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SPRINGVALE DRAIN AND FLOODVALE DRAIN FLOODPLAIN RISK MANAGEMENT STUDY & PLAN

FINAL REPORT

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December 2019

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Project Springvale Drain and Floodvale Drain Floodplain Risk Management Study & Plan	**Project Number** 115073
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Cover photo: Floodvale Drain December 2015

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FOREWORD

The NSW State Government's Flood Prone Land Policy provides a framework to ensure the sustainable use of floodplain environments. The Policy is specifically structured to provide solutions to existing flooding problems in rural and urban areas. In addition, the Policy provides a means of ensuring that any new development is compatible with the flood hazard and does not create additional flooding problems in other areas.

Under the Policy, the management of flood liable land remains the responsibility of local government. The NSW Government subsidises flood mitigation works to alleviate existing problems and provides specialist technical advice to assist Councils in the discharge of their floodplain management responsibilities. That said, there is limited funding available state-wide for such projects, and Bayside Council has elected to progress the Floodplain Risk Management Study without funding from OEH. Nevertheless, this Study has been undertaken in accordance with the NSW Flood Prone Land Policy.

Work within the NSW Flood Prone Land Policy is undertaken in the following five sequential stages:

1. ***Data Collection***
2. ***Flood Study***
   - Determine the nature and extent of the flood problem.
3. ***Floodplain Risk Management Study***
   - Evaluates management options for the floodplain in respect of both existing and proposed development.
4. ***Floodplain Risk Management Plan***
   - Involves formal adoption by Council of a plan of management for the floodplain.
5. ***Implementation of the Plan***
   - Construction of flood mitigation works to protect existing development, use of Local Environmental Plans to ensure new development is compatible with the flood hazard.

The current study constitutes the third and fourth stages of the process.

EXECUTIVE SUMMARY

The Springvale Drain and Floodvale Drain Floodplain Risk Management Study assesses floodplain management issues in the Bayside Council Study Area, and investigates potential management options. The study, which follows on from the flood study undertaken by BMT WBM in 2014, has been undertaken in accordance with the NSW Government's Flood Policy. A full assessment of the existing flood risk in the catchment has been carried out, including flood hazard across the Study Area, overfloor flooding of residential, commercial and industrial properties, identification of known flooding issues and hotspots, and emergency response during a flood event.

Background

The combined Springvale Drain and Floodvale Drain catchment covers an area of approximately 3.75 km^2 within the Bayside Council LGA in south-eastern Sydney. This includes the suburbs of Pagewood, Eastgardens, Botany and Banksmeadow. The drains originate in Pagewood in the north and flow south to Botany Bay via Penrhyn Estuary. The catchment is densely urbanised and consists of mainly industrial development in the south of the catchment and residential development in the upper catchment. The northern outskirts of the study area are characterised as *Low Density Residential* and are interspersed with smaller regions of *Medium Density Residential*, *Public Recreation* and other *Mixed Uses*. Bonnie Doon Golf course and Mutch Park intersect a large region in the north of the study area as well as Botany Golf course in the south. The two drains are generally underground pipes in the northern residential area and open channels between industrial properties in the south.

Existing Flood Environment

Throughout the Springvale Drain and Floodvale Drain catchment flooding is caused by overland flow, and flowpaths follow a similar route to the drainage network. The formalised drainage network is typically at capacity during a 20% AEP event without blockage factors being applied, leading to inundation of several residential areas in the north. In the Springvale and Floodvale Drains catchment the flooding duration is relatively short, with flood events typically lasting only a few hours, meaning that evacuation is not an appropriate floodplain risk mitigation option in this catchment.

Flooding hotspots include but are not limited to:

- Low lying areas around Holloway St, Gibson St and Banksia St, Botany;
- Pagewood Public School;
- Bay Street between Wentworth Ave and Lang St;
- Intersection of Banks Ave and Heffron Rd;
- Park Parade, Pagewood; and
- Exell Street Industrial area.

Economic Impact of Flooding

A flood damages assessment was carried out for the inundation of residential and commercial properties in the area. The assessment was based on estimated floor levels for all properties in the Study Area. The annual average damages for residential and commercial/industrial properties was found to be $2.6M.

Flood Risk Management Options

The Floodplain Risk Management Study includes an investigation of possible options for the management of flood risk in the Study Area. These flood modification works range from measures such as drainage upgrades and retarding basins, to response measures such as emergency response planning and property modification measures such as house raising. The measures were assessed for their ability to reduce flood risk while also considering their economic, social and environmental impact. A multi-criteria matrix assessment was used to directly compare the options. The options recommended are shown in Table 1.

Table 1 Mitgation Options Recomended

Type of Modification	Option	Mitigation Options Recommended	Report Reference
Flood	NW01	Dalley Avenue Drainage Upgrade	10.4.2
	NW02	Bay Street Drainage Upgrade	10.4.3
	NE01	Banks Avenue Drainage Upgrade	10.4.6
	NE02	Towner Gardens Drainage Upgrade	10.4.7
	NE03	Park Parade Drainage Upgrade	10.4.8
	FM02	Duplication of pipe under Botany Road	Appendix D
	FM03	Vegetation management (open channel sections)	Appendix D
	FM08	Debris removal and maintenance at Floodvale Drain/ SWSOOS No. 2 Culvert	Appendix D
	FM10	Local Drainage Improvements – Botany Road	Appendix D
Property	PM01	Review of Planning Policies	10.4.10
Response	RM01	Revisions to Local Flood Plan	10.4.11

1. INTRODUCTION

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

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

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

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

1.1. The Floodplain Risk Management Process

As described in the Floodplain Development Manual (Reference 1), the Floodplain Risk Management process is formed of sequential stages:

- Data Collection;
- Flood Study;
- Floodplain Risk Management Study;
- Floodplain Risk Management Plan; and
- Plan Implementation.

The first key stage of the process has been undertaken with the completion of the recent flood study in 2012 (Reference 2). Following this, the Floodplain Risk Management Study and Plan (FRMS&P) are undertaken for the catchment in two phases:

Phase I – Floodplain Risk Management Study in which the floodplain management issues confronting the study area are assessed, management options investigated and recommendations made.

Phase II – Floodplain Risk Management Plan which is developed from the floodplain risk management study and details how flood prone land within the study area is to be managed moving forward. The primary aim of the Plan is to reduce the flood hazard and risk to people and property in the existing community and to ensure future development is controlled in a manner consistent with the present and future flood hazard and risk.

The Plan consists of prioritised and costed measures for implementation.

2. BACKGROUND

2.1. Study Area

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

The Study Area has been expanded to include two residential areas at the northernmost end of the catchment. The first of these locations is along the boundary of Bonnie Doon Golf Course near Wentworth Avenue and includes the residential area along Bay Street east to Cowper Street. The second location is the residential area north of Jellicoe Park bounded by Banks Avenue, Bunnerong Road and Birdwood Avenue. Both of these locations were found to have areas of high flood hazard, and mitigation options for these areas have been considered in Section 10.

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

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

2.2. Land Use

The land use zones in the Study Area are identified by the 2013 LEP and State Environmental Planning Policy (Three Ports) 2013, and shown in Figure 3. The catchment is densely urbanised and consists of mainly industrial development in the south of the catchment and residential development in the upper catchment. The northern outskirts of the study area are characterised as *Low Density Residential* and are interspersed with smaller regions of *Medium Density Residential*, *Public Recreation* and other *Mixed Uses*. This includes Bonnie Doon Golf course and Mutch Park which intersect a large region in the north of the study area as well as Botany Golf course in the south.

The majority of the study area is developed for large-scale commercial-industrial use, particularly in the southern region. The southern sector of the study area is a short distance from Botany Bay

and Port Botany which house container terminal and bulk liquids handling facilities. This major port activity accounts for the concentration of industrial works within the south of the study area.

2.2.1. Future Development

Residential development forecasts assume the number of dwellings in Botany (Banksmeadow) will increase by an average of 123 dwellings per annum to 6,428 in 2036, with a steep rise in the number of dwellings developed between 2017 and 2020. Conversion of low to medium density dwellings to high rise buildings is expected to increase traffic congestion and put more pressure on street parking. Furthermore, traffic generally has limited access routes in and out of the area, with key roads such as Botany Road, Wentworth Avenue and Page Street conveying the majority of traffic. Key to coping with the increased demands on roads will be improving key intersections, and reducing inundation times during flood events.

2.3. Social Characteristics

The statistical information provided in this section is an analysis of the entire Botany Bay Local Government Area. The data is based on the Australian Bureau of Statistics' 2013 Census data available from stat.abs.gov.au.

The population of Botany Bay in 2013 was 43,292 with a median age of 36.5. Statistics show 17.8% of the population below the age of 14 and 12.4% of the population over the age of 65.

In the 2011 census 44.1% of residents spoke a language other than English at home, and 45.1% of residents were born overseas (2006 Census). Internal migration is high, with 10.6% of residents living at a different address 1 year ago, and 27% of residents who lived at a different address 5 years ago. These factors should be considered when developing community consultation material and issuing flood warnings.

In 2013 there were a total of over 2 million businesses based in the Bayside Council LGA, with nearly 252,000 of these employing more than 5 people, and there were 91,795 building approvals. This gives an indication of the high rate of development and evolving use of the land that occurs in the Bayside Council LGA, and may shape potential flood mitigation options.

Understanding the social characteristics of the area can help ensure floodplain risk management practices adopted are aligned with the communities at risk. For example, 'stable' communities (characterised by a high proportion of home ownership and low frequency of residents moving into or out of the area) are more likely to have a better understanding of the flood risks within the area as opposed to transient populations such as holiday tourists or short-term renters, who may have little experience with flooding in their area.

2.4. Local Environment

2.4.1. Flora and Fauna

The study area is highly developed with light Industrial land use in the lower catchment and residential in the upper catchment. Flora and fauna is confined to designated Council parklands on either side of Foreshore road in the lower catchment and Mutch Park in Pagewood. These areas are maintained by Council and the study area does not contain threatened ecological communities as identified by the Office of Environment and Heritage. More detail on the management of the environment characteristics of the study area is included in the Botany Bay Local Environment Plan 2013.

2.4.2. Main Waterway

The main waterways of Springvale and Floodvale Drains start in the residential areas of Pagewood and Botany as underground stormwater pipes. The drains travel south and in the lower reaches are open channel following the natural creek line, with some stretches lined with concrete. Both waterways intersect the SWS00S No. 2 before draining into the Penrhyn Estuary in Botany Bay.

2.5. Historical Flood Events

Availability of historical flood events and associated data in the Springvale Drain and Floodvale Drain catchment is limited. The largest historical event identified in the catchment occurred in February 1990, with more recent flooding occurring in February 2010. These two events were used to calibrate the model in the Flood Study.

Data from the 2010 event (12th – 13th February 2010) showed that the highest rainfall intensity was recorded at the gauge located nearest to the Springvale Drain and Floodvale Drain catchment (Eastlakes Sports Club) with the rainfall occurring as a single burst.

The Flood Study (Reference 2) also provides data concerning a rainfall event from February 1990. Four continuous read gauges and two daily read gauges were active during the event. The highest rainfall intensity was recorded at the gauge located nearest to the Springvale Drain and Floodvale Drain catchment (Eastlakes Sports Club) with the rainfall occurring as three distinct bursts.

2.6. Previous Studies

The Flood Study (Reference 2) was undertaken in 2014 by *BMT WBM* and is reviewed in detail in Section 3. This section provides a brief summary of other studies and assessments previously undertaken in the Springvale and Floodvale Drain catchment or that are relevant to the study area.

2.6.1. Investigation for Storm Drain Outfalls – Botany Bay Northern Foreshore Development (Laurie, Montgomerie & Pettit, 1975)

This report summarises the investigations regarding new outfalls for Springvale Drain and Floodvale Drain associated with the development of port facilities on the northern foreshore of Botany Bay. Of particular reference for this current study are the design plans for the culverts under the South Western Suburbs Ocean Outfall Sewer (SWSOOS No.2).

2.6.2. Catchment Management Study – Floodvale & Springvale Drains, Botany (SKM, 1992)

SKM completed a catchment management study for Springvale Drain and Floodvale Drain on behalf of Botany Municipal Council. This study developed a MOUSE model for both hydrological and hydraulic analysis of the upper piped reaches. The lower open channel reaches were modelled using HEC-2 software. The models were based on field survey obtained for the study, including both drainage survey (pit and pipe) and open channel survey.

2.6.3. Proposed Expansion of Container Port Facilities Botany Bay NSW - Hydrologic and Hydraulic Studies, Lawson and Treloar, 2003

In 2003 *Lawson and Treloar* completed a flood impact assessment for *Sydney Ports Corporation* to assess the potential impacts of the proposed expansion of container port facilities in Port Botany. This report includes hydrologic and hydraulic modelling of the Springvale and Floodvale catchment.

2.6.4. ORICA/ Goodman Southlands Remediation/ Development Project – Flood Investigations (Connell Wagner, 2007)

Orica Australia Limited and Goodman International Limited (previously Macquarie Goodman) jointly proposed developing the site known as ‘Southlands’ at Banksmeadow as part of an industrial development. Flood modelling was undertaken as part of the development application and planning process by Connell Wagner Limited. This flood investigation involved topographic survey, hydrologic modelling (using XP-RAFTS) and hydraulic modelling (using MIKE 11) to determine the existing flooding characteristics of the site and surrounding floodplain.

2.6.5. ORICA Southlands Remediation and Development Project – Hydraulic Modelling Report (Aurecon, 2010)

Following on from the previous flood investigations (Connell Wagner, 2007), additional flood modelling was undertaken by Aurecon Limited (previously Connell Wagner) to address comments from the NSW Department of Planning. The previous modelling work was updated and a two-dimensional hydraulic model (MIKE 21) was developed. The one and two dimensional hydraulic models (MIKE-11 and MIKE-21) were dynamically coupled using MIKE FLOOD. The models have subsequently been used to assess flooding impacts as a result of the proposed development. Topographic and model data from this report was used in the Flood Study (Reference 2).

3. REVIEW OF CURRENT FLOOD STUDY

Springvale Drain and Floodvale Drain Flood Study – BMT WBM, January 2014.
A flood study was carried out for the then City of Botany Bay Council (CBBC) in accordance with the NSW Government's Flood Policy. The Flood Study was aimed at determining design flood behaviour in the area and used a direct rainfall method in place of a hydrologic model, and a 1D/2D TUFLOW hydraulic model. The models and results are described below.

3.1. Topographic Data

3.1.1. Aerial Topographic Survey

LiDAR data covering the area was collected by AAM Hatch on two separate dates in 2007 and 2008. This LiDAR set was provided by Council for the Flood Study (Reference 2) and has a stated vertical accuracy of +/- 0.15 m and horizontal accuracy of 0.55 m (both with 68% confidence). The data was filtered to remove features such as vegetation and buildings to better represent the ground levels. The filtered ground data was converted into a 1 m resolution digital elevation model (DEM) using terrain modelling software (MapInfo Vertical Mapper). The DEM is shown in Figure 2.

3.1.2. Detailed Topographic Ground Survey

As described in Section 2.6.4, extensive topographic survey of the 'Southlands' site at Banksmeadow was undertaken for Orica's development proposal. This data was made available to the Flood Study (Reference 2) and included ground levels at the 'Southlands' site and adjacent industrial areas, elevations along McPherson Street, and various open channel reaches and culverts along Springvale and Floodvale Drains.

3.2. Stormwater Drainage Network

As used in the Flood Study, information on the pit and pipe drainage system was compiled from various sources including some of the previous reports described in 2.6. This data was supplemented with a GIS layer from Council, containing additional detail. Pit and pipe details were provided by NSW Roads and Maritime Services (RMS) along the various state roads within the study area, allowing more accurate schematisation of road drainage and connection to trunk drainage.

3.3. Hydrologic Model

The Flood Study (Reference 2) used a direct rainfall (or 'rainfall on grid') hydrological model. For this method, the design rainfall is applied directly to the individual cells of the 2D hydraulic model.

The direct rainfall approach means that only one TUFLOW model was developed which implicitly performs both hydrologic and hydraulic computation.

3.3.1. Rainfall Losses

The Flood Study's TUFLOW model utilises the initial loss-continuing loss model, where initial loss component represents a depth of rainfall effectively lost to 'wetting up' the catchment, and continuing loss represents the rainfall lost through soil infiltration once the catchment is saturated. Continuing loss is applied as a constant rate (mm/hr) for the duration of the runoff event.

The design loss rates depend on the perviousness of the surface: for pervious surfaces an initial loss of 50 mm and continuing loss of 5 mm/hour were found to provide a reasonable fit to the observed hydrological behaviour in the February 2010 event and are appropriate for well-draining sandy soils. The applied loss rates vary with the impervious percentage (i.e. 100% impervious – 0 mm initial and continuing loss applied). The impervious percentages applied to the various land use surface types are provided in Table 2.

Table 2 Percentage Imperviousness Adopted

Land Use Type	Impervious (%)
Grass (maintained)	0
Parkland	0
Dense Vegetation	0
Permanently wet area/ water bodies	100
Tidal inundation zone	100
Roads, car parks, open concrete, interceptor drain	100
Railway corridor	0
Buildings	100
Urban blocks	20
Industrial blocks	90

The values assigned to the percentage impervious are generally appropriate with the following exceptions:

- Grass – the grassed areas in the study area generally have 1% by area of paving (footpaths, kerbs etc);
- Parkland, also generally has some paving and impervious surfaces (up to 10%); and
- Railway corridor is expected to be greater than 0% due to rails and sleepers.

The proportion of the model area assigned these values however are relatively small, and have not warranted being altered from the Flood Study values.

3.4. Hydraulic Model

For the Flood Study (Reference 2) a 2D TUFLOW model was used due to the complex flooding environment which is characterised by large and shallow inundation with interconnecting and

varying flowpaths. TUFLOW has the capability to simulate the dynamic interaction of in-bank flows in open channels, major underground drainage systems, and overland flows through complex overland flowpaths using a linked 1D/2D flood modelling approach.

3.4.1. Hydraulic Structures

A number of culvert and bridge crossings over Springvale Drain and Floodvale Drain were incorporated into the hydraulic model to account for hydraulic losses associated with them and their influence on flood behaviour within the catchment. The structures modelled vary in terms of construction type and configuration and therefore have varying degrees of influence on local hydraulic behaviour.

3.4.2. Hydraulic Roughness

The Flood Study (Reference 2) used aerial photography and cadastral data to generate the land-use surface types and roughness zones for the study area. During the model calibration process the Manning's 'n' surface roughness values were adjusted locally to provide best fit for peak water level profiles. The degree of variability largely reflected the degree of channel vegetation, channel size and sinuosity.

For the Flood Study (Reference 2), the footprints of individual buildings were digitised from aerial photography and included in the flood model to restrict the flow that is able to pass through each building. Ground elevations defining selected building footprints were processed on an individual basis using elevations sourced from the LiDAR-based DEM. In general, buildings were modelled at ground level with a flood depth-dependent Manning's 'n' hydraulic roughness value. The selection of Manning's 'n' values is consistent with industry best practice and the acceptable ranges as listed in AR&R 1987 (Reference 7).

3.5. Blockage

The model review involved running the model provided by Council (23rd December 2015). The design results provided by BMT WBM used an envelope of blockage scenarios. For the assessment of mitigation options, one of these blockage scenarios was selected to provide a basis for comparison. WMAwater found that using Scenario 'B', i.e. 50% pipe blockage produced results most similar to those produced by BMT WBM, and this case formed the basis of assessment for the mitigation options investigated in Section 10. Note that for the comparison of options, the particular blockage case selected is not as critical as ensuring consistency across the options modelling.

3.6. Model Calibration

The Springvale and Floodvale Drain catchment is ungauged, and therefore stream flow data was not available for calibration. The Flood study relied on replicating the general pattern and

magnitude of flooding throughout the catchment for the February 1990 and February 2010 events. A comparison of observed peak water depths and flooded locations in historical events with modelled results confirmed the model was a sound representation of flood behaviour in the catchment.

3.7. Design Flood Behaviour

Design storms for the 20%, 10%, 5%, 2%, 1% and 0.5% AEP and PMF events were simulated in the Flood Study (Reference 2). Table 3 reproduces the Flood Study peak flood level results at key locations for each of the design events. A short description of the design flow behaviour is given below. The flood depths for the 20% AEP and 1% AEP events have been reproduced in Figure 4 A and B respectively, with the below locations marked.

Table 3 Summary of Peak Design Discharge

Location	Modelled Peak Flood Level (mAHD)						
	AEP Storm Event						PMF
	20%	10%	5%	2%	1%	0.5%	
Botany Golf Club	3.5	3.5	3.6	3.6	3.7	4.5	4.5
Botany Rd	3.6	3.6	3.7	3.8	3.9	3.9	4.5
McPherson St-Floodvale Drain	3.7	3.8	3.9	3.9	4.0	4.0	4.9
McPherson St-Springvale Drain	-	3.8	3.9	4.1	4.1	4.1	4.9
Southlands Site – McPherson St	3.7	3.8	3.9	4.1	4.1	4.1	4.9
Anderson St	7.6	7.6	7.7	7.7	7.7	7.8	8.2
Moore St	13.0	13.1	13.1	13.2	13.2	13.2	13.8
Pagewood Public School	13.7	14.0	14.2	14.3	14.3	14.3	14.8
Mutch Park	16.2	16.2	16.2	16.3	16.3	16.3	17.1
Heffron Rd	19.0	19.0	19.1	19.1	19.1	19.1	19.7

The results showed:

- Overland flow is significant to flooding throughout the catchment and generally follow a similar route to the formalised drainage network;
- Flow between the two drains occurs at Anderson Street and the Mobil site interceptor drain;
- The formalised drainage network is typically at capacity during a 20% AEP event without blockage factors being applied, leading to inundation of several residential areas in the north. These are discussed further in subsequent sections.

3.8. Critical Duration

The Flood Study (Reference 2) did not assign a critical duration for the Springvale Drain and Floodvale Drain catchment, but rather used an envelope of different storm events that were critical in different regions. During the model review it was found that the 9 hour design storm was critical in the Exell Street area, and was therefore used for the assessment and comparison of mitigation options, while the 3 hour event was critical for the PMF.

3.9. Summary of Model Review Findings

WMAwater found the Flood Study models to be well built and to produce results that reasonably represented flood behaviour in the Springvale Drain and Floodvale Drain Catchment.

4. AVAILABLE DATA FOR FLOODPLAIN RISK MANAGEMENT STUDY

4.1. Digital Elevation Model

LiDAR – Council provided aerial survey across the whole of the catchment. The survey was captured in 2007 and 2008 and was used for the Flood Study. It is assumed to be indicative of the current conditions within the catchment. The accuracy of ALS data is generally considered to be +/- 0.15 m to one standard deviation on hard surfaces.

4.2. GIS Data

Council provided the following GIS data for the Flood Study, results of which will be built upon for this FRMS:

- Cadastre – Cadastre including easements, roads and road names;
- Zoning – Land Zoning for the Botany LGA (Botany Bay LEP 2013); and
- Zoning – Land Zoning for the Three Ports area (SEPP 2013).

4.3. Site Inspection

A site inspection of the length of the two drainage lines (south from McPherson Street) was undertaken on the 21st December 2015 and attended by City of Botany Bay Council and WMAwater staff. It was not possible to access the Springvale Drain for much of its length, however the consulting team walked the length of Floodvale Drain from McPherson Street south to Botany Road, noting its condition and especially the state of vegetation along the drain.

4.4. Floor Level Survey

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

5. ASSESSMENT OF FLOOD RISK

5.1. Hydraulic Hazard

Provisional hazard categories were produced for two design events (20% and 1% AEP) in the Flood Study (Reference 2). The two categories of hazard shown in the figures (high and low hazard) are used to inform the management of flood risk in the Study Area, as they describe the severity of the flood at a certain location in terms of its depth and velocity. The provisional hydraulic hazard categories determined here were based on the method prescribed by the Floodplain Development Manual 2005, Appendix L.

The figures demonstrate that the area of high provisional hazard is fairly continuous in the 20% AEP event as it follows the main channels. In the 1% AEP event the High Hazard Area breaks out of the drains to extend along the rail line and into low points in grassed areas and between the drains at Coal Pier Road and Nant Street in the industrial park. The high hazard zone is broader in the 1% AEP, extending out from the main channel as its banks are overtopped. Areas of low provisional hazard make up the remainder of the floodway in both events.

5.2. Hydraulic Hazard Classification

5.2.1. Floodplain Development Manual

The Flood Study (Reference 2), and the results discussed in Section 3 defined the provisional hydraulic hazard which does not consider other factors which may influence the flood hazard. The Flood Study (Reference 2) found that high provisional hydraulic hazard corresponded to virtually all of the main waterway, and extending into the floodplain as the banks were overtopped. However, the hazard categories are limited to considering depth and velocity across the Study Area. To assess the true flood hazard, all adverse effects of flooding have to be considered. This assessment should consider criteria in addition to hydraulic hazard including threat to life, danger and difficulty in evacuating people and possessions, and the potential for damage, social disruption and loss of production. These factors and their relative weighting for hazard in the Springvale and Floodvale Drains catchment are detailed in Table 4.

