ATTACHMENT 2

engineering | environmental | economics | engagement

Proposed Development at Chatswood Chase

Independent Hydraulic Review Findings

DA2017/503

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1 Introduction

1.1 Overview

The Chatswood Chase Shopping Centre is located in Chatswood, within the Willoughby Council Local Government Area (LGA). It is bounded by Victoria Avenue in the south, Archer Street to the west, Malvern Avenue in the north, and Havilah Street to the east. Chatswood Chase is a regional shopping centre and has operated since 1983, with a major upgrade completed in 2009. A general locality of the shopping centre is provided in Figure 1-1. In this report it is referred to as the 'site' or the 'subject site'.

Figure 1-1. Site Locality

Vicinity Centres PM Pty Ltd (Vicinity Centres) has submitted a development application (DA2017/503) for works associated with the Chatswood Chase Shopping Centre (street address 345 Victoria Avenue, 12-14 Malvern Avenue and 5-7 Havilah Street). These works include the demolition of two commercial buildings (5-7 Havilah Street and 12-14 Malvern Avenue), reconstruction and expansion of the existing Chatswood Chase Shopping Centre. The associated works will expand the shopping centre footprint from approximately 3.53 hectares to 3.87 hectares (CJ Arms, 2018) with the inclusion of these additional properties on Havilah Street and Malvern Avenue. Figure 1-2 provides an overview of the shopping centre and the two properties (in red hatching).

Figure 1-2. Existing Shopping Centre and New Extension Areas (CJ Arms, 2018)

1.2 Background

Vicinity Centres lodged a DA for the proposed development on 21 December 2017. Following this submission, Willoughby City Council (Council) requested further information on the proposed development. This included the need to undertake a flood study for the proposed development to understand the impact of flooding at the site and understand potential changes to flood behaviour on the site. The scope of the study required an understanding of the flooding in the basement of the shopping centre.

CJ Arms (consultants) undertook a flood assessment on behalf of Vicinity Centres, which is detailed in their report *Chatswood Chase Flood Modelling Report* (CJ Arms, September 2018). This provided an overview on the flood behaviour, the potential impacts of the development, and the flooding associated with the shopping centre basement.

Following the submission of this report (and other associated documentation for the DA), Council completed an assessment of the DA (dated 7 December 2018) which outlines their review and their recommendation for a Deferred Commencement Consent. This included Conditions of Consent for the deferred commencement, three of which specifically relate to flooding (summarised in Section 2.4 of this report). Vicinity Centres

subsequently made a submission to the Sydney North Planning Panel (letter dated 18 December 2018) which outlined Vicinity Centres position to the flooding conditions specifically in Council's DA assessment.

The Sydney North Planning Panel, in their meeting dated 19 December 2018, subsequently recommended deferral with a revised set of conditions to be submitted by Council by 31 January 2019. This was to allow further discussion between the Vicinity Centres and Council in order to resolve some of the concerns of Council.

However, it was noted by the Sydney North Planning Panel that in respect to the conditions on flooding the positions of Council and Vicinity Centres was still far apart. As a result, the Sydney North Planning Panel recommended that an independent hydraulic expert be engaged to undertake a peer review of the advice (from both Council and Vicinity Centres). Rhelm has been engaged as this independent hydraulic expert (Section 1.3).

1.3 Objectives

The Sydney North Planning Panel, in their Record of Deferral from their meeting dated 19 December 2018, recommended the appointment of an independent hydraulic expert. Rhelm has been appointed by Vicinity Centres (in agreement with Council) to act as the independent hydraulic expert.

The key objective of the independent hydraulic expert is the following:

- Undertake an independent review of the advice that has been prepared by Council and Vicinity Centres and associated background reports;
- Prepare recommendations for draft consent conditions;
- Provide guidance to the two parties to reach full agreement on how to address the flooding, and if no agreement is reached, to provide recommendations to the Sydney North Planning Panel.

1.4 Independent Review

This independent review of the flooding for the proposed Chatswood Chase redevelopment (DA2017/503) has been undertaken based on the available information provided to Rhelm as identified in Section 3, and to fulfil the key objectives as identified in Section 1.3.

This review was undertaken in two stages:

- The review was undertaken on the reports and submissions Rhelm's involvement, and a draft review report was prepared (dated 23 January 2019);
- Following the issue of this report, additional discussions between Vicinity, Council and Rhelm were undertaken to resolve some of the outstanding matters. The outcomes of this have been incorporated into this report, primarily summarised in Section 7.

1.4.1 Meetings and Correspondence

Table 1-1 summarises the meetings and teleconferences that were undertaken with both parties (Vicinity Centres and Council).

As a part of the review process, a number of emails containing data requests were issued by Rhelm for data held by either Council or Vicinity Centres. Both parties were included in data requests to ensure transparency in the process. Information was also issued by Vicinity as an outcome of the discussions.

Table 1-1. Summary of Meetings/Teleconferences

Meeting	Date	Attendees	Summary
1	14 January 2019	Mark Bolduan & Scott Kavanagh from Council. Vince Russo from CJ Arms (project hydraulics consultant). Paul Neilsen (Vicinity Centres Chatswood Chase Project Director). Libby Walsh (Vicinity Centres) Rhys Thomson, Heath Sommerville and Bill Tran from Rhelm.	The purpose of this meeting was for both parties to provide an overview of the design, the flood behaviour, and the draft conditions of consent. Following the meeting, a site walkthrough was undertaken, where both parties provided an overview of the key constraints and flooding behaviour.
2	4 February 2019	See attached Meeting Notes (Appendix A).	See attached Meeting Notes (Appendix A).
3	8 February 2019	See attached Meeting Notes (Appendix A).	See attached Meeting Notes (Appendix A).
4	15 February 2019	See attached Meeting Notes (Appendix A).	See attached Meeting Notes (Appendix A).
5	20 February 2019	Mark Bolduan, Joseph Bazergy - Willoughby City Council Scott Button – Lyall & Assoc Libby Walsh, Vicinity Centres Vince Russo, Daniel Garzia– CJ Arms Louise Collier – Rhelm	Discussed additional assessments for depth in basement in PMF if the immunity is provided to 2000 year ARI. Depth considered to be reasonable for the extreme situation provided that Flood Emergency Response Plan reflects the risk and seeks to ensure this is managed. Agreed to condition additional design and impact requirements in draft conditions.

1.4.2 Structure of this Review

This report has been structured into the following sections based on the process that was undertaken for the review:

- An overview of the background, including a description of the flood behaviour, the previous redevelopment at Chatswood Chase and the draft conditions of consent from Council (Section 2);
- An overview of the available data that has informed this review (Section 3);
- A review of the 2018 flood analysis undertaken by CJ Arms (consultant) on behalf of Vicinity Centres (Section 4);
- A summary of the key planning documents that are relevant to the proposed development (Section 5);
- Review of the proposed development relative to the relevant planning controls identified above (Section 6)
- An overview of the design modifications and works that were undertaken by the parties to reach an agreement following the draft version of this report which was issued on 23 January 2019 (Section 7).

- The draft conditions of consent recommended following the outcomes of the above review (Section 8).

2 Background

2.1 Flood Behaviour

The flood behaviour at the site is described in detail in the flood study undertaken to assist with the development assessment (CJ Arms 2018) as well as in the flood study undertaken on behalf of Willoughby Council as part of the NSW state government's floodplain management process (Lyall and Associates 2011). The following provides a brief overview of the flood behaviour in the immediate vicinity of the site, focusing on the 1% AEP design flood event when reporting specific depths or flood levels.

The site is located within a complex urban floodplain in the upper reaches of the Scotts Creek catchment with the general direction of flow running west to east. There are multiple flowpaths arriving at the site as it is centralised within the upper catchment and a portion of the existing centre is constructed over a flow path.

The flowpaths of interest are:

- Ferguson Lane (west of site, adjacent to The Concourse);
- South-West;
- Archer Street; and
- Malvern Avenue.

In addition to flow paths, there are also low points, where floodwaters can accumulate (or 'pond') when the drainage system is at capacity or is blocked. The two low points of interest are in Victoria Avenue and Havilah Street.

Ferguson Lane Flowpath

Flows arrive at Ferguson Lane from further upstream, primarily via Help Street and the catchment contains a portion of the dense business district of Chatswood on the western side of the railway line. A large detention/ retention tank was constructed by Council on Ferguson Lane that has a reported capacity of 5000m^3 (CJ Arms, 2018). Approximately 4000m^3 of this is available for flood storage. While this is primarily used as a reuse system, Council are able to make a portion of this available (between 2000 and 4000m^3) following major storm event notification from Bureau of Meteorology (CJ Arms, 2018).

Downstream of this detention tank, overland flows meet with flows from Archer Street (and some localised flows from the north) and either proceed in a southerly direction toward the Archer Street/ Victoria Avenue intersection, or into the Mills Lane loading dock (associated with the site). There is a storage tank in this location (the Mills Lane Loading Dock) with a capacity of approximately 400m^3 (CJ Arms, 2018). The remainder of the water in this area that appears as overland flow lies within a trapped low point in the loading dock itself, with ponding in excess of 0.4 metres reported to occur in the loading dock area in a 1% AEP design flood (CJ Arms, 2018).

Figure 2-1. Ferguson Lane Flowpath (Lyall & Associates, 2011)

South West Flowpath

A flowpath originates from south west of the Archer Street/ Victoria Avenue intersection (refer Figure 2-3). This flowpath has a catchment that incorporates areas west of the railway line near Chatswood Park, as well as the detention basin at Chatswood Park. While previous work undertaken by Council (Lyall and Associates, 2011) suggested approximately 1200m^3 of flood storage is available in this park, work by CJ Arms (2018) indicated that overtopping occurred at a significantly lower volume. It is understood that Council agrees with this volume based on other investigations that they have undertaken (pers comm, S Cavanagh, 14/1/19). Historical ponding in the oval during the flood event of 5 June 2016 is shown in Figure 2.2 (Source: Maya Rowley, North Shore Times, 6 June 2016).

Figure 2-2. Chatswood Oval Historical Inundation (June 2016)

Downstream of this oval, overland flows make their way around and through residential apartment properties, the Westfield Chatswood carpark and around the Westfield Chatswood building, before eventually making their way to the Archer Street/ Victoria Avenue intersection.

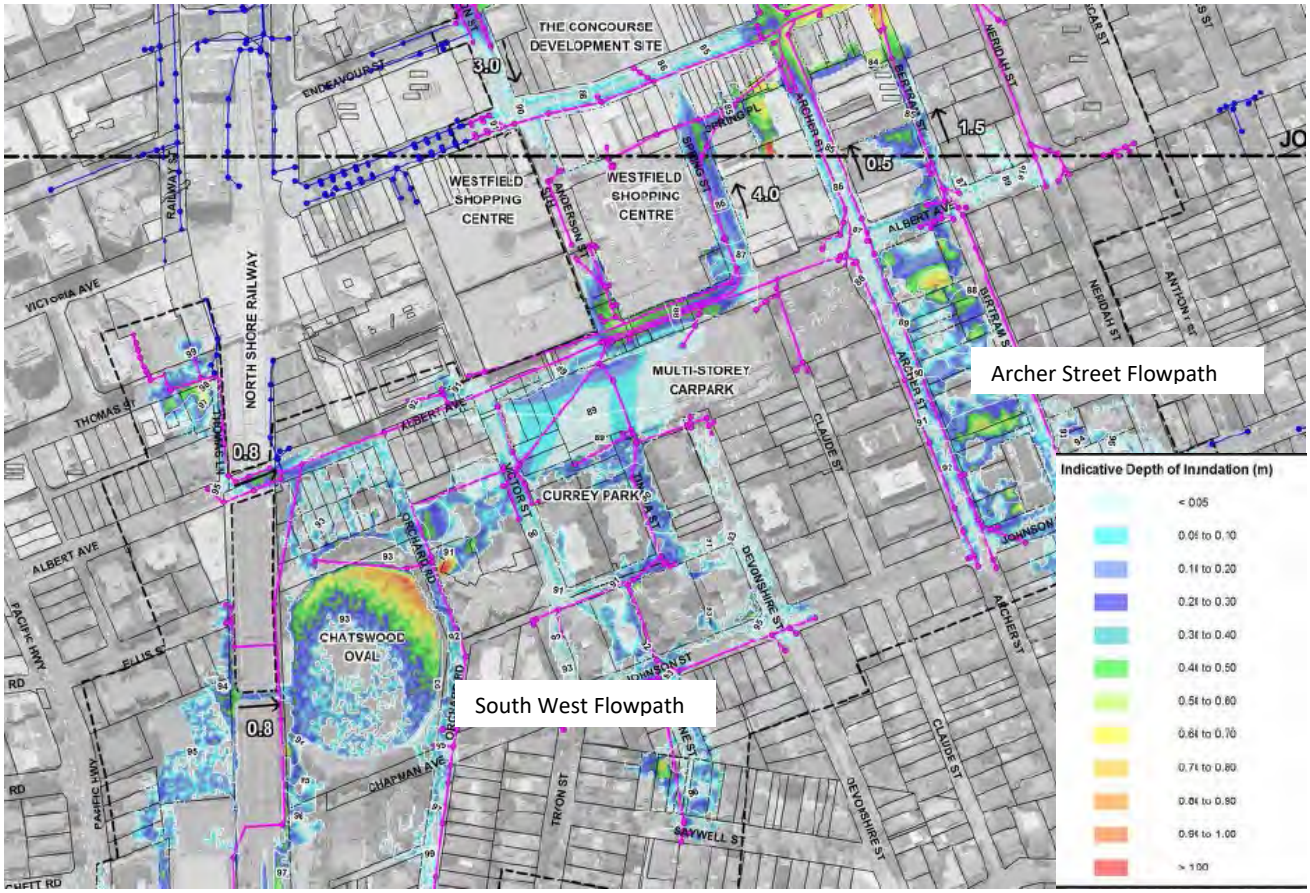
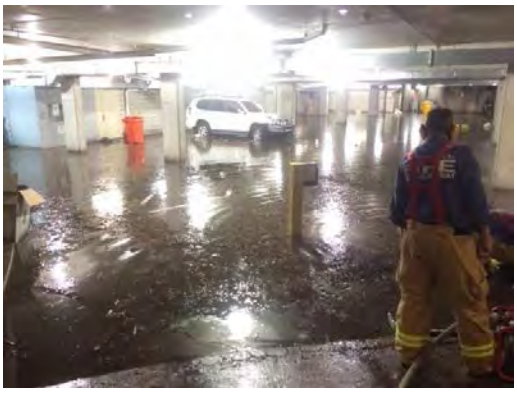


Figure 2-3. South West and Archer Street Flowpaths (Lyall & Associates, 2011)

Archer Street Flowpath



To the south of the Archer Street/ Victoria Avenue intersection, an additional overland flowpath originates from near Johnson Street (Figure 2-3). This flowpath moves in a northerly direction, flowing along Archer Street and Bertram Street before reaching Victoria Avenue. Previous flooding has occurred in this area including inundation of the police station basement carpark (corner of Albert Avenue and Archer Street) in the early hours of November 2013 (Source Nine News Twitter, 15 November 2013).

Victoria Avenue Low Point

The Victoria Avenue low point is located just east of the Victoria Avenue/ Archer Street intersection (Figure 2-7). Flows from the flow paths identified above arrive at this location. Due to the insufficient capacity of the underground stormwater network in large flood events, this area becomes a trapped low point. Ponding of water in this area builds up and a backwater effect occurs in Archer Street, Bertram Street, and the surrounding shops.

Figure 2-5. View of Victoria Avenue from Archer Street (source : Google Maps, 2019)

Once the ponding of water reaches a sufficient level, it will proceed down into the basement carpark of Chatswood Chase. A view of the carpark entry is provided in Figure 2.6. There is very little to no elevation difference between the invert of the gutter and the ramp entry level, with a grated drain the only way for flows to be captured before going down the basement entry ramp. This leads to a significant flood risk management issue in terms of the existing carpark entry arrangements.

Victoria Avenue continues to rise to Havilah Street, meaning that the depth of ponding in this trapped low point has to continue to increase before it can proceed around the corner (northwards) at Havilah Street. The elevation difference between the low point on Victoria Avenue and Havilah Street is understood to be approximately 600 – 700mm.

The floodplain in the vicinity of Chatswood Chase and upstream can be characterised as a flash flooding area. Critical durations are in the order of 2 hours or less, with peak levels being reached in shorter times that this (CJ Arms (2018) note that the basement for Chatswood Chase would start to be inundated in around 40 minutes from the start of the storm burst for a 2 hour event). This provides very little warning time other than through the Bureau of Meteorology severe weather warnings.

Malvern Avenue Flowpath

A flowpath also arrives at the northern side of the shopping centre, flowing north-west to south-east from Malvern Street (Figure 2-7). This flowpath primarily flows around the centre in an easterly direction towards Havilah Street. The shopping centre is protected by bunding which prevents any inundation in this area.

Havilah Street Low Point

Downstream of Chatswood Chase, overland flows from all upstream sources converge at the Havilah Street low point. The behaviour of this low point is controlled by the capacity of the Sydney Water culvert downstream, together with the capacity of the overland flowpath through the properties in this area. Ponding depths in this area are in the order of 300mm (CJ Arms, 2018).

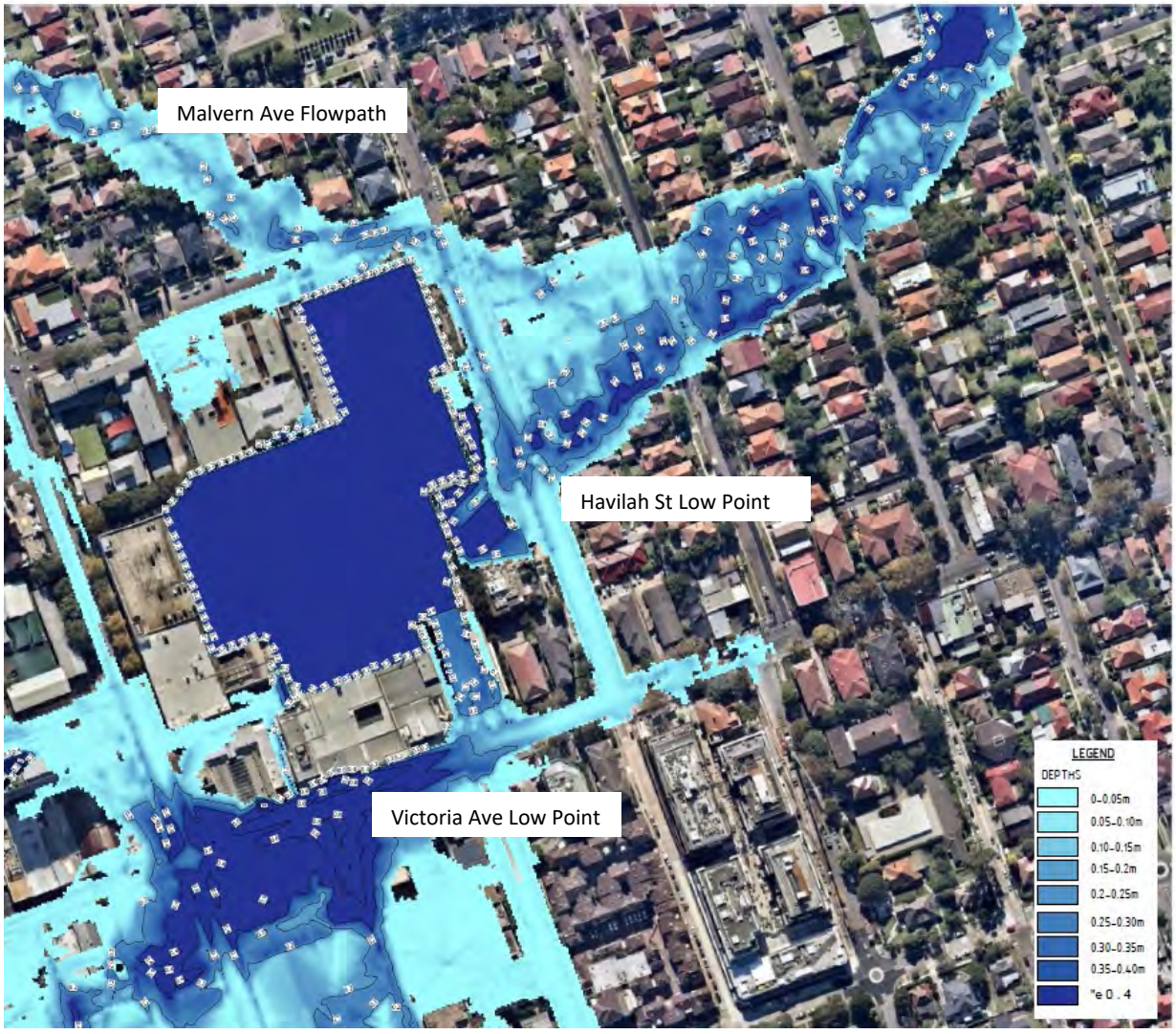


Figure 2-7. Victoria Avenue, Havilah Street Low Point, and Malvern Ave Flowpaths (CJ Arms, 2018)

2.2 Historical Flooding

There have been records of historical flooding in the vicinity of the centre. The following has been compiled based on discussions with Vicinity Centres and Council in the meeting on 14 January 2019, as well as the available reports for the area.

Table 2-1. Overview of Historical Flooding Events

Flood Event	Observations
April 1998	Anecdotal evidence suggests this was near a 1% AEP event (with 280mm of rainfall over a 24 hour period) (CJ Arms, 2018). The Asian supermarket on Victoria Avenue (located in the basement of this neighbouring building, approximately 100 metres west of the basement entry to Chatswood Chase) was flooded to a depth of around 900mm. Lyall & Associates (2008) identified that water flowed into the Chatswood Chase basement carpark – although it is unclear as to the magnitude of this.
2010	There was no forecast for this event, with very little time to respond. Flooded Victoria Avenue with water up to the hairdresser. Some water entered the basement but nothing significant.
November 2013	Flooding of the police station basement carpark. No information on flooding at Chatswood Chase.
June 2016	Flooding of Chatswood Oval (acting as detention). No information on flood at Chatswood Chase.
November 2018	Approximately 350mm of water on Victoria Avenue. No flooding of the basement. Some issues in the centre with a burst stormwater pipe (understood to be roof drainage).

2.3 Previous Redevelopment

As identified in Section 1, Chatswood Chase was subject to a major redevelopment which was completed in 2009. This redevelopment was classified as a Major Project (MP) and subject to Conditions of Approval issued by the Minister for Planning in December 2007 (MP06-0301).

The key consent condition related to flooding was condition B32, reproduced below:

> *Prior to issue of Construction Certificate CC3 a Flood Study shall be completed in accordance with the undertaking of Ove Arup Pty Ltd in a letter dated 5 September 2007. The results of the Flood Study shall inform the detailed design process for works in Zones D and E. Any amendments to the development plans noted in Condition A2 shall be approved by Willoughby City Council. The flood study shall be sufficiently completed prior to CC2 to also inform the detailed design on pumping or other measures to deal with water penetration should any water penetration occur. The basement car park levels shall require a pump-out drainage system comprising two submersible type pumps. The system shall be designed to work on an alternative basis to ensure both pumps receive equal use and neither remains continuously idle. In the event of power failure the system is to provide a holding well which has storage capacity equivalent to the run-off from a 2 hour 100 year ARI storm*

or as otherwise determined by the Flood Study. Grease, oil and sediment must be separated from water before water enters the stormwater drainage system.

It is understood that the GHD (2007) Flood Study sought to address the requirements of this condition. The GHD (2007) study shows significant volumes of water entering the basement carpark, and associated depths in the basement, as identified in Section 4.2.8.

The Flood Management Plan, prepared by Arup (2008), was prepared to mitigate the risks identified the GHD (2007) report. This Flood Management Plan primarily focused on flood emergency response planning in order to mitigate the risk of basement inundation. Other mitigation measures focused on protecting entry points to prevent the ingress of water to the shops of the centre.

2.4 Council Draft Conditions of Consent (DA2017/503)

Council undertook an assessment of the proposed DA for the Chatswood Chase redevelopment (Council, 2018). This assessment gave rise to a set of draft consent conditions for the development. The following provides an extract of the relevant flood portions of Council's draft conditions of consent:

6. Flooding

a) Flood Protection Measures

The applicant must develop and submit to Council measures designed by qualified a Civil engineer experienced in Flood analysis which are to be incorporated into the redevelopment of Chatswood Chase to prevent the ingress of overland flow into the carpark areas (existing and proposed) for all storm events up to the Probable Maximum Flood (PMF).

(Reason: Prevent property damage)

b) Flood Mitigation Measures

The applicant must develop measures designed which are to be incorporated into the redevelopment of Chatswood Chase to prevent any adverse flooding conditions being experienced in areas external to the site for all storm events up to the 1% Annual Exceedance Probability (AEP). A Flood Report prepared by a qualified Civil engineer experienced in Flood Analysis incorporating blockage factors to the trunk drainage system must be adopted as per Council's DCP and Technical Standards No.3 shall be submitted to Council.

(Reason: Managing flood risk)

c) Flood Mitigation Assessment

The applicant is to demonstrate to the satisfaction of Council that the proposed redevelopment of Chatswood Chase will not increase the risk of life in areas external to the site for storm events between the 1% Annual Exceedance Probability (AEP) and the Probable Maximum Flood (PMF). The assessment is to be carried out by a qualified civil engineer for the 0.5%, 0.2%, 0.1% and 0.05% AEP flood event, as well as the PMF and submitted to Council for assessment.

(Reason: Managing flood risk)

3 Available Data

The following provides an overview of the data that was made available to Rhelm and forms the basis of this review.

3.1 Documents

3.1.1 Flood Reports

There have been several flood studies and flood assessments that have been undertaken for Chatswood Chase and the Scotts Creek Catchment. The key studies relevant to the review are provided in Table 3-1. Of these, the two key studies are the CJ Arms (2018) flood study, which was undertaken for Vicinity Centres for the current application, and the Lyall & Associates 2011 Flood Study, which was undertaken for Council for the Scotts Creek catchment.

Table 3-1. Flood Studies

Author	Title	Date	Description
CJ Arms	Chatswood Chase Flood Modelling Report	September 2018	Flood report prepared for the proposed development at Chatswood Chase. This is the primary report prepared for Vicinity Centres for the flood behaviour at the site.
Lyall & Associates	Scotts Creek Updated Flood Study (2011)	December 2011	Flood study prepared for Council to define the flood behaviour in the Scotts Creek catchment. This flood study was based on the original 2008 flood study but updated the DRAINS modelling to represent some of the changes in the catchment, particularly those associated with The Concourse project. In addition, Lyall and Associates updated to the hydraulic model to a 2D Tuflow model, improving the previous 2008 HEC-RAS modelling (and DRAINS modelling) that was undertaken.
Lyall & Associates	Scotts Creek Flood study	March 2008	Flood study prepared for Council for the entire Scotts Creek catchment. Modelling undertaken through a combination of DRAINS and HEC-RAS for the channel flows. This is the adopted flood study for the area by Council. However, it is noted that the 2011 updated flood study provides more up to date information for the local area, particularly to changes that have occurred upstream with The Concourse development.
ARUP	Chatswood Chase Redevelopment Flood Management	July 2008	This report was prepared for the Chatswood Chase redevelopment that was completed in 2009. It provides the emergency response planning for the centre in the case of a flood. It is understood that it is intended for this to be updated as a part of the current redevelopment of the centre (identified by Vince Russo in Meeting 1 (see Table 1-1).
GHD	Chatswood Chase Redevelopment Flood Study	December 2007	This flood assessment was undertaken by GHD for ARUP as a part of the Chatswood Chase redevelopment application at that time. The flood modelling was focused on definition of the existing flood behaviour around the shopping centre. It is noted that changes upstream of the catchment (The Concourse etc) will alter the outcomes of this analysis.

