South Creek Floodplain Risk Management Plan

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North Sydney NSW 2060
Australia

Revision C

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South Creek Floodplain Risk Management Plan

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A	Draft Report – Issued for Review	RG R Golaszewski	CRT C Thomas		21/08/2019
B	Exhibition Draft	RG R Golaszewski	CRT C Thomas	 Chris Thomas	13/09/2019
C	Final Report	RG R Golaszewski	CRT C Thomas	 Chris Thomas	26/10/2019

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Acknowledgements

The following report was prepared by Advisian (*part of the Worley Group*) on behalf of the South Creek Floodplain Risk Management Committee acting in association with Penrith City Council and Department of Planning, Industry & Environment (*DPIE*).

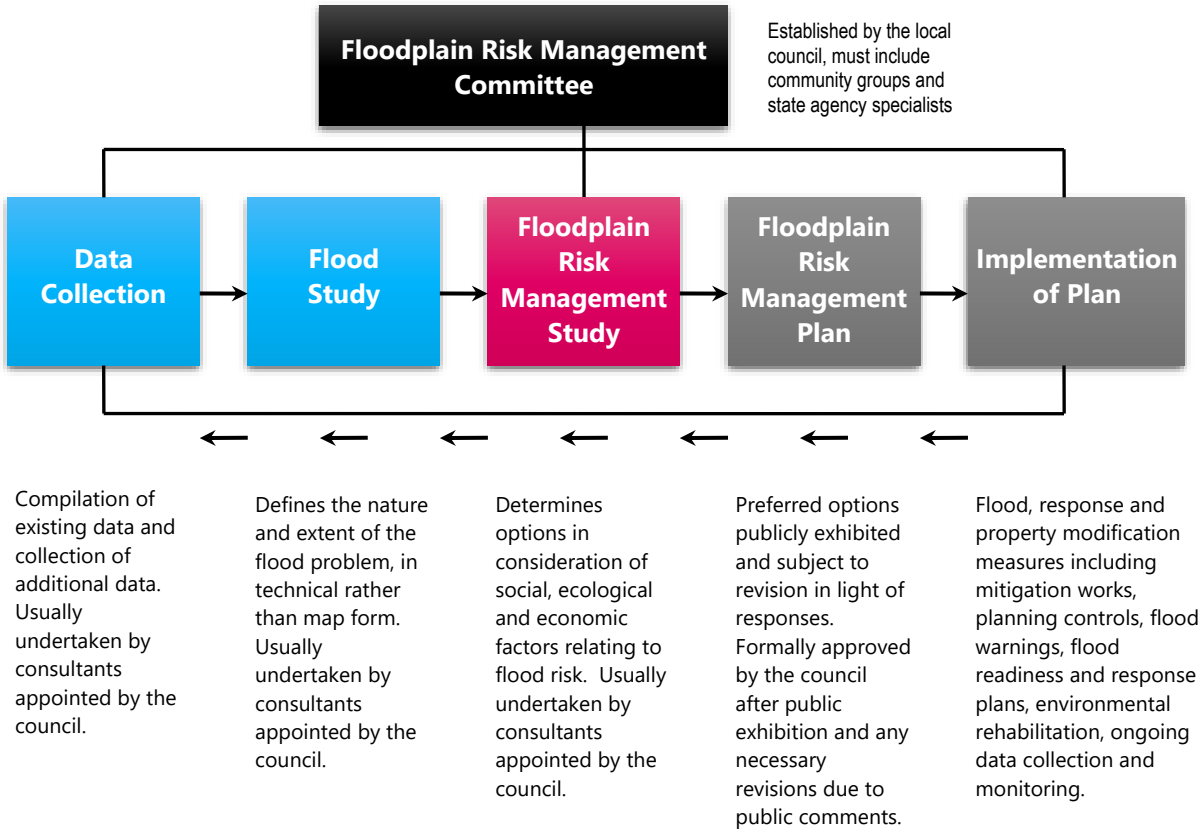
The study is the culmination of many months of investigation, analysis and flood modelling, which has been supported by valuable contributions from community representatives and Penrith City Council.

It has been prepared by incorporating contributions from individuals from the local community and key stakeholders. Contributions from members of the Floodplain Risk Management Committee have been essential to the formation of management strategies that have been considered as part of the project and are greatly appreciated.

The collegial manner in which input has been provided to the project from representatives from the Penrith City Council has been critical to its success.

Foreword

The State Government's Flood Policy is directed towards providing solutions to existing flooding problems in developed areas and ensuring that new development is compatible with the flood hazard and does not create additional flooding problems in other areas. Policy and practice are defined in the Government's Floodplain Development Manual (*2005*).



Source: 'Floodplain Development Manual' (2005)

Under the Policy, the management of flood liable land remains the responsibility of Local Government. The State Government subsidises flood mitigation works to alleviate existing problems and provides specialist technical advice to assist Local Government in the discharge of their floodplain risk management responsibilities.

Penrith City Council commenced this process in 2005, when WorleyParsons (*then Patterson Britton and Partners*) was engaged to undertake the Flood Study for South Creek and its tributaries.

Council has since proceeded further with the floodplain management process by engaging Advisian (*part of the Worley Group*) to continue the process by undertaking the Floodplain Risk Management Study and Plan for South Creek. These documents have been prepared to assist Council in identifying and assessing management options aimed at reducing flooding problems for existing development along the South Creek corridor and for managing flooding into the future.

1. SETTING

1.1 Introduction

Penrith City Council, through its Floodplain Risk Management Committee and Advisian Pty Ltd, has completed a Floodplain Risk Management Study for those sections of South Creek that fall within the Penrith local government area (LGA). The Floodplain Risk Management Study was prepared in accordance with the NSW Government's Flood Prone Land Policy and guidelines outlined in the NSW Government's '*Floodplain Development Manual*' (*2005*). It is the Committee's intention to place the Study on public exhibition in October 2019.

The Floodplain Risk Management Study documents the outcomes of a detailed assessment of the viability of a range of potential floodplain risk management options. These options were identified in consultation with the Committee and the broader community and were targeted toward reducing existing and potential future flooding problems.

The Study also provides information on a range of flood characteristics critical to land use planning including peak flood levels, flood hazard, hydraulic function and the pattern of floodwater movement during floods of varying severity. This data has been used to map Flood Planning Constraints Categories (*FPCC*) which can be applied with other planning constraints to optimally manage future land use.

In this regard, the Study also considered the suitability of Council's existing planning instruments and the existing State Emergency Services (SES) Sub-Plan for the study area. The Study provides guidance for changes to these plans and policies aimed at ensuring that land use controls are consistent with the predicted flood risk and flood hazard, and to ensure that the risk to life can be minimised.

1.2 The Study Area

South Creek is a tributary of the Hawkesbury River that drains a 414 km^2 catchment in western Sydney. As shown in **Figure 1.1**, the South Creek catchment extends from its headwaters near Narellan in the south, to its confluence with the Hawkesbury River near Windsor.

South Creek generally flows from south to north through the catchment with the commercial centres of Penrith and Blacktown located to the west and east, respectively. Large areas of the catchment have been urbanised, particularly in the vicinity of these commercial centres.

Ropes Creek is a major tributary of South Creek that falls within the Penrith City Council LGA. Minor tributaries that also fall within the Penrith LGA include Werrington, Claremont, Blaxland, Cosgroves and Badgerys Creeks.