Table 4: Flood Hazard Factors

Criteria	Weight	Comment
Size of the flood	Low	The size or magnitude of the flood can affect depths and velocities. Relatively low flood hazard is associated with more frequent minor floods while the less frequent major floods are more likely to present a high hazard situation. In the Study Area, small events are not well contained by the existing stormwater drainage system and can result in inundation of roads, driveways and footpaths.
Depth and velocity of floodwaters	High	The provisional hazard is the product of depths and velocity of flood waters. These can be influenced by the magnitude of the flood event. Generally in the Study Area, high hazard generally occurs in localised low lying residential areas or along the open channels in the south of the catchment. Hazardous depths and velocities are well represented by the provisional hydraulic hazard.

Criteria	Weight	Comment
Rate of rise of floodwaters	Medium	Rate of rise of floodwaters is relative to catchment size, soil type, slope and land use cover. It is also influenced by the spatial and temporal pattern of rainfall during events. The Springvale and Floodvale Drains catchment typically experiences a range of rate of rise (in flood level) depending on the part of the catchment and depth of inundation. In the northern residential areas, a rate of rise around 0.2 m/hr (in the 1% AEP design event) is typical of known hotspots such as the streets near Pagewood Public School, while the rate is closer to 0.15 m/hr in the southern industrial area in the 1% AEP event.
Duration of flooding	Low	The greater the duration of flooding the more disruption to the community and potential flood damages. A short period of inundation may allow some materials to dry and recover whereas a long duration may cause damages beyond repair. In the Springvale and Floodvale Drains Catchment the flooding duration is relatively short, with flood events typically lasting only a few hours. This means evacuation is an ineffective strategy, as there is simply insufficient time to alert and move residents before an event, and the actual event is over shortly after it begins.
Effective warning and evacuation time	Medium	This is dependent on the rate at which waters rise, an effective flood warning system and the awareness and readiness of the community to act. With a short warning time, Pagewood residents are generally not given sufficient time to receive a warning or relocate possessions to minimise damage, however areas of high hazard are well represented by the provisional hydraulic hazard.
Flood awareness and readiness of the community	High	The study area is characterised by a small proportion of residential lots compared to industrial area. Following community consultation it has become evident that the residents generally have had some experience with minor flooding on or near their properties, however it is likely that workers in the industrial park would have little experience with flooding in the Springvale and Floodvale Drains Catchment especially with only 5% of respondents from businesses. This should be taken into account when planning warning systems and flood awareness/ community education programs.
Effective flood access	High	Access is affected by the depths and velocities of flood waters, the distance to higher ground, the number of people using and the capacity of evacuation routes and good communication. Given the lack of warning times and short duration of flooding, evacuation is typically not undertaken in this catchment, however flooding of roads still poses a hazard to motorists and pedestrians.
Evacuation problems	High	Evacuation problems may occur as people are likely to try to self-evacuate, especially if water enters their accommodation. Several roads are liable to flood affectation which affects flood access. The short duration of events however means it is generally safer for residents to stay indoors.
Type of development	High	The type of flood prone development will to some degree correspond to the level of occupant awareness, mobility of people as well as population density. Occupants of Aged Care facilities will have less mobility than other residents, while workers in the industrial areas of the lower catchment may not be aware of susceptibility to flooding. It is generally the lower catchment that is more exposed to high hazard flooding.

Criteria	Weight	Comment
Additional Concerns	Medium	Debris and blockages in the channel and culverts can cause elevated flood levels. The waterway is relatively inaccessible, with most of the open channel reaches fenced and within private industrial properties, meaning that the chance of the public being swept into channels is relatively low.

Following consideration of the above factors and relative catchment weightings some amendments have been made to the provisional hydraulic hazard classification to produce the true hazard adequately. Amendments included upgrading low hazard areas surrounded by high hazard to a high hazard rating. The final true hazard for the 20% AEP event and 1% AEP event are shown in Figure 5 A-B.

5.2.2. Australian Institute of Disaster Resilience

In the Floodplain Development Manual (Reference 1) hazard classifications are essentially binary – either Low or High Hazard as described on Figure L2 of that document, and discussed above. However, in recent years there has been a number of developments in the classification of hazard especially in *Managing the floodplain: a guide to best practice in flood risk management in Australia (Third Edition)* (Reference 16). In addition to presenting hazard categorisation mapping based on the Floodplain Development Manual (described above), while this study presents revised mapping based on the methodology outlined in Reference 16. The classification is divided into 6 categories (H1-H6), listed in Table 5, which indicate constraints of hazard on people, buildings and vehicles appropriate to apply in each zone. The criteria and threshold values for each of the hazard categories are presented in Diagram 1.

Table 5: Hazard Categories

Category	Constraint to people/vehicles	Building Constraints
H1	Generally safe for people, vehicles and buildings	*No constraints*
H2	Unsafe for small vehicles	*No constraints*
H3	Unsafe for vehicles, children and the elderly	*No constraints*
H4	Unsafe for vehicles and people	*No constraints*
H5	Unsafe for vehicles and people	All buildings vulnerable to structural damage. Some less robust building types vulnerable to failure.
H6	Unsafe for vehicles and people	All building types considered vulnerable to failure

Diagram 1 Hazard Classifications

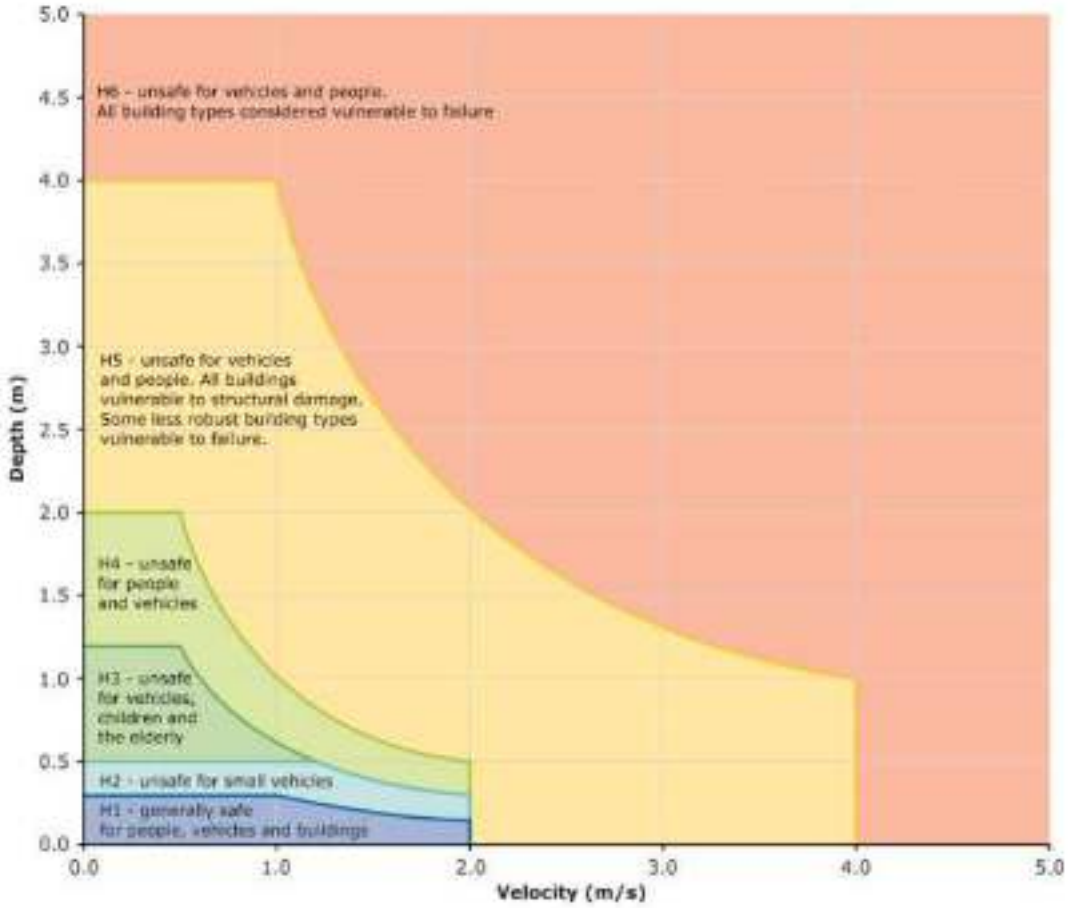

Figure 5 C-D present the hazard classification for the 20% AEP and 1% AEP events respectively. In the 20% AEP event, areas outside the main channels are generally classified as H1, indicating the flood affectation is generally safe for people, vehicles and buildings. This is consistent with the shallow flooding occurring in events of this frequency. Areas of greater depth, corresponding to the various hotspots, are classified as H2-H3, while the open channels, particularly Floodvale Drain, is classified as H4-H5 as a result of the higher velocities occurring within the channel. These trends occur in the 1% AEP event also, with higher degrees of hazard occurring in the Holloway Street, Banks Avenue and Pagewood Public School hotspots (up to H4).

5.3. Hydraulic Categories

5.3.1. Introduction

The Floodplain Development Manual (Reference 1) defines three hydraulic categories which can be applied to different areas of the floodplain; namely floodway, flood storage and flood fringe. The Floodplain Development Manual provides definitions for all three categories, however these are descriptive performance based definitions rather than being explicit criteria for directly calculating/assessing the categories. The definitions as per Reference 1 are provided below for clarity.

Floodways are those areas where a significant volume of water flows during floods and are often aligned with obvious natural channels. They are areas that, even if only partially blocked, would cause a significant increase in flood levels and/or a significant redistribution of flood flow, which may in turn adversely affect other areas. They are often, but not necessarily, areas with deeper flow or areas where higher velocities occur.

Flood storage areas are those parts of the floodplain that are important for the temporary storage of floodwaters during the passage of a flood. If the capacity of a flood storage area is substantially reduced by, for example, the construction of levees or by landfill, flood levels in nearby areas may rise and the peak discharge downstream may be increased. Substantial reduction of the capacity of a flood storage area can also cause a significant redistribution of flood flows.

Flood fringe is the remaining area of land affected by flooding, after floodway and flood storage areas have been defined. Development in flood fringe areas would not have any significant effect on the pattern of flood flows and/or flood levels.

As these definitions are performance based there is no explicit calculation method for defining these three categories or is there a prescribed method to delineate the flood prone land into them. Rather, their categorisation is iterative based on knowledge of the study area and its flood behaviour, hydraulic modelling and previous experiences. The Flood Study (Reference 2) defined hydraulic categories as:

Floodway:	Velocity x Depth > 0.5 m^2/s
Flood Storage:	Velocity* Depth < 0.5m^2/s and Depth >0.5 m
Flood Fringe	Velocity* Depth < 0.5 m^2/s and Depth <0.5 m

The hydraulic categories mapping has been reproduced for the 20% AEP and 1% AEP event in Figure 6A and B respectively.

5.4. Flooding Hotspots

Flooding hotspots are locations with a high flood hazard, a number of properties affected, are frequently inundated or do not drain well. In its Brief, Council identified 17 specific locations to be investigated for flood mitigation/ protection. These are listed below in Table 6 and shown in Figure 10. Two hotspots have also been added following expansion of the study area to the north. These correspond to the areas of high hazard on Bay Street between Lang Street and Wentworth Avenue, and Banks Avenue north of Jellicoe Park. Description of the flood affectation is provided below for identified flooding hotspots across the Study Area.

Table 6 Flooding Hotspots

No.	Specific Location	Comment
1	Flooding of McPherson and Exell Street, Banksmeadow	Addressed in Exell St Priority Area report (Appendix D)
2	Corner of Botany Road and Exell Street flooding issue	Addressed in Exell St Priority Area report (Appendix D)
3	Flooding of Heffron Road and Banks Avenue intersection, Pagewood	Addressed in Option NE01
4	Pagewood Primary School, Pagewood and adjacent properties flooding issue	Addressed in Option NW01
5	Holloway Street, Pagewood flooding issue	Addressed in Option NW03
6	Gibson Street, Pagewood flooding issue	Addressed in Option NW03
7	Banksia Street, Botany flooding issue	Addressed in Option NW03
8	Flooding of Spring Street and Dudley Street intersection, Pagewood	Addressed in Option NW03
9	Flooding of Anderson Street, Banksmeadow	Trapped low point, no options available
10	Adequacy of road gutter runoff in Baker Street, Banksmeadow	Trapped low point, no options available
11	Flooding issue in Port Feeder Road (Australand and Mobil Sites), Banksmeadow	Addressed in Exell St Priority Area report (Appendix D)
12	Flooding of Botany Road, Banksmeadow	Outside of study area bounds
13	Begonia Street, Pagewood flooding issue	Outside of study area bounds
14	Firmstone Reserve, Pagewood flooding issue	Addressed in Option NW03
15	Flooding of Park Parade, Pagewood	Addressed in Option NW03
16	Flooding of Stephen Road, Botany	Addressed in Option NW03
17	Flood Impact for the new development sites (details to be provided by council)	To be addressed as required
Additional Hotspots		
18	Bay Street, between Lang St and Wentworth Ave	Addressed in Option NW02
19	Banks Avenue north of Jellicoe Park	Addressed in Option NE02 and NE03

5.4.1. Low lying area between Holloway St and Gibson St, Pagewood (#5 & #6)

Identified as Hotspots # 5 and # 6 in Table 6, there is a low lying area between Holloway St and Gibson St to the west of Page St in the north west of the Study Area. There is a 900 mm pipe that runs underground between No. 21 and 23 Holloway Street and south between No. 14 and 16 Gibson Street. Analysis has shown that this pipe is full in events as small as the 20% AEP. During heavy rain events, stormwater accumulates between houses in the backyards of properties around the drain. Despite there being a pit at the rear of No. 21 Holloway St, water cannot escape due to the limited pipe capacity. 13 properties are affected in the 20% AEP event, and up to 16 impacted in the 1% AEP event. An option to duplicate the pipes in this vicinity have been investigated and discussed in Section 10.4.4.

5.4.2. Pagewood Primary School, Pagewood (#4)

As noted in the Flood Study (Reference 2), rainfall runoff drains overland along roadways and initially ponds at the low points along Page Street (between Wentworth Ave and Dalley Ave), and Dalley Ave near Page St. The inundation spreads and covers much of the school grounds during the 20% AEP event. Flood depths are greatest along Dalley Avenue at its lowest point (approximately located outside No. 11 Dalley Avenue). The pipes draining this area are small, with the pipe beneath the school grounds only 600 mm in diameter. As expected, analysis showed all pipes in the vicinity are full in the 20% AEP event.

An option to reduce flood levels in this area has been investigated in Section 10.4.2, and involves lowering the school grounds to create a small detention basin and the installation of an additional pipe to drain Dalley Avenue.

5.4.3. Bay Street (Between Wentworth Ave and Lang Street) (#18)

This hotspot has been identified by WMAwater and lies just north of the original Study Area boundary, and for this reason was not addressed in the Flood Study. It is an area of low hazard in the 1% AEP and the 20% AEP events, with 10-15 residential properties affected. Rainfall runoff tends to accumulate in front yards on either side of Bay Street, spilling onto the road. There are no pits nor drainage pipes in this location, and water ponds midway between Wentworth Ave and Lang St posing a risk to motorists and pedestrians.

Section 10.4.3 describes an option to install pits at the low point on Bay Street and a pipe to convey stormwater north and discharge into The Lakes Golf Course at an appropriate location.

5.4.4. Heffron Rd and Banks Ave Intersection, Pagewood (#3)

Identified as Hotspot No. 3 in Table 6, the intersection of Heffron Rd and Banks Avenue is located in the north east of the study area and is subject to low hazard flooding across a range of design events. Rainfall runoff drains overland along roadways in the vicinity, specifically, south along Banks Avenue and west along Park Parade and Heffron Road to the intersection. Pipes along Park Parade and Banks Avenue are full in the 20% AEP event. Water ponds initially on Banks Avenue north of the intersection before inundating the intersection and spreading north along

Banks Avenue and east along Heffron Road and Park Parade. Option NE01, assessed in Section 10.4.6, comprises an upgraded stormwater drainage system to allow the discharge of water from Banks Avenue into a lowered section of Bonnie Doon Golf Course.

5.4.5. Park Parade, Pagewood (#15)

Just east of the Heffron Road and Banks Avenue intersection there is another area of low hazard encompassing a number of residential properties south of Park Parade, between Maxwell Road and Kenny Road. The pit and pipe system here reaches its capacity in the 20% AEP event, indicating that the 300 mm diameter pipes are insufficient. An option to reduce flooding both at this location and the intersection of Heffron Road and Banks Avenue has been investigated in Section 10.4.6.

5.4.6. Exell Street Area (#1, #2, #11)

There is flood risk to some existing development as a result of catchment rainfall-derived flooding. Overtopping of the open channel banks between McPherson St and Botany Rd during intense storms results in inundation of properties adjacent the channel, as well as high hazard flooding of major arterial roads. Flood risk specific to this area has been addressed in an FRMS&P pertaining directly to the Exell Street Focus Area (Reference 3). This report has been included in Appendix D.

6. EXISTING PLANNING INSTRUMENTS

6.1. State Legislative and Planning Context

It is important to understand the state legislation that overarches all local planning so as to enable appropriate floodplain risk management measures to be proposed that are in keeping with both state and local statutory requirements. This section discusses the state legislation that influences planning in relation to flood risk at the local government level.

6.1.1. Environmental Planning and Assessment Act 1979 – as amended

The NSW Environmental Planning and Assessment Act (1979) (EP&A Act) provides the framework for regulating and protecting the environment and controlling development. Many other Acts relating to the Environment in NSW rely on the EP&A Act to implement their policy.

In relation to flooding, the Act imposes on Council the responsibility to facilitate the implementation of the NSW Government's Flood Prone Land Policy through the preparation of Local Environment Plans (LEPs) and Development Control Plans (DCPs).

Direction No. 4.3 Flood Prone Land

Under the section 117(2) of the EP&A Act, Direction No. 4.3 is specific to managing flood prone land and applies to all Council's that are responsible for flood prone land within their LGA. The objectives of the direction are:

- *To ensure that development of flood prone land is consistent with the NSW Government's Flood Prone Land Policy and the principles of the Floodplain Development Manual 2005; and*
- *To ensure that the provisions of an LEP on flood prone land is commensurate with flood hazard and includes consideration of potential flood impacts both on and off the subject land.*

The direction prevents land within flood planning areas being rezoned from lower vulnerability uses such as recreation, rural or environmental protection zones to higher vulnerability uses such as residential, business or industrial. Council should refer to the direction for full details on this. The direction also requires that proposals must not allow development in floodways or that will result in significant impacts to other properties. Furthermore, development should not be allowed that would result in substantially increased requirement for government spending on flood mitigation, infrastructure or services. Flood Planning Levels (FPLs) are required to be consistent with the Floodplain Development Manual 2005.

The choice of FPLs is further described in the *Guideline on Development Controls on Low Risk Flood Areas – Floodplain Development Manual*, a recent guideline to be read as part of the Floodplain Development Manual. The guideline assists councils in determining FPLs for

residential development and recommends the 100-year flood (equivalent to 1% AEP or 100 year ARI) as the basis for the FPL.

Model Local Provisions

In December 2010 the Director General advised Councils of model local provisions which had been settled through parliamentary Council. Clause 7.3 relates to Flood Planning and it was recommended that Council adopt this clause where ever possible. The clause introduces the Flood Planning Area and Map and the relevant matters that must be considered when determining development on land subject to the FPA.

6.2. NSW Flood Prone Land Policy

The primary objectives of the NSW Government's Flood Prone Land Policy are:

- to reduce the impact of flooding and flood liability on individual owners and occupiers of flood prone land; and
- to reduce public and private losses resulting from floods whilst utilising ecologically positive methods wherever possible.

The NSW Floodplain Development Manual 2005 (the Manual), relates to the development of flood prone land for the purposes of Section 733 of the Local Government Act 1993 and incorporates the NSW Flood Prone Land Policy.

The Manual outlines a merits approach based on floodplain management. At the strategic level, this allows for the consideration of social, economic, cultural, ecological and flooding issues to determine strategies for the management of flood risk.

6.3. State Environmental Planning Policy (Exempt and Complying Development Codes (2008))

The aims of State Environmental Planning Policy (Exempt and Complying Development) 2008 are:

This Policy aims to provide streamlined assessment processes for development that complies with specified development standards by:

- *providing exempt and complying development codes that have State-wide application, and*
- *identifying, in the exempt development codes, types of development that are of minimal environmental impact that may be carried out without the need for development consent, and*
- *identifying, in the complying development codes, types of complying development that may be carried out in accordance with a complying development certificate as defined in the Act, and*
- *enabling the progressive extension of the types of development in this Policy, and*

- *providing transitional arrangements for the introduction of the State-wide codes, including the amendment of other environmental planning instruments.*

6.4. Existing Council Policy

6.4.1. Local Environmental Plan, 2013

The Botany Bay LEP 2013 aims to make local environmental planning provisions for land in Botany Bay in accordance with the relevant standard environmental planning instrument under section 33A of the Act. The Botany Bay LEP currently includes the following clause:

> ***6.3 Stormwater management***
>
> *(1) The objective of this clause is to minimise the impacts of urban stormwater on land to which this clause applies and on adjoining properties, native bushland and receiving waters.*
>
> *(2) This clause applies to all land in residential, business and industrial zones.*
>
> *(3) Development consent must not be granted to development on land to which this clause applies unless the consent authority is satisfied that the development:*
>
> *(a) is designed to maximise the use of water permeable surfaces on the land having regard to the soil characteristics affecting on-site infiltration of water, and*
>
> *(b) includes, if practicable, on-site stormwater retention for use as an alternative supply to mains water, groundwater or river water, and*
>
> *(c) avoids any significant adverse impacts of stormwater runoff on adjoining properties, native bushland and receiving waters, or if that impact cannot be reasonably avoided, minimises and mitigates the impact.*

In its current form, the LEP does not include the typical clause used by several Councils in NSW pertaining to Floodplain Management, such as Rockdale City Council for example. Some aspects of this clause are captured in Clause 6.3, Stormwater Management, shown above, however further clarification of flood planning criteria may be required to ensure Council is adequately covered. Amalgamation of the City of Botany Bay Council with Rockdale City Council provides an opportunity for review of the LEP and inclusion of appropriate floodplain risk management clauses. A recommendation to this effect has been included in Section 10.4.10 as Option PM01.

6.4.2. Botany Bay Development Control Policy

Development controls relating to flood liable land are addressed in Botany Bay DCP Part 3G – Stormwater Management and Part 10 – Stormwater Management Technical Guidelines. Controls pertaining to flooding are covered in both documents and set out the main requirements for

development, specifically that development must be compatible with the existing flood risk, and not worsen flood levels, damages or risk (i.e. loss of life). The basic content of the two documents is adequate, however revision and consolidation would allow for ease of interpretation and application by Council and property developers alike.

As for the LEP, formation of Bayside Council provides an opportunity for review of the DCP and revision to include, clarify and consolidate controls pertaining to flood liable land. A recommendation to this effect has been included in Section 10.4.10 as Option PM01.

6.4.3. Section 10.7 Planning Certificates

Formerly known as Section 149 Planning Certificates, Section 10.7 Planning Certificates describe how a property may be used and the controls on development applicable to that property. The Planning Certificate is issued under Section 10.7 of the Environmental Planning and Assessment Act 1979. When land is bought or sold, the Conveyancing Act 1919 and Conveyancing (Sale of Land) Regulation 2010 requires that a Section 10.7 Planning Certificate be attached to the contract of sale for the land.

Section 10.7 of the EP&A Act states:

(1) A person may, on payment of the prescribed fee, apply to a council for a certificate under this section (a planning certificate) with respect to any land within the area of the council.

(2) On application made to it under subsection (1), the council shall, as soon as practicable, issue a planning certificate specifying such matters relating to the land to which the certificate relates as may be prescribed (whether arising under or connected with this or any other Act or otherwise).

(3) (Repealed)

(4) The regulations may provide that information to be furnished in a planning certificate shall be set out in the prescribed form and manner.

(5) A council may, in a planning certificate, include advice on such other relevant matters affecting the land of which it may be aware.

(6) A council shall not incur any liability in respect of any advice provided in good faith pursuant to subsection (5). However, this subsection does not apply to advice provided in relation to contaminated land (including the likelihood of land being contaminated land) or to the nature or extent of contamination of land within the meaning of Schedule 6.

(7) For the purpose of any proceedings for an offence against this Act or the regulations which may be taken against a person who has obtained a planning certificate or who might reasonably be expected to rely on that certificate, that certificate shall, in favour of that person, be conclusively presumed to be true and correct.

7. EMERGENCY RESPONSE REVIEW

The Springvale Drain and Floodvale Drain catchment is located within the Botany Bay Precinct and is subject to the Botany Bay Precinct Emergency Sub Plan (2011). Flood emergency management for the study is organised under the NSW State Emergency Management Plan (EMPLAN).

The EMPLAN details emergency preparedness, response and recovery arrangements for NSW to ensure the coordinated response to emergencies by all responsible agencies. The EMPLAN has been prepared to coordinate the emergency management options necessary at State level when an emergency occurs, and to provide direction at Regional and Local levels.

