure of $220 per week is acceptable without justification, where above floor flooding occurs. Any extra amount needs justification.

These factors are used in deriving the floodplain specific damage equations in the equations worksheet.

Two Storey Houses

- *Flood Depth Adjustment Factors.* Different factors are applied depending upon whether or not water overtops the second storey. The factors of 70% below and 115% above the second floor depth are recommended unless otherwise justified.

- *Typical Curve Equations:* provides equations for a typical house on the floodplain based upon the input and base curves from the ***input*** worksheet.
- *Typical Curve Output.* Provides tabulated and graphical representation for single storey slab on ground/low set, high set and two storey houses. These curves are generated based upon worksheet input including steps in curves and starting point for single storey slab on ground and high set input into this worksheet.
- *AWE Stats.* This provides average weekly earnings (AWE) statistics for total full time earnings from 1983 to 2006.
- *Terms.* This provides a summary of some of the key terms used in the spreadsheet.

Section 2 Work by DECC and Risk Frontiers

What Residential Damage Figures Should We Use?

There is no definitive data available on flood damage. Flood damage would ideally be calculated based on a combination of immersion or contact and velocity damage components. However, no NSW studies have been undertaken that separate the damage from these affects. Without this kind of study for a range of types of buildings, of different ages, after a reasonably large flood event, calculation of flood damages will continue to rely on the current flawed data sets.

This section considers the use of current information to establish an effective method of deriving flood damages for houses in the floodplain based upon the available information and makes recommendations on an approach to adopt until better data is available.

Basis of this Discussion

This section considers:

- the Floodplain Development Manual 2005, requiring consideration of the PMF and including major drainage. Flood damage calculations need to consider more than just older style houses on the traditional floodplains as more modern style dwellings are affected.
- Risk Frontiers analysis of available data from Katherine with reference to Brisbane data to examine whether the quantums of damages from these events resulted in significantly different figures from other methods and made recommendations on curves for the future use. This analysis relies on insurance payout information.
- Updated FLDAMAGE analysis and ANUFLOOD damages figures.
- Itemised damage assessment to cross check results.

It also discusses reasons for differences in these figures.

Background on Available Data

Risk Frontiers (2002) Report

This report proposed changes in the quantum and methods of calculating flood damage for residential property. These calculations are based around flood damages from Katherine in 1998, with reference to the 1974 data from Brisbane flooding. This advice is likely to be skewed to the high side due to its reliance on insurance payout figures. Some important points on this data are noted below.

- It is based upon 361 insurance claims from Katherine.
- It is based upon actual claims paid rather than loss estimates.
- Introduces the concept of post event inflation into analyses for building damages. This relates to the difference in actual relative to estimated reconstruction costs which was very evident in Katherine where a large-scale event in a relatively small community inflated repairs around 50% above assessor's estimates. This factor can be significant in large-scale events, particularly outside metropolitan areas.
- Introduces consideration of regional building factors to allow for variation in costs with location. This can be derived from Rawlinsons and applies to building damages.
- Uses AWE to update damage figures rather than CPI as this is a better indicator of growth in societal wealth. Figures are provided in the spreadsheet.
- Brisbane 1974 data was derived from the 1975 SMEC report. There was reportedly little external damage in Brisbane, and not enough information to consider post event inflation in building claims.
- Average Katherine contents damages were 2.5 times those of Brisbane, even allowing for AWE changes since 1974. Three possible reasons were put forward for the difference:
  - Brisbane involved estimates for restoring or replacing with a similar standard article (average remaining value). Actual replacement cost is twice as high as this value.

- Average home sizes in Brisbane in 2000 are 1.8 times larger than in 1974 (Table 1). More floor areas means more contents.
- AWE may not reflect the real change in household goods adequately. This could reflect increased investment of private income into households.

Multiplication of the first 2 factors equates to 3.6, almost 50% higher than the difference after AWE adjustments. Therefore the reason may fall within these factors or extra factors may be present.

FLDAMAGE

FLDAMAGE data is based around actual damage assessments from a number of towns in NSW including Forbes, Eugowra and Nyngan, Inverell with reference to Georges River damage data from western Sydney. Typical information from Forbes Flood Damages Study (1990 flood) by Water Studies is given below.

- 18 houses surveyed, 3 (relatively new houses) of which were not affected above floor level and bedrooms weren't flooded in 3 others.
- The newest house would be 36 years old with 83% of the sample over 50 years old in 2001.
- The average house size was 167sqm. The average size of a house from 1985/86, Table 1, well above the average house size in the 1950's when they were build (<135sqm) and only slightly lower than average size of new houses around 1992, the year of the study. This may reflect larger than average house sizes to begin with or extensions to houses over time.
- The average above floor depth of flooding (AFD) was 0.54m. It was only > 0.9m in 2 cases. Therefore local lifting of goods would have been effective in reducing damages.
- 3 houses were slab on ground, 1 mid set, 2 were two storey, and the remaining 12 were low set.
- Only 4 houses had gyprock lining, 6 had AC sheeting, 4 brick and 1 timber. Only gyprock was damaged by immersion and was replaced, ie 4 houses, significantly less than it would be today.
- Swollen doors were trimmed and rehung, not possible with current hollow core doors.
- Built in cupboards (kitchen and bathroom) were significant sources of damage to the structure, though most houses did not have any built-in cupboards in bedrooms.
- Little serious structural damage was noted.

The study was based upon practices of the early 1990's and resident expectations of the time. The FLDAMAGE manual was written in 1992 and its input data was bought up to date using AWE to reflect changes over time. A GST component was also added.

Table 1 Average Floor Area of New Houses (sqm) by State/Territory from various ABS reports

Year	NSW	VIC	QLD	SA	WA	TAS	NT	ACT	Aus
1971	135	132	115	124	126	130		143	
1972	137	135	117	128	125	132		148	
1973	145	137	121	131	132	137		159	
1975–76	145	146	129	132	142	150		146	141
1976–77	139	149	133	136	144	145	130	159	142
1977–78	143	145	132	145	143	146	147	145	142
1978–79	146	142	135	155	146	134	136	144	144
1979–80	152	151	144	160	160	140	140	153	152
1985–86	169	169	165	166	196	151	147	149	170
1995–96	199	190	201	192	221	177	184	174	200
1999–00	241	212	224	207	219	194	185	214	222

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ANUFLOOD

The Victorian Natural Resources and Environment, Rapid Assessment Method (RAM) for Floodplain Management, May 2000, indicates that ANUFLOOD estimates needed to be increased by 60% to be in the vicinity of Water Studies damages surveys. Even with this adjustment ANUFLOOD estimates are still well below those determined using this guideline.

Discussion of Differences between Guideline and FLDAMAGE Estimates

Damage figures for a slab on ground house and a breakdown into 5 relevant components are provided in Table 2 for comparison between FLDAMAGE and the methodology in this guideline in December 2006 terms. The differences are discussed below considering the data used to derive the estimating formulae. Figure 1, indicates the difference on damage quantum between the guideline and adjusted FLDAMAGE.

Structural Damages

These are damages to the structure as it remains when sold, rather than any insurance definition. There is a significant difference (61% for 1m deep) in the structural damage estimates between FLDAMAGE and the Guideline. Some differences between the methods and their basis are discussed below.

- FLDAMAGE calculations are based upon studies, such as Forbes with older style houses. The main components of structural damage were built-ins cupboards, internal linings, floors, external linings, doors, and foundations. However, most built-in cupboards were in the kitchen and bathroom, whereas modern houses often have built in cupboards in bedrooms and the laundry and the total damage to the structure is well below the replacement cost of a kitchen and bathroom fittings in todays dollars which may reflect size, material and technology changes. Clean up practice at Forbes is unlikely to have included removing wall panels as gyprock lining only (4 of 14 houses) had to be was replaced, along with lifting wall tiles, bowing timber and repainting or repapering of damaged surfaces. Walls in the remaining houses were not removed or replaced.

  Advice out of the United States indicates that mould may have a significant health risk and flooding of homes can provide ideal conditions for its growth. It can be found in wallpaper, behind tiles, carpets, under floor coverings, insulation, wall linings, within wall cavities and in paper products. Given the nature of above floor flooding in flood affected properties, mould may be a significant health risk. This needs to be considered in recommendations for best practice for post flood clean up. Drying out cavities is therefore important and may mean that linings, whether deteriorating or not, are removed, at least partially to allow for more effective drying, inspection and treatment. This change in practice would increase labour and material costs.
- Doors at Forbes were trimmed and rehung. This is not possible with modern hollow core doors.
- The average house size was 167sqm. The average new house size in NSW in 1999/2000 is 240sqm (Table 1). More floor area equates to more wall length, doors, probably a larger kitchen, more bathrooms and bedrooms and therefore more structural damage. Increasing FLDAMAGE damages by 33% (1992 to 2001) reduces the differences from 61% to 48%.
- All 14 houses in Forbes were >36 years old. The building materials and practices used in construction are different from modern houses. Modern materials are generally less water-resistant as new houses generally rely on adequate protection levels, due to appropriate planning decisions, for flood protection. Extensions to houses below the FPL may not be of flood resistant materials.
- FLDAMAGE assumes structure damage is constant above 0.2m depth. This appears inconsistent with additional damages to items such as kitchens, wall linings, etc.

Considering these points, the quantum of repairing and replacing material damage to the building is likely to be higher than the Forbes estimates. As the Katherine data set is larger and more modern and considering the health issues associated with mould, the higher structural damage estimates of the guideline are likely to be more realistic.

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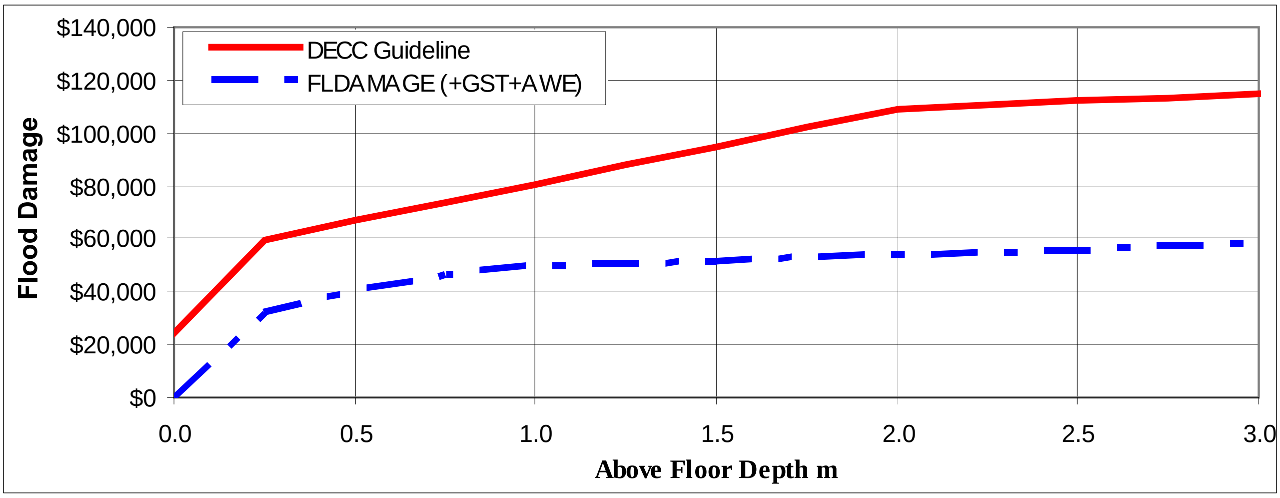
Table 2. Damage Comparison — DECC Guideline and FLDAMAGE Estimates at December 2006

	Above floor depth	0.25m	0.75m	1.25m	1.75m	2.25m	2.75m
FLDAMAGE	Structure	$11,077	$11,077	$11,077	$11,077	$11,077	$11,077
Guideline	Structure	$21,908	$26,334	$30,760	$30,154	$39,611	$44,036
% difference		49%	58%	64%	69%	72%	75%
FLDAMAGE	Contents	$10,436	$21,652	$24,923	$26,584	$28,246	$29,907
Guideline	Contents	$27,778	$39,375	$50,625	$61,875	$67,500	$67,500
% difference		63%	45%	51%	57%	58%	56%
FLDAMAGE	External damage	$6,000	$6,000	$6,000	$6,000	$6,000	$6,000
Guideline	External damage	$8,375	$8,375	$8,375	$8,375	$8,375	$8,375
% difference		28%	28%	28%	28%	28%	28%
FLDAMAGE	Clean up	$4,543	$7,442	$8,288	$8,717	$9,146	$9,576
Guideline	Clean up	$5,000	$5,000	$5,000	$5,000	$5,000	$5,000
% difference		9%	-49%	-66%	-74%	-83%	-92%
FLDAMAGE	Accommodation	$11,133	$11,133	$11,133	$11,133	$11,133	$11,133
Guideline	Addit accom	$825	$825	$825	$825	$825	$825
% difference		-912%	-912%	-912%	-912%	-912%	-912%
FLDAMAGE	Total	$32,113	$46,226	$50,343	$52,434	$54,525	$56,616
Guideline	Total	$64,508	$80,184	$95,860	$111,535	$121,586	$126,011
% difference		50%	42%	47%	53%	55%	55%

Figure 1. DECC Guideline vs FLDAMAGE (December 2006) for Single Storey Slab on Ground



Contents Damages

Contents are those items that are removed from the house if sold. This is where there is the biggest quantum difference (around 48% for 1m deep) in damages between methods.

- FLDAMAGE figures are based around repair and replacement costs. The major damage was to floor coverings with minor damage to furniture and electricals. Given that the flood depths averaged 0.54m, with only 2 above 0.9m, it enabled most (non-fixed) goods to be lifted onto table or benchtops to mitigate damages. This was assisted by the significant warning time available. Average internal damages at Forbes were only $5,500, well below typical levels of contents insurance today.
- Increasing FLDAMAGE figures based upon average house size increases (33% from 1992 to 2001) would reduce this difference to 32%

Considering the Guideline is based upon insurance data and therefore replacement costs and FLDAMAGE is based upon actual and therefore residual values, the adjusted difference of 32% is reasonable.

External Damage

Constant values are similar between the models.

Clean Up

The guideline's constant clean up figure is significantly lower than the values calculated from FLDAMAGE. However, relative to structural and contents damages this figure and the associated difference is not considered significant.

Additional Accommodation Costs

The two approaches are significantly different with the guideline based on extra cost, whereas FLDAMAGE considered all costs and not just accommodation. The guideline figures may under-estimate the extra cost of meals away from home, travel, etc. However, this figure is relatively minor in the context of overall damage.

Examination of Other Data

A range of other curves are available for particular areas including Lismore, Wollongong, Nerang, and the Gold Coast. Curves for these areas have been derived from previous studies.

These curves need to be multiplied by between 0.95 and 1.33 to get a least squares fit to Risk Frontiers data. This suggests that Risk Frontiers data remains close to an upper bound of damage.

In addition, a preliminary elemental analysis for a house examining damages versus depth and the rectification costs for cases was undertaken for comparison with Risk Frontiers. The figures are in the same ballpark as the Risk Frontiers data.

What to Adopt?

The answer probably lies somewhere between the quantum of the two approaches of Risk Frontiers and FLDAMAGE but without better quality data it is difficult to provide a single recommendation. However, given the extent of Katherine and Brisbane datasets relative to other available information and that the Katherine data is significantly more recent, it is recommended that the quantum of the Risk Frontiers curves be used, but with the following adjustments:

- That the contents damages from Risk Frontiers by multiplied by a factor of between 0.75 and 0.90. Structural damage costs may also be reduced by a factor of between 0.85 and 1.0. Damage is larger for longer inundation duration.
- Structural damages and contents figures be altered considering the average house size in the study area, where information is known or can be interpreted.
- Adjust figure for AWE to alter between timeframes.
- Adjust structural damage figures for post event inflation, where the event is significant in relation to the size of the community.

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SECTION 3 Advice on Specific Concerns with Damage Curves

Damage Reduction Factor

The actual to potential damage reduction factor (DRF) has been assumed to operate over the entire range of flood depth in all methods.

This is not considered reasonable in the majority of cases given the limited capacity of people to remove materials from the site to somewhere dry in most cases and that goods can only be generally raised onto benchtops or tables. Most people will only have a car and perhaps a trailer and may not have anywhere to store removed goods.

As such, unless there is a documented reason to continue the DRF past 0.9m above floor depth, AFD of flooding, the typical height of table or benchs, onto which goods would be raised, it should be negated.

Curves with Significant External and Below Floor Damage Components

There are a number of curves being used with significant external and below floor damage components. The danger in the use of such curves is that management measures could be justifiable based on external benefits, which appear to include motor vehicles in some cases, rather than reduction to damages to the house and contents and the associated flood impacts.

External benefits should be limited in accordance with the recommendations, unless it can be justified otherwise.

Consideration of Damage to Vehicles

The calculations in this guideline do not allow any specific inclusion for vehicles. However, if it is felt that an allowance for vehicles is necessary due to the inability to effectively remove vehicles from the flood affected area this can be considered. However, it should only be considered as a sensitivity analysis to base damage calculations which exclude specific vehicle damage costs.

This approach ensures that decision makers understand what they are protecting in making decisions on mitigation measures and can instigate mitigation measures appropriate to the problem, such as appropriate parking restrictions where feasible (for example having no parking zones adjacent to culverts and causeways) to reduce the potential for damage to vehicles or their potential impacts in blocking downstream structures.

Building destruction

Brisbane and Katherine data does not indicate the flow velocities at the site. Therefore building destruction is excluded from the above table.

Its calculation needs to consider average regional building costs from Rawlinsons, average house sizes from the Australian Bureau of Statistics (where information on house sizes is not available for the study) and potential for destruction, depending upon flow velocities and depths and the structure type.

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SECTION 4 TYPICAL RESIDENTIAL DAMAGE CALCULATIONS

This section includes some general guidance on residential damage calculation and the associated parameters used. In addition, the spreadsheet incorporates the following example worksheets relevant to this section:

- Eg House Damage Calcs
- Fixed Eg AAD & NPV Calcs
- Open Eg AAD & NPV Calcs

DECC has provided these examples to demonstrate the linkage between typical damage curve development and damage calculations including AADs and NPV. Use outside this purpose is at the users own risk.

Example House Damage Calculations

This provides an example linking typical damage curve derivation (Section 1) and some example house stock. Some key points for the example and damages in general are outlined below.

The freeboard allocated in the FPL needs to be considered where this may impact upon damages. Freeboard is not to be relied upon to provide protection above the design event to which it is applied as it is there to account for uncertainties in flood behaviour, factors which are not dealt with in modelling, and uncertainties relating to performance of flood mitigation structures, see Appendix K of the Floodplain Development Manual. The freeboard should be entered in location provided.

This may result in the "Protection Level" being less than the ground level in some cases. However, this is an artificial level for calculation of damages not a real level. The decision was made to adjust floor levels by the freeboard rather than add the freeboard to each of the various flood levels to reduce the potential for confusion and errors in quoting flood levels from the spreadsheet and to reduce the number of additional columns in the spreadsheet.

Base information such as Survey No, Street, House No, Lot Section, No Storeys, whether the house is able to be raised, floor level and ground level, and property type are included in the example to indicate the typical minimum information required. For vacant properties the number of storeys and the floor level should both be equal to zero for existing cases. For full development cases vacant properties should be classified as 1 or 2 storey dependant upon current development trends in the area and flood levels set at the FPL relevant to the particular location.

Flood levels for various events, eg PMF, 0.2% AEP, 0.5% AEP, 1% AEP, 2% AEP, 5% AEP and 10% AEP should be added as relevant. Damages are calculated based upon depths of inundation in these events, considering the freeboard, and accessing the typical damage curve derived for the floodplain in question.

AAD & NPV Calculations

AADs are calculated on the basis of area under the damage versus probability curve. A fixed example is provided in the worksheet Fixed Eg AAD & NPV Calculations.

General points for all AAD and NPV calculations include:

- It is important to have points above the FPL, say a 0.2% or 0.5% event as this will be a point where damages may rise suddenly even with effective development controls as well as an extreme flood.
- AAD is based upon the area under the damage versus probability curve. AAD per annum in today's terms is then assumed to apply for each year of the NPV of damages calculations.
- AAD per annum in today's terms are assumed to apply for each year of the NPV of damages calculations. NPV calculations should be based on a reasonable project lifespan, say 50 years for mitigation works.
- Discount factors of 4%, 7% and 11% should be used based upon Treasury guidance. The range of NPV should be provided to indicate its sensitivity to the discount rate.

Fixed Eg AAD/NPV of Damages Worksheet

This fixed example assumes a typical damage curve from a previous project.

