Flood Risk Assessment

For Proposed Development of Three Contiguous Sites:

Site 1: Lot 6 in DP 1040572

Site 2: Lot 1 in DP745233, Lots 21 & 22 in DP979378

Site 3: Comprising proposed consolidation of Lots from DP127989, DP616419, and DP862630

Prepared for: N.F. BILLYARD PTY LTD

Document No.WS170030-RPT-F01

Issue: B

Disclaimer

This report has been prepared in accordance with the scope of services described in the contract or agreement between ACOR Consultants Pty Ltd and the Client. The report relies upon data, surveys, measurements and results taken at or under the particular times and conditions specified herein. Changes to circumstances or facts after certain information or material has been submitted may impact on the accuracy, completeness or currency of the information or material.

This report has been prepared solely for use by the Client, ACOR Consultants accepts no responsibility for its use by other parties without the specific authorization of ACOR Consultants Pty Ltd. ACOR Consultants Pty Ltd reserves the right to alter, amend, discontinue, vary or otherwise change any information, material or service at any time without subsequent notification. All access to, or use of, the information or material is at the user's risk and ACOR Consultants Pty Ltd accepts no responsibility for the results of any actions taken on the basis of information or material provided, nor for its accuracy, completeness or currency.

Issue	Date	Purpose	Flood Model Prepared by	Report Prepared by
A	12/05/2017	ISSUE FOR REVIEW AND COMMENT	EM	RGE
B	07/07/2017	ISSUE FOR APPROVAL	EM	RGE

Table of Contents

1. INTRODUCTION & BACKGROUND

This flood study and report has been prepared by ACOR Consultants to address potential impacts and design issues associated with possible flooding at the three adjoining subject sites, which is summarised generally as follows:

- The sites are deemed by Penrith City Council to be potentially affected by
  - local flooding, and
  - mainstream flooding from the Nepean River.
- The development applications must therefore each demonstrate that the respective development proposal for each site is compatible with the State Government Floodplain Development Manual and Penrith City Council's Development Control Plan (DCP).

This flood study and report is based upon previous Council approved flood models and reports for the Castlereagh Road industrial and residential precincts, namely as follows:

- Report of August 2003 titled "*Lakeside Village, Hawkesbury-Nepean Flooding*", and
- ACOR Consultants subsequent calibrated modelling and report covering the equivalent floodplain area (refer Figure 1), titled "*Flood Study Addendum II - Waterside Corporate, Andrews Road, Cranebrook Industrial Subdivision - October 2014 - Issue B*"

We understand from all previous flood reports in the Castlereagh Road development area that Penrith Council require the following:

- The flood study report shall coordinate the findings and recommendations from the previously accepted flood reports associated with the development site and demonstrate that the proposed subdivision and new building layout do not adversely impact on flood levels and overland flow paths for all storms, including the 0.2% AEP
- As such, the flood modelling shall be carried out for the 0.2% AEP and the 1% AEP storm events, but not for the PMF.

This report forms an integral part of the development application submission for the proposed development at each of the three subject sites which are defined as follows:

Site 1: Known as Lot 6 in DP 1040572

Site 2: Known as Lot 1 in DP745233, Lots 21 & 22 in DP979378

Site 3: Comprising proposed consolidation of Lots from DP127989, DP616419, and DP862630

For the purposes of this report it has been taken that each of the three subject sites is to be developed concurrently with the other two; thus, the effects of the compounded floodplain impacts are considered and addressed in this report.

This report inherently constitutes an addendum to, and provides amendment to, the "*Flood Study Addendum II - Waterside Corporate, Andrews Road, Cranebrook Industrial Subdivision - October 2014 - Issue B*" prepared by ACOR Consultants.

This report should consequently also be read in conjunction with the following foundational flood studies and associated flood reports:

1. Regional flooding: 'Lakeside Village, Penrith, Hawkesbury – Nepean Flooding- Addendum', prepared by Patterson Britton & Partners Pty. Ltd., Issue 4, dated 9 November 2004 which is herein referred as "Lakeside Regional Flood Study Addendum 1".
2. Local flooding: 'Waterside Green Flooding and Stormwater Advice' report prepared by Worley Parsons, dated 9 January 2013 which is herein referred to as "Waterside Subdivision Local Flood Study".

Coupled with reference to the ACOR Consultants' October 2014 report addendum, the above previously approved post-development flood model of 2004, prepared and documented in the "Lakeside Village, Penrith, Hawkesbury - Nepean Flooding – Addendum [1]", was part of a regional two dimensional (2-D) Nepean River flood study conducted by Patterson Britton to assess the impacts of the then proposed subdivision development upon the breakaway flood flows emanating from Nepean River through the subject site during the 0.5% AEP (Annual Exceedance Probability), 0.2% AEP flood events.

Similar to ACOR Consultants' October 2014 report addendum the Council approved post-development flood parameters of 2004 have therefore been adopted as the base model for this report incorporating the proposed development layouts and the revised flood model has been calibrated to match the base model of the Lakeside Regional Flood Study Addendum [1] results in order to maintain continuity and consistency when addressing Council's floodplain management considerations.

This post-development flood model is based upon the previously Council approved 2014 report with appropriate revisions to incorporate the newly proposed development layouts for the three sites as fresh model input which was then run to determine the change in flood characteristics as a result of the current proposed layouts for the three subject sites.

The primary objectives of this flood study are consequently to:

i) Adopt the Council approved flood model associated with the most recent local flood report for the area titled "*Flood Study Addendum II - Waterside Corporate, Andrews Road, Cranebrook Industrial Subdivision - October 2014*", and then

ii) Based upon the October 2014 base flood model, prepare a revised flood model incorporating the current proposed development layouts for the three subject sites to assess the effects and impacts of the new proposals upon the previously approved flood parameters for the 1% AEP and 0.2% AEP flood events.

The TUFLOW model extents and Digital Elevation Model (DEM) are presented in **Figure 1**.

