Area 4 - Iron Cove Options Assessment

Leichhardt Flood Risk Management Study and Plan

NA49913094

Prepared for
Inner West Council

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1 Iron Cove Catchment Description

The majority of the Iron Cove catchment is located within the suburb of Rozelle. Overland flowpaths to the north of Balmain Road and Perry Street are primarily contained within Leichhardt Park, Rozelle Hospital and King George Park.

The overland flow in these areas impacts on existing infrastructure, such as the buildings within the Rozelle Hospital grounds. Significant ponding occurs around the electrical substation to the south east of King George Park, and this may have implications on the operation of this substation during a significant flood event. A small section of the King George Park tributary also affects properties south of Victoria Road.

The location of the Iron Cove Catchment within the study area is shown in **Figure 1-1**

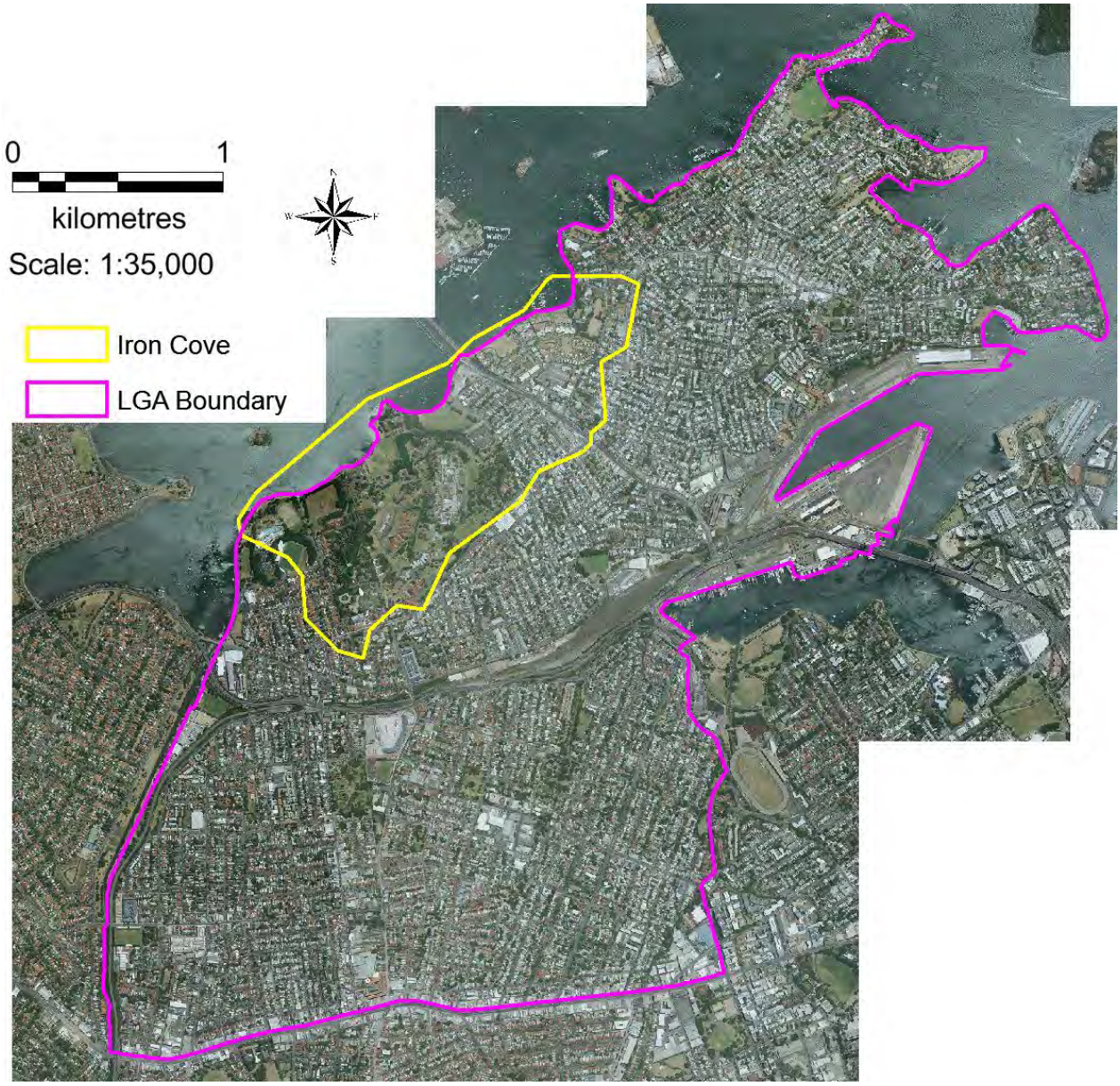

Figure 1-1 Iron Cove Catchment Location

2 Flood Mitigation Options Identification

2.1 Flood Modification Measures for Iron Cove

The existing flood behaviour within the Iron Cove catchment is detailed in the Leichhardt Flood Study (Cardno 2014). Based on the flood model results, historical information and engineering judgement, possible flood modification measures (i.e. structural measures) for the study area were identified.

The various management options were identified taking into consideration the:

- flood behaviour and flow in the 20 year ARI event;
- grade of pipe (upstream and downstream); and
- preliminary availability and location of easements.

Flood modification measures for the Iron Cove Catchment have been identified based on opportunities to connect with future upgrades and improvements.

2.2 Iron Cove Flood Mitigation Options

Within the Iron Cove catchment four sets of options were modelled. These are shown in **Table 2-1** and **Figure 2-1**. The 100yr, 20yr and 5yr ARI peak water level difference plots for each mitigation option are attached at the end of this appendix report.

Table 2-1 Iron Cove Mitigation Options

Option Description	Option Name	ID
Victoria Road Branch – Additional pipes from the Victoria Rd/Terry St intersection that drains into Iron Cove	Victoria Road Branch IC-FM1	IC-FM1
Manning Street Branch – Additional pipes that crosses Mannings St at three locations onto other street. Toelle St, Callan St and Springside St.	Manning Street Branch IC-FM2	IC-FM2
Glover Street Branch – Additional pipe along Glover St between Perry St and Church St.	Glover Street Branch IC-FM3	IC-FM3
Longview Street Branch – Additional pipes to drain flooding from the low point on Longview Street.	Longview Street Branch IC-FM4	IC-FM4

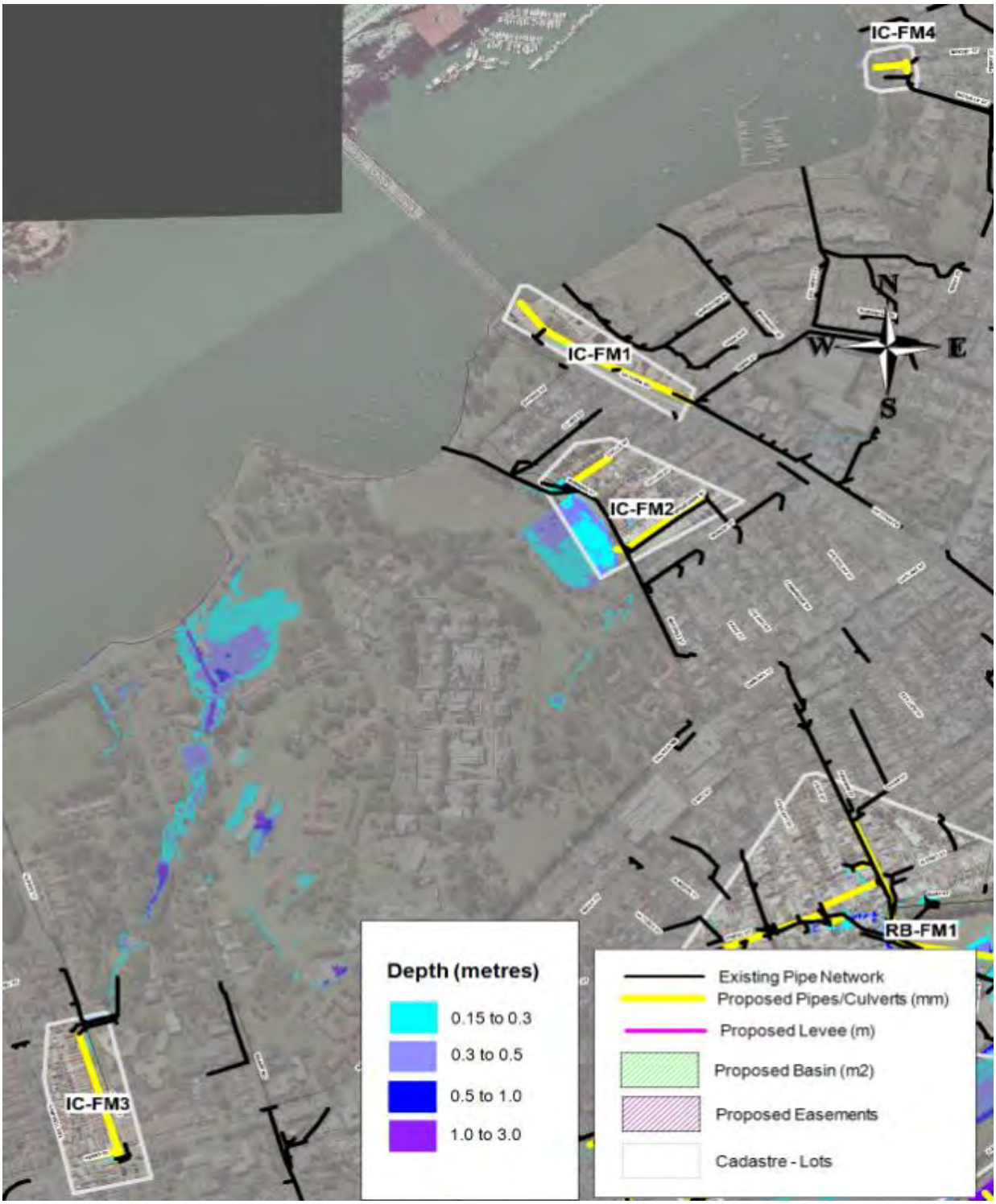

Figure 2-1 Iron Cove Mitigation Options Locations

2.2.1 Victoria Road Branch IC-FM1

IC-FM1 proposed an additional pipe along Victoria Road. The pipe starts from the Victoria Rd / Terry St intersection then drains into Iron Cove. The 750mm diameter pipe is 290m in length and is proposed to minimise the flooding on Victoria Road in a 20 year ARI storm event. Victoria Road is subjected to depths of around 0.25m due the 20 year ARI event.

A potential constraint for this measure includes the pipe construction along Victoria Road due to construction, services and traffic management requirements and costs.

RMS could potentially be responsible for funding all the works involved in this mitigation option.

2.2.2 Manning Street Branch IC-FM2

The Manning Street option proposes two sections of pipes. The pipes are proposed to be located along Toelle Street (450mm diameter) and Springside Street (600mm diameter). IC-FM2 aims to mitigate the flooding under existing conditions at Callan Street, Springside Street and potentially King George Park. An additional pipe (375mm diameter) from Balmain road to the electrical substation has also been proposed. The area impacted by the option is inundated with flood depths under existing conditions of around 1.6m in a 20 year ARI storm event.

2.2.3 Glover Street Branch IC-FM3

Two types of pipes (600mm diameter and 1050mm diameter) are proposed as part of the Glover Street Option. The pipes are proposed to run along Glover Street between Perry Street and Church Street.

Glover Street experiences flood depths in existing conditions of around 0.25m due to the 20 year ARI storm event.

Funding from RMS may be available for the transverse drainage works on Perry Street.

2.2.4 Longview Street Branch IC-FM4

This option proposes additional pipes (600mm diameter and 7500mm diameter) at Longview Street to mitigate flooding at the low point on Longview Street. The existing 600mm pipeline and the inlet system of pits have been identified to be undersized based on the modelled flows arriving at this location.

3 Mitigation Option Modelling Outcomes

The Iron Cove flood mitigation options were assed for the 5, 10, 20, 50 and 100 Year ARI design flood events, along with the PMF event.

The outcomes of the modelling are shown in the 5, 20, and 100 Year ARI water level difference plots attached at the end of this catchment report.

A summary of the impacts on flood behaviour for each option is provided below.

3.1 Victoria Road Branch IC-FM1

The mitigation option IC-FM1 has no discernible reduction in flood depths on Victoria Road in all the modelled design events. As such, no flood level impact mapping has been provided for this option.

3.2 Manning Street Branch IC-FM2

Duplicating the existing pipe downstream of Darling Street results in reductions of flood levels of up to 0.07m along Springside Street, Manning Street, at the electrical substation and King George Park.

The results indicate that properties along Springside Street would experience only minor decreases in water levels in the more frequent flood events.

3.3 Glover Street Branch IC-FM3

Mitigation option IC-FM3 shows a decreases in water levels along parts of Perry Street, Glover Street and Church Street in an order of 0.01m to 0.08m in all the modelled design events. Results indicate properties along Glover Street would experience decrease in water levels in frequent storms. However, these properties do not experience overfloor flooding under existing conditions, and flooding will not be removed from their properties completely. As such, there is no reduction in the flood damages for these events.

3.4 Longview Street Branch IC-FM4

Mitigation option IC-FM4 shows significant decrease in water levels on Longview Street. The water level decreases are up to 0.25m in a 100 Year ARI event at the low point on the street. Results indicate the benefits of this option are largely confined to the road with only limited benefits to private property.

There is a reduction of flood levels on one property of 0.16m. However, as this property does not experience overfloor flooding, the flood damages remain unchanged.

4 Economic Assessment of Flood Damages in the Iron Cove Catchment

4.1 Iron Cove Mitigation Options Damages Assessment

An assessment of damages for the existing condition in the Iron Cove Catchment is presented in the Floodplain Risk Management Study. The approach adopted for calculating the existing damages has been repeated for the modelling results from the mitigation options proposed for the Iron Cove catchment.

The economic flood damage results for each of the options and the existing scenarios are presented in **Table 4-1** to **Table 4-4**. The reductions in properties affected by overground and overfloor flooding, total damages and AAD are provided. Negative values represent increases from the existing scenario.

The total reduction in damaged properties and the associated reduction in damage costs for each mitigation strategy is summarised in **Table 4-5**. This table represents a summary of differences between existing and Mitigation scenarios presented in **Table 4-1** to **Table 4-4**.

The flood damages assessment is a useful tool for comparing the merits of various options, it is not a precise flood risk analysis tool and the limitation associated with the assessment should be considered when interpreting the results.

The following information should be considered when interpreting the damages data:

- Negative property or dollar values represent increases from the existing scenario.
- Where an option results in a reduction in flood depths there may not be any reduction in the flood damages where:
    - The reduction in flood depths or extent occur in open space or roadways; or
    - The reduction in flood depths occurs on properties that were not impacted by over floor flooding (i.e. the flooding on the property grounds is shallower but still exists).
- The flood damages are calculated at a discrete location on each property. This location is where the floor level and ground level survey was obtained from. As such, if the flooding occurs at another location on the property other than the survey point, this property will not register any damages with regards to this damages assessment.

Table 4-1 IC_FM1 Flood Damage Assessment Summary

Event / Property type	Properties with Overfloor Flooding		Properties with Overground Flooding		Estimated Total Damage ($ June 2016)	
	Existing Case	*Mitigation Case*	*Existing Case*	*Mitigation Case*	*Existing Case*	*Mitigation Case*
PMF Event						
Residential	3	3	5	5	$ 717,024	$ 712,085
Commercial	0	0	0	0	$ -	$ -
Industrial	1	1	1	1	$ 3,829	$ 3,829
PMF Total	**4**	**4**	**6**	**6**	**$ 720,852**	**$ 715,913**
100yr ARI						
Residential	0	0	0	0	$ -	$ -
Commercial	0	0	0	0	$ -	$ -
Industrial	0	0	0	0	$ 3,829	$ 3,829
100yr ARI Total	**0**	**0**	**0**	**0**	**$ 3,829**	**$ 3,829**
50yr ARI						
Residential	0	0	0	0	$ -	$ -
Commercial	0	0	0	0	$ -	$ -
Industrial	0	0	0	0	$ 3,829	$ 3,829
50yr ARI Total	**0**	**0**	**0**	**0**	**$ 3,829**	**$ 3,829**
20yr ARI						
Residential	0	0	0	0	$ -	$ -
Commercial	0	0	0	0	$ -	$ -
Industrial	0	0	0	0	$ 3,829	$ 3,829
20yr ARI Total	**0**	**0**	**0**	**0**	**$ 3,829**	**$ 3,829**
10yr ARI						
Residential	0	0	0	0	$ -	$ -
Commercial	0	0	0	0	$ -	$ -
Industrial	0	0	0	0	$ 3,829	$ 3,829
10yr ARI Total	**0**	**0**	**0**	**0**	**$ 3,829**	**$ 3,829**
5yr ARI						
Residential	0	0	0	0	$ -	$ -
Commercial	0	0	0	0	$ -	$ -
Industrial	0	0	0	0	$ 3,829	$ 3,829
5yr ARI Total	**0**	**0**	**0**	**0**	**$ 3,829**	**$ 3,829**
Total Annual Average Damage					**$ 4,925**	**$ 4,900**

Table 4-2 IC_FM2 Flood Damage Assessment Summary

Event / Property type	Properties with Overfloor Flooding		Properties with Overground Flooding		Estimated Total Damage ($ June 2016)	
	Existing Case	*Mitigation Case*	*Existing Case*	*Mitigation Case*	*Existing Case*	*Mitigation Case*
PMF Event						
Residential	39	39	48	48	$ 2,588,325	$ 2,573,259
Commercial	0	0	0	0	$ -	$ -
Industrial	2	2	2	2	$ 824,277	$ 822,573
PMF Total	**41**	**41**	**50**	**50**	**$ 3,412,602**	**$ 3,395,832**
100yr ARI						
Residential	7	7	7	7	$ 526,334	$ 524,750
Commercial	0	0	0	0	$ -	$ -
Industrial	1	1	1	1	$ 6,455	$ 4,237
100yr ARI Total	**8**	**8**	**8**	**8**	**$ 532,789**	**$ 528,988**
50yr ARI						
Residential	7	7	7	7	$ 507,283	$ 504,747
Commercial	0	0	0	0	$ -	$ -
Industrial	1	1	1	1	$ 5,693	$ 3,065
50yr ARI Total	**8**	**8**	**8**	**8**	**$ 512,975**	**$ 507,813**
20yr ARI						
Residential	7	7	7	7	$ 482,203	$ 479,334
Commercial	0	0	0	0	$ -	$ -
Industrial	1	1	1	1	$ 4,946	$ 2,602
20yr ARI Total	**8**	**8**	**8**	**8**	**$ 487,148**	**$ 481,935**
10yr ARI						
Residential	6	6	7	7	$ 429,189	$ 426,419
Commercial	0	0	0	0	$ -	$ -
Industrial	1	1	1	1	$ 4,190	$ 2,321
10yr ARI Total	**7**	**7**	**8**	**8**	**$ 433,380**	**$ 428,739**
5yr ARI						
Residential	4	4	5	5	$ 222,480	$ 219,957
Commercial	0	0	0	0	$ -	$ -
Industrial	1	1	1	1	$ 3,609	$ 3,609
5yr ARI Total	**5**	**5**	**6**	**6**	**$ 226,090**	**$ 223,566**
Total Annual Average Damage					**$ 129,856**	**$ 128,569**

Table 4-3 IC_FM3 Flood Damage Assessment Summary

Event / Property type	Properties with Overfloor Flooding		Properties with Overground Flooding		Estimated Total Damage ($ June 2016)	
	Existing Case	*Mitigation Case*	*Existing Case*	*Mitigation Case*	*Existing Case*	*Mitigation Case*
PMF Event						
Residential	32	32	43	43	$ 2,063,827	$ 2,048,696
Commercial	3	3	3	3	$ 1,243,585	$ 1,243,585
Industrial	0	0	0	0	$ -	$ -
PMF Total	**35**	**35**	**46**	**46**	**$ 3,307,412**	**$ 3,292,282**
100yr ARI						
Residential	0	0	0	0	$ -	$ -
Commercial	0	0	0	0	$ -	$ -
Industrial	0	0	0	0	$ -	$ -
100yr ARI Total	**0**	**0**	**0**	**0**	**$ -**	**$ -**
50yr ARI						
Residential	0	0	0	0	$ -	$ -
Commercial	0	0	0	0	$ -	$ -
Industrial	0	0	0	0	$ -	$ -
50yr ARI Total	**0**	**0**	**0**	**0**	**$ -**	**$ -**
20yr ARI						
Residential	0	0	0	0	$ -	$ -
Commercial	0	0	0	0	$ -	$ -
Industrial	0	0	0	0	$ -	$ -
20yr ARI Total	**0**	**0**	**0**	**0**	**$ -**	**$ -**
10yr ARI						
Residential	0	0	0	0	$ -	$ -
Commercial	0	0	0	0	$ -	$ -
Industrial	0	0	0	0	$ -	$ -
10yr ARI Total	**0**	**0**	**0**	**0**	**$ -**	**$ -**
5yr ARI						
Residential	0	0	0	0	$ -	$ -
Commercial	0	0	0	0	$ -	$ -
Industrial	0	0	0	0	$ -	$ -
5yr ARI Total	**0**	**0**	**0**	**0**	**$ -**	**$ -**
Total Annual Average Damage					**$ 16,535**	**$ 16,460**

Table 4-4 IC_FM4 Flood Damage Assessment Summary

Event / Property type	Properties with Overfloor Flooding		Properties with Overground Flooding		Estimated Total Damage ($ June 2016)	
	Existing Case	*Mitigation Case*	*Existing Case*	*Mitigation Case*	*Existing Case*	*Mitigation Case*
PMF Event						
Residential	3	3	5	5	$ 717,024	$ 714,154
Commercial	0	0	0	0	$ -	$ -
Industrial	1	1	1	1	$ 3,829	$ 3,843
PMF Total	**4**	**4**	**6**	**6**	**$ 720,852**	**$ 717,998**
100yr ARI						
Residential	0	0	0	0	$ -	$ 15
Commercial	0	0	0	0	$ -	$ -
Industrial	0	0	0	0	$ 3,829	$ 3,858
100yr ARI Total	**0**	**0**	**0**	**0**	**$ 3,829**	**$ 3,873**
50yr ARI						
Residential	0	0	0	0	$ -	$ 29
Commercial	0	0	0	0	$ -	$ -
Industrial	0	0	0	0	$ 3,829	$ 3,876
50yr ARI Total	**0**	**0**	**0**	**0**	**$ 3,829**	**$ 3,906**
20yr ARI						
Residential	0	0	0	0	$ -	$ 47
Commercial	0	0	0	0	$ -	$ -
Industrial	0	0	0	0	$ 3,829	$ 3,827
20yr ARI Total	**0**	**0**	**0**	**0**	**$ 3,829**	**$ 3,875**
10yr ARI						
Residential	0	0	0	0	$ -	$ -
Commercial	0	0	0	0	$ -	$ -
Industrial	0	0	0	0	$ 3,829	$ 3,829
10yr ARI Total	**0**	**0**	**0**	**0**	**$ 3,829**	**$ 3,829**
5yr ARI						
Residential	0	0	0	0	$ -	$ -
Commercial	0	0	0	0	$ -	$ -
Industrial	0	0	0	0	$ 3,829	$ 3,829
5yr ARI Total	**0**	**0**	**0**	**0**	**$ 3,829**	**$ 3,829**
Total Annual Average Damage					**$ 4,925**	**$ 4,914**

Table 4-5 Reduction in Damages Associated with Each Option

	Overfloor flooding properties reduction	Overground flooding properties reduction	Total Damage Reduction ($)	AAD Reduction ($)
IC-FM1				
PMF event	0	0	$ 4,939	$25
100yr ARI event	0	0	$ -	$0
50yr ARI event	0	0	$ -	$0
20yr ARI event	0	0	$ -	$0
10yr ARI event	0	0	$ -	$0
5yr ARI event	0	0	$ -	$0
Total				**$25**
IC-FM2				
PMF event	0	0	$ 16,770	$103
100yr ARI event	0	0	$ 3,801	$45
50yr ARI event	0	0	$ 5,163	$156
20yr ARI event	0	0	$ 5,213	$246
10yr ARI event	0	0	$ 4,640	$358
5yr ARI event	0	0	$ 2,524	$379
Total				**$1,286**
IC-FM3				
PMF event	0	0	$ 15,131	$76
100yr ARI event	0	0	$ -	$0
50yr ARI event	0	0	$ -	$0
20yr ARI event	0	0	$ -	$0
10yr ARI event	0	0	$ -	$0
5yr ARI event	0	0	$ -	$0
Total				**$76**
IC-FM4				
PMF event	0	0	$ 2,855	$14
100yr ARI event	0	0	-$ 44	-$1
50yr ARI event	0	0	-$ 77	-$2
20yr ARI event	0	0	-$ 46	-$1
10yr ARI event	0	0	$ -	$0
5yr ARI event	0	0	$ -	$0
Total				**$10**

4.2 Benefit to Cost Ratio of Options

The economic evaluation of each modelled measure was assessed by considering the reduction in the amount of flood damages incurred for the design events and by then comparing this value with the cost of implementing the measure.

