Draft Floodplain Risk Management Plan

Marrickville Valley Floodplain Risk Management Study and Plan

59915195

Prepared for
Inner West Council

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Cardno
Shaping the Future

Contact Information

Cardno (NSW/ACT) Pty Ltd
Trading as Cardno (NSW/ACT)
ABN 95 001 145 035

Level 9, The Forum, 203 Pacific Highway
St Leonards NSW 2065
PO Box 19 St Leonards NSW 1590Level 9, The Forum, 203 Pacific Highway
St Leonards NSW 2065
PO Box 19 St Leonards NSW 1590

Telephone: 02 9496 7700
Facsimile: 02 9439 5170
International: +61 2 9496 7700

sydney@cardno.com.au
www.cardno.com

Author(s): 
Shefali Chakrabarty
Senior Engineer

Approved By: 
David Whyte
Manager – Water Engineering

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Foreword

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

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

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

1. Formation of a Committee -

   Established by a Local Government Body (Local Council) and includes community group representatives and State agency specialists.

2. Data Collection -

   The collection of data such as historical flood levels, rainfall records, land use, soil types etc.

3. Flood Study -

   Determines the nature and extent of the flood problem.

4. Floodplain Risk Management Study –

   Evaluates floodplain management measures for the floodplain in respect of both existing and proposed development.

5. Floodplain Risk Management Plan –

   Involves formal adoption by Council of a management plan for the floodplain.

6. Implementation of the Plan –

   Implementation of actions to manage flood risks for existing and new development.

This Marrickville Valley Floodplain Risk Management Plan is developed based on the previous Marrickville Valley Flood Study (WMAwater) adopted by Council in 2013. It follows on from the Marrickville Valley Floodplain Risk Management Study prepared in conjunction with this Plan which includes updates to the flood study model.

Executive Summary

Overview and Purpose

This Floodplain Risk Management Plan (FRMP) for the Marrickville Valley floodplain has been prepared by Cardno for Inner West Council in accordance with the New South Wales (NSW) Flood Prone Land Policy and the principles of the Floodplain Development Manual (NSW Government, 2005).

The Marrickville Valley FRMP has been developed to direct and co-ordinate the future management of flood prone land within the Marrickville Valley catchment. It also aims to educate the community about flood risks so that they can make more informed decisions regarding their individual exposure and responses.

The preparation of this FRMP follows on from previous documents which have been prepared to assist in addressing flood risk for the Marrickville Valley floodplain; namely the Marrickville Valley Flood Study (WMAwater, 2013) and the Draft Marrickville Valley Floodplain Risk Management Study (FRMS) (Cardno, 2017).

Study Area

The Marrickville Valley catchment comprises a 7.9 km2 catchment which ultimately drains into the Cooks River via four outfalls:

> Eastern Channel –This Channel drains approximately 345 hectares or 44% of the Marrickville Valley. It also receives flow from the low lying areas and the Central Channel.

> Central Channel – This channel starts at Sydenham Road near Fraser Park and alternates between an open channel and closed box culvert. Two pumping stations are located within the catchment of this channel.

> Western Channel – This Channel starts at Malakoff Street with the upper reaches discharging flows into Malakoff Tunnel. The channel alternates between an open concrete channel and a concrete box culvert.

> Malakoff Tunnel (Western Channel Amplification) – This is a closed box culvert which starts at Malakoff Street. It extends to Cooks River and discharges below Warren Park.

A distinguishing factor for the Marrickville Valley catchment is that there are three existing pump stations in the catchment to help reduce flooding. These pumps are run by Sydney Water and are located in Sydenham, Mackey Park and the northern end of Carrington Road.

Existing Flood Behaviour and Economic Damages

The impact of flooding across the catchment is significant, with the number of properties in the catchment that would be impacted by overfloor flooding in the 2 year ARI event being 198 properties. Economic impacts of flooding are also significant due to flooding over the floor level of both residential and commercial properties, as well as structural and garden damage for residential properties combining to represent a significant expense in flood events ranging from the 2 Year ARI to the PMF event. The Annual Average Damage for the catchment under existing conditions is expected to be approximately $21 million.

Preferred Management Options and Implementation Program

The Floodplain Risk Management Study examined a range of flood mitigation options aimed at reducing the likelihood and / or consequences of flooding. These included:

> Flood modification measures (e.g. drainage works and upgrades);

> Property modification measures (e.g. house raising, voluntary purchase, land swap); and

> Emergency management measures (e.g. flood warning systems, education and awareness).

The implementation plan is shown in the following table. The implementation plan is based on the preferred options from the FRMS, synergies between options and anticipated future works by Council and other agencies.

Flood modification measures

Option ID	Description	Capital Cost	Responsibility	Priority**	Implementation Notes
FM5.6	Increase inlet capacity in Illawarra Road, York and Shephard Streets via 450mm diameter pipes	$324,600	Council / OEH	H	Stand-alone project Approval from Sydney Water required
FM12.4	*Install a weir in the central channel to divert the flows into the Mackey Park pump station (DPS2)*	$95,500	Sydney Water / Council	H	Design and implementation of option should be coordinated with Options FM12.1 and FM12.2 Approval from Sydney Water required
FM12.1 & 12.2*	Upgrade drainage in Cary St and Premier St to install new 750mm diameter pipes and inlet pits. Upgrade drainage in Renwick St to install 750mm diameter pipes Cost based on cut down version of modelled option	$430,550	Council	M	Optimise option by reducing length of pipes to be local to western channel only Design and implementation of option should be coordinated with Option FM12.4 Approval from Sydney Water required
FM2.1	Install orifice plate on Marrickville Oval basin outlet to maximise basin flood attenuation for up to the 20% AEP event	$72,000	Council / OEH	M	Undertake further investigation of option in tandem with review of Dam Safety Emergency Plan is required in 2017-18
FM5.3 & FM5.4	Upgrade drainage in Addison Rd between Park Rd and Gordon Lane via 600mm diameter pipes. New raised road thresholds at Park St, Neville St and Essex St	$1,465,800	Council / OEH / RMS	H	Design and implementation of option should be coordinated with proposed bidirectional separated cycleway in Addison Road and Options FM6.4 and FM6.1
FM6.4	Install new inlet pits and 600mm diameter pipes along England Ave, Agar St and Wemyss St	$580,800	Council	H	Design and implementation of option should be coordinated with proposed bidirectional separated cycleway in Addison Road
FM6.1	Upgrade drainage in Newington Rd to 600mm diameter pipes	$422,900	Council	M	Design and implementation of option should be coordinated with proposed bidirectional separated cycleway in Addison Road. Approval from Sydney Water required
FM3.2	New *1200mm diameter pipe along Sydenham Rd starting at Petersham Rd and joining the existing box culvert underneath Malakoff Street (Malakoff Tunnel)*	$2,288,700	RMS / Council / OEH	M	Design and implementation of option should be coordinated with Option FM3.3 Project is contingent on support and funding assistance from RMS.
FM3.3	New drainage in Sydenham Road and connect to Western Channel via 600mm diameter pipes	$526,300	Council / RMS	M	Design and implementation of option should be coordinated with Option FM3.2 Project is contingent on support and funding assistance from RMS.
FM14.1	Upgrade the existing 675mm diameter pipe to a 1200mm diameter pipe or duplicate the pipe underneath Bolton St and railway line	$563,300	Council / Sydney Metro	M	Design and implementation of option should be coordinated with Sydeny Metro works
FM11.1 & FM11.2	Construct overland flow path from Unwins Bridge Road around edge of Tillman park to connect with rail culvert Construct overland flow path from childcare centre around edge of park to rail culvert	$477,900	Council / OEH	H	Design and implementation of option should be coordinated with Renewal of public toilet as identified in the Public Toilet Strategy and Options FM11.3 and FM11.4
FM11.3	Upgrade drainage in Unwins Bridge Rd and Terry St via 600mm diameter pipes to connect to existing twin 900mm diameter pipes	$404,300	Council / OEH	H	Design and implementation of option should be coordinated with Options FM11.1, FM11.2 and FM11.4

Option ID	Description	Capital Cost	Responsibility	Priority**	Implementation Notes
FM11.4	Upgrade drainage in Unwins Bridge Rd at Bridge Street via 450mm diameter pipe	$404,400	Council	M	Design and implementation of option should be coordinated with Options FM11.1, FM11.2 and FM11.3
FM1.1	Install new 900mm diameter pipe to re-direct flows from Morton Ave, down Frazer St to Frazer St low point adjacent to Lawson Ave. Install a new 1.8m X 1.2m box culvert from the low point along Frazer St to a new surcharge pit in Marrickville Oval. Additional sag inlet pits to increase inflows into the pipes.	$2,328,000	Council	M	Stand-alone project Undertake further investigation of option in tandem with review of Dam Safety Emergency Plan is required in 2017-18
FM3.1	Divert flows from Jarvie Park to Malakoff Tunnel with a new minimum 1050mm diameter pipe, upgrade drainage in Petersham Rd to 750mm diameter pipe and Northcote St to 450mm diameter pipe	$936,100	Council	M	Stand-alone project Approval from Sydney Water required
FM15.10	Divert Buckley St and Wilkinson Ln along Shirlow St to Sydenham pit via 1500mm diameter pipe Drainage works along Saywell Street. Duplicate 2.0m x 1.2m box culvert between Cadogan Lane and Sloane St and duplicate 3.0m x 1.2m box culvert between Sloane St and Sydenham pit. New junction chamber to connect existing and new culverts	$4,112,200	Sydney Water / Council / OEH	M	Project is contingent on support and funding assistance from Sydney Water.
FM 7.1 & FM7.5	Upgrade drainage and additional inlet capacity near Smith St, Enmore Rd and Cook Rd. Install 600mm diameter pipes along Enmore Rd and Cook Rd, and 1800mm x 600mm box culvert along Smith St. Duplicate existing 600mm diameter pipe and new pits in Denby St and threshold on Denby St at Addison Rd	$1,681,100	Council / RMS / OEH	L	Stand-alone project Optimise option by excluding works in Addison Road and Denby Street. Project is contingent on support and funding assistance from RMS.
FM15.1 & 15.2	Upgrade and extend drainage in Victoria Road south of Sydenham Rd and Victoria Lane to 600mm diameter pipes and Victoria Lane and Meeks Road to 600mm diameter pipes. Upgrade and extend Drainage in Victoria Road north of Sydenham Rd to 600mm diameter pipes	$946,900	Council	L	Stand-alone project Project is contingent on support and funding assistance from RMS.
FM2.3	Divert George Street catchment from Livingstone Road sag to Centennial St via 600mm diameter pipes	$2,436,000	Council	L	Stand-alone project
FM3.4	Increase inlet capacity on Despointes St with 450mm diameter pipes, Silver St with 450mm diameter pipes and Sydenham Road near Garners Ave with 600mm diameter pipes	$631,200	Council	L	Stand-alone project Optimise option by excluding works in Sydenham Road and including additional capacity in Illawarra Road, Le Clos Lane and Peace Lane.
FM13.1, 13.2 & 13.5	Upgrade drainage in Gannon St and Edwin St to 600mm diameter pipes Upgrade drainage in Griffiths St to 600mm diameter pipes. Upgrade drainage in Brooklyn St and Union St to install 375mm - 450mm diameter pipes	$660,600	Council	L	Stand-alone project Consider implementing minor works in Brooklyn and Union Streets only.
FM10.4	Divert flows from rail and Charlotte Ave into Western Channel via 900mm diameter pipe	$499,300	Council	L	Stand-alone project. May be impacted by proposed Sydney Metro drainage works

Option ID	Description	Capital Cost	Responsibility	Priority**	Implementation Notes
FM5.2	Demolish brick wall and structures built over drainage easement between Park and Neville Streets and upsize pipe to 450mm.	$222,600	Council	L	Consider demolition of brick wall only. Project cannot be implemented prior to option FM5.3 and FM5.4 due to downstream impacts.
FM10.1	Divert Marrickville Rd flows down Barclay Street to Sydenham Detention Basin via 600mm diameter pipes	$811,600	Council	L	Stand-alone project. Project should be implemented after FM15.10 to maximise benefit
FM9.1	New drainage in Marrickville Road and connect to Malakoff tunnel via 600mm diameter pipes	$774,800	Council	L	Stand-alone project. Optimise connection to Malakoff Tunnel to reduce adverse impacts in major events. Approval from Sydney Water required
FM8.1 & 8.2	New drainage in Arthur Street and connect to Malakoff tunnel via 600mm diameter pipe. New drainage in Robert Street via 600mm diameter pipe	$343,800	Council	L	Stand-alone project. Optimise connection to Malakoff Tunnel to reduce adverse impacts in major events. Approval from Sydney Water required
FM1.2	Divert flows from Wardell Rd via Morgan St and down Bishop St to Marrickville Oval via 600mm diameter pipes. Install a new 1.8m X 1.2m box culvert from the low point along Frazer St to a new surcharge pit in Marrickville Oval.	$2,208,900	Council	L	Stand-alone project. Project should be implemented after FM1.1 to maximise benefit

Emergency Management and Property modification measures

Option ID	Description	Capital Cost	Responsibility	Priority**
EM2	Information transfer to NSW SES	$1,000	Council	H
EM6	Interactive Flood Mapping	$50,000	Council	H
EM5	Flood Awareness and Education	$1,000	Council / SES	H
EM3	Flood Response for Vulnerable Properties	$1,000	Council	H
EM7	Education and Awareness of Littering	$20,000	Council / EPA	M
EM4	Local Evacuation Measures	$1,000	Council / SES	M
PM5	Increased Street Sweeping	$100,000 p.a.	Council	M
EM1	New Evacuation Centres	$1,000	Council / SES	M

* Adjusted cost based on cut down version of modelled option.

**H = higher priority; M = medium priority; L = lower priority.

This FRMP represents the considered opinion of the local community on how to best manage its flood risk and its flood prone land. It provides a long-term guide for the future development of the community, and will be subject to periodic revision.

It should be noted that at the time of writing significant flood mitigation works are currently in planning stages by Sydney Metro or developers in the following areas:

- Carrington Road
- Marrickville Station, McNeilly Park, Livingstone Road, Station Street and Byrnes Street
- Sydenham Station and Bolton Street

It is intended these works will compliment works proposed in this FRMP.

This plan should be regarded as a dynamic instrument requiring review and modification over time. The catalysts for change include new flood events and experiences, legislative change, alterations in the availability of funding and reviews of Council planning policies. In any event, a review every ten years or so is warranted to ensure the ongoing relevance of the Plan.

