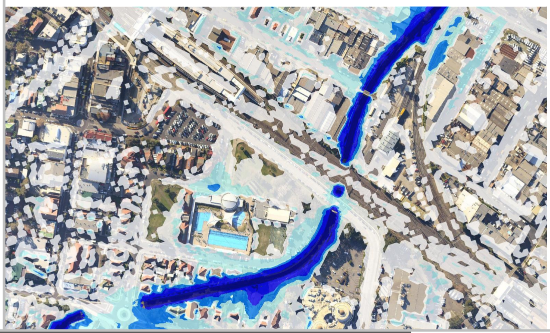

PROPOSED DEVELOPMENT

10-42 EAST STREET, GRANVILLE

FLOOD IMPACT ASSESSMENT REPORT
ISSUE B

Prepared for

Develotek Property Group Pty Ltd

Thursday, 23 October 2014

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1 EXECUTIVE SUMMARY

This document is a flood study and impact report for the proposed mixed-use development located at 10-42 East Street, Granville.

The Client is proposing a residential development to replace the existing warehouses. The Concept Plans prepared by Architex show five levels of basement car parking, eighteen residential levels plus ground level commercial/residential. The proposed development is illustrated in Figure 1.1 below.

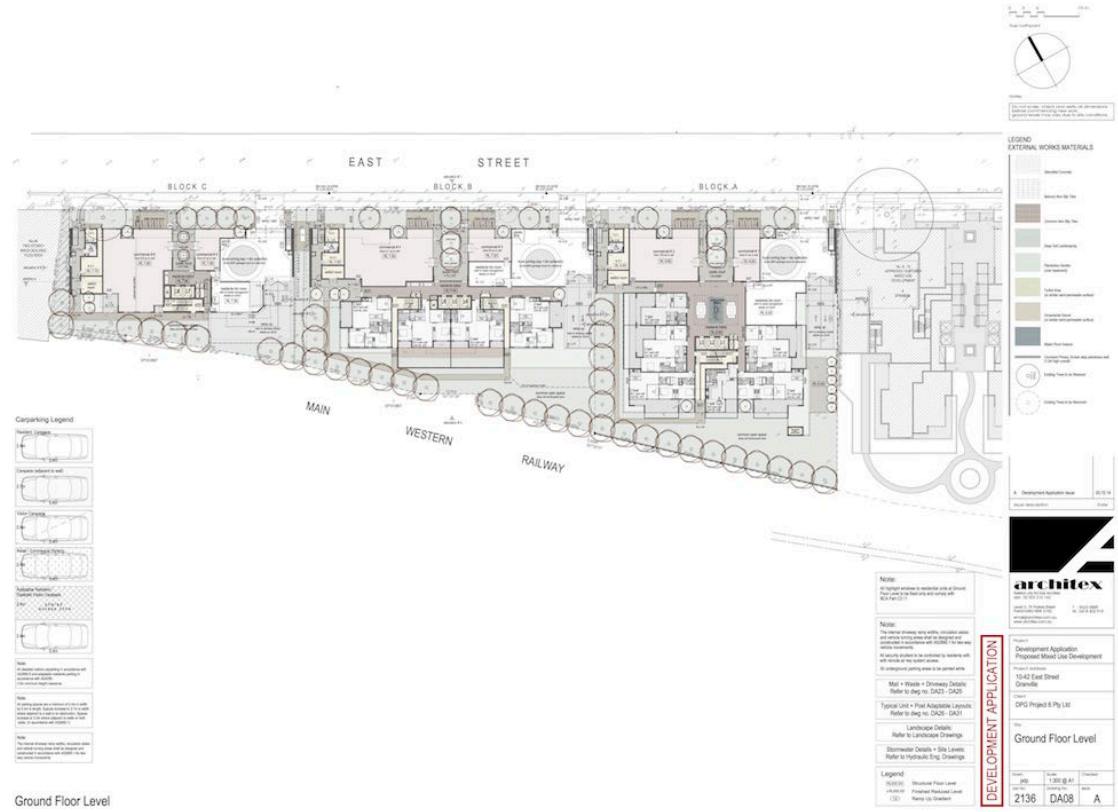


Figure 1.1 Proposed Site Plan

The flood assessment report provides:-

- An assessment of flooding from Duck Creek; and
- Addressing the requirements of the local council and the NSW Floodplain Development Manual in relation to Flood Planning Level, potential impact on flooding, flood risk management and evacuation in rare events exceeding the design storm.

The proposed development has been revised to incorporate the results of this flood study.

The Flood Planning Level (FPL) adopted for the proposed is set at 0.5m above the 100-yr ARI flood level and meets the requirements of Council as per Table 1.1 below. The entries into the basement car park levels are raised to provide protection from flooding and meet the policy requirements.

Table 1.1 Proposed Flood Planning Levels

Block	U/S Flood Level	D/S Flood Level	FPL	Driveway Crest Level
A	6.10	5.70	6.60	6.20
B	6.70	6.30	7.20	6.80
C	7.40	6.70	7.90	7.20

The results of the modelling and the comparison of the pre-development conditions to the post development conditions indicate that the proposed development does not have an adverse impact on flooding depth, velocity and behaviour elsewhere in the floodplain.

Due to the nature of flooding associated with the Duck Creek floodplain, on-site evacuation is considered most suitable (shelter in place). It is proposed to evacuate the ground floor occupants to higher levels of the building which are above the PMF flood level. Detailed discussion on evacuation and flood risk management is included in Section 9.

2 INTRODUCTION

2.1 Brief

S&G Consultants Pty Ltd (SGC) have been engaged by Develotek Property Group Pty Ltd to carry out a flood impact assessment report in support of the proposed mixed-use development at 10-42 East Street, Granville.

Parramatta City Council (PCC) requires the flood study due to the proximity of the site to the Duck Creek stormwater channel and its location within a flood prone land.

The following tasks were carried out:-

- A site visit was undertaken on the 21st of August 2014 to ascertain on-site conditions and familiarise with the local catchment;
- Supplied documents and previous studies were reviewed;
- A flood study involving the set-up of a fully dynamic 1D/2D model is carried out to determine the peak discharges and the flood levels; and
- This report has been compiled.

2.2 Limitations

This report is intended solely for Develotek Property Group Pty Ltd as the Client of SGC and no liability will be accepted for use of the information contained in this report by other parties than this client.

This report is limited to visual observations and to the information including the referenced documents made available at the time when this report was written.

2.3 Reference Documents

The following documents have been referenced in this report:-

1. Site survey prepared by StrataSurv ref. 3535DT-01 sheets 1 & 2 dated 26/05/2014;
2. Architectural drawings prepared by Architex ref. 2136;
3. NSW Government The Floodplain Development Manual – The management of Flood Liable Land (2005);
4. PCC Local Floodplain Risk Management Policy (2006);
5. PCC Development Control Plan (2011);
6. Bureau of Meteorology (2003). The Estimation of Probable Maximum Precipitation in Australia: Generalised Short-Duration Method, June;
7. Engineers Australia, *Australian Rainfall & Runoff* (AR&R 1999);
8. Aerial Scanning Data (ALS) for the study area received from AAM Surveys; and
9. Duck River & Duck Creek Flood Study Review Report by WMA Water issue 3 dated 02/08/2011.

3 NATURAL & BUILT ENVIRONMENT

3.1 Local and Regional Context

The site is situated on the sourthern side of William Street in the suburb of Granville, approximately 23kms west of Sydney CBD. The site falls in the Local Government Area of Parramatta City Council.

The site is bounded by William Street to the north, Main Western Railway corridor to the south and adjoining properties to the east and to the west.

The site is made of several separate lots. Currently, the site is developed with industrial warehouses.

The site has a trapezoidal shape and is characterised by a gentle natural gradient in a west-east direction. Figure 3.1 shows the location of the site.