The major urban centres located along South Creek and its tributaries and at risk of flooding are St Clair (*population 19,837*), Erskine Park (*population 6,436*), Claremont Meadows (*population 4,776*), St Marys (*population 12,195*), Werrington and Werrington County (*population 7,702*). The semi-rural suburbs of Llandilo and Berkshire Park are located to the north of the study area and downstream of the Ropes Creek confluence.

Flooding of South Creek typically occurs as a result of local catchment runoff breaking out of the main channel and spilling across the adjoining floodplain.

However, the lower reaches of South Creek also serve as a large flood storage area during major flooding of the Hawkesbury-Nepean River system. As a result, floodwaters can 'back-up' along South Creek from its confluence with the Hawkesbury River, leading to inundation of areas of the South Creek floodplain to beyond the area that would typically be flooded in local catchment events.

The largest two floods to have occurred in the South Creek catchment in the last 50 years occurred in the 1980s. The August 1986 flood and the April 1988 flood are two of the largest floods to have occurred in the catchment since European settlement. The 1988 flood is considered to be in the order of a 1% Annual Exceedance Probability (AEP) flood along the lower half of South Creek; that is, it was a flood which has one chance in 100 of occurring in a given year. The 1986 flood is considered to be in the order of the 1% AEP flood for Ropes Creek. Other significant floods occurred in 1867, 1956, 1961, 1978 and 2017.

2. THE EXISTING FLOODING PROBLEM

2.1 Introduction

The existing flooding problem relates to those areas where flood damages are likely to arise as a consequence of flooding. It relates to existing dwellings, industrial complexes and commercial premises that would be inundated during a flood, as well as all associated infrastructure within the floodplain, including roads, railways and utility services.

In this context, the existing flooding problem is usually addressed by structural measures which aim to modify flood behaviour and thereby reduce flood damages.

The *'Updated South Creek Flood Study'* (*2015*) established the following characteristics.

(1) The adopted design 1% Annual Exceedance Probability (AEP) flood was based on a 1% AEP catchment flood condition occurring concurrently with a 1% AEP flood along the Hawkesbury-Nepean River. The concurrence of flooding along South Creek and the Hawkesbury-Nepean River was adopted for all design events; i.e., 5%, 2%, 1%, 0.5% and 0.2% and the Probable Maximum Flood (*PMF*).

(2) Backwater flooding from the Hawkesbury-Nepean system was found to influence flood behaviour as far upstream as Dunheved Road for flood up to and including the 0.2% AEP flood, and up to the Main Western Railway in the PMF. Adopted tailwater levels at Richmond Road with and without concurrent flood peaks along the Hawkesbury-Nepean River are listed in **Table 2.1**.

(3) A critical duration of 36 hours was found to apply to South Creek and Ropes, Kemps, Badgerys Blaxland and Cosgroves Creeks. Thompson and Claremont Creeks were determined to have a critical duration of 9 hours and Werrington Creek 2 hours.

Table 2.1 Adopted 'Local Catchment' and Hawkesbury River Downstream Boundary Conditions (Levels)

ANNUAL EXCEEDANCE PROBABILITY (*AEP*)	LOCAL CATCHMENT TAILWATER LEVEL (*mAHD*)	HAWKESBURY-NEPEAN TAILWATER LEVEL (*mAHD*)	LEVEL DIFFERENCE (*m*)
PMF	12.3	26.4	14.1
0.2%	9.5	20.2	10.7
0.5%	9.0	18.7	9.7
1%	**8.6**	**17.3**	**8.7**
2%	8.3	15.7	7.4
5%	7.9	13.7	5.8

(4) At the peak of the 1% AEP flood the majority of inundation occurs across undeveloped parts of the floodplain, particularly in the upper reaches of the catchment to the south of the Warragamba Pipeline. Inundation across urban areas is predicted at Oxley Park, St Marys, Claremont Meadows and Werrington. Significant inundation is predicted to occur in the lower reaches of South Creek (*downstream of Munitions Road and the Ropes Creek Confluence*) across parts of Llandilo and Berkshire Park.

(5) Peak flow velocities in the 1% AEP flood are generally predicted to range between 0.8 and 1.2 m/s within the South Creek channel between Elizabeth Drive and the Western Motorway (M4). Tributaries such as Cosgroves, Claremont and Ropes Creek experience comparable average in-channel velocities despite much lower discharges due to the steeper channel and narrower floodplain.

(6) Downstream of Dunheved Road in-channel velocities are predicted to steadily decrease as the floodplain widens and the influence of backwater flooding from the Hawkesbury River increases. During the 1% AEP flood, peak flow velocities are not predicted to exceed 0.5 m/s downstream of Stoney Creek Road.

(7) A detailed analysis of flooding at major road and rail crossings is presented in Appendix J of the Flood Study (*2015*). The analysis includes graphs and cross-sections for the predicted rating curve and flood level hydrographs upstream of each crossing. This information could be used by the State Emergency Services (SES) to understand the depths and duration of inundation possible at each crossing. The findings are summarised in **Table 2-2**.

Table 2-2 Predicted Flood Immunity of the Major Crossings within the Study Area

Road Crossing	Event (AEP) and Depth at which Overtopping is first Predicted	Severity of Overtopping
Elizabeth Drive crossing of Badgerys Creek	100 mm at peak of 5% AEP flood	High
Elizabeth Drive crossing of South Creek	80 mm at peak of 2% AEP flood	High
Elizabeth Drive crossing of Kemps Creek	300 mm at peak of 5% AEP flood	High
Western Motorway (M4) crossing of South Creek	305 mm at peak of 1% AEP flood	Moderate
Western Motorway (M4) crossing of Ropes Creek	1.0 metre at peak of the PMF	Low
Great Western Highway crossing of South Creek	100 mm at peak of 5% AEP flood	High
Great Western Highway crossing of Ropes Creek	300 mm at peak of the PMF	Low
Railway Line crossing of South Creek	1.25 metres at peak of the PMF	Low
Railway Line crossing of Ropes Creek	100 mm at peak of the PMF	Low
Dunheved Road crossing of South Creek	900 mm at peak of 5% AEP flood	High
Debrincat Ave crossing of Ropes Creek	150 mm at peak of 1% AEP flood	Moderate

(8) Predicted lag times for the 1% AEP flood are listed in **Table 2-3** for critical locations across the study area. The modelling indicates that the 1% AEP flood wave would take approximately 5½ hours to traverse South Creek from Elizabeth Drive to Richmond Road.

Table 2-3 Predicted Lag Times for the 1% AEP Flood

	DESCRIPTION OF LOCATION	TIME OF PEAK FLOOD LEVEL (*hours after start of design storm*)*
South Creek	**Elizabeth Drive Crossing**	22.5
	Warragamba Pipeline	23.5
	Luddenham Road, St Clair	24.0
	Western Motorway (*M4*)	25.0
	Great Western Highway	26.0
	Main Western Railway	26.0
	Dunheved Road, Dunheved	26.5
	Munitions Road	27.0
	Ropes Creek Confluence	27.5
	Eighth Avenue, Shanes Park	27.5
	Stony Creek Road	27.5
	Richmond Road	28.0
Ropes Creek	**Capitol Hill Drive Crossing**	19.0
	Warragamba Pipeline	20.0
	M4 Motorway	21.0
	Great Western Highway	21.5
	Main Western Railway	22.0
	Debrincat Ave, Tregear	22.0
	Forrester Road, Dunheved	22.5
Kemps Creek	Elizabeth Drive Bridge Crossing	21.0
	Kemps Creek Dam	22.5

(9) The hydraulic performance of existing flood mitigation works constructed to protect residential areas at St Marys and Werrington has previously been assessed as part of the Flood Study (*2015*) (*refer* Appendix J). The analysis that was completed for the flood study was revisited as part of the Floodplain Risk Management Study (FRMS), including re-modelling using more recent topographic data. The FRMS investigations determined the following.

