6 Current Economic Impact of Flooding

6.1 Background

Flooding is likely to cause significant social and economic damages to the communities. The flood damages are classified into different categories, which are summarised in **Table 6-1**.

Table 6-1 Flood Damages Categories

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

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

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

6.2 Floor Level and Property Survey

A combined floor level and property survey data utilised for the flood damage estimation consists of survey data from the following sources:

- A detailed floor level and property survey undertaken by Cardno surveyors;
- Two floor level and property survey spreadsheets provided by Council;
- Data interpolated for properties based on the survey data provided by Cardno and Council; and
- A floor level and property survey data from Green Square West Kensington Flood Study (WMA, 2011).

A detailed floor level and property survey was undertaken by Cardno surveyors in February 2013, including 1344 properties. The survey results were provided by Cardno surveyors in GIS format.

Council provided two floor level and property survey spreadsheets, which include 540 survey samples. The Council's survey spreadsheets were converted into GIS layers based on coordinates of the survey locations provided in these spreadsheets.

Some modifications were made to floor levels for calculation of the flood damages.

6.3 Damage Analysis

A flood damage assessment for the existing catchment and floodplain conditions has been undertaken as part of the current study. The assessment is based on damage curves that relate the depth of flooding on a property, to the potential damage within the property.

Ideally, the damage curves should be prepared for the particular catchment for which the study is being carried out. However, damage data in most catchments is not available and recourse is generally made to damage curves from other catchments. OEH has carried out research and prepared a methodology (draft) to develop damage curves based on state-wide historical data. This methodology is only for residential properties and does not cover industrial or commercial properties.

The OEH methodology is only a recommendation and there are currently no strict guidelines regarding the use of damage curves in NSW. However, correspondence at the outset of this project with OEH (then Department of Natural Resources (DNR)) confirmed that the use of OEH curves was appropriate.

The following sections set out the methodology for the determination of damages within Alexandra Canal floodplain.

6.3.1 Residential Damage Curves

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

- Single storey, slab-on-ground;
- Two storey, slab-on-ground; and
- Single storey, high-set (i.e. on piers).

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

Damages are generally incurred on a property prior to any over-floor flooding. The OEH curves allow for a damage of $10,720 (November 2012 dollars) to be incurred when the water level reaches the base of the house (the base of the house is determined by 0.3m below the floor level for slab on ground). Damages of this type are generally direct external damages (sheds, gardens), direct structural damages (foundational damage) or indirect damages (garden amenity and debris clean-up). According to the damage curves this amount of damage remains constant from the base of the house to the floor level of the house.

Given some of the inconsistencies in the data set, the following was assumed:

- When the depth of flooding on the property exceeded 0.3 metres, a nominal $1000 of garden damage was assumed since the majority of residential properties are terrace houses; and
- When the flood level is a 0.1 metres below the floor level, then a damage of $10,720 is incurred, as per the OEH damage curves.

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

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

6.3.2 Average Weekly Earnings

The OEH curves are derived for late 2001, and were updated to represent November 2012 dollars. General recommendations by OEH are to adjust values in residential damage curves by Average Weekly Earnings (AWE), rather than by the inflation rate as measured by the Consumer Price Index (CPI). OEH proposes that AWE is a better representation of societal wealth, and hence an indirect measure of the building and contents value of a home. The most recent data for AWE from the Australian Bureau of Statistics at the time of the assessment was for November 2012. Therefore all ordinates in the residential flood damage curves were updated to November 2012 dollars.

While not specified, it has been assumed that the curves provided by OEH were derived in November 2001, which allows the use of November 2001 AWE statistics (issued quarterly) for comparison purposes. November 2001 AWE is shown in Table D1 of the DECC guidelines, and November 2012 AWE were taken from the Australian Bureau of Statistics website (www.abs.gov.au), as shown in **Table 6-2.**

Table 6-2 CPI Statistics for Residential Damage Curves

Month	Year	AWE
November	2001	$676.40
November	2012	$1081.30
Change	60%	

Consequently, all ordinates on the damage curves were increased by 60%. GST is not included in these values.

6.3.3 Commercial Damage Curves

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

- Low value commercial;
- Medium value commercial; and
- High value commercial.

In determining these damage curves, it has been assumed that the effective warning time is approximately zero, and the loss of trading days as a result of the flooding has been taken as 10 days.

These curves are determined based on the floor area of the property. The floor level survey provides an estimate of the floor area of the individual properties. For some commercial properties without the surveyed floor area, the floor area was estimated from aerial photographs.

The Consumer Price Index (CPI) was used to bring the 1990 data to March 2013 dollars (this data was obtained from the Australian Bureau of Statistics website (www.abs.gov.au). The CPI data is shown in **Table 6-3**.

The commercial properties were not classified into different value categories (low, medium, or high) in the survey data. Medium value was assumed for all commercial properties.

Table 6-3 CPI Statistics for Commercial Property Damage Estimation

Month	Year	CPI
June	1990	102.50
March	2013	183.60
Change	79%	

Consequently, damages have been increased by 79%. GST is not included in these values.

6.3.4 Industrial Damage Curves

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

The curves were prepared for three categories:

- Low value industrial (e.g. small factories and workshops);
- Medium value industrial (e.g. large industrial properties in the corner of Castlereagh Road and Railway); and
- High value industrial (e.g. BHP steelworks in Wollongong).

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

The survey conducted only accounts for structural and contents damage to the property. Clean up costs and indirect financial costs were estimated based on FLDamage Manual. Actual internal damage could be estimated, along with potential internal damage, using various factors within FLDamage. Using both the actual and potential internal damages, estimation of both the cleanup costs and indirect financial costs could be made. The values were adjusted to March 2013 dollars using the CPI statistics shown in **Table 6-4**.

The industrial properties were not classified into different value categories (low, medium, or high) in the survey data. Medium value was assumed for all industrial properties.

Table 6-4 CPI Statistics for Industrial Property Damage Estimation

Month	Year	CPI
June	1998	121.00
March	2013	183.60
Change	51%	

Consequently, damages have been increased by 51%. GST is not included in these values.

6.4 Adopted Damage Curves

The adopted damage curves are shown in **Figure 6-1**. The commercial and industrial damage curves are for a property with a floor area of 100m^2.

To normalise the damages for property size, the curves have been factored to account for floor area. For the commercial\industrial properties, the floor area was estimated from aerial photographs.

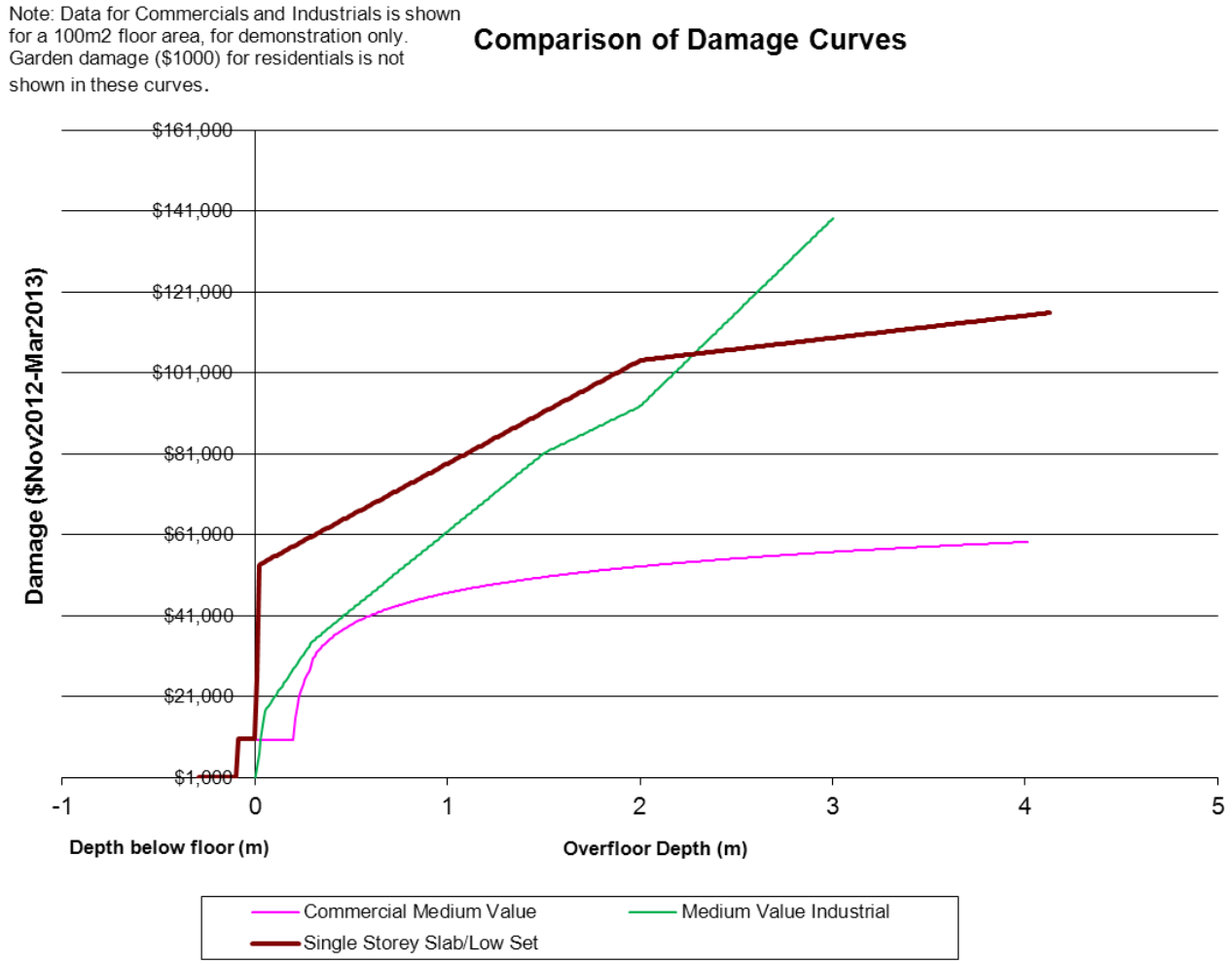


Figure 6-1 Damage Curves Developed for Alexandra Canal Catchment

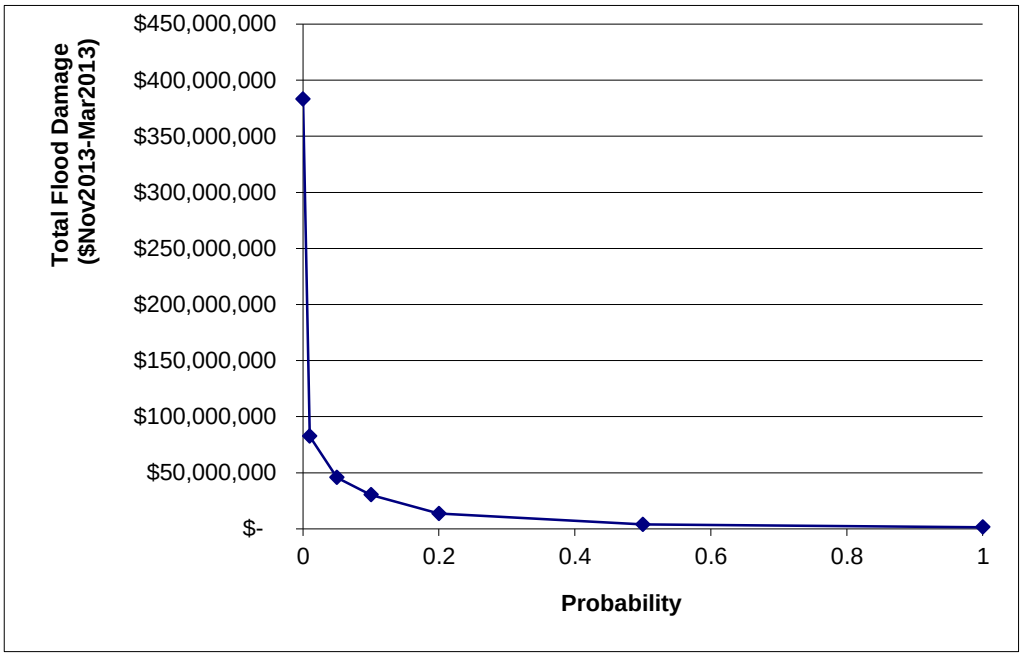
6.5 Average Annual Damage

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

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

AAD attempts to quantify the flood damage that a floodplain would receive on average during a single year. It does this using a probability approach. A probability curve is drawn, based on the flood damages calculated for each design event (**Figure 6-2**). For example, the 100 year ARI design event has a probability of occurring of 1% in any given year, and as such the 100 year ARI flood damage is plotted at this point on the AAD curve (**Figure 6-2**). AAD is then calculated by determining the area under this curve.

