



Rhodes East Priority Investigation Area

RobertsDay / Department of Planning & Environment

Hydrology and Flooding Report

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Document history and status

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Important note about this report

The sole purpose of this report and the associated services performed by Jacobs is to document the flood assessment undertaken for the Rhodes East Investigation Area in accordance with the scope of services set out in the contract between Jacobs and the Client. That scope of services, as described in this report, was developed with the Client.

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1. Introduction

1.1 Background

The Department of Planning & Environment (DP&E) is working with City of Canada Bay Council to prepare a rezoning proposal for the Rhodes East Investigation Area. The investigation area comprises 36 hectares of land on the Rhodes Peninsula bounded by the Parramatta River, Mary Street and the Northern Rail Line.

The Rhodes East Investigation Area is the result of City of Canada Bay Council submitting a request to the Minister for Planning and Environment for the area to be declared a Priority Precinct (formerly Urban Activation Precinct).

DP&E has commissioned Jacobs along with RobertsDay to undertake this investigation.

1.2 Purpose and Objective

This report has been prepared to provide an overview of the nature and extent of flooding for the area. This will afford an opportunity to identify flooding issues in the precinct and outline the constraints and opportunities for Rhodes East from a drainage and flooding perspective.

This report should be considered as documenting work in progress, and using identified information to inform the development and assessment of the precinct proposals.

The overall objective of investigating the flooding of Rhodes East is as stated in the Floodplain Development Manual (2005):

“To reduce the impact of flooding and flood liability on individual owners and occupiers of flood prone property, and to reduce private and public losses resulting from floods, utilising ecologically positive methods wherever possible.”

Hence, the primary objective is to ensure that the proposed re-development for the Rhodes East Priority Investigation Area does not lead to increased flood risk to property and any planning controls proposed to achieve this outcome form part of a consistent and coordinated strategy to reduce flood risks.

1.3 Available Data

The following information was available to Jacobs:

- 1m LiDAR digital elevation model (DEM) data covering the study area (LPI 2013);
- Stormwater infrastructure including pits and pipes provided by City of Canada Bay Council in 2016; and
- Additional GIS layers including aerial imagery, local environmental plan (LEP) layers, cadastre, road network and railway lines.

A site visit was also undertaken on 3 February 2016 to gain an appreciation of the area and drainage features.

2. Flood Behaviour for Existing Conditions

2.1 Sources of Flooding

The study area is located on a peninsula, bounded by the Parramatta River to the north and east, the Northern Railway Line to the west and Mary Street to the south. The elevation ranges from sea level (at the Parramatta River) to approximately 21m AHD. The main sources of flooding include catchment rainfall runoff, flooding in the Parramatta River (catchment area 220 km²) and tidal inundation. A review of the Lower Parramatta River Floodplain Risk Management Study: Flood Study Review (SKM 2005) indicates that flooding in the Parramatta River in the vicinity of the study area is dominated by tide. Tide levels of 1.27m AHD, 1.34 m AHD, 1.39 m AHD and 1.42 m AHD were estimated (SKM 2005) corresponding to 5, 20, 50 and 100 year ARI events.

2.2 Hydrologic Modelling

Hydrologic modelling was undertaken to estimate rainfall runoff generated from the study area and the adjoining areas draining through the study area. Sub-catchments were delineated across the study area using the 1m DEM and the stormwater drainage network. Figure A-1 (see **Appendix A**) shows the location of the study area with the DEM and the sub-catchments that were delineated. The areas to which the sub-catchments drain are indicated by the arrows. The sub-catchments cover an area of approximately 67ha.

The hydrology model for Rhodes East was developed using DRAINS (O'Loughlin & Stack 2014). DRAINS has been widely used across Australia to simulate urban catchment runoff and stormwater networks. The sub-catchment impervious areas were adopted based on the land use defined by the LEP (Figure A-2 in **Appendix A**), and adjusted using the aerial imagery as necessary. Generally, the adopted impervious fractions for different land uses are shown in **Table 2-1**.

Table 2-1 Approximate adopted impervious fractions for different land uses

Land use	Impervious fraction
Low-Medium Density Residential	0.5
High Density residential, Commercial, Industrial	0.9
Open Space	0.1
Road Corridor	0.7
Rail Corridor	0.7

Sub-catchment flow travel times were estimated based on runoff flow velocities during a storm event of 0.5m/s for grassed areas and 1m/s for paved areas. The DRAINS model was developed for the purpose of deriving local catchment runoff hydrographs for input into the flood hydraulic model. Pits and pipes were therefore not represented in the DRAINS model. The model was developed using the ILSAX program to calculate the runoff from each catchment with the following parameters:

- Depression storage: Paved areas – 1mm; Grassed areas – 5mm
- Soil type: Type 3, which represents a not particularly well drained soil landscape
- Antecedent moisture condition: This represents the degree of soil wetness at the onset of a storm, which affects its infiltration capacity. A value of 4 was adopted for storms from the 50% AEP event up to the PMP event. A value of 4 represents “completely saturated” soil conditions due to total rainfall exceeding 25mm in the preceding 5 days prior to the modelled storm event (O'Loughlin & Stack 2014).

The model uses AR&R 1987 IFD data for Rhodes East to generate rainfall hyetographs (Pilgrim 1987). The 'Generalised Short Duration Method' for Eastern Australia (Bureau of Meteorology 2003) was used to generate the probable maximum precipitation hyetographs.

2.3 Hydraulic Modelling

The flood hydraulic model was developed using TUFLOW (BMT WBM 2016). TUFLOW is an industry-standard modelling software package capable of representing flow in two dimensions, including the implementation of 1D or 2D hydraulic structures. The model was set up and run using TUFLOW version 2016-03-AA-w64 in double precision mode. The model covers the study area of interest including all of the catchments modelled in DRAINS (see Figure A-1). This area was modelled in the 2D domain using the LiDAR DEM data, sampled across a 2m regular grid. This grid size was selected to allow the features of the landscape to be represented with reasonable accuracy.

Due to the limited availability of data on stormwater pits and pipes, the entire drainage network of the area was not included in the TUFLOW model; instead 1D structures were included where any drainage structures cross roads. Roads are typically raised along the median to allow drainage to gutters and pits. At sag points, water will pond if it cannot cross the road. To avoid this occurring in the model, the existing drainage which carries flow from one side of the road to the other was included. Invert levels for the structures were not available and hence these were estimated based on the LiDAR DEM and engineering judgement. The structures were assumed to not be blocked and an inlet capacity was dictated by the pipe capacity.

There is currently no data for model calibration or verification, so typical Manning's 'n' values were adopted in the model for each land use layer, as dictated by the LEP (Figure A-2 in **Appendix A**). These are outlined in **Table 2-2**. Existing buildings were not explicitly included in the model, rather the material roughness was increased to account for this. The purpose of the model was to define the 'existing' conditions without modelling the buildings explicitly so that natural flow path locations could be determined without being impeded by the existing building structures. This will enable a more sensible analysis of the flood impact with the concept master plan.