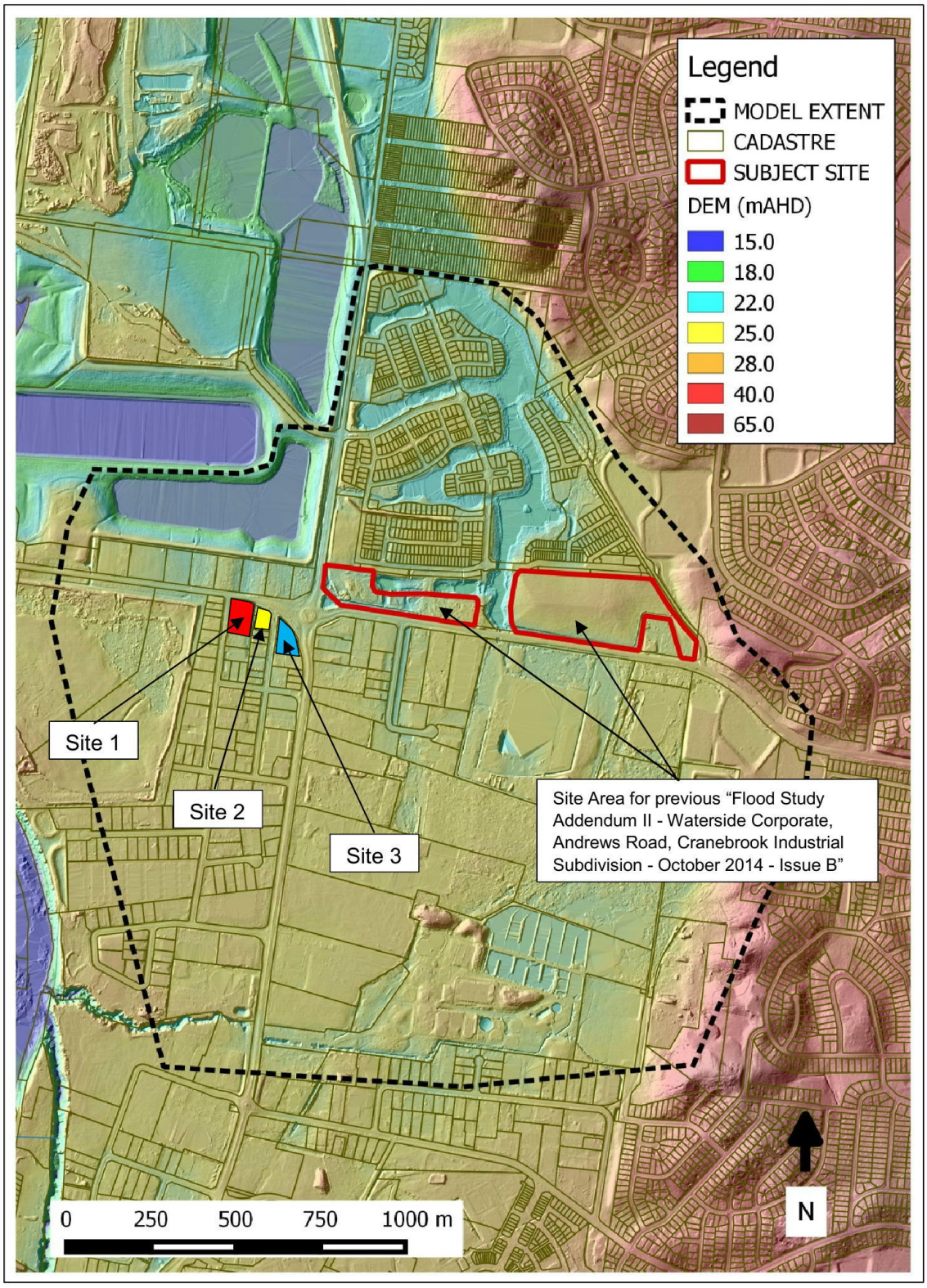


Figure 1 - TUFLOW Model Extent and DEM

2. AVAILABLE FLOOD DATA

The background data available for the flood study includes:

- *Flood Study Addendum II - Waterside Corporate, Andrews Road, Cranebrook Industrial Subdivision - October 2014 - Issue B*" prepared by ACOR Consultants
- Lakeside Regional Flood Study Addendum [1] dated 9 November 2004, prepared by Patterson Britton & Partners
- Modelling results associated with the above report for the 0.2% AEP flood events; and terrain contour at 1.0m interval for the site in 2003
- Waterside Local Flood Study dated 9 January 2013, prepared by Worsley Parsons
- LiDAR survey and cadastral information supplied by Penrith Council in September 2014
- The base TUFLOW flood model previously applied to the "Flood Study Addendum II - Waterside Corporate, Andrews Road, Cranebrook Industrial Subdivision - October 2014 [Rev. B]"

3. FLOOD MODEL BACKGROUND

As previously outlined, the most recently approved flood regime presented in ACOR Consultants' flood report addendum of October 2014 has been adopted as the base flood model for this report.

All associated regional flood model calibration and alignment with previous flood reports was achieved in the 2014 model and report.

Therefore, the following flood model parameters apply to this report.

4. TUFLOW MODEL PARAMETERS

The key inputs for the TUFLOW model of this report are, based upon the base TUFLOW flood model, as follows:

- Digital Elevation Model (DEM) of 2011 as supplied by Council
- Model surface roughness base upon observations of aerial photography
- 1D element input for culvert and channel structures in the base flood model
- 2D element input for bridge structures in the base flood model
- Boundary flood flow conditions related to the development sites cadastre

The post-development flood model DEM was generated from the available LiDAR data supplied to ACOR coupled with the proposed development building footprints of the proposals.

Under the post-developed conditions the current proposed terrain model (DEM) was simply inserted into the previously Council approved post-development flood model of 2014.

The modelled surface roughness coefficients adopting Manning's roughness coefficient 'n' was determined based upon observations and interpretation of aerial photographic images. The roughness values adopted for the model are listed in Table 1 below.

Table 1 - Flood Model Surface Roughness Values

Land-use	Manning's roughness value
Industrial lots with building footprint	0.300
Residential lots with building footprint	0.200
Creek	0.060
Pasture with tall trees	0.045
Short grass	0.035
Pasture with tall trees	0.045
Road	0.020

The inflow distribution for 1% AEP and 0.2% AEP storms as extracted directly from Lakeside Regional Flood Study Addendum was adopted as the hydraulic boundary condition.

A grid size of 3m x 3m, which is recommended for urban flood modelling, was applied to enhance the modelling output quality.

