Danny Kataieh
Development Manager
HB+B Property
Building 1, Level 3, 75-85 O'Riordan Street
Alexandria NSW 2015

Arcadis Australia Pacific Pty Ltd
Level 16, 580 George Street
SYDNEY NSW 2000
Tel No: +61 2 8907 9000
www.arcadis.com/au

Subject: Review of Flood Assessment for 221 Luddenham Road

1 March 2022

Dear Danny,

In November 2020, Arcadis prepared a Flood Assessment (dated 13/11/2020) for HB+B Property for the proposed ALSPEC Industrial Business Park located at 221-227 & 289-317 Luddenham Road, Orchard Hills. An updated masterplan (SK022k, dated February 2022) was provided based on revised information from the draft Cumberland Plain Conservation Plan (Plan). The Plan includes an area at the southwestern corner of the site which is required to be re-zoned to E2 Conservation. This has resulted in approximately 16ha of developable area being removed from the masterplan. The updated masterplan also includes the areas identified as the Additional Land, on the eastern side fronting Luddenham Road and the Southern Land, at the southeastern corner of the site in addition to the previous development area.

A review of the updated masterplan has been undertaken to determine if the current Flood Assessment and its outcomes remain valid, as documented in the following. This letter should be read in conjunction with the Flood Assessment dated 13/11/2020.

Unnamed Creek Developed Area

As part of the Flood Assessment, a DRAINS model was developed for the project site to determine the size of the onsite detention basin (OSD) Basin 1 which manages the stormwater flows from the western side of the proposed development (as shown in Figure 4 of the Flood Assessment). The modelling indicated that Basin 1 would require a storage capacity in the order of 26,000m^3. The updated masterplan reduces the percentage of developed area of the catchment draining to Basin 1 which is expected to reduce the required storage capacity. As such, the capacity used in the Flood Assessment is still sufficient considering the updated masterplan. The storage requirement for Basin 1 could be optimised during future design stages.

For the Flood Assessment, a TUFLOW flood model was developed to simulate the pre and post-development flow regime and to assess the effectiveness of the proposed flood mitigation measures. The flood model determined that in the existing condition for the 1% AEP flood event there is significant water ponding to the south of Patons Lane lying within the proposed development area. The proposed development requires filling of the area which would lead to a loss of 33,000m^3 floodplain storage. To compensate for this loss of storage and to avoid flood level increases downstream of Patons Lane, two excavation areas together with surrounding levees are proposed on the floodplain to the west of the development area. The updated masterplan shows no significant changes in the area of these proposed flood mitigation measures and as such, the proposed excavation areas are still suitable.

The developed condition flood modelling indicated that the proposed development would not lead to adverse flood impact to the adjoining properties. The proposed development would not significantly alter the flood hazard nor velocity distribution across the floodplain and would also be unlikely to affect the operation of Patons Lane over the simulated flood events.

Additional Land and Southern Land

The Additional Land and the Southern Land areas of the updated masterplan are both located outside of the Flood Planning Area shown in the Penrith Local Environmental Plan 2010 (6350_COM_FLD_014_020_20100512), as shown below in Figure 1.

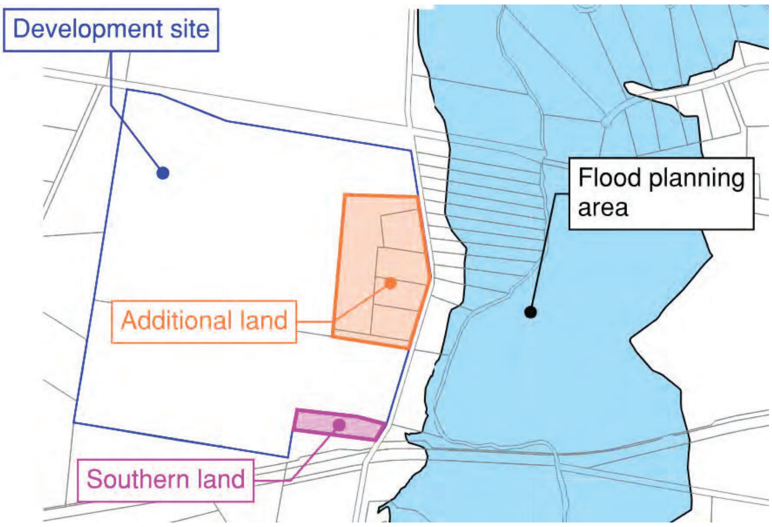

Figure 1 Flood planning area, Penrith Local Environment Plan 2010

The Flood Assessment also shows that the Additional Land and Southern Land areas are not impacted due to flooding of the unnammed creek under existing conditions shown in Figure AA.2 1% AEP Flood, Existing Conditions with extract shown below in Figure 2.