Table 2-2 Catchment materials and roughness values

Landuse	Manning's 'n'
Roads	0.02
Industrial areas	0.03
Low density residential	0.15
Medium density residential	0.1
High density residential	0.06
Mixed land use	0.06
Recreational / grassed	0.035
Railway corridor	0.04
Parramatta River	0.03

A selection of design events were modelled with the inflows simulated by the DRAINS model and a fixed tailwater level at the Parramatta River boundary. The events simulated are outlined in **Table 2-3** below.

Table 2-3 Flood events simulated

Flood Event	Durations	Tailwater boundary ¹
100 year ARI	15min, 30min, 45min, 60min, 90min, 120min	Static 20 year ARI tide level (1.34m AHD)
200 year ARI	15min, 30min, 45min, 60min, 90min, 120min	Static 20 year ARI tide level (1.34m AHD)
PMF	15min, 30min, 45min, 60min	Static 100 year ARI tide level (1.42m AHD)

¹ Sourced from the *Lower Parramatta River Floodplain Risk Management Study: Flood Study Review* (SKM 2005)

The larger flood events have been simulated – the 100 year and 200 year ARI events and PMF events. These events are important to define the depth and extent of flooding for the planning level flood (100 year ARI event) and the maximum expected flood extent (PMF) for flood safety and evacuation purposes. The more frequent flood events (5 year to 50 year ARI) have not been simulated as these will be utilised to investigate local drainage concerns.

2.4 Flood Behaviour

2.4.1 Flood Extent

The flood map for the 100 year ARI flood is shown in **Appendix A** (Figure A-3). The map shows the flood extent and depth. Flood depths below 0.1m have been filtered from these results. Several flow paths can be seen flowing into the Parramatta River. There is one significant drainage line flowing from just north of Rhodes Station to the east. This flow path crosses the railway line and Concord Road and flows through Mcllwaine Park. Another significant flow path exists north of this one, also flowing east across Concord Road and through the existing residential area, along Cropley Lane. There are also other minor flow paths that discharge into Parramatta River. A major area of ponding occurs in the eastern side of Leeds Street, with flood depths reaching just over 0.6m. Other isolated areas of ponding are also present.

The flood map for the 200 year ARI flood is shown in **Appendix A** (Figure A-4). The map shows the flood extent and depth. Flood depths below 0.1m have been filtered from these results. The flood behaviour is generally similar to the 100 year ARI event, with the 200 year ARI having a slightly greater extent.

The flood map for the PMF event is shown in **Appendix A** (Figure A-5). The map shows the flood extent and depth. Flood depths below 0.1m have been filtered from these results. The flow paths are more prominent in the PMF and the minor flow paths contribute to the extent of flooding. The higher tailwater level (100 year ARI tide) does not encroach much further than the 20 year ARI tide tailwater level.

2.4.2 Flood Hazard

The flood hazard map for the 100 year ARI flood is also shown in **Appendix A** (Figure A-6). The flood hazard has been classified according to the NSW Floodplain Development Manual (NSW Government 2005). It is based on the flood depth and velocity, as shown in **Figure 2-1**.

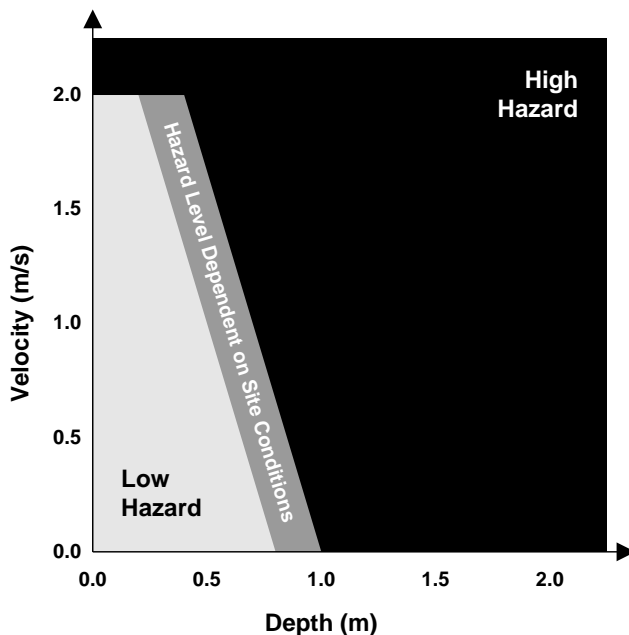


Figure 2-1 Hydraulic hazard category diagram (reproduced from Figure L2 in *NSW Floodplain Development Manual 2005*)

The Manual (2005) identifies 'high hazard' flooded areas as "possible danger to personal safety; evacuation by trucks difficult; able-bodied adults would have difficulty in wading to safety; potential for significant structural damage to buildings". 'Low hazard' flooded areas are defined in the Manual as "should it be necessary, truck could evacuate people and their possessions; able-bodied adults would have little difficulty in wading to safety". For Rhodes East, the 'intermediate hazard' region has been conservatively considered as 'high hazard'.

Hazard categories delineated in this study are based on depths and velocities of floodwaters and do not consider evacuation, isolation, flood damages and social impacts of flooding, hence, these categories are considered provisional.

The Rhodes East area is generally 'low hazard' in the 100 year ARI (Figure A-6). Outside of the Parramatta River, there are only minor areas where localised high velocities cause a high hazard to be triggered, but these are not considered to be significant. The 200 year ARI (Figure A-7) displays similar results, with the majority of overland flooding being classified as 'low hazard'.

The flood hazard map for the PMF event is also shown in **Appendix A** (Figure A-8). The map shows that 'high hazard' areas exist along Blaxland Road just north of the railway station, and in other areas along that major flowpath including where it crosses Concord Road and areas in McIlwaine Park. There is also an area of high hazard at the intersection of Concord Road and Llewellyn Street. Areas of high hazard also exist along Blaxland Road near the rail underpass, continuing north to the boat ramp on the Parramatta River. Other isolated areas of high hazard also exist along the other flow paths within Rhodes East.

2.5 Flood Planning Area

A Flood Planning Area (FPA) map for Rhodes East has been prepared on the basis of the following considerations:

- Flood Planning Level (FPL): The FPL is defined as the 100 year ARI flood level plus an appropriate freeboard.
- Freeboard: A typical freeboard of 0.5m is generally adopted to define floor levels of residential development in areas which may be impacted by mainstream flooding and a lower freeboard is adopted for residential development on flat and wider floodplains or development on areas which may be subject to shallow overland flooding. A recommendation is currently under consideration by City of Canada Bay

Council to adopt a freeboard of 0.5m for mainstream flooding in Powells Creek and 0.3m freeboard due to overland flooding for the Concord West Precinct (Jacobs 2015).

