	typically require major extensions of existing urban services, such as roads, water supply, sewerage and electric power.
	redevelopment: refers to rebuilding in an area. For example, as urban areas age, it may become necessary to demolish and reconstruct buildings on a relatively large scale. Redevelopment generally does not require either rezoning or major extensions to urban services.
disaster plan (DISPLAN)	A step by step sequence of previously agreed roles, responsibilities, functions, actions and management arrangements for the conduct of a single or series of connected emergency operations, with the object of ensuring the coordinated response by all agencies having responsibilities and functions in emergencies.
discharge	The rate of flow of water measured in terms of volume per unit time, for example, cubic metres per second (m^3/s). Discharge is different from the speed or velocity of flow, which is a measure of how fast the water is moving for example, metres per second (m/s).
ecologically sustainable development (ESD)	Using, conserving and enhancing natural resources so that ecological processes, on which life depends, are maintained, and the total quality of life, now and in the future, can be maintained or increased. A more detailed definition is included in the Local Government Act 1993. The use of sustainability and sustainable in this manual relate to ESD.
effective warning time	The time available after receiving advice of an impending flood and before the floodwaters prevent appropriate flood response actions being undertaken. The effective warning time is typically used to move farm equipment, move stock, raise furniture, evacuate people and transport their possessions.
emergency management	A range of measures to manage risks to communities and the environment. In the flood context it may include measures to prevent, prepare for, respond to and recover from flooding.
flash flooding	Flooding which is sudden and unexpected. It is often caused by sudden local or nearby heavy rainfall. Often defined as flooding which peaks within six hours of the causative rain.
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 local overland flooding associated with major drainage before entering a watercourse, and/or coastal inundation resulting from super-elevated sea levels and/or waves overtopping coastline defences excluding tsunami.
flood awareness	Flood awareness is an appreciation of the likely effects of flooding and a knowledge of the relevant flood warning, response and evacuation procedures.
flood education	Flood education seeks to provide information to raise awareness of the flood problem so as to enable individuals to understand how to manage themselves an their property in response to flood warnings and in a flood event. It invokes a state of flood readiness.
flood fringe areas	The remaining area of flood prone land after floodway and flood storage areas have been defined.

flood liable land	Is synonymous with flood prone land (i.e. land susceptible to flooding by the probable maximum flood (PMF) event). Note that the term flood liable land covers the whole of the floodplain, not just that part below the flood planning level (see flood planning area).
flood mitigation standard	The average recurrence interval of the flood, selected as part of the floodplain risk management process that forms the basis for physical works to modify the impacts of flooding.
floodplain	Area of land which is subject to inundation by floods up to and including the probable maximum flood event, that is, flood prone land.
floodplain risk management options	The measures that might be feasible for the management of a particular area of the floodplain. Preparation of a floodplain risk management plan requires a detailed evaluation of floodplain risk management options.
floodplain risk management plan	A management plan developed in accordance with the principles and guidelines in this manual. Usually includes both written and diagrammetic information describing how particular areas of flood prone land are to be used and managed to achieve defined objectives.
flood plan (local)	A sub-plan of a disaster plan that deals specifically with flooding. They can exist at State, Division and local levels. Local flood plans are prepared under the leadership of the State Emergency Service.
flood planning area	The area of land below the flood planning level and thus subject to flood related development controls. The concept of flood planning area generally supersedes the Aflood liable land@ concept in the 1986 Manual.
Flood Planning Levels (FPLs)	FPL=s are the combinations of flood levels (derived from significant historical flood events or floods of specific AEPs) and freeboards selected for floodplain risk management purposes, as determined in management studies and incorporated in management plans. FPLs supersede the Astandard flood event@ in the 1986 manual.
flood proofing	A combination of measures incorporated in the design, construction and alteration of individual buildings or structures subject to flooding, to reduce or eliminate flood damages.
flood prone land	Is land susceptible to flooding by the Probable Maximum Flood (PMF) event. Flood prone land is synonymous with flood liable land.
flood readiness	Flood readiness is an ability to react within the effective warning time.
flood risk	Potential danger to personal safety and potential damage to property resulting from flooding. The degree of risk varies with circumstances across the full range of floods. Flood risk in this manual is divided into 3 types, existing, future and continuing risks. They are described below. **existing flood risk:** the risk a community is exposed to as a result of its location on the floodplain. **future flood risk:** the risk a community may be exposed to as a result of new development on the floodplain.

	continuing flood risk: the risk a community is exposed to after floodplain risk management measures have been implemented. For a town protected by levees, the continuing flood risk is the consequences of the levees being overtopped. For an area without any floodplain risk management measures, the continuing flood risk is simply the existence of its flood exposure.
flood storage areas	Those parts of the floodplain that are important for the temporary storage of floodwaters during the passage of a flood. The extent and behaviour of flood storage areas may change with flood severity, and loss of flood storage can increase the severity of flood impacts by reducing natural flood attenuation. Hence, it is necessary to investigate a range of flood sizes before defining flood storage areas.
floodway areas	Those areas of the floodplain where a significant discharge of water occurs during floods. They are often aligned with naturally defined channels. Floodways are areas that, even if only partially blocked, would cause a significant redistribution of flood flows, or a significant increase in flood levels.
freeboard	Freeboard provides reasonable certainty that the risk exposure selected in deciding on a particular flood chosen as the basis for the FPL is actually provided. It is a factor of safety typically used in relation to the setting of floor levels, levee crest levels, etc. Freeboard is included in the flood planning level.
habitable room	**in a residential situation:** a living or working area, such as a lounge room, dining room, rumpus room, kitchen, bedroom or workroom. **in an industrial or commercial situation:** an area used for offices or to store valuable possessions susceptible to flood damage in the event of a flood.
hazard	A source of potential harm or a situation with a potential to cause loss. In relation to this manual the hazard is flooding which has the potential to cause damage to the community. Definitions of high and low hazard categories are provided in the Manual.
hydraulics	Term given to the study of water flow in waterways; in particular, the evaluation of flow parameters such as water level and velocity.
hydrograph	A graph which shows how the discharge or stage/flood level at any particular location varies with time during a flood.
hydrology	Term given to the study of the rainfall and runoff process; in particular, the evaluation of peak flows, flow volumes and the derivation of hydrographs for a range of floods.
local overland flooding	Inundation by local runoff rather than overbank discharge from a stream, river, estuary, lake or dam.
local drainage	Are smaller scale problems in urban areas. They are outside the definition of major drainage in this glossary.
mainstream flooding	Inundation of normally dry land occurring when water overflows the natural or artificial banks of a stream, river, estuary, lake or dam.

major drainage

Councils have discretion in determining whether urban drainage problems are associated with major or local drainage. For the purpose of this manual major drainage involves:

- $ the floodplains of original watercourses (which may now be piped, channelised or diverted), or sloping areas where overland flows develop along alternative paths once system capacity is exceeded; and/or
- $ water depths generally in excess of 0.3 m (in the major system design storm as defined in the current version of Australian Rainfall and Runoff). These conditions may result in danger to personal safety and property damage to both premises and vehicles; and/or
- $ major overland flow paths through developed areas outside of defined drainage reserves; and/or
- $ the potential to affect a number of buildings along the major flow path.

mathematical/computer models

The mathematical representation of the physical processes involved in runoff generation and stream flow. These models are often run on computers due to the complexity of the mathematical relationships between runoff, stream flow and the distribution of flows across the floodplain.

merit approach

The merit approach weighs social, economic, ecological and cultural impacts of land use options for different flood prone areas together with flood damage, hazard and behaviour implications, and environmental protection and well being of the State=s rivers and floodplains.

The merit approach operates at two levels. At the strategic level it allows for the consideration of social, economic, ecological, cultural and flooding issues to determine strategies for the management of future flood risk which are formulated into Council plans, policy and EPIs. At a site specific level, it involves consideration of the best way of conditioning development allowable under the floodplain risk management plan, local floodplain risk management policy and EPIs.

minor, moderate and major flooding

Both the State Emergency Service and the Bureau of Meteorology use the following definitions in flood warnings to give a general indication of the types of problems expected with a flood:

minor flooding: causes inconvenience such as closing of minor roads and the submergence of low level bridges. The lower limit of this class of flooding on the reference gauge is the initial flood level at which landholders and townspeople begin to be flooded.

moderate flooding: low-lying areas are inundated requiring removal of stock and/or evacuation of some houses. Main traffic routes may be covered.

major flooding: appreciable urban areas are flooded and/or extensive rural areas are flooded. Properties, villages and towns can be isolated.

modification measures

Measures that modify either the flood, the property or the response to flooding. Examples are indicated in Table 2.1 with further discussion in the Manual.

peak discharge

The maximum discharge occurring during a flood event.

Probable Maximum Flood (PMF)	The PMF is the largest flood that could conceivably occur at a particular location, usually estimated from probable maximum precipitation, and where applicable, snow melt, coupled with the worst flood producing catchment conditions. Generally, it is not physically or economically possible to provide complete protection against this event. The PMF defines the extent of flood prone land, that is, the floodplain. The extent, nature and potential consequences of flooding associated with a range of events rarer than the flood used for designing mitigation works and controlling development, up to and including the PMF event should be addressed in a floodplain risk management study.
Probable Maximum Precipitation (PMP)	The PMP is the greatest depth of precipitation for a given duration meteorologically possible over a given size storm area at a particular location at a particular time of the year, with no allowance made for long-term climatic trends (World Meteorological Organisation, 1986). It is the primary input to PMF estimation.
probability	A statistical measure of the expected chance of flooding (see AEP).
risk	Chance of something happening that will have an impact. It is measured in terms of consequences and likelihood. In the context of the manual it is the likelihood of consequences arising from the interaction of floods, communities and the environment.
runoff	The amount of rainfall which actually ends up as streamflow, also known as rainfall excess.
stage	Equivalent to Awater level@. Both are measured with reference to a specified datum.
stage hydrograph	A graph that shows how the water level at a particular location changes with time during a flood. It must be referenced to a particular datum.
survey plan	A plan prepared by a registered surveyor.
water surface profile	A graph showing the flood stage at any given location along a watercourse at a particular time.
wind fetch	The horizontal distance in the direction of wind over which wind waves are generated.

Appendix B

Bayside Council
Serving Our Community

SPRINGVALE AND FLOODVALE DRAIN
Floodplain Risk Management Study & Plan
Community Information Newsletter October 2016

Introduction

- In 2014 the City of Botany Bay Council undertook the Springvale Drain and Floodvale Drain Catchment Flood Study
- This report used modelling to define flood levels and identify flood issues
- Council has recently appointed engineering consultant *WMAwater* to undertake the Floodplain Risk Management Study and Plan

Study Area

The combined Springvale Drain and Floodvale Drain catchment includes the suburbs of Pagewood, Eastgardens, Botany and Banksmeadow. The drains originate in Pagewood in the north and flow south to Botany Bay via Penrhyn Estuary. The catchment is densely urbanised and consists of mainly industrial development in the south of the catchment and residential development in the upper catchment.

Flooding Hotspot Locations:

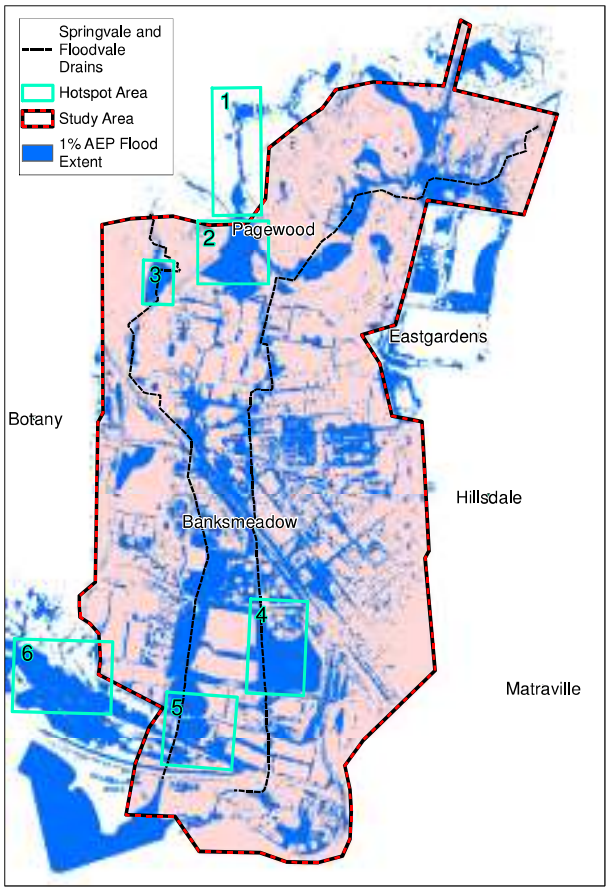
- Properties along Wentworth Ave and Page St
- Pagewood Primary School and adjacent properties
- Properties bounded by Holloway Street and Gibson Street
- McPherson St and Nant St
- McPherson St and Exell St
- Botany Rd, Banksmeadow

What is the Floodplain Risk Management Study & Plan (FRMS&P)?

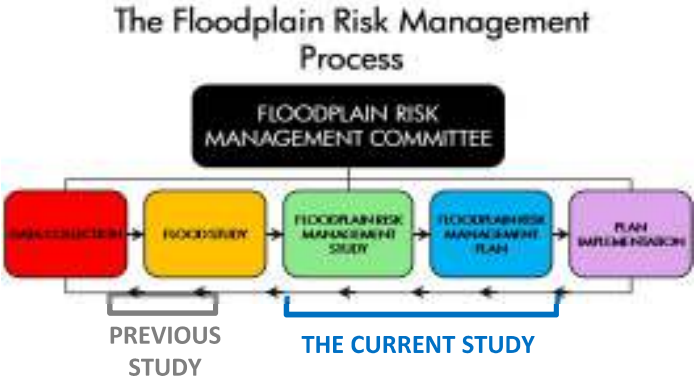
The Floodplain Risk Management Study is a part of the Floodplain Risk Management Process (see right) for the Springvale and Floodvale Drain catchment (study area). The process, which is set out by the NSW Government's Flood Policy, involves a series of stages, of which the current study forms the third and fourth. The Flood Study defined the flood behaviour in the catchment, while the current stage makes a complete assessment of flood risk, including identification and assessment of risk management measures.

Mitigation measures may include:

- Structural improvements – modifying channels, culverts etc.
- Planning measures
- Response measures – improving community response during a flood event



▲ **Flooding Hotspot**



▲ **Flooding in Botany Road June 2016 (Image www.abc.net.au)**

Community involvement in the Study is important. The Botany Bay Floodplain Management Committee includes members from Council, Office of Environment and Heritage, the State Emergency Services and local residents who will oversee this Study. A **questionnaire** is included with this newsletter so that your views and ideas can be included in this Study. You are also invited to attend a community workshop where we welcome you to provide input into potential flood management options in more detail as well as to discuss the Study.

How can I have my say?

Complete this Questionnaire

A questionnaire is enclosed with this newsletter. Please complete this and return with any photos/attachments to:

WMAwater
Reply Paid 71772
Sydney NSW 2000

No stamp required

Please make sure that all surveys are returned before Friday 25th November 2016 or they may not be able to be considered in the Study.

You may also complete the survey online at:
https://www.surveymonkey.com/r/SpringvaleFRMS

Community Consultation Workshop

The easiest and best way to be heard is to attend the community workshop:

Date: **Tuesday 22nd November**
Time: **4-7pm**
Location: Botany Town Hall (corner Edward St and Botany Rd)

Further Information

More information, including a PDF of this Questionnaire and the Flood Study, can be found at:
http://studies.wmawater.com.au/SpringvaleFRMS/

Contacts

If you would like to know more or have any information on flooding which would assist in this Study, please complete the relevant sections on the questionnaire and return using the provided 'postage paid' envelope. Additional information and comments can be attached to the questionnaire when you return it or provided to the contact below:

Catherine Goonan
Project Engineer
botany@wmawater.com.au

WMAwater
Level 2, 160 Clarence Street
Sydney, NSW 2000

Ph: 02 9299 2855

Address .....

How long have you lived in the area? ..... Years ..... Months

How long have you lived at your current address? ..... Years ..... Months

Type of building:
- ☐ Residential
- ☐ Business/Commercial/ Retail
- ☐ Industrial

How many people live/ work at this address? .....

Your Experience

Q1. Have you ever experienced flooding since living/working in the Study Area?

- ☐ Floodwaters entered my house/ business
- ☐ Floodwaters entered my yard
- ☐ The road was flooded
- ☐ Other parts of my neighbourhood were flooded
- ☐ I saw water flowing out of street drains or manholes
- ☐ I haven't experienced flooding

Q2. If you have experienced a flood, how did the flooding affect you and your family/ business?

