on-ground survey information was completed in and around the study area to properly define the existing overland flow path cross section and features.

The proposed development levels were then added to the pre-developed survey surface to create a post developed surface to use in the TUFLOW model and scenario modelling. This DTM was inputted into the TUFLOW model to simulate land filling and proposed compensation areas in and around the flood affected land.

The surveys and design surfaces were used as the basis for the digital terrain model (DTM) used in the hydraulic modelling of the pre and post development scenario respectively.

F.1.3 Previous Studies

A previous study of Reference to the *Nepean River Flood Study, Exhibition Draft Report* (16 August 2017) completed for Penrith City Council by Advisian (formerly Worley Parsons). As noted above, we understand the study will be adopted by Council toward the end of 2018 following minor technical updates to the hydraulic output. Consultation was made with Councils flooding engineer Mr Myl Senthilvasan (refer Appendix G) regarding the localised assessment relating to this project. We understand the minor changes to the council study to not affect the hydraulic output in and around the development site and that the draft flood study should be used to validate the localised assessment required for this development. As such downstream boundary levels, flows and flood levels from the Nepean River study were utilised to calibrate and validate the model completed by Costin Roe Consulting.

It is also noted that a previous development application upon the site by Iplex Pipelines approved under DA13/1174 included a flood study for the site prepared by Worley Parsons (reference 301015-02973-IPLEX FIA, dated 18 September 2014). The 2017 Nepean River study, completed by the same consultants, precedes the 2014 study and although the 2014 study provides good background information has not been utilised in our assessment.

The 2017 *Nepean River Flood Study* was utilised to validate hydrological and flood surface results produced in our assessment for the pre-developed condition. It can be seen when comparing the flood depth results of the Costin Roe Consulting model with the output from the 2017 Flood Study that the results are generally consistent and that the Costin Roe Consulting model is suitable for use in modelling post development scenarios.

F.2 CATCHMENT INVESTIGATION & HYDROLOGY

F.2.1 Contributing Catchment Definition

The Nepean River is located approximately 800 metres west of the proposed site. The river flows south to north through Penrith until it reaches the Penrith Lakes Scheme and International Regatta Centre, at which point it veers sharply west. This change in direction of the river is located directly west of the development site.

Due to the location of the site in close proximity to the Nepean River there is potential during large floods for floodwaters to overtop the banks of the river and inundate the adjoining floodplain and parts of the site. Detailed two-dimensional modelling completed as part of the *Nepean River Flood Study* indicated that extensive flooding will occur across areas east of Castlereagh Road where the site is located.

The contributing catchment associated with the site flooding is associated with the overtopping with the Nepean River banks and has been extrapolated from the Table 7 of the *Nepean River Flood Study* as a percentage of the total flow within the Nepean River floodwaters.

F.2.2 Hydrological Assessment of Existing Catchment

Flood hydrographs for the different flood events were required to be confirmed. Utilising the flood hydrograph defined in *The Nepean River Flood Study* in Table 7, a percentage of the total flow is shown overtopping the river banks at Castlereagh Road. This percentage was applied to the overall Nepean River flood hydrograph to model flows affecting the proposed site. Inflow hydrographs were extrapolated for the 1% AEP and 0.5% AEP events as shown in **Figure F1** and **Figure F2**. Local rainfall was not considered in this assessment and the inflow hydrograph only allows for flooding from the Nepean River.