St Marys Earthen and Concrete Levee

a. Three locations where the levee crest was identified as either falling below the predicted 1% AEP flood level or does not deliver the 0.5 metre freeboard criteria.

b. The crest of the concrete levee at the "tie-in" to the Great Western Highway roadway is approximately 0.8 metres above the road surface creating an opportunity for floodwaters to flow around the levee despite not overtopping the concrete levee crest.

c. Visual inspection of the levee highlighted extensive vegetation growth along the levee that may result in the integrity of the levee being compromised by intrusive root growth and/or by providing habitat for burrowing animals such as rabbits or snakes.

Werrington Road and Earthen Levee:

a. Crest elevations along the levee are above the predicted 1% AEP flood level.

b. The levee crest does not achieve the 0.5 metre freeboard criteria along 470 metres of the total 800 metre levee length. The freeboard is lowest between Albert Street and Princess Street where the levee crest is only 0.05 metres above peak 1% AEP flood levels.

c. Visual inspection indicates that the levee is in good condition with grass and vegetation appearing to be routinely maintained.

(10) Updated flood hazard mapping for the 1% AEP flood was prepared as part of the FRMS to reflect the hazard categories and criteria recommended within *Australian Rainfall and Runoff 2019* (*ARR19*). The hazard mapping was further updated to reflect 'true' hazards by taking into consideration other factors such as access and evacuation constraints, warning times and the rate of rise of floodwaters. True flood hazard mapping for the 1% AEP flood is presented in **Figures A1** to **A12**, which are included within **Appendix A**.

(11) The 1% AEP hazard mapping demonstrates that the populated areas within the floodplain for areas upstream of Dunheved Road would generally be exposed to hazards of up to H3. The hazard generally increases downstream of the Ropes Creek confluence within hazards ranging between H4 to H5 across Llandilo and H5 to H6 across Berkshire Park.

(12) Updated hydraulic category mapping was prepared as part of the FRMS to reflect changes to the extent of flood storages and the flood fringe following mapping of the 1% AEP flood to 2011 LiDAR. No changes to the floodway corridor were required reflecting the rigorous methodology applied as part of the Flood Study (*2015*). Hydraulic category mapping for the 1% AEP flood is shown in **Figures B1** to **B12** included in **Appendix B**.

2.2 Flood Damages

The South Creek Floodplain Risk Management Study assessed the damage caused by flooding to properties located within the floodplain that fall within the Penrith City LGA. The findings from the damages assessment are summarised in the following.

- **Table 2-4** for total number of properties inundated above floor level for a range of design events;
- **Table 2-5** for total Average Annual Damages (AAD) for the study area; and
- **Chart 2-1** for the total number of properties inundated above floor level by suburb.

Table 2-4 Number of Properties Inundated Above Floor Level for a Range of Design Events

Property Type	Number of Properties					
	5% AEP	2% AEP	1% AEP	0.5% AEP	0.2% AEP	PMF
Residential	30	66	125	202	516	2338
Commercial	5	6	10	13	26	77
Industrial	1	1	15	15	22	191
Recreation	4	5	8	10	14	22
Other	3	3	4	5	9	11
TOTAL	**43**	**81**	**162**	**245**	**587**	**2639**

Table 2-5 Total Flood Damages Predicted for the South Creek Study Area

Property Type	Total flood damage for event ($1000s)						Total AAD ($1000s)
	5% AEP	2% AEP	1% AEP	0.5% AEP	0.2% AEP	PMF	
Residential	2,203	5,191	9,899	17,237	41,772	267,037	***$ 817***
Commercial	213	294	466	620	1,238	5,831	***$ 40***
Industrial	112	226	1,057	1,533	3,009	44,754	***$ 81***
Recreation	58	108	168	240	384	788	***$ 11***
Other	224	279	449	537	1,089	2,550	***$ 37***
TOTAL	**2,811**	**6,097**	**12,038**	**20,168**	**47,492**	**320,960**	***$ 985***

