Park Avenue, Waitara Redevelopment

Final Report - Flood Assessment

On behalf of Statewide Planning

November 2019

grc HYDRO

Park Avenue, Waitara Redevelopment – Flood Assessment

Final Report

Project:	Park Avenue Waitara Redevelopment – Flood Assessment
Project Number:	180010
Client:	Statewide Planning
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Date	Version	Description
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Contents

1. Introduction

GRC Hydro have been engaged by Statewide Planning to undertake a flood study for proposed development at 22 – 32 Park Avenue, Waitara (the subject site), opposite Mark Taylor Oval. The site is currently zoned as High Density Residential (R4) and the locality is host to several similar residential developments. Figure 1 presents the site's locality (see rear of report for figures). This flood study has been carried out using the 2D hydrodynamic modelling program, TUFLOW.

The subject site lies at the downstream end of a 25 hectare local overland flow catchment to the east. The headwaters of the catchment area upstream of the subject site begin in the vicinity of Ingalara Avenue. Much of this catchment drains into a man-made basin at the Mark Taylor Tennis Courts. Ultimately the subject site drains into Hornsby Creek (approximately 1.1 km downstream of the site). Hornsby Creek flows in a north easterly direction and is a tributary of Cockle Creek.

The site is currently composed of eight residential homes built on individual lots. The proposed development consists of a merge of the existing property lots and the construction of five multi-storey residential developments with an underground car park.

2. Background

The site is subject to limited flooding in the 1% AEP event (100 year ARI) (see Figure 4 at rear of report). A council owned drainage easement is located at the site's southern boundary.

The following work scope has been executed:

- Site Visit;
- Contacted Hornsby Shire Council (Council) to obtain trunk drainage details;
- Development of detailed hydrologic and hydraulic flood models for the site;
- Provision of relevant flood information for the site inclusive of mapping, levels etc;
- Assessment of flood impacts associated with the proposed building alignment; and
- Reporting inclusive of relevant flood mitigation and flood policy requirements for the proposed development.

The goal of the work was to provide a flood report to accompany the Development Application to Council. This work also involved summarising applicable flood provisions from the Hornsby Development Control Plan 2013 and providing recommendations regarding the development and compliance with consent requirements.

A Development Application for the site was submitted to Council in November 2018. In response to this submission, Council have provided the following flooding related comments which have been addressed in the current study:

Engineering Comments

1. *Submit cross sections of the overland flow through the drainage easement at 5m intervals along the southern boundary of the development assuming that the pipes above the size of 750mm in diameter will have only 50% capacity to carry 1 in 100 year ARI flow in accordance with clause 5.8 of Stormwater Drainage Design Specifications (Council website- Development Applications - Aus-*

Spec Specifications – Design Specifications-0074 Stormwater Drainage (design)– clause 5.8 and) on the basis of following:

1.1. Existing Council pipe within the drainage easement along southern boundary being replaced in accordance with Council's Plan No. 554.38 and include the following, see attachment- 2120 001:

1.1.1. 66.5m of 2.4m (w) x 0.750m (h) RCBC at 1.68% grade

1.1.2. Upstream invert: 171.750 AHD at south eastern corner

1.1.3. Downstream invert: 170.630 AHD

1.1.4. Two pits, G10273I and G10273H connecting the pipeline (upstream and downstream) are to be constructed in accordance with the Council Plan No. 554.38.

2. The 1% flow is 7.04 m3/sec

3. Provide cross sections to show building line of the development at 16-20 Park Avenue, the proposed wall of the development, floor level of the proposed units, existing and post development finished level of the ground with 1 in 100 year ARI water level., see attachment 2119 001.

4. Demonstrate that the velocity depth product does not exceed the safety factor 0.4m3 per second to comply with Council Civil Works Specifications. A table showing the product at every section must be submitted.

5. A flood risk management plan, including location of warning signs is to be submitted.

A flood risk management plan is presented in Appendix A.

3. Relevant Policy

3.1 Hornsby Shire Development Control Plan (DCP) (Reference 3)

The Hornsby Shire Development Control Plan (DCP) 2013 was adopted by Council in October 2013 and is applicable to this development proposal.

The following relevant controls are outlined in Section 1C.3.2 Flooding:

General

Clause a. Where a development proposal is on land shown as 'Flood Planning areas' on the HLEP Flood Planning Map or is on other land at or below the flood planning level, a comprehensive flood study should be prepared by a qualified hydraulic engineer and is to be submitted with any development application on land that demonstrates that:

- *The development addresses the provisions of Clause 6.3 of the HLEP, and*
- *The development complies with best practice.*

Clause b. The overland flow path should not be built upon and should have minimal planting. Development is required to demonstrate that any overland flow is maintained for 1 in 100 year average recurrence interval (ARI) flood.

Clause c. All potential pollutants that are stored or detained on-site (such as on-site effluent treatment facilities, chemicals or hazardous materials) should be stored 0.5 metres above 1 in 100 year ARI flood level. Details should be provided as part of any application.

3.2 Hornsby Local Environmental Plan 2013 (HLEP) (Reference 4)

The Hornsby Local Environment Plan (HLEP) 2013 is applicable to the proposed development. Section 6.3 Flood Planning outlines the following controls relevant to the development:

Clause 3. Development consent must not be granted to development on land to which this value applied unless the consent authority is satisfied that the development:

a) is compatible with the flood hazard of the land, and
b) will not 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) will not significantly adversely affect the environment or cause avoidable erosion, siltation, destruction of riparian vegetation or reduction in stability of river banks or watercourses, and
e) is not likely to results in unsustainable social and economic costs to the community as a consequence of flooding.

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.

3.3 Hornsby Shire Development Design Specification 0074 -Stormwater Drainage Design (Reference 2)

The Hornsby Shire Development Design Specification 0074 for Stormwater Drainage Design provides guidance on the hydrologic and hydraulic modelling of catchments within the Hornsby Shire LGA. A summary of the flood related specifications relevant to the development is provided below.

Section 4.10 - Alternative Models and Computer Analysis addresses the use of hydrologic models for the calculation of design flow estimates in accordance with ARR1987. The current study has undertaken calculation in accordance with the specification with input details presented in Section 4.1.

Section 5.6 – Open Channels provides detail on the design of open channels in the LGA. This includes Manning's "n" coefficients and velocity/depth product criteria. This criterion has been addressed in Section 6.3.