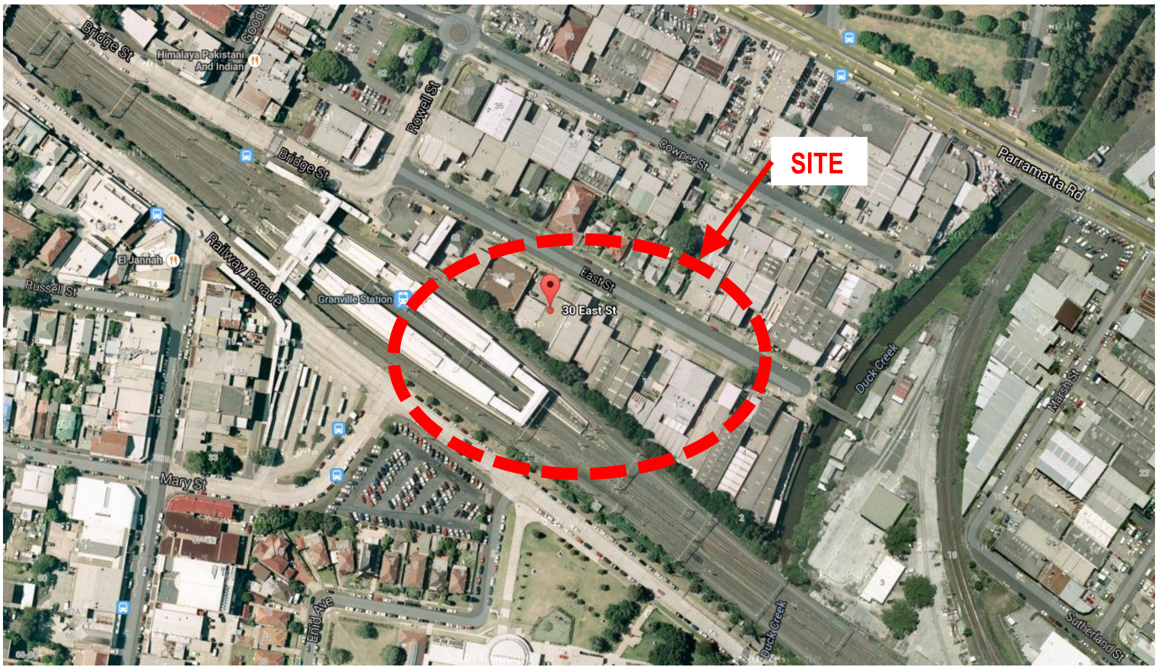


Figure 3.1 Locality Plan

The site is located downstream of the confluence of Duck Creek and Little Duck Creek. The channel is piped under the intersection of Blaxcell Street and William Street with two twin concrete culverts. The channel daylights again before it goes under Memorial Park Drive and the Main Western Railway Line. The channel daylights again before it becomes a culvert under Parramatta Road. The creek becomes a natural watercourse downstream of the M4. It wraps around the Parramatta racecourse before it merges with Duck River and discharges into Parramatta River.

The following photographs show the site, Duck Creek and Little Duck Creek in the vicinity of the site, upstream and downstream.

Figure 3.2 Duck Creek Channel & Culverts under intersection of William Street & Blaxcell Street

Figure 3.3 Duck Creek Channel Upstream of Site

Figure 3.4 Duck Creek Downstream of William Street roundabout

Figure 3.5 Little Duck Creek Upstream of Confluence

Figure 3.6 Duck Creek Culverts Under Memorial Park Drive & Main Western Railway Line

3.2 Development Description

Architex is proposing a mixed-use and a high-rise development on site. Key features of the proposed development include:-

- Five levels of basement car parking accessible from William Street;
- A ground floor level with combined retail outlets and residential units; and
- Eighteen residential levels above.

More details of the proposed development are included on the architectural drawings by Architex.

4 GLOSSARY

Annual Exceedance Probability (AEP)

The chance of a flood of a given or a larger size occurring in any one year, usually expressed as a percentage.

Australian Height Datum (AHD)

A common national surface level datum approximately corresponding to mean sea level.

Average Recurrence Interval (ARI)

The long term average number of years between the occurrence of a flood as big as or larger than the selected event.

Catchment

The land area draining through the main stream, as well as tributary streams, to a particular site. It always relates to an area above a specific location.

Flood

Relatively high stream flow which overtops the natural or artificial banks in any part of a stream, river, estuary, lake or dam, and/or local overland flooding associated with major drainage before entering a watercourse.

Flood Liable Land or Flood Prone Land

Land susceptible to flooding by the PMF.

Flood Planning Levels (FPLs)

Are the combinations of flood levels and freeboards selected for floodplain risk management purposes.

Freeboard

Is a factor of safety typically used in relation to the setting of floor levels.

Habitable Room

In industrial or commercial situation: an area used for offices or to store valuable possessions susceptible to damage in the event of a flood.

Peak Discharge

The maximum discharge occurring during a flood event.

Probable Maximum Flood

PMF is the largest flood that could conceivably occur at a location, usually estimated from probable maximum precipitation.

Probable Maximum Precipitation

PMP is the greatest depth of precipitation for a given duration meteorologically possible over a given size storm area at a particular location at a particular time of the year.

Runoff

The amount of rainfall which actually ends up as stream flow.

5 AUTHORITIES REQUIREMENTS

5.1 Local Floodplain Risk Management Policy

In 2006, Parramatta City Council adopted the Local Floodplain Risk Management Policy (LFRMP) for all land identified as flood prone. The policy adopted the Flood Planning Level as 0.5m above the 100-yr ARI flood level.

For the purpose of the LFRMP, the proposed development falls under the “residential” and the “commercial/industrial” land use categories.

The following controls apply based on a Medium Flood Risk precinct. The site adjoins Low and Medium Flood Risk precincts.

5.1.1 Floor Levels

- Habitable floor levels to be equal to or greater than the 100-yr flood level plus freeboard; and
- A restriction is to be placed on the title of the land, pursuant to S.88B of the Conveyancing Act, where the lowest *habitable floor area* is elevated more than 1.5m above finished ground level, confirming that the subfloor space is not to be enclosed.

5.1.2 Building Components

All structures to have flood compatible building components below the 100-yr flood level plus freeboard.

5.1.3 Structural Soundness

Engineers report to certify that the structure can withstand the forces of floodwater, debris and buoyancy up to and including a 100-yr ARI flood plus freeboard.

5.1.4 Flood Affectation

Engineers report required to certify that the development will not increase *flood affectation* elsewhere, having regard to: (I) loss of flood storage; (ii) changes in flood levels, flows and velocities caused by alterations to flood flows; and (iii) the cumulative impact of multiple potential developments in the vicinity.

5.1.5 Car Parking and Driveway Access

- The minimum surface level of open spaces or carports shall be as high as practical, but no lower than 0.1m below the 100 year ARI flood level. In the case of garages, the minimum surface level shall be as high as practical, but no lower than the 100 year ARI flood level;
- Garages capable of accommodating more than 3 motor vehicles on land zones for urban purposes, or enclosed car parking, must be protected from inundation by floods equal to or greater than the 100 year ARI flood. Ramp levels to be no lower than 0.5m above the 100 year ARI flood level;
- The level of the driveway providing access between the road and parking spaces shall be no lower than 0.2m below the 100 year ARI flood level;
- Enclosed car parking and car parking areas accommodating more than 3 vehicles, with a floor below the 100 year ARI flood level, shall have adequate warning systems, signage, exits and evacuation routes; and
- Restraints or vehicle barriers to be provided to prevent floating vehicles leaving a site during a 100 year ARI flood.

5.1.6 Evacuation

- Reliable access for pedestrians and vehicles is required from the site to an area of refuge above the PMF level, either on site (eg. second storey) or off site;
- Applicant to demonstrate the development is consistent with any relevant *flood evacuation strategy* or similar plan; and
- Adequate flood warning is available to allow safe and orderly evacuation without increased reliance upon SES or other authorised emergency services personnel.

5.1.7 Management and Design

- Site Emergency Response Flood plan required where the site is affected by the 100 year ARI flood level, (except for single dwelling-houses);
- Applicant to demonstrate that area is available to store goods above the 100 year *flood* level plus *freeboard*; and
- No storage of materials below the 100 year *ARI flood level*.

6 DUCK CREEK

Duck Creek, a major tributary of Duck River, is a concrete lined open stormwater channel which flows in a south-north direction at the dead end of East Street (Figure 6.1).

Figure 6.1 Existing Site Plan

6.1 Previous/Current Studies

WMA Water have carried out a flood study for the Duck River and Duck Creek systems. The study identified the extent of flooding along the corridor of these systems and mapped the depth, the velocity and the risk of flooding on the affected lands.

An extract of the design flood levels in 100-yr ARI is shown in Figure 6.2 below. While the site is not shown to be flood affected by mainstream flooding, overland flooding will impact the site.

The table below (Figure 6.3) is an extract of the flood levels in Duck Creek at the dead end of East Street. The flood levels affecting the site are highlighted for reference. The 100-yr flood level for the site is RL 5.42m AHD and the PMF flood level is RL7.89m AHD.