Open EG AAD/NPV of Damages Calc Worksheet

This is an editable example of AAD, NPV and benefit cost ratio calculations based upon damages for different events. The user could, at their own risk, use this with project figures, but they should first ensure they understand the associated assumptions.

This spreadsheet requires the user to enter the relevant floods to be assessed. Errors will result if there are gaps between events and zeros are not placed in any spare ARI spaces. An ARI event for which damage can be considered zero also needs to be entered.

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Wellington Council

WELLINGTON FLOODPLAIN RISK MANAGEMENT STUDY 2013

Appendix D

Emergency Management

July 2013

Date: 23/07/2013

Table of Contents

Page No

List of Tables

List of Figures

D1. INTRODUCTION AND SCOPE

Implementation of an effective emergency management system is an effective response modification strategy for mitigating the residual risk of flood damage. This is the risk which remains after floodplain management measures have been implemented. The overall system consists of a number of separate processes:

Before the flood:

- identification of the areas at risk from flooding (through historic flooding or a flood study);
- educating the affected community about their risk from flooding and how to prepare for it;
- planning for possible flooding when Flood Watches are issued. In NSW Flood Watches provide a 24 to 48 hours “heads up” of flood producing rainfall. In recent years they have been issued prior to 70% of all floods and over 90% of major floods.

During the flood:

- prediction of flood severity and time of onset of particular levels of flooding;
- interpretation of the prediction to determine flood impacts on the community;
- construction of warning messages describing what is happening, the expected impact, and what action should be taken;
- the dissemination of warnings to flood prone residents.

After the flood:

- the recovery of the community in the flood aftermath;
- reviews of the warning system after the event.

(Emergency Management Australia, 1995)

This Appendix is a review of the flood preparedness and response system in Wellington. The original appendix, prepared as part of the 1996 Floodplain Management Study, has been updated to incorporate the recent improvements in the emergency management system in Wellington, including the installation of a new telemetered river gauge and a new version of the SES’s *Wellington Local Flood Plan* (September, 2008).

State-wide arrangements for emergency management are summarised in **Section D2**. The Wellington Flood Management System is described in **Section D3**. Recommendations for inputs to the *Wellington Local Flood Plan*, based on the results for the technical analysis carried out for this FPRM Study, are provided in **Section D4**.

D2. EMERGENCY MANAGEMENT – NSW ARRANGEMENTS

Information in this section was obtained from the NSW Government Office for Emergency Service's website: http://www.emergency.nsw.gov.au and outlines the legislation governing emergency management as well as the roles and responsibilities of various individuals and groups involved in emergency management in NSW.

D2.1 Legislation

Emergency management arrangements for NSW, as they relate to floods, currently operate under two acts:

- *State Emergency Service Act 1989*
- *State Emergency and Rescue Management Act 1989*

The State Emergency Service Act 1989 establishes the State Emergency Service and defines its functions as well as making provision for the handling of certain emergencies. The *State Emergency Service Act* (1989) replaced the *SES and Civil Defence Act* which had been in place since 1972.

The *State Emergency and Rescue Management Act 1989* establishes the legislative base for NSW disaster management. Specifically, the Act provides for:

- the responsibilities of the Minister;
- a State Emergency Operations Controller;
- the State Disaster Council;
- the State Emergency Management Committee;
- the State Disaster Plan; and
- a State Emergency Operations Centre.

D2.2 Emergency Management

The Minister for Emergency Services has overall responsibility for ensuring that arrangements are made at State level to prevent, prepare for, respond to and assist recovery from emergencies.

The State Disasters Council is responsible for advising the Minister on all aspects relating to prevention of, preparation for, response to and recovery from emergencies, including coordination.

The State Emergency Management Committee (SEMC) is the principal committee for emergency management planning at State level. The resources of the State are grouped into functional areas for emergency management purposes and the appointed State coordinator for each functional area is a member of the SEMC.

For emergency management purposes, NSW is divided into emergency management districts, each of which has a District Emergency Management Committee (DEMC) which is chaired by the District Emergency Operations Controller (DEOCON), supported by the District Emergency Management Officer (DEMO). The DEMO is also responsible for assisting local committees and communities within the relevant District on emergency management matters. For emergency management purposes Wellington is part of the Western Slopes Emergency Management District.

The State is further divided into Local Government areas. At this level there is a Local Emergency Management Committee (LEMC) which is chaired by a senior representative of the council for the area and is supported by a Council appointed Local Emergency Management Officer (LEMO). The LEMO is appointed by the Commissioner of Police for each Local Government area.

Wellington falls under the control of the Macquarie SES Division.

In recent years, Flood Warning Consultative Committees have been established in all States. This Committee provides a suitable vehicle for the review of flood warning procedures and responsibilities.

D2.3 Emergency Plans

The key element of emergency management planning in NSW is the State Disaster Plan (DISPLAN). The objective of the DISPLAN is to ensure a co-ordinated response by all agencies having responsibilities and functions in emergencies. The DISPLAN:

- identifies the combat agency primarily responsible for responding to the emergency;
- specifies the tasks to be performed by all agencies in the event of an emergency;
- provides for the co-ordination of the activities of other agencies in support of the combat agencies; and
- specifies the responsibilities of the Minister and the State, District, or Local Emergency Operations Controller.

The NSW *State Flood Plan* (SES, 2000) is a sub-plan of the DISPLAN. The aim of this Plan is to set out the mitigation, preparation, warning, response and recovery arrangements for flooding in NSW and the responsibilities of agencies and organisations with regard to these functions.

Each SES Local Controller in whose area there is a flood threat is responsible, with the assistance of the SES State Headquarters and the appropriate SES Division Headquarters, for the development and maintenance of a Local Flood Plan. The Flood Plan should cover all known flood threats within the council area at all potential levels of severity and should cover all foreseeable consequences.

D2.4 Flood Forecasting, Warning and Recovery

Flood forecasting is the designated responsibility of the Commonwealth Bureau of Meteorology (BoM). The warning phase is generally under the supervision of the State Emergency Service (SES) acting through its local unit, often with considerable local Council input. The SES generally supervises evacuation, though the Police will often also be involved. If necessary, the Defence Forces will be brought in to provide assistance to the civil authorities through Emergency Management Australia. Finally, volunteers and welfare agencies play a key role in the recovery phase, along with councils and state government agencies.

D3. WELLINGTON FLOOD WARNING SYSTEM

D3.1 Flooding

Flooding in the Wellington Council area is influenced by flooding in the Macquarie and Bell Rivers. As discussed in **Appendices A** and **B** of the FRMS 2013, flood flows on the Macquarie River are greatly reduced by the mitigating effects of Burrendong Dam which reduces outflow peaks but necessarily extends the period of outflow in some cases.

While the travel time of outflows from the dam to Wellington is only around 48 hours, the practical warning time is longer as upstream flooding is monitored to determine the gate operation procedure. As well, due to the large size of the flood mitigation storage in Burrendong Dam, there is often a time lag between earlier flooding from local rivers, such as the Bell, and flooding due to high spills from the Dam.

Flooding in the Bell River is more sudden due to the smaller size of catchment and the relative steepness of the stream. Although the travel time from the headwaters around Molong to Wellington may be up to 16 hours, earlier flooding of the agricultural areas in the lower Bell River floodplain may be caused by high flows from the middle and lower areas of the Bell River catchment, as well as from Macquarie River flooding.

D3.2 Wellington Flood Warning Service

Information on flood warnings and flood warning disseminations has been obtained from discussions with the Bureau of Meteorology (BoM).

The BoM provides a Flood Warning Service for Wellington which is delivered through the Flood Warning Centre and Regional Forecasting Centre for NSW. The range of information provided at Wellington includes:

- A Flood Watch is issued if flood producing rain is expected to occur in the near future (generally 24 to 48 hours). These are normally provided on a whole-catchment basis for the Macquarie River system and may also cover a number of neighbouring catchments.
- Warnings of 'Minor', 'Moderate' or 'Major' flooding, which will identify the locations expected to be flooded, the likely severity of the flooding and when it is likely to occur.
- Predictions of the expected height of a river at key locations along both the Bell and Macquarie Rivers, and the time that this height is expected to be reached. This allows the local SES and people in the flood threatened area to more precisely determine the area and likely depth of the flooding.

D3.2.1 Flood Warning Gauges

The location of the flood warning gauges in the Bell River catchment and on the Macquarie River downstream of Burrendong Dam is shown on **Figure D3.1** and listed in **Table D3.1** below.

Table D3.1: Flood Warning Gauges

Name	Creek/River	Owner	Description/Comment
RAINFALL GAUGES			
Fernleigh		BoM	telemetered
Neurea		BoM	telemetered
Stuart Town		BoM	telemetered
Molong		BoM	telemetered
Borenore		BoM	telemetered
Euchareena			unofficial
Store Creek			unofficial
Farnham			unofficial
Mumbil			unofficial
STREAM GAUGES			
Molong	Molong Creek		manual
Molong (421050)	Bell River	DWE	
Larras Lee	Bell River	Council	manual
Bakers Swamp	Bell River	Council	manual
Boomey Road	Bell River		telemetered
Gowan Green	Bell River		telemetered
Neurea (421018)	Bell River	DWE	telemetered
Wellington	Bell River		manual
D/S Burrendong Dam (421040)	Macquarie River	DWE	telemetered
Wellington (421003)	Macquarie River	DWE	telemetered

D3.2.2 Macquarie River and Burrendong Dam

Predictions of outflow from Burrendong Dam are supplied by State Water/DWE. The flood operation procedure for Burrendong Dam is designed to obtain maximum benefits from the use of available flood mitigation storage in reducing peak outflows, while ensuring its paramount objective of dam safety. It is based on the estimation of the likely flood inflows derived from upstream telemetric river gauging stations: the Macquarie River at Bruinbun, the Cudgegong River at Yamble Bridge and the telemetric river gauging station at Neurea, which provides data on the Bell River flows to the gate operators.

Releases are timed, where possible, to lag the flood peaks generated by the major tributaries such as the Bell, Little and Talbragar Rivers. Flood peaks take around 4 to 8 hours to traverse the 30 km reach from the dam to Wellington.

State Water and DWE inform BoM and SES regarding releases to the Macquarie River from Burrendong Dam. When BoM announces events that could create significant floods, State Water assumes "Flood Operations Mode", which is an alert stage where 24 hour monitoring occurs and which continues for the duration of the flood event.

State Water calculates inflows to the dam based on BoM's predictions upstream of the dam, checks actual inflow measurements and determines the discharge release from the dam, based on operational rules.

State Water then advises the local Wellington SES, SES Headquarters and BoM regarding predicted releases. Based on this information, BoM estimate flood levels downstream of the dam and inform SES. State Water and DWE liaise within themselves internally on operational rules for dam releases, which are primarily based on dam safety considerations.

A separate flood warning system operates for Burrendong Dam. A sensor on the dam detects rapid changes in water levels or certain water levels which sends alarms and signals to telephones at the dam, the Local SES and houses below the dam.

D3.2.3 Bell River

The BoM carry out a unit hydrograph analysis for the Bell River at Neurea and translate this level to the Bell River at Wellington flood gauge. The BoM also use information from other upstream gauges in the Bell River catchment near Molong to develop flood predictions. A new telephone telemetered flood warning river gauge has recently been installed at Gowan Green on the Bell River (as shown on **Figure D3.1**). Telemetered flood warning gauges are also located at Boomey Road on the Bell River and downstream of Burrendong Dam on the Macquarie River (also shown on **Figure D3.1**).

D3.3 Dissemination of Flood Warnings

The mechanism for dissemination of flood warnings for Wellington is shown in **Figure D3.2**.

To avoid the possibility of conflicting information being provided to communities, flood warning information is issued as a Flood Bulletin by SES Division Headquarters to media outlets, after consultation with the SES Local Controller. Flood Bulletins must include verbatim the first paragraph of the predictions section of the latest warning issued by the BoM. Flood Bulletins also include, as appropriate:

- the data section of the latest flood warning issued by the BoM.
- what the predicted height means in terms of areas likely to be flooded and the depth and nature of the expected flooding;
- local Flood Advices;
- advice on what actions people should take to protect themselves and their property (and indicating appropriate time frames for these actions);
- areas of danger to be avoided;
- roads currently closed, roads which may become closed, and roads which will not be closed;
- contact details for SES units in the event of assistance being required;

- contact details for obtaining road information.

The SES deliver flood warning information other than via the media when severe flooding or a need for evacuation is anticipated.

Following the issuing of a flood warning, the SES State Headquarters maintains regular contact with the BoM until the flood potential has passed.

D3.4 Discussion

From discussions with BoM, the following observations may be made about the Wellington flood warning system:

- The ability of the dam operators to predict inflows to the dam and the presence of a tried and tested operation procedure for the gates provide the basis of an effective system for predicting flood peaks along the Macquarie River. Communications between DWE, BoM and SES have been shown to be adequate.
- BoM consider that the distribution of rainfall gauges between Molong and Neurea is adequate for forecasting in the Wellington area. Rainfall predictions are now more reliable and provide reasonable guidance as to the occurrence of flood producing rains.

  The BoM predictions are primarily based upon unit hydrograph models and cross checked against other upstream gauges. BoM's experience has been that the UHG provides superior guidance along the rising limbs of floods than RORB or RAFTS. BoM use different UHGs for different rainfall patterns so therefore account for non linear flood behaviour.
- BoM consider that the telephone telemetered rainfall and river network system is adequate. The BoM experience is that landline technology across NSW has performed reasonably well in recent floods over the past decade or so.
- BoM and SES are now more proactive in providing warnings. Across NSW around 70% of floods are now being preceded by a Flood Watch. As well, about 70% of Flood Watches are accurate and are followed by a Flood Warning.
- BoM suggested that Council/SES could prepare a Flood Education Package that could be strategically released when BoM issue a Flood Watch for the area, as people would be more receptive to flood education when there is an immediate threat.

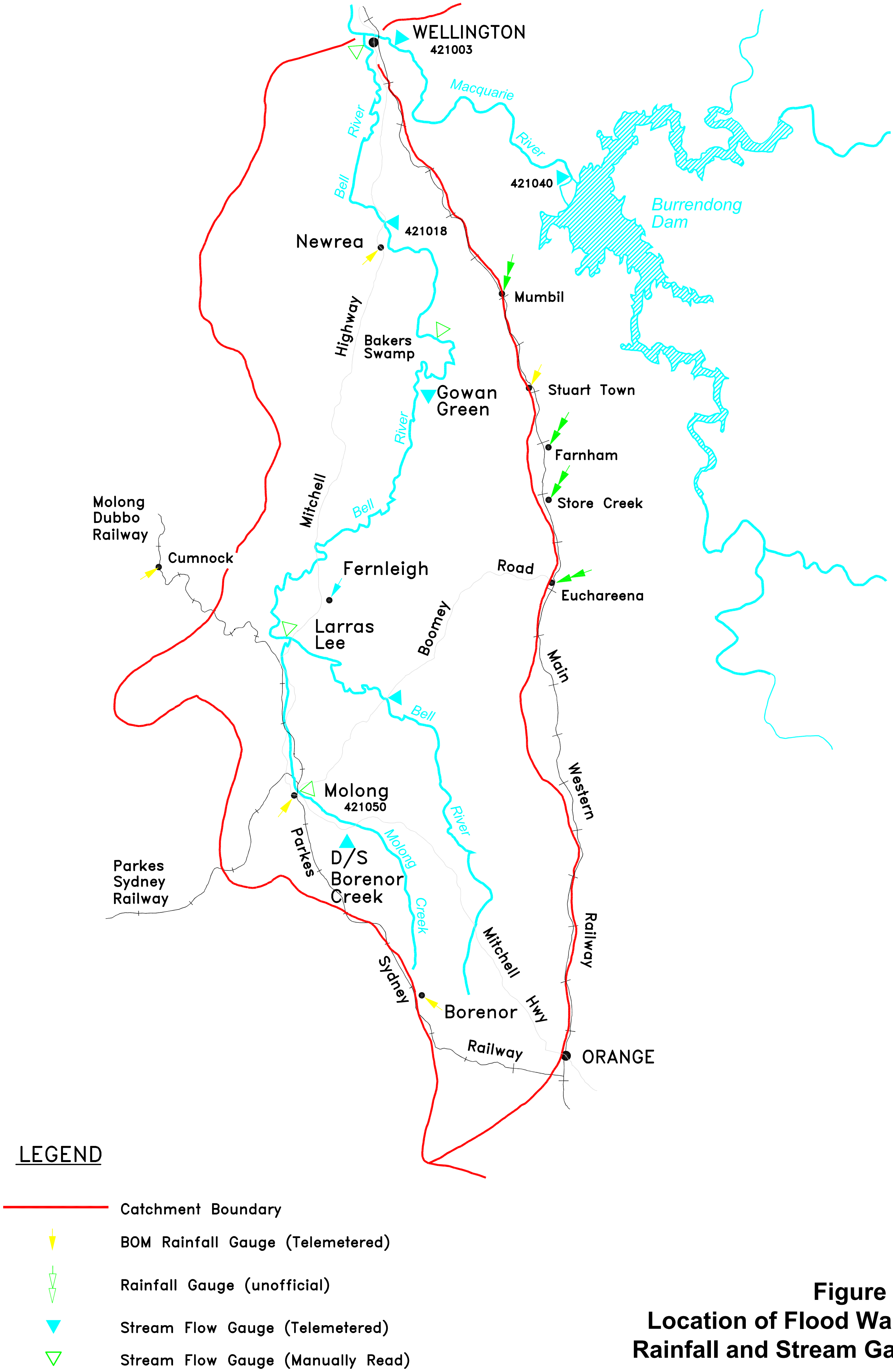
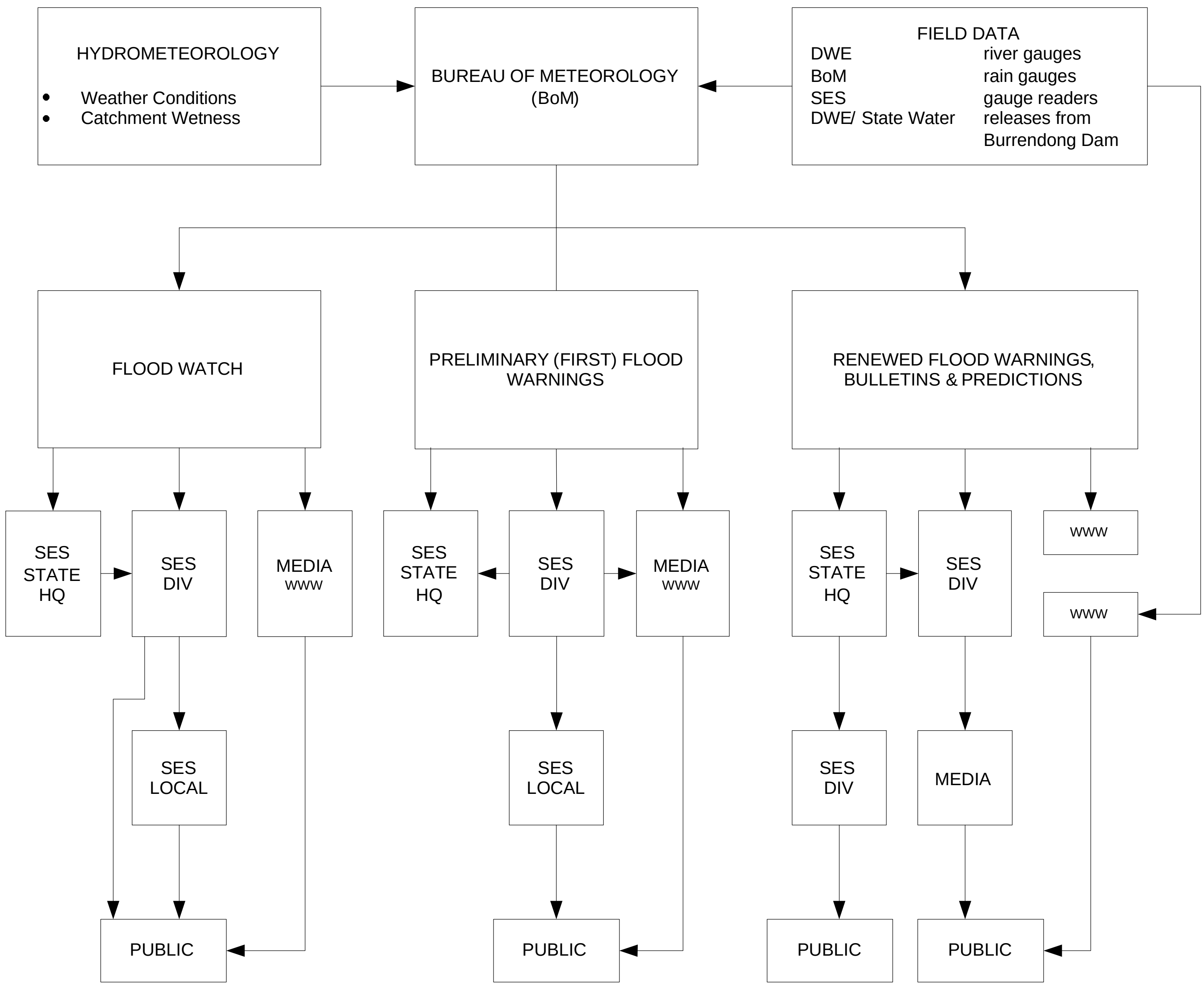


Figure D3.1: Location of Flood Warning Rainfall and Stream Gauges



Burrendong Dam Flood Warning System

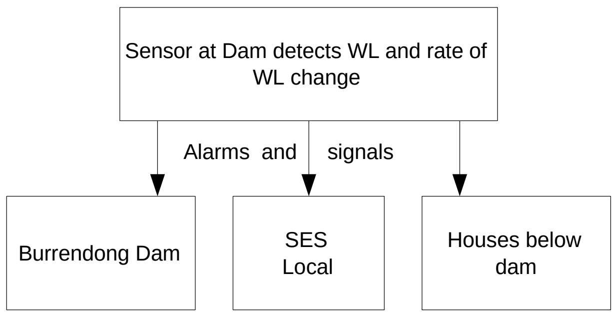


Figure D3.2:
Distribution of Flood Warnings

D4. WELLINGTON LOCAL FLOOD PLAN

The SES operate under the *Wellington Local Flood Plan* (September, 2008), a sub-plan of the Wellington Local Disaster Plan. This plan covers preparedness measures, the conduct of response operations and the coordination of immediate recovery measures for flooding within the Wellington local Council area.