Glossary and Abbreviations

Australian Height Datum (AHD)	A standard national surface level datum approximately corresponding to mean sea level.
Average Exceedance Probability (AEP)	Refers to the probability or risk of a flood of a given size occurring or being exceeded in any given year. A 90% AEP flood has a high probability of occurring or being exceeded each year; it would occur quite often and would be relatively small. A 1% AEP flood has a low probability of occurrence or being exceeded each year; it would be fairly rare but it would be relatively large. The 1% AEP event is equivalent to the 1 in 100 year Average Recurrence Interval event.
Average Recurrence Interval (ARI)	The average or expected value of the periods between exceedances of a given rainfall total accumulated over a given duration. It is implicit in this definition that periods between exceedances are generally random. That is, an event of a certain magnitude may occur several times within its estimated return period.
Catchment	The area draining to a site. It always relates to a particular location and may include the catchments of tributary streams as well as the main stream.
Design flood	A significant event to be considered in the design process; various works within the floodplain may have different design events. E.g. some roads may be designed to be overtopped in the 1% AEP flood event.
Development	The erection of a building or the carrying out of work; or the use of land or of a building or work; or the subdivision of land.
Discharge	The rate of flow of water measured in terms of volume over time. It is to be distinguished from the speed or velocity of flow, which is a measure of how fast the water is moving rather than how much is moving.
Flash flooding	Flooding which is sudden and often unexpected because it is caused by sudden local heavy rainfall or rainfall in another area. Often defined as flooding which occurs within 6 hours of the rain which causes it.
Flood	Relatively high stream flow which overtops the natural or artificial banks in any part of a stream, river, estuary, lake or dam, and/or overland runoff before entering a watercourse and/or coastal inundation resulting from super elevated sea levels and/or waves overtopping coastline defences.
Flood prone land	Land susceptible to inundation by the probable maximum flood (PMF) event, i.e. the maximum extent of flood liable land. Floodplain Risk Management Plans encompass all flood prone land, rather than being restricted to land subject to designated flood events.
Floodplain	Area of land which is subject to inundation by floods up to the probable maximum flood event, i.e. flood prone land.
Floodplain management measures	The full range of techniques available to floodplain managers.
Floodplain management options	The measures which might be feasible for the management of a particular area.
Flood planning levels (FPLs)	Flood levels selected for planning purposes, as determined in floodplain management studies and incorporated in floodplain management plans. Selection should be based on an understanding of the full range of flood behaviour and the associated flood risk. It should also take into account the social, economic and ecological consequences associated with floods of different severities. Different FPLs may be appropriate for different categories of land use and for different flood plains. The concept of FPLs supersedes the “Standard flood event” of the first edition of the Manual. As FPLs do not necessarily extend to the limits of flood prone land (as defined by the probable maximum flood), floodplain management plans may apply to flood prone land beyond the defined FPLs.
Hydraulics	The term given to the study of water flow in a river, channel or pipe, in particular, the evaluation of flow parameters such as stage and velocity.

Management plan	A document including, as appropriate, both written and diagrammatic information describing how a particular area of land is to be used and managed to achieve defined objectives. It may also include description and discussion of various issues, special features and values of the area, the specific management measures which are to apply and the means and timing by which the plan will be implemented.
Mathematical/computer models	The mathematical representation of the physical processes involved in runoff and stream flow. These models are often run on computers due to the complexity of the mathematical relationships. In this report, the models referred to are mainly involved with rainfall, runoff, pipe and overland stream flow.
Overland Flow	The term overland flow is used interchangeably in this report with “flooding”.
Probable maximum flood (PMF)	The flood calculated to be the maximum that is likely to occur.
Probability	A statistical measure of the expected frequency or occurrence of flooding. For a more detailed explanation see AEP and Average Recurrence Interval.

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Tables

Figures

1 Introduction

Cardno (NSW/ACT) Pty Ltd ('Cardno') was commissioned by Inner West Council to undertake a Floodplain Risk Management Study and Plan for the Marrickville Valley catchment shown in **Figure 1-1**.

The purpose of the Floodplain Risk Management Study (FRMS) was to define the existing flooding behaviour and associated hazards, and to investigate possible management options to reduce flood damage and risk. The Draft FRMS report details the flood damages assessment, and the investigations undertaken into potential flood mitigation options.

The Floodplain Risk Management Plan (FRMP) describes how flood prone land in the Marrickville Valley catchment is to be used and managed, and presents the preferred floodplain risk management options identified in the FRMS.

Both documents have been prepared in accordance with the New South Wales (NSW) Flood Prone Land Policy and the principles of the Floodplain Development Manual (NSW Government, 2005), and both have been undertaken alongside community consultation to ensure that community concerns are addressed appropriately

This project has been completed with financial and technical assistance from the NSW Office of Environment and Heritage (OEH).

1.1 Purpose of the Plan

In the past, flooding of the Marrickville Valley catchment has caused property damage, restricted property access and has been a general inconvenience to the community. These flooding issues have prompted Inner West Council to prepare a comprehensive and integrated Floodplain Risk Management Study and Plan for the Marrickville Valley floodplain.

The preparation of the Marrickville Valley Floodplain Risk Management Study and Plan follows on from the Marrickville Valley Flood Study (WMAwater, 2013). This FRMP represents the fifth stage of the floodplain risk management process as defined by the Floodplain Development Manual (NSW Government, 2005):

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

The objectives of the Floodplain Risk Management Plan are to:

- Reduce the flood hazard and risk to people and property in the existing community and to ensure future development is controlled in a manner consistent with the flood hazard and risk (taking into account the potential impacts of climate change);
- Reduce private and public losses due to flooding;
- Where possible, protect and enhance the creek and floodplain environment;
- Be consistent with the objectives of relevant state policies, in particular, the Government's Flood Prone Lands and State Rivers and Estuaries Policies and satisfy the objectives and requirements of the Environmental Planning and Assessment Act 1979;
- Be consistent with the objectives of Marrickville Strategy for a Water Sensitive Community and Stormwater Assets Management Plan;
- Ensure actions arising out of the draft plan are sustainable in social, environmental, ecological and economic terms;

> Ensure that the floodplain risk management plan is fully integrated with the local emergency management plan (flood plan) and other relevant catchment management plans; and

> Establish a program for implementation and mechanism for the funding of the plan which should include priorities, staging, funding, responsibilities, constraints, and monitoring.

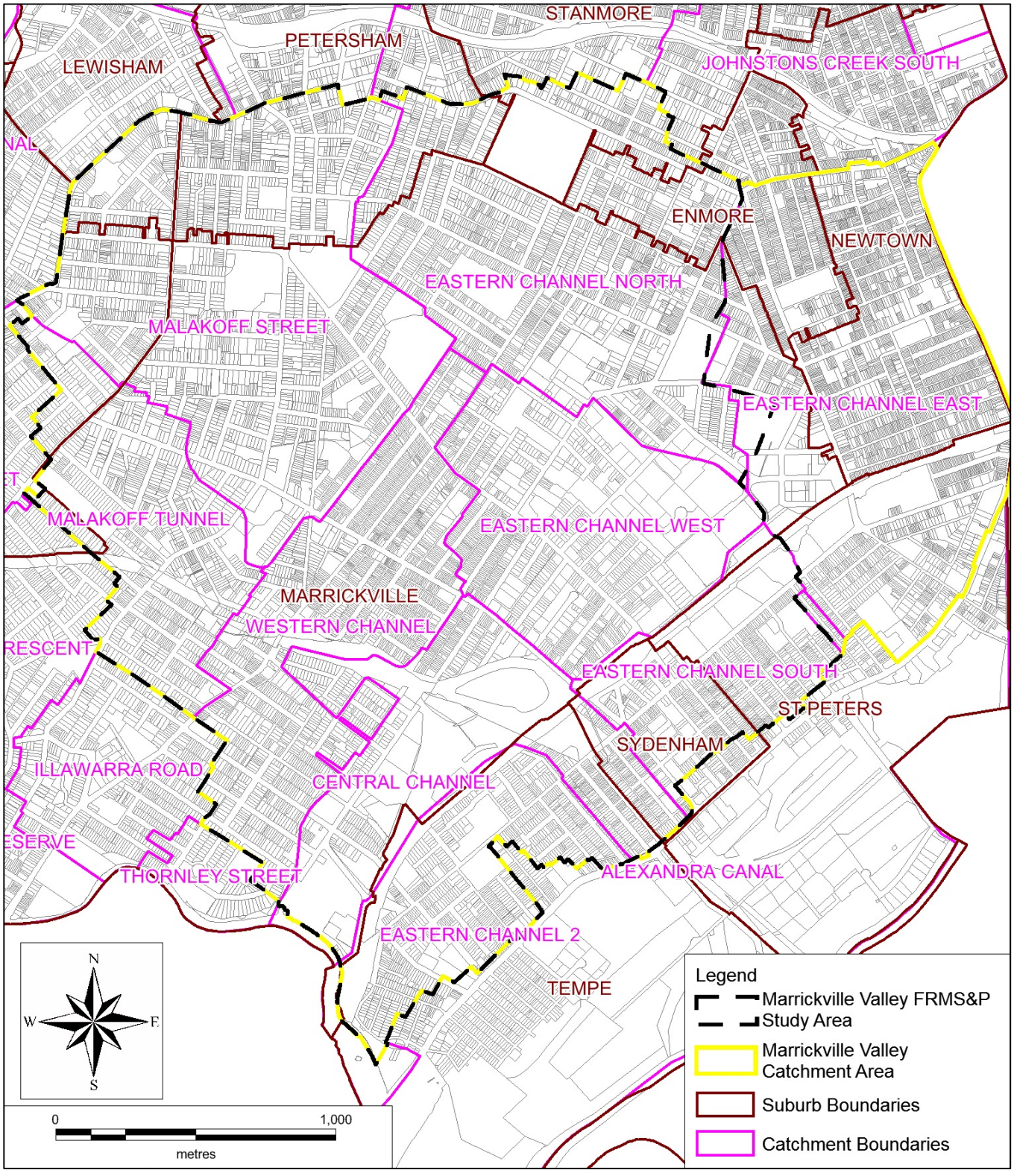

Figure 1-1 Marrickville Valley Study Area and Catchments

1.2 Structure of the Plan

The structure of this FRMP is outlined below:

> **Chapter 2** provides a description of the flood behaviour;

> **Chapter 3** provides background on the emergency and planning considerations;

> **Chapter 4** summarises the outcomes of the FRMS, including the options to be adopted in the FRMP;

> **Chapter 5** provides guidance on implementation of the Plan;

> **Chapter 6** includes concluding remarks;

> **Chapter 7** identifies qualifications relevant to the FRMP; and

> **Chapter 8** includes a list of references used in this report.

2 Flood Behaviour and Economic Damages

2.1 Catchment Characteristics

The Marrickville Valley catchment comprises a 7.9 km2 catchment which ultimately drains into the Cooks River via four outfalls:

> Eastern Channel – This Channel drains approximately 345 hectares or 44% of the Marrickville Valley. It also receives flow from the low lying areas and the Central Channel.

> Central Channel – This channel starts at Sydenham Road near Fraser Park and alternates between an open channel and closed box culvert. Two pumping stations are located within the catchment of this channel.

> Western Channel – This Channel starts at Malakoff Street with the upper reaches discharging flows into Malakoff Tunnel. The channel alternates between an open concrete channel and a concrete box culvert.

> Malakoff Tunnel (Western Channel Amplification) – This is a closed box culvert which starts at Malakoff Street. It extends to Cooks River and discharges below Warren Park.

The low-lying land in the centre of the Marrickville Valley starting from Addison Rd was previously part of the Gumbramorra Swamp which has had a long history of flooding. The size of this brackish and freshwater swamp varied depending on the season and rainfall and could double in size during wet periods.

The Marrickville Valley area has relatively gentle slopes from north-west to south-east, with some undulating terrain along the western border of the study area. The ridgeline that forms the upper boundary of the catchment runs along the northern (near Stanmore Road) and western (near New Canterbury Road) edges of the catchment and has elevations between approximately 35 – 50m AHD. The eastern boundary of the study area is another ridgeline of comparatively lower elevation (20 – 25m AHD) close to the Princes Highway. This eastern ridgeline separates the Marrickville Valley from the Alexandra Canal catchment to the east.

A distinguishing factor for the Marrickville Valley catchment is that there are three existing pump stations in the catchment to help reduce flooding. These pumps are run by Sydney Water and are located in Sydenham, Mackey Park and the northern end of Carrington Road.

2.2 Existing Flood Behaviour

The Marrickville Valley catchment is subject to widespread inundation for all the design flood events. Following areas experience significant flooding:

> Marrickville Industrial Area;

> Frazer Street and Lawson Avenue;

> Malakoff Street and generally the area downstream of Marrickville Oval and on the southern side of Sydenham Road;

> Addison Road;

> Marrickville Railway Station;

> Sydenham Railway Station; and

> Carrington Road.

Modelling results also showed that:

> the Eastern Channel has sufficient capacity to convey flows of up to the 1% AEP event;

> Central Channel has insufficient capacity to convey flows for all the modelled design events;

> Western Channel has capacity to convey flows for up to the 5 year ARI event; and,

> lower reaches of Malakoff Tunnel has sufficient capacity to convey flows of up to the 1% AEP event.

2.3 Future Flood Behaviour

The NSW Floodplain Development Manual (NSW Government, 2005) requires consideration of climate change in the preparation Floodplain Risk Management Studies and Plans. Guidelines on assessing climate change include:

> IPCC Fourth Assessment Synthesis Report - Summary for Policymakers (IPCC, 2007).

> NSW Sea Level Rise Policy Statement (NSW Government, 2009);

> Floodplain Risk Management Guideline: Practical Consideration of Climate Change (NSW Government, 2007);

Sensitivity testing of the hydraulic model for the impact of climate change was conducted as part of the Marrickville Valley Flood Study (WMAwater, 2013). The effects of climate change have been assessed in two ways:

> Sea Level Rise: Flooding of low lying coastal floodplains is expected to be affected by potential sea level rise in the future;

> Rainfall Increase: In NSW, it is common for rainfall intensity increases to be modelled resulting from climate change.