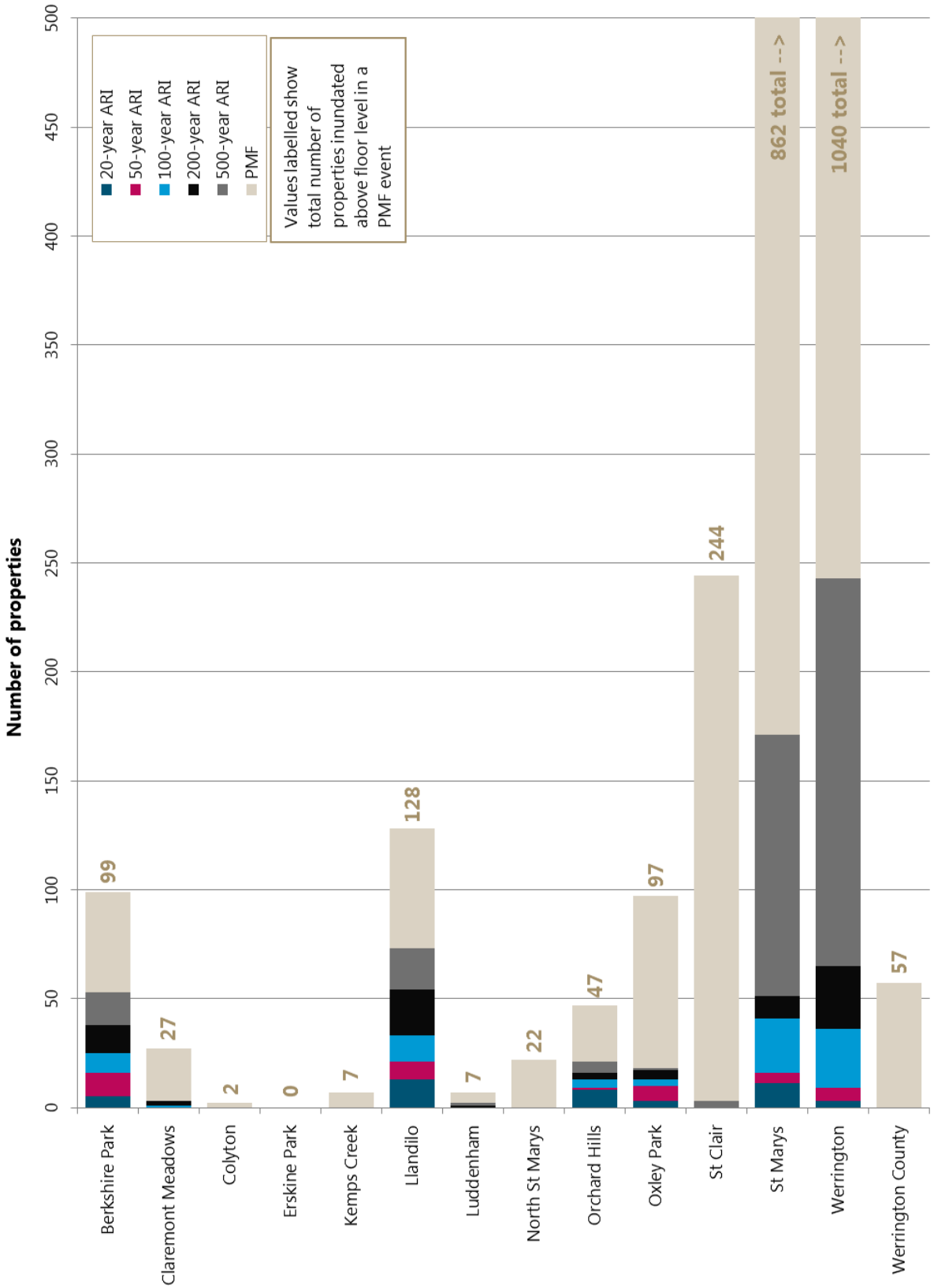


Chart 2-1 Total Number of Properties Inundated Above Floor Level by Suburb

2.3 Options to Address the Existing Flood Problem

Information presented in the *'Updated South Creek Flood Study'* (*2015*) and the damages analysis outlined above, indicates that there is potential for substantial damages and loss to be incurred by those living and working in the South Creek floodplain during circumstances where major flooding occurs. These damages would include financial losses to individual property and business owners and losses to the overall community as a result of damage to infrastructure and disruption to everyday life.

Flood affected areas at St Marys, Oxley Park, Orchard Hills, Werrington, Llandilo and Berkshire Park would incur the greatest proportion of the total damage cost. Accordingly, where possible, mitigation measures have been proposed to reduce the flood damages that the community could be exposed to.

A list of options was originally developed in consultation with representatives from Council, the Office of Environment & Heritage (*OEH*), SES and the Floodplain Risk Management Sub-Committee. These options were devised with a view to reducing existing flood damages and providing a mechanism for ensuring that the risk faced by future development is minimised.

According to the categories outlined in the NSW *'Floodplain Development Manual'* (*2005*), the potential flood mitigation measures fall into the following categories:

- **Flood Modification Measures**

  These are typically structural works, such as flood protection levees, flood detention basins or bypass floodways, which help to reduce flood damages.

- **Property Modification Measures**

  These measures typically include flood planning measures for future development, and can also include voluntary house raising and purchase, or flood-proofing of buildings.

- **Response Modification Measures**

  These typically include emergency response management measures, flood predictions and warnings and community flood awareness and preparedness.

The Flood and Property Modification Measures that were adopted for investigation are listed in **Table 2-6**. Each of these measures was investigated to assess their respective advantages and disadvantages considering issues associated with flood hydraulics, environmental constraints and economics.

It is noted that no flood modification measures were proposed for Llandilo and Berkshire Park despite flood damage estimates for development in these suburbs making up a significant amount of the total AAD for the study area. This recognises that flooding at these properties is governed by backwater flooding from the Hawkesbury River. Therefore, the primary factor influencing the proportionally high damages in these suburbs is flooding that emanates from an adjoining catchment and which occurs on a much larger scale. Accordingly, local works to redirect floodwaters originating from this mechanism would likely be ineffective.

Therefore, it was determined that it would be more appropriate to manage the existing hazard in the Llandilo and Berkshire Park areas via appropriate property modification or planning measures, combined with improved emergency response.

Table 2-6 Potential Flood Mitigation Options

Measure^	Location	Description
F-1A	Oxley Park	Floodplain excavation downstream of the railway bridge (*low cut scenario*)
F-1B	Oxley Park	Floodplain excavation downstream of the railway bridge (*high cut scenario*)
F-2	Oxley Park	Flood Protection Levee
F-3	Oxley Park	Railway Bridge Widening
F-4	Oxley Park	Additional Storage Upstream of the Railway Crossing
F-5	Werrington	Raise Werrington and Rance Road
F-6	St Clair Erskine Park	Raise low-points along Mamre Road
F-7A	St Marys	Upgrades to the St Marys Levee
F-7B	St Marys	Option F-7A plus installation of a Flap Gate
P-1	Llandilo, Berkshire Park, Orchard Hills	Voluntary House Raising
P-2	Llandilo, Berkshire Park	Voluntary House Purchase

^ *Measures starting with 'F' are structural measures with a focus on Flood Modification and 'P' on Property Modification.*

2.4 Method of Assessment

The Flood Modification Measures were assessed using a triple bottom line (TBL) analysis approach that considered economic, social and environmental issues. The economic assessment was based on the results of a detailed hydraulic analysis of each measure. The results of the assessment were used to develop an Assessment Matrix which gave the Committee a mechanism for evaluating the relative importance of the range of factors that require consideration before option implementation can occur.

2.4.1 Hydraulic Assessment

The hydraulic benefit and dis-benefit that would be afforded by each measure was determined using the RMA-2 flood model that was originally developed as part of the *'Updated South Creek Flood Study'* (*2015*). Additional versions of the flood model were developed for each Flood Modification Measure and each was used to simulate flood behaviour with each of the potential measures "in place".

Difference maps were created by comparing peak flood level estimates from simulations undertaken for both existing and post-development (*i.e., incorporating the proposed management measures*) scenarios. This effectively created a contour map of predicted changes in peak flood levels associated with each potential Flood Modification Measure.

2.4.2 Benefit - Cost Assessment

A benefit-cost analysis was undertaken to assess the economic viability of implementing the potential Flood Modification Measures. The cost of construction works was estimated and compared with the predicted monetary benefit offered by each measure in terms of the potential reduction in flood damage across the range of events.

Direct and indirect costs were included in all damage cost estimates. For consistency, all documented values in this report are based on 2017 dollars, including cost estimates for measures. In this way, a relative comparison of benefits and costs is provided and therefore the results of the analysis are considered to also reflect what the benefit-cost would be in today's dollars.

The reduction in flood damages has been determined on the basis of the reduced level of flooding that would occur if the respective measures were implemented over the full range of design floods; that is, for all standard floods between the 5% AEP event and the Probable Maximum Flood.

All cost estimates and reductions in damages were based on the total present value over a 30 year design life assuming a real discount rate of 7%. This approach was adopted to determine the Net Present Value (NPV) of the all monetary benefits and costs.

The benefit-cost ratios for each of the Flood Modification Measures that were identified are summarised in **Table 2-7**.