Section 5.8 – Major System Criteria addresses criterion such as pipe blockage and floor level requirements for developments within Stormwater Flow Paths. These specifications require 100% blockage of pipes of less than 0.75 m in diameter and 50% blockage of structures greater than 0.75 m in diameter (see Section 4.2). This guideline requires a freeboard of 0.5 m above the 100 year flood level for the habitable floor level and 0.3 m above the 100 year flood level for garages and entrances to underground car parks (see Section 6.4).

4. Methodology

Existing design flood behaviour for the subject site is defined by hydrologic and hydraulic modelling developed as a part of the current study. This modelling is based on the use of a hydrologic model (WBNM) to convert rainfall into runoff and then a hydraulic model (TUFLOW) to convert applied runoff into flood extents, depths, levels and velocities. Both WBNM and TUFLOW are widely used in Australia and are considered best practice.

The study was conducted in accordance with Australian Rainfall and Runoff 1987 (AR&R, Reference 1).

4.1 Hydrologic Model

A hydrologic model was developed using WBNM to simulate the rainfall/runoff process to generate flows for input in the TUFLOW hydraulic model. This process involves an analysis on the 25 hectare catchment upstream of site (shown in Figure 2). The following information was used in this model:

- Percentage impervious for each catchment. For leafy residential area such as the subject site, an impervious percentage of 35% was used;
- Bureau of Meteorology 1987 rainfall intensities;
- A lag parameter of 1.6 (default and recommended in the absence of gauged data justifying adoption of other values);
- For the 1% AEP Event:
    - Initial Loss: 15 mm
    - Continuing Loss: 2.5 mm/hr
      (as per ARR 1987 Guidelines (Reference 1))
- For the PMF Event:
    - Initial Loss: 0 mm
    - Continuing Loss: 1.0 mm/hr
      (as per ARR 1987 Guidelines (Reference 1))

4.2 Hydraulic Model

GRC Hydro have developed a TUFLOW modelling system to undertake the following assessment. TUFLOW is a hydraulic modelling tool that can utilise one and two-dimensional model elements.

The hydraulic modelling system is comprised of the following elements:

- LiDAR data has been used to inform a 2 m TUFLOW grid resolution. LiDAR data has a typical accuracy of ±0.15 m (1st confidence interval);
- Pipe elements (shown in Figure 3) are based on data obtained from various sources.
    - Council provided the preliminary pipe configuration and pipe sizes for the catchment (shown in Appendix B);
    - Additional data was obtained from site visits and discussions with Council engineers working on the Park Avenue drainage upgrade (April 2018). This upgrade involved significantly enhancing the existing drainage capacity along Park Avenue and increasing the number of pit inlet locations. The Park Avenue drainage upgrade has been incorporated into the existing case TUFLOW model;

    - Advice from Council's comments to the Development Application submitted in November 2018 (see comment 1 (Section 2)); and
    - Where existing pipe sizes were not available, sizes were estimated based on GRC Hydro's experience in similar urban scenarios. Furthermore, pipe inverts were informed by an offset from Lidar ground elevations.
- Blockage of pipe elements has been undertaken as per Section 5.8 of Council's Design Specification (see Section 3.3) with pipe sizes of 0.75 m in diameter or less, fully blocked and those greater than 0.75 m in diameter, 50% blocked.
- Hydraulic features that impact on flood behaviour have been represented in the model as breaklines. These features include the kerb/gutter and road crests, the levels of which were determined by analysis of the LiDAR;
- Buildings can block flood waters natural flow path and therefore significantly impact flood behaviour. As such, buildings in the vicinity of the subject site were blocked out of the TUFLOW model;
- Manning's roughness values were applied as follows (shown in Figure 3):
    - General: 0.04
    - Roads: 0.02
    - Dense Vegetation: 0.07
    - Public Recreation: 0.04
- A free draining outlet was allowed at the catchment's downstream boundary.

Critical duration analysis was undertaken in the TUFLOW model which found that the 2 hour storm duration was critical for the 1% AEP event.

5. Existing Flood Behaviour

Figure 4 shows the 1% AEP existing flood behaviour in the vicinity of the subject site. In the 1% AEP event, the capacity of the existing drainage system is exceeded, and the additional flow is conveyed overland. Once flood waters on Balmoral street overtop the kerb and gutter, flow moves between the existing buildings and approaches the subject site from the east. Flood waters in the 1% AEP event then flow through the subject site in a north-westerly direction and exit onto Park Avenue.

Examination of these results indicate that the subject site currently experiences moderate flood affection. Flood depths of up to 0.5 m occur toward the south end of the site in the 1% AEP event.

5.1 Verification of Model Flows

The 1% AEP flows were verified based on advice from Council, which specified 7.04 m^3/s of flow at south-western corner of the subject site. This flow rate has been compared to the peak flows extracted from the TUFLOW hydraulic model (shown in Figure 4) along the southern flow path (inclusive of pipe flow). A peak flow of 7.4 m^3/s was modelled across the southern flow path in the hydraulic model.

6. Proposed Case Compliance

6.1 Proposed Case Configuration

The proposed building alignment was implemented in the TUFLOW model, assuming no significant change to the existing ground level topography. The following flood mitigation measures were also executed to achieve compliant flood level impacts:

- Implementing a 1.05 m diameter pipe along the southern boundary connecting to the existing Council trunk drainage in the drainage easement south of the subject site;
- A clear grassed swale or grated open channel along the eastern and northern boundaries. Channel dimensions are shown in cross sections on Figure 5;
- A wall along the perimeter of the development. Levels of the wall are shown in the cross sections on Figure 5 and are labelled in the south of the development. The level of this wall has been set at the 1% AEP flood level plus a freeboard of 0.3 m;
- A wall along the northern boundary. Levels of the wall are shown in the cross sections on Figure 5. The level of this wall has been set at the 1% AEP flood level plus a freeboard of 0.3 m; and
- Clear fencing (or palisade fencing) along the external perimeter of the proposed open channel to allow for entry of overland flows (up to depths of 0.2 m) into the channel while preventing public assess (see Section 6.3) (shown in Figure 5).