For these two types of climate change impacts there are a range of different conditions that the NSW State Government recommends for considerations. This has resulted in a total of 8 climate change scenarios being assessed within the Flood Study:

> 0.4m rise in tailwater level in the Cooks River;

> 0.9m rise in tailwater level in the Cooks River;

> 10% increase in design rainfall intensity;

> 20% increase in design rainfall intensity;

> 30% increase in design rainfall intensity;

> 10% increase in design rainfall intensity plus a 0.4m rise in tailwater level in the Cooks River;

> 10% increase in design rainfall intensity plus a 0.9m rise in tailwater level in the Cooks River; and

> 30% increase in design rainfall intensity plus a 0.4m rise in tailwater level in the Cooks River.

The results indicate that a 0.4m sea level rise will increase the 1% AEP flood levels by a maximum of 0.1m and a 0.9m sea level rise by a maximum of 0.2m. These increases are confined to the lower parts of the catchment.

The increase in the design rainfalls result in a more general increase in flood levels across the entire catchment. The 10%, 20%, and 30% rainfall increases result in approximate maximum increases of 0.1m, 0.2m, and 0.3m respectively throughout the catchment.

The combinations of a rainfall increase and sea level rise increase indicated the similar results to the addition of the individual rainfall and sea level rise scenario increases.

2.4 Economic Damages from Flooding

An assessment of flood damages was undertaken for both the existing catchment conditions, and for a range of scenarios investigating the potential economic benefits of implementing some of the individual flood management options. The assessment findings are reported in the FRMS.

The results from the damages assessment are shown in **Table 2-1**.

The average annual damage value attempts to quantify the flood damage that a floodplain would receive on average during a single year. The average annual damages for the Marrickville Valley floodplain under existing conditions is $21,264,981.

The results show that there is potential for substantial damages to occur in relation to relatively small flood events such as the 2 year ARI event, due to inundation above the floor level for 198 properties.

Table 2-1 Flood Damages Assessment Summary

Property Type	Number of Properties	Properties with Overfloor Flooding	Average Overfloor Flooding Depth (m)	Maximum Overfloor Flooding Depth (m)	Total Damage ($May 2016)
PMF					
Residential	4384	1382	0.60	2.97	$121,867,236.81
Commercial	279	43	0.56	1.89	$1,202,224.62
Industrial	986	745	1.73	3.48	$21,762,171.72
Public	121	44	0.45	1.47	$742,373.59
Total	**5770**	**2214**			**$145,574,006.74**
1% AEP					
Residential	4384	473	0.19	1.28	$47,408,775.55
Commercial	279	20	0.25	1.2	$728,457.12
Industrial	986	425	0.35	1.37	$5,994,034.27
Public	121	15	0.25	0.55	$355,698.72
Total	**5770**	**933**			**$54,486,965.65**
10% AEP					
Residential	4384	263	0.15	0.65	$30,415,229.71
Commercial	279	20	0.17	1.08	$639,275.84
Industrial	986	206	0.16	0.97	$2,986,415.46
Public	121	10	0.16	0.09	$281,165.66
Total	**5770**	**499**			**$34,322,086.67**
20% AEP					
Residential	4384	210	0.14	1.28	$26,528,896.97
Commercial	279	20	0.14	1.2	$609,416.99
Industrial	986	128	0.14	1.37	$2,425,506.72
Public	121	8	0.15	0.55	$266,429.03
Total	**5770**	**366**			**$29,830,249.71**
2Year ARI					
Residential	4384	119	0.12	0.46	$18,750,270.81
Commercial	279	13	0.14	0.99	$546,749.48
Industrial	986	61	0.13	0.8	$1,927,913.03
Public	121	5	0.08	0.09	$242,854.73
Total	**5770**	**198**			**$21,467,788.05**

2.5 Floodplain Management Issues

The FRMS identified the following key issues in the Marrickville Valley floodplain:

> The drainage systems are limited in flood conveying capacity;

> Flooding of existing developed areas (residential and commercial) results in economic and social impacts (e.g. damage to property, social disruption);

> Flooding damages public assets and critical infrastructure;

> The flooding in the catchment is of flash flooding nature;

> Due to rapid onset of flooding (generally within an hour), there is not enough time to evacuate the floodplain before the existing road network is inundated; and

> Climate change-related increases in rainfall intensity are predicted to exacerbate current flooding levels.

These issues form the basis of the options assessment presented in the FRMS, and this FRMP seeks to address these issues through the implementation of identified actions (**Chapter 4**).

2.6 Consultation

The draft Marrickville Valley Floodplain Risk Management Study and Plan will be placed on Public Exhibition together, with the purpose of the Public Exhibition being to seek community feedback on the options selected for implementation.

The stakeholders (Sydney Water Corporation, Office of Environment and Heritage, Roads and Maritime services & SES) have played an important role in assisting Council in the preparation of the Floodplain Risk Management Study and Plan.

Early in the project, a newsletter describing the study and a questionnaire designed to gauge community awareness of flood related issues and request feedback were made available on Council's 'Have Your Say' webpage. The 'Have Your Say' webpage also allowed the community to pinpoint locations of flooding on an interactive map and to provide their flooding stories.

Council sent the newsletter to 12,000 properties within the study area and posted personalised letters to stakeholder groups and businesses. In addition, newsletters were sent to 1,765 property owners whose properties had been flood tagged within the study area.

Community input was sought to inform the development and assessment of Flood Modification Options through a series of workshops. The purpose of the workshops was to present the preliminary findings of the Flood Modification Options assessment and gain feedback on the community acceptance of those options, any possible modifications of those options and preferred options not already considered in the study. The outcome of this feedback identified strong support of options in the vicinity of Northcote Street (in particular Options FM3.1, FM3.2, FM 3.3 and FM3.4). Options near Marrickville Oval (Options 2.1 and 2.2) and Addison Road Community Centre (Option 5.6) were also given support. No negative feedback was received on the options presented.

3 Emergency and Planning Considerations

3.1 Emergency Response Review

Flooding in the Marrickville Valley catchment generally occurs as flash flooding, that is, inundation occurs quickly from increased water levels that may be elevated for only short periods of time. This flooding behaviour results in a limited time period in which to provide a flood warning or to arrange for evacuations.

When determining the flood risk to life, the flood hazard for an area does not directly imply the danger posed to people in the floodplain. This is due to the capacity for people to respond and react to flooding, ensuring they do not enter floodwaters. This concept is referred to as flood emergency response.

To help minimise the flood risk to occupants of the floodplain, it is important that there are provisions for flood emergency response. There are two main forms of flood emergency response that may be adopted:

- Evacuation: The movement of occupants out of the floodplain before the property becomes flooded;
- Shelter-in-place: The movement of occupants to a building that provides vertical refuge on the site or near the site before their property becomes flood affected.

The FRMS reviewed the current emergency response systems that are in place and the feasibility for flood evacuation based on critical infrastructure and vulnerable developments, key locations of road overtopping, and the evacuation timeline for the floodplain. In addition the shelter-in-place potential was assessed, and based on guidance for emergency response in flash flooding, a comment on evacuation versus shelter-in-place was made for the Marrickville Valley Catchment.

3.1.1 Summary and Recommendations

For the Marrickville Valley there is an existing local emergency management document for flooding, the *Marrickville Flood Emergency Sub Plan* (SES, 2015). This document outlines the emergency response procedures and the responsible parties and their roles in the event of flooding. Upon review, the provisions of the Plan are mostly appropriate.

For vulnerable properties that are affected by the 1% flood event it is recommended that individual flood response plans are developed.

With respect to the evacuation timeline for the Marrickville Valley, as the catchment is affected by flash flooding there is insufficient time to evacuate residents using the SES assisted doorknock approach. A number of alternatives were considered to improve the evacuation timeline:

- Use of alternative flood warning systems including radio and television warnings, social media and telephone based approaches all providing potential reductions to the time required for evacuation compared to doorknocking.
- Self-managed evacuation which can be implemented for all new developments through requirements within development controls relating to preparation of a flood emergency response plan and site specific flood warning systems.
- Improved flood awareness is likely to significantly reduce the time required for residents to evacuate as it improves awareness of the severity of the flood risk and the flash flooding nature of the catchment.

While not the preferred form of emergency response, the review conducted in the FRMS found that shelter-in-place is a feasible form of emergency response for the new development in the catchment through development controls. This approach reduces the strain on SES resources and reduces the time required for response.

3.2 Policy and Planning Review

The Marrickville Valley floodplain is located in the Marrickville Area of Inner West Council LGA where development is controlled through the Marrickville Local Environment Plans (LEP), Marrickville Development Control Plan (DCP) and associated policies.

A LEP is a planning instrument that designates land uses and permissible development in the LGA, whilst a DCP regulates development using specific guidelines and parameters. Management policies and plans are often used to provide additional information regarding development guidelines and parameters.

The FRMS provided a review of flood controls covered by the LEP, DCP and relevant policies and plans.

3.2.1 Summary and Recommendations

Review of flood planning and policy considerations for the Marrickville Valley concluded that generally the current development controls for the Marrickville Valley are appropriate based upon a review of relevant manuals and guidelines.

A strategic planning review completed based on land use zoning mapping from the 2011 Marrickville LEP, showed that low density residential and industrial land uses are the most flood affected developable land and that they are the major source of flood risk for the study area.

In discussion of the potential intensification of development that may occur in the floodplain resulting from these land use zones, redevelopment offers the opportunity to replace relatively high flood risk existing developments with new developments that have a low flood risk through the use of flood mitigation measures and flood-related development controls. In relation to higher density residential development in the floodplain, multi-unit residential developments provide several advantages over the existing typical smaller lot single storey residential currently within Marrickville Valley.

Review of the current Flood Planning Level showed that the residential FPL is appropriate based on a review of the flood behaviour of the catchment and current guidance in both the Floodplain Development Manual and S117 Directive. Review of these guidelines showed that there is scope to potentially revise the current Commercial / Industrial FPL which could provide significant benefits in the Marrickville Valley considering the amount of flood affected industrial zoned land.

Review of the climate change impacts in the Marrickville Valley suggested that the impacts of climate change can be suitably accounted for within the standard freeboard allowance. Therefore it is recommended that the current climate 1% AEP event be maintained as the design event for the FPL in Marrickville Valley.

Finally a review was conducted of the development controls applicable above the FPL up to the PMF level in light of the S117 Directive requirement for ‘exceptional circumstances’ applications:

- It is recommended that specific development controls be developed for high risk ‘vulnerable developments’ such as childcare centres, medical centres and aged care facilities. Typically floor level requirements for these developments are set at the PMF level. Development controls up to the PMF level for these development types are exempt from ‘exceptional circumstances’ application requirement of the S117 directive.
- Currently there are several development controls relating to emergency response which are applicable up to the PMF. However these controls do not require an application for ‘exceptional circumstances’ with the State Government, the reason for this is that an exemption is made for ‘critical emergency response and recovery facilities’. Therefore the current controls are suitable, with potential to apply additional controls relating specifically to shelter-in-place.
- The current basement carpark entry requirements are to the 1% AEP plus 0.5 metre freeboard, with requirements for pumping and emergency response for the basement are considered appropriate. Increasing entry level requirements to the PMF is not recommended as it would require an application to the State Government for ‘exceptional circumstances’ which do not seem appropriate based on flood risk in the Marrickville Valley.

4 Floodplain Management Options

Flood risk can be categorised as existing, future or residual risk.

> **Existing Flood Risk** – existing buildings and development on flood prone land. Such buildings and developments by virtue of their presence and location are exposed to an 'existing' risk of flooding;

> **Future Flood Risk** – buildings and developments that may be built on flood prone land in the future. Such buildings and developments would be exposed to a flood risk when they are built; and

> **Residual Flood Risk** – buildings and development that would be at risk if a flood were to exceed management measures already in place. Unless a floodplain management measure is designed to withstand the PMF, it may be exceeded by a sufficiently large event at some time in the future.

The alternate approaches to managing risk are outlined in **Table 4-1**.

Table 4-1 Flood Risk Management Alternatives (SCARM, 2000)

Alternative	Examples
Preventing / Avoiding risk	Appropriate development within the flood extent, setting suitable planning levels.
Reducing likelihood of risk	Structural measures to reduce flooding risk such as drainage augmentation, levees, and detention.
Reducing consequences of risk	Development controls to ensure structures are built to withstand flooding.
Transferring risk	Via insurance – may be applicable in some areas depending on insurer.
Financing risk	Natural disaster funding.
Accepting risk	Accepting the risk of flooding as a consequence of having the structure where it is.

A range of flood risk management options were considered as part of the FRMS, and subjected to a cost-benefit analysis to assist in identifying appropriate, reasonable and technically feasible options for implementation in this FRMP. Further information can be found in Sections 9 to 11 of the FRMS, which details each of the options and assesses their relative costs and benefits.

The findings of the FRMS are briefly summarised in the following sections.

4.1 Flood Modification Measures

Flood modification measures are options aimed at preventing / avoiding or reducing the likelihood of flood risks. These measures reduce the risk through modification of the flood behaviour in the catchment.

4.1.1 Preliminary Flood Modification Options

Flood modification measures modify the behaviour of the flood itself by reducing flood levels or flow velocities, or by excluding floodwaters from areas under threat (NSW Government, 2005).

Flood modification measures are a common and effective means of reducing flood risk; however, they are often costly and can result in negative impacts on the natural environment (NSW Government, 2005). The adoption of any individual flood modification measure is therefore a trade-off between economic factors, social benefits, and the potential environmental impacts of the option.

A total of 69 preliminary flood modification options across 15 areas were identified for the Marrickville Valley floodplain. These options were developed to address all of the flood affected areas where practicable. The location of preliminary flood modification options and areas are provided in **Figure 4-1**.