Table 4-6 summarises the results of the economic assessment of each of the flood management options. The indicator adopted to rank these measures on economic merit is the benefit-cost ratio (B/C), which is based on the net present worth (NPW) of the benefits (reduction in AAD) and the costs (capital and ongoing), adopting a 7% discount rate and an implementation period of 50 years.

The benefit-cost ratio provides an insight into how the damage savings from a measure, relate to its cost of construction and maintenance:

- Where the benefit-cost is greater than 1 the economic benefits are greater than the cost of implementing the measure;

- Where the benefit-cost is less than 1 but greater than 0, there is still an economic benefit from implementing the measure but the cost of implementing the measure is greater than the economic benefit;
- Where the benefit-cost is equal to zero, there is no economic benefit from implementing the measure; and
- Where the benefit-cost is less than zero, there is a negative economic impact of implementing the measure.

Table 4-6 Summary of Economic Assessment of Flood Management Options

Option ID	Option Description	NPW of Reduction in AAD	NPW of Cost of Implementation	B/C Ratio	Economic Ranking
IC_FM1	Victoria Road Branch – Additional pipes from the Victoria Rd/Terry St intersection that drains into Iron Cove	$0	$1,580,000	0.00	4
IC_FM2	Manning Street Branch – Additional pipes that crosses Mannings St at three locations onto other street. Toelle St, Callan St and Springside St.	$18,000	$2,285,000	0.01	1
IC_FM3	Glover Street Branch – Additional pipe along Glover St between Perry St and Church St.	$1,000	$1,507,000	0.00	2
IC_FM4	Longview Street Branch – Additional pipes to drain flooding from the low point on Longview Street.	$0	$316,000	0.00	3

Iron Cove Mitigation Option Figures

Figure IC_FM2_5yr_WlDiff
Figure IC_FM2_20yr_WlDiff
Figure IC_FM2_100yr_WlDiff
Figure IC_FM3_5yr_WlDiff
Figure IC_FM3_20yr_WlDiff
Figure IC_FM3_100yr_WlDiff
Figure IC_FM4_5yr_WlDiff
Figure IC_FM4_20yr_WlDiff
Figure IC_FM4_100yr_WlDiff

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IC_FM2 5YR ARI WL DIFF
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INNER WEST COUNCIL
LEICHHARDT FRMS&P
IC_FM2 20YR ARI WL DIFF
MITIGATION LESS EXISTING
FIG_A4_5

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IC_FM2_20yr_WIDiff
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INNER WEST COUNCIL
LEICHHARDT FRMS&P
IC_FM2 100YR ARI WL DIFF
MITIGATION LESS EXISTING
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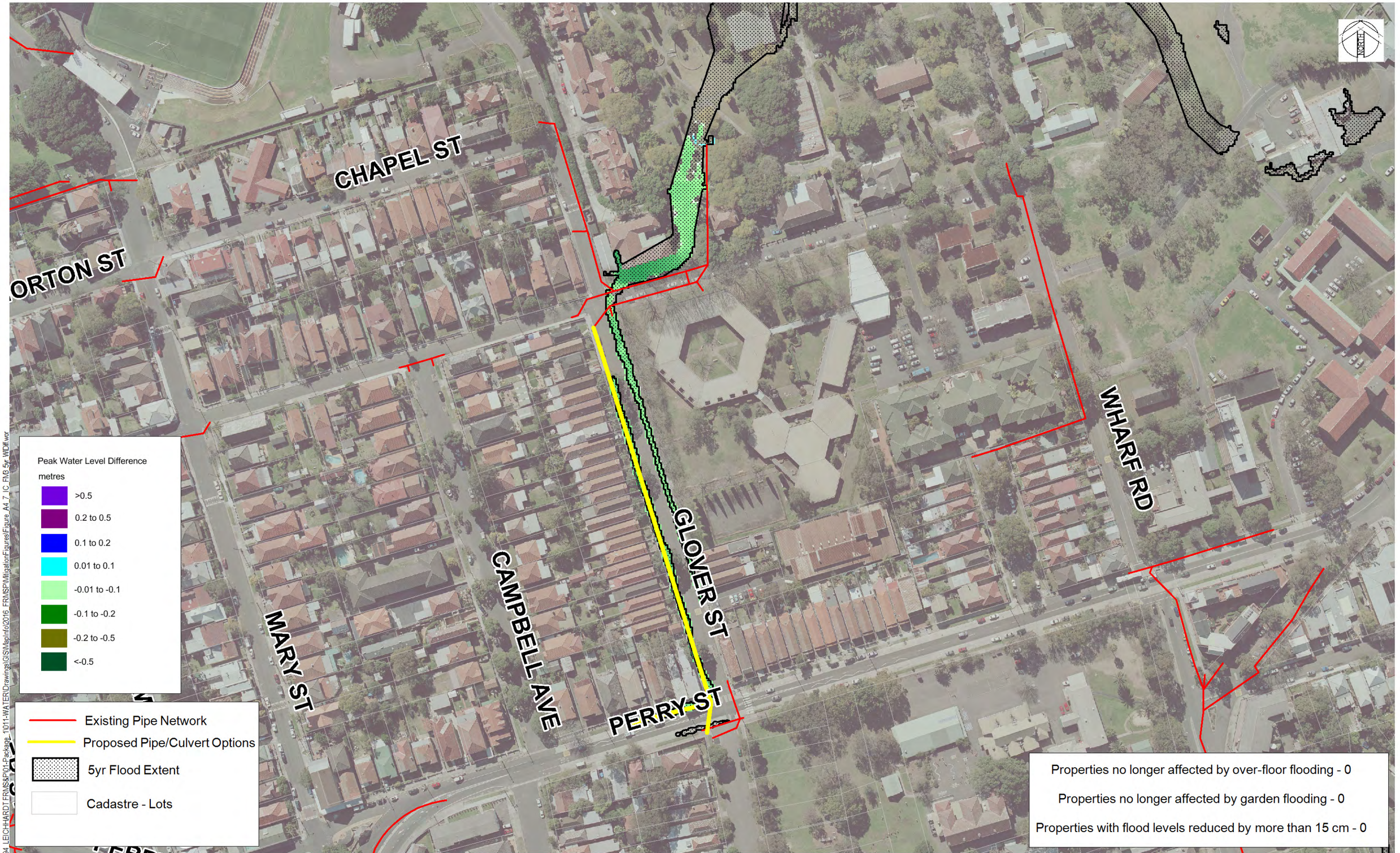

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INNER WEST COUNCIL
LEICHHARDT FRMS&P
IC_FM3 5YR ARI WL DIFF
MITIGATION LESS EXISTING
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INNER WEST COUNCIL
LEICHHARDT FRMS&P
IC_FM3 20YR ARI WL DIFF
MITIGATION LESS EXISTING
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INNER WEST COUNCIL
LEICHHARDT FRMS&P
IC_FM3 100YR ARI WL DIFF
MITIGATION LESS EXISTING
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LEICHHARDT FRMS&P
IC_FM4 5YR ARI WL DIFF
MITIGATION LESS EXISTING
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INNER WEST COUNCIL
LEICHHARDT FRMS&P
IC_FM4 20YR ARI WL DIFF
MITIGATION LESS EXISTING
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INNER WEST COUNCIL
LEICHHARDT FRMS&P
IC_FM4 100YR ARI WL DIFF
MITIGATION LESS EXISTING
FIG_A4_12

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03/2017

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Drawing Number

03
Revision

Area 5 - Mort Bay Options Assessment

Leichhardt Flood Risk Management Study and Plan

NA49913094

Prepared for
Inner West Council

Cardno
Shaping the Future

Table of Contents

Tables

Figures

1 Mort Bay Catchment

Mort Bay Catchment is located in Birchgrove, Balmain and Balmain East. Overland flowpaths are located to the north of Darling Street and discharges into Mort Bay. In a number of cases, the streets in this area are aligned such that the majority of the overland flow proceeds along them, rather than directly through the houses. Significant ponding occurs at the low point on Cameron Street.

The location of the Mort Bay Catchment within the study area is shown in **Figure 1-1.**

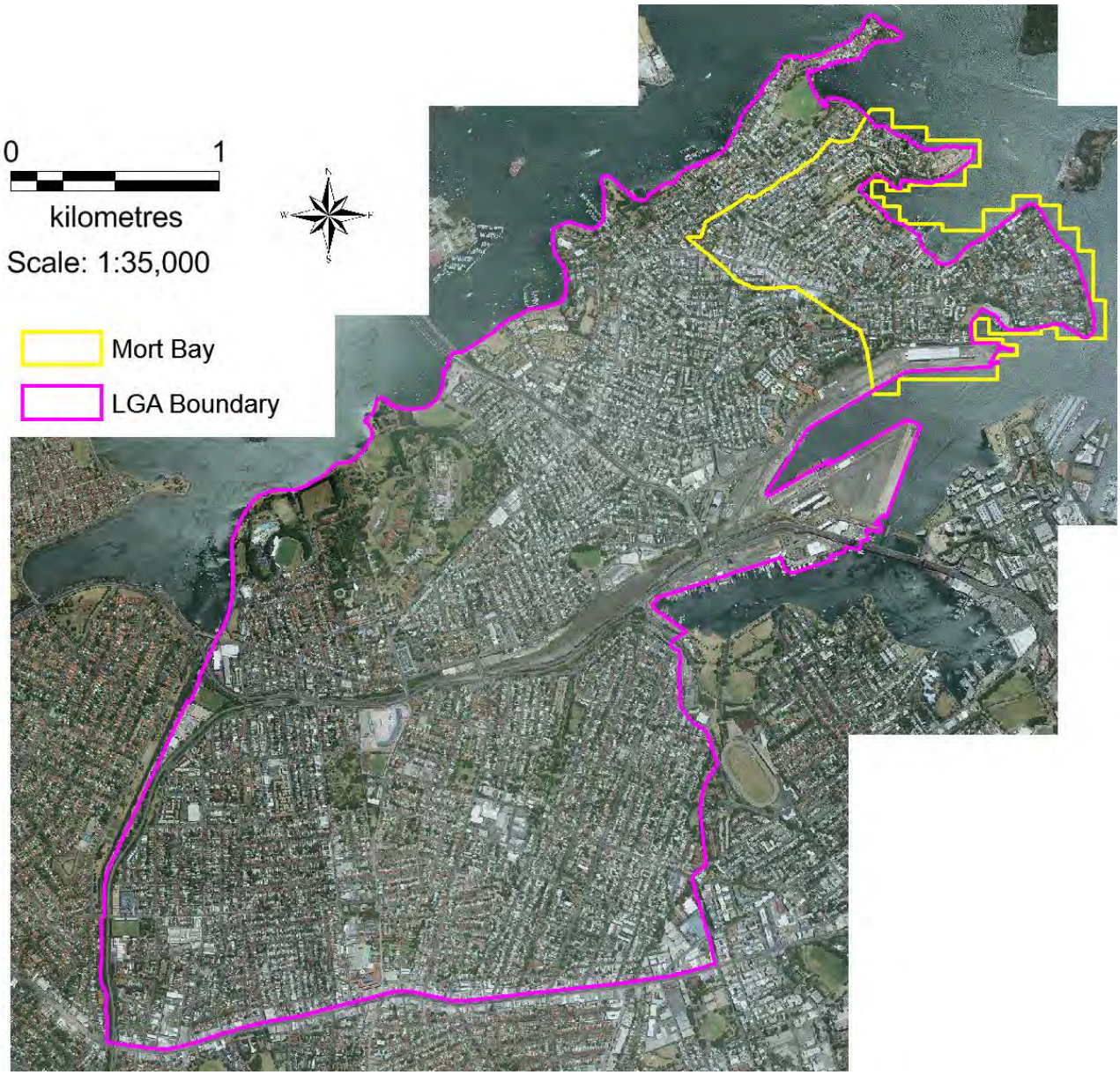


Figure 1-1 Mort Bay Catchment Location

2 Flood Mitigation Options Identification

2.1 Flood Modification Measures for Mort Bay

The existing flood behaviour within the Mort Bay Catchment is detailed in the Leichhardt Flood Study (Cardno 2014). Based on the flood model results, historical information and engineering judgement, possible flood modification measures (i.e. structural measures) for the study area were identified.

The various management options were identified taking into consideration the:

- flood behaviour and flow in the 20 year ARI event;
- grade of pipe (upstream and downstream); and
- preliminary availability and location of easements.

2.2 Mort Bay Flood Mitigation Options

Within the Mort Bay catchment four (4) sets of options were modelled. These are shown in **Table 2-1** and **Figure 2-1**. The 100yr, 20yr and 5yr ARI peak water level difference plots for each mitigation option are attached at the end of this appendix report.

Table 2-1 Mitigation Options

Option Description	Option Name	ID
Colgate Street Branch – Proposing additional pipes to be incorporated into the existing network. Starting from Darling St/Queens Pl intersection, passes along Colgate Av and drains into Mort Bay. There are also additional pipes on St Andrews St and Cooper St.	Colgate Street Branch MB-FM1	MB-FM1
Curtis Rd Branch – Propose additional pipes along Mort St and Clayton St and connecting to an additional proposed pipe on Cameron St (MB-FM4) which drains into Mort Bay.	Curtis Rd Branch MB-FM3	MB-FM3
College Street Branch – Additional pipe network starting from the Cardwell/North St intersection, travelling along (SE) Macquarie St and the Curtis Rd. The pipe branches off into Phillip St, Church St and College St and finally connects into the existing Sydney Water pipe and to the proposed pipe on Cameron St which drains into Mort Bay.	College Street Branch MB-FM4	MB-FM4
McKell Street Branch – Additional pipe from Short St that crosses McKell St and drain into Mort Bay	McKell Street Branch MB-FM5	MB-FM5

Figure 2-1 Mort Bay Mitigation Options Locations

2.2.1 Colgate Avenue Branch MB-FM1

MB-FM1 proposes additional pipes to be incorporated into the existing network. A 450mm diameter pipe is proposed from Darling Street / Queens Place intersection, pipes with diameters of 600mm, 900mm and 1050mm are then proposed along Colgate Avenue, which then drain into Mort Bay. There are also additional pipes proposed on St. Andrews Street (375mm diameter) and Cooper Street (750mm and 1200mm diameter) that drain into Mort Bay.

The Colgate Avenue main branch has four proposed side branches attached to it consisting of pipe diameters of 350mm and 450mm. Additionally, the St Andrews Branch has one side branch proposed with a pipe diameter of 1200mm.

In 20 Year ARI storm event under existing conditions, flooding in this area occurs between Colgate Avenue and Cooper Street. Flood depths ranging from 0.30m to 0.50m are observed on Walumil Street.

A potential constraint to the implementation of this option may include the unforeseen costs associated with construction, services and traffic management requirements on Darling Street.

2.2.2 Curtis Rd Branch MB-FM3

This option proposes additional pipes from the recently completed drainage works in Curtis Road to Cameron Street. A proposed 600mm diameter pipe is proposed from the intersection of Clayton Street and Curtis Road, along Curtis Road and then connecting to a proposed 1200mm pipe at the Cameron Street / Mort Street intersection.

The other proposed branch is located along Mort Street (1050mm diameter pipe) which then connects to a proposed 1200mm diameter pipe at the Cameron Street / Mort Street intersection before draining into Mort Bay. Additionally, there is a short branch (450mm diameter pipe) proposed at Clayton Street.

Flood depths up to 0.15m on Clayton Street and Mort Street occur in an existing 20 Year ARI event.

A potential constraint to the implementation of this option may include the unforeseen costs associated with construction, services and traffic management requirements.

2.2.3 College Street Branch MB-FM4

This option proposes an additional pipe network starting from the Cardwell Street / North Street intersection, travelling along Macquarie Terrace (in a south east direction) and then on Curtis Rd (consisting of 600mm and 900mm diameter pipes). A 1000mm diameter pipe is proposed along Phillip Street and Spring Street, a 1200mm diameter pipe is proposed along Church Street, which is proposed to connect to a proposed 1500mm diameter pipe on Cameron Street, which will then drain into Mort Bay through a proposed 1800mm diameter pipe. Additional pipes are proposed along Church Street (1000mm diameter) and along College Street (900mm diameter). It should be noted that the proposed Church Street branch connects to the existing Sydney Water pipe on Cameron Street.

Flooding under existing conditions due to the 20 year ARI storm results in flood depths up to 0.30m on Cameron Street.

A potential constraint to the implementation of this option may include the unforeseen costs associated with construction, services and traffic management requirements.

2.2.4 McKell Street Branch MB-FM5

This option proposes pipes along McKell Street that drain into Mort Bay. This option comprises of 900mm and 1050mm diameter pipes. Existing infrastructure exists in this area and is proposed to be increased in capacity. The proposed pipes will aim to drain the low point on McKell Street around the buildings to Mort Bay. The impacted buildings experience flood depths under existing conditions of around 0.5m in the 20 Year ARI storm event.

3 Mitigation Option Modelling Outcomes

The Mort Bay Catchment flood mitigation options were assed for the 5, 10, 20, 50 and 100 Year ARI design flood events, along with the PMF event.

The outcomes of the modelling are shown in the 5, 20, and 100 Year ARI water level difference plots attached at the end of this catchment report.

A summary of the impacts on flood behaviour for each option is provided below.

3.1 Colgate Avenue Branch MB-FM1

The increase in drainage capacity at the College Street Branch proposed in MB-FM1 is shown to decrease flood levels by 0.01m – 0.1m in all the design storms in the vicinity of Colgate Avenue, Cooper Street and Walumil Street. Results indicate that the properties at the low point on Malumil Street only would experience a decrease in water level of up to 0.10m in the all the design storms due to this mitigation strategy.

The decrease in flood levels results in a minor reduction in flood damages (due to reduced depth of flooding). However, no reduction in the actual number of properties being flooded is achieved.

3.2 Curtis Rd Branch MB-FM3

The proposed increase in drainage capacity of mitigation option MB-FM3 is shown to reduce overland flows along the flow path. The water level difference results show a decrease of 0.01m – 0.10m along the flow path in all the design storms on Clayton Street and Mort Street. The results show that the large extent of reduction of flood levels occurs in the open space area downstream of Cameron Street.

The decrease in flood levels results in a minor reduction in flood damages (due to reduced depth of flooding). However, no reduction in the actual number of properties being flooded is achieved.

3.3 College Street Branch MB-FM4

Mitigation option MB-FM4 shows reduction in water levels along the flow paths where the drainage network is proposed. The reductions of flood depths are in an order of 0.01m to 0.10m in all the design storms along the flow paths in Curtis Road, Church Street, College Street and Cameron Street. The increased conveyance of flow through the proposed drainage works indicate that the properties at the low point on Cameron Street would experience a decrease in water level of more than 0.10m in all flood events.

3.4 McKell Street Branch MB-FM5

Mitigation option MB-FM5 shows a decrease in flood levels along McKell Street due to the proposed drainage works. The water level decreases in both the 20 Year ARI and a 100 Year ARI are approximately 0.25m and 0.30m respectively. Results indicate that the properties at the low point on McKell Street would experience a decrease in water level of more than 0.25m in the 20 Year ARI event due to this mitigation strategy.

4 Economic Assessment of Flood Damages in the Mort Bay Catchment

4.1 Mort Bay Mitigation Options Damages Assessment

An assessment of damages for the existing condition in the Mort Bay Catchment is presented in the Floodplain Risk Management Study. The approach adopted for calculating the existing damages has been repeated for the modelling results from the mitigation options proposed for the Mort Bay catchment.

The economic flood damage results for each of the options and the existing scenarios are presented in **Table 4-1** to **Table 4-4**. The reductions in properties affected by overground and overfloor flooding, total damages and AAD are provided. Negative values represent increases from the existing scenario.

The total reduction in damaged properties and the associated reduction in damage costs for each mitigation strategy is summarised in **Table 4-5.** This table represents a summary of differences between existing and Mitigation scenarios presented in **Table 4-1** to **Table 4-4**.

The flood damages assessment is a useful tool for comparing the merits of various options, it is not a precise flood risk analysis tool and the limitation associated with the assessment should be considered when interpreting the results.

The following information should be considered when interpreting the damages data:

- Negative property or dollar values represent increases from the existing scenario.
- Where an option results in a reduction in flood depths there may not be any reduction in the flood damages where:
    - The reduction in flood depths or extent occur in open space or roadways; or
    - The reduction in flood depths occurs on properties that were not impacted by over floor flooding (i.e. the flooding on the property grounds is shallower but still exists).
- The flood damages are calculated at a discrete location on each property. This location is where the floor level and ground level survey was obtained from. As such, if the flooding occurs at another location on the property other than the survey point, this property will not register any damages with regards to this damages assessment.
- Commercial and industrial damages are only incurred when over floor flooding exists.
- The reduction in the number of properties impacted as a result of an option may vary between different flood events due to the performance of the proposed work under the different flow behaviour of each flood event.