Further information on the calculation of AAD is provided in Appendix M of the Floodplain Development Manual (NSW Government, 2005).



Note: The probability of the PMF occurring is assumed as 0.0001%

Figure 6-2 Average Annual Damage Curve for Alexandra Canal Catchment

6.6 Results

Table 6-5 shows the results of the flood damage assessments. Based on the analysis described in **Section 6.3**, the average annual damage estimated for the Alexandra Canal floodplain under existing conditions is approximately **$13 million** (excluding GST).

The average annual damage reflects of the likelihood of each design flood event in one year and the damages likely to occur as a result of that event. Whilst this is a useful tool for evaluating the benefit of flood management options and assessing the flood damage to an area over a long period of time, it is also important to note the actual damages estimated to occur as a result of each design flood event. The cost to the community of flood damage is not incurred as an average annual amount. The costs will be borne at one time by the damage incurred by a specific flood event.

Financial and community attitude surveys and analysis undertaken in other areas of Sydney (e.g. the Hawkesbury Nepean Valley) (Gillespie et al, 2002) suggests that many people would have real difficulties dealing with the cost of recovering from severe flooding.

Table 6-5 Flood Damage Assessment Summary

Property Type	Properties with Overfloor Flooding	Average Overfloor Flooding Depth (m)	Maximum Overfloor Flooding Depth (m)	Properties with Overground Flooding	Total Damage ($Nov 2012-Mar 2013) (ex. GST)
PMF					
Residential	1263	0.78	3.26	1345	$91,800,740
Commercial	196	0.71	2.95	207	$97,607,569
Industry	125	0.99	3.16	131	$193,627,407
Total	1584			1683	$383,035,716
100 Year ARI					
Residential	580	0.23	1.51	988	$30,121,637
Commercial	71	0.30	0.96	110	$19,240,425
Industrial	54	0.31	1.58	89	$33,190,832
Total	705			1187	$82,552,895
20 Year ARI					
Residential	271	0.19	0.74	602	$16,236,372
Commercial	42	0.20	0.60	76	$9,928,007
Industrial	35	0.25	0.96	60	$19,491,268
Total	348			738	$45,655,647
10 Year ARI					
Residential	175	0.16	0.55	439	$10,272,581
Commercial	26	0.18	0.43	50	$6,163,448
Industry	29	0.21	0.52	43	$13,817,069
Total	230			532	$30,253,098
5 Year ARI					
Residential	106	0.16	0.39	338	$6,262,566
Commercial	8	0.19	0.29	27	$2,485,745
Industry	16	0.19	0.43	35	$4,889,260
Total	130			400	$13,637,570
2 Year ARI					
Residential	30	0.11	0.29	132	$1,653,255
Commercial	3	0.10	0.24	14	$1,397,261
Industry	6	0.17		15	$856,874
Total	39			161	$3,907,389
1 Year ARI					
Residential	1	0.11	0.19	29	$71,664
Commercial	2	0.13	0.20	8	$1,016,841
Industry	3	0.11		6	$371,364
Total	6			0	$1,459,869

6.7 Discussion

The results of the damage calculation indicate that 6 properties are exposed to overfloor flooding in a 1 year ARI event and 130 properties are exposed to overfloor flooding in a 5 year ARI event. These numbers would appear relatively high. However, there are a few key points to note:

- The average and maximum overfloor flooding depths in these events is relatively low. For example, the average overfloor flooding in a 5 year ARI event is 0.15 metres. Depending on localised factors (such as localised obstructions inside of properties, whether the front door was closed etc), the actual extent of inundation within the building may be lower than indicated;
- Further to the above, the rapid response of this type of overland flow, where in general the flood may only be at its peak for a short period of time, may result in doors and other obstructions providing some protection; and,

- There may also be localised obstructions within the property which result in slightly different water levels than indicated by the modelling.

Another consideration is the experience of property owners within the catchment. Approximately 20% of the responses (95 responses in total) from the resident survey (described in **Section 4**) identified that floodwaters had entered their house or business. Of all residential responses, around 60% have resided in the catchment for less than 10 years.

As described in **Section 5.3**, the Cardno (2013) Flood Study identified that the largest storm event in the period 2001 to 2010 was in 2001 corresponding roughly to a 1 year ARI event. April 1998 was the largest event within the last 15 years with an estimated return period of between 10 and 20 years. Therefore, there is unlikely to have been significant experience of very large events within the catchment. Based on responses listed in **Section 4**, only around 15% of the total respondents would have experienced the 1984 event, which was roughly equivalent to a 100 year ARI event.

Considering the above and that 20% of responses observed floodwaters in their house or business, potentially this type of flooding behaviour occurs for even relatively frequent events. This would tend to correspond with the outcomes of the damages analysis.

7 Environmental and Social Characteristics

Environmental and social characteristics of the study area may influence the type and extent of flood management options able to be implemented. Environmental characteristics, such as habitats, threatened species, topography and geology are constraints of structural flood modification sites.

Social characteristics such as housing and demographics may impact the community's response to flooding and therefore affect the type of flood management options proposed.

The following environmental and social characteristics have been considered in the assessment:

- Geology, Soils, Geomorphology and Groundwater;
- Demographic Characteristics;
- Flora and Fauna; and
- Aboriginal and Non-Aboriginal Cultural Heritage.

The detailed environmental and social assessment is provided in **Appendix C**.

Environmental and social issues to be considered in the development of floodplain management strategies for the Alexandra Canal Catchment include:

- The soil types that are present may potentially pose issues related to earth movement and construction due to erosion risk, low soil fertility, poor soil drainage and high permeability.
- The area adjacent to Alexandra Canal has a high probability of Acid Sulfate Soils, within 1m of the ground surface (severe environmental risk if ASS materials are disturbed by activities such as shallow drainage, excavation or clearing).
- There are 28 contaminated sites and three Protection of the Environment and Operations Act 1997 licenced premises within the catchment.
- The Alexandra Canal Catchment is located on the Botany Sand Beds aquifer. The aquifer is highly vulnerable to contamination due to the permeability of the sands and the generally shallow water table. The Botany Sands Beds Aquifer plays an important role in the Decentralised Water Master Plan 2012 – 2030. Flood management options may provide opportunities to align with the Master Plan.
- Almost a third of people living in the Alexandra Canal catchment are within the 25-34 year age bracket. In fact, 72% of the population are aged below 55 years. This indicates a community which may be primarily able-bodied, able to evacuate effectively and/or assist with evacuation procedures.
- English was the only language spoken in approximately 62% of homes in the Alexandra Canal catchment. The most common languages spoken at home other than English are Greek, Chinese languages, Indo-Aryan languages, South-east Asian languages, Russian and Spanish.
- Most of the plant species found within the catchment are introduced species or species that are not indigenous to the Sydney Area. Only the *Syzygium paniculatum* (Magenta Lilly Pilly) is known to occur within the immediate catchment area.

- Only a small number of threatened or endangered fauna species have been recorded within the immediate catchment area. This included the endangered Green and Golden Bell Frog.
- Only one Aboriginal heritage site (the Wynyard Station Midden) was identified within the vicinity of the study area.
- 31 non-Aboriginal heritage items are found within or surrounding the catchment area which have been listed by the Heritage Council under the NSW Heritage Act 1977. A further 825 items were found within or surrounding the catchment area which have been listed by local council and state government agencies.

8 Flood Emergency Response Arrangements

8.1 Flood Emergency Response

The majority of flooding within the Alexandra Canal catchment is characterised by overland flow. The critical duration is between 1 and 3 hours across the catchment, with the peak of the flood reached approximately 30 minutes to 1 hour after the start of the storm. This is considered short duration “flash” flooding.

Due to the short interval between the start of the storm and the peak of the flood, there is little in the way of warning that can be provided. Any warning provided would be for immediate safety precautions such as temporary refuge (if available nearby or onsite), raising of items off the ground and accounting for people on site.

The short duration until flooding occurs does not allow sufficient time to evacuate residents from their properties. In these situations, evacuation is generally not recommended as the response during a flood event as it is likely to be hurried and uncoordinated, which can expose evacuees to a hazardous situation. As such, the preferred response to flooding in flash flooding catchments, is for people to remain within the property, preferably within the upper levels, if available. The suitability of the shelter-in-place approach should be considered in consultation with the State Emergency Service for the preparation of a Local Flood Plan (**Section 8.2.2**).

It is important that residents are aware of signs that will signal an approaching flood, and are aware of the correct response such that the small time period before the flood arrives may be used as effectively as possible to move people and belongings to a close, safe location.

8.2 Flood Emergency Responses Documentation

Flood emergency measures are an effective means of reducing the costs of flooding and managing the continuing and residual risks to the area. Current flood emergency response arrangements for management flooding in the Alexandra Canal Catchment are discussed below.

8.2.1 DISPLAN

The Alexandra Canal Catchment is located within the Sydney East Emergency Management District. Flood emergency management for the Alexandra Canal Catchment is organised under the New South Wales State Disaster Plan (DISPLAN) (2010). No district DISPLAN has been prepared for this district.

The DISPLAN details emergency preparedness, response and recovery arrangement for NSW to ensure the coordinated response to emergencies by all agencies having responsibilities and functions in emergencies.

The DISPLAN has been prepared to coordinate the emergency management measures necessary at State level when an emergency occurs, and to provide direction at District and Local level.

The plan is consistent with district plans prepared for areas across NSW and covers the following aspects at a state level:

- Roles and strategies for prevention of disasters;
- Planning and preparation measures;
- Control, coordination and communication arrangements;
- Roles and responsibilities of agencies and officers;

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

The DISPLAN states that:

"Each District and Local Emergency Management Committee is to develop and maintain its own District / Local Disaster Plan, with appropriate Supporting Plans and Sub Plans, as required by Functional Area Coordinators and Combat Agency Controllers at the appropriate level. Supporting plans are to be the exception at local level and their development must be approved by District Functional Area Coordinators."