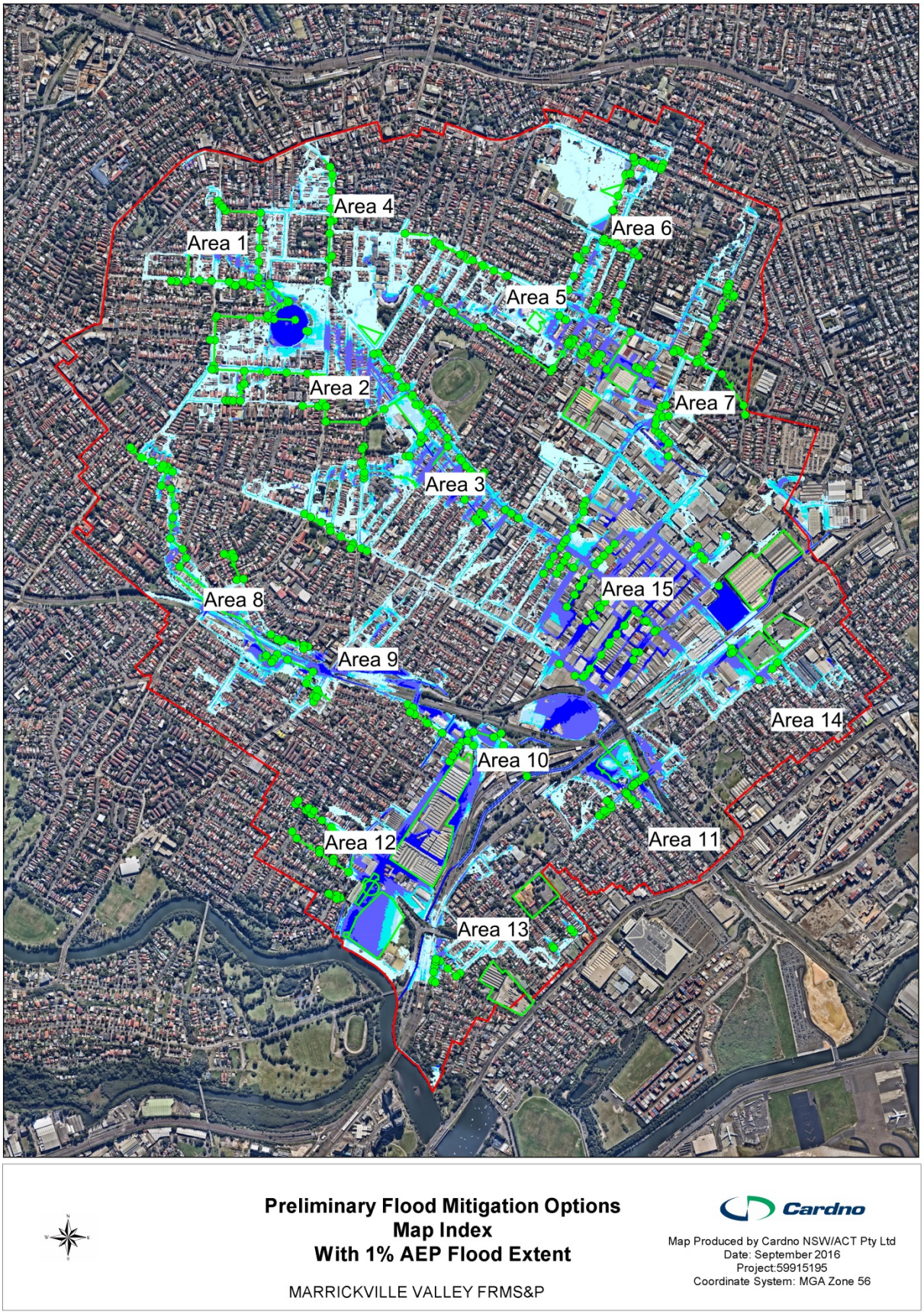

Figure 4-1 Location of Preliminary Flood Modification Options for Marrickville Valley Catchment

An initial desktop assessment was undertaken for the preliminary flood modification options based on approximate capital cost, number of flood affected properties benefitting (directly and indirectly), and likely constraints. From the list of preliminary options, a final list of 40 measures was compiled in consultation with Council to determine which options were to be assessed through detailed hydraulic modelling. A summary of the final flood modification options selected for assessment is presented in **Table 4-2**.

Table 4-2 Final List of Floodplain Risk Management Options for Marrickville Valley Catchment

Drainage Line/Area	ID	Modification Type
Wardell Rd, Frazer Rd, Lawson Ave	FM1.1	Install new 900mm diameter pipe to re-direct flows from Morton Ave, down Frazer St to Frazer St low point adjacent to Lawson Ave. Install a new 1.8m X 1.2m box culvert from the low point along Frazer St to a new surcharge pit in Marrickville Oval. Additional sag inlet pits to increase inflows into the pipes.
	FM1.2	Divert flows from Wardell Rd via Morgan St and down Bishop St to Marrickville Oval via 600mm diameter pipes. Install a new 1.8m X 1.2m box culvert from the low point along Frazer St to a new surcharge pit in Marrickville Oval.
Pile St, Livingstone Rd and Marrickville Oval	FM2.1	Install orifice plate on Marrickville Oval basin outlet to maximise basin flood attenuation for up to the 20% AEP event
	FM2.3	Divert George Street catchment from Livingstone Road sag to Centennial St via 600mm diameter pipes
Northcote St and Sydenham Rd	FM3.1	Divert flows from Jarvie Park to Malakoff Tunnel with a new minimum 1050mm diameter pipe, upgrade drainage in Petersham Rd to 750mm diameter pipe and Northcote St to 450mm diameter pipe
	FM3.2	Duplicate the open western channel by installing new pits and 1200mm diameter pipe along Sydenham Rd to divert flows from the intersection of Sydenham Rd and Petersham Rd to Malakoff Tunnel.
	FM3.3	New drainage in Sydenham Road and connect to Western Channel via 600mm diameter pipes
	FM3.4	Increase inlet capacity on Despointes St with 450mm diameter pipes, Silver St with 450mm diameter pipes and Sydenham Road near Garners Ave with 600mm diameter pipes
Neville St, Surrey St and Illawarra Rd	FM5.2	Demolish brick wall and structures built over drainage easement between Park and Neville Streets and upsize pipe to 450mm.
	FM5.3	Upgrade drainage in Addison Rd between Park Rd and Gordon Lane via 600mm diameter pipes
	FM5.4	New raised road thresholds at Park St, Neville St and Essex St
	FM5.6	Increase inlet capacity in Illawarra, York and Shephard Streets via 450mm

Drainage Line/Area	ID	Modification Type
		diameter pipes
Addison Rd, Newington Rd and Browns Ave	FM6.1	Upgrade drainage in Newington Rd to 600mm diameter pipes
	FM6.4	Install new inlet pits and 600mm diameter pipes along England Ave, Agar St and Wemyss St
Marrickville Industrial Area (MIA) - Addison Rd and Enmore Rd	FM 7.1	Upgrade drainage and additional inlet capacity near Smith St, Enmore Rd and Cook Rd. Install 600mm diameter pipes along Enmore Rd and Cook Rd, and 1800mm x 600mm box culvert along Smith St.*
	FM7.5	Duplicate existing 600mm diameter pipe and new pits in Denby St and threshold on Denby St at Addison Rd*
Crawford Pl, Livingstone Rd, Arthur St and Moyes St	FM8.1	New drainage in Arthur Street and connect to Malakoff tunnel via 600mm diameter pipe
	FM8.2	New drainage in Robert Street via 600mm diameter pipe
Marrickville Rd and Illawarra Rd	FM9.1	New drainage in Marrickville Road and connect to Malakoff tunnel via 600mm diameter pipes
Marrickville Industrial Area (MIA) Marrickville Rd, Meeks Rd, Myrtle St	FM10.1	Divert Marrickville Rd flows down Barclay Street to Sydenham Detention Basin via 600mm diameter pipes
	FM10.4	Divert flows from rail and Charlotte Ave into Western Channel via 900mm diameter pipe
Unwins Bridge Rd and Tilman Park	FM11.1	Construct overland flow Path from Unwins Bridge Road around edge of Tillman park to connect with rail culvert
	FM11.2	Construct overland flow path from childcare centre around edge of Tillman park to connect with rail culvert
	FM11.3	Upgrade drainage in Unwins Bridge Rd and Terry St via 600mm diameter pipes to connect to existing twin 900mm diameter pipes
	FM11.4	Upgrade drainage in Unwins Bridge Rd at Bridge Street via 450mm diameter pipe
Carrington Rd	FM12.1	Upgrade drainage in Cary St and Premier St to install new 750mm diameter pipes and inlet pits
	FM12.2	Upgrade drainage in Renwick St to install 750mm diameter pipes
	FM12.4	Install a weir in the central channel to divert the flows into the Mackey Park pump station (DPS2)

Drainage Line/Area	ID	Modification Type
	FM12.5	Raise channel wall to stop overflows in Cary street
Unwins Bridge Rd and Tramway Ave	FM13.1	Upgrade drainage in Gannon St and Edwin St to 600mm diameter pipes
	FM13.2	Upgrade drainage in Griffiths St to 600mm diameter pipes
	FM13.5	Upgrade drainage in Brooklyn St and Union St to install 375mm - 450mm diameter pipes
Sutherland St and Unwins Bridge Rd	FM14.1	Upgrade the existing 675mm diameter pipe to a 1200mm diameter pipe or duplicate the pipe underneath Bolton St and railway line
Marrickville Industrial Area (MIA) - Victoria Rd and Sydenham Rd	FM15.1	Upgrade and extend drainage in Victoria Road south of Sydenham Rd and Victoria Lane to 600mm diameter pipes and Victoria Lane and Meeks Road to 600mm diameter pipes
	FM15.2	Upgrade and extend Drainage in Victoria Road north of Sydenham Rd to 600mm diameter pipes
	FM15.3	Divert Buckley St and Wilkinson Ln along Shirlow St to Sydenham pit via 1500mm diameter pipe
	FM15.5	Upgrade drainage in Faversham St to 600mm diameter pipes
	FM15.7	Upgrade drainage in Sydney Street with 600mm diameter pipe and Vincent Street with 900mm diameter pipe
	FM15.9	Drainage works along Saywell Street. Duplicate 2.0m x 1.2m box culvert between Cadogan Lane and Sloane St and duplicate 3.0m x 1.2m box culvert between Sloane St and Sydenham pit. New junction chamber to connect existing and new culverts.
	FM15.10	Combination of FM15.3 and FM15.9

A brief description of the floodplain management options is provided in **Appendix A**. Options FM 1.2, FM 12.5, FM 15.5 and FM15.7 have not been included as they are considered to be non-viable.

4.1.2 Economic Assessment of Flood Modification Options

The preferred options are listed in **Table 4-3**.

Table 4-3 Summary of Economic Assessment of Flood Modification Options

Option ID	Cost of Implementation of Option*	Benefit Cost Ratio	Economic Outcome
FM5.6	$373,000	19.19	Good

Option ID	Cost of Implementation of Option*	Benefit Cost Ratio	Economic Outcome
FM2.1	$83,000	12.36	Good
FM5.2	$256,000	11.75	Good
FM 11.1 & FM 11.2	$549,000	8.15	Good
FM 11.3	$465,000	3.53	Good
FM5.3 & FM5.4	$1,683,000	2.05	Good
FM6.4	$667,000	1.98	Moderate
FM6.1	$486,000	1.67	Moderate
FM 11.4	$465,000	1.55	Moderate
FM3.3	$605,000	1.55	Moderate
FM 14.1	$647,000	1.27	Moderate
FM 9.1	$890,000	0.87	Moderate
FM 13.1, FM 13.2 & FM 13.5	$759,000	0.86	Moderate
FM1.1	$2,673,000	0.79	Moderate
FM3.2	$2,628,000	0.58	Moderate
FM 12.4	$110,000	0.57	Moderate
FM 12.1 & FM 12.2	$1,978,000	0.48	Moderate
FM 8.1 & FM 8.2	$395,000	0.43	Good
FM 10.1	$932,000	0.29	Moderate
FM2.3	$2,797,000	0.28	Moderate
FM 15.9	$2,920,000	0.24	Moderate
FM1.2	$2,536,000	0.19	Moderate
FM 15.10	$4,721,000	0.18	Moderate
FM 15.3	$1,842,000	0.17	Moderate
FM 10.4	$574,000	0.11	Moderate
FM 15.1 & FM 15.2	$1,088,000	0.09	Moderate
FM3.1	$1,075,000	0.06	Moderate

Option ID	Cost of Implementation of Option*	Benefit Cost Ratio	Economic Outcome
FM3.4		0.05	Moderate
FM 7.1 & FM 7.5		0.04	Moderate
FM 15.7		-0.02	Poor
FM 12.5		-0.03	Poor
FM 15.5		-0.05	Poor

*Net present worth of cost of implementation, incorporating both capital and maintenance costs with a 7% discount rate and an implementation period of 50 years

4.2 Property Modification Measures

Property modification measures are focused on preventing, avoiding or reducing consequences of flood risks. Rather than modify the flood behaviour, these measures aim to modify existing properties (e.g. by house raising) and/or impose controls on property and infrastructure development (NSW Government, 2005). Property modification measures, such as effective land use planning and development controls, are essential for ensuring that future flood damages are appropriately contained, while at the same time allowing ongoing development and use of the floodplain.

The FRMS assessed the following four property modification measures:

> PM1 – Voluntary purchase, involves properties being purchased by Council at an equitable price and only when voluntarily offered, and is an alternative to the construction of flood modification measures for properties where house raising is not possible;

> PM2 – House raising, a measure designed to reduce the incidence of over-floor flooding of existing buildings through works funded by Council, and with assistance from the NSW Office of Environment and Heritage (OEH);

> PM 3 – Land swap, an alternative to voluntary purchase is a land swap program whereby Council swaps a parcel of land outside of the flood prone area, such as an existing park, for a parcel of flood prone land with the appropriate transfer of any existing facilities to the acquired site;

> PM4 – Flood proofing, undertaking structural changes and other procedures in order to reduce or eliminate the risk to life and property, and thus the damage caused by flooding;

> PM5 – Increased street sweeping, reduces the potential for the drainage inlets to become blocked and subsequently reduce the frequency of uncontrolled overland flows on streets and through private properties.; and

> PM6 – Stormwater pit maintenance, reduces the potential for inlet pits to become blocked.

Voluntary purchase, house raising, and land swap measures were not considered reasonable or feasible for the Marrickville Valley floodplain. This is due to the high cost of property in the floodplain, and the inherent challenges in making an equitable land swap that does not unduly impact community assets such as parks and reserves.

4.3 Emergency Response Modification Measures

Emergency response modification measures aim to reduce the consequences of flood risks by:

> Increasing the effective warning time, such as via the use of flood warning systems;

> Planning the evacuation of an area so that it proceeds smoothly during a flood event;

> Preparing for a flood event (e.g. stockpiling sand and sandbags for future deployment); and

> Enabling recovery following a flood event.

These types of measures are typically incorporated into the local flood plan, and education of the community on the contents of the plan is very important. As noted within the Floodplain Development Manual (NSW Government, 2005) these measures effectively modify the response of the community at risk to better cope with a flood event.

Of all the floodplain risk management options available for consideration, it is only emergency management modifications (which includes community planning) that addresses the residual flood risk after all the flood and property modification options have been implemented. Emergency management and education measures are an effective ongoing flood risk management tool (NSW Government, 2005).