5. EXECUTIVE SUMMARY

The proposed developments fundamentally consist of the following:

Development Site Number	Proposed development description	Minimum habitable floor level proposed	Minimum car parking area level proposed
Site 1: Lot 6 in DP 1040572	2 x industrial units of 1388m^2 floor area	24.50m AHD	c. 24.3m AHD
Site 2: Lot 1 in DP745233, Lots 21 & 22 in DP979378	1 x factory unit of 1217m^2 floor area	25.2m AHD	c. 24.5m AHD
Site 3: Lot consolidation from DP127989, DP616419, & DP862630	6 x industrial units of 345-546m^2 floor area	25.00m AHD	c. 22m AHD basement parking

From the assessment of prepared TUFLOW flood modelling and local flood information, coupled with compilation and assessment of the available data, the fundamental flood design criteria which applies to the proposed development based upon the impacts related to the critical flood regime have been determined and assessed generally as follows:

Development Site Number	Critical 1% AEP (Q_{100}) flood level	Critical 0.2% AEP (Q_{500}) flood level
Site 1: Lot 6 in DP 1040572	23.9m AHD*	25.35m AHD
Site 2: Lot 1 in DP745233, Lots 21 & 22 in DP979378	23.9m AHD*	25.30m AHD
Site 3: Lot consolidation from DP127989, DP616419, & DP862630	23.9m AHD*	25.43m AHD
* Q_{100} flood level taken at the corner of Andrews Road and Lambridge Place roughly 400m east of Camden Street		

In an assessment of the flood model outcomes, it is our opinion that the designated Q_{100} flood event extent is not applicable to the existing site conditions.

In determining the flood impacts and consequent design criteria it was found that the local flood regime defined the static flood parameters (critical flood depth) and dynamic flood parameters (flow depth & velocity, debris etc.) as modelled, using TUFLOW flood software.

The proposed developments are located above the Q_{100} flood extents and therefore the proposed development will not reduce flood storage and will not increase the pre-developed flood water levels in the floodplain.

Notwithstanding the modelled outcomes of the theoretical Q_{100} designated design storm, flood precaution measures have been proposed on the basis that the three sites are located within lower frequency storm events e.g. 0.2% AEP (Q_{500}) and consequently the PMF event.

Design Habitable Floor Levels

Habitable floor levels shall be no lower than the following:

Development Site Number	Minimum allowable habitable floor level
Site 1: Lot 6 in DP 1040572	24.40m AHD i.e. 100mm below the proposed FFL
Site 2: Lot 1 in DP745233, Lots 21 & 22 in DP979378	24.40m AHD i.e. 800mm below the proposed FFL
Site 3: Lot consolidation from DP127989, DP616419, & DP862630	24.40m AHD i.e. 600mm below proposed FFL

Car Parking

The car park areas shall be no lower than the following based upon a maximum depth of inundation during the Q100 designated design storm of 150mm:

Development Site Number	Proposed minimum ground surface car park level (excluding basement parking)	Minimum allowable car park level
Site 1: Lot 6 in DP 1040572	24.29m AHD	24.05m AHD i.e. 240mm below the proposed minimum FFL
Site 2: Lot 1 in DP745233, Lots 21 & 22 in DP979378	24.05m AHD	24.05m AHD i.e. equal to proposed minimum FFL
Site 3: Lot consolidation from DP127989, DP616419, & DP862630	24.50m AHD	24.05m AHD i.e. 450mm below proposed FFL

Further to the above, and as an additional precautionary measure it is recommended that all basement car parking access drives be provided with a minimum 300mm high crest levee above the nearest street frontage boundary line levels in order to maximise protection from inundation of the basement during the Q100 designated design storm.

Safety & Evacuation

Considering the negligible influence of the Q100 designated design flood level upon each of the three sites it is our opinion that a formal Flood Emergency Response Plan (FERP) is not considered warranted, subject to council requirements.

Nevertheless, we recommend that a site plan of action be prepared and implemented to provide flood response actions associated with maintaining safety at the site particularly with regard to the risk to basement parking in flood exceeding the designated Q100 design flood.

Building Components

As a precautionary measure, we recommend that while each of the three sites buildings are located above the Q100 flood level all structural elements should be of flood compatible materials up to the following nominal levels based upon the 0.2%AEP flood levels:

Development Site Number	Nearest 1% AEP (Q_{100}) flood level	Nearest 0.2% AEP (Q_{500}) flood level
Site 1: Lot 6 in DP 1040572	23.9m AHD*	25.35m AHD
Site 2: Lot 1 in DP745233, Lots 21 & 22 in DP979378	23.9m AHD*	25.30m AHD
Site 3: Lot consolidation from DP127989, DP616419, & DP862630	23.9m AHD*	25.43m AHD

Structural Soundness

This aspect of the development is not required with regard to the Q100 designated design flood, however this can be readily accommodated within the structural configuration by adopting a traditional reinforced concrete slab configuration with steel superstructure which can be designed to withstand nominal static and dynamic flow and buoyancy stresses in anticipation of floods exceeding the Q100 event.

Flood Impacts

The flood impacts of the development need to be controlled to ensure that the development will not increase flood effects elsewhere having regard to:

- Loss of floodplain storage volume

  In our opinion the flood modelling indicates that three will be no loss of floodplain storage, therefore, the Q_{100} storages for the design flood regime remains effectively unchanged from pre-development or existing site conditions

- Changes in existing flood levels and velocities

  Similarly, the flood velocities and flood levels for the design flood regime remains effectively unchanged from the pre-development characteristics due to the minor nature of impacts upon the existing flood flow regime presented by the proposed development.

Management & Design

The storage of materials and goods above the Q100 flood level is readily achievable.

6. BACKGROUND & AVAILABLE FLOOD DATA

The flood modelling prepared by ACOR Consultants under the previous "*Flood Study Addendum II - Waterside Corporate, Andrews Road, Cranebrook Industrial Subdivision - October 2014 - Issue B*" formed the basis for flood modelling of the three subject sites and was adopted as the current pre-development flood regime model for the purposes of this report.

The flood level contours produced indicate that there is flood flow affecting the local environs within the catchment of the three sites but not the actual properties, however under the development control policies of Penrith City Council coupled with the flood sensitivity of the general area, a site specific TUFLOW flood model was prepared for the three sites.

The Q100 designated design flood within the site was modelled demonstrating the flood regime associated with the full and concurrent development of the three separate sites and the results used to make an assessment of the risk presented by the proposed developments.

