

Final Floodplain Risk Management Plan

Marrickville Valley Floodplain Risk Management Study and Plan

59915195

Prepared for
Inner West Council

11 September 2017



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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 Final 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 pumped flows 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 estimated as 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.

Community Consultation

Consultation with the community and stakeholders has been an important component in the development of the Marrickville Valley Floodplain Risk Management Study and Plan. The consultation was undertaken through the use of letters to stakeholders, a community information newsletter, an online questionnaire and mapping interface, and a series of workshops on flood mitigation options. The Final Draft Floodplain Risk Management Study and Plan was placed on public exhibition to provide the community with an opportunity to review the documents and provide feedback.

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).

During the exhibition process Council have undertaken further optimisation of some mitigation options to further inform the plan.

The implementation plan is shown in the following table. The implementation plan is based on the preferred options from the FRMS including the optimised options, synergies between options and anticipated future works by Council and other agencies. Prioritisation of options have been based on the Multi-Criteria Assessment (MCA) scores and opportunities for integration with other works.

Flood modification measures

Option ID	Description	Capital Cost	MCA Score	Responsibility	Priority**	Implementation Notes
FM5.6	Increase inlet capacity in Illawarra Road, York and Shephard Streets via 450mm diameter pipes	\$324,600	16.52	Council / OEH	H	Stand-alone project. Sydney Water connection approval required.
FM12.4	Install a weir in the central channel to divert the flows into the Mackey Park pump station (DPS2)	\$95,500	10.27	Sydney Water / Council	H	Design and implementation of option should be coordinated with Options FM12.1 and FM12.2. Work with Sydney Water to design and develop the option.
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	7.71	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. Sydney Water connection approval 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	8.42	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	14.63	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. Sydney Water connection approval required.
FM6.4	Install new inlet pits and 600mm diameter pipes along England Ave, Agar St and Wemyss St	\$580,800	11.27	Council	H	Design and implementation of option should be coordinated with proposed bidirectional separated cycleway in Addison Road. Sydney Water connection approval required.
FM6.1	Upgrade drainage in Newington Rd to 600mm diameter pipes	\$422,900	9.06	Council	M	Design and implementation of option should be coordinated with proposed bidirectional separated cycleway in Addison Road. Sydney Water connection approval required.
FM3.4	Increase inlet capacity on Despointes St, Convent Ln, Peace Ln, Le Cos Ln, Illawarra Rd and Silver St with 600mm diameter pipes and additional inlet pits	\$450,500	11.29	Council	H	Stand-alone project. Sydney Water connection approval required for new assets.
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	8.67	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. Sydney Water connection approval required.
FM3.3	New drainage in Sydenham Road and connect to Western Channel via 600mm diameter pipes	\$526,300	8.81	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	9.94	Council / Sydney Metro	H	Design and implementation of option should be coordinated with Sydney Metro works. Sydney Water connection approval required.
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	13.67	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	12.42	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	8.63	Council	M	Design and implementation of option should be coordinated with Options FM11.1, FM11.2 and FM11.3. Sydney Water connection approval required.