Under the plan, the SES Local Controller is responsible for dealing with floods, directs the activities of SES units operating within the Council area and coordinates the actions of supporting agencies including police, Council, bush fire brigades, NSW Agriculture, welfare service and utility authorities.

D4.1 Input to the Local SES Flood Plan

Appendix D of the 1996 *Wellington Floodplain Management Study* provided a review of the Wellington flood preparedness and response system and made recommendations for improvements to the system. This included suggestions for improvements in SES operations and the SES Flood Plan.

However, current thinking by OEH and the SES is that it is neither necessary nor appropriate to require consultants to review the emergency management arrangements described in the SES Flood Plan. The SES is the nominated agency for flood emergency management in NSW and has their own planning specialists, guidelines and review processes. The SES also has a specialist flood education section and has a thorough understanding of the issues and challenges in this area.

Floodplain Risk Management Studies should instead review the underpinning flood behaviour/engineering information upon which SES planning and education is based. SES plans depend implicitly on having sound flood behaviour/engineering data and also on the correct interpretation of that data. Important and potentially useful areas include the provision of information that the SES can use to update their flood intelligence system e.g. for entry into GIS or other database systems.

Accordingly, this section provides commentary on the flood behaviour information contained in the *Wellington Local Flood Plan 2008*.

D4.1.1 Annex A – The Flood Threat

Annex A to the *Wellington Local Flood Plan 2008* describes physical flood behaviour and the flood threat. The information presented in this annexure includes the information on flooding presented in the 1996 Floodplain Management Study which is still current.

This current study has modelled the impacts of a revised extreme flood on the Macquarie River (referred to as Case 2 Extreme within the Flood Plan). However, Annex A does not discuss specific flood levels and velocities for this event and therefore no amendments are necessary.

D4.1.2 Annex B – Effects of Flooding on the Community

Annex B of the *Wellington Local Flood Plan* describes specific risk areas in the context of flood consequences. Information which the SES could include in this Annexure is provided below.

The table containing the total number of properties inundated should be updated as from information presented in **Appendix C**.

Essential Services located on flood prone could be included:

- SES facilities
- Council Chambers
- Police Station
- Ambulance Station
- Telephone Exchange
- Hospital.

Table D4.1 below provides a list of utilities and the frequency at which flooding occurs which could be included in Annex B.

Table D4.1: Utilities at Risk from Flooding

Facility / Damage Sector	Frequency at which flooding commences
Electricity	
Power poles at Herbert St bridge and pole mounted transformer on Macquarie/Bell floodplain	2% AEP
Pad mounted transformer on Maughan Street adjacent to Bowling Club	0.5% AEP
Telephone	
Telephone exchange	EMAC/EBELL
Sewerage Reticulation	
Pump station in vicinity of Arthur and Gobolion Streets	2% AEP
Sewage Treatment Plant	EMAC/EBELL
Water Supply	
Treatment works	0.2% AEP
Other	
SES HQ	EMAC
Hospital on Gisborne Street	EMAC

Properties located within the 1% AEP high and low hazard zone are provided in **Appendix G**. This information could be incorporated into the SES mapping.

D4.2 Flood Intelligence

Information from this FRMS 2013 which could be provided to the SES for inclusion in the Local Plan includes:

- Plan indicating cross section and long section locations;
- River long sections and cross sections showing flood levels for design events at a readable scale on A3 plans;
- A spreadsheet of ground levels, floor levels and flood levels for design events, to AHD based on the information used for the damage calculation;
- Maps showing flood extents.

Refer **Appendix A** for tabulated data and flood profiles which could be used for SES flood intelligence.

D5. SUMMARY

This review of the Emergency Management System in Wellington has indicated that the BoM are satisfied with the Wellington flood warning system. The telephone telemetered rainfall and river network system is adequate and flood watches and warnings are being issued more proactively and are becoming more accurate. Therefore there appears to be no recommendations for improvements to the flood warning system.

Current thinking in SES and OEH is that it is neither necessary nor appropriate to require consultants to review the emergency management arrangements described in the SES Flood Plan, as was carried out in the 1996 FPM Study.

Instead, a review of the underpinning flood behaviour/engineering information within the *Wellington Local Flood Plan* has been undertaken. The information in Annex A is generally acceptable, as it has been based on the information presented in the 1996 FPM Study. Annex B can be updated with information provided in this FRMS 2013. In addition, **Appendix A** provides useful flood intelligence which should be supplied to the SES.

D6. REFERENCES

Australian Water Resources Council (1992). *Floodplain Management in Australia Volume 2: Main Report.* Water Management Series No. 21.

Emergency Management Australia (1995). *Flood Warning: An Australian Guide*.

Department of Land & Water Conservation (1995). *Wellington Flood Study.*

McKay G. (1991). *Flood Forecasting in New South Wales by the Bureau of Meteorology.* 31st Annual Flood Mitigation Conference, Port Macquarie.

NSW Government (2005). *Floodplain Development Manual*.

NSW State Emergency Services (undated). *NSW SES and CD Organisation - roles, responsibilities and organisation at local government level*.

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WELLINGTON COUNCIL NSW Australia

Wellington Council

WELLINGTON FLOODPLAIN RISK MANAGEMENT STUDY 2013

Appendix E

Planning Issues

August 2013

Date: 9/08/2013

Table of Contents

Annexures

Figures

E1 INTRODUCTION

GLN Planning, in association with Evans & Peck, has been engaged to provide town planning input into the review and an update of the 1996 *Wellington Floodplain Management Study* (FMS) and *Floodplain Management Plan* (FMP).

The purpose of this Appendix is to:

- outline the state and local planning policy context;
- identify the issues associated with implementing flood risk planning strategies for the study area;
- discuss options to address these planning issues; and
- make recommendations for incorporation into the FRMP 2013.

This Appendix focuses on recommendations for future reviews of the recently adopted Wellington Local Environmental Plan (LEP) 2012 and the Wellington Development Control Plan 2013 (DCP 2013). The review undertaken in this Appendix seeks to ensure consistency with the 2005 *Floodplain Development Manual* as amended by the 2007 *Flood Planning Guideline* issued by the (then) state government departments of Planning and Natural Resources, including the findings of this FRMS 2013.

This Appendix replaces **Appendix E** of the 1996 Study.

E2 DEFINITIONS AND TERMINOLOGY

A number of the definitions provided in the 1996 Appendix are superseded by the 2005 Floodplain Development Manual (the '2005 FDM'). To establish consistent terminology between the 2005 FDM and the relevant Council planning documents, it is recommended that Council adopt the following definitions for the purposes of the FRMP:

Flood liable land	is the area of land which is subject to inundation by floods up to and including an extreme flood such as a probable maximum flood (PMF). It is synonymous with *flood prone land* and *floodplain*.
Flood mitigation work	means work designed and constructed for the express purpose of mitigating flood impacts. It involves changing the characteristics of flood behaviour to alter the level, location, volume, speed or timing of flood waters to mitigate flood impacts. Types of works may include excavation, construction or enlargement of any fill, wall, or levee that will alter riverine flood behaviour, local overland flooding, or tidal action so as to mitigate flood impacts.
Flood planning levels (FPL)	are the combinations of flood levels (derived from significant historical flood events or floods of specific AEPs) and freeboards selected for floodplain risk management purposes, as determined in management studies and incorporated in management plans.
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 typical residential uses). (See also risk).
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.
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.

Probable maximum flood (PMF)	is the largest flood that could conceivably occur at a particular location.
Hazard	flooding which has the potential to cause damage to the community. Definitions of high and low hazard categories are provided in Appendix L of the 2005 FPM.
High Flood Risk Precinct	are those parts of the floodplain where the depth and velocity of flood waters and evacuation difficulties would pose an unacceptable risk to types of development and activity. For Wellington, the High Flood Risk Precinct is the area of land subject to **high hydraulic hazard (floodway) in a 1% AEP flood event**. The flood hazard in this area cannot be reduced by methods such as filling without creating unacceptable flood hazard elsewhere on the floodplain. In comparison, the flood hazard in a high hydraulic flood fringe area can be managed by methods such as filling without adversely affecting flood hazard elsewhere on the floodplain.
Medium Flood Risk Precinct	are those parts of the floodplain where there would still be a significant risk of flood damage, but these damages can be minimised by the application of appropriate development controls. For Wellington, the Medium Flood Risk Precinct applies to land area **below the extent of the 1% AEP flood level +0.5 m, but above the high hazard 1% AEP extent.**
Low Flood Risk Precinct	are those parts of the floodplain where the risk of damages is low for most land uses and, therefore, most land uses would be permitted. Those uses considered critical or requiring maximum protection against risk from flooding should be identified as undesirable land uses in this precinct. For Wellington, the Low Flood Risk Precinct **applies to all land within the floodplain (i.e. within the extent of the PMF) not identified as being within either the High or Medium Flood Risk Precincts.**
Merit approach	The principles of the merit approach are embodied in the FDM (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 wellbeing of the State's rivers and floodplains.

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

A number of aspects of these proposed definitions should be noted:

- Flood prone land represents the maximum extent of land likely to be inundated. Floodplain Risk Management Plans must encompass all flood prone land.
- The PMF event should form the basis of evacuation planning and the identification of refuge areas. The PMF event should be adopted as the basis for the FPL for emergency services planning, i.e. for determining the location and floor levels of services that could be essential during a catastrophic flood, such as new telephone exchanges, police stations, hospitals, etc.
- For the purposes of land use planning in the township of Wellington, the extreme flood caused by combined flooding from the Macquarie and Bell Rivers (designated EMAC) is taken as representing the PMF.
- Selection of FPLs is based on an understanding of flood behaviour and the associated flood risk. FPLs take into account the social, economic and environmental consequences associated with floods of different severities, in accordance with the merit based approach of the 2005 FDM. Refer **Section 3** of the FRMS 2013 for the background analysis undertaken to determine the appropriate FPLs for Wellington.

E3 NSW FLOOD RISK MANAGEMENT FRAMEWORK

E3.1 Objectives and Approach

The NSW flood risk management policy framework is ultimately directed to the production of flood risk management solutions that best meet the particular circumstances of each individual floodplain. This requires a balancing of economic, social and environmental considerations to determine policies for the management of existing and future risk to property and persons within a floodplain based on the level of risk acceptable to the community. This is referred to as the merits-based approach, which is fundamentally based on risk management principles consistent with AS/NZS 4360:2004 Risk Management.

The primary objective of flood risk management, as expressed within the NSW Flood Prone Lands Policy (2005 FDM, page 1) is as follows:

> *"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."*

Within the scope of this Appendix, the relevance of the above objective is primarily to ensure that future development does not lead to increased flood risk to property and persons and that the planning controls proposed to achieve this outcome form part of a consistent and coordinated strategy to reduce flood risks in Wellington.

E3.2 Flood Risk Management Measures

As outlined in the FRMS, the 2005 FDM provides that the measures incorporated into a FRMP for managing flood risk to life and property can be grouped into three categories:

- property modification measures;
- response modification measures; and
- flood modification measures.

This Appendix is primarily concerned with property modification measures and secondly with response modification measures. The role of planning relates primarily to the implementation of property modification measures and, to a lesser extent, response modification measures particularly in regard to the manner in which it informs the community through planning policies in regard to flood risk. Accordingly, the role of planning can be summarised as follows:

- **Strategic Planning**: Directing strategic planning as to the location of new areas or the redevelopment of areas in a manner which does not expose people and property to unacceptable flood risk.
- **Development and Building Controls**: Where development is permitted in locations where flood risk remains, to ensure that planning and building controls are applied in a manner which minimises risk to acceptable levels.
- **Communication of Flood Risk**: Ensuring that the planning policies and controls and associated documentation communicates flood risk in a responsible manner to allow the community to make informed decisions where discretion exists and to complement emergency management education and preparedness programs.

E3.3 Relationship with EP&A Legislation

The plan making processes under the *Environmental Planning and Assessment Act* (EP&A Act) such as for Local Environmental Plans (LEPs) and Development Control Plans (DCPs) operate independently of the preparation of FRMPs under the 2005 FDM. While these two processes could be overlapped, it has been the usual practice to undertake the processes separately.

Ultimately the planning recommendations of the FRMP will need to be reflected in planning instruments and policies brought into force in accordance with the EP&A Act. Accordingly the FRMP can provide appropriate input to the EPA Act planning processes in three ways:

- Providing direction at a local (and state) strategic planning level in addressing flood risk management (e.g. where urban growth should occur and the distribution of land uses therein);
- Recommendation of development controls to be incorporated in appropriate planning instruments (e.g. LEPs and DCPs) to mitigate the risk to development where permitted in the floodplain; and
- Ensuring that the planning controls and associated documents (e.g. S149 Planning Certificates) contribute to ensuring the community is appropriately informed about the flood risk.

E4 EXISTING PLANNING FRAMEWORK

E4.1 General

The following provides an outline of policy that is potentially relevant because it either directs the flood risk management planning controls that could be adopted or affects the way that flood risk is identified in the planning controls.

E4.2 State Environmental Planning Policies

A State Environmental Planning Policy (SEPP) is a planning document prepared in accordance with the EP&A Act by the Department of Planning and eventually approved by the Minister, which deals with matters of significance for environmental planning for the State. Regional Environmental Plans (REPs) no longer form part of the statutory planning framework in NSW and existing REPs are now considered deemed SEPPs.

No SEPP has been prepared dealing specifically with the issue of flooding, but some regulate development in response to potential flood risks. SEPP (Housing for Seniors or People with a Disability) 2004 applies to urban land or land adjoining urban land where dwellings, hospitals and similar uses are permissible. The Seniors Living SEPP would apply to parts of the floodplain, and would effectively override Council's planning controls to permit residential development for older and disabled persons to a scale permitted by the SEPP. Clause 6(2)(a) of the SEPP restricts its application if land is identified as "floodways", "natural hazard" or "high flooding hazard" in Council's LEP.

There are no pertinent REPs.

E4.3 2007 Flood Planning Guideline

On January 31, 2007 the NSW Planning Minister announced a new guideline for development control on floodplains (the "*Flood Planning Guideline*"). An overview of the new Guideline and associated changes to the EP&A Act and Regulation was issued by the Department of Planning in a Circular dated January 31, 2007 (Reference PS 07-003). The *Flood Planning Guideline* issued by the Minister relates to a package of directions and changes to the EP&A Act, Regulation and the 2005 FDM.

The *Flood Planning Guideline* provides an amendment to the 2005 FDM. The Guideline confirms that unless there are "exceptional circumstances", Councils are to adopt the 100 year ARI (1% AEP) flood as the basis for setting 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 this FPL (100 year ARI flood plus freeboard) may be imposed subject to an "exceptional circumstances" justification being agreed to by the Department of Natural Resources (now the Office of Environment & Heritage (OEH)) and the Department of Planning (now the Department of Planning & Infrastructure (DP&I)) prior to the exhibition of a Draft LEP or Draft DCP.

Consistent with the 1996 FMP, Council's preceding DCP No.2 2006 (Urban & Public Lands) adopts the 200 year ARI (0.5% AEP) flood (with no freeboard) as the FPL for controls on residential development. However, DCP No.2 applies the 100 year ARI flood (plus freeboard) as the residential floor FPL and does not impose any specific controls above this level.

The *Guideline* also provides directions in regard to Section 117 Directions, the content of LEPS, DCPs and Section 149 Planning Certificates. These directions are discussed separately below.

E4.4 Section 117 Directions

Ministerial directions pursuant to Section 117(2) of the EP&A Act specify matters which local councils must take into consideration in the preparation of LEPs. Direction 4.3, as currently applies, deals specifically with flood [liable] prone land and has the following two objectives:

(a) To ensure that the development of flood prone land is consistent with the NSW Government's Flood Prone Land Policy and the principles of the Floodplain Development Manual, 2005.

(b) To ensure that the provisions of an LEP on flood prone land is commensurate with flood hazard and includes consideration of the potential flood impacts both on and off the subject land.

The Direction applies to all councils that contain flood prone land when an LEP proposes to "create, remove or alter a zone or provision that affects flood prone land." In such cases, the Direction requires draft LEPs ensure the following:

- Consistency with the principles of the 2005 FDM (including the *2007 Flood Planning Guideline*);
- Do not rezone flood prone land zoned special use, recreation, rural or environmental protection to a residential, business, industrial or special use area zone;
- Do not permit development in floodways that would result in significant flood impacts on others, permit a significant increase in development on the floodplain, require substantial government spending on flood mitigation, or allow development without consent except for agriculture or flood mitigation works;
- That flood related development controls are not imposed on residential development above the "residential flood planning level" unless adequate justification to the satisfaction of the DP&I (and OEH) is provided; and
- Flood planning levels must be consistent with the *2007 Flood Planning Guideline*.

Clause (6) of the Direction specifies circumstances which must be satisfied for the Director-General or nominee to allow for a variation to the Direction, which includes being consistent with a FRMP.

While Section 117 Directions are not relevant to DCPs, the *Flood Planning Guideline* does indicate that the approval of the DP&I is also required prior to the exhibition of a draft DCP that varies from the *Guideline*.

E4.5 Changes to Environmental Plan Making in NSW

On 31 March 2006, the NSW Government gazetted the *Standard Instrument (Local Environmental Plans) Order 2006*. This required all councils to use the standard instrument to prepare a new principal LEP for their local government area within 5 years. Councils can add local provisions to address local issues and control the scale of development within different zones.

The template contains no compulsory clauses or map requirements specifically relevant to addressing flood hazards. However, the DP&I has adopted a model local clause in regard to flooding. A model local clause is one which has been settled by Parliamentary Counsel as acceptable and the DP&I encourage that it is used as is. The DP&I also typically encourages the inclusion of a flood planning map overlay within the gazetted LEP map package.

Wellington LEP 2012 is in the Standard Instrument format. LEP 2012 adopted the model local flood planning clause and incorporates flood planning maps.

In 2013 the NSW Government released a White Paper and Draft Exposure Bills for "*A New Planning System for NSW*" that is intended to commence in 2014. The primary implication for this document is likely to be a future requirement to roll the LEP and DCP(s) into one standardised Local Plan and to include flood mapping where available. The Government's objective is to maximise the proportion of development that is approved as complying or code assessable (80% within 5 years). This will necessitate the provision of mapped triggers and controls to ensure flood issues are addressed within these approval processes or elevated to an application to the merit assessment DA process where required.

E4.6 Section 149 Certificates

A Section 149 Planning Certificate is a zoning certificate issued under the provisions of the EP&A Act that is available to any person on request and must be attached to a contract prepared for the sale of property. The matters to be contained within the Section 149(2) Certificate are prescribed within Schedule 4 of the *Environmental Planning and Assessment Regulation*, 2000 and generally relate to whether planning controls (but not necessarily flood related risks) apply to a property.