- ☐ Parts of my house/ business building were damaged
- ☐ The contents of my house/business were damaged
- ☐ My garden, yard and/ or surrounding property were damaged
- ☐ Other property was damaged (specify)

_____

- ☐ The flood disrupted my daily routine
- ☐ The flood didn't affect me

Q3. Do you have any photos you can provide to show the flooding you experienced?
- ☐ Yes (Date the flood occurred on) _____
- ☐ No

Q4. What do you believe to be the main cause of flooding in your area?
- ☐ Local creeks overtopping their banks
- ☐ Lack of capacity in the stormwater network causing drainage systems to surcharge
- ☐ Rainfall runoff flowing to a creek or drain
- ☐ Other_____

Q5. Are you concerned about climate change and how this might impact flooding in your area?
- ☐ Yes
- ☐ No

Please return this questionnaire with any photos/attachments in the envelope provided or to:

WMAwater
Reply Paid 71772
Sydney NSW 2000

No stamp required

Please make sure that all surveys are returned before 25th November 2016 or they may not be able to be considered in the Study.

You may also complete the survey online at:
https://www.surveymonkey.com/r/SpringvaleFRMS

Q6. You may have your own ideas about how to reduce flood risk. Which of the following management options would you prefer for affected areas (1 = least preferred, 5 = most preferred)? Please include comments or suggestions for appropriate locations

Proposed Option	**Preference**
Stormwater harvesting such as rainwater tanks	1 2 3 4 5
Retarding or detention basins; these temporarily hold water and reduce peak flows	1 2 3 4 5
Culvert/ pipe enlargement	1 2 3 4 5
Additional planning and flood related development controls to ensure future development does not add to the existing flood risk	1 2 3 4 5
Education of community, providing greater awareness of potential hazards	1 2 3 4 5
Flood warning, evacuation planning and emergency response	1 2 3 4 5

Please specify any options you believe are suitable, or identify other problem areas.

.....

.....

.....

Can we contact you for further information? ☐Yes ☐ No

Preferred contact method: ☐ Phone ☐ Email

Please provide contact details below

Name : .....Phone: .....

Email:.....

Bayside Council
Serving Our Community

Springvale Drain and Floodvale Drain Floodplain risk management Study

APPENDIX E
Public Exhibition Summary

Contents

1.0 Overview

Community engagement is an important element of the floodplain risk management process and is important in the development of a flood study as it provides an opportunity for the community to 'have their say' and raise awareness of flood prone land. Engagement can also help with community acceptance of the overall project through greater understanding of the process.

2.0 Engagement Activities

2.1 Community engagement during preparation of flood study

Community Survey – October 2016

A newsletter and questionnaire were distributed to 900 residences and businesses within the catchment in October 2016. The newsletter described the role of the Floodplain Risk Management Study and requested information on residents' experiences of flooding in the catchment. 42 responses were received via both hardcopy and online submissions.

Of the responses received, 7% of those had experienced flood water entering their home or business while a fairly even distribution of respondents had experienced flooding on other areas such as their yard, street, or other areas of the neighbourhood. Approximately 23% of all respondents had not experienced flooding. The responses were analysed and reported in the Flood Study.

A copy of the newsletter and questionnaire are provided below:

Figure 2.1.1: Community Newsletter

Address .....

How long have you lived in the area? ..... Years ..... Months

How long have you lived at your current address? ..... Years ..... Months

Type of building:
- ☐ Residential
- ☐ Business/Commercial/ Retail
- ☐ Industrial

How many people live/ work at this address? .....

Your Experience

Q1. Have you ever experienced flooding since living/working in the Study Area?

- ☐ Floodwaters entered my house/ business
- ☐ Floodwaters entered my yard
- ☐ The road was flooded
- ☐ Other parts of my neighbourhood were flooded
- ☐ I saw water flowing out of street drains or manholes
- ☐ I haven't experienced flooding

Q2. If you have experienced a flood, how did the flooding affect you and your family/ business?

- ☐ Parts of my house/ business building were damaged
- ☐ The contents of my house/business were damaged
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_____

- ☐ The flood disrupted my daily routine
- ☐ The flood didn't affect me

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- ☐ Local creeks overtopping their banks
- ☐ Lack of capacity in the stormwater network causing drainage systems to surcharge
- ☐ Rainfall runoff flowing to a creek or drain
- ☐ Other_____

Q5. Are you concerned about climate change and how this might impact flooding in your area?
- ☐ Yes
- ☐ No

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Q6. You may have your own ideas about how to reduce flood risk. Which of the following management options would you prefer for affected areas (1 = least preferred, 5 = most preferred)? Please include comments or suggestions for appropriate locations

Proposed Option	Preference
Stormwater harvesting such as rainwater tanks	1 2 3 4 5
Retarding or detention basins; these temporarily hold water and reduce peak flows	1 2 3 4 5
Culvert/ pipe enlargement	1 2 3 4 5
Additional planning and flood related development controls to ensure future development does not add to the existing flood risk	1 2 3 4 5
Education of community, providing greater awareness of potential hazards	1 2 3 4 5
Flood warning, evacuation planning and emergency response	1 2 3 4 5

Please specify any options you believe are suitable, or identify other problem areas.

Can we contact you for further information? ☐Yes ☐ No
Preferred contact method: ☐ Phone ☐ Email
Please provide contact details below

Name : .....Phone: .....

Email:.....

Figure 2.1.2: Springvale Drain and Floodvale Drain Flood Study Questionnaire

2.2 Community Consultation on Draft Floodplain Risk Management Study Report

The Springvale Drain and Floodvale Drain Flood Study consultation period was open for four weeks from Tuesday 6 August 2019 to Friday 6 September 2019 for community feedback.

Engagement activities:

- Letters were sent to all 1% AEP flood affected owners and residents (2,500 letters).
- The public exhibition was advertised on Council's website (have your say).
- In the local newspaper on Tuesday 20 August 2019 (Southern Courier).
- A drop in session was held at Eastgardens Library on 22 August 2019. A total of 4 people attended

A letter was sent to flood affected residents and landowners as below:

Figure 2.2.1: Letter sent out to Flood affected residents for feedback on study

HAVE YOUR SAY

Residents have many opportunities to take part in discussions on key projects and provide feedback that helps shape the delivery of Council services.

Officers will be on hand at the following locations to hear your thoughts and address any questions you may have on the following projects.

Flood Studies for the Suburbs of Banksmeadow, Daceyville, Eastgardens, Hillsdale and Pagewood

Bayside and Randwick Councils have jointly completed a Flood Study of the Birds Gully and Bunnerong Road catchment. Bayside Council also completed a Flood Study of the Springvale Drain and Floodvale Drain catchments. These studies will be on public exhibition between 6 August and 6 September.

Enquiries on (02) 9137 5004 or email flooding@bayside.nsw.gov.au

Draft Swimming Pool Inspection Program

A draft will be available for public comment until 27 August.

Muddy Creek Masterplan

Council is developing a Master Plan for the Muddy Creek precinct in Kyeemagh and needs your feedback. The draft document is open for comment until 25 August.

Proposed Voluntary Planning Agreement

For 83-85 Railway Street, Rockdale. The proposed VPA on public exhibition. Submissions close on 30 August.

View all documents:	**Online**	haveyoursay.bayside.nsw.gov.au
	In person	at Council's Customer Service Centres
Provide feedback:	**Online**	haveyoursay.bayside.nsw.gov.au
	Via email	haveyousay@bayside.nsw.gov.au
	In writing	PO Box 21, Rockdale NSW 2216

Figure 2.2.2: The Southern Courier Advertisement in August 2019

3.0 Have your Say website summary of engagement on Draft Floodplain Risk Management Study

Table 3.1: Have your say summary

Number of days open	71 days
Number of visits to Have Your Say website	73
Maximum Visitors per day	13
Number of Document visits	25
Number of Document downloads	26
Number of visitor attended at drop in session	4

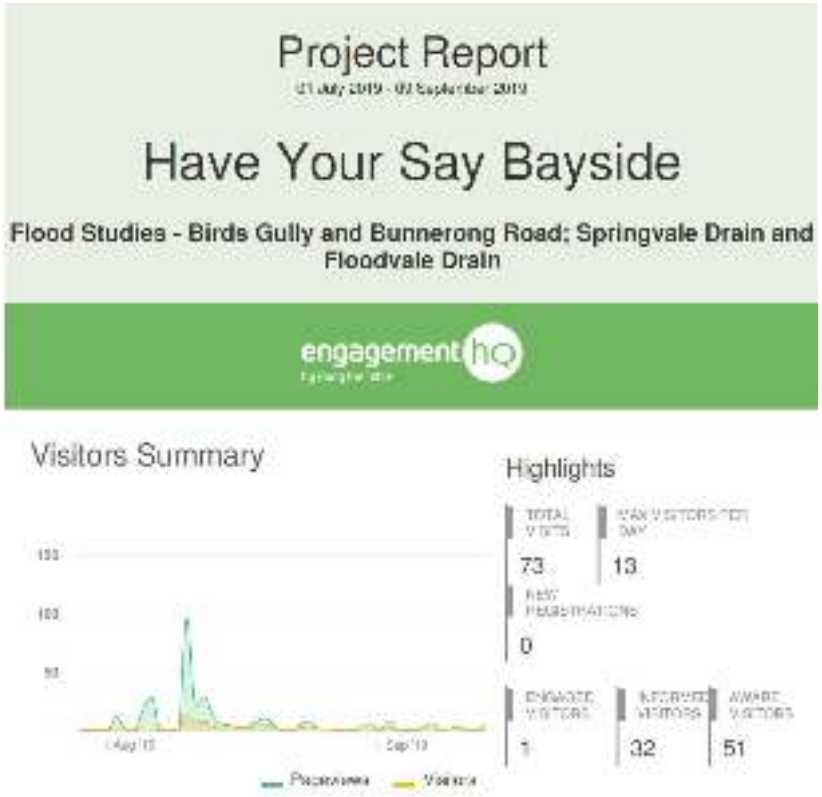


Figure 3.1: Have your say project report

Table 3.2: Have your say participant summary

Aware Participants	51
Aware Actions Performed	Participants
Visited a Project or Tool Page	51
Informed Participants	**32**
Informed Actions Performed	Participants
Viewed a video	0
Viewed a photo	0
Downloaded a document	22
Visited the Key Dates page	1
Visited an FAQ list Page	18
Visited Instagram Page	0
Visited Multiple Project Pages	30
Contributed to a tool (engaged)	1

Engaged Participants	1		
Engaged Actions Performed	Registered	Unverified	Anonymous
Contributed on Forums	0	0	0
Participated in Surveys	0	0	0
Contributed to Newsfeeds	0	0	0
Participated in Quick Polls	0	0	0
Posted on Guestbooks	0	0	0
Contributed to Stories	0	0	0
Asked Questions	1	0	0
Placed Pins on Places	0	0	0
Contributed to Ideas	0	0	0

Table 3.3: Engagement Summary

Widget Type	Engagement Tool Name	Visitors	Views/Downloads
Document	Birds Gully and Bunnerong Road - Flood Study Volume 1 (compressed)	14	14
Document	Birds Gully and Bunnerong Road - Study Area Map	13	14
Document	Springvale Drain and Floodvale Drain - Flood Study	7	8
Document	Springvale Drain and Floodvale Drain - Study Area Map	6	6
Document	Springvale Drain and Floodvale Drain - Floodplain Risk Management ...	5	5
Document	Birds Gully and Bunnerong Road - Flood Study Volume 2 (compressed)	5	5
Document	Springvale Drain and Floodvale Drain - Appendix A Figures 19-34	3	3
Document	Springvale Drain and Floodvale Drain - Appendix A Figures 1-18	3	3
Document	deleted document from	1	1
Document	Springvale Drain and Floodvale Drain - Appendix B	1	1
Faqs	faqs	13	15
Key Dates	Key Date	1	1

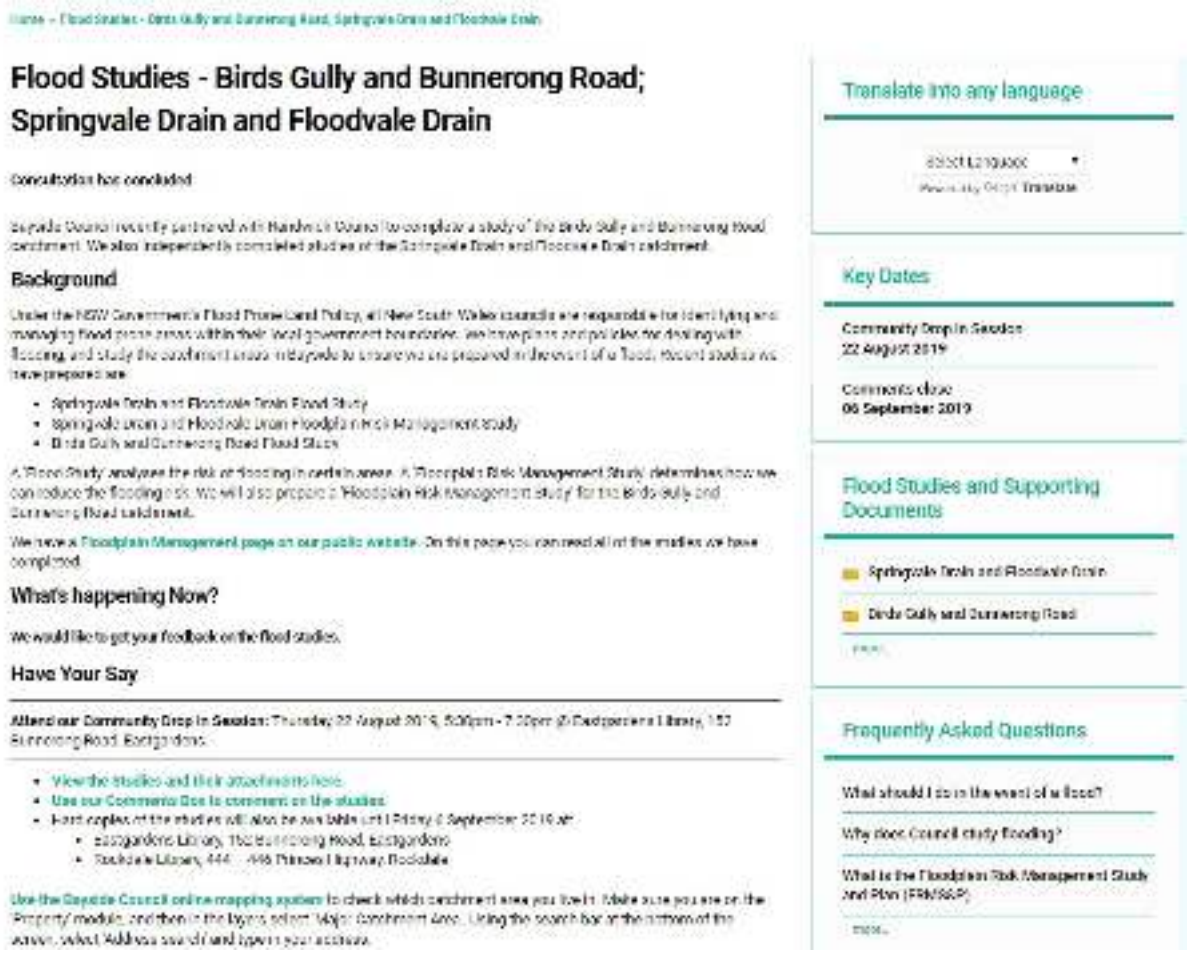


Figure 3.2: Have your say project webpage

4.0 Submissions

There were a total of 5 comments received from the community via 3 sources.

Table 4.1: Submission Summary

Submission source/forum	# Submissions received
Phone	2
Email	1
Drop in session	2
Total	5

All submissions and responses to the comments regarding the Springvale Drain and Floodvale Drain Draft Floodplain Risk Management Study are provided in the table 4.2.