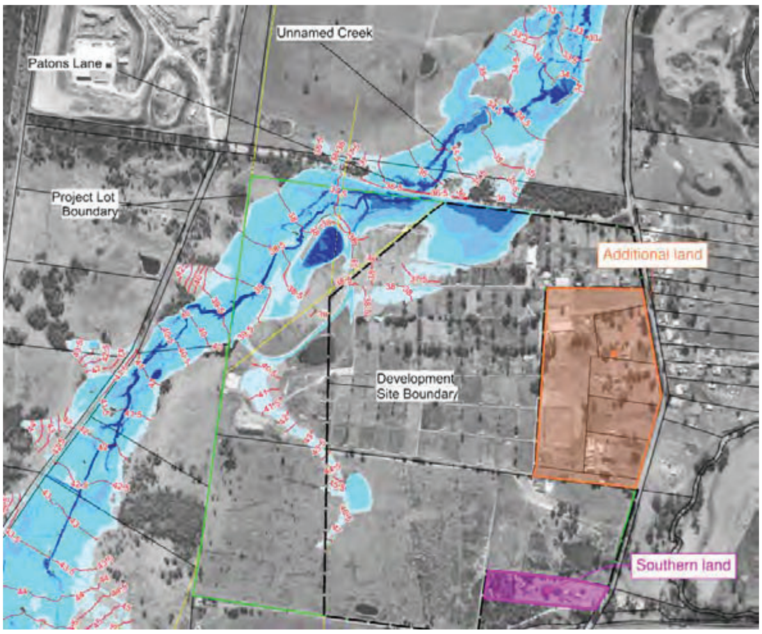

Figure 2 Extract from Figure AA.2 Flood Assessment, 1% AEP Flood Existing Conditions (Arcadis, 2020)

As noted in Section 5.1 of the Flood Assessment the eastern portion of the site which includes the Additional Land and Southern Land areas will be managed by separate OSDs which will discharge to South Creek. The inclusion of the Additonal Land and Southern Land areas to the masterplan does not impact the outcomes of the Flood Assessment as they are located outside of the existing flood extents and stormwater runoff will be managed by separate OSDs.

Final Remarks

The updated masterplan with a reduced development area as discussed above does not impact the outcomes of the Flood Assessment and as such the conclusions of the Flood Assessment (dated 13/11/2020) are still valid for the updated masterplan (SK022k, dated February 2022).

Any further changes to the assumptions or data relied upon in the Flood Assessment (refer Section 3 Available Data), aside from the reduction of developable area and inclusion of the Additonal Land and Southern Land areas discussed above, will require an update to the flood modelling and assessment. Any reduction in the size of Basin 1 or the two flood mitigation excavation areas would also require the flood modelling to be revised. Optimisation of the flood mitigation measures is possible in future design stages with flood modelling required to support.

Yours sincerely,

Michelle Fletcher
Senior Engineer
02 8907 3952
michelle.fletcher@arcadis.com

ALSPEC INDUSTRIAL BUSINESS PARK

Flood Assessment

13 NOVEMBER 2020

CONTACT

ALEX BLACK
Principal Engineer
Project Manager

T +612 8907 3954
E alex.black@arcadis.com

Arcadis
Level 16, 580 George Street
Sydney, NSW, 2000

HB+B PROPERTY
ALSPEC INDUSTRIAL BUSINESS PARK

Flood Assessment

Author	Vincent Ng	VN
Checker	Darlan Castro	DC
Approver	Alex Black	AB

Report No	01
Date	13/11/2020
Revision Text	NIL

This report has been prepared for HB+B Property in accordance with the terms and conditions of appointment for Alspec Industrial Business Park. Arcadis Australia Pacific Pty Limited (ABN 76 104 485 289) cannot accept any responsibility for any use of or reliance on the contents of this report by any third party.

REVISIONS

Revision	Date	Description	Prepared by	Approved by
01	13/11/2020	Flood Assessment	VN	AB

CONTENTS

APPENDICES

1 INTRODUCTION

1.1 Background

HBB Property has commissioned Arcadis to undertake a flood assessment for the proposed ALSPEC Industrial Business Park located at 221-227 & 289-317 Luddenham Road, Orchard Hills. The site has an approximate area of 81.3 hectares, bounded by private properties to the south, Luddenham Road, and private properties to the east and Patons Lane to the north. To the west of the site is an unnamed creek. Regional flood studies prepared by Penrith City Council (PCC) indicates that the site will be affected by 1% AEP and PMF flood extent. The South Creek flood study, also prepared by PCC shows that the proposed site is higher than the PMF flood level and will not be affected by the South Creek flooding.