Option ID	Description	Capital Cost	MCA Score	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	9.58	Council	H	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, provide new pits along Petersham Rd, and upgrade drainage in Northcote St and Malakoff St to 450mm diameter pipes	\$794,200	7.71	Council	M	Stand-alone project. Sydney Water connection approval 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	7.71	Sydney Water / Council / OEH	M	Project is contingent on support and funding assistance from Sydney Water.
FM4.2	Divert flows from Chester St and Oxford St to Audley St via 450mm diameter pipes, new raised road thresholds at Chester St and Oxford St, and new dish drains across Oxford St and Chester St to direct flows towards Audley St	\$220,100	7.52	Council	M	Stand-alone project.
FM7.6	Install new 600mm, 750mm, 900mm and 1050mm diameter pipes on Addison Rd and Philpott St with additional inlet pits	\$707,700	8.46	Council / RMS / OEH	M	Stand-alone project. Project is contingent on support and funding assistance from RMS. Sydney Water connection approval required.
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	8.10	Council / RMS / OEH	M	Stand-alone project. Optimise option by excluding works in Addison Road and Denby Street. Project is contingent on support and funding assistance from RMS. Sydney Water connection approval required.
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	7.10	Council	L	Stand-alone project. Project is contingent on support and funding assistance from RMS. Sydney Water connection approval required.
FM2.3	Divert George Street catchment from Livingstone Road sag to Centennial St via 600mm diameter pipes	\$2,436,000	7.04	Council	L	Stand-alone project.
FM13.1 & 13.2	Provide large inlet pits at intersection of Gannon St, Griffiths St and Unwins Bridge Rd. Duplicate the existing 1500mm X 700mm box culvert underneath the railway corridor	\$404,800	6.48	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	5.85	Council	L	Stand-alone project. May be impacted by proposed Sydney Metro drainage works. Sydney Water connection approval required.
FM5.2	Demolish brick wall and structures built over drainage easement between Park and Neville Streets and upsize pipe to 450mm.	\$222,600	5.79	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	MCA Score	Responsibility	Priority**	Implementation Notes
FM10.1	Divert Marrickville Rd flows down Barclay Street to Sydenham Detention Basin via 600mm diameter pipes	\$811,600	4.35	Council	L	Stand-alone project. Project should be implemented after FM15.10 to maximise benefit. Sydney Water connection approval required.
FM9.1	Install new 450mm and 600mm diameter pipes at the intersection of Livingstone Rd and Marrickville Road, new 900mm diameter pipe along Marrickville Rd to Petersham Rd, a new 1050mm diameter pipe from Petersham Rd connecting to Malakoff Tunnel via an approximately 100m ³ underground storage	\$2,439,600	3.00	Council	L	Stand-alone project. Sydney Water connection approval 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	1.73	Council	L	Stand-alone project. Optimise connection to Malakoff Tunnel to reduce adverse impacts in major events. Sydney Water connection approval 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	2.29	Council	L	Stand-alone project. Project should be implemented after FM1.1 to maximise benefit.
FM3.6	Provide detention of approximately 2300m ³ of storage volume in the Wilkins School Oval through bunding and excavation with surface area of approximately 4000m ²	\$727,900	1.85	Council / Department of Education	L	Stand-alone project. Project is contingent on support and assistance from Department of Education.
FM5.9	Install a new 825mm diameter pipe along Essex St and through the backyard of properties along Surrey St and Gordon Sq	\$874,500	3.79	Council	L	Stand-alone project. Project is contingent on support and assistance from the private property owners.
FM8.3	Divert flows from Marrickville Rd to Livingstone Rd via a new 1050mm diameter pipe, provide approximately 8000m ³ underground storage in McNeily Park with surface area of approximately 4000m ² , and install a new 1200mm diameter pipe from Hollands Ave to the proposed underground storage	\$3,561,400	6.21	Council / OEH / Sydney Water	L	Stand-alone project. Sydney Water connection approval required.
FM10.2	Install new 600mm diameter pipe between Harriet St and Myrtle St and 750mm and 900mm diameter pipes from Myrtle St to pump station SPS271	\$619,100	5.31	Council / OEH / Sydney Water	L	Stand-alone project. Sydney Water connection approval required.
FM13.4	Divert flows down Edgar St to a new connection to Eastern Channel via a 1050mm diameter pipe	\$725,100	1.92	Council / OEH / Sydney Water	L	Stand-alone project. Sydney Water connection approval required.

Emergency Management and Property modification measures

Option ID	Description	Capital Cost	MCA Score	Responsibility	Priority**
EM2	Information transfer to NSW SES	\$1,000	10.13	Council	H
EM6	Interactive Flood Mapping	\$50,000	8.30	Council	H
EM5	Flood Awareness and Education	\$1,000	7.02	Council / SES	H
EM3	Flood Response for Vulnerable Properties	\$1,000	5.42	Council	H
EM7	Education and Awareness of Littering	\$20,000	3.75	Council / EPA	M
EM4	Local Evacuation Measures	\$1,000	3.64	Council / SES	M
PM5	Increased Street Sweeping	\$100,000 p.a.	3.19	Council	M
EM1	New Evacuation Centres	\$1,000	2.04	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 complement 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 Recurrence Interval (ARI) The long-term average period between occurrences equalling or exceeding a given value. For example a 20 year ARI flood would occur on average once every 20 years.

The probability of an event occurring or being exceeded within a year. For example, a 5% AEP flood would have a 5% chance of occurring in any year. An approximate conversion between ARI and AEP is provided.

Average Exceedance Probability (AEP)

AEP	ARI
63.2 %	1 year
39.3 %	2 year
18.1 %	5 year
10 %	10 year
5 %	20 year
2 %	50 year
1 %	100 year
0.5 %	200 year
0.2 %	500 year

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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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.

