

Manly to Seaforth Flood Study

Flood Study Report - Preliminary

NA49913018

Prepared for
Northern Beaches Council

8 March 2018



Contact Information

Cardno (NSW/ACT) Pty Ltd

ABN 95 001 145 035

Level 9, The Forum
203 Pacific Highway St Leonard NSW 2065Telephone: 61 2 9496 7700
Facsimile: 61 2 9439 5170
International: 61 2 9496 7700sydney@cardno.com.au
www.cardno.com

Author(s):

Andrew Reid
Senior Engineer

Approved By:

David Whyte
Manager – Water Engineering

Document Information

Prepared for
Project Name
Northern Beaches Council
Flood Study Report -
PreliminaryFile Reference
Manly to Seaforth Flood
Study Preliminary Draft
Final Report Revision
G.docmJob Reference
Date
NA49913018
8 March 2018Version Number
Rev FEffective Date
8 March 2018Date Approved:
8 March 2018

Document History

Version	Effective Date	Description of Revision	Prepared by:	Reviewed by:
A	23/02/2016	Preliminary		
B	05/04/2016	Council Review	JC	AR
C	07/04/2016	Council Review	JC	AR
D	02/05/2016	Council Review	JC	AR
E	06/10/2017	Draft in progress	AR	
F	15/02/2018	Draft Final	AR	
G	08/03/2018	Revised Draft Final	AR	

© Cardno. Copyright in the whole and every part of this document belongs to Cardno and may not be used, sold, transferred, copied or reproduced in whole or in part in any manner or form or in or on any media to any person other than by agreement with Cardno.

This document is produced by Cardno solely for the benefit and use by the client in accordance with the terms of the engagement. Cardno does not and shall not assume any responsibility or liability whatsoever to any third party arising out of any use or reliance by any third party on the content of this document.

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 management 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 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 –

This may involve the construction of flood mitigation works (e.g. culvert amplification, overland flowpath modification) to protect existing or future development. It may also involve the use of Environmental Planning Instruments to ensure new development is compatible with the flood hazard.

The process is iterative, and following the implementation of the plan, it is important that ongoing monitoring and evaluation is undertaken.

This Flood Study has been prepared for Northern Beaches Council by Cardno, and addresses Parts 2 and 3 of the Floodplain Management process. This Study was funded by Northern Beaches Council, the New South Wales Government, and the Commonwealth Government (under the Natural Disaster Mitigation Program).

Prior to the formation of Northern Beaches Council on 12th May 2016 this study was called the Manly LGA Flood Study.

Executive Summary

Cardno was commissioned by Northern Beaches Council to undertake the Flood Study for urban catchments, which comprises the suburbs of Clontarf and Balgowlah Heights and parts of Seaforth, Balgowlah, Fairlight, and Manly. Prior to the formation of Northern Beaches Council on 12th May 2016 this study was called the Manly Local Government Area (LGA) Flood Study.

In 2013, a Flood Study was completed for the Manly Lagoon Catchment, which is north of this study area.

This study incorporated community consultation throughout and included a community questionnaire distributed to the community to gain an understanding of flood awareness and experience in the catchment. It comprised of 10 questions that were mailed to approximately 5,500 properties within the study area.

A set of four detailed 1D/2D models have been developed to describe flooding behaviour in the study area using SOBEK. The models incorporate 1D elements (pits and pipes) and a 2D surface of grid cell size 2.5 m x 2.5 m.

The models were validated to three historical storms; February 2010, June 2013 and October 2013. The 2010 event was in the order of a 10% - 5% Annual Exceedance Probability (AEP) event whilst the other two events were estimated to be between a 50% and 20% AEP.

The model hydrology was also verified against a traditional hydrological model (XP-RAPTS). The match between the XP-RAPTS model and the SOBEK model for timing, volume and peak flow was very good, with virtually identical timings and volumes recorded.

Using the established models, the study has determined flood behaviour for the 20%, 10%, 2%, 1%, 0.5% AEP and PMF. The primary flood characteristics reported include depths, level, velocities, flow rates and provisional flood hazard for flood-affected areas.

A number of scenarios including blockage and climate change have also been considered.

The outcomes of this study can be used for future planning and studies to investigate various management and flood mitigation options for the existing catchment conditions and will assist in evaluating long-term flood management strategies now that existing flood risks have been defined in this study.

This Draft Flood Study has been prepared to facilitate the Floodplain Risk Management Study (FRMS) for the study area.