- **Climate Change:** Scientific data regarding the effect of climate change on rainfall intensities is not sufficiently advanced to provide specific guidance for the assessment of flood risk and no relevant planning benchmarks have been adopted by NSW Government related to rainfall intensity changes. However, government guidelines recommend the undertaking of a sensitivity analysis, which assumes nominal increases in rainfall intensities. Due to relatively small catchment areas draining into the Parramatta River, the impact of changes in rainfall intensities on overland flood behaviour in Rhodes East is expected to be minor. This is reflected in the minor change in flood behaviour for the 100 year and 200 year ARI events.

In 2009, the NSW Government adopted sea level rise planning benchmarks (measured as an increase above 1990 mean sea levels) of 0.40m by 2050 and 0.90m by 2100. The NSW Government disbanded these benchmarks as Government policy in September 2012 and requires Council to consider local conditions when determining future hazards. A recommendation is currently under consideration by City of Canada Bay Council to adopt floor level level to basement car park and the habitable floor level at or above RL 3 m AHD to address future flood risk for the Concorde West Precinct (Jacobs 2015).

The provisional FPA map can be found in **Appendix A** (Figure A-9).

3. Development Constraints and Opportunities

3.1 Development Constraints

The 100 year ARI flood extent will provide constraints on the building footprint locations. The high hazard areas would also pose a constraint to development/re-development, however, there are no significant areas of high hazard in the 100 year ARI flood. There are, however, several locations that are impacted by stormwater flooding in the 100 year ARI event. These are outlined below and identified in **Appendix A** (Figure A-10).

The following areas are impacted by stormwater flooding:

1. Leeds Street low point - The cul-de-sac at the end of Leeds Street is subject to inundation.
2. Concord Road Bridge - An overland flow path runs adjacent to Concord Road.
3. Concord Road - There is a sag point located on Concord Road where water ponds.
4. Cropley Lane - There is a significant flow path located along Cropley lane.
5. Llewellyn Street - Properties along Llewellyn Street are subject to flooding.
6. Rhodes Station. Flooding occurs in the vicinity of Rhodes Station.

The FPA should also be considered as a constraint. The FPA covers an area which is approximately 25% of the total area of Rhodes East Priority Investigation Area. The current Flood Policies and Planning Controls that would control development of this land are outlined in **Section 5**.

3.2 Development Opportunities

There is potential to decrease the risk due to flooding within the Rhodes East Investigation Area when redevelopment occurs. This can reduce the flood extent, the area impacted by flooding and also reduce the flood planning level. The following sections describe the opportunities that exist to decrease the risk of flooding with the re-development.

3.2.1 Upgrading stormwater drainage

The following areas (identified in **Section 3.1**) are impacted by stormwater flooding and the flooding issues may be alleviated by improving the stormwater drainage:

1. Leeds Street low point. The drainage in this area can be improved through the provision of culverts or a swale incorporated in an open space area or drainage easement.
2. Overland flow path adjacent to Concord Road Bridge. A flow path needs to be maintained in this area. If necessary, the land can be re-graded form a swale and direct flows to the Parramatta River.
3. Sag point on Concord Road. In order to improve access to the area, the drainage in this area can be upgraded if possible to alleviate flooding issues. This would involve the installation of new pits and/or upsizing the underground stormwater pipes. There would be regional benefits to improving the drainage and flood immunity of the road.
4. Cropley Lane flow path. There is a significant flow path located along Cropley lane. The drainage along Cropley Lane can be improved to mitigate flooding issues through improving stormwater drainage and minimising overland flow. In addition, a drainage easement could be provided to convey the overland flow.
5. Properties along Llewellyn Street. Stormwater drainage can be improved to alleviate flooding problems in this area.
6. Rhodes Station. The flooding in this area is a result of flows discharged by a large railway culvert conveying flows from the western side of the railway to the eastern side, with the addition of local stormwater runoff. Upgrading the drainage system in the area would help mitigate the flooding problem and improve the flood immunity of Concord Road, which is also affected.

3.2.2 Provision of flood wall

The provision of a flood wall along the Parramatta River foreshore would increase the amount of developable land. The land located below the 3m AHD level has been included in the flood planning area. In order to reduce the amount of land subject to development controls and improve the flooding risk due to the Parramatta River, a flood wall can be developed along the foreshore area to protect those properties located adjacent to the Parramatta River.

3.2.3 Consolidation of development

Higher density residential development typically involves the consolidation of development into single multi-storey buildings. By consolidating development there can be better allowance for dedicated flow paths that convey flood water more effectively. Consolidated development can also allow better evacuation as there is more chance of the building having flood-free access.

3.2.4 Stormwater quantity and quality improvement

There is an opportunity to improve the quantity and quality of the stormwater runoff that enters the Parramatta River in the redevelopment of the area. As a minimum, rainwater tanks and on-site detention can be considered for all new developments and gross pollutant traps can be provided on all outlets to the river. Further investigation can identify further opportunities to improve the stormwater quality through water sensitive urban design. This would also align with the objectives of the “Let’s make Parramatta River swimmable again by 2025” program, of which City of Canada Bay Council is a supporter.

4. Draft Structure Plan

4.1 Introduction

The current Draft Structure Plan for the Rhodes East Priority Investigation Area is shown in **Figure 4.1** which outlines character areas, connectivity and land uses within the area. At this stage, there are no indicative building footprints or earthworks and details on the existing stormwater network and as such, the proposed development cannot be adequately represented in the flood modelling software. This section provides flooding advice based on the current Plan for the area and makes recommendations for progressing with the precinct structure plan.

4.2 Structure Plan

It is expected that the Structure Plan for the Rhodes East precinct would include a number of opportunities for managing flood risk for the area discussed in **Section 3.2** which may involve unavoidable landform filling. However, the following points should be considered in finalising the Structure Plan/ Master Plan:

- Flow paths – the flow paths that have been identified in the 100 year ARI flood extent map should be maintained. Development that impedes on a flow path will cause afflux upstream and potentially undesirable impacts to adjacent properties. While it is best to avoid development that impedes on a flow path, it may be possible to modify or divert the flow around or through the development. Detailed flood modelling is to be undertaken to confirm acceptable changes to flood behaviour.
- Compensatory flood storage – any loss of floodplain storage areas that will be filled due to development should be offset by providing compensatory flood storage in another area. Preferably, the development will avoid those significant flood storage areas so as to not alter the flood behaviour of the area.
- Drainage – Adequate provision for cross drainage are to be provided at new road crossings.

The Structure Plan/ Master Plan needs to consider the relevant flood policies and planning controls identified in **Section 5**.

Figure 4.1 : Illustrative Master Plan



**RHODES EAST PRIORITY PRECINCT STRUCTURE PLAN
LAND USE PLAN**



5. Flood Policies and Planning Controls

5.1 Background

This section provides an overview on the NSW flood risk management framework and existing policies and planning controls applicable to the study area and recommends additional controls to be considered for the Rhodes East Priority Investigation Area.