It is recommended that a DISPLAN be prepared for the Sydney East Emergency Management District to outline emergency response arrangement specific to the district. In particular the purpose of a District DISPLAN is to:

- Identify responsibilities at a District and Local level in regards to the prevention, preparation, response and recovery for each type of emergency situation likely to affect the district.
- Detail arrangements for coordinating resource support during emergency operations at both a District and Local level.
- Outline the tasks to be performed in the event of an emergency at a District and Local level.
- Specifies the responsibilities of the South West Metropolitan District Emergency Operations Controller and Local Emergency Operations Controllers within the South West Metro EM District.
- Detail the responsibilities for the identification, development and implementation of prevention and mitigation strategies.
- Detail the responsibilities of the District & Local Emergency Management Committees within the District
- Detail agreed Agency and Functional Area roles and responsibilities in preparation for, response to and recovery from, emergencies.
- Outline the control, coordination and liaison arrangements at District and Local levels
- Detail arrangements for the acquisition and coordination of resources.
- Detail public warning systems and responsibility for implementation.
- Detail public information arrangements and public education responsibilities.
- Specifies arrangements for reporting before, during and after an operation.
- Detail the arrangements for the review, testing, evaluation and maintenance of the Plan.

8.2.2 Local Flood Plan

A local flood plan has not been prepared for the local area containing the Alexandra Canal Catchment. As such, the New South Wales State Flood Sub-plan (2008) is used to set out the arrangements for the emergency management of flooding.

The State Flood Sub-plan is a sub-plan to the state DISPLAN. The Sub-plan sets out the emergency management aspects of prevention, preparation, response and initial recovery arrangements for flooding and the responsibilities of agencies and organisations with regards to these functions.

There is a requirement for the development and maintenance of a Flood Sub-plan for:

a) The State of New South Wales;

b) Each SES Region; and

c) Each council area with a significant flood problem. In some cases the flood problems of more than one council area may be addressed in a single plan or the problems of a single council area may be addressed in more than one.

Annex B of the Sub-plan lists the Local Flood Sub Plans which exist or are to be prepared in New South Wales and indicates which river, creek and/or lake systems are to be covered in each plan. The City of Sydney is not listed in Annex B. However, it may be useful for the City of Sydney to prepare a local flood plan in conjunction with the SES to outline the following details:

- Evacuation centres in close proximity to the floodplain which allow flood free access to the centres and are flood free sites;
- Inclusion of a description of local flooding conditions;
- Identification of potentially flood affected vulnerable facilities; and
- Identification of key access road subject to flooding.

8.3 Emergency Service Operators

The emergency response to any flooding of the Alexandra Canal Catchment will be coordinated by the lead combat agency, the SES, from their Local Command Centre located at Erskineville.

However, the City of Sydney Security and Emergency Management Centre located at Town Hall is on the notification list for SES flood warning alerts and that direct liaison between the SES and the Security and Emergency Management Centre may be conducted via a dedicated radio frequency. The Manager - Security and Emergency Management may then pass on the flood warnings to any affected Council or Community Building within the Alexandra Canal Catchment.

The Security and Emergency Management Centre will continue to receive regular updates from the SES throughout a flood event.

The relevant flood information from the draft Alexandra Canal Catchment Flood Study (Cardno, 2013) should be transferred to the Security and Emergency Management Centre.

8.4 Flood Warning Systems

The critical duration and response times for the Alexandra Canal floodplain limit the implementation of a flood warning system. The short duration flooding experienced in local systems is not well suited to flood warning systems. However, for flash flood catchments (such as Alexandra Canal Catchment), the BoM provides general warning services, including:

- Severe Thunderstorm Warnings
- Severe Weather Warnings
- Flood Watches

These services are typically issued for a much larger region, or catchment, that includes the local flash flood site. This information can sometime be used at a local level as discussed below.

Flood Warnings Issued by BoM

Alexandra Canal Catchment is affected by flash flooding (i.e. floods where the warning time is less than 6 hours). As such it is difficult to provide any flood warning in advance of floods. Where possible, the Bureau of Meteorology (BoM) will issue a severe weather / flood warning to the Regional SES headquarters in Bankstown. Where that alert is relevant to the Alexandra Canal

Catchment, the SES Regional Command will pass the BoM's warning on to the Local Command based in Erskineville. In some cases, 2-3 days advanced notice may be available (e.g. where an East Coast Low develops off Sydney). However, at other times it may only be possible to issue a flood warning a few hours in advance, if at all.

Activation of Local SES Command

SES staff are advised and placed on alert when the SES Local Command has been issued with a flood warning by the BoM. The BoM's flood warning is also forwarded by SMS to the relevant individuals and organisations, including the City of Sydney Security and Emergency Management Centre located at Town Hall.

It is noted that the SES is the designated lead combat agency in an emergency such as a flood event. However, local authorities may wish to act on the advice provided by the SES to minimise the level of risk in the lead up to the flood event.

Depending on the amount of lead time provided, Council may undertake any relevant priority works, such as cleaning out stormwater pits to reduce the risk of blockage. In addition, Council's Rangers are placed on standby and report any issue directly to the SES (e.g. cars parked in overland flow paths, etc.).

Management of the Public Domain

A number of open, public areas are located within the Alexandra Canal Catchment. The provision of temporary refuges which can be accessed in a few minutes, even a small warning time may provide the public with sufficient time to seek refuge. The provision of rapid flood warnings within the Alexandra Canal Catchment may be delivered through an automated process that triggers a warning (e.g. with the installation of water level sensors placed in trapped depression areas). The warning itself could be delivered through the use of suitably located electronic information boards at key locations.

Another option is to have a public address system, which can relay a recorded message. The system could be similar to what the City of Sydney has already installed to manage emergencies in the busy streets of the City. An example of this system can be found near the main entrance of the Council building at Town Hall Square, where the public address speakers are installed on a traffic light pole.

8.5 Access and Movement During Flood Events

Any flood response suggested for the study area must take into account the availability of flood free access, and the ease with which movement may be accomplished. Movement may be evacuation from flood affected areas, medical personnel attempting to provide aid, or SES personnel installing flood defences.

8.5.1 Access Road Flooding

Table 8-1 provides a summary of road flooding in the Alexandra Canal Catchment.

It is recommended that permanent flood depth markers be installed on either side of roads which are subject to significant inundation to provide an indication to motorists of water levels at these locations when the road is flooded. Locations inundated in the 1 Year ARI event and which exceed 0.3m depth in any event up to the 100 Year ARI have been identified in **Table 8-1** and depth markers are recommended at these locations (this may also include adjacent intersections and low points).

Table 8-1 Access Road Flooding

ID	Location of Road Flooding (As shown on Map)	Depth Marker	Depth of Flooding (m)					
			1 Year ARI	2 Year ARI	5 Year ARI	20 Year ARI	100 Year ARI	PMF
1	Charles Street	N	0.00	0.24	0.34	0.44	0.52	1.05
2	Burren Street	N	0.00	0.20	0.25	0.33	0.41	0.90
3	Park Street	N	0.00	0.00	0.21	0.36	0.45	1.24
4	Newton Street	N	0.00	0.00	0.31	0.68	1.00	2.08
5	Copeland Street	N	0.00	0.00	0.29	0.53	0.73	1.34
6	Ashmore Street	N	0.00	0.16	0.25	0.34	0.45	1.79
7	Union Street	N	0.00	0.17	0.25	0.34	0.44	1.03
8	George Street/Macdonald Street	N	0.00	0.00	0.33	0.59	0.80	2.00
9	Coulson Street	Y	0.33	0.50	0.82	1.20	1.41	2.59
10	Mitchell Road / Coulson Street	N	0.00	0.23	0.38	0.76	0.97	2.16
11	Arthur Street	Y	0.43	0.65	0.82	0.95	1.06	1.59
12	Nobbs Street	Y	0.21	0.26	0.37	0.54	0.78	1.44
13	Cleveland Street	N	0.00	0.00	0.14	0.19	0.26	0.90
14	Charles Street	N	0.00	0.19	0.35	0.48	0.60	1.31
15	Bourke Street	N	0.00	0.00	0.23	0.34	0.43	1.29
16	Boronia Street	Y	0.17	0.32	0.48	0.60	0.70	1.26
17	Baptist Street	N	0.00	0.24	0.13	0.23	0.33	1.74
18	Phillip Street	Y	0.24	0.38	0.72	1.05	1.27	2.63
19	Chalmers Street	Y	0.54	0.64	0.73	0.80	0.86	1.12
20	Walker Street	Y	0.22	0.32	0.46	0.67	0.90	2.10
21	Young Street	N	0.00	0.23	0.28	0.39	0.62	1.64
22	Mcevoy Street	Y	0.34	0.51	0.66	0.75	0.80	1.04
23	Powell Street	N	0.00	0.21	0.40	0.79	1.45	2.95
24	Botany Road	Y	0.24	0.33	0.48	0.61	0.72	1.66
25	Wellington Street/ Cope Street	Y	0.15	0.18	0.26	0.59	0.77	1.41
26	Cope Street	Y	0.20	0.32	0.65	1.00	1.19	1.82
27	Wyndham Street/ Wellington Street	N	0.00	0.00	0.27	0.37	0.51	1.08
28	Buckland Street	Y	0.51	0.59	0.67	0.72	0.77	1.36
29	Mcevoy Street	Y	0.19	0.21	0.26	0.32	0.44	1.61
30	Lachlan Street	N	0.00	0.39	0.57	0.67	0.73	1.05
31	O'Dea Avenue	N	0.21	0.22	0.25	0.29	0.31	0.42
32	Joynton Avenue	Y	0.53	0.86	1.34	1.75	1.87	2.66
33	Botany Road (near Green Square)	Y	0.20	0.28	0.37	0.45	0.53	1.57
34	O'Riordan Street	Y	0.37	0.51	0.69	0.84	0.93	1.46
35	Bourke Road (near Bowden Street)	Y	0.15	0.18	0.33	0.55	0.67	2.45
36	Mandible Street	Y	0.24	0.32	0.45	0.69	0.89	3.08
37	Bowden Street	Y	0.30	0.33	0.37	0.47	1.02	3.62
38	Maddox Street	Y	0.63	0.76	0.81	0.85	0.88	2.71
39	Huntley Street	N	0.00	0.27	0.11	0.14	0.35	2.09
40	Harcourt Parade	Y	0.18	0.21	0.26	0.31	0.36	0.71

ID	Location of Road Flooding (As shown on Map)	Depth Marker	Depth of Flooding (m)					
			1 Year ARI	2 Year ARI	5 Year ARI	20 Year ARI	100 Year ARI	PMF
41	Tweedmouth Avenue	Y	0.26	0.30	0.35	0.40	0.45	0.75
42	Botany Road/Collins Street	Y	0.21	0.31	0.43	0.63	0.82	1.64
43	Morley Avenue	Y	0.40	0.58	0.77	1.00	1.17	1.73
44	Hayes Road	Y	0.20	0.27	0.35	0.46	0.56	1.22
45	Tweedmouth Avenue	N	0.00	0.00	0.22	0.29	0.40	1.13
46	Harcourt Parade/Durdans Avenue	Y	0.56	0.66	0.78	0.90	1.01	1.73
47	Botany Road\Harcourt Parade	N	0.00	0.17	0.26	0.37	0.48	1.18
48	Doody Street	Y	0.18	0.23	0.28	0.33	0.37	0.64
49	Euston Road	Y	0.42	0.47	0.55	0.63	0.74	1.68