Table 2-7 Benefit/Cost Ratio for Proposed Flood Modification Measures

Mitigation Measure	Cost of Works (*PV*)	Reduction in AAD	Present Value of Damage Reduction	Benefit-Cost Ratio
F-1A - Oxley Park Low Cut	**$356,600**	**$20,000**	**$268,100**	**0.75**
F-1B - Oxley Park High Cut	**$914,400**	**$28,000**	**$375,400**	**0.41**
F-2 - Oxley Park Levee	**$694,000**	**$45,000**	**$603,000**	**0.87**
F-3 - Railway Bridge Widening	**$1M to $1.5M**	Measure did not progress beyond modelling to benefit-cost analysis based on low benefit compared to F-1A		
F-4 - Additional Storage Upstream of the Railway Crossing	Measure did not progress beyond modelling based on low benefits compared to F-1A			
F-5 - Raise Werrington and Rance Road	**$1,086,000**	**$35,000**	**$470,000**	**0.43**
F-6 - Raise Mamre Road	Measure focused on improving emergency response with minimal reduction in flood damages			
F-7A – Upgrades to St Marys Levee	**$634,000**	**$13,000**	**$174,000**	**0.27**
F-7B – F-7A plus Installation of Flap Gate	**$744,000**	**$42,000**	**$563,000**	**0.76**
P-1 - Voluntary House Raising	**$988,000**	**$32,000**	**$425,800**	**0.43**
P-2 - Voluntary House Purchase	**$8,569,000**	**$125,000**	**$1,660,000**	**0.19**

2.4.3 Triple Bottom Line Assessment

In addition to calculation of the economic benefit for each measure (*i.e., benefit-cost ratio*), further assessment was undertaken to allow a comparison of the social and environmental benefits and dis-benefits associated with each measure. The inclusion of this assessment effectively ensured that a Triple Bottom Line (*TBL*) approach was incorporated into the analysis, thereby ensuring that the three "pillars of sustainability" were considered; i.e., economic, social and environmental factors.

A summary of the TBL assessment results for all of the Flood Modification Measures is provided in **Table 2-8**. Further details of the assessment are available in the *South Creek Floodplain Risk Management Study* (*2019*).

Table 2-8 Benefit/Cost Ratio for Proposed Flood Modification Measures

Mitigation Measure	TBL Score	Rank
F-1A - Oxley Park Low Cut	**93.5**	**1**
F-1B - Oxley Park High Cut	**81**	**4**
F-2 - Oxley Park Levee	**88**	**3**
F-3 - Railway Bridge Widening	**62.5**	10
F-4 - Additional Storage Upstream of the Railway Crossing	**71.5**	**7**
F-5 - Raise Werrington and Rance Road	**73.0**	**6**
F-6 - Raise Mamre Road	**55**	**11**
F-7A – Upgrades to St Marys Levee	**70.5**	**8**
F-7B – F-7A plus Installation of Flap Gate	**91**	**2**
P-1 - Voluntary House Raising	**73.5**	**5**
P-2 - Voluntary House Purchase	**68**	**9**

2.5 Recommended Flood Modification Measures

The following Flood Modification Measures were recommended for inclusion in the Plan. Reference is made to Chapter 9 of the *South Creek Floodplain Risk Management Study* for a comprehensive description of the measures and the detailed analysis that was carried out.

2.5.1 Measure F-1A – Oxley Park Low Cut

Oxley Park is located on the western floodplain of Ropes Creek upstream of the Western Railway Line. The flood damages analysis found that three (3) properties were at risk of being inundated above floor during a 5% AEP flood, ten (10) during a 2% AEP flood and thirteen (13) during a 1% AEP flood. Ninety seven (97) properties were at risk during floods up to and including the PMF.

The total AAD for Oxley Park is calculated to be $54,000 which represents 6% of the total AAD for the study area.

Although the total AAD and total number of at risk properties is not high compared to other suburbs, it is the concentration of high-risk properties in Oxley Park that makes it a viable location for implementing a flood mitigation solution. In that regard, all properties at risk of above floor inundation during floods up to and including the 1% AEP flood (*i.e., 13 properties in total*) are all located along Melbourne Street upstream of the Western Railway Line bridge crossing.

The proposed extent of Measure F-1A is shown in **Figure 2-1**.

Measure F-1A aims to reduce flood damages and risk to the thirteen (13) properties at Oxley Park by increasing the hydraulic efficiency of the existing railway bridge crossing of Ropes Creek. This is proposed by excavating the floodplain immediately downstream of the bridge crossing to reduce the hydraulic impediment to floodwaters caused by the sharp bend in the alignment of Ropes Creek immediately downstream of the crossing. Excavation over an area of approximately 1.2 hectares (ha) to depths of up to 1.45 metres is proposed.

The results of the flood modelling indicate that Measure F-1A could reduce the peak of the 1% AEP flood level for properties fronting Melbourne Street by up to 0.12 metres. A breakdown of the predicted benefit for other flood events is provided in **Table 2-8**.

Table 2-8 Predicted Change in Flood Levels to Properties along Melbourne Street, Oxley Park, as a Result of Flood Modification Measure F-1A

Design Event (*AEP*)	Predicted Flood Level Change (*metres*)
5%	- 0.13
2%	- 0.12
1%	- 0.12
0.5%	- 0.13
0.2%	- 0.11

By reducing flood levels to the magnitudes shown in **Table 2-8**, Measure F-1A has the potential to reduce the total number of properties that would experience flooding to both below and above floor level.

As shown in **Table 2-9**, the 0.13 metre reduction in peak 5% AEP flood level is predicted to result in three (3) less properties experiencing over floor flooding in that event. Three (3) less properties are also predicted to experience flooding to above floor level in the 1% AEP event.

The present value of the works associated with Measure F-1A is estimated to be about **$356,600**. This estimate includes an allowance for excavation of the area, levelling, revegetation and the ongoing maintenance of the area including those areas disturbed within the riparian corridor. It also includes a 20% contingency.

Table 2-9 Predicted Change in Flood Affectation of Properties in Local Area (Below and Above Floor Flooding)

Design Event (*AEP*)	Below Floor Flooding		Above Floor Flooding	
	Existing	Post Mitigation	Existing	Post Mitigation
5%	12	12 *(- 0)*	3	0 *(- 3)*
2%	8	9 *(+ 1)*	10	7 *(- 3)*
1%	7	9 *(+ 2)*	13	10 *(- 3)*
0.5%	8	5 *(- 3)*	17	15 *(- 2)*
0.2%	12	10 *(- 2)*	18	17 *(- 1)*
PMF	14	14 *(- 0)*	97	88 *(- 9)*

2.5.2 Measure F-2 – Oxley Park Levee

Measure F2 is proposed as an alternative to Measure F-1A for the reduction of flood risk and damage to properties fronting Melbourne Street at Oxley Park. Measure F2 consists of a flood protection levee designed to prevent floodwaters from entering properties during major flooding of Ropes Creek up to and including the 1% AEP flood.

The proposed alignment and extent of the flood protection levee is shown in **Figure 2-2**.

To provide flood protection during events up to and including the 1% AEP flood, the levee will need to be constructed with crest elevations of between 33.60 and 33.66 mAHD and will need to extend over a total length of approximately 220 metres. The minimum crest elevations have been determined based on the predicted 1% AEP flood levels plus 0.5 metres freeboard. The levee crest would be a maximum 1.8 metres above the existing natural surface along the levee alignment.

A review of the topography west of the proposed levee indicates that a 27 ha catchment could capture and convey runoff towards the levee. Hydrologic modelling indicates that the runoff volume could be sufficient for long duration events to lead to ponding behind the levee to depths sufficient to cause damage to properties along Melbourne Street. The proposed levee would therefore require cross-drainage to allow any local build-up of overland runoff behind the levee to be conveyed onwards to Ropes Creek.

The results of the flood modelling indicate that Measure F2 could prevent flooding to those properties fronting Melbourne Street during floods up to and including the 1% AEP flood. This will result in the protection of thirteen (13) properties from above floor flooding and a further seven (7) from below floor flooding during 1% AEP flood.

Despite the levee displacing floodwaters there is predicted to be no flood level increases across other properties during floods up to and including the 0.5% AEP flood.