5.2 NSW Flood Risk Management Framework

5.2.1 Objectives and Approach

The primary objective of NSW Flood Risk Management (FRM), as expressed within the NSW Flood Prone Lands Policy (Floodplain Development Manual 2005, page 1) is as follows:

“To reduce the impact of flooding and flood liability on individual owners and occupiers of flood prone property, and to reduce private and public losses resulting from floods, utilising ecologically positive methods wherever possible.”

Within the scope of this report, the relevance of the above objective is primarily to ensure that the Structure Plan for Rhodes East does not lead to increased flood risk to property and persons and that the planning controls proposed to achieve this outcome form part of a consistent and coordinated strategy to reduce flood risks.

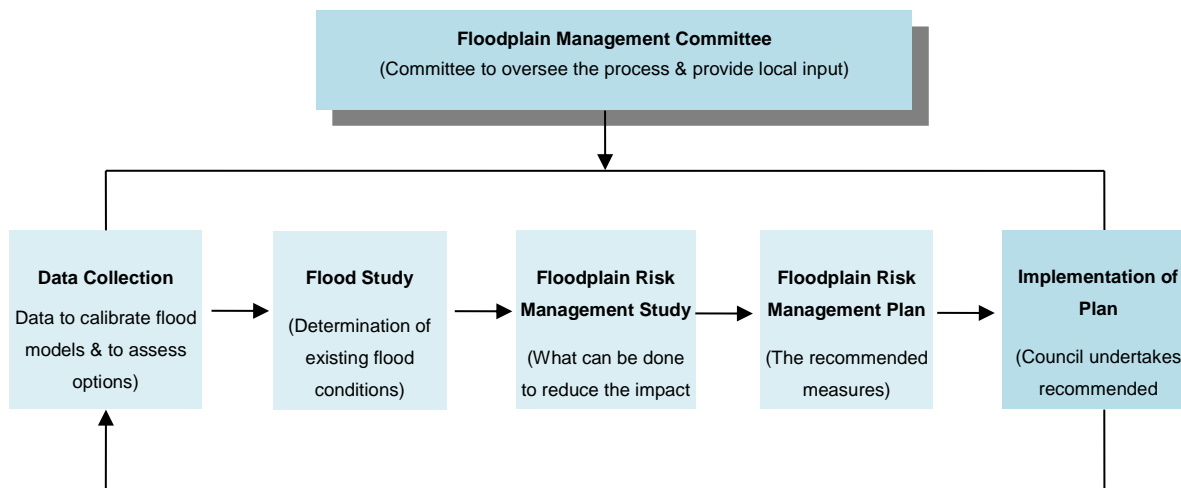
5.2.2 NSW FRM Policy and Guidelines

The NSW Flood Prone Land Policy as produced within Section 1.1 of the Floodplain Development Manual (FDM 2005) is consistent with that first introduced in 1984, which places the primary responsibility for implementation on local councils. This provides the opportunity for FRM to be integrated within council's normal planning processes.

The NSW Flood Policy and the FDM provide a platform for the management of floodplains in a manner that follows a risk management approach. The FDM is a manual which provides guidance with regard to how to implement the NSW Flood Prone Land Policy. The FDM requires the level of flood risk acceptable to the community is to be determined through a process overseen by a committee comprised of local elected representatives, community members and state and local Government officials (including the SES). This process is shown in **Figure 5-1**.

The ultimate outcome is the preparation of a Floodplain Risk Management Plan (FRMP), which is a plan formally adopted by a local council in accordance with the NSW Flood Prone Land Policy. FRMPs should have an integrated mix of management measures that address existing, future and continuing risk.

City of Canada Bay is yet to form a Floodplain Management Committee (FMC) which is a key requirement for preparation of Floodplain Risk Management Plan. Council could consider forming a FMC to comply with the requirements of the FDM 2005.



■ **Figure 5-1 NSW FRM Process (Adapted from FDM 2005)**

5.2.3 2007 Flood Planning Guideline

On January 31, 2007 the NSW Planning Minister announced a new guideline for development control on floodplains (the “Flood Planning Guideline”). An overview of the new Guideline and associated changes to the Environmental Planning and Assessment Act, 1979 (EPA Act) and Environmental Planning and Assessment Regulation 2000 (Regulation) was issued by the Department of Planning in a Circular dated January 31, 2007 (Reference PS 07-003). The Flood Planning Guideline issued by the Minister in effect relates to a package of directions and changes to the EPA Act, Regulation and FDM.

This Flood Planning Guideline provides an amendment to the Manual. The Guideline confirms that unless there are “exceptional circumstances”, Councils are to adopt the 100 year flood as the flood planning level (FPL) for residential development, with the exception of some sensitive forms of residential development such as seniors living housing. The Guideline does provide that controls on residential development above the 100 year flood may be imposed subject to an “exceptional circumstance” justification being agreed to by the Department of Natural Resources (now the Office of Environment and Heritage -OEH) and the Department of Planning (now the Department of Planning and Infrastructure - DPI) prior to the exhibition of a Draft LEP or Draft DCP.

The “Guideline on Development Controls on Low Flood Risk Areas – Floodplain Development Manual” defines Standards for Flood Controls for Residential Development. Whilst the flood used to define the residential FPL is a decision of Council, FDM highlights that FPLs for typical residential development would generally be based around the 100 year flood plus an appropriate freeboard (typically 0.5m).

A flood planning area (FPA) map has been prepared for the study area for the existing conditions in accordance with this guideline and recommendations currently under consideration by City of Canada Bay Council for the Concord West Precinct. The FPA map shows that approximately 25% of Rhodes East Priority Investigation Area is located at or below the FPL.

5.2.4 Flood Risk Management Measures

The FDM provides that the measures incorporated into a FRMP for managing flood risk to life and property can be grouped into three categories:

- **property modification measures** - these comprise controls on future development of property and community infrastructure. Planning and development controls can generally be implemented for minimal cost and would ensure that the potential for flood damage does not increase in the future;
- **response modification measures** - these modify people’s response to flooding and usually include measures that provide additional warning of flooding, improved public awareness of the flood risk and improvements to emergency management during floods; and
- **flood modification measures** - being structural measures such as the construction of flood walls, upgrade of stormwater network, detention basins, augmentation of culverts and bridges, etc.

This section is primarily concerned with property modification measures and secondly with response modification measures. Planning's role relates primarily to the implementation of property modification measures, and to a lesser extent response modification measures, particularly in regard to the manner in which it informs the community through planning policies in regard to flood risk. Accordingly, the role of planning can be summarised as follows:

- **Strategic Planning:** Directing strategic planning as to the location of new areas or the redevelopment of areas in a manner which does not expose people and property to unacceptable flood risk.
- **Development and Building Controls:** Where development is permitted in locations where flood risk remains, to ensure that planning and building controls are applied in a manner which minimises risk to acceptable levels.
- **Communication of Flood Risk:** Ensuring that the planning policies and controls and associated documentation communicates flood risk in a responsible manner to allow the community to make informed decisions where discretion exists.