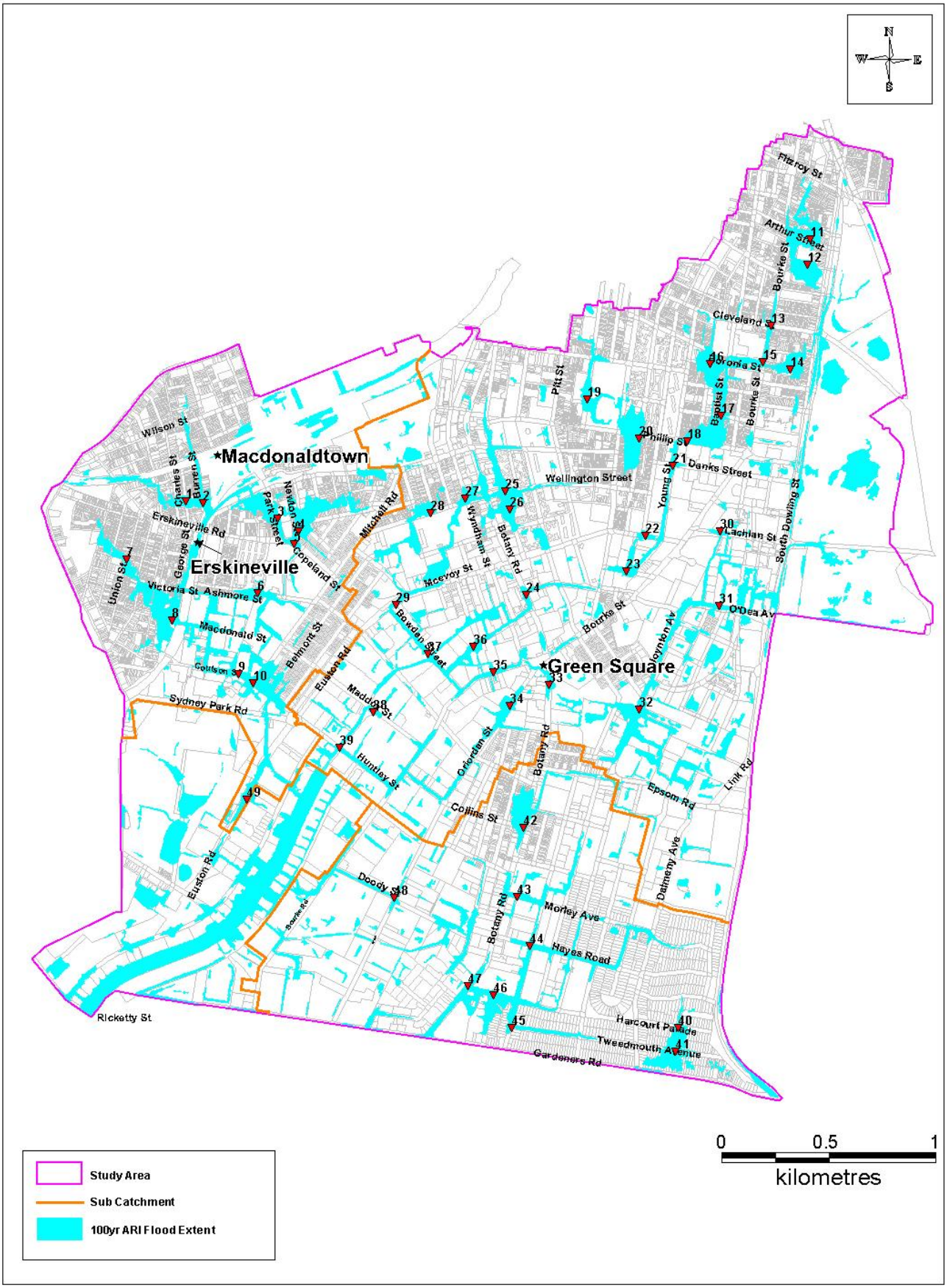


Figure 8-1 Access Road Flooding

8.5.2 Evacuation Centres

Several flood free locations have been identified in **Table 8-2** and **Figure 8-2** that may be suitable to function as evacuation centres during and following a flood event. Council and the SES should liaise with the owners and / or managers of the venues identified to determine appropriate evacuation centres. The selected locations should be identified in a local flood plan when it is prepared.

Table 8-2 Possible Evacuation Centres

ID*	Name of Venue	Address
1	Newtown High School of the Performing Arts	350 King Street Newtown NSW 2042
2	Newtown Public School	Norfolk Street Newtown NSW 204
3	St Mary's Primary School	54 Swanson Street Erskineville NSW 2043
4	Erskineville Public School	Swanson Street Sydney NSW 2043
5	Wunanbiri Pre-School	Belmont Street Alexandria NSW 2015
6	Alexandria Park Community Centre / Alexandria Park Community School	Power Avenue Alexandria NSW 2015
7	Surry Hills Neighbourhood Centre	405 Crown Street Surry Hills NSW 2010
8	Bourke Street Public School	590 Bourke Street Surry Hills NSW 2010
9	Sydney Boys High School	Cleveland Street Moore Park NSW 2021
10	Sydney Girls High School	Cleveland Street Moore Park NSW 2021
11	Moore Park Gardens Preschool & Long Day Care Centre	4/780 Bourke Street Redfern NSW 2016
12	SDN Redfern Children's Education and Care Centres	141-145 Pitt Street Redfern NSW 2016
13	The Factory Community Centre	67 Raglan Street Waterloo NSW 2017
14	Shop Women & Childrens Centre/ The Waterloo Girl's Centre	133 Morehead Street Waterloo NSW 2017
15	Our Lady of Mount Carmel	2-6 Kellick Street Waterloo NSW 2017
16	Taylors College	965 Bourke Street Waterloo NSW 2017
17	Waterloo Public School	237 Botany Road Waterloo NSW 2017
18	KU James Cahill Preschool	7 Raglan Street Waterloo NSW 2017

*ID as shown on Figure 8-2

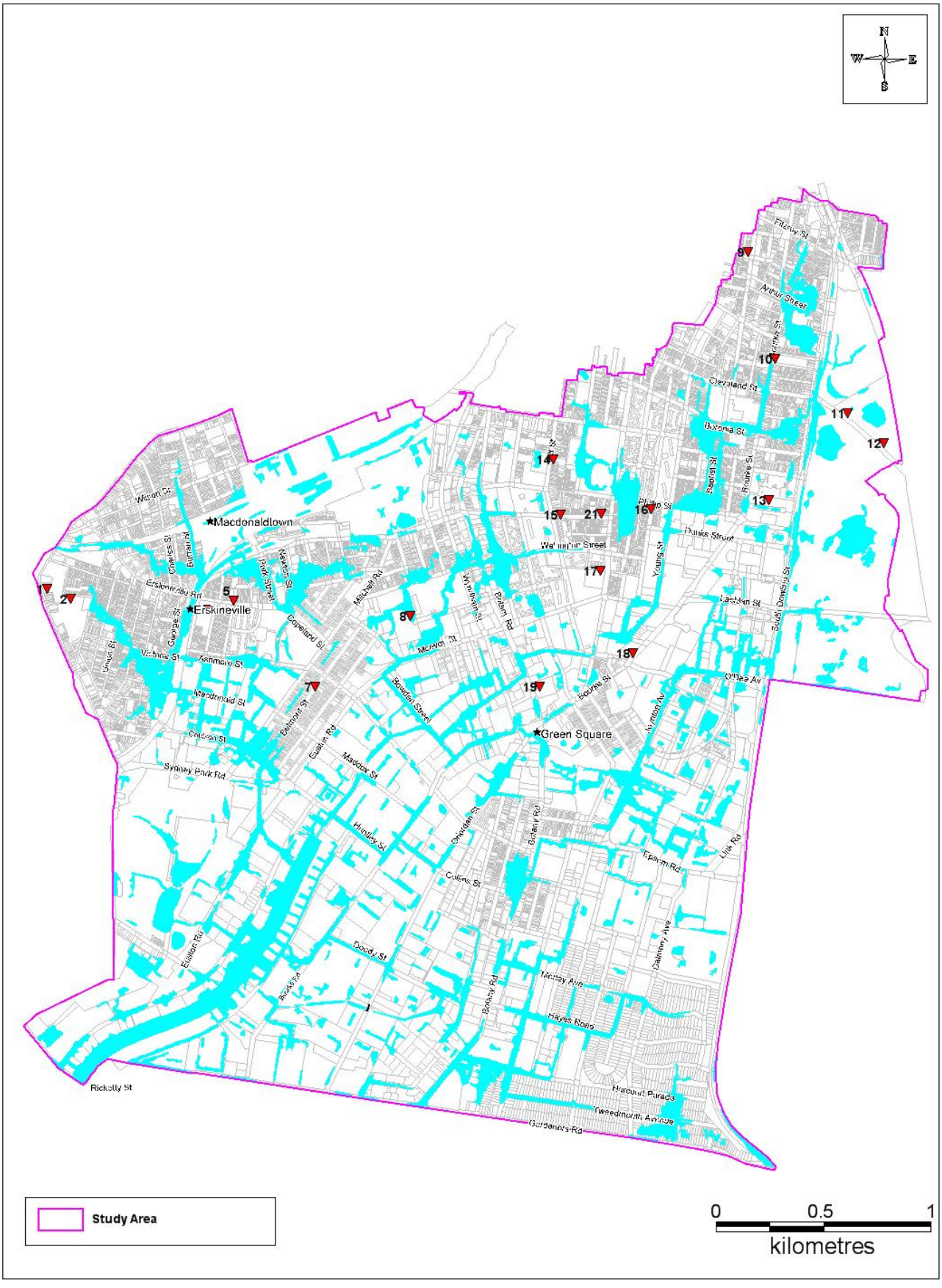


Figure 8-2 Locations of Possible Evacuation Centres

8.6 Flood Emergency Response Planning Classifications

To assist in the planning and implementation of response strategies the State Emergency Service (SES) classifies communities according to the impact flooding has on them. Flood affected communities are those in which the normal functioning of services is altered either directly or indirectly because a flood results in the need for external assistance. This impact relates directly to the operational issues of evacuation, resupply and rescue. The classifications adopted by the SES are (DECC, 2007):

- **Flood Islands.** These are inhabited or potentially habitable areas of high ground within a floodplain linked to the flood-free valley sides by a road across the floodplain and with no alternative overland access. The road can be cut by floodwater, closing the only evacuation route and creating an island. Flood islands can be further classified as:
    - High Flood Island (the flood island contains enough flood free land to cope with the number of people in the area or there is opportunity for people to retreat to higher ground).
    - Low Flood Island (the flood island does not have enough flood free land to cope with the number of people in the area or the island will eventually become inundated by flood waters).
- **Trapped Perimeter Areas.** These would generally be inhabited or potentially habitable areas at the fringe of the floodplain where the only practical road or overland access is through flood prone land and unavailable during a flood event. The ability to retreat to higher ground does not exist due to topography or impassable structures. Trapped Perimeter Areas are further classified according to their evacuation route:
    - High Trapped Perimeter (the area contains enough flood free land to cope with the number of people in the area or there is opportunity for people to retreat to higher ground).
    - Low Trapped Perimeter (the area does not have enough flood free land to cope with the number of people in the area or the island will eventually become inundated by flood waters).
- **Areas Able to be Evacuated.** These are inhabited areas on flood prone ridges jutting into the floodplain or on the valley side that are able to be evacuated.
    - Areas with Overland Escape Route (access roads to flood free land cross lower lying flood prone land).
    - Areas with Rising Road Access (access roads rise steadily uphill and away from the rising floodwaters).
- **Indirectly Affected Areas.** These are areas which are outside the limit of flooding and therefore will not be inundated nor will they lose road access. However, they may be indirectly affected as a result of flood damaged infrastructure or due to the loss of transport links, electricity supply, water supply, sewage or telecommunications services and they may therefore require resupply or in the worst case, evacuation.
- **Overland Refuge Areas.** These are areas that other areas of the floodplain may be evacuated to, at least temporarily, but which are isolated from the edge of the floodplain by floodwaters and are therefore effectively flood islands or trapped perimeter areas.