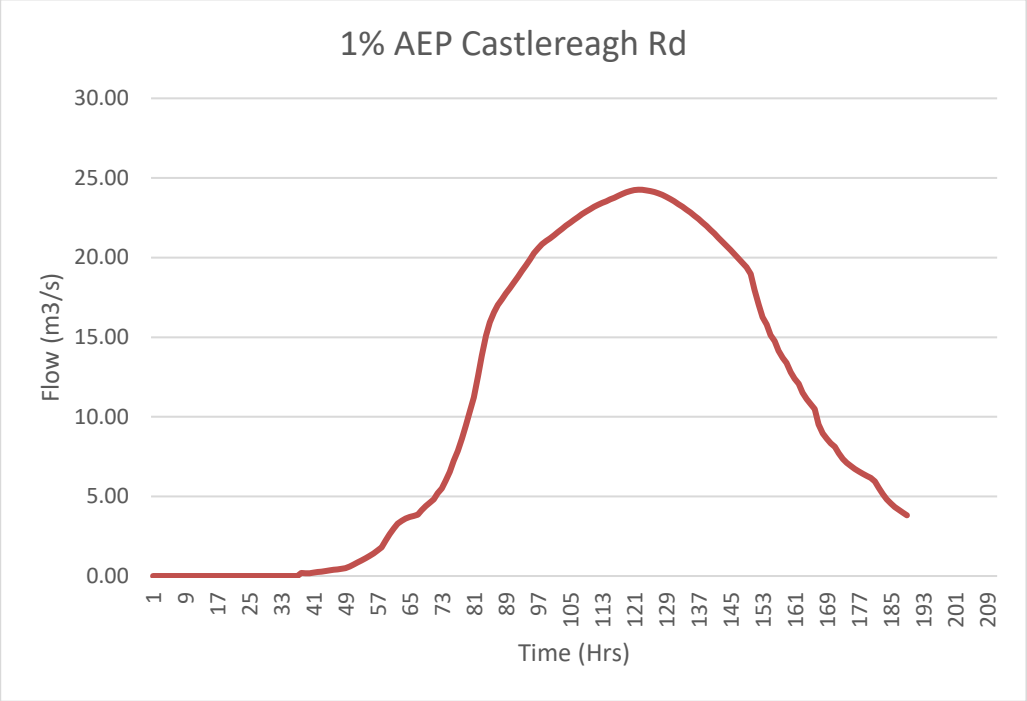

Figure F1 1% AEP Inflow Hydrograph

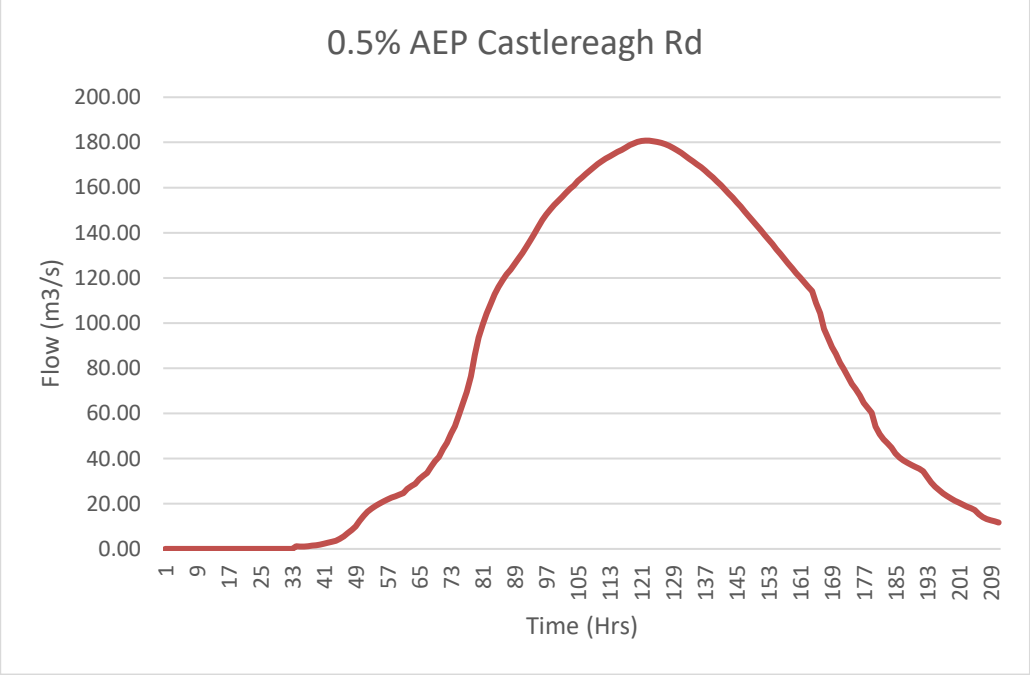

Figure F2 0.5% AEP Inflow Hydrograph

F.3 HYDRODYNAMIC MODEL DEVELOPMENT

F 3.1 Extent and Topography

The model extent is shown in **Figure F.9** of this appendix. The model begins approximately 920m upstream of the development and extending approximately 520m to the north.

F.3.2 Boundary Conditions

Inflow Boundaries

Design inflow hydrographs for the model have been included at a location approximately 920m upstream of the development site with the flows based on hydrology as discussed in **Section F.2** of this Appendix.

The upstream boundary was located sufficiently upstream of the development to ensure the extent of predicted impacts from the development would be covered and any modelling iterations would be resolved clear of the development affectation zone.

Downstream Water Level Boundaries

Downstream boundary location has been included at a distance of approximately 520m downstream of the study area. The downstream water levels have been based on flood levels included in the *Nepean River Flood Study* as follows:

AEP	Boundary Level (m)
1%	24.0
0.5%	25.0

Table F2. Downstream Boundary Water Levels.

Refer **Figure F.3** on following page.