Considering the fact that a significant area of Rhodes East is located within the FPA, the following issues need to be considered:

- Safety of people and damages to vehicles in basement car parks;
- Access and egress to properties during flood events rarer than the 100 year ARI event; and
- Flood education and preparedness.

5.2.5 Relationship with EPA Legislation

The plan-making processes under the EPA Act, such as for a Local Environmental Plan (**LEP**) and a Development Control Plan (**DCP**), operate independently of the preparation of FRMPs under the FDM. While these two processes could be overlapped, it has been the usual practice to undertake the processes separately. Ultimately the planning recommendations of the FRMP will need to be reflected in planning instruments and policies brought into force in accordance with the EPA Act.

5.3 Existing Policies & Planning Controls

The imposition of planning controls can be an effective means of managing flood risks associated with future development (including redevelopment). Such controls might vary from prohibiting certain land uses to specifying development controls such as minimum floor levels and building materials.

In principle, the degree of restriction that is imposed on development due to flooding relates to the level of risk that the community is prepared to accept after balancing economic, environmental and social considerations. In practice, the planning controls that may ultimately be imposed are influenced by a complex array of considerations including state imposed planning policy and directions, existing local planning strategies and policies and ultimately the acceptability of conditions that could be imposed through the development application process.

The following provides an outline of policy that is potentially relevant because it either directs the FRM planning controls that could be adopted or affects the way flood risk is identified in the planning controls.

5.3.1 State Environmental Planning Policies

A State Environmental Planning Policy (SEPP) is a planning document prepared in accordance with the EPA Act by the NSW Department of Planning and Environment and eventually approved by the Minister, which deals with matters of significance for environmental planning for the State. Clause 1.19 of the Codes SEPP has been amended so that land identified as 'flood control lot' is no longer excluded from the application of the General Housing Code. Instead, specified development and development standards have been added to the General Housing Code for development on low hazard flood control lots. The development standards have been designed to ensure that complying development is not allowed on high hazard or high risk flood control lots

including floodways, flood storage areas, a flowpath or areas identified in local flood plans as high hazard or high risk.

In the 100 year ARI event, some lots within the precinct are subject to low flood hazards and all high hazard areas are located on public lands.

5.3.2 Regional Planning Strategies

The study area is located within the Central subregion of the Draft Sydney Metropolitan Strategy to 2031 which is relatively general but identifies the following policies relating to natural hazard including flooding:

- Natural hazards will be considered and planned for at an early stage
- Development, particularly infrastructure, will be avoided in locations at risk from natural hazards unless the risks are demonstrated to be manageable

5.3.3 Climate Change Policies

Climate change is expected to have adverse impacts upon sea levels and rainfall intensities, both of which may have a significant influence on flood behaviour at specific locations. Rainfall intensities will have a wide influence on flooding while the sea level rise will have a diminished effect as the distance from the tidal influences of coastal waters increases. The study area drains into the Parramatta River which is hydraulically influenced by ocean tides.

Scientific data regarding the effect of climate change on rainfall intensities is not sufficiently advanced to provide specific guidance for the assessment of flood risk. No relevant planning benchmarks have been adopted by Government related to rainfall intensity changes. However, NSW Government guidelines recommend the undertaking of a sensitivity analysis, which assumes nominal increases in rainfall intensities.

In 2009, the NSW Government adopted sea level rise planning benchmarks (measured as an increase above 1990 mean sea levels) of 0.40m by 2050 and 0.90m by 2100. The NSW Government disbanded these benchmarks as Government policy in September 2012 and requires Council to consider local conditions when determining future hazards.

In recognition of the potential impacts of sea level rise and the draft recommendations for the Concord West Precinct, it is considered prudent to consider additional freeboard to set the access level to basement car park and the habitable floor level at or above RL 3 m AHD.

5.3.4 Section 117 Directions

Ministerial directions pursuant to Section 117(2) of the EPA Act specify matters which local councils must take into consideration in the preparation of LEPs. Direction 4.3, as currently applies, deals specifically with flood [liable] prone land and has the following two objectives:

“(a) To ensure that the 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.

“(b) To ensure that the provisions of an LEP on flood prone land is commensurate with flood hazard and includes consideration of the potential flood impacts both on and off the subject land”.

The Direction applies to all councils that contain flood prone land when an LEP proposes to “create, remove or alter a zone or provision that affects flood prone land.” In such cases, the Direction requires draft LEPs to ensure the following:

- (4) *A planning proposal must include provisions that give effect to and are consistent with the NSW Flood Prone Land Policy and the principles of the Floodplain Development Manual 2005 (including the Guideline on Development Controls on Low Flood Risk Areas).*

- (5) *A planning proposal must not rezone land within the flood planning areas from Special Use, Special Purpose, Recreation, Rural or Environmental Protection Zones to a Residential, Business, Industrial, Special Use or Special Purpose Zone.*
- (6) *A planning proposal must not contain provisions that apply to the flood planning areas which:*
 - a. *permit development in floodway areas,*
 - b. *permit development that will result in significant flood impacts to other properties,*
 - c. *permit a significant increase in the development of that land,*
 - d. *are likely to result in a substantially increased requirement for government spending on flood mitigation measures, infrastructure or services, or*
 - e. *permit development to be carried out without development consent except for the purposes of agriculture (not including dams, drainage canals, levees, buildings or structures in floodways or high hazard areas), roads or exempt development.*
- (7) *A planning proposal must not impose flood related development controls above the residential flood planning level for residential development on land, unless a relevant planning authority provides adequate justification for those controls to the satisfaction of the Director-General (or an officer of the Department nominated by the Director-General).*
- (8) *For the purposes of a planning proposal, a relevant planning authority must not determine a flood planning level that is inconsistent with the Floodplain Development Manual 2005 (including the Guideline on Development Controls on Low Flood Risk Areas) unless a relevant planning authority provides adequate justification for the proposed departure from that Manual to the satisfaction of the Director-General (or an officer of the Department nominated by the Director-General).*

The Structure Plan includes significant increase in development on lands located within the FPA and the Structure Plan would result in substantial increase in resident population within the study area. Construction of a flood wall along the eastern and the northern perimeter of Rhodes East peninsula and augmentation and improvement of stormwater networks are recommended to minimise flood risk to people and properties to ensure consistency with the S117 Direction.

5.3.5 Local Environmental Plan (LEP)

Canada Bay Local Environmental Plan 2013 applies to the study area. The study area contains land within a number of standard urban zones such as IN1 General Industrial, R2 Low Density Residential, R3 Medium Density Residential, RE1 Public Recreation and B1 Neighbourhood Centre. These can be seen in the map provided in **Appendix A** Figure A-2.

Clause 6.2 of the LEP deals with earthworks to ensure that earthworks for which development consent is required will not have a detrimental impact on environmental functions and processes, neighbouring uses, cultural or heritage items or features of the surrounding land.