In the existing case, there are broadly two flowpaths emerging from the development site joining to the unnamed creek to the west. The proposed development would raise the site ground level and fill part of the existing floodplain to the south of the Patons Lane. The adopted stormwater concept proposes the diversion of the existing catchment to three on-site-detention basins, of which Basin 1 would discharge to the unnamed Creek immediately upstream of Patons Lane, at the north western corner of the site. Basin 2 and 3 would discharge to the South Creek floodplain. Refer to Figure 1 for the locality and the site-specific information relating to flooding.

The subject flood assessment focuses on the unnamed creek only. The main objectives of this assessment are to investigate if there will be adverse flood impact to the neighbouring properties associated with the proposed development, and to inform the subdivision design in the future. The flood assessment report will be a supporting document for the planning submission for approval.

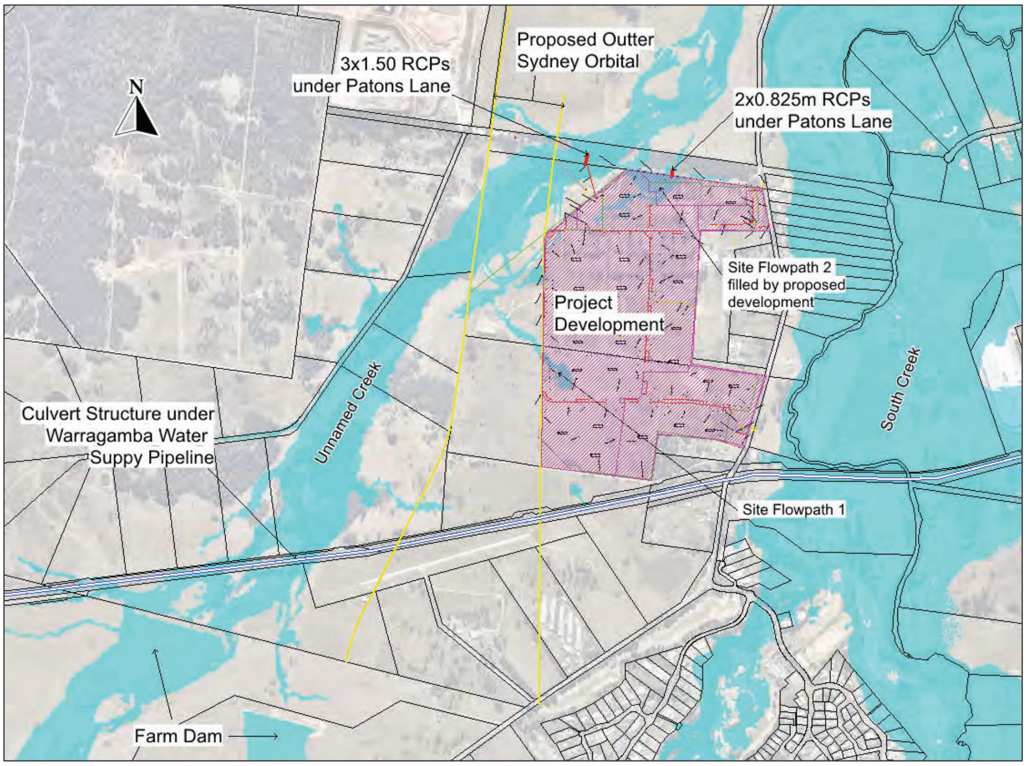

Figure 1 - Project Development Site Map

1.2 Interim Technical Memo

An interim flood assessment technical memo has been issued as advanced information to support the planning submission for the ALSPEC industrial business park under consideration by Council. This report can be considered as an extension of the technical memo, and provides the comprehensive reporting on the flood investigation works, which include additional details in modelling works and the full flood mapping.

It is noted that the flood modelling results presented in the technical memo have been based on TUFLOW HPC solution technique. The use of HPC computation technique has speeded up the flood modelling process in the order of 5 times as opposed to the Classic solution approach.

The current flood report has adopted the flood results calculated using TUFLOW Classic solution as specified by Penrith City Council. The latest flood results are similar to previous reported results and the conclusions of the investigation remains unchanged.