The present value of the works associated with Measure F2 is estimated to be **$694,000**. This estimate includes an allowance for site preparation, construction of the levee and levee core, batter shaping, surface treatment post construction and the ongoing maintenance of the levee. A $50,000 allowance has also been included for analysis and construction of cross-drainage plus a 20% contingency on the final cost estimate.

2.5.3 Measure F-7B – Upgrades to the St Marys Levee Plus Flap Gate Installation

The St Marys levee was constructed along the western floodplain of South Creek to protect residential and commercial/industrial properties to the east of South Creek and upstream of the Great Western Highway at St Marys. The combined earthen and concrete levee is approximately 1,700 metres long. The concrete section of the levee forms the most northerly section and extends for approximately 60 metres. Byrnes Creek flows along the eastern side of the concrete section of the levee.

Despite the existing levee, the damages analysis found that sixteen (16) properties behind the levee are at risk of being inundated to above floor level during a 1% AEP flood, with a further thirty-three (33) at risk of experiencing below floor flooding. Six hundred and thirty-nine (639) properties are at risk of over floor flooding during floods up to and including the PMF.

The total AAD for St Marys is $254,300 which represents 28% of the total AAD for the study area. The part of St Marys protected by the levee (*i.e., properties located upstream of the Great Western Highway*) contributes $131,000 in AAD of this total.

The works to be completed as part of Measure F-7B and which have been included in costing the measure are discussed in the following. The locations of each work item and a profile along the levee are shown graphically in **Figure 2-3** and **Figure 2-4**, respectively.

- Extension of the St Marys Levee at the upstream end (*south of Hall Street*) by a length of approximately 20 metres
- Upgrades to the levee near Saddington Street to raise the levee by approximately 0.2 metres along a length of 80 metres to meet freeboard requirements
- Upgrades to the levee near the transition from earthen levee to concrete levee to raise crest elevations to be at the predicted 1% AEP flood level plus 0.5 metres freeboard
- Sandbagging (*allowance for one occurrence*) across the Great Western Highway downstream of the concrete levee to prevent floodwaters flowing around the levee
- Supply and installation of a flap gate at the outlet of the Byrnes Creek culvert. Plans indicate the culvert dimensions to be 3.7 metres high by 3.5 metres wide.

The present value of the works associated with Measure F-7B (*outlined above*) is estimated to be about **$782,000**. This estimate includes an allowance for the ongoing maintenance of the levee and flap gate and a 20% contingency.

The results of the flood modelling indicate that Measure F-7B could prevent floodwaters entering areas behind the levee (*to the east*) for floods up to and including the 1% AEP flood. A reduction in flood levels for the 0.5% AEP flood of 0.17 metres is predicted. No changes to flood behaviour is predicted for the 0.2% AEP and PMF.

Although the proposed levee upgrades and flap gate would displace floodwaters which would currently enter the area behind the levee, the total volume of floodwaters and peak flow represent less than 0.25% of the total flow at the peak of the 1% AEP flood. This is considered to represent a negligible increase and is confirmed by the modelling to cause no measurable changes to downstream flood levels.

3. FUTURE FLOOD PROBLEM

3.1 Background

The potential *future* flooding problem relates to consideration of flooding across those areas of the floodplain that are likely to be proposed for future development or which could be the subject of future rezoning applications.

As the land available for development becomes increasingly scarce, pressures mount for development to occur in areas of the floodplain where it might otherwise have been avoided. These pressures are typically driven by population growth, but are compounded by economic pressures. For example, the costs associated with delivering infrastructure to new areas above the level of the PMF are typically much greater than the cost of augmenting existing infrastructure within the floodplain. Hence, there will undoubtedly be pressure for development of floodplain land and the future flooding problem is a real issue that needs to be considered from a planning perspective.

The future flooding problem has potential to cause additional flood damages in the South Creek floodplain and presents a potential risk to loss of life. Council has a duty of care to ensure that its current planning instruments recognise this potential flood risk. Council also has a responsibility to ensure that a Floodplain Risk Management Plan is in place and that this Plan, or an associated *Flood Policy*, can be used to support decisions to approve or reject development proposals on flood affected sections of the LGA.

In addition, unless the Probable Maximum Flood (*PMF*) is adopted as the basis for determining structural and planning measures aimed at reducing flood damages, there will always be a *residual* or continuing flooding problem.

The adoption of the PMF as the 'planning flood' is not realistic or practical because it would sterilise a large area of land, thereby forcing development to areas of higher ground which may not historically be serviced or which could introduce unrealistically high infrastructure costs. Hence, a lesser flood standard is adopted. Penrith City Council has adopted the *1% Annual Exceedance Probability* (*AEP*) flood plus a freeboard of 500 mm.

As a result, measures that are put in place to control flood damage will ultimately be overwhelmed by a flood that is larger than that adopted as the threshold for the planning control of land use, or as the limiting flood for the design of structural measures.

Accordingly, Council must also consider the implications of floods greater than the adopted planning flood and to work with the State Emergency Service (*SES*) to develop a contingency plan for such events.

3.2 Flood Planning Level

Following the formal adoption of the *'Updated South Creek Flood Study'* (*2015*), Penrith City Council proceeded with preparation of Flood Planning Area (FPA) mapping for the South Creek floodplain. The FPA mapping was prepared using waterRIDE^{TM} by applying a 0.5 metre freeboard to the detailed flood modelling results for the 1% AEP flood. The surface was then stretched by applying the 2002 Aerial Laser Survey (ALS) to pick-up the edges of the FPA.

In order to account for potential backwater flooding from the Hawkesbury-Nepean system, the adopted 1% AEP modelling incorporates a tailwater level equivalent to the 1% AEP Hawkesbury River flood level predicted at Windsor Bridge; i.e., 17.3 mAHD. Despite the fact that the focus of this study is the management of local catchment flooding, the tailwater effects from the Hawkesbury River will influence peak flood levels at the very downstream limit of the study area, specially across large areas of Llandilo and Berkshire Park. Accordingly, consideration of Hawkesbury-Nepean River flooding is appropriate for the purposes of setting the Flood Planning Level.

The availability of more recent topographic data such as the 2011 Light Detection and Ranging (*LiDAR*) survey is recommended for consideration in re-mapping the FPA extent. This would align the FPA mapping better with recently produced True Hazard Mapping and mapping of Flood Planning Constraints Categories (*FPCC*).

3.3 Measures to Address the Future Flood Problem

Measures to address the future flood problem typically comprise Property Modification Measures and Response Modification Measures. These include the implementation of appropriate planning measures and controls aimed at minimising the potential for additional damages during future floods.

Measures that have been assessed during the Floodplain Risk Management Study and recommended for inclusion in the Plan are as follows.

RM.1 A review of the Local Flood Plan (April 2012) identified that all references to the monitoring of gauges is focussed on flooding from the Hawkesbury-Nepean River. The plan does not currently propose the reliance on any of the existing gauges within the South Creek catchment that are located upstream of Elizabeth Drive, the Great Western Highway or Debrincat Avenue. Because the local gauges are not relied within the flood plan there is no reference point against which preparation, evacuation or recovery can be co-ordinated against.

Based on the above, it is recommended that the Local Flood Plan for the South Creek catchment be updated to include:

(i) Reference to all existing gauges within the study area which can be used to monitor the progression of a local flood event.

(ii) Nominate minor, moderate and major gauge heights so that reference markers would be available against which warning times and known problem locations can be monitored.