Figure 5 presents the proposed flood mitigation measures listed above. The grassed swale has been modelled in the hydraulic model with an average slope of 1.3% and a Manning's 'n' of 0.04. The dimensions of the channel must be such that the peak 1% AEP flows labelled on Figure 5 can be conveyed.

6.2 Flood Impact Assessment

A flood impact assessment has been undertaken which assessed the proposed development using the TUFLOW hydraulic model and the measures listed in Section 6.1.

The flood level impacts associated with the proposed development, inclusive of these measures listed in Section 6.1, are shown in Figure 6. These impacts present the change in flood level between the existing and proposed conditions for the 1% AEP event.

Flood level impacts of 0.01 m or less are considered within the tolerance of the hydraulic model to determine and are therefore shown as no impact.

Figure 6 indicates that, in the 1% AEP event, generally flood levels are decreased on neighbouring lots in the proposed scenario. There are some flood level increases on Park Avenue however generally there are also flood level decreases surrounding the development. Most of the subject site is no longer affected by flooding in the 1% AEP event.

Figure 7 presents the proposed case peak flood levels and depths in the 1% AEP event.

Figure 9 presents the proposed case peak flood levels and depths in the PMF event.

6.3 Velocity Depth Product

Council's Design specifications for Open Channels (see Section 3.3) require that a velocity depth product greater than 0.4 m^2/s will be required to specifically provide for the safety of persons who may enter the channel. The proposed development includes an open channel along the eastern and northern property boundary and Figure 8 presents the velocity depth product in the proposed 1% AEP event. The open channel area has a velocity depth product of greater than 0.4 m^2/s and as such, it is recommended that the channel is adequately fenced to prevent public access while also providing fence openings (or palisade fencing) up to depths of 0.2 m to allow for the inflow of overland flow.

6.4 Entrance Levels

Council's design specifications (see Section 3.3) provide guidance on entrance levels for floor levels and garages. Along stormwater flow paths, Council require a freeboard of 0.5 m above the 100 year (or 1% AEP) flood level for habitable floor levels. For garages and entrances to underground car parks, a freeboard of 0.3 m above the 100 year flood level is required.

In determining an appropriate floor level for the proposed development a measured approach which takes into account PMF[1] flood levels at the subject site, has been used. This approach has also considered the Client's need to maintain continuity and accessibility for occupants.

In response to the fact that flood levels at the location don't scale[2] (see Figure 9 - PMF results) a freeboard of 0.3 m is proposed such that habitable floor levels will be 0.3 m above the 100 year flood event. This level of freeboard is consistent with other Sydney Metropolitan Areas affected by overland flow.

Proposed garage entrance levels are compliant with Council's design specifications described above (freeboard of 0.3 m above the 100 year flood level).

7. Conclusions

This flood study and flood impact assessment has been undertaken by qualified civil engineers (specialising in floodplain modelling), in accordance with Australian Rainfall and Runoff, the NSW Floodplain Development Manual and Council's DCP and HLEP.

Flood behaviour for the subject site has been modelled using a WBNM/TUFLOW, hydrologic/hydraulic modelling system.

The existing conditions and proposed development flood behaviour has been examined. To mitigate the flood level impacts associated with the proposed development, mitigation elements are proposed herein (see Figure 5). Compliance has also been achieved with the velocity depth product and the proposed garage entrance levels. An alternative freeboard is proposed for habitable floor

[1] The Probable Maximum Flood event will occur once every 10 million years on average as per ARR 2019.

[2] Scaling refers to the change in flood level relative to change in probability of a design flood event. The degree of scaling of design flood levels will tend to correlate to catchment size. With a 25 ha catchment, the subject site scales very little. That is, as event magnitude increases (for example 200Y ARI event versus 100Y ARI event), design flood level does not increase significantly.

levels being 0.2 m lower than the Council prescribed 0.5 m. The 0.3 m freeboard is reasonable given the fact that design flood levels at the subject site to do not scale as indicated by the PMF results.

8. References

1. Pilgrim DH (Editor in Chief), *Australian Rainfall and Runoff – A Guide to Flood Estimation*, Institution of Engineers, Australia, 1987.