2 FLOOD MODELLING APPOACH

2.1 Consultation with Penrith City Council

A video meeting with the Penrith City Council (PCC) attended by Arcadis and HBB was held on 1st July 2020 regarding the flood assessment modelling approach and requirements. The following has been agreed at the meeting: -

a. PCC would provide South Creek flood model input and output files relevant to the flood assessment.

b. Flood assessment would be based on XP-RAFTS hydrologic model, adopting ARR 2019 methodology.

c. Flood hydraulic would be based on TUFLOW Classic solution.

d. Flood assessment would consider 5%, 1%, 0.5% and PMF flood events.

e. Report on afflux, flood hazards, velocity, and velocity changes and flood storage. Afflux more than 20mm is not acceptable.

f. Model boundary has been agreed as downstream boundary at South Creek confluence and upstream boundary at downstream of Warragamba pipeline.

g. All farm dams will be modelled as “full”.

h. Detention basins should be located outside of 1% AEP floodplain.

The minutes of meeting has been included in the **Appendix D** for reference.

In addition to the points outlined above it was also understood from the discussion with PCC that the flood assessment would focus on assessment of the unnamed creek only. The development site sits well above the South Creek PMF flood level and the river flood from South Creek would be unlikely an issue. Minor flowpaths flowing eastwards from the project site to the South Creek floodplain could be managed under the stormwater design package undertaken by Henry and Hymas Consulting Engineers (H&H).

2.2 Adopted Flood Modelling Methodology

The flood assessment has been carried out in the following broad steps upon considering the requirements by PCC: -

a. Data Collection and Review.

b. Development of a site-specific hydrologic XP-RAFTS hydrologic model.

c. Development of a site-specific TUFLOW hydraulic flood model to define the pre-development condition as the baseline conditions for impact assessment.

d. Development of post-development flood model by modifying from pre-development model.

e. Assessment of flood impact and development of mitigation options.

f. Assessment of effectiveness of mitigation options.

g. Report and flood mapping.

The flood modelling has been undertaken using TUFLOW HPC computation solution technique for the establishment of the flood regime and determination of appropriate flood mitigation option. The final modelling results documented in this report have been confirmed with TUFLOW Classic computation solution.

3 AVAILABLE DATA

Table 1 - Available Data for the Current Flood Assessment:

Data	Source	Remarks
Aerial photo	Nearmap 2020 photography	Use for establishment of roughness in hydrologic and hydraulic modelling
LiDAR	ELVIS elevation and Depth data	1m asc grids 2019, flood model base DEM
Cadastre	SIX Map websites	Use for identification of lot boundaries
Updated South Creek Flood study Vol 1 and 2 (2015), report and flood maps	Worley Parsons for Bankstown, Liverpool, Fairfield and Penrith City Councils	
Updated South Creek Flood study (2015), GIS flood maps	Worley Parsons for Bankstown, Liverpool, Fairfield and Penrith City Councils	Including flood depth, level and velocities for ARI 20, 50, 100, 200, PMF GIS in MapInfo
South Creek XP-RAFTS model	Worley Parsons for Bankstown, Liverpool, Fairfield and Penrith City Councils	Model files and results
Penrith Overland Flow Flood "Overview Study" report (2006)	Cardno Lawson Treloar for Penrith Council	The project site is in the Southern Rural (Zone 3)
Penrith Overland Flow Flood "Overview Study" GIS Mapping	Cardno Lawson Treloar for Penrith Council	Including flood level mapping of 1%, 5% AEP and PMF GIS in MapInfo
Stormwater drainage design	Henry and Hymas Consulting Engineers (H&H)	DRAINS model showing configuration of preliminary on-site-detention basin information including basin and outlet configuration, catchment plans, development layout and design ground shaping tin. **Appendix E**

4 HYDROLOGIC ASSESSMENT

4.1 Review of Councils XP-RAFTS Model

Both the Updated South Creek Flood Study and Penrith Overland Flow Overview Study adopted the XP-RAFTS hydrological model for generation of inflows to the respective 2-D hydraulic models.

South Creek has a total catchment of about 410 sq. km and the critical design storm duration was found to be 36-hour event. **Table 2** summaries the adopted parameters employed in the South Creek XP-RAFTS model. The adopted initial loss (IL) and continuing loss (CL) parameters were determined based on the calibration of the historical 1986 and 1988 flood events, which were long duration flood events exceeding 24 hours.