(iii) Prepare flood intelligence cards for the existing gauges that show the predicted flood level hydrograph for a range of design events plus indicators of times when roads, regions and critical facilities (*such as nursing homes, childcare centres, schools*) would start to be flooded or at risk of isolation.

RM.2 It is a further recommendation that the Local Flood Plan for Penrith be updated to take into consideration the flood data generated as an outcome of the FRMS. The following information provided within the FRMS should be considered:

(i) Mapping of Emergency Response Management Planning Communities (ERMPC), particularly areas of high risk where isolation is possible; i.e., high and low flood islands

(ii) Identified schools and vulnerable communities within the study area

(iii) Community Data Sheets and flood risk mapping along all local roads within the study area.

(iv) 'Local Flood Precincts' should be established so that flood risks can be established and recommended evacuation routes be more clearly identified for each community. The communities adopted within the FRMS for preparation of Community Data Sheets could be appropriate.

RM.3 Install a continuous river level gauge along South Creek near the Warragamba Pipeline to maximise potential warning times whilst still capturing approximately 50% of catchment runoff.

The modelling completed as part of the *Updated South Creek Flood Study* (*2015*) indicates that over 1 hour of additional warning time could be gained by monitoring flooding at the new proposed gauge location compared to at the existing gauge at the Great Western Highway. The additional warning time would be relevant for communities such as St Marys, Werrington, Llandilo and Berkshire Park.

PM.1 Updateable annexures be added to the DCP to include the following mapping prepared as part of the FRMS:

(i) True Flood Hazard Mapping

(ii) Updated Hydraulic Category Mapping

PM.2 Future Floodplain Risk Management Studies for watercourses within the Penrith LGA be required to prepare Flood Planning Constraints Category (FPCC) mapping similar to the FPCC prepared for South Creek and included as Appendix D. Once FPCC mapping is available for the LGA, it is recommended that DCP controls be updated to ensure development is guided by the FPCC mapping.

PM.3 Amendments to the DCP be made to update the following development controls:

(i) <u>Extensions to Existing Development</u>

The following additional controls are recommended:

- No flood related restrictions will apply to an increase in the floor area sited above the FPL, provided the applicant can satisfy that there is no increase to the population at risk associated with the proposal (*i.e. no additional strain on emergency services*) and the increase in floor level does not result in an increase in building footprint within the floodplain with the potential to impact flood behaviour.
- If a dwelling exists in a floodway and is destroyed by fire or other natural event the replacement of the dwelling may be considered only if the following can be achieved:
  - The dwelling had been permanently occupied prior to the loss of the dwelling.
  - The replacement dwelling must meet current flood planning requirements. This may require the dwelling to be relocated to a less hazardous area within the property and/or for floor levels to be raised.
  - Similar controls should also apply for non-residential development.

- A Flood Impact Assessment or Flood Risk Assessment will be required for all development within the FPA including any extensions which will lead to an increase in the overall building footprint.

(ii) Change of Use

The following additional controls are recommended:

- A change of use will generally not be supported if a use is proposed with greater vulnerability to flooding; i.e. a change from commercial to residential.

(iii) Rural Development

The following additional controls are recommended for any rural development classed as '*flood island*', '*trapped perimeter*', '*rising road access*' and '*overland escape routes*' as defined by the Floodplain Risk Management Guideline titled, *Flood Emergency Response Planning Classification of Communities* (*OEH, 2007*).

- The applicant must demonstrate that there is sufficient warning time available (*eight hours*) to facilitate evacuation along the proposed route.
- Safe evacuation will need to be provided from the development to land above the PMF level.
- Where the above is not possible, the proposed evacuation route must conform with the following requirements as a minimum:
- The minimum flood immunity for an evacuation route, including any proposed access road, is the 5% AEP flood level.
- The evacuation route should grade upwards towards land above the PMF.
- Where it is not feasible for an access road to facilitate safe evacuation to an area flood free during the PMF, an alternate all weather access track must be available which leads to land above the PMF (*i.e. high ground on or adjacent to the site*).
- If access to a site above the PMF is not possible the FPL shall be raised to the PMF to provide on-site flood security (*subject to consideration of hazards and risks of structural damage*).

PM.4 Revise development controls relating to the assessment of flood impacts.

(i) Reduce criteria for maximum allowable flood level increases

Current Criteria	Peak flood levels not increased by more than 0.1 m (100 mm) *(DCP reference C.14.a.i)*
Recommended Criteria	Peak flood levels not increased by more than 0.02 m (20 mm) outside of the development site

(ii) Remove control for velocity and flow distribution and replace with a hazard control

Current Criteria	Downstream velocities are not increased by more than 10% by the proposed filling *(DCP reference C.14.a.ii)* Proposed filling does not distribute flows by more than 15% *(DCP reference C.14.a.iii)*
Recommended Criteria	On the development site itself, flood hazard is not increased to greater than "low" based on current ARR criteria for hazard. Low hazard zones are defined in ARR as where D.V < 0.4 m^2/s for children and D.V < 0.6 m^2/s for adults and should be applied depending on the type of development. Isolated areas of high hazard may be considered at Council's discretion where people are prevented from entering the area i.e. dedicated flow paths. Hazard should never increase to exceed 0.8 m^2/s as this is the limiting working flow for experienced personnel such as trained rescue workers. Flood hazard should be assessed for the duration of the event and is not necessarily the flood hazard at the time of the peak flood level. Flood hazard on surrounding properties should not increase.

(iii) Modify wording for requirements of cumulative impact assessment

Current Criteria	The potential for cumulative effects of possible filling proposals in that area is minimal *(DCP reference C.14.a.iv)*
Recommended Criteria	The potential for cumulative effects of possible development proposals in that area is minimal.

(iv) Update control for additional flood storage where it can be shown there is no offsite impact

Current Criteria	There are alternative options for flood storage *(DCP reference C.14.a.v)*
Recommended Criteria	Where possible, any losses in floodplain storage are to be offset by compensatory cut at the same or a similar elevation.

(v) Combine controls requiring consideration of impacts on surrounding properties

Current Criteria	The development potential of surrounding properties is not adversely affected by the filling proposal *(DCP reference C.14.a.vi)* The flood liability of buildings on surrounding properties is increased *(DCP reference C.14.a.vii)*
Recommended Criteria	The flood liability and flood hazard of surrounding land is not adversely affected by the development.

(vi) Require assessment of impact criteria to all development

Current Criteria	No local drainage flow/runoff problems are created by the filling *(DCP reference C.14.a.viii)*
Recommended Criteria	No local drainage flow/runoff problems are created by the development.

(vii) Specify that controls must be met for the 1% AEP flood, however, Council may request additional events to be assessed at their discretion

PM.5 Additions to the DCP including:

(i) Additional controls for critical facilities (e.g. schools, hospitals, aged care facilities, etc)

Consent to critical facilities within the floodplain should be on a merits-based approach with consideration of the following:

- Vulnerable development is located outside of the 1% AEP flood extent, and outside of the PMF extent, where possible.
- Flood behaviour at the development site and surrounding area is defined for a range of flood events up to and including the PMF. As a minimum this is to include peak flood levels, depths, flow velocities, hazard and hydraulic category mapping.
- Evacuation and emergency response procedures must be carefully considered and detailed. This must include information such as the effective warning time available, nominated evacuation routes (in case necessary) and evacuation and/or shelter-in-place procedures.
- Where emergency response procedures may be reliant (even if partly) on the SES this is to be detailed. Consultation with the SES is required to review emergency response plans and to identify if the additional pressure on emergency services can be accommodated. Reference should be made to *Guidelines on Safety Design Criteria* outlined in *Australian Rainfall and Runoff 2016* (*Chapter 7, ARR16*) which also considers children and the elderly in its flood hazard classifications and should be applied depending on the development use.
  - The replacement dwelling must meet current flood planning requirements. This may require the dwelling to be relocated to a less hazardous area within the property and/or for floor levels to be raised.
  - Similar controls should also apply for non-residential development.
- A Flood Impact Assessment or Flood Risk Assessment will be required for all development within the FPA including any extensions which will lead to an increase in the overall building footprint.