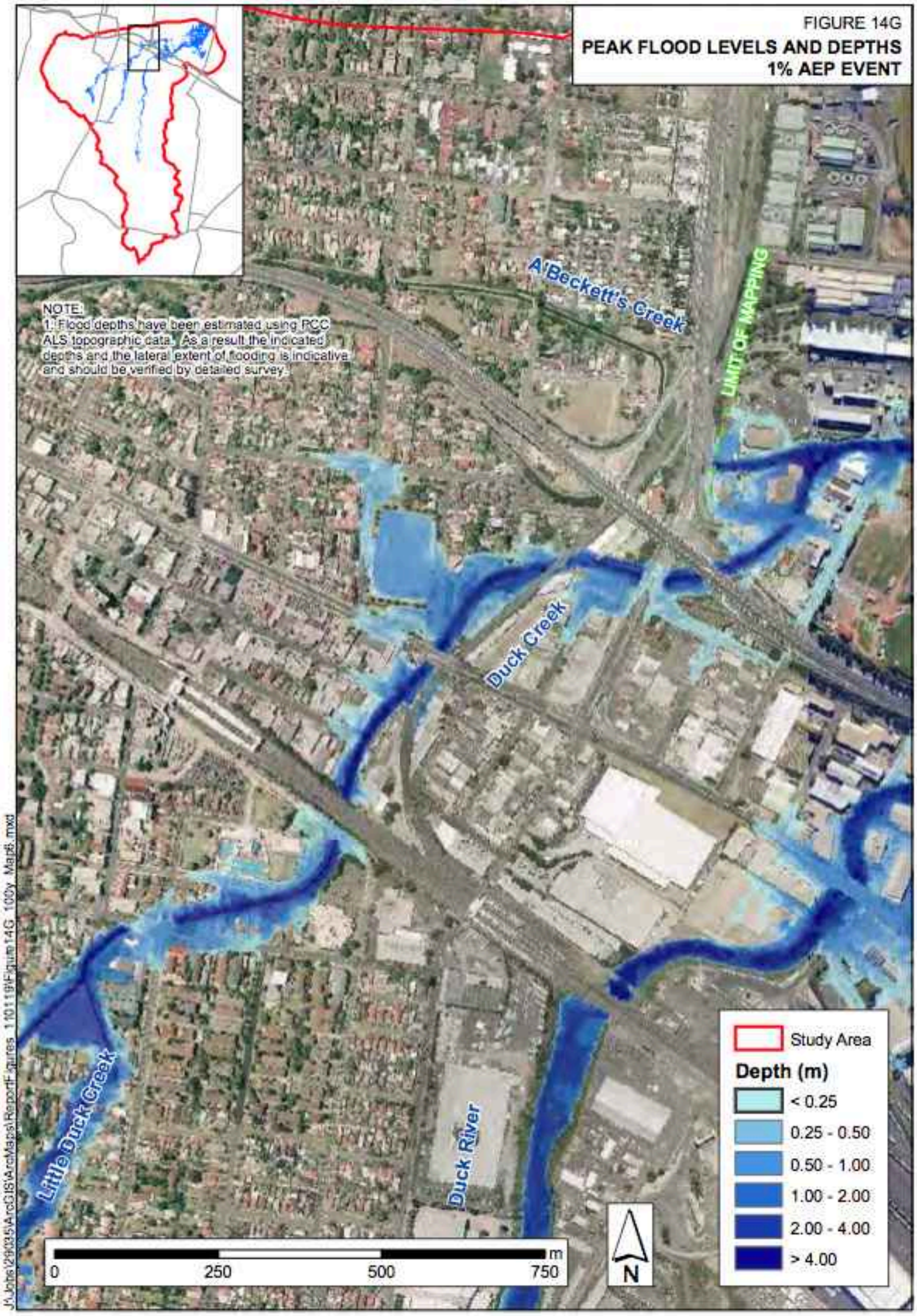


Figure 6.2 Flood Depth Map – WMA Water Flood Study

Duck Creek	d/s Woodville Road	9.4	10.0	10.3	10.5	13.4
Duck Creek	u/s Louis Street	9.2	9.9	10.2	10.4	12.5
Duck Creek	Adjacent Brunswick Street	7.7	8.1	8.3	8.5	11.6
Duck Creek	u/s The Avenue	6.6	7.2	7.6	8.0	10.3
Duck Creek	u/s Elizabeth Street	5.8	6.5	7.0	7.3	9.4
Duck Creek	"Dog Park"	5.4	6.3	6.8	7.2	9.3
Duck Creek	Confluence Duck and Little Duck Creek (u/s SWP)	5.3	6.3	6.8	7.1	9.2
Duck Creek	u/s William Street	4.9	6.0	6.5	6.8	9.1
Duck Creek	u/s Memorial Park Drive	4.4	5.1	5.6	6.0	8.7
Duck Creek	u/s Parra Rd	4.2	4.7	5.1	5.4	7.8
Duck Creek	u/s James-Russ	4.1	4.6	4.9	5.1	7.5
Duck Creek	u/s M4	4.1	4.6	4.8	5.0	7.3
Duck Creek	u/s Kay Street	4.1	4.5	4.8	5.0	7.0
Duck Creek	u/s SWP	3.6	4.1	4.5	4.7	6.8
Little Duck Creek	u/s Rawson Road	30.9	31.0	31.0	31.0	31.5
Little Duck Creek	Rawson Road	30.8	30.9	30.9	30.9	31.5
Little Duck Creek	Excelsior Street (u/s channel)	27.9	28.0	28.0	28.0	28.2
Little Duck Creek	u/s Brazier Place	26.8	26.9	27.0	27.0	27.0
Little Duck Creek	Willoughby Street	22.9	23.0	23.0	23.0	23.3
Little Duck Creek	u/s Guildford Road	22.5	22.6	22.6	22.6	23.0
Little Duck Creek	u/s Eve Street	18.9	19.3	19.4	19.5	19.7
Little Duck Creek	u/s Adam Street	16.5	16.7	16.8	16.9	17.4
Little Duck Creek	Lavinia Street	13.9	13.9	14.0	14.0	14.9
Little Duck Creek	u/s Lackey Street	12.1	12.2	12.3	12.3	13.8
Little Duck Creek	u/s Lisgar Street	12.1	12.2	12.2	12.2	13.1
Little Duck Creek	u/s Farnell Street	10.6	10.7	10.8	10.8	11.5
Little Duck Creek	u/s Thomas Street	9.4	9.7	9.9	10.1	10.8
Little Duck Creek	u/s Louis Street	8.3	8.7	8.8	8.9	10.1
Little Duck Creek	u/s John Street	6.6	7.0	7.3	7.6	9.8
Little Duck Creek	u/s Elizabeth Street	6.0	6.8	7.2	7.5	9.4

Figure 6.3 Design Flood Levels – WMA Water Flood Study

6.2 Objectives

The purpose of this flood study is to determine the impacts (if any) that the proposed development will have on the flooding within the site and its surroundings.

The flood study will also determine how the proposed building will be constructed without affecting the flood characteristics (i.e. flood level, velocity and impact on adjoining properties).

In summary, the objectives are as follows:-

- Develop a 1-D/2-D computer model that can be used to predict the magnitude and extent of future flood events. The model will replicate the model adopted by Council (WMA Water – August 2011) for the existing site conditions;
- Define design flood levels, velocities and depths for the catchment to establish a benchmark;
- Amend the model to include the proposed development and determine if the latter has an impact on the flooding;
- Propose mitigation measures to eliminate any impacts;
- Provide evacuation measures during extreme and rare events (PMF); and
- Address the requirements of the LFRMP.

7 HYDROLOGY

A hydrologic model combines rainfall information with local catchment characteristics to estimate a runoff hydrograph. The flows in Duck Creek and Little Duck Creek upstream of the site were obtained from WMA Water flood study as per the table below (Figure 7.1).

The flows are entered at the upstream nodes as inflow hydrographs with the peak flows at the top of the hydrograph. A time to peak of 1-hour is chosen.

Duck River and Duck Creek Flood Study Review

Duck Creek	u/s The Avenue	29	39	48	49	175
Duck Creek	u/s Elizabeth Street	31	42	53	53	176
Duck Creek	Confluence (US SWP)	48	62	71	79	298
Duck Creek	u/s William Street	48	62	73	85	285
Duck Creek	u/s Memorial Park Drive	49	63	73	80	259
Duck Creek	u/s Parramatta Road	48	62	73	82	203
Duck Creek	u/s James-Russ	51	64	72	83	217
Duck Creek	u/s SWP	92	110	121	130	100
Little Duck Creek	Rawson Road	4.6	7.1	8.4	10	19
Little Duck Creek	Excelsior Street (u/s Channel)	1.6	2.4	3.3	4.4	23
Little Duck Creek	u/s Brazier Place	5.4	8.1	10	12	36
Little Duck Creek	Willoughby Street	6.2	9.6	11	13	44
Little Duck Creek	u/s Guildford Road	5.6	8.8	11	12	56
Little Duck Creek	u/s Eve Street	7.1	11	14	16	60
Little Duck Creek	u/s Adam Street	7.6	13	17	19	76
Little Duck Creek	Lavinia Street	10	14	16	19	92
Little Duck Creek	u/s Lackey Street	16	21	24	26	115
Little Duck Creek	u/s Lisgar Street	21	31	37	42	115
Little Duck Creek	u/s Farnell Street	16	25	29	34	132
Little Duck Creek	u/s Thomas Street	18	25	28	31	142
Little Duck Creek	u/s Louis Street	22	31	41	49	147
Little Duck Creek	u/s John Street	21	35	44	52	132
Little Duck Creek	u/s Elizabeth Street	18	25	28	30	128

Figure 7.1 Peak Flows – WMA Water Flood Study

XP-STORM was used for the local catchment directly upstream of the site. For the purpose of this hydrologic analysis, rain-on-grid method is used.

7.1 Design Rainfall

The design Intensity-Frequency-Duration (IFD) parameters obtained from the Bureau Of Meteorology (BOM) for the catchment are presented in Appendix 1.

7.2 Rainfall Losses

The model adopts the same rainfall losses used in Duck River & Duck Creek Flood Study (WMA Water, 2011) as listed in Table 7.1 below.

Table 7.1 Model Land Use Roughness & Losses

Land Use	Roughness	Initial Loss (mm)	Continuing Loss (mm/hr)
Overall	0.08	10	2.5
Residential	0.20	0	0
Road, car parks	0.02	0	0
Railway	0.06	0	0
Recreation/parks	0.05	10	2.5
Commercial/industrial	0.15	0	0
Light vegetation	0.04	10	2.5
Medium vegetation	0.08	10	2.5
Heavy vegetation	0.15	10	2.5

7.3 Pit Losses

Hydraulic head losses at pits are not part of the modelling capabilities in the current version of the software modelling suite. Losses were considered in the model by adopting a higher conduit entrance and exit loss of 0.5.