7. TUFLOW Modelling

7.1. General Methodology

The pre-development TUFLOW model adopted for this report, being the "*Flood Study Addendum II - Waterside Corporate, Andrews Road, Cranebrook Industrial Subdivision - October 2014 - Issue B*" contained the extent of flood modelling as shown in the figure below indication the location of the three subject development sites:

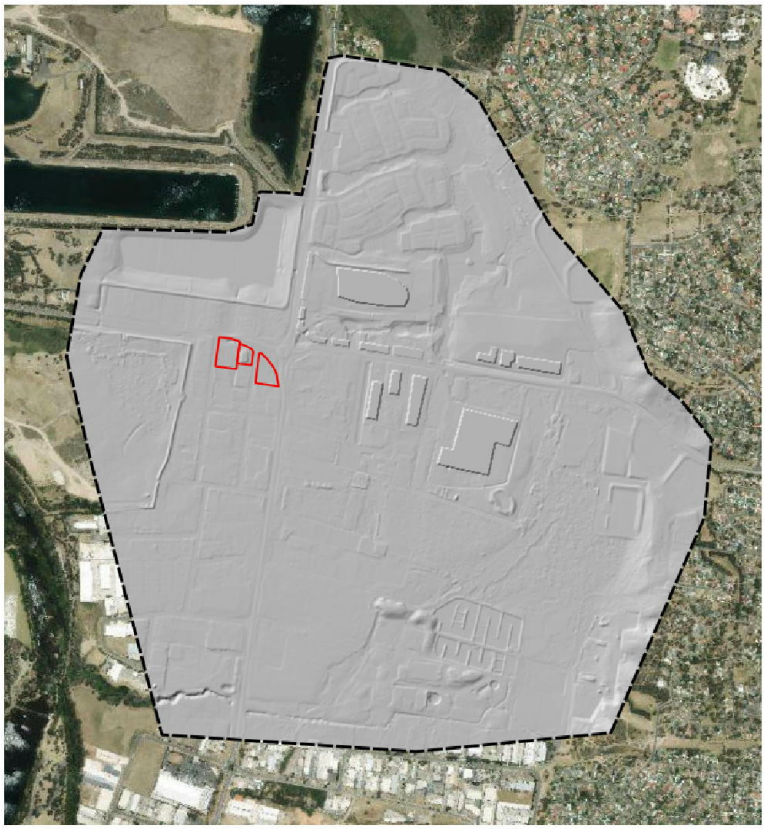


Figure 2: Flood Modelling Extent and Digital Elevation Model

The subsequent post-development flood model was then run by inserting the proposed development boundary conditions and hydraulic controls.

The TUFLOW flood modelling outputs for the pre-development and post-development scenarios were then compared to evaluate the impacts of the post development Q100 flood characteristics. The outputs including:

i) Flood levels,

ii) Flood depths,

iii) Flood velocities, and

iv) Flood hazards

7.2. Local Flood Model Input Data

For the purpose of this report, data required for input into the hydrological and hydraulic models has been obtained from various sources including:

- Survey information/ Digital Elevation Model (DEM) - the overland flow assessment is based on LIDAR survey provided by land and property information department (LPI)
- Design rainfall - design rainfall depths and temporal patterns for the 1% AEP (Q100) events were developed using guidelines outlined in AR&R (2016)
- Observations of existing site flood flow hydraulic boundaries and/or obstructions under normal expected conditions as inspected historically on NEARMAP and GOOGLE MAP, and as further confirmed from observations at site inspection of March 28, 2017
- Model surface roughness based upon observations of aerial photography

7.3. Hydrological Modelling

In order to determine the peak Q100 flow rate, a direct rainfall method was applied to the site specific catchment TUFLOW model.

It is in our opinion that this approach to rainfall modelling is advantageous for defining overland flow paths, since surface runoff over a plain is not conveyed along predetermined paths (one dimensional), but is routed based on calculations for each grid cell (two dimensional).

A further site specific model was created by applying the predetermined Q100 flow rate hydrograph at a location upstream of the proposed development and the cell sized reduced to achieve a more intricate and representative model.

7.4. Hydraulic Modelling

The modelled area, as shown in the figure above, extends over the subject site and into the adjoining upstream and downstream catchment areas. A two-dimensional hydraulic model was developed using TUFLOW software to assess the flooding behaviour associated with the existing flood regime and the proposed development.

Flood Model Outline

TUFLOW is computational flood modelling software that provides one- dimensional (1d) and two-dimensional (2d) solutions of the free-surface flow equations to simulate flood and, where necessary, tidal wave propagation. The TUFLOW hydraulic model simulates the movement of floodwaters through the topographical waterway reaches, and incorporating the effects of storage depressions, hydraulic controls including adoption of composite surface roughness coefficients (i.e. Manning's 'n').

The model calculates theoretical flood levels and flow patterns and models the complex effects of afflux, backwater, surface roughness, overtopping of embankments, waterway confluences, building obstructions and flow constrictions, and other hydraulic controls across the study catchment area.

Model Catchment Terrain and Surface Definition

The study area is presented in the existing LIDAR as a Digital Elevation Model (DEM) and includes the manually inserted input for the micro-flood effects of the existing buildings near and upon the subject site and other permanent obstructions. This included the 'block out' of the existing and proposed building footprint.

The catchment surface roughness parameters adopted for the hydraulic model are based on site observations, aerial photomaps. The Table below presents the catchment surface composite roughness values adopted in the TUFLOW hydraulic modelling prepared by ACOR Consultants Pty Ltd.

Table 2 Catchment Surface Composite Roughness Coefficients

Surface Description	Manning's 'n'
Road	0.02
Commercial/Urban Lot	0.035
Open/Recreation Park	0.06
Residential/Urban Lot	0.035

7.5. TUFLOW Modelling Outputs

Design flood estimation for the worst-case design storm event was input into the TUFLOW model in order to determine the predicted flooding behaviour for the Q100 proposed developments designated design storm event.

The theoretical local flood regime characteristics for the Q100 designated design storm determined with the local flood TUFLOW are illustrated on the following model outputs:

Pre-Development Scenario (Refer Appendix A)

- Pre-development 1% AEP (Q100) flood depth and contour plan
- Pre-development 1% AEP (Q100) flood velocity plan
- Pre-development 1% AEP (Q100) flood hazard plan
- Pre-Development 0.2% AEP flood level and flood hazard plan

Post-Development Scenario (Refer Appendix B)

- Post development 1% AEP (Q100) flood depth and contour plan
- Post development 1% AEP (Q100) flood velocity plan
- Post development 1% AEP (Q100) flood hazard plan

Hydraulic Hazard

The degree of flood hazard during the Q100 event, attributed to the proposed development is considered in terms of the outcomes of the hydraulic modelling in association with the following considerations:

- size of flood (depth of flood waters)
- hazard of flood (i.e. depths and velocity x depth factors)
- effective warning time
- evacuation route/s
- flood awareness (localise Vs regional)
- rate of rise of floodwater
- duration of flooding
- evacuation constraints
- effective emergency services flood access
- type of development (i.e. to flood sensitivity e.g. aged care facility Vs industrial/commercial)

Flood hazard categories are generally defined as being either High, Medium or Low hazard as presented in the guidelines outlined in the NSW Floodplain Development Manual (2005) and as defined in Section 6 of this report.