5.3.6 Development Control Plan (DCP)

City of Canada Bay Development Control Plan 2013 (DCP 2013) applies to the study area. Council's guidelines on stormwater controls are provided in the City of Canada Bay "Specification for the Management of Stormwater" (SMS) document revised in February 2009.

The objectives of Council's Stormwater Policy as detailed in SMS (2009) are:

- To provide uniform guidelines and application of systems to achieve consistency in the assessment and conditioning of development applications in relation to stormwater runoff from all developments.
- To minimise any adverse impact on properties caused by stormwater runoff from developments.
- To ensure that the water qualities of receiving waterways are not adversely affected by pollutants such as nutrients, pathogens, and situation, resulting from development sites.

- To ensure that uniform stormwater controls are applied throughout the whole of the City of Canada Bay Council Local Government Area.

The following controls are recommended in SMS (2009) to achieve the above objectives:

- The provision of safe overland flowpaths within developments and on public land
- The definition of floodways for major storms within developments and on public land
- The provision of controls such as on-site stormwater detention, community basins and the like and on-site retention systems to reduce and control stormwater runoff
- The application of alternative methods of merit based stormwater control and conveyance devices
- The removal of flood effected development from known floodways and the prohibition of future developments in such floodways
- The provision of minimum free-boards for assigning floor levels to reduce the risk of flood damage to property
- The installation of pipe/channel systems to minimise hazard to pedestrian and vehicular traffic caused by uncontrolled surface stormwater runoff
- The installation of water quality control devices such as trash screens, gross pollutant traps, water quality ponds and the like to protect the quality of receiving waters.

In addition to the above controls, SMS (2009) makes the following specific stormwater controls will be applicable to the study area:

- Provision of overland flow routes
- The minimum freeboard according to SMS (2009) shall be as follows:
 - 150mm for roadways - between the 100-year ARI overland flow route and warehouse, factory, and garage floor levels and entrances to underground carparks.
 - 300mm for roadways - between the 100-year ARI overland flow route and office, living rooms, retail space, storeroom, and show room floor levels.
 - 300mm for surcharge paths e.g. easements - between the 100-year ARI overland flow route and all internal building floor levels, garages and basement carparks.
 - 500mm for channels, creeks and rivers - between the 100-year flood water level and all internal building floor levels, garages, and basement carparks.
- Design velocities and depths of surface flows shall be in accordance with Figures G1 and G2 of the New South Wales Government Floodplain Management Manual: The management of flood liable land, with hazard category classed as "low hazard". It is to be noted that SMS (2009) needs to be updated to refer to Figures L1 and L2 of the FDM 2005.
- Easements for stormwater drainage are to be provided within private properties to comply with Council's Policy on Drainage Easements – this means proposed flood storage areas and the floodway included in the mitigation strategy for Site 1 and 2 should be classified as drainage easements.

Freeboards specified in the SMS (2009) are inconsistent with the FPL adopted in this study. The SMS (2009) does not include any controls based on emergency flood evacuation needs (e.g. fire, medical needs) during extreme events or identify flood compatible materials for building components to be used for new development or redevelopment. In addition, the SMS does not consider potential impacts of climate change and specify types of fencing to be used to mitigate flood impacts to neighbouring properties.

Considering the gaps in the current DCP, it is recommended that Council considers to develop a new DCP specifically for Rhodes East to address requirements of Section 117 Directions specifically for the Structure Plan. The new DCP should identify controls for defining habitable floor levels and access to basement car parks for the low lying areas within the precinct. It is recommended that as a minimum, habitable floor levels and access to basement car park be set at RL 3 m AHD for the precinct.

5.3.7 Section 149 Certificates

Council under the provisions of Section 149 of the Environmental Planning and Assessment Act 1979 issues Certificates which are also known as zoning certificates. The certificate provides information on planning controls and any development restrictions which may apply to a particular parcel of land within the Council area. They are usually required upon the sale or purchase of a property. The flood assessment undertaken in this report did not include the entire stormwater network for Rhodes East and hence it is recommended that Council should not include information on flooding in Section 149 Certificates.

6. Conclusions and Recommendations

The Department of Planning & Environment (DP&E) is working with City of Canada Bay Council to prepare a rezoning proposal for the Rhodes East Investigation Area. The investigation area comprises 36 hectares of land on the Rhodes Peninsula bounded by the Parramatta River, Mary Street and the Northern Rail Line.

A hydrologic and hydraulic assessment has been undertaken for the existing conditions to determine the nature and extent of flooding in the area. This investigation has involved hydrologic and hydraulic modelling of the 100 year and 200 year ARI events and the PMF. The Rhodes East area is subject to stormwater flooding from several overland flow paths. Additionally, the area is also subject to tidal inundation from the Parramatta River. Flood depth and hazard maps have been produced for the events investigated (**Appendix A**). There are no significant areas subject to high hazard in the 100 year ARI flood event. The flood planning area (FPA) has also been delineated using the 100 year ARI flood level plus 0.3m freeboard. The 3m AHD level has also been included in this area to account for inundation from Parramatta River (100 year ARI tide level plus allowances for sea level rise and freeboard). The FPA covers approximately 25% of the Rhodes East study area.

A number of development constraints have been identified from the flood behaviour of the existing conditions, including those areas where stormwater flooding is an issue and those areas covered by the FPA. While these constraints exist, there are also opportunities to improve the flooding situation and hence reduce these constraints. The following opportunities have been identified based on the existing flood behaviour:

- Upgrading stormwater drainage
- Provision of a flood wall
- Consolidation of development
- Stormwater quality improvement.

A draft structure plan has been prepared outlining character areas, connectivity and land uses within the Rhodes East Priority Investigation Area. It is recommended that further development of this structure plan should consider the relevant flood policies and planning controls for the area. It is recommended that further flood modelling and investigations be undertaken at the subsequent stages of the design process.

7. References

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City of Canada Bay 2009, *Specification for the Management of Stormwater*.

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Jacobs (2015) Concord West Precinct Master Plan Flood Study, Draft Final Report, City of Canada Bay.

NSW Government 2005, *Floodplain Development Manual, the management of flood liable land*. Department of Infrastructure, Planning and Natural Resources, Sydney, Australia.

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O'Loughlin, G & Stack, B 2014, *DRAINS User Manual*, Watercom Pty Ltd, Sydney.

Pilgrim, DH 1987, *Australian Rainfall & Runoff – A Guide to Flood Estimation*, Institution of Engineers, Australia, Barton, ACT.

SKM 2005, *Lower Parramatta River Floodplain Risk Management Study: Flood Study Review*, Parramatta City Council.