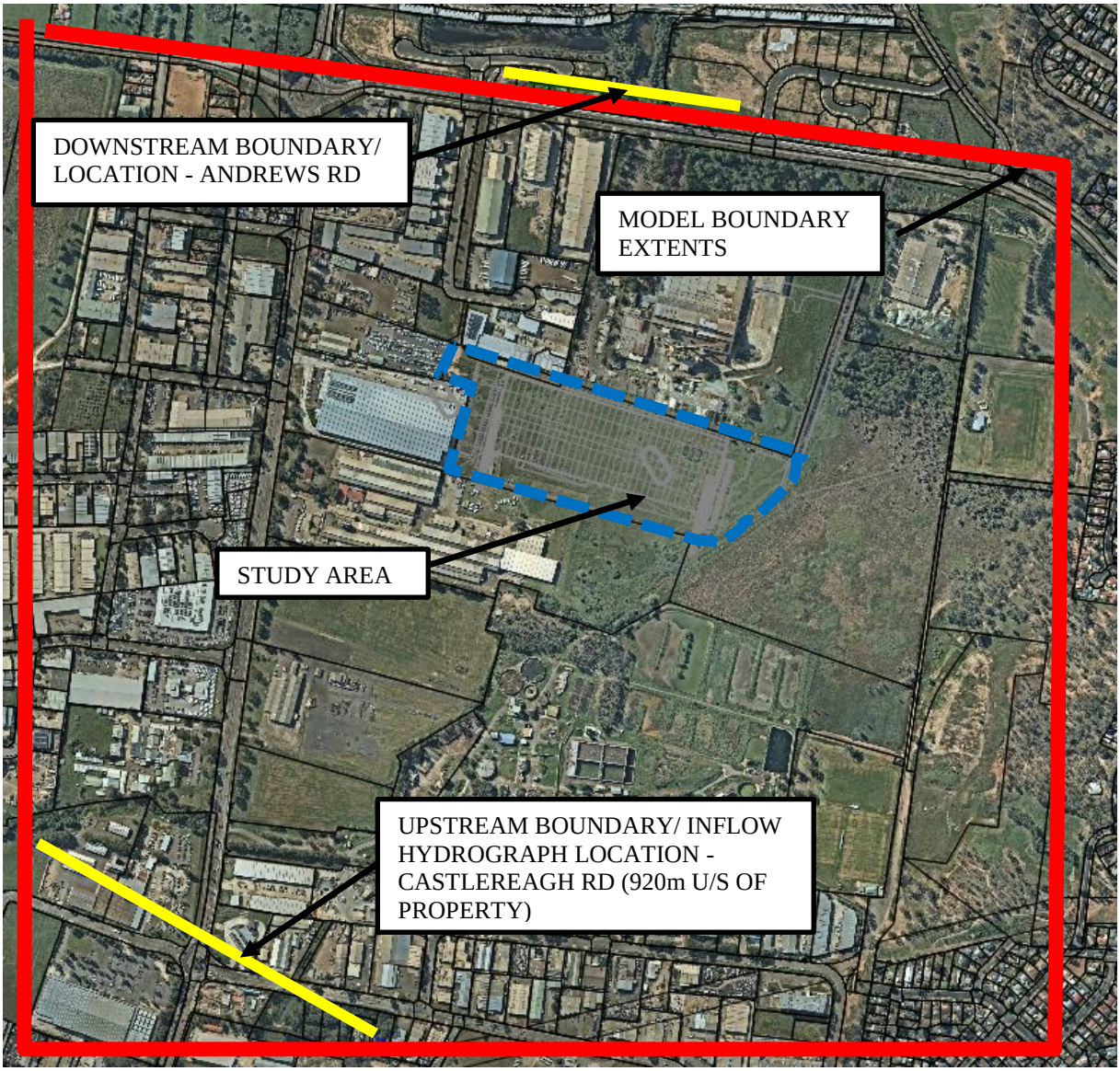

Figure F3. Model Extent and Model Boundary Locations

F.3.3 Channel and Floodplain Roughness

Roughness values adopted in the model are contained in **Table F3** below. These are generally consistent with those included in the *Table 2* of the *Nepean River Flood Study*, except where adjusted to ensure validation of model results and achieving consistency with the results of the *Nepean River Flood Study*.

Table F3. Adopted TUFLOW Element Roughness Values

Model Element	Description	Roughness Parameter Value (Nepean River Flood Study	Roughness Parameter Value (TUFLOW Study)
1	Grassland	0.04	**0.04**
2	Bushland	0.05	**0.05**
3	Roads	0.03	**0.03**
4	Buildings	Block Out	**10.0**
5	Industrial Area	0.07	**0.07**

A figurative representation of where the above roughness values have been applied can be found in **Figure F4.**

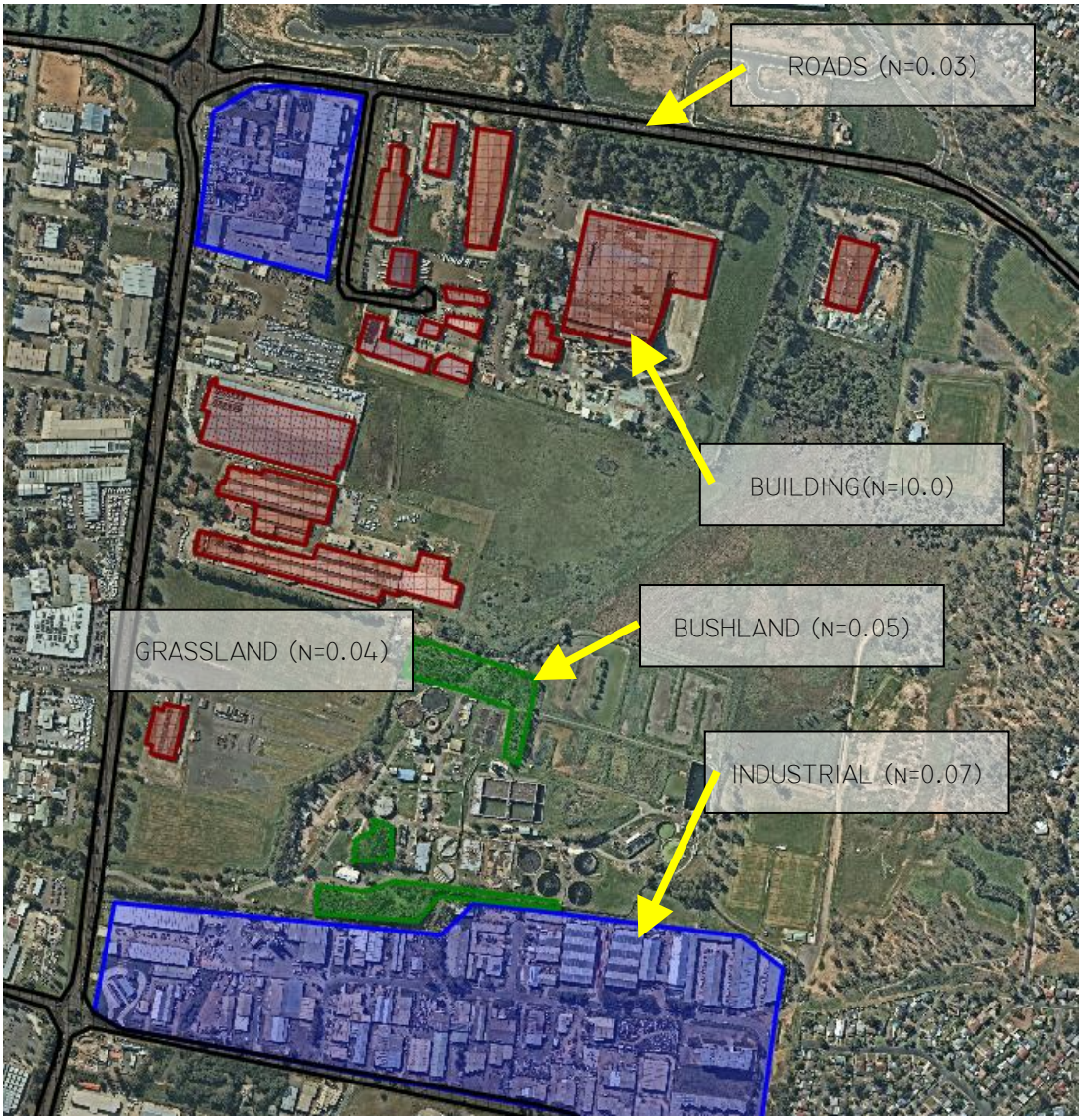

Figure F4 Manning's Roughness Surface Areas

F.3.4 Model Validation

Model validation has been completed by comparing results of the TUFLOW modelling against the results contained in the *Nepean River Flood Study* and adjusting as required to achieve good agreement between the two models. The process for the validation was as follows:

- Establish hydrology, peak flows and hydrograph for modelled events;
- Establish TUFLOW Model using defined parameters;
- Compare results of TUFLOW modelling with South Creek Study including flood depths, flood levels (taking into account the use of consistent DTM's), flood extents and hydraulics. The comparison is made at the peak of the predicted parameters;

- Adjust roughness factors to align TUFLOW flood depths and to within 100mm of *Nepean River Study* Results.