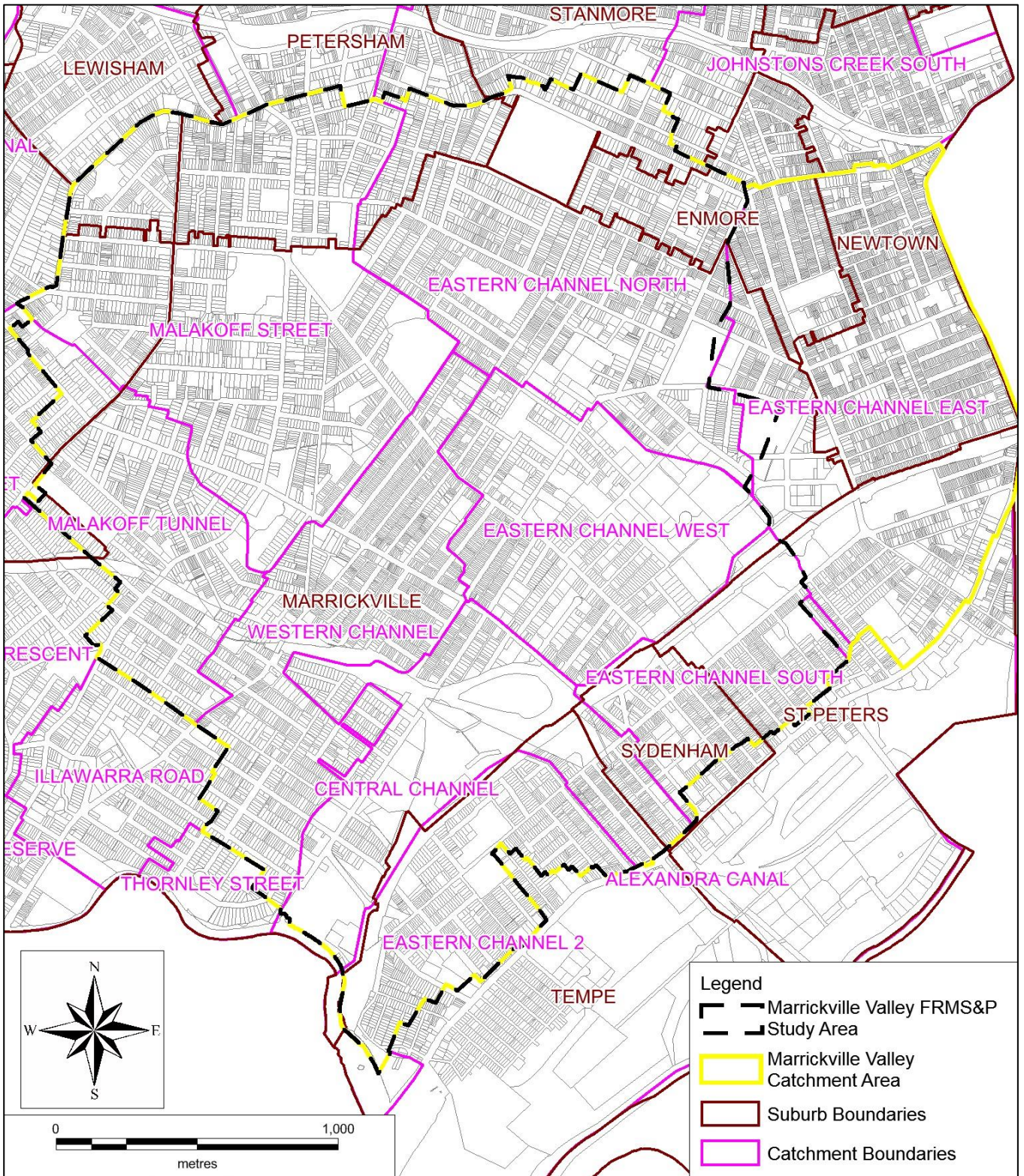


Figure 1-1 Marrickville Valley Study Area and Catchments

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 of 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 community and key 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.