Schedule 4 of the Regulation was amended, commencing on February 16, 2007, to specify flood related information that can be shown on Section 149(2) Certificates. The amendment provisions require the following:

7A Flood related development controls information

(1) Whether or not development on that land or part of the land for the purposes of dwelling houses, dual occupancies, multi dwelling housing or residential flat buildings (not including development for the purposes of group homes or seniors housing) is subject to flood related development controls.

(2) Whether or not development on that land or part of the land for any other purpose is subject to flood related development controls.

(3) Words and expressions in this clause have the same meanings as in the instrument set out in the Schedule to the Standard Instrument (Local Environmental Plans) Order 2006."

A Section 149(5) Certificate, being a more complete but more expensive certificate, requires councils to advise of "other relevant matters affecting the land of which it may be aware". These more complete certificates are not mandatory for inclusion with property sale contracts – a Section 149(2) Certificate being the minimum required. Where a Section 149(5) Certificate is obtained, this could require a council to notify of all flood risks of which it is aware.

S149 certificates should not be solely relied upon as community education tools as they have only limited circulation. The majority of flood-affected properties would not be reached in a given year. However, information on a S149 Certificate can reflect information that may be provided to people making general enquiries and are important sources of information for the community that influence what is the understood (or perceived) flood risk of property. With the existing system of notifications on S149(2) certificates, if no notification appears, then it is often misunderstood to mean that property is "flood free" rather than there are no flood related development controls.

As stated in the 2007 Guideline, the new Clause 7(A)(1) of Schedule 4 of the EP&A Regulation means that councils are not to 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) councils 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 dated 31 January 2007 it is assumed to be the same as that adopted for the purposes of this FRMS.

Wellington Council has advised that Section 149(2) Certificates may either respond with "No" or the following to the requirements of clause 7A of Schedule 4 of the Regulation:

> *Yes – The land is shown on Council's flood mapping as land that is above the 0.5% AEP flood event but below the 1% AEP flood event.*

No additional information in regard to flood risk is identified on a S149(5) Certificate.

The above S149(2) notification could more precisely respond to clause 7A of Schedule 4 of the EP&A Regulation. That is the S149(2) notification could refer to the specific flood related planning controls and provide supplementary references to flood risk mapping where available. The notification could also note where Council has insufficient information to determine if a property is flood prone. If a flood study prepared at the DA stage identifies flood liability, it would be expected that the planning controls would then be applied.

Care is also required to ensure that S149 certificates are not interpreted as confirmation that land is not flood affected when Council is directed not to provide this advice or does not have information to confirm whether or not a property is flood affected. The 2005 FDM defines flood liable land as all land potentially affected by inundation during a flood, up to the PMF. This includes both riverine flooding and flooding from major overland flow paths. Flood mapping will typically identify the areas subject to major flooding but may not include all overland flow paths or riverine flooding beyond the modelled flood extents.

The recommended form and content of Section 149 Certificates should be reviewed to consider the following:

- All properties known to be in the PMF (or extreme flood) should be notified that flood related planning controls apply. This would be subject to the full implementation of the DCP controls recommended below, until which time notifications will need to specify that flood related development controls do not apply to residential development other than specified sensitive uses. This would also have the effect of identifying that the property is a "flood control lot" for the purposes of complying development provisions (as discussed in **Section E5.4** below).
- Inundation from stormwater and overland flow (except for 'local drainage') is 'flooding' under the 2005 FDM and should be recognised on Council's Section 149 certificates.
- Where Council is unsure of whether a property contains flood liable land (due to the lack of flood investigations and mapping in particular areas) a general notation to this effect could be provided with an explanation that a flood study may identify that the land is subject to flooding, in which case flood related controls could apply.
- Noting further flood risk information may be available upon enquiry to Council and/or (if a S149(2) Certificate is being issued) in a Section 149(5) Certificate.
- Provide information on a Section 149(5) certificate that reflects whether a property is known to be flood affected based on existing studies or Council cannot confirm whether a property is flood affected or not due to the absence of existing information.

Appropriate wording for the notifications should be determined based on legal advice. This should occur concurrently with the adoption of the recommended review of LEP 2013 and amendments to DCP 2013 or before. Ideally the revised notifications should reference the flood risk precinct category if known for a property and include its definition.

E5 REVIEW OF LEP 2012

E5.1 Flood Planning Clause and Mapping

The 1996 Study reviewed the 1987 LEP and the draft 1995 LEP. Council has since adopted 1995 LEP, which was subsequently replaced with LEP 2012. LEP 2012 contains the DP&I standard local clause, being:

6.1 Flood planning

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

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

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

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

(2) *This clause applies to:*

(a) *land identified as "Flood planning area" on the Flood Planning Map, and*

(b) *other land at or below the flood planning level.*

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

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

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

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

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

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

(4) *A word or expression used in this clause has the same meaning as it has in the Floodplain Development Manual (ISBN 0 7347 5476 0) published by the NSW Government in April 2005, unless it is otherwise defined in this clause.*

(5) *In this clause:*
land at or below the flood planning level means land at or below the level of a 1:100 ARI (average recurrent interval) flood event plus 0.5 metres freeboard.

The LEP incorporates flood planning maps that cover the townships of Wellington and Geurie. The maps generally align with the outer edge of the medium flood risk precinct (1% AEP flood plus 0.5 m freeboard) mapped for the Wellington FRMS. That is the flood planning maps do not include land within the low flood risk precinct (i.e. up to the PMF) where flood mapping is available or distinguish the medium and high flood risk precincts.

Generally, the LEP flood planning clause is considered appropriate. Such a clause provides recognition of flood risk as a relevant consideration when assessing a development application. The clause does not prohibit development but identifies the specific matters to be addressed with a development application.

The issues with the LEP flood planning clause are whether the area to which the clause applies should also include the low flood risk precinct and whether the flood planning maps should differentiate between the medium and high flood risk precincts. The important considerations are:

- Consistency with government policy.
- Avoiding confusing the public by inadvertently implying some areas are not subject to flood risk but in effect are only not subject to flood related planning controls.
- Allowing scope for flood risks associated with any development proposal to be considered when relevant.
- Avoiding misinterpretation and unnecessarily burdening the development assessment process.
- Maintaining flood risk mapping that is consistent with the FRMP and the recommended DCP.
- Capability of supporting more appropriate detailed controls in a DCP.

The LEP flood planning clause, specifically sub-clause (2), provides for the application of the clause by the mapping of any area as the "flood planning area" subject to the restrictions provided by the Flood Planning Guideline.

The LEP flood planning clause discussion document does not automatically prevent the consideration of a definition of a flood planning area other than the extent of the 1% AEP flood plus freeboard. The Flood Planning Guideline restrains the introduction of provisions that apply to standard residential development above this level, and only if an exceptional circumstances exemption has not been granted. The consequence of the LEP flood planning clause, and the outcome reflected in the LEP 2012 Flood Maps, is that only the residential flood planning area[1] is mapped and not the full flood planning area as recommended by the FRMS.

The LEP and DCP controls that deal with flood risk must provide an integrated and consistent package of planning controls such as those proposed in the following table:

[1] The residential flood planning area in this context is a reference to the 100 year ARI (plus 0.5m) FPL (medium and high flood risk precincts) and not the low flood risk precinct where emergency management measures are also relevant.

Planning Purpose	LEP	DCP
To specify FRM matters to consider when determining a DA.	High level considerations that apply generally to all potential forms of development.	Detail controls that allow the assessment of individual types of development against specific criteria with regard to flooding characteristics of individual sites.
Readily identify when the FRM provisions apply.	Define and where available provide mapping of all flood prone land (up to the PMF) because flood risk management planning controls will apply to some forms of development across the whole of this area.	Define and where available provide mapping of flood risk precincts (FRPs) because more detailed flood risk management planning controls will apply differently to development depending on the severity of flooding.
Responsibly and consistently contribute to the communication of flood risk.	Maps and definitions provide a broad coverage of all land potentially at risk of flooding, consistent with the 2005 FDM and information available to Council in flood studies. This does not necessarily translate to restrictions on all types of development.	Maps and definitions, together with detailed planning controls will provide a graded set of controls that vary depending on the sensitivity of development to flood risk and the severity of flooding across the floodplain.

In principle the flood planning LEP maps could be amended to map all land up to the PMF consistent with the definition of flood liable land provided by the 2005 FDM and encapsulate the three flood risk precincts mapped as part of the FRMS. However, this would not address those flood liable lands not currently mapped. For simplicity it is suggested that the clause also be amended to define flood liable land consistent with the 2005 FDM as all land inundated up to the PMF, and provide that the clause applies to all flood liable land. This would allow for the terms "flood planning area", "flood planning level" (FPLs) and "flood planning map" to be dispensed with as the 2005 FDM definitions applying pursuant to LEP flood planning clause 6.1(4) would suffice.

This would allow the DCP to be consistent with the LEP where the DCP imposes the few minor but important requirements on critical and sensitive uses above the 1% AEP flood plus freeboard, which are not subject to the restrictions in the Flood Planning Guideline. Where a DCP provision is inconsistent with an LEP, the DCP provision has no effect in accordance with clause 74C(5) of the EP&A Act.

It is considered that the above refinements to the LEP clause will retain consistency with the intent of the clause and provide greater simplicity and clearer information to the public. This will be a matter for Council to discuss with the DP&I when reviewing LEP 2012 in the future.

E5.2 Prohibiting Development in High Flood Risk Area

The LEP flood planning clause does not allow the introduction of prohibitions on flood sensitive developments generally or within certain parts of the floodplain (e.g. in a floodway). However, Council should consider the full risks of flooding when deciding upon the land use zone to apply to individual properties. If appropriate, Council should apply restrictive zones (such as an 'Environmental' zone) and development standards (such as a larger minimum lot size) available within LEP 2012 when undertaking future reviews.

E5.3 Review of Land Use zones in High Flood Risk Area

A preliminary review was undertaken of the appropriateness of the land use zones within the Wellington township having regard to flood risk. The methodology employed was to examine an overlay of the flood risk maps with the LEP 2012 land use zone maps and minimum lot size maps and aerial photography. Where the extent of a high flood risk precinct could potentially affect a property such that any development or redevelopment of the site currently permitted is unlikely to be acceptably achievable then the suitability of the land use was identified for review. The ability to acceptably develop the land was generally based on the DCP controls recommended in the 1996 Study and reviewed later in this report.

The review identified the following for consideration:

- The land immediately south of Montefiores Street is substantially within a high flood risk precinct. The E3 Environmental Management zoning could be considered appropriate but the minimum lot size of 2,000 m^2 may not always be sufficient to facilitate the development of dwelling houses on a vacant lot where there is inadequate land outside of the high flood risk precinct.
- Similarly the vacant land at the eastern end of Gobolion Street is zoned E3 but the 2,000 m^2 minimum applicable lot size may not be sufficient to facilitate the development of a dwelling house.
- The residential sized lots surrounding Paringa Place are zoned E3 and subject to a minimum lot size of 2,000 m^2. While some of these lots are substantially within high flood risk precinct the lots appear to be all currently developed with dwelling houses. While not ideal, this is an existing flood risk issue and the recommended DCP controls aim to permit minor extensions where it can be demonstrated that flood risk is not worsened or redevelopment where flood risk is reduced.
- The vacant land at the western end of Apsley Street and Hawkins Street is zoned E3 but the 2,000 m^2 minimum applicable lots size may not be sufficient to facilitate the development of a dwelling house.

This preliminary review of land use zones was based on the level of accuracy permitted by the available overlay mapping. A final determination of the suitability of the land use zone should involve a broader consideration of planning issues (i.e. not only flood risk) and the potential for structural engineering solutions (including filling) that would not have cumulative unacceptable impacts.

E5.4 Exempt and Complying Development

Exempt development (such as outbuildings, air conditioning units, fences, etc) is development for which no consent is required. Complying development (such as change of use, demolition, general housing, etc) is development for which a complying development certificate must be obtained from Council or a private certifier. Both exempt and complying developments are generally low scale and low impact types of development, with exempt development being at the lower end of the scale. Various planning instruments specify criteria to be met in order to qualify as exempt or complying development, such as whether flood affected.

The specification of exempt and complying development is primarily governed by State Environmental Planning Policy (Exempt and Complying Development Codes) 2008 (the 'Codes SEPP'). Wellington LEP 2012 defaults to the Codes SEPP.

The Codes SEPP is divided into a number of "Codes" that deal with exempt development and different types of complying development. Those Codes of specific relevance to the FRMS are the Exempt Development Codes (Part 2), the General Housing Code (Part 3) and the Rural Housing Code (Part 3A).

The SEPP provides the following relevant definition:

> ***flood control lot*** *means a lot to which flood related development controls apply in respect of development for the purposes of dwelling houses, dual occupancies, multi dwelling housing or residential flat buildings (other than development for the purposes of group homes or seniors housing).*
> ***Note.*** *This information is a prescribed matter for the purpose of a certificate under section 149 (2) of the Act.*

The SEPP provides a number of exclusions to what can be considered exempt development, including:

- earthworks and retaining walls on a flood control lot are excluded (clause 2.29);
- a fence or gate behind the building line on a flood control lot in urban areas is excluded (clause 2.33);
- a fence or gate forward of the building line on a flood control lot in urban areas are excluded (clause 2.35); and
- must not "redirect or interrupt the flow of surface water" at any time (clause 2.36).

The General Housing and Rural Housing Codes also provides a number of exclusions and criteria (within clauses 3.36C and 3A.38 respectively) which in summary include:

- excludes development on a flood control lot unless specified to <u>not</u> be a:
    - flood storage area;
    - floodway area;
    - flow path;
    - high hazard area;
    - high risk area;

- must satisfy certain standards such as:
    - the floor level standard set by Council and use of flood compatible materials below that level;
    - car parking to be at the 20 year ARI flood level or higher;
    - structural soundness;
    - not increase flood effects elsewhere;
    - driveways between car parking spaces and the connecting public roadway to not be inundated by a depth of water greater than 0.3 m during a 100 year ARI flood.

High hazard and high risk areas are defined (clause 3.36C (6)) to be as identified in Council's flood study or FRMS.

The application of the Codes SEPP in relation to flood liable land is summarised on **Figure E1**.

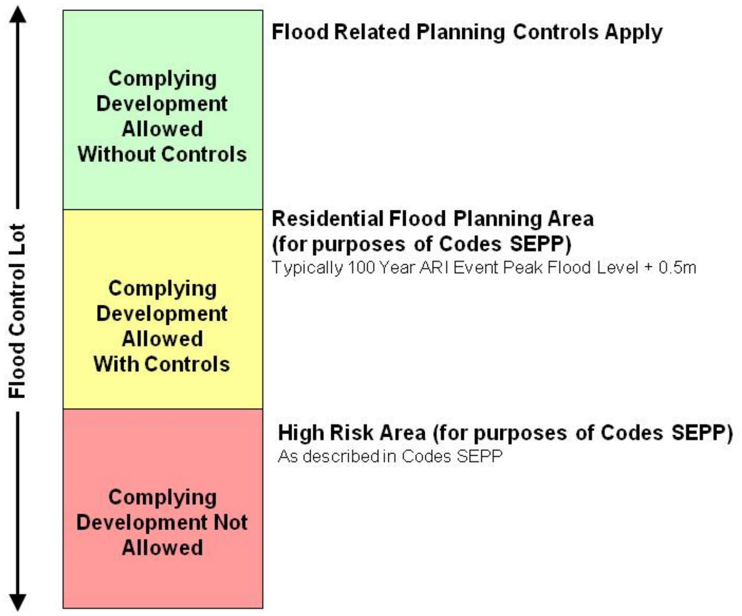


Figure E1: Application of Codes SEPP to Flood Liable Land

The Codes SEPP provides Council with the opportunity to determine where the relevant Codes would not apply, by providing that these areas can be defined as high risk or hazard by the FRMP. Where flood risk mapping is available the areas of high risk are identified. The flood risk mapping provided by the FRMS therefore provides an appropriate basis for the application of the Codes SEPP in Wellington township.

The Codes SEPP provides that unless there is sufficient information to confirm that a site is not subject to high flood risks/hazards then the relevant Codes SEPP provisions cannot be applied. That is, unless there is certainty that a site is not high risk/hazard, it must be assumed that it is for the purposes of applying the Codes SEPP. Council advises that they do not have sufficient information to confidently advise that any land is not subject to high flood risk/hazard listed in clauses 3.36C and 3A.38 of the Codes SEPP. It is understood that even with the now available flood mapping in the township there remains some uncertainty as to some of categories listed in the SEPP.

It is recommended that the FRMP specify that, at a minimum, all areas with no flood risk mapping must be assumed to be a flood storage area, floodway area, flow path, high hazard area, or high risk area for the purposes of the Codes SEPP. Should Council consider that even in the areas where flood risk mapping is now available there remains some uncertainty as to whether some category such as a flow path may exist, Council should specify that these areas also are assumed to be subject to that category. This would have the effect of excluding the application of the Codes SEPP in areas where sufficient flood risk information is not currently available, which would consequently require the lodgement of a DA where flood risk management issues could be reviewed by Council.

The Codes SEPP provides different limitations on what could be permitted as exempt development. The primary issues for flood risk management would be the potential for non-rural fences to be constructed as exempt development that detrimentally obstruct the flow of flood waters. The Codes SEPP (clauses 2.33 to 2.36) excludes such fencing from being exempt development on a flood control lot. This would necessitate the lodgement of a development application for such fencing. This is considered to provide adequate opportunity to address flood impact issues, subject to guidance being provided within DCP controls.

E6 DEVELOPMENT CONTROL

E6.1 Background

On 22 February 2006, Wellington Council resolved to amend DCP No. 1, which was the document reviewed in the 1996 FRMS. The amendment deleted everything from DCP No. 1, except the provisions for exempt and complying development. Those matters that were deleted, including provisions relating to flood prone land, were revised and incorporated into DCP No. 2.

Wellington DCP 2013 was adopted by Council on 22 May 2013 and became effective on 1 July 2013. DCP 2013 replaced DCP No.2 and reincorporated flood related development controls.

DCP 2013 now contains provisions relating to flood prone land recommended in the 1996 FRMS but not revisions prepared since, including the current FRMS. The recommendations in this section provide suggested updates to DCP 2013 that accord with the approach outlined in the current FRMS, including this appendix.

The amendments to DCP 2013 would be best undertaken in conjunction with the future review of LEP 2012 recommended above. This would ensure consistency between the LEP and DCP, particularly in regard to the definition of flood liable land and reliance of the flood risk maps (showing high medium and low flood risk precincts). Alternatively the introduction of the recommended DCP controls may be staged, but this would not be preferred.

E6.2 Risk Management Approach to Development Control

The concept of applying a risk management approach to flood risk management to determine what is appropriate development within the floodplain was described in a paper[2], documented as part of the Hawkesbury-Nepean Flood Management Strategy[3] and later developed in greater detail within the document entitled "*Managing Flood Risk through Planning Opportunities*"[4] .

A four step process for applying a risk management approach to the preparation of planning strategies and development controls to address flood risk is described below:

- **Step 1 - Mapping flood risk precincts** – this involves dividing the floodplain (i.e. all land affected up to the PMF) into areas with similar levels of risk. The number of precincts may vary between different floodplains but as a general guide it is desirable to maintain the three tier category of low, medium and high.
- **Step 2 – Categorising flood risk precincts** – identifying the risk to development, including both property and persons, associated with each of the flood risk precincts.

2 Bewsher & Grech, May 1997

3 HNFMAC, November 1997, Appendix C

4 HNFMSC, June 2006(a), pages 113 – 136

- **Step 3 – Prioritising land uses in the floodplain** – this involves identifying discrete categories of land uses with similar levels of vulnerability to the flood hazard and identifying the flood risk precincts within which they should be permitted or prohibited. Ideally this would be undertaken as part of the planning process as discussed above.
- **Step 4 – Identifying controls to modify building form and response to flooding** - where the planning process determines land uses are appropriate, but still subject to flood risk. Different planning and building controls can be imposed to minimise potential damages and to maximise the ability of the community to respond (i.e. preparedness and capacity to evacuate) during a flood. The types of development controls that would typically be applied are discussed later.

The above approach was recommended in earlier draft reviews of the 1996 Study. This approach will require an amendment to DCP 2013 to replace the existing flood related development controls contained in section ***C2 Flood Hazard*** of the DCP. The intent is for the new draft flood risk management DCP provisions to be ratified through the 2005 FDM process and endorsed with the adoption of Wellington FRMP 2013, prior to being implemented by Council through the EP&A Act process.