The findings of the FRMS review of emergency response arrangements in the Marrickville Valley floodplain are summarised in **Section 3.1** of this FRMP.

A total of six emergency management options were developed:

- EM1 – SES evacuation centres: Using suitable flood free buildings/centres within the floodplain to improve emergency response at a local scale;
- EM2 – Information transfer to SES: Providing catchment specific flooding information including details of flood risks at specific locations for planning of operational tasks and for the future review of the Marrickville Flood Emergency Sub-Plan;
- EM3 – Flood response for vulnerable properties: Providing provision in the DCP to develop individual flood response plans for those vulnerable developments that are affected by the 1% AEP flood event;
- EM4 – Local Evacuation Measures: Investigating alternative evacuation procedures to doorknocking such as radio and television warnings, social media, and self-managed evacuation or use of shelter-in-place provisions which can be applied to new development through development controls;
- EM5 - Public awareness and education: Developing a program of flood awareness for the entire LGA;
- EM6 – Interactive Flood Mapping: Providing an interactive web viewer to present the results of the floodplain risk management process so that the community is able to see where their neighbourhood is affected, view potential egress routes in case of evacuations and understand the extent of flood risk within their community; and
- EM7 – Education and awareness of flooding, raises awareness and educates the community to influence peoples' behaviour and encourage them to dispose litter appropriately and responsibly.

It is recommended that all of these are adopted as actions in this FRMP.

4.4 Multi-criteria Assessment of Options

A multi-criteria analysis (MCA) approach was used for the comparative assessment of all options identified using a similar approach to that recommended in the Floodplain Development Manual (2005). This approach uses a subjective scoring system to assess the merits of each option. The principal value of such a system is that it allows comparisons to be made between alternatives using a common index. In addition, it makes the assessment of alternatives "transparent" (i.e. all important factors are included in the analysis).

Each option is given a score according to how well the option meets specific considerations. In order to keep the scoring system simple a framework has been developed for each criterion.

The scoring system subjectively ranks each option against a range of criteria given the background information on the nature of the catchment and floodplain as well as community preferences. The scoring is based on a triple bottom line approach; incorporating economic, social and environmental criteria. Each of the criteria has been given a weighting to reflect its importance with regards to floodplain management.

Economic	Benefit cost ratio
	Implementation complexity
	Staging of works
Social	Reduction in risk to life

	Emergency access
	Social disruption
	Community and stakeholder support
Environmental	Heritage conservation areas and heritage items
	Recreation and flora / fauna impacts including street trees
	Acid sulfate soils and contaminated land
	Visual impact

Table 4-4 provides a ranked list of flood modification options.

Table 4-4 Summary of MCA Evaluation of Flood Modification Options

Option ID	BCR	MCA Score	Overall Rank
FM5.6	19.19	16.52	Good
FM5.3 & 5.4	2.05	14.63	Good
FM11.1 & 11.2	8.15	13.67	Good
FM11.3	3.53	12.42	Good
FM6.4	1.98	11.27	Good
FM12.4	0.57	10.27	Good
FM14.1	1.27	9.94	Moderate
FM1.1	0.79	9.58	Moderate
FM6.1	1.67	9.06	Moderate
FM3.3	1.55	8.81	Moderate
FM3.2	0.58	8.67	Moderate
FM11.4	1.55	8.63	Moderate
FM3.4	0.05	8.50	Moderate
FM2.1	12.36	8.42	Moderate
FM7.1 & 7.5	0.04	8.10	Moderate
FM15.10	0.18	7.71	Moderate
FM12.1 & 12.2	0.48	7.71	Moderate
FM13.1, 13.2 & 13.5	0.86	7.21	Moderate
FM15.1 & 15.2	0.09	7.10	Moderate
FM15.9	0.24	7.04	Moderate

Option ID	BCR	MCA Score	Overall Rank
FM2.3	0.28	7.04	Moderate
FM3.1	0.06	6.04	Moderate
FM10.4	0.11	5.85	Poor
FM5.2	11.75	5.79	Poor
FM15.3	0.17	5.31	Poor
FM10.1	0.29	4.35	Poor
FM9.1	0.87	3.79	Poor
FM1.2	0.19	2.29	Poor
FM8.1 & 8.2	0.43	1.73	Poor
FM12.5	-0.03	N/A*	Not Recommended
FM15.5	-0.05	N/A*	Not Recommended
FM15.7	-0.02	N/A*	Not Recommended

***** *Options FM 12.5, FM 15.5 and FM15.7 have a negative economic impact and have been excluded from the multi criteria analysis since there are other options in the same drainage line/area that provide higher economic benefits.*

Table 4-4 provides a ranked list of flood modification options for consideration for inclusion in the FRMP. The options selected for inclusion should be based on both their likely benefits and the likely funding available from Council and the State Government.

Table 4-5 Summary of MCA Evaluation of Property and Emergency Modification Options

Option	MCA Score	Overall Rank
EM2 – Information transfer to NSW SES	10.13	Good
EM6 – Interactive Flood Mapping	8.30	Good
EM5 – Flood Awareness and Education	7.02	Good
EM3 – Flood Response for Vulnerable Properties	5.42	Good
EM7 – Education and Awareness of Littering	3.75	Moderate
EM4 – Local Evacuation Measures	3.64	Moderate
PM5 – Increased Street Sweeping	3.19	Moderate
EM1 – New SES Evacuation Centres	2.04	Moderate
PM4 – Flood Proofing	0.68	Moderate
PM6 – Stormwater Pit Maintenance	-0.93	Poor

The rankings are proposed as the basis for selecting management options for inclusion in the FRMP, and for prioritising their implementation.

It is noted that both structural (flood modification) and non-structural (property modification and emergency response) options have been considered separately. It is difficult to directly compare these two types of measures. Furthermore, funding sources and implementation timeframes for the two different types of measures are typically different.

5 Implementation Program

5.1 Overview

The floodplain management options outlined in **Section 4** are recommended for implementation as an outcome of the Floodplain Risk Management process. In order to achieve the implementation of relevant management actions, a program of implementation has been developed.

The steps in progressing the floodplain risk management process from this point onwards are:

> The Floodplain Risk Management Committee will consider the Draft Plan and make recommendations;

> Council will adopt the final Plan;

> Recommended management actions will be implemented in accordance with the established priorities as funds become available from the OEH, the Commonwealth, other state government agencies and/or from Council's own resources; and

> In some cases implementation will require more detailed cost benefit analysis, assessment and mitigation of environmental impacts and / or detailed design.

5.2 Implementation Plan

The list of recommended management options (**Table 4-4**) has been developed into an implementation plan.

Table 5-1 lists the following information relevant to the implementation of the management actions:

> An estimate of capital costs for each structural action;

> The agency or organisation likely to be responsible for the action and/or funding;

> The priority for implementation (high, medium, or low) as an outcome of the FRMS; and

> Performance measures to allow for the evaluation of the implementation of the FRMP.

The measures identified in **Table 5-1** represent a capital outlay of approximately $32.1M over the life of the plan. However, priority actions have a total cost of approximately $16.8M.

Experience with these types of Plans has identified that the works are undertaken when and as funding becomes available, as well as when various opportunities might arise specifically for an option. In general:

> Non-structural measures can generally be implemented in the short term (1 to 3 years), as they are relatively low in capital expenditure and generally revolve around policy and information; and

> Priority structural measures can generally be implemented in the medium term (3 to 20 years), and will be implemented as funding and opportunities arise.

Specific notes on the implementation of the proposed options and integration with other works are outlined below.

5.2.1 FM 5.6 Illawarra Road, York and Shephard Street Drainage Upgrade

This project is a stand-alone project that can be implemented with few constraints. It is recommended this project proceed in 2018-2020. Consideration should also be given to improved accessibility, rain gardens and streetscape improvements. This project would be funded by Council with possible grant funding from OEH. Approval would be required from Sydney Water.

5.2.2 FM 12.1, 12.2 & 12.4 Carrington Road Drainage Upgrade

This project is a stand-alone project which can be implemented with few constraints. Options 12.1 and 12.2 should be optimised by reducing length of pipes to be local to western channel only. This will greatly reduce the capital expenditure while providing a comparable outcome in flood reduction.

Pending Sydney Water approval of central channel modifications it is recommended this project proceed in 2018-2020.This project may be funded through a joint funding arrangement with Sydney Water. Approval would be required from Sydney Water.

5.2.3 FM 2.1 Marrickville Oval Drainage Upgrade

A review of the Dam Safety Emergency Plan is required in 2017-18. Further investigation and design of this project should be undertaken at the same time as the DSEP review to enable the impacts on possible dam break scenarios to be fully understood. Pending confirmation of the projects compatibility with dam safety requirements it is recommended this project be implemented in 2010-2021. This project would be funded by Council with possible grant funding from OEH.

5.2.4 FM5.3 & 5.4, FM6.1 and FM6.4 Addison Road Drainage Upgrade

A bidirectional separated cycleway is currently proposed on the southern side of Addison Road, and the concept design has recently been completed. Based on current levels of funding implementation is anticipated to be undertaken in 2019-2021. The stormwater works should be coordinated with this project to minimise any rework and disturbance to residents and road users. This project would be funded by Council with possible contributions by Sydney Metro. Approval would be required from Sydney Water.

5.2.5 FM 3.2 & 3.3 Sydenham Road

This project is a stand-alone project. Due to the significant cost and complexity of this project and the location of the works within a state road, this project is contingent on support and funding assistance from RMS. Without support from RMS this project cannot proceed. This project would be funded jointly by RMS and Council. Approval would be required from Sydney Water.

5.2.6 FM14.1 Bolton Street Drainage Upgrade

Sydney Metro Stage 3 is currently undertaking a reference design for upgrade works around Sydenham Station including a proposal for major drainage works. It is likely an upgrade of cross track drainage will be required to provide flood protection. This project should be coordinated with the delivery of the Sydeny Metro drainage works which are anticipated to be undertaken in 2021-2023. This project would be funded by Council with possible grant funding from RMS and/or OEH.

5.2.7 FM11.1 11.2 11.3 & 11.4 Tillman Park and Unwins Bridge Road Drainage Upgrade

Overland flow path through park will require demolition of existing public toilet building. Renewal of the public toilet building is identified in the Public Toilet Strategy as a high priority. Based on current levels of funding the toilet is anticipated to be renewed around 2021- 2023. The stormwater works should be coordinated with this to minimise any rework and disturbance to residents and park users. This project would be funded by Council with possible grant funding from OEH.

5.2.8 FM1.1 Morton Avenue and Frazer Street Drainage Upgrade

This project is a stand-alone project that can be implemented with few constraints. Based on its priority it is recommended this project proceed in 2022-2025. These future works should be allowed for in any future upgrade of Marrickville Park.

5.2.9 FM3.1 Jarvie Park and Northcote Street Drainage Upgrade

This project is a stand-alone project that can be implemented with few constraints. Approval would be required from Sydney Water. Based on its priority it is recommended this project proceed in 2022-2025. These future works should be allowed for in any future upgrade of Marrickville Park.

5.2.10 FM 15.10 Industrial Area Drainage Upgrade

This project is a stand-alone project. Due to the significant cost and complexity of this project and the location of the works, this project is contingent on support and funding assistance from Sydney Water. Without support from Sydney Water this project cannot proceed. This project would be funded jointly by Sydney Water and Council. Proposed works in the vicinity of the Sydenham Pit proposed as part of Sydney Metro should take into consideration the future implementation of this project.

Table 5-1 Implementation Plan

Option ID	Description	Capital Cost	Responsibility	Priority**	Implementation Notes
FM5.6	Increase inlet capacity in Illawarra Road, York and Shephard Streets via 450mm diameter pipes	$324,600	Council / OEH	H	Stand-alone project Approval from Sydney Water required
FM12.4	*Install a weir in the central channel to divert the flows into the Mackey Park pump station (DPS2)*	$95,500	Sydney Water / Council	H	Design and implementation of option should be coordinated with Options FM12.1 and FM12.2 Approval from Sydney Water required
FM12.1 & 12.2*	Upgrade drainage in Cary St and Premier St to install new 750mm diameter pipes and inlet pits. Upgrade drainage in Renwick St to install 750mm diameter pipes Cost based on cut down version of modelled option	$430,550	Council	M	Optimise option by reducing length of pipes to be local to western channel only Design and implementation of option should be coordinated with Option FM12.4 Approval from Sydney Water required
FM2.1	Install orifice plate on Marrickville Oval basin outlet to maximise basin flood attenuation for up to the 20% AEP event	$72,000	Council / OEH	M	Undertake further investigation of option in tandem with review of Dam Safety Emergency Plan is required in 2017-18
FM5.3 & FM5.4	Upgrade drainage in Addison Rd between Park Rd and Gordon Lane via 600mm diameter pipes. New raised road thresholds at Park St, Neville St and Essex St	$1,465,800	Council / OEH / RMS	H	Design and implementation of option should be coordinated with proposed bidirectional separated cycleway in Addison Road and Options FM6.4 and FM6.1
FM6.4	Install new inlet pits and 600mm diameter pipes along England Ave, Agar St and Wemyss St	$580,800	Council	H	Design and implementation of option should be coordinated with proposed bidirectional separated cycleway in Addison Road
FM6.1	Upgrade drainage in Newington Rd to 600mm diameter pipes	$422,900	Council	M	Design and implementation of option should be coordinated with proposed bidirectional separated cycleway in Addison Road. Approval from Sydney Water required
FM3.2	New *1200mm diameter pipe along Sydenham Rd starting at Petersham Rd and joining the existing box culvert underneath Malakoff Street (Malakoff Tunnel)*	$2,288,700	RMS / Council / OEH	M	Design and implementation of option should be coordinated with Option FM3.3 Project is contingent on support and funding assistance from RMS.
FM3.3	New drainage in Sydenham Road and connect to Western Channel via 600mm diameter pipes	$526,300	Council / RMS	M	Design and implementation of option should be coordinated with Option FM3.2 Project is contingent on support and funding assistance from RMS.
FM14.1	Upgrade the existing 675mm diameter pipe to a 1200mm diameter pipe or duplicate the pipe underneath Bolton St and railway line	$563,300	Council / Sydney Metro	M	Design and implementation of option should be coordinated with Sydeny Metro works
FM11.1 & FM11.2	Construct overland flow path from Unwins Bridge Road around edge of Tillman park to connect with rail culvert Construct overland flow path from childcare centre around edge of park to rail culvert	$477,900	Council / OEH	H	Design and implementation of option should be coordinated with Renewal of public toilet as identified in the Public Toilet Strategy and Options FM11.3 and FM11.4
FM11.3	Upgrade drainage in Unwins Bridge Rd and Terry St via 600mm diameter pipes to connect to existing twin 900mm diameter pipes	$404,300	Council / OEH	H	Design and implementation of option should be coordinated with Options FM11.1, FM11.2 and FM11.4
FM11.4	Upgrade drainage in Unwins Bridge Rd at Bridge Street via 450mm diameter pipe	$404,400	Council	M	Design and implementation of option should be coordinated with Options FM11.1, FM11.2 and FM11.3