Table 2 - XP-RAFTS Model Parameters Adopted in Council's Study

Model parameters	South Creek Flood Study	Penrith Overland Flow Study
Initial loss (IL), mm	37.1	10.0
Continuing loss (CL), mm/hr	0.94	2.5
Bx	1.3	Unavailable
PERN Mannings Value	0.025	Unavailable
Vectored slope	0.55 – 0.66%	Unavailable

Figure 2 presents the South Creek XP-RAFTS catchment showing the unnamed creek where it crosses the site, located between Blaxland and Cosgroves Creeks. The unnamed tributary is represented by the Catchment Nodes 13.00 and 13.01 and It has a total catchment of approximate 12.8 km^2. South Creek flood model documentation indicates that the unnamed tributary has a peak flow of 72.6 m^3/s in the 1% AEP 36-hour event.

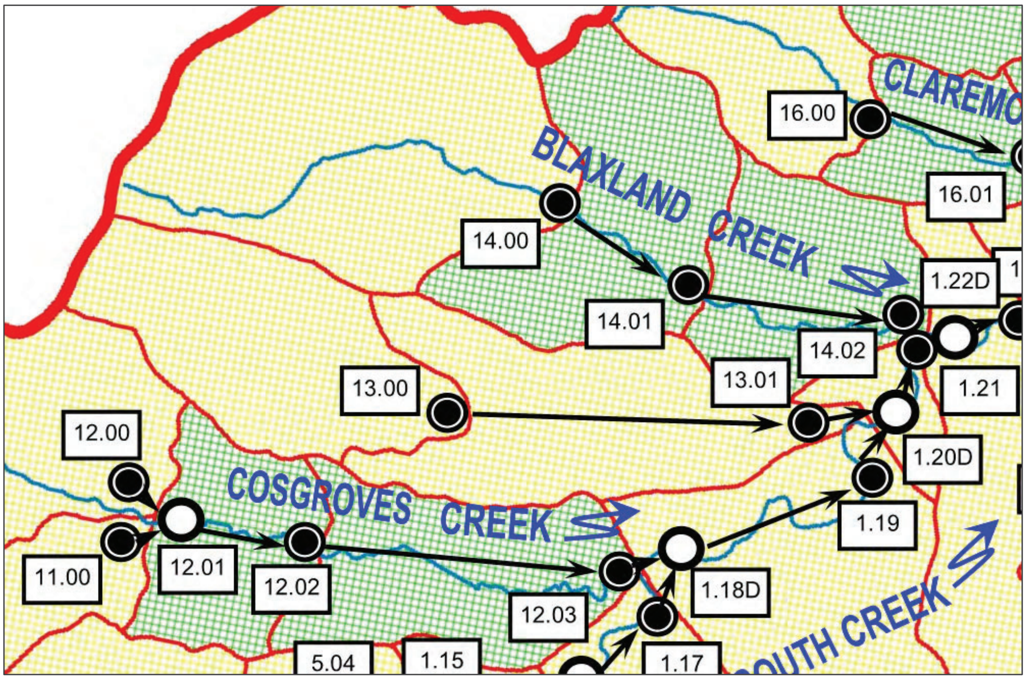

Figure 2 – Unnamed Creek XP-RAFTS catchment extracted from Figure 4.1 of Updated South Creek Flood Study

The Penrith Overland Flow Flood Study report documented that the study adopted the EMU Plain XP-RAFTS hydrological model input. The adopted IL and CL values were 10.0mm and 2.5mm/hr. They are typical values used in ARR 1987 approach without calibration. Other XP-RAFTS parameters such as Bx and catchment parameters could not be found amongst the documents received. EMU Plain XP-RAFTS has not been made available for this assessment.

4.2 Arcadis Site-Specific XP-RAFTS Model

Arcadis has developed a site-specific XP-RAFTS model for the unnamed tributary to provide the hydrological input to the TUFLOW flood model.

Figure 3 presents the XP-RAFTS model configuration and the catchment delineation of the existing catchment conditions. Model parameters have been adopted as follows:

a. Impervious percentage has been estimated using the 2020 Nearmap photo.

b. Catchment delineation has been derived from the 2019 LiDAR contours.

c. IL 10mm and CL 2.5mm/hr as employed in EMU Plain Council Overland Flood Study. IL of 37.1mm derived from long duration events, reported in South Creek Flood Study may not be appropriate for shorter duration events such as 2 to 6-hour storm events that are likely critical for the unnamed tributary catchment under investigation. The relatively small total rainfall depth in a short duration event could be “consumed” by the use of large IL value and this may lead to underestimation of peak flow prediction.

d. Impervious PERN values of 0.015, pervious PERN value 0.05 (Rural) and 0.025 (Urban) as recommended by RAFTS Manual (Version 5).

e. Bx = 1.3 as employed in South Creek Flood Study.

f. Travel times for links between model nodes have been calculated basing on the assumption of 1.5m per second.