Hydrology and peak flows were established as described in **Section F2** of this report. The hydrological information used in the TUFLOW model is consistent with those of the Nepean River Study.

A number of trial models and iterations of the TUFLOW model were performed. Adjustment of roughness parameters were used to align the flood levels with those compiled in the Nepean River Study.

The comparison of the flood level results shows good alignment of those produced in the TUFLOW model when compared with those of the Nepean River Study. Flood water levels were seen to have a difference less than 100mm and generally in the order of 30-70mm through the floodplain areas. The predicted flood extent is consistent between the two models for the different flood events modelled.

Given the differences in modelling techniques, parameters, predicted model accuracy (+/-200mm) and model components these differences are considered acceptable for the base model and for continuation of post-developed scenario modelling.

F.4 MODEL OUTPUT

Model output for pre and post development conditions for the Nepean River flooding events as discussed in earlier sections have been included in the following Figures.

We note figures represent predicted values at the peak of each event.

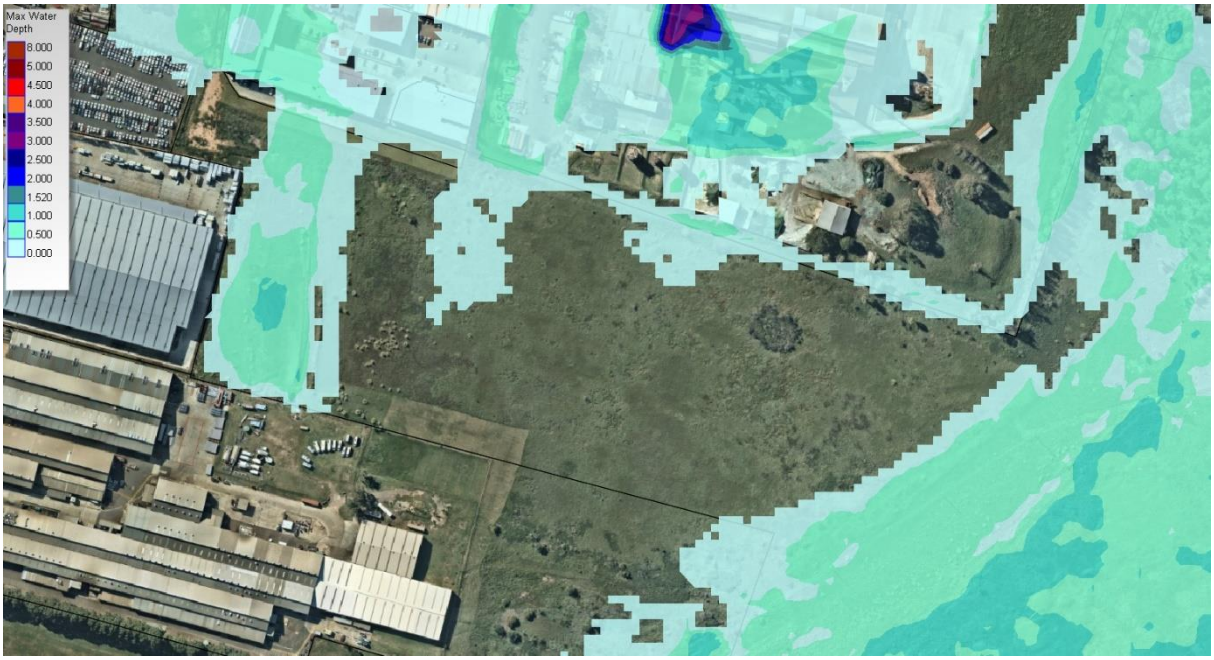

Figure F5 – 1% AEP Flood Depths – Pre-Development

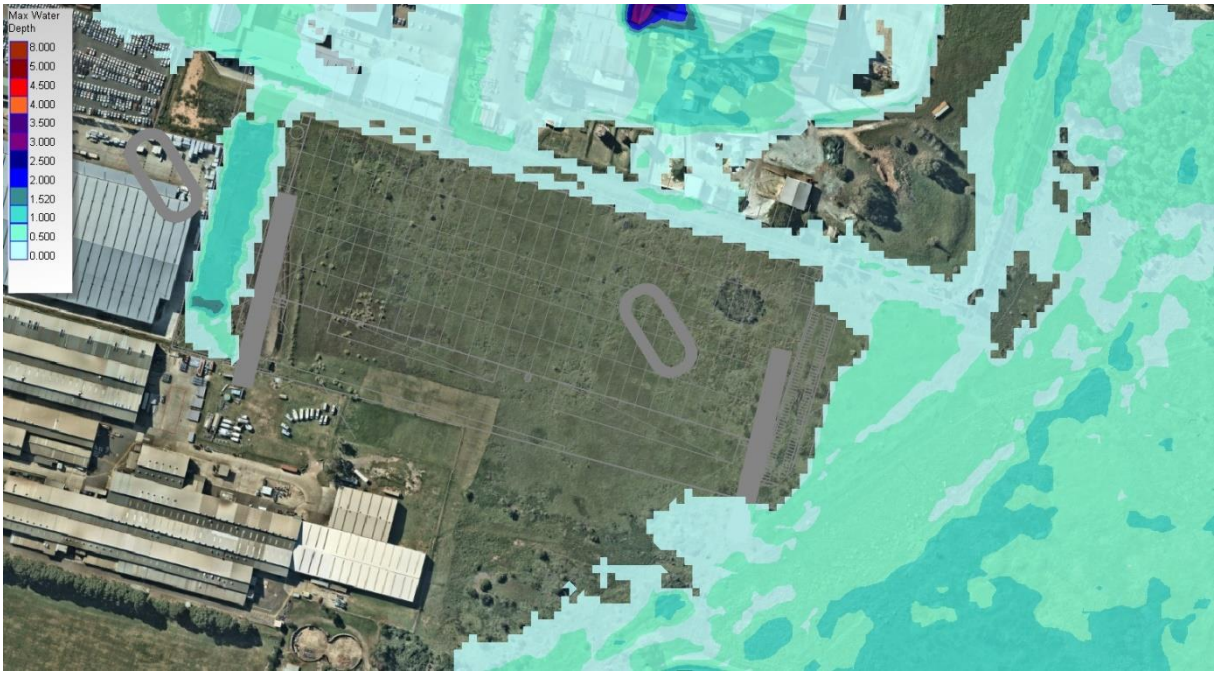

Figure F6 – 1% AEP Flood Depths – Post Development

Figure F7 – 1% AEP Flood Levels – Pre-Development

Figure F8 – 1% AEP Flood Levels – Post Development

Figure F9 – 1% AEP Flood Velocity – Pre-Development

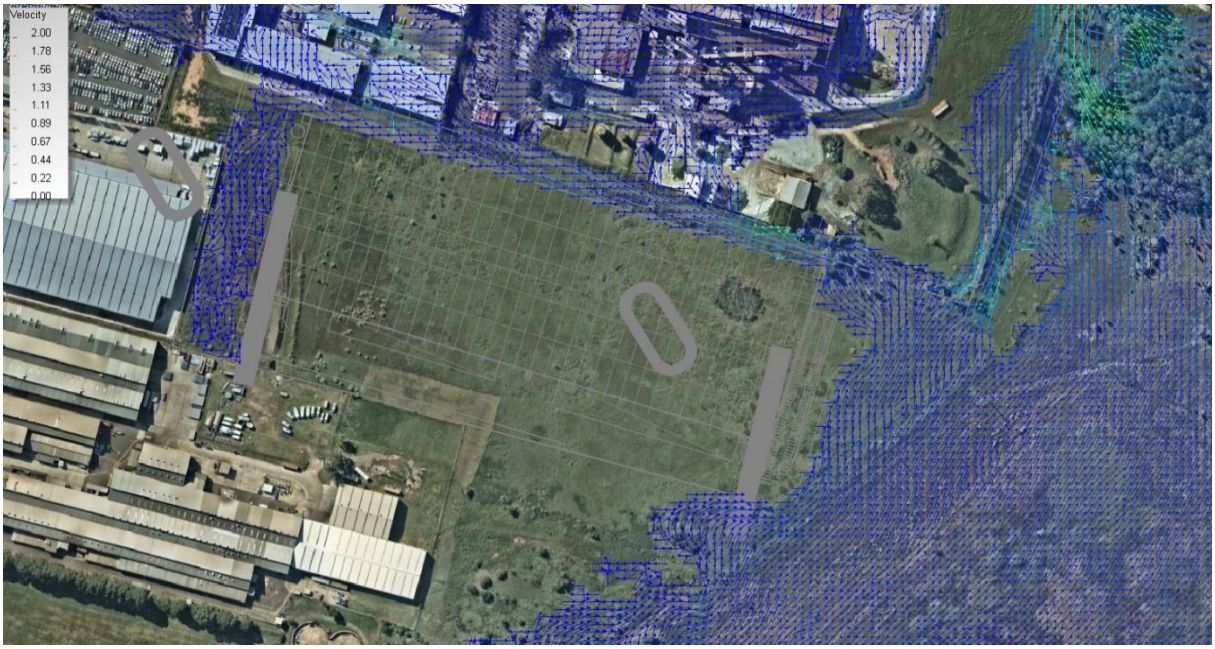

Figure F10 – 1% AEP Flood Velocity – Post Development

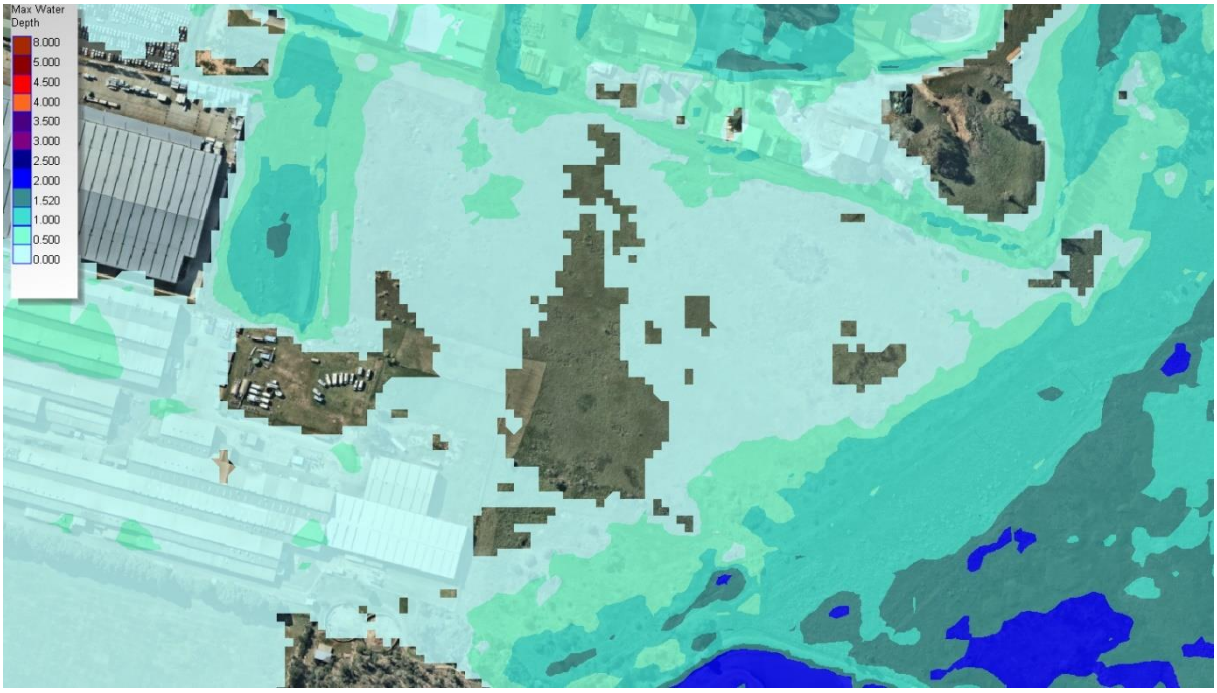

Figure F11 – 0.5% AEP Flood Depth – Pre-Development

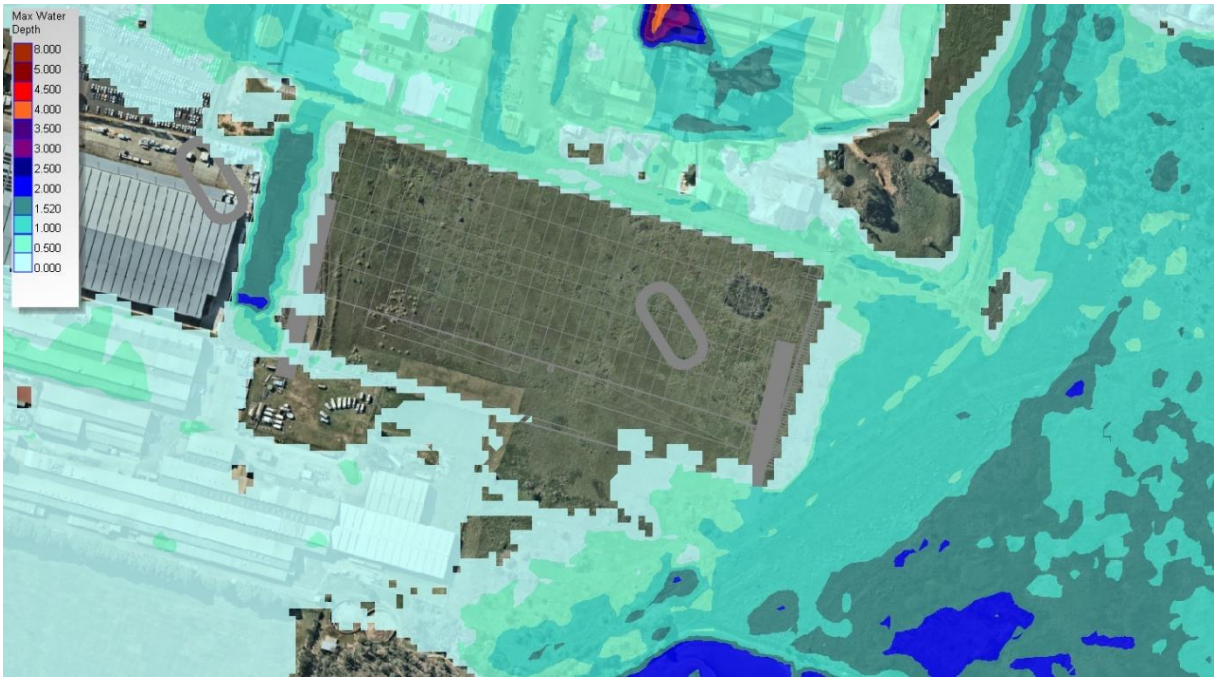

Figure F12 – 0.5% AEP Flood Depth – Post Development

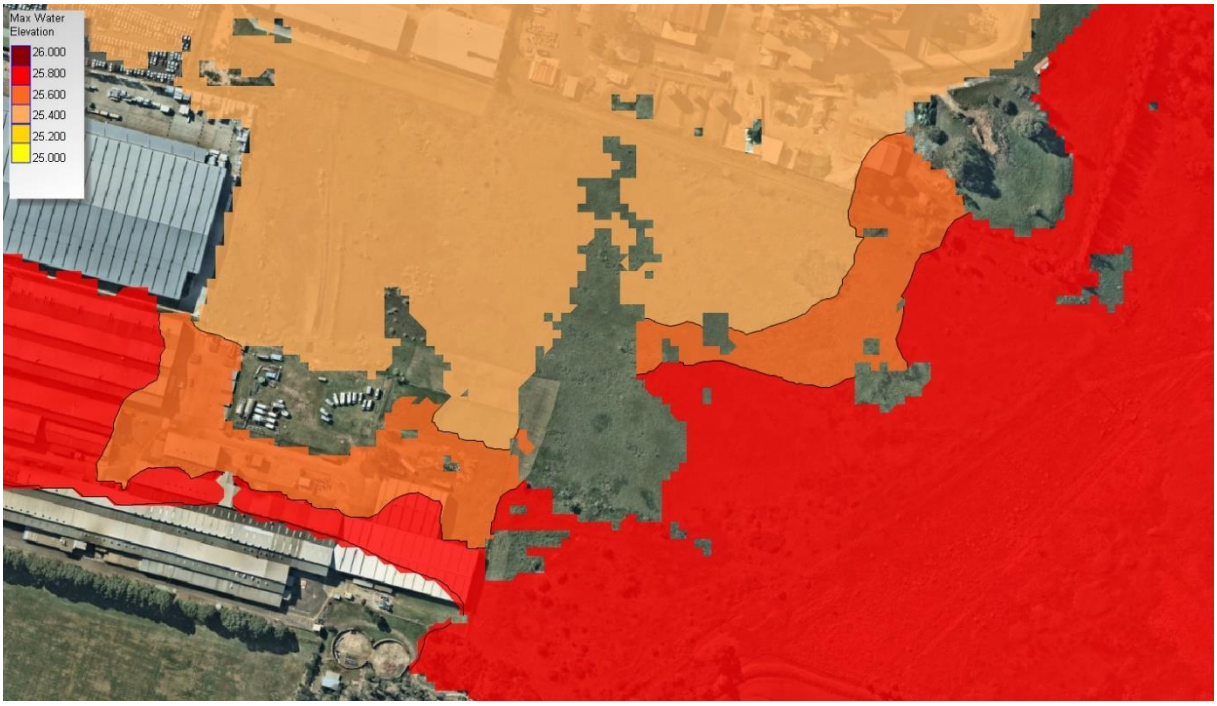