Option ID	Description	Capital Cost	Responsibility	Priority**	Implementation Notes
FM1.1	Install new 900mm diameter pipe to re-direct flows from Morton Ave, down Frazer St to Frazer St low point adjacent to Lawson Ave. Install a new 1.8m X 1.2m box culvert from the low point along Frazer St to a new surcharge pit in Marrickville Oval. Additional sag inlet pits to increase inflows into the pipes.	$2,328,000	Council	M	Stand-alone project Undertake further investigation of option in tandem with review of Dam Safety Emergency Plan is required in 2017-18
FM3.1	Divert flows from Jarvie Park to Malakoff Tunnel with a new minimum 1050mm diameter pipe, upgrade drainage in Petersham Rd to 750mm diameter pipe and Northcote St to 450mm diameter pipe	$936,100	Council	M	Stand-alone project Approval from Sydney Water required
FM15.10	Divert Buckley St and Wilkinson Ln along Shirlow St to Sydenham pit via 1500mm diameter pipe Drainage works along Saywell Street. Duplicate 2.0m x 1.2m box culvert between Cadogan Lane and Sloane St and duplicate 3.0m x 1.2m box culvert between Sloane St and Sydenham pit. New junction chamber to connect existing and new culverts	$4,112,200	Sydney Water / Council / OEH	M	Project is contingent on support and funding assistance from Sydney Water.
FM 7.1 & FM7.5	Upgrade drainage and additional inlet capacity near Smith St, Enmore Rd and Cook Rd. Install 600mm diameter pipes along Enmore Rd and Cook Rd, and 1800mm x 600mm box culvert along Smith St. Duplicate existing 600mm diameter pipe and new pits in Denby St and threshold on Denby St at Addison Rd	$1,681,100	Council / RMS / OEH	L	Stand-alone project Optimise option by excluding works in Addison Road and Denby Street. Project is contingent on support and funding assistance from RMS.
FM15.1 & 15.2	Upgrade and extend drainage in Victoria Road south of Sydenham Rd and Victoria Lane to 600mm diameter pipes and Victoria Lane and Meeks Road to 600mm diameter pipes. Upgrade and extend Drainage in Victoria Road north of Sydenham Rd to 600mm diameter pipes	$946,900	Council	L	Stand-alone project Project is contingent on support and funding assistance from RMS.
FM2.3	Divert George Street catchment from Livingstone Road sag to Centennial St via 600mm diameter pipes	$2,436,000	Council	L	Stand-alone project
FM3.4	Increase inlet capacity on Despointes St with 450mm diameter pipes, Silver St with 450mm diameter pipes and Sydenham Road near Garners Ave with 600mm diameter pipes	$631,200	Council	L	Stand-alone project Optimise option by excluding works in Sydenham Road and including additional capacity in Illawarra Road, Le Clos Lane and Peace Lane.
FM13.1, 13.2 & 13.5	Upgrade drainage in Gannon St and Edwin St to 600mm diameter pipes Upgrade drainage in Griffiths St to 600mm diameter pipes. Upgrade drainage in Brooklyn St and Union St to install 375mm - 450mm diameter pipes	$660,600	Council	L	Stand-alone project Consider implementing minor works in Brooklyn and Union Streets only.
FM10.4	Divert flows from rail and Charlotte Ave into Western Channel via 900mm diameter pipe	$499,300	Council	L	Stand-alone project. May be impacted by proposed Sydney Metro drainage works
FM5.2	Demolish brick wall and structures built over drainage easement between Park and Neville Streets and upsize pipe to 450mm.	$222,600	Council	L	Consider demolition of brick wall only. Project cannot be implemented prior to option FM5.3 and FM5.4 due to downstream impacts.

Option ID	Description	Capital Cost	Responsibility	Priority**	Implementation Notes
FM10.1	Divert Marrickville Rd flows down Barclay Street to Sydenham Detention Basin via 600mm diameter pipes	$811,600	Council	L	Stand-alone project. Project should be implemented after FM15.10 to maximise benefit
FM9.1	New drainage in Marrickville Road and connect to Malakoff tunnel via 600mm diameter pipes	$774,800	Council	L	Stand-alone project. Optimise connection to Malakoff Tunnel to reduce adverse impacts in major events. Approval from Sydney Water required
FM8.1 & 8.2	New drainage in Arthur Street and connect to Malakoff tunnel via 600mm diameter pipe. New drainage in Robert Street via 600mm diameter pipe	$343,800	Council	L	Stand-alone project. Optimise connection to Malakoff Tunnel to reduce adverse impacts in major events. Approval from Sydney Water required
FM1.2	Divert flows from Wardell Rd via Morgan St and down Bishop St to Marrickville Oval via 600mm diameter pipes. Install a new 1.8m X 1.2m box culvert from the low point along Frazer St to a new surcharge pit in Marrickville Oval.	$2,208,900	Council	L	Stand-alone project. Project should be implemented after FM1.1 to maximise benefit

Emergency Management and Property modification measures

Option ID	Description	Capital Cost	Responsibility	Priority**
EM2	Information transfer to NSW SES	$1,000	Council	H
EM6	Interactive Flood Mapping	$50,000	Council	H
EM5	Flood Awareness and Education	$1,000	Council / SES	H
EM3	Flood Response for Vulnerable Properties	$1,000	Council	H
EM7	Education and Awareness of Littering	$20,000	Council / EPA	M
EM4	Local Evacuation Measures	$1,000	Council / SES	M
PM5	Increased Street Sweeping	$100,000 p.a.	Council	M
EM1	New Evacuation Centres	$1,000	Council / SES	M

* Adjusted cost based on cut down version of modelled option.

**H = higher priority; M = medium priority; L = lower priority.

5.3 NSW Floodplain Management Authority Project Assessment and Priority Ranking

The FRMS adopted a multi-criteria assessment approach to better understand the reduction in flood risk and other benefits and impacts of the various options considered. The recommendations of the FRMP have been based on the outcomes of this assessment. Funding and implementation of these recommendations will not necessarily be undertaken in accordance with the ranking of the options.

The NSW Government's floodplain management grants support local government to manage flood risk. The funding for these grants comes from two programs, the NSW Floodplain Management Program and the Floodplain Risk Management Grants Scheme (jointly funded by the NSW Office of Emergency Management and the Commonwealth Government).

Applications for funding can be made by Council for the implementation of actions identified in a FRMP. The information provided in the applications for each management action is used to rank the priority for funding of all actions across NSW.

The information presented in the FRMS and this FRMP can be used to complete the relevant applications for funding.

5.4 Works by others

It should be noted that at the time of writing significant flood mitigation works are currently in planning stages by Sydney Metro or developers in the following areas:

- Carrington Road
- Marrickville Station, McNeilly Park, Livingstone Road, Station Street and Byrnes Street
- Sydenham Station and Bolton Street

It is intended works by others will compliment works proposed in this FRMP.

6 Conclusion

This report presents the Floodplain Risk Management Plan for Marrickville Valley catchment.

The investigations and consultations undertaken as part of the Floodplain Risk Management Study identified several issues for the floodplain; including but not limited to flash flooding, under capacity stormwater drainage and the impact of increase in rainfall intensity due to Climate Change. To address these issues, a series of floodplain management measures has been developed.

The assessment of management options in the Floodplain Risk Management Study facilitated the identification of the most beneficial options (in terms of hydraulics, economics, environmental and social issues). A priority list has been recommended in this Floodplain Risk Management Plan that is a mix of structural and non-structural options to reduce the likelihood and / or consequence of flooding at locations in the catchment.

This plan should be regarded as a dynamic instrument requiring review and modification over time. The catalysts for change include new flood events and experiences, legislative change, alterations in the availability of funding and reviews of Council planning policies. In any event, a review every five years or so is warranted to ensure the ongoing relevance of the Plan.

7 Qualifications

This report has been prepared by Cardno for Inner West Council. It should not be used by a third party without proper reference.

The investigation and modelling procedures adopted for this project follow industry standards and considerable care has been applied to the preparation of the results.

Model set-up and calibration depends on the quality of data available, and the flow regime and flow control structures are complicated and can only be represented by schematised model layouts. Hence there will be a level of uncertainty in the results and this should be borne in mind in their application.

The report relies on the accuracy of the data provided.

Study results should not be used for purposes other than those for which they were prepared.

8 References

Cardno (2017) *Draft Floodplain Risk Management Study.*

IPCC (2007) *IPCC Fourh Assessment Synthesis Report - Summary for Policymakers*.

Marrickville Council (2011a) *Marrickville Local Environmental Plan 2011*.

Marrickville Council (2011b) *Marrickville Development Control Plan 2011*.

NSW Government (2005) *NSW Floodplain Development Manual: The Management of Flood Liable Land.*

NSW Government (2007) *Floodplain Risk Management Guideline: Practical Consideration of Climate Change.*

NSW Government (2007) *S117 Directive - Guideline on development controls on low flood risk areas – floodplain development manual, January*.

NSW Government (2009) *NSW Sea Level Rise Policy Statement*.

NSW SES (2015) *Marrickville Flood Emergency Sub Plan*, Volume 1.

WMAwater (2013) *Marrickville Valley Flood Study*, Final Report.

Marrickville Valley Floodplain Risk Management Study and Plan

APPENDIX A

FLOOD MODIFICATION OPTIONS

Cardno
Shaping the Future

FM 1.1

Description

An existing 750mm diameter pipe collects runoff from Morton Ave and traverses through properties along Wardell Rd, Jarvie Ave and Bishop St to connect to an existing 1050mm diameter pipe that runs underneath Marrickville Oval. In this option a new 900mm diameter pipe with additional inlet pits will re-direct runoff from Morton Ave to Frazer St and continue down Frazer St to connect to a new 1800mm X 1200mm box culvert from the sag along Frazer St to a new surcharge pit in Marrickville Oval. This option aims to reduce flooding for properties along Wardell Rd, Jarvie Ave, Bishop St, and Lawson Ave where up to approximately 600mm depth of flooding is observed in the 2 year ARI event.

***Modelling* Results**

The results highlight that the proposed diversion provides water level reductions of up to 30mm in the 2 year ARI event along Wardell Rd and Jarvie Ave, up to 90mm along Bishop St and up to 150mm along Frazer St and Lawson Ave. For the 1% AEP event water level reductions of up to 50mm are observed along Wardell Rd, Jarvie Ave, Bishop St, Frazer St and Lawson Ave. For the 1% AEP event this option removed over floor flooding for 7 properties.

FM 1.2

Description

An existing 750mm diameter pipe collects runoff from Morton Ave and traverses through properties along Wardell Rd, Jarvie Ave and Bishop St to connect to an existing 1050mm diameter pipe that runs underneath Marrickville Oval. In this option, additional inlet pits will collect runoff from Wardell Rd at the intersection of Morgan St and direct flows to the low point in Frazer St via new 600mm and 900mm diameter pipes in Morgan St and Bishop St, respectively. A new 1800mm X 1200mm box culvert will connect from the sag along Frazer St to a new surcharge pit in Marrickville Oval. This option may result in reduced flooding for properties along Wardell Rd, Jarvie Ave, Bishop St, Frazer Ave and Lawson Ave where up to approximately 600mm depth of flooding is observed in the 2 year ARI event.

***Modelling* Results**

The results highlight that the proposed diversion provides water level reductions of up to 20mm in the 2 year ARI event along Wardell Rd and Jarvie Ave, up to 60mm along Bishop St and up to 150mm along Frazer St and Lawson Ave. Increases in flood levels of up to 40mm are observed along Wardell Rd but these are confined within the road corridor and within the Marrickville Oval. For the 1% AEP event water level reductions of up to 60mm are observed along Bishop St, Frazer St and Lawson Ave. Increases in flood levels of up to 60mm are observed along Wardell Rd but these are confined within the road corridor.

The increases along Wardell Road are attributed to changes in catchment inflows, which for the option are applied to the new pit and pipe network along Morgan Street.

FM 2.1

Description

This option is to modify the basin outlet pit to install a 450mm outlet pit from the existing pit connected to a new pit with a high level inlet (approximately 500mm above the existing grate). In order to retain flows in a 20% AEP, the basin spillway to the north (approximately 9m wide) is raised to the existing 20% AEP flood level and modified to maintain the same spillway discharge for larger events. The objective of the proposed option is to throttle flows at the basin outlet to maximise basin flood attenuation up to the 20% AEP event. This option may result in reduced flooding for properties downstream of the basin in Livingstone Road and Petersham Road.

***Modelling* Results**

The results highlight that the proposed option increases the detention depth in Marrickville oval by up to 160mm in the 2 year ARI event and hence water level reductions of up to 80mm are observed downstream for properties along Livingstone Rd, Brereton Ave, Petersham Rd, Sydenham Rd and Boland Ave. For the 1% AEP event increases in water levels of up to 50mm are observed within the basin and properties downstream along Livingstone Rd, Brereton Ave, Petersham Rd, Sydenham Rd and Boland Ave. This is due

to overtopping of the basin which is resulting in increased flooding downstream. This is due to the limitations in the model grid size to accurately fine tune the modified spillway to maintain the same flows. It is believed that refinements to the model setup would enable better results to be achieved for the 1% AEP with no increases in flood levels.

FM 2.3

Description

An existing 450mm diameter pipe runs along George St and connects to a 750mm diameter pipe along Livingstone Rd which then connects to a 750mm diameter pipe along Pile St. This option proposes a new 600mm diameter pipe with additional inlet pits along George St that will divert the runoff from George St and Livingstone Rd to the 1450mm X 2100mm box culvert underneath Centennial St via Hawkhurst St. This option may result in reduced flooding for properties along Livingstone Rd, Brereton Ave and Petersham Rd, which currently lie along an overland flow path from George St, Pile St and north of Marrickville Oval and experience approximately 30mm to 400mm depth of flooding in the 2 year ARI event.