The model was firstly verified with the catchment flow at Node 13.00 predicted by the South Creek XP-RAFTS for the same catchment using the ARR1987 methodology. Arcadis XP-RAFTS predicted an outlet flow of 74.7 m^3/s which is comparable with 72.6 m^3/s from the South Creek model for the 1% AEP 36-hr event. This represents about a 3% difference (and slightly conservative) which is considered a reasonable match. The model setup would be adopted for generation of inflows to TUFLOW flood model.

4.3 Hydrological Modelling Results

As agreed with the Penrith Council, the flood assessment would adopt the ARR2019 framework. Under the new guideline, the use of an ensemble of ten temporal patterns is recommended. The median flow is defined as the flow first exceeding mean or median peak flow rate from the ensemble of ten temporal patterns at any given location. The adopted temporal pattern is referred to as the “median temporal pattern”. Hydrologic simulation has also employed the design losses depending on AEP and storm duration, as recommended by ARR_Datahub. The process has been facilitated with the use of Storm Injector software developed by Catchment Simulation Solution.

Table 3 tabulates the median flows at key locations predicted by XP-RAFTS. The 5%, 1%, 0.5% AEP flows have been generated using on ARR2019 methodology. PMF flows have been calculated from PMP calculated from Bureau of Meteorology Generalised Short-Duration Method. **Appendix F** includes the IFD – ARR_Datahub and PMP calculations for reference.

It is to note that there are two sizable farm dams located immediate upstream of the Warragamba pipeline (refer to **Figure 1**). The modelling has assumed that these farm dams are full at the beginning of the events.

As presented in **Table 3** the main creek has a critical duration of 6-hour for the 5%, 1% and 0.5% AEP and 2-hour for PMF events. The two local flowpaths from the development site catchments (1J_3A and 1I_4A) have a critical duration varying from 1.5-hour to 3-hour for the 5% to 0.5% AEP and 1-hour for PMF under the pre-development conditions. The predicted 1% AEP peak flows are 1.9m^3/s and 5.2m^3/s for the two local catchments.

Table 3 - XP-RAFTS Flow Summary at Key Locations - Pre-Development Conditions

Key Location	RAFTS ID	5% AEP	1% AEP	0.5% AEP	PMF
Main Creek - Warragamba water supply pipeline	Node 1G	32.1 (6h)	50.6 (6h)	54.6 (6h)	373 (2h)
Main Creek – upstream lot boundary	Node 1H	36.5 (6h)	57.1 (6h)	61.5 (6h)	419 (2h)
Main Creek – downstream lot boundary	Node 1J	45.0 (6h)	57.1 (6h)	61.5 (6h)	419 (2h)
Main Creek – outlet	Node 1N	49.0 (6h)	74.0 (6h)	80.7 (6h)	528 (2h)
Site Flow 1	Node 1I_4A	1.2 (1.5h)	1.9 (2h)	2.1 (2h)	17.4 (1h)
Site Flow 2 just upstream of Patons Lane	Node 1J_3A	3.2 (3h)	5.2 (2h)	5.8 (2h0	27.4 (1h)