Table 4-1 MB_FM1 Flood Damage Assessment Summary

Event / Property type	Properties with Overfloor Flooding		Properties with Overground Flooding		Estimated Total Damage ($ June 2016)	
	Existing Case	*Mitigation Case*	*Existing Case*	*Mitigation Case*	*Existing Case*	*Mitigation Case*
PMF Event						
Residential	21	21	53	53	$ 1,250,174	$ 1,058,464
Commercial	0	0	0	0	$ -	$ -
Industrial	0	0	0	0	$ -	$ -
PMF Total	**21**	**21**	**53**	**53**	**$ 1,250,174**	**$ 1,058,464**
100yr ARI						
Residential	1	1	9	8	$ 37,963	$ 34,737
Commercial	0	0	0	0	$ -	$ -
Industrial	0	0	0	0	$ -	$ -
100yr ARI Total	**1**	**1**	**9**	**8**	**$ 37,963**	**$ 34,737**
50yr ARI						
Residential	1	1	7	7	$ 34,827	$ 34,505
Commercial	0	0	0	0	$ -	$ -
Industrial	0	0	0	0	$ -	$ -
50yr ARI Total	**1**	**1**	**7**	**7**	**$ 34,827**	**$ 34,505**
20yr ARI						
Residential	1	1	6	6	$ 34,531	$ 31,019
Commercial	0	0	0	0	$ -	$ -
Industrial	0	0	0	0	$ -	$ -
20yr ARI Total	**1**	**1**	**6**	**6**	**$ 34,531**	**$ 31,019**
10yr ARI						
Residential	1	1	6	6	$ 31,232	$ 27,309
Commercial	0	0	0	0	$ -	$ -
Industrial	0	0	0	0	$ -	$ -
10yr ARI Total	**1**	**1**	**6**	**6**	**$ 31,232**	**$ 27,309**
5yr ARI						
Residential	1	1	5	5	$ 30,900	$ 26,265
Commercial	0	0	0	0	$ -	$ -
Industrial	0	0	0	0	$ -	$ -
5yr ARI Total	**1**	**1**	**5**	**5**	**$ 30,900**	**$ 26,265**
Total Annual Average Damage					**$ 17,230**	**$ 14,871**

Table 4-2 MB_FM3 Flood Damage Assessment Summary

Event / Property type	Properties with Overfloor Flooding		Properties with Overground Flooding		Estimated Total Damage ($ June 2016)	
	Existing Case	*Mitigation Case*	*Existing Case*	*Mitigation Case*	*Existing Case*	*Mitigation Case*
PMF Event						
Residential	83	79	120	118	$ 6,369,742	$ 6,250,964
Commercial	0	0	0	0	$ -	$ -
Industrial	0	0	0	0	$ -	$ -
PMF Total	**83**	**79**	**120**	**118**	**$ 6,369,742**	**$ 6,250,964**
100yr ARI						
Residential	2	2	5	5	$ 75,386	$ 73,878
Commercial	0	0	0	0	$ -	$ -
Industrial	0	0	0	0	$ -	$ -
100yr ARI Total	**2**	**2**	**5**	**5**	**$ 75,386**	**$ 73,878**
50yr ARI						
Residential	2	2	5	5	$ 74,972	$ 73,510
Commercial	0	0	0	0	$ -	$ -
Industrial	0	0	0	0	$ -	$ -
50yr ARI Total	**2**	**2**	**5**	**5**	**$ 74,972**	**$ 73,510**
20yr ARI						
Residential	2	2	5	5	$ 74,681	$ 73,228
Commercial	0	0	0	0	$ -	$ -
Industrial	0	0	0	0	$ -	$ -
20yr ARI Total	**2**	**2**	**5**	**5**	**$ 74,681**	**$ 73,228**
10yr ARI						
Residential	2	2	5	5	$ 74,280	$ 72,843
Commercial	0	0	0	0	$ -	$ -
Industrial	0	0	0	0	$ -	$ -
10yr ARI Total	**2**	**2**	**5**	**5**	**$ 74,280**	**$ 72,843**
5yr ARI						
Residential	2	2	3	3	$ 74,142	$ 72,714
Commercial	0	0	0	0	$ -	$ -
Industrial	0	0	0	0	$ -	$ -
5yr ARI Total	**2**	**2**	**3**	**3**	**$ 74,142**	**$ 72,714**
Total Annual Average Damage					**$ 57,485**	**$ 56,396**

Table 4-3 MB_FM4 Flood Damage Assessment Summary

Event / Property type	Properties with Overfloor Flooding		Properties with Overground Flooding		Estimated Total Damage ($ June 2016)	
	Existing Case	*Mitigation Case*	*Existing Case*	*Mitigation Case*	*Existing Case*	*Mitigation Case*
PMF Event						
Residential	94	92	146	146	$ 7,317,898	$ 7,209,644
Commercial	0	0	0	0	$ -	$ -
Industrial	0	0	0	0	$ -	$ -
PMF Total	**94**	**92**	**146**	**146**	**$ 7,317,898**	**$ 7,209,644**
100yr ARI						
Residential	1	1	4	4	$ 46,505	$ 46,663
Commercial	0	0	0	0	$ -	$ -
Industrial	0	0	0	0	$ -	$ -
100yr ARI Total	**1**	**1**	**4**	**4**	**$ 46,505**	**$ 46,663**
50yr ARI						
Residential	1	1	3	3	$ 45,565	$ 42,593
Commercial	0	0	0	0	$ -	$ -
Industrial	0	0	0	0	$ -	$ -
50yr ARI Total	**1**	**1**	**3**	**3**	**$ 45,565**	**$ 42,593**
20yr ARI						
Residential	1	1	3	3	$ 44,682	$ 41,684
Commercial	0	0	0	0	$ -	$ -
Industrial	0	0	0	0	$ -	$ -
20yr ARI Total	**1**	**1**	**3**	**3**	**$ 44,682**	**$ 41,684**
10yr ARI						
Residential	1	1	3	3	$ 43,405	$ 40,462
Commercial	0	0	0	0	$ -	$ -
Industrial	0	0	0	0	$ -	$ -
10yr ARI Total	**1**	**1**	**3**	**3**	**$ 43,405**	**$ 40,462**
5yr ARI						
Residential	1	1	2	2	$ 43,397	$ 40,353
Commercial	0	0	0	0	$ -	$ -
Industrial	0	0	0	0	$ -	$ -
5yr ARI Total	**1**	**1**	**2**	**2**	**$ 43,397**	**$ 40,353**
Total Annual Average Damage					**$ 51,684**	**$ 50,136**

Table 4-4 HC_FM5 Flood Damage Assessment Summary

Event / Property type	Properties with Overfloor Flooding		Properties with Overground Flooding		Estimated Total Damage ($ June 2016)	
	Existing Case	*Mitigation Case*	*Existing Case*	*Mitigation Case*	*Existing Case*	*Mitigation Case*
PMF Event						
Residential	7	7	7	7	$ 641,836	$ 625,715
Commercial	0	0	0	0	$ -	$ -
Industrial	0	0	0	0	$ -	$ -
PMF Total	**7**	**7**	**7**	**7**	**$ 641,836**	**$ 625,715**
100yr ARI						
Residential	1	0	2	1	$ 61,140	$ 3,000
Commercial	0	0	0	0	$ -	$ -
Industrial	0	0	0	0	$ -	$ -
100yr ARI Total	**1**	**0**	**2**	**1**	**$ 61,140**	**$ 3,000**
50yr ARI						
Residential	1	0	2	1	$ 48,544	$ 3,000
Commercial	0	0	0	0	$ -	$ -
Industrial	0	0	0	0	$ -	$ -
50yr ARI Total	**1**	**0**	**2**	**1**	**$ 48,544**	**$ 3,000**
20yr ARI						
Residential	0	0	2	1	$ 25,993	$ -
Commercial	0	0	0	0	$ -	$ -
Industrial	0	0	0	0	$ -	$ -
20yr ARI Total	**0**	**0**	**2**	**1**	**$ 25,993**	**$ -**
10yr ARI						
Residential	0	0	2	0	$ 5,999	$ -
Commercial	0	0	0	0	$ -	$ -
Industrial	0	0	0	0	$ -	$ -
10yr ARI Total	**0**	**0**	**2**	**0**	**$ 5,999**	**$ -**
5yr ARI						
Residential	0	0	1	0	$ 3,000	$ -
Commercial	0	0	0	0	$ -	$ -
Industrial	0	0	0	0	$ -	$ -
5yr ARI Total	**0**	**0**	**1**	**0**	**$ 3,000**	**$ -**
Total Annual Average Damage					**$ 6,881**	**$ 3,218**

Table 4-5 Reduction in Damages Associated with Each Option

	Overfloor flooding properties reduction	Overground flooding properties reduction	Total Damage Reduction ($)	AAD Reduction ($)
MB-FM1				
PMF event	0	0	$ 191,709	$975
100yr ARI event	0	1	$ 3,226	$18
50yr ARI event	0	0	$ 322	$58
20yr ARI event	0	0	$ 3,513	$186
10yr ARI event	0	0	$ 3,923	$428
5yr ARI event	0	0	$ 4,635	$695
Total				**$2,359**
MB-FM3				
PMF event	4	2	$ 118,778	$601
100yr ARI event	0	0	$ 1,508	$15
50yr ARI event	0	0	$ 1,462	$44
20yr ARI event	0	0	$ 1,453	$72
10yr ARI event	0	0	$ 1,437	$143
5yr ARI event	0	0	$ 1,427	$214
Total				**$1,089**
MB-FM4				
PMF event	2	0	$ 108,254	$540
100yr ARI event	0	0	-$ 157	$14
50yr ARI event	0	0	$ 2,972	$90
20yr ARI event	0	0	$ 2,998	$149
10yr ARI event	0	0	$ 2,943	$299
5yr ARI event	0	0	$ 3,045	$457
Total				**$1,549**
MB-FM5				
PMF event	0	0	$ 16,120	$371
100yr ARI event	1	1	$ 58,140	$518
50yr ARI event	1	1	$ 45,544	$1,073
20yr ARI event	0	1	$ 25,993	$800
10yr ARI event	0	2	$ 5,999	$450
5yr ARI event	0	1	$ 3,000	$450
Total				**$3,662**

4.2 Benefit to Cost Ratio of Options

The economic evaluation of each modelled measure was assessed by considering the reduction in the amount of flood damages incurred for the design events and by then comparing this value with the cost of implementing the measure.

Table 4-6 summarises the results of the economic assessment of each of the flood management options. The indicator adopted to rank these measures on economic merit is the benefit-cost ratio (B/C), which is based on the net present worth (NPW) of the benefits (reduction in AAD) and the costs (capital and ongoing), adopting a 7% discount rate and an implementation period of 50 years.

The benefit-cost ratio provides an insight into how the damage savings from a measure, relate to its cost of construction and maintenance:

- Where the benefit-cost is greater than 1 the economic benefits are greater than the cost of implementing the measure;
- Where the benefit-cost is less than 1 but greater than 0, there is still an economic benefit from implementing the measure but the cost of implementing the measure is greater than the economic benefit;

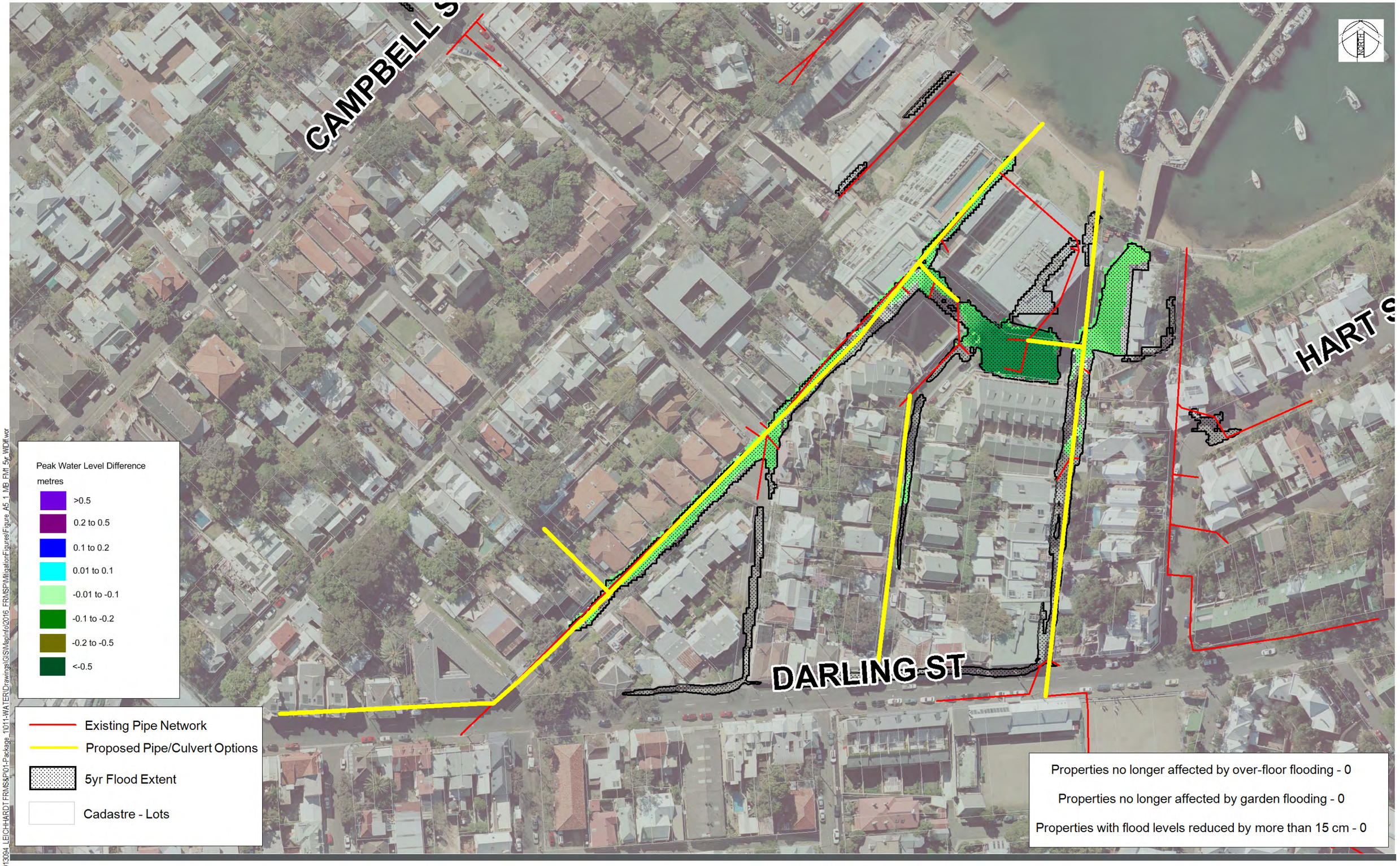
- Where the benefit-cost is equal to zero, there is no economic benefit from implementing the measure; and
- Where the benefit-cost is less than zero, there is a negative economic impact of implementing the measure.

Table 4-6 Summary of Economic Assessment of Flood Management Options

Option ID	Option Description	NPW of Reduction in AAD	NPW of Cost of Implementation	B/C Ratio	Economic Ranking
MB_FM1	Colgate Street Branch – Proposing additional pipes to be incorporated into the existing network. Starting from Darling St/Queens Pl intersection, passes along Colgate Av and drains into Mort Bay. There are also additional pipes on St Andrews St and Cooper St.	$33,000	$4,924,000	0.01	2
MB_FM3	Curtis Rd Branch – Propose additional pipes along Mort St and Clayton St and connecting to an additional proposed pipe on Cameron St (MB-FM4) which drains into Mort Bay.	$15,000	$4,820,000	0.00	3
MB_FM4	College Street Branch – Additional pipe network starting from the Cardwell/North St intersection, travelling along (SE) Macquarie St and the Curtis Rd. The pipe branches off into Phillip St, Church St and College St and finally connects into the existing Sydney Water pipe and to the proposed pipe on Cameron St which drains into Mort Bay.	$21,000	$8,860,000	0.00	4
MB_FM5	McKell Street Branch – Additional pipe from Short St that crosses McKell St and drain into Mort Bay	$51,000	$646,000	0.08	1

Mort Bay Mitigation Option Figures

Figure MB_FM1_5yr_WlDiff
Figure MB_FM1_20yr_WlDiff
Figure MB_FM1_100yr_WlDiff
Figure MB_FM3_5yr_WlDiff
Figure MB_FM3_20yr_WlDiff
Figure MB_FM3_100yr_WlDiff
Figure MB_FM4_5yr_WlDiff
Figure MB_FM4_20yr_WlDiff
Figure MB_FM4_100yr_WlDiff
Figure MB_FM5_5yr_WlDiff
Figure MB_FM5_20yr_WlDiff
Figure MB_FM5_100yr_WlDiff



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INNER WEST COUNCIL
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CAMPBELL S

HART S

DARLING ST

NORTH

Peak Water Level Difference
metres

- >0.5
- 0.2 to 0.5
- 0.1 to 0.2
- 0.01 to 0.1
- -0.01 to -0.1
- -0.1 to -0.2
- -0.2 to -0.5
- <-0.5

Existing Pipe Network

Proposed Pipe/Culvert Options

20yr Flood Extent

Cadastre - Lots

Properties no longer affected by over-floor flooding - 0

Properties no longer affected by garden flooding - 0

Properties with flood levels reduced by more than 15 cm - 0

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INNER WEST COUNCIL
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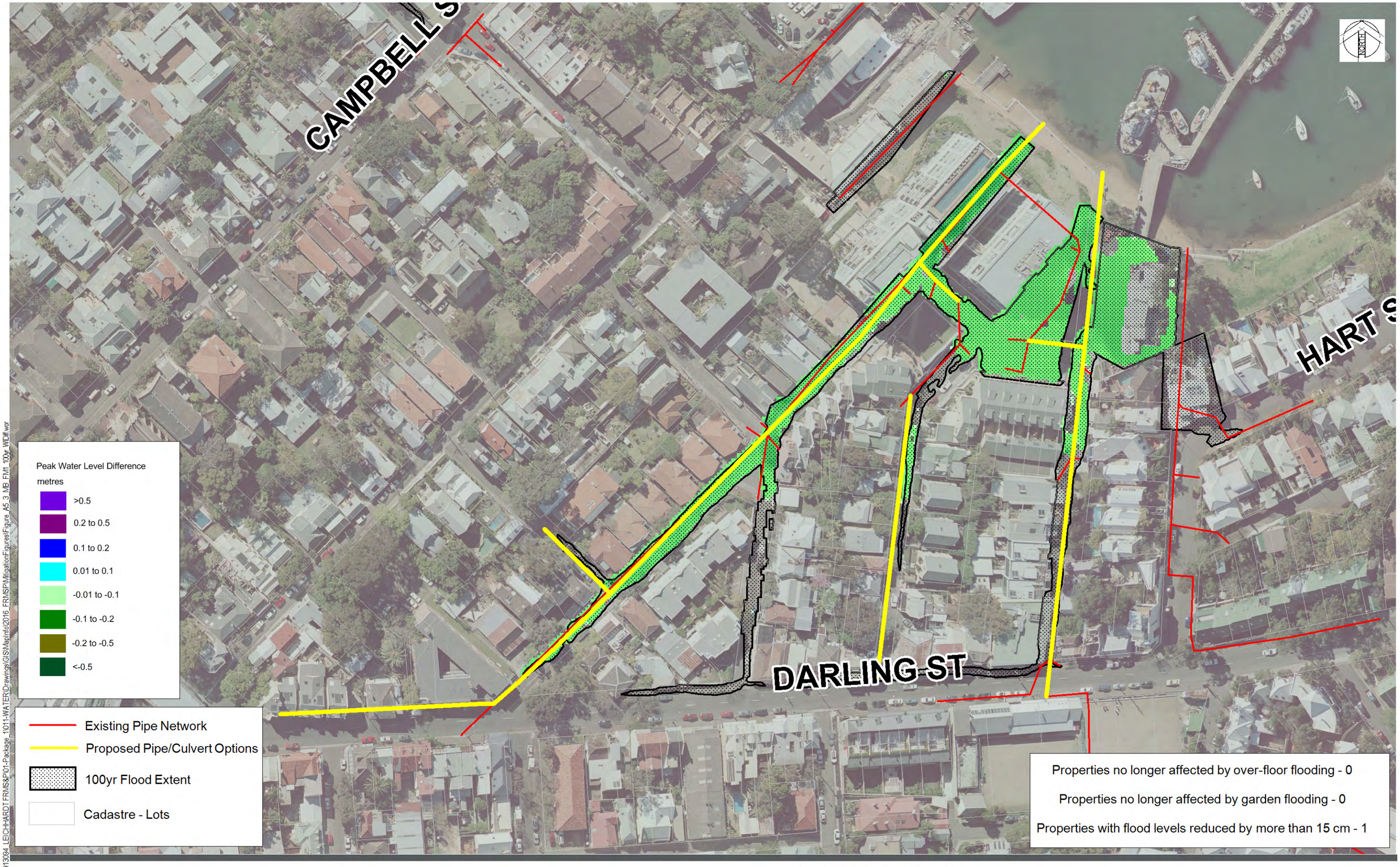

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Peak Water Level Difference
metres

- >0.5
- 0.2 to 0.5
- 0.1 to 0.2
- 0.01 to 0.1
- -0.01 to -0.1
- -0.1 to -0.2
- -0.2 to -0.5
- <-0.5

NORTH

CAMERON ST

MORT ST

CLAYTON ST

THAMES ST

CAMPBELL ST

CURTIS RD

CHURCH ST

- Existing Pipe Network
- Proposed Pipe/Culvert Options
- 5yr Flood Extent
- Cadastre - Lots

Properties no longer affected by over-floor flooding - 0

Properties no longer affected by garden flooding - 0

Properties with flood levels reduced by more than 15 cm - 0

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INNER WEST COUNCIL
LEICHHARDT FRMS&P
MB_FM3 5YR ARI WL DIFF
MITIGATION LESS EXISTING
FIG_A5_7

Date
03/2017

Size
A3

MB_FM3_5yr_WIDiff
Drawing Number

03
Revision

Peak Water Level Difference
metres

- >0.5
- 0.2 to 0.5
- 0.1 to 0.2
- 0.01 to 0.1
- -0.01 to -0.1
- -0.1 to -0.2
- -0.2 to -0.5
- <-0.5

CAMERON ST

MORT ST

CLAYTON ST

THAMES ST

CAMPBELL ST

CURTIS RD

CHURCH ST

LEGE ST

RD

- Existing Pipe Network
- Proposed Pipe/Culvert Options
- 20yr Flood Extent
- Cadastre - Lots

Properties no longer affected by over-floor flooding - 0

Properties no longer affected by garden flooding - 0

Properties with flood levels reduced by more than 15 cm - 1

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INNER WEST COUNCIL
LEICHHARDT FRMS&P
MB_FM3 20YR ARI WL DIFF
MITIGATION LESS EXISTING
FIG_A5_8

Date
03/2017

Size
A3

MB_FM3_20yr_WlDiff
Drawing Number

03
Revision

Peak Water Level Difference
metres

- >0.5
- 0.2 to 0.5
- 0.1 to 0.2
- 0.01 to 0.1
- -0.01 to -0.1
- -0.1 to -0.2
- -0.2 to -0.5
- <-0.5

NORTH

CAMERON ST

MORT ST

CLAYTON ST

THAMES ST

CAMPBELL ST

CURTIS RD

CHURCH ST

LEGE ST

RD

- Existing Pipe Network
- Proposed Pipe/Culvert Options
- 100yr Flood Extent
- Cadastre - Lots

Properties no longer affected by over-floor flooding - 0

Properties no longer affected by garden flooding - 0

Properties with flood levels reduced by more than 15 cm - 1

DATE PLOTTED: 04-Nov-2016 BY: Matthew Prumm
FILE: N:\Projects\499\FY13\NA49913094_LEICHHARDT FRMS&P\01-Package_1\011-WATER\Drawings\GIS\MapInfo\2016_FRMSP\MitigationFigures\Figure_A5_9_MB_FM3_100yr_WIDiff.wor

INNER WEST COUNCIL
LEICHHARDT FRMS&P
MB_FM3 100YR ARI WL DIFF
MITIGATION LESS EXISTING
FIG_A5_9

Date
03/2017

Size
A3

MB_FM3_100yr_WIDiff
Drawing Number

03
Revision

Peak Water Level Difference
metres

- >0.5
- 0.2 to 0.5
- 0.1 to 0.2
- 0.01 to 0.1
- -0.01 to -0.1
- -0.1 to -0.2
- -0.2 to -0.5
- <-0.5

NORTH

MACQUARIE TCE
CARDWELL ST
TURNER
NORTH ST
ROWNTREE ST
CURTIS RD
SHORT ST
PHILLIP ST
CHURCH ST
COLLEGE ST
MORT ST
CAMERON ST
MORT ST
CLAYTON ST
THAMES
CURTIS R

- Existing Pipe Network
- Proposed Pipe/Culvert Options
- 5yr Flood Extent
- Cadastre - Lots

Properties no longer affected by over-floor flooding - 0

Properties no longer affected by garden flooding - 0

Properties with flood levels reduced by more than 15 cm - 0

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FILE: N:\Projects\49913094_LEICHHARDT_FRMS&P\01-Package_1\011-WATER\Drawings\GIS\Mapinfo\2016_FRMSP\MitigationFigures\Figure_A5_10_MB_FM4_5yr_WIDiff.wor

INNER WEST COUNCIL
LEICHHARDT FRMS&P
MB_FM4 5YR ARI WL DIFF
MITIGATION LESS EXISTING
FIG_A5_10

Date
03/2017

Size
A3

MB_FM4_5yr_WIDiff
Drawing Number

03
Revision

Peak Water Level Difference
metres

- >0.5
- 0.2 to 0.5
- 0.1 to 0.2
- 0.01 to 0.1
- -0.01 to -0.1
- -0.1 to -0.2
- -0.2 to -0.5
- <-0.5

MACQUARIE TCE
CARDWELL ST
TURNER
NORTH ST
ROWNTREE ST
SHORT ST
PHILLIP ST
CHURCH ST
COLLEGE ST
MORT ST
CURTIS RD
CAMERON ST
MORT ST
CLAYTON ST
THAMES

- Existing Pipe Network
- Proposed Pipe/Culvert Options
- 20yr Flood Extent
- Cadastre - Lots