8 HYDRAULIC

8.1 Definition

A hydraulic model converts runoff (traditionally from a hydrological model) into water levels and velocities throughout the major drainage/creek systems in the study area (known as the model 'domain', which includes the definition of both terrain and roughness). The model simulates the hydraulic behaviour of the water within the study area by accounting for flow in the major channels as well as potential overland flow paths, which develop when the capacity of the channels is exceeded. It relies on boundary conditions, which include the runoff hydrographs produced by the hydrologic model and the appropriate downstream boundary.

A 1D/2D fully dynamic hydraulic model was established for the study area. XP-STORM (1D) and XP-2D, a dynamic hydraulic modelling system developed by XP SOLUTIONS was used in this study. XP-2D is a 2-Dimensional model which uses TUFLOW as its 2D engine. TUFLOW is used world-wide and has been shown to provide reliable, robust simulation of flood behaviour in urban and rural areas through a vast number of applications.

The model allows addition of a 2-Dimensional (2D) domain (representing the study area topography) to a 1-Dimensional (1D) network (representing the channels in the study area) with the two components dynamically coupled and solved simultaneously.

An important feature of the model is the ability to model the hydraulic structures in the 1D component rather than in the 2D domain. The benefit of this approach is that structure hydraulics are modelled more precisely than the approximate representation possible in a 2D domain.

Stormwater drainage pits, pipes and channels are represented in the model as 1-Dimensional elements which are dynamically linked to the water conveyed across the elevation grid.

8.2 Model Schematisation

The survey data included in the model was extrapolated from Digital Terrain Model (DTM) created from the ALS (Airborne Laser Scanning) received from AAM surveys.

Duck Creek is an open concrete channel which converts into culverts under roadway and railway lines. The channel is modelled as a 1-D element. Once the channel capacity is exceeded, flow is able to spill into the two-dimensional (2D) overland flow grid, which overlies the 1D elements in the model. As floodwater recedes, flow is also generally able to drain from the overland areas back into the canal.

The stormwater infrastructure under East Street has not been modeled and is assumed to be fully blocked. This approach is somewhat conservative and assumes that the runoff from the contributing local catchment upstream of the site is conveyed overland only.

8.3 1D Model Set-up

For the 1D components of the model, the channel cross sections were located such that all flow controls were captured, and so that the cross sections adequately represented the variations in the channel definition. Details of structures within the study area (such as bridges and culverts) were also included in the model as measured on site.

8.4 2D Model Set-up

Two-dimensional (2D) hydraulic modelling was carried out to determine the flood behaviour in the study area. A grid size (4m x 4m) was deemed necessary to define the extent of the flooding through the developed areas. This resulted in approximately 75 thousand grid cells for the model domain in the study area.

8.5 Model Terrain

A terrain grid (also referred to as a 'topographic' grid) was developed to represent ground elevations based on ALS data provided by AAM Surveys, with some modifications based on the cross-section ground survey.

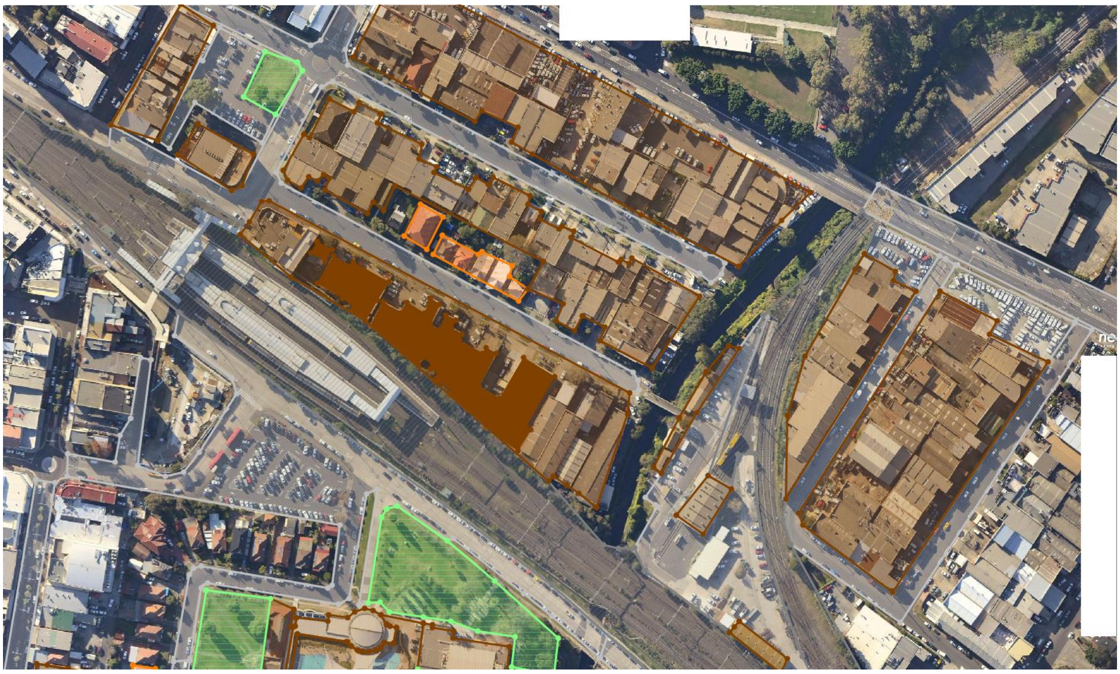
8.6 Buildings

Existing buildings within the site were modeled with relatively high Manning's n in the topographic grids. This was based on existing building outlines extracted from the survey drawings and ortho-rectified imagery and the proposed footprint of the new development.

Proposed buildings within the site were conservatively assumed to block the overland flow, and were modelled as raised fill areas in the topographic grids. As the rainfall-on-grid approach was adopted in the modelling, runoff from the impervious roof areas of buildings is modelled.

8.7 Hydraulic Roughness

The hydraulic roughness for the 2D model grid was determined using both aerial photography and site inspections carried out during the study. The Manning's roughness as adopted in the rain-on-grid model for every land use is included in Table 7.1. Figure 8.1 below is a representation of the roughness zones adopted.



(Grey: Road, Green: Parks, Brown: Commercial Roofs, Orange: Residential Roofs)

Figure 8.1 Land Use Zones – Existing Scenario

For the proposed scenario, the new development replaces the existing houses with al larger footprint as shown in Figure 8.2 below. The new building footprint is modelled as raised fill at the FPL to simulate the blockage caused by the proposed development.

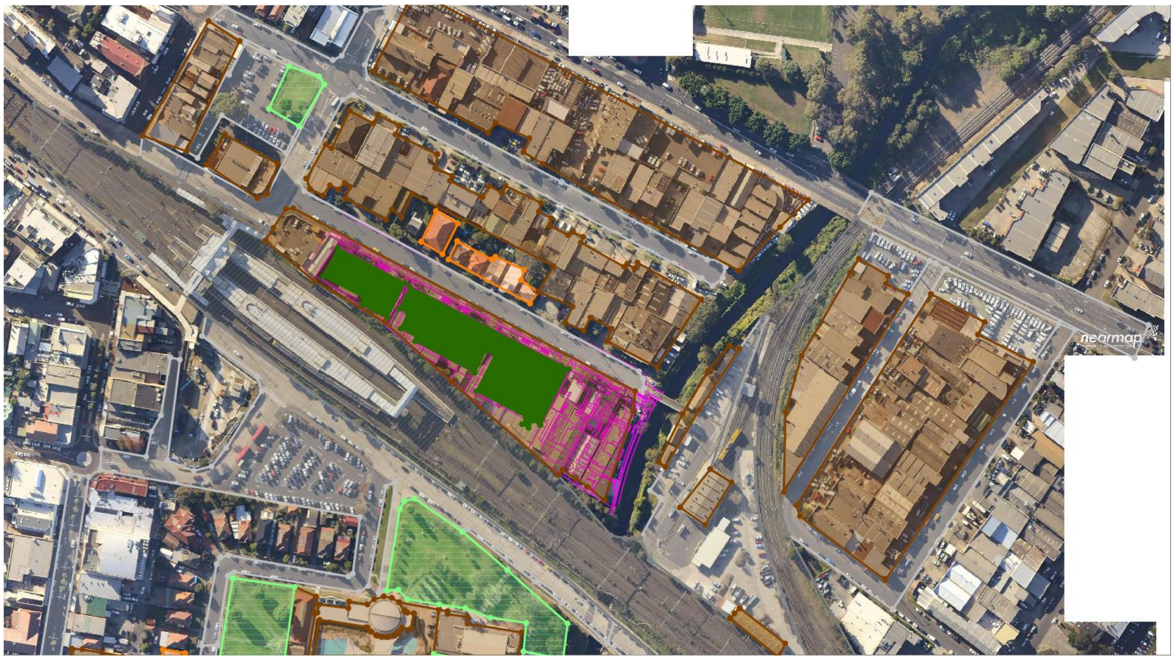


Figure 8.2 Land Use Zones – Proposed Scenario

8.8 Boundary Conditions

8.8.1 Flow Hydrograph

Flow hydrographs in Duck Creek and Little Duck Creek just upstream of the confluence are entered into the model as provided by Council from Duck River & Duck Creek Flood Study Review (WMA Water, August 2011).