E6.3 Recommended DCP Controls

The recommended basic structure of the new FRM DCP chapter is set out as follows:

- The existing simplified flood hazard section within clause C2 of DCP 2013 should be replaced.
- The chapter should be generally structured to conform to the style and level of detail of the overall DCP as far as possible. However, due to the complex nature of flooding issues and the relative significance of the issue, the flood risk management provisions will unavoidably be more complex.
- The chapter should apply to all areas within the LGA affected by flooding (irrespective of whether mapped or not);
- Definitions to be consistent with the 2005 FDM where relevant.
- Objectives to include the broader flood risk management issues such as emergency evacuation and climate change.
- Controls are to relate to the following considerations:
  - (a) Floor level:
  - (b) Building components and method;
  - (c) Structural soundness;
  - (d) Flood affectation;
  - (e) Car parking and driveway access;
  - (f) Evacuation; and
  - (g) Management and design.
- Multiple flood planning levels to be applied to different parts of a development (e.g. habitable and non-habitable floors, car parking, etc) and different land uses, where appropriate.

- No controls are to apply to standard residential development on land above the 1% AEP (plus freeboard), except a requirement to consider emergency management issues (i.e. ability to safely evacuate or shelter during floods up to an extreme flood). This exception will invoke a requirement to apply for "exceptional circumstances" dispensation in accordance with the 2007 *Flood Planning Guideline*. To avoid delaying the implementation of the recommended DCP planning controls, the DCP could be amended in two stages. The second amendment could provide additional emergency management controls deferred until "exceptional circumstances" dispensation has been granted.
- Controls to apply FPLs up to the PMF to land uses considered more sensitive to flood hazards or which may be critical to emergency management operations or the recovery of the community post floods.
- Special considerations for filling and fencing.
- General considerations to recognise that compliance with the FRM controls is not authorisation for development that would be otherwise unacceptable due to other issues (e.g. excessive height leading to unacceptable streetscape and/or environmental and amenity impacts).
- Information requirements which specify the need and scope for a flood study where existing information is not available but flood hazards are suspected.

The use of flood compatible building materials and methods can be an important flood risk management measure. This matter is addressed in detail within "*Reducing Vulnerability of Buildings to Flood Damage – Guidance on Building in Flood Prone Areas"* (HNFMAC, June 2006c). This document is an invaluable source of information but is not presented in a format that would be readily applicable in the Development Application (DA) assessment or Construction Certificate (CC) Certification processes. The relevant elements of this document require translation to a "building code" that could be appended to or referred to in Council's DCP as a standard condition for building in parts of the floodplain. Additionally a draft national standard is being prepared through the Australian Building Codes Board. Consequently while a generalised definition of flood compatible materials and methods can be provided in the DCP it is recommended that this be reviewed at a later date.

Draft recommended DCP provisions are provided at **Annexure E1**. These recommended provisions should be considered by Council and ultimately adopted in accordance with the DCP making process specified by the EP&A Act. Central to the recommended DCP controls is the flood planning control matrix (**Schedule A** of **Annexure E1**). The principal controls contained within the matrix within the DCP include:

- Minimum floor level of residential dwellings located within the Medium and Low Flood Risk Precinct must be the flood level corresponding to the 1% AEP flood plus 500 mm.
- Controls on earthworks and fill that alter land surface levels.
- Controls on the location of essential services such as hospitals and emergency services.
- Restrictions on buildings within the High Flood Risk Precinct - developments must be located outside the High Flood Risk Precinct.

- Strict controls on earthworks and fill that alter land surface levels within the High Flood Risk Precinct.

Note that these controls are similar to those proposed in the 1996 Study and therefore do not result in any additional imposition for developers. The land use categories of subdivision and tourist related development have been deleted and dealt with elsewhere to simplify the matrix. Schedule B is included to clarify what development types are included in each land use category utilising the group term definitions from the Standard Instrument (on which LEP 2012 is based).

E7 REFERENCES

Bewsher, D. & P. Grech, May 1997, *A New Approach to the Development of Floodplain Controls for Floodplains*. Paper presented to the 37th Annual Floodplain Management Conference - Maitland.

Georges River Floodplain Management Committee (May 2004). *Georges River Floodplain Risk Management Study & Plan.* Prepared by Bewsher Consulting Pty Ltd and Don Fox Planning Pty Ltd.

Hawkesbury-Nepean Floodplain Management Steering Committee (HNFMSC), June 2006a, 'Managing Flood Risk Through Planning Opportunities – Guidance on Land Use Planning in Flood Prone Areas'.

Hawkesbury-Nepean Floodplain Management Steering Committee (HNFMSC), June 2006b, '*Designing Safer Subdivisions – Guidance on Subdivision Design in Flood Prone Areas*'.

Hawkesbury-Nepean Floodplain Management Steering Committee (HNFMSC), June 2006c, 'Reducing Vulnerability of Buildings to Flood Damage – Guidance on Building in Flood Prone Areas'.

NSW Government (2005). *The Floodplain Development Manual.* Department of Infrastructure, Planning and Natural Resources

Annexure E1 – Draft Recommended DCP Controls

C2 Flood Hazard

C2.1 Aim

- To manage the risk to human life and damage to property caused by flooding through controlling development on land affected by potential floods.

Notes

1. The planning controls in this section reflect the recommendations of the Wellington Floodplain Risk Management Plan 2013 prepared in accordance with the State Government Flood Prone Lands Policy and Floodplain Development Manual. In areas where Floodplain Risk Management Plans have not yet been adopted, the planning controls reflect Council Policy and are considered to be consistent with the principles of the State Government Flood Prone Lands Policy and *Floodplain Development Manual*.

2. This section should be read in conjunction with the Wellington LEP controls, in particular clause 6.1. Definitions provided by clause 6.1 of the LEP apply and are derived from the *Floodplain Development Manual*. For ease of reference, pertinent definitions include:

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

   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 flooding associated with major drainage before entering a watercourse, as defined by the Floodplain Development Manual (NSW Government 2005).*

   Flood compatible building components and methods *refers to the type and positioning floor coverings, wall and roof structure, wall and ceiling linings, doors, windows, insulation, wiring (including outlets, switches and junctions) in a manner that is capable of withstanding flooding.*

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

3. For the purposes of applying this plan within the township of Wellington, an equivalent flood, being an extreme flood from the Macquarie River (**EMAC**) is used in place of a PMF.

4. This section of the DCP does not apply in the circumstances of local drainage inundation as defined in the Floodplain Development Manual and determined by Council. Local drainage problems can generally be minimised by the adoption of building controls requiring a minimum difference between finished floor and ground levels.

C2.2 Objectives

1. The risk associated with the inundation of development is minimised and not increased beyond the level acceptable to the community.
2. The additional economic and social cost which may arise from damage to property from inundation is not greater than that which can reasonably be managed by the property owner and general community.
3. Effective warning time is available for the safe evacuation of an area potentially affected by floods.
4. Development does not detrimentally increase the potential flood impact 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.
5. Development does not result in significant impacts upon the amenity of an area by way of unacceptable overshadowing of adjoining properties, privacy impacts (e.g. by unsympathetic house-raising) or by being incompatible with the streetscape or character of the locality.
6. To avoid an unacceptable adverse impact upon the ecological value of the waterway corridors, and where possible, provide for their enhancement.
7. To ensure fencing is designed to have a minimal effect on flood behaviour and to avoid the potential to become debris that is carried away with flood waters.

C2.3 General Development Requirements

1. Compliance with the requirements of **Schedule A.** Refer to **Schedule B** for the applicable land use category for the purposes of applying **Schedule A**.

C2.4 Development Requirements for Fencing

1. All new solid (non-porous) and continuous fences above 0.6m high within a high flood risk precinct must be a security/ permeable/ open type/safety fence of a type approved by Council.
2. The fence should not create impediment to the flow of floodwaters. Appropriate fences must satisfy the following:
   a. An open collapsible hinged fence structure or pool type fence;
   b. Other than a brick or other masonry type fence (which will generally not be permitted); or
   c. A fence type and siting criteria as prescribed by Council.
3. Other forms of fencing may be considered by Council on merit.

C2.5 Development Requirements for Filling

1. For the purposes of this clause, filling means the placing of material on a site to raise the level of the site as at the date of the adoption of this section of the DCP, by more than 100mm over 200m².

2. Filling on flood prone land is not permitted unless a report from a suitably qualified civil engineer is submitted to Council that certifies that the development will not increase flood impacts elsewhere, or Council otherwise determines that a report is not required.

C2.6 Information Requirements

1. For large scale developments (such as residential development involving more than 20 lots or dwellings), or developments in critical situations (such as in a High Flood Risk Precinct), a flood study using a fully dynamic one or two dimensional computer model may be required.

2. For smaller developments consideration may be given to the use of historical flood levels or a flood study prepared in a manner consistent with the "*Australian Rainfall and Runoff*" publication and the *2005 Floodplain Development Manual*.

3. Where the controls require an assessment of structural soundness during potential floods, the following impacts must be addressed having regard to the likely depths and velocities of flood waters:
   a. Hydrostatic pressure;
   b. Hydrodynamic pressure;
   c. Impact of debris; and
   d. Buoyancy forces.

Schedule A: Flood Planning Control Matrix

Planning Consideration	High Flood Risk						Medium Flood Risk						Low Flood Risk					
	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					1	4			2,6	1,5,6	1	4		3		1,5,6	2,6	4
Building Components and Method					1	1			1	1	1	1		1		1	1	1
Structural Soundness					1	1			1	1	1	1		3			2	
Flood Effects					1	1			2	2	2	2		2		2	2	
Car Parking and Driveway Access					2,4, 6,7	2,3, 4,6,7			1,3, 5,7	1,3, 5,7	2,4, 6,7	2,3, 4,6,7		1,3, 5,6,7		1,3, 5,7	1,3, 5,7	2,3, 4,6,7
Evacuation					4	2			2,3	1,3	4	2		2,3,4	2,3, 4,5	1,3	2,3	
Management and Design					1,2,3,5	2,3,5			1	1,2,3,5	1,2,3,5	2,3,5		4,5	1	1	1	

Notes: Controls to be deferred until 'exceptional circumstances' dispensation is obtained. Not Relevant Unsuitable Land Use

1 Freeboard equals an additional height of 500 mm.
2 The relevant environmental planning instruments (generally the Local Environmental Plan) identify development permissible with consent in various zones in the local government area. Notwithstanding, constraints specific to individual sites may preclude Council granting consent for certain forms of development on all or part of a site. The above matrix identifies where flood risks are likely to determine where certain development types will be considered 'unsuitable' due to flood related risks.
3 Filling of the site, where acceptable to Council, may change the flood risk precinct considered to determine the controls applied in the circumstances of individual applications.

Floor Level
1 All floor non-habitable levels to be equal to or greater than the 2% AEP flood level unless justified by site-specific assessment.
2 Habitable floor levels to be equal to or greater than the 1% AEP flood level plus freeboard.
3 All floor levels to be equal to or greater than the EMAC level plus freeboard.
4 Floor levels to be equal to or greater than the 1% AEP flood level plus freeboard. 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 Habitable floor levels to be equal to or greater than the 1% AEP flood level plus freeboard. If this level is impractical for a development in a Business zone, the floor level should be as high as possible.
6 A restriction is to be placed on the title of the land, pursuant to Section 88B of the *Conveyancing Act 1919*, where the lowest habitable floor area is elevated more than 1.5 metres above finished ground level, confirming that the undercroft area is not to be enclosed. Also, if the flood depth at the location is greater than 1.5 metres the restriction should also prevent site filling for slab on ground construction.

Building Components and Method
1 All structures to apply flood compatible building components and methods below the 1% AEP flood level plus freeboard.

Structural Soundness
1 Engineers report to certify that the structure can withstand the forces of floodwater, debris and buoyancy up to and including a 1% AEP flood plus freeboard.
2 Applicant to demonstrate that the structure can withstand the forces of floodwater, debris and buoyancy up to and including a 1% AEP flood plus freeboard. 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 an EMAC. An engineer's report may be required.

Flood Effects
1 Engineers report required to certify that the development will not increase flood effects elsewhere, having regard to: (i) loss of flood storage; (ii) changes in flood levels, flows and velocities caused by alterations to flood flows; and (iii) the cumulative impact of multiple similar developments in the vicinity.
2 The impact of the development on flooding elsewhere to be considered having regard to the three factors listed in consideration 1.

Car Parking and Driveway Access
1 The minimum surface level of a car parking space, which is not enclosed (e.g. open parking space or carport) shall be as high as practical, but no lower than the 5% AEP flood level or the level of the crest of the road at the location where the site has access.
2 The minimum surface level of a car parking space, which is not enclosed, shall be as high as practical.
3 Enclosed car parking or basement car parks capable of accommodating more than 3 motor vehicles on land zoned for urban purposes, must be protected from inundation by floods equal to or greater than the 1% AEP flood plus 0.1 m.
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 The level of the driveway providing access between the road and parking space shall be a minimum of 0.1m above the 1% AEP flood or such that depth of inundation during a 1% AEP flood is not greater than either the depth at the road or the depth at the car parking space. 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 three vehicles at a level below the 5% AEP flood level or at a level that is more than 0.8m below the 1% AEP 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 1% AEP flood. Note: A flood depth of 0.3m is sufficient to cause a typical vehicle to float.

Evacuation
1 Reliable access for pedestrians required during a 1% AEP flood.
2 Adequate flood warning is available to allow safe and orderly evacuation without increased reliance upon the SES or other authorised emergency services personnel.
3 The development is to be consistent with any relevant flood evacuation strategy or similar plan.
4 The evacuation requirements of the development are to be considered. An engineer's report will be required if circumstances are possible where the evacuation of persons might not be achieved within the effective warning time.
5 Reliable access for pedestrians or vehicles required during an EMAC to a publicly accessible location above the EMAC.

Management and Design
1 Applicant to demonstrate that potential development as a consequence of a subdivision proposal can be undertaken in accordance with this Plan.
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 area is available to store goods above the 1% AEP flood level plus freeboard.
4 Applicant to demonstrate that area is available to store goods above the EMAC level.
5 No storage of materials below the design floor level which may cause pollution or be potentially hazardous during any flood.

Schedule B: Land Use Categories

Critical Uses and Facilities	Sensitive Uses and Facilities	Residential
Emergency services facilities; 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; correctional centre; telecommunications facility; educational establishments; liquid fuel depot; electricity generating works; development including sewerage treatment plant; telecommunications facility; and water treatment facility 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; respite day care centres; and seniors housing.	Caravan park (long-term sites for permanent occupants i.e. other than short-term sites)(see Note 1); child care centre; exhibition home; home based child care centre; home business; home industry; home occupancy; home occupation (sex services); hostel; moveable dwelling; neighbourhood shop; permanent group home; tourist and visitor accommodation
Commercial or Industrial	**Recreation or Non-urban Uses**	**Concessional Development**
Air transport facility; amusement centre; car park; community facility (other than critical and sensitive uses and facilities); correctional centre; crematorium; depot; entertainment facility; exhibition village; freight transport facility; function centre; health services facility; heavy industrial storage establishments; highway service centre; industrial retail outlet; industrial training facility; industry; liquid fuel depot; mixed use development; mortuary; passenger transport facility; place of public worship; public administration building (other than critical uses and facilities); recreation facility (major); registered club; restricted premises; retail premises; rural industry; service station; sex services premises; storage premises; transport depot; truck depot; vehicle body repair workshop; vehicle repair station; veterinary hospital; warehouse or distribution centre; waste or resource management facility; and wholesale supplies.	Agriculture; airstrip; animal boarding or training establishment; biosolids treatment facility; boat launching ramp; boat repair facility; boat shed; Camp site and caravan site – short term sites(see Note 1); caravan park (with non permanent occupants) (see Note 1); cemetery; charter and tourism boating facility; environmental facility; environmental protection works; extractive industry; farm building: helipad: information and education facility; kiosk; jetty; marina; mine; mining; plant nurseries; port facilities; public utility undertaking (other than critical uses or facilities); recreation area; recreation facility (indoor); recreational facility (outdoor); research station; resource recovery facility; roadside stall; stock and sale yard; utility installations (other than critical uses and facilities); water recreation structure; and water supply systems.	(i) Redevelopment for the purposes of substantially reducing the extent of flood affectation to the existing building, or (ii) Additions or alterations to an existing dwelling up to 20m² to the habitable floor area which existed at the date of commencement of this Plan; or (iii) Garages or outbuildings with a maximum floor area of 20 m².

Note 1: As defined by the Local Government (Manufactured Home Estates, Caravan Parks, Camping Grounds and Moveable Dwellings) Regulation 2005

Wellington Council

WELLINGTON FLOODPLAIN RISK MANAGEMENT STUDY

Appendix F
Apsley Drainage Study

January 2013

Date: 16/01/2013

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

F1. INTRODUCTION

Wellington Council engaged Evans & Peck Pty Ltd in 2011 to undertake a drainage study of the Apsley Drain. This drainage study was to present an assessment of overland flow flood conditions in the Apsley Drain catchment, and an assessment of options for the mitigation of flood impacts. **Figure F1** displays the Apsley Drain catchment area and major drainage lines.

F1.1 Background

Wellington Council engaged Lyall & Macoun Consulting Engineers to prepare the 1996 *Wellington Floodplain Management Study and Plan*. The Study and Plan were subsequently adopted by Wellington City Council. The Study described the Wellington floodplain and defined flooding characteristics, quantified flood damages and determined flood hazards. Existing and potential floodplain management measures were described and appropriate measures for inclusion in the Floodplain Management Plan were identified and prioritised.

Subsequently, Wellington Council engaged Evans & Peck to carry out a review and update of the 1996 *Wellington Floodplain Management Study and Plan*, including undertaking an overland flow assessment of the Apsley Drain.

This Drainage Study presents Evans & Peck's assessment of flood conditions in the Apsley Drain catchment, and forms an appendix to the 2013 *Wellington Floodplain Risk Management Study and Plan*. This Drainage Study is not intended to be a formal flood study or stand-alone floodplain risk management study in accordance with the NSW Floodplain Development Manual, but to instead present sufficient hydrologic and hydraulic analysis to enable a simple assessment of flood mitigation options within the catchment and recommend a potential flood mitigation option for further development.

F1.2 Objectives

The primary objectives of this Drainage Study are to:

- Define the overland flow flood behaviour of the catchment by quantifying overland flood flows and levels for a range of design flood events under existing catchment conditions along the trunk stormwater channel, via the development of a hydrologic/hydraulic model of the trunk channel system;
- Assess the effectiveness of a number of physical flood mitigation measures by modelling their impact in the hydrologic/hydraulic model and comparing results to those for existing conditions;
- Determine, in collaboration with Wellington Council, the preferred flood mitigation option for the catchment.

F1.3 Catchment Description

The Apsley Drain collects a network of stormwater drainage for a mostly urban catchment area of approximately 100 ha in the southern area of Wellington, NSW. The Apsley Drain flows generally west into the Bell River, which then converges a short distance north with the Macquarie River. The catchment is shown on **Figure F1**.

The catchment contains predominantly low density residential properties, with the rail corridor passing through the centre of the catchment, and two parks, Apex Park east of the rail corridor, and Kennard Park west of the corridor. The Mitchell Highway (locally Arthur Street), the main highway through Wellington, runs through the most downstream section of the catchment adjacent to Apsley Street.

The rail corridor effectively creates two distinct sub-catchments within the catchment, one upstream and one downstream of the rail corridor. All runoff from the area upstream of the rail corridor drains to a culvert beneath the railway embankment, so the culvert and embankment have the potential to form an informal detention basin in large floods. It is possible in very large floods that water could pond to a depth that would overtop the railway embankment. The low point of the railway embankment is slightly north of the culvert, adjacent to Maxwell Street. There is the potential for runoff to spill into the railway corridor from the drains along its eastern boundary in large floods. Downstream of the rail corridor, the drainage system is predominantly open channel, passing through a number of blocks of residential properties before discharging into a natural channel at the western end of Apsley Street.

An additional rural area of approximately 85 ha is also included in this Drainage Study. Stormwater from two small rural areas is generated from hills that drain into a local dam south-east of the Apsley Drain catchment and also directly to Charles Street and Pierce Street (see **Figure F1**). In flood events, overland flow from these rural catchments may flow north-west along Pierce Street to the intersection with Charles Street, from where a proportion may spill into the Apsley Drain catchment along Pierce Street and flow to the culvert beneath the railway embankment.

F1.4 Description of Drainage System

Figure F1 shows the layout of the drainage system within the catchment.