The hazard categories for Q100 flood waters affecting the site are mapped on the following plans:

- Pre-Development 1% AEP (Q100) flood hazard plan – Appendix A
- Post-Development 1% AEP (Q100) flood hazard plan – Appendix B

8. Flood Impacts

The comparative flood characteristics for the 1% AEP (Q100) Pre-Development Vs Post-Development scenarios of the flood model in terms of the differences in flood levels around the proposed development sites has been assessed.

From this comparison, it is evident that the impacts upon the existing flood regime induced by the proposed development are as follows for each of the three sites.

In our opinion, the impacts of the proposed development are as follows;

- The proposed development does not reduce the flood storage volume on the basis that the site is not within the Q100 (1% AEP) flood storage area
- The proposed development does not affect the existing catchment flood hazard
- The proposed development presents no detrimental impacts upon the existing flood regime

9. Definitions

Q100

The 1% annual exceedance probability event being that storm event with a 1% probability of occurring in any year.

1% AEP

The 1% annual exceedance probability event being that storm event with a 1% probability of occurring in any year.

0.2% AEP

The 0.2% annual exceedance probability event being that storm event with a 0.2% probability of occurring in any year, and otherwise equates to a Q500 event.

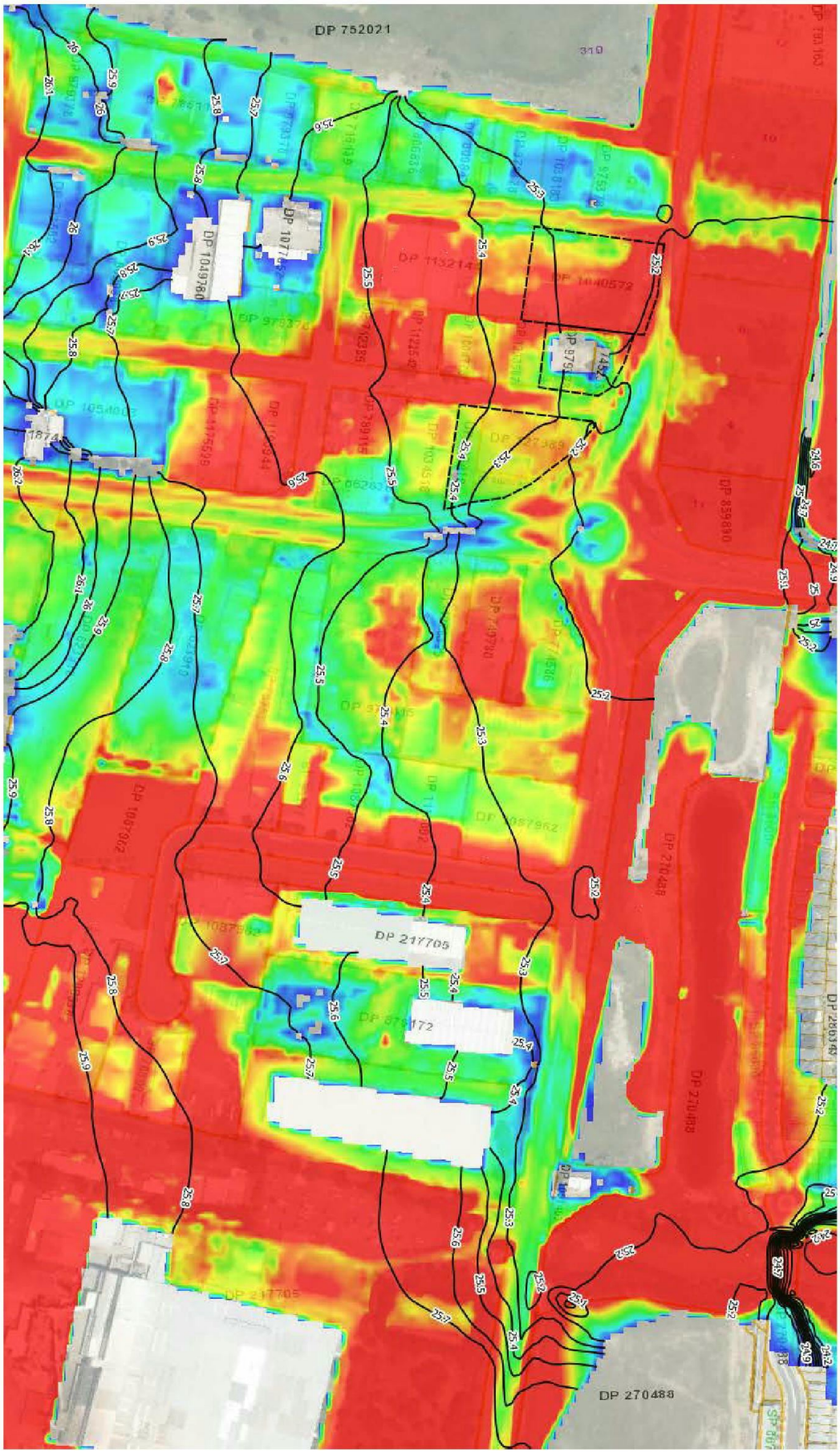
Q500

The 0.2% annual exceedance probability event being that storm event with a 0.2% probability of occurring in any year.