2. Hornsby Shire Council, Development Design Specification 0074 – Stormwater Drainage (Design), July 2016.

3. Hornsby Shire Council, Hornsby Development Control Plan 2013, March 2018.

4. NSW Government, Hornsby Local Environmental Plan 2013, April 2018.

5. NSW Government, NSW Floodplain Development Manual, April 2005, DIPNR

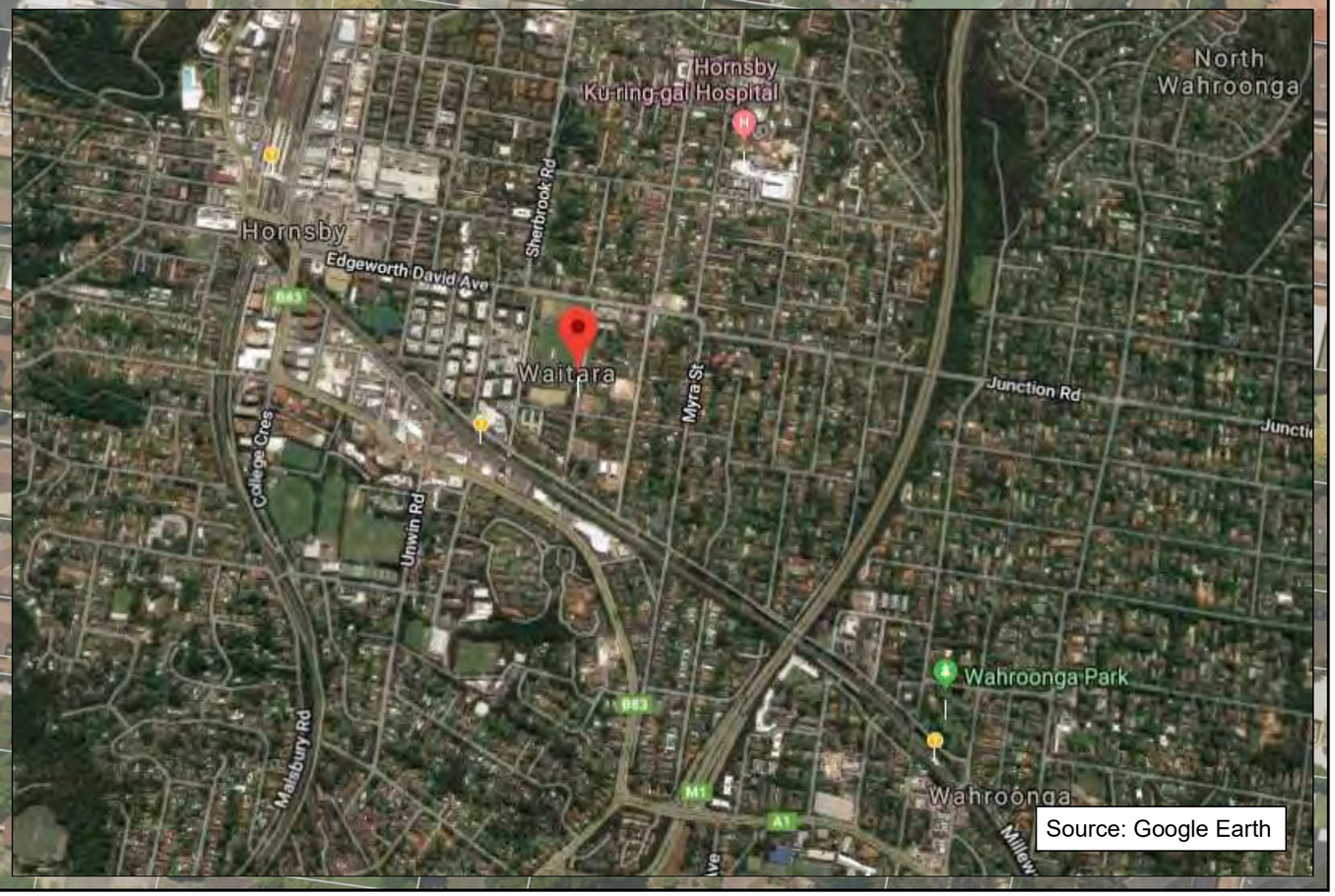
FIGURES

FIGURE 1
PARK AVENUE DEVELOPMENT
SUBJECT SITE LOCATION

PARK AVENUE

BALMORAL STREET

PARK LANE



Source: Google Earth

Subject Site

Cadastral Boundaries

N

0 100

metres

grc HYDRO

FIGURE 2
PARK AVENUE DEVELOPMENT
UPSTREAM CATCHMENT & GROUND LEVEL

PARK AVENUE

BALMORAL STREET

MYRA STREET

Ground Level (m AHD)
- 168 to 170
- 170 to 172
- 172 to 174
- 174 to 176
- 176 to 178
- 178 to 180
- 180 to 185
- 185 to 190
- 190 to 195
- 195 to 200

Upstream Catchment

Subject Site

Cadastral Boundaries

N

grc HYDRO

0 280

metres

FIGURE 3
PARK AVENUE DEVELOPMENT
HYDRAULIC MODEL ROUGHNESS VALUE

PARK AVENUE

BALMORAL STREET

PARK LANE

Manning's Value
- General Residential (Manning's Value = 0.04)
- Roads (Manning's Value = 0.02)
- Vegetation (Manning's Value = 0.07)
- Public Recreation (Manning's Value = 0.04)

Stormwater Network
- Pits
- Pipes

Existing Building Alignment

Subject Site

Cadastral Boundaries

N

grc HYDRO

0 80
metres

FIGURE 4
PARK AVENUE DEVELOPMENT
EXISTING CASE
1% AEP PEAK FLOOD DEPTHS & LEVELS

PARK AVENUE

PARK LANE

BALMORAL STREET

Overland Flow (m3/s) Southern Flowpath
Pipe Flow (m3/s) Southern Flowpath
Overland Flow (m3/s) Northern Flowpath
Stormwater Pit
Stormwater Pipe
Existing Buildings
Subject Site
Cadastral Boundary
Major Flood Level Contours (1.0m spacing)
Minor Flood Level Contours (0.2m spacing)

Flood Depth (m)

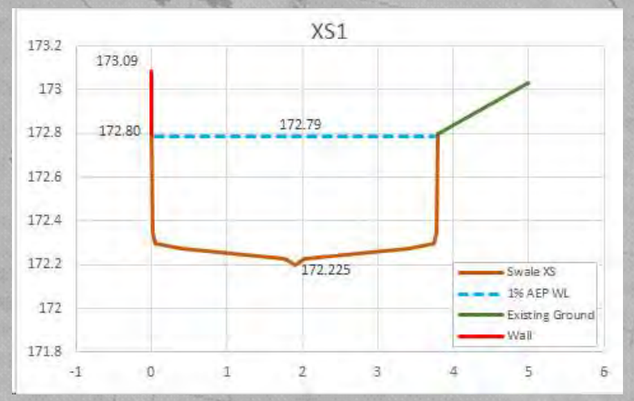
0.0	to 0.01
0.01	to 0.1
0.1	to 0.3
0.3	to 0.5
0.5	to 1.0
> 1.0	