East (upstream) of the rail embankment in the main catchment area, a small open drain runs south along Kennard Street from the intersection of Swift Street and Kennard Street, collecting runoff from Swift, Simpson, Thornton and Jean Streets. This drain then runs along the western boundary of Apex Park adjacent to the railway corridor, but is poorly defined in places. At the southern edge of Apex Park it enters two culvert headwalls, both of which pass under Maxwell Street and discharge into an open channel that runs south adjacent to Railway Avenue to the culvert beneath the railway embankment. A number of large diameter pipes that drain a sub-catchment including Thornton and Pierce Streets also discharge into the open channel at the intersection of Maxwell Street and Railway Avenue. A separate pipeline (not modelled) drains the southern sub-catchment via Zouch Street to the culvert beneath the railway embankment. As mentioned above, some overland flow may spill into this catchment from the intersection of Charles and Pierce Streets in large floods.

The culvert beneath the railway embankment is a twin culvert, with a circular 900 mm culvert in parallel with a brick arch culvert 1500 mm wide and 1150 mm high.

West (downstream) of the railway embankment, flow exiting the railway culvert enters a culvert beneath Cross Street immediately downstream of the railway corridor. Downstream of Cross Street an open concrete channel runs through a number of properties, with the channel becoming covered at the rear of 72 Zouch Street and passing beneath Zouch Street. The concrete channel then re-opens as it passes through the north-west corner of Kennard Park, before it passes through a culvert beneath Simpson Street. Between Simpson and Arthur Streets, the concrete channel is open for the entire length, passing some 220 m through residential properties. The channel in this area is approximately 1 m deep and 2.5 m wide at the top. The channel then passes beneath Arthur Street in a 3 m wide and 0.9 m high box culvert, before opening again into a concrete channel that flows adjacent to Apsley Street before discharging to a natural channel at the western end of Apsley Street.

For the purposes of this Drainage Study, the focus of the modelling was on the open channel trunk drainage system, not the contributing pit and pipe system, as the objective was to determine the extent of overland flow flooding along this trunk line.

Wellington Council has indicated that it considers the potential flooding in the catchment to be major overland flow flooding as defined by the NSW Floodplain Manual, as it occurs along a trunk system, involves depths of flow in excess of 0.3 m, and has the potential to flood a number of properties.

F1.5 Areas of Potential Flooding Concern

Wellington Council requested that the assessment specifically examine the existing flood behaviour around the following properties:

- the single property on the railway side of the intersection between Kennard Street (Simpson Street) and Swift Street;
- several properties facing the railway line along Railway Avenue east of the culvert beneath the railway embankment;
- properties adjacent to and above the concrete channel in the residential block surrounded by Cross Street, Maxwell Street, Simpson Street and Zouch Street.
- several properties along the eastern side of Arthur St between Zouch Street and Hawkins Street adjacent to the open channel to the north and south.

Council’s concerns were based mainly on the perceived potential for flooding to occur in these areas rather than confirmed reports of flooding at these properties in the past.

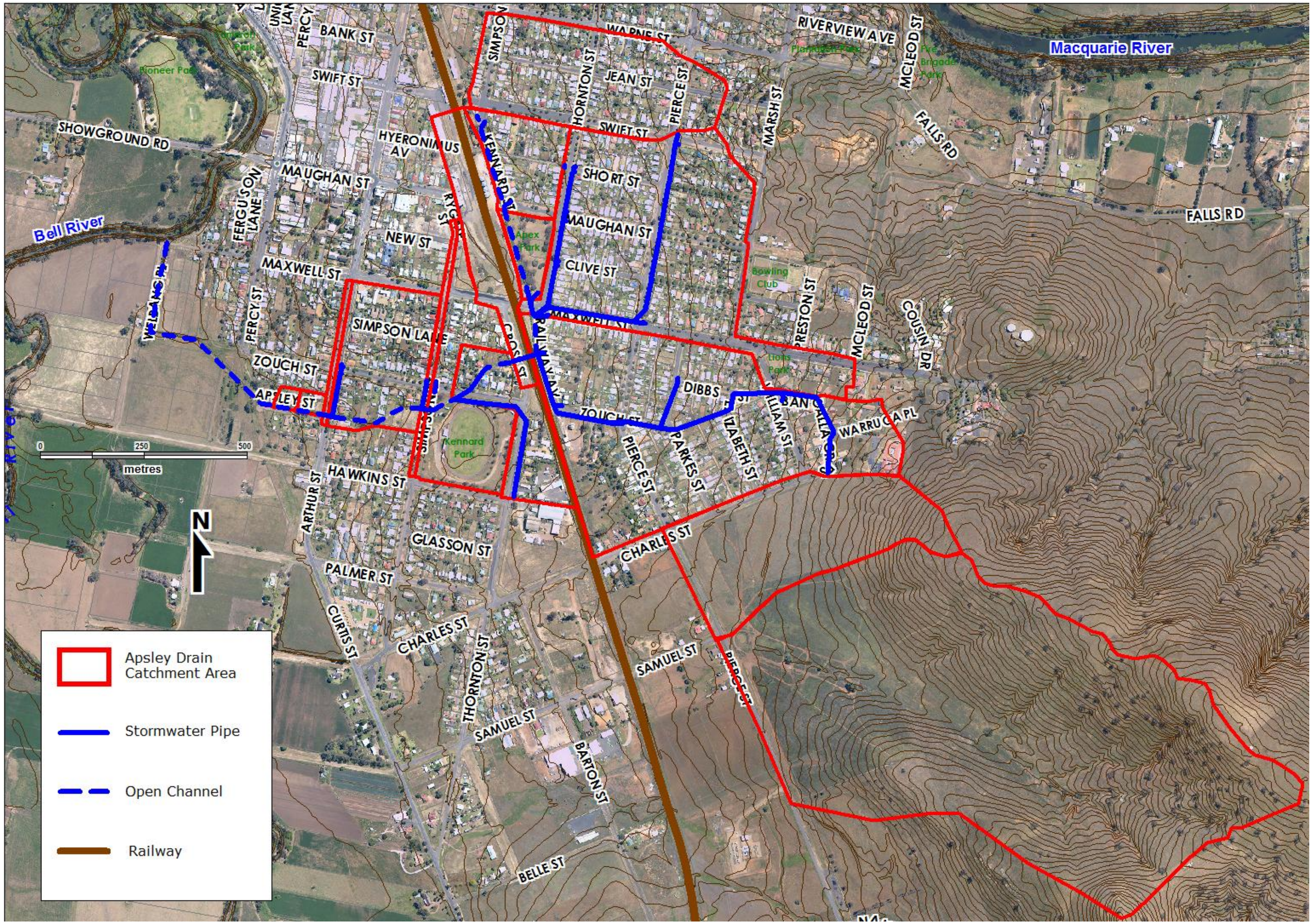


Figure F1: Apsley Drain Catchment Area and Major Drainage Lines

F2. DATA

Data utilised for this Drainage Study included data provided by Wellington Council and data sourced independently by Evans & Peck. Further details are provided in the following section.

F2.1 Design Rainfall Data

Design rainfall data for use in the hydrologic/hydraulic model was generated within the DRAINS model using intensity-frequency-duration (IFD) data for Wellington sourced from the Bureau of Meteorology's online IFD tool. Design rainfall patterns were generated within DRAINS for events from 5 to 100 years average recurrence interval (ARI) and for storm durations from 5 minutes to 9 hours for Australian Rainfall and Runoff (AR&R) Rainfall Zone 2. An antecedent moisture condition of 2 was used for each rainfall event generated from a scale of 1 to 4. This represents "rather dry" conditions with 0-12.5 mm of rain in the preceding 5 days before the storm.

F2.2 Survey

Survey of the Apsley Drain channel was initially undertaken by Wellington Council in March 2012. A dxf file was provided showing the location and elevation of surveyed points along the trunk channel and along road crests, along with some 0.2 m contours in suspected ponding areas, and ground spot levels within properties in potentially susceptible areas. Information on culvert sizes was subsequently provided.

As Evans & Peck required channel cross sections in horizontal offset vs. elevation format, Evans & Peck calculated the required offsets for each channel cross section used. In addition, as the Council channel survey was limited to the channel only to the top of bank, the GIS and LiDAR elevation data (refer Section 2.3 below) was used to extend each channel cross section into the floodplain.

In October 2012, Wellington Council provided some additional survey detail and photographs of the pipes and culverts in the vicinity of the intersection of Maxwell and Thornton Streets, as well as corrections to a number of culvert dimensions throughout the catchment.

F2.3 GIS Data

GIS data was provided to Evans & Peck by Wellington Council in two main packages. The first package was provided in May 2011 and contained the majority of Council's GIS layers. Those layers utilised for this Study included:

- Aerial photography;
- 2 m contours;
- Cadastre, road boundaries and street names;
- Stormwater pits and pipes;
- Main river flood extents and flood affected properties.

The secondary package was provided in March 2012 and included a number of layers sourced from the NSW Land and Property Information:

- LiDAR ground surface elevation spot levels;
- 0.5 m contours.

Using this data, Evans & Peck created GIS layers to represent key features of the modelling undertaken for the Drainage Study, in particular to identify sub-catchment boundaries (see **Figure** F1) and channel cross section extensions.

F2.4 Historical Flood Information

As described in **Section F1.5**, Wellington Council expressed concern regarding the perceived potential for property flooding at a number of locations within the catchment. However, no specific information was provided for historical flood dates, flood levels or properties inundated. This has meant that the hydrologic/hydraulic model was not able to be calibrated against any known flood conditions, and as such its accuracy cannot be determined. **Section F4.5** discusses model results in the areas of concern and identifies properties with the potential for flooding.

F3. METHODOLOGY

F3.1 Site Visit

A site visit was undertaken by Evans & Peck in May 2005 in the company of Council's David Babicci. The modelled trunk channel was viewed from Swift Street to Apsley Street, with the exception of inaccessible sections within private properties between Cross Street and Zouch Street, and Simpson Street and Arthur Street. In these areas, the extent of the channel observed was limited to that which could be viewed from these cross streets. Photographs were taken of all accessible areas of the trunk channel, a selection of which is presented in **Figure F2.**

F3.2 Drains Modelling

The DRAINS model was utilised for this Drainage Study as it was able to model both the catchment hydrology and the channel hydraulics within one model to provide a basic assessment of potential flood levels, and it enabled the assessment of various physical flood mitigation options. DRAINS is a one dimensional model which performs a backwater hydraulic grade line analysis, looking at each individual cross section location to calculate the predicted flood level at each section. Unlike some steady state channel models, DRAINS calculates the full flow hydrograph at all nodes within the model, meaning the full impact of detention of floodwaters is properly analysed. However, DRAINS is not a two dimensional model capable of modelling the extent, velocity and depth of floodwaters across the floodplain as defined by a 3D ground surface model, but instead relies on the model developer to enter the cross sections where flow depth is to be calculated.

F3.2.1 Drainage Network

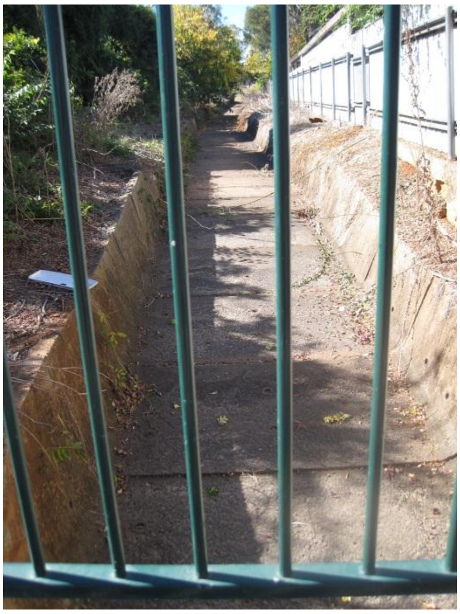
The drainage network is characterised by open earth and concrete channels, interspersed with circular and box culverts where the channel passes beneath roads or properties. The open drain and channel sections were modelled in DRAINS using the irregular channel link, which allows irregular channel cross sections to be entered and main channel and overbank areas to be defined. Nodes were introduced where channel properties changed, or where the channel enters or exits culverts.

The culvert function was used to model the culverts beneath roads and properties, with the culvert size and grade nominated along with the elevation at which flow would spill over the culvert entrance and across the road or property above the culvert, and the width of this spillway.

Where ponding of floodwater was anticipated, such as upstream of the railway corridor in Railway Avenue, at the intersection of Swift Street and Kennard Street, and on Arthur Street, detention basins were used in the model. These basins had surface areas entered for a number of elevations to determine their storage capacity. Spillage or overflow from these basins is via one or more overflow paths, for which an elevation and weir width is specified. Irregular shaped overflow crests were modelled using a number of basin overflows at differing elevations and with differing widths.

The railway culvert consists of a circular 900 mm culvert and a brick arch culvert 1500 mm wide and 1150 mm high. This culvert was modelled as a single culvert (1.8 m (W) x 1.15 m (H)) with the same height and conveyance capacity, as DRAINS is unable to model such a complex outflow arrangement from a detention basin. The large size of this culvert in conjunction with the relatively small available storage volumes in the "detention basin" in Railway Avenue resulted in some instabilities in the outflow hydrograph through the railway culvert. These instabilities occur only at the beginning and tail end of the hydrographs, and do not impact on the peak flows or flood levels presented in this report.

View upstream of Apsley St Channel



View upstream from Arthur St

View upstream from Simpson St (Kennard Pk)

View downstream from Cross St

View downstream of railway culverts

View east of houses adjacent to railway culvert

Figure F2: Photographs of Apsley Drainage System

F3.2.2 Catchment Definition and Properties

The overall catchment boundary of the Apsley Drain catchment and the boundaries of the internal sub-catchments within the overall catchment were drawn in the MapInfo GIS program using the 2 m contour lines provided by Wellington Council, in addition to the aerial photography and the layer of stormwater pipes. Sub-catchments were drawn for key locations along the trunk channel. The size of the sub-catchments varies from 0.3 ha to 70 ha, although discounting the rural sub-catchments to the south the largest sub-catchment is 25 ha.

The impervious percentage of each sub-catchment was estimated based on the GIS aerial photography. A basic residential sub-catchment was assigned a percentage impervious of 35% due to the low density nature of the residential development. Impervious percentages for sub-catchments varied from 2-90%.

Times of concentration for each sub-catchment are calculated within DRAINS using the flow path length, slope and roughness specified for each sub-catchment that are based on sub-catchment properties calculated within the GIS. Roughness values used in the kinematic wave equation calculations were 0.015 for paved areas, and 0.3 - 0.4 for grassed areas, using values quoted in the DRAINS help manual as having been sourced from AR&R 87.

F3.2.3 Definition of Overland Flow Paths

Overland flow paths were defined for all nodes in the DRAINS model where overflow can occur. While much of the trunk system was modelled as irregular open channels which do not overflow, overflow can occur at culverts, detention basins and transitions from open to covered channels where the capacity of the outlet pipe/channel and the available storage capacity are exceeded. Where an overland flow path was required, the elevation at which overflow occurs is specified along with the width of the flow path. Flow routing utilised the kinematic wave method, with a flow path length entered for each overland flow path, along with the flow path slope and typical cross section. The flow hydrograph at the downstream end of each flow path therefore allowed for routing of the hydrograph.

For areas of potential ponding of floodwaters which were modelled as detention basins, a number of overland flow paths were used to represent the variable spill levels. For example, if an overflow crest had a width of 10 m but a difference in elevation of 1 m from one end to the other, overflow from the basin may have been modelled as five 2 m wide spillways, elevated at 0.2 m elevations to replicate the true crest shape in a “stepped” fashion.

F3.2.4 Rainfall Losses and Soil Type

A paved area depression storage of 1 mm was used in the hydrological model within DRAINS, along with a grassed area depression storage of 5 mm.

The soil type was specified as 3 on a scale of 1 to 4, where 4 is the least permeable and causes the highest runoff. A soil type of 3 represents a slow infiltration rate.

F3.2.5 Manning’s Roughness

Manning’s roughness values were estimated using guidance values provided in the DRAINS program help manual. Values were specified for each irregular channel cross section, with different values potentially entered for the main channel, left overbank and right overbank. Values used in the model varied from 0.015 for the concrete channel to 0.04 for vegetated bank areas in residential garden areas, and 0.05 in vegetated areas adjacent to the rail corridor.

F3.2.6 Model Calibration

As discussed in **Section F2.4**, no historical flood information was available in the areas of concern. As such, no calibration was possible to verify the model's accuracy. The model results were assessed to determine if they appeared logical given the absence of any record of frequent property inundation but assuming the possibility of property inundation in larger floods, and the results were deemed to be logical and reasonable.

F3.3 Mitigation Options

Evans & Peck's proposal in 2011 suggested up to six potential physical flood mitigation options could be assessed. After discussion with Wellington Council, two of these options (1. diversion of headwater runoff to reduce catchment runoff, 2. regrading of Pierce Street to prevent inflows from the rural catchments) were discounted as they were not expected to have any appreciable impact on flood levels, and a further option (enlargement of the covered channel from Cross Street to Kennard Park) was included. The five physical flood mitigation options assessed were:

- **M1** – A surface detention basin in Apex Park upstream of the railway. Apex Park is the only open space available upstream of the railway embankment, and is therefore the only available space where detention of floodwaters can reduce the severity of flooding at Railway Avenue. The detention basin scheme involves earthworks in Apex Park to provide a base level of approximately 301.65 m AHD and provision for a top water level of 303.0 m AHD. The required surface area of the storage zone is 6,000 m^2 at a level of 302.0 m AHD, and 10,000 m^2 at the top water level of 303.0 m AHD. This provides for a potential storage volume of approximately 8,500 m^3 at the top water level. The outlet was modelled as a single 600 mm pipe under Maxwell Street with an invert level of 301.65 m AHD. The basin would be grass covered on the base and batters. Some drainage works would be required to divert stormwater pipes from Maxwell Street into the basin where they currently discharge to the channel downstream of Maxwell Street;
- **M2** – Enlargement of the culvert beneath the railway at Railway Parade to a 2.4m (W) x 1.2 m (H) box culvert. Enlargement of this culvert can potentially have an adverse impact on downstream areas as larger flow rates can pass under the railway embankment as the detention effect of the existing culvert is lost;
- **M3** – Enlargement of the culvert beneath the Mitchell Highway (Arthur St) to a 3.6 m (W) x 0.9 m (H) box culvert. The existing width is 3 m. The height of the culvert is limited due to the channel invert levels in the area and the limited cover above the culvert under Arthur Street, and the width is limited by the available channel width along Apsley Street downstream of Arthur Street;
- **M4** – Widening of the open channel for the 120 m section immediately upstream of the Highway (Arthur St) to 3.5 m base width (from the existing 2.5 m top width). This width is limited by the width of the channel easement between the residential properties in this area;
- **M5** – Enlargement of the covered channel from the rear of 72 Zouch Street to Kennard Park to a 2.4m (W) x 0.9 m (H) box culvert. It is currently 1.85 m wide. The extent of this enlargement was limited by the size of the channel in Kennard Park, as there is little to no advantage to be gained in introducing a significantly larger channel which then constricts to a smaller channel a short distance downstream.

Each of these options was modelled in DRAINS with the impact on flood levels at all locations within the model assessed to determine if the mitigation option had a beneficial impact. **Section F4** presents the results of the modelling.