Appendix A. Mapping

Figure A-1: DRAINS catchments and DEM

Figure A-2: Current LEP

Figure A-3: 100 year ARI Flood Depth Map

Figure A-4: 200 year ARI Flood Depth Map

Figure A-5: PMF Depth Map

Figure A-6: 100 year ARI Provisional Flood Hazard Map

Figure A-7: 200 year ARI Provisional Flood Hazard Map

Figure A-8: PMF Provisional Hazard Map

Figure A-9: Flood Planning Area

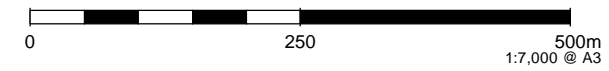
Figure A-10: Flooding areas of concern



Legend

- Study Area
- DRAINS Catchments
- Overland Flow Direction
- Railway
- Stormwater Network

1m DEM (m)		6 - 9		15 - 18
		< 3		9 - 12
		3 - 6		12 - 15
				> 18

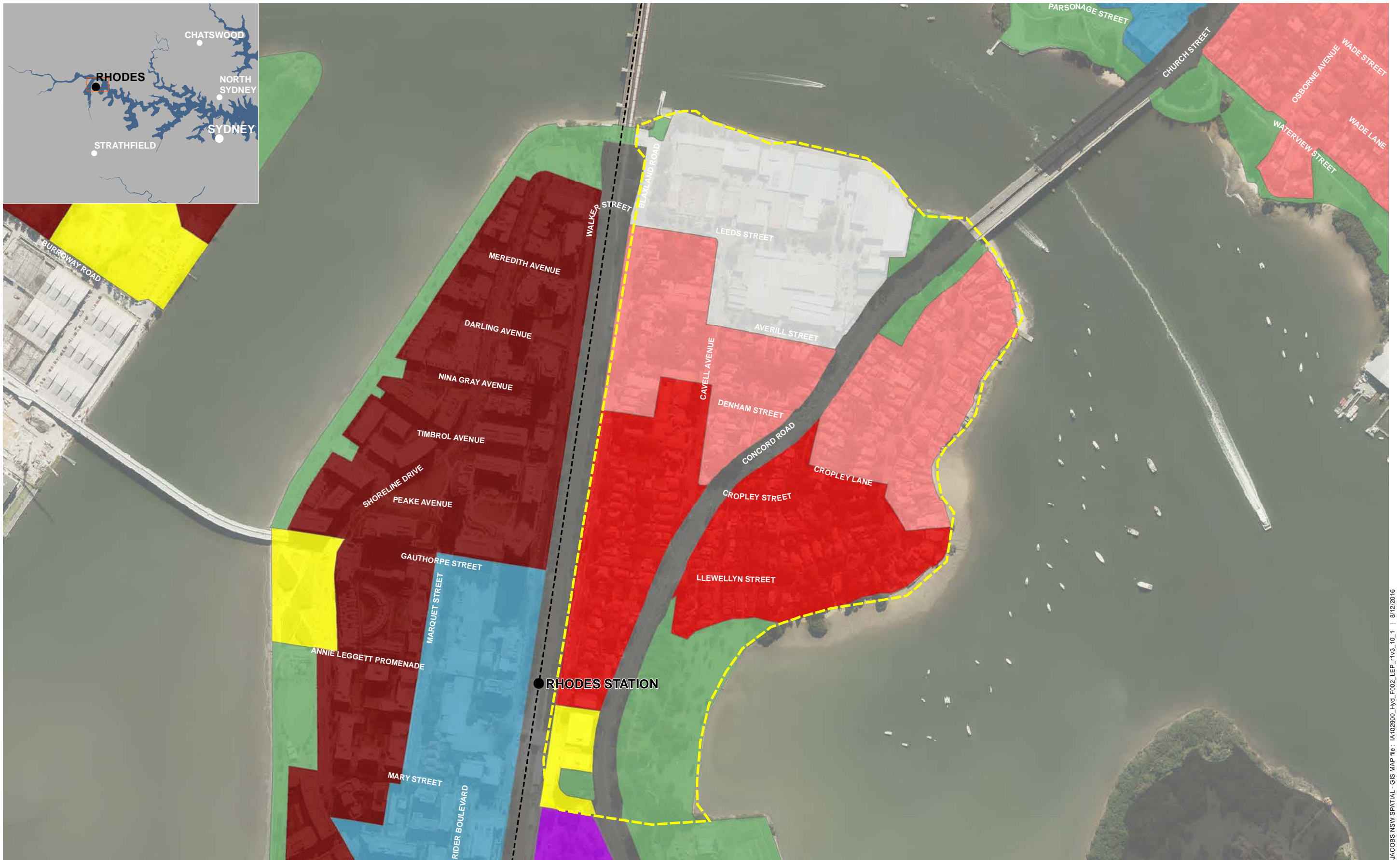


Data sources

Jacobs 2015
Ausimage 2016
LPI 2015

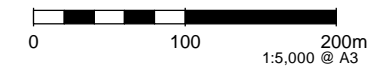
Figure A-1 | Drains catchments and 1m DEM

JACOBS NSW SPATIAL - GIS MAP file : I:\102900_Hyd_F001_Catchments_r1v3_10_1 | 8/12/2016



Legend

- | | | | | | |
|------------|------------------|--------------------------|----------------------------|----------------|----------------------|
| Study Area | LEP Zones | General Industrial | Medium Density Residential | Infrastructure | Neighbourhood Centre |
| Railway | Business Park | High Density Residential | Low Density Residential | Mixed Use | Public Recreation |



Data sources

Jacobs 2015
Ausimage 2016
LPI 2015

Figure A-2 | Local Environmental Plan (LEP) Zoning

RHODES EAST

JACOBS NSW SPATIAL - GIS MAP file : I:\102800_Hyd_F002_LEP_riv3_10_1 | 8/12/2016



Legend

- Study Area
- 3m AHD contour line
- Railway
- 100 year ARI Flood Depth (m) < 0.25
- 0.25 - 0.5
- 0.5 - 1
- 1 - 2
- > 2



Data sources

Jacobs 2015
 Ausimage 2015
 LPI 2015

Figure A-3 | 100 year ARI flood depth map

Flood depths below 0.1m have been trimmed from this map
 The flood extent outside the study area has been trimmed from this map

RHODES EAST

JACOBS NSW SPATIAL - GIS MAP file : I:\102800_Hyd_F003_100yFloodDepth_r1v3_10_1 | 8/12/2016



Legend

- Study Area
- 3m AHD contour line
- Railway
- 200 year ARI Flood Depth (m) < 0.25
- 0.25 - 0.5
- 0.5 - 1
- 1 - 2
- > 2