It is recommended that a Regional Emergency Management Plan (REMPLAN) and Local Emergency Management Plan (LEMPLAN) be prepared for the Botany Bay Emergency Management District to outline an emergency response approach specific to the region. These more focussed plans could include information on the specific waterways of the Springvale Drain and Floodvale Drain including their rate of rise and effective warning time. Section 10.4.11 lists suggestions for inclusion in the LEMPLAN, including roads overtopped and Flood Emergency Response Classification of the Study Area.

8. STAKEHOLDER CONSULTATION

8.1. Previous Consultation (Flood Study)

Community consultation is an important element of the floodplain risk management process ultimately facilitating community engagement and acceptance of the overall project. During the Flood Study (Reference 2), community consultation was undertaken to collect information on historical flooding and previous flood experience, and to inform the community about the development of the Flood Study. Key elements of the community consultation undertaken for the Flood Study included a media release, information website and community questionnaire.

The questionnaire was delivered to all residential properties and businesses (1300 letters delivered) within the study area to collect information on their flood experience and related issues. The focus was historical flooding information that could have been useful for model calibration.

Key findings:

- 104 completed questionnaires (out of 1300) – return rate of 8%, with majority from residential areas and only two from industrial areas near Baker Street;
- Respondents did not make reference to specific events, but rather to locations that were regularly flooded;
- Several flood depths provided at various locations, though not always linked to a specific event;
- 25 respondents had experienced some degree of flooding on the grounds of their property, two of which were above floor level;
- Key areas that are identified as having experienced flooding are: (no. times mentioned)
    - Page St, Pagewood (6)
    - Intersection of Park Pde and Kenny Rd, Pagewood (4)
    - Maxwell Rd, Pagewood (3)
    - Stephen Rd, Pagewood (3)
    - Intersection of Heffron Rd and Banks Rd, Pagewood (3)
    - Towner Gardens, Pagewood (3)
    - Pagewood Primary School (2)
    - Anderson St, Pagewood (2)
    - Mutch Park, Pagewood (2)
    - Wentworth Ave, Pagewood (Outside East Gardens) (2)
    - Spring St, Pagewood (2)

Note that these areas are captured in the list of hotspots in Table 6.

Seven individuals attended a community information session held as part of the Draft Flood Study Public Exhibition. Issues raised included:

- Property value;
- Property flooding impact;
- Road raising (and its adverse impact on flooding);
- Insufficient drainage (especially at Banks Ave, Page St and Heffron Rd);
- Frequency of street cleaning and debris removal;
- Impacts of new developments; and
- Concerns regarding vegetation, both in terms of channel blockage and root damage to pipes.

8.2. Community Consultation as Part of this Study

8.2.1. Newsletter and Questionnaire

A newsletter explaining the purpose of the Floodplain Risk Management Study & Plan was prepared in order to inform residents of the work Council was undertaking and how it related to the work undertaken in the Flood Study. A questionnaire accompanied this newsletter and was designed to allow residents and business owners to make suggestions regarding possible mitigation measures that could be implemented.

The newsletter was issued in October 2016 to 900 residences and businesses (limited to properties within the PMF extent) and is included in Appendix C of this report.

8.2.2. Responses to Questionnaire

Responses to the survey closed on the 25th of November 2016. At this time WMAwater had received 42 responses, approximately 5% of the total mail-out which is typical of this type of investigation. A significant number of responses (10) came from Page St and Heffron Road which are addressed by the mitigation options in the Northeast Residential Zone (Section 10.4.5). The location of respondents is shown in Figure 7.

Results and statistics from the survey have been presented in Figure 8. Out of the 42 respondents, the majority (95%) were residents. Only 7% of respondents had experienced flood waters entering their home or business while a fairly even distribution of respondents had experienced flooding on other areas such as their yard, street, or other areas of the neighbourhood. Approximately 23% of all respondents had not experienced flooding.

The main focus of the community for flood mitigation included increased drainage to reduce the effects of water ponding. Options have been assessed in Section 10.4 to improve drainage in the low points around in the northern residential area, especially Holloway and Gibson streets as noted in the community consultation responses.

8.3. Further Stakeholder Engagement

In addition to consultation with the local community and community groups, other key stakeholders such as Council planners and business owners have been consulted regarding the study and their output needs from the study. There are a range of other stakeholders that should be consulted as potential mitigation options are investigated further beyond this study, they include:

- Roads and Maritime Services (RMS);
- State Rail Authority; and
- the State Emergency Services (NSW SES).

The consultation required will depend on the mitigation option selected to be pursued by Council and the issues that pertain specifically to that option. Specific stakeholders have been identified where necessary in the mitigation options assessed in Section 10.

8.4. Public Exhibition

Public exhibition of the Draft Floodplain Risk Management Study and Plan is required by the Local Government Act (1993, Section 402). This clause stipulates that Council must exhibit the draft plan for public comment for a period of at least 28 days, and that submissions must be considered by the Council before the plan is endorsed or amended.

The Draft Springvale Drain and Floodvale Drain FRMS&P public exhibition period ran from Tuesday 6 August 2019 to Friday 6 September 2019 for community feedback. The below engagement activities were undertaken:

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

Details of the engagement activities, public participation, submissions and responses are provided in Appendix C.

9. ECONOMIC IMPACT OF FLOODING

Flood impact can be quantified in the calculation of flood damages. Flood damage calculations do not include all impacts or costs associated with flooding. They do, however, provide a basis for assessing the economic loss of flooding and also a non-subjective means of assessing the merit of flood mitigation works such as retarding basins, levees, drainage enhancement etc. The quantification of flood damages is an important part of the floodplain risk management process. By quantifying flood damages for a range of design events, appropriate cost effective management measures can be analysed in terms of their benefits (reduction in damages) versus the cost of implementation. The cost of damage and the degree of disruption to the community caused by flooding depends upon many factors including:

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

The estimation of flood damages tends to focus on the physical impact of damages on the human environment but there is also a need to consider the ecological cost and benefits associated with flooding. Flood damages can be defined as being tangible or intangible. Tangible damages are those for which a monetary value can be easily assigned, while intangible damages are those to which a monetary value cannot easily be attributed.

The assessment of flood damages not only looks at potential costs due to flooding, but also identifies when properties are likely to become flood affected by either flooding on the property or by over floor flooding. Figure 9 shows all properties in the study area that are flooded above floor, categorised by the event in which they first experience over-floor flooding.

The standard way of expressing flood damages is in terms of average annual damages (AAD). AAD represents the equivalent average damages that would be experienced by the community on an annual basis, by taking into account the probability of a flood occurrence. This means the smaller floods, which occur more frequently, are given a greater weighting than the rare catastrophic floods.

9.1. Tangible Flood Damages

Tangible flood damages are comprised of two basic categories; direct and indirect damages. Direct damages are caused by floodwaters wetting goods and possessions thereby damaging them and resulting in either costs to replace or repair or in a reduction to their value. Direct damages are further classified as either internal (damage to the contents of a building including

carpets, furniture), structural (referring to the structural fabric of a building such as foundations, walls, floors, windows) or external (damage to all items outside the building such as cars, garages). Indirect damages are the additional financial losses caused by the flood for example the cost of temporary accommodation, loss of wages by employees etc.

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

In order to quantify the damages caused by inundation for existing development, floor levels of the properties within the PMF were estimated based on a combination of LiDAR data, visual inspection and site visit. Dwellings that appeared to be at ground level were given a minimum floor level of 100 mm above ground. This is a reasonable assumption of slab depth and prevented the flood affectation to be exaggerated by the rainfall on grid model.

Each of these techniques has a different level of accuracy associated with the estimate, which is not quantified in the final estimate of economic damage cost for each property. The level of accuracy is considered suitable for two reasons. Firstly, the estimation of property damage due to flooding is inherently difficult to estimate, given the large variation in building types, their contents, the duration of flooding and other factors, and so the accuracy of floor heights should be in line with this accuracy. Secondly, the economic damages assessment is only intended to be used as an estimate of the LGA-wide flood affectation, and not on a per-property basis.

The damages were calculated using a number of height-damage curves derived from OEH Guidelines (Reference 6) which relate the depth of water above the floor with tangible damages. Each component of tangible damages is allocated a maximum value and a maximum depth at which this value occurs. Any flood depths greater than this allocated value do not incur additional damages as it is assumed that, by this level, all potential damages have already occurred.

The following sections provide a more detailed overview of the assessment for residential and commercial/industrial damages.

The database compiled for undertaking damages calculations including floor level information and design flood levels will be provided to Council as part of the handover information for this project. Note that the terminology used refers to a property or lot being the land within the ownership boundary. Flooding of a property does not necessarily mean flooding above floor level of a building on that property/lot.

9.1.1. Residential Properties

Flood damages assessment for residential development was undertaken in accordance with OEH guidelines (Reference 6). For residential properties, external damages (damages caused by flooding below the floor level) were set at $6,700 and additional costs for clean-up as $4,000. For additional accommodation costs or loss of rent a nominal value of $220 per week was allowed assuming that the property would have to be unoccupied for up to three weeks. These assumptions account for freestanding garages, which in this catchment are often located closer to the road and much lower than the house itself. Internal (contents) damages were allocated a maximum value of $67,500 occurring at a depth of 2 m above the building floor level (and linearly proportioned between the depths of 0 to 2 m). Private garages on residential properties were considered to be subject to external damages. These estimated values are in line with what has been applied in other recent studies in New South Wales.

Structural damages vary depending on whether the property is slab/low set or high set. For the purpose of this study, any property with a floor level of 0.5 m or more above ground level was assumed to be high set. For two storey properties, damages (apart from external damages) are reduced by a factor of 70% where only the ground floor is flooded as it is assumed some contents will be on the upper floor and unaffected and that structural damage costs will be less. In some instances external damage may occur even where the property is not inundated above floor level and therefore tangible damages include external damages which may occur with or without house floor inundation.

A summary of the residential flood damages for the study area is provided in Table 7. Overall, for residential properties in the area there is a large difference in the average tangible damages per property between the frequent and rare flood events. This is reflective of the rarer floods, in particular the PMF, having a far wider flood extent than frequent events, and of these rare events being more costly, even after their rarity has been accounted for.

Table 7: Estimated Residential Flood Damages for Springvale and Floodvale Drain Catchment

Event	No. Properties Affected (Flooded below floor)	No. Properties Flooded Above Floor Level	Total Damages for Event	Ave. Damage Per Flood Affected Property	Contribution to AAD	% Contribution to AAD
PMF	428	287	$16,946,000	$ 39,600	$ 60,222	2.8%
0.5%	266	130	$ 7,191,200	$ 27,000	$ 34,411	1.6%
1.0%	248	118	$ 6,573,100	$ 26,500	$ 62,490	2.9%
2.0%	240	108	$ 5,924,800	$ 24,700	$ 162,247	7.5%
5.0%	226	88	$ 4,891,600	$ 21,600	$ 216,484	10.0%
10.0%	203	70	$ 3,767,700	$ 18,600	$ 349,553	16.1%
20.0%	192	58	$ 3,223,300	$ 16,800	$ 1,289,333	59.3%
Average Annual Damages (AAD)			**$ 2,174,700**	**$ 5,100**		**100.0%**

9.1.2. Commercial and Industrial Properties

The tangible flood damage to commercial and industrial properties is more difficult to assess. Commercial and industrial damage estimates are more uncertain and larger than residential damages. Costs to business can occur for a range of reasons, some of which will affect some businesses more than others dependent on the magnitude of flooding and the type of businesses. Common flood costs to businesses are:

- Removal and storage of stock before a flood if warning is given;
- Loss of production – caused by damaged stock, assets and availability of staff;
- Loss of stock and/or assets;
- Reduced stock through reduced or no supplies;
- Trade loss – by customers not being able to access the business or through business closure;
- Cost of replacing damages or lost stock or assets; and
- Clean-up costs.

No specific guidance is available for assessing flood damages to non-residential properties. Therefore for this Study, commercial and industrial damages were calculated using the methodology for residential properties but with the costs/damages increased to a value which is consistent with commercial/industrial development. For example, the maximum value of internal (contents) damages was increased to $191,250 since the building contents are generally of higher value whilst loss of rent was set at $1,000 per week to account for the loss of business through having to close for a period. Flooding below floor level uses the same damages curve as the residential properties.

Though the original OEH guidelines for flood damages calculations are not applicable to non-residential properties, they can still be used to create comparable damage figures. The damages value figure should not be taken as an actual likely cost rather it is useful when comparing potential management options and for benefit-cost analysis. A summary of the commercial/industrial flood damages for the study area is provided in Table 8.

Table 8 Estimated Commercial and Industrial Flood Damages for Springvale and Floodvale Drain Catchment

Event	No. Properties Affected (Flooded below floor)	No. Properties Flooded Above Floor Level	Total Damages for Event	Ave. Damage Per Flood Affected Property	Contribution to AAD	% Contribution to AAD
PMF	29	19	$1,859,600	$64,100	$6,460	1.7%
0.5%	14	6	$729,600	$52,100	$3,635	1.0%
1.0%	14	6	$724,200	$51,700	$7,169	1.9%
2.0%	13	6	$709,500	$54,600	$20,889	5.5%
5.0%	13	6	$683,100	$52,500	$32,900	8.7%
10.0%	12	5	$632,900	$52,700	$62,281	16.5%
20.0%	12	5	$612,700	$51,100	$245,097	64.8%
Average Annual Damages (AAD)			**$378,400**	**$13,000**		**100.0%**

9.1.3. Combined Damages

The combined results are provided in Table 9. This flood damages estimate does not include the cost of restoring or maintaining public services and infrastructure. It should be noted that damages calculations do not take into account flood damages to any basements or cellars, hence where properties have basements damages can be underestimated.

Table 9: Estimated Combined (Residential and Commercial/Industrial) Flood Damages for Springvale and Floodvale Drain Catchment

Event	No. Properties Affected (Flooded below floor)	No. Properties Flooded Above Floor Level	Total Damages for Event	Ave. Damage Per Flood Affected Property	Contribution to AAD	% Contribution to AAD
PMF	457	306	$18,805,600	$ 41,200	$ 66,682	2.6%
0.5%	280	136	$ 7,920,800	$ 28,300	$ 38,045	1.5%
1.0%	262	124	$ 7,297,300	$ 27,900	$ 69,658	2.7%
2.0%	253	114	$ 6,634,300	$ 26,200	$ 183,136	7.2%
5.0%	239	94	$ 5,574,700	$ 23,300	$ 249,384	9.8%
10.0%	215	75	$ 4,400,600	$ 20,500	$ 411,834	16.1%
20.0%	204	63	$ 3,836,100	$ 18,800	$ 1,534,430	60.1%
Average Annual Damages (AAD)			**$ 2,553,200**	**$ 5,600**		**100.0%**

It is important to note that the damages figure is designed to indicate the relative effects of different sized events and provide a basis for the comparison of various mitigation options. Damages assessments for mitigation options can be supplied once options have been shortlisted by Council.

9.2. Intangible Flood Damages

The intangible damages associated with flooding, by their nature, are inherently more difficult to estimate in monetary terms. In addition to the tangible damages discussed previously, additional costs/damages are incurred by residents affected by flooding, such as stress, risk/loss to life, injury, loss of sentimental items etc. It is not possible to put a monetary value on the intangible damages as they are likely to vary dramatically between each flood (from a negligible amount to several hundred times greater than the tangible damages) and depend on a range of factors such as the size of flood, the individuals affected, and community preparedness. However, it is still important that the consideration of intangible damages is included when considering the impacts of flooding on a community and the assessment of flood mitigation options. Indirect and intangible elements of assessed flood mitigation options are captured via a multi-criteria matrix assessment, presented in Section 11.

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

During any flood event there is the potential for injury as well as loss of life due to causes such as drowning, floating debris or illness from polluted water. Generally, the higher the flood velocities and depths the higher the risk. Section 5.1 describes the main sources of high hazard in the study area. However, there will always be local high risk (high hazard) areas where flows may be concentrated around buildings or other structures within low hazard areas.

10. FLOODPLAIN RISK MANAGEMENT OPTIONS

10.1. Background

Floodplain risk management measures are actions which can be undertaken in both the short and long term which manage the risk of flooding. Measures range from flood modification measures such as levees and retarding basins, to response measures such as emergency response planning and property modification measures such as house raising. These types are described in the following section. The section also describes the management measures that may be assessed in detail for the study area.

As part of this FRMS&P a number of potential floodplain risk mitigation options have been considered and tested for their effectiveness in reducing flood levels and hazard to the community.

10.2. Options for Consideration

10.2.1. Flood Modification Options

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

10.2.1.1. Improving Flow Paths

Residential development has restricted the space around the waterway, so improving flow paths by increasing channel sizes will be difficult to achieve. This option however may be modelled by:

- Increasing existing culvert sizes;
- Removing/raising footbridges;
- Lowering channel beds to effectively increase capacity; and
- Increasing channel size where appropriate.

10.2.1.2. Retention Basins

Retarding basins store runoff temporarily and then release it at a reduced rate. Although they do not reduce the total volume of runoff significantly, they reduce the rate at which runoff occurs, thus reducing downstream flood levels. They also typically include a spillway on the embankment wall, which is a slightly lower section that allow controlled overtopping if the basin capacity is exceeded.

10.2.1.3. Riparian Management

Vegetation maintenance including regular spraying of weeds and clearing of debris may yield improvements in channel capacity.

10.2.1. Property Modification Options

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

10.2.2. Response Modification Options

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

10.2.3. Relative merits of Management Measures

A number of methods are available for judging the relative merits of competing measures. The benefit/cost (B/C) approach has long been used to quantify the economic worth of each option enabling the ranking against similar projects in other areas. A B/C ratio is the benefits expressed in monetary terms (as a reduction in flood damage), compared to the actual likely cost of achieving those benefits. It is a standard method for using the time value of money to appraise long-term projects of the reduction in flood damages (benefit) compared to the cost of the works (including ongoing maintenance). Generally the ratio expresses only the reduction in tangible damages as it is difficult to accurately include intangibles such as a reduction in risk to life (as discussed in Section 9.2). Once options have been reviewed, a shortlist of options will be subjected to a damages and cost assessment to prepare a B/C ratio for further prioritisation.

The potential environmental and social impacts, and other intangible benefits of any proposed flood mitigation measure must be considered in the assessment and cannot be evaluated using the traditional B/C approach. The approach also does not consider the financial feasibility of works that require a large capital outlay, the impact on emergency services, the political or administrative feasibility of an option, its effect on the risk to life, as well as its long term performance. For this reason a matrix type assessment has been used which enables a value (including non-economic worth) to be assigned to each measure.

Multi-criteria decision matrices are recommended in the Floodplain Development Manual and therefore it is also a recommendation herein that multi-variate decision matrices be developed allowing detailed benefit/cost estimates, community involvement in determining social and other intangible values, and local assessment of environmental impacts. A multi-criteria matrix assessment has been completed in Section 11.

10.3. Mitigation Options not further considered

10.3.1. Voluntary House Raising

Voluntary house raising (VHR) seeks to reduce the frequency of exposure to flood damage of the house and its contents by raising the house above the minimum Flood Planning Level (FPL), and accordingly reduce the frequency of household disruption and associated trauma and anxiety. VHR is eligible for OEH funding based on eligibility criteria set out in the OEH Guidelines for Voluntary House Raising Schemes (Reference 8). VHR was considered for properties along the main waterway, however many of these are apartment blocks and are not suitable for raising, besides which VHR is inappropriate in a floodway. For these reasons this option was not considered further.

10.3.2. Voluntary Purchase

Voluntary purchase (VP) is recognised as an effective floodplain risk management measure for existing properties in areas where:

- There are highly hazardous flood conditions and the principal objective is to remove people living in these properties and reduce the risk to life of residents and potential rescuers;
- A property is located within a floodway and its removal may contribute to a floodway clearance program that aims to reduce significant impacts of flood behaviour elsewhere in the floodplain by improving the conveyance of the floodway; or
- Purchase of a property enables other flood mitigation works to be implemented (e.g. channel improvements or levee construction).

Voluntary purchase typically has the most benefit when houses that are frequently subjected to inundation over floor level can be removed from the floodway; both reducing the risk to life and improving flow conveyance through the vacated lot. Within the Springvale and Floodvale Drain catchments no properties meet this criteria, and there are no properties eligible for Voluntary Purchase as defined by the Office of Environment and Heritage Guideline (Reference 9). While several properties (or their driveways, for example) encroach on the waterway easement, the removal of houses would not significantly benefit the residents nor improve downstream flood levels. There are only a couple of properties that are subject to high hazard (in the 1% AEP event), and these are in the unit complexes at the downstream end of the waterway. Furthermore, demand for property in Botany is high, with a significant amount of development currently being undertaken to provide accommodation. It is unlikely house owners would agree to sell, and the value of the house itself may be cost prohibitive even with funding. This option has therefore not been considered further.

There is a high rate of redevelopment within the LGA. It is expected that ongoing redevelopment in the area will continue to improve flood risk, as new dwellings are built to comply with flood related development controls that ensure adequate floor levels are constructed and that impacts on flood levels are prevented.

10.3.3. Evacuation

Evacuation is typically required in larger catchments in which over floor flooding typically occurs. It requires substantial warning time to effectively remove affected residents from the area, and is usually of greater benefit when the duration of inundation is days or even weeks, rather than hours. The short warning time, rapid rate of rise and short duration of flooding in the catchment mean evacuation improvements would have little benefit, and focus should be placed on education and preparedness. This report has not considered evacuation improvements further.

10.3.4. Catchment-Wide Vegetation Management

Vegetation management has been assessed as a targeted measure in the southern (downstream) reaches of Springvale Drain and Floodvale Drain, in which parts of the open channel sections are heavily vegetated with weeds. In these areas, such dense vegetation serves to back up flow and raise peak flood levels along the open channels. This option has therefore been assessed and recommended as part of the Exell Street Focus Area report in Appendix D. Catchment wide vegetation management was not assessed in this investigation as Council currently undertakes street sweeping and leaf control measures to address culvert blockage.

10.4. Flood Modification Options Considered – Overview

A number of flood risk mitigation options have been assessed throughout the catchment, which has been divided into three key zones. These zones include the Northwest Residential Zone, Northeast Residential Zone, and the Exell Street Focus Area. The options that have been assessed are listed in Table 10.

Table 10 Mitigation Measures Considered

Zone	Option	Mitigation Options Considered	Report Reference
Northwest Residential Zone	NW01	Dalley Avenue Drainage Upgrade	10.4.2
	NW02	Bay Street Drainage Upgrade	10.4.3
	NW03	Holloway Street Drainage Upgrade	10.4.4.
Northeast Residential Zone	NE01	Banks Avenue Drainage Upgrade	10.4.6
	NE02	Towner Gardens Drainage Upgrade	10.4.7
	NE03	Park Parade Drainage Upgrade	10.4.8
Exell St Focus Area[1]	FM02	Duplication of pipe under Botany Road	Appendix D
	FM03	Vegetation management (open channel sections)	Appendix D
	FM08	Debris removal and maintenance at Floodvale Drain/ SWSOOS No. 2 Culvert	Appendix D
	FM10	Local Drainage Improvements – Botany Road	Appendix D
Property	PM01	Review of Planning Policies	10.4.10
Response	RM03	Revisions to Local Flood Plan	10.4.11
[1]Only the recommended options arising from Reference **3** have been listed. See full report for all options considered in this area			

10.4.1. Zone 1: Northwest Residential Area

The northwest residential zone is located in the upper parts of the Floodvale Drain catchment, and include Pagewood Public School and a number of flooding hotspots around Ocean St, Gibson St, Holloway St and Banksia St (Hotspots No. 4-8). This zone also includes the hotspot at Bay Street, one of the locations that prompted the expansion of the Study Area to the north. Flood risk in these areas is generally caused by water ponding in trapped low points with insufficient or ineffective drainage. A number of mitigation options have been assessed and are described below.

10.4.2. Option NW01: Dalley Avenue Drainage Upgrade

10.4.2.1. Option Description

Option NW01 aims to reduce flood affectation on Dalley Avenue and the residential properties in the vicinity of Pagewood Public School. This area has been noted as hotspot #4 in Council's brief. There is currently a pipe network that conveys water from Wentworth Ave (north and south of Page Street) and Page Street south to the Springvale Drain. An offtake pipe has been added in this option to alleviate the demand on this system, and allow a portion of the water from upstream of Dalley Ave to drain directly to an area of lowered ground on Pagewood Public School oval to act as a detention basin. At this stage a 1.35 m diameter pipe with a length of 14 m has been trialled to drain the current low point on Dalley Ave into the school oval.

The detention basin was modelled by lowering the ground surface in the school's playing field area by between 1.0 and 1.2 m to a level of 12 mAHD on the western side, and 11.65 mAHD on the eastern side. The area is approximately 2340 m^2, which creates a volume of approximately 2800 m^3. It should be noted that the depth and area of excavation is based on a 'first-pass' assessment where only the effect on flooding is determined. If there is shown to be a benefit, the environmental and social constraints would be carefully considered. At this stage outlet pipe(s) have not been considered, though if the option were to progress drainage of the oval would need to be addressed.

10.4.2.2. Modelled Impacts

The effects of this option are relatively limited, and occur only for smaller design flood events. The option achieves minimal reductions in flood level in the 20% AEP event of up to 0.05 m both on the school grounds and properties along Dalley Ave, to just north of Page Street. The 1% AEP event found negligible impacts with the option in place. The change in peak flood level for the assessed option is shown on Figure 12 (1% AEP) and Figure 13 (20% AEP).