3.1.2 Other Documentation

Other documentation relevant to the review is listed in Table 3-2.

Table 3-2. Other Documentation

Author	Title/ Subject	Date	Description
Sydney North Planning Panel	Record of Deferral	19 December 2018	Record of Deferral from Sydney North Planning Panel following the meeting dated 19 December 2018. This provides the reasoning behind the deferral as well as the need for an independent hydraulic expert.
Vicinity Centres	Letter to Sydney North Planning Panel on flooding	18 December 2018	This letter to the Sydney North Planning Panel outlines Vicinity Centres response to the Councils draft conditions of consent (see item below) to the flooding aspects and following a meeting with Council on 17 December 2018
Urbis	Letter to Sydney North Planning Panel on Amendments to Draft Conditions	14 December 2018	This letter provides Vicinity Centres response and amendments to the draft conditions of consent as outlined in the Council Assessment Report from 7 December 2018 (see below). In regards to flooding it attached the CJ Arms letter from 12 December 2018, as identified below.
CJ Arms	Memorandum to Vicinity Centres on the Council Assessment Report and Conditions of Consent	12 December 2018	This memorandum was provided to Vicinity Centres to summarise CJ Arms response to each of the conditions of consent from Council in the Council Assessment Report (see below).
Willoughby Council	Council Assessment Report	7 December 2018	This report provides an overview of Council's review of the DA application. Its recommendation is for a Deferred Commencement Approval with Conditions of Consent outlined in Schedule 1 of the report. These conditions of consent are outlined further in Section 2.4.
Colonial First State	Letter to Council summarising the proposed Flood Management	March 2008	This letter was provided to Council following a meeting in February 2008 and provides a summary of proposed flood management measures associated with the redevelopment of the shopping centre at that time. This included: • Mitigation Measures • Flood Alert System • Staged Response Plan • Operational procedures associated with the flood emergency response plan
Minister for Planning	Determination of Major Project No. 06_0301	19 December 2007	This provides the Ministers approval for the proposed redevelopment of the Chatswood Chase shopping centre (at that time), including the recommended conditions of approval.

Author	Title/ Subject	Date	Description
ARUP	Chatswood Chase Redevelopment Flood Study Methodology	5 September 2007	This letter from ARUP to Coffey Projects outlines the proposed flood study methodology for the Chatswood Chase Redevelopment at that time.

3.2 Hydrologic and Hydraulic Models

3.2.1 CJ Arms Models

CJ Arms provided the hydrological and hydraulic models that were used to define the existing scenario modelling for the proposed development. A summary of these models is provided in Table 3-3.

Table 3-3. CJ Arms Models

Type	Software	Description
Hydrology	RORB	The existing condition RORB model was provided by CJ Arms on 14 January 2019. The outputs from the model were provided on 17 January 2019.
Hydraulics	Tuflow	The existing condition Tuflow model, with 50% pit blockage, as defined in the CJ Arms (2018) report, was provided to Rhelm on 14 January 2019. Some additional input files were subsequently requested and provided on 17 January 2019. CJ Arms also provided the model outputs and results on 17 January 2019.

3.2.2 Council Models

Council provided hydrological and hydraulic models from the 2011 updated flood study for Scotts Creek (Lyall & Associates, 2011). Details are provided in Table 3-4.

Table 3-4. Council Models

Type	Software	Description
Hydrology/ Hydraulics	DRAINS	DRAINS models were provided by Council on 11 January 2019. There were three separate DRAINS models that were provided: • Scotts Creek DRAINS Model • Post-Concourse DRAINS Model • City-Wide DRAINS model These models were used to provide inflows to the Tuflow model below. An overview of the application of the three models and where inflows were applied is detailed in Lyall & Associates (2011).
Hydraulics	Tuflow	The model setup files were provided by Council on 11 January 2019. These included the boundary inputs, model components and run setup files.

3.3 Survey Data

3.3.1 Site Survey

Survey was provided to Rhelm by CJ Arms on 17 January 2019. The survey plans were prepared by RPS Australia East Pty Ltd, dated 4 December 2017 (Drawing number PR138237-DTL-002-B, Sheets 1 to 7). This survey primarily defines the ground levels on the streets that border Chatswood Chase, being Victoria Avenue, Archer Street, Malvern Street and Havilah Street. The survey also defines the ground levels for the basement entry ramp to the Chatswood Chase carpark. An overview of the survey extent is provided in Figure 3-1.

Figure 3-1. Overview of Ground Survey (RPS Australia East Pty Ltd, 2017)

3.3.2 Catchment Terrain

CJ Arms (2018) identified that 0.5 contour LiDAR data was used as the basis to define levels in their hydraulic model beyond the extent of the ground survey (Section 3.3.1). This data was used to generate a digital elevation model (DEM) of the catchment relevant to the site. The DEM was provided by CJ Arms (2018) as a part of the Tuflow hydraulic model in an ascii grid format.

3.4 Design Plans

A summary of the relevant design plans that were available from Council's online DA portal are provided in Appendix C.

3.5 Information provided following the Issue of the Draft Review

A volume of information was provided immediately prior to or following the issue of the Draft version of this Review on 23 January 2019. This information is listed in Table 3-5 and is discussed further in Section 7.

Table 3-5. Information Provided in Response to Draft Review

Author	Title/ Subject	Date	Description
Willoughby City Council	Memo to Rhelm - Council's Position on Flood Requirements	21 January 2019	The memo seeks to confirm the background to Council's position with respect to the issues at the site. The memo includes an attachment which is a mark up of the hazard curves commonly referenced as McLuckie et al, 2014 for the existing flood scenario at the site.
Vicinity/CJ Arms	Chatswood Chase Flood Modelling Review - Amended Model Results	1 February 2019	Email from Vicinity to Rhelm/Council forwarding Email from CJ Arms dated 31/01/2019 and accompanying revised flood model results (extent and depth) in response to flood model re-schematisation arising from Rhelm review comments dated 23 Jan 2019.
CJ Arms	Flood Model Results for Concept Option	8 February 2019	Email from CJ Arms to Rhelm/Council with flood model results for concept option discussed at meeting of 4 Feb 2019.
CJ Arms	Concept Option Plan and Long Section	15 February 2019	Email from CJ Arms to Rhelm/Council with concept plan and long section and flood model results for concept option discussed at meetings of 4 Feb 2019 and 8 Feb 2019.
CJ Arms	Revised Modelling and Updated Concept Option and Long Section	20 February 2019	Email from CJ Arms to Rhelm/Council with updated model results, concept plan and long section discussed at meetings of 4 Feb 2019, 8 Feb 2019 and 15 Feb 2019.

4 Review of Flood Analysis

As a part of this independent review, Rhelm has undertaken a review of the flood modelling that was undertaken by CJ Arms which informed the work in their report (CJ Arms, 2018). It is noted that this section of the report was prepared based on the CJ Arms (2018) modelling work. As a result of this review, CJ Arms undertook some revisions to the modelling and this is discussed further in Section 7.

The flood modelling is comprised of two separate models:

- Hydrological model to estimate the runoff from the catchment. CJ Arms adopted the RORB software for the hydrological modelling;
- Hydraulic model to estimate the flow characteristics (flood depths, water levels, velocities etc). CJ Arms used the Tuflow software (with one-dimensional and two-dimensional elements) to undertake this analysis.

A review of the model setup and configuration is provided in the following sections.

4.1 Hydrological Models

The CJ Arms (2018) hydrological model was completed within RORB. The RORB model was supplied to Rhelm as part of this project and has been reviewed. Supplied was the CATG file, "*20180709 Chatswood Chase Lumped Hydrographs.catg*", and the results files for the 1% AEP existing conditions. The parameter files were not supplied for this review and results for the climate change were not supplied.

This meant the IFD parameters could not be directly checked and the inputs for the climate change runs could not be assessed.

4.1.1 Australian Rainfall and Runoff 2016

Australian Rainfall and Runoff 2016 (ARR2016) (Ball et al., 2016) provides the latest guideline document for flood analysis in Australia and updates the previous Australian Rainfall and Runoff from 1987 (ARR87). Given the relatively recent release of ARR2016, many councils are still in a transitionary period of adopting ARR2016 in their various flood studies or flood study updates that are being undertaken. In many cases, ARR87 is being continued to be used for development assessment while councils understand the implications of ARR2016 within their LGAs.

In this development assessment, CJ Arms (2018) has adopted ARR87 for the modelling work. It is unclear if this is based on direction from Council. However, given that the current flood study for the area from Council was undertaken in ARR87, it provides a more ready comparison with that previous study. If this is part of Council's current approach to development assessment, then this may be appropriate.

One feature of ARR2016 is the adoption of more than one temporal pattern for each rainfall duration that is assessed. In some urban catchments, rainfall patterns may not provide a large influence on the peak flows. However, it may influence the timing and volume characteristics of the hydrograph. This can be important for areas such as the ponding that occurs on Victoria Avenue and the subsequent volume entering the basement.

4.1.2 Catchment Definition

The RORB CATG model was setup using the sub catchment delineation as shown in Figure 4-1. It is noted that the RORB catchment has not been spatially setup using GIS. This makes it more difficult to assess flow path lengths and elevations. However, a manual check of the sub catchments has been completed for area, slope and reach length and these were found to be suitable. The CATG file was setup using lined channel / pipe reaches which is appropriate for this urban setting.

Some of the downstream catchments were not explicitly modelling in RORB (Figure 4-1) and were not included in the modelling. Refer to Section 4.2.1.

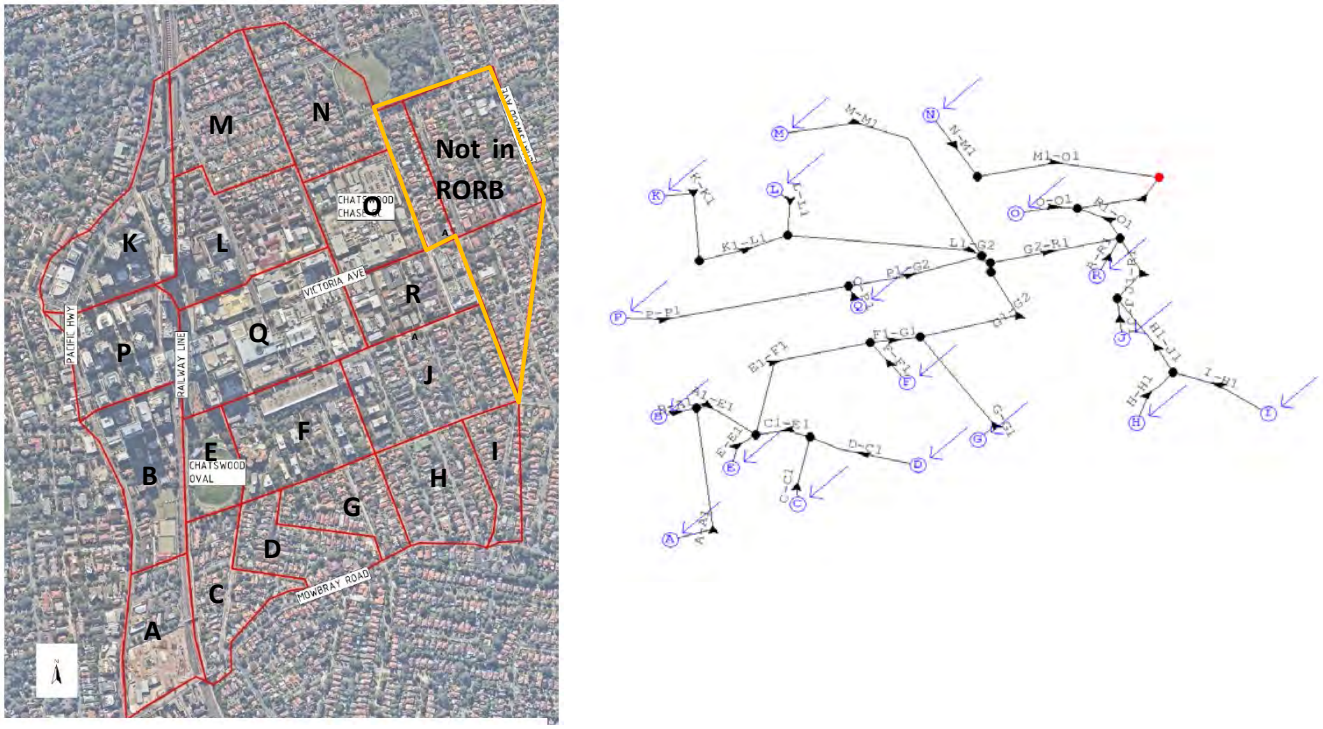


Figure 4-1. RORB sub catchments and CATG setup (CJ Arms, 2018)

4.1.3 Fraction Impervious

The fraction impervious was assessed against the values within the CJ Arms model and the CJ Arms (2018) report (Table 4-1). Overall, most sub catchments were suitably defined with fraction impervious (FI) values ranging from 60% to 85%. Generally, there were some sub catchments where the values appeared to be too low, particularly catchment "L" which was set at 30% imperviousness. This area is north of Ferguson Lane with a boundary at the rail line and has some relatively dense urban areas, with the remainder residential housing which would be expected to be higher than 30% impervious.

The overall area weighted fraction impervious for the catchment was 66% using the CJ Arms values. Rhelm undertook an independent estimate of the imperviousness and estimated this to be closer to a catchment weighted 78% (Table 4-1). This suggests that there could be an increase in the FI to add some conservatism and be closer to the actual impervious fraction for the catchment (which in turn would result in a greater amount of runoff).

To understand the potential effect of this change, Rhelm have undertaken some preliminary hydrological modelling with these higher imperviousness values in the CJ Arms RORB model. These runs resulted in peak flows at the boundary of the model (downstream of Chatswood Chase) increasing by 4 to 8%. The largest change was to sub catchment L due to the large change in imperviousness and was in the order of a 24% increase in peak flow. Overall the changes are relatively low through the model with the end of model flow increasing by 4% to 8% across the 1% AEP event durations.

Table 4-1. Fraction impervious review for the RORB model

RORB Sub Catchment	Area (Ha)	CJ Arms Fraction Impervious (FI)	Rhelm review of FI	Comment
A	5.7	0.85	Ok	
B	7.4	0.8	Ok	
C	5.7	0.75	0.8-0.85	Slightly low based on the aerial imagery
D	4.9	0.75	ok	
E	3.4	0.4	ok	Chatswood oval is in this catchment, hence the lower FI
F	8.1	0.8	ok	
G	4.6	0.75	ok	
H	6.5	0.73	ok	
I	5.4	0.72	ok	
J	9.7	0.8	ok	
K	8.8	0.6	0.8-0.85	This area is quite a dense urban area, suggest increase
L	9.2	0.3	0.85	Unclear why FI was 0.3. Recommend higher value
M	8.3	0.65	0.65-0.75	Generally ok, although could be increased.
N	8.0	0.6	ok	
O	6.1	0.6	0.9	Given the density in this area, suggest an increase
P	6.9	0.6	0.8-0.9	Very dense commercial areas included
Q	11.9	0.6	0.9	Very dense commercial areas included
R	5.3	0.8	ok	
S	8.6	0.7	ok	Not included in supplied CATG file
T	2.7	0.7	ok	Not included in supplied CATG file
U	9.7	0.6	0.7-0.75	Not included in supplied CATG file
Total Area and Avg. FI	**146.9**	**0.66**	**0.78**	**The area weighted FI could be higher based on the review.**

4.1.4 Design Simulations

The RORB assessment used an initial loss and runoff coefficient (RoC) approach to runoff routing. The initial loss was set at 12 mm and the RoC was set at 0.6. This is a typical loss rate for RORB and should be suitable for this area.

The Intensity-Frequency-Duration (IFD) parameters have been determined from ARR87. These have been independently sourced from the Bureau of Meteorology (BoM) and tested within the RORB model. The results indicate that the IFD parameters have been sourced suitably, however the original IFD values were not supplied for review.

The design events have been assessed using filtered patterns (to avoid embedded storms) and the Siriwardene and Weinmann areal reduction factors. These are appropriate for the assessment of the catchment given the study area.

The 1% AEP design flood event was simulated by Rhelm using the BoM IFD parameters, RORB version 6.42 and using the same loss rates, RoC and ARI factors as the CJ Arms model and the output hydrographs were consistent.

4.1.5 Summary of Hydrology Review

Overall, the fraction imperviousness assumptions are considered to be too low for some catchments, particularly for the very dense urban areas within Chatswood. More conservative assumptions would result in higher flows in the model, roughly 4 – 8% at the downstream end of the model. The influence of this on the hydraulic model has not been assessed at this stage and would be worth incorporating in the assessments given that flood storage effects in the catchment are influential on design flood behaviour.

Updating the hydrology to ARR2016 is not recommended at this stage due to the need for reference to the previous studies and a lack of definitive Council guidelines for parameterisation. It could be worth checking to manage risk but at this stage the comparison is based on the original studies which used the ARR87 information.

No checks were made on the climate change hydrology as these result files and storm files were not supplied. It would be expected that rainfall intensity increases of 10-20% would be reasonable to design for given the design life of the proposed modifications to the site.

4.2 Hydraulic Models

4.2.1 Inflows to TUFLOW

The RORB model was used to generate excess rainfall hydrographs for the hydraulic model. These are transferred to TUFLOW via the excess rainfall hydrographs within the "*bc_database*". Within the hydraulic model the excess rainfalls were then split via equal distribution to the pits within the sub catchments or to the low point within the sub catchment where there were no pits.

Within the bc_database there are three locations assigned as zero hydrographs. These correspond to catchments "Not in RORB" in Figure 4-1. These are all located downstream of the site of interest so are unlikely to influence the basement storage volumes, however they will influence the downstream flood behaviour and the carrying capacity of the 1D network downstream of the site.

Inspection of the models by Rhelm found that there was some inconsistency with the selection of the output hydrograph from RORB as some excess rainfall may not have been selected appropriately. This seems to have been caused by the output order of RORB not matching the sub catchment assigned names. The review assessed the hydrograph output order within the RORB catchment editor and this did not match the order applied to TULOW in the bc_database.

To assess the influence of this finding on the hydraulic model, the TUFLOW model was run by Rhelm using the hydrographs for the 1% AEP, 2 hour duration design flood with the hydrographs selected based on the approach of utilising the excess rainfall from each sub catchment. No other changes were made to the model (i.e. no fraction impervious changes or catchment delineation changes).

The TUFLOW results were compared using the peak flood levels for the 1% AEP, 2 hour duration with 50% pipe blockage and on site detention added (this was supplied by CJ Arms). The resulting peak level difference is shown in Figure 4-2. The difference is the revised model run (Rhelm) less the results supplied by CJ Arms. Hence a positive difference indicates that the updated run produced higher levels than the original run and negative differences indicate lower levels produced by the update.

For most of the area there was limited change to the inflows hence there were only small changes to the results. Upstream of Ferguson Lane there was an increase in levels of 5 to 12 cm. Similarly, other flow paths have some minor changes. At the Chatswood Chase centre the levels along Victoria Street are not influenced greatly and the car park flood levels increase by approximately 2cm.

Overall, the change in inflow hydrographs did not change the results by a large amount but the flow distribution through the catchment was altered.

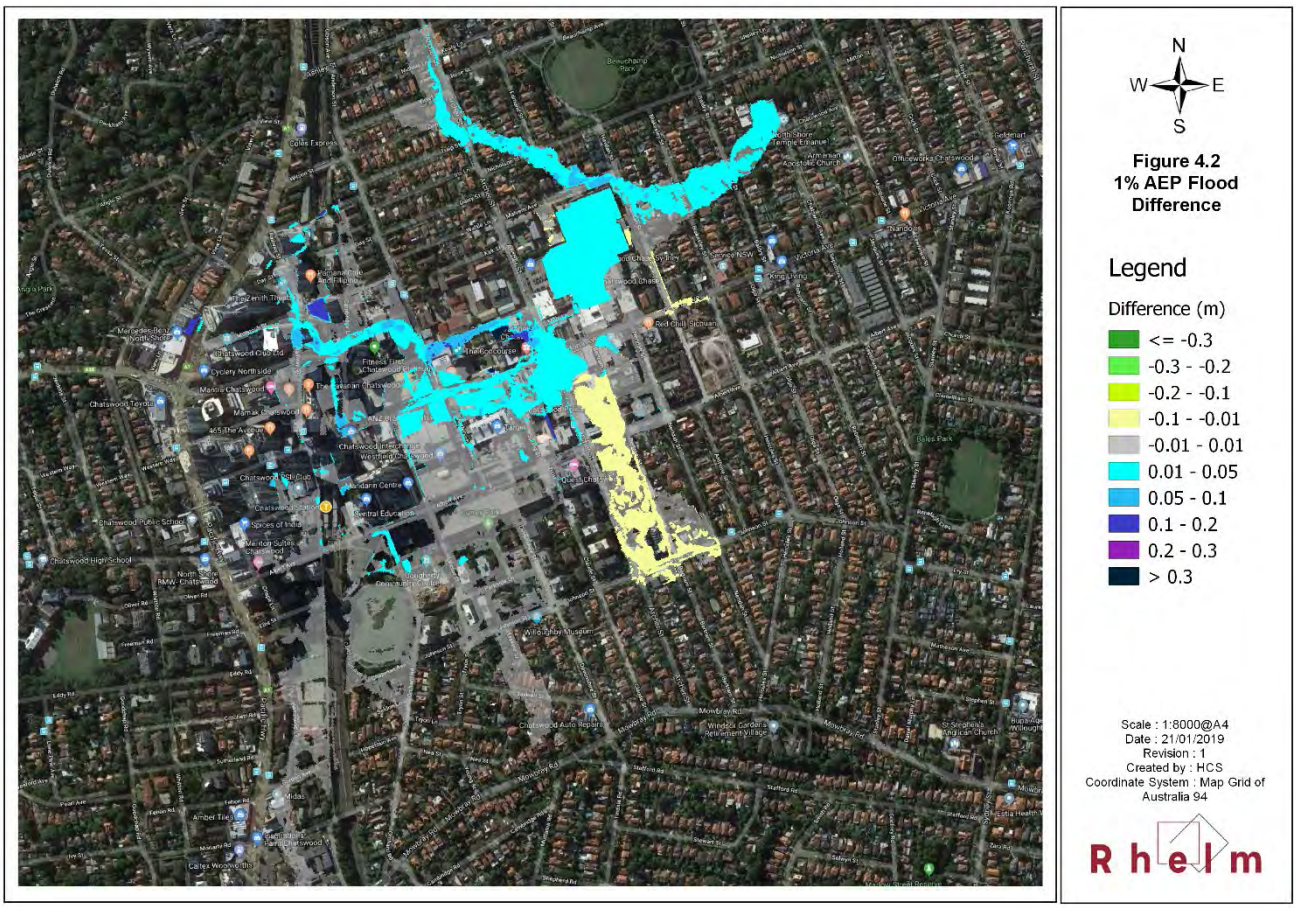


Figure 4-2. Difference plot 1% AEP, 2 hour with OSD - RHELM inflows versus CJ Arms inflows

4.2.2 DEM – Local Area

The DEM from the supplied TUFLOW model is shown in Figure 4-3. The basement has been set at 75.8mAHD which corresponds to the lower carpark level (B2) of the site under existing conditions. The car park entry matches the supplied survey information at 83.3mAHD. The corner of Victoria Avenue and Archer Street is set at 83.75mAHD and the corner of Victoria Avenue and Havilah Street is set at 83.85mAHD. The car park is known to have a lower level than both these locations which results in the preferential flow into the car park. This matches what is expected from the survey and the site inspection conducted by Rhelm.

Overall the DEM matches what is expected for the site and appears suitable for the assessment.

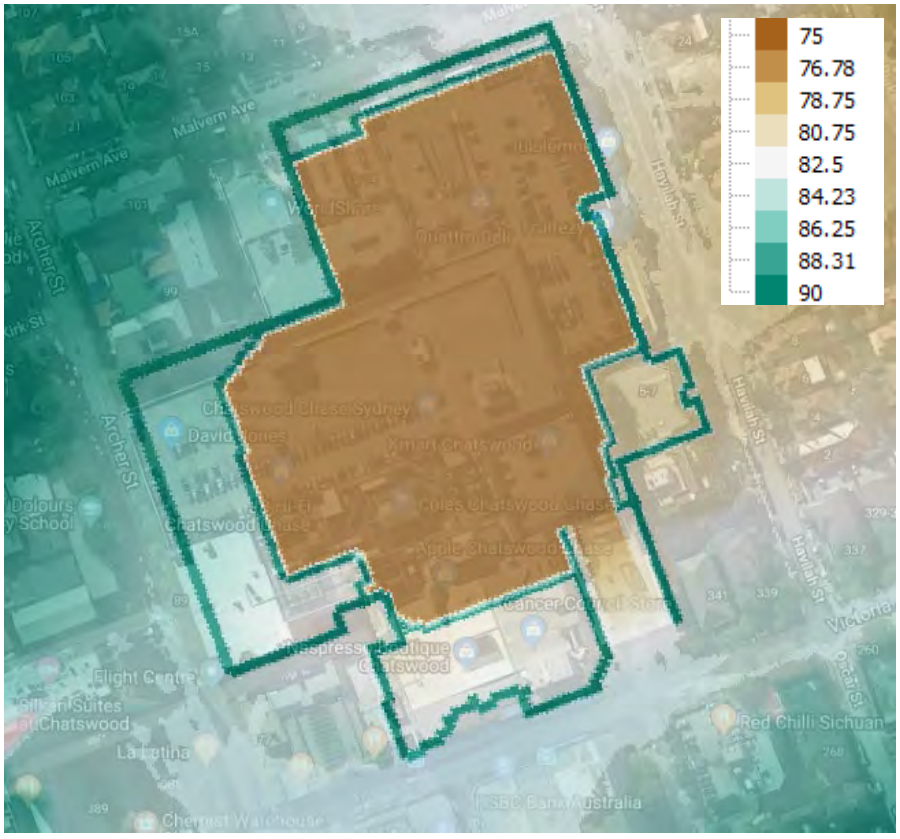


Figure 4-3. DEM from the supplied TUFLOW model around the Chatswood Chase Centre

4.2.3 Buildings / Flow Paths

A review of the flow paths within the hydraulic model was undertaken visually following the rerun of the TUFLOW model. A few locations where flow paths may require some modification were noted. The key locations are discussed.

Westfield site – Flows through the Westfield Shopping Centre at Albert Street and Spring Street are unlikely (Figure 4-4). In the Lyall & Associates (2011) modelling this building was blocked from the hydraulic model to force flow around the site. The flow paths would be more likely restricted to the street in this instance and flows would be forced around the building. In the CJ Arms (2018) modelling the buildings were not blocked out, allowing flows to move through the Westfield shopping centre. This may alter the timing of flows arriving at the downstream Chatswood Chase Shopping Centre. But this is likely to be conservative as flows will be arriving sooner than if the building was blocked from the floodplain.

Figure 4-4. Flow path noted through the Westfield Shopping Centre (CJ Arms Model Results)

Regency Tower – The flows at this location are more likely to pool at the sag of Help Street before flowing around the corner as shown in Figure 4-5. There is flood protection here to stop flows entering the site. As the building is not blocked in the CJ Arms (2018) model, flows are able to cut through the building reducing the ponding that is likely to occur in this location. As this is upstream of Ferguson Lane this may be worth refining as it will affect the flow timing at the site.

Figure 4-5. Flows passing through the Regency Tower site at Help Street

Chapman Ave / Chatswood Oval – There is a sizable connection under the railway at this location (the shared pathway). Currently there is a large volume of water trapped in the model upstream that would freely flow through to Chatswood Oval. This influence of this may not be large as Chatswood Oval is not yet at full capacity in these model runs but the connection should be included in model runs. The location of the underpass is shown in Figure 4-6 for reference.