Downstream Boundary

A maximum tailwater level of 5.0m AHD has been adopted as the downstream boundary condition for the open channel just upstream of Kay Street culverts. This tailwater level has no impact on the flood modeling results as it is taken a significant distance from the site.

9 RESULTS

9.1 Design Flood Modelling Results

Design flood modelling was undertaken for the 100-yr ARI design flood event. The peak water level, depth, and velocity for each 4mx4m grid cell in the study area were determined. The flooding occurs due to overland flows being carried out by the road network when the in-ground drainage capacity is exceeded.

The existing (base) scenario was modeled with the existing warehouses on site. The flood level obtained downstream of the railway line were comparable with the flood levels given by Council (WMA Water, 2011).

Table 9.1 Comparison of Flood Levels

Location	Flood Level (m AHD) SGC	Flood Level (m AHD) WMA Water	Difference (m)
Downstream of Western Railway Line	5.62	5.48	+0.14
East St – Downstream End of Site	5.70	-	-
East St – Upstream End of Site	7.40	-	-

The flows conveyed by East Street are 5.64m3/s and 7.20m3/s at the upstream and the downstream ends of the site respectively. Figure 9.1 and Figure 9.2 below show the flow hydrographs in 100-yr ARI storm event for both the upstream and the downstream ends of the site in East Street.

The proposed scenario is modeled with the building footprint added as a fill area which will divert the overland flow around the building. The results are presented in Appendix 2 of this report.

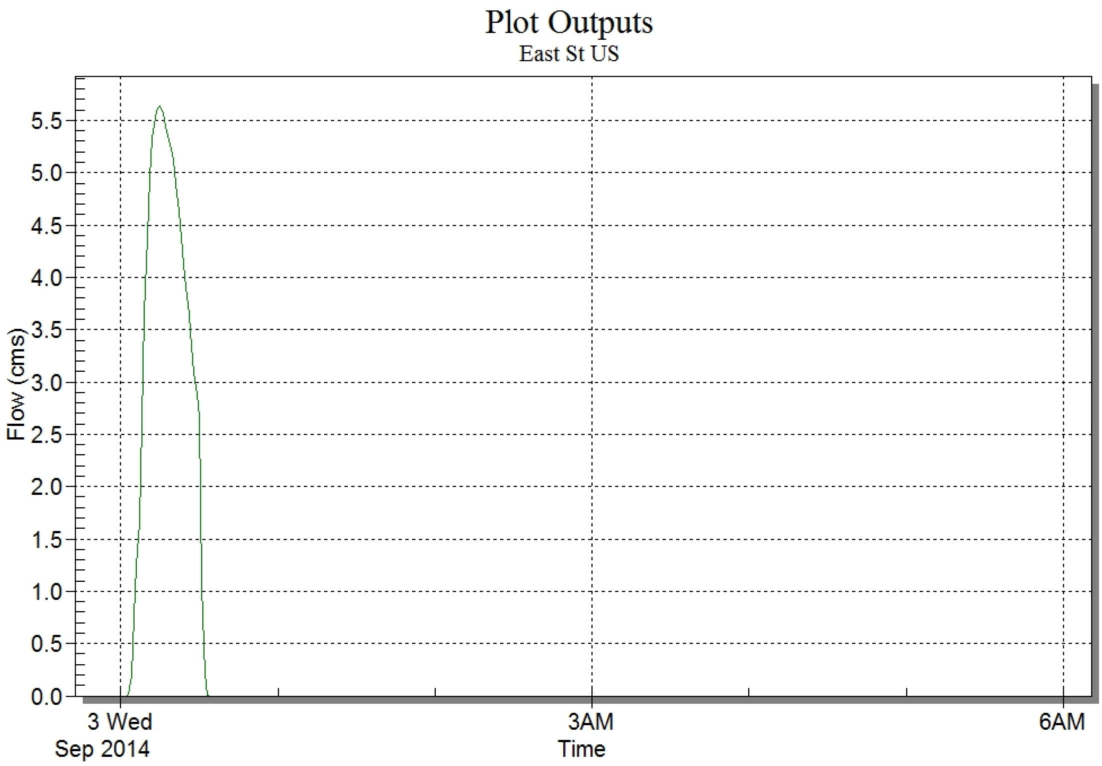


Figure 9.1 Upstream Flow Hydrograph in East Street

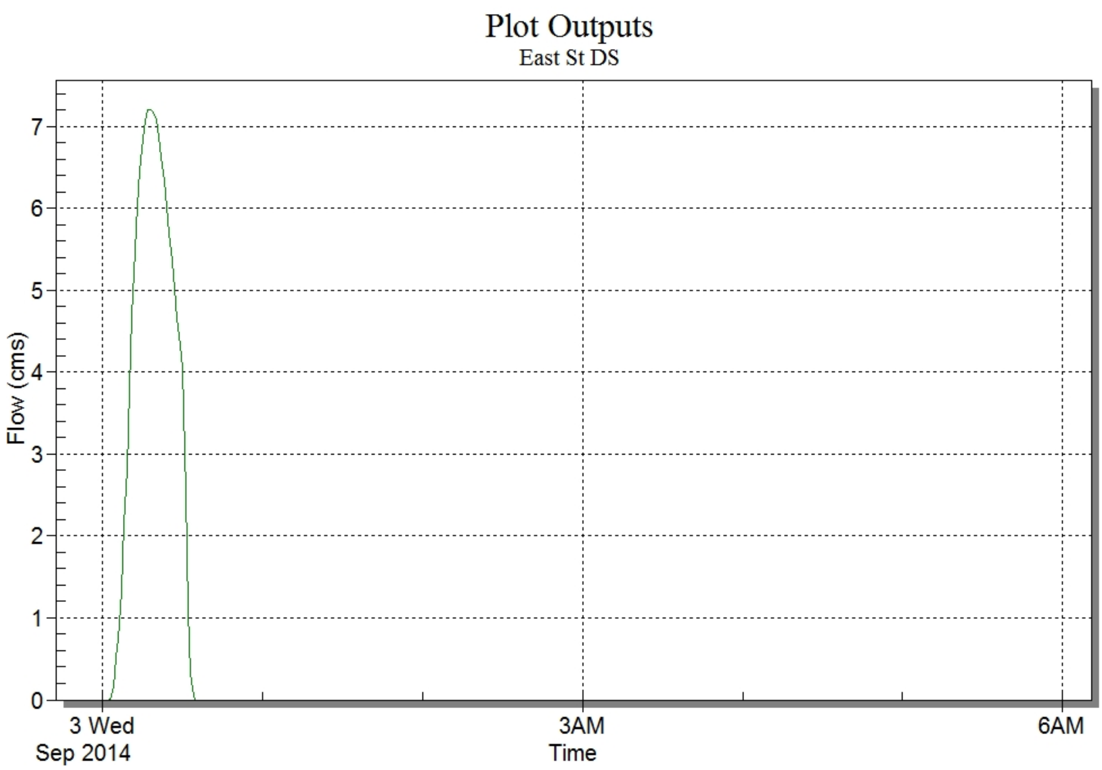


Figure 9.2 Downstream Flow Hydrograph in East Street

9.2 Flood Planning Level

The Flood Planning Level (FPL) recommended in the NSW Floodplain Development Manual (2005) is 0.5m above the calculated 100-yr ARI flood level across the site.

PCC requires the habitable floor levels to be at the FPL. On-grade car parking must be a minimum of 0.1m below the 100-yr flood levels. Any basement car parking should have a driveway with a crest set at 500mm above the 100-yr flood level.

The 100-yr flood level varies because of the natural gradient of the site and the fronting street. The suggested ground floor level for each building is as follows:-

Table 9.2 Proposed Flood Planning Levels

Block	U/S Flood Level	D/S Flood Level	FPL	Driveway Crest Level
A	6.10	5.70	6.60	6.20
B	6.70	6.30	7.20	6.80
C	7.40	6.70	7.90	7.20

9.3 Discussion

9.3.1 Impact of Proposed Development

Flooding occurs along the open drain when the formed channel capacity is exceeded. The site is not directly affected by mainstream flooding from the stormwater channel. The site is however affected by overland flooding from the upstream local catchment. This occurs when the capacity of the local infrastructure capacity is exceeded and runoff is conveyed by the road network and through private property.

The peak flow carried by East Street at the downstream end of the site is approximately 7.20m3/s assuming that the in-ground infrastructure is fully blocked and all the runoff is conveyed overland. This is somewhat a conservative approach which provides additional flood protection to the development.

The proposed development has been modelled and it does not increase the flood levels in its vicinity and as such does not increase the flood hazard or risk to other properties due to the following reasons and assumptions made in the model:-

The results of the hydraulic modeling of the open drain and the localised catchment indicate that the proposed development on 10-42 East Street does not have an adverse impact on the flooding behaviour elsewhere in the floodplain. There is no upstream afflux created by this development.

The modeling results also suggest that there is no downstream impact in the adjoining sites along East Street.

A flood impact map (Figure A 2.6) has been reproduced to show the extent of the impact of the development on the 100-yr ARI flood level. A +0.01m threshold was adopted to simulate a neutral impact.

9.3.2 Council's Requirements

This section of the report demonstrates how the proposed development will achieve Council's requirements as outlined in the LFRMP.