F4. MODEL RESULTS

F4.1 Overview

The DRAINS model was run for the 5, 20 and 100 year ARI events, for storm durations from 5 minutes to 9 hours. Analysis of the results showed that the 25 minute storm duration was the critical duration for the catchment in terms of peak channel flows and for the peak water levels in the various potential detention areas for all three ARI events. Each of the flood mitigation models was run with the 25 minute duration storm to generate the tables of flows and flood levels presented in **Sections F4.2** and **0.**

Figure F3 on the following page shows the location of the model nodes quoted in the tables in **Sections F4.2** and **0.**

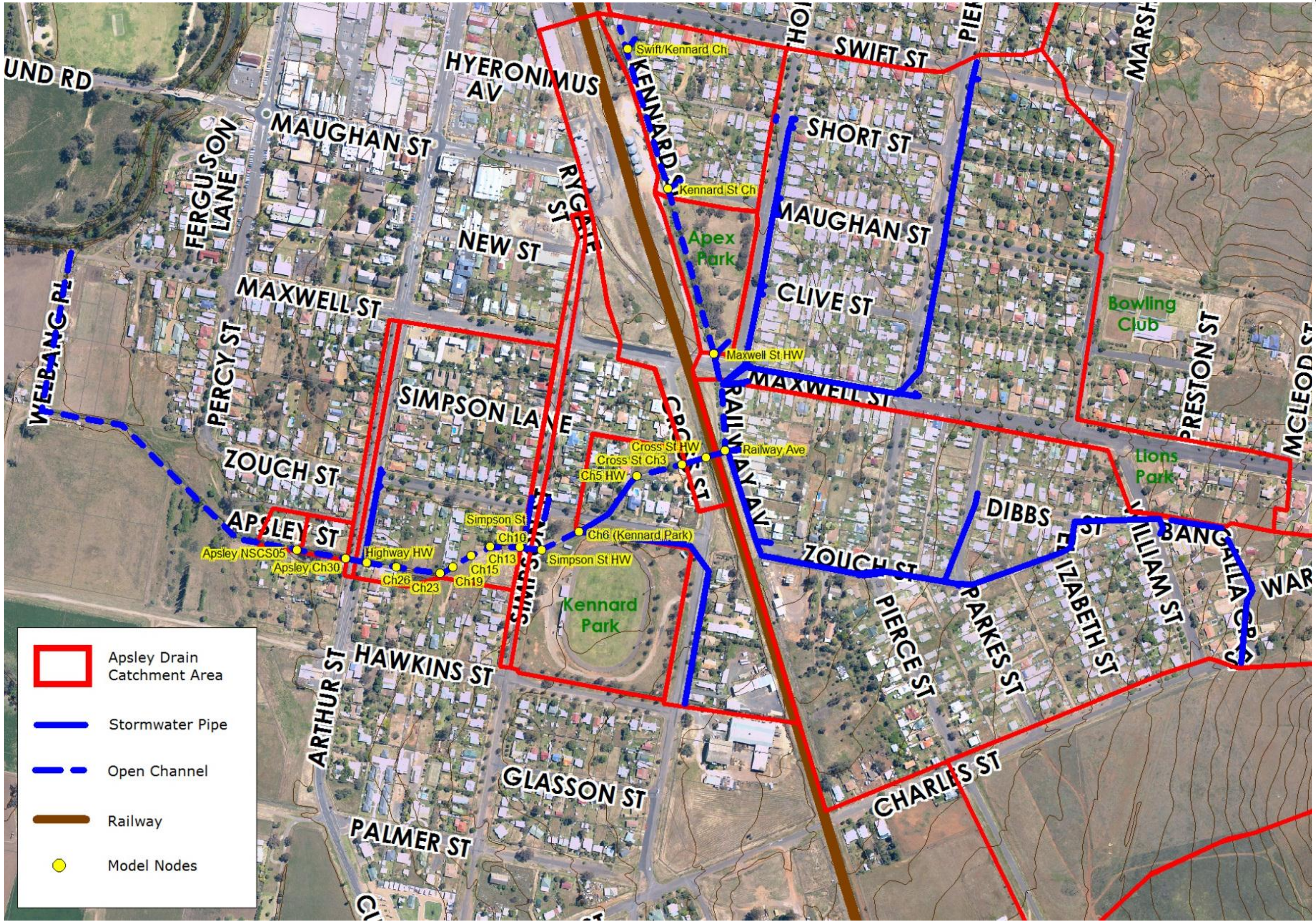


Figure F3: Model Node Locations

F4.2 Peak Flows

Table F4.1 to **Table F4.3** below present the peak flows estimated by the DRAINS model at key locations throughout the catchment. For open channel sections, a single peak flow is provided. Where flow enters a culvert, both the peak culvert flow and the peak overflow across the road surface are provided separately. **Figure F3** shows the approximate location of the quoted locations.

Table F4.1: Peak Flows (m^3/s.) - 5 year ARI Event

Location	Exist	M1	M2	M3	M4	M5
Swift/Kennard Ch	0.8	0.8	0.8	0.8	0.8	0.8
Kennard St Ch	1.1	1.1	1.1	1.1	1.1	1.1
Box Maxwell	1.1	0.4	1.1	1.1	1.1	1.1
OFlow Maxwell	0.0	0.0	0.0	0.0	0.0	0.0
Railway Ch	2.5	0.4	2.5	2.5	2.5	2.5
Railway Culv	4.0	2.1	4.0	4.0	4.0	4.0
Railway OFlow	0.0	0.0	0.0	0.0	0.0	0.0
Cross St Culv	4.1	2.2	4.1	4.1	4.1	4.1
OFlow Cross St	0.0	0.0	0.0	0.0	0.0	0.0
Cross St Ch3	4.1	2.2	4.1	4.1	4.1	4.1
Ch5 Covered Ch	3.9	2.2	3.9	3.9	3.9	4.1
OFlow Ch5	0.2	0.0	0.2	0.2	0.2	0.0
Ch6 (Kennard Park)	4.2	2.5	4.2	4.2	4.2	4.4
Simpson St Culv	4.2	2.7	4.2	4.2	4.2	4.2
OFlow Simpson St	0.4	0.0	0.4	0.4	0.4	0.4
Simpson St Ch10	4.6	2.8	4.6	4.6	4.6	4.7
Simpson Arthur Ch19	4.6	2.8	4.6	4.6	4.6	4.7
Highway Culv	4.9	3.0	4.9	4.9	4.9	5.0
OFlow Hwy HW	0.0	0.0	0.0	0.0	0.0	0.0
OFlow to Apsley	0.0	0.0	0.0	0.0	0.0	0.0
OFlow South Hwy	0.0	0.0	0.0	0.0	0.0	0.0
Apsley Ch30	4.9	3.0	5.0	4.9	4.9	5.0
Apsley NSCS05	4.9	3.0	5.0	4.9	4.9	5.0

Table F4.2: Peak Flows (m^3/s) - 20 year ARI Event

Location	Exist	M1	M2	M3	M4	M5
Swift/Kennard Ch	1.3	1.3	1.3	1.3	1.3	1.3
Kennard St Ch	1.7	1.7	1.7	1.7	1.7	1.7
Box Maxwell	1.5	0.6	1.5	1.5	1.5	1.5
OFlow Maxwell	0.5	0.0	0.4	0.5	0.5	0.5
Railway Ch	4.1	0.6	4.1	4.1	4.1	4.1
Railway Culv	6.1	2.7	6.4	6.1	6.1	6.1
Railway OFlow	0.0	0.0	0.0	0.0	0.0	0.0
Cross St Culv	4.4	2.9	4.5	4.4	4.4	4.4
OFlow Cross St	1.8	0.0	2.2	1.8	1.8	1.8
Cross St Ch3	6.3	2.9	6.6	6.3	6.3	6.3
Ch5 Covered Ch	4.4	2.9	4.4	4.4	4.4	5.5
OFlow Ch5	1.9	0.0	2.2	1.9	1.9	0.8
Ch6 (Kennard Park)	4.9	3.4	4.9	4.9	4.9	5.9
Simpson St Culv	4.2	3.7	4.6	4.2	4.2	4.3
OFlow Simpson St	3.0	0.0	3.4	3.0	3.0	3.0
Simpson St Ch10	7.1	3.9	7.3	7.1	7.1	7.2
Simpson Arthur Ch19	7.1	3.9	7.3	7.1	7.1	7.2
Highway Culv	7.5	4.4	7.6	7.5	7.5	7.6
OFlow Hwy HW	0.0	0.0	0.0	0.0	0.0	0.0
OFlow to Apsley	0.0	0.0	0.0	0.0	0.0	0.0
OFlow South Hwy	0.0	0.0	0.0	0.0	0.0	0.0
Apsley Ch30	7.5	4.5	7.7	7.5	7.5	7.6
Apsley NSCS05	7.5	4.6	7.7	7.5	7.5	7.6

Table F4.3: Peak Flows (m^3/s) - 100 year ARI Flood

Location	Exist	Ex + CC	M1	M2	M3	M4	M5
Swift/Kennard Ch	1.9	2.3	1.9	1.9	1.9	1.9	1.9
Kennard St Ch	2.6	3.0	2.6	2.6	2.6	2.6	2.6
Box Maxwell	1.5	1.5	0.7	1.5	1.5	1.5	1.5
OFlow Maxwell	1.8	2.2	0.0	1.8	1.8	1.8	1.8
Railway Ch	6.2	7.3	0.7	6.2	6.2	6.2	6.2
Railway Culv	6.9	7.1	4.0	9.0	6.9	6.9	6.9
Railway OFlow	1.6	3.4	0.0	0.0	1.6	1.6	1.6
Cross St Culv	4.6	4.7	4.3	4.6	4.6	4.6	4.6
OFlow Cross St	4.2	6.0	0.1	4.6	4.2	4.2	4.2
Cross St Ch3	8.8	10.7	4.3	9.3	8.8	8.8	8.8
Ch5 Covered Ch	4.6	4.8	4.0	4.7	4.6	4.6	5.8
OFlow Ch5	4.1	5.9	0.3	4.6	4.1	4.1	2.9
Ch6 (Kennard Park)	5.3	5.6	4.7	5.5	5.3	5.3	6.4
Simpson St Culv	4.3	4.4	4.3	4.4	4.3	4.3	4.4
OFlow Simpson St	5.9	8.3	1.3	6.7	5.9	5.9	5.9
Simpson St Ch10	9.7	11.9	5.8	10.5	9.7	9.7	9.7
Simpson Arthur Ch19	9.7	11.9	5.8	10.5	9.7	9.7	9.7
Highway Culv	8.4	8.7	6.6	8.5	9.9	8.4	8.4
OFlow Hwy HW	1.8	3.9	0.0	2.7	0.3	1.8	1.8
OFlow to Apsley	0.1	0.5	0.0	0.3	0.0	0.0	0.0
OFlow South Hwy	1.7	3.4	0.0	2.4	0.3	1.7	1.7
Apsley Ch30	8.5	9.2	6.7	8.8	9.9	8.5	8.5
Apsley NSCS05	8.6	9.3	6.7	8.9	10.0	8.6	8.6

Analysis of the peak flow rates across the various mitigation options shows that Option 1 is very effective at reducing peak flows throughout the main channel, with flow reductions of around 40% common. Option 2 causes increased flows through the rail culvert, which are then conveyed further downstream, causing increases of around 10 % in peak channel flow upstream of Arthur Street. The impact of Option 3 on flows is only felt downstream of the Highway culvert with an increase of around 18 %. While Option 4 has no discernible impact on peak flows, Option 5 causes a localised increase in channel flow and decrease in overland flow around node Ch5. The impact of this extends to Simpson Street but not beyond. Option 1 therefore has the most pronounced and beneficial impact on peak flood flows within the catchment.

F4.3 Peak Flood Levels

The DRAINs model conducts a full hydraulic grade line analysis from the downstream end of the model to the most upstream node. The hydraulic grade line is presented at each node in the model, which may be a culvert entrance, a channel node or a detention basin. **Table F4.4** to **Table F4.6** present the peak flood levels at each key node location throughout the catchment as estimated by the DRAINS model.

The entries in **Table F4.4** to **Table F4.6** are colour coded to provide information on how the flood level relates to the level of the channel banks or nearby buildings, and also on what impact the mitigation option has on the flood level when compared to existing conditions. The adopted colour coding is provided below.

Text Colour	
303.91	Water level is within channel banks
303.91	Water level has broken banks but is unlikely to flood habitable areas
303.91	Water level may flood habitable areas
Cell Shading	
303.91	Mitigation scheme causes no change in flood levels
303.91	Mitigation reduces flood level when compared to existing conditions
303.91	Mitigation increases flood level by <0.03 m when compared to existing conditions
303.91	Mitigation increases flood level by >0.03 m when compared to existing conditions

Table F4.4: Flood Level (m AHD) - 5 year ARI Event

Location	Est. Floor Levels#	Key Control Levels*	Exist	M1	M2	M3	M4	M5
Swift/Kennard Ch	305.20	TB304.88	304.60	304.55	304.60	304.60	304.60	304.60
Kennard St Ch	304.80	TB303.99	303.75	303.93	303.75	303.75	303.75	303.75
Maxwell St HW (Apex Pk)	303.25	TB302.81 S302.98	302.68	302.31	302.68	302.68	302.68	302.68
Railway Ave	302.76	TB302.24 S302.83	302.10	301.68	301.89	302.10	302.10	302.10
Cross St HW	(301.45)^	TB301.56 S301.90	301.84	301.44	301.84	301.84	301.84	301.84
Cross St Ch3	(301.10)^	TB301.10	**301.16**	300.73	**301.17**	**301.16**	**301.16**	**301.16**
Ch5 HW (Zouch St)	300.55	TB300.32 S300.50	**300.55**	300.19	**300.55**	**300.55**	**300.55**	300.40
Ch6 (Kennard Park)	N/A	TB298.82	298.59	298.37	298.59	298.59	298.59	298.62
Simpson St HW	N/A	TB297.92 S298.15	**298.18**	297.86	**298.18**	**298.18**	**298.18**	**298.18**
Simpson St Ch10	297.80	TB297.89	297.29	297.04	297.29	297.29	297.29	297.30
Simpson Arthur Ch13	297.50	TB296.85	296.72	296.60	296.72	296.72	296.72	296.72
Simpson Arthur Ch15	296.60	TB296.34	296.09	295.80	296.09	296.09	296.09	296.09
Simpson Arthur Ch19	296.30	TB295.79	295.56	295.30	295.56	295.56	295.28	295.57
Simpson Arthur Ch23	296.30	TB295.33	**295.47**	294.99	**295.47**	**295.47**	294.91	**295.47**
Simpson Arthur Ch26	294.53	TB294.39	**294.62**	294.34	**294.63**	**294.62**	294.31	**294.63**
Highway HW	294.53	TB294.38 S294.45	293.78	293.51	293.78	293.67	293.78	293.79
Apsley Ch30	293.74	TB294.01	293.39	293.11	293.40	293.39	293.39	293.40
Apsley NSCS05	292.96	TB293.03	292.84	292.52	292.84	292.84	292.84	292.84

* TB nominates the level at which the channel will break its banks, S nominates the lowest spill level of the headwall or pond area.
# Habitable floor levels estimated based on closest ground level to house + 300 mm
^ Property is not immediately adjacent to the channel area and may not be inundated by floodwaters

Table F4.5: Flood Levels (m AHD) - 20 year ARI Flood

Location	Est. Floor Levels#	Key Control Levels*	Exist	M1	M2	M3	M4	M5
Swift/Kennard Ch	305.20	TB304.88	304.70	304.63	304.70	304.70	304.70	304.70
Kennard St Ch	304.80	TB303.99	303.82	**304.01**	303.82	303.82	303.82	303.82
Maxwell St HW (Apex Pk)	303.25	TB302.81 S302.98	**303.02**	302.50	**303.01**	**303.02**	**303.02**	**303.02**
Railway Ave	302.76	TB302.24 S302.83	**302.55**	301.83	302.26	**302.55**	**302.55**	**302.55**
Cross St HW	(301.45)^	TB301.56 S301.90	**302.00**	301.60	**302.01**	**302.00**	**302.00**	**302.00**
Cross St Ch3	(301.10)^	TB301.10	**301.25**	300.84	**301.26**	**301.25**	**301.25**	**301.25**
Ch5 HW (Zouch St)	300.55	TB300.32 S300.50	**300.71**	300.35	**300.73**	**300.71**	**300.71**	**300.62**
Ch6 (Kennard Park)	N/A	TB298.82	**299.02**	298.49	**299.02**	**299.02**	**299.02**	**299.08**
Simpson St HW	N/A	TB297.92 S298.15	**298.28**	298.08	**298.30**	**298.28**	**298.28**	**298.28**
Simpson St Ch10	297.80	TB297.89	**297.91**	297.19	**297.91**	**297.91**	**297.91**	**297.91**
Simpson Arthur Ch13	297.50	TB296.85	296.83	296.68	296.84	296.83	296.83	296.83
Simpson Arthur Ch15	296.60	TB296.34	296.28	296.03	296.28	296.28	296.28	296.28
Simpson Arthur Ch19	296.30	TB295.79	295.72	295.50	295.82	295.72	295.53	295.73
Simpson Arthur Ch23	296.30	TB295.33	**295.54**	295.17	**295.54**	**295.54**	295.10	**295.54**
Simpson Arthur Ch26	294.53	TB294.39	**294.78**	**294.55**	**294.79**	**294.78**	**294.58**	**294.78**
Highway HW	294.53	TB294.38 S294.45	294.30	293.72	294.34	293.95	294.30	**294.33**
Apsley Ch30	293.74	TB294.01	293.57	293.27	293.58	293.57	293.57	293.58
Apsley NSCS05	292.96	TB293.03	292.94	292.82	292.94	292.94	292.94	292.94

* TB nominates the level at which the channel will break its banks, S nominates the lowest spill level of the headwall or pond area.

\# Habitable floor levels estimated based on closest ground level to house + 300 mm

^ Property is not immediately adjacent to the channel area and may not be inundated by floodwaters

Table F4.6: Flood Levels (m AHD) - 100 year ARI Event

Location	Est. Floor Levels#	Key Control Levels*	Exist	Exist+ CC**	M1	M2	M3	M4	M5
Swift/Kennard Ch	305.20	TB304.88	304.78	304.79	304.72	304.78	304.78	304.78	304.78
Kennard St Ch	304.80	TB303.99	303.91	303.95	**304.10**	303.91	303.91	303.91	303.91
Maxwell St HW (Apex Pk)	303.25	TB302.81 S302.98	**303.07**	**303.08**	302.86	**303.07**	**303.07**	**303.07**	**303.07**
Railway Ave	302.76	TB302.24 S302.83	**302.95**	**303.00**	302.11	**302.74**	**302.95**	**302.95**	**302.95**
Cross St HW	(301.45)^	TB301.56 S301.90	**302.07**	**302.12**	**301.91**	**302.08**	**302.07**	**302.07**	**302.07**
Cross St Ch3	(301.10)^	TB301.10	**301.32**	**301.35**	**301.17**	**301.33**	**301.32**	**301.32**	**301.32**
Ch5 HW (Zouch St)	300.55	TB300.32 S300.50	**300.85**	**300.94**	**300.57**	**300.87**	**300.85**	**300.85**	**300.78**
Ch6 (Kennard Park)	N/A	TB298.82	**299.06**	**299.07**	298.66	**299.07**	**299.06**	**299.06**	**299.09**
Simpson St HW	N/A	TB297.92 S298.15	**298.36**	**298.42**	**298.23**	**298.38**	**298.36**	**298.36**	**298.36**
Simpson St Ch10	297.80	TB297.89	**297.94**	**297.96**	297.59	**297.94**	**297.94**	**297.94**	**297.94**
Simpson Arthur Ch13	297.50	TB296.85	**296.93**	**296.99**	296.78	**296.96**	**296.93**	**296.93**	**296.93**
Simpson Arthur Ch15	296.60	TB296.34	296.33	296.37	296.16	296.35	296.33	296.33	296.33
Simpson Arthur Ch19	296.30	TB295.79	**295.93**	**295.97**	295.65	**295.94**	**295.93**	295.68	**295.93**
Simpson Arthur Ch23	296.30	TB295.33	**295.58**	**295.61**	**295.51**	**295.59**	**295.58**	**295.54**	**295.58**
Simpson Arthur Ch26	294.53	TB294.39	**294.90**	**294.99**	**294.71**	**294.94**	**294.90**	**294.73**	**294.90**
Highway HW	294.53	TB294.38 S294.45	**294.60**	**294.71**	294.01	**294.65**	**294.49**	**294.60**	**294.60**
Apsley Ch30	293.74	TB294.01	293.61	293.64	293.53	293.63	293.67	293.61	293.61
Apsley NSCS05	292.96	TB293.03	292.97	292.99	292.90	292.98	293.02	292.97	292.97

Habitable floor levels estimated based on closest ground level to house + 300 mm
* TB nominates the level at which the channel will break its banks, S nominates the lowest spill level of the headwall or pond area.
**EX+CC = Existing conditions with climate change allowance – 15% increase in rainfall intensity for critical duration event.
^ Property is not immediately adjacent to the channel area and may not be inundated by floodwaters

The flood level results show that flow is above bank height along the majority of the trunk channel in the 100 year ARI flood under existing conditions, and that it is sufficiently high to threaten habitable buildings in a number of locations.

When the impact of the various mitigation options on flood levels is assessed, it is clear that Mitigation Option 1 has the most pronounced beneficial impact, reducing flood levels along almost all channel sections. It does not however eliminate the potential risk of property flooding between Cross Street and Zouch Street, and along the eastern side of Arthur Street.