Properties no longer affected by over-floor flooding - 0

Properties no longer affected by garden flooding - 0

Properties with flood levels reduced by more than 15 cm - 1

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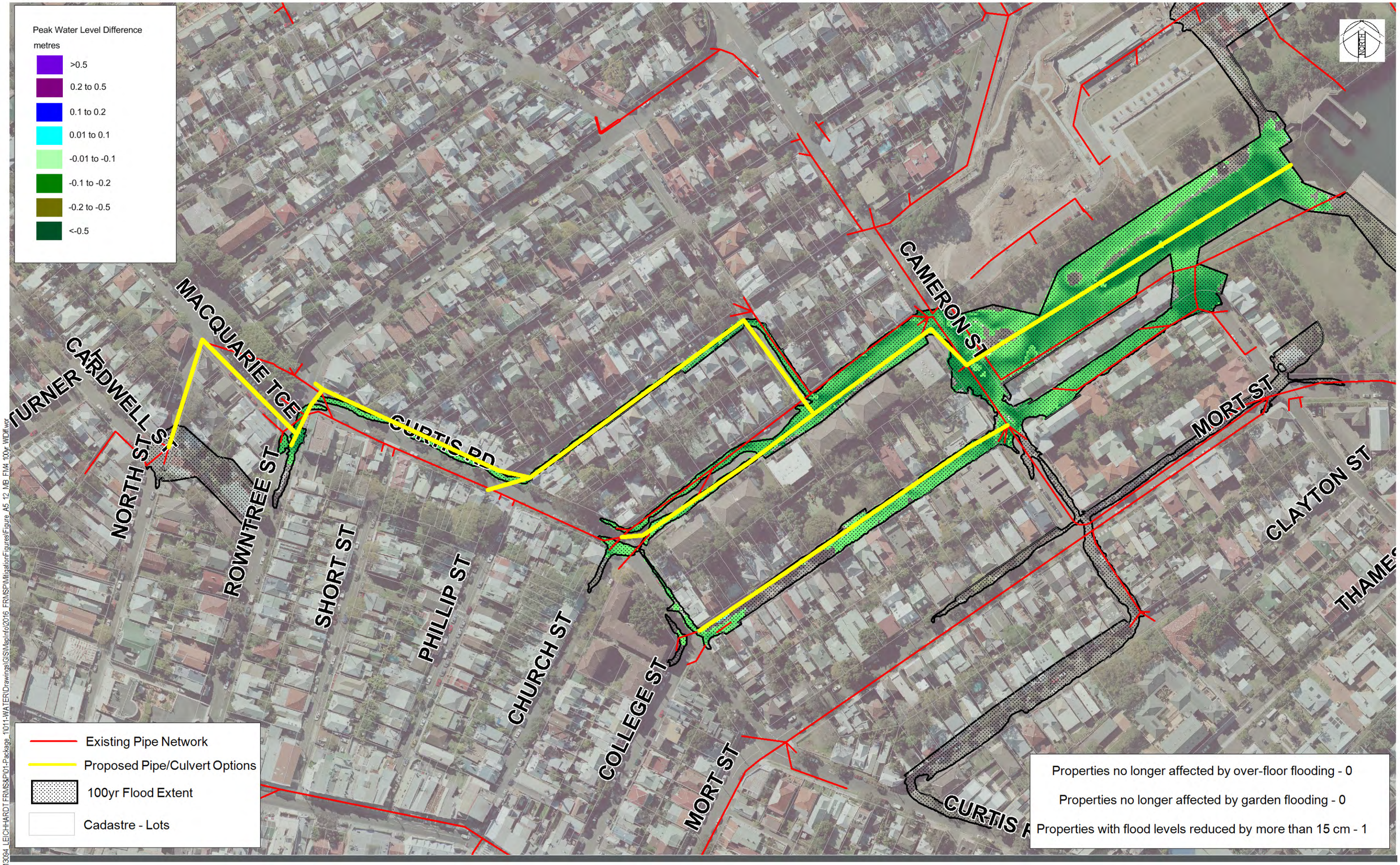
INNER WEST COUNCIL
LEICHHARDT FRMS&P
MB_FM4 20YR ARI WL DIFF
MITIGATION LESS EXISTING
FIG_A5_11

Date
03/2017

Size
A3

MB_FM4_20yr_WlDiff
Drawing Number

03
Revision



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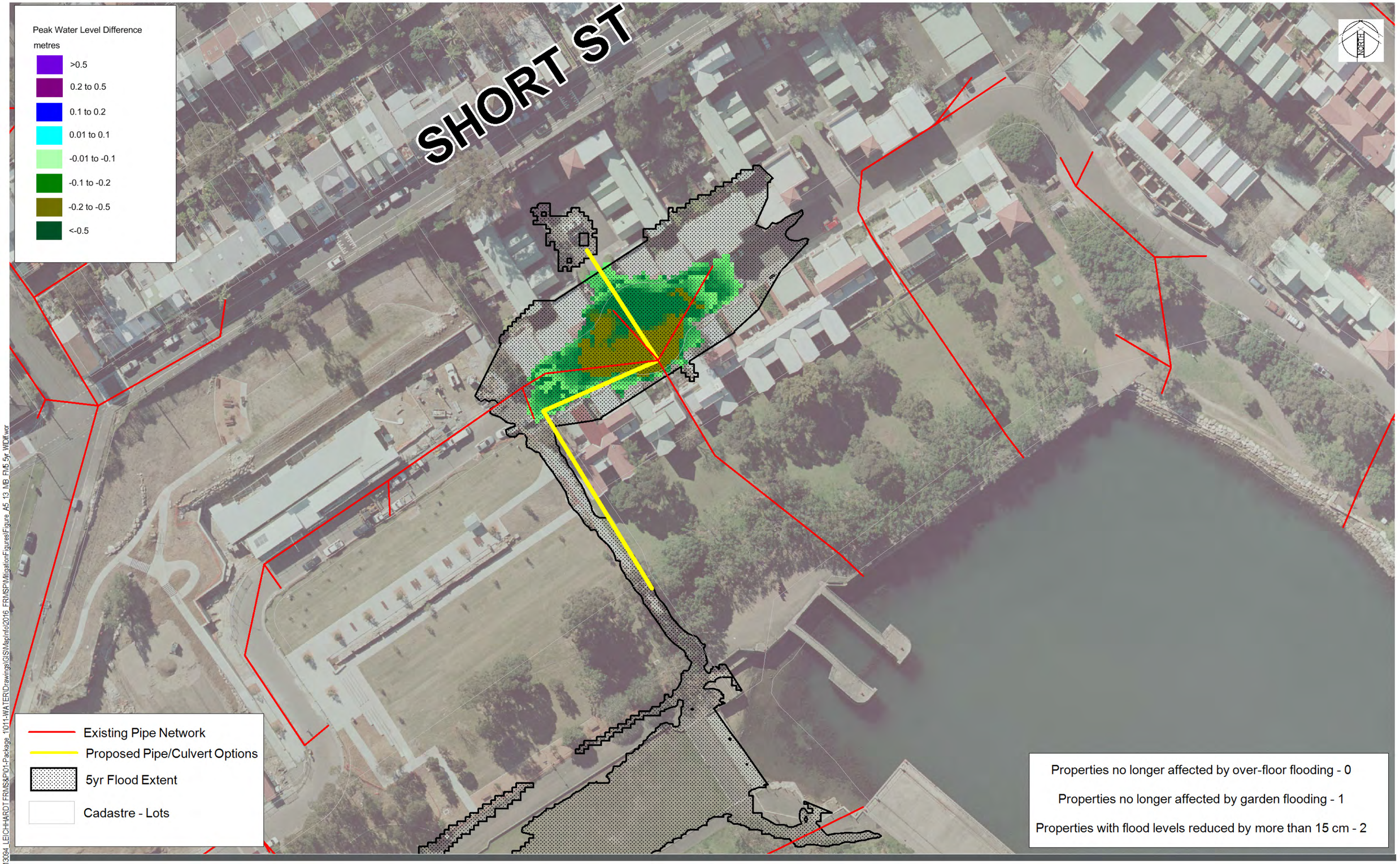
INNER WEST COUNCIL
LEICHHARDT FRMS&P
MB_FM4 100YR ARI WL DIFF
MITIGATION LESS EXISTING
FIG_A5_12

Date
03/2017

Size
A3

MB_FM4_100yr_WIDiff
Drawing Number

03
Revision



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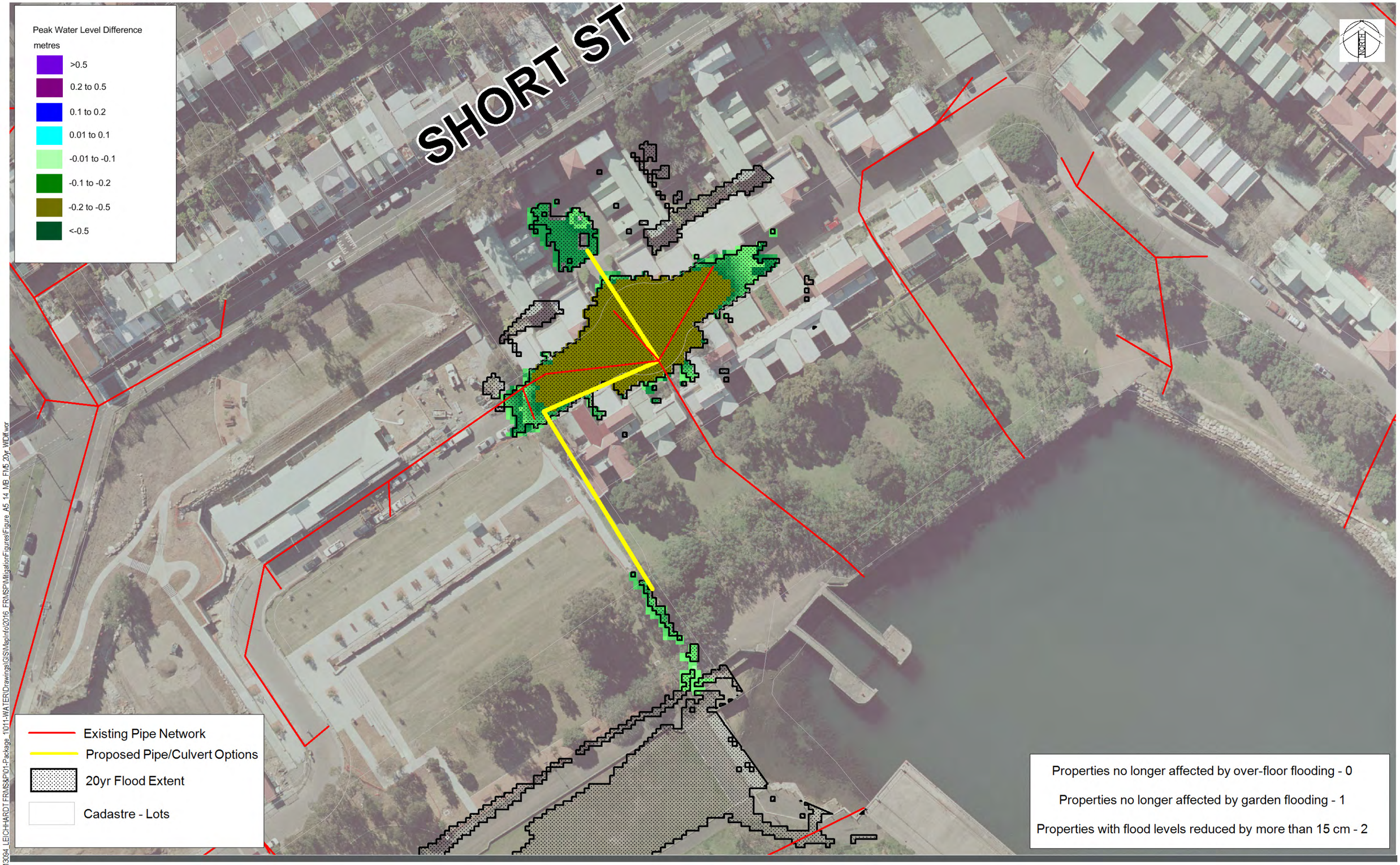
INNER WEST COUNCIL
LEICHHARDT FRMS&P
MB_FM5 5YR ARI WL DIFF
MITIGATION LESS EXISTING
FIG_A5_13

Date
03/2017

Size
A3

MB_FM5_5yr_WlDiff
Drawing Number

03
Revision



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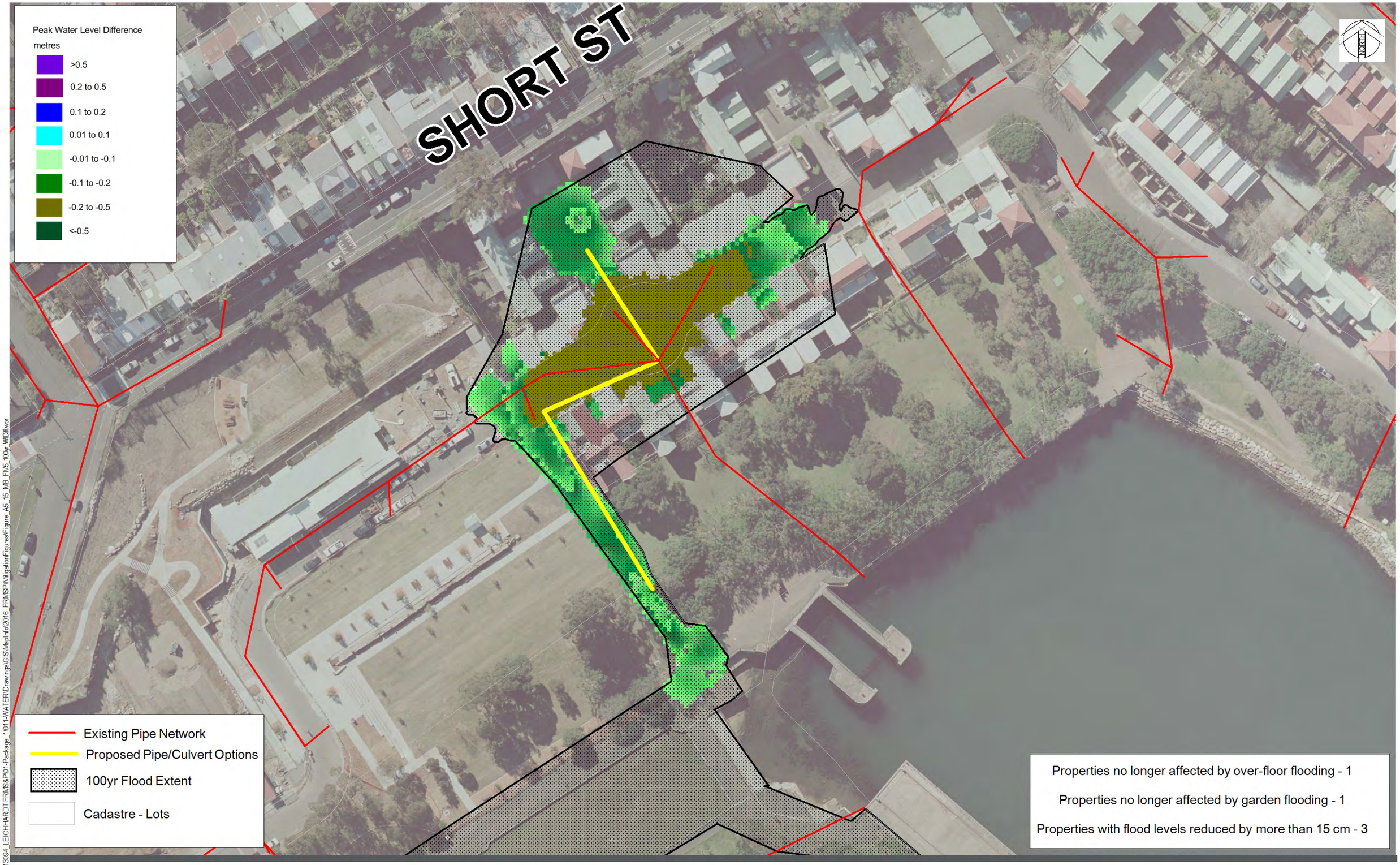
INNER WEST COUNCIL
LEICHHARDT FRMS&P
MB_FM5 20YR ARI WL DIFF
MITIGATION LESS EXISTING
FIG_A5_14

Date
03/2017

Size
A3

MB_FM5_20yr_WIDiff
Drawing Number

03
Revision



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INNER WEST COUNCIL
LEICHHARDT FRMS&P
MB_FM5 100YR ARI WL DIFF
MITIGATION LESS EXISTING
FIG_A5_15

Date
03/2017

Size
A3

MB_FM5_100yr_WlDiff
Drawing Number

03
Revision

Area 6 - Parramatta River and Snails Bay Options Assessment

Leichhardt Flood Risk Management Study and Plan

NA49913094

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Tables

Figures

1 Parramatta River and Snails Bay Catchments Description

Both Parramatta River and Snails Bay Catchments are within Balmain and Birchgrove suburbs. Smaller overland flowpaths are located in these catchments and the overland flows discharge to the Parramatta River and Snails Bay. In a number of cases, the streets in this area are aligned such that the majority of the overland flow proceeds along them, rather than directly through the houses. Significant ponding does occur on Birchgrove Oval, due to the low grades in this area.

The options proposed for assessment in the report are located within the study area portion of the Parramatta River and Snails Bay Catchment.

The location of the Parramatta River and Snails Bay Catchment within the study area is shown in **Figure 1-1**

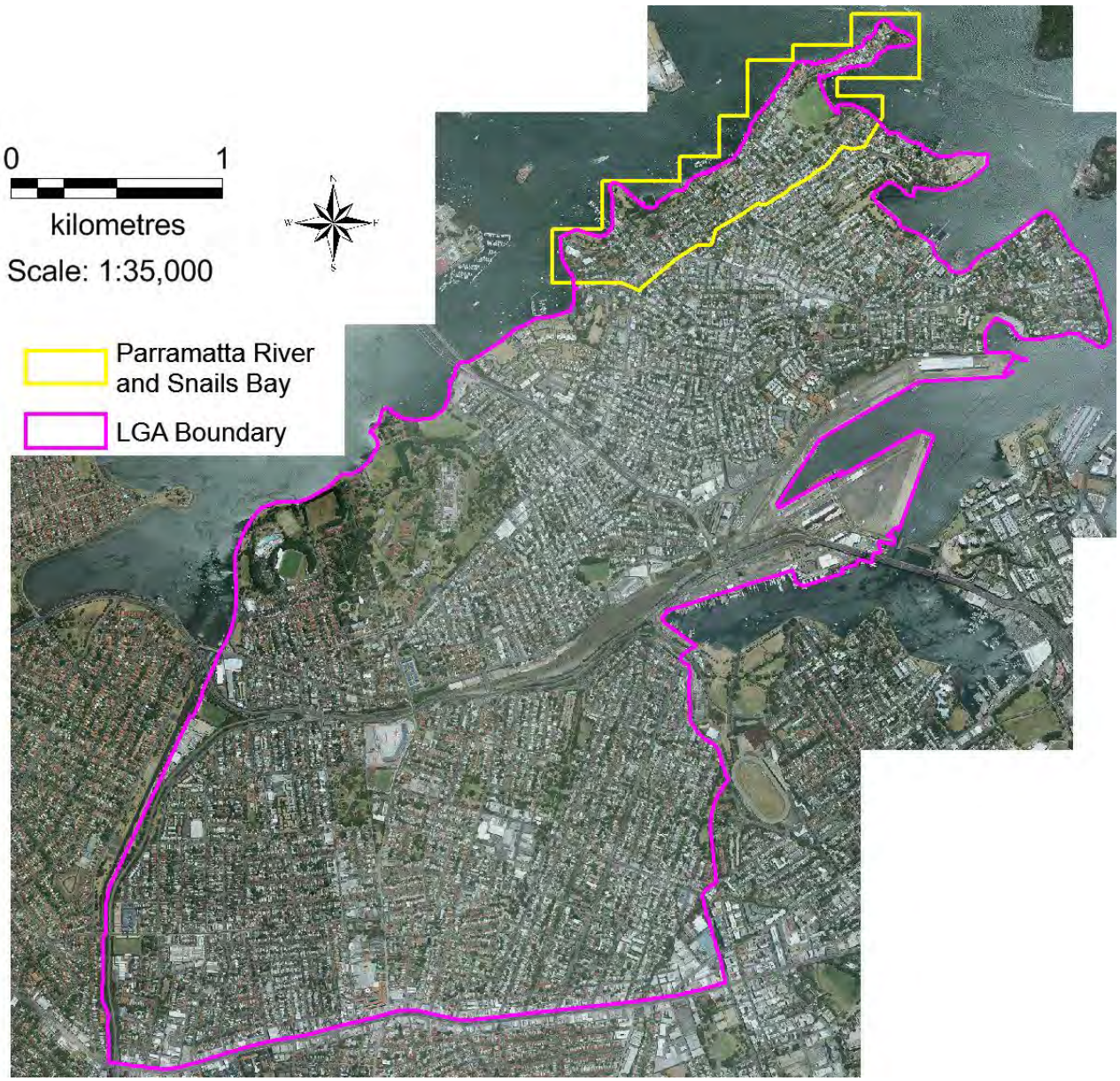

Figure 1-1 Parramatta River and Snails Bay Catchment Location

2 Flood Mitigation Options Identification

2.1 Flood Modification Measures for the Parramatta River and Snails Bay Catchments

The existing flood behaviour within the Parramatta River and Snails Bay Catchments are detailed in the Leichhardt Flood Study (Cardno 2014). Based on the flood model results, historical information and engineering judgement, possible flood modification measures (i.e. structural measures) for the study area were identified.

The various management options were identified taking into consideration the:

- flood behaviour and flow in the 20 year ARI event;
- grade of pipe (upstream and downstream); and
- preliminary availability and location of easements.

2.2 Parramatta River and Snails Bay Catchments Flood Mitigation Options

While several preliminary options were identified as part of the preliminary options report within these catchments, subsequent revision of flood modelling and mapping identified reduced and in some cases no flood risk in those location previously identified for potential options. As a result only one option was identified for further assessment, this option is located in the Snails Bay Catchment. This option is shown in Table 2-1 and Figure 2-1. The 100yr, 20yr and 5yr ARI peak water level difference plots for each mitigation option are attached at the end of this appendix report.

Table 2-1 Parramatta River and Snails Bay Mitigation Options

Option Description	Option Name	ID
Cove Street Branch – The proposed pipe starts from the Cove/Birchgrove St Intersection and then goes along Ferdinand St and connects to the existing pipe network in The Terrace. Additional pipes along Grove St, Rose St and Bay St.	Cove St Branch and Additional Pipes SB-FM1	SB-FM1

Figure 2-1 Snails Bay Mitigation Options Locations

2.2.1 Cove St Branch and Additional Pipes SB-FM1

Following extensive review of the flooding conditions and impacts in the Snails Bay catchment, it was identified that SB-FM1 is the only potentially effective option to justify further assessment. The option consists of a proposed pipe starting from the Cove Street / Birchgrove Street Intersection (600mm diameter), which then goes along Ferdinand Street and connects to the existing pipe network in The Terrace. Additional pipes (450mm diameter) are also proposed along Grove Street, Rose Street and Bay Street.

Flood depths along this flow path under existing conditions reach 0.2m in the 20 Year ARI event.

3 Mitigation Option Modelling Outcomes

The Snails Bay flood mitigation option was assessed for the 5, 10, 20, 50 and 100 Year ARI design flood events, along with the PMF event.

The outcomes of the modelling are shown in the 5, 20, and 100 Year ARI water level difference plots attached at the end of this catchment report.

A summary of the impacts on flood behaviour for the option is provided below.

3.1 Cove St Branch and Additional Pipes SB-FM1

Mitigation option SB-FM1 shows decreases in water levels along parts of Cove Street, Ferdinand Street, Sardinia Place and Grove Street in an order of 0.01m to 0.05m. The maximum flood depth prior to implementation of the option is 0.2m in a 20 Year ARI event.

There is very little decrease in flood level on private properties. As a result there is no change in the flood damages for all events except the PMF.

4 Economic Assessment of Flood Damages in the Snails Bay Catchment

4.1 Snails Bay Mitigation Options Damages Assessment

An assessment of damages for the existing condition in the Parramatta River and Snails Bay Catchment is presented in the Floodplain Risk Management Study. The approach adopted for calculating the existing damages has been repeated for the modelling results from the mitigation options proposed for the Snails Bay catchment.

The economic flood damage results for the option and the existing scenario are presented in Table 4-1. The reductions in properties affected by overground and overfloor flooding, total damages and AAD are provided in Table 4-2. Negative values represent increases from the existing scenario.

The total reduction in damaged properties and the associated reduction in damage costs for SB-FM1 is also provided in Table 4-2.

The flood damages assessment is a useful tool for comparing the merits of various options, it is not a precise flood risk analysis tool and the limitation associated with the assessment should be considered when interpreting the results.

The following information should be considered when interpreting the damages data:

- Negative property or dollar values represent increases from the existing scenario.
- Where an option results in a reduction in flood depths there may not be any reduction in the flood damages where:
    - The reduction in flood depths or extent occur in open space or roadways; or
    - The reduction in flood depths occurs on properties that were not impacted by over floor flooding (i.e. the flooding on the property grounds is shallower but still exists).
- The flood damages are calculated at a discrete location on each property. This location is where the floor level and ground level survey was obtained from. As such, if the flooding occurs at another location on the property other than the survey point, this property will not register any damages with regards to this damages assessment.
- Commercial and industrial damages are only incurred when over floor flooding exists.
- The reduction in the number of properties impacted as a result of an option may vary between different flood events due to the performance of the proposed work under the different flow behaviour of each flood event.