Figure 4-6. Large flow connection to Chatswood oval under the railway line

4.2.4 Artificial Trapped Low Points

There are also a few additional locations in the CJ Arms model where there are artificial trapped low points noted. Some of these include:

- Sandcastles Childcare (1 Cambridge Lane)
- Meriton Suites Chatswood (79 Albert Street)
- Ecclesia Mission (Victoria Street)
- Tingha Street and Parkside Lane (reaches 1.9m depth)
- Ferguson Lane (reaches 2.9m on the 1D storage node)

These artificial low points appear to be caused by DEM tin issues. They are not likely to take a significant volume of floodwater from the model, but it is worth noting that these are not actually flood storage areas and could instead have the buildings blocked to remove these issues from the CJ Arms model.

These example locations are shown in Figure 4-7 for reference.

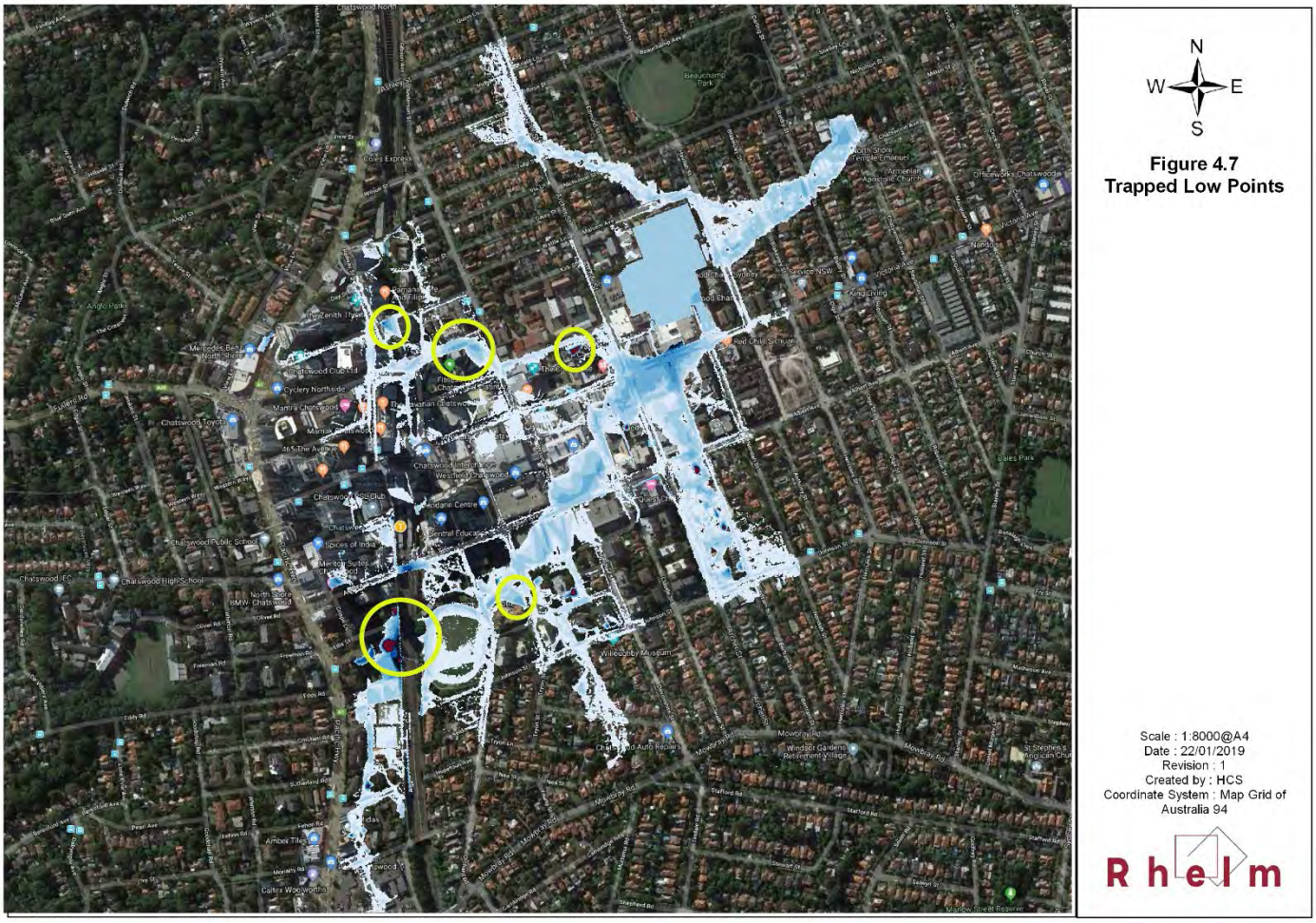


Figure 4-7. Artificial trapped low point examples

4.2.5 Representation of Basins/ Detention

The key flood storage locations within the study are the Chatswood Oval, Ferguson Lane storage and the Chatswood Chase basement car park (Levels B1 and B2).

Chatswood Oval is discussed within the CJ Arms report as having less volume available for storage than previously reported. This is a conservative approach to the assessment of flood storage in this location. It should be noted however that this location is compromised as the upstream flow above the railway line are limited to the pipe connection and the underpass is not included within the model (see Section 4.2.3).

The Ferguson Lane storage tank is reported to have a capacity of 5000m^3 which was confirmed by Council during the site inspection. Council suggested that approximately 2000m^3 of this storage is set aside for the 88 Ferguson Lane development flood mitigation. The system is linked to Weatherzone and pumps down prior to any event.

Hence the assumption that 2000 or 4000m^3 of storage volume is available is reasonable by CJ Arms in their assessment of mitigation options. Within the hydraulic model the tank is represented by a 1D storage which has a stage-storage relationship that allows for storage up to 4000m^3 of volume. Of concern however is that there is also some 2D surface storage at this location. In the 1% AEP, 2 hour event this reaches 2.9 m of depth over an area of 170m^2, this adds some storage volume that may not be available.

The Chatswood Chase car park has been setup at the B2 carpark level with the entrance suitably defined. For the purpose of this assessment this model definition is considered to be reasonable.

4.2.6 Mills Lane Inundation

Mills Lane is located upstream of the intersection of Victoria Avenue and Archer Street. It is understood to have some inundation during larger flood events that becomes trapped at a loading dock located in this area. From the hydraulic model results there appears to be a flow path that is active passing from Victoria Avenue to Mills Lane. It is worth establishing if this flow path would be active during inundation events as this appears to be an important source of flooding in Mills Lane, contributing to the ponding in this area. Figure 4-8 and Figure 4-9 shows a view of where this flowpath is, and it is understood to represent an access way through a closed door shown in the photo. From discussions (V Russo, pers comm 14 January 2019), it is understood that there is some access corridor through this location. Given the doorway in this location, it is unclear how much water would actually move between Victoria Avenue and Mills Lane. Depending on the risk to inundation of the loading dock (see Section 6.1.1) this may need to be reviewed.

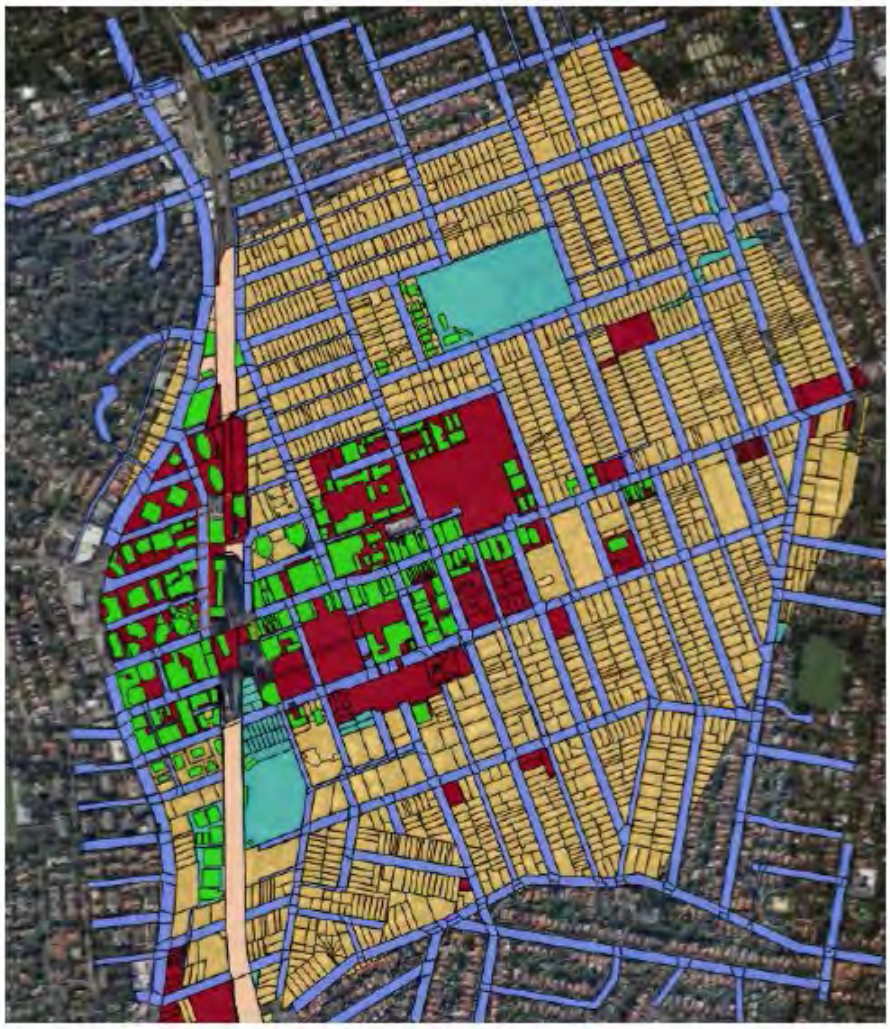
Figure 4-8. Flow connection to Mills Lane from Victoria Avenue (1% AEP, 2 hour event)

Figure 4-9. Flow connection to Mills Lane from Victoria Avenue (1% AEP, 2 hour event)

4.2.7 Roughness

The hydraulic model roughness used within the CJ Arms model is shown in Figure 4-10. The values are reasonable for the commercial buildings and properties. Roads are in line with expectations as are parks and the railway line. The residential properties roughness is low relative to industry standard and the likely barriers to flow within residential properties i.e. fences, buildings, garden beds etc.

This is not expected have a large impact on results, but it may allow for overland flows to reach the site of interest faster than expected. This is likely to be conservative for the Chatswood Chase basement car park as increased roughness would slow overland flows to the basement car park entry point.



Manning's 'n' Roughness	
Residential Properties	0.05
Commercial Properties	0.1
Commercial Buildings	0.4
Roads	0.02
Parks & Reserves	0.03
Railway Line	0.02

Figure 4-10. Hydraulic roughness within the CJ Arms TUFLOW model

4.2.8 Boundary Conditions

The CJ Arms model assumes a downstream boundary with a constant level of 73.5mAHD. This has been based on the observed level at Chatswood Avenue reported by Council following the 1998 flood event. This location is suitably downstream to not interfere with the assessment of the location of interest and is suitable for the assessment.

4.2.9 Critical Duration

CJ Arms (2018) identified that the 2 hour duration was the critical duration for the study area (i.e. Victoria Avenue near Chatswood Chase). Results were also provided as plans for the 1 hour and the 4.5 hour duration, and it would appear that the 2 hour produces the critical inundation of the basement carpark and therefore is the critical duration. This appears to be an appropriate assumption, noting that the adjustment of other factors identified elsewhere in this report may affect this conclusion.

4.2.10 Reported Level Issues

The CJ Arms reporting of peak levels (CJ Arms, 2018) is difficult to verify as the specific point locations for comparison have not been mapped for comparison to the flood depth and level mapping. Similarly, there are

no level and depth difference maps for the various scenarios to illustrate areas of change of flood behaviour across the floodplain.

The review of the peak flood levels indicates that there are some concerns with the runs as the 1% AEP, 10% climate change scenario at the site (CCSC) Basement (using 50% pipe blockage) indicates a peak level of 76.155mAHD, which is lower than the existing conditions and design conditions at the same location.

A summary of the Existing, Design and 10% Climate Change results extracted from Table 5 and 6 (CJ Arms, 2018) is shown in Table 4-2. The levels in the CCSC Basement and at Havilah Street are lower in the climate change run as compared to the existing results, whereas the Mills Lane levels are 39 cm higher in the 10% climate change. It is not evident why this is the case as the 10% climate change should be higher throughout the catchment.

Table 4-2. Peak levels extracted from Table 5 and Table 6 (CJ Arms, 2018)

1% AEP Event	**Existing (50% blk)**	**Design Cond. (50% blk), 2000 m^3 Detention**	**Design Cond. (50% blk), 4000 m^3 Detention**	**10% Climate Change (50% blk)**	**Difference (10%CC less Existing)**
CCSC Basement	76.268	76.252	76.158	76.155	**-0.113**
Havilah Street	79.92	79.908	79.876	79.895	**-0.025**
Victoria St at basement entry	83.788	83.793	83.78	83.789	0.001
Intersection Havilah and Victoria	83.986	83.986	83.986	83.99	0.004
Victoria Street Ped entry	84.02	84.04	84.004	84.055	0.035
Intersection Archer St and Victoria	84.14	84.153	84.126	84.196	0.056
Mills Lane	81.701	81.712	81.705	82.092	**0.391**
Unknown (no label in report table)	82.294	82.296	82.295	82.313	0.019

These differences raise some question as to why the levels are inconsistent and indicate further checking for consistency across the model scenarios and runs. Consideration should be made for supplying depth difference plots for scenario runs comparing back to the base case to demonstrate where depths and levels are changing in each scenario. At present the changes are only based on seven (7) point locations.

Rhelm recommends developing difference plots for the design flood model runs against the base case scenario to assist with determining the influence that each developed run has on the flood depths and levels throughout the catchment around the Chatswood Chase Shopping Centre. At present there is some ambiguity as to the reasons for the lower levels in the 10% climate change results.

4.3 Comparison with Previous Studies

The results of the CJ Arms (2018) flood study was compared with the previous studies that have been undertaken for the area. A summary of the peak flood levels is provided in Table 4-3. A comparison of the flood levels and flood volumes entering the Chatswood Chase shopping centre basement are provided in Table 4-4.

The model results show that the levels are generally consistent across the models. In areas like the low point on Victoria Avenue (at the Chatswood Chase pedestrian entry), all models generally align and this suggests similar volumes of water reaching this storage between the models.

However, the volumes between the models differ in terms of the water entering the basement carpark. Lyall & Associates (2011) suggests around 12,000m^3, while CJ Arms (2018) has around 8,300m^3. This difference may be due to the slightly higher levels on Victoria Avenue near the carpark entry in the Lyall & Associates (2011) model, or slightly lower assumed driveway levels, which would result in additional water overtopping the driveway and entering the carpark. This results in slightly deeper ponding in the basement under the Lyall & Associates (2011) model (0.6 metres versus the 0.47 metres in the CJ Arms (2018) model). Overall, this is within the order of accuracy of the two models and suggests that the two models are producing reasonably consistent results for this critical location.

The GHD (2007) model suggests significantly higher volumes entering the basement carpark. It is not clear why this is the case. It is possible that the entry levels to the carpark were not the same as the current levels. Given that this model is now older and predates the 2007-2009 redevelopment of Chatswood Chase (see Section 2.2), as well the works at The Concourse, it would be recommended to not utilise this model for the selection of design flood levels.

While not reported, CJ Arms (2018) provided figures for the 20% AEP and 0.05% AEP. Lyall & Associates (2011) also provided results for the 20%, 5% and 1% AEP and the Probable Maximum Flood (PMF) event. These are summarised for the basement flooding depths for Table 4-5. These provide a useful summary of the potential variance in flood depths for different probability events. Further, CJ Arms (2018) provided information on the flood depths for 0% and 100% blockage, together with the base case of 50% blockage.

The comparison points are shown in Figure 4-11 for reference.

Table 4-3. Peak Water Level Comparison (m AHD) – 1% AEP

Location	CJ Arms (2018)	Lyall & Associates (2011)	GHD (2007)[1]
Intersection of Victoria Avenue and Archer Street	84.14	NR	84.3 – 84.4
Victoria Avenue Low Point[2]	84.02	84.0	84.2
Victoria Avenue at Carpark Entry	83.79	NR	83.7 – 83.8
Havilah Street Low Point	79.83	80.0	80.1
Archer Street at Mills Lane	84.2	NR	84.5 – 84.6

NR – Not reported

[1] Based on the results for the proposed development (at that time)

[2] This is near to the pedestrian entry to Chatswood Chase on Victoria Avenue

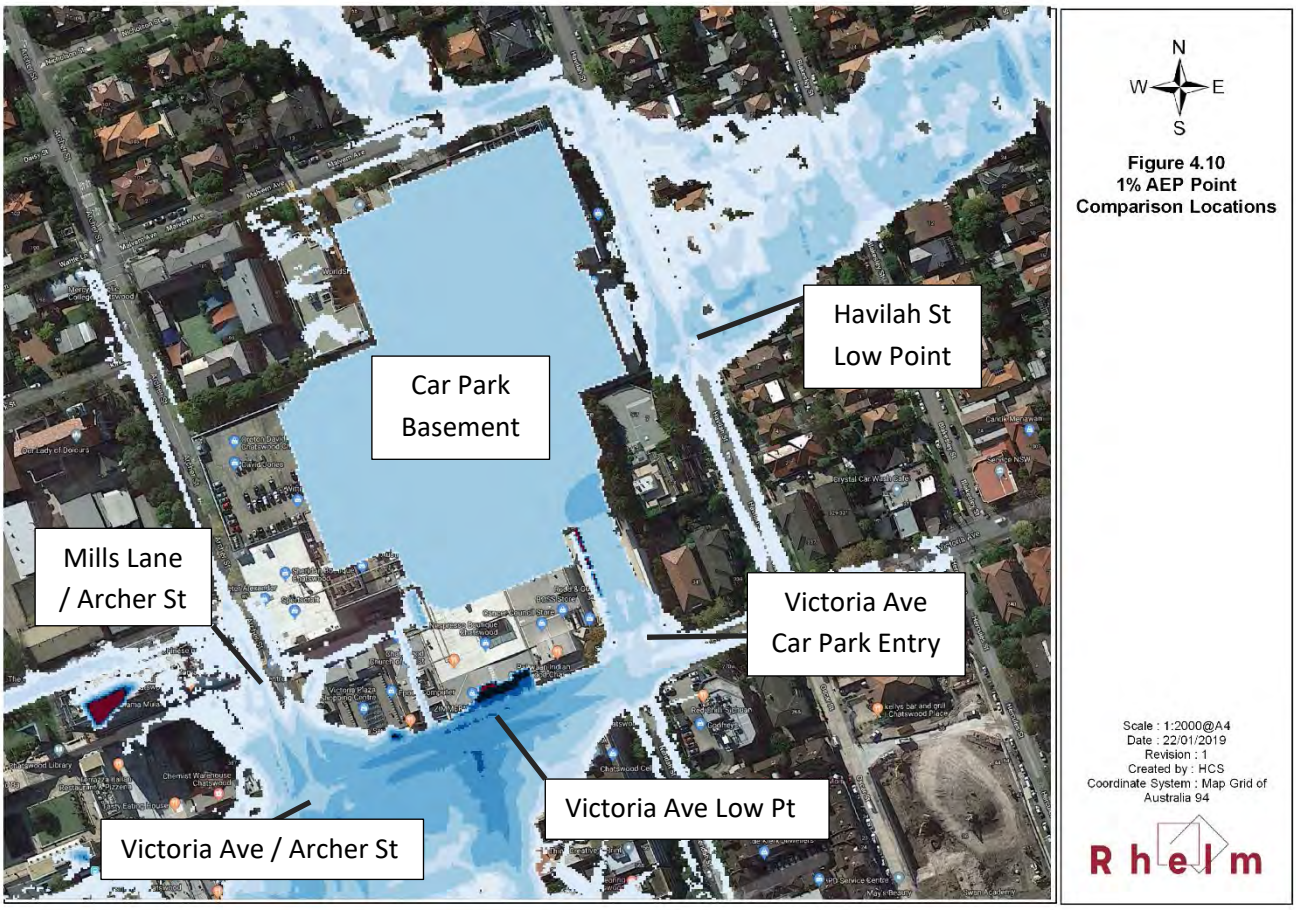


Figure 4-11. Comparison Point Locations

Table 4-4. Chatswood Chase Basement (B2) Comparison – 1% AEP

Location	CJ Arms (2018)	Lyall & Associates (2011)	GHD (2007)
Water Level in Basement (Basement RL 75.8)	76.27	76.4[3]	79.1
Depth in Basement (m)	0.47	0.6	3.30
Volume of Water entering the Basement (m^3)	8,300	12,000	60,000

Table 4-5. Comparison of Flood Depths in the Basement (B2) for Different Events

Event	CJ Arms (2018)			Lyall & Associates (2011)
	0% Blockage	50% blockage	100% Blockage	
20% AEP	N/A	<0.05	N/A	0.1
5% AEP	N/A	N/A	N/A	0.2 – 0.3
1% AEP	0.35	0.47	4.0	0.6
0.05% AEP	N/A	1.19	N/A	N/A
PMF	N/A	N/A	N/A	4.7

[3] Estimated based on the RL for the basement and the depth reported in Lyall & Associates (2011)

4.4 Summary of Model Review

Rhelm's review of the modelling would suggest that there are a few parameters and configurations in the CJ Arms modelling that should ideally be updated. The comparison with previous modelling undertaken, as well as preliminary analysis by Rhelm, would suggest that the combination of these factors may not result in a significant change to peak flood levels or volumes entering the basement. However, there seems to be enough uncertainty that some of the identified concerns should be addressed prior to finalisation of the reporting.

The basement flooding (within the Chatswood Chase Shopping Centre) is of key concern for the development (refer Section 6). The CJ Arms (2018) model demonstrates that this area is at risk of inundation. There are a number of factors (such as pit blockage, the rainfall temporal pattern etc) that may influence the exact volume of water that enters the basement in both a design flood event and a real flood event. CJ Arms (2018) have undertaken a preliminary analysis of some of these factors, which suggests relatively high potential variability in volumes entering the basement and likely in excess of the parameter review issues that have been identified in this review. However, as there is some uncertainty as to why runs such as the 10% climate change produced lower levels in the car park than existing conditions and Rhelm recommends this to be reviewed and amended.

It is evident from this review (Table 4-5) that the basement may flood to depths in the order of 0.5 metres in a 1% AEP event but given the potential risks it is recommended that these uncertainties be mitigated through model review, update and via additional reporting. Understanding the influence of mitigations options can be assisted using water surface or depth difference maps of the flood results to show the range of influence of mitigation options. This will allow Council to assess the relative merits of the benefit of protecting ingress of flood waters to the carpark against the impact on the surrounding properties. Difference plots of the OSD options, Ferguson Lane tank influence and flood barrier options is encouraged to clearly show the effects within the floodplain.

Table 4-6 and Table 4-7 provide an outline of the updates that should be reviewed and undertaken in the modelling. There are two priority levels for these updates:

- High Priority – these should be incorporated;
- Low Priority – these would be ideal to be incorporated but are not essential.

Table 4-6. Recommended RORB Model Updates

Parameter/ Configuration	Modification	Priority (High (H)/ Low(L))
Review output hydrographs from RORB (i.e. sub catchment Q not output in the CATG supplied)	Output all sub catchments	H
Review fraction impervious	Update fraction impervious to reflect aerial imagery	H
Review ARR2016	Assess catchment for ARR2016 temporal patterns, revised rainfall and losses	L
Extending the RORB model to provide inputs to downstream catchments	Add the catchments immediately downstream of Chatswood Chase into the hydrology	L

Table 4-7. Recommended Tuflow Model Updates

Parameter/ Configuration	Modification	Priority (High (H)/ Low(L))
Hydrology inflow translation to TUFLOW	Assign appropriate hydrographs to TUFLOW catchments	H
Include the Chapman Avenue underpass to Chatswood Oval	Add flow connection	H
Climate change	Establish why 10% climate change is lower in key locations than existing conditions	H
Update mapping	Use of water surface or depth difference plots to demonstrate the influence and range of flood behaviour changes	H
Review Mills Lane connections	Check levels for entrance and via connection via Victoria Ave (at Church)	H
Building footprints as flow paths	Review flow paths through large protected buildings i.e. Westfield and Rialto Tower	L
Adding inflow hydrographs for the three downstream catchments	Add inflows for the three catchments immediately downstream to the shopping centre	L
Volume lost to building footprints	Infill building footprints where DEM is storing water inappropriately	L
Ferguson Lane Tanks	Check the surface storage at this location	L
Hydraulic roughness	Increase residential roughness to approximately 0.1	L

5 Planning Context

5.1 Local Environment Plan

Willoughby City Council's LEP Part 6, Clause 6.3, covers the requirements for development with respect to flooding. The relevant clauses are reproduced below:

> *6.3 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 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 by the NSW Government in April 2005, 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.*

It is important to note that the 1:100 ARI is the same as the 1%AEP referred to throughout this report.

5.2 Development Control Plan

Willoughby City Council's Development Control Plan (DCP) outlines relevant controls for flooding within *Part C.5 Water Management*. The objective of this policy, as it relates to flooding, is to ensure that all development in the LGA "reduces flood risk in urban areas". The reference within the DCP is primarily to the Technical Standard No. 3 (see below), but there is some specific discussion relevant to flooding and overland flow within the DCP.

In regards to overland flows, the following applies:

Existing overland flow paths, including flows from adjacent allotments, are to be preserved and retained.

Naturally diffuse surface waters (sheet flows) are not to be concentrated.

Catchment flood studies or drainage analysis must be carried out for sites where there is a risk or record of flooding from overland flow.

Approval to straighten, widen, line or pipe open channels may be granted in some instances, subject to environmental and hydrological considerations.

No structure or fill is to be placed within the flow path where it could:

- *cause a rise in the flow depth*
- *increase the velocity beyond the allowable safety limit as defined by AR&R (1997), or*
- *have an adverse effect on adjacent properties.*

With respect to floodplain management, the DCP primarily refers to the Technical Standard No. 3. However, it does identify the following as a summary of the requirements of that Technical Standard:

This limit is based on the 1% Annual Exceedance Probability (AEP) event, also referred to as the 1 in 100 years Average Recurrence Interval (ARI) storm event.

When a proposed development site is adjacent to a creek or a drainage reserve or stormwater drainage pipeline or within a low point, the applicant must assess whether the property is at risk of inundation.

A flood study must be submitted for developments deemed to be at risk so that the overland flow volume, depth, velocity and extent can be ascertained.

5.3 Technical Standard No. 3

The Technical Standard No. 3 is the primary document referred to in the DCP for floodplain management. The primary objectives of the document are:

- *Provide consistent guidelines and criteria for developers and other land users of overland flow/flood prone properties in the Willoughby Council LGA in the submission of Development Applications.*
- *Ensure that development on flood prone properties have to adopt measures to mitigate the adverse social and economic impacts to surrounding properties.*
- *Reduce the potential risks to property damage and loss of life arising from the development of overland flow/flood prone land,*
- *Increase public awareness through education of the potential adverse impacts of development on properties adjoining overland flow/flood prone properties.*

With respect to the size of the event that is considered in the Technical Standard, the size of the flood event that is to be considered is outlined from the Technical Standard below. It is noted that while this appears to be focused on the 1% AEP event, it is referring specifically to Flood Planning Levels, rather than risk to life which is another objective of this Technical Standard.

The FDM [Floodplain Development Manual] defined flood prone lands as lands affected by the Probable Maximum Flood (PMF), which is the largest flood that could physically occur in a location

of interest. From the perspective of an urban council, it is not feasible or economically desirable to alienate land from development within the PMF.