APPENDIX A

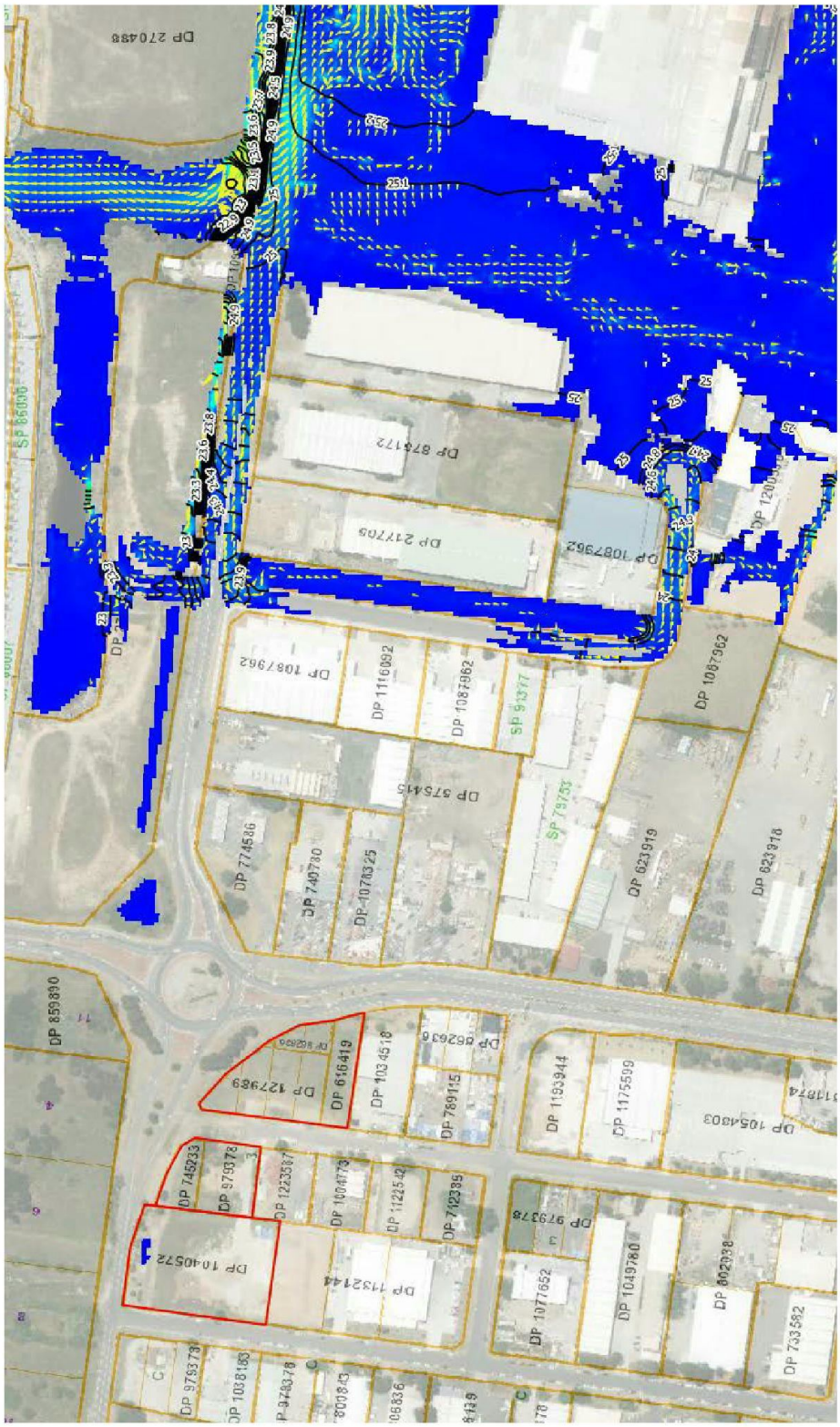
Pre-Development Flood Maps

0.2% AEP Flood Hazard Depth (m) and Flood Level Contour Plan (Pre-Development)