Table of Contents

Glossary

Abbreviations

1	Introduction	1
1.1	Study Context	1
1.2	Study Objectives	1
1.3	Study Location	1
1.4	About This Report	2
2	Review and Compilation of Data	3
2.1	Previous Reports and Studies	3
2.2	Council GIS Data	3
2.3	Survey Information	3
2.3.1	Pit and Pipe Survey	3
2.3.2	Detailed Ground Survey	4
2.4	Site Inspections	5
2.5	Historic Flood Information	5
2.6	Rainfall and Gauge Data	5
3	Community Consultation	7
3.1	Project Website and Mailout	7
3.2	Community Questionnaire	7
3.2.1	Question 1 – Contact Details	7
3.2.2	Question 2 – Property Type	7
3.2.3	Question 3 – Time at Residence	7
3.2.4	Question 4 – Property Occupancy	8
3.2.5	Question 5 – Awareness of Flooding	8
3.2.6	Question 6 – Property Inundation	9
3.2.7	Question 7 – Flooding in the Catchment	10
3.2.8	Question 8 – Flood Experience	12
3.2.9	Question 9 – Drain and Culvert Blockage	12
3.2.10	Question 10 – Additional Comments.	13
3.3	Flood Study Working Group	14
4	Flood Model Establishment	15
4.1	Model Terrain	15
4.2	Buildings	15
4.3	Pits and Pipes	16
4.4	Roughness	16
4.5	Downstream Boundary	19
4.6	Manly Oval Detention Basin	19
5	Flood Model Validation	20
5.1	Historic Storm Events	20
5.1.1	Event Data	20
5.1.2	Selected Storms	20
5.1.3	Available Rainfall Data	20
5.2	Hydraulic Model Validation	24
5.2.1	February 2010 Event	25

5.2.2	September 2010	26
5.2.3	January 2012	26
5.2.4	Summary	27
5.3	Hydrologic Verification	28
6	Existing Flood Behaviour	30
6.1	Model Scenarios	30
6.2	Result Maps	30
6.3	Discussion of Results	30
6.3.1	Manly	30
6.3.2	Balgowlah and Balgowlah Heights	31
6.3.3	Clontarf	31
6.4	Hydraulic Categories	31
6.5	Provisional Hazard	32
6.5.1	General	32
6.5.2	Provisional Flood Hazard	32
7	Sensitivity Modelling	35
7.1	Catchment Roughness	35
7.2	Catchment Rainfall	35
7.3	Tailwater Level	35
7.4	Open-Ocean Elevated Water Level	35
8	Scenario Modelling	37
8.1	Conduit Blockage	37
8.2	Climate Change – Rainfall	37
8.3	Climate Change – Rainfall and Sea Level Rise	37
9	Flood Planning	38
10	Conclusion	39
11	References	40
12	Qualifications	41

Appendices

Appendix A	Validation Figures
Appendix B	Design Event Figures
Appendix C	Sensitivity Figures
Appendix D	Community Consultation

Tables

Table 1-1	ARI to AEP Conversion	2
Table 2-1	Pit Survey	3
Table 2-2	Pipe Survey	4
Table 2-3	Rainfall Data Record Length of Rainfall Gauges	6
Table 3-1	Time of Residence	8
Table 3-2	Type of Occupancy	8

Table 3-3	Property Inundation Dates	10
Table 3-4	Flooding in the Catchment	10
Table 3-5	Blocked Drains / Culverts	13
Table 4-1	Model Zone Grid Cells Number	15
Table 4-2	Model Roughness Values	16
Table 4-3	Adopted Tailwater Levels	19
Table 5-1	Summary of Available Historical Storm Event Data	20
Table 5-2	Summary of Available Rainfall Data for Recent Storms	21
Table 5-3	Equivalent ARI Estimates	24
Table 5-4	XP-RAFTS Subcatchments	28
Table 6-1	Event Critical Durations	30
Table 7-1	Open-Ocean Elevated Water Level Sensitivity Scenarios	36

Figures

Figure 2-1	Site Inspection Locations	5
Figure 2-2	Pluviometer Locations	6
Figure 3-1	Flood Awareness of Respondents	9
Figure 3-2	Property Inundation	10
Figure 3-3	Flood experience	12
Figure 4-1	Hydraulic Model Setup	17
Figure 4-2	Roughness Values	18
Figure 5-1	Rainfall Distribution 12/02/2010	21
Figure 5-2	Rainfall Distribution 10/06/2012-11/06/2012	22
Figure 5-3	Rainfall Distribution 2/06/2013	22
Figure 5-4	Rainfall Distribution 28/10/2013	23
Figure 5-5	Central Ave in 2010 Event - Looking Towards Post Office (Source - Manly Council)	25
Figure 5-6	2010 Event Validation Flood Extent - Central Avenue	25
Figure 5-7	Intersection of Raglan Street and Belgrave Street in September 2010 Event (Source - Manly Council)	26
Figure 5-8	Intersection of Sydney Road and Belgrave Street in 2012 Event (Source - Manly Council)	26
Figure 5-9	Kangaroo Lane (near Raglan Street) in 2012 Event (Source - Manly Council)	27
Figure 5-10	Raglan Street (near Intersection with Belgrave Street) in 2012 Event (Source - Manly Council)	27
Figure 5-11	XP-RAFTS Catchments	28
Figure 5-12	Catchment C1 Validation Results	29
Figure 5-13	Catchment C2 Validation Results	29
Figure 6-1	Provisional Hazard Categories from Appendix L of the Floodplain Development Manual	33
Figure 6-2	Provisional Hazard Categories from AR&R	34