***Modelling* Results**

The results highlight that the proposed diversion provides water level reductions of up to 30mm in the 2 year ARI event along Livingstone Rd, Brereton Ave, and several adjoining properties. Minor increases in flood levels of up to 40mm are observed but these are confined within the open channel between Boland Ln and Centennial St. Minimal differences are observed in 1% AEP event.

FM 3.1

Description

An existing 1050mm diameter pipe carries stormwater flows from Petersham Rd to the open Western Channel near Northcote St via Jarvie Park. In this option, a new 1050mm diameter pipe will divert flows from Jarvie Park to the existing box culvert underneath Malakoff Street (Malakoff Tunnel). In addition, pipes along Petersham Rd near Graham Ave and Stanley St will be upgraded to 750mm diameter and a new 450mm diameter pipe will be installed at the junction of Yabsley Ave and Northcote St. These upgrades aim to alleviate flooding in Jarvie Park and for properties along Petersham Rd, Northcote St and Carew Ln, where approximately 10mm to 300mm depth of flooding is observed in the 2 year ARI event, by diverting flows to Malakoff Tunnel from Western Channel, which the downstream section is currently running at capacity in a 2 year ARI event.

***Modelling* Results**

The results highlight that the proposed diversion and upgrades provide water level reductions of up to 100mm in the 2 year ARI event in Jarvie Park and for properties along Northcote St, Carew Ln and Malakoff St. For the 1% AEP event water level reductions of up to 30mm are observed in Jarvie Park and for properties along Carew Ln. However, localised increases in water level of up to 20mm are observed along Convent Ln and Warnam Ln. These increases are caused due to the additional flows in the Malakoff Tunnel which is at capacity in the 1% AEP event. The addition of flows results in reduced capacity of the upper Malakoff Tunnel to accept flows from the Sydenham Rd area. This results in increases in water levels in the area thereby causing increased overland flow for properties along Convent Ln and Warnam Ln.

FM 3.2

Description

This option involves installation of a new 1200mm diameter pipe along Sydenham Rd starting at Petersham Rd and joining the existing box culvert underneath Malakoff Street (Malakoff Tunnel). Additional pits and pipes will connect Park Rd and Neville St drainage to this new pipe. This option will collect overland flows off Sydenham Rd and divert it from the Western Channel to Malakoff Tunnel aiming to have general water level reductions along the route of the pipe and adjacent areas.

***Modelling* Results**

For the 2 year ARI event, water level reductions of up to 40mm are observed along Sydenham Rd, Northcote St, Carew Ln, Malakoff St, Warnam St, Despointes St and Peace Ln. Reductions in water levels of up to 130mm are observed in the Western Channel extending up to Garners Ln. For the 1% AEP event water level

reductions of up to 40mm are observed along Sydenham Rd, Northcote St, Carew Ln and Warnam St. For the 1% AEP event this option removed over floor flooding for 1 property.

FM 3.3

Description

This option includes a new 600mm diameter pipe along Sydenham Rd starting near Despointes St and connecting to the Western Channel box culvert underneath Illawarra Rd. This option will collect overland flows off Sydenham Rd and discharge to the Western Channel.

***Modelling* Results**

For the 2yr event, water level reductions of up to 20mm are observed at some locations along Sydenham Rd, Despointes St and Peace Ln. Increases of up to 40mm are observed in the Western Channel downstream of Peace Ln. For the 1% AEP event water level reductions of up to 30mm are observed along Illawarra Rd and increases of up to 50mm are observed in the Western Channel upstream and downstream of Peace Ln.

FM 3.4

Description

Existing 300mm diameter pipes collect street runoff from Despointes St and Silver St and discharge into the Western Channel. In this option, these pipes will be upgraded to 450mm diameter to help alleviate flooding along the streets where 200mm to 900mm depth of flooding is observed in the 2 year ARI event. In addition, a new 600mm diameter pipe along Sydenham Rd between Garners Ave and Garners Ln will collect overland flows off Sydenham Rd and discharge to the Western Channel.

***Modelling* Results**

For the 2 year ARI event, water level reductions of up to 30mm are observed on Despointes St, Sydenham Rd and Garners Ave and up to 180mm along Silver St. Increases of up to 110mm are observed in the Western Channel downstream of Peace Ln. For the 1% AEP event water level reductions of up to 60mm are observed along Sydenham Rd, Despointes St, Peace Ln, Illawarra Rd, Le Clos Ave and Silver St. Increases of up to 180mm are observed in the Western Channel between Malakoff St and Garners Ave. In addition increases of up to 420mm are observed at a few properties along Frampton Ave. This is attributed to the increases in water levels in the Western Channel preventing this area from draining to an outlet location with capacity to accept the flows.

FM 5.2

Description

This option involves demolition of existing brick walls and structures built over the existing drainage easement between 80-82 Neville Street and 34-36 Park Road and upgrade the existing 300mm diameter pipe along this easement to a 450mm diameter pipe. The option may result in reduced flooding along Park Rd and Neville St, however, may have small increases in flooding downstream of Neville St due to the additional flow coming through the drainage easement.

***Modelling* Results**

The results highlight that the proposed upgrades provide localised water level reductions of up to 170mm in the 2 year ARI event for a few properties along Park Rd and Neville St. However, increases in water levels of up to 50mm are observed along Surrey St, Essex St, several adjoining properties and at the Addison Road Community Centre. For the 1% AEP event water level reductions of up to 50mm are observed for a few properties along Park Rd and Neville St and increases in water levels of up to 20mm along Surrey St, Essex St and at the Addison Road Community Centre.

FM 5.3 and FM 5.4

Description

The existing 750mm diameter pipes along Addison Rd between Park Rd and East St have capacity to take more flows based on the pipe capacity assessment (**Section 5.4**). In this option, new 600mm diameter pipes with additional inlet pits between Park Rd and Gordon Ln will divert the overland flows to the existing

Addison Rd 750mm pipe network with additional capacity. In addition, the road levels (thresholds) at the intersections of Park St, Neville St and Essex St with Addison Rd will be raised by 100mm to prevent overtopping of overland flows from Addison Rd.

***Modelling* Results**

The results highlight that the proposed raising of road thresholds and new pipes provide water level reductions of up to 50mm in the 2 year ARI event along Neville Ln, Surrey St, Essex St and at the Addison Road Community Centre. For the 1% AEP event water level reductions of up to 30mm are observed along Park Rd, Neville Ln, Surrey St, Essex St, Charles St and at the Addison Road Community Centre. For the 1% AEP event this option removed over floor flooding for 4 properties.

FM 5.6

Description

Existing 300mm to 375mm diameter pipes collect street runoff from Illawarra Rd, York St and Shepherd St and discharge into the Eastern Channel which traverse these streets. The pipes will be upgraded to 450mm diameter to help alleviate overland flooding from Addison Road.

***Modelling* Results**

For the 2 year ARI event, water level reductions of up to 400mm are observed along York St, 150mm along Illawarra Rd and Meeks Ln, and 50mm along Shepherd St, Meeks Ln and Handley St. Increases of up to 260mm are observed in the Eastern Channel downstream of Meeks Ln. These are confined within the open channel. For the 1% AEP event water level reductions of up to 120mm are observed along York St, 60mm along Illawarra Rd, Shepherd St, Meeks Ln, Handley St, Jazeb St, Denby St, Brompton St, Cook Rd and Smith St. However, minor increases of up to 10mm are observed in the Eastern Channel downstream of Meeks Ln and also for properties along Fitzroy St, Lillian Fowler St, Saywell St and Sydenham pit. This is attributed to the increases in flow in the Eastern Channel causing flows to breakout of the channel along Smith St. For the 1% AEP event this option removed over floor flooding for 14 properties.

A possible solution could be to raise the channel walls to prevent the breakout. This option can be optimised to resolve these issues during future investigation and design stages.

FM 6.1

Description

An existing 300mm diameter pipe on Newington Rd between Wemyss St and England Ave diverts runoff from Brown Ave and Wemyss St to a 1050mm diameter interallotment drainage pipe that runs between the rear of properties along England Ave and Agar St and connects to Addison Rd drainage. This pipe will be upgraded to a 600mm diameter pipe with additional inlet pits and a new 600mm diameter pipe along the other side of Newington Rd will collect and convey additional flows to the existing 1050mm diameter pipe. This option may help alleviate flooding for the properties along England Ave and Agar St where approximately 30mm to 230mm depth of flooding is observed in the 2 year ARI event.

***Modelling* Results**

The results demonstrate that the proposed upgrade and new pipe provides water level reductions of up to 40mm in the 2 year ARI event flor properties along England Ave and Agar St. Minor increases of up to 30mm are observed on Newington Rd but these are within the road reserve. For the 1% AEP event minor water level reduction**s of up to 20mm are observed along few properties along England Ave and Agar St.**

FM 6.4

Description

This option involves new 600mm diameter pipes and inlet pits along England Ave, Agar St and Wemyss St. These pipes will divert overland flows to the drainage lines along Addison Rd which have additional capacity. This option may result in water level reductions for properties north and south of Addison Rd where approximately 20mm to 650mm depth of flooding is observed in the 2 year ARI event.

***Modelling* Results**

For the 2 year ARI event, water level reductions of up to 20mm are observed along Illawarra Rd, York St, Shepherd St, and Meeks Ln. For the 1% AEP event water level reductions of up to 20mm are observed along England Ave, Addison Rd, Shepherd St, Meeks Ln, Denby St, Brompton St, Cook Rd and Smith St. However minor increases of up to 20mm are observed in a 1% AEP event at some properties along England Ave and Agar St. Minor increases of up to 30mm are also observed in the Eastern Channel and Sydenham pit due to the increased flows upstream in the pipe network. This has attributed to the increase in flow in the Eastern Channel. For the 1% AEP event this option removed over floor flooding for 4 properties.

FM 7.1 and FM 7.5

Description

This option involves a new 600mm diameter pipe along Cook Rd and Enmore Rd to connect to a new 1800mm x 600mm box culvert along Smith St that will connect to the existing open channel (Eastern Channel) at the back of the properties along Smith St. This may help alleviate flooding along Cook Rd, Enmore Rd, Smith St and Victoria Rd where approximately 100mm to 400mm depth of flooding is observed in the 2 year ARI event.

In addition, a new 600mm diameter pipe along Denby St together with raised road threshold levels at the intersection of Denby St with Addison Rd may prevent overtopping of overland flows from Addison Rd and reduce flooding along Denby St where approximately 100mm to 800mm depth of flooding observed in the 2 year ARI event.

***Modelling* Results**

For the 2 year ARI event, water level reductions of up to 110mm on Brompton St, 50mm on Cook Rd and Enmore Rd, 100mm on Victoria and 300mm on Smith St are observed. Increases of up to 90mm are observed in the open channel. No impacts are observed near Denby St.

For the 1% AEP event water level reductions of up to 50mm are observed along Enmore Rd and Smith St, up to 40mm along Victoria Rd between Enmore Rd and Central Ln, and for properties on the eastern side of Victoria Rd. Increases of up to 30mm are observed in the open channel, properties along Fitzroy St and the Sydenham pit. Water level reductions of up to 50mm are observed along Addison Rd and Philpott St. For the 1% AEP event this option removed over floor flooding for 6 properties.

FM 8.1 and FM 8.2

Description

An existing 600mm diameter pipe along Arthur St connects to a 1050mm diameter pipe underneath the railway corridor which then connects into the Malakoff Tunnel underneath McNeilly Park. It is proposed that a new 900mm diameter pipe will connect the existing 600mm diameter pipe to the Malakoff Tunnel underneath Arthur St. In addition, a new 600mm diameter pipe along Robert St will connect to the existing 600mm diameter pipe along Arthur St.

This option could help alleviate flooding along Livingstone St, Arthur St, Warburton St, Jersey St, Illawarra Rd and the railway corridor where approximately up to a 1m depth of flooding is observed in the 2 year ARI event.

***Modelling* Results**

For the 2 year ARI event water level reductions of up to 50mm are observed along Livingstone St, Arthur St, Illawarra Rd, the railway corridor and Western Channel. For the 1% AEP event widespread reductions of up to 50mm are observed at McNeilly Park and along Illawarra Rd, Byrnes St, O'Hara St, Myrtle St, Carrington Rd and at Mackey Park. However, widespread increases in water levels of up to 70mm are observed along properties south of Sydenham Rd between Northcote St and Garners Ave and in the Marrickville Industrial Area (MIA) including the Sydenham Pit.

In the 1% AEP event Malakoff Tunnel is running at capacity between Malakoff St and McNeilly Park, hence the addition of flows at Arthur St results in reduced capacity of the upper Malakoff Tunnel to accept flows from the Sydenham Rd area. This results in increases in water levels in the area thereby causing increased overland flow along properties south of Sydenham Rd and diverting flows down Sydenham Rd to the MIA which increases loads on the Sydenham Rd and MIA drainage networks.

A possible solution could be to connect the new 900mm diameter pipe to Malakoff Tunnel downstream of McNeilly Park where it has capacity for PMF flows as shown in the pipe capacity assessment (**Section 5.4**). This option can be optimisated to resolve these issues during future investigation and design stages.

For the 1% AEP event this option removed over floor flooding for 22 properties.

FM 9.1

Description

This option involves new a 600mm diameter pipe with inlet pits along Marrickville Rd between Livingstone Rd and Malakoff St. The new pipe will connect to the existing 2.9m X 2.9m box culvert underneath Malakoff St (Malakoff Tunnel). This option may help alleviate flooding for the properties along Lilydale St, Marrickville Rd, Petersham Rd and Malakoff St where approximately 20mm to 300mm depth of flooding is observed in the 2 year ARI event.

***Modelling* Results**

The results highlight that the proposed new pipe provides water level reductions of up to 50mm in the 2 year ARI event for properties along Cecilia St, Carew Ln and Malakoff St. For the 1% AEP event minor water level reductions of up to 20mm are observed at a few properties along Depot Ln, Malakoff St and Cecilia St.

However minor increases of up to 20mm are observed along Malakoff St, Convent Ln, Despointes St, Peace Ln and Illawarra Rd near the Western Channel in a 1% AEP event. These increases at the upstream end of Malakoff Tunnel are caused due to the additional flows in the Malakoff Tunnel which is at capacity in the 1% AEP event (as per description for FM8.1 and FM8.2).

It is recommended that this option could be optimised through alternative pit placement, pipe connections and possible throttling of flows into Malakoff Tunnel for higher events. This option may also be more effective in combination with another option which reduces flows entering Malakoff Tunnel at the upstream end near Sydenham Road.