9.3.2.1 Floor Levels

The proposed flood study has determined the flood level across the site in a 100-yr ARI storm event and proposed a suitable Flood Planning Level in accordance with Council's requirements and the floodplain Development Manual.

The increase of risk to life associated with the flooding of the ground floor level in rare storm events such as the PMF is reduced through the provision of evacuation measures and flood risk management plans to be implemented by the building management.

9.3.2.2 Building Components

This flood study recommends that all structures to have flood compatible building components and be able to withstand the hydraulic forces of 100-yr ARI velocities, up to the PMF (RL:7.84mAHD as provided by WMA Water).

9.3.2.3 Structural Soundness

This flood study recommends that a Flood Risk Assessment by a suitably qualified structural engineer be carried out during detailed design stage to certify that any structure can withstand the forces of floodwater, debris and buoyancy up to the PMF. This will be provided during detailed design stage.

9.3.2.4 Flood Affectation

The results of the modelling undertaken for this flood study indicates that the proposed development will not increase flooding depth nor negatively impact on the velocities of the flood waters upstream or downstream in a 100-yr ARI flood event.

The flood impact map included in Appendix 2 clearly demonstrates that there are no cumulative impacts for multiple potential developments in the vicinity because the proposed development does not increase the footprint of the building and does not alter the existing ground levels.

The characteristics of the overland flooding are not altered by the proposed development (i.e. extents, flows, velocities, hazard). If all other proposed developments achieve the same outcomes, then the cumulative impact will be negligible in the floodplain.

9.3.2.5 Car Parking and Driveway Access

Car parking is provided at ground level and is elevated above the 100-yr flood level plus freeboard.

- The basement car parking levels are accessible from three separate driveways with each driveway servicing one building. All accessed are from East Street. The basements are separate. The driveway ramps provide crests which are set at the 100-yr ARI flood level plus 0.5m freeboard. As such, the basement car parking levels are protected as required by Council;
- In larger storm events exceeding the 100-yr design storm, the basements will be subject to inundation as the crests will be overwhelmed when the floodwaters rise. The evacuation from the basement car parking levels will be through the two (2) exit stairs (per building) that lead to higher floor levels above the PMF flood level; and
- A warning probe and flood signs should be installed at the entries and in the basement levels alerting entering vehicles about the flooding of the basement in extreme and rare events. An alarm system should be installed which is triggered by the rising of the floodwaters in the basement. The alarm should trigger when the water depth reaches more than 100mm.

9.3.2.6 Evacuation

The flooding associated with Duck Creek channel is considered flash flooding. Flash flooding do not give enough warning times to allow evacuation off site in a suitable and safe manner. As such, it is more prudent to remain within the site and evacuate vertically. The time of rise of floodwaters in the PMF event is as per Figure 9.3 below (WMA Water, 2011). A rate of rise of floodwaters of 1.1m/hr is noted from the graph.

The extent of the flood during the PMF covers all the streets surrounding the site. Off site evacuation is not a real possibility.

Because the proposed development offers habitable floor levels above the PMF (i.e. level 1 and above), it is proposed that all occupants of the ground floor level and the persons at risk in the basement at the time of flooding evacuate to level 1 and above and shelter in place until such time the flood levels have receded, which would be around 3.5 to 4.5 hours.

The following table shows the estimated times for the driveways to be inundated from the start of the PMP storm. Building "A" closer to the channel and provides the lowest level will be the most critical. However, occupants, visitors and other users of the car park have around 50mins to evacuate the basement and take refuge in the higher levels. This is considered acceptable and a manageable risk.

Table 9.3 Estimated Times for Inundation to Start

Building	Crest level (m AHD)	Time to inundation (mins)
A	6.20	48
B	6.80	72
C	7.20	90

It is important that persons at risk in the basements relocate to level 1 prior to or at maximum when the floodwaters reach the driveway crest.

Figure 9.3 PMF Flood Level Hydrograph

On ground floor, the number of direct persons at risk is estimated at XX. This is based on:-

- An average of 1.5 persons per 1-Bed unit (1 unit proposed) totaling 1.5 persons;
- An average of 2.5 persons per 2-Bed unit (8 units proposed) totaling 20 persons;
- 31.5 persons visiting the retail outlets. This is based on figures from Warringah Mall reported number of visitors which equals 0.04 persons per sqm (because it accounts for periods when the retail outlets are not trading);

- The number of persons at risk in the car parking levels was based on the estimate that 1 in 2 persons would be driving and parking in the basement levels provided. Other retailers may be using other means of transport or would park in the street. This gave an estimate of 16 persons;
- The number of residents that would be in the car parking levels at any given time is assumed to be 10 residents per building, totaling 30 persons.

The total number of persons at risk is estimated at 99 persons. For the purpose of flood evacuation and refuge, it is proposed that an equal number of persons at risk are in each building, i.e. 33 persons.

It is proposed that evacuation to level 1 foyer be made. Based on figures obtained from the Building Code of Australia (2008), a density of 1m2 per person is recommended for halls and theatres. For 10-42 East Street, a density of 2m2 per person is proposed because of the duration of inundation estimated at an average of 4 hours.

Based on the above, an area of 66m2 is required. The lobby areas on level 1 provide sufficient space to accommodate all the evacuated persons.

A Flood Emergency and Evacuation Plan should be prepared as part of this development which can easily demonstrate that all residents are safely sheltered in place in a PMF event.

9.3.2.7 Management and Design

A Site Emergency Response Flood Plan should be prepared for the site alerting the stakeholders of the development of the potential flooding on site.

Due to the residential nature of this development, the storage of materials which may cause pollution or be potentially hazardous during a flood is not proposed.

10 CONCLUSIONS

A detailed investigation on the flooding behaviour has been undertaken for the proposed development at 10-42 East Street Granville, NSW.

A detailed 1D/2D hydraulic model was established. This model incorporates the overland flow from the local catchment and has a fine 2D resolution of 4m. Hydrological modelling was undertaken utilising rain-on-grid method for the local catchment contributing runoff towards the site and inflow hydrographs for the external catchments discharging into the main drains.

Utilising the established models, the study has determined the flood behaviour for the 100-yr design floods. The primary flood characteristics reported for the design events considered include depths, levels and velocities.

The study looked into the impact of the proposed development on the overland flooding behaviour and its impact on the flood levels both upstream and downstream. The flood maps are included under Appendix 2.

The on-site evacuation in rare storm events exceeding the 100-yr is discussed.

A.1 Appendix 1

Rainfall Data

Figure A 1.1 IFD Table (Parramatta City Council – Granville)

Intensity-Frequency-Duration Table

Location: 33.825S 151.000E NEAR.. Parramatta Issued: 19/3/2014

Rainfall intensity in mm/h for various durations and Average Recurrence Interval

Average Recurrence Interval

Duration	1 YEAR	2 YEARS	5 YEARS	10 YEARS	20 YEARS	50 YEARS	100 YEARS
5Mins	83.7	107	136	152	174	203	224
6Mins	78.4	101	128	143	164	190	211
10Mins	64.2	82.2	104	117	134	156	173
20Mins	46.9	60.0	76.1	85.3	97.5	113	126
30Mins	38.1	48.9	61.9	69.4	79.3	92.3	102
1Hr	25.8	33.2	42.2	47.4	54.2	63.2	70.0
2Hrs	16.9	21.8	27.9	31.5	36.2	42.4	47.1
3Hrs	13.1	16.8	21.8	24.7	28.5	33.4	37.2
6Hrs	8.38	10.8	14.2	16.2	18.8	22.2	24.9
12Hrs	5.43	7.06	9.35	10.7	12.5	14.8	16.7
24Hrs	3.57	4.66	6.20	7.12	8.31	9.89	11.1
48Hrs	2.33	3.04	4.04	4.64	5.41	6.45	7.24
72Hrs	1.76	2.29	3.05	3.51	4.10	4.89	5.50

(Raw data: 33.24, 7.04, 2.29, 63.06, 14.83, 4.89, skew=0.00, F2=4.3, F50=15.83)

Figure A 1.1 IFD Table (Parramatta City Council – Granville)