The Flood Planning Levels adopted for this policy is generally the 1% Annual Exceedance Probability (AEP) event, which is also sometimes loosely known as the 1 in 100 years Average Recurrence Interval (ARI) flood plus a freeboard.

Further in Section 9 (Special Requirements), the Technical Guidance elaborates further on the consideration of evacuation and consideration of larger flood events (such as the PMF). Based on the description within the Technical Guidance, it would appear that it is necessary to consider events up to the PMF when there is a potential risk to life and there are potentially susceptible people (elderly, children) who may be at greater risk in the event of a flood than able bodied adults. These factors would generally be considered to apply in the case of Chatswood Chase.

For some developments, Council may require additional flood planning control such as safe evacuation from the site and flood proofing of the existing structure. Further, Council will also consider the cumulative impact and effects of the development to adjoining properties.

Further, it must be noted that Council has adopted the 1% AEP event as the standard flood in this policy. The largest flood that could conceivably occur is also known as the probable maximum flood (PMF). The PMF is estimated from the probably maximum precipitation. It may be necessary for some developments to consider the effects of the PMF especially if the development may house young children, the frail and the elderly and is located on or near the major drainage system.

The Technical Guideline also considers flood impacts.

To reduce the impact of flooding on flood affected properties, all redevelopment must be located within the footprint of the existing structure(s), preferably clear of the 1% AEP event or the overland flow path. Any encroachment on these paths is not permissible unless a cumulative impact study of the floodwaters to both upstream and downstream properties is undertaken by the applicant and Council is satisfied that there is no adverse impact to other land owners.

Appendix D of the Technical Guideline provides the planning controls for different types of development. The following are the key controls for main stream flooding (assumed to be this site) for commercial buildings:

- Follow footprint of existing building or Conduct Flood Study
- No structure to impede flood flows
- Habitable Floor Level 1% AEP plus 0.5 metres
- Non-Habitable Floor Level 1% AEP plus 0.5 metres
- Underside of structure minimum of 0.3 metres above 1% AEP.

The Technical Guideline also discusses Climate Change and potential consideration for developments. The requirement in the Technical Guideline is not clear, with a note that “Willoughby Council may consider imposing a higher flood level than the current flood planning level if the nature and circumstances affecting the development warrants such consideration in the future”.

5.4 Floodplain Development Manual

The NSW Floodplain Development Manual (NSW Government, 2005) provides guidance on the process of undertaking flood and flood-related studies. It is called as a reference document in the Local Environment Plan.

To date, Council has undertaken a Flood Study for the floodplain relevant to the subject site in accordance with the Manual and has adopted that study (Lyall & Associates, 2008), noting that the study has subsequently been updated (Lyall & Associates, 2011).

Council has not yet embarked on the next stage of the floodplain management process, outlined in the Manual, being the floodplain management study and the subsequent floodplain management plan. As a consequence, options for the management of flood risk in the wider Scotts Creek floodplain have not yet been identified or evaluated. Options would include floodplain modification options, property modification options or emergency response modification options.

As a consequence, the common controls in the LEP and DCP are applied without any localised Plan to inform their specific local application.

5.5 Summary of Requirements for Chatswood Chase Redevelopment

Table 5-1 provides an overview of key controls as interpreted by Rhelm from the planning controls, based on the LEP, DCP and Floodplain Development Manual.

Table 5-1. Summary of Key Controls

Control	Reference	Comment
No adverse impacts on other developments or properties.	LEP – 6.3(1)(c), 6.3(3)(b) DCP – Section " Overland Flowpaths" Technical Guideline – Section 3, Section 6, Section 12	The flood events to be considered based on the Technical guideline are the 20 year ARI and the 100 year ARI. It is noted that there is a requirement to assess the maximum of the 100 year ARI with 50% blockage and the 20 year ARI with 100% blockage of the enclosed drainage system. The Technical Guideline defines adverse impacts as increases in water level or velocity on neighbouring properties. This also implies that there is no adverse impact on risk to life on neighbouring properties.
Floor levels to be at the 1% AEP (100 year ARI) plus 0.5 metres	LEP – 6.3(1)(a), 6.3(3)(e) DCP – N/A Technical Guideline – Appendix D	The controls refer to habitable floor levels (normally addressing where persons reside) and non-habitable floor levels (which could be any other use) but there is no specific reference to requirements for basement parking threshold levels. It is possible that non-habitable floor levels could be interpreted to be basement carparking threshold, however it could equally be interpreted as shop floor levels instead.

Control	Reference	Comment
Minimise risk to life. Incorporate measures to manage risk to life within the development up to the PMF.	LEP – 6.3 (1)(a), 6.3(3)(c) DCP – N/A Technical Guideline – Section 3, Section 9	Consideration of events up to the PMF is identified within the Technical Guideline for developments where children, elderly etc may be affected. The LEP does not specifically identify in its objectives or controls the event for consideration of risk to life. The only constraint is that it applies only to properties within the 100 year ARI plus 0.5 metre, but no discussion on which events to consider in the assessment.

5.6 Council Draft Conditions of Consent

Table 5-2 identifies the draft conditions of consent from Council (see Section 2.4), and Rhelm's review of the applicability of this condition based on the planning policies and requirements.

Table 5-2. Council Draft Conditions of Consent and Planning Requirements

Draft Condition from Council	Rhelm Response
a) Flood Protection Measures The applicant must develop and submit to Council measures designed by qualified a Civil engineer experienced in Flood analysis which are to be incorporated into the redevelopment of Chatswood Chase to prevent the ingress of overland flow into the carpark areas (existing and proposed) for all storm events up to the Probable Maximum Flood (PMF).	The need for a flood analysis is consistent with the Technical Guideline. Water ingress into the basement carpark is most significantly a risk to life issue followed by a property damage issue, particularly in regard to the number of likely cars in the basement and the number of people at risk. In this regard, the draft condition would appear to be consistent with the LEP and DCP. A further consideration however is the incremental risk represented by the development (relative to the existing conditions as approved in 2007, see Section 2.2). This is further discussed in Section 6.
b) Flood Mitigation Measures The applicant must develop measures designed which are to be incorporated into the redevelopment of Chatswood Chase to prevent any adverse flooding conditions being experienced in areas external to the site for all storm events up to the 1% Annual Exceedance Probability (AEP). A Flood Report prepared by a qualified Civil engineer experienced in Flood Analysis incorporating blockage factors to the trunk drainage system must be adopted as per Council's DCP and Technical Standards No.3 shall be submitted to Council.	This has been undertaken to a large degree by CJ Arms (2018). However, it is noted that Council's policy does address the need for consideration of the 5% AEP, and therefore it may be appropriate to consider this event within the CJ Arms Flood Assessment. It is noted that the CJ Arms (2018) report identifies that there are no impacts off-site for the proposed development in the 1% AEP.
c) Flood Mitigation Assessment The applicant is to demonstrate to the satisfaction of Council that the proposed redevelopment of Chatswood Chase will not increase the risk of life in areas external to the site for storm events between the 1% Annual Exceedance Probability (AEP) and the Probable Maximum Flood (PMF). The assessment is to be carried out by a qualified civil engineer for the 0.5%, 0.2%, 0.1% and 0.05% AEP flood event, as well as the PMF and submitted to Council for assessment.	The DCP and Technical Guideline do not specifically address the issue of risk to life external to the property. The focus of the Technical Guideline would appear more about the management of risk on the property itself. However, it does have the objective of "reduc[ing] the potential risks to…. loss of life arising from the development of overland flow/ flood prone land". It also aligns more generally with the objects of the LEP. The number of events for consideration however may be excessive, although within the planning policies in general terms. Further discussion on this is provided in Section 6.

6 Review of Proposed Development

A review has been undertaken on the proposed development in accordance with the requirements of the LEP, DCP and Floodplain Development Manual. Consideration has also been given to the draft consent conditions as outlined in Section 2.4.

In considering the key issues of contention between Vicinity Centres and Willoughby Council, these generally relate to the draft conditions of consent as per Section 2.4.

6.1 Flood Planning Level

Based on the requirements of the Technical Guideline No. 3, it is understood that the relevant planning level for the shopping centre is the 1% AEP plus 0.5 metres.

There are two key access points to the shopping centre that need to meet this requirement:

- Pedestrian entry on Victoria Avenue;
- Pedestrian entry on Archer Street.

A comparison of the flood level for the design scenario (50% pit blockage) from the CJ Arms (2018) modelling against the ground floor level (as shown on DA2010, Rev4) is provided in Table 6-1. This suggests that the 500mm freeboard is met at these locations. The design plans would suggest that access to the lower ground would differ from the existing scenario, with the entries now rising up to the Ground Level and accessing the Lower Ground from within the building. This should provide additional protection over the existing scenario for the Lower Ground Level.

There is insufficient information in the CJ Arms (2018) report to provide a review of the flood planning levels at other potential entry locations for floodwaters to the shopping centre. There are a number of access doors around the centre. A review of these would suggest that many of these are protected by bunding or are likely to internally rise up to the Ground Floor level (based on the design plans) and therefore likely to be higher than the flood planning level. However, this needs to be confirmed.

The key area for consideration is the north-west corner of the site fronting Archer Street. In this location, while some of the doorways are protected, one is open adjacent to the driveway ramp (as shown in Figure 6-1). An estimate of the flood level at this location is provided in Table 6-1 based on the information in the CJ Arms (2018) report. It is assumed that this door opens immediately onto the Ground Level based on the design plans available. It is recommended that this location be reviewed and potential protection measures be provided in order to achieve the Flood Planning Level. However, it is recognised that the flows down Archer Street are relatively shallow, and potentially a lower freeboard than 0.5 m could be considered by Council.

Recommendations

- Review flood planning level on North West corner of shopping centre to determine freeboard on the access door in this location. Council to consider a lower freeboard in this location given the shallow flows.
- Review access doors at other locations around the building to ensure that freeboard conditions in accordance with Council's Technical Guideline No 3 are met.

Table 6-1. Flood Planning Level Review

Location	Flood Level	Floor Level	Available Freeboard (m)
Archer Street Pedestrian Entry	85.00	86.68	1.68
Victoria Avenue at Pedestrian Entrance	84.04	86.68	1.64
Archer Street Access Door	87.00	86.68	-0.32

Figure 6-1. Entry to Access Doors near North West Corner of Site (Google Maps, 21/1/19)

6.1.1 Mills Lane Loading Dock

CJ Arms (2018) reports the flood level in Mills Lane to be 81.71m AHD. This is a trapped low point with only limited stormwater drainage capacity to relieve this area. Depths in this area pond to over 400mm based on the flood results provided by CJ Arms (Section 3.2.1).

Following the site inspection (see Section 1.4), it was noted that the internal access corridors all step up in this location. However, the Lower Ground Floor has a level of 81.35m AHD, and it is unclear if there is access from this loading dock to the Lower Ground Floor.

A review of the model results provided by CJ Arms would suggest that the depths entering Mills Lane are very low (only a few centimetres). The existing entry is already raised as shown in Figure 6-2. Consideration should be given for raising the entry to this laneway to mitigate any adverse impacts in this location, as well as potential impacts to stock and other goods that might be stored in this location. The peak flow down Mills Lane is less than $0.1m^3/s$, and therefore diverting this small flow to the Archer Street/ Victoria Avenue intersection is unlikely to have any material impact.

The other source of water into the loading dock is through the connection identified in Section 4.2.6. This connection should be reviewed as per the recommendations in Section 4.2.6.

Recommendation

- Review the potential to raise the entry to Mills Lane to prevent water inflow in this area and protect the loading dock;
- Review the flood planning level for the Lower Ground Floor based on the ponding in this location.

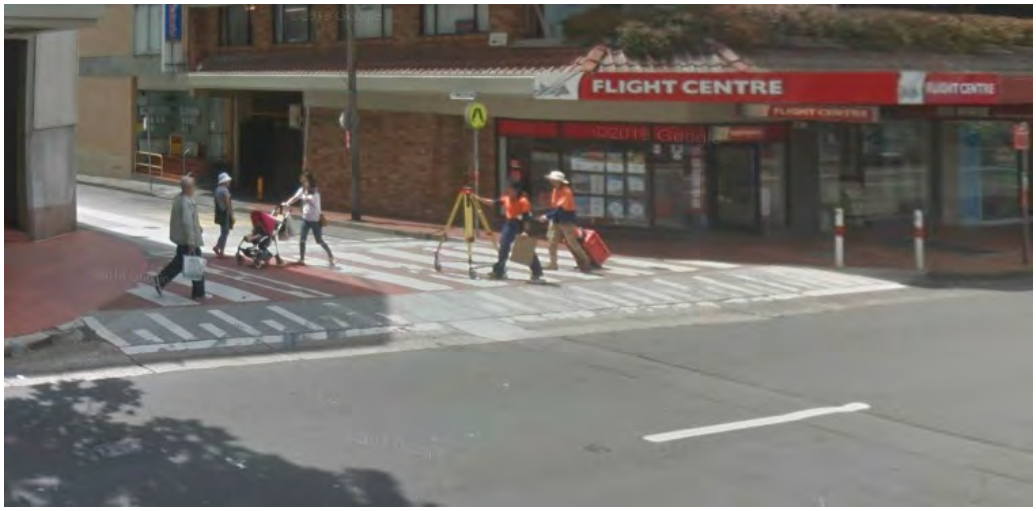


Figure 6-2. Existing Entry to Mills Lane off Archer Street (Google Maps, 21/1/19)

6.2 Flood Impact Assessment

The CJ Arms (2018) report provided an analysis of the existing and proposed design conditions to consider flood impacts. The results of these analyses were presented in a series of tables. A summary of the peak water levels for the existing scenario and design scenario (with 50% pit blockage and 2000m^3 being available in the Ferguson Lane storage) is provided in Table 6-2. The corresponding location of these peak water levels was estimated based on the description in the CJ Arms (2018) report and is shown in Figure 6-3.

The comparison shows that generally the changes in peak water level are within +/-0.01 metres. However, it is unclear why some areas in the model are observed to have an increase, such as the 0.02m increase at the Victoria Avenue pedestrian entry to the Chatswood Chase shopping centre. CJ Arms (2018) also reports an additional 1000m^3 entering the basement, although it is unclear as to the source of this additional water. The slight increase in levels on Victoria Avenue may explain the additional water entering the basement. Regardless, it is not clear as to the source of this additional water on Victoria Avenue, as there would not appear to be elements of the new centre that would impact on this area. Therefore, it is recommended that this be reviewed.

It is also noted that no flood level difference plots were provided with the CJ Arms (2018) report, as per Section 4.2. This makes the assessment of the scale and level of impact of any changes difficult to ascertain. It is recommended that this be included in updated assessments.

Recommendation

- Review of existing and design models to understand the source of the additional flow on Victoria Avenue under the design scenario;
- Provide flood impact figures to provide a better understanding of the flood level differences around the proposed development.

Table 6-2. Comparison of Peak Water Levels (m AHD)[4]

ID	Location	Existing	Design	Difference (m)
A	CCSC Basement (B2)	76.27	76.25	-0.02[5]
B	Intersection Havilah & Victoria	83.99	83.99	0.00
C	Victoria Avenue at Basement Entrance	83.79	83.79	0.00
D	Havilah Street	79.92	79.91	-0.01
E	Intersection Archer & Victoria	84.14	84.15	0.01
F	Mills Lane	81.70	81.71	0.01
G	Victoria Avenue at Pedestrian Entrance	84.02	84.04	0.02

Figure 6-3. Water Level Reporting Locations[6]

[4] For the 50% blockage scenario

[5] Note that the design incorporates additional basement storage, as well as a larger plan area, and therefore there is a reduction in level even though there is greater volume entering the basement.

[6] Locations estimated based on descriptions in CJ Arms (2018) report

6.3 Water Ingress to Basement Carpark

The flood modelling from CJ Arms (2018) and Lyall & Associates (2011) both show water entering the basement of Chatswood Chase. Based on the conditions of consent from Council (Section 2.4), and the discussions with Council and Vicinity during the meeting on 14 January 2019, this is the primary area of contention between the two parties.

6.3.1 Overview of Existing Inundation

Table 6-3 provides an overview of the depths of flooding in the basement under some of the scenarios assessed by CJ Arms (2018), as well as those from Lyall & Associates (2011). Order of magnitude depths have been estimated based on both these studies in Table 6-4 to provide some level of understanding of the likelihood and consequence of flooding associated with the basement parking. The flood depths and review have been estimated based on the available results across the two studies, given that they generally provide reasonably consistent results in terms of the basement flooding.

To aid in the discussion and understanding on the consequence, the number of car, motorcycle and bicycle spots are identified in Table 6-5. A very high level understanding of the potential economic value of the vehicles in the basement is also provided assuming a full carpark and an average value of $20,000 per car. Whether the carpark would be full at the time of the flood is difficult to estimate, but this an indication of the order of magnitude cost involved.

In general, the depths of flooding in the basement are expected to reach in the order of 0.5 metres in level B2 in the 1% AEP. However, as with all modelling, there is a level of uncertainty. This is associated with the modelling approach, as well as inputs to the modelling like design rainfalls and temporal pattern shape, and loss conditions at the start of a “real” storm. The inflows to the basement are particularly sensitive to changes in model assumptions and inputs. As identified by CJ Arms (2018), a 30% increase in flows can increase depths in the basement to approximately 0.89 metres, while a 100% blockage scenario of pits in the catchment can lead to depths of 4 metres in the basement.

While it is difficult to adequately identify the order of magnitude uncertainty for the estimates, it may be reasonable to adopt an order of magnitude depth of between 0.5 to 1 metre in the 1% AEP event. At these depths, there is likely to be widespread economic costs in terms of damage to vehicles (particularly on B2 with around 573 cars potentially affected, although higher velocity flows on B1 as it flows to B2 may cause damage as well). There is also an associated risk to life, both in the overall depth of inundation in B2, but also in the higher velocity flow entering through B1 before flowing into B2.

At the other end of the frequency of storms, flows enter the basement in at least a 20% AEP (although possibly more frequently), although the depths are not significant. In the 5% AEP, depths are potentially reaching around 0.3 metres, and therefore there may be damage to some vehicles in the B2 carpark. In both cases, high velocities would be expected down the entry ramp into the basement that would likely represent a high hazard flow.

The depth of inundation is significantly greater in the PMF event, with depths from Lyall & Associates (2011) suggesting around 4.7 metres. This would represent a complete inundation of B2, and around 2 metres in B1. This would represent a significant impact in terms of number of vehicles affected (approximately 1062 cars potentially affected if the car park is full), and the risk to life would be significant.

Table 6-3. Comparison of Flood Depths in the Basement for Different Events[7]

Event	CJ Arms (2018) – Existing Scenario			CJ Arms (2018) – Design Scenario[8]		Lyall & Associates (2011)
	0% Blockage	50% blockage	100% Blockage	Climate Change – 10%	Climate Change – 30%	
20% AEP	N/A	<0.05	N/A	N/A	N/A	0.1
5% AEP	N/A	N/A	N/A	N/A	N/A	0.2 – 0.3
1% AEP	0.35	0.47	4.0	0.36(?)[9]	0.89	0.6
1 in 2000 AEP	N/A	1.19	N/A	N/A	N/A	N/A
PMF	N/A	N/A	N/A	N/A	N/A	4.7

Table 6-4. Order of Magnitude Basement Flooding Depths for Different Events

	B2	B1
Floor Level (m AHD)	75.8	78.45
20% AEP	0.05 – 0.1	-
5% AEP	0.2 – 0.3	-
1% AEP	0.5 – 1.0	-
1 in 2000 AEP	1.2 – 2.0	-
PMF	Complete Inundation	~ 2

Table 6-5. Basement Carparking - Existing

Level	Cars	Motorcycles	Bicycles	Indicative Economic Value[10]
B1	573	0	28	$11 – 12M
B2	489	0	0	$10M

Preliminary Risk Assessment

A preliminary risk assessment for the basement has been undertaken based on the principles provided in AIDR (2017), as well as the methodology in Collier et al (2017). This is to provide an example of the type of risk assessment that could be undertaken to demonstrate the overall risk to the basement. This outlined in Table 6-6. In this assessment, the consequence has been estimated from the above discussion, assuming:

- $10 million is considered a major consequence, while > $20 million is catastrophic

[7] N/A – Not available for this event
[8] While an existing scenario climate change analysis has not been undertaken, the similarity between existing and design provides a reasonable representation.
[9] Uncertainty on this level, given that it is lower than the existing. Refer to Section 4.2.10.
[10] Based on an indicative average of $20,000 per vehicle

- There is potential for loss of life in a 1% AEP, but this increases significantly for larger events.
- A loss of life is considered catastrophic.

Overall, based on this assessment, the carpark might be considered to be a high risk for both economic damage and risk to life.

Table 6-6. Preliminary Risk Assessment – Existing Conditions

		Consequence				
		Insignificant	**Minor**	**Moderate**	**Major**	**Catastrophic**
Likely	>10%		O			
Unlikely	1 - 10%				X O	
Rare to very rare	0.01 to 1%				O	X
Extremely rare	<0.01%					X O

X=economic costs, O = potential loss of life

Very Low
Low
Medium
High
Extreme

6.3.2 Proposed Basement

The CJ Arms (2018) modelling demonstrates that there is likely to be minimal changes in inundation in the basement. With the provision of some additional storage and a slightly larger floor area, the flood levels reduce marginally in comparison to the existing scenario, but only to a minor degree.

The key change in the risk relative to the existing scenario is the number of cars, motorcycles and bicycles in the basement. Table 6-7 provides a summary of the existing and proposed cars, motorcycle and bicycle parking.

A few key points to note:

- B2 represents the highest risk area, as this area will be inundated and fill in events up to the 1 in 2000 AEP. After this, B1 will then start to fill (although flows will proceed across B1 in all events).
- There is an increase in 47 cars, and 19 motorcycle parking spots on B2, which as identified above is the higher risk area;
- There is an increase in 13 motorcycle spots, and 294 bicycle spots on B1, representing an increase in consequences for rare events (greater than 1 in 2000 AEP).

The increase in cars, motorcycles and bicycles will increase the risk exposure within the two basement levels. A simple risk assessment matrix (such as Table 6-6) does not have the resolution to provide for incremental changes such as this. However, the increase in vehicles will result in an elevation of the risk within the high risk profile.

Table 6-7. Basement Carparking – Proposed

Level	Cars			Motorcycles			Bicycles		
	Existing	Proposed	Change	Existing	Proposed	Change	Existing	Proposed	Change
B1	573	570	-3 (0.5%)	0	13	+13	28	322	+294
B2	489	536	+47 (10%)	0	19	+19	0	0	0

6.3.3 Summary of the Issue

The existing car park for Chatswood Chase already has a high risk in terms of potential loss of life and damage to infrastructure. However, it is important to note that this is an existing situation. The proposed design then exacerbates this with the introduction of additional parking, particularly on B2, which is the highest risk given the relative frequency of relatively deep ponding.

In order to meet with the general objectives of the LEP, as well as the DCP, it is suggested that the development should demonstrate an improvement to the risk to life, as well as the economic impact of the inundation of the basement, in events up to the PMF. It is noted that this should be measured relative to the existing scenario.

6.3.4 Potential Measures

There are a number of potential measures that might be possible to mitigate the existing and design scenario risk to the basement carpark. Some stand-alone options for consideration are outlined in Table 6-8.

Combinations of the measures in Table 6-8 are also potential options (See Section 7).

Table 6-8. Potential Stand-Alone Measures for Consideration

Option	Comment
Raise the carpark entry to prevent water ingress to the basement	This is a possibility, but it would result in increases along Victoria Avenue. This has been demonstrated in the CJ Arms (2018) analysis as well as testing undertaken by Rhelm. In order to prevent any ingress of water, a barrier of around 0.4 – 0.5m would be required across the full length of the existing pedestrian crossing across the entry point to the car park, resulting in associated increases in peak water level on Victoria Avenue which would have impacts on a number of shops in this area. It is not clear how much this would reduce inundation in the PMF event (or events larger than the 1% AEP) so there still may remain a residual risk to life under this scenario, albeit improved over the existing scenario.
Raise the carpark entry to prevent water ingress to the basement. Provide additional drainage around to Havilah Street (within the Victoria Avenue road reserve).	This is similar to above but would include additional pipe drainage from Victoria Avenue to Havilah Street (potentially surcharging in Havilah Street). Initial testing by Rhelm suggests that this might provide relief for any increases in water level on Victoria Avenue, but would come at the cost of increases in the flowpaths downstream of Havilah Street through the residential areas. Further testing and investigations would be required to determine as to whether this would be feasible.

Option	Comment
Bunding on B1	CJ Arms have proposed bunding (0.15m high) on B1 to hold water on B1 before overtopping onto B2. This would provide some relief by "spreading" the storage between B1 and B2. This would be particularly useful for the more frequent flooding by reducing the depth on both levels. This may assist in reducing flood damages particularly in the basement for events up to the 1% AEP. It is noted however that there may be a number of challenges in implementing this solution, including sealing of joints and ensuring that all entrances are above the required level. Bunding alone without restricting flows to the basement does not manage the existing risk to life.
Control flood water ingress to basement via recessed flood gates that activate after a certain volume of floodwater have entered	The control of floodwaters to a depth that would be considered acceptable from a risk to life perspective (i.e. to allow pedestrians to safely leave the basement via internal stairs or ramps) is an option. Once activated the impacts on adjacent properties of the remaining portion to be bypassed would require assessment.
Remove proposed additional carparking spaces from the DA	One of the issues with the proposed development is the introduction of additional vehicles (mainly cars) into the basement, and the associated increase in economic cost and risk to life. An option could be considered to remove these additional car, motorcycle and bicycle parking from the basement, in recognition of the high risk in this area. This option would require alteration of minimum parking requirements related to the increase in gross floor area of the centre.
Relocate basement car park entry from Victoria Avenue to a location that is not flood-affected	This would mean that no flood flows enter the basement at all. The flood storage associated with the basement carpark would need to be offset in some manner, however the more critical issue is the traffic network issues that this option would present. Other access points are either via less utilised residential streets (e.g. Havilah Street or Malvern Avenue) or via Archer Street which would necessitate significant re-routing of traffic through Chatswood to direct traffic to this location.
Drainage System Duplication/Amplification	The existing culvert under the car park could be duplicated or amplified to carry a greater amount of flow. However, it is unlikely that even a significantly amplified system could carry the entire flow during an extreme event.
Flood Emergency Response Planning	A Flood Emergency Response Plan (FERP) already exists for the centre. However, there are improvements that could be made to this plan. This would include: • Improved detection of floodwaters entering the car park via monitoring at the entry threshold • Better trigger levels associated with evacuation; • A review of the inundation levels that are used for evacuation; • Better signage throughout the basement to direct pedestrians within the basement to safe egress points; • Warning signs on the entry to the basement; • Automatic gates to close entry to the basement carpark (for both pedestrian and cars) at certain trigger points

Option	Comment
	• Intelligent signage in Victoria Avenue and surrounding streets to divert cars from entering the basement car park during a flood event. It is understood that this is intended to be updated, but it should form part of the strategy to mitigate the risk to life.

6.4 Review of Council Conditions

Based on the review of the development, Rhelm has provided a response to the conditions as identified by Council.