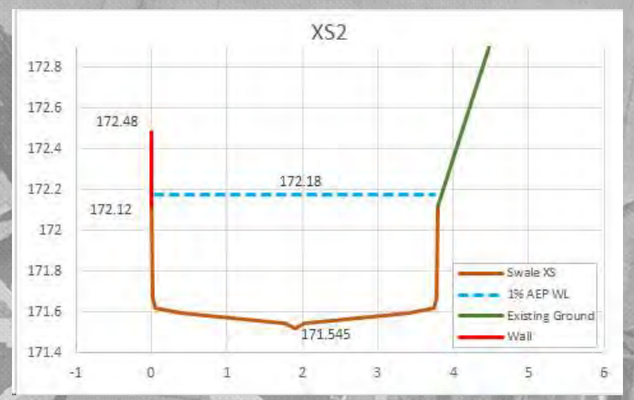
N

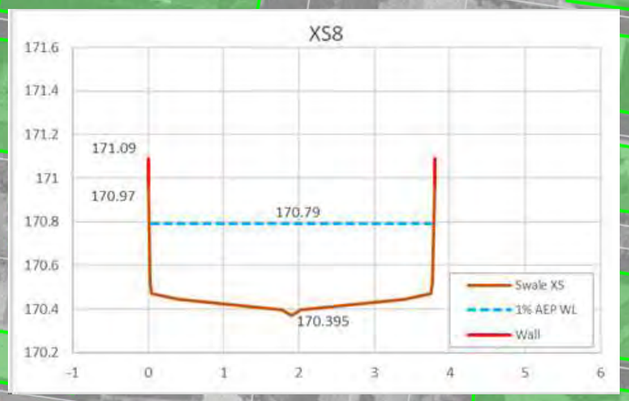
grc HYDRO

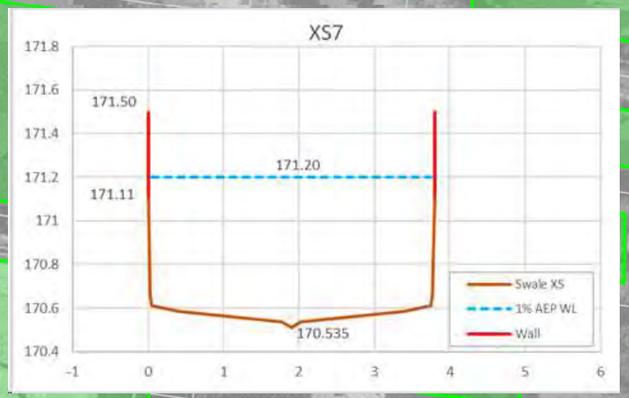
0 80
meters

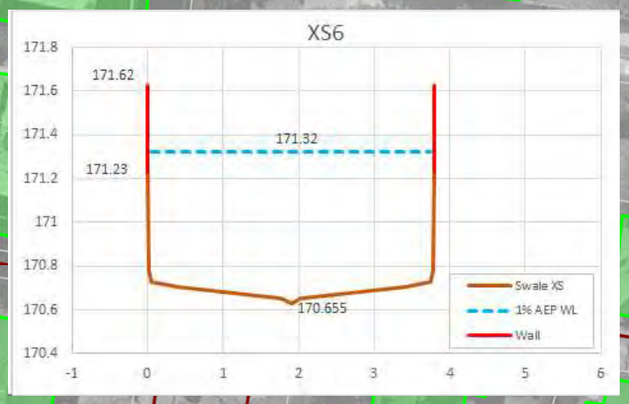
FIGURE 5
PARK AVENUE DEVELOPMENT
PROPOSED CASE
FLOOD MITIGATION MEASURES

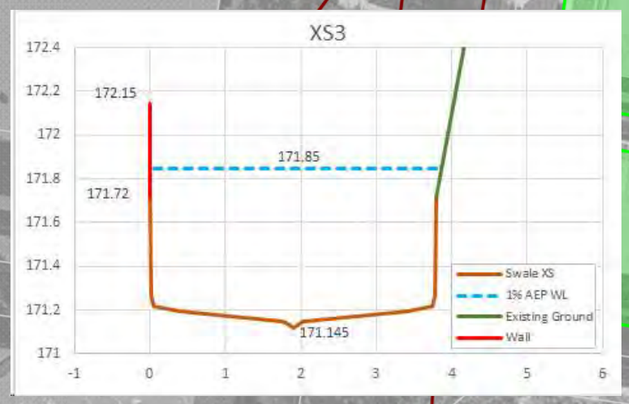


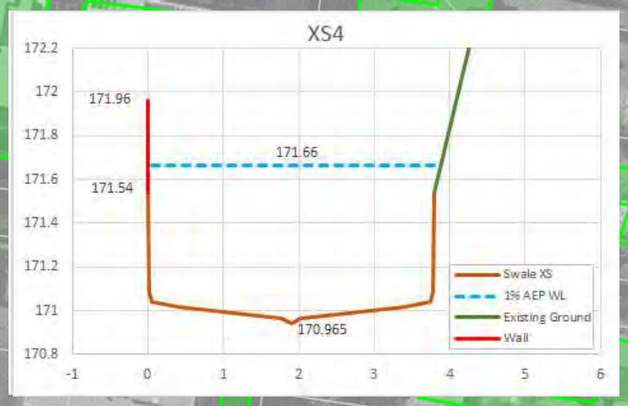












- Proposed Fence
- Proposed Swale as 1D
- Proposed Swale
- Proposed Wall
- Proposed Northern Wall
- ABC — Minimum wall height above natural ground (m) *
- Existing Stormwater Pit
- Existing Stormwater Pipe
- Proposed Stormwater Pit
- Proposed Stormwater Pipe
- ABC — Proposed Stormwater Pit Invert Level (mAHD)
- Existing Buildings
- Proposed Buildings
- Subject Site
- Cadastral Boundary

0 — 80
meters

N
1

FIGURE 6
PARK AVENUE DEVELOPMENT
PROPOSED CASE
1% AEP PEAK FLOOD LEVEL IMPACTS

PARK AVENUE

BALMORAL STREET

PARK LANE

Proposed Swale as 1D
Proposed Swale
Proposed Wall
Proposed Northern Wall
Existing Stormwater Pit
Existing Stormwater Pipe
Proposed Stormwater Pit
Proposed Stormwater Pipe
Existing Buildings
Proposed Buildings
Subject Site
Cadastral Boundary

Change in Flood Levels (m)

- < -0.3
- -0.2 to -0.1
- -0.1 to -0.01
- No Impact
- 0.01 to 0.1
- 0.1 to 0.2
- 0.2 to 0.3
- > 0.3
- Newly Flooded
- No Longer Flooded

N

grc HYDRO

0 80
meters

FIGURE 7
PARK AVENUE DEVELOPMENT
PROPOSED CASE
1% AEP PEAK FLOOD DEPTHS & LEVELS

PARK AVENUE

PARK LANE

BALMORAL STREET

Ramp Access Level Required (mAHD)
Floor Level Required (mAHD)
Proposed Swale as 1D
Proposed Swale
Proposed Wall
Proposed Northern Wall
Existing Stormwater Pit
Existing Stormwater Pipe
Proposed Stormwater Pit
Proposed Stormwater Pipe
Existing Buildings
Proposed Buildings
Subject Site
Cadastral Boundary
Major Flood Level Contours (1.0m spacing)
Minor Flood Level Contours (0.2m spacing)