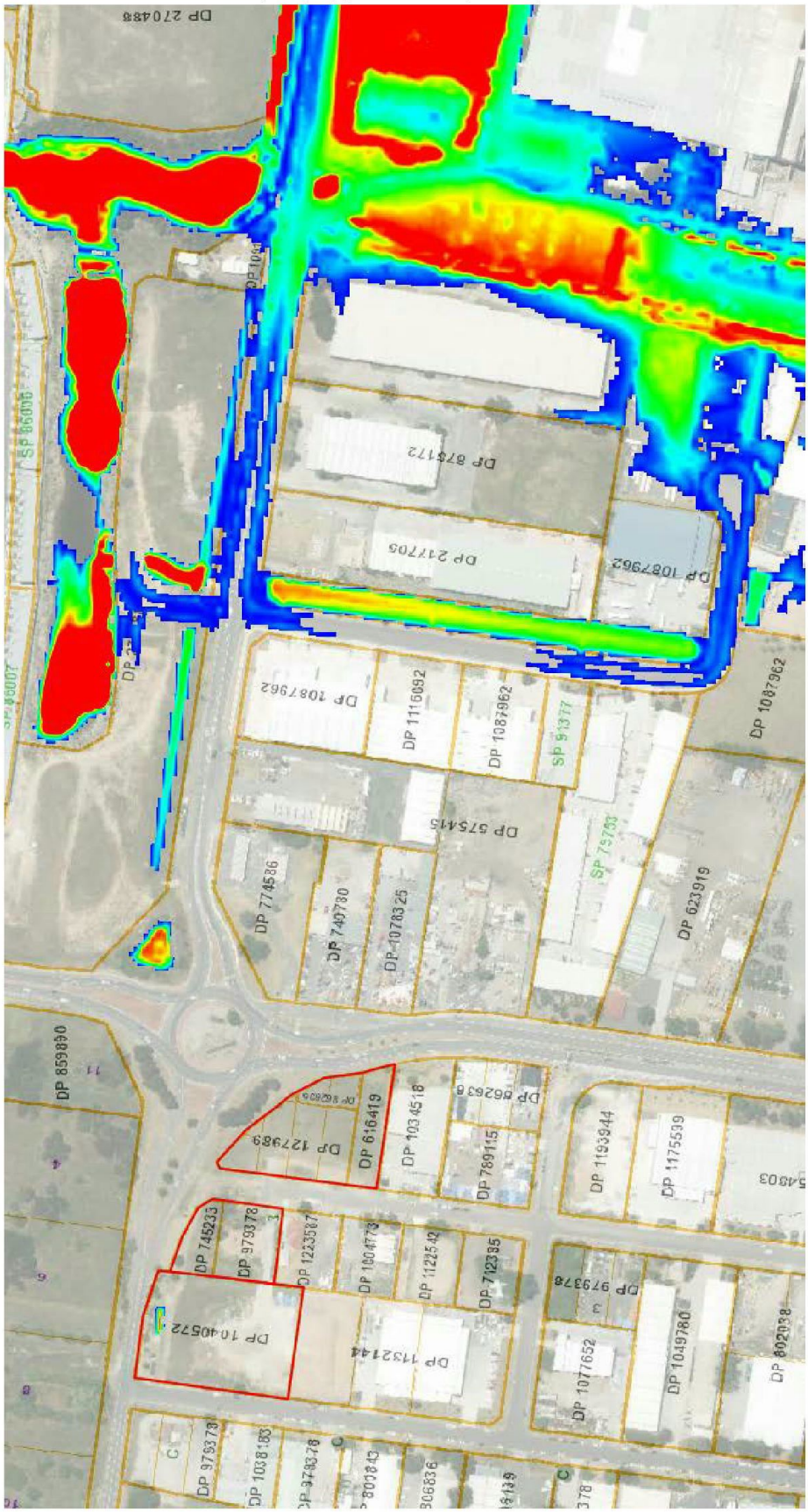


WS170030 – Flood Model Maps

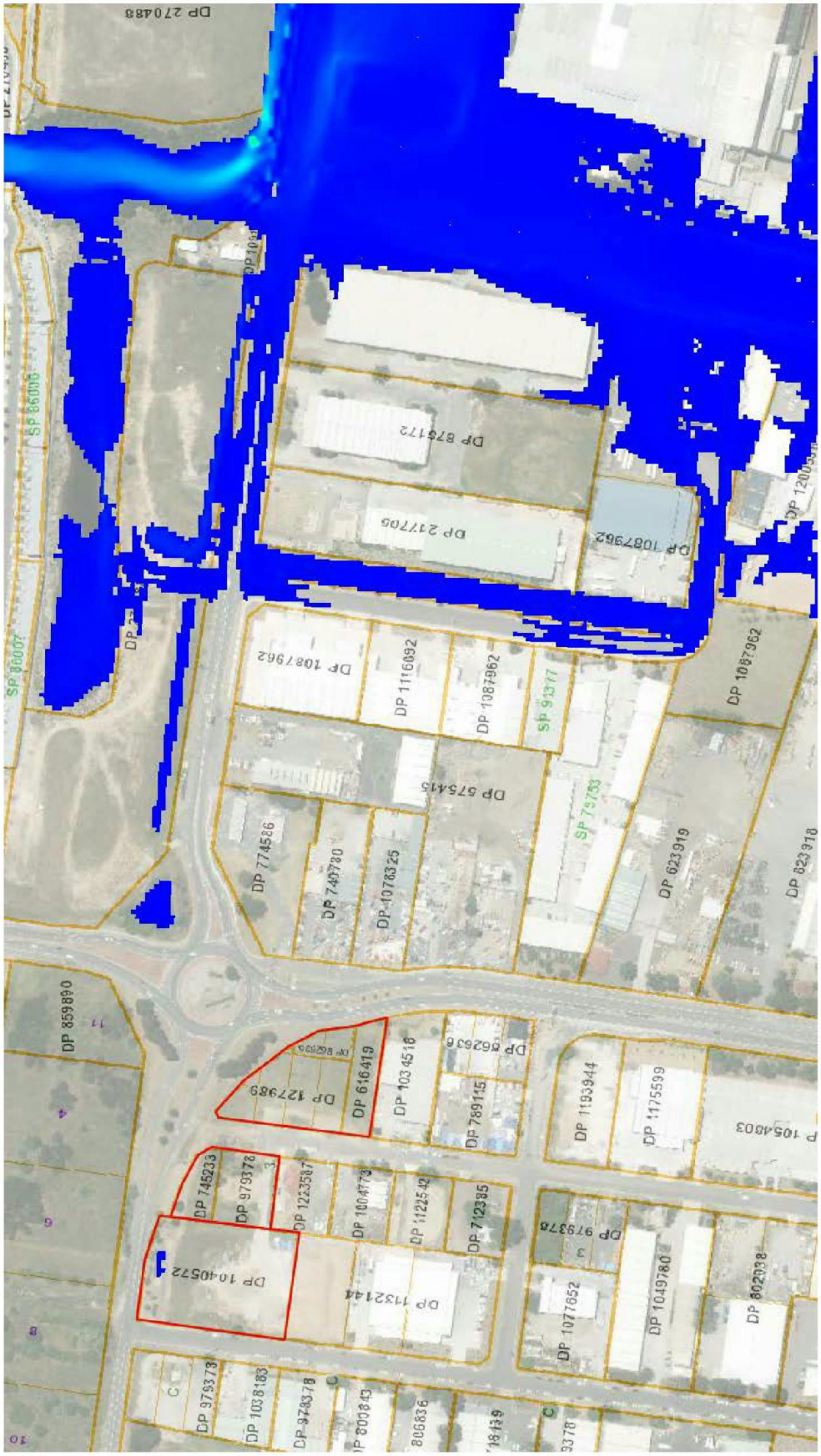
1% AEP Flood Flow Extents and Flood Contour Plan (Pre-Development)



1% AEP Flood Hazard Depth (m) (Pre-Development)



1% AEP Flood Hazard VxD (m^2/s) (PRE-Development)