2.6.1 Public Exhibition

The Draft Marrickville Valley Flood Risk Management Study and Plan was placed on public exhibition from 24 July 2017 to 27 August 2017. The plan was made available on Council's 'Your Say Inner West' webpage and the exhibition promoted through Council's e-newsletter. Community members were invited to view the plan and indicate the extent of their support for the plan. Community members were also able to provide comment on which options they support, which options they do not support and whether there were any other flood affected areas that had not been addressed in the plan.

Eight submissions were received through the website and one submission was received via email. Six survey submissions were received from residents of Marrickville, with one submission each from residents of St Peters and Dulwich Hill. Of the eight submissions received four submissions strongly supported the draft plan, three submissions supported the plan, and one submission neither supported nor opposed the plan.

A summary of submissions received and responses to those submissions are provided in the Marrickville Valley Floodplain Risk Management Study. Based on the submissions received, any adjustment or further assessment to address issues raised were not warranted based on the outcomes of the public exhibition.

During the exhibition process Council have undertaken further optimisation of some mitigation options to further inform the plan. This additional assessment is described further in this document.

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

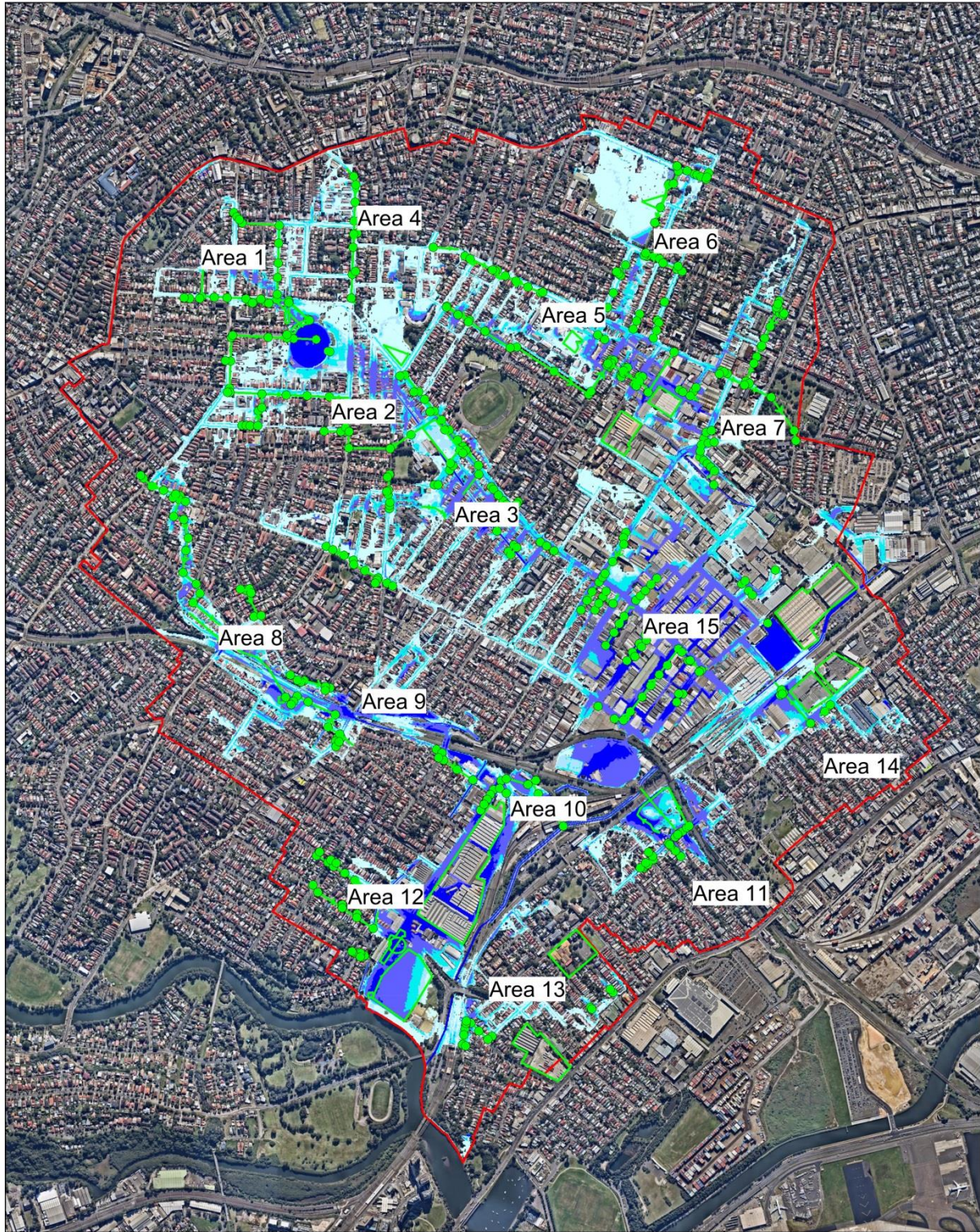
Flood modification measures are options aimed at preventing / avoiding or reducing the likelihood of flood risks. These measures reduce the risk through modification of the flood behaviour in the catchment.