10.4.2.3. Evaluation

The proposed basin would provide minor benefit to the area's flood risk in small events, including benefit for property flooding, and reducing hazard to motorists and pedestrians on Dalley Ave. This first-pass investigation has highlighted that the benefits available in the 1% AEP event are negligible due to the sheer volume of water at the site. A much more expansive excavation would

be required to have any flood benefit. Furthermore, there are significant limitations associated with this option which would need to be considered further, including:

- Capital costs of this option are estimated to be in the order of $650,000, assuming the field is excavated to form the basin (rather than subsurface storage). To achieve a Cost-Benefit Ratio (BCR) of 1, the option would need to reduce Average Annual Damages by approximately $51,000. Figure 9 indicates six (6) properties in the vicinity of the option are flooded over floor in the 20% AEP event. The reduction in peak flood levels in the 20% AEP event caused by Option NW01 (shown on Figure 13) could potentially prevent over floor inundation to these properties, with minor benefits also afforded to other properties in the vicinity. This indicates the option may be economically feasible (BCR >1), despite not having a material impact on property damages in rarer events.
- Inundation of the playing surface may reduce the recreational utility of the school oval, for example by killing grass or resulting in nuisance inundation, causing ground closure. If an all-weather surface is installed, it would need to be confirmed whether this surface could withstand prolonged deep inundation without causing damage or reduction in the effective design life of the surface;
- Detention basins reduce flood levels for adjacent areas, but increase the hazard of flooding within the basin itself. The additional risk to life within the basin area would need to be considered, especially within the grounds of a primary school ; and
- Constructing a subsurface water storage beneath the oval may address the above issues, but would likely be prohibitively expensive; and
- The effect of this option on over-road flooding, as well as a range of other tangible and intangible factors, have been considered via a multi-criteria matrix assessment, presented in Section 11.

It is noted that Options NE01 and NE03, described in Section 10.4.6 and 10.4.8 respectively, act to reduce the upstream demand on the stormwater drainage network, yielding benefits in the Pagewood Public School/ Dalley Avenue area. If either of these options are implemented, the works involved in Option NW01 could be reduced substantially (e.g. the basin component could perhaps be omitted).

☑ **NW01 Recommendation**

This option provides localised benefits in frequent flood events, both to over-floor property affectation and reduced flood risk to motorists over Dalley Avenue. It is recommended as a low priority option to be further investigated, noting that it relies on excavation of the Pagewood Public School oval which may not be acceptable to the community due to loss of amenity and potential risk to life during flash flood events. Investigation of Option NW01 should also consider Options NE01 and NE03, which yield benefits in this area also as they reduce upstream demand on the stormwater drainage network.

10.4.3. Option NW02: Bay Street Drainage Upgrade

10.4.3.1. Option Description

Option NW02 comprises the installation of two new pits on Bay Street (approximately mid-way between Wentworth Ave and Lang St), and installation of a pipe to convey water northwards and into the swamp within The Lakes Golf Course. At present there is a trapped low point on Bay Street, classified as low hazard. This hotspot was not identified in the Flood Study nor Council's brief as it lies just north of the original Study Area boundary, however as it is located within the model boundary, the Study Area has been extended to include it for consideration in this report.

The proposed pipe has been modelled as a 1350 mm diameter pipe approximately 112 m long that would discharge into an open swale drain. The drain would run north for 260 m and discharge into the existing water body within the golf course.

10.4.3.2. Modelled Impacts

The proposed works result in reductions of up to 0.64 m on Bay Street and in surrounding properties in the 20% AEP, with some properties no longer flooded in the 20% AEP. Bay Street itself is no longer flooded in either the 1% or 20% AEP event. The excavated channel is newly flooded at its upstream end, and flood levels reduced in the downstream reach due to the excavation. The effects in the 1% AEP are similar to the 20%, with a slightly greater extent of benefits in the residential area. Both events show a minimal increase in water level in the northern golf course pond. These impacts are shown on Figure 14 and Figure 15 for the 1% AEP and 20% AEP events respectively.

10.4.3.3. Evaluation

The option achieves significant reduction in peak flood level for 10-15 properties on Bay Street, with a number of houses no longer flooded in both the 20% AEP and 1% AEP events. The option effectively drains Bay Street, removing inundation and hence improving safety for motorists and pedestrians. Liaison with The Lakes Golf Club would be required to determine the most suitable and cost effective swale drain easement, or if a new discharge into the golf course is acceptable altogether.

With a capital cost estimated at approximately $400,000 ex GST, this option is considered economically feasible due to the reduction in over-floor property affectation it provides in Bay Street and surrounds. Other direct benefits, such as the reduction in inundation on Bay Street itself, are captured via a multi-criteria matrix assessment presented in Section 11.

NW02 Recommendation

☑ This option is recommended due to the positive benefits it brings to several residential properties and Bay Street itself for relatively minor construction works.

10.4.4. Option NW03: Holloway Street Drainage Upgrade

10.4.4.1. Option Description

As identified in Section 5.4.1, the low lying residential area between Holloway Street and Gibson Street is not able to drain effectively due to a lack of pipe capacity. Existing pipes in the vicinity are full in events as frequent as the 20% AEP. This option assesses the effectiveness of duplicating pipes from Holloway Street to as far south as Coal Pier Road for an approximate total length of 1.5 km.

10.4.4.2. Modelled Impacts

This option results in notable improvement to flood depths for properties in a localised area along Holloway St and Gibson streets, with some areas no longer flooded in both the 1% and 20% AEP events. The impact of the works on the 1% AEP and 20% AEP peak flood level is shown Figure 16 and Figure 17 respectively. In the 1% AEP event, the maximum impact occurs on Gibson St with a maximum reduction of 0.35 m. In the 20% AEP event, this option also benefits properties on Gibson and Holloway Streets with maximum reductions of approximately 0.22 m.

Due to the existing stormwater drainage network already being full even in frequent events, the pipe duplication is required to be continued for the full length of the below-ground network for it to have a positive impact at its entry point on Holloway Street. The pipe discharges to the Floodvale Drain open channel at the northern end of Coal Pier Road. At this location, peak flood levels increase by 0.16 m between Coal Pier Road and Nant Street in the 20% AEP event. In the 1% AEP event, there are increased flood levels of 0.02 m in the industrial park in the area between Coal Pier Road and Nant Street. These impacts could be mitigated by the downstream works proposed in the Exell Focus Area report, in Appendix D.

10.4.4.3. Evaluation

There is significant work involved in the pipe duplication as the pipe needs to be duplicated for 1.5 km to be effective. A shorter pipe would need to join the already-full network, and while this would provide some additional storage, would quickly fill and become ineffective. With such a long duplication, capital costs are significant, estimated to be in the order of $2.2M. Construction would involve cooperation between a number of stakeholders including Council, private land owners, state government (Three Ports), RMS and Sydney Trains. It is unlikely that the benefits afforded to so few properties will justify such an extensive and costly design and construction process.

NW03 Recommendation

☒ This option is not recommended due to the high costs, difficulty of construction and adverse downstream impacts for limited benefits to property damages.

10.4.5. Zone 2: Northeast Residential Area

Zone 2 is in the north-eastern corner of the revised Study Area and includes properties east of Banks Avenue around Jellicoe Oval and to the north as far as Birdwood Avenue. The area is bounded on the east by Bunnerong Road. This section investigates several mitigation options that seek to drain excess water away from properties to either Jellicoe Park or from Banks Avenue to Bonnie Doon Golf Course. The mitigation options considered in this area are shown in Figure 11 Sheet B.

10.4.6. Option NE01: Banks Avenue Drainage Upgrade

10.4.6.1. Option Description

Option NE01 comprises an upgraded stormwater drainage system to allow the discharge of water from Banks Avenue into a lowered section of Bonnie Doon Golf Course. This area has been noted as Hotspot #3 in Council's brief. Two additional 1050 mm diameter pipes are proposed to drain the western side of Banks Avenue, and discharge into an excavated basin with an area of approximately 18,850 m^2 and average depth of approximately 2 m. The excavation is primarily designed for ease of drainage from Banks Avenue. A drainage swale at the western side of the basin is proposed to ensure the basin does not normally store water, but rather is empty so as to provide some benefit during a flood event.

10.4.6.2. Modelled Impacts

The flood impacts for the 1% AEP event are shown in Figure 18 with significant reductions in flood levels around Banks Avenue and surrounding residential areas, some parts of which are no longer flooded. This option significantly reduces the amount of water entering the drainage system creating significant benefits downstream through Heffron Road and Mutch Park, as far as Pagewood Public School and Baker Street (up to 0.3 m).

Impacts in the 20% AEP event are shown in Figure 19, and also show reduction of flooding on Banks Avenue up to 0.2 m with some parts of the road no longer flooded. The increased drainage capacity reduces flood affectation for the residential areas east of Banks Ave north of Heffron Road. The reduction in peak flood levels range from between 0.02 and 0.2 m, with the greatest benefits closest to Banks Avenue. There are also some benefits to the low lying areas of Mutch Park and Heffron Road (approx 0.07 m). Inundation of the Banks Avenue and Heffron Road intersection is reduced by approximately 30 minutes in the 1% AEP event and 10 minutes in the 20% AEP event. In both the 1% and 20% AEP events the newly excavated area in the golf course is newly flooded in parts, however the excavation also causes a reduction in flood levels.

10.4.6.3. Evaluation

The lowering of the golf course and additional drainage of Banks Avenue has benefits for properties not only upstream, but also downstream as the demand on drainage is lessened. The

construction requirements are relatively limited, with two new pits and pipes installed on the western side of Banks Avenue (not crossing the road). Capital costs are estimated in the order of $7.5M, owing to the significant excavation required within the golf course. To achieve a BCR of 1, the AAD is to be reduced by approximately $600,000. With the benefits available in terms of peak flood level reduction both around Banks Avenue and Page Street, this is considered feasible. The cost estimate assumes the excavation is virgin natural material, however based on experience in the area, it is possible that the excavated spoil may be contaminated, leading to higher capital costs than currently estimated. The quality of soil should be determined via a geotechnical investigation if this option were to proceed.

Construction within the golf course may entail a challenging approvals process, as the proposed excavation would have substantial consequences for the layout of the golf course. Further investigation is likely to be necessary to achieve an effective solution that is acceptable to all stakeholders.

NE01 Recommendation

☑ This option has significant benefits for properties and roads both upstream and downstream of the works and is recommended for further investigation. Key factors to be considered include the quality of spoil, and if costly waste disposal would be required, as well as the feasibility of altering the topography of the golf course.

10.4.7. Option NE02: Towner Gardens Drainage Upgrade

10.4.7.1. Option Description

This option seeks to reduce flood affectation in the streets and properties around Towner Gardens and Prince Edward Circuit in the north east of the revised study area. A new 1050 mm pipe is proposed to be installed from Prince Edward Circuit, across Banks Avenue and into an excavated channel in Bonnie Doon Golf Course. The pipe is proposed to be approximately 80 m in length, and the channel has been modelled at this stage as 15 m wide and 150 m long, though the size and location of this may be optimised in consultation with the golf club.

10.4.7.2. Modelled Impacts

The modelled flood impacts in the 1% AEP event are shown in Figure 20 and indicate minor reductions in flood level in the residential area around Prince Edward Circuit and Towner Gardens (~ 0.01 m) and up to 0.1 m reductions through Bonnie Doon Golf Club. The impacts in the 20% AEP are shown in Figure 21, and show minor reductions in flood level through the residential areas of up to 0.05 m. Further, inundation of Prince Edward Circuit is delayed by approximately 1 hour in both the 1% and 20% AEP event, and the duration of flooding is reduced by one hour in each event. Flood levels through the southern parts of Bonnie Doon Golf Club are reduced by up to 0.1 m.

10.4.7.3. Evaluation

The proposed pipe installation and excavation area yield benefits for the target residential area, in which approximately 15 properties are estimated to be flooded over floor in a 20% AEP event. With capital costs estimated at less than $400,000, a reduction in AAD of $21,000 would be required to achieve a BCR equal to 1, which is considered feasible given the broad area of peak flood level reductions in the 20% event.

As with previous options, the works within the Bonnie Doon Golf Club would be subject to an approvals process, and may need significant alteration to arrive at an effective option acceptable to the golf club. Nevertheless, the benefits to property damages and inundation of Towner Gardens, Wark Avenue and Prince Edward Circuit, mean the option warrants further investigation. The multi-criteria matrix assessment presented in Section 11 captures a range of additional tangible and intangible criteria.

NE02 Recommendation

☑ This option provides benefits to a localised residential area, particularly in frequent events and should be considered for further investigation. Consultation with Bonnie Doon Golf Club will form a key element of the investigation to determine the feasibility of this option moving forward.

10.4.8. Option NE03: Park Parade Drainage Upgrade

10.4.8.1. Option Description

This option targets flood affectation on the residential properties south and east of Jellicoe Park through the addition of drainage pits and pipes and lowering of Jellicoe Park by approximately 2.5 m to form a retarding basin with a capacity of approximately 57,500 m^3.

10.4.8.2. Modelled Impacts

Similarly to Option NE01, this option reduces the demand on the downstream drainage system and yields benefits beyond the immediate works zone. The flood impacts in the 1% AEP event are shown on Figure 22. In this option Jellicoe Oval would be newly inundated, as its ground level is lowered and receives inflow from two pipes on Park Parade. This reduces flood affectation to residential properties between Heffron Road and Park Parade, especially at the Banks Avenue Intersection, with maximum reductions of 0.16 m in the 1% AEP event. Inundation at this intersection is reduced by up to 10 minutes in the 20% AEP event. Further downstream benefits of up to 0.12 m on Wentworth Ave and Page St (Pagewood Public School) are also noted. The impacts in the 20% AEP, shown in Figure 23, are more localised to the works zone, with reductions of up to 0.2 m around the Banks Avenue/Heffron Road intersection, and lesser reductions at the proposed new pipe locations (only around 0.01 m). There are also some small patches of reductions seen through the low lying areas of Mutch Park. Total inundation time of Heffron Road near Mutch Park is reduced by approximately 50 minutes in the 20% AEP.

10.4.8.3. Evaluation

This option provides benefits both in the immediate vicinity of the proposed works and further downstream as the demand on the drainage system is relieved. However, there is likely to be community opposition to lowering Jellicoe Park, especially as it is used for sporting fixtures (at the time of writing, Jellicoe Park was one of the home grounds for the Pagewood-Botany Football Club). Creating a basin in a publicly accessible area also constitutes an increase in the flood hazard classification. Construction of subsurface water storage may provide a solution to this issue whilst also providing water for park irrigation.

With a depth of 2.5 m, the construction costs of this option are expected to be over $11M, based on earthwork rates applicable to excavated natural material. At this cost, the option is unlikely to be economically feasible, as it would need to reduce AAD by nearly $1M to achieve a BCR of 1. It is likely however that, with further investigation, the basin depth could be reduced to optimise benefits to properties in frequent events. This option is recommended for further investigation to develop the concept design further and assess the acceptability of this option to the community.

☑ **NE03 Recommendation**

This option is recommended for further investigation as it has the potential to provide extensive benefits to properties immediately adjacent to Jellicoe Park, and further downstream as the demand on the drainage network is reduced. The investigation should consider alternative water storage methods and sizing to replace the proposed large scale excavation and associated increase in hazard to the community.

10.4.9. Zone 3: Exell Street Area

The Exell Street area includes both the Springvale and Floodvale Drains in the southern part of the catchment, where the land use is generally industrial and commercial and the drains are open channels. A flood mitigation options assessment was undertaken in August 2016 by WMAwater as a standalone focus area report. This report can be found in Appendix D. The report investigated and recommended the options as listed in Table 11. Flood impact maps for all options are included in Appendix D.

Table 11 Options considered in the Exell St Focus Area (Table 6 in Appendix D).

Option	Description	Recommended (Yes/No)	Priority	Adverse Impacts (Yes/No)	Council Preference
FM01	Lowering Botany Rd, partial duplication of pipe	Yes	Medium	Yes	No
FM01A	Option FM01 + Swale Drain along Golf Course	Yes	Medium	Yes	No
FM01B	Swale Drain along Golf Course only	Yes	High	No	Yes

Option	Description	Recommended (Yes/No)	Priority	Adverse Impacts (Yes/No)	Council Preference
FM02	Duplication of pipe under Botany Road	Yes	Medium	-	Yes
FM03[1]	Ongoing Channel Maintenance Works	Yes	High	Yes	Yes
FM04	Combined Option FM01 & FM03	Yes	Medium	No	No
FM05	Combined Option FM02 & FM03	No	-	-	Yes
FM06	Increase Springvale Drain Cross Sectional Area	No	-	-	No
FM07	Removal of Springvale Drain Culvert	Yes	High	Yes	Already undertaken
FM08	Improvement of Floodvale/SWSOOS No. 2 Intersection	Yes	Medium	Yes	No
FM09	Combination of FM01, FM03, FM07 and FM08	Yes	Low	Yes	No
FM10	Local Drainage Improvements	Yes	High	No	Yes

[1]"Ongoing Channel Maintenance Works" had been investigated in Appendix D with a focus on vegetation management. Vegetation management refers to activities such as removal of weeds and exotics intended to prevent densification of vegetation which can increase hydraulic roughness along the open channels, and subsequently reduce the conveyance capacity and increase peak flood levels. Following completion of the Exell Street Focus Area report (Appendix D) a broader review was undertaken by Council which identified a range of maintenance activities and minor works at specific locations that would also contribute to maintaining conveyance in the open channels. Specific actions included removal or modification of footbridges over the channels, modification of fencing, removal of sedimentation, and negotiations with land owners to manage floodplain vegetation and maintain channels on private property (e.g. the linking channel between Springvale and Floodvale Drains at the northern end of Coal Pier Road).

10.4.10. Option PM01: Review of Planning Policies

10.4.10.1. Review of LEP

The Botany Bay Local Environmental Plan (2013) as it stands does not include some clauses relating to flood prone land typically included in other Council LEPs. The LEP currently belonging to Rockdale Council contains a more comprehensive Flood Planning clause. It is recommended that the content of this clause, as shown below, are adopted by the amalgamated Bayside Council to ensure Council is adequately covered. There may be issues arising with Councils compliance with the gazetted Floodplain Development Manual (Reference 1) if such a clause is not included. "*[The Floodplain Development Manual] replaces the 1986 Floodplain Development Manual as the Government's manual relating to the management of flood liable land in accordance with Section 733 of the Local Government Act 1993. This provides councils and statutory authorities, and their staff, with indemnity for decisions made and information provided in good faith from the outcomes of the management process."* (Reference 1).

Rockdale LEP 2011

6.6 Flood planning

(1) The objectives of this clause are as follows:

(a) to minimise the flood risk to life and property associated with the use of land,

(b) to allow development on land that is compatible with the land's flood hazard, taking into account projected changes as a result of climate change,

(c) to avoid significant adverse impacts on flood behaviour and the environment.

(2) This clause applies to:

(a) land that is shown as "Flood planning area" on the Flood Planning Map, and

(b) other land at or below the flood planning level.

(3) Development consent must not be granted to development on land to which this clause applies unless the consent authority is satisfied that the development:

(a) is compatible with the flood hazard of the land, and

(b) is not likely to significantly adversely affect flood behaviour resulting in detrimental increases in the potential flood affectation of other development or properties, and

(c) incorporates appropriate measures to manage risk to life from flood, and

(d) is not likely to significantly adversely affect the environment or cause avoidable erosion, siltation, destruction of riparian vegetation or a reduction in the stability of river banks or watercourses, and

(e) is not likely to result in unsustainable social and economic costs to the community as a consequence of flooding.

(4) A word or expression used in this clause has the same meaning as it has in the Floodplain Development Manual (ISBN 0 7347 5476 0), published in 2005 by the NSW Government, unless it is otherwise defined in this clause.

(5) In this clause:

***flood planning level** means the level of a 1:100 ARI (average recurrent interval) flood event plus 0.5 metre freeboard.*

***Flood Planning Map** means the Rockdale Local Environmental Plan 2011 Flood Planning Map.*

10.4.10.2. Development Control Plan, 2013

As described in Section 6.4.2, development controls pertaining to flood liable land are addressed in Botany Bay DCP 2013 Part 3G – Stormwater Management and Part 10 – Stormwater Management Technical Guidelines. The formation of a specific Flood Liable Land section may improve the ease of interpretation and application of flood related development controls, both for Council staff and development proponents.

An example of an appropriate DCP Section is shown below:

Example DCP – Flood Related Development Controls

The specific controls (listed below) have been formulated having regard to the following objectives:

a) To minimise risk to life and damage to property by controlling development on flood prone land;
b) To ensure that the impacts of the full range of flood sizes up to and including the PMF are considered when assessing development on flood prone areas;
c) To ensure that development does not have a significant impact on flood behaviour, people's safety, surrounding properties and structures, and the natural environment;
d) To ensure that the effects of climate change are considered when assessing development in flood prone areas, including increased ocean level boundary conditions;
e) To ensure that development on the floodplain is consistent with the NSW Flood Prone Land Policy (1984) and NSW Floodplain Development Manual (2005)
f) To ensure that developers and the community are conscious of the potential flood hazard and consequent risk associated with the use and development of land within the floodplain;
g) To protect the integrity of floodplains and floodways, including riparian vegetation, environmental processes and water quality;
h) To ensure that all land uses and essential services are appropriately sited and designed in recognition of all potential floods; and
i) To ensure that development on flood prone land does not place an unacceptable financial burden on landowners or the community.

Appropriate land use planning and development controls can reduce future flood risk and associated flood damages by ensuring that development is compatible with flood risk. Planning instruments can be used as tools to:

- Guide new development away from high flood risk locations;
- Prevent inappropriate development from occurring;
- Ensure that new development does not increase flood risk elsewhere; and
- Develop appropriate evacuation and disaster management plans to better reduce flood risks to the existing population.

The Botany DCP is currently under revision. It is recommended that flood planning controls are addressed consistently and are consolidated for clarity and ease of use.

☑	**PM01 Recommendation** • Update Bayside Council LEP to include Flood Liable Land policy as per Rockdale LEP 2011; and • Form DCP section specific to flood related development controls.

10.4.11. Option RM01: Revisions to Local Flood Plan

A number of additions are proposed for inclusion in the appropriate section in accordance with *SES Requirements from the FRM Process* (Reference 10). These are described below, and include notification of roads frequently inundated and Flood Emergency Response Planning classification of the floodplain.

10.4.11.1. Roads Inundated

A number of roads in the Springvale and Floodvale Drain Catchments are affected by flooding in a range of different event sizes. Even in a relatively small and frequent events roads can become overtopped and can be hazardous to motorists and pedestrians. Table 12 lists the roads affected and the approximate depth to which they may be inundated in each design event. It is recommended that this information be included in the relevant section of the Local Emergency Management Plan (LEMPLAN).

Table 12 Roads affected by Flooding

Road	Location	Flood Event Overtopped
Prince Edward Cir	Between Banks Ave and Birdwood Ave	20% AEP
Towner Gardens	Between Prince Edward Cir and Monash Gardens	20% AEP
Wark Ave	Between Prince Edward Cir and Monash Gardens	20% AEP
Monash Gardens	Between Wark Ave and White Rd	20% AEP
White Rd	Between Birdwood Ave and Monash Gardens	20% AEP
Keysor Rd	Between Wark Ave and Bunnerong Rd	20% AEP
Banks Ave	Between Park Pde and Heffron Rd	20% AEP
Heffron Rd	Between Banks Ave and Kenny Rd Between Page St and Banks Ave	20% AEP
Bay St	Between Wentworth Ave and Lang Ave	20% AEP

Road	Location	Flood Event Overtopped
Page St	Between Dalley Ave and Wentworth Ave	20% AEP
Dalley Ave	Between Page St and Holloway St	20% AEP
Holloway St	Between Dudley St and Page St	20% AEP
Gibson St	Between Dudley St and Page St	20% AEP
Baker St	Between Wentworth Ave and Anderson St	20% AEP
Spring St	Between Ocean St and Dudley St	20% AEP
Anderson St	Between Ocean St and Baker St	20% AEP
Coal Pier Rd	Between the Railway Line and Mcpherson St	20% AEP
McPherson St	Between Exell St and Nant St Between Nant St and the Railway Line	20% AEP
Nant St	Between the Railway Line and Mcpherson St	20% AEP
Botany Rd	Between Exell St and Foreshore Rd	20% AEP
Exell St	Between Greenfield St and Mcpherson St	10% AEP
Park Pde	Between Banks Ave and Maxwell Rd	5% AEP
Holloway St	Between Page St and Wentworth Ave	2% AEP

10.4.11.2. Flood Emergency Response Planning Classification of Communities

The Australian Emergency Management (AEM) Institute worked with NFRAG to update national best practice in flood risk management through the publication of *AEM Handbook 7* (Reference 12) and various supporting guidelines. This handbook provides guidelines to classify communities according to the impact that flooding has upon them. These classifications consider flood affected communities as those in which the normal functioning of services is altered, either directly or indirectly, because a flood results in the need for external assistance. This impact relates directly to the operational issues of evacuation, resupply and rescue. Communities are classified based on these guidelines using the Flow Chart in Diagram 2 (Reference 13).