Table 6-9. Review of Council Conditions

Draft Condition from Council	Rhelm Response
a) Flood Protection Measures The applicant must develop and submit to Council measures designed by qualified a Civil engineer experienced in Flood analysis which are to be incorporated into the redevelopment of Chatswood Chase to prevent the ingress of overland flow into the carpark areas (existing and proposed) for all storm events up to the Probable Maximum Flood (PMF).	As identified above, there are challenges in achieving this condition without resulting in increases in flood levels external to the site. It is recommended that an alternative be to look at the incremental increase in the risk to life and economic impact of the carpark, and assess the development on that basis (achieving an improvement over the existing case, rather than a complete removal of all flooding).
b) Flood Mitigation Measures The applicant must develop measures designed which are to be incorporated into the redevelopment of Chatswood Chase to prevent any adverse flooding conditions being experienced in areas external to the site for all storm events up to the 1% Annual Exceedance Probability (AEP). A Flood Report prepared by a qualified Civil engineer experienced in Flood Analysis incorporating blockage factors to the trunk drainage system must be adopted as per Council's DCP and Technical Standards No.3 shall be submitted to Council.	As noted in this report, the applicant generally meets this condition based on the CJ Arms (2018) report. Very little has changed in the key flowpaths and therefore limited impacts would be considered. However, the retention of condition (a) from Council would lead to subsequent difficulties for this condition.
c) Flood Mitigation Assessment The applicant is to demonstrate to the satisfaction of Council that the proposed redevelopment of Chatswood Chase will not increase the risk of life in areas external to the site for storm events between the 1% Annual Exceedance Probability (AEP) and the Probable Maximum Flood (PMF). The assessment is to be carried out by a qualified civil engineer for the 0.5%, 0.2%, 0.1% and 0.05% AEP flood event, as well as the PMF and submitted to Council for assessment.	It is unclear the focus of this condition on areas external to the site. At present, it is unlikely that the development would adversely affect flood behaviour external to the site. However, no assessment has been undertaken for the PMF or events larger than the 1% AEP in general. It may be appropriate to assess the PMF, but the focus should be on risk to life changes rather than changes in peak water level etc.

7 Design Modifications to Resolve Basement Flood Issues

Following the issue of the draft version of this independent review (on 23 January 2019), further meetings and assessments were undertaken as documented in Table 1-1 and Table 3-5 respectively. Appendix A documents the discussions held and agreed outcomes through this period as the parties sought to find a workable solution to the issues raised. CJ Arms modified the flood models created to respond to the review comments in Section 4 and these modified models were used to assess potential options raised collaboratively between the parties during meetings and telephone conferences.

The primary outcome was the identification of a combination of measures to reduce the existing flood risk to the basement and manage the future risk associated with the proposed development. The concept proposed (See Appendix B) is a combination of measures identified in Table 6-8, being:

- Flood gates on the car park entry to the B1 and B2 levels – these gates activate after the 1%AEP flood event flows to allow flow depths of less than 0.2 m into the basement and minimise flood impacts on adjacent properties, in accordance with Council's requirement to consider impacts up to the 1%AEP event. Actions within a Flood Emergency Response Plan will seek the safe evacuation of any persons within the basement when flood flows enter the basement.
- A formal flood diversion channel/conduit that will convey flows through the proposed building to discharge to Havilah Street – this channel/conduit will operate in events greater than a 1%AEP flood event (when the flood gates activate) and up to the 0.05%AEP (1 in 2000 year event)
- For events greater than the 0.05%AEP, a wall along the channel will overtop and flood flows in excess of the diversion will enter the carpark up to a depth of approximately 0.6 m in B2. Actions within a Flood Emergency Response Plan will seek the safe evacuation of any persons within the basement in this extreme situation.
- Other modifications to related facilities including:
    - Mills Lane – flood protection works will be required to prevent ingress of flood flows via the Mills Lane loading dock.
    - Energy dissipation works at the outlet of the flood diversion conduit to Havilah Street
    - Modification of stair access to the Victoria Avenue loading dock.

The design modifications and proposed concept prepared by CJ Arms (20 February 2019) are considered to provide an adequate resolution of this issues associated with the risk of flooding for the basement area, noting that there will be some residual risk that will require management.

One matter not explored in the discussions around the concept solution relates to the adequacy of the existing floor levels with respect to meeting flood planning level requirements (under the revised flood modelling arrangements). This matter has been conditioned.

It is recommended that Council proceed to the next stage of the Floodplain Risk Management process, as outlined in the Floodplain Development Manual (NSW Government, 2005) as soon as practically possible to seek to manage those risks in the Scott Creek floodplain that have been highlighted through this review.

The Draft Conditions of Consent (Section 8) have been framed on the basis of the concept option in Appendix B of this report.

8 Proposed Flood-related Conditions of Consent

Draft Conditions of Consent were prepared for comment (See Appendix D) and an amended version has been prepared in response to comments from Vicinity Centres (and their consultants) and Willoughby City Council (and their consultant).

The proposed conditions are listed below in terms of the relevant stages of the post consent process, being:

- Prior to issue of Construction Certificate
- For the life of the development
- During the construction phase
- Prior to the issue of the Occupation Certificate.

As a concept solution has been developed that has largely demonstrated that the solution is workable, there are no deferred commencement consent conditions recommended.

8.1 Prior to CC

Flood Condition 1 - Prior to the lodgement of a Construction Certificate, an updated Flood Study Report shall be prepared by a suitably qualified and experienced Professional and approved by Council. Council may require the report to be independently reviewed. The Report shall:

- assess the extent of the 1% AEP, 0.5%AEP, 0.05%AEP design flood and the Probable Maximum Flood event associated with the Sydney Water stormwater system and related overland flow paths through and around the property. The extents shall be shown with and without the proposed development and flood risk management concept solutions for the basement car park prepared by CJ Arms & Associates dated 20 February 2019 and show the difference in flood levels and flood hazard in accordance with the McLuckie et al 2014 H1 – H6 hazard classification system.
- assess the levels of the 1% AEP and the PMF event at all entry points to the building to confirm that the floor levels of retail and commercial areas are set above the flood planning level of the 1%AEP plus 0.3 m and to confirm no additional flood protection measures are required to control flooding of the basement up to the PMF apart from those proposed in the concept option prepared by CJ Arms & Associates dated 20 February 2019.
- indicate that the proposed development will not increase the 1% AEP flood levels or peak flood flow velocities on adjacent properties and that the proposed building and basement car park can withstand the likely conditions experienced during the 1%AEP flood event without suffering significant damage.
- Indicate that the proposed development will not increase the flood hazard categorisation or risk to life on private property surrounding the development (e.g. residential and commercial allotments) for all events up to the PMF.

Flood Condition 2 - Prior to issue of the Construction Certificate, a report by a suitably qualified and experienced Structural Engineer registered on the Engineers Australia National Engineers Register shall be submitted to the nominated Accredited Certifier and lodged with the certifiers report to Council, indicating that the proposed flood gate and related flood-control facilities can withstand the likely conditions (including structural load forces) experienced up to the Probable Maximum Flood event. The report should be completed in accordance with the requirements of AS/NZS 1170.1-2002, *Structural design actions - Permanent, imposed and other actions*.

Flood Condition 3 - Prior to the issue of a Construction Certificate, a Flood Emergency Response Plan shall be submitted to the nominated Accredited Certifier (and a copy provided to Council for reference) to demonstrate that permanent, fail-safe measures are incorporated in the development to ensure the timely, orderly and safe evacuation of people from the basement areas affected by flooding and any other locations in the development below the Probable Maximum Flood level in the event of a flood. Such evacuation measures are to be designed for rainfall events up to the Probable Maximum Flood event. The plan shall include the following:

- a way of ensuring the management of the centre are made aware of the plan,
- emergency contact numbers,
- measures to be put in place to ensure occupants are prepared for flooding and evacuation, how to prepare for a flood event,
- what to do during a flood event, including Plans of each flood affected level with clearly marked routes and exits to areas above the PMF level,
- an evacuation procedure for persons within the Centre and its car park, including how to know when to evacuate and where to go, the place of refuge inside the building must be located above the PMF level and must be able to accommodate the total number of persons evacuated from the basement areas.
- Details of wording and location of flood warning signs to be installed in the basement and at the entry from Victoria Avenue to increase flood awareness and provide direction as to the safest path for pedestrians using the Centre to evacuate to higher ground within the Centre.
- Details of a flood warning system that is to be triggered by the ingress of water into the basement. This is to include a plan showing the location of water level sensors on levels B1 and B2.
- Details of the flood gates at the car park entry and how they are to be operated (including specifying trigger levels for their operation)
- Specific measures that identify the location of accessible parking spaces and how persons using those spaces can safely leave the basement.
- Details of the post-flood recovery for the basement, including pump out and clean-up arrangements and details of consultation with Sydney Water for arrangements to pump floodwater from the basement to their stormwater system.

The extent and depth of the PMF flow path shall be shown on the engineering plans and indicated on work as executed plans. These are to be included in the Flood Emergency Response Plan.

8.2 For the Life of the Development

Flood Condition 4 – The flood risk management concept solutions for the basement car park prepared by CJ Arms & Associates dated 20 February 2019 shall be operational and maintained by the Centre or its agents for the life of the development, being:

- Flood gates on the Victoria Avenue car park entry to the B1 and B2 levels – these gates are to be designed to activate after the 1%AEP flood event flows to allow flow depths of less than 0.2 m at each level into the basement and to cause no afflux in the 1%AEP and to minimise flood impacts in greater storms on adjacent properties.
- A formal flood diversion channel/conduit that will convey flows through the proposed building to discharge to Havilah Street – this cannel/conduit shall operate in events greater than a 1%AEP flood

event (when the flood gates activate) and shall have the capacity to convey flows up to and including 0.05% AEP (1 in 2000 year event).

- For events greater than the 0.05%AEP, a wall along the flood diversion channel can overtop and flood flows in excess of the diversion may enter the carpark up to a depth of approximately 0.6 m on Level B2. Actions within the Flood Emergency Response Plan for the site are to seek the safe evacuation of any persons within the basement in this extreme situation.
- Other modifications to related facilities including:
    - Mills Lane – flood protection works are required to prevent ingress of flood flows via the Mills Lane loading dock.
    - Energy dissipation works are required at the outlet of the flood diversion conduit to Havilah Street
    - Modification of stair access to the Victoria Avenue loading dock to prevent flood ingress up to the PMF event.

Flood Condition 5 - The minimum floor level of any retail or commercial area with the portion of the Centre that is the subject of this consent shall be 0.3 metres above the level of the 1%AEP flood.

Flood Condition 6 - A flood warning system is to be provided on the property to alert people when flooding is occurring. The alarm aspect of the flood warning system shall be designed to trigger when flood flows commence flowing into the basement from Victoria Avenue. The system is to be tested annually to ensure that it remains in working order and confirmation that testing has occurred shall be forwarded to Council.

Flood Condition 7 - All new or replacement electrical and mechanical facilities or equipment to be installed below the level of the 1%AEP flood level is to be flood-proofed and/or incorporate residual current devices to protect occupants of the basement from electrocution during a flood event.

Flood Condition 8 - All existing and new fire-related facilities installed in the basement area are to be flood-proofed to ensure they can operate effectively under all flood conditions, including up to the Probable Maximum Flood event.

Flood Condition 9 - All materials to be used in the basement area are to be flood-compatible up to a depth of 0.6 m.

Flood Condition 10 -No hazardous materials are to be stored below the 1%AEP flood level.

Flood Condition 11 – A restriction as to use of the flood channel through the building proposed within 5-7 Havilah Street shall be placed on the title of the lot preventing any alteration to the flow path.

Flood Condition 12 - The Flood Emergency Response Plan prepared to meet Flood Condition 3 shall operate for the life of the development. Annual testing shall occur of the system in its entirety (including flood gates, depth trigger sensors and basement pump-out system) on an annual basis by a suitably qualified professional and evidence of that testing is to be submitted to Council by 31 January of every year.

8.3 During the Construction Phase

Flood Condition 13 - The subject land is subject to flooding and as such, construction may be inundated by flood waters during periods of flooding. Accordingly, all building work that is located below the Probable Maximum Flood level shall be provided with adequate flood proofing.

Flood Condition 14 - All drainage works shall be carried out in accordance with the Plumbing and Drainage Act 2011 and Australian Standard AS/NZS 3500 except where otherwise provided in the Local Government Act 1993, or the Local Government (General) Regulation.

8.4 Prior to issue of Occupation Certificate

Flood Condition 15 - Prior to any occupation of the development or the issue of any Occupation Certificate, the creation of a Restriction on Use of Land and Positive Covenant over the flood gates, flow diversion facilities and all flood-related facilities shall be registered. The Covenant shall be in favour of Willoughby Council.

9 References

Australian Institute for Disaster Resilience [AIDR] (2017). *Managing the Floodplain: A Guide to Best Practice in Flood Risk Management in Australia*, Handbook 7.

Ball J, Babister M, Nathan R, Weeks W, Weinmann E, Retallick M & Testoni I, (Editors) (2016). *Australian Rainfall and Runoff: A Guide to Flood Estimation,* Commonwealth of Australia.

C J Arms (2018). *Chatswood Chase Flood Modelling Report*, September, prepared for Vicinity Centres, Revision A.

Lyall & Associates (2011). *Scotts Creek Updated Flood Study*, December, prepared for Willoughby City Council, Volume 1 and 2.

Pilgrim, DH (Ed) (1987) *Australian Rainfall and Runoff - A Guide to Flood Estimation*, Institution of Engineers, Australia, Barton, ACT, 1987.

NSW Government (2005) *Floodplain Development Manual – the management of flood-liable land*.

Appendix A

Meeting Notes

MEETING NOTES

Chatswood Chase Independent Flood Review

February 4, 2019

Time 9:45 – 12:15

Reference J1205

Attendees: Ian Arnott, Mark Bolduan, Scott Kavanagh, Joseph Bazergy, Ron Yip - Willoughby City Council
Libby Walsh, Vicinity Centres
Vince Russo, Will Barlow – CJ Arms (Vicinity's Flood Consultant)
Scott Button – Lyall & Assoc (Council's Flood Consultant)
Louise Collier – Rhelm

Apologies: David Waldren- Vicinity Centres, Rhys Thomson - Rhelm

Item	Discussion	Action
1	**Queries/Comments on Rhelm Report** Council and Vicinity both provided comments by email on the Rhelm draft report documenting the findings of the independent review (dated 23 Jan 2019). Council's comments received by email 30 Jan 2019 and CJ Arms response via Vicinity dated 1 Feb 2019. Essential matters raised include the absence of direct comment on a combined solution of flood gates and flow diversion. Rhelm noted that the effects of such an option were unknown at the time of issue of review (as per comments in Section 4.4). Discussed potential removal of proposed additional car parking to retain existing risk to property and life. Discussed the question of existing risk associated with the development as it is approved and the management of incremental risk increase associated with alterations and additions.	• Rhelm to update report with commentary on combined option. See below for assessment and action on combined option. • Rhelm to update report with additional notes associated with feedback during the meeting on potential options and issues arising.
2	**Updated Flood Modelling by CJ Arms** CJ Arms discussed updates to the flood models as per the recommendations in the Rhelm draft report. This addresses comments by Council and Rhelm on model validity for design analysis and impact assessment purposes. Results appear to be reasonable for establishing baseline conditions for impact assessment.	• CJ Arms to use the updated model as the basis for assessments.
3	**Flood Risk Management for Events up to 1%AEP** Discussed the control of ingress of flood flows up to the 1%AEP event to the basement (B1 and B2) via retrofitting of the car park entry ramp with	

a flood gate that would be operated in a manner that allows existing flood flows to be redistributed over a greater basement area to a max. depth of < 200 mm in B1 and B2. This depth is less than the threshold of vehicle stability (see McLuckie et al, 2014).

4 Flood Risk Management for Events in Excess of 1%AEP and Inspection of Potential High Flow Diversion and Discussion

Discussed management of flood events greater than the 1%AEP given the significant risk to life, property damage and the potential for essential services (e.g. fire control pumps in the basement) to be inundated and damaged in events greater than a 1%AEP event. A range of options and issues associated were discussed. One option involves a potential high flow diversion engineering solution.

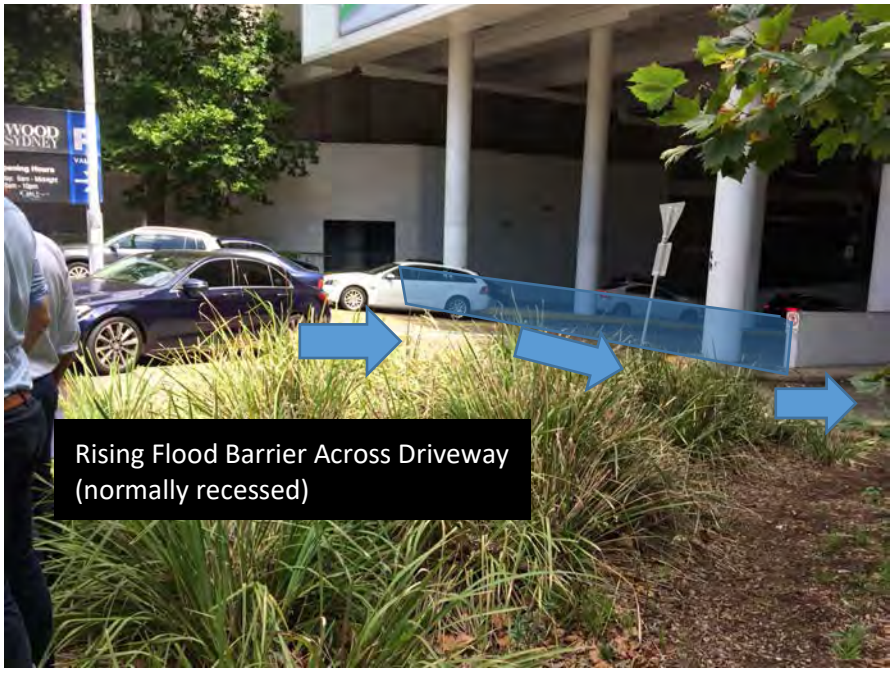
The majority of meeting participants viewed the basement carpark entry off Victoria Avenue and a potential high flow diversion flow path through the 5-7 Havilah Street site (over and/or adjacent to the existing Sydney Water underground culvert). See annotated images following.

This approach would require a modification to the proposed alterations and additions to accommodate the flow diversions (in the extension to the B1 area) as there is currently no flow path envisaged in the plans. It was noted that the existing culvert is intended to be realigned and reconstructed to meet Sydney Water requirements to construct over the culvert. An additional flow path would be required within the basement area of the building to discharge at the low point in Havilah Street.

Vicinity suggested that should the 'Potential Option' be deemed viable in a design sense and once cost impacts (approx.) have been assessed, it was requested that some agreement be reached on a "s94 contributions offset" for a portion (to be determined) of the costs to carry out these works. It is the position of Vicinity that Council should also assist in resolution of this existing issue and this is not solely a Vicinity issue to resolve.

Council advised during the meeting they would discuss this internally and consider this once we know more detail on the viability of the solution.

- Vicinity/CJ Arms to consider whether a high flow diversion system could be incorporated in the building design as an adjustment.
- Council to consider whether a Section 94 contribution adjustment could be made associated with this potential diversion.



5 Agreed Approach to Assessment of Potential Option

- CJ Arms to proceed with additional modelling to inform design and impact assessment.

Discussion was held to consider how best to evaluate the potential flood risk management option for the basement car park.

Agreed that modelling for the potential option should be undertaken for the 50% blockage scenario for the following design flood events (noting that the critical duration for the site will potentially vary between these events):

- 1%AEP event
- 0.2%AEP event (500 year ARI)
- 0.05%AEP event (2000 year ARI)
- PMF event.

Discussed how potential impacts might be considered if they are identified to occur downstream of the Centre. Agreed to consider the

magnitude of those impacts and their associated risks once they are quantified.

6 Draft Conditions of Consent

Rhelm agreed to draft conditions of consent for comment by 8 Feb 2019. These conditions could potentially be moved into the main body of the consent (ie not deferred commencement consent) if the potential option is found to be workable and impacts can be managed. Comment to be included in the conditions regarding accessible parking spaces and issues arising during a flood for aged and disabled persons using these spaces.

- Conditions to be drafted by Rhelm for comment.

7 Follow up Meeting

Follow up meeting to be tentatively set to discuss outcomes of potential rare flood events diversion concept for Thurs 7 Feb 2 – 3 pm – Libby Walsh to schedule.

- Vicinity to coordinate as required.

8 Other Matters

Lyall & Associates requested a copy of 3D survey data of the car park entrance off Victoria Avenue.

- Vicinity to provide 3D survey data of the car park entrance to Lyall & Associates.

TELECONFERENCE NOTES

Chatswood Chase Independent Flood Review **February 8, 2019**

Time **10:30 – 11:20**

Reference **J1205**

Attendees: Mark Bolduan, Scott Kavanagh, Ron Yip - Willoughby City Council
Libby Walsh, Vicinity Centres
Vince Russo, Will Barlow + ??– CJ Arms (Vicinity's Consultant)
Louise Collier – Rhelm

Unable to Dial in: Scott Button – Lyall & Assoc (Council's Flood Consultant)

Item	Discussion	Action
1	**Updated Flood Modelling and Concept Design by CJ Arms** CJ Arms discussed additional flood model runs and associated results for base case and with concept high flow diversion option case. The concept option basic details being an outcome of the meeting on 4 February 2019 viz: - Basement carpark to flood up to the 1%AEP event with depth controlled in B1 and B2 by internal arrangements (details to be defined) - Flood gate across Victoria Avenue car park entry to activate after 1%AEP flood volume enters (location assumed to be part way down the ramp (details to be defined). Max. height likely to be approx. 1.5 m (dependent on location) - Flow to be diverted down east side (loading dock lane), protections to substation located part-way along to be provided - Flood gate also required within loading dock area - Flow to be conveyed between LG and B1 via a 'channel' of dimensions approx. 4.5 x 1.2 to discharge flows to Havilah Street. Modelling results (difference plots) were issued by email just prior to the commencement of the meeting for the - 1%AEP event - 0.2%AEP event (500 year ARI) - 0.05%AEP event (2000 year ARI) - PMF event.	• CJ Arms to provide flood modelling results to assist with risk analysis of the effects of the concept option in rare and extreme events. • CJ Arms to issue H1-H6 hazard classification exported from Tuflow (flood model) to GIS to allow for assessment of changes to flood hazard classification.

2 Outcomes – Matters for Design

Discussion regarding some of the design details to be resolved:

- Energy dissipation at Havilah Street – discussed release of the high flow diversion through open stair case to dissipate energy, with potential planter boxes or other permanent street furniture to be incorporated in the streetscape.
- Location, style and height of flood gate to be incorporated in the design (across Victoria Ave entrance and loading dock)

- CJ Arms to prepare concept plans of the proposed high flow diversion option to show that levels and dimensions can be accommodated within an amended building design. Plan and long section to be prepared.

3 Outcomes – Matters for Risk Assessment

Noted the impacts over the majority of the affected area in rare and extreme events are of the order of 0.1 – 0.2 m with some locations with higher impacts (up to approx. 0.8 m). Discussion regarding risk assessment matters to be resolved:

- Risk change and property damage change to retail properties in Victoria Avenue
- Risk change and property damage change to residential properties downstream of the site (Havilah Street and beyond).

- As per above, CJ Arms to provide flood modelling results to assist with analysis of the effects of the concept option in rare and extreme events.

Follow up Meeting

Follow up meeting to be tentatively set to discuss outcomes of potential rare flood events diversion concept for Fri 15 Feb 10:30-11:30am. Libby Walsh to schedule.

- Vicinity to coordinate as required.

TELECONFERENCE NOTES

Chatswood Chase Independent Flood Review

February 15, 2019

Time 10:30am – 12:00pm

Reference J1205

Attendees: Mark Bolduan, Scott Kavanagh, Ron Yip, Joseph Bazergy - Willoughby City Council
Scott Button – Lyall & Assoc (Council's Flood Consultant)
Libby Walsh, Vicinity Centres
Vince Russo, Daniel Garzia– CJ Arms (Vicinity's Consultant)
Louise Collier – Rhelm

Item	Discussion	Action
1	**Updated Flood Modelling and Concept Design by CJ Arms** CJ Arms discussed a refined concept and associated flood model runs for the high flow diversion option case. Reference was made to a concept plan and long section emailed on 15 February 2019 prepared by CJ Arms being: • Drawing CONCEPT – CONCEPT PLAN, Preliminary, P1 20/8/2018 • Drawing STORMLS - STORMWATER LONGITUDINAL SECTION BASEMENT FLOODING, Preliminary, P1 20/8/2018 The email also contained recommendations made by CJ Arms relating to the cost and technical feasibility for the PMF event of the flood gates (impractical to provide flood gates high enough to stop water entering the loading dock for a period of 20 minutes within the PMF event due to the constriction between Chatswood Chase and 1-3 Havilah Street being the control) and suggesting that the height of the gates be limited to the 2000 year ARI event. The concept option basic details being an outcome of the meeting on 4 February 2019 and further discussed on 8 Feb 2019 viz: - Basement carpark to flood up to the 1%AEP event with depth controlled in B1 and B2 by internal arrangements (details to be defined but would include bunding of flood affected elements within the basement and stair access) - Flood gate across Victoria Avenue car park entry to activate after 1%AEP flood volume enters (location assumed to be part way down the ramp (details to be defined). Max. height approx. 1.5 m to control the 1 in 2000 year ARI event	• N/A

- Flow to be diverted down east side (loading dock lane), protections to substation located part-way along to be provided
- Flood gate within loading dock area
- Flow to be conveyed between LG and B1 via a 'channel' of dimensions approx. 4.5 x 1.2 to discharge flows to Havilah Street.
- Sensors to be installed on the floor throughout the basement to assist with informing the activation of the flood gates once the threshold depth of flooding was reached in B1 and B2.

Modelling results (difference plots, hazard analysis to FDM and VxD, max depths) were issued by email just prior to the commencement of the meeting for the following events:

- 0.05%AEP event (2000 year ARI)
- PMF event.

2 Discussion of Concept Design and CJ Arms Recommendations

Concept design queries arising during the discussion were:

- Protection of the western stairs to the loading dock from Victoria Avenue – these will require modification to prevent ingress of water to the loading dock – this is to be annotated on the revised concept plans.
- Modelling of the property at 5-7 Havilah Street under the existing conditions scenario requires review as the model currently appears to allow no flow through this property – ground survey to be reviewed by CJ Arms and the existing scenario model to be re-schematised as required. Likely outcome is that more water is directed to Havilah Street under the existing scenario and that the proposed scenario will have less impact than that shown in the difference plots presented to date.
- If the 2000 year ARI was the event that the concept option is designed for, what is the effect of overtopping into the basement in the PMF event? The spill mechanism would be likely over the eastern wall into the driveway. CJ Arms to investigate and seek to calculate the max depth that might occur in the car park (B1/B2). Reporting point in the model to be added to show the rate of rise in the car park to evaluate the evacuation time available for car park occupants. If risk to life could be managed in this circumstance (with modifications to the Flood Emergency Response Plan) then this may be a workable option from a cost and technical feasibility perspective.
- Question of Community Benefit and nexus with Section 94 contributions – Council advised that legal advice provided that the proposed works to control flooding to the basement area were not considered to provide a significant community benefit.
- Difference plots need to show areas that were not previously flooded, but would now be flooded with the concept option and place and also those areas that are currently flooded, but would not be under the concept option proposal.

Matters associated with the design as per discussions on 8 Feb 2019 regarding some of the design details remain to be resolved:

- Base case model to be reschematised to show flow path alongside east side of Chatswood Chase through 5-7 Havilah Street.
- Potential overtopping point to be considered into basement for events greater than 2000 year ARI event.
- CJ Arms to provide flood modelling results to assist with risk analysis of the effects of the concept option in rare and extreme events.
- CJ Arms to issue H1-H6 hazard classification exported from Tuflow (flood model) to GIS to allow for assessment of changes to flood hazard classification.

- Energy dissipation at Havilah Street – discussed release of the high flow diversion through open stair case to dissipate energy, with potential planter boxes or other permanent street furniture to be incorporated in the streetscape.