Table 4-1 SB-FM1 Flood Damage Assessment Summary

Event / Property type	Properties with Overfloor Flooding		Properties with Overground Flooding		Estimated Total Damage ($ June 2016)	
	Existing Case	*Mitigation Case*	*Existing Case*	*Mitigation Case*	*Existing Case*	*Mitigation Case*
PMF Event						
Residential	28	28	57	57	$ 1,604,314	$ 1,531,771
Commercial	0	0	0	0	$ -	$ -
Industrial	0	0	0	0	$ -	$ -
PMF Total	**28**	**28**	**57**	**57**	**$ 1,604,314**	**$ 1,531,771**
100yr ARI						
Residential	0	0	0	0	$ -	$ -
Commercial	0	0	0	0	$ -	$ -
Industrial	0	0	0	0	$ -	$ -
100yr ARI Total	**0**	**0**	**0**	**0**	**$ -**	**$ -**
50yr ARI						
Residential	0	0	0	0	$ -	$ -
Commercial	0	0	0	0	$ -	$ -
Industrial	0	0	0	0	$ -	$ -
50yr ARI Total	**0**	**0**	**0**	**0**	**$ -**	**$ -**
20yr ARI						
Residential	0	0	0	0	$ -	$ -
Commercial	0	0	0	0	$ -	$ -
Industrial	0	0	0	0	$ -	$ -
20yr ARI Total	**0**	**0**	**0**	**0**	**$ -**	**$ -**
10yr ARI						
Residential	0	0	0	0	$ -	$ -
Commercial	0	0	0	0	$ -	$ -
Industrial	0	0	0	0	$ -	$ -
10yr ARI Total	**0**	**0**	**0**	**0**	**$ -**	**$ -**
5yr ARI						
Residential	0	0	0	0	$ -	$ -
Commercial	0	0	0	0	$ -	$ -
Industrial	0	0	0	0	$ -	$ -
5yr ARI Total	**0**	**0**	**0**	**0**	**$ -**	**$ -**
Total Annual Average Damage					**$ 8,021**	**$ 7,658**

Table 4-2 Reduction in Damages Associated with Option SB-FM1

	Overfloor flooding properties reduction	Overground flooding properties reduction	Total Damage Reduction ($)	AAD Reduction ($)
SB-FM1				
PMF event	0	0	$ 72,544	$363
100yr ARI event	0	0	$ -	$0
50yr ARI event	0	0	$ -	$0
20yr ARI event	0	0	$ -	$0
10yr ARI event	0	0	$ -	$0
5yr ARI event	0	0	$ -	$0
Total				**$363**

4.2 Benefit to Cost Ratio of Options

The economic evaluation of each modelled measure was assessed by considering the reduction in the amount of flood damages incurred for the design events and by then comparing this value with the cost of implementing the measure.

Table 4-3 summarises the results of the economic assessment of each of the flood management options. The indicator adopted to rank these measures on economic merit is the benefit-cost ratio (B/C), which is based on the net present worth (NPW) of the benefits (reduction in AAD) and the costs (capital and ongoing), adopting a 7% discount rate and an implementation period of 50 years.

The benefit-cost ratio provides an insight into how the damage savings from a measure, relate to its cost of construction and maintenance:

- Where the benefit-cost is greater than 1 the economic benefits are greater than the cost of implementing the measure;
- Where the benefit-cost is less than 1 but greater than 0, there is still an economic benefit from implementing the measure but the cost of implementing the measure is greater than the economic benefit;
- Where the benefit-cost is equal to zero, there is no economic benefit from implementing the measure; and
- Where the benefit-cost is less than zero, there is a negative economic impact of implementing the measure.

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

Option ID	Option Description	NPW of Reduction in AAD	NPW of Cost of Implementation	B/C Ratio	Economic Ranking
SB_FM1	Cove Street Branch – The proposed pipe starts from the Cove/Birchgrove St Intersection and then goes along Ferdinand St and connects to the existing pipe network in The Terrace. Additional pipes along Grove St, Rose St and Bay St.	$5,000	$3,004,000	0.00	1

Parramatta River and Snails Bay Mitigation Option Figures

Figure SB_FM1_5yr_WlDiff
Figure SB_FM1_20yr_WlDiff
Figure SB_FM1_100yr_WlDiff

DATE PLOTTED: 04-Nov-2016 BY: Matthew Prumm
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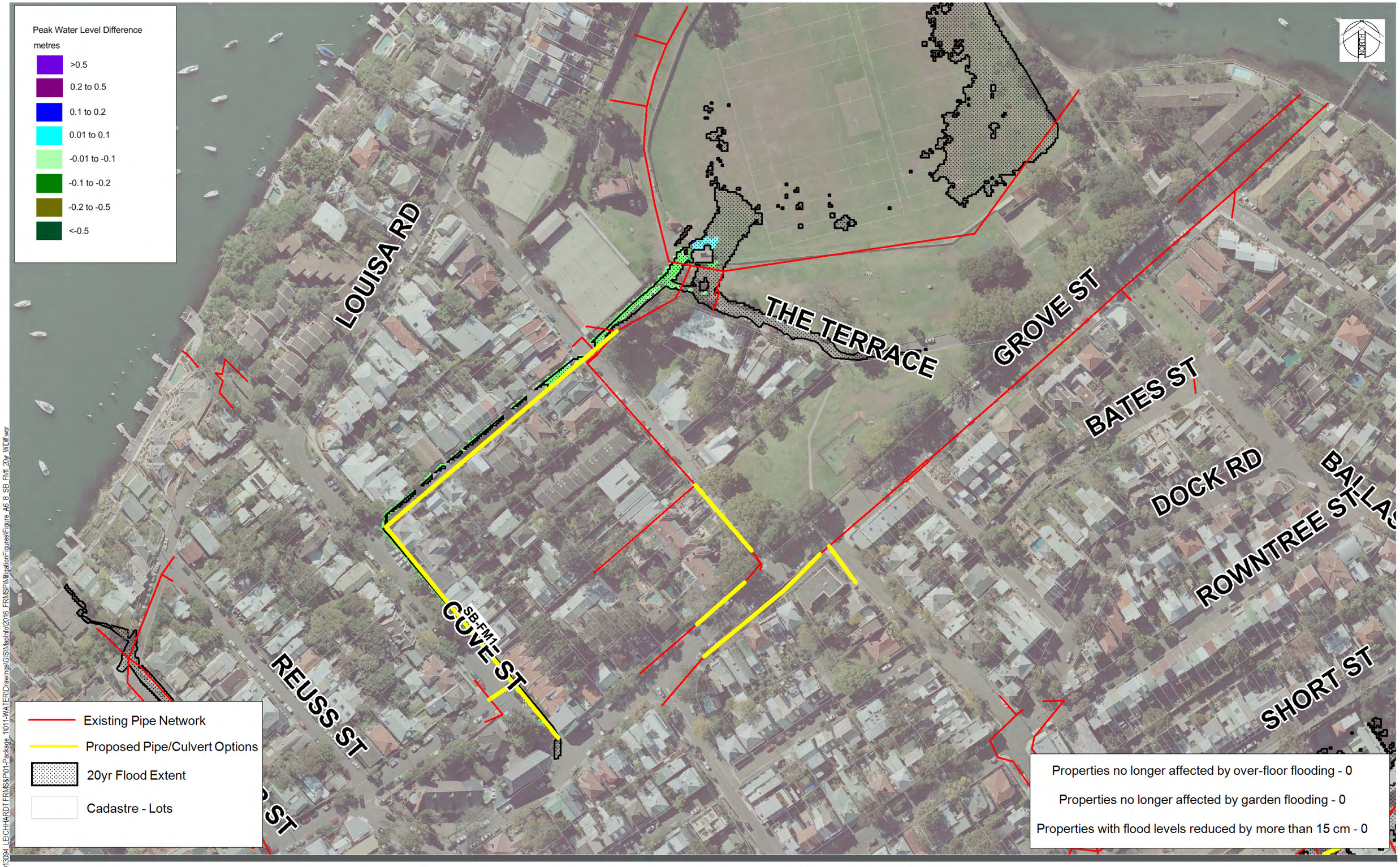
INNER WEST COUNCIL
LEICHHARDT FRMS&P
SB_FM1 5YR ARI WL DIFF
MITIGATION LESS EXISTING
FIG_A6_7

Date
03/2017

Size
A3

SB_FM1_5yr_WlDiff
Drawing Number

03
Revision



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INNER WEST COUNCIL
LEICHHARDT FRMS&P
SB_FM1 20YR ARI WL DIFF
MITIGATION LESS EXISTING
FIG_A6_8

Date
03/2017

Size
A3

SB_FM1_20yr_WlDiff
Drawing Number

03
Revision

Peak Water Level Difference
metres

- >0.5
- 0.2 to 0.5
- 0.1 to 0.2
- 0.01 to 0.1
- -0.01 to -0.1
- -0.1 to -0.2
- -0.2 to -0.5
- <-0.5

LOUISA RD

THE TERRACE

GROVE ST

BATES ST

DOCK RD

ROWNTREE ST

SHORT ST

REUSS ST

SB-FM1

COVE ST

- Existing Pipe Network
- Proposed Pipe/Culvert Options
- 100yr Flood Extent
- Cadastre - Lots

Properties no longer affected by over-floor flooding - 0

Properties no longer affected by garden flooding - 0

Properties with flood levels reduced by more than 15 cm - 0

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INNER WEST COUNCIL
LEICHHARDT FRMS&P
SB_FM1 100YR ARI WL DIFF
MITIGATION LESS EXISTING
FIG_A6_9

Date
03/2017

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SB_FM1_100yr_WIDiff
Drawing Number

03
Revision

Area 7- Rozelle Bay Options Assessment

Leichhardt Flood Risk Management Study and Plan

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Tables

Figures

1 Rozelle Bay Catchment Description

A large portion of the Rozelle Bay Catchment is located within the suburb of Lilyfield. The majority of the catchment drains towards the Rozelle old rail yards and then into Rozelle Bay. Significant ponding occurs in the rail yards, with the flood levels controlled by the centreline of the City West Link.

The location of the Rozelle Bay Catchment within the study area is shown in **Figure 1-1.**

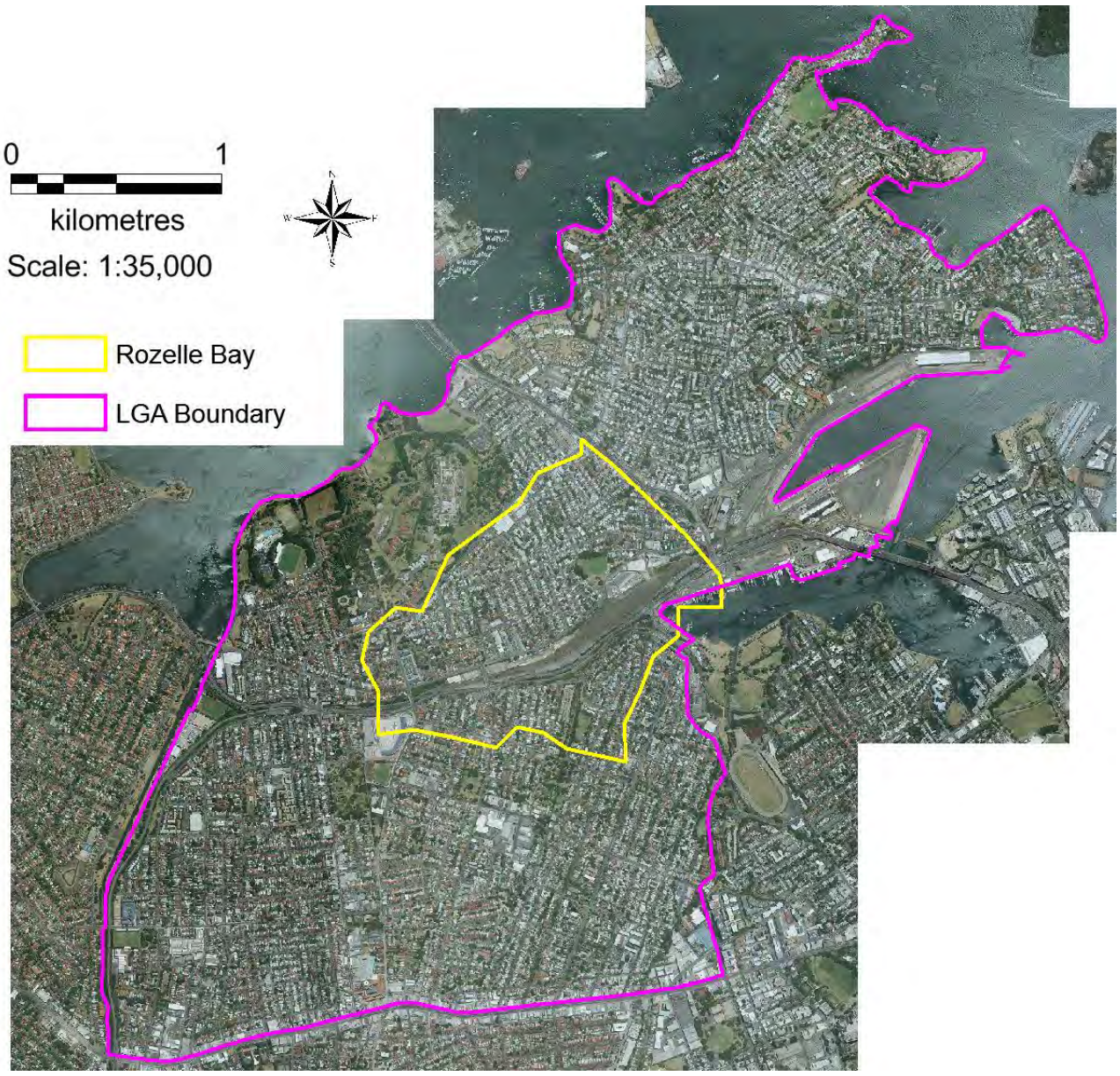

Figure 1-1 Rozelle Bay Catchment Location

2 Flood Mitigation Options Identification

2.1 Flood Modification Measures for Rozelle Bay

The existing flood behaviour within the Rozelle Bay Catchment is detailed in the Leichhardt Flood Study (Cardno 2014). Based on the flood model results, historical information and engineering judgement, possible flood modification measures (i.e. structural measures) for the study area were identified.

The various management options were identified taking into consideration the:

- flood behaviour and flow in the 20 Year ARI event;
- grade of pipe (upstream and downstream); and
- preliminary availability and location of easements.

2.2 Rozelle Bay Flood Mitigation Options

Within the Rozelle Bay catchment two (2) sets of options were modelled. These are shown in Table 2-1 and Figure 2-1.

The 100yr, 20yr and 5yr ARI peak water level difference plots for each mitigation option are attached at the end of this appendix report.

Table 2-1 Rozelle Bay Mitigation Options

Option Description	Option Name	ID
Lilyfield Road Flow Path – Proposing additional pipes or duplication of existing pipe network. Proposed pipes connecting into the existing network at O' Neill St. Additional pipes from the low point on Denison St to the outlet at Rozelle Bay. Additional pipe network in Quirk Street, Gordon Street and Lilyfield Road with a branch along Alfred Street.	Lilyfield Street Branch RB-FM1	RB-FM1
Additional Culverts/Pipes across Lilyfield Road at four locations. From Joseph Street along Halloran Street to Lilyfield Road, Edward St, Justin St, Cecily St and Brenan Street South of the railyards.	Additional Culverts at Lilyfield Rd RB-FM2	RB-FM2

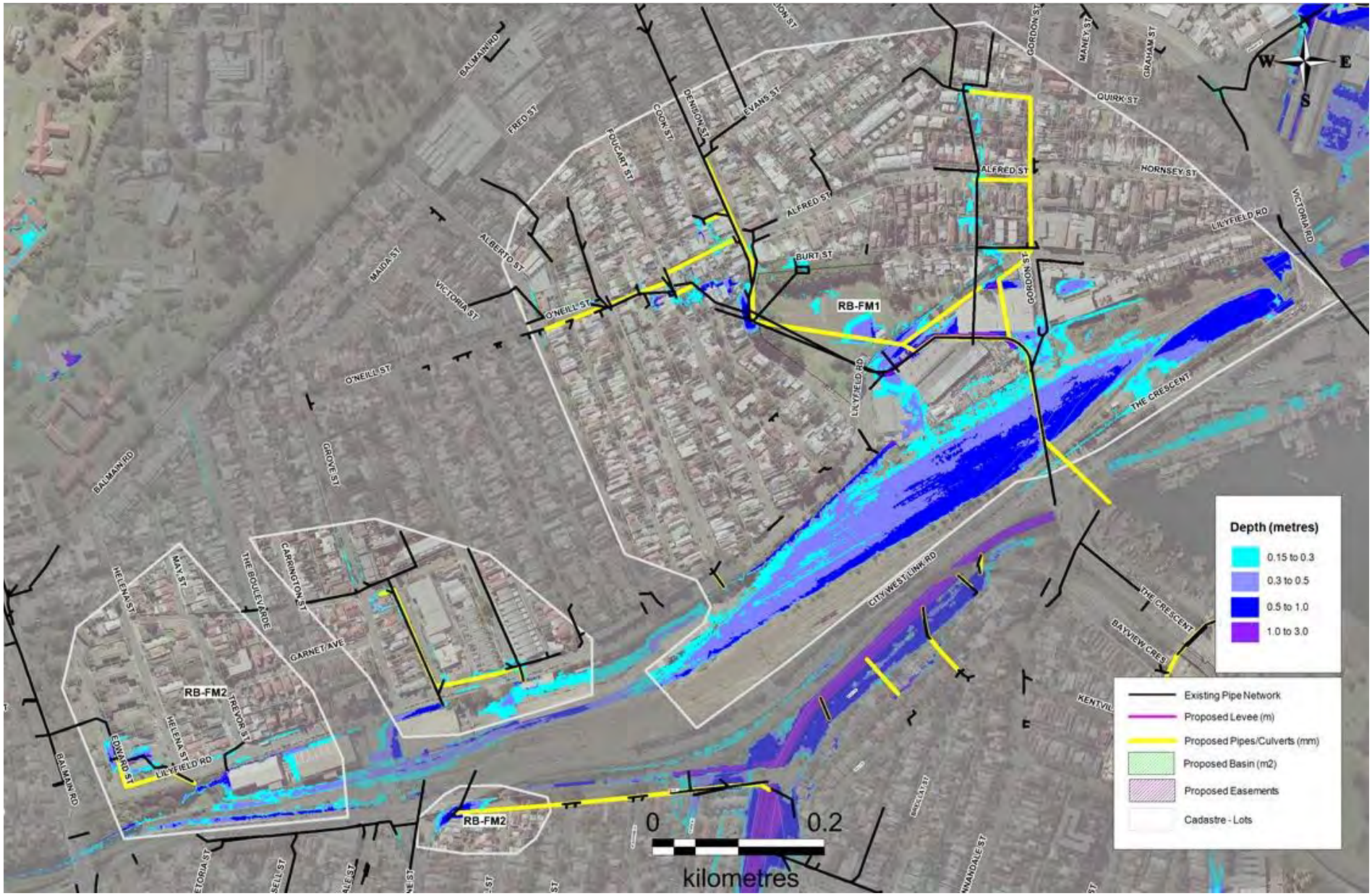

Figure 2-1 Rozelle Bay Mitigation Options Locations

2.2.2 Lilyfield Street Branch RB-FM1

The Lilyfield Road Flow Path proposes additional pipes and duplication of the existing pipe network. The option starts on O'Neill Street where a proposed pipe (900mm diameter) connects into the existing network at O' Neill Street. The proposed pipe continues onto Denison Street and connects to the proposed Dennison Street pipe at a junction point between a 1050mm diameter and a 1400mm diameter pipe. The 1400mm diameter pipe then connects to a box culvert (1.8m x 1.2m) which crosses Easton Park. At the southern end of the park, the culvert branches out into a 3.6m x 2.1m culvert and 1500mm diameter pipe. The final culvert eventually drains into Rozelle Bay.

The option also includes a proposed additional pipe network consisting of 750mm, 900mm and 1050mm diameter pipes in Quirk Street, Gordon Street and Lilyfield Road with a branch along Alfred Street.

The worst flooding under existing conditions occurs between Easton Park and Rozelle Bay with flood depths reaching around 2.8m in the 20 Year ARI event.

Potential constraints for this measure includes vegetation removal in Easton Park and changes to recreational use of Easton Park depending on the configuration of the adopted works.

This option will require communication with the rail stakeholders.

2.2.3 Additional Culverts / Pipes Lilyfield Rd RB-FM2

RB-FM2 proposes three pipes that cross Lilyfield Road towards north of the railyards and a proposed 900mm diameter pipe on Brenan Street South of the railyards.

The three pipes crossing Lilyfield Road start from Edward Street (900mm and 1200mm diameter pipes), Joseph Street along Halloran Street, Justin Street (900mm and 1200mm diameter pipes) and Cecily Street (900mm diameter pipe). Significant flood depths, due to the 20 Year ARI storm event, occur in the vicinity of Edward Street with depths up to 0.7m.

Funding from RMS may be available for the transverse pipe crossing works on Lilyfield Road.

3 Mitigation Option Modelling Outcomes

The Lilyfield Catchment flood mitigation options were assed for the 5, 10, 20, 50 and 100 Year ARI design flood events, along with the PMF event.

The outcomes of the modelling are shown in the 5, 20, and 100 Year ARI water level difference plots attached at the end of this catchment report.

A summary of the impacts on flood behaviour for each option is provided below.

3.1 Lilyfield Street Branch RB-FM1

The proposed mitigation option RB-FM1 shows reduction in flood levels along both O'Neill and Alfred Street flow path. The proposed increase in drainage capacity of mitigation option RB-FM1 is shown to decrease flood levels in an order of 0.01m – 0.30m in a 100 Year ARI. The mitigation strategy shows water level decreases along sections of O'Neil Street, Foucart Street, Brockley Street, Cheltenham Street, Denison Street and along Easton Park.

Along the Alfred Street flowpath, the reduction in water levels are in an order of 0.01m – 0.20m. Significant reductions in flood levels up to 0.50m are seen on Lilyfield Road and 0.10m on the railyards in a 100 Year ARI due to this proposed additional drainage. Results indicate many properties would experience a decrease in water level in a 100 Year ARI event due to this mitigation strategy.

3.2 Additional Culverts/Pipes Lilyfield Rd RB-FM2

The increase in drainage capacity at Edward Street, Halloran Street and Cecily Street flowpaths resulted in lower flood levels by 0.01m to 0.10m in a 100 Year ARI event. Significant reductions in flood levels up to 0.70m are seen on corner of Catherine Street and Brenan Street due to the proposed 900mm diameter additional pipe.

4 Economic Assessment of Flood Damages in the Rozelle Bay Catchment

4.1 Rozelle Bay Mitigation Options Damages Assessment

An assessment of damages for the existing condition in the Rozelle Bay Catchment is presented in the Floodplain Risk Management Study. The approach adopted for calculating the existing damages has been repeated for the modelling results from the mitigation options proposed for the Rozelle Bay catchment.

The economic flood damage results for each of the options and the existing scenarios are presented in **Table 4-1** and **Table 4-2**. The reductions in properties affected by overground and overfloor flooding, total damages and AAD are provided. Negative values represent increases from the existing scenario.

The total reduction in damaged properties and the associated reduction in damage costs for each mitigation strategy is summarised in **Table 4-3**. This table represents a summary of differences between existing and Mitigation scenarios presented in **Table 4-1** and **Table 4-2**.

The flood damages assessment is a useful tool for comparing the merits of various options, it is not a precise flood risk analysis tool and the limitation associated with the assessment should be considered when interpreting the results.

The following information should be considered when interpreting the damages data:

- Negative property or dollar values represent increases from the existing scenario.
- Where an option results in a reduction in flood depths there may not be any reduction in the flood damages where:
    - The reduction in flood depths or extent occur in open space or roadways; or
    - The reduction in flood depths occurs on properties that were not impacted by over floor flooding (i.e. the flooding on the property grounds is shallower but still exists).
- The flood damages are calculated at a discrete location on each property. This location is where the floor level and ground level survey was obtained from. As such, if the flooding occurs at another location on the property other than the survey point, this property will not register any damages with regards to this damages assessment.
- Commercial and industrial damages are only incurred when over floor flooding exists.
- The reduction in the number of properties impacted as a result of an option may vary between different flood events due to the performance of the proposed work under the different flow behaviour of each flood event.