The flood emergency response planning classifications for the floodplain are shown in **Figure 8-3**.

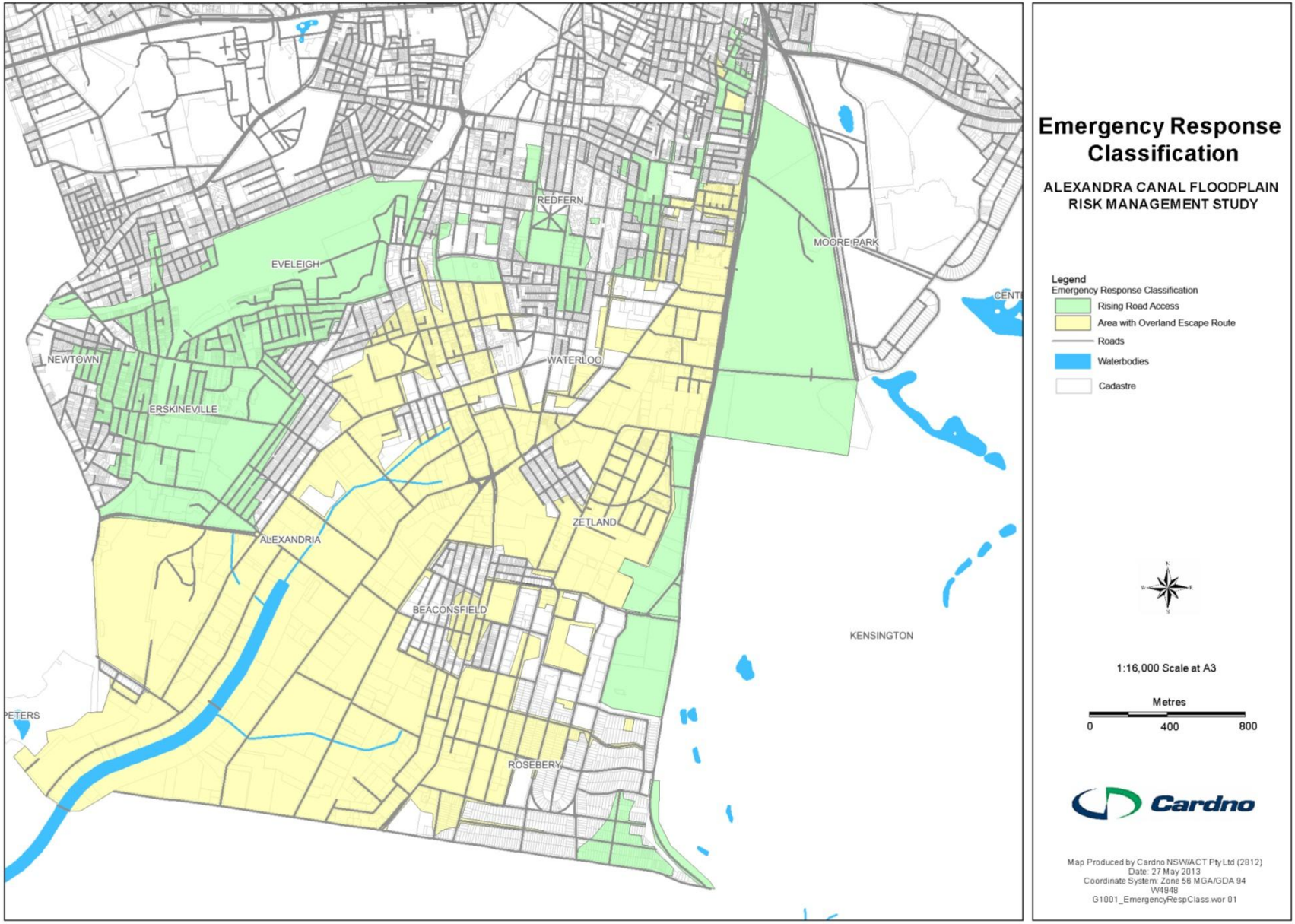


Figure 8-3 Emergency Response Classification Map

The flood affected areas of Alexandria, Beaconsfield, Zetland and Waterloo are primarily classified as “Areas with Overland Escape Routes”. These areas have access roads to flood free land which cross lower lying flood prone land. Evacuation can take place by road only until access roads are closed by floodwater. Escape from rising floodwater is possible but by walking overland to higher ground. Anyone that requires assistance during a flood event that is not able to walk out will require specialised access by SES or other emergency services.

The flood affected areas of Erskineville, Eveleigh, Redfern, Moore Park and the outskirts of Zetland and Beaconsfield are primarily classified as “Areas with Rising Road Access”. These areas have access roads rising steadily uphill and away from the rising floodwaters. The community cannot be completely isolated before inundation reaches its maximum extent (in the 100 Year ARI). Evacuation can take place by vehicle or on foot along the road as floodwater advances. People should not be trapped unless they delay their evacuation from their homes. For example people living in two storey homes may initially decide to stay but reconsider after water surrounds them.

Table 8-3 outlines the response recommended in the *Flood Risk Management Guideline* (DECC, 2007) for different flood emergency response planning classifications. It is noted that although evacuation is recommended in these guidelines for both of the emergency response classifications identified in the catchment. However, the catchment is primarily affected by short duration “flash” flooding and evacuation may not always be possible or safe in these circumstances. The classification should be used by emergency response providers to identify that these areas will potentially be isolated for a short period of time and appropriate response to this situation is required.

Table 8-3 Emergency Response Requirements (as recommended in DECC, 2007)

Classification	Response Required		
	Resupply	Rescue / Medivac	Evacuation*
High Flood Island	Yes	Possibly	Possibly
Low Flood Island	No	Yes	Yes
Area with Rising Road Access	No	Possibly	Yes
Area with Overland Escape Routes	No	Possibly	Yes
Low Trapped Perimeter	No	Yes	Yes
High Trapped Perimeter	Yes	Possibly	Possibly
Indirectly Affected Areas	Possibly	Possibly	Possibly

**note that in this catchment is primarily affected by “flash” flooding and evacuation may not always be safe or appropriate in these circumstances.*

9 Policies and Planning

9.1 Planning Instruments / Policy

The Alexandra Canal Catchment is located in the City of Sydney LGA where development is controlled through the Sydney Local Environment Plan (LEP) 2012 and Development Control Plans (DCP). The LEP is a planning instrument which designates land uses and development in the LGA, which the DCPs regulates development with specific guidelines and parameters. Management policies and plans are often used to provide additional information regarding development guidelines and parameters.

This section reviews flood controls covered by the LEP, relevant DCPs, policies and plans.

9.2 Sydney Local Environmental Plan 2012

9.2.1 Flood Controls

Section 7.15 Flood Planning of the LEP outlines control and objectives for land below the flood planning level (100 Year ARI + 0.5m). The objectives of this section are:

- to minimise the flood risk to life and property associated with the use of land,
- to allow development on land that is compatible with the land's flood hazard, taking into consideration projected changes as a result of climate change,
- to avoid significant adverse impacts on flood behaviour and the environment.

It is stated that development consent must not be granted to development on land to which this clause applies unless the consent authority is satisfied that the development:

- is compatible with the flood hazard of the land,
- is not likely to significantly adversely affect flood behaviour resulting in detrimental increases in the potential flood affectation of other development or properties,
- incorporates appropriate measures to manage risk to life from flood,
- is not likely to 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
- is not likely to result in unsustainable social and economic costs to the community as a consequence of flooding.

Several other state planning instruments also apply to specific areas within the catchment. **Table 9-1** provide a summary of the relevant flood related objectives and controls contained within those instruments.

Table 9-1 State Planning Controls

Planning Control	Flood Management Objectives and Controls
South Sydney LEP 114	The Council shall not grant consent to the erection of a building or the carrying out of works on land to which this plan applies if, in the opinion of the Council: (a) the land is within a floodway, and (b) the carrying out of the development is likely: (i) to adversely impede the flow of flood waters on that land or land in its immediate vicinity, or

Planning Control	Flood Management Objectives and Controls
	(ii) to imperil the safety of persons on that land or land in its immediate vicinity in the event of those lands being inundated with flood waters, or (iii) to aggravate the consequences of floodwaters flowing on that land or land in its immediate vicinity with regard to erosion or siltation, or (iv) to have an adverse effect on the water table of that land or of land in its immediate vicinity. This plan does not apply to land to which South Sydney Local Environmental Plan 1998 applies.
South Sydney Local Environmental Plan 1998	The Council must not consent to development on land within the Green Square Town Centre unless it is satisfied that the development: (a) will not adversely affect flood behaviour, including: (i) the flood peak at any point upstream or downstream of the proposed development, and (ii) the flow of floodwater on adjoining lands, and (b) will not significantly increase any flood hazard or the likelihood of flood damage to any property, and (c) will not restrict the capacity of any floodway, and (d) will not increase the risk to the lives or personal safety of members of the public or emergency services and rescue personnel, and (e) incorporates any freeboard levels and other flood proofing measures adopted by the Council in any relevant floodplain risk management policy. Without limiting the subclause above, the Council must not consent to development on land situated on the southern corner of Botany Road and O'Riordan Street, unless it is satisfied that: (a) the development is consistent with any relevant floodplain risk management policies and local flood plans that have been adopted by the Council, and (b) on completion of the development, the land will achieve a low hazard categorisation for a 100 Year ARI flood event, having regard to the design of the development, including flood proofing and flood modification measures, and (c) the development does not create or materially contribute to a significant risk to the safety of persons in a probable maximum.
SEPP Major Development 2005	The objectives of the flood related clauses are: (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. The flood related clause applies to land at or below the flood planning level. 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 or 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. In this clause: flood planning level means the level of a 1:100 ARI (average recurrent interval) flood event plus 0.5m freeboard.

9.2.2 Current Land Use and Zoning

The Alexandra Canal Catchment is primarily comprised of a combination of urban zones with some areas of open space.

The land use within the Alexandra Canal Catchment is controlled by the Sydney LEP 2012. The zoning of the study area is shown in **Figure 9-1**, and these zones and the flood affected areas within each zone are described in **Table 9-2**.