Flood Depth (m)
0.0 to 0.01
0.01 to 0.1
0.1 to 0.3
0.3 to 0.5
0.5 to 1.0
> 1.0

N

grc HYDRO

0 80
meters

FIGURE 8
PARK AVENUE DEVELOPMENT
PROPOSED CASE
1% AEP PEAK FLOOD V.D PRODUCT

PARK AVENUE

BALMORAL STREET

PARK LANE

Proposed Swale as 1D
Proposed Swale
Proposed Wall
Proposed Northern Wall
Existing Stormwater Pit
Existing Stormwater Pipe
Proposed Stormwater Pit
Proposed Stormwater Pipe
Existing Buildings
Proposed Buildings
Subject Site
Cadastral Boundary

VelocityxDepth Product (m2/s)
0 to 0.4
> 0.4

N

grc HYDRO

0 80
meters

FIGURE 9
PARK AVENUE DEVELOPMENT
PROPOSED CASE
PMF PEAK FLOOD DEPTHS & LEVELS

PARK AVENUE

PARK LANE

BALMORAL STREET

Proposed Swale as 1D
Proposed Swale
Proposed Wall
Proposed Northern Wall
Existing Stormwater Pit
Existing Stormwater Pipe
Proposed Stormwater Pit
Proposed Stormwater Pipe
Existing Buildings
Proposed Buildings
Subject Site
Cadastral Boundary
Major Flood Level Contours (1.0m spacing)
Minor Flood Level Contours (0.2m spacing)

Flood Depth (m)
0.0 to 0.01
0.01 to 0.1
0.1 to 0.3
0.3 to 0.5
0.5 to 1.0
> 1.0

N

grc HYDRO

0 80
meters

APPENDIX A

Job Number: *180010*
Date: *29 November 2019*

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Re: 22-32 Park Avenue, Waitara Redevelopment- Flood Risk Management Plan

Introduction

Development is proposed for 22 to 32 Park Avenue (the Subject Site). The proposed development consists of merging the existing lots and construction of five-multi-storey residential developments with an underground car park. In response to a Development Application for the site submitted to Hornsby Shire Council (Council) in November 2018, Council requested a flood risk management plan (FRMP) is developed. GRC Hydro have derived a Flood Risk Management Plan to ensure compliance with Council's conditions. Council's request is presented below.

Engineering Comments

5. A flood risk management plan, including the location of warning signs is to be submitted.

This letter provides a FRMP in compliance with Council's conditions.

The Subject Site

The subject site is located at 22 to 32 Park Avenue, Waitara, opposite Mark Taylor Oval. The site is currently zoned as High Density Residential (R4) and the locality is host to several similar residential developments.

The subject site lies at the downstream end of a 25 hectare local overland flow catchment to the east. The headwaters of the catchment area upstream of the subject site begin in the vicinity of Ingalara Avenue. Much of this catchment drains into a man-made basin at the Mark Taylor Tennis Courts.

Previous Studies

Detailed hydraulic and hydrologic analysis of the overland flow catchment affecting the subject site has been undertaken by GRC Hydro as a part of a Flood Assessment for the proposed development (November 2019). This study developed a WBNM and TUFLOW hydrologic-hydraulic modelling system to determine the existing and proposed flood affectation at the subject site for the 1% AEP and PMF events.

The 1% AEP and Probable Maximum Flood (PMF) results were used as the basis for the current Flood Risk Management Plan.

Proposed Flood Behaviour

1% AEP event

Figure A1 presents the proposed case 1% AEP flood depths at the subject site. In the 1% AEP event, floodwater enters the site primarily along the eastern boundary. Flood water in the 1% AEP event is conveyed around the site via a swale/open channel on the eastern and northern boundaries and a 1.05 m diameter pipe along the southern boundary.

Figures A2 and A3 present the 1% AEP peak velocity and flood hazard, respectively. Flood velocities through the site vary with the greatest velocities occurring within the proposed swale. Within the swale, peak velocities are typically below 3 m/s with small areas exceeding this value. The entire site is classified as low hazard in the 1% AEP event except for floodwaters within the proposed swale. It is proposed that the swale/open channel is fenced off to prevent entry from the public and allow for safe movement around the remainder of the site.

The proposed development has flood immunity for all flood magnitudes up to the 1% AEP event through the implementation of proposed flood mitigation measures such as the swale.

PMF event

Figure A4, A5 and A6 present the proposed PMF[1] flood depths, peak velocity and flood hazard, respectively. Typically, velocities between 0.1 – 2.0 m/s occur around the site, with velocities exceeding 3 m/s in the proposed swale. In the PMF event, the site is predominantly affected by low hazard flooding. High hazard flooding occurs within the swale area and in small areas of the proposed development.

Although significant flow along the overland flow paths is only likely to occur in rare flood events, this flow presents a significant risk to a person walking or standing in the area in the PMF event and is likely to destabilise a person or cause vehicles to float. An analysis of the PMF event therefore yields the requirement that people are not moving around the site once a certain threshold of depth is crossed. It is clear, however, that this threshold event will occur rarely (less often than once per one hundred years).

Overview of Flood Risk

Residential areas of the site will remain flood free for events up to and including the 1% AEP event (100 year ARI). This indicates that the flood response plan will only come into effect very occasionally.

The features of the site pertinent to the emergency response during a flood are:

- Vehicular access to the site is achieved via two ramps off Park Avenue at the northern and southern ends of the site. These ramps are proposed to lead to underground car parks and will have a proposed crest level of the 1% AEP level plus a 0.3 m freeboard.
- In events greater than the 1% AEP event, overland flow traverses the site through centre of the site moving east to west.

[1] The PMF however is an event with a probability of 1 in 10 million years (on average) and as per NSW legislation the PMF has a limited role to play in assessing the viability of residential development.

Access and Egress

The site is accessible by road in flood events up to and including the 1% AEP event. During events greater than the 1% AEP event, Park Avenue will be inundated causing access to be unsafe. Site access into and out of the site and the basement carpark should be restricted during extremely rare events although the short duration of flooding (minutes) reduces the chance for interaction with flood waters.

Duration, Warning and Rate of Rise

Due to the size of the site's upstream catchment, storm events that cause flooding of the site will typically be of short duration (minutes). The effective flood warning time, as per the Floodplain Development Manual (NSW,2005) is effectively non-existent. There will typically be Bureau of Meteorology warnings issued for flood-producing rainfall on the day, including 'Flood Watch' (24 hours' notice of potential flooding), 'Severe Weather Warning' and 'Severe Thunderstorm Warning' (0.5 to 2 hours' notice of impending severe storms). For small urban catchments there is insufficient time to warn people of an ongoing flood. The rate of rise for this type of event is very rapid. The peak flood depth experienced in the 1% AEP may occur within a matter of minutes.