(ii) Requirement for Flood Impact Assessment (FIA) and Flood Risk Assessments (FRA) commensurate to development size, type and flood risk

(iii) Climate Change

Statutory requirements require that planning policies account for projected sea level rise and the impact of climate change. At present, there is no consideration for climate change (*increased rainfall*) within the DCP.

PM.6 Revise format of the DCP to set out different development types and flood risk into matrix approach.

- In regard to the structure of the DCP, it is recommended that each land use type (*and/or precinct*) is addressed in an individual sub-section of a chapter addressing applicable flood related development controls. This could also include a section listing what (*if any*) controls are common to all land uses.
- While this approach may generate a certain repetition of controls, it is considered to better delineate different controls for the majority of users of the Flood DCP. Similarly, this process can be streamlined when used in conjunction with a matrix approach.
- A matrix approach is recommended to summarise the development controls applicable to different types of development. A sample matrix is provided in the Hawkesbury Nepean Floodplain Management Steering Committee's report *Managing Flood Risk Through Planning Opportunities: Guidance on Land Use Planning in Flood Prone Areas* (*2006*).

4. FLOODPLAIN RISK MANAGEMENT PLAN

4.1 Recommended Flood Modification Works

The following Flood Modification Measures are recommended for implementation as part of the Floodplain Risk Management Plan. Reference is made to Chapter 9 of the Floodplain Risk Management Study for a comprehensive description of the measures.

1. Construct either of the following Flood Modification Measures to protect properties with high flood damages along Melbourne Street at Oxley Park:

a. Measure F-1A – Oxley Park Low Cut

The present value of the all required investigation, construction and maintenance costs for the measure is estimated to be **$356,600**. This measure is expected to reduce the Average Annual Damage (AAD) by **$20,000**.

b. Measure F-2 – Oxley Park Levee

The present value of the all required investigation, construction and maintenance costs for the measure is estimated to be **$694,000**. This measure is expected to reduce the Average Annual Damage by **$45,000**.

2. Construct the following Flood Modification Measure to protect properties at risk of inundation in St Marys upstream of the Great Western Highway.

a. Measure F-7B – Upgrades to the St Marys Levee plus Installation of a Flap Gate

The present value of the all required investigation, construction and maintenance costs for the measure is estimated to be **$744,000**. This measure is expected to reduce the Average Annual Damage by **$45,000**.

4.2 Recommended Response Modification Measures

The following Response Modification Measures are recommended for implementation as part of the Floodplain Risk Management Plan. Reference is made to Chapter 10 of the Floodplain Risk Management Study for a comprehensive description of the measures.

3. It is recommended the Local Flood Plan for the South Creek catchment be updated to include:

a. Reference to all existing gauges within the study area which can be used to monitor the progression of a local flood event.

b. Nominate minor, moderate and major gauge heights so that reference markers would be available against which warning times and known problem location can be monitored.

c. Prepare flood intelligence cards for the existing gauges that show the predicted flood level hydrograph for a range of design events plus indicators of times when roads, regions and critical facilities (*such as nursing homes, childcare centres, schools*) would start to be flooded or at risk of isolation.

d. Install flood boom gates either side of the Eighth Avenue bridge crossing at Llandilo and implement a vegetation management plan for the crossings and areas immediately upstream and downstream.

4. It is recommended that the Local Flood Plan for Penrith be updated to take into consideration the flood data generated as an outcome of the FRMS. The following information provided within the FRMS should be considered:
   a. Mapping of Emergency Response Management Planning Communities (ERMPC), particularly areas of high risk where isolation is possible; i.e., high and low flood islands
   b. Identified schools and vulnerable communities within the study area
   c. Community Data Sheets and flood risk mapping along all local roads within the study area
   d. 'Local Flood Precincts' should be established so that flood risks can be established and recommended evacuation routes be more clearly identified for each community. The communities adopted within the FRMS for preparation of Community Data Sheets could be appropriate
5. Install a continuous stream gauge along South Creek near the Warragamba Pipeline to maximise potential warning times whilst still capturing approximately 50% of catchment runoff.

4.3 Recommended Property Modification Measures – Planning Controls and Policies

The following Property Modification Measures are recommended for implementation as part of the Floodplain Risk Management Plan. Reference is made to Chapter 11 of the Floodplain Risk Management Study for a comprehensive description of the measures.

6. Updateable Annexures be added to the DCP to include the following mapping:
   a. True Flood Hazard Mapping
   b. Updated Hydraulic Category Mapping
7. Future Floodplain Risk Management Studies for watercourses within the Penrith LGA be required to prepare Flood Planning Constraints Category (FPCC) mapping similar to the FPCC prepared for South Creek and included as Appendix D.
8. Amendment to development controls regarding:
   a. Extensions to existing development – no increase to population at risk
   b. Change of use – consider location, proposed use and evacuation
   c. Rural Development – consider evacuation
9. Revise DCP regarding assessment of impact including:
   a. Reduce criteria for maximum allowable increase in peak flood levels
   b. Remove control for velocity and flow distribution and replace with a hazard control
   c. Update control for additional flood storage where it can be show there is no offsite impact
   d. Require assessment of impact criteria in regard to all development (not just existing buildings or potential development sites)
   e. Specify that controls must be met for the 1% AEP flood, however, Council may request additional events to be assessed at their discretion.

10. Additions to the DCP including:

a. Additional controls for critical facilities (e.g. schools, hospitals, aged care facilities etc.)

b. Require consideration of evacuation from the proposed development as well as the effect of new development on evacuation from existing areas

c. Requirement for FIA / FRA commensurate to development size, type and flood risk

d. Need to include consideration of climate change

11. Revise format of the DCP to set out different development types and flood risk into matrix approach.

4.4 Implementation Strategy

The recommended measures for adoption as part of the Plan are summarised in the Implementation Schedule that is enclosed within **Appendix C**. An indication of the priority and cost associated with implementing the measures is provided therein.

The priority classification has been developed in consideration of the implications associated with each option. The adopted prioritisation is as follows:

(1) Represents tasks with a high priority, where a delay in implementing the recommendation has the potential to prejudice flood related planning matters or expose residents to significant flood risks.

(2) Represents tasks with a medium priority, where a delay in implementing the recommendations has some potential to expose residents to moderate flood risks.

(3) Represents tasks with a lower priority that are less urgent, which should proceed at some time over the next 3 to 6 years, but may be dependent on the outcomes of other strategies.

Appendix A – True Flood Hazard Mapping

(1% AEP flood)

Appendix B – Updated Hydraulic Category Mapping

(Re-Mapped Fringe and Storage)

Appendix C – Implementation Schedule