Phone	Resident from [censored] Sargent Larkin Crescent, Daceyville: - Where is birds gully and SDFD catchment - People has fear of flooding - Not flooded in last 60 years. - No flood history	Birds Gully catchment encompasses the suburbs of Daceyville and Hillsdale and part of Eas Springvale Drain and Floodvale Drain catchment include the suburbs of Pagewood, Eastgar Banksmeadow. Under the NSW Government's Flood Prone Land Policy Council is responsible for identifying prone areas within their local government boundary. There is no new change in flood affecta flooding to this site. Through the flood study, Council now has a better understanding of floo This will help the community to prepare for the flooding event. Floods do not occur in a regular pattern. There may be a period of no floods and a period of example, the last time the Brisbane River flooded before the 2011 disaster was in 1974. Res in more recent times had not experienced flooding until the floods in January 2011. Followin floods can occur.
Phone	Resident from [censored] Bunnerong Road, Hillsdale Q What is the flood study? Is the risk only to my unit? Q It seems Bunnerong Road has depression in front of my property. Is there any drainage upgrade you will do so that flood risk goes away? Q Will it cost me anything?	Flooding can cause significant damage to property and risk to life. Flood study identifies floo the areas flooded, water depth, hazard categories and the likelihood of flooding within the ca adjacent to [road number censored, Bunnerong Road] are in the risk of 1% AEP flooding. A floodplain risk management study (FRMS) for Birds Gully Bunnerong Road catchment will future to identify options to mitigate flood risk in this area subject to the funding and budget. Planning controls are considered the best and most economical approach to reduce flood ris The next step is for Council to further investigate the most feasible options to mitigate floodi subject to funding. Future FRMS and mitigation options will not cost anything to the residents and property own
Email	[No address was provided] Could you please provide me with a link or a copy of the recent flood study reported that is on exhibition, or inform me where I can review it. I look forward to your reply.	You can download the report from the have your say website. Please find the link below: https://haveyoursay.bayside.nsw.gov.au/flood-studies https://haveyoursay.bayside.nsw.gov.au/flood-studies/documents Thank you
in session	Resident from [censored] Heffron Road, Pagewood: - Drainage easement through the site gets blocked with leaves - Road drainage caused ponding in front of the driveway and in heavy rainfall, floods the property. -Neighbouring property has planted more trees in the driveway outside the property which will.	Council's city works department confirmed that tree roots have been removed and all the joi A CCTV investigation was completed in September 2019. It was identified that the 300mm p the western boundary of this property connecting the pit along the road gutter travels uphill a around 5m which causes the accumulation of sediment and debris. Pits and pipes has signif sediment. City works department has engaged a consultant to remove the sediment and cle Council will investigate the option to install soakage pits in Heffron Road to increase absorpt overland flow through the existing easement.

in session	open spaces?	

ack received via have your say website and online enquiry form

Appendix C

APPENDIX C: FLOOD DAMAGES ASSESSMENT

C.1. Quantification of Damages

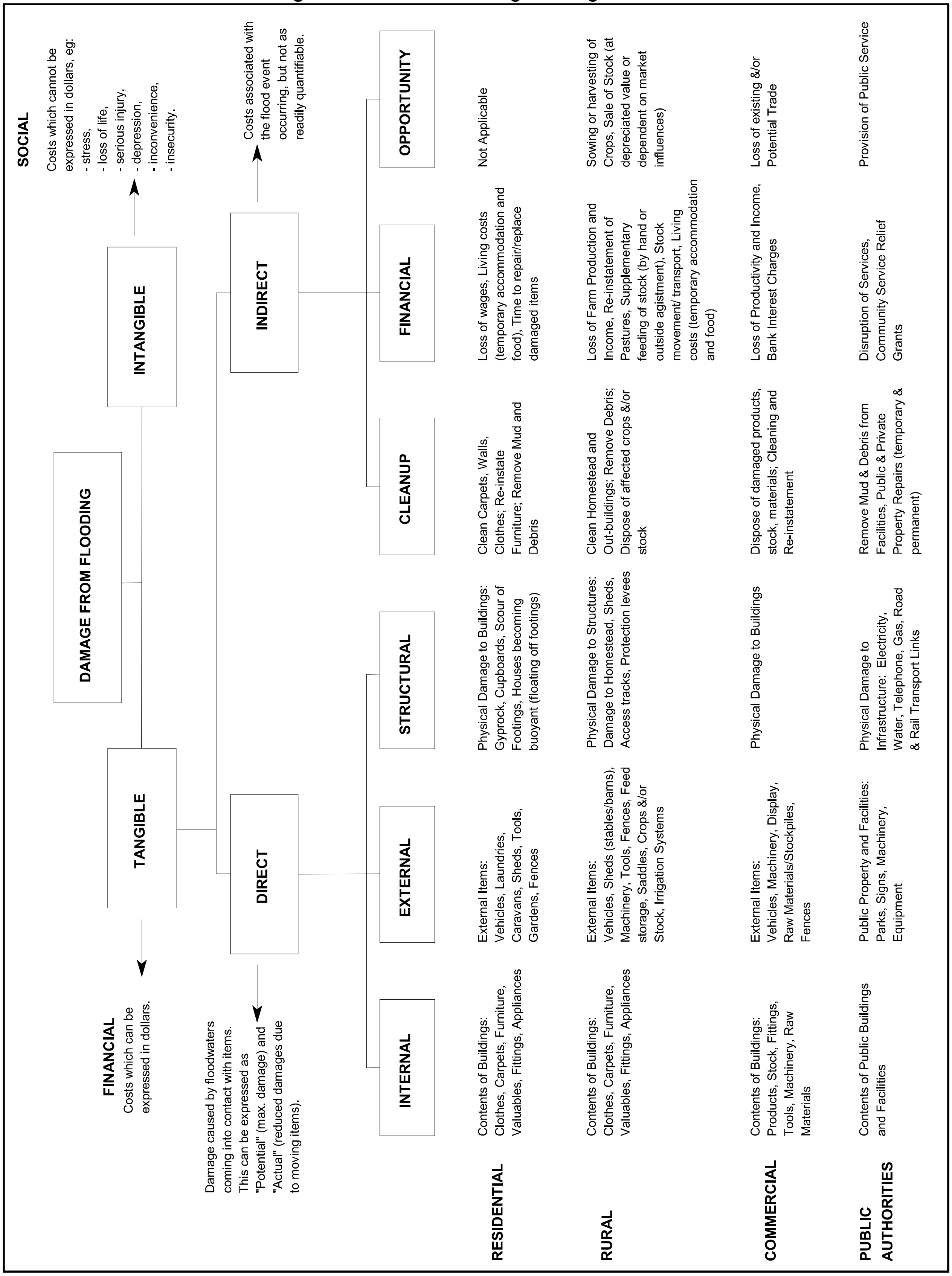
The quantification of flood damages is an important part of the floodplain risk management process. Flood damages can be defined as actual or potential, where actual damage refers to the damage incurred during known flood events, and potential damage is an estimation of the damage that could occur. Calculating potential flood damages gives a potential value of damage per property per design flood event, and an overall average annual damages value which is the average cost to property owners per year owing to flood damages. By quantifying flood damage for a range of design events, appropriate cost effective management measures can be analysed in terms of their benefits (reduction in damages) versus the cost of implementation. The cost of damage and the degree of disruption to the community caused by flooding depends upon many factors including;

- The magnitude (depth, velocity and duration) of the flood;
- Land use and susceptibility to damages;
- Awareness of the community to flooding;
- Effective warning time;
- The availability of an evacuation plan or damage minimisation program;
- Physical factors such as failure of services (sewerage), flood borne debris; and
- The types of asset and infrastructure affected.

The estimation of flood damages tends to focus on the physical impact of damages on the human environment and can be defined as being tangible or intangible. Tangible damages are those for which a monetary value can be easily assigned, while intangible damages are those to which a monetary value cannot easily be attributed. Types of flood damages are shown on Diagram C1 overleaf.

The floor levels of the residential and industrial properties within the PMF extent have been estimated by WMAwater with the use of ALS data in combination with visual inspection of property floor level heights above ground. The floor levels are used in the approximation of flood damages in Section 9.

Diagram C1: Flood Damage Categories



C.2. Identifying Flood Affected Properties

The damages assessment does not only look at potential costs due to flooding but also identifies when properties are likely to become flood affected by either flooding on the property or by over floor flooding.

C.3. Tangible Flood Damages

Tangible flood damages are comprised of two basic categories; direct and indirect damages (Diagram C1). Direct damages are caused by floodwaters wetting goods and possessions resulting in cost of replacement or repair, or in a reduction of their value. Direct damages are further classified as either internal (damage to the contents of a building including carpets, furniture), structural (referring to the structural fabric of a building such as foundations, walls, floors, windows) or external (damage to all items outside the building such as cars, garages). Indirect damages are the additional financial losses caused by the flood for example the cost of temporary accommodation, loss of wages by employees etc.

Given the variability of flooding and property and content values, the total likely damages figure in any given flood event is useful to get a feel for the magnitude of the flood problem, however it is of little value for absolute economic evaluation. However, considering damages estimates is useful when studying the economic effectiveness of proposed mitigation options. Understanding the total damages prevented over the life of the option in relation to current damages, or to an alternative option, can assist in the decision making process.

C.4. Expressing Flood Damages

Average Annual Damages (AAD) is equal to the damage caused by all floods over a period of time divided by the number of years in that period, and represents the equivalent average damages that would be experienced by the community on an annual basis. This means that the smaller floods, which occur more frequently, are given a greater weighting than the rare catastrophic floods. Total potential damage refers to the total damage estimated for a given flood event. Average damage per property is the total damage estimated for a particular flood event divided by the number of properties flood affected in this event; either by flooding on the yard and/or above floor level of a building.

C.5. Calculating Tangible Flood Damages

The flood damages assessment was undertaken for existing development in accordance with current OEH guidelines (Reference 9) and the Floodplain Development Manual (Reference 8). Potential flood damages were calculated with the use of height-damage curves which relate the depth of water above the floor with tangible damages. The height-damage curves were established in accordance with OEH guidelines (Reference 9)

For residential damages the values used are based on the recommendations in the guidance with a post late 2001 adjustment factor applied to increase damage values

according to changes in Average Weekly Earnings (AWE) since 2001. Separate curves were established for non-residential damages.

Structural damages vary on whether the property is slab/low set or high set. For the purpose of this study, any property with a floor level of 0.5 m or more above ground level was assumed to be high set.

In calculating AAD, it was assumed that there would be no flood damages in events smaller than the 5-year ARI event.

Commercial and industrial damages are typically higher than residential damages, and as such a multiplier was applied to the total damage per property for each event by adjusting the typical building size value within the curve development calculations. Other factors, including the clean-up costs and external damages, were adjusted to reflect the differences between commercial and residential properties.

To adjust the residential damage curve to be applicable to non-residential development, the average contents damages for a business was estimated to be $150,000 and the clean-up costs have been estimated at $4,000. This was done to take into account the higher costs that businesses would incur compared to residential dwellings when flooded above floor level. The commercial damages curves were also amended to reduce the bench height based on the assumption that many commercial premises would have stock from floor level. External damage was set at $1,250 as per residential properties. The parameters assumed in the stage-damages curves are presented in Table C1, and the resultant curves are shown in Diagram D2 and D3. The Rock and Lockhart FRMS&P investigated a range of methods for the assessment of commercial damages in consultation with OEH, the preferred method is that which has been adopted for this study. The adopted values for the residential damages assessment are listed below.

Table C1 Stage-Damage Curve Parameters

SITE SPECIFIC INFORMATION FOR RESIDENTIAL DAMAGE CURVE DEVELOPMENT			
Version 3.01 June 2011			
PROJECT	**DETAILS**	**DATE**	**JOB No.**
Springvale Drain and Floodvale Drain FRMS	**Residential Only**	**Feb 2017**	**115073**
BUILDINGS			
Regional Cost Variation Factor	1.00	*From Rawlinsons*	
Post late 2001 adjustments	1.50	*Changes in AWE see AWE Stats Worksheet*	
Post Flood Inflation Factor *Multiply overall structural costs by this factor*	1.00	*1.0 to 1.5 Judgement to be used. Some suggestions below*	
	Regional City		*Regional Town*

	Houses Affected		Factor	Houses Affected		Factor
Small scale impact	<	*50*	*1.00*	<	*10*	*1.00*
Medium scale impacts in Regional City		*100*	*1.20*		*30*	*1.30*
Large scale impacts in Regional City	>	*150*	*1.40*	>	*50*	*1.50*
Typical Duration of Immersion	2 to 10	hours				
Building Damage Repair Limitation Factor	0.85	*due to no insurance*		*short duration*		*long duration*
		Suggested range		*0.85*	*to*	*1.00*
Typical House Size	240	m^2	*240*	*m^2 is Base*		
Building Size Adjustment	1.0					
Total Building Adjustment Factor	**1.28**					
CONTENTS						
Average Contents Relevant to Site	$ 60,000		*Base for 240 m^2 house*		*$ 60,000*	
Post late 2001 adjustments	1.50	*From above*				
Contents Damage Repair Limitation Factor	0.90	*due to no insurance*		*short duration*		*long duration*
		Suggested range		*0.75*	*to*	*0.90*
Sub-Total Adjustment Factor	1.35					
Level of Flood Awareness	low	*low or high only. Low default unless otherwise justifiable.*				
Effective Warning Time	0	hour				
Interpolated DRF adjustment (Awareness/Time)	1.00	IDRF = Interpolated Damage Reduction Factor				
Typical Table/Bench Height (TTBH)	0.90	*0.9m is typical height. If typical is 2 storey house use 2.6m.*				
Total Contents Adjustment Factor AFD <= TTBH	**1.35**	AFD = Above Floor Depth				
Total Contents Adjustment Factor AFD > TTBH	**1.35**					
Most recent advice from Victorian Rapid Assessment Method						
Low level of awareness is expected norm (long term average) any deviation needs to be justified.						
Basic contents damages are based upon a DRF of	*0.9*					
Effective Warning time (hours)	***0***	***3***	***6***	***12***	***24***	
RAM Average IDRF Inexperienced (Low awareness)	*0.90*	*0.80*	*0.80*	*0.80*	*0.70*	
DRF (ARF/0.9)	*1.00*	*0.89*	*0.89*	*0.89*	*0.78*	
RAM AIDF Experienced (High awareness)	*0.80*	*0.80*	*0.60*	*0.40*	*0.40*	
DRF (ARF/0.9)	*0.89*	*0.89*	*0.67*	*0.44*	*0.44*	
Site Specific DRF (DRF/0.9) for Awareness level for iteration	*1.00*	*0.89*	*0.89*	*0.89*	*0.78*	
Effective Warning time (hours)	*0*	*3*	*0*			
Site Specific iterations	*1.00*	*0.89*	*1.00*			
ADDITIONAL FACTORS						
Post late 2001 adjustments	1.50	*From above*				
External Damage	$ 6,700	*$6,700 recommended without justification*				
Clean Up Costs	$	*$4,000 recommended without*				

	4,000		*justification*			
Likely Time in Alternate Accommodation	3	weeks				
Additional accommodation costs /Loss of Rent	$ 220	*$220 per week recommended without justification*				
TWO STOREY HOUSE BUILDING & CONTENTS FACTORS						
Up to Second Floor Level, less than	2.6	m	70%	Single Storey Slab on Ground		
From Second Storey up, greater than	2.6	m	115%	Single Storey Slab on Ground		
Base Curves		AFD = Above Floor Depth				
Single Storey Slab/Low Set	13164	+	4871	x	AFD	in metres
Structure with GST	AFD	greater than	0.0	m		
Validity Limits	AFD	less than or equal to		6	m	
Single Storey High Set	16586	+	7454	x	AFD	
Structure with GST	AFD	greater than	-0.001	m		
Validity Limits	AFD	less than or equal to		6	m	
Contents	20000	+	20000	x	AFD	
Contents with GST	AFD	greater than		0		
Validity Limits	AFD	less than or equal to		2		