Probable Maximum Flood (PMF) Risk

The PMF is an estimate of the largest flood that could possibly occur at a location and as per ARR 2019 it has a probability (for small urban catchments) in the order of 1 in 10 million years. As shown on Figure Ap4, in the PMF shallow flood waters surround the site as flow moves toward Park Avenue with depths ranging from between 0.01 and 0.6 m in the internal overland flow path.

Flood Emergency Response Plan

A flood response plan for the site needs to be realistic and aligned with normal instincts. Owing to the lack of effective warning time and the safety of the building versus the street a shelter-in-place policy is preferable.

Given the rarity of hazardous flooding, it is recommended that the following simple guidelines are implemented to keep occupants of the site safe during a significant flood event:

1. Signposts advertising the flood liability of the overall site, particularly at the underground carparks and thoroughfares between buildings;
2. Flood depth marker in the swale/open channel to indicate flood liability; and
3. Induction of new owners/tenants should include information of site flood liability and highlight the need to shelter-in-place as there is hazardous flow in rare events through the site.

Preparedness

The swale/open channel should be well maintained to convey flows during times of flood. The area should be kept clean and clear of potential debris. Warning signage to notify of the flood hazard should be posted. The signage will indicate that it is unsafe to enter flood waters either on foot or in a vehicle during times of bad weather and will be of similar appearance to signage used by Sydney Water at stormwater channels, which reads 'Danger: Flood Zone. For your safety, do not enter – water levels can rise quickly. Emergencies call 000'

It is recommended that if general weather forecasts indicate that heavy rainfall or severe weather events are likely, then site occupants ensure that:

- Bureau of Meteorology (BoM) and NSW SES websites be monitored for Flood Warnings, Severe Weather Warnings or Severe Thunderstorm Warnings in the region;
- If these Warnings are forecast for the region then the following measures should be put in place;
    - Clear the overland flow paths through the site to allow for easy of flow through the site; and
    - Ensure that all site occupants are informed of the potential for flooding on site.

An Emergency FloodSafe Kit for the Site should be prepared as outlined at - https://www.ses.nsw.gov.au/floodsafe/prepare-your-home/emergency-kit/

The site's Property Managers should review this plan on a yearly basis (or after a significant flood event) and informing each new owner or tenant of the Plan, as well as making it readily available to all occupants.

Response

If flooding is threatening the grounds surrounding the buildings, the following measures are recommended;

- Ensure that no one is inside of the swale area (which will be fenced);
- Recommend occupants stay indoors, or if travelling, take the normal precautions exercised during heavy rainfall and leave the site before flood depths on Park Avenue exceed 0.3 m;
- Notify the NSW SES of the situation.

Recovery

- If electrical or gas services have been inundated do not turn these appliances on until they have been checked by a qualified electrician or gas fitter;
- Following a flood event, there may be damage along the swale. If damage has incurred, it will require repair following the flood event.

Yours Sincerely,

Steve Gray
Director

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Tel: +61 413 631 447

FIGURES

FIGURE A1
PARK AVENUE DEVELOPMENT
PROPOSED CASE
1% AEP PEAK FLOOD DEPTHS & LEVELS

PARK AVENUE

PARK LANE

BALMORAL STREET

170.9
171
171.7
172.2
172.3

Ramp Access Level Required (mAHD)
Floor Level Required (mAHD)
Proposed Swale as 1D
Proposed Wall
Proposed Northern Wall
Existing Stormwater Pit
Existing Stormwater Pipe
Proposed Stormwater Pit
Proposed Stormwater Pipe
Existing Buildings
Proposed Buildings
Subject Site
Cadastral Boundary
Major Flood Level Contours (1.0m spacing)
Minor Flood Level Contours (0.2m spacing)

Flood Depth (m)

0.0 to 0.01
0.01 to 0.1
0.1 to 0.3
0.3 to 0.5
0.5 to 1.0
> 1.0

N

grc HYDRO

0 80
meters

FIGURE A2
PARK AVENUE DEVELOPMENT
PROPOSED CASE
1% AEP PEAK FLOOD VELOCITY

PARK AVENUE

BALMORAL STREET

PARK LANE

Proposed Swale as 1D
Proposed Wall
Proposed Northern Wall
Existing Stormwater Pit
Existing Stormwater Pipe
Proposed Stormwater Pit
Proposed Stormwater Pipe

Existing Buildings
Proposed Buildings
Subject Site
Cadastral Boundary

Velocity (m/s)
0 to 0.2
0.2 to 0.5
0.5 to 1.0
1.0 to 2.0
2.0 to 3.0
> 3.0

N

grc HYDRO

0 80
meters

FIGURE A3
PARK AVENUE DEVELOPMENT
PROPOSED CASE
1% AEP PEAK FLOOD HAZARD

PARK AVENUE

PARK LANE

BALMORAL STREET

Proposed Swale as 1D
Proposed Wall
Proposed Northern Wall
Existing Stormwater Pit
Existing Stormwater Pipe
Proposed Stormwater Pit
Proposed Stormwater Pipe
Existing Buildings
Proposed Buildings
Subject Site
Cadastral Boundary

Flood Hazard Category
Low Hazard
High Hazard

N
1

grc HYDRO

0 80
meters

FIGURE A4
PARK AVENUE DEVELOPMENT
PROPOSED CASE
PMF PEAK FLOOD DEPTHS & LEVELS

PARK AVENUE

PARK LANE

BALMORAL STREET

171 172 173 174 176 177

Proposed Swale as 1D
Proposed Wall
Proposed Northern Wall
Existing Stormwater Pit
Existing Stormwater Pipe
Proposed Stormwater Pit
Proposed Stormwater Pipe
Existing Buildings
Proposed Buildings
Subject Site
Cadastral Boundary
Major Flood Level Contours (1.0m spacing)
Minor Flood Level Contours (0.2m spacing)

Flood Depth (m)