Table 4-1 RB_FM1 Flood Damage Assessment Summary

Event / Property type	Properties with Overfloor Flooding		Properties with Overground Flooding		Estimated Total Damage ($ May 2015)	
	Existing Case	*Mitigation Case*	*Existing Case*	*Mitigation Case*	*Existing Case*	*Mitigation Case*
PMF Event						
Residential	141	123	228	223	$ 9,598,169	$ 8,508,429
Commercial	0	0	0	0	$ -	$ -
Industrial	4	4	4	4	$ 2,051,997	$ 1,714,311
PMF Total	**145**	**127**	**232**	**227**	**$ 11,650,166**	**$ 10,222,739**
100yr ARI						
Residential	30	23	48	47	$ 2,540,987	$ 1,944,581
Commercial	0	0	0	0	$ -	$ -
Industrial	2	1	2	2	$ 996,564	$ 340,243
100yr ARI Total	**32**	**24**	**50**	**49**	**$ 3,537,550**	**$ 2,284,824**
50yr ARI						
Residential	30	22	44	44	$ 2,410,925	$ 1,843,621
Commercial	0	0	0	0	$ -	$ -
Industrial	2	1	2	2	$ 899,702	$ 269,153
50yr ARI Total	**32**	**23**	**46**	**46**	**$ 3,310,627**	**$ 2,112,774**
20yr ARI						
Residential	25	20	40	40	$ 2,171,712	$ 1,240,251
Commercial	0	0	0	0	$ -	$ -
Industrial	2	1	2	2	$ 765,193	$ 234,546
20yr ARI Total	**27**	**21**	**42**	**42**	**$ 2,936,905**	**$ 1,474,797**
10yr ARI						
Residential	23	17	36	35	$ 1,959,699	$ 808,069
Commercial	0	0	0	0	$ -	$ -
Industrial	2	1	2	2	$ 657,015	$ 225,902
10yr ARI Total	**25**	**18**	**38**	**37**	**$ 2,616,713**	**$ 1,033,972**
5yr ARI						
Residential	17	13	29	28	$ 1,629,893	$ 551,422
Commercial	0	0	0	0	$ -	$ -
Industrial	1	1	1	1	$ 499,187	$ 218,493
5yr ARI Total	**18**	**14**	**30**	**29**	**$ 2,129,080**	**$ 769,914**
Total Annual Average Damage					**$ 899,377**	**$ 406,734**

Table 4-2 RB_FM2 Flood Damage Assessment Summary

Event / Property type	Properties with Overfloor Flooding		Properties with Overground Flooding		Estimated Total Damage ($ May 2015)	
	Existing Case	*Mitigation Case*	*Existing Case*	*Mitigation Case*	*Existing Case*	*Mitigation Case*
PMF Event						
Residential	44	45	83	83	$ 3,069,550	$ 3,056,221
Commercial	8	8	11	11	$ 491,606	$ 491,988
Industrial	9	9	10	10	$ 1,633,151	$ 1,633,157
PMF Total	**61**	**62**	**104**	**104**	**$ 5,194,306**	**$ 5,181,365**
100yr ARI						
Residential	8	7	19	19	$ 342,009	$ 296,432
Commercial	0	0	0	0	$ -	$ -
Industrial	1	1	3	3	$ 17,644	$ 19,343
100yr ARI Total	**9**	**8**	**22**	**22**	**$ 359,653**	**$ 315,775**
50yr ARI						
Residential	8	7	17	17	$ 305,513	$ 274,085
Commercial	0	0	0	0	$ -	$ -
Industrial	1	1	3	3	$ 14,822	$ 15,370
50yr ARI Total	**9**	**8**	**20**	**20**	**$ 320,335**	**$ 289,455**
20yr ARI						
Residential	7	6	15	15	$ 276,499	$ 253,173
Commercial	0	0	0	0	$ -	$ -
Industrial	1	1	2	2	$ 11,922	$ 12,687
20yr ARI Total	**8**	**7**	**17**	**17**	**$ 288,421**	**$ 265,860**
10yr ARI						
Residential	6	5	14	14	$ 230,276	$ 202,147
Commercial	0	0	0	0	$ -	$ -
Industrial	1	1	2	2	$ 9,733	$ 10,464
10yr ARI Total	**7**	**6**	**16**	**16**	**$ 240,009**	**$ 212,611**
5yr ARI						
Residential	3	3	12	11	$ 128,046	$ 102,204
Commercial	0	0	0	0	$ -	$ -
Industrial	1	1	2	2	$ 7,652	$ 8,330
5yr ARI Total	**4**	**4**	**14**	**13**	**$ 135,698**	**$ 110,534**
Total Annual Average Damage					**$ 92,649**	**$ 83,538**

Table 4-3 Reduction in Damages Associated with Each Option

	Overfloor flooding properties reduction	Overground flooding properties reduction	Total Damage Reduction ($)	AAD Reduction ($)
RB-FM1				
PMF event	18	5	$1,427,426	$13,399
100yr ARI event	8	1	$1,252,726	$12,253
50yr ARI event	9	0	$1,197,853	$39,899
20yr ARI event	6	0	$1,462,108	$76,121
10yr ARI event	7	1	$1,582,742	$147,095
5yr ARI event	4	1	$1,359,165	$203,875
Total				**$492,643**
RB-FM2				
PMF event	0	0	$ 12,941	$284
100yr ARI event	1	0	$ 43,878	$374
50yr ARI event	1	0	$ 30,880	$802
20yr ARI event	1	0	$ 22,561	$1,249
10yr ARI event	1	0	$ 27,399	$2,628
5yr ARI event	0	1	$ 25,164	$3,775
Total				**$9,111**

4.2 Benefit to Cost Ratio of Options

The economic evaluation of each modelled measure was assessed by considering the reduction in the amount of flood damages incurred for the design events and by then comparing this value with the cost of implementing the measure.

Table 4-12 summarises the results of the economic assessment of each of the flood management options. The indicator adopted to rank these measures on economic merit is the benefit-cost ratio (B/C), which is based on the net present worth (NPW) of the benefits (reduction in AAD) and the costs (capital and ongoing), adopting a 7% discount rate and an implementation period of 50 Years.

The benefit-cost ratio provides an insight into how the damage savings from a measure, relate to its cost of construction and maintenance:

- Where the benefit-cost is greater than 1 the economic benefits are greater than the cost of implementing the measure;
- Where the benefit-cost is less than 1 but greater than 0, there is still an economic benefit from implementing the measure but the cost of implementing the measure is greater than the economic benefit;
- Where the benefit-cost is equal to zero, there is no economic benefit from implementing the measure; and
- Where the benefit-cost is less than zero, there is a negative economic impact of implementing the measure.

Table 4-4 Summary of Economic Assessment of Flood Management Options

Option ID	Option Description	NPW of Reduction in AAD	NPW of Cost of Implementation	B/C Ratio	Economic Ranking
RB-FM1	**Lilyfield Road Flow Path** – Proposing additional pipes or duplication of existing pipe network. Proposed pipes connecting into the existing network at O' Neill St. Additional pipes from the low point on Denison St to the outlet at Rozelle Bay. Additional pipe network in Quirk Street, Gordon Street and Lilyfield Road with a branch along Alfred Street.	$6,799,000	$ 18,517,000	0.37	1
RB-FM2	**Additional Culverts/Pipes across Lilyfield Road** at four locations. From Joseph Street along Halloran Street to Lilyfield Road, Edward St, Justin St, Cecily St and Brenan Street South of the railyards.	$126,000	$ 3,108,000	0.04	2

Rozelle Bay Mitigation Option Figures

Figure RB_FM1_5yr_WlDiff
Figure RB_FM1_20yr_WlDiff
Figure RB_FM1_100yr_WlDiff
Figure RB_FM2_5yr_WlDiff
Figure RB_FM2_20yr_WlDiff
Figure RB_FM2_100yr_WlDiff

Peak Water Level Difference
metres

- >0.5
- 0.2 to 0.5
- 0.1 to 0.2
- 0.01 to 0.1
- -0.01 to -0.1
- -0.1 to -0.2
- -0.2 to -0.5
- <-0.5

FRED ST
COOK ST
FOUCART ST
DENISON ST
EVANS ST
QUIRK ST
ALFRED ST
HORNSEY ST
LILYFIELD RD
VICTORIA RD
BURT ST
GORDON ST
VICTORIA ST
O'NEILL ST
Lilyfield
THE CRESCENT
CITY WEST LINK RD
BAYVIEW CRES
KENTVILLE

Existing Pipe Network
Proposed Pipe/Culvert Options
5yr Flood Extent
Cadastre - Lots

Properties no longer affected by over-floor flooding - 4

Properties no longer affected by garden flooding - 1

Properties with flood levels reduced by more than 15 cm - 15

DATE PLOTTED: 04-Nov-2016 BY: Matthew.Prumm
FILE: N:\Projects\4999\FY13\NA49913094_LEICHHARDT FRMS&P\01-Package 1\011-WATER\Drawings\GIS\MapInfo\2016_FRMSP\MitigationFigures\Figure_A7_1_RB_FM1_5yr_WlDiff.wor

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INNER WEST COUNCIL
LEICHHARDT FRMS&P
RB_FM1 5YR ARI WL DIFF
MITIGATION LESS EXISTING
FIG_A7_1

Date
03/2017

Size
A3

RB_FM1_5yr_WlDiff
Drawing Number

03
Revision

Peak Water Level Difference
metres

- >0.5
- 0.2 to 0.5
- 0.1 to 0.2
- 0.01 to 0.1
- -0.01 to -0.1
- -0.1 to -0.2
- -0.2 to -0.5
- <-0.5

FRED ST
COOK ST
FOUCART ST
DENISON ST
EVANS ST
ALFRED ST
BURT ST
O'NEILL ST
VICTORIA ST
LILYFIELD RD
GORDON ST
QUIRK ST
HORNSEY ST
LILYFIELD RD
VICTORIA RD
THE CRESCENT
CITY WEST LINK RD
BAYVIEW CRES
KENTVILLE

- Existing Pipe Network
- Proposed Pipe/Culvert Options
- 20yr Flood Extent
- Cadastre - Lots

Properties no longer affected by over-floor flooding - 6

Properties no longer affected by garden flooding - 0

Properties with flood levels reduced by more than 15 cm - 27

DATE PLOTTED: 04-Nov-2016 BY: Matthew.Prumm
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INNER WEST COUNCIL
LEICHHARDT FRMS&P
RB_FM1 20YR ARI WL DIFF
MITIGATION LESS EXISTING
FIG_A7_2

Date
03/2017

Size
A3

RB_FM1_20yr_WlDiff
Drawing Number

03
Revision

Peak Water Level Difference
metres

- >0.5
- 0.2 to 0.5
- 0.1 to 0.2
- 0.01 to 0.1
- -0.01 to -0.1
- -0.1 to -0.2
- -0.2 to -0.5
- <-0.5

FRED ST
FOUCART ST
COOK ST
DENISON ST
EVANS ST
QUIRK ST
ALFRED ST
HORNSEY ST
LILYFIELD RD
VICTORIA RD
BURT ST
GORDON ST
VICTORIA ST
O'NEILL ST
THE CRESCENT
CITY WEST LINK RD
BAYVIEW CRES
KENTVILLE

- Existing Pipe Network
- Proposed Pipe/Culvert Options
- 100yr Flood Extent
- Cadastre - Lots

Properties no longer affected by over-floor flooding - 18

Properties no longer affected by garden flooding - 5

Properties with flood levels reduced by more than 15 cm - 37

DATE PLOTTED: 04-Nov-2016 BY: Matthew.Prumm
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INNER WEST COUNCIL
LEICHHARDT FRMS&P
RB_FM1 100YR ARI WL DIFF
MITIGATION LESS EXISTING
FIG_A7_3

Date
03/2017

Size
A3

RB_FM1_100yr_WIDiff
Drawing Number

03
Revision

Peak Water Level Difference
metres

- >0.5
- 0.2 to 0.5
- 0.1 to 0.2
- 0.01 to 0.1
- -0.01 to -0.1
- -0.1 to -0.2
- -0.2 to -0.5
- <-0.5

BALMAIN RD
GROVE ST
HELENA ST
MAY ST
THE BOULEVARDE
CARRINGTON ST
GARNET AVE
TREVOR ST
EDWARD ST
LILYFIELD RD
BALMAIN RD
ELD RD
PRETORIA ST
RUSSELL ST
LONSDALE ST
CATHERINE ST
PERCIVAL ST
STARLING ST
BRENAN ST
GLADSTONE ST
WHITE ST

NORTH

Existing Pipe Network
Proposed Pipe/Culvert Options
5yr Flood Extent
Cadastre - Lots

Properties no longer affected by over-floor flooding - 0

Properties no longer affected by garden flooding - 1

Properties with flood levels reduced by more than 15 cm - 2

DATE PLOTTED: 04-Nov-2016 BY: Matthew Prumm
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INNER WEST COUNCIL
LEICHHARDT FRMS&P
RB_FM2 5YR ARI WL DIFF
MITIGATION LESS EXISTING
FIG_A7_4

Date
03/2017

Size
A3

RB_FM2_5yr_WlDiff
Drawing Number

03
Revision

Peak Water Level Difference
metres

- >0.5
- 0.2 to 0.5
- 0.1 to 0.2
- 0.01 to 0.1
- -0.01 to -0.1
- -0.1 to -0.2
- -0.2 to -0.5
- <-0.5

BALMAIN RD
GROVE ST
CARRINGTON ST
THE BOULEVARDE
MAY ST
HELENA ST
GARNET AVE
TREVOR ST
HELENA ST
EDWARD ST
LILYFIELD RD
BALMAIN RD
ERIC ST
ELD RD
PRETORIA ST
RUSSELL ST
LONSDALE ST
CATHERINE ST
PERCIVAL ST
STARLING ST
BRENAN ST
GLADSTONE ST
WHITE ST

NORTH

Existing Pipe Network
Proposed Pipe/Culvert Options
20yr Flood Extent
Cadastre - Lots

Properties no longer affected by over-floor flooding - 1

Properties no longer affected by garden flooding - 0

Properties with flood levels reduced by more than 15 cm - 0

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FILE: N:\Projects\4991FY13\NA49913094_LEICHHARDT FRMS&P\01-Package 1\011-WATER\Drawings\GIS\MapInfo\2016_FRMSP\MitigationFigures\Figure_A7_5_RB_FM2_20yr_WIDiff.wor

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INNER WEST COUNCIL
LEICHHARDT FRMS&P
RB_FM2 20YR ARI WL DIFF
MITIGATION LESS EXISTING
FIG_A7_5

Date
03/2017

Size
A3

RB_FM2_20yr_WIDiff
Drawing Number

03
Revision

Peak Water Level Difference
metres

- >0.5
- 0.2 to 0.5
- 0.1 to 0.2
- 0.01 to 0.1
- -0.01 to -0.1
- -0.1 to -0.2
- -0.2 to -0.5
- <-0.5

BALMAIN RD
GROVE ST
CARRINGTON ST
THE BOULEVARDE
HELENA ST
MAY ST
GARNET AVE
TREVOR ST
EDWARD ST
LILYFIELD RD
BALMAIN RD
ELD RD
PRETORIA ST
RUSSELL ST
LONSDALE ST
CATHERINE ST
PERCIVAL ST
STARLING ST
BRENAN ST
GLADSTONE ST
WHITE ST

NORTH

Existing Pipe Network
Proposed Pipe/Culvert Options
100yr Flood Extent
Cadastre - Lots

Properties no longer affected by over-floor flooding - 1

Properties no longer affected by garden flooding - 0

Properties with flood levels reduced by more than 15 cm - 0

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INNER WEST COUNCIL
LEICHHARDT FRMS&P
RB_FM2 100YR ARI WL DIFF
MITIGATION LESS EXISTING
FIG_A7_6

Date
03/2017

Size
A3

RB_FM2_100yr_WIDiff
Drawing Number

03
Revision

Area 8 - White Bay Options Assessment

Leichhardt Flood Risk Management Study and Plan

NA49913094

Prepared for
Inner West Council

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Tables

Figures

1 White Bay Catchment Description

The Whites Bay Catchment is approximately 120 hectares in size. The majority of the catchment is within Balmain. The two main flowpaths in this catchment discharge into Whites Bay. In both cases, properties have historically been constructed across the flowpaths resulting in significant obstruction to overland flows and associated ponding of water in streets and properties. In some cases, this obstruction to flow also results in an effective detention basin with a flood benefit to the properties downstream (as the obstruction from the properties slows and holds back the water, reducing the potential flooding downstream).

In the downstream portion of both of these flowpaths, flood levels are controlled by the culverts under Robert Street and the port at White Bay and the ability for flows to overtop the port area. In addition, a long section of the port is obstructed by a high level fence. The combination of these factors results in significant ponding of water in this location along Robert Street.

The location of the White Bay Catchment within the study area is shown in **Figure 1-1.**

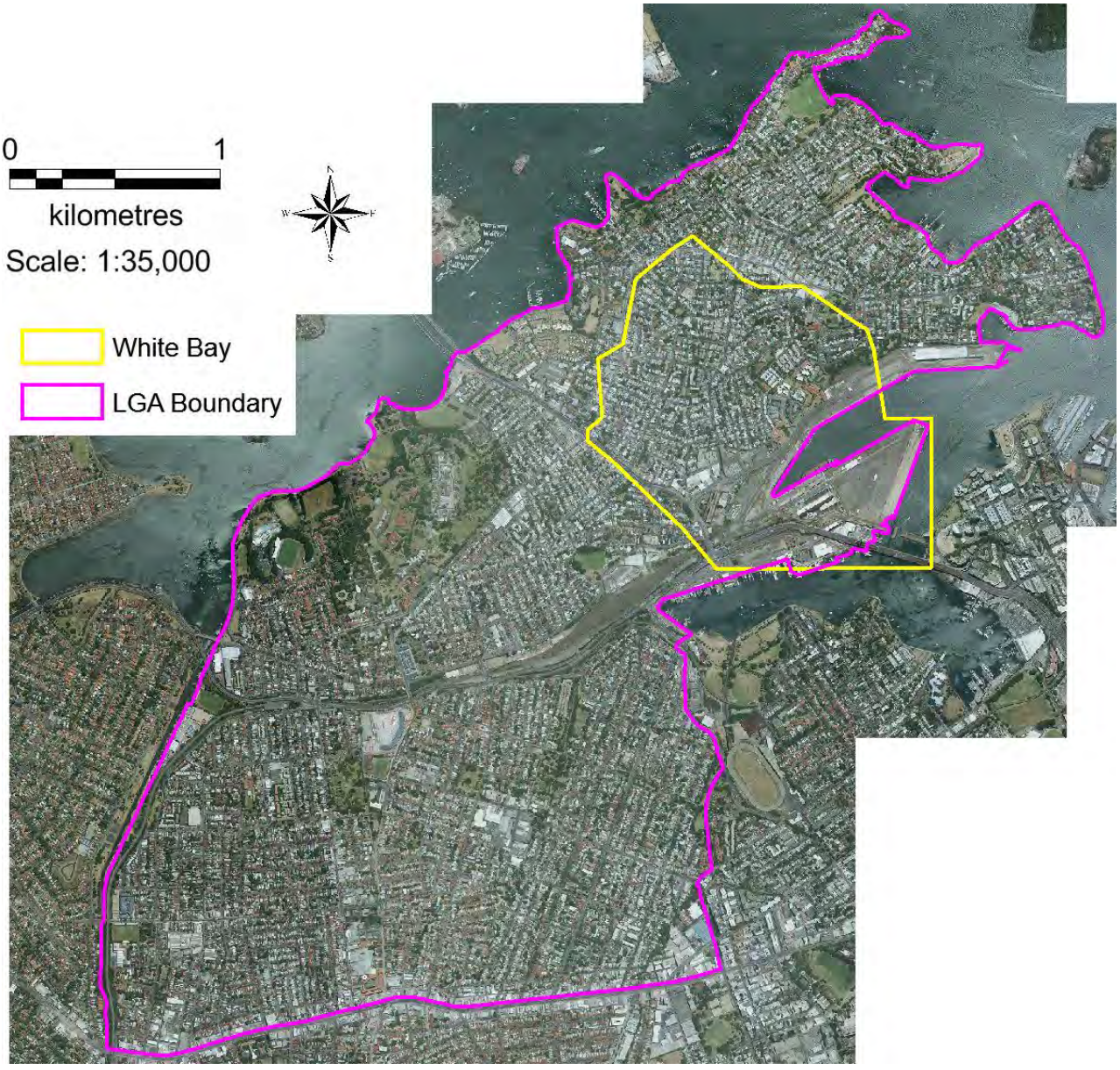

Figure 1-1 White Bay Catchment Location

2 Flood Mitigation Options Identification

2.1 Flood Modification Measures for White Bay

The existing flood behaviour within the Whites Bay is detailed in the Leichhardt Flood Study (Cardno 2014). Based on the flood model results, historical information and engineering judgement, possible flood modification measures (i.e. structural measures) for the study area were identified.

The various management options were identified taking into consideration the:

- flood behaviour and flow in the 20 year ARI event;
- grade of pipe (upstream and downstream); and
- preliminary availability and location of easements.

It should also be noted that Sydney Water and RMS may also play a major role in regards to fund allocation for the options recommended. Sydney Water's approach to flood-related improvement works on its assets is that Sydney Water will work with Councils to deliver the works (typically on a 50:50 cost-sharing basis) and provided Sydney Water has funding available within its Flood Risk Program. It is assumed that RMS will provide all the funding for the transverse pipe sections across State roads. Currently no allocation of RMS funding has been assigned for infrastructure travelling longitudinally along State Roads.

2.2 White Bay Flood Mitigation Options

Within the White Bay catchment six (6) sets of options were modelled, these are shown in **Table 2-1** and **Figure 2-1.** The 100yr, 20yr and 5yr ARI peak water level difference plots for each mitigation option are attached at the end of this appendix report.

Table 2-1 White Bay Mitigation Options

Option Description	Option Name	ID
Beattie Street Branch – Proposing a new pipe network or duplication of existing pipe network. Starting from Llewellyn St to the outlet at White Bay. The trunk drainage starts from Roseberry St at the start and Robert St to the end. Then travelling East, parallel to Robert St and eventually draining into White Bay.	Beattie Street Branch WB-FM1	WB-FM1
Wortley Street Branch – Proposing additional pipes to be incorporated into the existing pipe network. Additions at Creek St, Wortley St, Foy St, Hyam St, Roseberry Place and eventually crossing Robert St to drain into White bay.	Wortley Street Branch WB-FM2	WB-FM2
Reynolds Street/(Wortley Street) Proposed Basin – Proposed basin in Punch park, situated next to Reynolds St.	Reynolds Street Proposed Basin WB-FM3	WB-FM3
Montague Street Branch and additional pipes – Proposing additional pipes from Montague St that connect into the existing network.	Montague Street Branch WB-FM4	WB-FM4
Booth Street Proposed Basin – at Gladstone park (Balmain Public School) next to Booth St.	Booth Street Proposed Basin WB-FM5	WB-FM5
Elliot Street Basin	Elliot Street Basin WB-FM6	WB-FM6

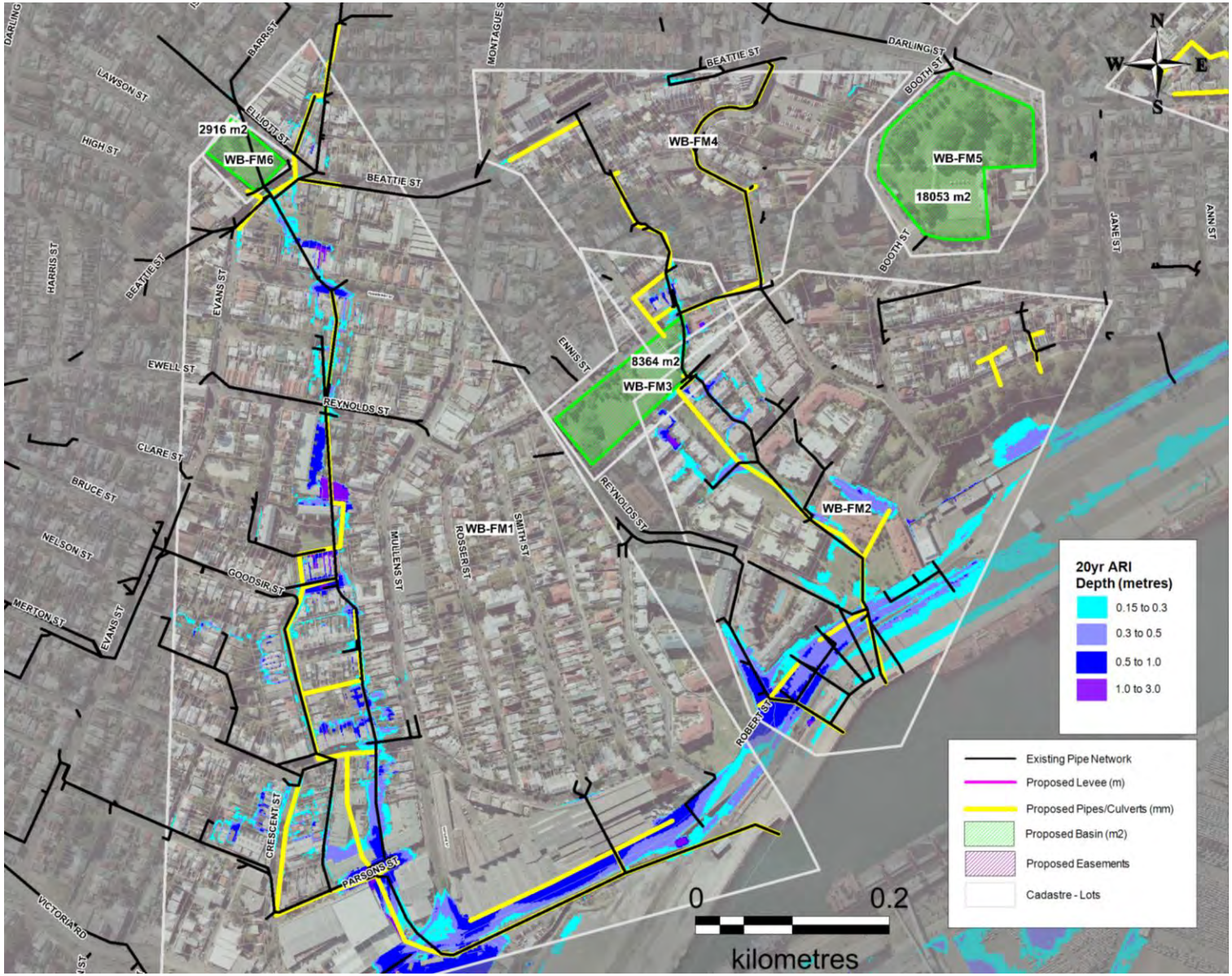

Figure 2-1 White Bay Mitigation Options Locations

2.2.1 Beattie Street Branch WB-FM1

The Beattie Street Branch proposes new pipes and duplication of the existing pipe network. WB-FM1 starts with a proposed 600mm diameter pipe north of the Beattie Street / Elliot Street intersection, with the proposed works culminating in a proposed 2.8m x 1.8m culvert draining to White Bay. The proposed branch which starts at Llewellyn Street includes proposed 600mm and 900mm diameter pipes, which join the existing Sydney Water 900mm diameter pipe in Evans Street. The main pipe branch of this option crosses Roseberry Street (1200mm diameter pipe), Reynolds Street (1500mm diameter pipe), Goodsir Street (1650mm diameter pipe), Perrett Street (1650mm diameter pipe), Mullens Street (1650mm diameter pipe), Mansfield Street (1650mm diameter pipe) and ending on Parsons Street (1650mm diameter pipe). Side branches (900mm, 1200mm, 1000mm diameter pipes) drain into the main branch at various locations between Beattie Street and Parson Street. On Parson Street the pipe drains onto a 2.8m x 1.8m box culvert located along Robert Street before eventually draining into White Bay.