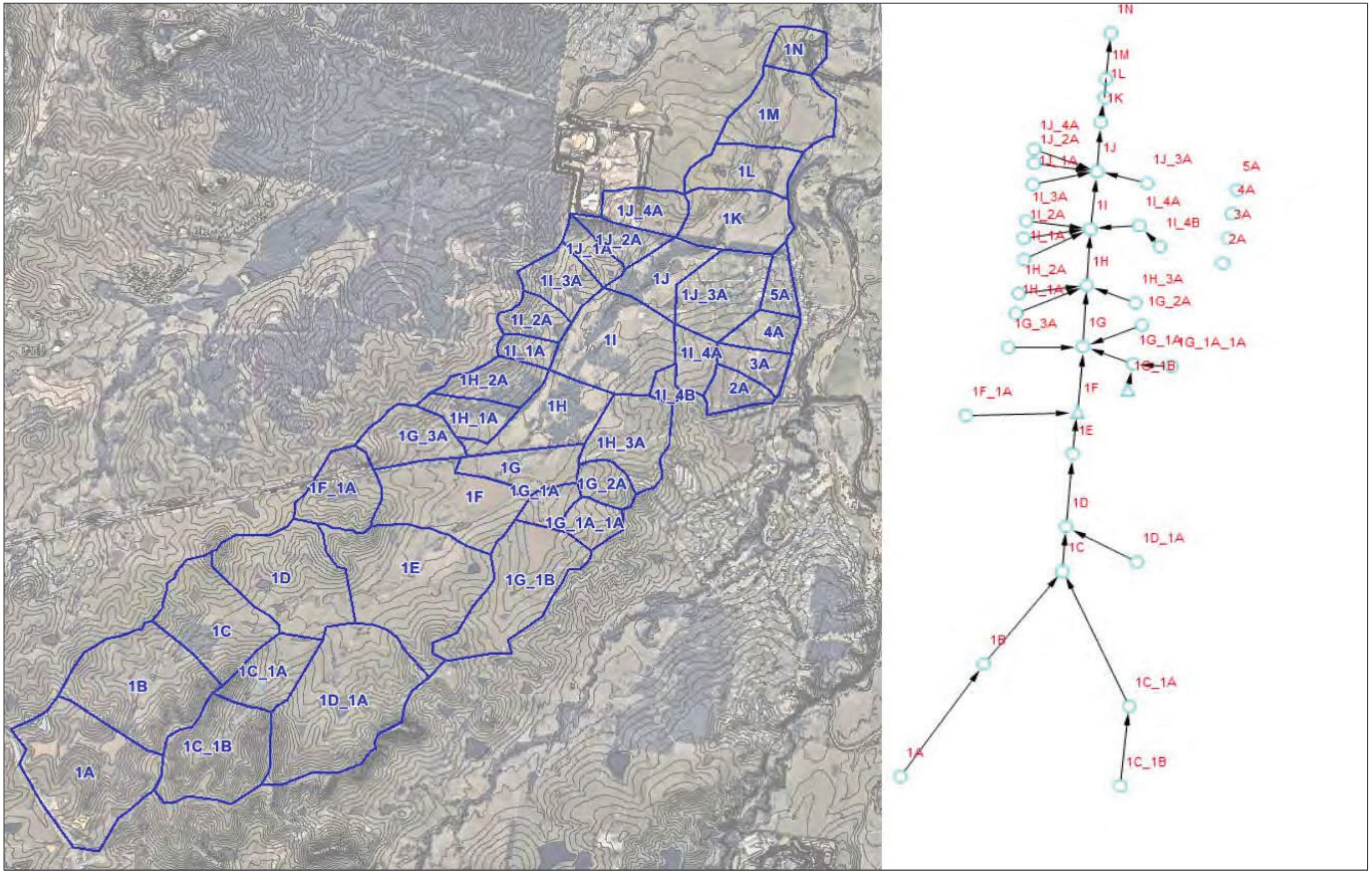

Figure 3 – RAFTS layout and Catchment

5 SITE INTERNAL DRAINAGE

5.1 Proposed Development

The proposed development site has an area of approximately 71 hectares. The existing landuse is rural residential property and open space agricultural land. The site is proposed to be redeveloped into an industrial subdivision, which would classify as commercial and industrial land use. The masterplan has allowed three stormwater detention basins to offset the increase in imperviousness within the project site. The western and northern part of the site would drain towards the unnamed creek and are proposed to be treated via Basin 1. The eastern portion of the site will drain to Basin 2 and Basin 3 and eventually discharge to the South Creek floodplain. The Basin 2 and 3 are for controlling catchments draining towards South Creek and would not be considered in this assessment. **Figure 4** shows the catchment plan of the development.

5.2 Project site DRAINS modelling

Arcadis has developed a DRAINS model for the project area to undertake the hydraulic design of Basin1. The DRAINS has been “calibrated” to match the peak XP-RAFTS flows for the local project catchments 1J_3A and 1I_4A. Details of “calibration” are included in **Appendix G** for reference.

The catchment draining to Basin 1 is approximately 57.66 ha. The proposed basin has been configurated to control the maximum peak flow for the developed conditions not to be higher than the maximum peak flow from the existing conditions.

The proposed basin has an invert level of 37.1mAHD and possesses a total storage of about 26,000 m^3 at R.L. 39.23m AHD. Details of basin and DRAINS configurations are summarised in **Appendix G**.

Table 4 below summarises the peak flows rate for the existing and developed conditions from the project site for the modelled storm events. The recorded peak flows for the post-development scenario has included the 1.5 ha catchment bypassing Basin 1. Tabulation shows that there is a reduction in the maximum peak flows for the 5% and 1% AEP events under the developed conditions, noting that the critical duration events are different for the pre- and post-development scenarios.

It can be seen that there are increases in the project site flows for shorter duration events if the same storm event is considered. The effect of this would be investigated in the flood modelling and discussed in the later section.