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**.





**Preliminary Flood Mitigation Options
Map Index
With 1% AEP Flood Extent**

MARRICKVILLE VALLEY FRMS&P



Map Produced by Cardno NSW/ACT Pty Ltd
Date: September 2016
Project: 59915195
Coordinate System: MGA Zone 56

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 forty (40) measures was compiled in consultation with Council to determine which options were to be assessed through detailed hydraulic modelling. Following this further optimisation of twelve (12) mitigation options was undertaken to help achieve greater benefits to the community and reduce further flood risks. 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, provide new pits along Petersham Rd, and upgrade drainage in Northcote St and Malakoff St to 450mm diameter pipes
	FM3.2	Install 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, Convent Ln, Peace Ln, Le Cos Ln, Illawarra Rd and Silver St with 600mm diameter pipes and additional inlet pits
	FM3.6**	Provide detention of approximately 2300m ³ of storage volume in the Wilkins School Oval through bunding and excavation with surface area of approximately 4000m ²
Livingstone Rd and Addison Rd	FM4.2**	Divert flows from Chester St and Oxford St to Audley St via 450mm diameter pipes, new raised road thresholds at Chester St and Oxford St,

Drainage Line/Area	ID	Modification Type
		and new dish drains across Oxford St and Chester St to direct flows towards Audley St
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 diameter pipes
	FM5.9**	Install a new 825mm diameter pipe along Essex St and through the backyard of properties along Surrey St and Gordon Sq
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*
	FM7.6**	Install new 600mm, 750mm, 900mm and 1050mm diameter pipes on Addison Rd and Philpott St with additional inlet pits
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
	FM8.3**	Divert flows from Marrickville Rd to Livingstone Rd via a new 1050mm diameter pipe, provide approximately 8000m ³ underground storage in McNeily Park with surface area of approximately 4000m ² , and install a new 1200mm diameter pipe from Hollands Ave to the proposed underground storage
Marrickville Rd and Illawarra Rd	FM9.1*	Install new 450mm and 600mm diameter pipes at the intersection of Livingstone Rd and Marrickville Road, new 900mm diameter pipe along Marrickville Rd to Petersham Rd, a new 1050mm diameter pipe from Petersham Rd connecting to Malakoff Tunnel via an approximately 100m ³ underground storage

Drainage Line/Area	ID	Modification Type
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
	FM10.2*	Install new 600mm diameter pipe between Harriet St and Myrtle St and 750mm and 900mm diameter pipes from Myrtle St to pump station SPS271
	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)
	FM12.5	Raise channel wall to stop overflows in Cary street
Unwins Bridge Rd and Tramway Ave	FM13.1*	Provide large inlet pits at intersection of Gannon St, Griffiths St and Unwins Bridge Rd
	FM13.2*	Duplicate the existing 1500mm X 700mm box culvert underneath the railway corridor
	FM13.4	Divert flows down Edgar St to a new connection to Eastern Channel via a 1050mm diameter pipe
	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

Drainage Line/Area	ID	Modification Type
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

*These options have been optimised during Public Exhibition of the Final Draft Marrickville Valley Floodplain Risk Management Study and Plan.

**These are new options identified and assessed during Public Exhibition of the Final Draft Marrickville Valley Floodplain Risk Management Study and Plan.

A brief description of the floodplain management options is provided in **Appendix A** including the 2 year ARI and 1% AEP flood level difference plots (**Appendix A1**), option cost breakdown (**Appendix A2**) and the multi-criteria score assessment for each option (**Appendix A3**). Options FM 1.2, FM 12.5, FM 15.5 and FM15.7 have not been included as they are not considered to be viable.

4.1.2 Economic Assessment of Flood Modification Options

The economic evaluation of each modelled option was performed by considering the reduction in the amount of flood damages incurred for the design events and then comparing this value with the cost of implementing the option. The preferred options are listed in **Table 4-3**. A cost breakdown for each option is provided in **Appendix A2**.