Further additional drainage works are proposed from Hanover Street (450mm, 600mm and 900mm diameter pipes) to the existing main trunk drainage at Parsons Street.

Flooding is present under existing conditions in the area with depths reaching up to 2m as result of the 20 year ARI storm event.

Potential constraints for this measure include the buyback of two properties and costs due to construction, services and traffic management requirements on Robert Street.

Funding from Sydney Water (for the main trunk drainage) and RMS funding may be available for a majority of the cost. The RMS funding has been allocated towards the transverse pipe upgrade on Robert Street.

2.2.2 Wortley Street Branch WB-FM2

This option proposes additional pipes from Pashley Street to Roberts Street. The proposed drainage passes through Creek Street, Wortley Street, Foy Street, Hyam Street, Roseberry Place and eventually crossing Robert Street to drain into White Bay.

2.2.3 Reynolds Street Proposed Basin WB-FM3

WB-FM3 consists of a proposed basin with an area of 8,400 square meters. The basin is proposed in Punch Park, next to Reynolds Street. The basin is required to hold a volume of 2,300 cubic meters. The aim of the basin is to mitigate flood inundation around the area due to the 20 year ARI storm event. Depths under existing conditions can reach around 1.6m in the 20 year ARI storm event.

Potential constraints for this measure includes vegetation removal in Punch Park and changes to recreational use of Punch Park, depending on the configuration of the basin and if underground storage is adopted.

2.2.4 Palmer Street Branch WB-FM4

Additional 750mm pipes are proposed from Beattie Street, connecting at the downstream end to the existing pipe network at Wortley Street.

2.2.5 Booth Street Proposed Basin WB-FM5

The preliminary options modelling reviewed the potential for a basin located at Gladstone Park (Balmain Public School), near to Booth Street. However, preliminary results indicated that there were very little, if any reductions in flood levels as a result of the proposed basin. As such, this option has not been assessed further.

2.2.6 Elliot Street Basin WB-FM6

WB-FM6 is a detention basin that has been proposed to be located at Ann Cashman Reserve north-west of the Elliot Street/Beattie Street intersection. The basin has an area of 2916 square meters and is proposed to hold a volume of around 2500 cubic meters. The aim of the basin is to mitigate flood inundation around that specific block. Under existing conditions flood depths reach up to 1m due to the 20 year ARI storm event.

Potential constraints for this measure includes vegetation removal from the grounds and changes to recreational use of the grounds. The specific design of the basin configuration and / or the use of underground storage may mitigate some of these impacts.

3 Mitigation Option Modelling Outcomes

The Whites Bay flood mitigation options were assed for the 5, 10, 20, 50 and 100 Year ARI design flood events, along with the PMF event.

The outcomes of the modelling are shown in the 5, 20, and 100 Year ARI water level difference plots in **Appendix D**.

A summary of the impacts on flood behaviour for each option is provided below.

3.1 Beattie Street Branch WB-FM1

The proposed increase in drainage capacity of mitigation option WB-FM1 is shown to reduce overland flows for the majority of the Beattie Street flow path. The water level difference results show a decrease of 0.1m – 0.85m along the flow path in the 20 Year ARI event. The mitigation strategy particularly shows significant water level decreases on Beattie Street, Roseberry Street, Reynolds Street, Goodsir Street, Moore Street, Perrett Street, Pine Street, Mansfield Street, Parsons Street and Robert Street. Decreases in water levels up to 0.10m are also observed on Hanover Street, Murdoch Street, Collins Street and Crescent Street.

Modelling of this mitigation strategy indicates that many properties in this catchment would have a reduction in water levels in all events, with a number of properties no longer experiencing over floor flooding in both frequent and rare events.

3.2 Wortley Street Branch WB-FM2

Mitigation option WB-FM2 shows significant water level decreases along the Wortley Street Branch flowpath. The increase in drainage capacity at Roberts Street has significant reductions in flood levels (up to 0.70m in a 100 Year ARI event). Decreases in flood levels are also seen on Wortley Street, Foy Street, Hyam Street, Rosebery Place and Buchanan Street. The reductions in flood levels along the flowpath are in an order of 0.10m and 0.30m for all the modelled design flood events.

Over floor flooding is removed for up to 10 properties in most events assessed.

3.3 Reynolds Street Proposed Basin WB-FM3

The proposed detention basin option at Reynolds Street (WB-FM3) shows slight reductions in flood levels downstream of the basin. The reductions are in an order of 0.01m to 0.10m in a 5 Year ARI event.

3.4 Palmer Street Branch WB-FM4

Mitigation option WB-FM4 shows decreases in flood levels along the Palmer Street flowpath and the Little Street flowpath in all the modelled flood events. The reductions are in an order of 0.01m to 0.10m vicinity of the proposed option.

The option does not remove flooding entirely from the grounds of any properties, but may result in two properties no longer being affected by overfloor flooding in all events up to and including the 100 year ARI event.

3.5 Elliot Street Basin WB-FM6

The basin proposed at Elliot Street results in only minor decreases in flood levels and results in flood level increases of approximately 0.2m immediately downstream of the basin.

The minor flood level reductions are relatively widespread and so result in an overall flood damages reduction in the more frequent events, despite the increased damages locally to the basin. However, in the rarer events (50 Year ARI and greater) the increase in flood levels immediately downstream of the basin exceed the benefits further downstream and result in an overall increase in flood damages. Due to these increases in flood damages, this option has not been assessed with regards to its benefit costs ratio.

4 Economic Assessment of Flood Damages in the Whites Bay Catchment

4.1 Whites Bay Mitigation Options Damages Assessment

An assessment of damages for the existing condition in the White Bay Catchment is presented in the Floodplain Risk Management Study. The approach adopted for calculating the existing damages has been repeated for the modelling results from the mitigation options proposed for the White Bay catchment.

The economic flood damage results for each of the options and the existing scenarios are presented in **Table** 4-1 to **Table 4-5**. The reductions in properties affected by overground and overfloor flooding, total damages and AAD are provided. Negative values represent increases from the existing scenario.

The total reduction in damaged properties and the associated reduction in damage costs for each mitigation strategy is summarised in **Table 4-6**. This table represents a summary of differences between existing and Mitigation scenarios presented in **Table 4-1** to **Table 4-5.**

The flood damages assessment is a useful tool for comparing the merits of various options, it is not a precise flood risk analysis tool and the limitation associated with the assessment should be considered when interpreting the results.

The following information should be considered when interpreting the damages data:

- Negative property or dollar values represent increases from the existing scenario.
- Where an option results in a reduction in flood depths there may not be any reduction in the flood damages where:
    - The reduction in flood depths or extent occur in open space or roadways; or
    - The reduction in flood depths occurs on properties that were not impacted by over floor flooding (i.e. the flooding on the property grounds is shallower but still exists).
- The flood damages are calculated at a discrete location on each property. This location is where the floor level and ground level survey was obtained from. As such, if the flooding occurs at another location on the property other than the survey point, this property will not register any damages with regards to this damages assessment.
- Commercial and industrial damages are only incurred when over floor flooding exists.
- The reduction in the number of properties impacted as a result of an option may vary between different flood events due to the performance of the proposed work under the different flow behaviour of each flood event.

Table 4-1 WB_FM1 Flood Damage Assessment Summary

Event / Property type	Properties with Overfloor Flooding		Properties with Overground Flooding		Estimated Total Damage ($ June 2016)	
	Existing Case	*Mitigation Case*	*Existing Case*	*Mitigation Case*	*Existing Case*	*Mitigation Case*
PMF Event						
Residential	357	316	531	525	$ 22,742,301	$ 20,166,820
Commercial	2	2	7	7	$ 79,707	$ 79,733
Industrial	39	37	43	43	$ 9,367,993	$ 8,775,617
PMF Total	**398**	**355**	**581**	**575**	**$ 32,190,001**	**$ 29,022,170**
100yr ARI						
Residential	104	83	154	145	$ 5,595,125	$ 4,289,188
Commercial	0	0	0	0	$ -	$ -
Industrial	26	12	26	26	$ 5,076,109	$ 4,413,319
100yr ARI Total	**130**	**95**	**180**	**171**	**$ 10,671,235**	**$ 8,702,507**
50yr ARI						
Residential	96	80	150	142	$ 5,019,880	$ 4,095,138
Commercial	0	0	0	0	$ -	$ -
Industrial	24	9	26	26	$ 4,681,605	$ 4,077,309
50yr ARI Total	**120**	**89**	**176**	**168**	**$ 9,701,484**	**$ 8,172,447**
20yr ARI						
Residential	85	72	138	135	$ 4,396,833	$ 3,762,711
Commercial	0	0	0	0	$ -	$ -
Industrial	21	9	24	23	$ 4,429,241	$ 3,907,988
20yr ARI Total	**106**	**81**	**162**	**158**	**$ 8,826,073**	**$ 7,670,699**
10yr ARI						
Residential	77	65	123	121	$ 3,991,635	$ 3,241,294
Commercial	0	0	0	0	$ -	$ -
Industrial	18	9	23	10	$ 4,106,883	$ 3,714,501
10yr ARI Total	**95**	**74**	**146**	**131**	**$ 8,098,518**	**$ 6,955,795**
5yr ARI						
Residential	50	42	89	86	$ 2,826,076	$ 2,202,891
Commercial	0	0	0	0	$ -	$ -
Industrial	15	6	15	14	$ 2,650,756	$ 2,340,196
5yr ARI Total	**65**	**48**	**104**	**100**	**$ 5,476,832**	**$ 4,543,087**
Total Annual Average Damage					**$ 2,517,469**	**$ 2,132,696**

Table 4-2 WB_FM2 Flood Damage Assessment Summary

Event / Property type	Properties with Overfloor Flooding		Properties with Overground Flooding		Estimated Total Damage ($ June 2016)	
	Existing Case	*Mitigation Case*	*Existing Case*	*Mitigation Case*	*Existing Case*	*Mitigation Case*
PMF Event						
Residential	96	96	143	143	$ 10,160,824	$ 10,160,824
Commercial	1	1	3	3	$ 289,104	$ 289,104
Industrial	16	16	16	16	$ 7,461,065	$ 7,461,065
PMF Total	**113**	**113**	**162**	**162**	**$ 17,910,993**	**$ 17,910,993**
100yr ARI						
Residential	28	24	40	39	$ 2,233,888	$ 1,469,113
Commercial	0	0	0	0	$ -	$ -
Industrial	12	6	12	12	$ 3,244,299	$ 2,844,632
100yr ARI Total	**40**	**30**	**52**	**51**	**$ 5,478,187**	**$ 4,313,745**
50yr ARI						
Residential	26	22	40	39	$ 2,146,353	$ 1,397,231
Commercial	0	0	0	0	$ -	$ -
Industrial	11	4	12	12	$ 2,888,702	$ 2,505,333
50yr ARI Total	**37**	**26**	**52**	**51**	**$ 5,035,055**	**$ 3,902,564**
20yr ARI						
Residential	24	22	38	37	$ 1,920,098	$ 1,391,384
Commercial	0	0	0	0	$ -	$ -
Industrial	9	2	11	11	$ 2,470,792	$ 2,133,331
20yr ARI Total	**33**	**24**	**49**	**48**	**$ 4,390,890**	**$ 3,524,715**
10yr ARI						
Residential	21	19	34	33	$ 1,670,693	$ 1,144,833
Commercial	0	0	0	0	$ -	$ -
Industrial	9	2	10	9	$ 2,085,534	$ 1,797,925
10yr ARI Total	**30**	**21**	**44**	**42**	**$ 3,756,227**	**$ 2,942,758**
5yr ARI						
Residential	18	16	29	28	$ 1,445,713	$ 993,860
Commercial	0	0	0	0	$ -	$ -
Industrial	8	1	8	8	$ 272,794	$ 76,702
5yr ARI Total	**26**	**17**	**37**	**36**	**$ 1,718,507**	**$ 1,070,563**
Total Annual Average Damage					**$ 502,048**	**$ 500,033**

Table 4-3 WB_FM3 Flood Damage Assessment Summary

Event / Property type	Properties with Overfloor Flooding		Properties with Overground Flooding		Estimated Total Damage ($ June 2016)	
	Existing Case	*Mitigation Case*	*Existing Case*	*Mitigation Case*	*Existing Case*	*Mitigation Case*
PMF Event						
Residential	35	35	36	36	$ 5,395,415	$ 5,335,719
Commercial	1	1	1	1	$ 289,104	$ 289,131
Industrial	0	0	0	0	$ -	$ -
PMF Total	**36**	**36**	**37**	**37**	**$ 5,684,519**	**$ 5,624,849**
100yr ARI						
Residential	20	18	22	22	$ 1,464,784	$ 1,304,625
Commercial	0	0	0	0	$ -	$ -
Industrial	0	0	0	0	$ -	$ -
100yr ARI Total	**20**	**18**	**22**	**22**	**$ 1,464,784**	**$ 1,304,625**
50yr ARI						
Residential	19	17	21	21	$ 1,415,370	$ 1,249,483
Commercial	0	0	0	0	$ -	$ -
Industrial	0	0	0	0	$ -	$ -
50yr ARI Total	**19**	**17**	**21**	**21**	**$ 1,415,370**	**$ 1,249,483**
20yr ARI						
Residential	19	16	21	21	$ 1,261,857	$ 1,114,281
Commercial	0	0	0	0	$ -	$ -
Industrial	0	0	0	0	$ -	$ -
20yr ARI Total	**19**	**16**	**21**	**21**	**$ 1,261,857**	**$ 1,114,281**
10yr ARI						
Residential	16	14	19	19	$ 1,054,304	$ 899,479
Commercial	0	0	0	0	$ -	$ -
Industrial	0	0	0	0	$ -	$ -
10yr ARI Total	**16**	**14**	**19**	**19**	**$ 1,054,304**	**$ 899,479**
5yr ARI						
Residential	14	12	15	15	$ 882,709	$ 749,194
Commercial	0	0	0	0	$ -	$ -
Industrial	0	0	0	0	$ -	$ -
5yr ARI Total	**14**	**12**	**15**	**15**	**$ 882,709**	**$ 749,194**
Total Annual Average Damage					**$ 377,463**	**$ 328,028**

Table 4-4 WB_FM4 Flood Damage Assessment Summary

Event / Property type	Properties with Overfloor Flooding		Properties with Overground Flooding		Estimated Total Damage ($ June 2016)	
	Existing Case	*Mitigation Case*	*Existing Case*	*Mitigation Case*	*Existing Case*	*Mitigation Case*
PMF Event						
Residential	86	83	132	131	$ 6,177,358	$ 6,019,987
Commercial	1	1	4	4	$ 289,104	$ 288,353
Industrial	0	0	0	0	$ -	$ -
PMF Total	**87**	**84**	**136**	**135**	**$ 6,466,462**	**$ 6,308,340**
100yr ARI						
Residential	24	22	35	35	$ 1,569,261	$ 1,499,172
Commercial	0	0	0	0	$ -	$ -
Industrial	0	0	0	0	$ -	$ -
100yr ARI Total	**24**	**22**	**35**	**35**	**$ 1,569,261**	**$ 1,499,172**
50yr ARI						
Residential	23	22	36	36	$ 1,492,568	$ 1,435,410
Commercial	0	0	0	0	$ -	$ -
Industrial	0	0	0	0	$ -	$ -
50yr ARI Total	**23**	**22**	**36**	**36**	**$ 1,492,568**	**$ 1,435,410**
20yr ARI						
Residential	22	21	34	34	$ 1,423,753	$ 1,364,256
Commercial	0	0	0	0	$ -	$ -
Industrial	0	0	0	0	$ -	$ -
20yr ARI Total	**22**	**21**	**34**	**34**	**$ 1,423,753**	**$ 1,364,256**
10yr ARI						
Residential	20	19	30	30	$ 1,201,420	$ 1,147,428
Commercial	0	0	0	0	$ -	$ -
Industrial	0	0	0	0	$ -	$ -
10yr ARI Total	**20**	**19**	**30**	**30**	**$ 1,201,420**	**$ 1,147,428**
5yr ARI						
Residential	17	16	27	27	$ 1,021,235	$ 950,024
Commercial	0	0	0	0	$ -	$ -
Industrial	0	0	0	0	$ -	$ -
5yr ARI Total	**17**	**16**	**27**	**27**	**$ 1,021,235**	**$ 950,024**
Total Annual Average Damage					**$ 429,176**	**$ 405,870**

Table 4-5 WB_FM6 Flood Damage Assessment Summary

Event / Property type	Properties with Overfloor Flooding		Properties with Overground Flooding		Estimated Total Damage ($ June 2016)	
	Existing Case	*Mitigation Case*	*Existing Case*	*Mitigation Case*	*Existing Case*	*Mitigation Case*
PMF Event						
Residential	296	298	402	402	$ 17,585,743	$ 17,780,398
Commercial	0	0	0	0	$ -	$ -
Industrial	34	34	38	38	$ 3,347,421	$ 3,339,273
PMF Total	**330**	**332**	**440**	**440**	**$ 20,933,164**	**$ 21,119,672**
100yr ARI						
Residential	100	100	150	150	$ 4,983,405	$ 4,975,314
Commercial	0	0	0	0	$ -	$ -
Industrial	22	22	22	22	$ 2,439,372	$ 2,450,042
100yr ARI Total	**122**	**122**	**172**	**172**	**$ 7,422,777**	**$ 7,425,356**
50yr ARI						
Residential	92	93	146	146	$ 4,415,728	$ 4,436,709
Commercial	0	0	0	0	$ -	$ -
Industrial	20	19	22	22	$ 2,394,427	$ 2,385,119
50yr ARI Total	**112**	**112**	**168**	**168**	**$ 6,810,156**	**$ 6,821,827**
20yr ARI						
Residential	82	83	134	134	$ 3,839,152	$ 3,835,032
Commercial	0	0	0	0	$ -	$ -
Industrial	17	17	20	20	$ 2,323,403	$ 2,322,578
20yr ARI Total	**99**	**100**	**154**	**154**	**$ 6,162,555**	**$ 6,157,610**
10yr ARI						
Residential	74	74	119	119	$ 3,449,964	$ 3,445,416
Commercial	0	0	0	0	$ -	$ -
Industrial	14	14	19	19	$ 2,242,490	$ 2,239,377
10yr ARI Total	**88**	**88**	**138**	**138**	**$ 5,692,454**	**$ 5,684,793**
5yr ARI						
Residential	48	48	86	86	$ 2,348,242	$ 2,337,902
Commercial	0	0	0	0	$ -	$ -
Industrial	11	11	11	11	$ 983,743	$ 981,414
5yr ARI Total	**59**	**59**	**97**	**97**	**$ 3,331,985**	**$ 3,319,316**
Total Annual Average Damage					**$ 1,654,916**	**$ 1,652,801**

Table 4-6 Reduction in Damages Associated with Each Option

	Overfloor flooding properties reduction	Overground flooding properties reduction	Total Damage Reduction ($)	AAD Reduction ($)
WB-FM1				
PMF event	43	6	$3,167,831	$25,680
100yr ARI event	35	9	$1,968,728	$17,489
50yr ARI event	31	8	$1,529,038	$40,266
20yr ARI event	25	4	$1,155,375	$57,452
10yr ARI event	21	15	$1,142,723	$103,823
5yr ARI event	17	4	$ 933,745	$140,062
Total				**$384,773**
WB-FM2				
PMF event	0	0	$ -	$5,822
100yr ARI event	10	1	$1,164,442	$11,485
50yr ARI event	11	1	$1,132,491	$29,980
20yr ARI event	9	1	$ 866,175	$41,991
10yr ARI event	9	2	$ 813,469	$73,071
5yr ARI event	9	1	$ 647,944	$97,192
Total				**$259,540**
WB-FM3				
PMF event	0	0	$ 59,669	$1,099
100yr ARI event	2	0	$ 160,158	$1,630
50yr ARI event	2	0	$ 165,887	$4,702
20yr ARI event	3	0	$ 147,576	$7,560
10yr ARI event	2	0	$ 154,825	$14,417
5yr ARI event	2	0	$ 133,515	$20,027
Total				**$49,436**
WB-FM4				
PMF event	3	1	$ 158,122	$1,141
100yr ARI event	2	0	$ 70,088	$636
50yr ARI event	1	0	$ 57,158	$1,750
20yr ARI event	1	0	$ 59,497	$2,837
10yr ARI event	1	0	$ 53,992	$6,260
5yr ARI event	1	0	$ 71,211	$10,682
Total				**$23,306**
WB-FM6				
PMF event	-2	0	-$ 186,508	-$945
100yr ARI event	0	0	-$ 2,579	-$71
50yr ARI event	0	0	-$ 11,672	-$101
20yr ARI event	-1	0	$ 4,944	$315
10yr ARI event	0	0	$ 7,661	$1,016
5yr ARI event	0	0	$ 12,669	$1,900
Total				**$2,114**

[1] A modelling instability produced unreliable results for the PMF design event for FM2. The results available, would suggest the flow behaviour would not be impacted significantly in the PMF as a result of this option.

4.2 Benefit to Cost Ratio of Options

The economic evaluation of each modelled measure was assessed by considering the reduction in the amount of flood damages incurred for the design events and by then comparing this value with the cost of implementing the measure.

Table 4-7 summarises the results of the economic assessment of each of the flood management options. The indicator adopted to rank these measures on economic merit is the benefit-cost ratio (B/C), which is based on the net present worth (NPW) of the benefits (reduction in AAD) and the costs (capital and ongoing), adopting a 7% discount rate and an implementation period of 50 years.

The benefit-cost ratio provides an insight into how the damage savings from a measure, relate to its cost of construction and maintenance:

- Where the benefit-cost is greater than 1 the economic benefits are greater than the cost of implementing the measure;
- Where the benefit-cost is less than 1 but greater than 0, there is still an economic benefit from implementing the measure but the cost of implementing the measure is greater than the economic benefit;
- Where the benefit-cost is equal to zero, there is no economic benefit from implementing the measure; and
- Where the benefit-cost is less than zero, there is a negative economic impact of implementing the measure.