Figure F13– 0.5% AEP Flood Level – Pre-Development

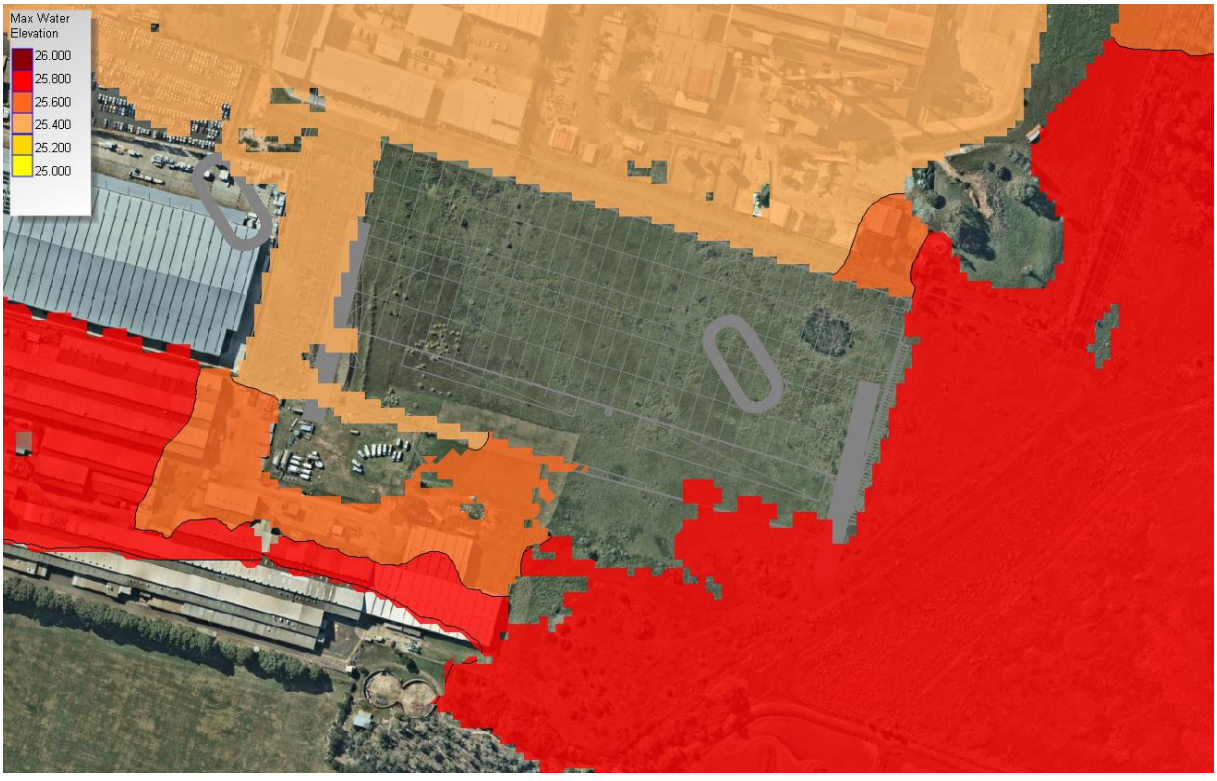

Figure F14 – 0.5% AEP Flood Level – Post Development

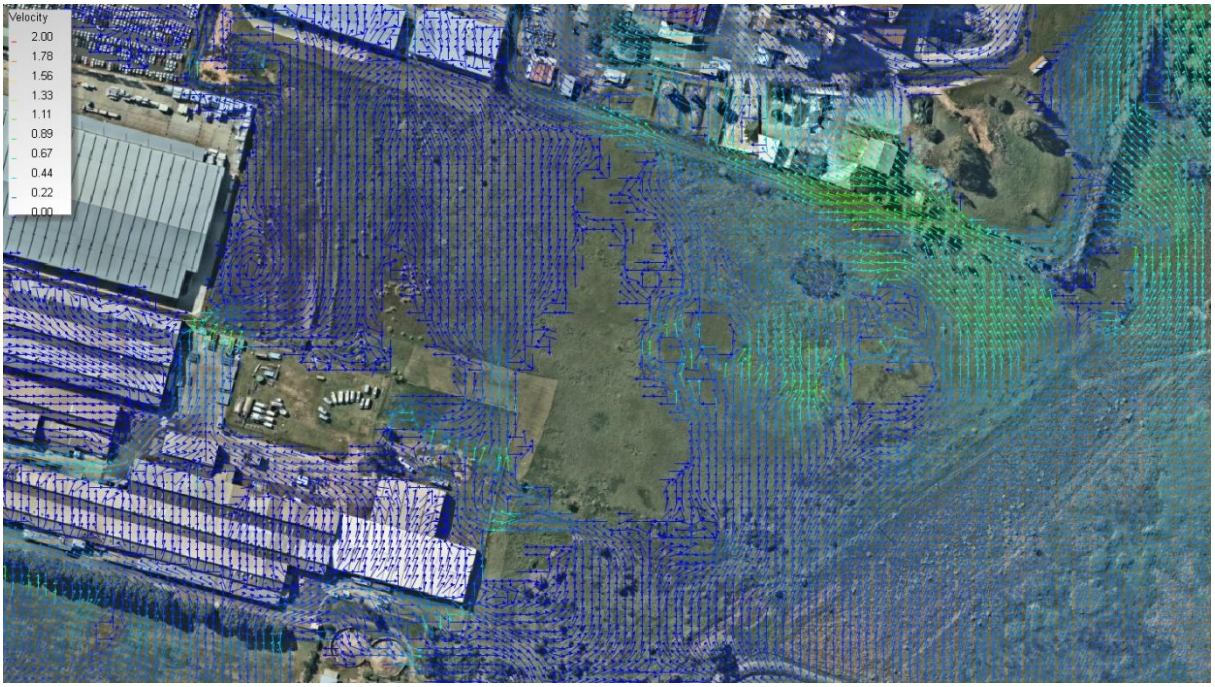

Figure F15 – 0.5% AEP Flood Velocity – Pre-Development

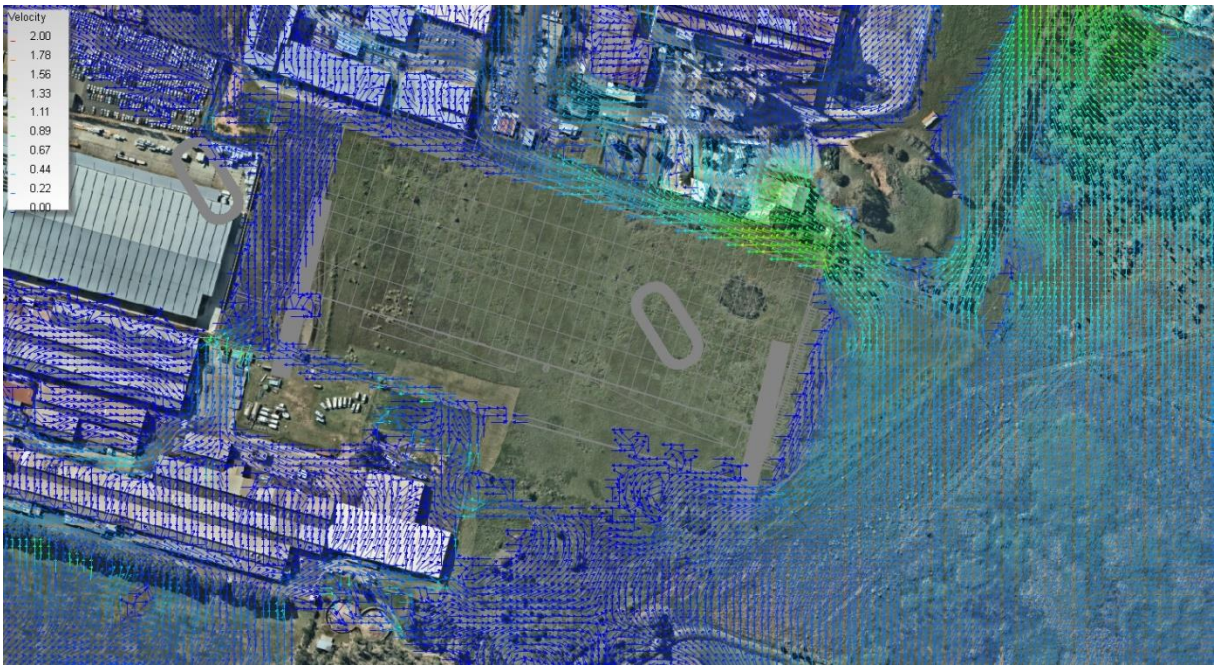

Figure F16 – 0.5% AEP Flood Velocity – Post Development

F.5 FLOOD SAFETY AND EVACUATION

F5.1 Introduction

This section of the report presents the relevant information in relation to egress and evacuation during the approach of a significant flood event.

This framework has been completed with consideration to the State Emergency and Rescue Management Act 1989 (NSW), the State Emergency Service Act 1989 (NSW), and the Penrith City Council Local Flood Plan 2012. The analysis is based on modelling results, prepared as part of the Nepean River Flood Study, and review of evacuation procedures outlines in the Hawkesbury River Flood Emergency Sub Plan 2014. The Sub Plan indicates that flood warnings and evacuation planning across the site would be based on monitoring of the Victoria Bridge Flood Gauge.