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

Option ID	Cost of Implementation of Option*	Reduction in Average Annual Damages (AAD)*	Benefit Cost Ratio	Economic Outcome
FM5.6	\$373,000	\$7,159,000	19.19	Good
FM2.1	\$83,000	\$1,026,000	12.36	Good
FM5.2	256000	\$3,009,000	11.75	Good

Option ID	Cost of Implementation of Option*	Reduction in Average Annual Damages (AAD)*	Benefit Cost Ratio	Economic Outcome
FM11.1 & 11.2	\$549,000	\$4,477,000	8.15	Good
FM11.3	\$465,000	\$1,643,000	3.53	Good
FM5.3 & 5.4	\$1,683,000	\$3,447,000	2.05	Good
FM6.4	\$667,000	\$1,322,000	1.98	Good
FM6.1	\$486,000	\$810,000	1.67	Good
FM11.4	\$465,000	\$721,000	1.55	Good
FM3.3	\$605,000	\$937,000	1.55	Good
FM14.1	\$647,000	\$824,000	1.27	Good
FM3.4	\$518,000	\$445,000	0.86	Moderate
FM3.1	\$912,000	\$742,000	0.81	Moderate
FM1.1	\$2,673,000	\$2,099,000	0.79	Moderate
FM3.6	\$836,000	\$638,000	0.76	Moderate
FM3.2	\$2,628,000	\$1,517,000	0.58	Moderate
FM7.6	\$813,000	\$467,000	0.57	Moderate
FM12.4	\$110,000	\$63,000	0.57	Moderate
FM12.1 & 12.2	\$1,978,000	\$956,000	0.48	Moderate
FM5.9	\$1,004,000	\$471,000	0.47	Moderate
FM8.1 & 8.2	\$395,000	\$170,000	0.43	Moderate
FM10.2	\$1,099,000	\$471,000	0.43	Moderate
FM10.1	\$932,000	\$266,000	0.29	Moderate
FM2.3	\$2,797,000	\$794,000	0.28	Moderate
FM4.2	\$253,000	\$62,000	0.25	Moderate
FM15.9	\$2,920,000	\$707,000	0.24	Moderate
FM1.2	\$2,536,000	\$487,000	0.19	Poor
FM8.3	\$2,435,000	\$461,000	0.19	Poor
FM13.1, 13.2 & 13.5	\$2,531,000	\$471,000	0.19	Poor

Option ID	Cost of Implementation of Option*	Reduction in Average Annual Damages (AAD)*	Benefit Cost Ratio	Economic Outcome
FM15.10	\$4,721,000	\$853,000	0.19	Poor
FM15.3	\$1,842,000	\$318,000	0.17	Poor
FM13.4	\$2,769,000	\$471,000	0.17	Poor
FM9.1	\$2,801,000	\$319,000	0.11	Poor
FM10.4	\$574,000	\$61,000	0.11	Poor
FM15.1 & 15.2	\$1,088,000	\$98,000	0.09	Poor
FM7.1 & 7.5	\$1,930,000	\$69,000	0.04	Poor
FM15.7	\$1,093,000	-\$19,000	-0.02	Poor
FM12.5	\$399,000	-\$10,000	-0.03	Poor
FM15.5	\$177,000	-\$8,000	-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

*Net present worth of reduction in AAD, 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.

<u>Economic</u>	Benefit cost ratio
	Implementation complexity
	Staging of works
<u>Social</u>	Reduction in risk to life
	Emergency access
	Social disruption
	Community and stakeholder support
<u>Environmental</u>	Heritage conservation areas and heritage items
	Recreation and flora / fauna impacts including street trees
	Acid sulfate soils and contaminated land
	Visual impact

The assignment of each option with a score for each criteria is shown in its entirety in **Appendix A3**.

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.

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.