Table 4-7 Summary of Economic Assessment of Flood Management Options

Option ID	Option Description	NPW of Reduction in AAD	NPW of Cost of Implementation	B/C Ratio	Economic Ranking
WB-FM1	**Beattie Street Branch** – Proposing a new pipe network or duplication of existing pipe network. Starting from Llewellyn St to the outlet at White Bay. The trunk drainage starts from Roseberry St at the start and Robert St to the end. Then travelling East, parallel to Robert St and eventually draining into White Bay.	$5,310,000	$ 26,063,000	0.20	3
WB-FM2	**Wortley Street Branch** – Proposing additional pipes to be incorporated into the existing pipe network. Additions at Creek St, Wortley St, Foy St, Hyam St, Roseberry Place and eventually crossing Robert St to drain into White bay.	$3,582,000	$ 8,675,000	0.41	1
WB-FM3	**Reynolds Street (Wortley Street) Proposed Basin** – Proposed basin in Punch park, situated next to Reynolds St.	$682,000	$ 1,728,000	0.39	2
WB-FM4	**Montague Street Branch and additional pipes** – Proposing additional pipes from Montague St that connect into the existing network.	$322,000	$ 2,190,000	0.15	4
WB-FM5	**Booth Street Proposed Basin** – at Gladstone park (Balmain Public School) next to Booth St.	*Not Feasible*			
WB-FM6	**Elliot Street Basin**	*Not Feasible*			

White Bay Mitigation Option Figures

Figure WB_FM1_5yr_WlDiff
Figure WB_FM1_20yr_WlDiff
Figure WB_FM1_100yr_WlDiff
Figure WB_FM2_5yr_WlDiff
Figure WB_FM2_20yr_WlDiff
Figure WB_FM2_100yr_WlDiff
Figure WB_FM3_5yr_WlDiff
Figure WB_FM3_20yr_WlDiff
Figure WB_FM3_100yr_WlDiff
Figure WB_FM4_5yr_WlDiff
Figure WB_FM4_20yr_WlDiff
Figure WB_FM4_100yr_WlDiff
Figure WB_FM6_5yr_WlDiff
Figure WB_FM6_20yr_WlDiff
Figure WB_FM6_100yr_WlDiff

Peak Water Level Difference
metres

- >0.5
- 0.2 to 0.5
- 0.1 to 0.2
- 0.01 to 0.1
- -0.01 to -0.1
- -0.1 to -0.2
- -0.2 to -0.5
- <-0.5

Existing Pipe Network

Proposed Pipe/Culvert Options

5yr Flood Extent

Cadastre - Lots

Properties no longer affected by over-floor flooding - 16

Properties no longer affected by garden flooding - 4

Properties with flood levels reduced by more than 15 cm - 34

DATE PLOTTED: 04-Nov-2016 BY: Matthew Prumm
FILE: N:\Projects\84991FY13\N4-49912004_LEICHHARDT FRMS&P\01-Package_1\011-WATER\Drawings\GIS\Mapinfo\2016_FRMSP\MitigationFigures\Figure_A8_1_WB_FM1_5yr_WIDiff.wor

INNER WEST COUNCIL
LEICHHARDT FRMS&P
WB_FM1 5YR ARI WL DIFF
MITIGATION LESS EXISTING
FIG_A8_1

Date
10/2016

Size
A3

WB_FM1_5yr_WIDiff
Drawing Number

01
Revision

Peak Water Level Difference
metres

- >0.5
- 0.2 to 0.5
- 0.1 to 0.2
- 0.01 to 0.1
- -0.01 to -0.1
- -0.1 to -0.2
- -0.2 to -0.5
- <-0.5

Existing Pipe Network

Proposed Pipe/Culvert Options

20yr Flood Extent

Cadastre - Lots

Properties no longer affected by over-floor flooding - 26

Properties no longer affected by garden flooding - 4

Properties with flood levels reduced by more than 15 cm - 81

DATE PLOTTED: 04-Nov-2016 BY: Matthew Prumm
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INNER WEST COUNCIL
LEICHHARDT FRMS&P
WB_FM1 20YR ARI WL DIFF
MITIGATION LESS EXISTING
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10/2016

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WB_FM1_20yr_WIDiff
Drawing Number

01
Revision

Peak Water Level Difference
metres

- >0.5
- 0.2 to 0.5
- 0.1 to 0.2
- 0.01 to 0.1
- -0.01 to -0.1
- -0.1 to -0.2
- -0.2 to -0.5
- <-0.5

Existing Pipe Network

Proposed Pipe/Culvert Options

100yr Flood Extent

Cadastre - Lots

Properties no longer affected by over-floor flooding - 43

Properties no longer affected by garden flooding - 6

Properties with flood levels reduced by more than 15 cm - 112

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INNER WEST COUNCIL
LEICHHARDT FRMS&P
WB_FM1 100YR ARI WL DIFF
MITIGATION LESS EXISTING
FIG_A8_3

Date
10/2016

Size
A3

WB_FM1_100yr_WIDiff
Drawing Number

01
Revision

Peak Water Level Difference
metres

- >0.5
- 0.2 to 0.5
- 0.1 to 0.2
- 0.01 to 0.1
- -0.01 to -0.1
- -0.1 to -0.2
- -0.2 to -0.5
- <-0.5

BEATTIE ST
EVANS ST
EWELL ST
REYNOLDS ST
CLARE ST
BRUCE ST
NELSON ST
GOODSIR ST
MERTON ST
TIONAL ST
MULLENS ST
ROSSER ST
SMITH ST
ENNIS ST
REYNOLDS ST
BOOTH ST
JANE ST
ANN ST
STEPHEN ST
ROBERT ST
PARSONS ST
QUIRK ST

Properties no longer affected by over-floor flooding - 9

Properties no longer affected by garden flooding - 1

Properties with flood levels reduced by more than 15 cm - 9

- Existing Pipe Network
- Proposed Pipe/Culvert Options
- 5yr Flood Extent
- Cadastre - Lots

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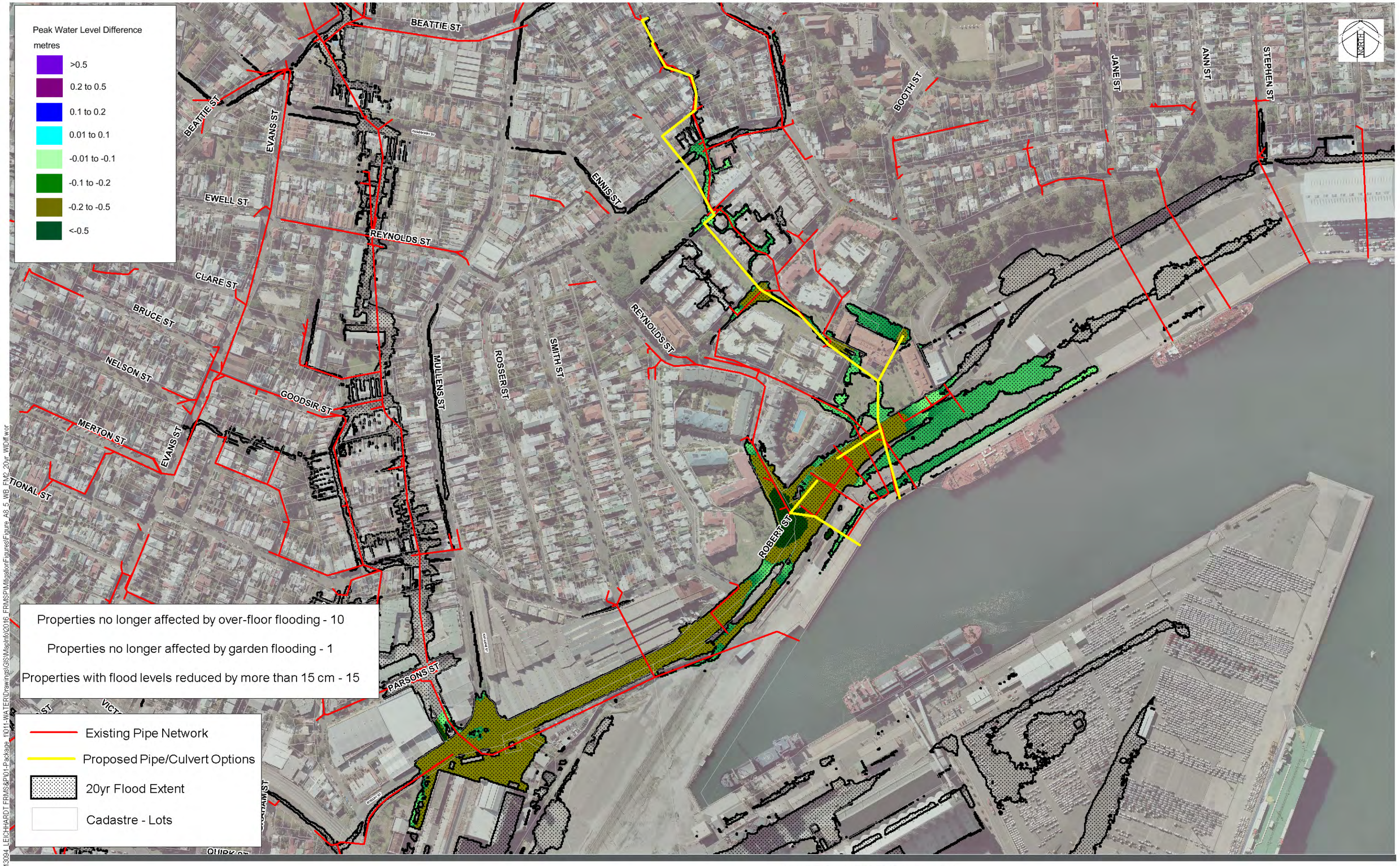
INNER WEST COUNCIL
LEICHHARDT FRMS&P
WB_FM2 5YR ARI WL DIFF
MITIGATION LESS EXISTING
FIG_A8_4

Date
10/2016

Size
A3

WB_FM2_5yr_WIDiff
Drawing Number

01
Revision



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INNER WEST COUNCIL
LEICHHARDT FRMS&P
WB_FM2 20YR ARI WL DIFF
MITIGATION LESS EXISTING
FIG_A8_5

Date
10/2016

Size
A3

WB_FM2_20yr_WIDiff
Drawing Number

01
Revision

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LEICHHARDT FRMS&P
WB_FM2 100YR ARI WL DIFF
MITIGATION LESS EXISTING
FIG_A8_6

Date
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Size
A3

WB_FM2_100yr_WIDiff
Drawing Number

01
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WB_FM3 5YR ARI WL DIFF
MITIGATION LESS EXISTING
FIG_A8_7

Date
10/2016

Size
A3

WB_FM3_5yr_WIDiff
Drawing Number

01
Revision

Peak Water Level Difference
metres

- >0.5
- 0.2 to 0.5
- 0.1 to 0.2
- 0.01 to 0.1
- -0.01 to -0.1
- -0.1 to -0.2
- -0.2 to -0.5
- <-0.5

ENNIS ST

8364 m2

REYNOLDS ST

SM

NORTH

Properties no longer affected by over-floor flooding - 3

Properties no longer affected by garden flooding - 0

Properties with flood levels reduced by more than 15 cm - 11

- Existing Pipe Network
- Proposed Basin
- 20yr Flood Extent
- Cadastre - Lots

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INNER WEST COUNCIL
LEICHHARDT FRMS&P
WB_FM3 20YR ARI WL DIFF MITIGATION LESS EXISTING
FIG_A8_8

Date
10/2016

Size
A3

WB_FM3_20yr_WIDiff
Drawing Number

01
Revision

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LEICHHARDT FRMS&P
WB_FM3 100YR ARI WL DIFF
MITIGATION LESS EXISTING
FIG_A8_9

Date
10/2016

Size
A3

WB_FM3_100yr_WlDiff
Drawing Number

01
Revision

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LEICHHARDT FRMS&P
WB_FM4 5YR ARI WL DIFF
MITIGATION LESS EXISTING
FIG_A8_10

Date
10/2016

Size
A3

WB_FM4_5yr_WIDiff
Drawing Number

01
Revision

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LEICHHARDT FRMS&P
WB_FM4 20YR ARI WL DIFF
MITIGATION LESS EXISTING
FIG_A8_11

Date
10/2016

Size
A3

WB_FM4_20yr_WIDiff
Drawing Number

01
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LEICHHARDT FRMS&P
WB_FM4 100YR ARI WL DIFF
MITIGATION LESS EXISTING
FIG_A8_12

Date
10/2016

Size
A3

WB_FM4_100yr_WIDiff
Drawing Number

01
Revision

Peak Water Level Difference
metres

- >0.5
- 0.2 to 0.5
- 0.1 to 0.2
- 0.01 to 0.1
- -0.01 to -0.1
- -0.1 to -0.2
- -0.2 to -0.5
- <-0.5

ST

DARLING ST

BOOTH ST

18053 m2

BOOTH ST

JANE ST

ANN ST

NORTH

Properties no longer affected by over-floor flooding - 0

Properties no longer affected by garden flooding - 0

Properties with flood levels reduced by more than 15 cm - 0

- Existing Pipe Network
- Proposed Basin
- 5yr Flood Extent
- Cadastre - Lots

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INNER WEST COUNCIL
LEICHHARDT FRMS&P
WB_FM5 5YR ARI WL DIFF
MITIGATION LESS EXISTING
FIG_A8_13

Date
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Size
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WB_FM5_5yr_WIDiff
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LEICHHARDT FRMS&P
WB_FM5 20YR ARI WL DIFF
MITIGATION LESS EXISTING
FIG_A8_14

Date
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Size
A3

WB_FM5_20yr_WIDiff
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WB_FM5 100YR ARI WL DIFF
MITIGATION LESS EXISTING
FIG_A8_15

Date
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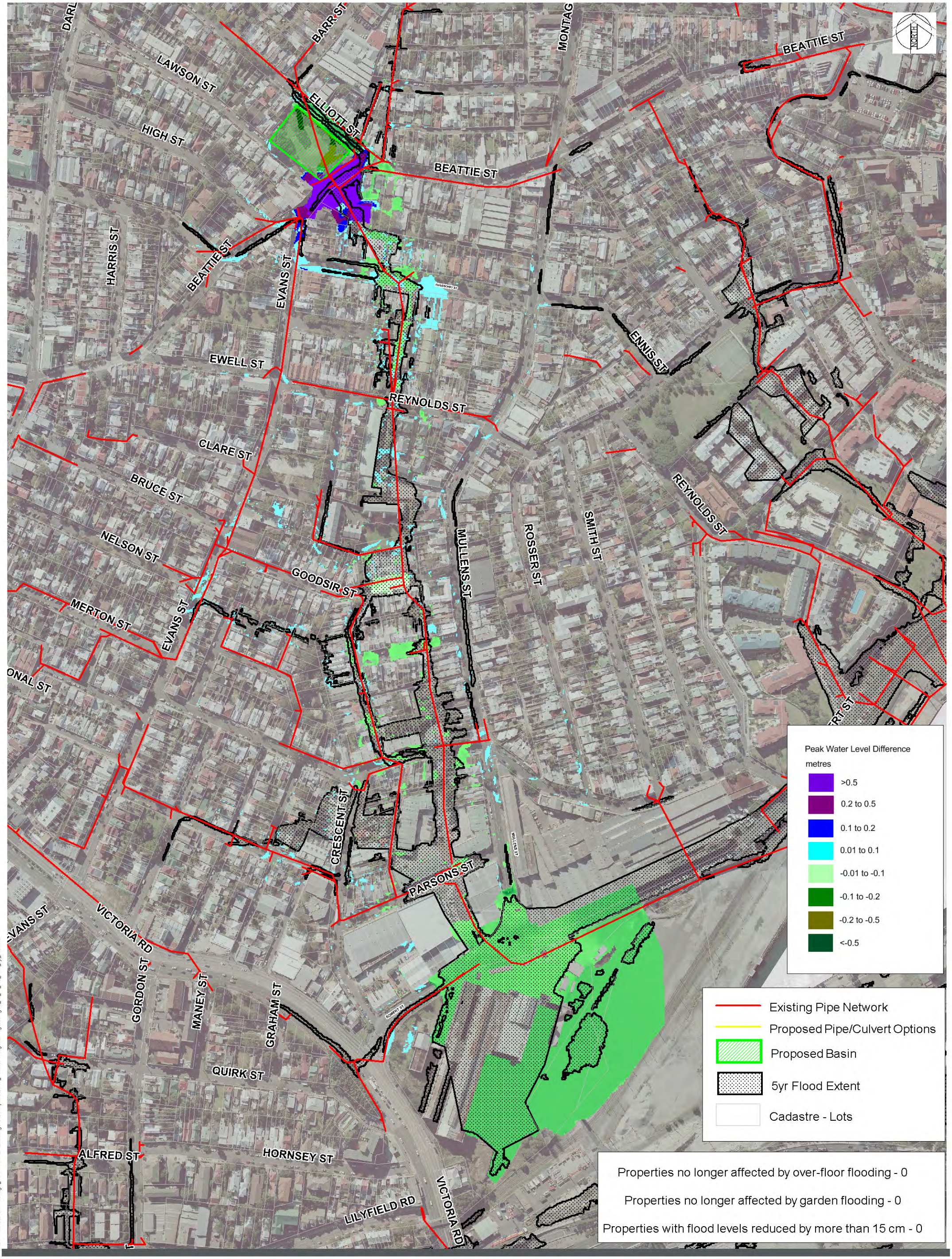
Size
A3

WB_FM5_100yr_WIDiff
Drawing Number

01
Revision



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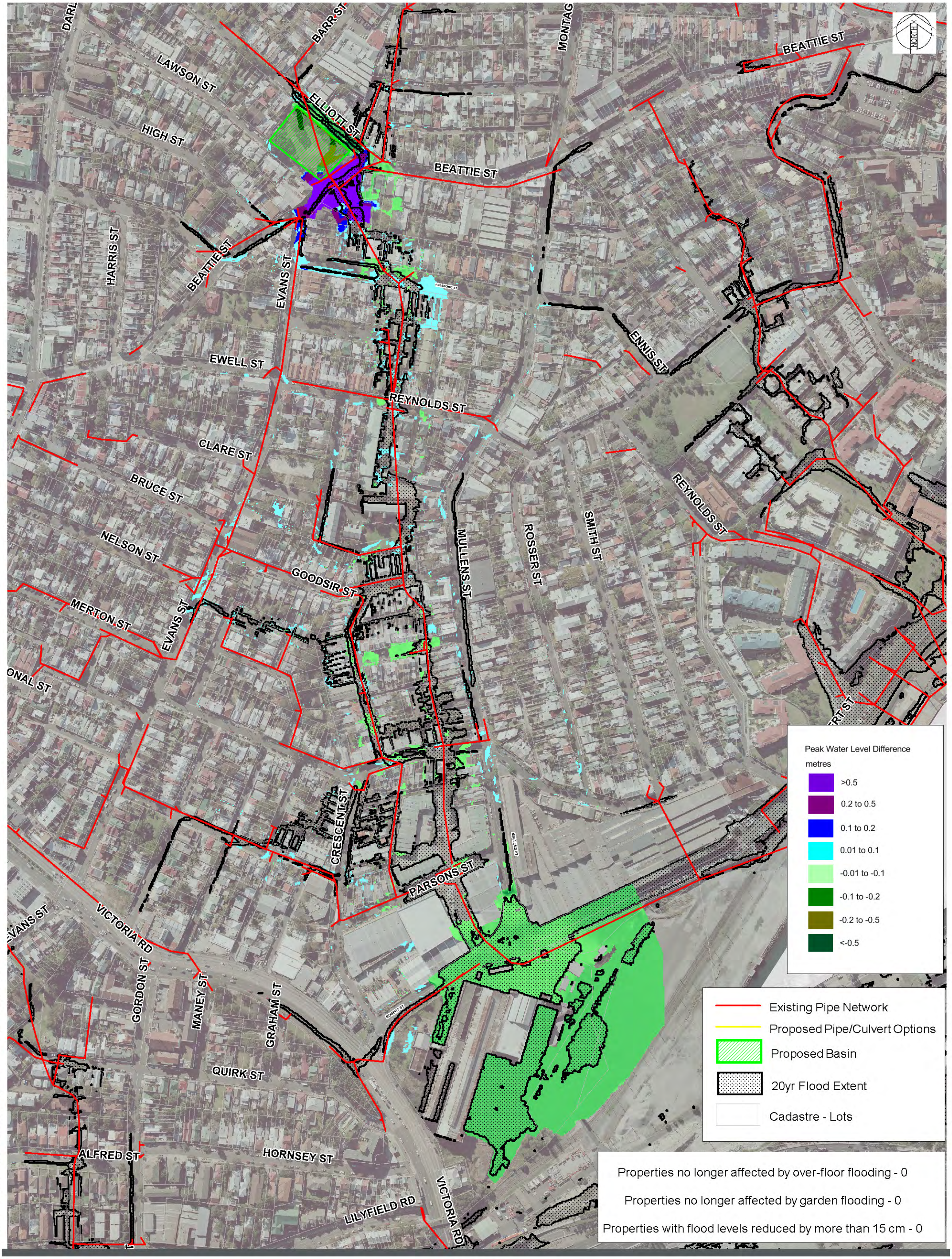
MITIGATION LESS EXISTING
FIG_A8_16

Date
03/2017

Size
A3

WB_FM6_5yr_WIDiff
Drawing Number

03
Revision



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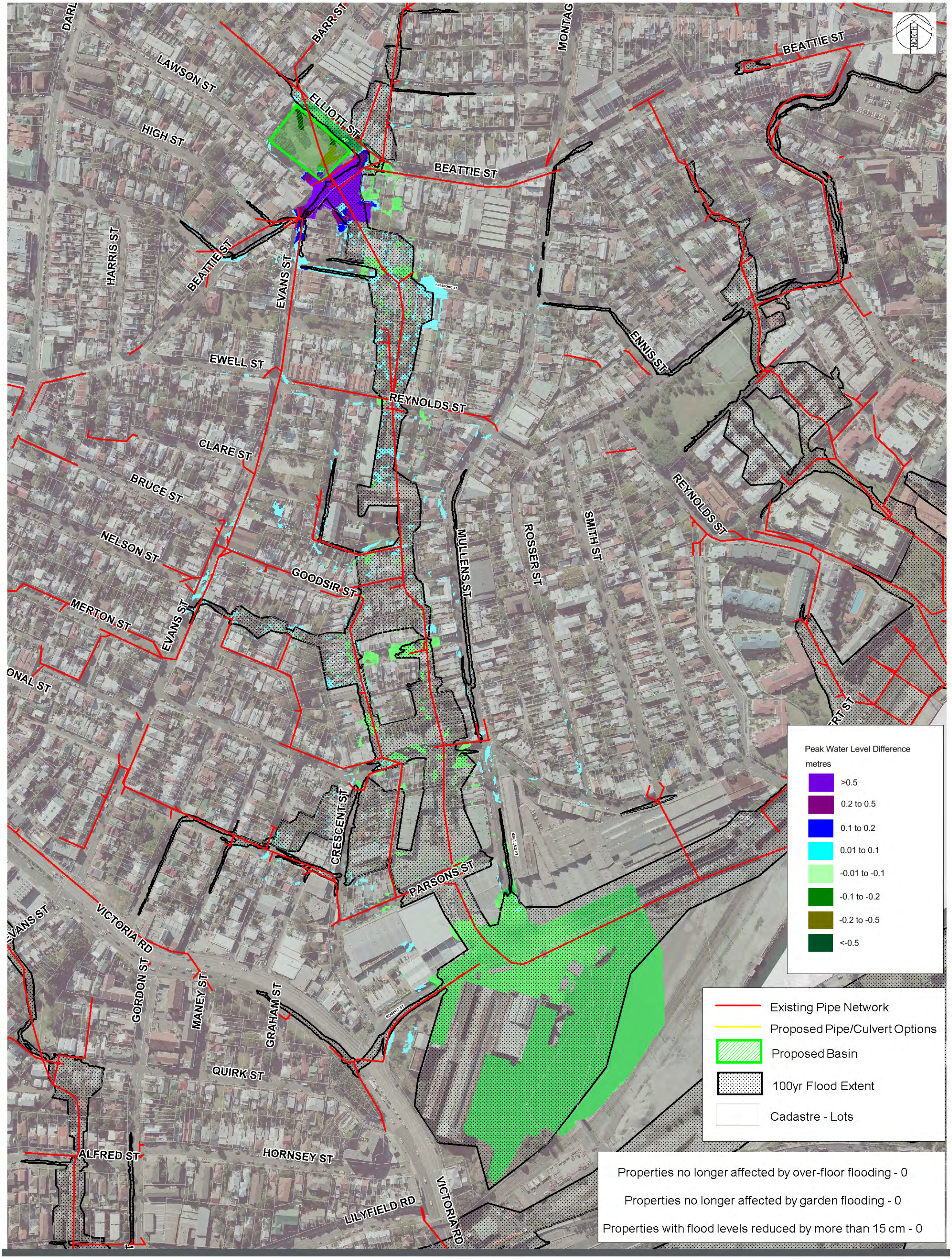
WB_FM6 20YR ARI WL DIFF
MITIGATION LESS EXISTING
FIG_A8_17

Date
03/2017

Size
A3

WB_FM6_20yr_WIDiff
Drawing Number

03
Revision



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MITIGATION LESS EXISTING
FIG_A8_18

Date
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Size
A3

WB_FM6_100yr_WlDiff
Drawing Number

03
Revision