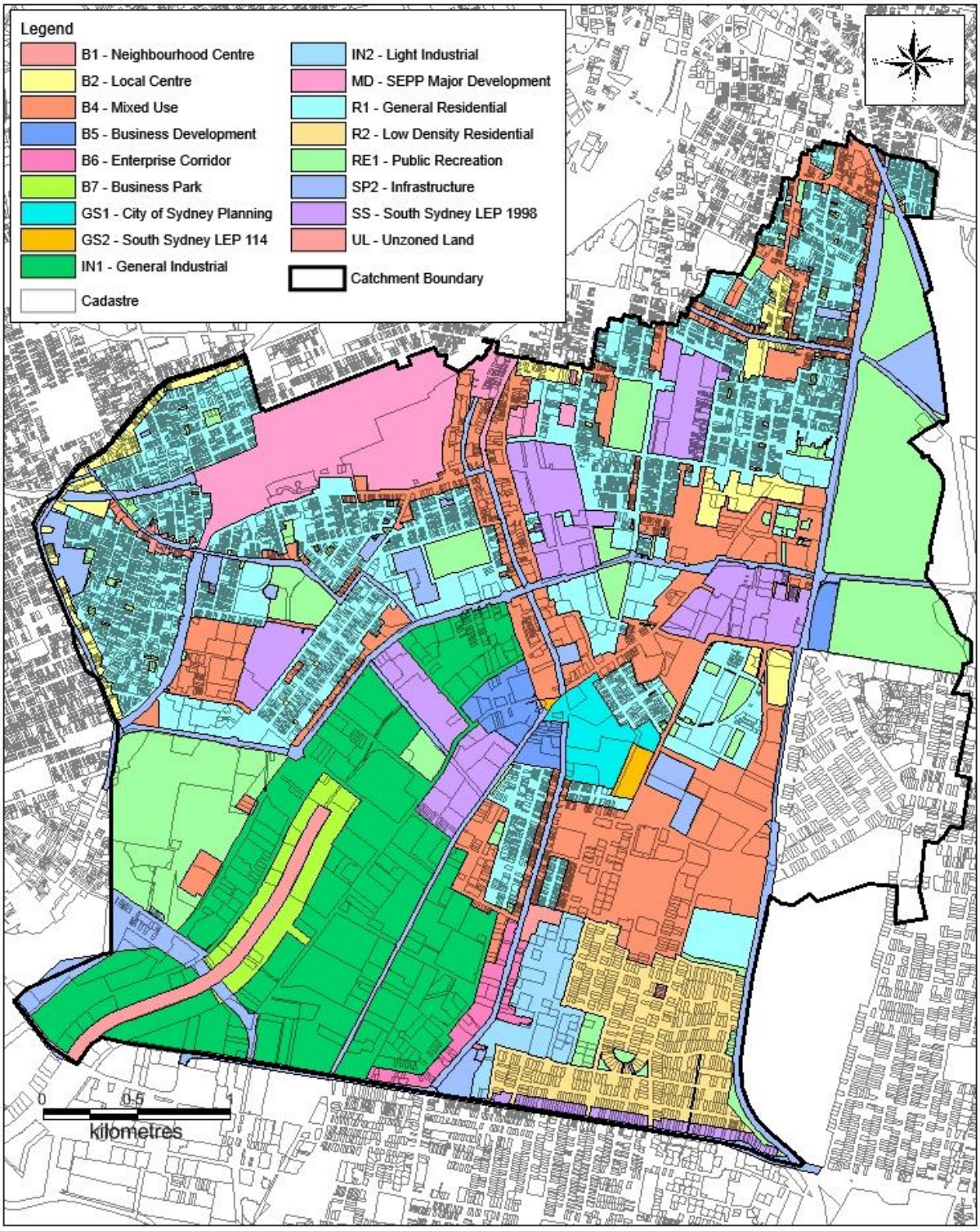


Figure 9-1 LEP Zones

Table 9-2 Alexandra Canal Catchment Land Uses

Zone	Land Use	Description	Area Affected by PMF (ha)	Area Affected by 100 Year ARI (ha)
Business	B1 Neighbourhood Centre	To provide a range of small-scale retail, business and community uses that serve the needs of people who live or work in the surrounding neighbourhood. To allow appropriate residential uses so as to support the vitality of neighbourhood centres.	3.18	0.2
	B2 Local Centre	To provide a range of retail, business, entertainment and community uses that serve the needs of people who live in, work in and visit the local area. To encourage employment opportunities in accessible locations. To maximise public transport patronage and encourage walking and cycling. To allow appropriate residential uses so as to support the vitality of local centres.	24.4	1.2
	B4 Mixed Use	To provide a mixture of compatible land uses. To integrate suitable business, office, residential, retail and other development in accessible locations so as to maximise public transport patronage and encourage walking and cycling. To ensure uses support the viability of centres.	177.6	21
	B5 Business Development	To enable a mix of business and warehouse uses, and bulky goods premises that require a large floor area, in locations that are close to, and that support the viability of, centres. To encourage employment opportunities. To enable other land uses that provide facilities or services to meet the day to day needs of the community. To promote uses with active street frontages	13.4	1.8
	B6 Enterprise Corridor	To promote businesses along main roads and to encourage a mix of compatible uses. To provide a range of employment uses (including business, office, retail and light industrial uses). To maintain the economic strength of centres by limiting retailing activity. To provide for residential uses, but only as part of a mixed use development.	9.2	0.5
	B7 Business Park	To provide a range of office and light industrial uses. To encourage employment opportunities. To enable other land uses that provide facilities or services to meet the day to day needs of workers in the area. To ensure uses support the viability of nearby centres.	16	5.6
City of Sydney Planning	GS1	Green Square	12.2	1.76

Zone	Land Use	Description	Area Affected by PMF (ha)	Area Affected by 100 Year ARI (ha)
South Sydney LEP 114	GS2 – Zone 5 (a) Special Uses Zone South Sydney Hospital	The objective is to identify land which is currently used by public authorities, institutions, organisations or for Council to provide certain community facilities, services or utilities.	2.6	0.5
Industrial	IN1 General Industrial	To provide a wide range of industrial and warehouse land uses. To encourage employment opportunities. To minimise any adverse effect of industry on other land uses. To support and protect industrial land for industrial uses. To ensure uses support the viability of nearby centres.	165.8	23.4
	IN2 Light Industrial	To provide a wide range of light industrial, warehouse and related land uses. To encourage employment opportunities and to support the viability of centres. To minimise any adverse effect of industry on other land uses. To enable other land uses that provide facilities or services to meet the day to day needs of workers in the area. To support and protect industrial land for industrial uses.	17.7	3.4
Major Development	MD SEPP Major Development	Redfern-Waterloo Authority Sites	55.4	6.4
Residential	R1 General Residential	To provide for the housing needs of the community. To provide for a variety of housing types and densities. To maintain the existing land use pattern of predominantly residential uses To enable other land uses that provide facilities or services to meet the day to day needs of residents.	266	• • • • 36.2
	R2 Low Density Residential	To provide for the housing needs of the community within a low density residential environment. To enable other land uses that provide facilities or services to meet the day to day needs of residents.	56	6.8
Recreation	RE1 Public Recreation	To enable land to be used for public open space or recreational purposes. To provide a range of recreational settings and activities and compatible land uses. To protect and enhance the natural environment for recreational purposes. To provide links between open space areas. To retain and promote access by members of the public to areas in the public domain including recreation facilities and waterways and other natural features.	143.4	16.4

Zone	Land Use	Description	Area Affected by PMF (ha)	Area Affected by 100 Year ARI (ha)
Special Purpose Zones	SP2 Infrastructure	To provide for infrastructure and related uses. To prevent development that is not compatible with or that may detract from the provision of infrastructure.	104	17.3
South Sydney LEP	SS – Zone No.2 (b) Residential (medium density)	to enhance the amenity of existing medium density residential areas, and to nominate those localities which are primarily residential and where future residential development is likely to occur, and to ensure that building form including alterations and additions, is in character with the surrounding built environment and does not detract from the amenity enjoyed by nearby residents or the existing quality of the environment, and to provide limited opportunities for non-residential development which provides goods, services or employment for residents and is of a type and scale that is compatible with existing or planned residential development and does not detract from the amenity enjoyed by nearby residents or the existing quality of the environment, and to facilitate a higher density and diverse forms of residential development on appropriate sites, and to facilitate opportunities for small scale local business activity which is compatible with existing residential areas.	74	9
	SS – Zone No.10 (b) Mixed Uses	to provide urban housing and a range of compatible vibrant non-residential uses, such as shops, offices, retail and studio-type workshops, and to promote mixed use planning by encouraging the location of facilities such as housing, places of employment and shops in close proximity to each other and so as to be accessible by public transport, and to allow up to 25% non-residential use of the total floorspace proposed for each development site, and to ensure non-residential uses are environmentally compatible with residential uses, and do not adversely affect residential amenity, within the zone, and to minimise any adverse impact, including social impact, on residential amenity by devising appropriate design assessment criteria and applying specific impact mitigation requirements by the use of development control plans, and to ensure that the nuisance generated by non-residential development, such as is caused by operating hours, noise, loss of privacy, vehicular and pedestrian traffic or other factors, is controlled, so as to preserve the quality of life for residents in the area, and to ensure that development contributes to a sustainable, vibrant community, and reflects equal and integrated consideration of social, economic and environmental design issues, and to enhance and enliven Green Square through the implementation of public art where appropriate.		

Zone	Land Use	Description	Area Affected by PMF (ha)	Area Affected by 100 Year ARI (ha)
South Sydney LEP	SS – Zone No.10 (d) Mixed Uses	to establish a predominantly employment based zone while allowing not more than 15% residential use of the total floorspace proposed for each development site, but only if it supports those employment uses, and to encourage appropriate business activities which contribute to economic growth and employment opportunities within the Green Square area, and to promote the vitality of the public domain by encouraging the location of active retail and entertainment uses at ground and first floor levels, particularly in areas fronting the Green Square Railway Station, and to ensure through the design of a high quality public domain that a high level of amenity is provided for pedestrians, shoppers and workers within the zone, and to minimise any adverse impact, including social impact, on residential amenity by devising appropriate design assessment criteria and applying specific impact mitigation requirements by the use of development control plans, and to ensure that existing and future development on land zoned industrial under this plan is preserved and promoted so as to protect the existing employment within South Sydney, and to ensure that development within the zone contributes to a sustainable, vibrant community, and reflects equal and integrated consideration of social, economic and environmental design issues, and to enhance and enliven Green Square through the implementation of public art where appropriate.		
South Sydney LEP	SS – Zone No.10 (e) Mixed Uses	to establish a predominantly employment-based zone while allowing residential use on appropriate development sites, and to allow for appropriate business activities which contribute to economic growth and employment opportunities within the Green Square area, provided they are environmentally compatible in terms of design and operational requirements with residential development, and to allow residential development within the zone, provided it is designed so as to be compatible with other non-residential uses and will not adversely affect the operations of existing lawfully operating industrial uses, and to minimise any adverse impact, including social impact, on residential amenity by devising appropriate design assessment criteria and applying specific impact mitigation requirements by the use of development control plans, and to ensure that development within the zone contributes to a highly sustainable, vibrant community, and reflects equal and integrated consideration of social, economic and environmental design issues.		