Data sources

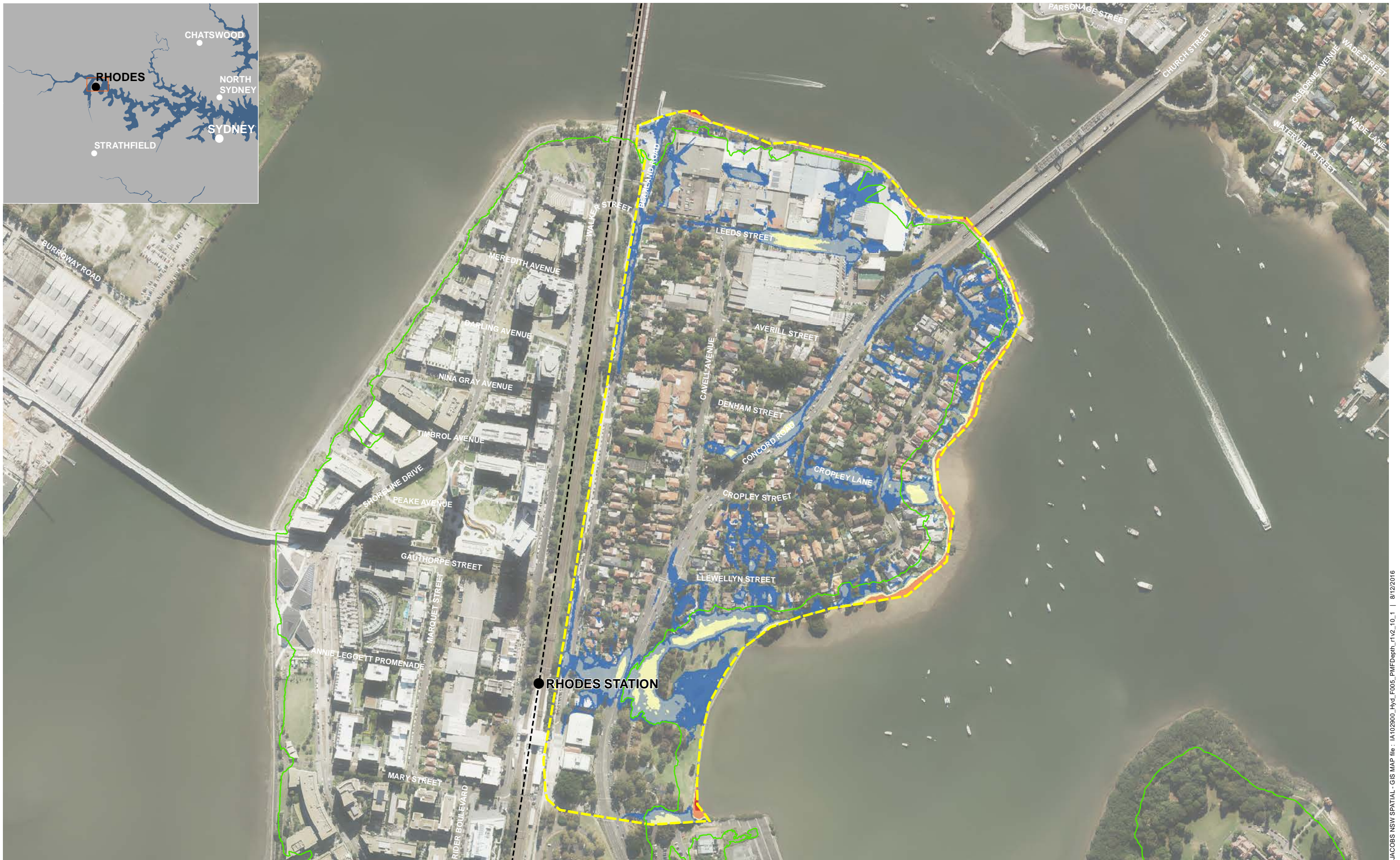
Jacobs 2015
 Ausimage 2015
 LPI 2015

Figure A-4 | 200 year ARI flood depth map

Flood depths below 0.1m have been trimmed from this map
 The flood extent outside the study area has been trimmed from this map

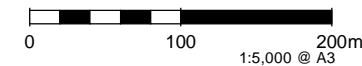
RHODES EAST

JACOBS NSW SPATIAL - GIS MAP file : I:\102800_Hyd_F004_200yFloodDepth_r1v2_10_1 | 8/12/2016



Legend

- Study Area
- 3m AHD contour line
- Railway
- PMF Flood Depth (m) < 0.25
- 0.5 - 1
- 0.25 - 0.5
- 1 - 2
- > 2



Data sources

Jacobs 2015
Ausimage 2016
LPI 2015

Figure A-5 | PMF preliminary flood depth map

Flood depths below 0.1m have been trimmed from this map
The flood extent outside the study area has been trimmed from this map

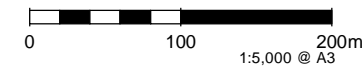
RHODES EAST

JACOBS NSW SPATIAL - GIS MAP file : I:\102900_Hyd_F005_PMFDepth_r1v2_10_1 | 8/12/2016



Legend

- Study Area
- 3m AHD contour line
- 100 year ARI Flood Hazard
- High hazard
- Railway
- Low hazard



Data sources

Jacobs 2015
Ausimage 2016
LPI 2015

Figure A-6 | 100 year ARI provisional flood hazard map

Flood depths below 0.1m have been trimmed from this map
The flood extent outside the study area has been trimmed from this map

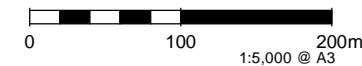
RHODES EAST

JACOBS NSW SPATIAL - GIS MAP file : I:\102900_Hyd_F006_100yFloodHazard_rtv3_10_1 | 8/12/2016



Legend

- Study Area
- 3m AHD contour line
- 100 year ARI Flood Hazard
- High hazard
- Railway
- Low hazard



Data sources

Jacobs 2015
Ausimage 2016
LPI 2015

Figure A-7 | 200 year ARI provisional flood hazard map

Flood depths below 0.1m have been trimmed from this map
The flood extent outside the study area has been trimmed from this map

RHODES EAST

JACOBS NSW SPATIAL - GIS MAP file : I:\102800_Hyd_F007_200yFloodHazard_rv2_10_1 | 8/12/2016



Flood depths below 0.1m have been trimmed from this map
The flood extent outside the study area has been trimmed from this map

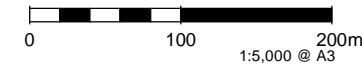
RHODES EAST

JACOBS NSW SPATIAL - GIS MAP file : I:\102800_Hyd_F008_PMFHazard_r1v3_10_1 | 8/12/2016



Legend

- Study Area
- Flood Planning Area
- Railway



Data sources

Jacobs 2015
 Ausimage 2016
 LPI 2015

Figure A-9 | Flood Planning Area Map

Flood depths below 0.1m have been trimmed from this map
 The flood extent outside the study area has been trimmed from this map

RHODES EAST



Legend

- Study Area
- 100 year ARI Flood Extent
- Railway



Data sources

Jacobs 2015
 Ausimage 2016
 LPI 2015

Figure A-10 | Flooding areas of concern

Flood depths below 0.1m have been trimmed from this map
 The flood extent outside the study area has been trimmed from this map

RHODES EAST

JACOBS NSW SPATIAL - GIS MAP file : I:\102800_Hyd_F010_DrainageImprovements_r1v3_10_1 | 8/12/2016