3 Outcomes – Matters for Risk Assessment

Noted the impacts over the majority of the affected area in rare and extreme events are of the order of 0.1 – 0.2 m with some locations with higher impacts (up to approx. 0.8 m). Discussion regarding risk assessment matters to be resolved:

- Risk change and property damage change to retail properties in Victoria Avenue
- Risk change and property damage change to residential properties downstream of the site (Havilah Street and beyond).

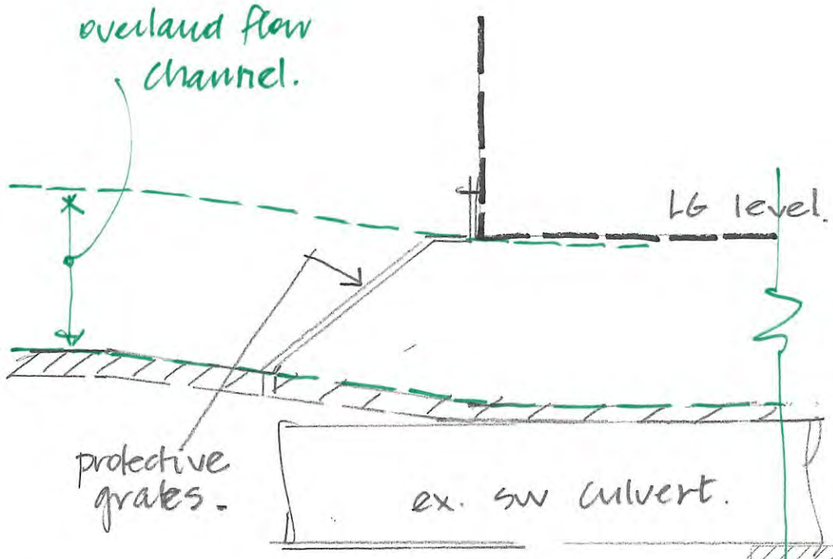
Follow up Meeting

Follow up meeting to be tentatively set to discuss outcomes of potential rare flood events diversion concept for Wed 20 Feb 12:30-1:30pm. Libby Walsh to schedule.

- Vicinity to coordinate as required.

Appendix B

Concept Plan, Section and Modelling Results



PHONE (03) 9285 2800 www.cjarms.com
PROJECT NUMBER CJA 14291

REVISIONS	No	DATE	AMENDMENTS	AUT.
	P1	20/08/18	ISSUED FOR INFORMATION	DG

CLIENT VICINITY CENTRES

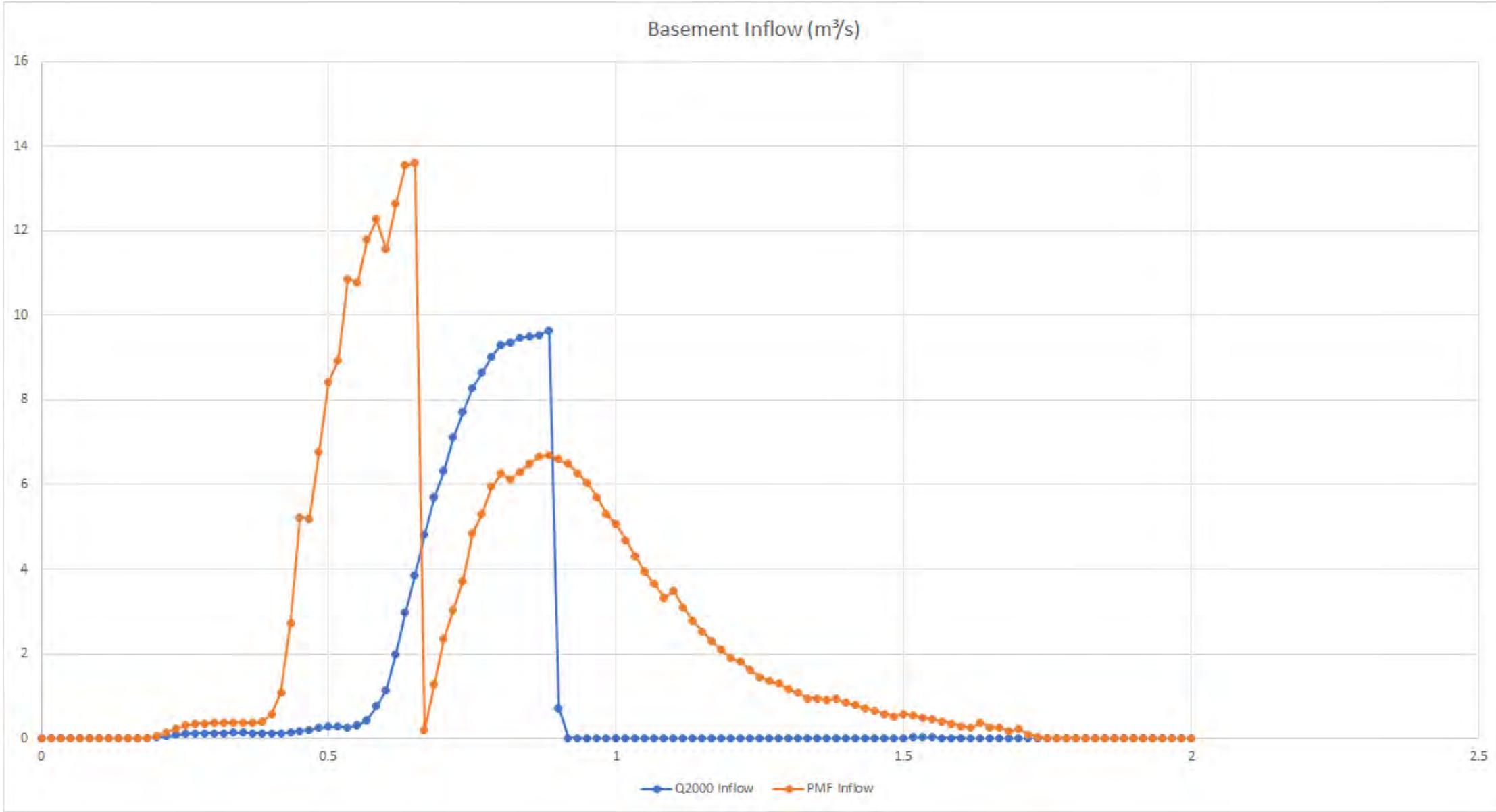
CONSULTANT CJ ARMS & ASSOCIATES www.cjarms.com

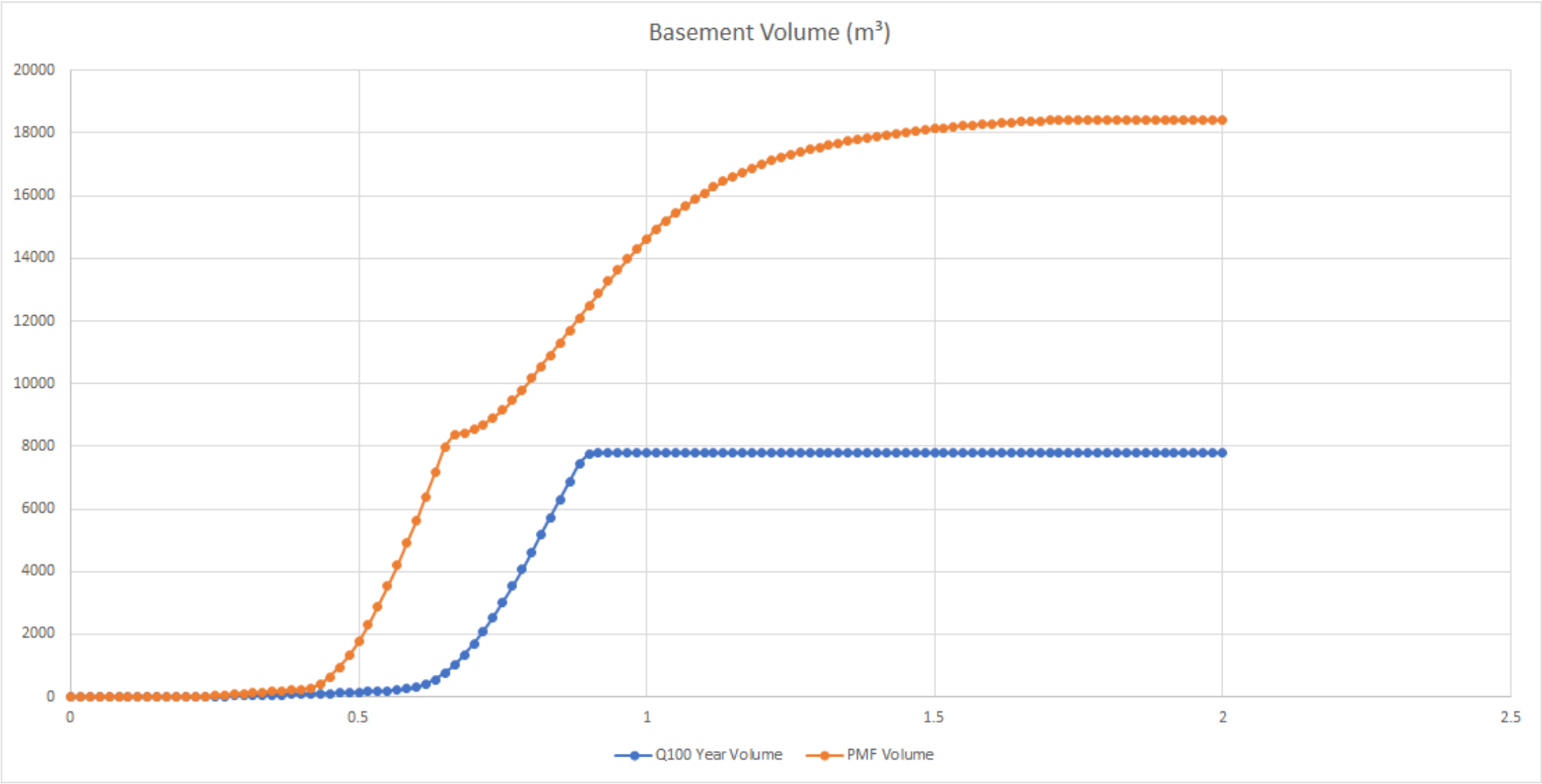
PROJECT CHATSWOOD CHASE SC
345-363 VICTORIA AVENUE, CHATSWOOD
NSW, 2067
CITY OF WILLOUGHBY

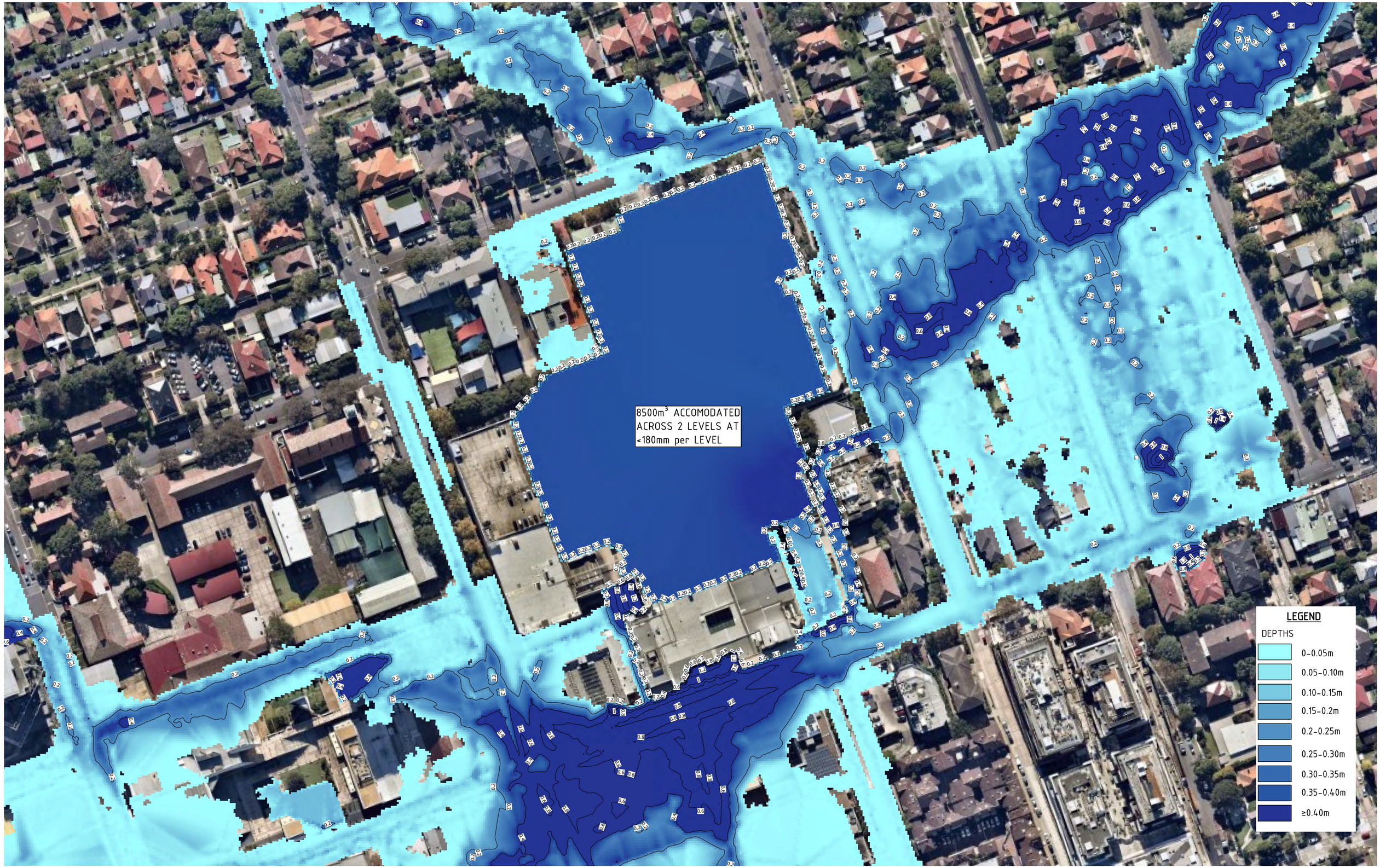
DRAWING CONCEPT PLAN
OVERLAND FLOW PATH

DRAWING STATUS PRELIMINARY
PROJECT STATUS PRELIMINARY

SCALE A1 1:200H 1:40V
DESIGN DG
DRAWN DG
DATE 20.08.2018
DRAWING & REV. CONCEPT P1


Basement Inflow (m³/s)
16
14
12
10
8
6
4
2
0
0
0.5
1
1.5
2
2.5
Q2000 Inflow
PMF Inflow


Basement Volume (m³)
20000
18000
16000
14000
12000
10000
8000
6000
4000
2000
0
0
0.5
1
1.5
2
2.5
Q100 Year Volume
PMF Volume



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PROJECT NUMBER CJA 14291

REVISIONS	No	DATE	AMENDMENTS	AUT.
	P1	20/02/19	ISSUED FOR INFORMATION	DG

CLIENT VICINITY CENTRES

CONSULTANT CJ ARMS & ASSOCIATES
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PROJECT **CHATSWOOD CHASE SC**
345-363 VICTORIA AVENUE, CHATSWOOD
NSW, 2067
CITY OF WILLOUGHBY

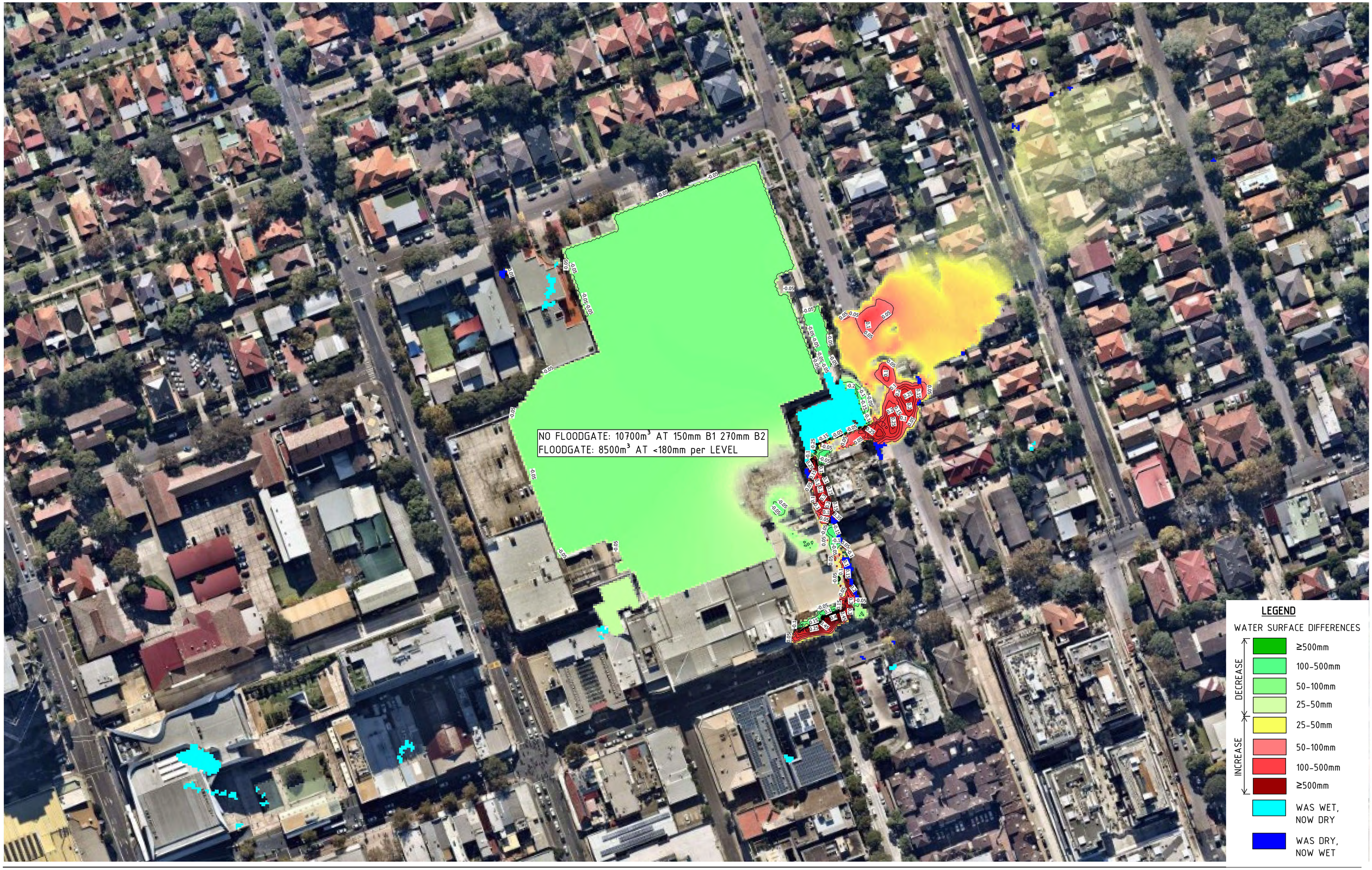
DRAWING PEAK FLOOD DEPTH
0.50% AEP - 2 HOUR STORM
FLOOD GATE & OLF

DRAWING STATUS PRELIMINARY
PROJECT STATUS PRELIMINARY

N

SCALE A1 N.T.S
DESIGN DG
DRAWN DG
DATE 20.08.2018

DRAWING & REV. 200Y-D P1



PROJECT NUMBER CJA 14291

PHONE (03) 9285 2800 www.cjarms.com

REVISIONS	No	DATE	AMENDMENTS	AUT.
	P1	20/02/19	ISSUED FOR INFORMATION	DG

CLIENT VICINITY CENTRES

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PROJECT **CHATSWOOD CHASE SC**
345-363 VICTORIA AVENUE, CHATSWOOD
NSW, 2067
CITY OF WILLOUGHBY

DRAWING PEAK FLOOD DEPTH
0.5% AEP - 2 HOUR STORM
DEPTH COMPARISON

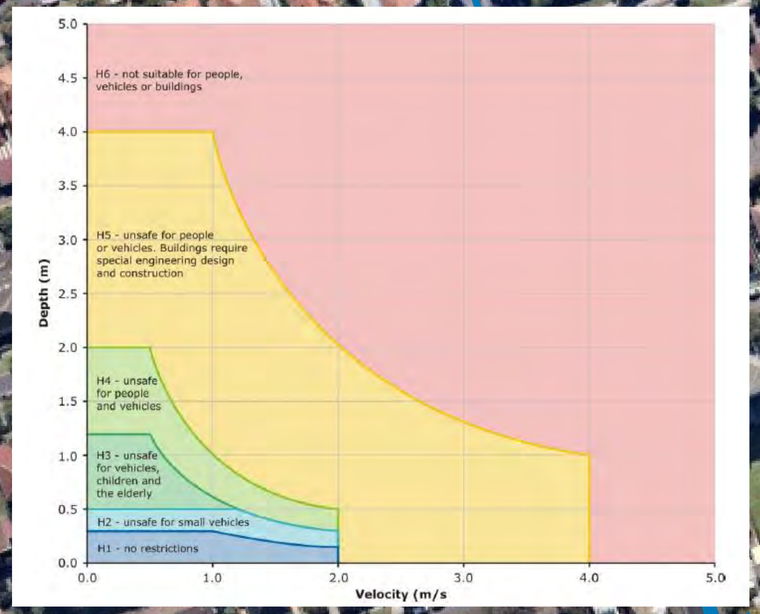
DRAWING STATUS PRELIMINARY

PROJECT STATUS PRELIMINARY

N

SCALE A1 N.T.S
DESIGN DG
DRAWN DG
DATE 20.08.2018

DRAWING & REV. **200Y-COMP-D** P1



Hazard Classification	Description
H1	Relatively benign flow conditions. No vulnerability constraints.
H2	Unsafe for small vehicles.
H3	Unsafe for all vehicles, children and the elderly.
H4	Unsafe for all people and all vehicles.
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H6	Unconditionally dangerous. Not suitable for any type of development or evacuation access. All building types considered vulnerable to failure.

LEGEND

HAZARD CLASSIFICATION

- H1
- H2
- H3
- H4
- H5
- H6

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PROJECT NUMBER CJA 14291

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No	DATE	AMENDMENTS	AUT.
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CLIENT VICINITY CENTRES

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PROJECT **CHATSWOOD CHASE SC**
345-363 VICTORIA AVENUE, CHATSWOOD
NSW, 2067
CITY OF WILLOUGHBY

DRAWING PEAK FLOOD DEPTH
0.5% - 2 HOUR STORM
FLOOD HAZARD

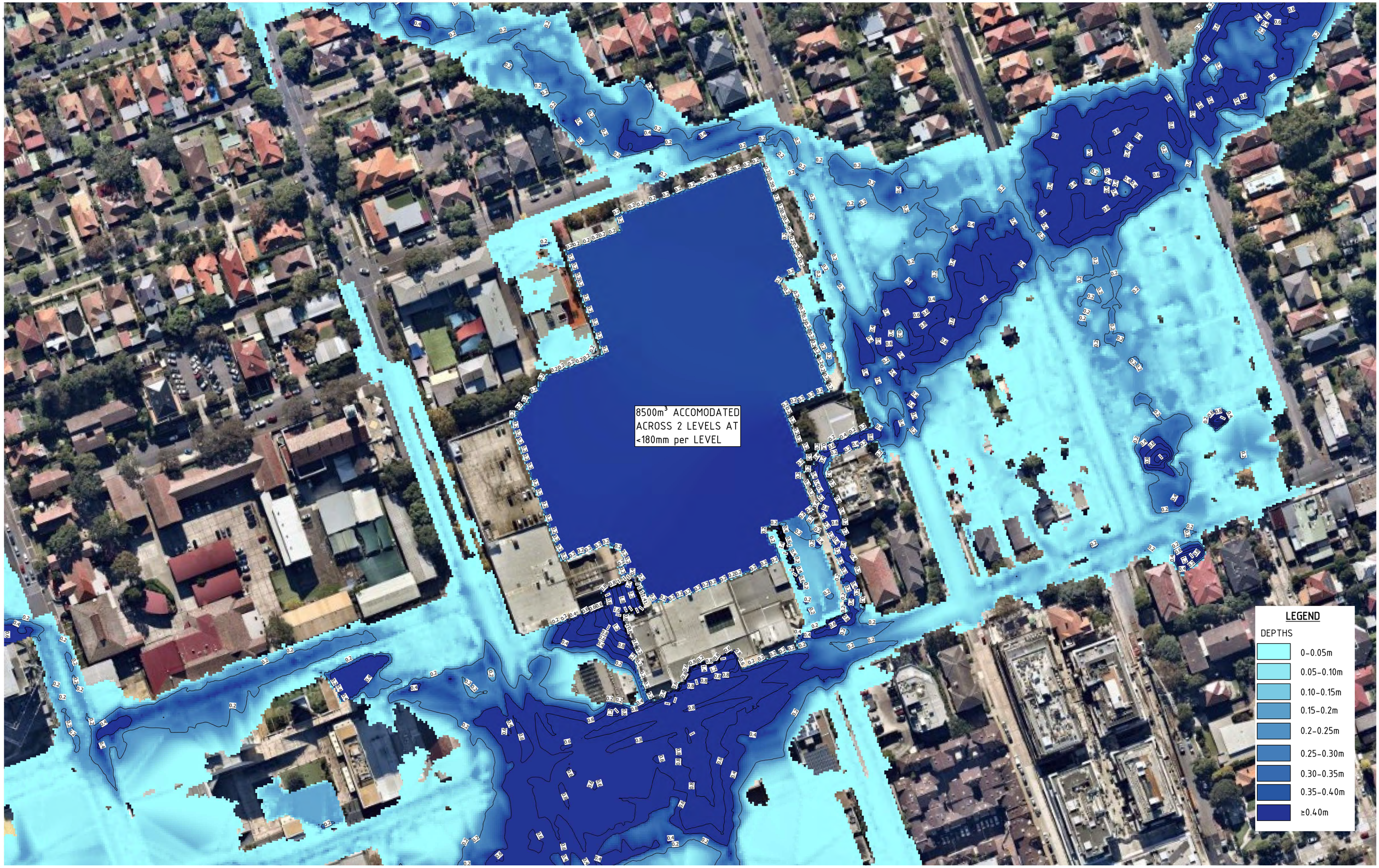
DRAWING STATUS PRELIMINARY

PROJECT STATUS PRELIMINARY

N

SCALE A1 N.T.S
DESIGN DG
DRAWN DG
DATE 20.08.2018

DRAWING & REV. **200-HAZARD** P1



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PROJECT NUMBER CJA 14291

REVISIONS

No	DATE	AMENDMENTS	AUT.
P1	20/02/19	ISSUED FOR INFORMATION	DG

CLIENT VICINITY CENTRES

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PROJECT **CHATSWOOD CHASE SC**
345-363 VICTORIA AVENUE, CHATSWOOD
NSW, 2067
CITY OF WILLOUGHBY

DRAWING PEAK FLOOD DEPTH
0.20% AEP - 2 HOUR STORM
FLOOD GATE & OLF

DRAWING STATUS PRELIMINARY
PROJECT STATUS PRELIMINARY

N

SCALE A1 N.T.S
DESIGN DG
DRAWN DG
DATE 20.08.2018
DRAWING & REV. 500Y-D P1

NO FLOODGATE: 15400m³ AT 150mm B1 470mm B2
FLOODGATE: 8500m³ AT <180mm per LEVEL

LEGEND

WATER SURFACE DIFFERENCES

DECREASE
- ≥500mm
- 100-500mm
- 50-100mm
- 25-50mm

INCREASE
- 25-50mm
- 50-100mm
- 100-500mm
- ≥500mm

- WAS WET, NOW DRY
- WAS DRY, NOW WET

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PROJECT NUMBER CJA 14291

REVISIONS	No	DATE	AMENDMENTS	AUT.
	P1	20/02/19	ISSUED FOR INFORMATION	DG

CLIENT VICINITY CENTRES

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PROJECT **CHATSWOOD CHASE SC**
345-363 VICTORIA AVENUE, CHATSWOOD
NSW, 2067
CITY OF WILLOUGHBY