Zone	Land Use	Description	Area Affected by PMF (ha)	Area Affected by 100 Year ARI (ha)
South Sydney LEP	SS – Zone No.11 (a) Green Square Town Centre	to establish the Green Square Town Centre as the major commercial, retailing, cultural and entertainment centre for Green Square, and to allow for a mix of land uses that will: (i) ensure that there is an appropriate balance between residential, retail, commercial and other land uses within the Green Square Town Centre, and (ii) encourage the provision of a range of services and facilities to help meet the needs of the population and users of the Green Square Town Centre, and (iii) generate employment in the Green Square Town Centre, and to facilitate the development of buildings and works that are of a scale, character and design quality consistent with the other objectives of the zone, and to encourage development that is compatible with the surrounding heritage conservation areas and heritage items, and to ensure that the public domain of the Green Square Town Centre is fronted by high-quality buildings having a scale and alignment that both define, and contribute positively to the amenity of, the public spaces (including parks, plazas and streets) they adjoin, and to protect the amenity of parks and community places by protecting access to sunlight, providing shelter from the rain and minimising wind speeds, and to provide active frontages to streets and other identified public spaces (including parks and plazas), and to promote the vitality of the public domain by encouraging the location of active retail, food and beverage and entertainment uses, and of community and cultural facilities, at ground level (particularly at the edges of public plazas), and to accommodate and integrate the management of stormwater (including floodwater) into the function and design of buildings in the Green Square Town Centre.		
Unzoned Land	UZ	N/A	10.2	10

9.3 Development Control Plans

A development control plan (DCP) is a non-legal document that supports the LEP with more detailed planning and design guidelines. Several DCPs are in place in the City of Sydney LGA, the key document within the Alexandra Canal Catchment being the Sydney DCP 2012.

The flood related objective of the Sydney DCP 2012 is to:

- Ensure that development manages and mitigates flood risk, and does not exacerbate the potential for flood damage or hazard to existing development and to the public domain.

Whilst the objective is clearly defined in the Sydney DCP 2012, no specific development controls are provided to achieve this objective (except for those relating to on-site detention).

The DCP outlines the requirements for site specific flood studies. However, there seems to be some inconsistency between the DCP and the LEP, as the DCP states that site specific flood studies may be required by Clause 7.17 of the Sydney LEP 2012. There is no mention of flood management in Clause 7.17 and no reference as to when a site specific flood study may be required in Sydney LEP 2012.

Development within the Green Square Town Centre is managed under the Green Square Town Centre DCP 2012. The objectives of the flood related provisions in this DCP are to:

- Ensure that new development is not subjected to undue flood risk, nor exacerbates the potential for flood damage or hazard to existing development and to the public domain both during and after the event.
- Ensure that flood risk management within the Green Square Town Centre addresses public safety and protection from flooding.

The Green Square Town Centre DCP 2012 requires all development application to be prepared in accordance within the Green Square West Kensington Flood Study and Flood Risk Management Study and Plan (WMA, 2011).

The DCP also provides guidance on preparing site specific flood studies, and outlines key flood management principals which development must adhere to (e.g. incorporation of flow paths, detention areas and upgraded culverts).

Specific flood planning levels (FPLs) are documented for various development types. Further details are provided on this in **Section 10**.

9.4 Relevant Policies and Plans

9.4.1 Floodplain Management Policy

Council is currently preparing a Floodplain Management Policy. The purpose of the policy is to ensure the flood related objectives of the Sydney LEP 2012 are met and to provide specific development principals, controls and guidance not available in the LEP or DCP.

A review of the current (in preparation) Floodplain Management Policy identifies the following components contained within:

- Development application requirements and inclusions;
- Performance criteria;
- Allowances for concessional development;
- Specific controls relating to residential and industrial / commercial development, fencing, car parking, filling, on-site sewer management and storage hazardous substances.

- Flood planning levels (FPLs) are provided for various development types and components.
- Details regarding flood compatible materials.

9.4.2 Decentralised Water Master Plan 2012 - 2030

The Decentralised Water Master Plan 2012–2030 has been prepared by City of Sydney Council to position the city to deliver 30 per cent of the city's water demand from recycled water by 2030. Floodplain management in Alexandra Canal needs to consider the objectives of the Master plan, primarily to look for opportunities to achieve the dual outcomes of flood risk reduction and alternative water delivery (e.g. detention and retention storage, groundwater recharge). However, floodplain management planning also needs to consider the constraints imposed by the Master Plan such as coordinating flood works and decentralised water works within large scale development. The compatibility of floodplain risk management options with the Master Plan has been considered in the multi-criteria matrix assessment (**Section 13**).

Guidelines for on-site detention (OSD) are provided in Stormwater Drainage Connection Information (City of Sydney, 2006). The policy requires all development sites in the LGA greater than 250 m^2 and less than 1000 m^2 to incorporate OSD to reduce the 100 Year ARI post-development site runoff to the 5 Year ARI site run off.

9.5 Planning Recommendations for Alexandra Canal Floodplain

Based on the review of the documents presented in the previous sections, the following recommendations have been made. Additional details are provided in **Section 11.4**.

- Whilst the Sydney LEP 2012 is the primary state planning document relating to the catchment the South Sydney LEP 114, South Sydney LEP 1998 and the SEPP Major Development 2005 are also relevant to specific areas or development types in the catchment. These other documents contain more detailed consideration of flood management than the Sydney LEP 2012. Council may wish to consider updating the Sydney LEP 2012 to be consistent with the flood related clauses in these other documents.
- There was a lack of consistency between the Sydney LEP 2012 and the Sydney DCP 2012. It is recommended that either the LEP or the DCP or both are updated to ensure accurate cross referencing between the two documents.
- The requirements for a site specific flood study are provided in the Sydney DCP 2012. However, the DCP notes that the Sydney LEP 2012 outlines when a site specific flood study is required. The LEP does not contain this information. Either the LEP or the DCP or both should be updated to ensure this information is provided.
- The Sydney DCP 2012 outlines the objective of the DCP with regards to flooding and the requirements for a site specific flood study. However, no specific flood related development controls are provided. It is understood that Council is currently preparing a *Floodplain Management Policy*, which will include more detailed controls and requirements for flood planning. Reference to this policy should be included in the DCP or the key controls outlined in the Policy could also be included in the DCP.
- The flood management provisions in the Sydney DCP 2012 do not provide consideration of the impacts of climate change on flooding and how that should be responded to in development. The DCP should be updated to identify Council's current position on climate change and floodplain management. Alternatively, this information could be included in the Floodplain Management Policy.
- It is recommended that the Floodplain Management Policy should include controls relating to the following:

  - Impacts of climate change on flooding and how this should be considered in development and planning.
  - Consideration of the flood planning levels recommended in **Section 10**.
  - Consideration of emergency response provisions in new development with regards to short duration flooding in the catchment.

- Council may wish to consider using the outcomes of the Alexandra Canal Flood Study (Cardno, 2013) to develop OSD requirements specific to the catchment requirements. In particular, there may be areas in the catchment where OSD should not be incorporated, as it may adversely impact on downstream areas. Any such changes should also be considered as part of the implementation of the Decentralised Water Master Plan.
- There may be opportunities to incorporate flood management measures into new developments as a condition of consent, Section 94 contribution offsets or government-related funding. The nature of the flood controls implemented will be dependent on the location of the development, the flooding behaviour and the type of development. However, allowance and / or requirements for these works could be identified through amendments to the Sydney DCP 2012 or the Floodplain Management Policy.
- No local controls specific to Alexandra Canal have been identified for inclusion in the LEPs, DCPs or Floodplain Management Policy.

10 Flood Planning Level Review

10.1 Background

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

A variety of factors require consideration in determining an appropriate FPL. Of key consideration in the development of an FPL, is the flood behaviour and the risk posed by the flood behaviour to life and property in different areas of the floodplain and different types of land use.

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

- Risk to life;
- Long term strategic plan for land use near and on the floodplain;
- Existing and potential land use;
- Current flood level used for planning purposes;
- Land availability and its needs;
- FPL for flood modification measures (levee banks etc);
- Changes in potential flood damages caused by selecting a particular flood planning level;
- Consequences of floods larger than that selected for the FPL;
- Environmental issues along the flood corridor;
- Flood warning, emergency response and evacuation issues;
- Flood readiness of the community (both present and future);
- Possibility of creating a false sense of security within the community;
- Land values and social equity;
- Potential impact of future development on flooding;
- Duty of care.

These issues are dealt with collectively in the following sections.

10.2 Likelihood of Flooding

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

Analysis of the data presented in **Table 10-1** gives a perspective on the flood risk over an average lifetime. The data indicates that there is a 50% chance of a 100 Year ARI event occurring at least once in a 70 year period. Given this potential, it is reasonable from a risk management perspective to give further consideration to the adoption of the 100 Year ARI flood event as the basis for the FPL. Given the social issues associated with a flood event, and the non-tangible effects such as stress and trauma, it is appropriate to limit the exposure of people to floods.

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

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

Likelihood of Occurrence in Any Year (ARI)	Probably of Experiencing At Least One Event in 70 Years (%)	Probability of Experiencing At Least Two Events in 70 Years (%)
10 Year ARI	99.9	99.3
20 Year ARI	97	86
50 Year ARI	75	41
100 Year ARI	50	16
200 Year ARI	30	5

10.3 Current FPL

Based on the Sydney LEP 2012, Council currently utilises the 100 Year ARI flood level plus a freeboard of 0.5m to define the Flood Planning Level.

It is understood that Council are currently preparing a *Floodplain Management Policy* which will provide further details regarding flood planning levels for various types of development within the floodplain.

10.4 Land Use and Planning

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

A potential impact on flooding can arise through the intensification of development on the floodplain, which may either remove flood storage or impact on the conveyance of flows. DCP 2012 currently outlined controls relating to the installation of onsite detention to manage increased impervious area. No provisions exist within the current DCP 2012 or LEP 2012 to limit development within floodway or areas or limit filling in storage areas. However, it is understood that the proposed *Floodplain Management Policy* will include provisions relating to these issues. Given the current and proposed planning measures relating to this issue, it is not considered to be a significant issue within the catchment.

10.5 Damage Cost Differential Between Events

Based on an estimated flood damages for a property of $50,000, the incremental difference in Annual Average Damage (AAD) for different recurrence intervals is shown in **Table 10-2**. The table shows the AAD of an example property that experiences over-floor flooding in each design event, and the net present value (NPV) of those damages over 50 years at 7 percent.

Table 10-2 indicates that the largest incremental differences between AAD per property occurs between the more frequent events. The greatest difference between damages occurs between the 1 and 2 Year ARI events and 2 and 5 Year ARI events. It can be seen that the differences between the larger events are relatively small, suggesting that increasing the FPL beyond the 20 Year ARI level does not significantly alter the savings achieved from a reduction in damages.

Table 10-2 Damage Differential Costs

Event	AAD per Property	Change in AAD	NPV of AAD	Change in NPV
1 Year ARI	$50,000	-	$690,037	-
2 Year ARI	$25,000	$25,000	$345,019	$345,019
5 Year ARI	$10,000	$15,000	$138,007	$207,011
10 Year ARI	$5,000	$5,000	$69,004	$69,004
20 Year ARI	$2,500	$2,500	$34,502	$34,502
100 Year ARI	$500	$2,000	$6,900	$27,601
PMF	$0	$500	$0	$6,900

10.6 Incremental Height Difference Between Events

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

Based on the existing flood behaviour, the incremental height difference between events is shown in **Table 10-3** for selected events. These are average height differences determined based on the flood levels at each of the flood affected properties within the catchment as part of the flood damages analysis.