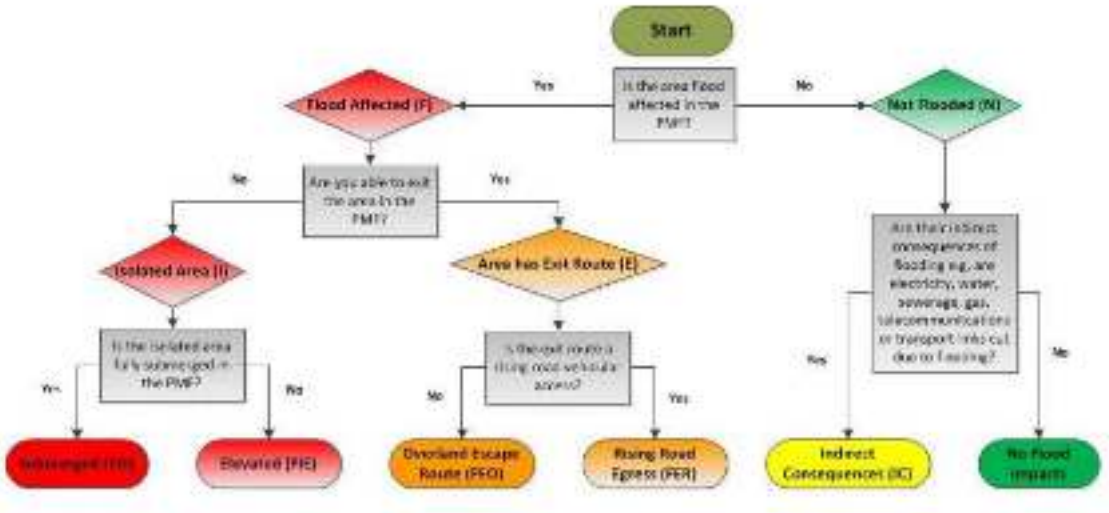

Diagram 2: Flow chart for determining flood emergency response classifications (Reference 3).

The classification can identify the type and scale of information needed to assist in emergency response planning. Section 10.4.11.3 provides a description of each of the Emergency Response Classification definitions.

Key considerations for flood emergency response planning in these areas include:

- Cutting of external access isolating an area;
- Key internal roads being cut;
- Transport infrastructure being shut down or unable to operate at maximum efficiency;
- Flooding of any key response infrastructure such as hospitals, evacuation centres, emergency services sites;
- Risk of flooding to key public utilities such as gas, power, sewerage; and
- The extent of the area flooded.

The flood emergency response classifications for the Springvale Drain and Floodvale Drain floodplain shown on Figure 24 are based on a preliminary assessment of the above considerations. The extensive existing development and evacuation route capacity constraints, make the emergency response constraints in the Bayside Council LGA more complicated than just the isolation and inundation of areas by flood water.

Figure 24 shows large areas of the industrial part of floodplain are isolated and become fully submerged in a PMF and are classified as Flooded Isolated Submerged. Residential areas in the north are generally classified as 'Indirect Consequences', as they are not inundated however access may be restricted by roads that are flood affected. The hotspots identified in Section 5.4 tend to be either Flooded Isolated Submerged or Flooded Isolated Elevated. These terms are defined in the following section.

10.4.11.3. Emergency Response Classifications Definitions

Flooded Isolated Elevated (FIE) (High Flood Island/High Trapped Perimeter) - The isolated area includes enough land higher than the limit of flooding (i.e. above the PMF) to cope with the number of people in the area. During a flood event the area is surrounded by floodwater and property may be inundated. However, there is an opportunity for people to retreat to higher ground above the PMF within the island and therefore the direct risk to life is limited.

Flooded Isolated Submerged (FIS) (Low Flood Island/Low Trapped Perimeter) - The isolated area is lower than the limit of flooding (i.e. below the PMF) or does not have enough land above the limit of flooding to cope with the number of people in the area. During a flood event the area is isolated by floodwater and property will be inundated.

Flooded Exit Route Overland Escape (FEO) - are those areas where access roads to flood free land cross lower lying flood prone land. Evacuation can take place by road only until access roads are closed by floodwater. Escape from rising floodwater is possible but by walking overland to higher ground.

Flooded Exit Rising Road (FER) - are those areas where access roads rising steadily uphill and away from the rising floodwaters. The community cannot be completely isolated before inundation reaches its maximum extent, even in the PMF. Evacuation can take place by vehicle or on foot along the road as floodwater advances. People should not be trapped unless they delay their evacuation from their homes. For example people living in two storey homes may initially decide to stay but reconsider after water surrounds them.

Indirect Consequences (ID) – are areas which are outside the limit of flooding and therefore will not be inundated nor will they lose road access. However, they may be indirectly affected as a results of flood damaged infrastructure or due to the loss of transport links, electricity supply, water supply, sewage or telecommunications services and they may therefore require resupply or in the worst case, evacuation.

☑	**RM01 Recommendation** Inclusion of the following data in the Local Emergency Management Plan: • Table of roads overtopped during flood events • Flood Emergency Response Planning Classifications of Communities

11. MULTI-CRITERIA MATRIX ASSESSMENT

11.1. Introduction

The Floodplain Development Manual (Reference 1) recommends the use of multi-criteria assessment matrices when assessing flood risk mitigation measures. A multi-criteria matrix assessment (MCMA) provides a method by which options can be assessed against a range of criteria, and offers a greater breadth of assessment than is available by considering only the reduction in flood risk or economic damages, for example. Such additional criteria may include social, political and environmental considerations and intangible flood impacts that cannot be quantified or included in a Cost-Benefit Analysis. It should be noted that the assessment of the suitability of floodplain mitigation options is a complex matter, and an MCMA will not give a definitive 'right' answer, but will provide a tool to debate the relative merits of each option.

11.2. Scoring System

A scoring system has been devised to assess the various options across a consistent basis to allow for direct comparison. The scoring system is divided into four key criteria: Flood Behaviour, Economic, Social and Environmental. Scores for each criterion are to be assigned to each option then summed to determine the overall score. Options with higher scores indicate benefits across a range of criteria and should be prioritised over those with lower positive scores, which may be more neutral or have a combination of pros and cons. Conversely, options with the lowest negative scores indicate the option would cause adverse outcomes in a number of criteria and should not be considered further. The scoring system is provided in Table 13, and outcomes of the assessment shown in Table 14. Discussion of the results is provided in Section 11.3.

Comparison of the economic benefits against the capital and ongoing costs			BC < 1	BC = 1 (Or NA)	BC > 1		
Potential design, implementation and operational challenges and constraints. Risk can increase with implementation timeframe	Major constraints and uncertainties which may render the option unfeasible	Constraints or uncertainties which may significantly increase costs or timeframes	Constraints or uncertainties which may increase costs or timeframes moderately	NA	Constraints that can be overcome with moderate investment of time and resources	Constraints that can be overcome easily	No const uncert
Ability to stage proposed works			Works cannot be staged	NA	Some minor components of the works may be staged	Some major components of the works may be staged	
Change in demand on emergency services (SES, Police, Ambulance, Fire, RFS etc).	Major disbenefit	Moderate Disbenefit	Minor Disbenefit	Neutral	Minor Benefit	Moderate Benefit	Major
Flood depths and duration changes for critical transport routes	Key access roads become flooded that were previously flood free	Significant increase in main road flooding	Moderate increase in local or main road flooding	No Change	Moderate decrease in local or main road flooding	Significant decrease in main road flooding	Local and previously floo fre
Disruption to critical facilities	Inoperational for several days	Inoperational for one day	Inoperational for several hours	No Change	Period of inoperation reduced by 0-4 hours	Period of inoperation reduced by > 4 hours	Prevents d critical facilit
No. of properties flooded over floor. Across all events	Broad Area adversely affected (> 20 properties)	Moderate Area adversely affected (10-20 properties)	Localised area adversely affected (<10 properties)	None	Localised area benefitted (<10 properties)	Moderate Area benefitted (10-20 properties)	Broad Area be prope
Change in hazard classification	Significantly increased in highly populated area (Increasing to H5/H6)	Moderately increased in populated area (Increasing by 2 or more categories)	Slightly increased (Increase by 1 category)	No Change	Slightly reduced (Decrease by 1 category)	Moderately reduced in populated area (Decrease by 2 or more categories)	Significantly highly popu (Decrease f
Change in community flood awareness, preparedness and response	Significantly reduced	Moderately reduced	Slightly reduced	No Change	Slightly improved	Moderately improved	Significantl
Closure of or restricted access to community facilities (including recreation)	Normal access significantly reduced or facilities disrupted for > 5 days	Normal access routes moderately reduced or facilities disrupted for 2-4 days	No Change to acess but facilities disrupted for up to 12 hours	No Change	Reduces duration of access disruption or facility disruption by up to 12 hours	Reduces duration of access disruptioin or facility disruption by 2-4 days	Prevents d access or faci
Level of agreement (expressed via formal submissions and informal discussions)	Strong opposition by numerous submissions	Moderate opposition in several submissions	Individual submissions with opposition	Neutral	Individual submissions with support	Moderate support in several submissions	Strong su numerous s
Impacts or benefits to flora/fauna	Likely broad-scale vegetation/habitat impacts	Likely isolated vegetation/habitat impacts	Removal of isolated trees, minor landscapng.	Neutral	Planting of isolated trees, minor landscapng.	Likely isolated vegetation/habitat benefits	Likely bro vegetation/ha
Impacts to heritage items	Likely impact on State, National or Aboriginal Heritage Item	Likely impact on local heritage item	Likely impact on contributory item within a heritage conservation area	No impact	Reduced impact on contributory item within a heritage conservation area	Reduced impact on local heritage item	Reduced imp National or Heritag
Disruption of PASS and/or Disruption of Contaminated Land	Hm: High probability, bottom sediments	L4: Low probability, > 3m below ground surface	Disturbed Terrain: No assessment of acid sulphate soil risk is possible	Works not within areas identified as PASS or contaminated land			
Capital and ongoing costs and funding sources available	Significant capital and ongoing costs, or no external funding or assistance available	Moderate capital and ongoing costs, no funding available	High capital and ongoing costs, partial funding available	NA	Moderate capital and ongoing costs, partial funding available; or low capital and ongoing costs, no funding available	Low to moderate capital and ongoing costs, partial funding available	Full external manageme
Level of compatibility	Conflicts directly with objectives of several plans, policies or projects	Conflicts with several objectives or direct conflict with one or few objectives	Minor conflicts with some objectives, with scope to overcome conflict	Not relevant	Minor support for one or few objectives	Some support for several objectives, or achieving one objective	Achieving o several plans proj

ties that, if flooded, would result in severe consequences to public health and safety. These may include fire, ambulance and police stations, hospitals, water and electricity supply, buses/train stations and chemical plants. Vul
with vulnerable occupants, such as nursing homes or schools.

ption	Economic Merits	Implementation Complexity	Staging of Works	Impact on Emergen Services	Emergency Access	Impact on critical an vulnerable facilities	Impact on Propertie	Impact on Flood Ha	Community Flood Awareness	Social Disruption	Community and Stakeholder Suppor	Impacts on Flora & Fauna (inc. street tr	Heritage Conservati Areas and Heritage Items4	Acid Sulfate Soils a Contaminated Land	Financial Feasibility Funding Availabilit
alley Avenue Drainage Upgrade	1	-1	2	1	1	0	1	0	3	-1	-1	0	0	0	-1
ay Street Drainage Upgrade	1	-1	2	3	3	0	1	2	2	1	-1	-1	0	0	2
olloway Street Drainage Upgrade	0	-1	2	0	2	0	1	2	3	1	3	0	0	-2	-1
anks Avenue Drainage Upgrade	1	-1	2	3	2	2	3	2	3	2	-2	-1	0	0	-3
owner Gardens Drainage pgrade	1	3	2	2	1	1	2	1	2	2	2	-2	0	0	2
ark Parade Drainage Upgrade	-1	-1	2	1	2	1	3	1	3	-2	-1	-1	0	0	-3
uplication of pipe under Botany oad	0	-3	2	2	1	1	1	1	2	1	3	0	3	-1	1
ngoing Channel Maintenance orks	1	-2	2	3	1	1	0	1	2	1	3	3	3	-3	3
ebris removal and maintenance Floodvale Drain/ SWSOOS No. Culvert	0	-1	2	1	1	2	1	1	1	0	2	0	3	-2	0
ocal Drainage Improvements – otany Road	0	2	2	2	1	3	0	1	2	1	3	0	0	-1	2
eview of Planning Policies	1	2	2	2	1	1	1	1	3	0	3	0	0	0	3
evisions to Local Flood Plan	1	3	2	3	1	1	0	0	3	0	1	0	0	0	3

11.3. Discussion of Results

The multi-criteria matrix assessment results, presented in Table 14, can be used to not only understand the benefits and disadvantages of individual options, but to also see trends across the full suite of options assessed in the FRMS&P. The following are noted:

- Cost Benefit Ratios (BCRs) were estimated as either greater than 1 (indicating the option has economic merits), less than 1 (indicating the option is not economically feasible), or equivalent to 1 (indicating the costs are approximately equivalent to the benefits). The BCRs were based on a comparison of capital costs and reduction in property damages, estimated from flood impact results for each option. Further investigation would be required to refine cost estimates, which at this stage include a 20% contingency to cover uncertainties in rates, quality of excavated material and an allowance for ongoing maintenance;
- Response Modification Measures and Property Modification Measures tend to score more highly than Flood Modification Measures, as they can be implemented for a relatively low cost, and over time can reduce property damage and improvement in community resilience in the long term while not incurring negative environmental impacts;
- The Towner Gardens Drainage Upgrade (NE02) received the highest score out of the flood modification options, as it reduces flood risk to a number of properties and roadways for relatively limited capital works. Whilst the community consultation outcomes indicated support for pipe upgrade options in urban areas, the option (in its current form) involves excavating vegetated land within the adjacent golf course, which may not be deemed acceptable by stakeholders in the golf club. Further optimisation of this design is likely to be required to progress this option.
- The Dalley Avenue Drainage Upgrade (NW01) received the lowest score as it involves large excavation, due to the proposed retention basin, for very little benefit in terms of flood risk reduction; and
- Options NW01, NE01, and NE03 propose the usage of a sports field/park as a retention basin and may attract opposition from stakeholders (local users, residents, sports clubs) as amenity is sacrificed for flood mitigation. These options received negative scores for ‘Community and Stakeholder Support’ as a result.

12. FLOODPLAIN RISK MANAGEMENT PLAN

This Plan summarises the recommended works investigated by the Springvale Drain and Floodvale Drain Floodplain Risk Management Study. The Study made an assessment of flood risk across the Study Area, and follows on from the Springvale Drain and Floodvale Drain Flood Study (Reference 2).

The Floodplain Development Manual (Reference 1) notes that 'An implementation program is to be included in the management plan. This is to be prioritised based upon how soon the management measures can be implemented, what constraints exist, and how effective the measures are. Measures with little cost that can readily be implemented and which are effective in reducing damage or personal danger should have high priority.

lists the mitigation measures assessed by the Springvale Drain and Floodvale Drain Floodplain Risk Management Study that have been recommended for implementation. The table describes the purpose of the measure, as well as its priority and the party responsible for its implementation. Detailed description of each recommendation is provided in Section 10 of the Study, which also contains measures that were assessed but were not viable for recommendation.

Table 15 Floodplain Risk Management Plan

Reference	Option	Description	Benefits	Concerns	Responsibility	Priority
FLOOD MODIFICATION MEASURES						
NE01	Banks Avenue Drainage Upgrade	Upgraded stormwater drainage system to allow the discharge of water from Banks Avenue into a lowered section of Bonnie Doon Golf Course.	Ease drainage from Banks Avenue, resulting in reductions in surrounding residential areas and some properties being no longer flooded. Relative limited construction required.	Consultation required with the golf club stakeholders.	Responsibility to be agreed on, as the drain would be on both Council and privately owned land.	High
FM03	Vegetation management (open channel sections)	Removal of vegetation and debris to increase the hydraulic conveyance of open channel reaches.	Reduce flood levels north of McPherson St and adjacent to both Floodvale and Springvale Drain.	Localised increase in flood levels at the intersection with the SWSOOS No. 2 upstream of the underground section of the drain.	Council would be responsible for engaging excavation and landscaping subcontractors and ongoing maintenance.	High
FM10	Local Drainage Improvements – Botany Road	Construction of a new stormwater drainage pipeline and inlet pits to drain the Botany Rd/ Excell St and Coal Pier Rd/ McPherson St intersections.	Reduce nuisance flooding impediments to traffic during frequent rainfall events (i.e. storm intensities occurring multiple times per year).	Impacts of these local drainage modifications were not modelled, since majority of benefits are likely to be observed for events more frequent than those considered in this study.	Council would be responsible for construction and maintenance.	High
NW02	Bay Street Drainage Upgrade	Installation of two new pits on Bay Street (approximately mid-way between Wentworth Ave and Lang St), and installation of a pipe to convey water northwards and into the swamp within The Lakes Golf Course.	Reduce time and depth of inundation on Bay Street and the surrounding residential properties, with some properties no longer flooded in the 20% AEP.	Impact of excavation works on Bay Street. Liaison with The Lakes Golf Club would be required . Minimal rise in water level in the northern golf course pond.	Responsibility to be agreed on, as the works would be on both Council and privately owned land.	Medium
NE02	Towner Gardens Drainage Upgrade	Installation of a new pipe is proposed to be installed from Prince Edward Circuit, across Banks Avenue and into an excavated channel in Bonnie Doon Golf Course.	Reduce flood affectation in the streets and properties around Towner Gardens and Prince Edward Circuit	Significant road works through Banks Avenue. Consultation required with the golf club stakeholders.	Responsibility to be agreed on, as the pipe would be on both Council and privately owned land.	Medium
FM02	Duplication of pipe under Botany Road	To increase capacity of culvert that runs beneath Botany Rd, Botany Golf Course and Foreshore Rd.	Reduce water levels on private property directly east of Floodvale Drain. Consider a localised pipe upgrade in conjunction with lowering Botany Rd, allowing further downstream upgrades in the future.	Offsite waste disposal as general waste is required, especially given the possibility of contamination. Difficult excavation and installation of pipes.	Council would be responsible for construction and maintenance.	Medium
NW01	Dalley Avenue Drainage Upgrade	Increase drainage capacity beneath Dalley Avenue and excavate the playing field within Pagewood Public School to provide flood storage.	Localised reductions in peak flood levels in frequent events, which will alleviate over-flood inundation to ~ 6 dwellings in the vicinity in the 20% AEP event.	Development of a basin within a primary school will require significant consideration of public safety, particularly to prevent children playing in the ponded water.	Council would be responsible for construction and maintenance.	Low
NE03	Park Parade Drainage Upgrade	Option Jellicoe Oval is newly inundated, as its ground level is lowered and receives inflow from two pipes on Park Parade.	Improves flood affectation on residential properties between Heffron Road and Park Parade, especially at the Banks Avenue Intersection. Reduces demand on downstream drainage system, with benefits on Wentworth Ave and Page St (Pagewood Public School).	Community opposition to lowering Jellicoe Park. Creating a basin in a publicly accessible area also increases the flood hazard classification.	Council would be responsible for construction and maintenance.	Low
FM08	Debris removal and maintenance at Floodvale Drain/ SWSOOS No. 2 Culvert	Clear out existing inverted siphone culvert to increase hydraulic conveyance.	Improve conveyance through Floodvale drain at the SWSOOS No. 2 crossing and reduce upstream flood levels.	Extensive and costly works involved to remove invert syphon and temporarily divert sewerage system.	Council would be responsible for construction in consultation with Sydney Water. Upon discussion, Sydney Water may provide ongoing operational assistance.	Low
PROPERTY MODIFICATION MEASURES						
PM01	Planning Policy Review	Update Bayside Council LEP to include Flood Liable Land policy as per Rockdale LEP 2011 and form DCP section specific to flood related development controls.	Ease of interpretation and application of flood related development controls, both for Council staff and development proponents.	None	Council - and to be clearly communicated to residents as required.	High
RESPONSE MODIFICATION MEASURES						
RM03	Revisions to Local Flood Plan	Inclusion of the following data in the Local Emergency Management Plan: • Table of roads overtopped during flood events • Flood Emergency Response Planning Classifications of Communities	Improved SES intelligence and information available within the Springvale and Floodvale Drain catchments.	Minimal ongoing maintenance of depth markers and flood posts required	SES and Council in cooperation	High

13. REFERENCES

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Technical flood risk management guideline: Flood Emergency response classification of the floodplain
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15. **NSW Government Office of Environment & Heritage**
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Figures