Diagram C2: Flood Damages Curves – Residential Property

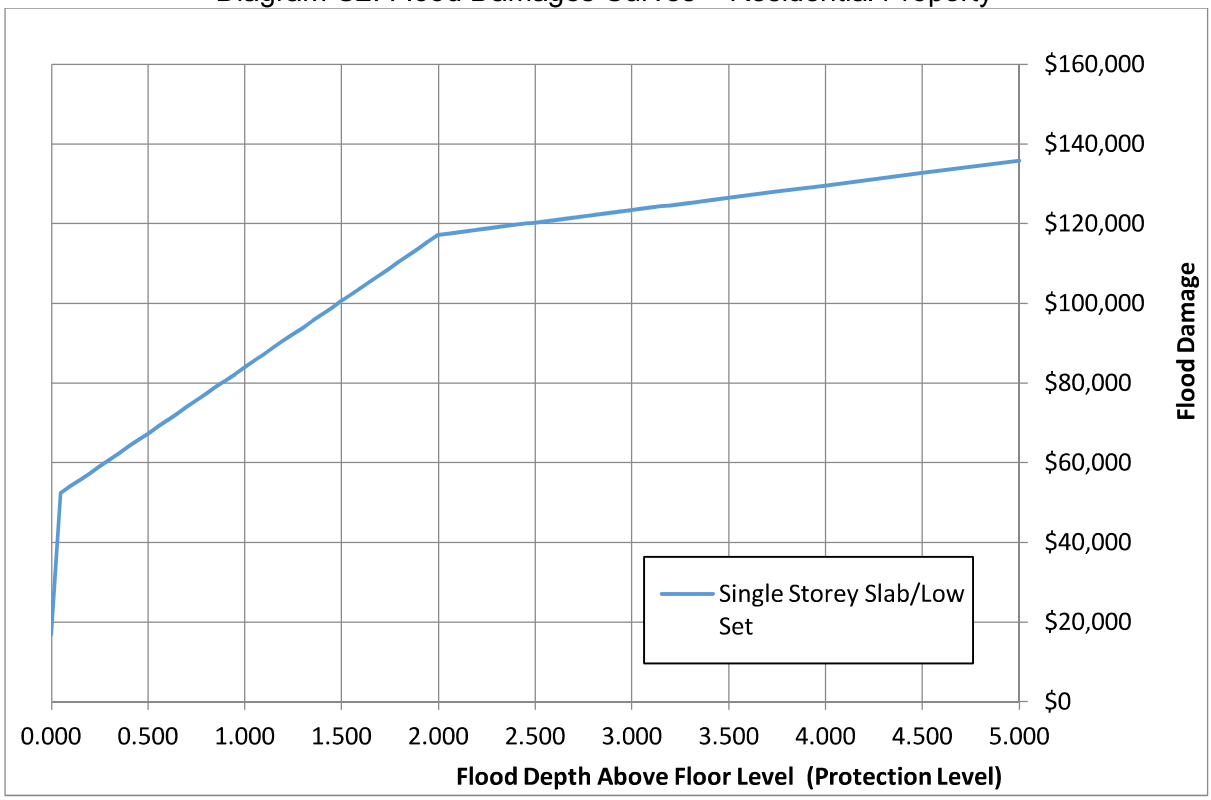
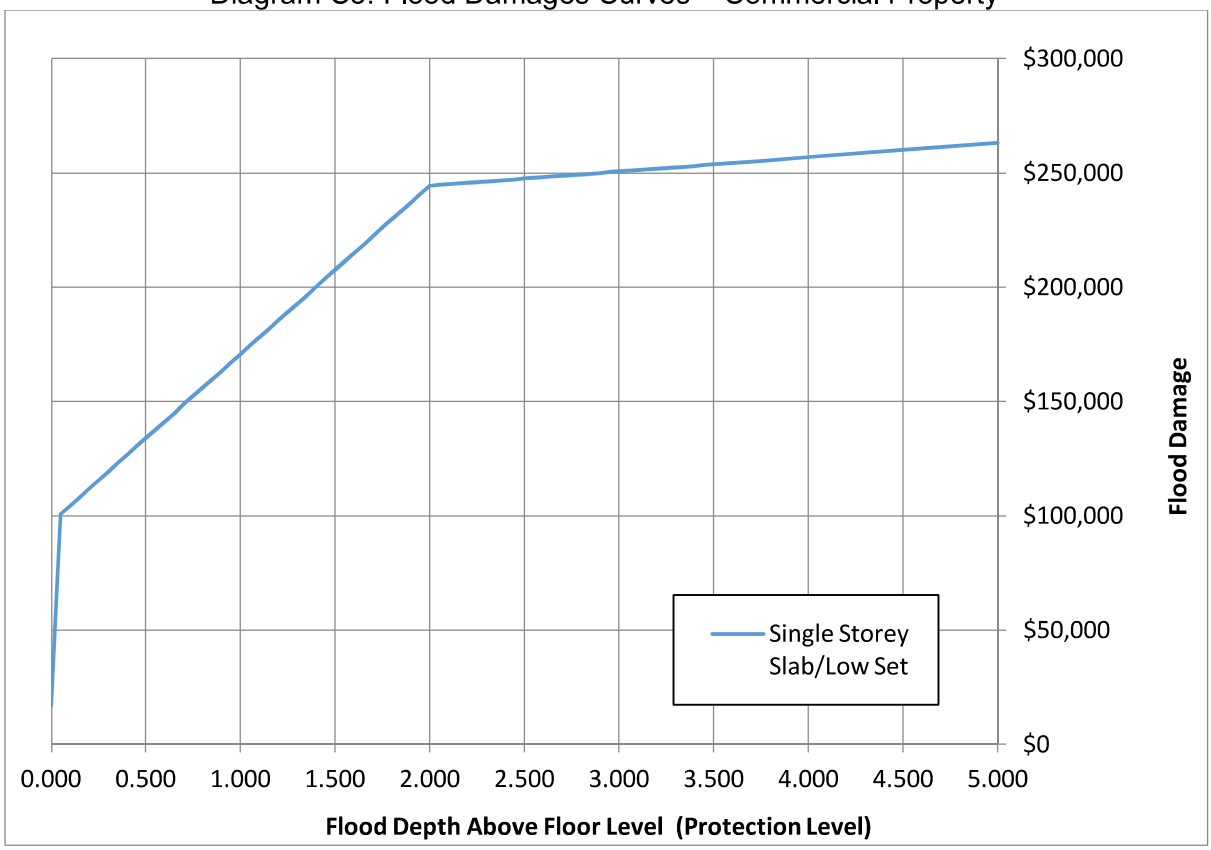


Diagram C3: Flood Damages Curves – Commercial Property



The OEH guidelines suggest a protection level be applied when calculating damages. This effectively reduces the floor level by the given amount (usually 0.5 m). This level of protection is considered overly conservative and has not been applied in this instance. Incorporating this 0.5 m 'level of protection' would lead to Council financing flood management measures that provide little benefit.

C.6. Intangible Flood Damages

The intangible damages associated with flooding, by their nature, are inherently more difficult to estimate in monetary terms. In addition to the tangible damages discussed above, additional costs/damages are incurred by residents affected by flooding, such as stress, risk/loss to life, injury, loss of sentimental items etc. It is not possible to put a monetary value on the intangible damages as they are likely to vary dramatically between each flood (from a negligible amount to several hundred times greater than the tangible damages) and depend on a range of factors such as the size of flood, the individuals affected, and community preparedness. However, it is still important that the consideration of intangible damages is included when considering the impacts of flooding on a community.

Post flood damages surveys have linked flooding to stress, ill-health and trauma for residents. For example the loss of memorabilia, pets, insurance papers and other items without fixed costs and of sentimental value may cause stress and subsequent ill-health. In addition flooding may affect personal relationships and lead to stress in domestic and work situations. In addition to the stress caused during an event (from concern over property damage, risk to life for the individuals or their family, clean up etc.) many residents who have experienced a major flood are fearful of the occurrence of another flood event and the associated damage. The extent of the stress depends on the individual and although the majority of flood victims recover, these effects can lead to a reduction in quality of life for the flood victims.

During any flood event there is the potential for injury as well as loss of life due to causes such as drowning, floating debris or illness from polluted water. Generally, the higher the flood velocities and depths the higher the risk. The Kiama Surf Beach study area generally is classified as high hazard for areas along the main waterway, however the hazard farther from the main channel is generally catergorised as low hazard.

C.7. Benefit/Cost Analyses for Management Options

To assess the full monetary benefits, including taking into account costs of construction and maintenance, Net Present Value (NPV) calculations were used and a Cost-Benefit (B/C) ratio established. The B/C approach is used to quantify the economic worth of each option enabling the ranking against other options. A B/C ratio is the benefits expressed in monetary terms, i.e. the reduction in AAD, compared to the actual likely cost of achieving those benefits, i.e. construction and maintenance costs.

The AAD per annum in today's monetary terms was assumed to apply for each year of the NPV damage calculation and was established for each year based on a discount rate of 7% as per the recommendation in the Residential Flood Damages FRM Guidelines (Reference 9). A construction cost was estimated and, using the NPV of the AAD assuming lifetime of 20-years, the B/C ratio was established for each of the options.

Appendix D

City of Botany Bay

SPRINGVALE AND FLOODVALE DRAIN FRMS/P LOWER CATCHMENT INVESTIGATION

FINAL REPORT

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May 2017

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SPRINGVALE AND FLOODVALE DRAIN FRMS/P LOWER CATCHMENT INVESTIGATION

FINAL REPORT

MAY 2017

Project **Springvale and Floodvale Drain FRMS/P Lower Catchment Investigation**	**Project Number** **115073**
Client City of Botany Bay Council	**Client's Representative** Abu Ahmed
Authors Catherine Goonan Rhys Hardwick-Jones Richard Dewar	**Prepared by**
Date 22 May 2017	**Verified by**

Revision	Description	Distribution	Date
2	Final Report: For inclusion in FRMS	Bayside Council	May 2017
1	Draft report for Lower Catchment Investigation	CBBC	Feb 2016

SPRINGVALE AND FLOODVALE DRAIN FRMS/P
LOWER CATCHMENT INVESTIGATION

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EXECUTIVE SUMMARY

This report assesses floodplain management issues in the lower region of the Springvale Drain and Floodvale Drain catchment around Exell St, McPherson St and Botany Rd, and investigates potential management options for the area. This area was identified as a priority for the FRMS/P due to capital works funding available if suitable works could be identified.

This report will form part of the complete catchment-wide Floodplain Risk Management Study (FRMS) which will be undertaken in the coming months. Following on from the Flood Study undertaken for the Springvale and Floodvale Drain catchments by BMT WBM (2014), this report has been undertaken in accordance with the NSW Government's Flood Prone Land Policy.

The assessment includes consideration of flood hazard across the focus area, flooding of commercial and industrial properties and identification of known flooding issues and hotspots. A range of measures aimed at managing this flood risk were also assessed for their efficacy across a range of criteria, which will allow options to be recommended as part of the Floodplain Risk Management Plan for the area. Measures investigated include:

- modifications of Botany Road to align overland flowpaths with the stormwater trunk drainage network;
- duplication of existing pipes;
- removal of unnecessary pipes and open channel obstructions, with and the clearing of open channel sections to increase conveyance where environmentally appropriate;
- clearing and maintenance of debris build-up where the SWSOOS crosses the primary open channels;
- modification of overland flow paths within Botany Golf Course to alleviate nuisance flooding of Botany Road; and
- additions to the local drainage system to alleviate nuisance flooding and improve traffic flow in the area during frequent rainfall events.

Background

Springvale Drain and Floodvale Drain are located within the Botany LGA and run from Pagewood in the north, south through Banksmeadow and terminate at ocean outfalls in Penrhyn Estuary, Botany Bay. The drains comprise both closed conduits and reaches of open channel. Covering an area of approximately 3.75 km^2, the catchment is characterised by low-lying industrial areas in the south and steeper slopes with residential development in the north.

This preliminary assessment focusses only on the southern part of the catchment, which is mainly developed with large-scale commercial-industrial use, and which has been identified by Council as a priority flood hot-spot.

Exell Street, McPherson Street and Botany Road Priority Area

There is a flood risk to some existing development as a result of catchment rainfall derived flooding for the focus area. Overtopping of the open channel banks between McPherson St and Botany Rd during intense storms will result in the inundation of properties adjacent the channel, as well as high hazard flooding of major arterial roads. Council has allocated capital works expenditure

for this area, and is the reason for this preliminary investigation into flood mitigation options for the Exell Street area.

Economic Impact of Flooding

A flood damages assessment has not been carried out at this stage. An assessment will be undertaken as part of the catchment-wide FRMS and will be based on estimated floor levels for affected properties in the study area.

Flood Risk Management Options

A range of site-specific management options were investigated for the area. Options were focussed on hotspots identified in the Flood Study, and locations identified by WMAwater during the model review process. Nine options were tested for their effect on flood behaviour in a range of design flood events, and included the lowering of Botany Rd at the Floodvale Drain, addition of swale drains, clearing of vegetation and upgrading of culverts. At this stage however, benefits are localised to the properties in the Exell Street area between McPherson Street and Botany Road. Any options recommended in this report will be revisited as part of the catchment-wide study to ensure the outcomes of the study are balanced for the broader catchment.

Recommendations

There are a number of flood mitigation options which modelling has shown to benefit the properties and roads in the Focus Area. Cost-effective and pragmatic options are identified in this report, and include the construction of a swale drain from Botany Bay Hotel into the golf course (FM01B), management of vegetation along the open channel sections of both drains (FM03) and drainage improvements at two intersections to reduce nuisance flooding (FM10). More complex and expensive mitigation measures include duplication of the pipe under Botany Road/ Botany Golf Course and maintenance of the Floodvale Drain and SWSOOS No. 2 intersection. These options will require further investigation and consultation before they can be undertaken. Section 4 also explores some measures that are not recommended for further investigation, due to being ineffective or too expensive.

1. INTRODUCTION

The Springvale Drain and Floodvale Drain Floodplain Risk Management Study and Plan (FRMS&P) is currently being undertaken by WMAwater on behalf of City of Botany Bay Council (Council) to determine appropriate and effective floodplain management options.

The flood behaviour of the Spingvale Drain and Floodvale drain catchment was defined through numerical modelling carried out by BMT WBM in January 2014 in the Springvale Drain and Floodvale Drain Flood Study (the Flood Study – Reference 2)

This Floodplain Risk Management Study assesses the floodplain management issues faced by the study area and investigates potential mitigation options. It has been carried out in accordance with the Floodplain Development Manual (Reference 1) with the following objectives:

- Review the recent flood study and update the hydraulic models where required;
- Identify requirements for floor level survey to undertake a flood damages assessment;
- Review Council's existing environmental planning policies and instruments, identify modifications required to current policies;
- Identify residential flood planning levels and flood planning area;
- Identify and assess works, measures and restrictions aimed at reducing the impacts and losses caused by flooding and consider their impacts if implemented, taking into account the potential impacts of climate change; and
- Review the local flood plan, examine the present flood warning system, community flood awareness and emergency response measures (involvement with the NSW State Emergency Service).

At the request of Council, this preliminary report focuses on a refined study area at **Exell Street**, to the south of the catchment. This report will later form part of the entire FRMS&P.

1.1. Study Area

The combined Springvale Drain and Floodvale Drain catchment covers an area of approximately 3.75 km^2 within the City of Botany Bay LGA in south-eastern Sydney. This includes the suburbs of Pagewood, Eastgardens, Botany and Banksmeadow. The drains originate in Pagewood in the north and flow south to Botany Bay via Penrhyn Estuary. The catchment is densely urbanised and consists of mainly industrial development in the south of the catchment and residential development in the upper catchment. The study area and focus area are shown in Figure 1.

Springvale Drain and Floodvale Drain form the trunk drainage system and is comprised predominantly of underground pipe in the upper catchment (north) and some open channel reaches in the lower catchment (south). The Flood Study (Reference 2) noted Springvale Drain had a total length of 3.9 km, comprising 2.5 km of closed conduit and 1.4 km of open channel, and the total length of Floodvale Drain as 2.9 km comprising 2.1 km of closed conduit and 0.8 km of open channel. The Flood Study (Reference 2) describes the alignments of both the Springvale Drain and Floodvale Drain in detail.

Located on the Botany Aquifer, the study area is characterised by highly permeable sandy soils. This can provide a high rate of infiltration following rainfall events, however due to the heavily urbanised development, there is a significant proportion of impervious land cover.

1.2. Focus Area

WMAwater are currently undertaking the Floodplain Risk Management Study for the entire study area, however Council has identified an area in the lower catchment around Exell Street, McPherson Street and Botany Road as requiring more immediate attention. Accordingly, WMAwater has prepared this report, which contains an investigation of several mitigations specific to this area, and will form part of the complete FRMS&P in the future.

2. FLOOD STUDY REVIEW

BMT WBM carried out the Springvale Drain and Floodvale Drain Flood Study on behalf of the City of Botany Bay Council in January 2014. WMAwater has undertaken a limited review of the model for the purposes of impact assessment of flood mitigation options in the Exell Street area as requested by Council. Review of the remainder of the model and suitability for other outcomes from the FRMS/P will be completed as part of the broader overall study.

The model review involved running the model provided by Council (23rd December 2015). WMAwater found that using Scenario 'B', i.e. 50% pipe blockage produced results most similar to those produced by BMT WBM. There were some differences which will be investigated further in the catchment-wide FRMS, but the results produced by WMAwater were deemed close enough for the purpose of undertaking an options assessment for this preliminary report.

The Flood Study (Reference 2) did not assign a critical duration for the Springvale Drain and Floodvale Drain catchment, but rather used an envelope of different storm events that were critical in different regions. During the model review it was found that the 9 hour design storm was critical in the Exell Street area, and was therefore used for the assessment and comparison of mitigation options.

Verification of the accuracy of the topography and some building footprints is still required. It is unclear whether some recent developments have been included in the modelling, and some further revision may be required for the catchment wide FRMS, which may change results slightly for both existing flood behaviour and the assessed options.