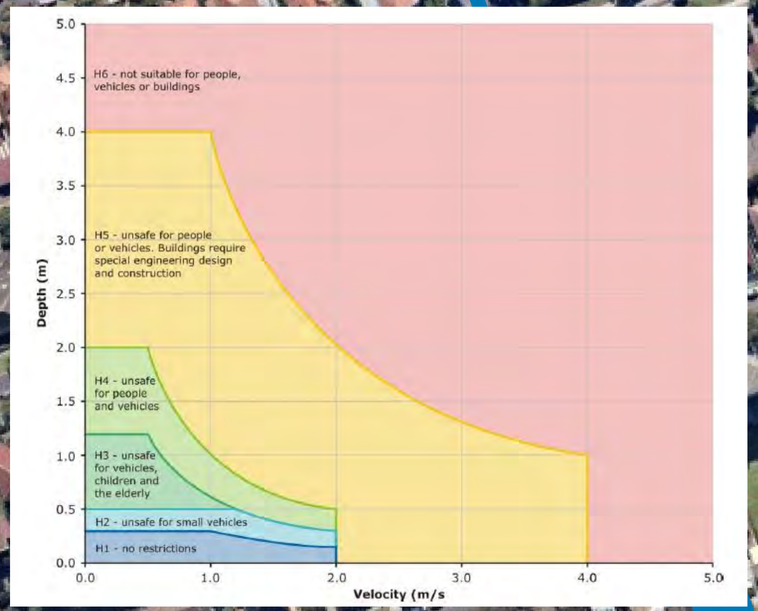
DRAWING PEAK FLOOD DEPTH
0.2% AEP - 2 HOUR STORM
DEPTH COMPARISON

DRAWING STATUS PRELIMINARY
PROJECT STATUS PRELIMINARY

N

SCALE A1 N.T.S
DESIGN DG
DRAWN DG
DATE 20.08.2018

DRAWING & REV. **500Y-COMP-D** P1



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LEGEND

HAZARD CLASSIFICATION

- H1
- H2
- H3
- H4
- H5
- H6

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PROJECT NUMBER CJA 14291

REVISIONS

No	DATE	AMENDMENTS	AUT.
P1	20/02/19	ISSUED FOR INFORMATION	DG

CLIENT VICINITY CENTRES

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345-363 VICTORIA AVENUE, CHATSWOOD
NSW, 2067
CITY OF WILLOUGHBY

DRAWING PEAK FLOOD DEPTH
0.2% - 2 HOUR STORM
FLOOD HAZARD

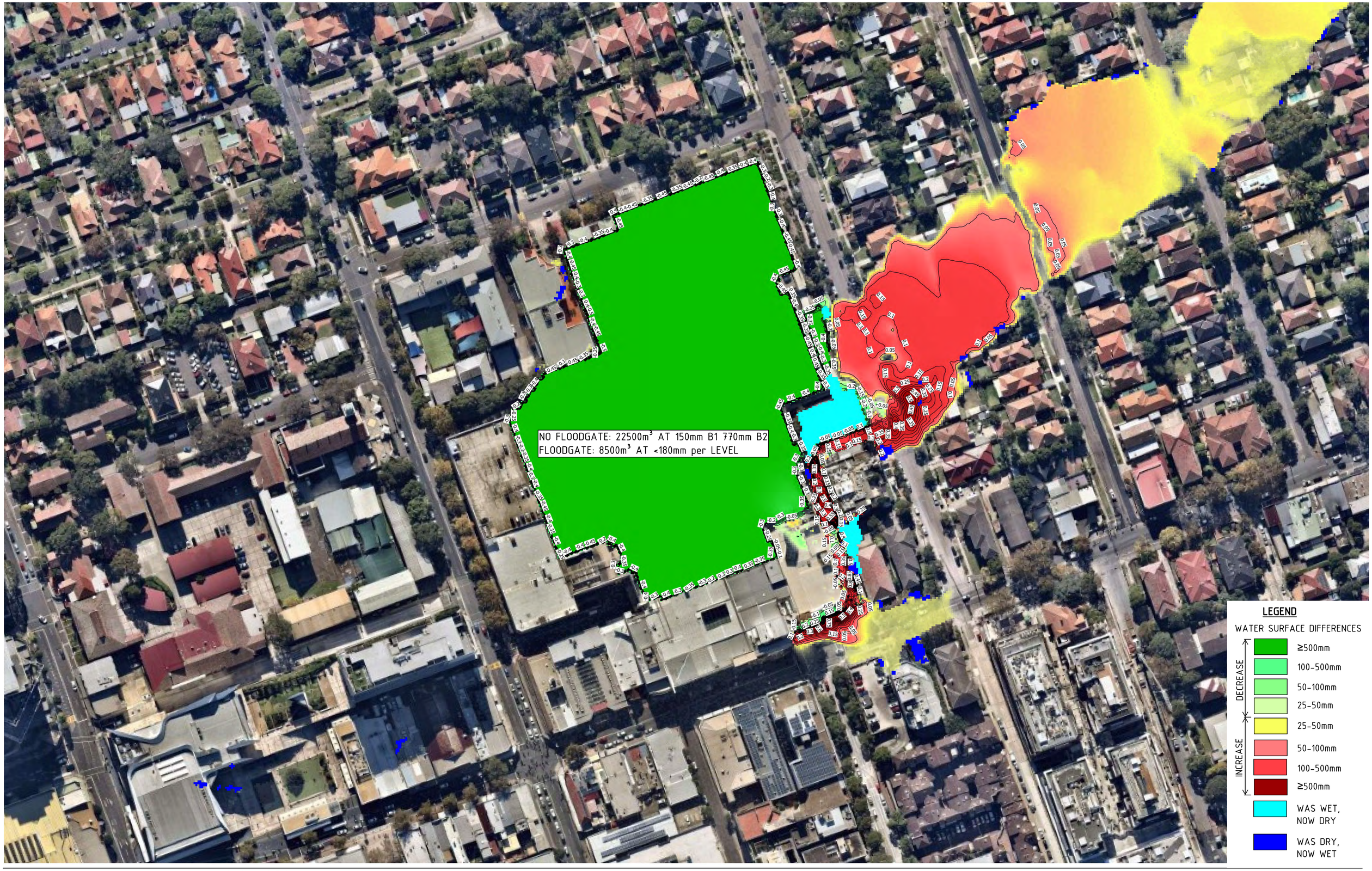
DRAWING STATUS PRELIMINARY

PROJECT STATUS PRELIMINARY

N

SCALE A1 N.T.S
DESIGN DG
DRAWN DG
DATE 20.08.2018

DRAWING & REV. **500-HAZARD** P1



LEGEND

WATER SURFACE DIFFERENCES

DECREASE
- ≥500mm
- 100-500mm
- 50-100mm
- 25-50mm

INCREASE
- 25-50mm
- 50-100mm
- 100-500mm
- ≥500mm

- WAS WET, NOW DRY
- WAS DRY, NOW WET

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PROJECT NUMBER CJA 14291

REVISIONS	No	DATE	AMENDMENTS	AUT.
	P1	20/08/18	ISSUED FOR INFORMATION	DG

CLIENT VICINITY CENTRES

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PROJECT **CHATSWOOD CHASE SC**
345-363 VICTORIA AVENUE, CHATSWOOD
NSW, 2067
CITY OF WILLOUGHBY

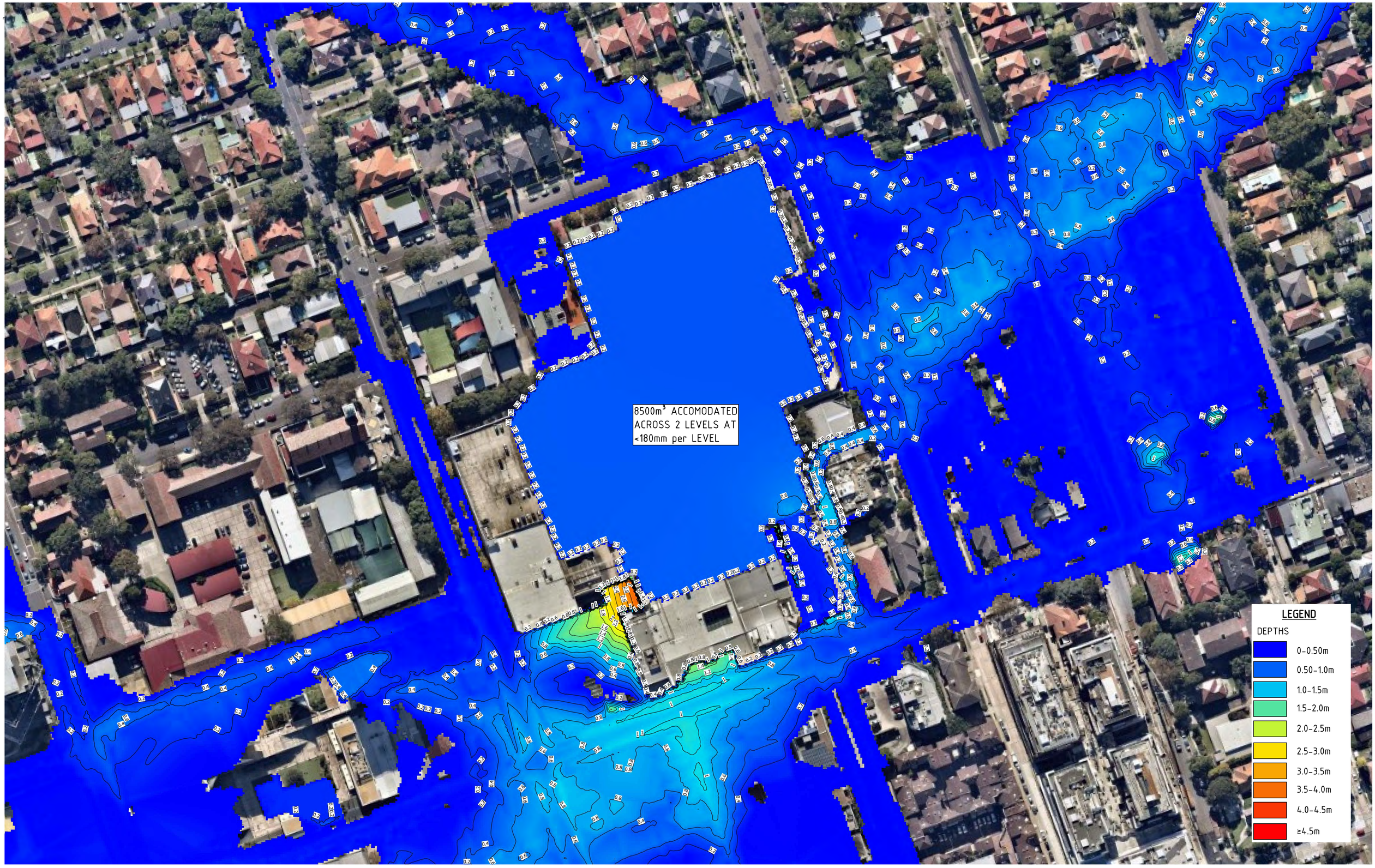
DRAWING PEAK FLOOD DEPTH
0.05% AEP - 2 HOUR STORM
DEPTH COMPARISON

DRAWING STATUS PRELIMINARY
PROJECT STATUS PRELIMINARY

N

SCALE A1 N.T.S
DESIGN DG
DRAWN DG
DATE 20.08.2018

DRAWING & REV. **2000Y-COMP-D** P1



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PROJECT NUMBER CJA 14291

REVISIONS	No	DATE	AMENDMENTS	AUT.
	P1	20/02/19	ISSUED FOR INFORMATION	DG

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NSW, 2067
CITY OF WILLOUGHBY

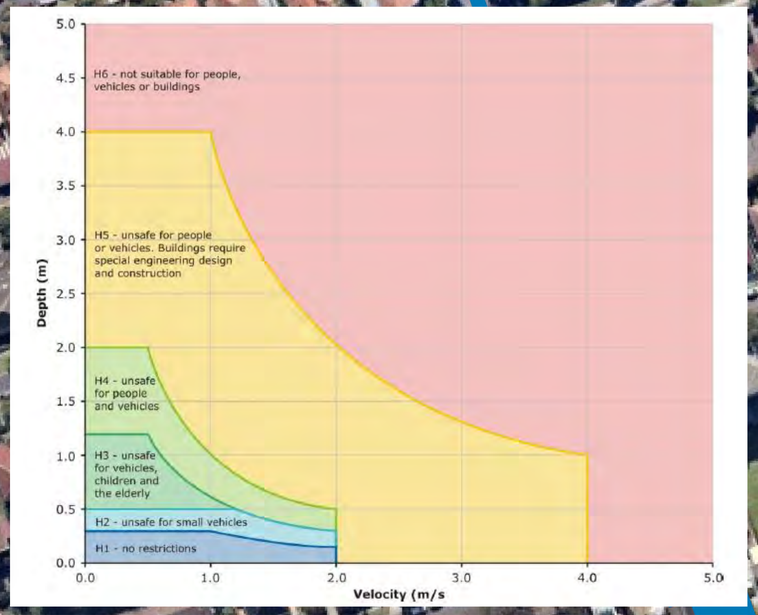
DRAWING PEAK FLOOD DEPTH
0.05% AEP - 2 HOUR STORM
FLOOD GATE & OLF

DRAWING STATUS PRELIMINARY
PROJECT STATUS PRELIMINARY

N

SCALE A1 N.T.S
DESIGN DG
DRAWN DG
DATE 20.08.2018

DRAWING & REV. 2000Y-D P1



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CLIENT VICINITY CENTRES

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CITY OF WILLOUGHBY

DRAWING PEAK FLOOD DEPTH
0.05% - 2 HOUR STORM
FLOOD HAZARD

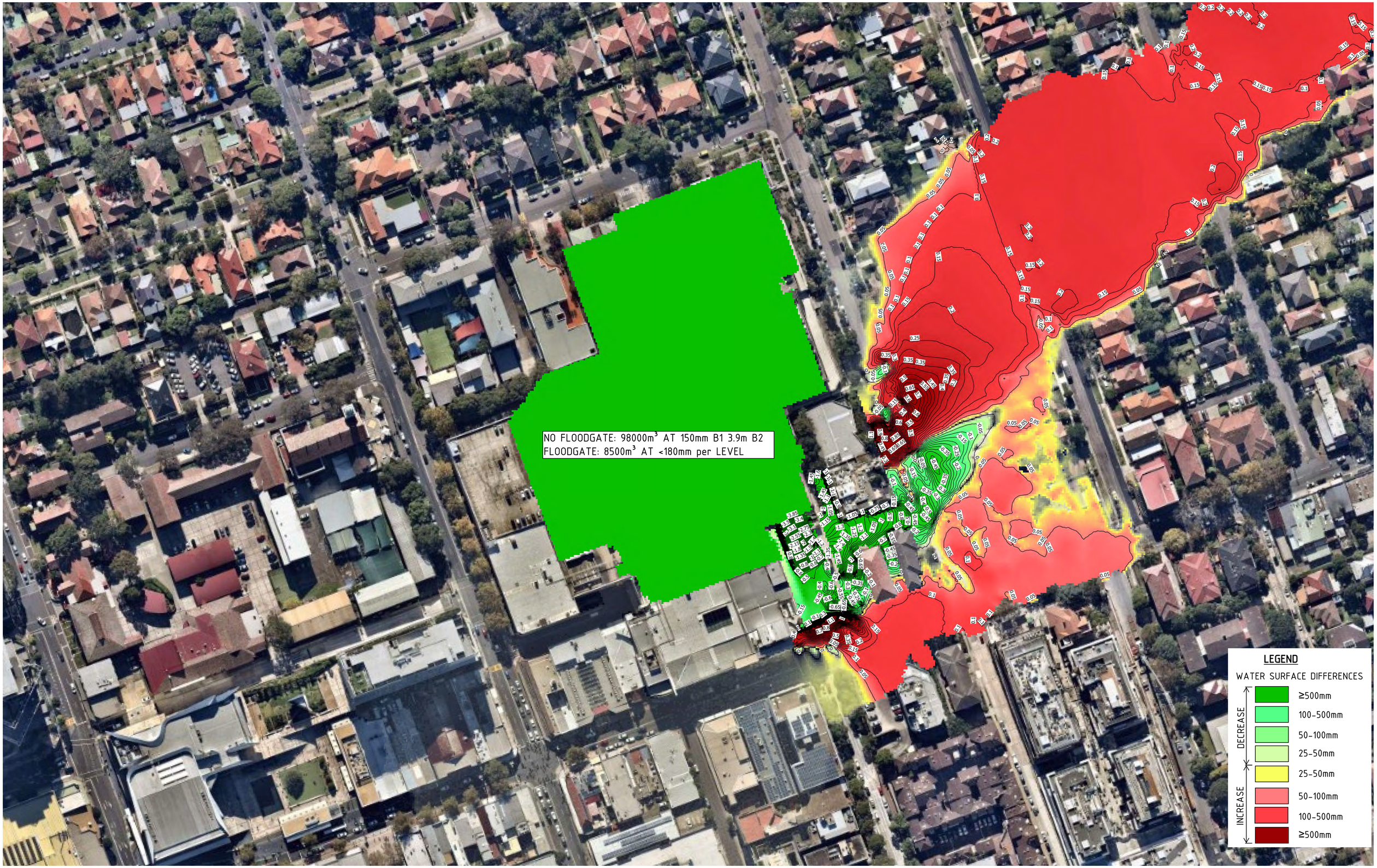
DRAWING STATUS PRELIMINARY

PROJECT STATUS PRELIMINARY

N

SCALE A1 N.T.S
DESIGN DG
DRAWN DG
DATE 20.08.2018

DRAWING & REV. 2000-HAZARD P1



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CITY OF WILLOUGHBY

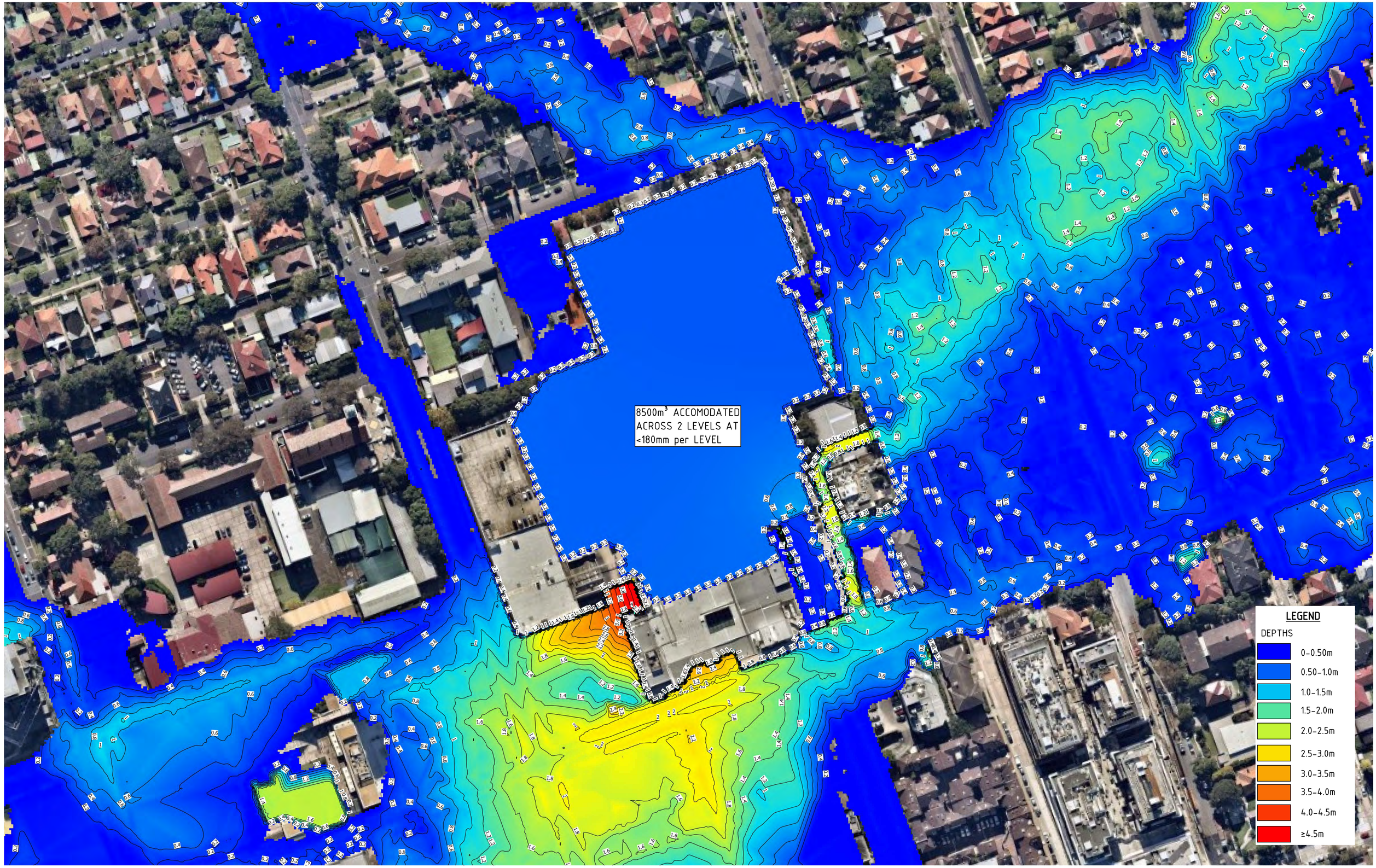
DRAWING PEAK FLOOD DEPTH
PMF - 2 HOUR STORM
DEPTH COMPARISON

DRAWING STATUS PRELIMINARY
PROJECT STATUS PRELIMINARY

N

SCALE A1 N.T.S
DESIGN DG
DRAWN DG
DATE 20.08.2018

DRAWING & REV. **PMF-COMP-D** P1



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PROJECT NUMBER CJA 14291

REVISIONS

No	DATE	AMENDMENTS	AUT.
P1	20/08/18	ISSUED FOR INFORMATION	DG

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PROJECT **CHATSWOOD CHASE SC**
345-363 VICTORIA AVENUE, CHATSWOOD
NSW, 2067
CITY OF WILLOUGHBY

DRAWING PEAK FLOOD DEPTH
PMF - 2 HOUR STORM
FLOOD GATE & OLF

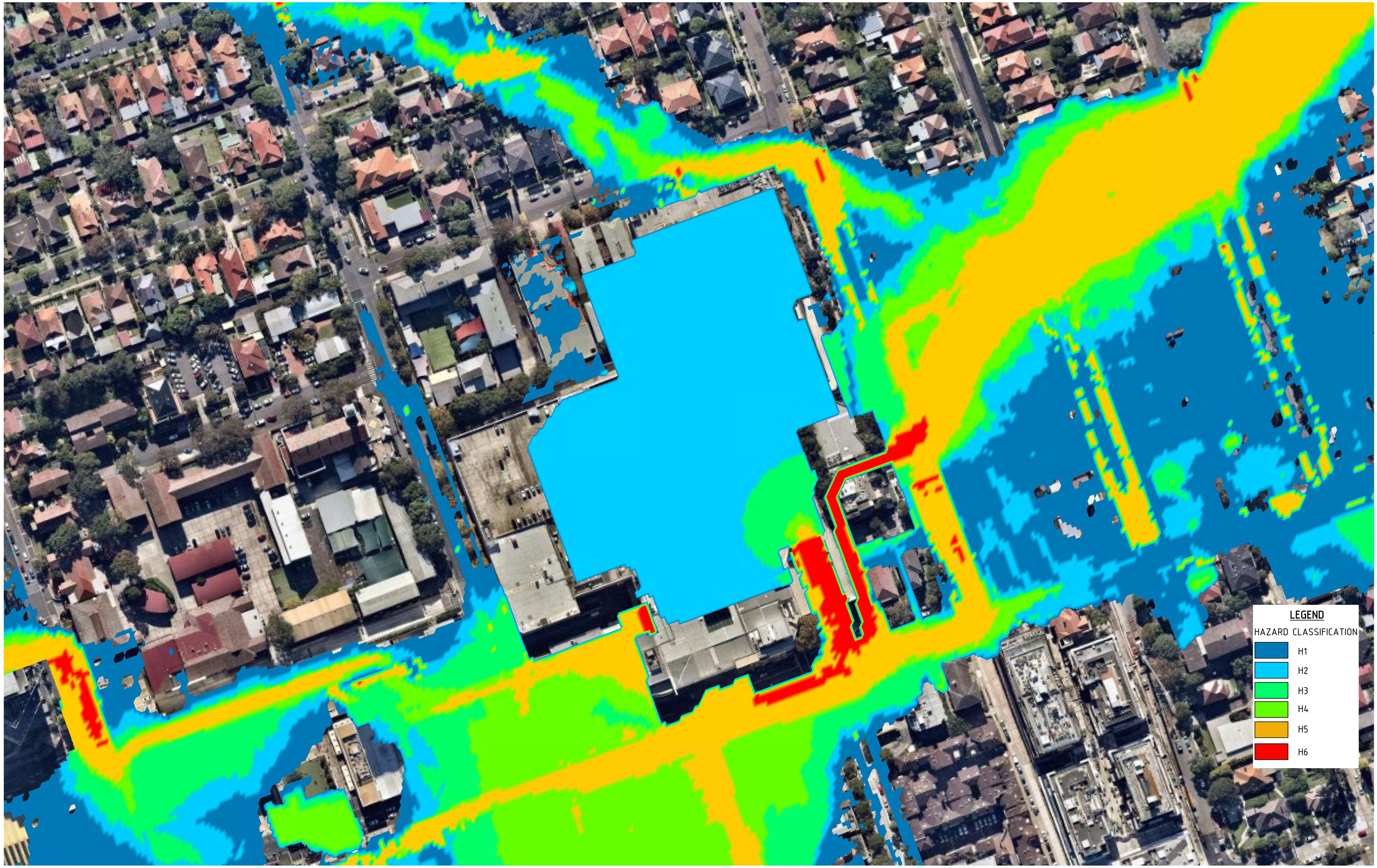
DRAWING STATUS PRELIMINARY

PROJECT STATUS PRELIMINARY

N

SCALE A1 N.T.S
DESIGN DG
DRAWN DG
DATE 20.08.2018

DRAWING & REV. PMF-FG-D P1



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PROJECT NUMBER CJA 14291

REVISIONS

No	DATE	AMENDMENTS	AUT.
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CITY OF WILLOUGHBY