Heffron Rd
Bay St
Wentworth Ave
Begonia St
Banksia St
Holloway St
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Baker St
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Stephen Rd
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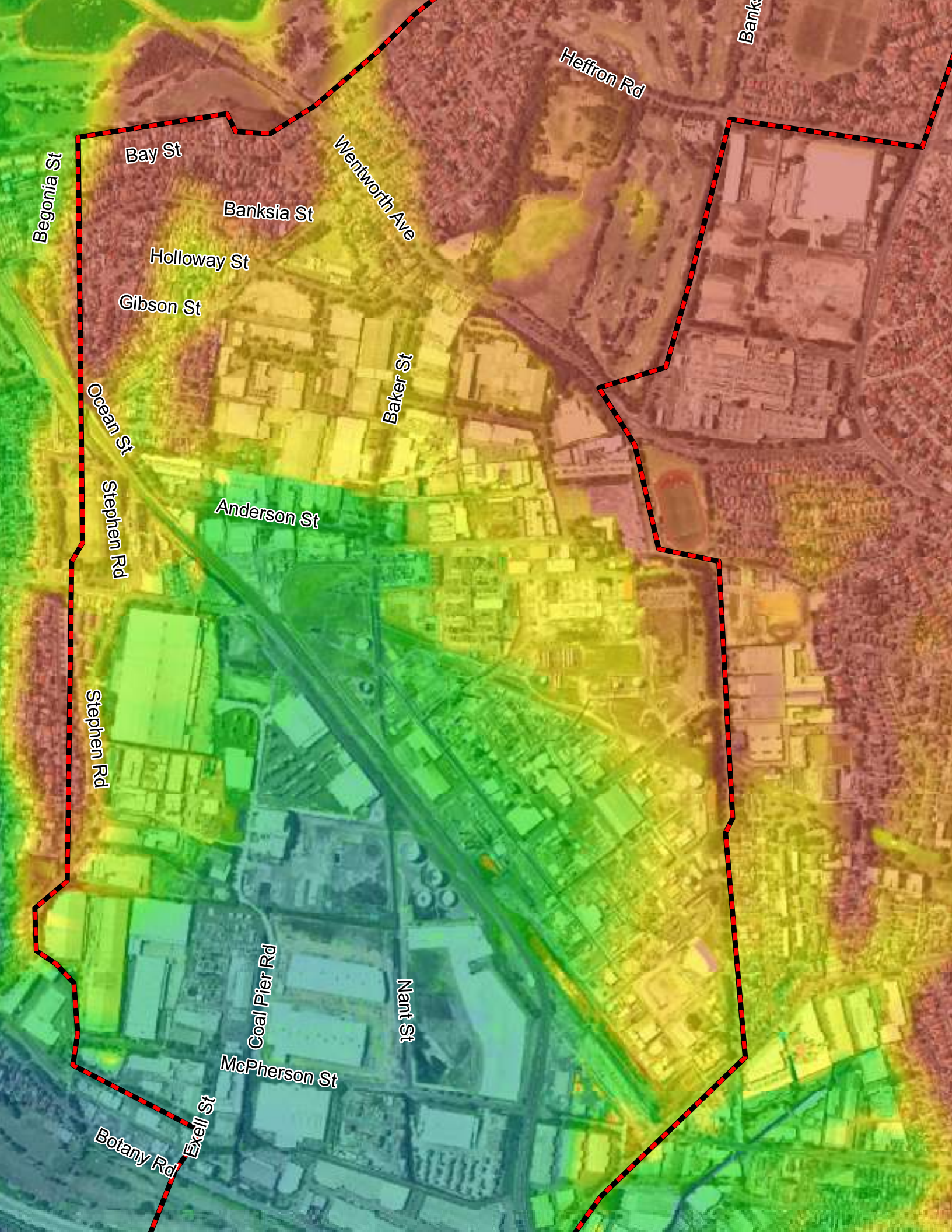
Exell St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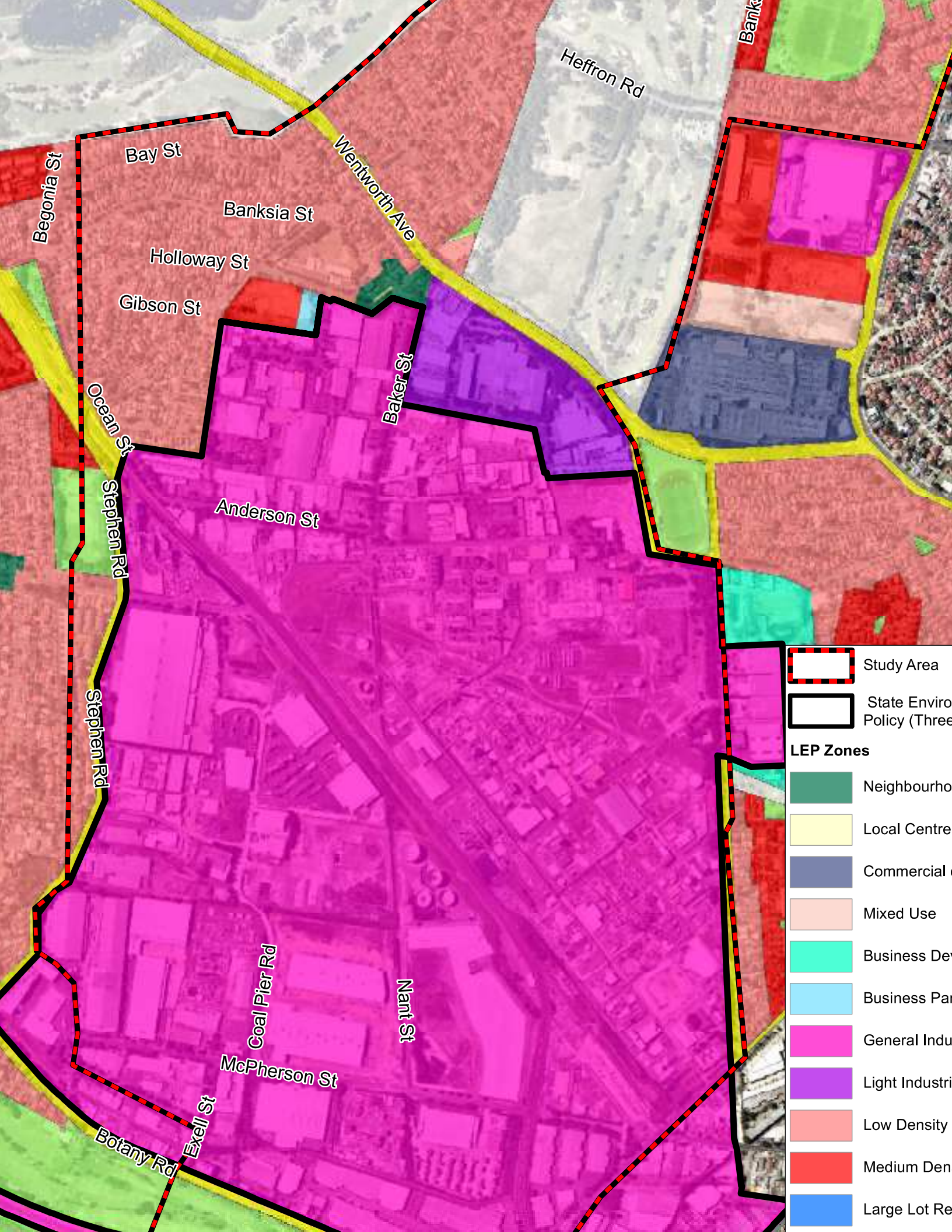
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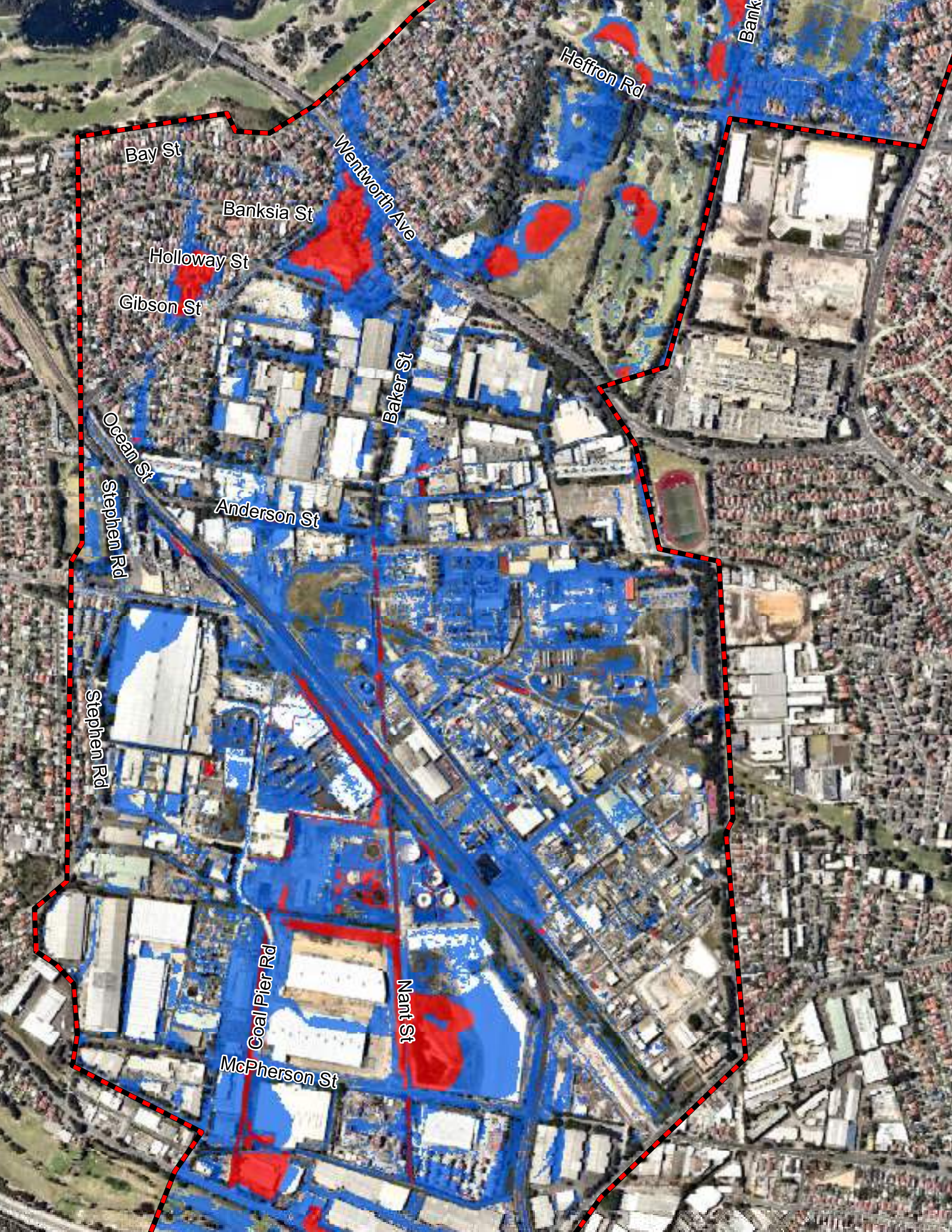
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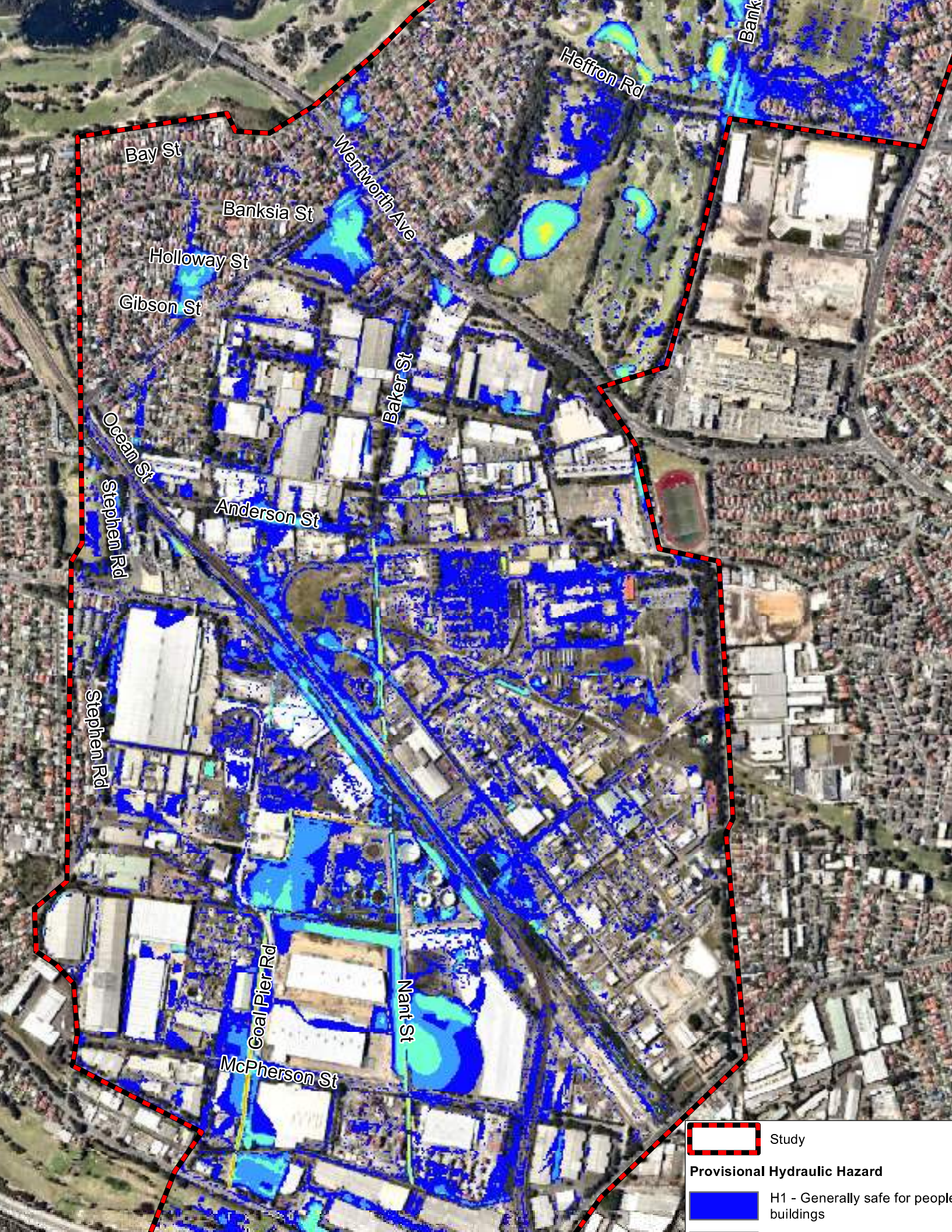
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H1 - Generally safe for people
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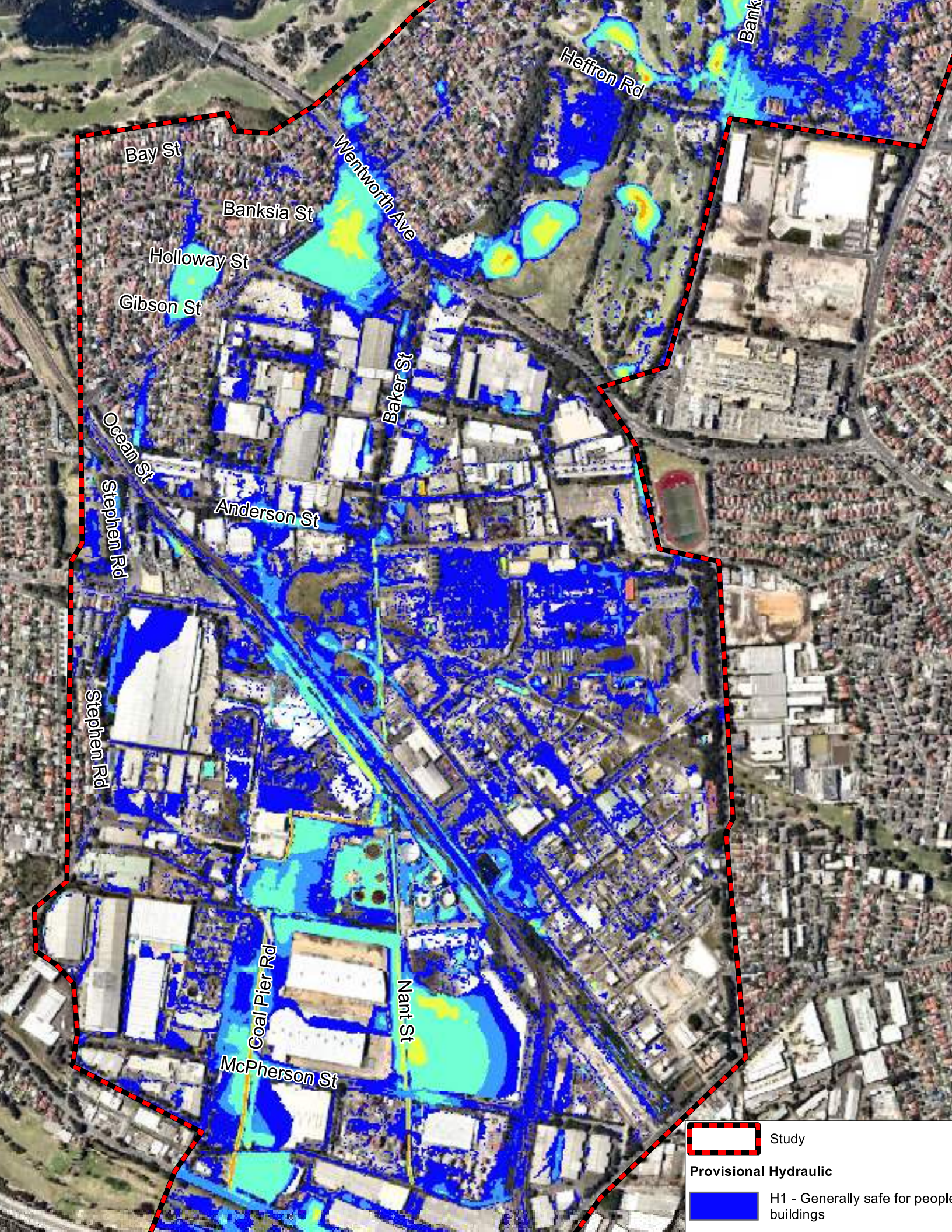
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H1 - Generally safe for people
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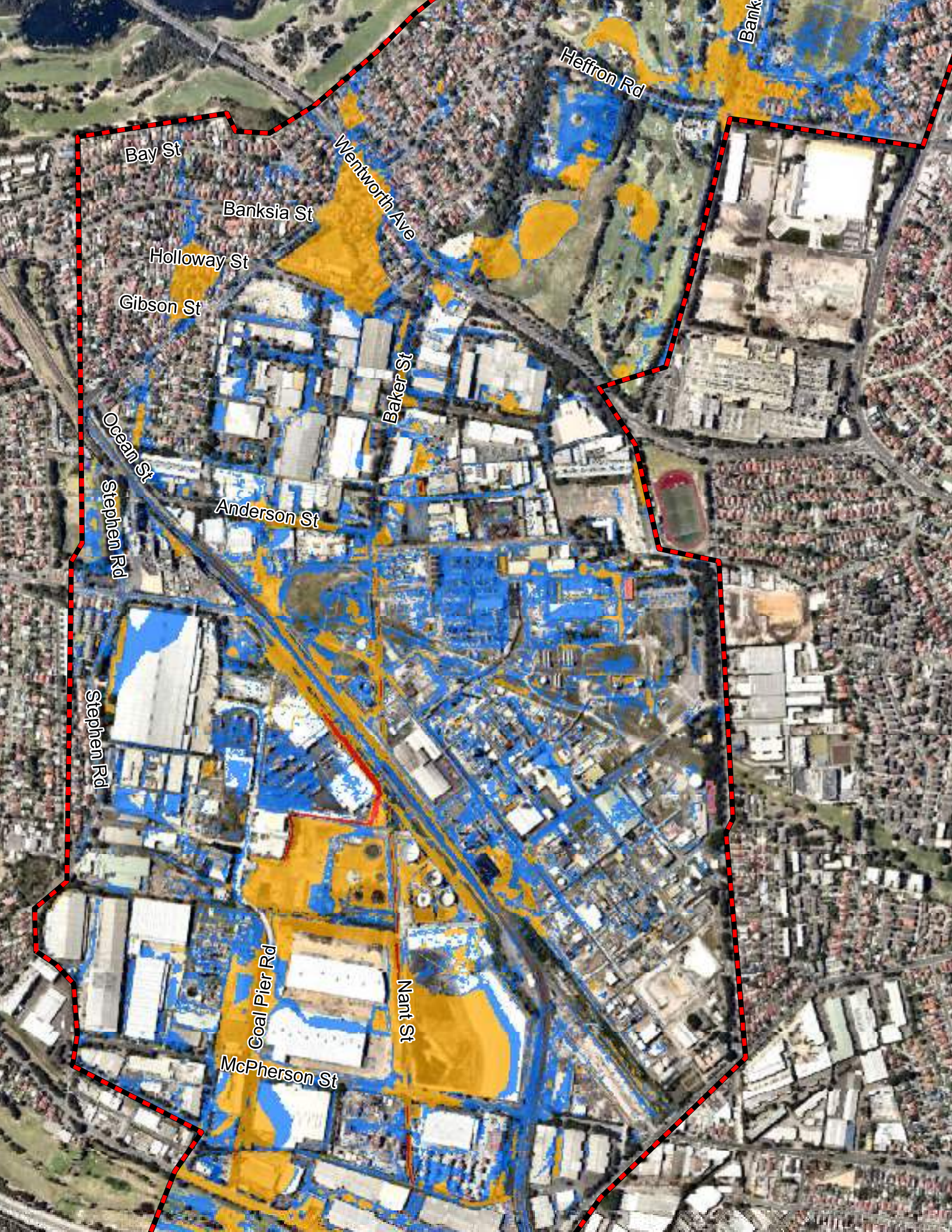
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Floodwaters
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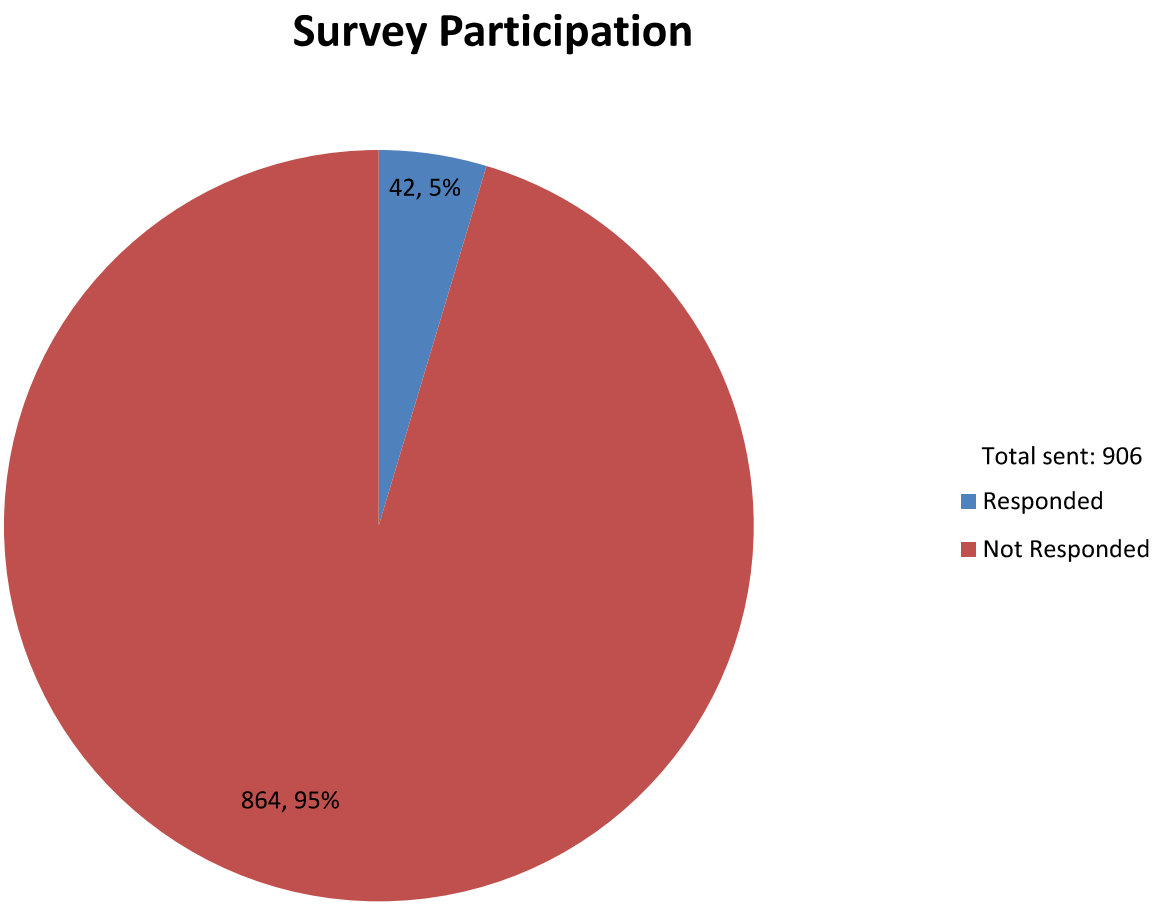
FIGURE 8A
SPRINGVALE AND FLOODVALE DRAINS
SURVEY SUMMARY



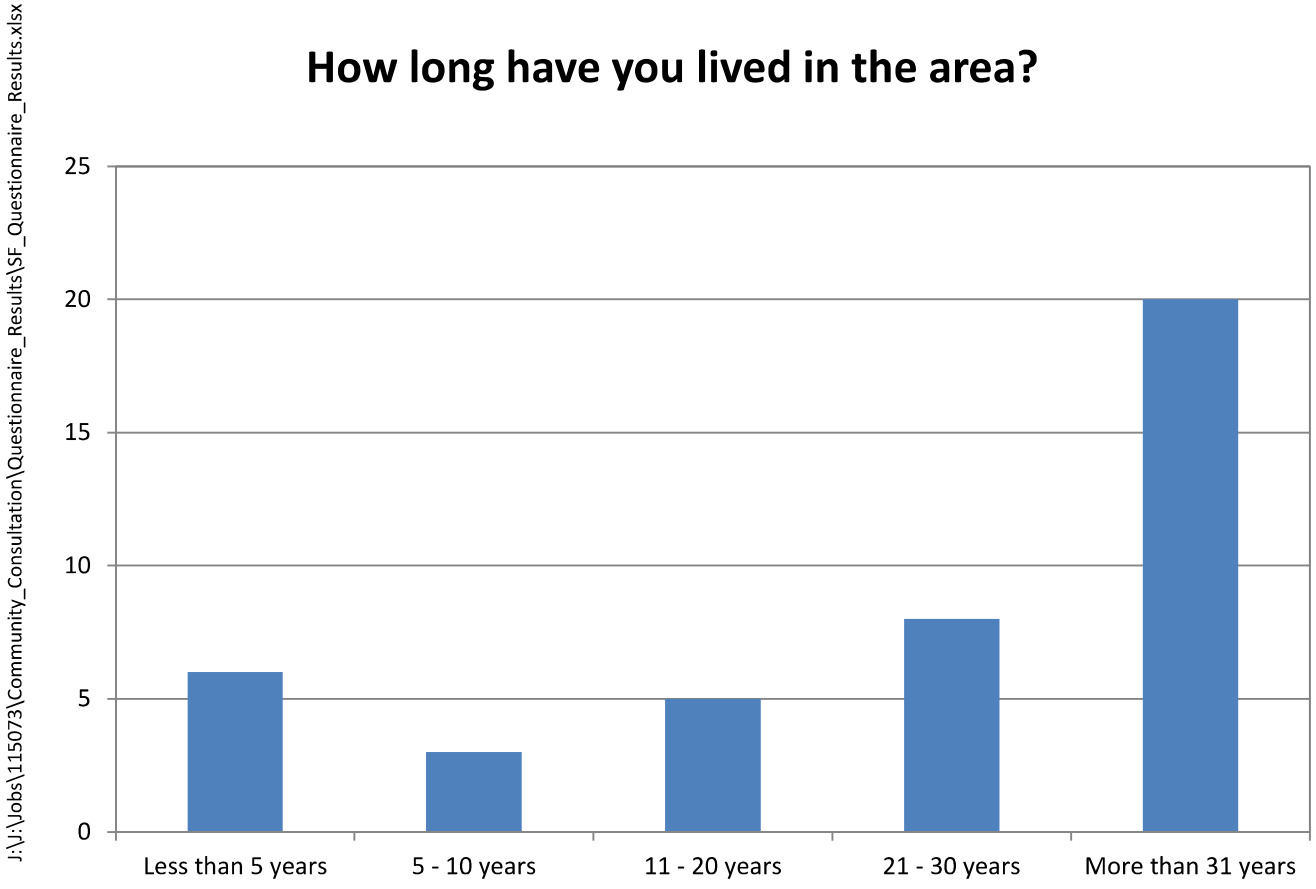


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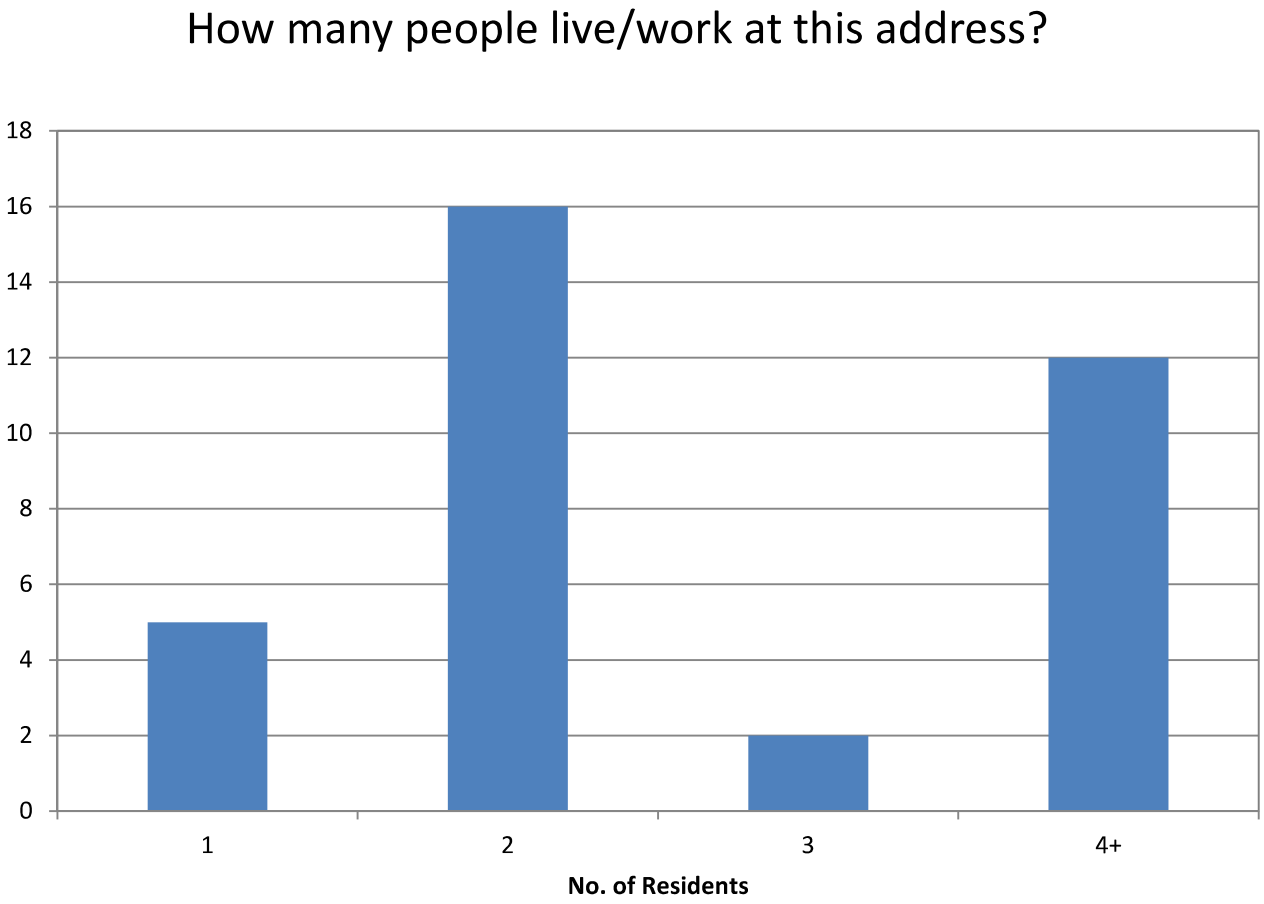
FIGURE 8B
SPRINGVALE AND FLOODVALE DRAINS
SURVEY SUMMARY