A.2 Appendix 2

Flood Mapping

Figure A 2.1 Extent of Rain-on-Grid Model

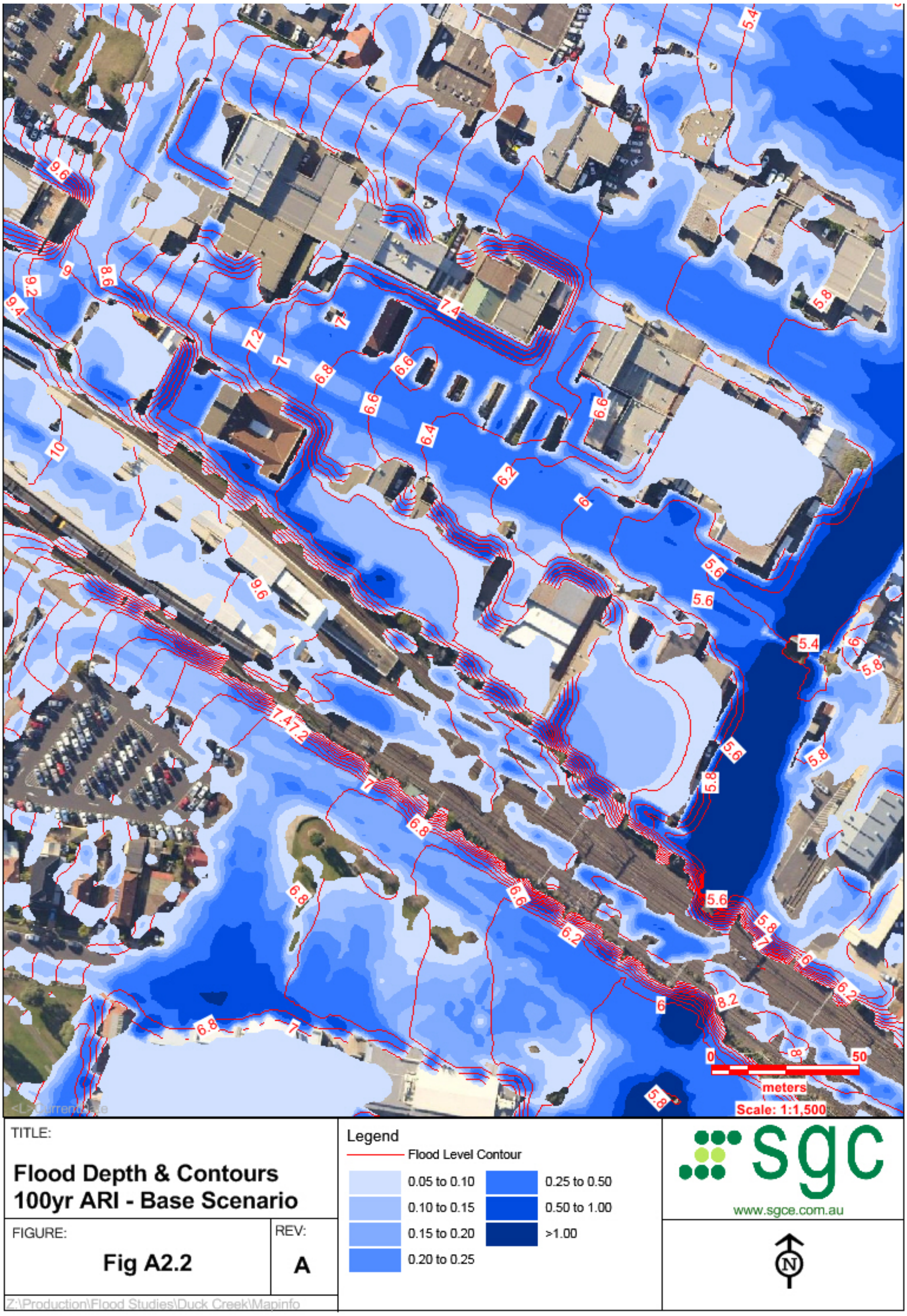


Figure A 2.2 100-yr ARI Flood Depth – Base Scenario

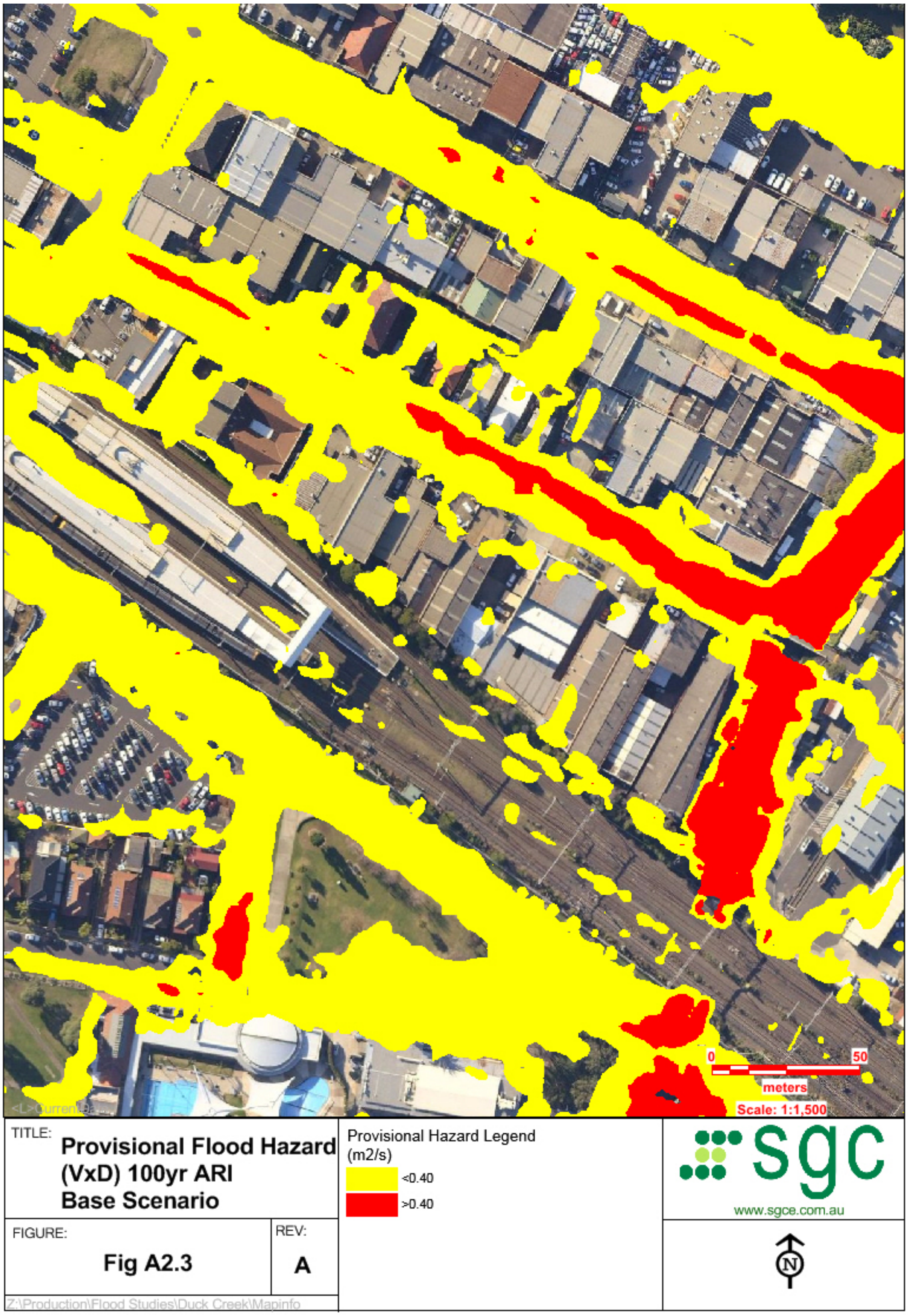


Figure A 2.3 100-yr ARI Flood Hazard – Base Scenario