Table 10-3 Relative Differences Between Design Flood Levels

Event	Average Difference to PMF (m)	Average Difference to 100 Year ARI (m)	Average Difference to 20 Year ARI (m)
100 Year ARI	0.59	-	-
20 Year ARI	0.69	0.10	-
10 Year ARI	0.72	0.13	0.03

Table 10-3 indicates a larger difference in the flood level of the PMF event compared to other events. The adoption of the 100 Year ARI event as the flood planning level is only marginally different from that of the 20 Year ARI (on average 0.1 m higher). Therefore, the adoption of the 100 Year ARI event would provide an increased level of risk reduction over the 20 Year ARI event, without a significant difference in the flood planning level height.

The adoption of the PMF event as the flood planning level would result in more significant increases in levels over the 100 Year ARI event (in the order of 0.59 metres) and may therefore potentially present an issue for the setting of flood planning levels in the catchment.

With regards to an appropriate freeboard, the average difference between the PMF and the 100 Year ARI is 0.59 m, indicating that basing the FPL on the 100 Year ARI level, with an appropriate freeboard would result in the protection of some buildings in the PMF event.

10.7 Consequence of Adopting the PMF as a Flood Planning Level

The use of the PMF as a flood planning level provides the greatest level of risk reduction available with regards to planning levels. However, the economic and planning consequences of the adoption of the PMF for these purposes often outweigh the potential benefits.

Analysis of the flood damages (**Table 10-2**) indicates that the choice of the PMF event over the 100 Year ARI event as the FPL would result in limited economic benefits (in annualised terms) to the community.

The difference in average flood levels between the 100 Year ARI and the PMF event (**Table 10-3**) indicate that the use of the PMF as the FPL would result in higher levels (0.59 metres on average), and as a result higher economic costs and inconvenience to the community

The use of the PMF level as the FPL may conflict with other development / building controls in the Council's DCPs.

Given the risk of exposure outlined in **Table 10-1**, it is recommended that emergency response facilities be located outside of the floodplain and any other future planning ensure critical facilities be limited to areas outside of the floodplain. Modifications to existing critical facilities within the floodplain are suggested to have a floor level at the PMF level.

10.8 Environmental and Social Issues

The FPL can result in housing being placed higher than it would otherwise be. This can lead to a reduction in visual amenity for surrounding property owners, and may lead to encroachment on neighbouring property rights. This may also cause conflict with other development controls already present within the Council's development assessment process such as those relating to heritage buildings and localities.

10.9 Climate Change

The impacts of climate change on flood behaviour in the catchment were assessed as part of the Flood Study (Cardno, 2013). Models were run for the 100 year ARI 90 minute storm for increased rainfall intensities of 10%, 20%, and 30% with an elevated tailwater level of 2.9m AHD. **Table 10-4** provides a summary of the key impacts of the climate change modelling.

Table 10-4 Climate Change Impacts

Event	Rainfall Intensity Increases		
	10%	20%	30%
Average flood level difference (m)	0.01	0.02	0.03
Median flood level difference (m)	0.00	0.00	0.00
Standard deviation (m)	0.05	0.06	0.08
Maximum flood level difference (m)	0.55	0.70	1.06

The model indicates that areas most sensitive to climate change impacts, and in particular increases in rainfall intensities, are the trapped low points throughout the study area. The increase in rainfall intensities results in a greater volume of runoff arriving at these locations, and an associated increase in peak water level as a result. Other locations that are sensitive are locations like Bowden Street, which is the confluence point for a number of flowpaths. Large increases are also observed along Alexandra Canal, which is directly affected by the backwater from the Cooks River.

10.10 Risk

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

Critical infrastructure, such as hospitals, fire stations, electricity sub-stations and other critical infrastructure, has wider spread implications should inundation occur. As such, FPLs are typically selected for these types of structures higher than for residential, commercial or industrial properties.

10.11 Culvert Blockage

Stormwater pits can potentially block through a number of factors, including the build-up of leaf litter, parked cars and garbage bins. Blockages to culverts and bridges within the study area can occur by the accumulation of debris washed down from upstream. This debris, from historical observations in other similar catchments, can include vegetation and trees, cars and garbage bins.

Culvert blockages were assessed as part of the Flood Study (Cardno, 2013) for two cases, 100% blockage and 50% blockage. The impact of pit and culvert blockages results in some significant localised increases in peak water levels.

For the 50% blockage, the main areas impacted are Bowden Street, with an approximate 0.7 metre increase, Euston Road, with an approximate 0.35 metre increase and Ralph Street, with an approximate increase of 0.3 metres. These locations are impacted by the culvert blockage together with the lower pit capacities.

The impact of the 100% blockage case results in more widespread impacts. Key areas impacted are the low lying trapped depression locations, such as Coulson Street, areas along Botany Road, the area to the north of Copeland Street and Erskineville Oval and the trapped low points in the vicinity of Danks Street. In these locations, the primary outflow points are via the pit and pipe system. If this system is to become blocked, then there are limited opportunities for outflow of water from these locations.

Whilst it can be seen that the flood levels some areas are sensitive to culvert blockage, the average increase in flood levels as a result of culvert blockage is only 0.02m for the 100% blockage scenario (with a standard deviation of 0.07m). Therefore, it is recommended that the effects of culvert blockages continue to be assessed when undertaking flooding investigations as they can significantly impact some properties. However, with respect to freeboard, the blockage rates have minimal flood level impacts on the majority of properties within the catchment and should not affect the selection of flood planning levels.

10.12 Freeboard Selection

As outlined in **Section 10.1**, a freeboard ranging from 0.3 – 0.5 metres is commonly adopted in determining the FPL. The freeboard accounts for uncertainties in deriving the design flood levels and as such should be used as a safety margin for the adopted FPL. The freeboard may account for factors such as:

- Changes in the catchment;
- Changes in the creek / channel vegetation;
- Accuracy of the model inputs (e.g. ground survey, design rainfall inputs for the area);
- Model sensitivity:
    - Local flood behaviour (due to local obstructions);
    - Wave action (e.g. wind induced waves or was from vehicles);
    - Culvert blockage; and
    - Climate change (affecting both rainfall and ocean levels).

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

- Afflux (local increase in flood levels due to small local obstructions not accounted for in the modelling) (+0.1m) (Gillespie, 2005).
- Local wave action (trucks and other vehicles) (allowances of +0.1m are typical).

- Accuracy of ground / aerial survey (+/- 0.15m).
- Climate change impacts on rainfall and sea level rise (+0.03m).
- Sensitivity of the model +/-0.05m.

Based on this analysis, the total sum of the likely variations is in the order of 400mm, excluding climate change. This would suggest that a freeboard allowance of 500mm would be appropriate for the Alexandra Canal Catchment.

When applied to design events less than the PMF, the freeboard may still result in the FPL being higher than the PMF in certain cases.

It should also be noted that flooding within the Alexandra Canal Catchment in many locations could be categorised as overland flow. A shallow overland flowpath may not be significantly impacted with respect to several of the factors listed above thus a freeboard may be adopted only where flood depths are significant. Other municipal councils have adopted a threshold depth of 0.3m for these purposes.

10.13 Flood Planning Level Recommendations

Based on the previous assessments, it is recommended that Council adopt a FPL of 100 Year ARI and a 0.5m freeboard for habitable residential development.

Commercial and industrial properties have often adopted high frequency flood events such as the 20 year ARI event. This is based on the perception of risk. Occupiers of these properties can make informed commercial decisions on their ability to bear the burden of economic loss through flood damage, while residential lots do not generally provide an income to offset the losses. Additionally, inventory, machinery and other assets can be stored above flood levels to lessen the economic loss as a result of a flood event.

There is only an average difference of 0.1m between the 20 year ARI and 100 year ARI event. Considering this relatively small difference between the events and the large number of industrial and commercial properties within the floodplain, it is recommended that the 100 year ARI plus 0.5m be adopted for commercial and industrial properties, as well as residential properties.

Underground car park entrances in addition to vents and openings are also to be set at the 100 year ARI + 0.5m, or PMF, whichever is the higher. These locations are a particularly high risk to life.

For critical infrastructure, such as hospitals, police stations and aged care, the PMF should be adopted as the FPL. It is important that these facilities, which are either difficult to evacuate or are essential during an emergency, remain flood free.

Due to the nature of flooding in the catchment and the large areas affected by shallow overland flow paths, a reduction to the freeboard may be appropriate in some cases. Where the depth of flow from local drainage overland flow paths is less than 0.25m for the 100 year ARI, the FPL could be set at two times the depth of flow with a minimum of 0.3 m above the surrounding surface.

A summary of the proposed flood planning levels for development are shown below in **Table 10-5**. These LGA-wide flood planning level recommendations outlined in the Draft Floodplain Management Policy (**Section 9.4.1**) are consistent with the requirements of the flood behaviour within the Alexandra Canal floodplain.

Table 10-5 Recommended FPLs for Alexandra Canal Catchment

Development		Type of flooding	Flood Planning Level
Residential	Habitable rooms	Inundated by mainstream flooding	100 year flood level + 0.5 m
		Inundated by local drainage flooding	100 year flood level + 0.5 m or Two times the depth of flow with a minimum of 0.3 m above the surrounding surface if the depth of flow in the 100 year flood is less than 0.25 m
		All other	0.3 m above surrounding ground
	Non-habitable rooms such as a laundry or garage (excluding below-ground car parks)	Inundated by mainstream or local drainage flooding	100 year flood level
Industrial or Commercial	Business	Inundated by mainstream or local drainage flooding	Merits approach presented by the applicant with a minimum of 100 year flood level
	Schools and child care facilities	Inundated by mainstream or local drainage flooding	Merits approach presented by the applicant with a minimum of 100 year flood level
	Residential floors within tourist establishments	Inundated by mainstream or local drainage flooding	100 year floor level + 0.5 m
	Housing for older people or people with disabilities	Inundated by mainstream or local drainage flooding	100 year flood level + 0.5 m or a the PMF, whichever is the higher
	On-site sewer management (sewer mining)	Inundated by mainstream or local drainage flooding	100 year floor level + 0.5 m
	Storage of hazardous substances	Inundated by mainstream or local drainage flooding	100 year flood level + 0.5 m
Below-ground garage or car park (*For this purpose a below-ground garage or car park is where the floor of the car park is more than 1 m below the surrounding natural ground.)*	Single property owner with not more than 2 car spaces.	Inundated by mainstream or local drainage flooding	100 year flood level + 0.5 m
	All other below-ground car parks	Inundated by mainstream or local drainage flooding	100 year flood level + 0.5 m or the PMF (whichever is the higher) See Note 1
	Below-ground car park outside floodplain		0.3 m above the surrounding surface
Above ground car park	All car parks	Inundated by mainstream or local drainage flooding	100 year flood level

Development		Type of flooding	Flood Planning Level
Critical Facilities (include hospitals and ancillary service; communication centres; police, fire and SES stations; major transport facilities, sewerage and electricity plants; any installations containing infrastructure control equipment, any operational centres for use in a flood.)	Floor level		100 year flood level + 0.5m or the PMF (whichever is the higher)
	Access to and from critical facility within development site		100 year flood level

10.14 Flood Planning Maps

Flood planning maps provide a mapping based tool to identify areas relevant to floodplain management. The floodplain is defined by the PMF extent; however, it is common practice to also consider the flood planning level extent for planning purposes. This is usually defined as the extent of the adopted FPL (e.g. 100 year ARI + 0.5m). Development within this extent would need to consider the adopted FPL for setting of floor levels and other flood protection design aspects.

The development of flood planning maps depends on the content of planning instruments. When considering updates to planning instruments, consideration should also be given to developing appropriate flood planning maps to support the planning instruments.