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
FM3.4	0.86	11.29	Good
FM6.4	1.98	11.27	Good
FM12.4	0.57	10.27	Good
FM14.1	1.27	9.94	Good
FM1.1	0.79	9.58	Good

Option ID	BCR	MCA Score	Overall Rank
FM6.1	1.67	9.06	Good
FM3.3	1.55	8.81	Moderate
FM3.2	0.58	8.67	Moderate
FM11.4	1.55	8.63	Moderate
FM7.6	0.57	8.46	Moderate
FM2.1	12.36	8.42	Moderate
FM7.1 & 7.5	0.04	8.10	Moderate
FM12.1 & 12.2	0.48	7.71	Moderate
FM3.1	0.81	7.71	Moderate
FM15.10	0.18	7.71	Moderate
FM4.2	0.25	7.52	Moderate
FM15.1 & 15.2	0.09	7.10	Moderate
FM2.3	0.28	7.04	Moderate
FM15.9	0.24	7.04	Moderate
FM13.1, 13.2 & 13.5	1.01	6.48	Poor
FM8.3	0.11	6.21	Poor
FM10.4	0.11	5.85	Poor
FM5.2	11.75	5.79	Poor
FM10.2	0.66	5.31	Poor
FM15.3	0.17	5.31	Poor
FM10.1	0.29	4.35	Poor
FM5.9	0.70	3.79	Poor
FM9.1	0.11	3.00	Poor
FM1.2	0.19	2.29	Poor
FM13.4	0.57	1.92	Poor
FM3.6	0.23	1.85	Poor
FM8.1 & 8.2	0.43	1.73	Poor

Option ID	BCR	MCA Score	Overall Rank
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 4-5 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

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 OEHL, 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** and **Table 4-5**) 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 multi-criteria assessment scores;
- > 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
- > Criteria to consider for implementation.

The measures identified in **Table 5-1** represent a capital outlay of approximately \$35.3M over the life of the plan. However, high and medium priority actions have a total cost of approximately \$18.5M.

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 OEHL. 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 Sydney 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	MCA Score	Responsibility	Priority**	Implementation Notes
FM5.6	Increase inlet capacity in Illawarra Road, York and Shephard Streets via 450mm diameter pipes	\$324,600	16.52	Council / OEH	H	Stand-alone project. Sydney Water connection approval required.
FM12.4	Install a weir in the central channel to divert the flows into the Mackey Park pump station (DPS2)	\$95,500	10.27	Sydney Water / Council	H	Design and implementation of option should be coordinated with Options FM12.1 and FM12.2. Work with Sydney Water to design and develop the option.
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	7.71	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. Sydney Water connection approval 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	8.42	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	14.63	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. Sydney Water connection approval required.
FM6.4	Install new inlet pits and 600mm diameter pipes along England Ave, Agar St and Wemyss St	\$580,800	11.27	Council	H	Design and implementation of option should be coordinated with proposed bidirectional separated cycleway in Addison Road. Sydney Water connection approval required.
FM6.1	Upgrade drainage in Newington Rd to 600mm diameter pipes	\$422,900	9.06	Council	M	Design and implementation of option should be coordinated with proposed bidirectional separated cycleway in Addison Road. Sydney Water connection approval required.
FM3.4	Increase inlet capacity on Despointes St, Convent Ln, Peace Ln, Le Cos Ln, Illawarra Rd and Silver St with 600mm diameter pipes and additional inlet pits	\$450,500	11.29	Council	H	Stand-alone project. Sydney Water connection approval required for new assets.
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	8.67	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. Sydney Water connection approval required.
FM3.3	New drainage in Sydenham Road and connect to Western Channel via 600mm diameter pipes	\$526,300	8.81	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	9.94	Council / Sydney Metro	H	Design and implementation of option should be coordinated with Sydney Metro works. Sydney Water connection approval required.
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	13.67	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	12.42	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	8.63	Council	M	Design and implementation of option should be coordinated with Options FM11.1, FM11.2 and FM11.3. Sydney Water connection approval required.