Glossary

Annual Exceedance Probability (AEP)	Refers to the probability or risk of a flood of a given size occurring or being exceeded in any given year. A 90% AEP flood has a high probability of occurring or being exceeded each year; it would occur quite often and would be relatively small. A 1% AEP flood has a low probability of occurrence or being exceeded each year; it would be quite rare but it would be relatively large.
Australian Height Datum (AHD)	A common national surface level datum approximately corresponding to mean sea level.
Average Recurrence Interval (ARI)	The average or expected value of the periods between exceedances of a given rainfall total accumulated over a given duration. It is implicit in this definition that periods between exceedances are generally random
Cadastre, cadastral base	Information in map or digital form showing the extent and usage of land, including streets, lot boundaries, water courses etc.
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.
Creek Rehabilitation	Rehabilitating the natural 'biophysical' (i.e. geomorphic and ecological) functions of the creek.
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 in 1 year or 100%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 fringe	The remaining area of flood-prone land after floodway and flood storage areas have been defined.
Flood hazard	Potential risk to life and limb caused by flooding.
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. These include structural flood modifications to change the way floods behave, property modification options to improve property resilience to floods and emergency response modification options to improve the response of emergency services and the community during flood events.
Floodplain management options	The measures which might be feasible for the management of a particular area. A variety of floodplain management measures are often reviewed for a catchment, although only some will ultimately prove to be successful. These successful measures become floodplain management options, which are assessed in further detail.
Flood planning area	The area of land below the flood planning level and thus subject to flood related development controls.
Flood planning levels	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.
Flood storages	Those parts of the floodplain that are important for the temporary storage of floodwaters during the passage of a flood.
Floodway areas	Those areas of the floodplain where a significant discharge of water occurs during floods. They are often, but not always, aligned with

naturally defined channels. Floodways are areas which, even if only partially blocked, would cause a significant redistribution of flood flow, or significant increase in flood levels. Floodways are often, but not necessarily, areas of deeper flow or areas where higher velocities occur. As for flood storage areas, the extent and behaviour of floodways may change with flood severity. Areas that are benign for small floods may cater for much greater and more hazardous flows during larger floods. Hence, it is necessary to investigate a range of flood sizes before adopting a design flood event to define floodway areas.

Geographical Information Systems (GIS)

A system of software and procedures designed to support the management, manipulation, analysis and display of spatially referenced data.

High hazard

Flood conditions that pose a possible danger to personal safety; evacuation by trucks difficult; able-bodied adults would have difficulty wading to safety; potential for significant structural damage to buildings.

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.

Hydrograph

A graph that shows how the discharge changes with time at any particular location.

Hydrology

The term given to the study of the rainfall and runoff process as it relates to the derivation of hydrographs for given floods.

Low hazard

Flood conditions such that should it be necessary, people and their possessions could be evacuated by trucks; able-bodied adults would have little difficulty wading to safety.

Mainstream flooding

Inundation of normally dry land occurring when water overflows the natural or artificial banks of the principal watercourses in a catchment. Mainstream flooding generally excludes watercourses constructed with pipes or artificial channels considered as stormwater channels.

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.

Overland Flow

Overland flow is excess rainfall runoff that runs across the land before it enters a watercourse / constructed drainage system or after rising to

the surface, such as the capacity is exceeded. The term overland flow is used interchangeably in this report with “flooding”.

Peak discharge	The maximum discharge occurring during a flood event.
Probable maximum flood	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 further explanation see Annual Exceedance Probability.
Risk	Chance of something happening that will have an impact. It is measured in terms of consequences and likelihood. For this study, it is the likelihood of consequences arising from the interaction of floods, communities and the environment.
Runoff	The amount of rainfall that actually ends up as stream or pipe flow, also known as rainfall excess.
Stage	Equivalent to 'water level'. Both are measured with reference to a specified datum.
Stage hydrograph	A graph that shows how the water level changes with time. It must be referenced to a particular location and datum.
Stormwater flooding	Inundation by local runoff. Stormwater flooding can be caused by local runoff exceeding the capacity of an urban stormwater drainage system or by the backwater effects of mainstream flooding causing the urban stormwater drainage system to overflow.
Topography	A surface which defines the ground level of a chosen area.