3. Assessment of Flood Risk

3.1. Overview of Flood Risk

The January 2014 Flood Study (Reference 2) defined existing levels of flood risk within the catchment. The Flood Study included consideration of pit/pipe, overland flow, open channel flow, and tidal flood mechanisms in the study area. The Flood Study identified significant areas of flood affectation, particularly in the lower catchment around McPherson St and Exell St, as well as residential areas in Pagewood near Pagewood Public School, Holloway and Gibsons Streets. In the affected areas, the following factors have a significant influence on the flood risk:

- development of low-lying land;
- lack of defined watercourses for major flows (with flows that exceed the trunk drainage capacity generally flowing along road reserves, or in some cases through private property);
- limited cross-drainage capacity at key floodplain features like the railway line and SWSOOS, with low-points near these features being susceptible to exacerbated flooding from blockage.

Apart from the flood risk to property, another significant issue for the catchment is the flooding of major arterial roads and potential interruption of daily activities during times of flooding. Key transport links in the catchment have historically been cut by nuisance flooding causing disruption. Assessment of trunk drainage capacity potential for blockage in relation to road serviceability is a key issue for the study. It is also important to provide suitable interpretation of the flood behaviour for the SES to identify priority locations and manage flood response accordingly.

3.2. Hydraulic Hazard

The provisional hydraulic hazard categories determined here are based on the method prescribed by the Floodplain Development Manual 2005, Appendix L (Reference 1). The two categories of hazard shown in the figures (high and low hazard) are used to inform the management of flood risk in the study area, as they describe the severity of the flood at a certain location in terms of its depth and velocity.

The figures provided in the Flood Study (Reference 2) were based on the enveloped critical storm durations. WMAwater reproduced these figures for the 9 hour duration, as this was found to be critical in the Focus Area. Figure 2 and Figure 3 show the provisional hazard categories for the 20% AEP and 1% AEP event respectively. The figures show areas of high hazard along Botany Road at the Botany Bay Hotel, and at the property at 1767 Botany Road. Reducing the hazard in these areas has become the target for several mitigation options.

3.3. True Hazard

True Hazard will be defined in the catchment-wide FRMS. The provisional hydraulic hazard was used for the purposes of flood mitigation option assessment in the Exell Street area.

3.4. Hydraulic Categories

Hydraulic categories describe the flood behaviour by categorising areas depending on their function during the flood event, specifically, whether they transmit large quantities of water (floodway), store a significant volume of water (flood storage) or do not play a significant role in either storing or conveying water (flood fringe). As with categories of hazard, hydraulic categories play an important role in informing flood-related planning decisions in an area. The hydraulic categories will be investigated as part of the full Floodplain Risk Management Study report, however are not included in this preliminary assessment.

3.5. Existing Floodplain Management

The Botany Bay City Council is currently undertaking various stages of the Floodplain Risk Management Process for its five main catchment areas in order to develop a comprehensive Floodplain Risk Management Plan for its LGA. The catchment areas include:

- Mascot, Eastlakes and part of Rosebery (Flood Study completed);
- Botany Bay Foreshore Beach (Flood Study underway);
- Springvale Drain & Floodvale Drain (FRMS/P underway);
- Bunnerong Creek (Shared with Randwick Council); and
- Daceyville (shared with Randwick Council).

3.6. Flooding Hotspots

A number of areas prone to inundation were identified in the Flood Study (Reference 2), however at the request of Council, this report focusses on flooding issues at the following locations:

- McPherson Street, Banksmeadow;
- Botany Road, Banksmeadow, at the following locations:
    - 1767 Botany Rd
    - Botany Bay Hotel
- Overbank flooding along Springvale Drain upstream of the SWSOOS No. 2 Intersection; and
- Overbank flooding along Floodvale Drain between the SWSOOS No. 2 and Botany Rd.

4. FLOOD MITIGATION OPTIONS

4.1. Background

Floodplain risk management measures are actions which can be undertaken in both the short and long term which mitigate the risk of flooding. These include flood modification measures such as drainage infrastructure upgrades and retarding basins, response measures such as emergency response planning and community education, and property modification measures such as house raising and development planning controls.

4.1.1. Categories of Floodplain Management Measures

Flood modification measures modify the physical behaviour of a flood including depth, velocity and redirection of flow paths. Typical measures include flood mitigation dams, retarding basins, on-site detention, channel improvements, levees or floodways. Pit and pipe improvement and even pumps may also be considered in some cases.

Property modification measures modify the existing land use and development controls for future development. This is generally accomplished through such means as flood proofing, house raising or sealing entrances, strategic planning such as land use zoning, building regulations such as flood-related development controls, or voluntary purchase.

Response modification measures modify the response of the community to flood hazard by educating flood affected property owners about the nature of flooding so that they can make better informed decisions. Examples of such measures include provision of flood warning and emergency services, improved information, awareness and education of the community and provision of flood insurance.

Table 1 below provides a summary of floodplain risk management measures that are typically considered during a Floodplain Risk Management Study.

Table 1: Flood Risk Management Measures

Flood Modification	Property Modification	Response Modification
Retarding basins	Land zoning	Community awareness/preparedness
Channel modifications	Voluntary purchase	Flood warning
Levees	Building & development controls	Evacuation planning
Temporary defences	Flood proofing	Evacuation access
Drainage Capacity Enhancement	House raising	Flood plan / recovery plan
	Flood access	Flood insurance

4.1.2. Options Considered

WMAwater has undertaken an assessment of several flood mitigation options in the focus area, that either alter design flood levels, properties affected by the floodwater or the response to the flood. These options include:

Option FM01: Modifications to Botany Road

Option FM02: Duplication of Floodvale Drain Pipe under Botany Rd

Option FM03: Vegetation management in open-channel sections (both drains)
Option FM04: Combination of Option FM01 and Option FM03
Option FM05: Combination of Option FM02 and Option FM03
Option FM06: Increasing the Springvale Drain open channel size
Option FM07: Removal of a culvert within Springvale Drain
Option FM08: Debris removal and maintenance at the Floodvale Drain/SWSOOS No.2 Culvert
Option FM09: Combination of Options FM01, FM03, FM07 and FM08

Each option was assessed for two design flood events, the 20% AEP and 1% AEP event. This was to gain an appreciation of the impacts the option had in a more frequent, smaller event, as well as a more significant event.

The following sections outline the works involved in each option, their impacts on flood behaviour, a preliminary costing where appropriate and a subsequent recommendation for Council.

4.2. Lowering of Botany Rd and Partial Duplication of Pipe (FM01)

4.2.1. Aim

To protect properties adjacent to Floodvale Drain directly north of Botany Road by directing overland flow across the road and into Botany Golf Course and increasing culvert capacity.

To reduce water levels on private property directly east of Floodvale Drain and Botany Road.

4.2.2. Discussion

Modelling undertaken in the Flood Study (Reference 2) has shown that the capacity of Floodvale Drain is exceeded and its banks overtopped in events as frequent as the 20% AEP event. This results in water ponding in the car parks around buildings, posing a risk to employees and potential threat to stock or goods stored on site. Option FM01 seeks to re-direct flows which exceed the Floodvale Drain culvert capacity at Botany Road into the golf course, rather than being diverted to the east and inundating commercial buildings as currently occurs. This diversion occurs primarily because the Botany Road sag point is not aligned with the trunk drainage alignment, and the road level is significantly higher than the development adjacent to the channel.

The option involves lowering a portion of Botany Road to 2.7 mAHD, which is the level of the lowest point in the carpark 1767 Botany Rd (Lot C, DP345113). This will cause water to flow across the road to the south, rather than spilling out to the east. At its lowest, the road would be up to 0.8 m lower than its existing level. This would create a new localised sag point in Botany Rd. Excavation of this road as part of the works would also provide an opportunity to duplicate a portion of the existing 1800mm pipe beneath Botany Road. Completion of the pipe duplication is investigated in Section 4.3. Modification of a segment of earth embankment along the north boundary of Botany Golf Course would be required (see Photo 1) to allow flow across the road, and possibly some minor works in the golf course itself to facilitate drainage from the area.

Botany Bay Golf Course is a 9-hole public golf course. It is located between Botany Rd and Foreshore Rd, bounded by Fremlin St on the west. There is a discontinuous earth embankment running along the north side of the golf course along Botany Rd. On average it is approximately 2.2 m high, and acts as a barrier during floods, causing water to accumulate on the road side of the embankment. The option would involve removal of a small portion of this embankment to existing ground level in order to improve overland flow. It is expected this could be achieved while still maintaining the amenity of the embankment for the golf course.

Photo 1 Botany Golf Club's earth embankments on Botany Rd

4.2.3. Impact on Flood Behaviour

To determine the impacts of Option FM01 on flood behaviour, the TUFLOW model was altered to represent the works described above. WMAwater lowered the existing road by a maximum of 0.8 m (to 2.7 mAHD) and removed a section of existing embankment. The exact width of the proposed floodway should be determined through detailed design if the works are undertaken. At this stage it has been modelled as approximately 20 m wide.

Table 2 Option FM01 Impact on Flood Behaviour

Event	Decreased Flood Levels	Newly Flooded Areas/ Increased Flood Level	Reference Figure
20% AEP	• 1767 Botany Road (-0.05 m to -0.01 m) • Golf course (as above)	Newly flooded area on Botany Rd and in the golf course (to depth of 0.17 m)	Figure 5
1% AEP	• 1767 Botany Rd and along Botany Rd east of works, • 1801 Botany Rd and the Botany Bay Hotel. (-0.1 m to -0.2 m), • Botany Rd wet of the works and the western half of the golf course (-0.01 m to -0.05 m).	Eastern half of the golf course (0.01 m to 0.05 m)	Figure 6

4.2.4. Hydraulic Hazard on Botany Road

As shown in Figure 2 and Figure 3 there is low hazard on Botany Road at the junction with Floodvale Drain in the 20% AEP and 1% AEP event respectively. In both events there is an area of high hazard to the east at the Botany Bay Hotel site, and on Botany Road just outside it. As Option FM01 involves the lowering of Botany Rd at the Floodvale Drain junction it was necessary to confirm the option's effects on hazard at the site. As shown in Figure 5 Botany Road is newly flooded, to a maximum depth of 0.17m. An analysis of the hydraulic hazard for this option (Figure 7) shows that the hazard is still categorised as 'Low' at this site, and that other sites experience a down grade in hazard from high to low, or low to no hazard.

In the 100 year ARI event however, the lowering of Botany Road causes more significant inundation over the road and upgrades the hazard from a low to high rating. The depth over the road reaches a maximum of 1.25 m, suggesting further investigation into the level and extent of the road lowering is required.

4.2.5. Costs

A brief summary of the tasks required for the construction of Option FM01 is listed in Table 3. Appendix A outlines the breakdown of the cost estimate based on discussion with local suppliers and experience with similar projects in similar areas.

Table 3 Option FM01 Required Tasks

Construction Tasks	Maintenance Tasks
1. Detailed Design 2. Traffic Management / Detours 3. Excavation of existing road 4. Installation of southern stormwater drainage pit and connection to Floodvale Drain pipe 5. Construction of design road subgrade and topping 6. Excavation of existing golf course embankment 7. Removal of spoil 8. Native grassing over removed earth bund and newly excavated area	1. Regular clearing of debris in stormwater drain 2. Annual Maintenance

4.2.6. Recommendation

It is recommended that Option FM01 be investigated further by Council as it reduces the depth of flooding on several properties and construction is feasible. Further investigation and modelling may be required to reduce the depth of water over Botany Road in a 1% AEP event, and subsequently reduce the hazard to keep the area safe for motorists and pedestrians.

Key construction issues include traffic management during the works, and working with the Botany Golf Club to find suitable spoil sites that do not impact on site storage at the golf course or cause any adverse upstream effects. Council should be aware of possible contamination issues and that

off-site disposal may be necessary. The golf course fence would need replacing to maintain the minimum height requirements.

4.2.7. Addition of swale drain from Botany Bay Hotel to Golf Course (FM01 (A))

Option FM01 (A) is a narrow swale drain that would run from the low point on Botany Road near the Botany Bay Hotel, to the west and drain into the golf course. The swale drain was modelled situated on the road side of the golf course embankment, but it is more likely that it would have more space within the golf course. At this stage it is deemed the flood impacts would be much the same for either alignment.

As shown in Figure 5 (A), in the 20% AEP the impacts on flood levels are much the same as in Option FM01, however the introduction of the swale drain reduces flood levels around the Botany Bay Hotel and along Botany Road to Penrhyn Road. Figure 6(A) shows the impact of the 1 AEP event, and illustrates how the proposed drain yields significant flood level reductions along the length of Botany Road from east of Penrhyn Road to Floodvale Drain, and minor reductions along the western part of Botany Rd, as far west as Fremlin Street.

WMAwater identified some issues with the DEM in the vicinity of the Botany Bay Hotel and the nearby roundabout on Botany Rd. The DEM indicates that there is a significant localised sag point, primarily within the Botany Bay Hotel area, which does not appear to be realistic. It is likely that this is a numerical artefact from the DEM processing rather than a real topographic feature. The DEM may need revision in this location as part of the ongoing FRMS work.

For the purposes of option assessment for the lower catchment focus area, this DEM issue is unlikely to significantly affect the outcomes, since it is included in both “existing” and “option” conditions. However, with the modelling as it is, the existing hazard in the hotel area and Botany Road itself is probably over-stated by the design flood modelling.

4.3. Duplication of Floodvale Drain under Botany Rd (FM02)

4.3.1. Aim

To protect properties directly north of Botany Road near Floodvale Drain by increasing the culvert capacity under Botany Rd.

To reduce water levels on private property directly east of Floodvale Drain.

Photo 2 Existing 1800mm Floodvale Drain Culvert under Botany Rd

4.3.2. Discussion

There is currently one 1800 mm diameter concrete pipe approximately 195 m long that runs below Botany Rd. It remains a closed underground conduit from the north side of Botany Rd, through Botany Golf Course and under Foreshore Rd to the outfall at Botany Bay. The Flood Study (Reference 2) notes that 'this reach of conduit is subject to tidal influence and the deposition of sand and silt may contribute to the reduction in capacity', thought this was not investigated during assessment of Option FM02.

It is proposed to duplicate this pipeline to increase its capacity and thereby reduce upstream flood levels. The works are outlined in Section 4.3.4 and would involve a road crossing beneath Botany Road and Foreshore Road, and trenching through the golf course.

At the Foreshore Road outfall, the trunk drain is significantly larger than the 1800 mm pipe at Botany Rd, comprising two large box culverts (see Photo 3). It is not currently known at what point the increase in pipe size occurs, although it is likely to be somewhere within the golf course between Botany Rd and Foreshore Drive, possible immediately upstream of Foreshore Drive.

Further inspection of this pipeline (possibly by CCTV robot) is required to determine the length of pipe from Botany Road that would need to be duplicated.

Photo 3 Floodvale Drain outlet downstream of Foreshore Road

Partial duplication of the pipe was investigated for this study, in conjunction with the lowering of Botany Rd (Section 4.2). It would be possible to duplicate the pipe beneath the road, even if complete duplication of the entire pipe length is not carried out at the same time.

4.3.3. Impact on Flood Behaviour

To determine the impacts of Option 2 on flood behaviour, the Springvale Drain & Floodvale Drain model was altered to test cases with twice the existing culvert capacity, equivalent to installing one identical pipe adjacent to the existing one.

Table 4 Option FM02 Impact on Flood Behaviour

Event	Decreased Flood Levels	Newly Flooded Areas/ Increased Flood Level	Reference
20% AEP	• Significant reduction (>0.3 m and majority of 1767 Botany Rd no longer flooded	None	Figure 9

	• Slight reduction along Floodvale Drain and adjacent properties • Slight reduction along Springvale Drain and adjacent properties		
1% AEP	• Moderate reduction on Botany Rd and western half of golf course (0.05 m to 0.1 m) • Minor reduction at 1767 Botany Rd, along Botany Rd (both east and west of proposed works) and eastern half of golf course	None	Figure 10

4.3.4. Costs

The tasks required for the construction of proposed Option FM02 include but are not limited to the items listed in Table 5. Appendix A outlines the breakdown of the cost estimate based on discussion with local suppliers and experience with similar projects in similar areas.