F4.4 Climate Change Sensitivity Analysis

The existing conditions model was run with a 15% increase in the 100 year ARI rainfall intensity for the 25 minute duration storm and rainfall distribution pattern to test the sensitivity of the DRAINS model results to climate change. **Table F4.6** shows that the maximum flood level impact was an increase of 110 mm, while the standard increase was around 40 mm. **Table F4.3** shows that the maximum increase in flow rate was approximately 100% for some overflow paths, although the increase is less pronounced in the main channel sections, ranging from about 6 % to 18 %.

F4.5 Properties at Risk of Flooding

This Drainage Study was not intended to definitively identify habitable properties that would be inundated in the various floods, as floor levels of residences were not surveyed by Council, and flood extents were not produced during the Drainage Study. However, by comparing ground surface levels in each lot with the estimated flood level at the closest channel cross section, it is possible to identify groups of properties that would be at risk of flooding. This is a coarse assessment that does not allow for variations in floor levels above ground level, undulations in ground levels between the channel and the building in question, or the presence of obstacles to flow such as fences or levees.

Those areas where flood levels represent a potential risk to habitable buildings are identified in **Table F4.4** to **Table F4.6** by bold red text. Under existing conditions, in a 5 year ARI flood event the modelling indicates that the properties at risk of inundation are:

- Those on the west side of Cross Street both north and south of the open channel;
- Those around the transition from open to covered channel that occurs at the rear of 72 Zouch Street in the group of properties between Cross Street and Zouch Street;
- The properties north and south of the open channel on the eastern side of Arthur Street.

In a 20 year ARI flood event the modelling indicates that the properties at risk of inundation are:

- Those on the west side of Cross Street both north and south of the open channel;
- Those between Cross Street and Zouch Street adjacent to the open channel and above the covered channel;
- Those both north and south of the open channel immediately west of Simpson Street, between Zouch and Hawkins Streets;
- The properties north and south of the open channel on the eastern side of Arthur Street.

In a 100 year ARI flood event the modelling indicates that the properties at risk of inundation are:

- The 6-8 properties on the eastern side of Railway Avenue adjacent to the railway culvert;

- Those on the west side of Cross Street both north and south of the open channel;
- Those between Cross Street and Zouch Street adjacent to the open channel and above the covered channel;
- Those both north and south of the open channel immediately west of Simpson Street, between Zouch and Hawkins Streets;
- The properties north and south of the open channel on the eastern side of Arthur Street.

It is important to note that while properties on the eastern side of Arthur Street have been included in this analysis of risk, this is due to their susceptibility to channel flooding, not due to the potential for river flooding from Bell River. Council's 500 year ARI flood extent for the Bells River in the GIS indicates that properties on Apsley Street and on both sides of Arthur Street are predicted to be flood affected due to river flooding. While the properties in Apsley Street have not been identified as susceptible to channel flooding in this Study, they are particularly vulnerable to impacts of tailwater levels in Bells River which if elevated could cause elevated channel water levels as compared to those quoted in this Study.

F5. EFFECTIVENESS OF FLOOD MITIGATION OPTIONS

F5.1 Structural Mitigation Options

F5.1.1 Mitigation Option 1 – Apex Park Detention Basin

The scheme is highly effective at reducing flows throughout the catchment, which leads to pronounced reductions in flood levels along the main channel. The scheme would effectively remove the potential for flooding of habitable areas in a 5 year ARI event, would almost remove that potential in a 20 year ARI event, and would remove that potential in some locations whilst minimising the extent of habitable flooding in some locations in a 100 year ARI event. Option 1 is more effective at reducing flood levels than the other schemes at all locations.

F5.1.2 Mitigation Option 2 – Railway Culvert

This scheme involves the enlargement of the railway culvert in isolation. This results in a 210 mm reduction in flood levels in Railway Parade in a 100 year ARI event, which would potentially avert flooding of habitable areas in Railway Parade. Due to the opening of this flow restriction however, the scheme causes minor increases in flood levels downstream of the railway, peaking at +0.05 m at the Highway. The modelling shows that habitable areas would be unlikely to be flooded in Railway Parade in a 20 year ARI event, so this scheme particularly targets the 100 year ARI event.

F5.1.3 Mitigation Option 3 – Arthur Street Culvert

This scheme involves the enlargement of the culvert beneath the Highway in isolation. The impact of this scheme is felt only immediately upstream of the Highway and in the channel along Apsley Street. In the 100 year ARI event, a reduction in flood level of 110 mm is achieved upstream of the Highway which could avert flooding of habitable areas. However, this causes a 50 mm increase downstream of the Highway due to the additional flow allowed to pass through the enlarged culvert. This 50 mm increase could take the flood level close to breaking the channel banks and flooding habitable areas in Apsley Street so this scheme may not be acceptable.

F5.1.4 Mitigation Option 4 – Arthur Street Channel

This scheme involves widening of the channel from Node 19 to the Highway, a distance of around 120 m. The scope to widen the channel in this area is limited by the width of the easement between properties. The widening has a localised impact, dropping flood levels by up to 250 mm in the 100 year ARI event. These reductions do not however alleviate the potential for flooding of habitable areas. As such, this scheme in isolation is not overly effective.

F5.1.5 Mitigation Option 5 – Zouch Street Covered Channel

This scheme targets a problem area that overflows and threatens habitable areas in all modelled events including the 5 year ARI event. The impact of the enlargement is limited to the headwall node “Ch5”, where a reduction of 70 mm is achieved in the 100 year ARI event. The enlargement does remove the potential for flooding of habitable floors in the 5 year ARI event, but not in the 20 or 100 year ARI events. In addition, this scheme would be very difficult to implement, and potentially expensive, as it involves channel enlargement through private properties and under a road. As such this scheme is not overly effective or beneficial in isolation.

F5.2 Drainage System Maintenance

Maintenance of the drainage system, including the open channel sections and pipe inlets and outlets, would complement any structural flood mitigation options, and could provide substantial benefits in its own right. As can be seen in **Figure F4** below, the inspection of the system in 2011 identified significant silting of channels and pipe inlets and outlets which substantially reduces the capacity of the system. This is a relatively inexpensive option to improve conveyance.

The overgrown concrete channel looking north upstream from the railway culvert

The silted culvert headwall inlet north (upstream) of Maxwell Street in Apex Park

Silted channel downstream of intersection of Maxwell Street and Railway Avenue

Silted culverts at outlet near intersection of Swift and Kennard Streets

Figure F4: Examples of Areas Requiring Maintenance

F6. RECOMMENDED FLOOD MITIGATION OPTION

Following discussions of the model results for all five mitigation options with Wellington Council, Council indicated that its preferred option was Option 1, the detention basin in Apex Park. Evans & Peck agrees with this decision. Option 1 is clearly the most advantageous mitigation option, capable of substantially reducing flows and flood levels throughout the catchment.

Option 1 would potentially remove the risk of habitable flooding in the Railway Avenue area in the 100 year ARI event, substantially reducing flood levels around the rail culvert. It would also potentially remove the risk of habitable flooding immediately downstream of Simpson Street, and would substantially reduce the risk of habitable flooding between Cross Street and Zouch Streets and on the eastern side of Arthur Street while ensuring the depth of inundation in these areas, if it occurred, was reduced.

After implementation of Option 1, it is important to note that there would still be a residual risk of habitable building flooding in the area between Cross Street and Zouch Street, and on the eastern side of Arthur Street.

The basic details of the required basin are as follows:

- Base level 301.65 m AHD
- Top Water Level 303.0 m AHD
- Surface Area at TWL 10,000 m^2
- Storage Volume at TWL 8,500 m^3
- Outlet Diameter 600 mm

The basin would require a low flow channel that would convey low flows in a contained fashion in a southerly direction along the western boundary adjacent to the rail corridor from Kennard Street to Maxwell Street.

Diversion of major stormwater pipelines would also be necessary to capture runoff from Thornton and Pierce Streets which currently discharges into the open channel downstream of Maxwell Street. An inlet and energy dissipation structure would be required where this pipe flow is introduced to the basin to ensure flow would not spill out into the dry basin area in small flood events, and to ensure the inflow would not cause erosion in larger events.

F7. RECOMMENDATIONS

In order to progress Mitigation Option 1, it is recommended that Wellington Council implement the following:

1. Investigate the invert levels and cover depths of the stormwater pipelines along Maxwell Street which currently discharge to the open channel downstream of Maxwell Street to determine if it is practicable to divert these pipelines into the detention basin in Apex Park;
2. Undertake concept designs of the inlet structure for these diverted pipes, the low flow channel, and the outlet at Maxwell Street to determine if the basin is practicably constructible for a reasonable cost;
3. Carry out an assessment of Apex Park to determine if there are any current land uses, buildings, buried or above ground services, heritage objects, or trees which would preclude the clearing and excavation work required to construct the basin or having it intermittently fill with water;
4. Consult with the local community to determine if they are amenable to the use of the Park as a detention basin given the benefits to the catchment;
5. Undertake a costing of Option 1;
6. As described in **Section F5.2** more regular and comprehensive channel maintenance can be employed in tandem with Option 1 to provide additional benefit for the catchment now and in the future.

Wellington Council

WELLINGTON FLOOD RISK MANAGEMENT STUDY 2013

Appendix G

Selection of Floodplain Management Measures

July 2013

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Table of Contents

G1. BACKGROUND

This Appendix sets out a range of factors which need to be taken into consideration when selecting the mix of works (eg. levees, channel improvements) and measures (eg. land use, zoning, flood warning) that should be included in the overall Floodplain Risk Management Plan. In the case of Wellington, which already enjoys considerable flood mitigation benefits as a result of Burrendong Dam, the opportunities to propose significant new measures are limited. The majority of the feasible activities outlined in **Section 4** are ones which will "tie up loose ends" rather than provide major flood mitigation benefits for the whole town. Nevertheless, it is important that, in developing an overall plan, Council has before it an analysis of the issues to be considered in making choices, even where some of them appear trivial for the particular circumstances.

Each community will have different priorities and, therefore, each needs to establish its own set of considerations used to assess the merits of different options. The considerations adopted by a community must, however, recognise the State Government requirements for floodplain management as set out in the Floodplain Development Manual and other relevant policies. A further consideration is that elements of the plan may be eligible for subsidy from State and Federal Government sources and the requirements for such funding must, therefore, be taken into account. Typically, State and Federal Government funding is given on the basis of merit as judged by a range of criteria:

- Degree of flood hazard and number of properties affected;
- Damage caused by flooding and the benefit:cost ratio of proposals;
- The importance given to strategic planning in the overall Plan;
- Compatibility of proposals with TCM and other government policies;
- Community involvement in plan preparation;
- Availability of local funding for proposed works.

The issues which need to be considered in developing a Floodplain Risk Management Plan typically fall under the following broad headings:

- Community Expectations and Social Impacts;
- Natural Resource Management and Environmental Impact;
- Economic and Financial Feasibility;
- Technical Merit.

The following sections present a review of a range of considerations under these four headings. The analysis which assesses the performance of each available option against the factors to be considered is provided in **Table 6.1** of the main report.

G2. COMMUNITY EXPECTATIONS AND SOCIAL IMPACTS

This area encompasses all those issues which are not directly economic or environmental in character such as:

- Community acceptance and expectations
- Public safety and welfare
- Compatibility with planning objectives, including future development limits
- Administrative and political issues

G2.1 Community Acceptance

Works and measures can have a range of effects on the community and individuals. These effects, if strongly negative, are often enough to deter the implementation of a proposal which might otherwise have significant merit. The issues impacting upon acceptance of a proposed measure are likely to include:

- potential for individual financial loss/gain;
- disruption to daily life during and after floods;
- perception of fair play;
- public safety and welfare.

In Wellington, the community are concerned about the impact on house values of any alteration to the designated flood. Whilst this is a serious consideration, Council is obliged to make decisions on behalf of the whole community and to consider the interests of future generations.

G2.2 Strategic Planning Objectives

Wellington Shire Council has developed a set of planning policies for future development which reflects the long term goals of the community. These policies are embodied in the Wellington Local Environmental Plan 2012 which has been reviewed in **Appendix E** and for which a number of suggested amendments have been outlined in **Section 4.3** and **Appendix E**. Planning controls will be a key element of the Floodplain Management Plan for Wellington. The recommended amendments are designed to ensure that the LEP, DCP and other Council policies and instruments relating to land use on the flood plain are consistent with the Floodplain Development Manual (2005) and current government thinking.

Proposals for other works and measures to be included in the Floodplain Management Plan must be assessed for consistency with the overall planning policy relating to floodplain management.

G2.3 Administrative/Political Issues

Effective floodplain management involves the co-ordinated action of the community, Council and state government agencies. Clearly, any recommendation contained in the Floodplain Management Plan will have more chance of success if it fits within current administrative structures and allocation of responsibilities. On the other hand, should an alteration to the administrative system be clearly beneficial to the Plan, it should be so stated and the implications accepted.

The majority of the parties with responsibilities for floodplain management and emergency response in the event of a flood are represented on the Floodplain Management Committee and have been consulted in the course of this study. None of the options presented in **Chapter 4** involve any radical changes to the existing administrative structures and responsibilities.

G3. NATURAL RESOURCE MANAGEMENT AND ENVIRONMENTAL IMPACT

G3.1 Total Catchment Management

Total Catchment Management (TCM) involves the coordinated and sustainable use and management of land, water, vegetation and other natural resources on a catchment basis. It allows for a cooperative forum where decisions may be made at both the community and government level. This is achieved through a Catchment Management Committee which consists of both community and government representatives.

The implementation of TCM aims to balance resource utilisation and conservation through the minimisation of land and soil degradation and the maintenance of water yield and quality. A catchment provides a natural planning unit for resource management in which to optimise economic development and the social well being of the community.

The Macquarie and Bell River catchments are located within the Central West Catchment Management Committee area. The issues of concern to the committee are:

- water quality decline;
- land conservation;
- vegetation management;
- land use management;
- community education and involvement;
- coordination and integration of existing and future natural resource information.

Aspects of a Floodplain Risk Management Plan which could have implications for TCM include any proposals for flood mitigation storages, levees or channel works. Such works are not economically viable for Wellington. Any activities undertaken to manage riparian vegetation so as to maintain hydraulic capacity while enhancing habitat value would be consistent with TCM objectives.

G3.2 Other Relevant Government Policies

The NSW Government has developed a number of polices which are of direct relevance to floodplain management. The first of these are the policies enshrined in the Floodplain Development Manual which forms the basis for the formulation of Floodplain Management Plans.

The second is the State Rivers and Estuaries Policy (NSW Water Resources Council, 1993) which is the umbrella policy statement for subsidiary policies including:

- Wetlands Policy
- Stream Management Policy
- Riparian Zone Policy

Of these, the proposed Riparian Zone Policy is most pertinent to the management of the floodplain in the Wellington area. The policy suggests that the overall objective should be to manage the riparian zones of NSW in ways which:

- Slow, halt or reverse the overall rate of degradation
- Ensure the long term sustainability of essential biophysical functions
- Maintains the beneficial use of these resources.

For the purposes of floodplain management, the riparian zone may be taken as the area above the low flow level to the inner edge of the floodplain. In practice, the riparian zone merges into the floodplain and any management policies or actions should not stop at artificially defined boundaries. Any activities to manage the riparian zone within Wellington would be consistent with this policy by improving:

- Stream stability
- Scenic amenity
- Buffer strip functioning
- Ecology and habitat
- Recreational amenity

G3.3 Environmental Impact

Few floodplain management measures could be considered seriously if the impact on the environment was extremely adverse. On the other hand, there are also opportunities for environmental enhancement in association with floodplain management works or measures.

G4. ECONOMIC AND FINANCIAL FEASIBILITY

G4.1 Economic Feasibility

There is a range of procedures available to judge the economic worth of making an investment in floodplain management works and measures. The most common is the benefit: cost ratio (B/C). On a purely theoretical basis, no investment should be made in a measure if the benefits do not exceed the costs. However, many public projects are undertaken where this is not the case because the intangible benefits, which are not able to be quantified, are considered important.

The benefits of floodplain management measures are largely the savings in damages to existing properties or developments and the savings in damages achieved by preventing flood sensitive developments occurring in the future. The costs are primarily the capital and operating costs of structural works, etc and of non-structural measures. Where appropriate, **Section 4** contain an assessment of the benefits and costs of various options. Not all of the measures applicable to Wellington area lend themselves to meaningful B/C analysis.

G4.2 Financial Feasibility

Measures proposed for the Floodplain Risk Management Plan for Wellington must be capable of being funded over the proposed period of implementation. The sources of funding are traditionally:

- Council
- NSW Government
- Commonwealth Government

Contributions from these three sources are such that, where the costs were attributable to approved floodplain management activities, Council would bear 20% of the overall cost with the balance being equally shared by NSW and Commonwealth Governments.

The limitations on Council funding will be related to the magnitude of Council income in any one year, its borrowing capacity and existing commitments. The total allocation and sources of funds will vary in any one year and are dependent on special grants. The funds which are available for floodplain management measures will be dependent on Council priorities but it appears that Council would have the capacity to allocate $50,000 dollars in a typical year.

The State Government contribution is limited by the allocation to flood mitigation programs on an annual basis. The allocations available by the Department of Water Resources (now OEH), the controlling authority, on behalf of NSW and the Commonwealth since 1985/86 have ranged from around $5M to $14M annually. Wellington would have to take its place alongside other centres competing for funding.

Since Council has many demands for drainage/flood mitigation works and flood free road access, the financial feasibility is likely to be a significant constraint to the rate at which works can be undertaken.

G5. TECHNICAL MERIT

G5.1 Engineering Feasibility

Floodplain management works, as distinct from measures, must be readily constructible and free of major engineering constraints to become an acceptable element of any plan. Maintenance requirements should also be considered in this assessment.

G5.2 Performance in Exceedance Floods

The Floodplain Risk Management Study has recommended the 1% AEP flood as the Flood Planning Level for defining the extent of land subject to development controls. Floor levels of future development are recommended to be set at the 1% AEP flood level plus 500 mm.

Any proposed floodplain management works or measures must be assessed assuming that at some future time they will be exposed to floods in excess of the 1% AEP flood. It is imperative that, should an extreme flood occur, the works and measures under consideration do not expose the community to unacceptable risks far beyond those experienced without the work or measure.

G6. RANKING OF OPTIONS

The considerations discussed above do not necessarily have equal weighting in the assessment of options for Wellington. Although multi objective assessment methods are now well accepted by Government for selecting from a range of options, the decision to provide state funds is still linked closely to economic and financial factors. The Floodplain Management Committee and the Community, however, have expectations which give more weight to social, environmental and planning issues.

Throughout the preparation of this report there has been close consultation with Council's Floodplain Management Committee which contains representatives of the community, Council and relevant Government agencies. Publicity about the study has been provided through the local press and through a brochure delivered to residents who are likely to be affected by flooding. In addition, a public meeting was held to explain the study and to seek community feedback, particularly regarding the selection of the Flood Planning Level.

Based on these consultations, and taking account of current government policies, a suggested approach to assessing the merits of various options is to use a subjective scoring system. The chief merits of such a system are that it allows comparisons to be made between alternatives using a common "currency". In addition it makes the assessment of alternatives "transparent" (ie all important factors are included in the analysis). The system does not, however, provide an absolute "right" answer as to what should be included in the plan and what should be left out. Rather, it provides a method by which the Council can re-examine its options and, if necessary, debate the relative scoring and weight given to aspects of the plan.

The assessment system involves three steps:

1. Each issue to be considered for assessing the merits of various proposals is given a weighting according to how important each is for the town. A suggested classification is:

   "Essential" - (weight = 1.0)

   - Gains community acceptance
   - Meets planning objectives
   - Positive or minimal environmental impacts

   "Desirable" - (weight = 0.5)

   - Economically justified
   - Financially feasible
   - Does not increase damage or risk in extreme floods

   "Considerations" - (weight = 0.25)

   - Consistent with Government policies
   - Consistent with TCM objectives
   - Consistent with current administrative arrangements and responsibilities

2. Each option is given a score according to how well the option meets the considerations discussed in **Sections G2 - G5**. In order to keep the scoring simple the following system is proposed:

   +2 Option rates very highly

   +1 Option rates well

   0 Option is neutral

   -1 Option rates poorly

   -2 Option rates very poorly.

3. The score for each option is multiplied by the relevant weighting for the issue under consideration and the weighted scores are added to get a total for each option.

Table 6.1 in the main report presents a scoring matrix for the options for Wellington which were reviewed in **Chapter 4**. This scoring has been used as the basis for prioritising the components of the Floodplain Risk Management Plan. It must be emphasised, however, that the scoring shown in **Table 6.1** is not "absolute" and Council should carefully review the proposed scoring and weighting as part of the process of finalising the overall Floodplain Risk Management Plan.