* Terminology in this Glossary have been derived or adapted from the NSW Government Floodplain Development Manual, 2005, where available.

Abbreviations

AAD	Average Annual Damage
AEP	Annual Exceedance Probability
ARI	Average Recurrence Intervals
BoM	Bureau of Meteorology
DCP	Development Control Plan
FPL	Flood Planning Levels
FRMP	Floodplain Risk Management Plan
FRMS	Floodplain Risk Management Study
GIS	Geographic Information System
ha	Hectare
IFD	Intensity Frequency Duration
km	Kilometres
km ²	Square kilometres
LEP	Local Environment Plan
LGA	Local Government Area
m	Metre
m ²	Square metre
m ³	Cubic Metre
mAHD	Metres to Australian Height Datum
mm	Millimetre
m/s	Metres per second
NSW	New South Wales
OEH	Office of Environment & Heritage
PMF	Probable Maximum Flood
PMP	Probable Maximum Precipitation
SES	State Emergency Service

1 Introduction

Cardno have been commissioned by Northern Beaches Council to undertake the Flood Study for urban catchments, which comprises the suburbs of Clontarf and Balgowlah Heights and parts of Seaforth, Balgowlah, Fairlight, and Manly. Prior to the formation of Northern Beaches Council on 12th May 2016 this study was called the Manly LGA Flood Study.

The study has been undertaken to define the existing flooding behaviour of the catchment due to overland flooding.

1.1 Study Context

The NSW Floodplain Management process progresses through six steps in an iterative process:

1. Formation of a Floodplain Management Committee
2. Data Collection
3. Flood Study
4. Floodplain Risk Management Study
5. Floodplain Risk Management Plan
6. Implementation of the Overland Flow / Floodplain Risk Management Plan

This document addresses Stages 2 and 3 of the process.

1.2 Study Objectives

The objectives of the Flood Study were to:

- Undertake a review of available data;
- Consult with the community to collect their observations on historic flood events and current flooding issues;
- Development of a hydrological / hydraulic model for the study area;
- Calibrate / validate the hydrological / hydraulic model;
- Define the existing flood behaviour of the study area for a range of flood events;
- Undertake sensitivity testing to confirm the selected model parameters; and
- Determine flood planning areas.

Results of the flood modelling will be output as electronic files suitable for incorporation into Council's Geographic Information System (GIS).

1.3 Study Location

The study area is located within the Northern Beaches Council LGA and includes the suburbs of Clontarf and Balgowlah Heights and parts of Seaforth, Balgowlah, Fairlight, and Manly. The land-use is predominantly residential with Manly Hospital, some retail, and the Manly central business district. It has several beaches including Manly Beach, North Steyne Beach, Queenscliff Beach, Shelley Beach, and Clontarf Beach as well as large areas of bushland including Sydney Harbour National Park and at Dobroyd Head.

Generally, the study area covers about 10.7 km² and is the southern part of the former Manly Local Government Area (LGA) that drains to Middle Harbour, North Harbour, and the Tasman Sea at numerous locations. It excludes the areas of the former LGA which are in the Manly Lagoon catchment which was part of a separate flood study.

1.4 About This Report

This Report has been prepared to document the Study objectives, methodology and outcomes.

- Section 1 Introduction – introduces the study.
- Section 2 Review and Compilation of Data – summarises the data used to inform the flood model.
- Section 3 Community Consultation – presents the community consultation undertaken.
- Section 4 Flood Model Establishment – provides information as to how the flood model was developed.
- Section 5 Flood Model Validation – provides information as to how the flood has been validated.
- Section 6 Existing Flood Behaviour – presents the flood behaviour as determined by the flood model.
- Section 7 Sensitivity Modelling - a discussion around sensitivity of the model by varying parameters.
- Section 8 Scenario Modelling – presents the scenarios modelled.
- Section 9 Conclusion
- Section 10 References
- Section 11 Qualifications

This report has adopted Annual Exceedance Probability (AEP) terminology to define flood events. Historically, Average Recurrence Intervals (ARI) terminology has been used to describe flood events but can lead to confusion with regard to the frequency of an event occurring. Therefore, an AEP terminology is most appropriate in conveying flood information to the community. **Table 1-1** correlates the AEP terminology with the ARI terminology.

Table 1-1 ARI to AEP Conversion

ARI (Average Recurrence Interval)	AEP (Annual Exceedance Probability)
1 Year	1EY (ie 1 Exceedance per Year)
2 Year	50%
5 Year	20%
10 Year	10%
20 Year	5%
50 Year	2%
100 Year	1%
200 Year	0.5%