Table 5 Option FM02 Required Works

Construction Tasks	Maintenance Tasks
1. Site establishment 2. Installation and maintenance of traffic control measures 3. Installation and maintenance of environmental controls 4. Excavate stormwater pipe trench including shoring where required 5. Excavate for and construction of standard access chambers including external vertical drops, step irons and CD. Inlets as required 6. Excavate for and construction of segmental manhole 7. Trench compaction test 8. Installation of 1800 mm reinforced concrete RRJ pipe 9. Backfill trench 10. Surface remediation works (grass seeding or as required by Botany Golf Club)	1. Regular clearing of debris in Floodvale drain 2. Annual Maintenance

4.3.5. Recommendation

It is recommended that Council investigate this option further given the reduction in flood levels it offers for a range of design flood events and the achievable construction process. Offsite disposal as general waste is expected to be required, especially given the possibility of contamination. The excavation of and installation of pipes in sandy soils commonly found in Botany may pose difficulty during construction and may require shoring of the trench. As discussed in Section 4.2, Council could consider a localised pipe upgrade in conjunction with lowering Botany Rd, possibly allowing for further downstream upgrades in the future when feasible. This would save a second phase of construction and resurfacing on Botany Road, as well as improving flood conveyance across the road to the golf course in the short term.

4.4. Vegetation Management in Open Channel Sections (FM03)

4.4.1. Aim

To reduce flood levels north of McPherson St and adjacent to both Floodvale and Springvale Drains by improving conveyance by removing overgrown vegetation, litter and debris in the open channel.

4.4.2. Discussion

Springvale Drain downstream (south) of McPherson Street was found to be in poor condition during WMAwater's site inspection on the 21st December 2015. The open channel was overgrown with weeds and non-native vegetation, and there was significant debris, litter and pollution present. This may have some effect on channel conveyance, affecting upstream flood levels. Works involved would include complete removal of noxious weeds and ongoing maintenance to spray other weeds and remove litter and debris. Floodvale Drain was in better condition, but there may still be opportunities to clear overgrown vegetation to improve conveyance.

Photo 4 Springvale Drain culvert under McPherson St (downstream end)

Photo 5 Green Cestrum, a noxious weed growing in Springvale Drain

Photo 6 Overgrown vegetation along Springvale Drain open channel

Photo 7 Overgrown vegetation along Floodvale Drain open channel

4.4.3. Impact on Flood Behaviour

The effect of removing weeds and debris was modelled by reducing the Mannings 'n' roughness value along the open channel reach of Springvale Drain and Floodvale Drain to 0.04. It was initially set to 0.09 to reflect existing conditions. Although the modelled reduction is greater than what may be realistically achievable, it was selected as a best case scenario for a tidy grass-lined channel.

In a 20% AEP event there are widespread reductions in flood levels both upstream and downstream of McPherson Street for Springvale Drain (see Figure 11).

The modelling indicates minimal impacts along Floodvale Drain in this event, although there may be a slight increase in flood level of up to 0.1 m between the SWSOOS and Botany Rd, due to slight changes in the peak flow and hydrograph timing.

In the 1% AEP event, clearing Springvale Drain would result in a localised increase in flood levels at the intersection with the SWSOOS No. 2 upstream of the underground section of the drain. This is due to increasing the capacity of the open channel while the culvert with the SWSOOS No. 2 has not been altered. The increase in flood levels is in the order of 0.01 m to 0.05 m and is localised to an area of 150 m^2 at the SWSOOS No. 2 intersection as shown on Figure 12.

Apart from this area, in the 1% AEP event the flood levels would be decreased along the Springvale and Floodvale Drains, most notably just downstream of the culvert about half way along the Springvale open channel. Modelling indicates that clearing the channel would result in a reduction of flood levels in the range of 0.2 m to 0.3 m as shown on Figure 12. Flood levels upstream as far back as 400 m north of McPherson St would be reduced slightly.

Clearing the vegetation along Floodvale Drain would result in a reduction in flood levels along McPherson St by up to 0.1 m, with minor benefits to properties adjacent to the channel.

Given the potential adverse downstream impact of clearing each drain (especially in more frequent events), this option was also assessed in conjunction with Options 1 and 2 as Options 4 and 5 respectively discussed in Sections 4.5 and 4.6, to determine whether a net benefit could be achieved for these areas.

4.4.4. Costs

The initial clearing of the open channel sections of Springvale Drain (190 m) and Floodvale Drain (260 m) may need to be undertaken by professional excavation and landscaping contractors, with environmental consultation prior to the removal of vegetation. An approximate costing for this work has been provided in Appendix A. It is assumed that the ongoing vegetation maintenance work would be undertaken by Council as part of routine maintenance. It would involve spraying weeds and the regular removal of litter and debris. Consultation with environmental specialists in regards to the identification of weeds to be removed, frequency and timing of spraying, and

selection of appropriate bank stabilising plants may be required. This may be able to be addressed by Council's in house capabilities or as part of existing maintenance programs.

4.4.5. Recommendation

It is recommended that Council remove overgrown vegetation, debris and litter (either with in-house equipment or engaging subcontractors) from both the Springvale and Floodvale Drains. An ongoing improved maintenance schedule is recommended. However, given the adverse downstream impacts, it would be preferable if such works were undertaken in conjunction with downstream drainage works (see Sections 4.5 and 4.6).

Further to improvements in flow capacity, it is the responsibility of the drain's owner to undertake maintenance of the weeds in Springvale Drain. Green Cestrum is a Class 3 noxious weed under the NSW Noxious Weeds Act 1993 in many areas of NSW. Class 3 control requirements are that '*the plant must be fully and continuously suppressed and destroyed'*, either by physical or chemical methods.

4.5. Combination of Option 1 and Option 3 (FM04)

4.5.1. Aim

To reduce flood levels north of McPherson St and adjacent to Springvale and Floodvale Drain by improving conveyance and providing adequate downstream drainage.

4.5.2. Discussion

Following investigation of Option FM03 (clearing the vegetation in the open channel reaches of both drains) it was found that in a 20% AEP event there were adverse impacts on the property at 1767 Botany Road.

Option FM04 therefore combines Option FM03 with Option FM01, the lowering of Botany Road and partial duplication of the pipe under Botany Road, to improve conveyance of the increased flow over the road and into the golf course (As described in Section 4.2).

4.5.1. Impact on Flood Behaviour

The combination of Options FM01 and FM03 would yield benefits for properties upstream of Botany Road along both Floodvale and Springvale Drains in the 20% AEP event (Figure 13). The most significant benefits would be at 1767 Botany Rd (on the corner of Floodvale Drain), with reductions in flood levels between 0.3 m and 0.42 m and much of the property no longer flooded. However, as in Option FM01, there would be increased inundation over Botany Road in the 20% AEP event.

The impacts on flood levels in the 1% AEP event would spread further along Botany Road, with varied reductions from just east of Penrhyn Road to as far west as Fremlin Street as shown in Figure 14. There would be minor reductions in flood level (up to 0.05 m north of McPherson Street) and more significant reductions closer to Botany Road (up to 0.3 m for 1767 Botany Road).

4.5.2. Recommendation

It is highly recommended that Council investigate this option further, as the added cost of regularly clearing vegetation from the open channels is relatively minor compared to the lowering of Botany Rd and yields more upstream benefits than the road lowering alone. The increased flooding over Botany Road in more frequent events is minor and is not likely to increase hazard and therefore risk to motorists and pedestrians. Combining Options FM01 and FM03 would therefore alleviate some of the drawbacks of implementing these options separately.

4.6. Combination of Option FM02 and Option FM03 (FM05)

4.6.1. Aim

To reduce flood levels north of McPherson St and adjacent to Springvale and Floodvale Drain by improving conveyance and providing adequate downstream drainage.

4.6.2. Discussion

Investigation of Option FM03 found that in a 20% AEP event there were adverse impacts on the property at 1767 Botany Road (on the corner of Floodvale Drain). Option FM05 therefore combines Option FM03 with Option FM02, the duplication of the existing 1800 mm pipe that runs beneath Botany Road, under the golf course and Foreshore Road into Penrhyn Estuary (described in Section 4.3), which would mitigate the localised adverse impacts from Option FM03.

4.6.3. Impact on Flood Behaviour

The impact of the combined Option FM05 in the 20% AEP event is shown in Figure 15 and in the 1% AEP event in Figure 16. The impacts in the 20% AEP show an improvement on Option 3 especially at the property at 1767 Botany Road, where there would be a significant reduction in flood extent and flood levels (between 0.3 m and 0.42 m). This option also provides the upstream benefits noted in Option 2, reducing flood levels along Floodvale Drain especially around McPherson Street.

Modelling suggests in the 1% AEP event, Option FM03 would not cause any adverse downstream impacts, apart from a small localised area at the entrance to the SWSOOS No. 2 intersection with Springvale Drain. However the modelled extent of the flood level reduction in the combined option is much broader, and extends north of McPherson Street for both the Springvale and Floodvale Drains, in both directions along Botany Road and across the golf course (See Figure 16).

4.6.4. Recommendation

It is highly recommended that Council investigate this option further, as the added cost of regularly clearing vegetation from the open channels is relatively minor compared to the pipe duplication, and magnifies the benefits in a number of areas. The combination of Option FM02 and FM03 therefore provides increased benefits, and mitigates some of the localised adverse impacts, compared to separate implementation.

4.7. Increasing Springvale Drain Open Channel Cross Section (FM06)

4.7.1. Aim

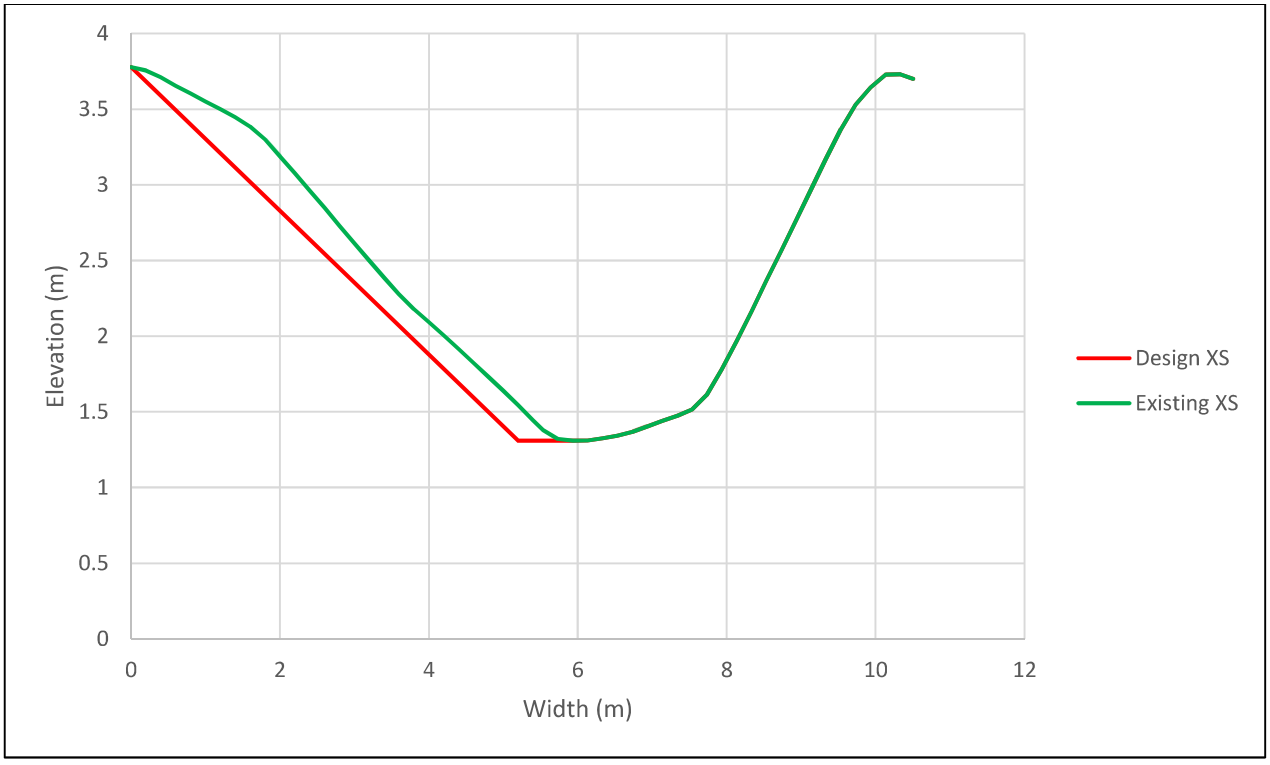
To reduce flood levels north of McPherson St and adjacent to Springvale Drain by improving hydraulic conveyance of the open channel.

4.7.2. Discussion

The purpose of this option was to investigate the existing cross section of Springvale Drain and determine if there would be any benefit to increasing it. The existing cross section is quite variable, and it has been assumed there is scope to neaten up the batters to increase the hydraulic conveyance of the open channel.

A typical section is shown in Diagram 1 below, and illustrates how the eastern bank of the Springvale Drain open channel could be altered, resulting in an average increase in cross sectional area of approximately 10%.

Diagram 1 Springvale Drain Typical Cross Section



4.7.3. Impact on Flood Behaviour

As shown in Figure 17 and Figure 18, there would be negligible impacts (less than 0.01 m difference) for the 20% AEP event and 1% AEP event respectively. This is because flow through this section of Springvale Drain is primarily controlled by the culvert at McPherson Street, and the downstream crossing at the SWSOOS.

4.7.4. Recommendations

The modelling has shown that increasing the cross sectional area of the Springvale Drain open channel would provide no significant benefit to adjacent properties, and therefore should not be considered further.

4.8. Removal of Springvale Drain Culvert (FM07)

4.8.1. Aim

To reduce flood levels north of McPherson St and adjacent to Springvale Drain by improving hydraulic conveyance.

4.8.2. Discussion

The modelling undertaken by BMT WBM incorporated two 1500 mm pipes, approximately 8.6 m long situated about half way along the open channel reach of Springvale Drain, about 70 m south of McPherson Street. The location and properties of the culvert as modelled are shown in Diagram 2 below. WMAwater modelled the removal of this culvert to increase the capacity of the channel, and reduce overtopping of the banks and inundation of the adjacent properties.

Inspection of aerial imagery did not clearly show the culvert, and so confirmation of the culvert's location is required before pursuing this option further. If it is found to have already been removed, the design modelling from the Flood Study will require updating.

Diagram 2 Screenshot from MapInfo showing Springvale Drain Culvert

4.8.3. Impacts on Flood Behaviour

The removal of the Springvale Drain culvert would yield significant benefits for the properties upstream of the culvert site in the 20% AEP event as shown in Figure 19, with reductions in flood

depths up to 0.3 m along Nant Street. Flood levels downstream of the removed culvert would be increased, however in the 20% AEP event would still not overtop the channel banks.

The modelled impacts in the 1% AEP event are shown on Figure 20, and include reductions in flood levels in the properties adjacent to the open channel, between McPherson St and the Springvale Drain/ SWSOOS No. 2 intersection. Reductions of up to 0.3 m for approximately 110 m either side of Nant St are indicated. Improvements along Springvale Drain would also facilitate minor reductions in flood levels along the Floodvale Drain through the connecting flow-path between Nant St and Coal Pier Rd. There would be a significant increase in flood levels within the Springvale Drain channel just downstream of the removed culvert, introducing inundation on the eastern boundary of the property. The depths over the newly inundated area would be 0.1 m-0.2 m for the 1% AEP event.

4.8.4. Recommendation

Option FM07 is recommended subject to consultation with the owners and tenants of the properties adjacent to the culvert, and the owner of Springvale Drain (if not Council).

During a site inspection undertaken after preliminary investigation of this option, the modelled culvert and embankment could not be located and appears to have already been removed. Therefore this option is redundant and does not require further consideration.

4.9. Improvement of Intersection of Floodvale Drain and SWSOOS No. 2 (FM08)

Photo 8 Inverted syphon at intersection of SWSOOS No. 2 and Floodvale Drain

4.9.1. Aim

To improve conveyance through Floodvale drain at the SWSOOS No. 2 crossing and reduce upstream flood levels.

4.9.2. Discussion

Floodvale Drain flows under the Southern and Western Suburbs Ocean Outfall Sewer 2 (SWSOOS No. 2) through an inverted syphon at the rear of the property at 1767 Botany Rd. The drain drops beneath the concrete encased sewer and rises again just downstream. The syphon appears to have largely filled with sediment (see Photo 8), posing a significant hydraulic impediment.

The works involved to remove the inverted syphon would be extensive, and would involve cutting into the SWSOOS, and possibly changing the cross section of the SWSOOS at this location to allow the total sewage capacity to be maintained. As this sewer is constantly in use, the construction would require a temporary diversion, and it is expected that the cost would be prohibitive for this option.