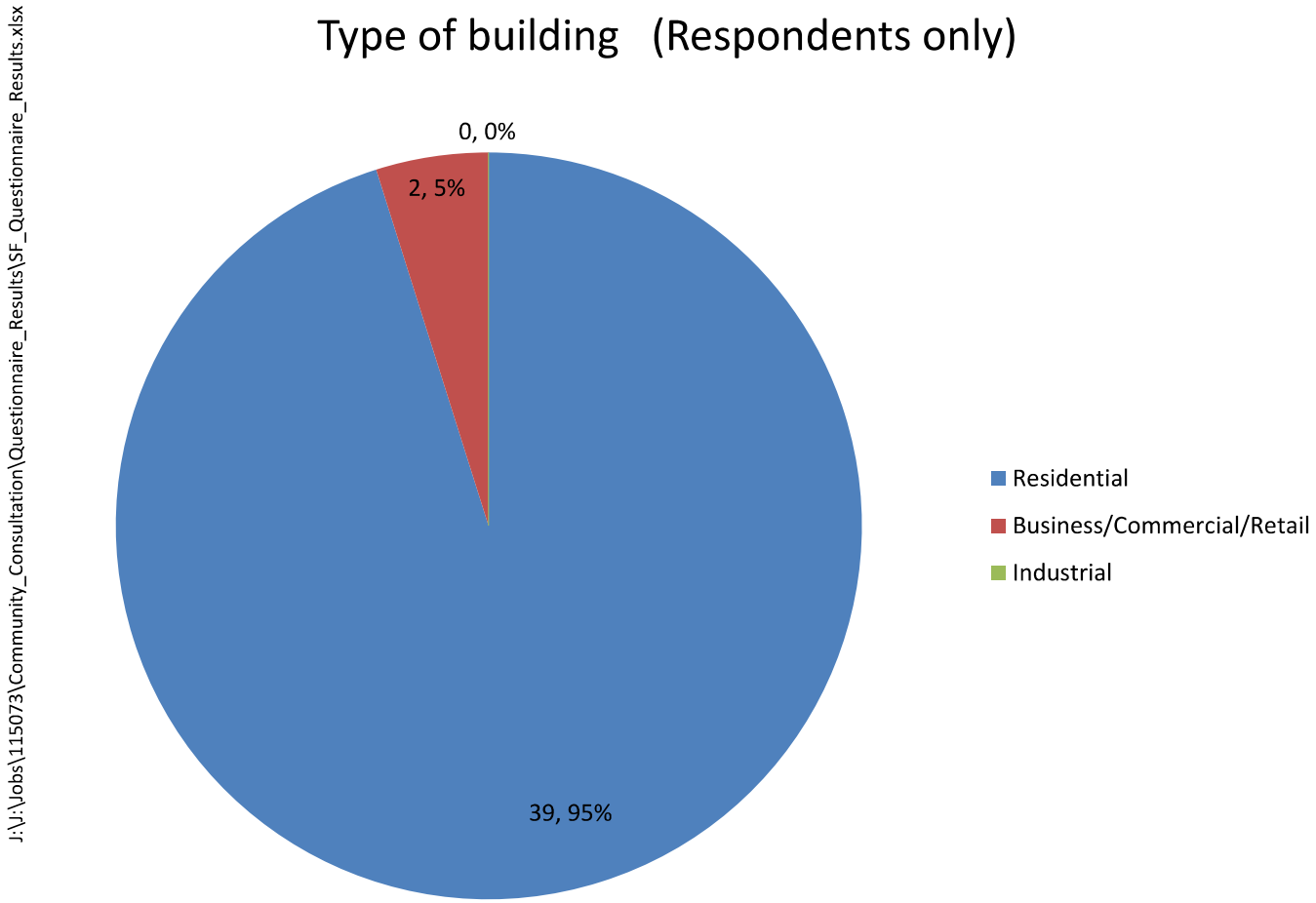


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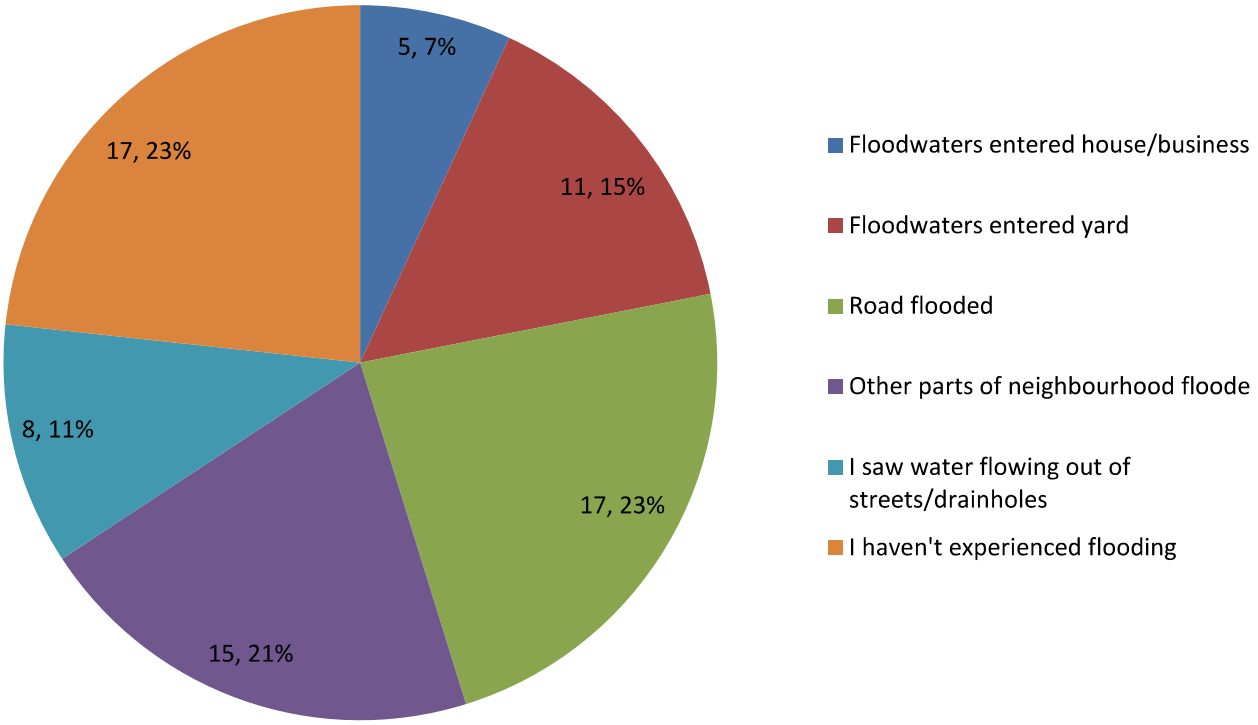
FIGURE 8C
SPRINGVALE AND FLOODVALE DRAINS
SURVEY SUMMARY

1. Have you ever experienced flooding since living/working in the area?



2. How did the flooding affect your home/business?

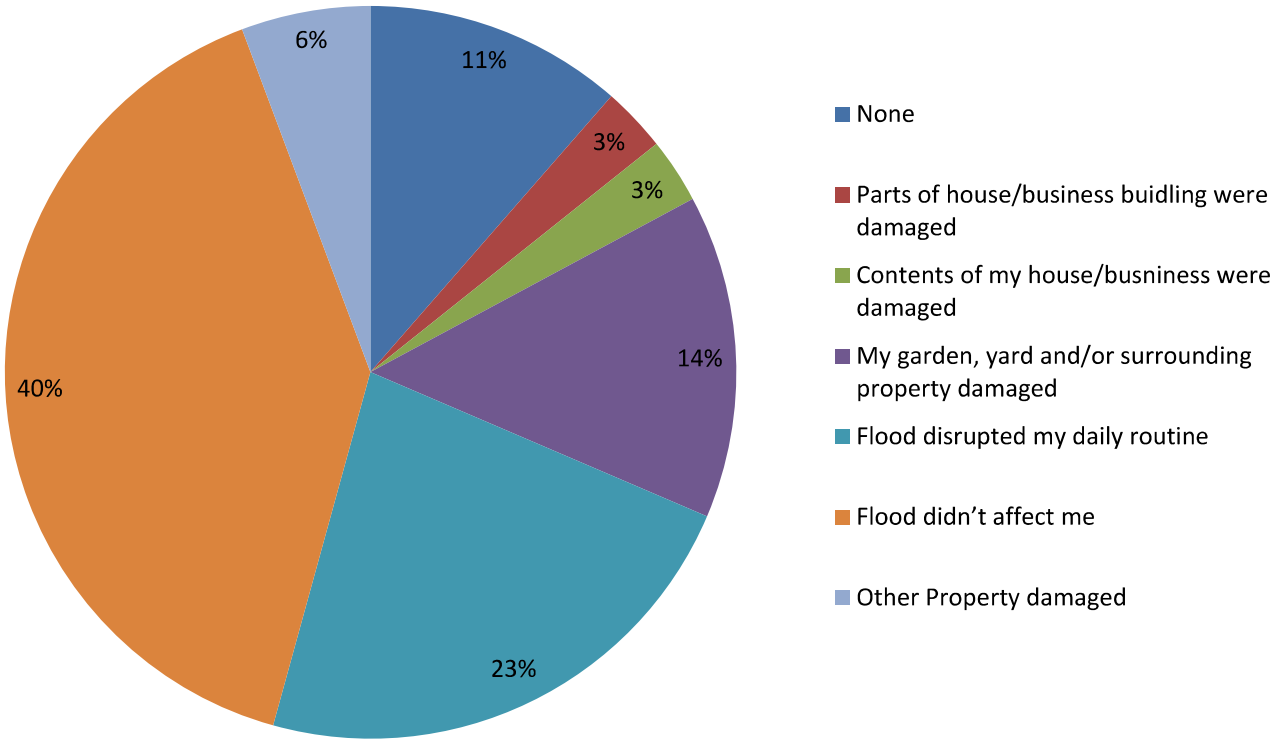


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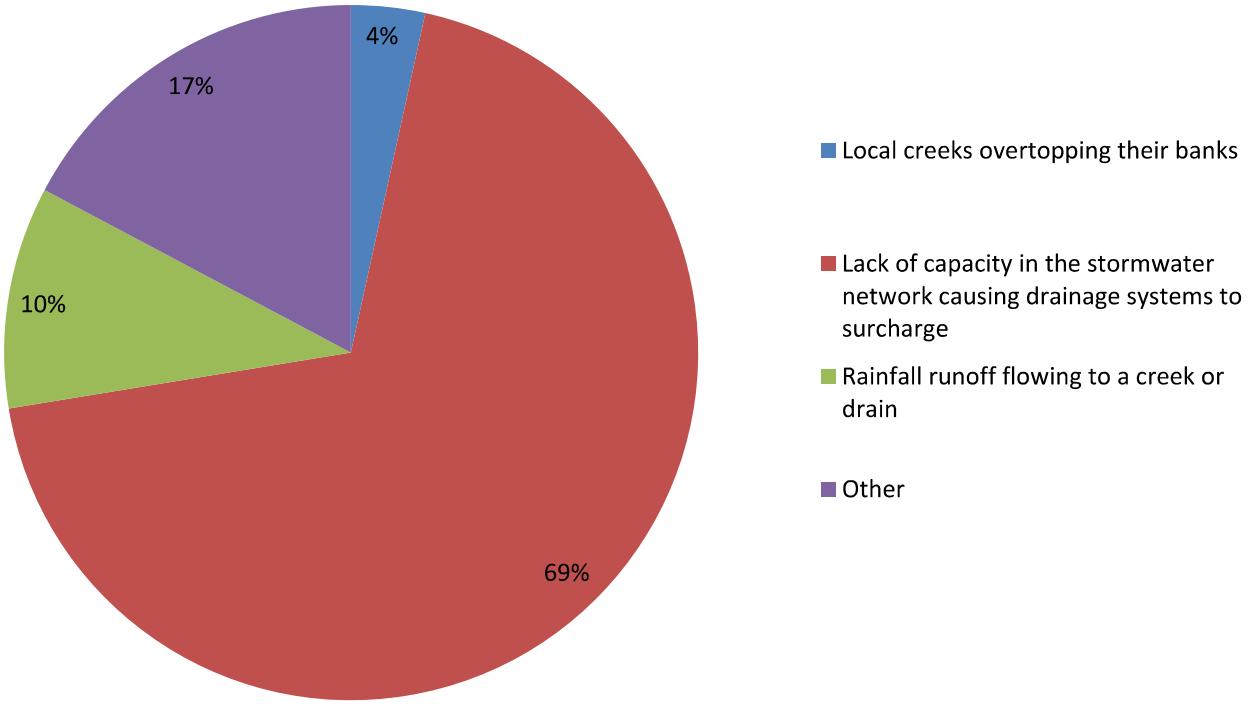
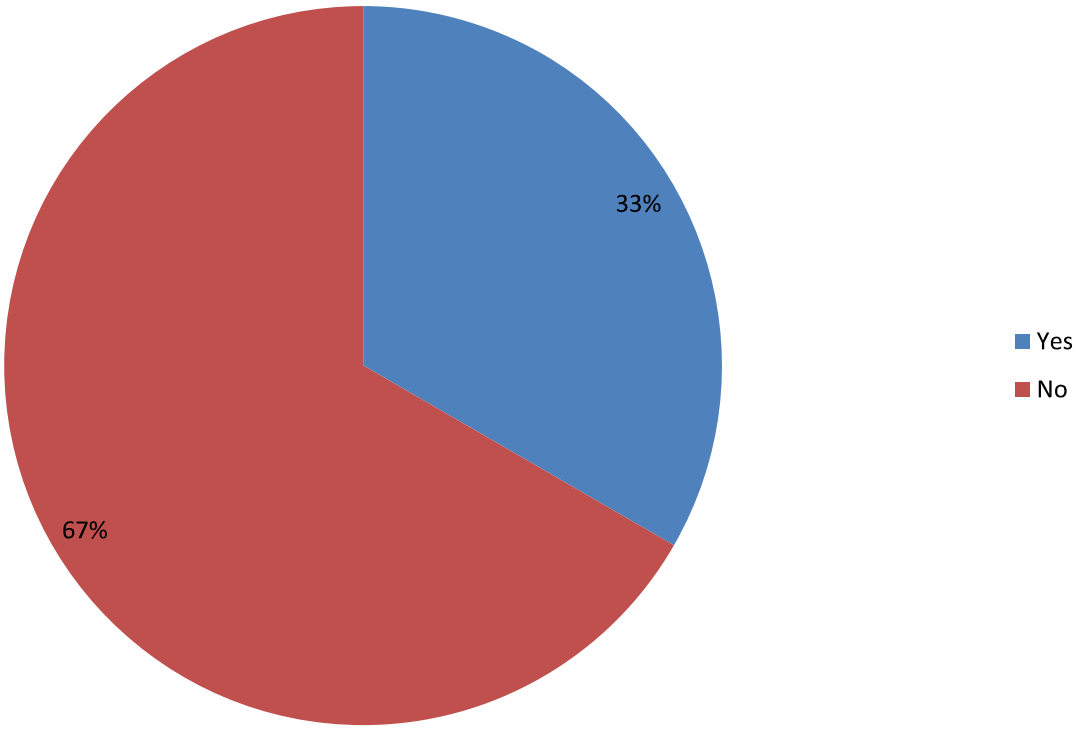
FIGURE 8D
SPRINGVALE AND FLOODVALE DRAINS
SURVEY SUMMARY

4. What do you believe to be the main cause of flooding in your area



5. Are you concerned about climate change and how this might impact flooding in your area?



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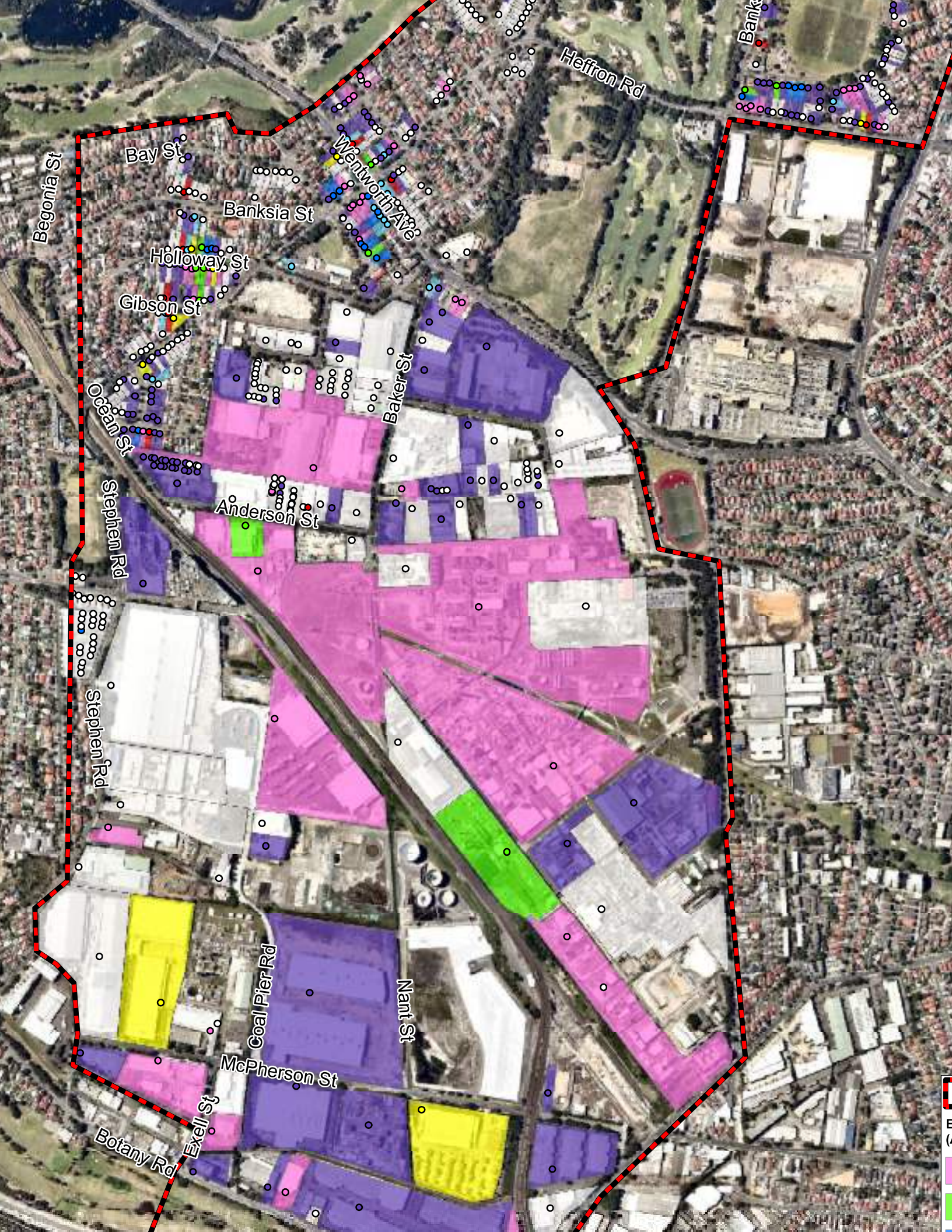
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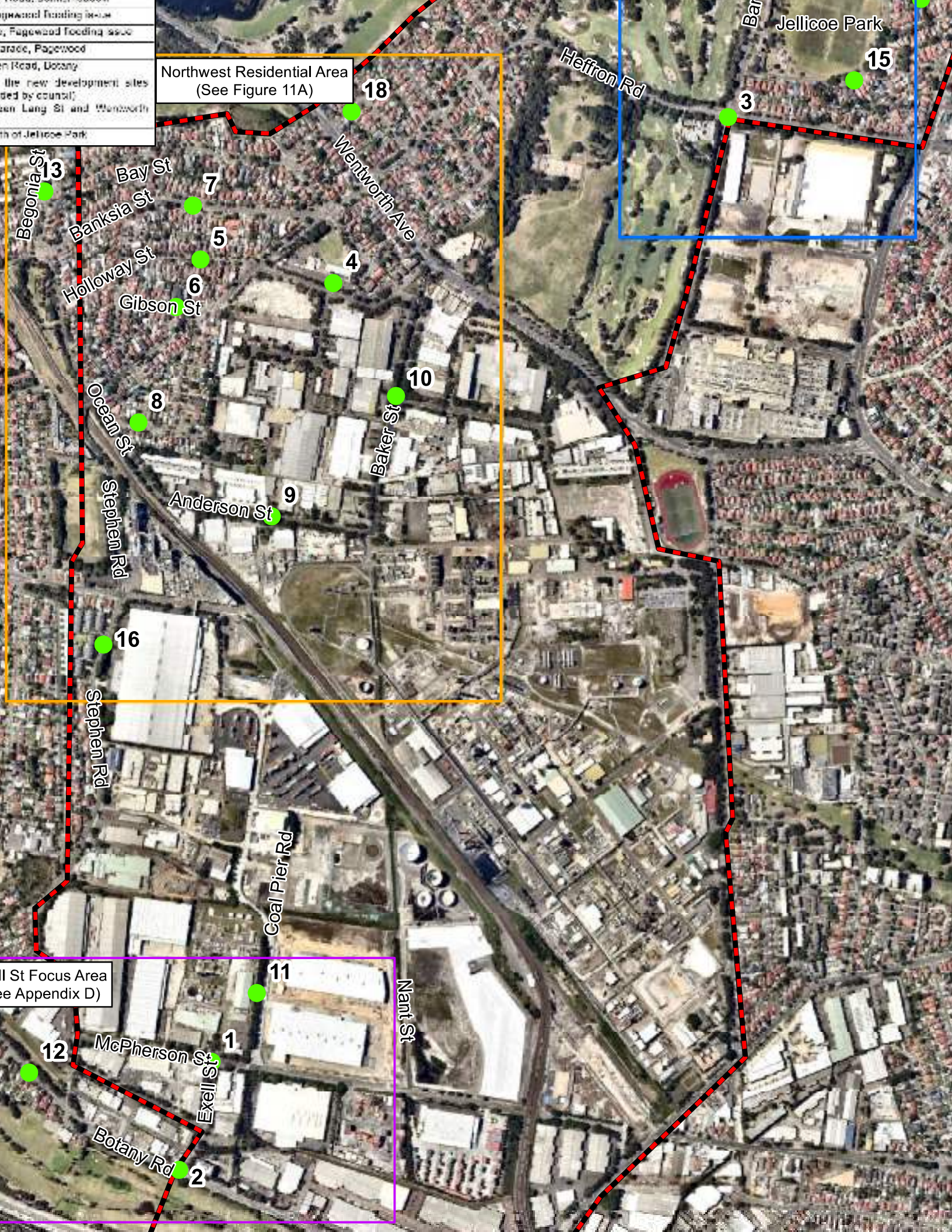
Northwest Residential Area
(See Figure 11A)
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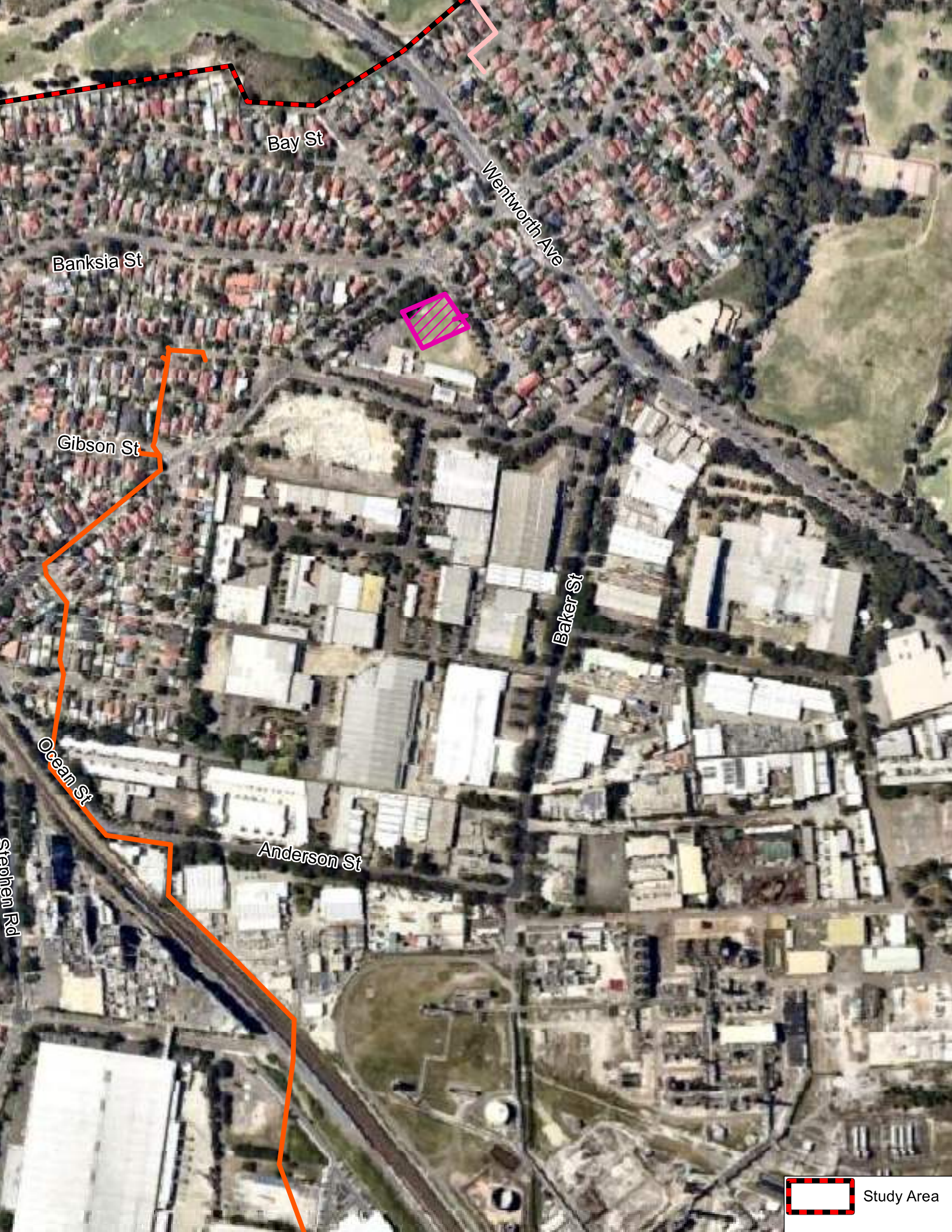
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Study Area