FM 10.1

Description

An existing 450mm diameter pipe along Marrickville Rd connects to a 750mm diameter pipe underneath Fraser Park. A new 600mm diameter pipe with inlet pits will re-direct flows from Marrickville Rd to Sydenham Rd via Barclay St.

***Modelling* Results**

For the 2 year ARI event the proposed diversion provides water level reductions of up to 140mm along Barclay St, 60mm along Marrickville Rd and 20mm at Fraser Park. No differences are observed in the 1% AEP.

FM 10.4

Description

This option involves a new 900mm diameter pipe with inlet pits along Myrtle St which will divert flows from Charlotte Ave to the Western Channel. This option may help alleviate flooding for properties along Charlotte Ave and Myrtle St where up to 700mm depth of flooding is observed in the 2 year ARI event.

***Modelling* Results**

For the 2 year ARI event the proposed new pipe provides water level reductions of up to 160mm along Victoria Rd at the rail bridge, 700mm for the property along Myrtle St and 30mm along Carrington Rd. Increases of up to 50mm are observed in the Western Channel. For the 1% AEP water level reductions of up to 50mm are observed along Victoria Rd at the rail bridge and Myrtle St.

FM 11.1 and FM 11.2

Description

This option involves construction of an overland flowpath along the north-eastern boundary of Tillman Park from Unwins Bridge Rd to the railway culvert and along the south-western boundary of Tillman Park from the

Early Learning Centre to the railway culvert. This option may alleviate flooding along Unwins Bridge Rd where up to 900mm depth of flooding is observed in the 2 year ARI event..

***Modelling* Results**

The modelling results highlight that this option provides water level reductions of up to 150mm along Unwins Bridge Rd and up to 220mm at the Early Learning Centre for the 2 year ARI event. Increases of up to 900mm are observed downstream but these are mainly along the constructed overland flowpaths and are confined to the Park. For the 1% AEP event water level reductions of up to 230mm are observed at several locations along Unwins Bridge Rd, Terry Street, Belmore St and Railway Rd. For the 1% AEP event this option removed over floor flooding for 12 properties.

FM 11.3

Description

An existing 525mm diameter and 600mm diameter pipe on Unwins Bridge Rd connects to twin 900mm diameter pipes underneath Tillman Park. In this option, new 600mm diameters pipes along Unwins Bridge Rd and Terry St will connect to the existing twin pipes to divert additional overland flows. This option may result in decreases in flood levels along Unwins Bridge Rd and surrounding areas where up to 900mm depth of flooding is observed in the 2 year ARI event.

***Modelling* Results**

For the 2 year ARI event up to 80mm decreases in water levels are observed along Unwins Bridge Rd and Belmore St. Increases of up to 600mm are observed downstream but these are mainly confined to the Park. For the 1% AEP event water level reductions of up to 20mm only are observed at several locations along Unwins Bridge Rd, Terry Street, Belmore St, Railway Rd and Tillman Park. For the 1% AEP event this option removed over floor flooding for 3 properties.

FM 11.4

Description

An existing 675mm diameter pipe along Unwins Bridge Rd connects into a 900m diameter and 750mm diameter pipe along Bridge St. A new 450mm diameter pipe and additional inlet pits along Unwins Bridge Rd near Bridge St will divert additional runoff to the existing pipes along Bridge St. This option may result in decreases in flood levels along Unwins Bridge Rd where up to 900mm depth of flooding is observed in the 2 year ARI event.

***Modelling* Results**

For the 2 year ARI event up to 80mm decreases in water levels are observed along Unwins Bridge Rd and up to 20mm along Belmore St. For the 1% AEP event minor water level reductions of up to 50mm are observed along Unwins Bridge Rd. For the 1% AEP event this option removed over floor flooding for 2 properties.

FM 12.1 and FM 12.2

Description

Existing 450mm diameter pipes along Renwick St, Cary St and Premier St and discharge into the Western Channel. New 750mm diameter pipes and inlet pits will collect additional overland flows from these streets and discharge into the Western Channel. This option aims to reduce flooding along the streets and intercept runoff from bypassing the Western Channel and entering Central Channel along Carrington Rd thereby reducing flooding along Carrington Rd.

***Modelling* Results**

For the 2 year ARI event decreases in water levels in the order of 20mm to 60mm are observed along Renwick St and Carrington Road. Increases in flood levels are seen in the Western Channel between Renwick St and Cary St due to additional flows. For the 1% AEP event decreases in water levels up to 80mm are observed along Renwick St. Increases in flood levels are seen in the Western Channel between Renwick St and Cary St due to additional flows and also up to 40mm for some properties along Renwick St. For the 1% AEP event this option removed over floor flooding for 3 properties.

FM 12.4

Description

This option includes installation of a weir in the central channel to divert the flows into the Mackey Park pump station (DPS2). The proposed option is to prevent the backflow from the Cooks River in the Central Channel entering the pump station and thereby optimising the pump station operations at Mackey Park to pump more catchment flows away from the area. The aim is to reduce flood levels on Carrington Road and surrounding industrial area.

***Modelling* Results**

The modelling results show that the reduction in flood levels in a 2 year ARI event are in the order of 20mm to 120mm in vicinity of Carrington Road, Renwick St east of Carrington Rd and along the Central Channel alignment. Maximum reductions up to 120mm are observed at a low point on Renwick Street. In a 1% AEP event the impacts are negligible due to the large volume of water stored in the area.

Further optimisation of this option could be to explore increasing the capacity of pumps to achieve further reductions in flood levels.

FM 12.5

Description

The proposed option is to raise the Western Channel wall between Renwick St and Cary St to prevent overflows into adjacent properties and in Cary Street. Reduction in flood levels are expected in Cary Street and Renwick Street

***Modelling* Results**

Raising the channel wall prevents the over flow entering the properties on the eastern side of the channel between Renwick Street and Cary Street in a 2 year ARI event. In a 1% AEP event the impacts are minor. This option does not provide major benefits as expected for properties along Renwick St and Cary St near the channel due to the topography grading back towards the channel. The raised wall traps some water behind it preventing it from entering back into the channel.

FM 13.1, FM 13.2 and FM 13.5

Description

This option involves new 600mm diameter pipes with inlet pits along Gannon St and Griffiths St to connect to an existing 1500mm x 700mm box culvert underneath the railway corridor. This option may help alleviate flooding along these streets where up to 700mm depth of flooding is observed in the 2 year ARI event. In addition new pits and 450mm diameter pipes at the intersection of Brooklyn St and Union St will connect to an existing 1200mm X 450mm box culvert.

***Modelling* Results**

The modelling results highlight that the proposed new pits and pipes provide reductions in water levels up to 50mm along Gannon St, however increases in water levels up to 100m along Gannon St, Griffiths St and Unwins Bridge Rd in the 2 year ARI event. The increases are due to the downstream pipe at capacity for the 2 year ARI event. Negligible benefits are observed on Brooklyn St and Union St. For the 1% AEP event minor decreases in water levels of up to 20mm are observed on Brooklyn St and Gannon St but some increases in water levels of up to 20mm are observed on properties along Unwins Bridge Rd and Griffiths St.

For the 1% AEP event this option removed over floor flooding for 2 properties.

FM 14.1

Description

Existing 600mm diameter pipes connect inlet pits at the intersection of Unwins Bridge Rd and Sutherland St to a 675mm diameter pipe that passes underneath the railway line and connects to the Eastern Channel. These pipes will be upgraded to 1200mm diameter pipes. This option may result in decreases in flood levels along Unwins Bridge Rd and surrounding areas by discharging additional flows into the Eastern Channel. Greater than 1m flood depth is observed in some of these areas for the 2 year ARI event.

***Modelling* Results**

The modelling results highlight that the proposed upgrades provide water level reductions of up to 150mm along the railway corridor and for a few properties along Bolton St and up to 30mm along Unwins Bridge Rd. For the 1% AEP event additional reductions of up to 80mm are observed along George St, Hogan Ave, Sutherland St and Briar Ln.

For the 1% AEP event this option removed over floor flooding for 1 property.

FM 15.1 and FM 15.2

Description

For Victoria Rd north of Sydenham Rd up to 300mm depth of flooding is observed in the 2 year ARI event. Two 450mm diameter pipes on either side of the road discharge runoff into an existing box culvert underneath the Victoria Rd and Sydenham Rd intersection which connects to the Sydenham pit. The pipe along the eastern side of the road will be extended and upgraded to a 600mm diameter pipe to help alleviate flooding in the area.

For Victoria Rd south of Sydenham Rd up to 500mm depth of flooding is observed in the 2 year ARI event. Two 375mm diameter pipes on either side of the road discharge runoff into an existing box culvert underneath the Victoria Rd and Sydenham Rd intersection which connects to the Sydenham pit. The pipe along the eastern side of the road will be extended and upgraded to 600mm diameter pipe to help alleviate flooding in the area.

In addition, new 600mm diameter pipes along Victoria Ln and Meeks Ln will collect additional flows and convey them to the Sydenham pit.

***Modelling* Results**

For the 2 year ARI event less than 20mm reductions in water levels are observed along Victoria Rd north of Sydenham Rd, no reductions along Victoria Rd south of Sydenham Rd and up to 20mm reductions along Victoria Ln, Meeks Ln and Vincent St. For the 1% AEP event no impact on flood behaviour is observed.

While this option does not provide any benefit in the 1% AEP event, this option combined with FM 15.3 could provide water level reductions in the area as FM 15.3 provides increased capacity in the network along Sydenham Rd, Sloane St and Saywell St.

FM 15.3

Description

This proposed option is to divert flows from Buckley St and Wilkinson Ln into Shirlow St via a new 1500mm diameter pipe to the Sydenham pit. This option may alleviate flooding in the vicinity of the proposed works.

***Modelling* Results**

The modelling results show there are negligible benefits for the 2 year ARI event but for the 1% AEP event the extent of reduction in flood levels is significant with reductions of up to 200mm observed along Shirlow St and Garden St. The reductions on Buckley St and Sydenham Rd are up to 80mm. The increases in levels in the Sydenham pit is due to the additional flows. This option provides increased capacity in the network along Sydenham Rd, Sloane St and Saywell St, which could provide opportunity for upgrades in the western industrial area catchments to improve flooding in those areas.

For the 1% AEP event this option removed over floor flooding for 7 properties.

FM 15.5

Description

An existing 450mm diameter pipe along Faversham St will be upgraded to a 600mm diameter pipe. This option will provide additional capacity and collect overland flows off Faversham St.

***Modelling* Results**

The modelling results highlight that this option has no impact on flood behaviour in the 2 year ARI and 1% AEP event. While this option has resulted in increased flows through the upgraded pipe, these are minor and hence do not provide any benefits to flooding.

FM 15.7

Description

An existing 600mm diameter pipe along Vincent St and Sydney St connects to a 1050mm diameter pipe along Sydenham Rd. A new 600mm dimeter pipe along Sydney St and 900mm diameter pipe along Vincent St will collect the overland flows and discharge downstream to the existing 1050mm diameter pipe that eventually discharges into the Sydenham Pit. This option may alleviate some of the flooding identified in the surrounding area.

***Modelling* Results**

The results highlight that while although up to 100mm reduction in water levels are observed along Sydney St, there is an increase in flood levels up to 10mm along Vincent St for the 2 year ARI event. The increases are a result of the additional flows in the downstream 1050mm diameter pipe from the new 600mm diameter pipe along Sydney St. This pipe is currently at capacity in a 2 year ARI event and the additional flows have surcharged onto Vincent St causing increased flooding. Similarly for the 1% AEP event increases in water level are observed along Sydenham Rd and Barclay St.

While this option does not provide much benefit and causes increases in flood depths along Vincent St and Barclay St, this option combined with FM 15.3 could provide water level reductions in the area as FM 15.3 provides increased capacity in the network along Sydenham Rd, Sloane St and Saywell St.

FM 15.9

Description

The proposed option is to duplicate the existing 2000mm x 1200mm box culvert underneath Saywell St between Cadogan Lane and Sloane St and duplicate the existing 3000mm x 1200mm box culvert underneath Saywell St between Sloane St and the Sydenham pit. A new junction chamber will be installed to connect existing and new culverts. A number of new large inlet pits are proposed to take more flows into the proposed pipe network. This option is expected to reduce flood levels in the industrial area between Saywell St and Sydenham Rd.

***Modelling* Results**

The modelling results show there are negligible benefits for the 2 year ARI event as this area only has small depths of flooding in the 2 year ARI event. For the 1% AEP event decreases in flood levels of up to 500mm are observed within the industrial area. The reduction of flood levels between Sydenham Rd and Marrickville Rd are in an order of 100mm to 150mm. Maximum reduction of flood levels are seen on Saywell St, Sydenham Rd, Shirlow St, Sloane Ln, Sloane St, Cadogan Ln and Cadogan St. The increases in water levels in the Sydenham pit are due to the additional flows. For the 1% AEP event this option removed over floor flooding for 17 properties.

It is likely that this option could be optimised for the 2 year ARI event by providing additional inlet pits in flooded areas such as between Sydenham Rd and Marrickville Rd as the underground network now has additional capacity to accept more flows from these areas.

FM 15.10

Description

This option is a combination of FM15.3 and FM15.9. The proposed works are to divert flows from Buckley St and Wilkinson Ln into Shirlow St via a 1500mm diameter pipe to Sydenham pit along with duplication of the existing drainage network in Saywell Street. This upgrade includes duplication of the existing 2000mm x 1200mm box culvert between Cadogan Lane and Sloane St and duplication of the existing 3000mm x 1200mm box culvert between Sloane St and Sydenham Pit.

***Modelling* Results**

The modelling results show there are negligible benefits for the 2 year ARI event as this area only has small depths of flooding in the 2 year ARI event. For the 1% AEP event decreases in flood levels of up to 600mm are observed within the industrial area. The reduction of flood levels are seen in the industrial area between Marrickville Rd and Saywell St. Maximum reduction of flood levels in the order of 200mm to 600mm are seen on Marrickville Rd, Barclay St, Buckley St, Sydenham Rd, Shirlow St, Sloane Ln, Sloane St, Cadogan Ln, Cadogan St and Saywell St. The increases in water levels in the Sydenham pit are due to the additional flows. For the 1% AEP event this option removed over floor flooding for 23 properties.

As per FM 15.9, it is likely that this option could be optimised for the 2 year ARI event by providing additional inlet pits in flooded areas such as between Sydenham Rd and Marrickville Rd as the underground network now has additional capacity to accept more flows from these areas.