F5.2 Preparedness

Development of Warning Systems

The proposed facility should have a facility specific plan which sets out flood warden, evacuation zones and responsible persons. As noted the advice in this report can be used as a framework for these site-specific plans, in conjunction with Penrith Council and SES sub plans as required.

The NSW SES Penrith Local Controller is responsible for monitoring the flood risk over the area and for issuing flood warnings to the community. Any person or group occupying the precinct at the time of flood danger should adhere to any warnings issued. The warning message will normally be issued via SMS (phone text) by the SES. During periods of heavy or forecast heavy rainfall it is important that one or some of the occupants of a facility should be able to receive such messages. The occupants must then immediately follow the flood evacuation plan in this report or the instructions of the SES controller in the area.

As described in **Section F5.3** below, the SES Warning System is based on gauges on the Nepean River. This river directly increases flood levels around the proposed site. The SES system will provide good initial guidance, however in addition to the SES flood warning system, it is recommended that an in-house or precinct wide warning system also be employed to cover more localised flood events.

If an SES warning message has not already been issued, the recommended flood evacuation actions within this flood evacuation framework should be followed when the water level meets or exceeds the 5% AEP depth marker and be placed on alert at the 10% AEP depth.

Preparation Steps

It is the responsibility of the occupants of the each facility to understand the risks and dangers of flooding across the precinct, and the need to evacuate in such an event.