WMAwater could not obtain design or construction drawings of the SWSOOS crossing in time for the preparation of this preliminary report. It was not clear from the site inspection how deep the syphon is, and how much of the built waterway area is filled with sediment. For modelling Option FM08, it was assumed that the total flow conveyance under the SWSOOS could be increased by

- Removing the sediment; and/or
- Upgrading the syphon to have increased area (by lowering the invert of the syphon further).

For the purposes of the assessment, the upgraded/cleaned syphon was assumed to be 2 m deep below the soffit (i.e. the underside of the SWSOOS).

4.9.3. Impact on Flood Levels

The SWSOOS intersection was modelled in the Flood Study (Reference 2) as a lowered rectangular culvert, with a “height” of only 0.35 m to reflect the presence of the silt. WMAwater modelled a possible alteration to the crossing by dropping the invert of the culvert and effectively increasing the syphon depth from 0.35 m to 2 m, to reflect removal of the silt and/or an increase to the syphon cross-section area.

In a 20% AEP event, modelling indicates a reduction in peak flood levels for properties upstream of the Floodvale/SWSOOS crossing in the order of 0.2 m to 0.3 m. This would also reduce the amount of flow redistributed to the Springvale Drain along the flow-path between Coal Pier Road and Nant Street, reducing flood levels along Springvale Drain (as shown in Figure 21). However the increase in conveyance through the culvert would produce a significant increase in flood levels at 1767 Botany Rd in the range of 0.2 m to 0.36 m above the existing levels for that event. There would also be newly inundated areas along Botany Road to the west of Floodvale Drain as far as the Botany Golf Club facilities.

In a 1% AEP event conversely, there would be a widespread reduction in flood levels in the range of 0.01 m to 0.05 m, with a small area of increased flood levels just downstream of the upgraded syphon. This is shown in Figure 22.

4.9.4. Recommendation

With significant benefits in terms of flood level reductions, the maintenance or expansion of the existing Floodvale Drain and SWSOOS No. 2 intersection is worthy of further investigation. It is estimated that there could be significant blockages beneath the SWSOOS in the inverted siphon, and that significant benefits could be achieved by clearing this out. Council may have the in-house capability to undertake this work, or may find it is more cost effective to engage an excavator to remove any blockages from the culvert. It is also recommended that Sydney Water be consulted before any works be undertaken, due to risks associated with potential damage to the SWSOOS. It is also possible that Sydney Water may provide funding or operational assistance to undertake maintenance works.

Further liaison with Sydney Water to identify the feasibility of improved maintenance is therefore highly recommended.

4.10. Combination of Options FM01, FM03, FM07 and FM08 (FM09)

4.10.1. Aim

To achieve widespread reductions in flood levels for properties surrounding both drains without causing significant adverse impacts.

4.10.2. Discussion

Option FM09 combines the following options applied in conjunction to gain an understanding of the potential improvements that could be achieved across the Exell Street area:

- Option FM01(A) (Section 4.2)
  - Lowering Botany Road;
  - Partial duplication of pipe under Botany Rd; and
  - Construction of swale drain along north edge of golf course
- Option FM03 (Section 4.4)
  - Clearing overgrown vegetation from both Springvale Drain and Floodvale Drain
- Option FM07 (Section 4.8)
  - Removing Springvale Drain culvert
- Option FM08 (Section 4.9)
  - Improving the Floodvale Drain/ SWSOOS No. 2 Junction

4.10.3. Impacts on Flood Behaviour

The impact of the combined works on flood behaviour during a 20% AEP event varies across the Exell St area. There are a number of properties where there would be significant reductions in flood levels (over 0.3 m) or a reduction in flood extents, especially the property at 1767 Botany Road and at the north eastern corner of Nant St and McPherson St. Construction of the swale drain along the golf course would reduce flooding on Botany Road and at the Botany Bay Hotel, as water is conveyed towards the new drainage point in the golf course. There would be a newly flooded section of Botany Road, above the Floodvale Drain culvert, where lowering is proposed, however depths reach a maximum of 0.13 m over the road. The impacts in a 20% AEP event are shown in Figure 23.

The impacts on flood levels in a 1% AEP event are shown in Figure 24, and show significant improvements over many roads and properties in the lower catchment focus area. There would be reductions in flood levels at both Botany Road and McPherson Street, up to 0.42 m and 0.1 m respectively. Flood levels at 1767 Botany Rd would reduce by up to 0.3 m across its entirety and at the corner of Nant St and McPherson St, and Nant Street itself, would reduce by up to 0.2 m.

Adverse impacts in the 1% AEP event would be limited to the intersection of Springvale Drain and the SWSOOS No. 2, with water overtopping the banks and inundating a few metres of the properties either side of the drain. These impacts are not extensive, and are matched by benefits of a similar magnitude further upstream within these sites. These impacts may therefore be considered acceptable by the land-owners and tenants. There are increased flood levels along the downstream reach of Springvale Drain, but these are generally contained within the channel

up to an including the 1% AEP event. The lowering of Botany Road would introduce a patch of newly flooded area at the north of the golf course, though this is not perceived to be significant issue during such major flood events.

4.10.4. Recommendations

Each of the works in this combination of options should be investigated further and consideration given to implementing them in conjunction, if funding is available. While each constituent option may yield its own benefits, as discussed earlier in the report some options would have some localised adverse impacts. By applying the works simultaneously more widespread benefits can be achieved and more adverse impacts avoided, especially as the capacity of both drains would increase in conjunction with increasing the capacity of downstream outlets.

4.11. Local Drainage Improvements (FM10)

4.11.1. Aim

To reduce nuisance flooding impediments to traffic during frequent rainfall events (i.e. storm intensities occurring multiple times per year).

4.11.2. Discussion

Commercial operators in the lower catchment area indicated that certain intersections are subject to frequent nuisance inundation that impedes truck movements through the area, leading to lost time and reduced productivity for their operations. The particular intersections identified as problematic are:

- Exell Street at Botany Road (Photo 9); and
- Coal Pier Road at McPherson Street (Photo 10).

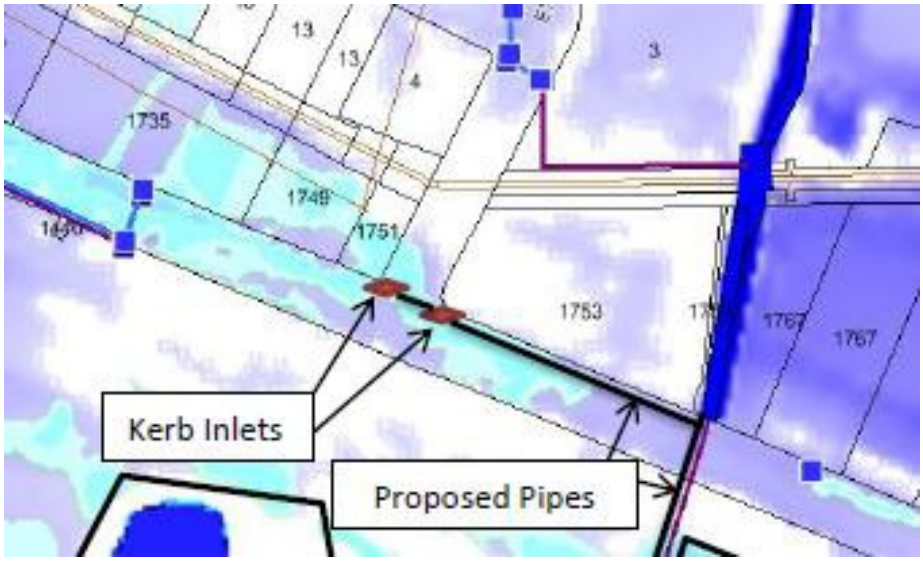
Photo 9 Sag point at corner of Exell Street and Botany Road

At Exell St/Botany Road, there is a local sag point that is not currently drained by any stormwater pits or pipes. When it rains, water ponds to sufficient depth that it can flow east down Botany Road to Floodvale Drain. This results in inundation of sufficient depth to hinder traffic exiting Exell Street to Botany Road, which is the main exit point for traffic from the local area. The nuisance inundation may be exacerbated by the presence of the traffic control islands which prevent a left turn from Botany Road into Exell Street.

Council therefore suggested the construction of a new stormwater drainage pipeline and inlet pits to drain the intersection. The proposal would include two new inlet stormwater pits, one on each

side of Exell Street, and new pipes running east along Botany Road to join Floodvale Drain (see Diagram 3).

Diagram 3: FM10 Proposed drainage system augmentation at Exell Street



At Coal Pier Road, there is a sag point adjacent to the Floodvale Drain, which is drained by a single inlet pit (see Photo 10). The road catchment area draining to this pit is relatively large, and it is likely that the capacity of the pit inlet is exceeded even in relatively frequent rainfall events.

Photo 10 Sag point at corner of Coal Pier Road and McPherson Street

It is likely that nuisance flooding at this location could be alleviated by a combination of measures:

a) Regrading of the landscaped area between the intersection and Floodvale Drain to reduce the ponding depth required before local runoff overtops into the drain;
b) Addition of regular kerb "cut-outs" along the western side of Coal Pier Road to facilitate drainage directly into Floodvale Drain north of the intersection, rather than runoff accumulating at the intersection; and/or
c) Filling to increase the height of the intersection, to the same level as the McPherson Road crossing over Floodvale Drain, to reduce the likelihood of overtopping of the drain into the intersection.

Of these options, (a) and (b) are likely to be the lowest cost, and also the most effective measures to reduce nuisance flooding of the area.

4.11.3. Impacts on Flood Behaviour

Impacts of these local drainage modifications were not modelled in TUFLOW, since the majority of benefit is likely to be observed for events much more frequent than those considered in this study (e.g. once every few months rather than every five years or ten years).

4.11.4. Recommendations

Given the evidence supplied by local residents of the nuisance flooding, and consideration of the likely contributing factors, the proposed options are likely to significantly improve typical stormwater drainage performance in the area, and would be a cost effective measure for implementation.

These local drainage improvements are therefore highly recommended for further investigation/implementation.

4.12. Backflow Prevention at Ocean Outfalls – Both Drains (FM11)

During the inception meeting on the 21st December 2015, it was brought to WMAwater's attention that Floodvale Drain experienced sedimentation and siltation due to tidal inflows. Installation of a backflow prevention valve was suggested for investigation as a potential mitigation option to be investigated in this report.

A backflow prevention device is designed to allow water to flow in one direction through piped stormwater systems and minimise tailwater flowing back up stormwater pipes. Backflow devices are effective at preventing stormwater flooding in certain circumstances, but there is no guarantee of full flooding protection. The ocean outfalls at Penrhyn Estuary are subject to tidal effects and sedimentation. Typically, one-way flow valves or pipe caps are not effective at preventing build-up of sedimentation, and in fact flooding can be exacerbated if such devices are installed but are then obstructed by sedimentation on the downstream side.

At this stage, the extent of sedimentation and its potential obstruction to flow has not yet been investigated. This could be investigated further as part of ongoing work for the catchment-wide FRMS.

5. Summary and Recommendations

Nine flood mitigation measures (or combinations of measures) were assessed for the focus area, including road modifications, pipe duplication, construction of swale drains, vegetation management and various combinations of these options.

A preliminary costing has been prepared for Options FM01, FM02 and FM03 and is presented in Appendix A. Options FM04 and FM05 are combinations of FM01, FM02 and FM03 as discussed in Section 4. Modelling indicated that Option FM06 would not reduce flood levels significantly, and so has not been recommended for future investigation and therefore a detailed cost estimate was not prepared. Option FM07 was not costed at this stage as the existence of the culvert in the Springvale Drain open channel is not certain, and if still present it is not expected that its removal and disposal would be a significant cost.

With regards to Option FM08, it is highly recommended that Council liaise with Sydney Water regarding the clearing of the Floodvale Drain/ SWSOOS No. 2 culvert, as any works in such close proximity to the SWSOOS No. 2 would require approval and coordination from Sydney Water. As the extent of sedimentation and size of the culvert is not yet known (pending receipt of construction drawings from Sydney Water), and access to the site would be difficult for an excavator, no cost estimate has been prepared for this option at this time. Once drawings are obtained and Sydney Water has been consulted, a better estimate of the cost of the works could be provided. It is also possible that Sydney Water may provide funding or operational assistance to undertake maintenance works.

An evaluation matrix has been completed to compare each proposed option based on a range of criteria. This is included in Appendix B and is summarised below.

Table 6 Summary of Recommendations

Option	Description	Recommended (Yes/No)	Priority	Adverse Impacts (Yes/No)	Council Preference
FM01	Lowering Botany Rd, partial duplication of pipe	Yes	Medium	Yes	No
FM01A	Option FM01 + Swale Drain along Golf Course	Yes	Medium	Yes	No
FM01B	Swale Drain along Golf Course only	Yes	High	No	Yes
FM02	Duplication of pipe under Botany Road	Yes (pending confirmation of length required)	Medium	-	Yes
FM03	Clearing overgrown vegetation (both drains)	Yes	High	Yes	Yes
FM04	Combined Option FM01 & FM03	Yes	Medium	No	No
FM05	Combined Option FM02 & FM03	No	-	-	Yes
FM06	Increase Springvale Drain Cross Sectional Area	No	-	-	No
FM07	Removal of Springvale Drain Culvert	Yes	High	Yes	Already undertaken
FM08	Improvement of Floodvale/SWSOOS No. 2 Intersection	Yes	Medium	Yes	No
FM09	Combination of FM01, FM03, FM07 and FM08	Yes	Low	Yes	No
FM10	Local Drainage Improvements	Yes	High	No	Yes
FM11	*Backflow Prevention*	*To be investigated further*			

Based on the above, the likely options to be adopted for implementation are FM01(B), FM02, FM03, FM10. WMAwater agrees in principle with this implementation plan, although it is highly recommended that Option FM08 also be pursued further, in consultation with Sydney Water. It is likely that Sydney Water can provide funding and operational assistance to undertake maintenance works, and the benefits of this option would be significant.

It is also noted that further investigation is required to determine the location where the Floodvale Drain pipe increases from 1800 mm diameter (at the Botany Rd inlet), to two large box culverts (at the outlet to Botany Bay). The length of works required to duplicate the pipe as part of option FM02 needs confirmation to determine the cost of the works, and the likely impacts on traffic during the upgrade.

6. References

NSW Government

1. **Floodplain Development Manual**
   2005

City of Botany Bay Council

2. **Springvale Drain and Floodvale Drain Flood Study**
   WMAwater, November 2014

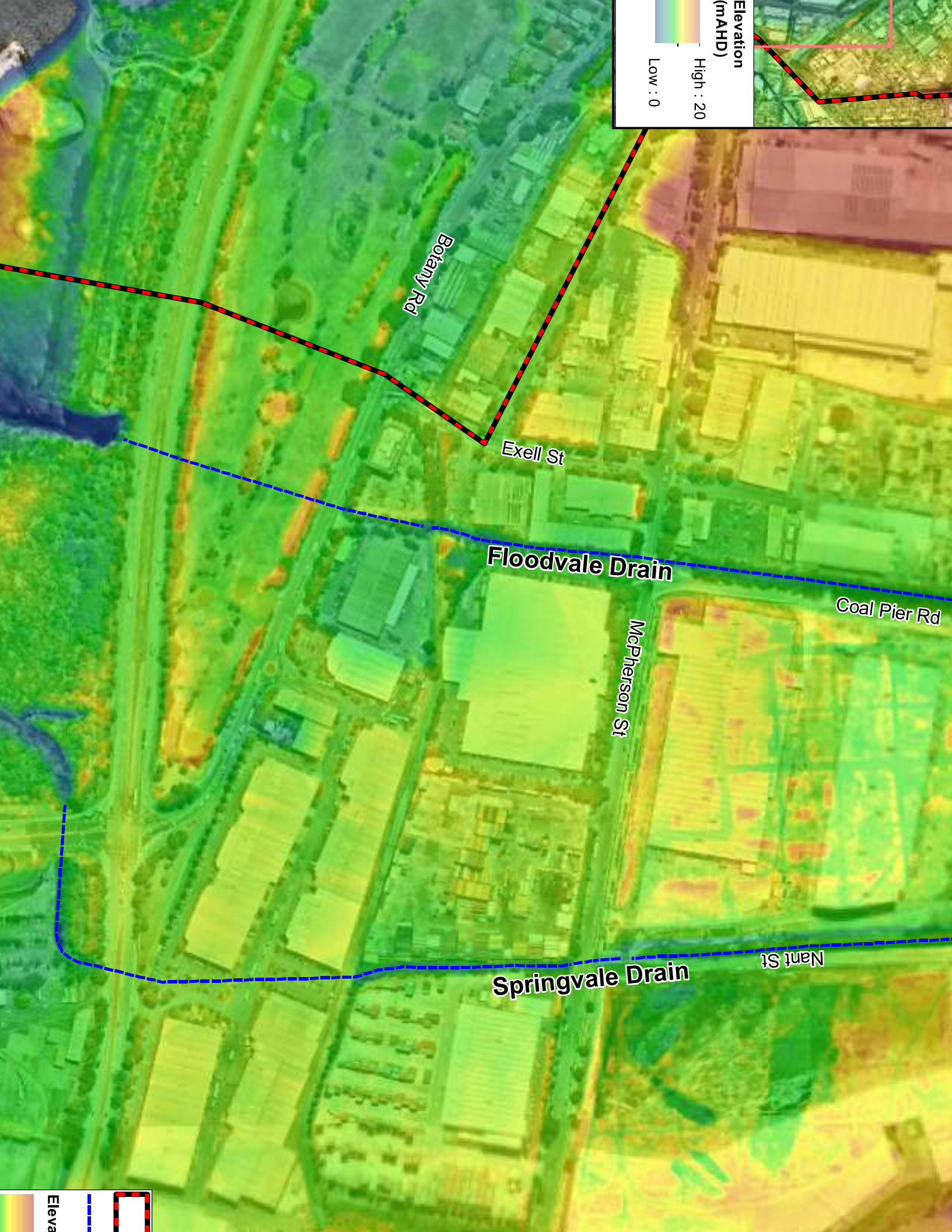
3. Howells L, McLuckie D., Collings G., Lawson N.