Banks Ave
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Study Area
Option NE03


Wentworth Ave
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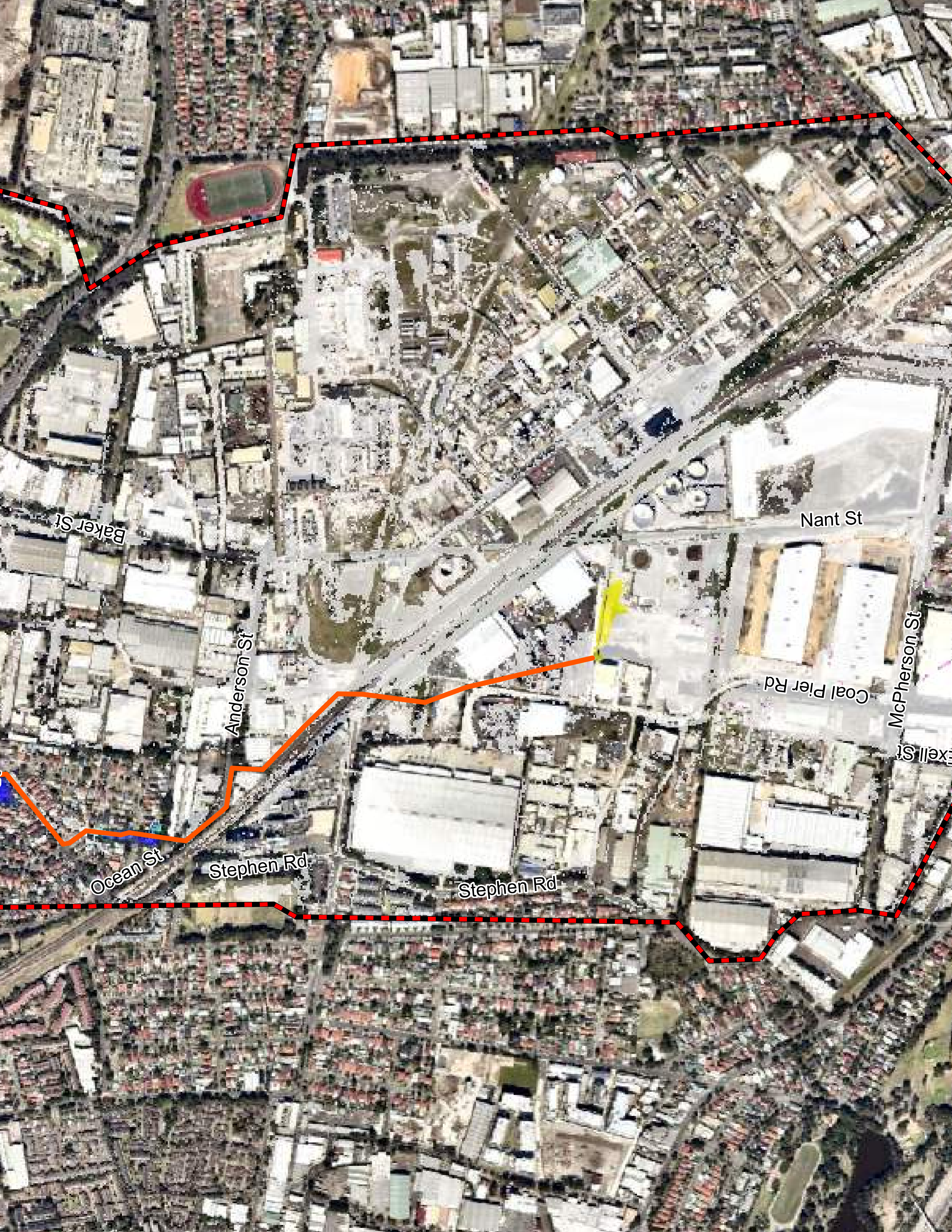

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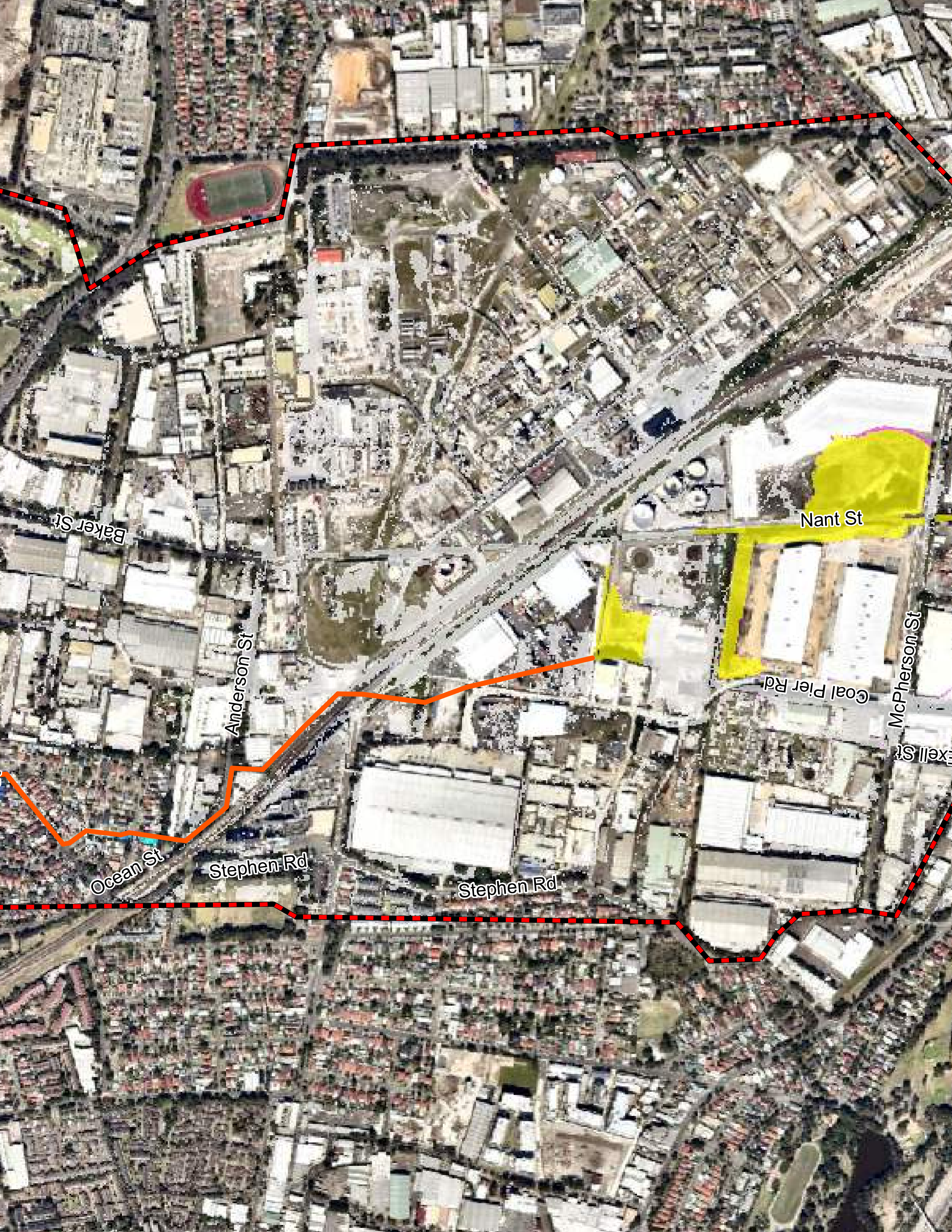

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Banks Ave
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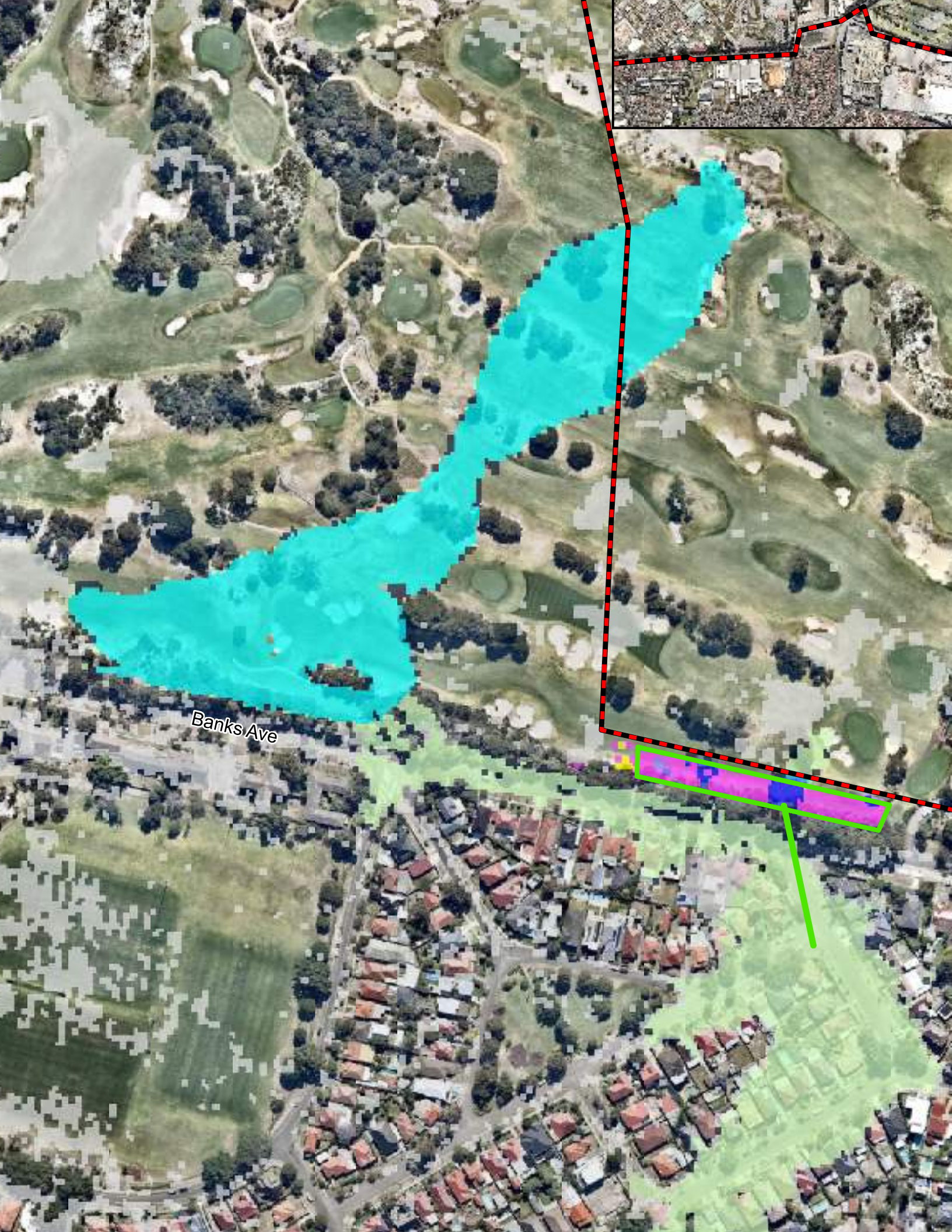
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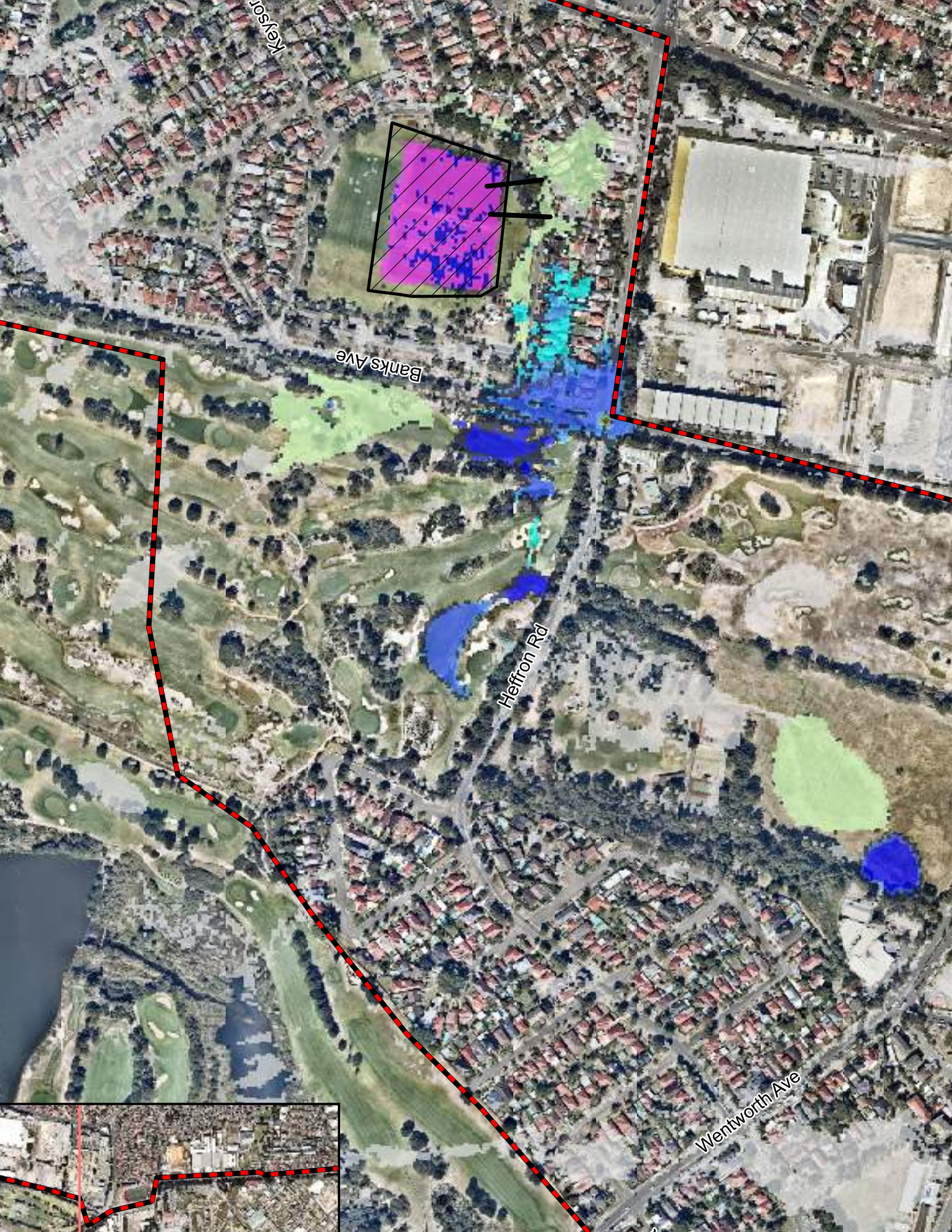
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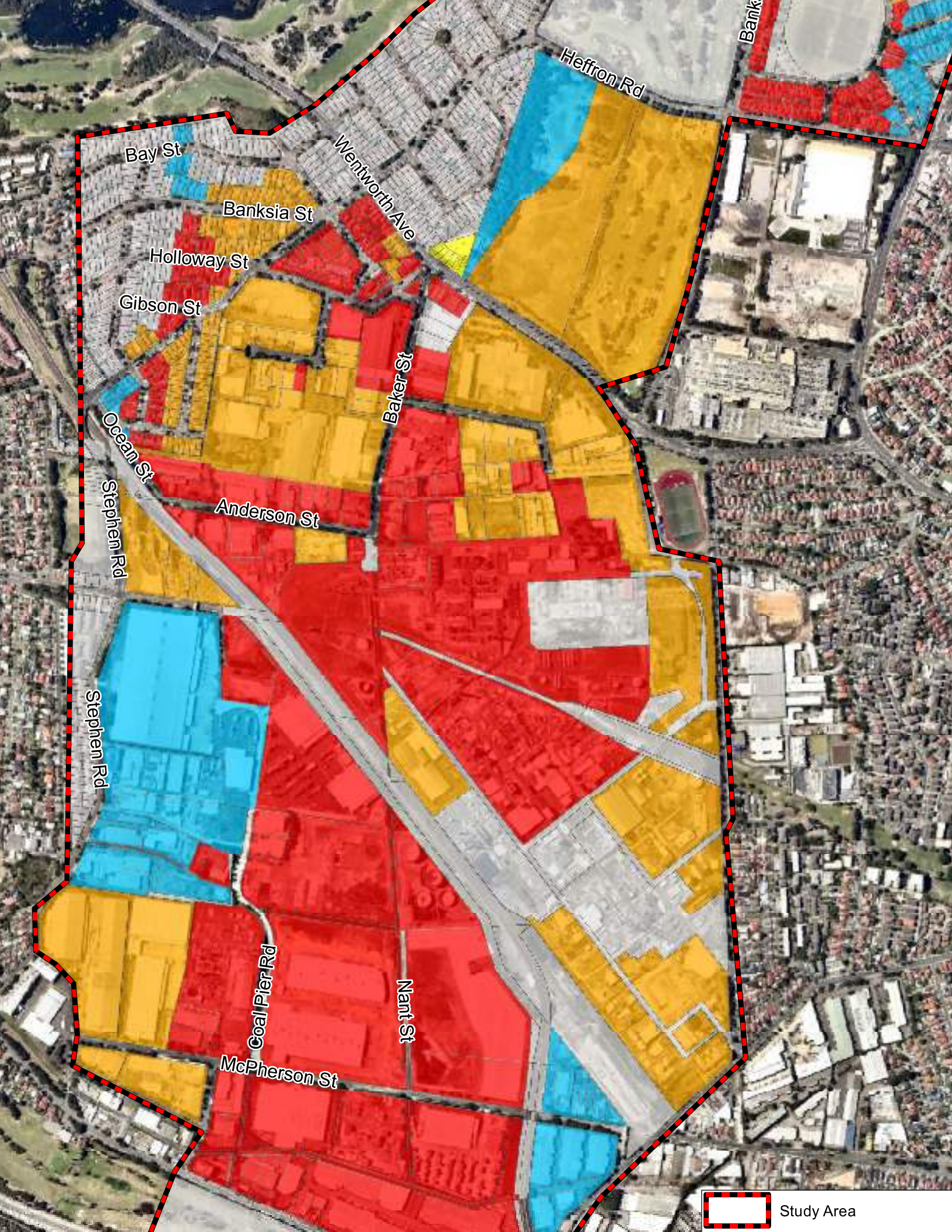
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McPherson St
Study Area

Appendix A

GLOSSARY

Taken from the Floodplain Development Manual (April 2005 edition)

acid sulfate soils	Are sediments which contain sulfidic mineral pyrite which may become extremely acid following disturbance or drainage as sulfur compounds react when exposed to oxygen to form sulfuric acid. More detailed explanation and definition can be found in the NSW Government Acid Sulfate Soil Manual published by Acid Sulfate Soil Management Advisory Committee.
Annual Exceedance Probability (AEP)	The chance of a flood of a given or larger size occurring in any one year, usually expressed as a percentage. For example, if a peak flood discharge of 500 m^3/s has an AEP of 5%, it means that there is a 5% chance (that is one-in-20 chance) of a 500 m^3/s or larger event occurring in any one year (see ARI).
Australian Height Datum (AHD)	A common national surface level datum approximately corresponding to mean sea level.
Average Annual Damage (AAD)	Depending on its size (or severity), each flood will cause a different amount of flood damage to a flood prone area. AAD is the average damage per year that would occur in a nominated development situation from flooding over a very long period of time.
Average Recurrence Interval (ARI)	The long term average number of years between the occurrence of a flood as big as, or larger than, the selected event. For example, floods with a discharge as great as, or greater than, the 20 year ARI flood event will occur on average once every 20 years. ARI is another way of expressing the likelihood of occurrence of a flood event.
caravan and moveable home parks	Caravans and moveable dwellings are being increasingly used for long-term and permanent accommodation purposes. Standards relating to their siting, design, construction and management can be found in the Regulations under the LG Act.
catchment	The land area draining through the main stream, as well as tributary streams, to a particular site. It always relates to an area above a specific location.
consent authority	The Council, government agency or person having the function to determine a development application for land use under the EP&A Act. The consent authority is most often the Council, however legislation or an EPI may specify a Minister or public authority (other than a Council), or the Director General of DIPNR, as having the function to determine an application.
development	Is defined in Part 4 of the Environmental Planning and Assessment Act (EP&A Act). **infill development:** refers to the development of vacant blocks of land that are generally surrounded by developed properties and is permissible under the current zoning of the land. Conditions such as minimum floor levels may be imposed on infill development. **new development:** refers to development of a completely different nature to that associated with the former land use. For example, the urban subdivision of an area previously used for rural purposes. New developments involve rezoning and