0.0	to 0.01
0.01	to 0.1
0.1	to 0.3
0.3	to 0.5
0.5	to 1.0
> 1.0	

N

grc HYDRO

0 80
meters

FIGURE A5
PARK AVENUE DEVELOPMENT
PROPOSED CASE
PMF PEAK FLOOD VELOCITY

PARK AVENUE

BALMORAL STREET

PARK LANE

Proposed Swale as 1D
Proposed Wall
Proposed Northern Wall
Existing Stormwater Pit
Existing Stormwater Pipe
Proposed Stormwater Pit
Proposed Stormwater Pipe
Existing Buildings
Proposed Buildings
Subject Site
Cadastral Boundary

Velocity (m/s)

0	to 0.2
0.2	to 0.5
0.5	to 1.0
1.0	to 2.0
2.0	to 3.0
> 3.0	

N

grc HYDRO

0 80
meters

FIGURE A6
PARK AVENUE DEVELOPMENT
PROPOSED CASE
PMF PEAK FLOOD HAZARD

PARK AVENUE

PARK LANE

BALMORAL STREET

Proposed Swale as 1D
Proposed Wall
Proposed Northern Wall
Existing Stormwater Pit
Existing Stormwater Pipe
Proposed Stormwater Pit
Proposed Stormwater Pipe
Existing Buildings
Proposed Buildings
Subject Site
Cadastral Boundary

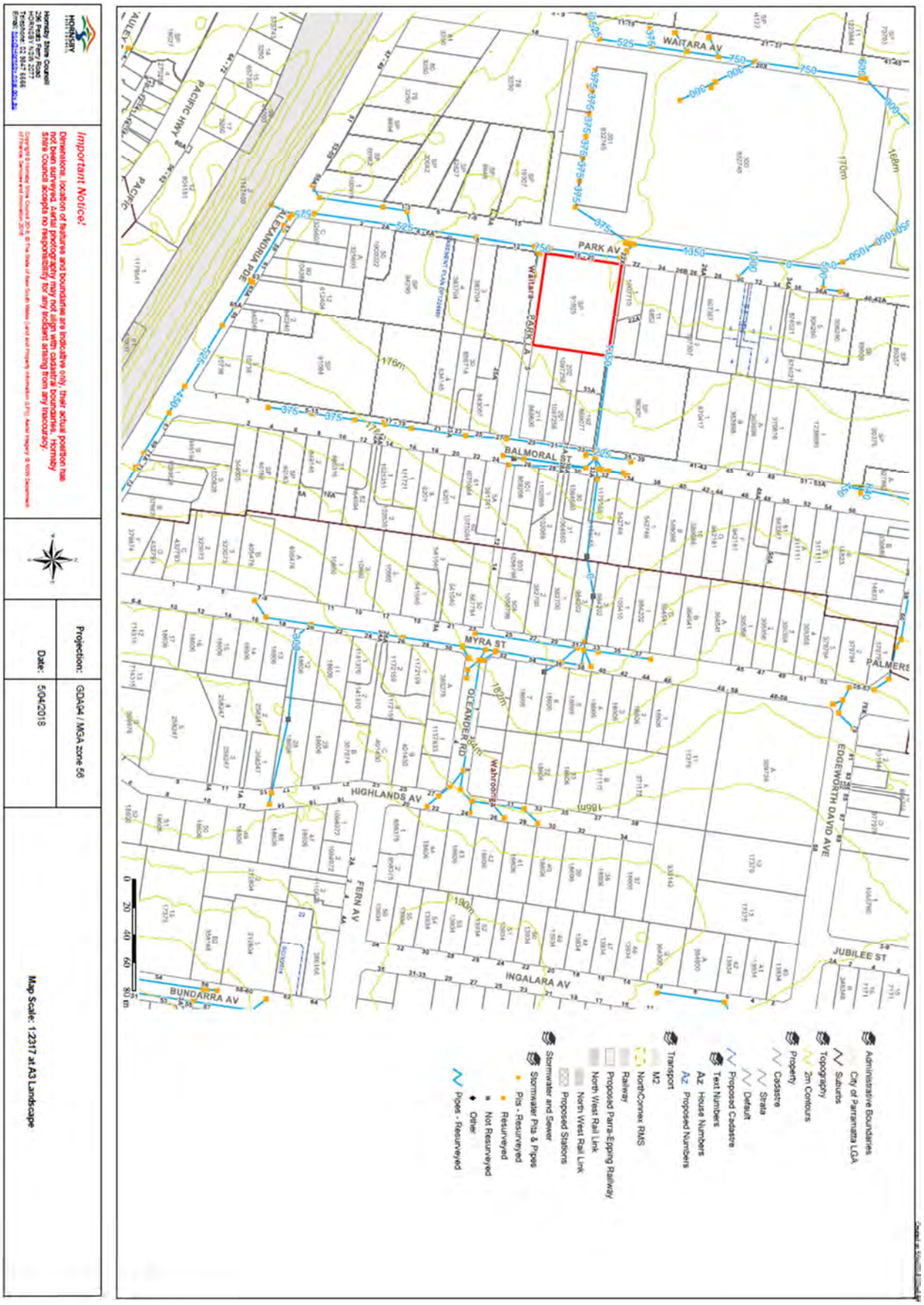
Flood Hazard Category
Low Hazard
High Hazard

N

grc HYDRO

0 80
meters

APPENDIX B


Hornsby Shire Council
Important Notice!
Projection: GDA94 / MGA zone 56
Date: 5/04/2018
Map Scale: 1:2317 at A3 Landscape
WAITARA AV
PARK AV
BALMORAL ST
MYRA ST
ALEXANDRA PDE
HIGHLANDS AV
FERN AV
INGALARA AV
BUNDARRA AV
JUBILEE ST
EDGEWORTH DAVID AVE
PACIFIC HWY
Waitara Park La
Wahroonga
Administrative Boundaries
City of Parramatta LGA
Suburb
Topography
2m Contours
Property
Cadastre
Strata
Default
Proposed Cadastre
Text Numbers
House Numbers
Proposed Numbers
Transport
M2
NorthConnex RMS
Railway
Proposed Parra-Epping Railway
North West Rail Link
North West Rail Link
Proposed Stations
Stormwater and Sewer
Stormwater Pits & Pipes
Pits - Resurveyed
Resurveyed
Not Resurveyed
Other
Pipes - Resurveyed