   Defining the Floodway – Can One Size Fit All?
   February 2004

4. TUFLOW User Manual, Version 2012-05-AA

   BMT WBM 2011

5. **Floodplain Risk Management Guidelines**
   NSW State Government, October 2007


Elevation (mAHD)
High : 20
Low : 0
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Exell St
Floodvale Drain
Coal Pier Rd
McPherson St
Springvale Drain
Nant St


Nant St
Coal Pier Rd
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Botany Rd


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FM03
FM07
FM06
FM08
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FM02
FM01(A&B)


Botany Rd
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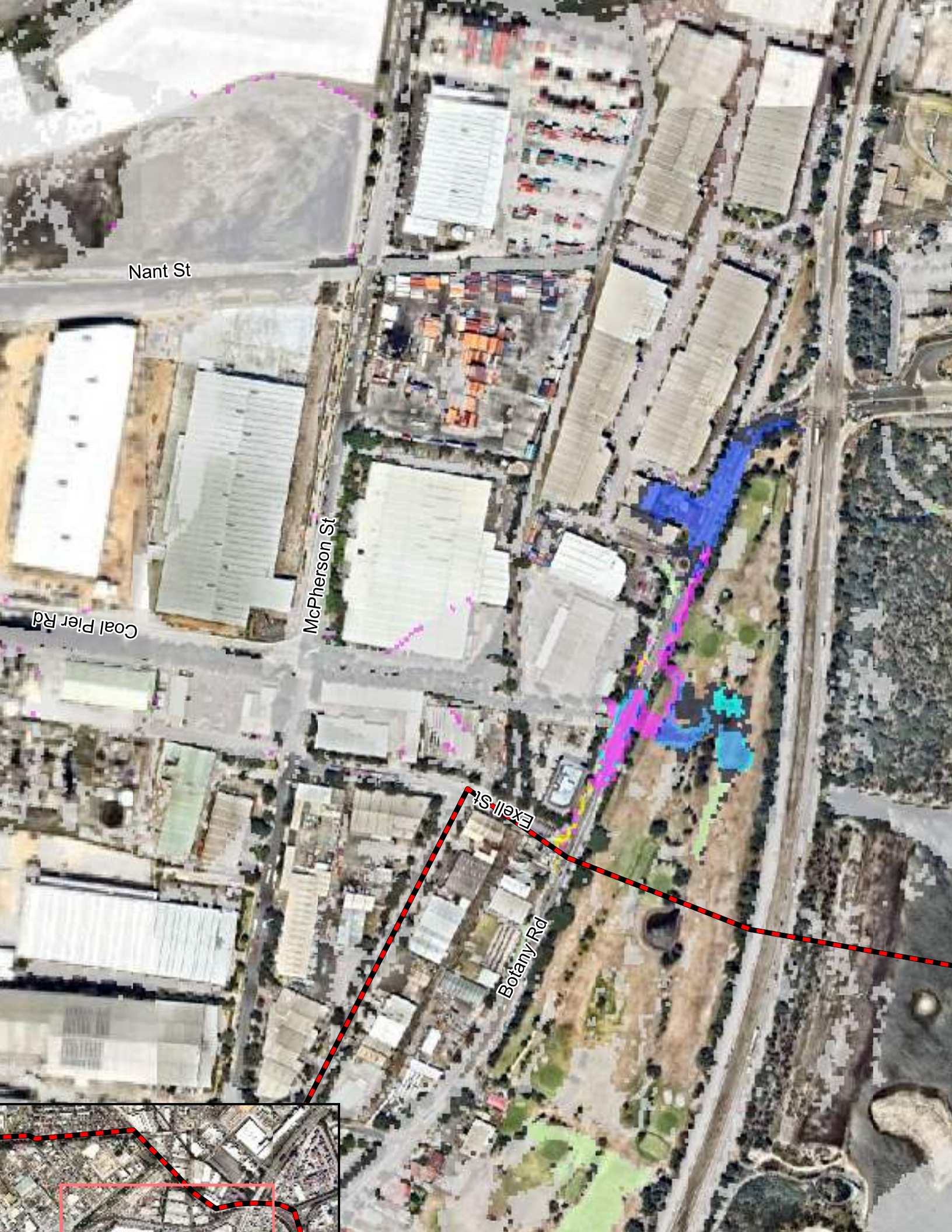
McPherson St
Coal Pier Rd
Nant St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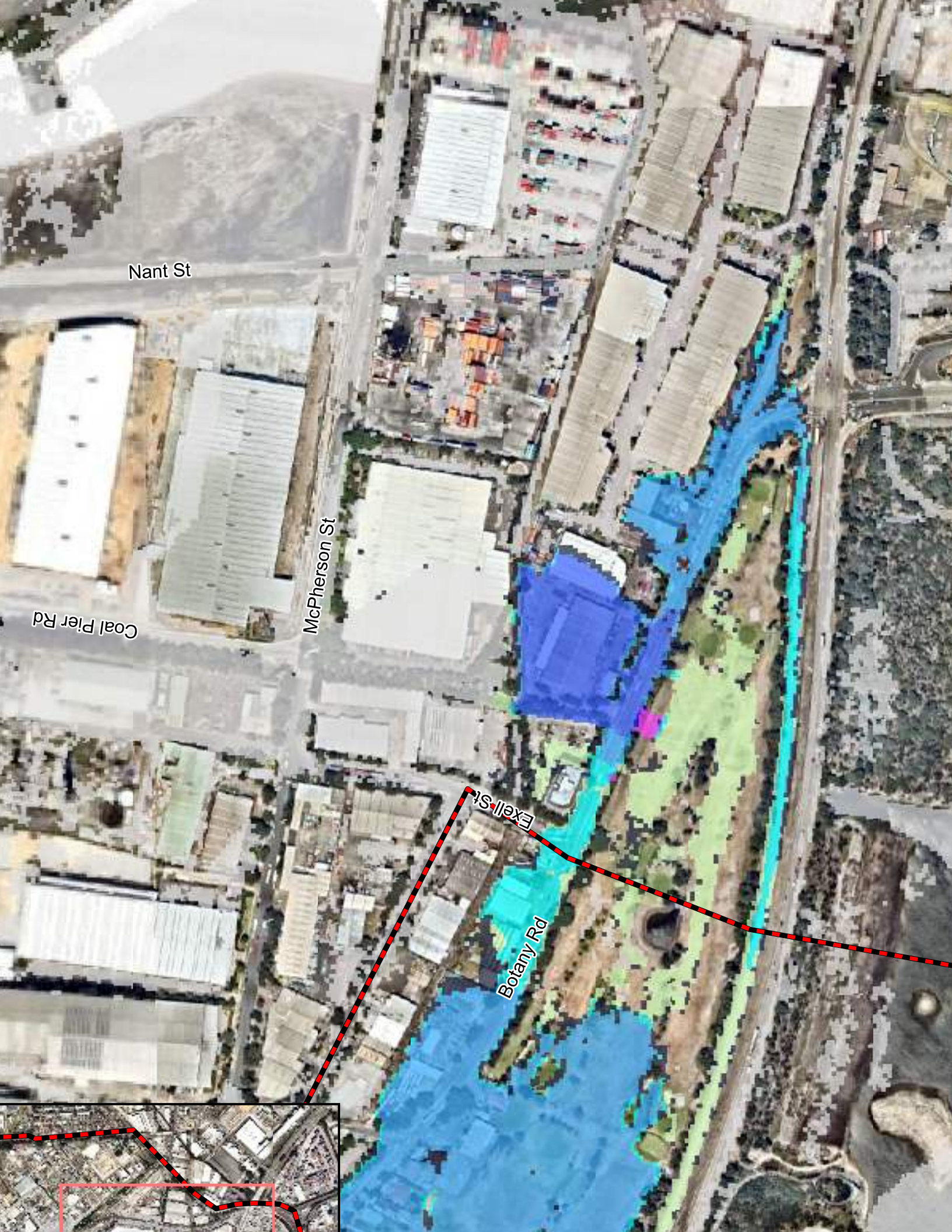
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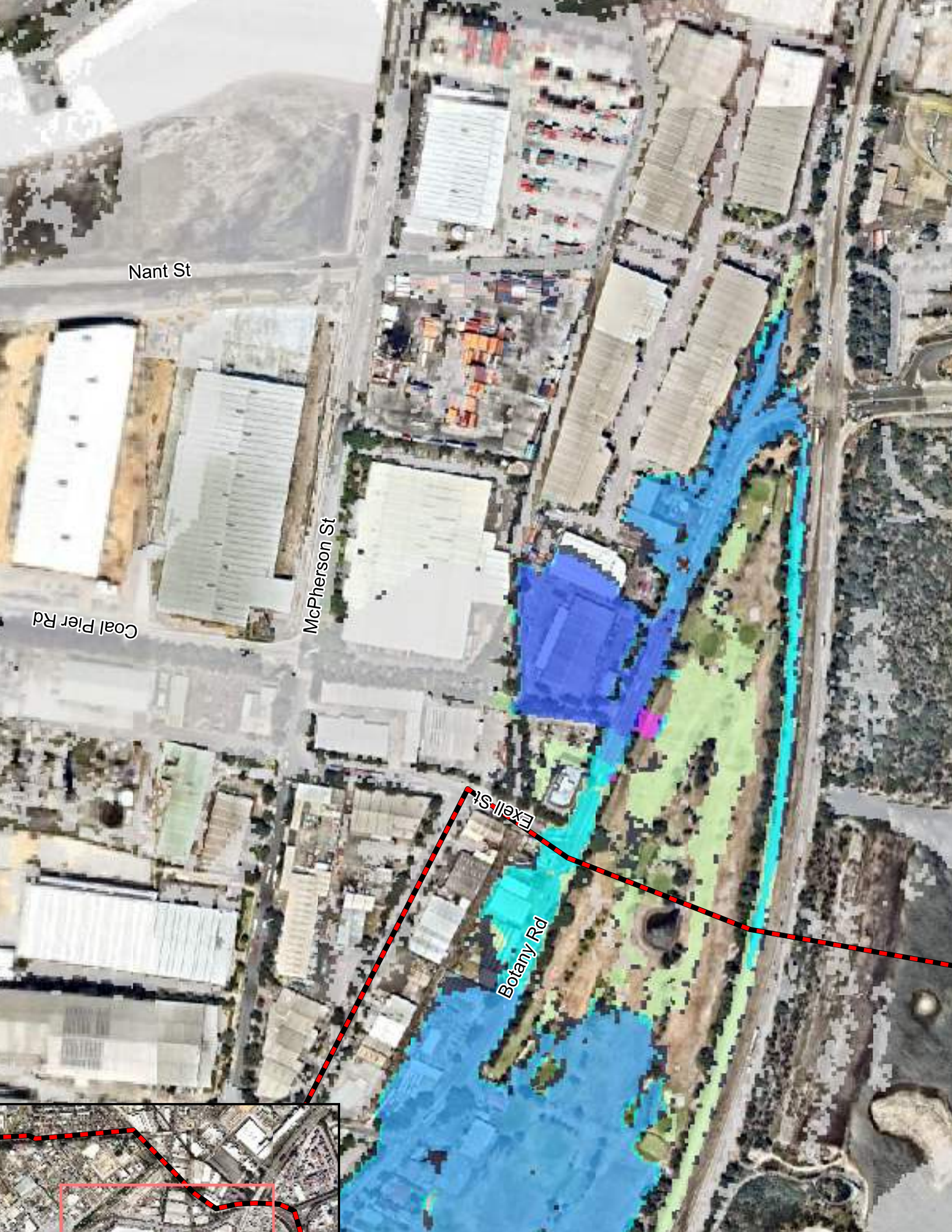
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Appendix A

		Impa	Bo	Num	Tech	Com	Acce	Econ	Finar	En	Ecolo	Impa	Polit	Long	Perfo	Risk	TOTA	R
cations to Botany	To redirect flow away from property and across Botany Rd into Golf Course	1	1	-2	0	3	-2	1	-1	-1	2	-1	1	8
Drain along Golf e	To convey water away from Botany Rd (at the Botany Bay Hotel) into the proposed low point in the golf course.	2	2	2	-1	3	3	1	3	1	3	3	22	1
ation of pipe Botany Road	To increase capacity of existing pipe that runs beneath Botany Rd, Botany Golf Course and Foreshore Rd.	3	3	-3	3	3	-3	0	0	-3	1	0	4	6
ation Management n-channel ns (both drains)	Removal of vegetation and debris to increase the hydraulic conveyance of open channel reaches.	-2	2	2	3	-2	3	2	0	0	3	0	11	2
nation of FM01 M03	Increase hydraulic conveyance of open channel reaches and improve downstream drainage.	3	3	-2	0	1	-2	2	0	0	3	0	8	3
nation of FM02 M03	Increase hydraulic conveyance of open channel reaches and improve downstream drainage.	3	3	-2	0	1	-3	1	0	-3	3	0	3	7
sing Springvale open channel size	Increase hydraulic conveyance of open channel reaches by increasing size of channel where possible.	0	0	2	3	0	-1	1	0	0	0	0	5	5
~~**val of a culvert Springvale Drain**~~	~~Increase hydraulic conveyance by removing unnecessary culvert in channel.~~	~~2~~	~~2~~	~~2~~	~~3~~	~~2~~	~~3~~	~~3~~	~~0~~	~~3~~	~~3~~	~~0~~		~~9~~
removal and enance at vale Drain/ OS No. 2 Culvert	Clear out existing inverted siphon culvert to increase hydraulic conveyance	-3	3	-1	0	3	-1	0	0	-1	0	0	0	9
nation of Options FM03, FM07 and	Clear vegetation from open channels, improve SWSOOS No. 2 Intersection, Remove Springvale Culvert and provide downstream drainage options	3	3	-3	3	3	-3	2	0	-3	2	0	7	4
Drainage vements	Reduce nuisance flooding impediments to traffic at Botany Rd/ Exell St and Coal Pier Rd/McPherson St intersections	3	1	3	3	3	3	0	0	0	2	0	18	2

	-3	-2	-1	0	1	2	3
Impact on Flood Behaviour	>100mm increase	50 to 100mm increase	<50mm increase	no change	<50mm decrease	50 to 100mm	>100mm decrease
Number of Properties Benefitted	>5 adversely affected	2-5 adversely affected	<2 adversely affected	none	<2	2 to 5	>5
Technical Feasibility	major issues	moderate issues	minor issues	neutral	moderately straightforward	straight forward	no issues
Community Acceptance	majority against	most against	some against	neutral	minor	most	majority
Economic Merits	major disbenefit	moderate disbenefit	minor disbenefit	neutral	low	medium	high
Financial Feasibility	major disbenefit	moderate disbenefit	minor disbenefit	neutral	low	medium	high
Environmental and Ecological Benefits	major disbenefit	moderate disbenefit	minor disbenefit	neutral	low	medium	high
Impacts on SES	major disbenefit	moderate disbenefit	minor disbenefit	neutral	minor benefit	moderate benefit	major benefit
Political/administrative Issues	major negative	moderate negative	minor negative	neutral	few	very few	none
Long Term Performance	major disbenefit	moderate disbenefit	minor disbenefit	neutral	positive	good	excellent
Risk to Life	major increase	moderate increase	minor increase	neutral	minor benefit	moderate benefit	major benefit