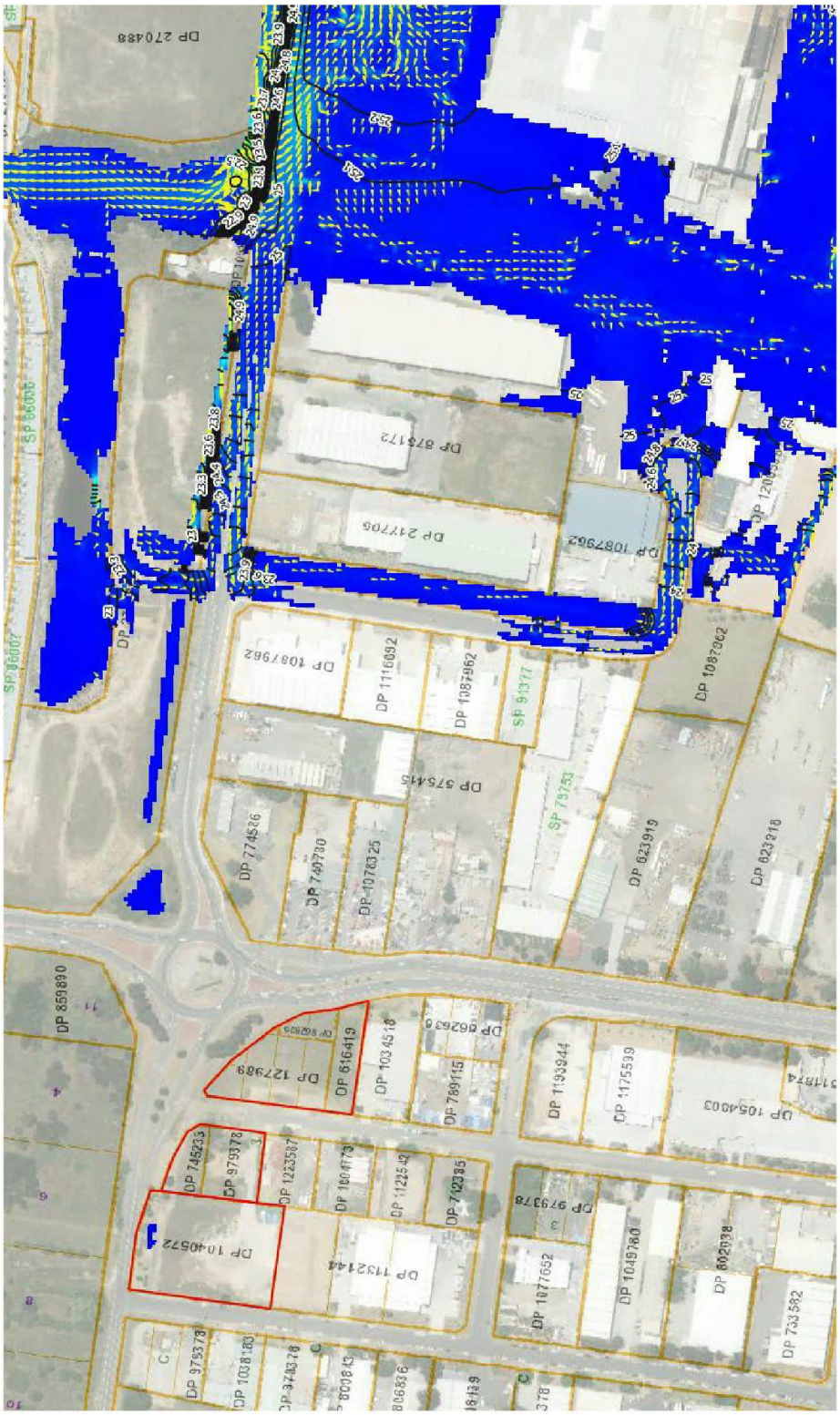


APPENDIX B

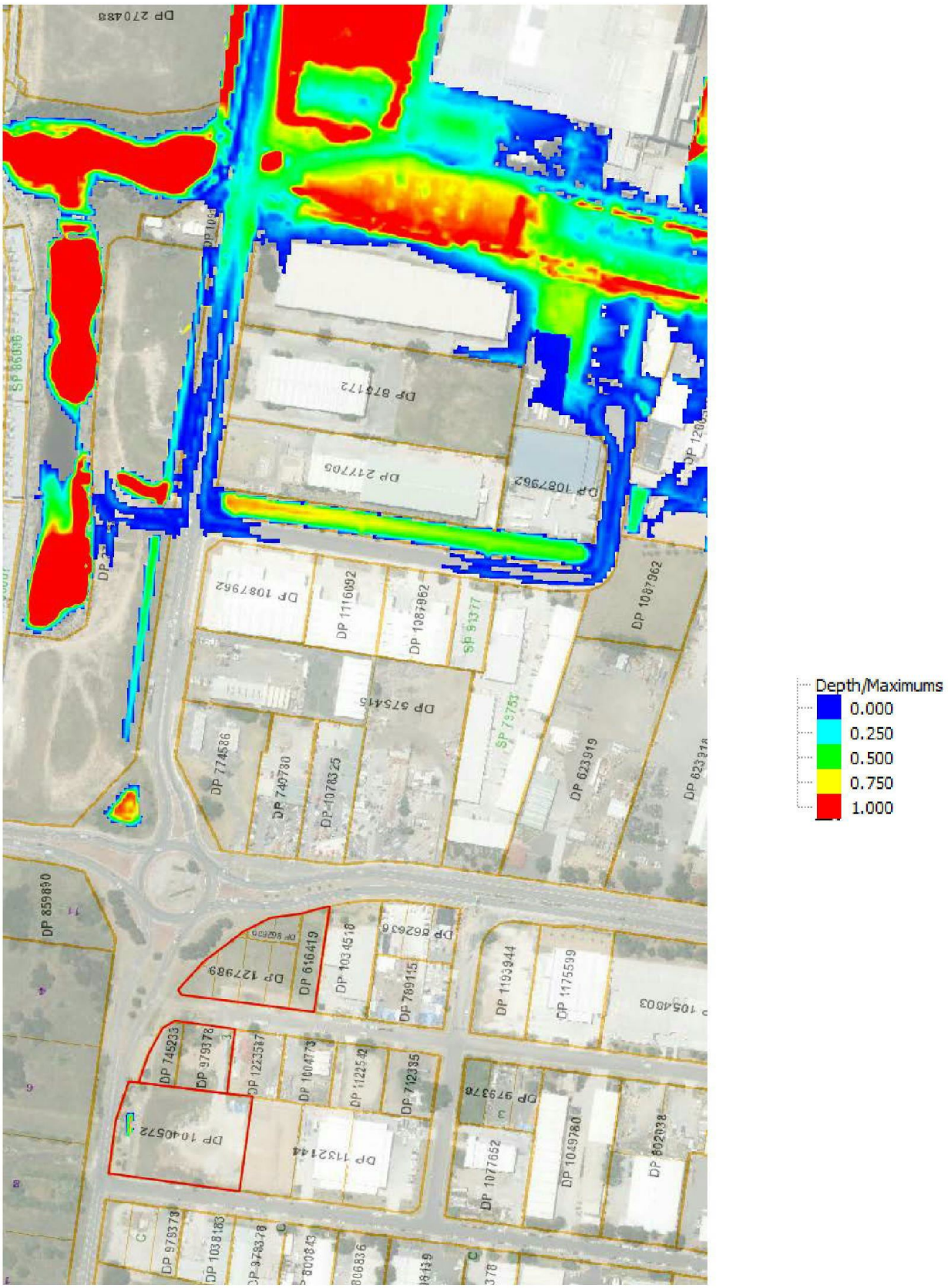
Post-Development Flood Maps

WS170030 – Flood Model Maps

1% AEP Flood Flow Extents and Flood Contour Plan (POST-Development)



1% AEP Flood Hazard Depth (m) (POST-Development)



1% AEP Flood Hazard VxD (m^2/s) (POST-Development)