Option ID	Description	Capital Cost	MCA Score	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	9.58	Council	H	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, provide new pits along Petersham Rd, and upgrade drainage in Northcote St and Malakoff St to 450mm diameter pipes	\$794,200	7.71	Council	M	Stand-alone project. Sydney Water connection approval 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	7.71	Sydney Water / Council / OEH	M	Project is contingent on support and funding assistance from Sydney Water.
FM4.2	Divert flows from Chester St and Oxford St to Audley St via 450mm diameter pipes, new raised road thresholds at Chester St and Oxford St, and new dish drains across Oxford St and Chester St to direct flows towards Audley St	\$220,100	7.52	Council	M	Stand-alone project.
FM7.6	Install new 600mm, 750mm, 900mm and 1050mm diameter pipes on Addison Rd and Philpott St with additional inlet pits	\$707,700	8.46	Council / RMS / OEH	M	Stand-alone project. Project is contingent on support and funding assistance from RMS. Sydney Water connection approval required.
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	8.10	Council / RMS / OEH	M	Stand-alone project. Optimise option by excluding works in Addison Road and Denby Street. Project is contingent on support and funding assistance from RMS. Sydney Water connection approval required.
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	7.10	Council	L	Stand-alone project. Project is contingent on support and funding assistance from RMS. Sydney Water connection approval required.
FM2.3	Divert George Street catchment from Livingstone Road sag to Centennial St via 600mm diameter pipes	\$2,436,000	7.04	Council	L	Stand-alone project.
FM13.1 & 13.2	Provide large inlet pits at intersection of Gannon St, Griffiths St and Unwins Bridge Rd. Duplicate the existing 1500mm X 700mm box culvert underneath the railway corridor	\$404,800	6.48	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	5.85	Council	L	Stand-alone project. May be impacted by proposed Sydney Metro drainage works. Sydney Water connection approval required.
FM5.2	Demolish brick wall and structures built over drainage easement between Park and Neville Streets and upsize pipe to 450mm.	\$222,600	5.79	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	MCA Score	Responsibility	Priority**	Implementation Notes
FM10.1	Divert Marrickville Rd flows down Barclay Street to Sydenham Detention Basin via 600mm diameter pipes	\$811,600	4.35	Council	L	Stand-alone project. Project should be implemented after FM15.10 to maximise benefit. Sydney Water connection approval required.
FM9.1	Install new 450mm and 600mm diameter pipes at the intersection of Livingstone Rd and Marrickville Road, new 900mm diameter pipe along Marrickville Rd to Petersham Rd, a new 1050mm diameter pipe from Petersham Rd connecting to Malakoff Tunnel via an approximately 100m ³ underground storage	\$2,439,600	3.00	Council	L	Stand-alone project. Sydney Water connection approval 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	1.73	Council	L	Stand-alone project. Optimise connection to Malakoff Tunnel to reduce adverse impacts in major events. Sydney Water connection approval 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	2.29	Council	L	Stand-alone project. Project should be implemented after FM1.1 to maximise benefit.
FM3.6	Provide detention of approximately 2300m ³ of storage volume in the Wilkins School Oval through bunding and excavation with surface area of approximately 4000m ²	\$727,900	1.85	Council / Department of Education	L	Stand-alone project. Project is contingent on support and assistance from Department of Education.
FM5.9	Install a new 825mm diameter pipe along Essex St and through the backyard of properties along Surrey St and Gordon Sq	\$874,500	3.79	Council	L	Stand-alone project. Project is contingent on support and assistance from the private property owners.
FM8.3	Divert flows from Marrickville Rd to Livingstone Rd via a new 1050mm diameter pipe, provide approximately 8000m ³ underground storage in McNeily Park with surface area of approximately 4000m ² , and install a new 1200mm diameter pipe from Hollands Ave to the proposed underground storage	\$3,561,400	6.21	Council / OEH / Sydney Water	L	Stand-alone project. Sydney Water connection approval required.
FM10.2	Install new 600mm diameter pipe between Harriet St and Myrtle St and 750mm and 900mm diameter pipes from Myrtle St to pump station SPS271	\$619,100	5.31	Council / OEH / Sydney Water	L	Stand-alone project. Sydney Water connection approval required.
FM13.4	Divert flows down Edgar St to a new connection to Eastern Channel via a 1050mm diameter pipe	\$725,100	1.92	Council / OEH / Sydney Water	L	Stand-alone project. Sydney Water connection approval required.

Emergency Management and Property modification measures

Option ID	Description	Capital Cost	MCA Score	Responsibility	Priority**
EM2	Information transfer to NSW SES	\$1,000	10.13	Council	H
EM6	Interactive Flood Mapping	\$50,000	8.30	Council	H
EM5	Flood Awareness and Education	\$1,000	7.02	Council / SES	H
EM3	Flood Response for Vulnerable Properties	\$1,000	5.42	Council	H
EM7	Education and Awareness of Littering	\$20,000	3.75	Council / EPA	M
EM4	Local Evacuation Measures	\$1,000	3.64	Council / SES	M
PM5	Increased Street Sweeping	\$100,000 p.a.	3.19	Council	M
EM1	New Evacuation Centres	\$1,000	2.04	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 complement 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

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