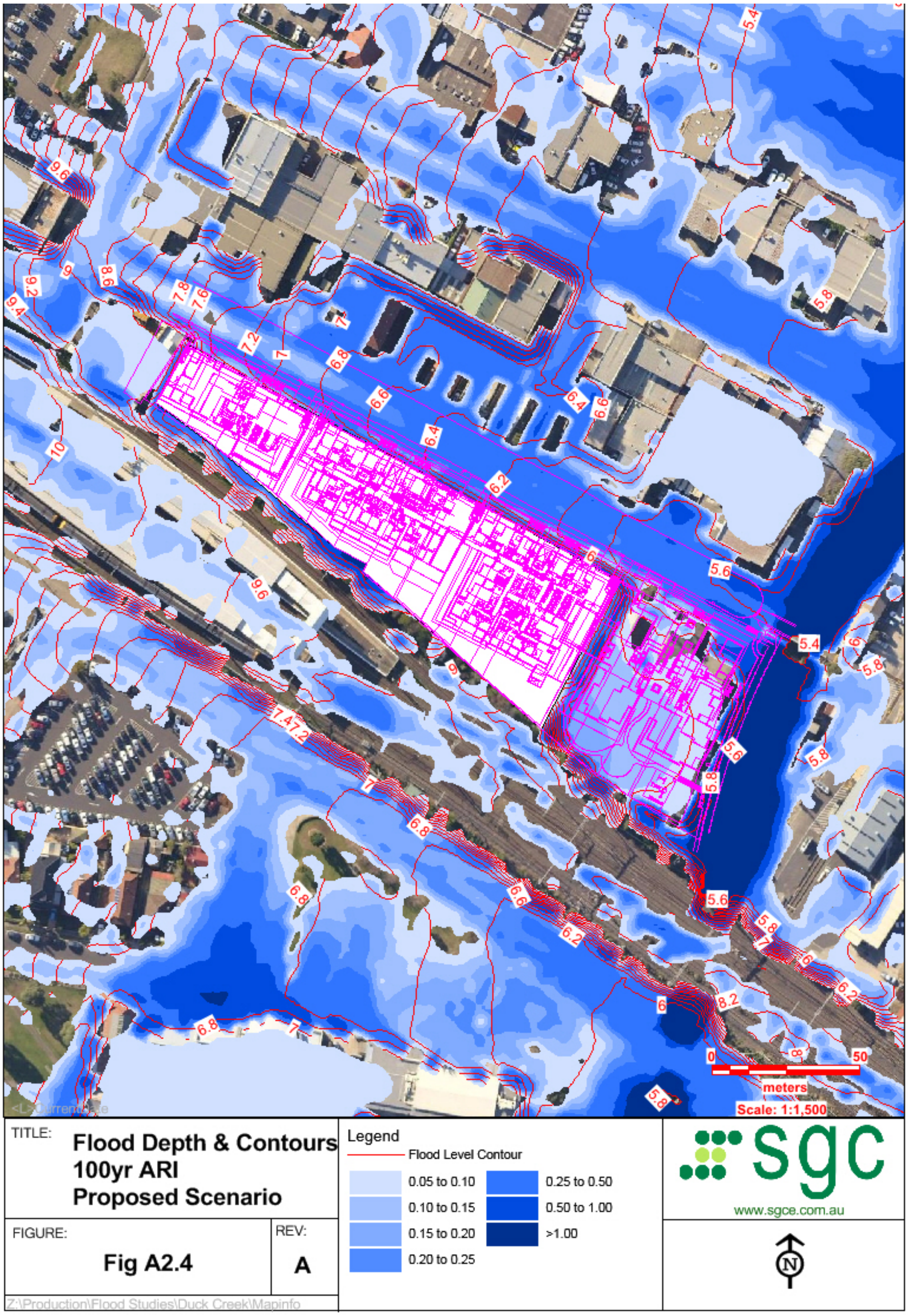


Figure A 2.4 100-yr ARI Flood Depth – Proposed Scenario

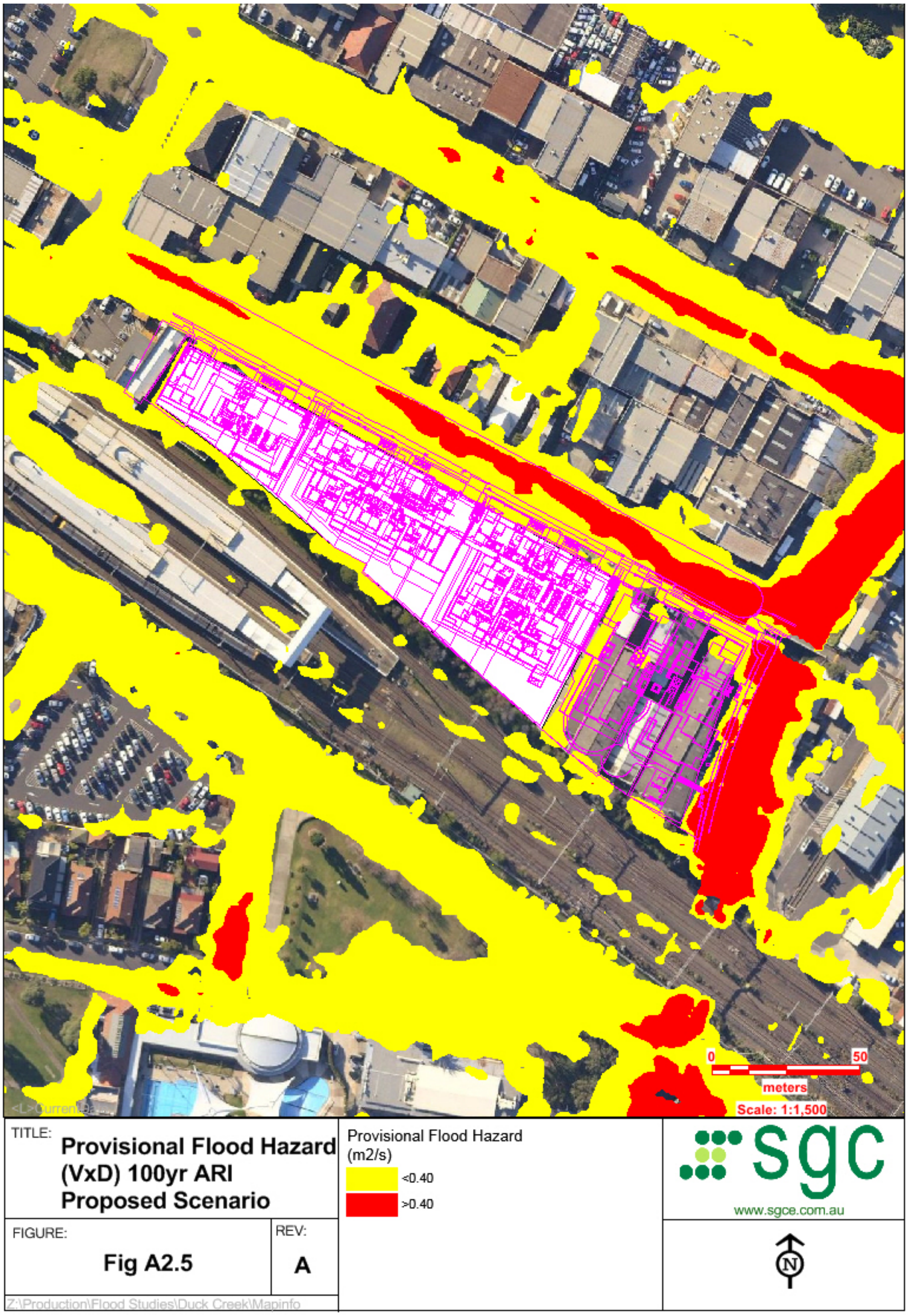


Figure A 2.5 100-yr ARI Flood Hazard – Proposed Scenario

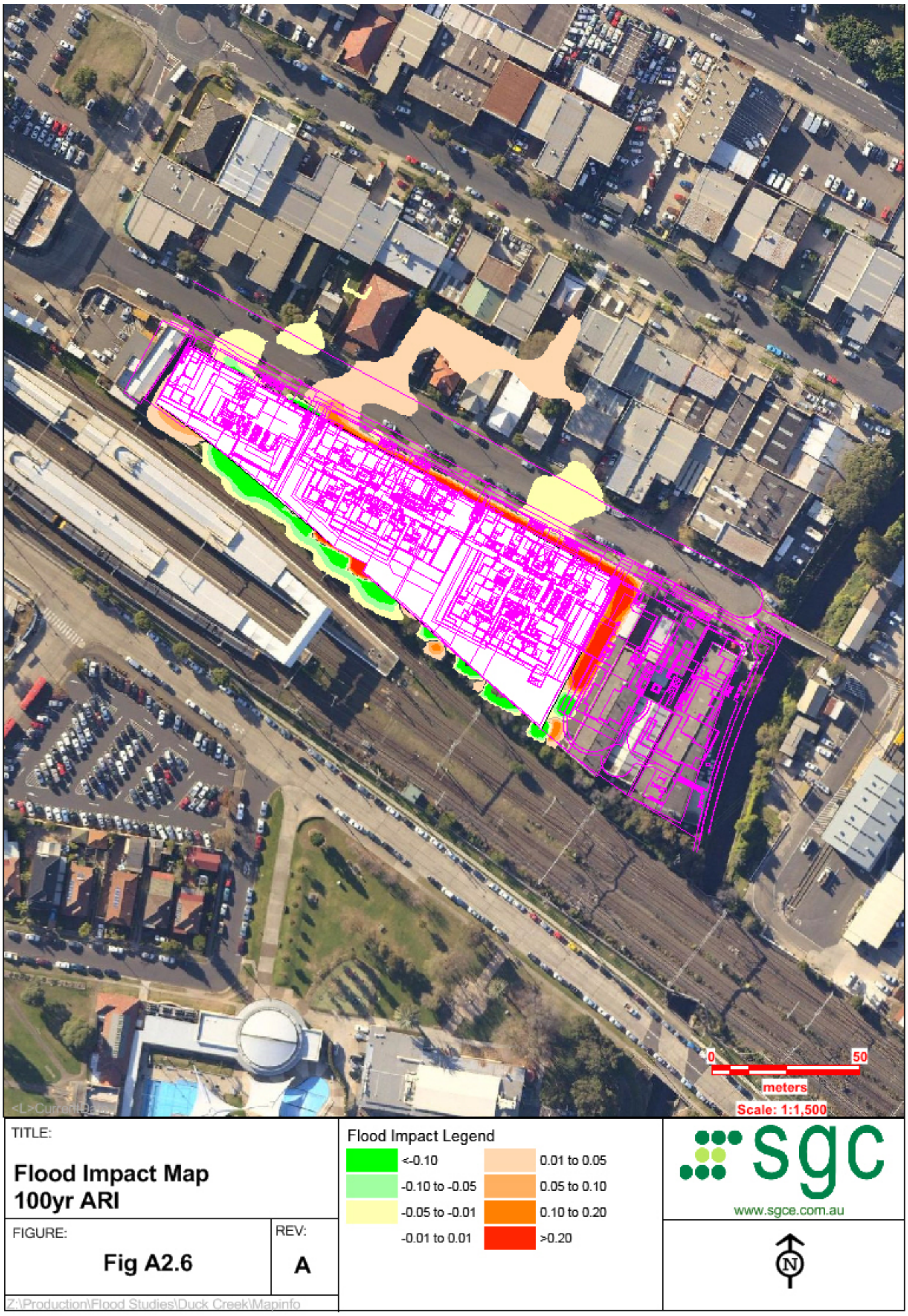


Figure A 2.6 100-yr ARI – Flood Impact Map