DRAWING PEAK FLOOD DEPTH
PMF - 2 HOUR STORM
FLOOD HAZARD

DRAWING STATUS PRELIMINARY

PROJECT STATUS PRELIMINARY

N

SCALE A1 N.T.S
DESIGN DG
DRAWN DG
DATE 20.08.2018

DRAWING & REV. **PMF-HAZARD** P1

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PROJECT NUMBER CJA 14291

REVISIONS	No	DATE	AMENDMENTS	AUT.
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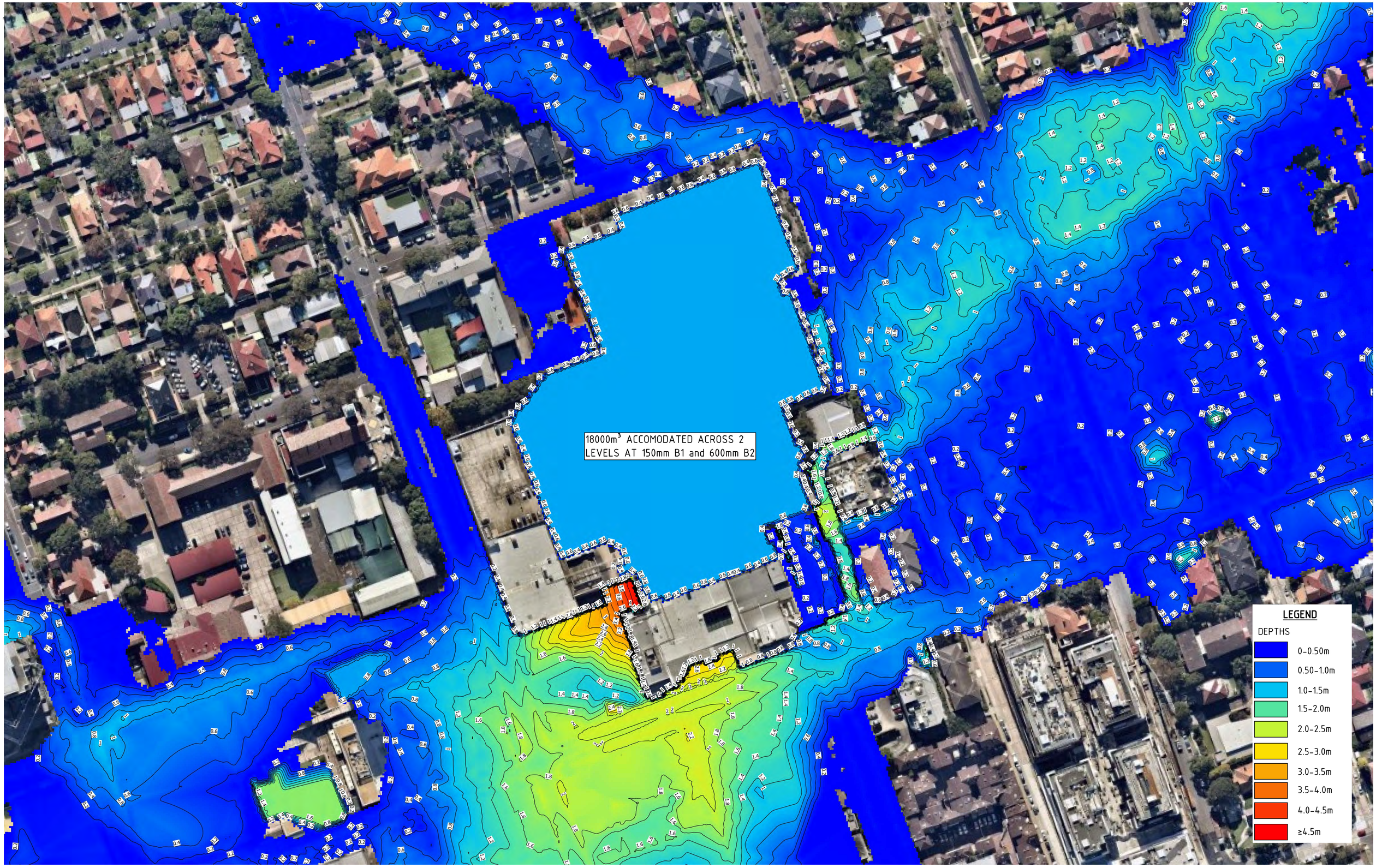
NSW, 2067
CITY OF WILLOUGHBY

DRAWING STATUS PRELIMINARY
PROJECT STATUS PRELIMINARY

N

DRAWING PEAK FLOOD DEPTH
PMF - 2 HOUR STORM
PARAPET OVERFLOW DEPTH
COMPARISON

SCALE A1 N.T.S
DESIGN DG
DRAWN DG
DATE 20.08.2018
DRAWING & REV. **PMF-OVERFLOW-COMP** P1



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PROJECT NUMBER CJA 14291

REVISIONS	No	DATE	AMENDMENTS	AUT.
	P1	20/02/19	ISSUED FOR INFORMATION	DG

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NSW, 2067
CITY OF WILLOUGHBY

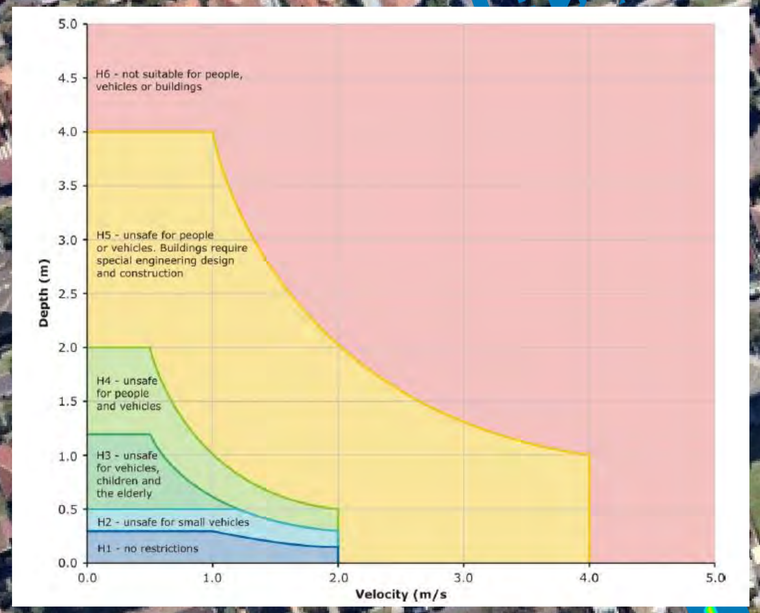
DRAWING STATUS PRELIMINARY
PROJECT STATUS PRELIMINARY

N

DRAWING PEAK FLOOD DEPTH
PMF - 2 HOUR STORM
PARAPET OVERLFLOW FLOOD DEPTH

SCALE A1 N.T.S
DESIGN DG
DRAWN DG
DATE 20.08.2018

DRAWING & REV. **PMF-OVERFLOW-D** P1



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LEGEND

HAZARD CLASSIFICATION

- H1
- H2
- H3
- H4
- H5
- H6

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PROJECT **CHATSWOOD CHASE SC**
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NSW, 2067
CITY OF WILLOUGHBY

DRAWING STATUS PRELIMINARY

PROJECT STATUS PRELIMINARY

N

DRAWING PEAK FLOOD DEPTH
PMF - 2 HOUR STORM
PARAPET OVERFLOW FLOOD HAZARD

SCALE A1 N.T.S
DESIGN DG
DRAWN DG
DATE 20.08.2018

DRAWING & REV. **PMF-OVERFLOW HAZARD** P1

Appendix C

DA Design Plans

Appendix C - Design Plans

Drawing Number	Date	Subject/Drawing Name	Author	Notes
DA0001	14/11/2018	Cover Sheet	Make Architects	Supersedes DA0001-Rev03
DA2007	31/07/2018	Level B2	Make Architects	Amended
DA2008	02/08/2018	Level B1	Make Architects	Amended
DA2009	30/11/2018	Level LG	Make Architects	Supersedes DA2009-Rev02
DA2009A	31/07/2018	Level LGA	Make Architects	Amended
DA2010	30/11/2018	Level 00	Make Architects	Supersedes DA2010-Rev03
DA2010A	12/11/2018	Level 00A	Make Architects	Supersedes DA2010A-Rev01
DA2011	12/11/2018	Level 01	Make Architects	Supersedes DA2011-Rev01
DA2011A	12/11/2018	Level 01A	Make Architects	Supersedes DA2011A-Rev01
DA2012	12/11/2018	Level 02	Make Architects	Supersedes DA2012-Rev01
DA2012A	12/11/2018	Level 02A	Make Architects	Supersedes DA2012A-Rev01
DA2013	12/11/2018	Level 03	Make Architects	Supersedes DA2013-Rev01
DA2013A	27/07/2018	Level 03A	Make Architects	
DA2014	30/11/2018	Level 04	Make Architects	Supersedes DA2014-Rev02
DA2014A	27/07/2018	Level 04A	Make Architects	Amended
DA2015	12/11/2018	Level 05	Make Architects	Supersedes DA2015-Rev01
DA2015A	27/07/2018	Level 05A	Make Architects	Amended
DA2016	27/07/2018	Level 06	Make Architects	Amended
DA2200	12/11/2018	Proposed Elevation - East	Make Architects	Supersedes DA2200-Rev01
DA2201	12/11/2018	Proposed Elevation - West	Make Architects	Supersedes DA2201-Rev01
DA2202	14/11/2018	Proposed Elevation -South	Make Architects	Supersedes DA2202-Rev02
DA2203	14/11/2018	Proposed Elevation-North	Make Architects	Supersedes DA2203-Rev02
DA2260	27/07/2018	Wall Sections	Make Architects	Amended
DA2261	31/07/2018	Wall Sections	Make Architects	Amended
DA2262	23/11/2018	Wall Sections	Make Architects	Supersedes DA2262-Rev01
DA2263	27/07/2018	Wall Sections	Make Architects	Amended
DA2300	23/11/2018	Proposed Sections	Make Architects	Supersedes DA2300-Rev00 Amended
DA2301	23/11/2018	Proposed Sections	Make Architects	Supersedes DA2301-Rev00
DA2302	23/11/2018	Proposed Sections	Make Architects	Supersedes DA2302-Rev00
DA2303	31/07/2018	Proposed Sections	Make Architects	Amended
DA2304	31/07/2018	Proposed Sections	Make Architects	Amended
DA2305	23/11/2018	Proposed Sections	Make Architects	Supersedes DA2305-Rev00 Amended
DA2400	31/07/2018	GFA Plans	Make Architects	
DA2401	31/07/2018	GFA Plans	Make Architects	
DA2402	31/07/2018	GFA Plans	Make Architects	
DA2403	31/07/2018	GFA Plans	Make Architects	
DA6900	31/07/2018	Photomontage	Make Architects	Amended
DA6901	23/11/2018	Photomontage	Make Architects	Supersedes DA6901-Rev00
DA6902	23/11/2018	Photomontage	Make Architects	Supersedes DA6902-Rev00
DA6903	23/11/2018	Photomontage	Make Architects	Supersedes DA6903-Rev00
DA6904	23/11/2018	Photomontage	Make Architects	Supersedes DA6904-Rev00
ATP-10002	27/07/2018	Existing Site Plan	BUCHAN	Amended
ATP-10100	27/07/2018	Existing Plan Basement Level B2	BUCHAN	Amended
ATP-10101	27/07/2018	Existing Plan Basement Level B1	BUCHAN	Amended
ATP-10102	27/07/2018	Existing Plan Lower Ground & Lower Ground A	BUCHAN	Amended
ATP-10103	27/07/2018	Existing Plan Ground & Ground A	BUCHAN	Amended
ATP-10104	27/07/2018	Existing Plan Level 1 & Level 1A	BUCHAN	Amended
ATP-10105	27/07/2018	Existing Plan Level 2 & Level 2A	BUCHAN	Amended
ATP-10106	27/07/2018	Existing Plan Level 3	BUCHAN	Amended
ATP-10110	02/08/2018	Basement B2 Plan Red/Blue Overlay	BUCHAN	Amended
ATP-10111	02/08/2018	Basement B1 Plan Red/Blue Overlay	BUCHAN	Amended
ATP-10112	02/08/2018	Lower Ground Level Red/Blue Overlay	BUCHAN	Amended

ATP-10113	02/08/2018	Ground & Ground A Level Red/Blue Overlay	BUCHAN	Amended
ATP-10114	02/08/2018	Level 1 & Level 1A Red/Blue Overlay	BUCHAN	Amended
ATP-10115	02/08/2018	Level 2 & Level 2A Red/Blue Overlay	BUCHAN	Amended
ATP-10116	02/08/2018	Level 3 Plan Red/Blue Overlay	BUCHAN	Amended
ATP-10150	27/07/2018	Aerial Photograph	BUCHAN	Amended
ATP-10151	27/07/2018	Precinct Plan	BUCHAN	Amended
ATP-10152	27/07/2018	Site Context Plan	BUCHAN	Amended
ATP-10160	27/07/2018	Existing Building Shadow Diagrams Winter Solstice	BUCHAN	Amended
ATP-10161	27/07/2018	Proposed Building Shadow Diagrams Winter Solstice	BUCHAN	Amended
ATP-10162	27/07/2018	Existing Building Shadow Diagrams Spring Equinox	BUCHAN	Amended
ATP-10163	27/07/2018	Proposed Building Shadow Diagrams Spring Equinox	BUCHAN	Amended
LS-DWG-E-1300	02/08/2018	Landscape Concept: Chatswood Chase Shopping Centre Elevations	Lat27	
LS-DWG-E-1301	02/08/2018	Landscape Concept: Chatswood Chase Shopping Centre Elevations	Lat27	
LS-DWG-P-1100	02/08/2018	Landscape Concept: Chatswood Chase Shopping Centre Ground Floor	Lat27	
LS-DWG-P-1101	02/08/2018	Landscape Concept: Chatswood Chase Shopping Centre Level One	Lat27	
LS-DWG-P-1102	02/08/2018	Landscape Concept: Chatswood Chase Shopping Centre Level Two	Lat27	
LS-DWG-P-1103	02/08/2018	Landscape Concept: Chatswood Chase Shopping Centre Level Three	Lat27	
LS-DWG-P-1104	02/08/2018	Landscape Concept: Chatswood Chase Shopping Centre Level Four	Lat27	
LS-DWG-P-1105	02/08/2018	Landscape Concept: Chatswood Chase Shopping Centre Level Five	Lat27	
LS-DWG-P-1106	02/08/2018	Landscape Concept: Chatswood Chase Shopping Centre The Recreation Centre	Lat27	
LS-DWG-P-1107	02/08/2018	Landscape Concept: Chatswood Chase Shopping Centre Outdoor Terraces	Lat27	
LS-DWG-P-1108	02/08/2018	Landscape Concept: Chatswood Chase Shopping Centre Victoria Avenue Entrance	Lat27	
LS-DWG-S-1200	02/08/2018	Landscape Concept: Chatswood Chase Shopping Centre Sections	Lat27	
LS-DWG-S-1201	02/08/2018	Landscape Concept: Chatswood Chase Shopping Centre Sections	Lat27	
LS-DWG-S-1202	02/08/2018	Landscape Concept: Chatswood Chase Shopping Centre Sections	Lat27	

LS-DWG-S-1203	02/08/2018	Landscape Concept: Chatswood Chase Shopping Centre Sections	Lat27	
LS-DWG-S-1204	02/08/2018	Landscape Concept: Chatswood Chase Shopping Centre Sections	Lat27	

Appendix D

Comments on Draft Conditions

Rhelm Draft Conditions		CJA Response	Urbis Comment	Lyall Comments	Council
Flood Condition 1 - Prior to the issue of a Construction Certificate, an updated Flood Study Report shall be prepared by a suitably qualified and experienced Professional and approved by Council. The Report shall:		acceptable			This condition is to be approved by Council prior to lodgement of the CC, rather than prior to issue. Council maintains that the updated Flood Study report should be reviewed by itself and the independent expert. The cost of the independent expert must be paid by the applicant.
• assess the extent of the 1% AEP, 0.5%AEP, 0.02%AEP design flood and the PMF event associated with the Sydney Water stormwater system and related overland flow paths through and around the property. The extents shall be shown with and without the proposed development and flood risk management concept solutions for the basement car park prepared by CJ Arms & Associates dated 20 February 2019 and show the difference in flood levels and flood hazard in accordance with the McLuckie et al 2014 H1 – H6 hazard classification system.		accptable		Should be 0.05% AEP, not 0.02% AEP. For consistency in naming expand PMF (typical comment as applies to other clauses).	
• assess the levels of the 1% AEP and the PMF event at all entry points to the building to confirm that the floor levels of retail and commercial areas are set above the flood planning level of the 1%AEP plus 0.5 m and to confirm no additional flood protection measures are required to control flooding of the basement up to the PMF apart from those proposed in the concept option prepared by CJ Arms & Associates dated 20 February 2019.		0.5 m free board to all existing floor areas is unreasonable. (previously adopted 0.3 m to existing floor areas) Can retain for new floor areas.	We understand DCP requirement for alterations and additions to retail, office and other commercial buildings is 1:100+0.3m. 0.5 is for new development only. Levels should reflect this 0.3m freeboard.	Agree freeboard could be reduced to 0.3 m for alterations and additions to commercial development.	
• indicate that the proposed development will not increase the 1% AEP flood levels or peak flood flow velocities on adjacent properties and that the proposed building and basement car park can withstand the likely conditions experienced during the 1%AEP flood event without suffering significant damage.		acceptable.			
• Indicate that the proposed development will not increase the flood hazard or risk to life on private property for all events up to the PMF.		assessment limited to private property controlled by Vicinity	Rhelm to clarify whether this is Vicinity Property or all Private Property.	Based on the discussions between the various parties it was our understanding that this clause applies to all privately owned development, not just property that is owned by Vicinity (for example, this condition applies to impacts on flooding behaviour in existing residential and commercial development that is located along Victoria Road and Havilah Street). We do not agree that it should be limited top property owned by Vicinity	
Flood Condition 2 - Prior to issue of the Construction Certificate, a report by a suitably qualified and experienced Structural Engineer registered on the Engineers Australia National Engineers Register shall be submitted to Council or the nominated Accredited Certifier, indicating that the proposed flood gate and related flood-control facilities can withstand the likely conditions (including structural load forces) experienced up to the Probable Maximum Flood event. The report should be completed in accordance with the requirements of AS/NZS 1170.1-2002, *Structural design actions - Permanent, imposed and other actions* .		acceptable			Council believes these are matters better assessed by a certifier. Council should however be provided with a copy of the certifier's report.
Flood Condition 3 - Prior to the issue of a Construction Certificate, a Flood Emergency Response Plan shall be submitted to demonstrate to Council that permanent, fail-safe measures are incorporated in the development to ensure the timely, orderly and safe evacuation of people from the basement areas affected by flooding and any other locations in the development below the Probable Maximum Flood level in the event of a flood. Such evacuation measures are to be designed for rainfall events up to the Probable Maximum Flood event. The plan shall include the following:		FERP to be updated		Need an additional condition which requires the applicant to submit stormwater management plans in relation to a permanent pump-out system (if not already present) that will de-water both B1 and B2 following a flood event. Evidence that approval has been granted by Sydney Water to pump floodwater which enters the basement to sewer is also to be provided prior to the issue of the Construction Certificate.	Council believes these are matters better assessed by a certifier. Council should however be provided with a copy of the certifier's report. The Flood Emergency Response Plan should include the following items listed on page 49 of the Rhelm report, namely: Automatic gates to close entry to the basement car park ;Trigger levels associated with evacuation
• a way of ensuring the management of the centre are made aware of the plan,		part of FERP			
• emergency contact numbers,		part of FERP			
• measures to be put in place to ensure occupants are prepared for flooding and evacuation, how to prepare for a flood event,		part of FERP			
• what do to during a flood event, including Plans of each flood affected level with clearly marked routes and exits to areas above the PMF level,		part of FERP		Should read "what to do" not "what do to"	
• an evacuation procedure including how to know when to evacuate and where to go, the place of refuge inside the building must be located above the PMF level and must be able to accommodate the total number of persons evacuated from the basement areas.		As previously noted the effect of the PMF is not isolated to the centre or the basements. While an evacuation procedure might direct people to higher ground, how do people then safely negotiate the surrounding streets? The solution could be that people are relocated to level 1 and told to wait-out the event. We believe the FMP needs to consider what happens in all events greater than the 1 in 100 year and should address the risk based on the flood water depth outside the building or in the basement.	Urbis reads that this condition relates only to evacuation within Chatswood Chase Shopping Centre and basements, and not land outside the building. Rhelm to confirm.	Believe Rhelm is referring to a shelter-in-place approach within the Centre, not evacuation out into the surrounding streets which all agree will be inundated by floodwater. Rhelm to confirm.	
• Details of wording and location of flood warning signs to be installed in the basement and at the entry from Victoria Avenue to increase flood awareness and provide direction as to the safest path for pedestrians to evacuate to higher ground within the Centre.		part of FERP			
• Details of a flood warning system that is to triggered by the ingress of water into the basement.		part of FERP			
• Specific measures that identify the location of accessible parking spaces and how persons using those spaces can safely leave the basement.		part of FERP		Need to include additional dot points along the following lines "Details of the trigger levels for the operation of the tractable flood gates" "Plan showing the location of the water level sensors on B1 and B2"	
The extent and depth of the PMF flow path shall be shown on the engineering plans and indicated on work as executed plans. A restriction as to use of the flood channel through the building proposed within 5-7 Havilah Street shall be placed on the title of the lot preventing any alteration to the flow path.		Again the PMF is not retricted to just the overland flow path and affects the entire building and all surrounding streets. Restriction to coincide with SW culvert easement.4.A restriction of the title (assuming this is an easement) of 5 to 7 Havilah (overland flow path) will need to be coordinated with the SW easement for the culvert.	This requirement should probably be split as it is not clear how the first sentence relates to the propsoed restriction on title for 5-7 Havilah Street. Rhelm to clarify the intent and reasons for this condition		
Flood Condition 4 – The flood risk management concept solutions for the basement car park prepared by CJ Arms & Associates dated 20 February 2019 shall be operational and maintained for the life of the development, being:		This requires a new plan to be put in place that provides yearly signoff on the flood management measures and ensures they are operational and effective. Refer to comments in Flood Condition 15.	Noted - need to clarify who is responsible for the operation and maintenance per condition 15.		This should be applicant's responsibility.
• Flood gates on the Victoria Avenue car park entry to the B1 and B2 levels – these gates are to be designed to activate after the 1%AEP flood event flows to allow flow depths of less than 0.2 m into the basement and minimise flood impacts on adjacent properties.		agreed		What AEP event(s) does the requirement to "minimise" flood impacts relate, noting that there is a requirement not to adversely affect flooding behaviour in adjacent properties for the 1% AEP event (refer third dot point under *Flood Condition 1*).	Thi sshould read- Flood gates on the Victoria Avenue car park entry to the B1 and B2 levels – these gates are to be designed to activate after the 1%AEP flood event to allow flow depths of no more than 180mm into the basement at each level, to cause no afflux in the 1%AEP and to minimise flood impacts in greater storms on adjacent properties.
• A formal flood diversion channel/conduit that will convey flows through the proposed building to discharge to Havilah Street – this channel/conduit is to operate in events greater than a 1%AEP flood event (when the flood gates activate) and up to the 0.05%AEP (1 in 2000 year event)		Overland flow channel will be restricted to flow below lower ground level RL 81.35	Noted. Confirm that this is captured the intent of the draft condition		A formal flood diversion channel/conduit that will convey flows through the proposed building to discharge to Havilah Street – this cannel/conduit shall operate in events greater than a 1%AEP flood event (when the flood gates activate) and shall have the capacity to convey flows up to and including 0.05% AEP (1 in 2000 year event)
• For events greater than the 0.05%AEP, a wall along the flood diversion channel can overtop and flood flows in excess of the diversion may enter the carpark up to a depth of approximately 0.6 m on Level B2. Actions within the Flood Emergency Response Plan for the site are to seek the safe evacuation of any persons within the basement in this extreme situation.		FERP must ensure that no persons are in the basement when water depth is at 200mm or greater.	Noted for incorporation into FERP when drafted		
• Other modifications to related facilities including:					
o Mills Lane – flood protection works are required to prevent ingress of flood flows via the Mills Lane loading dock.		accepted			
o Energy dissipation works are required at the outlet of the flood diversion conduit to Havilah Street		accepted			
o Modification of stair access to the Victoria Avenue loading dock to prevent flood ingress up to the PMF event.		accepted			
Flood Condition 5 - The minimum floor level of any retail or commercial area shall be 0.5 metres above the level of the 1%AEP flood.		**This cannot relate to the existing floor levels, cannot alter existing floor levels,** previous agreed to adopt 300mm freebaord above the 1 in 100 year level.	Noted CJ Arms position is consistent with approach within the DCP for alterations and Additions. Refer comment in line 8 above		
Flood Condition 6 - A flood warning system is to be provided on the property to alert people when flooding is occurring. The alarm system shall be designed to trigger when flood flows commence flowing into the basement from Victoria Avenue. The system is to be tested annually to ensure that it remains in working order and confirmation that testing has occurred shall be forwarded to Council.		part of FERP		Is it a flood warning system which includes an alarm system or simply an alarm system?	
Flood Condition 7 - All new or replacement electrical and mechanical facilities or equipment to be installed below the level of the 1%AEP flood level is to be flood-proofed and/or incorporate residual current devices to protect occupants of the basement from electrocution during a flood event.		part of FERP		Should be 1% AEP plus 0.3 m freeboard as there will be wave action in the flow as it enters B1 then B2.	
Flood Condition 8 - All existing and new fire-related facilities installed in the basement area are to be flood- proofed to ensure they can operate effectively under all flood conditions, including up to the Probable Maximum Flood event.		part of FERP			
Flood Condition 9 - All materials to be used in the basement area are to be flood-compatible up to a depth of		part of FERP		Suggest link to a specific flood event, not a depth as this may vary slightly depending on the final configuration of the flood gates and overtopping weir. Include freeboard if the decision is to relate it to the 1% AEP flood for the reason stated above.	
0.6 m.				Should be 1% AEP plus 0.3 m freeboard for the reason stated above.	
Flood Condition 10 - No hazardous materials are to be stored below the 1%AEP flood level.		part of FERP			
Flood Condition 11 – All electrical facilities located on Levels B1 and B2 shall be fitted with residual current devices to prevent electrocution in the event of the ingress of flood waters to the basement.		part of FERP			
Flood Condition 12 - The Flood Emergency Response Plan prepared to meet Flood Condition 3 shall operate for the life of the development. Annual testing shall occur of the system in its entirety by a suitably qualified professional and evidence of that testing is to be submitted to Council by 31 January of every year.		part of FERP		Need a condition which requires the testing of the flood gates, depth trigger sensors and basement pump-out system on an annual basis.	
8.3 During the Construction Phase					
Flood Condition 13 - The subject land is subject to flooding and as such, construction may be inundated by flood waters during periods of flooding. Accordingly, all building work that is located below the Probable Maximum Flood level shall be provided with adequate flood proofing.		possible contract conditions			
Flood Condition 14 - All drainage works shall be carried out in accordance with the Plumbing and Drainage Act 2011 and Australian Standard AS/NZS 3500 except where otherwise provided in the Local Government Act 1993, or the Local Government (General) Regulation.		possible contract conditions			
8.4 Prior to issue of Occupation Certificate					
Flood Condition 15 - Prior to any occupation of the development or the issue of any Occupation Certificate, the creation of a Restriction on Use of Land and Positive Covenant over the operation and maintenance of the flood gates, flow diversion facilities and all flood-related facilities shall be registered. Willoughby Council shall be nominated as the body empowered with authority to release, modify or vary the restrictions.		**This** gives the Council power to refuse an occupation permit if they are not fully satisfied with the construction of the works, also gives them the power to request further changes at any time. We believe this is unreasonable. Firstly, council should signoff the flood mitigation works at detailed design phase and they should be working with Vicinity to have these works finalised prior to Opening. We cannot be reliant on a final inspection for signoff to be given.	Clarify the intent of this condition. Who is the restriction and covenent in favour of? Who does Rhelm intend to be responsible for operation and maintenance of the flood gates. Urbis reading is that Council is responsible for operation and maintenance of these flood mitigation measures.	Should be Willoughby City Council	Covenant in favour of Council. Operation and maintenance of flood mitigtaion measures is applicant's responsibility.
		Changes to the flood mitigation measures or the FMP should only be able to be negotiated and agreed between Vicinity and Council as improvement measures not at the will of Council. This will require an annual review to be undertaken as part of flood condition 4 above.	Rhelm to clarify that this condition only relates to the establishment and registration of a restriction and positive covenant on title prior to issue of the occupation certificate. It is standard that a positive covenant can only be released, modified or varied by the Council. Confirm that this does not extend to the scope or method of flood mitigation measures which are to be signed off by council at design stage.		

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