Figure 4 –Site Development Catchment Plan

Table 4 - DRAINS Flow Summary from the Project site

Storm Duration	Existing 5% AEP	Developed 5% AEP	Difference 5% AEP	Existing 1% AEP	Developed 1% AEP	Difference 1% AEP
15	1.06	2.31	1.25	2.71	3.35	0.63
20	1.51	2.42	0.92	3.42	4.18	0.75
25	1.85	2.48	0.64	3.92	4.47	0.54
30	2.13	3.20	1.08	4.26	4.63	0.36
45	2.67	3.47	0.81	4.95	5.32	0.37
60	3.01	**3.76**	0.75	5.39	**5.60**	0.21
90	3.32	3.67	0.35	**5.77**	5.16	-0.61
120	3.74	3.54	-0.21	5.74	4.60	-1.14
180	**3.88**	3.30	-0.59	5.57	4.76	-0.81
270	2.53	2.31	-0.22	4.07	3.32	-0.75
360	3.64	2.44	-1.20	4.98	3.82	-1.16
Max	**3.88**	**3.76**	**-0.08**	**5.77**	**5.60**	**-0.17**

6 HYDRAULIC ASSESSMENT

6.1 TUFLOW Model Development

A TUFLOW 2D hydrodynamic model has been developed for the assessment. **Figure** 5 presents the model configuration. The model extends from immediately south of the Sydney Water Warragamba pipeline to the confluence of the unnamed creek and South Creek, downstream of Patons Lane.

The key features of the base case model are: -

a. The model has adopted a grid size of 2m which would be sufficiently refined to capture topographic changes between the pre- and post-development scenarios.

b. The modelling employs TUFLOW build version (2020-01-AB), HPC computation solution for mitigation optioneering and Classic solution for final flood mapping.

c. Adopted initial time step is 1.0 second except for PMF simulation, in which 0.5 second time step is used. Time step is automatically adjusted by HPC computation engine.

d. The embedded DEM adopted 2019 LiDAR survey combining with local topographic survey information.

e. The flow boundaries are flow hydrographs exported from Arcadis XP-RAFTS, except for the flows from the project site, which has been using hydrographs from DRAINS.

f. Tailwater water has assumed static boundary conditions interpreted from South Creek flood grids provided by Penrith City Council. Tailwater and flow boundaries are of the same exceedance probability, for example, a 1% AEP catchment coincides with 1% South Creek flood level at confluence.

Table 5 - Tuflow Tailwater Boundary

Event	Average Tail Water Level (mAHD)	Remarks
5% AEP	29.91	South Creek 5% AEP flood level
1% AEP	29.50	South Creek 1% AEP flood level
0.5% AEP	30.15	South Creek 0.5% AEP flood level
PMF	32.20	South Creek PMF flood level

g. Material roughness has been based on the following table

Table 6 - Material Roughness

Land use category	Mannings n
Industrial/commercial	0.20
Open pervious areas – grassed	0.04
Open pervious areas – shrubs	0.06
Open pervious areas, thick vegetation (trees)	0.08
Waterways/channels – minimal vegetation	0.03
Waterways/channels – vegetated	0.07
Concrete lined channels	0.015
Paved roads/car park/driveways	0.02
Wetlands (emergent vegetation)	0.06

h. Cross-drainage drainage structures included in the flood model are Patons Lane culverts and Warragamba Pipeline culvert. The main cross drainage structures at Patons Lane are 3x1.5m RCPs at main creek channel. There are three other structures at various locations across Patons Lane including a single 0.825m, 0.6m and 0.375m RCPs. The information has been based on site topographic survey. The Warragamba Pipeline culvert configuration has been assumed to be 3x1.5m(W)x1.2m(H) RCBCs. As there was difficulty to gain access within Sydney Water corridor during the recent site survey, the dimensions of the main culvert structure have been estimated based on aerial photo combined with LiDAR cloud points information. All drainage structures have been modelled as 1-D elements. Details of the estimation of Warragamba culvert and photos of Patons Lane culverts from site visit are included in **Appendix H** for reference.

i. Warragamba pipelines have been modelled as long “bridge” structures in 2-D. There are two pipeline runs parallelly along the corridor. It is typically supported on plinth structures, leaving a gap from the ground to allow overland flows passing underneath. The size of these gap varies along the length, it was estimated the gap to be about 0.3 to 0.5m wide, observed from Luddenham Road and photos of the pipeline at other locations. In the model, it is assumed an average gap height of 0.4m for the entire length of the pipeline within the model footprint. Photo H.1 to H.4 in **Appendix I** shows the typical arrangement of the Warragamba pipeline. As the gap are generally long, flow area is expected to be sufficiently large for overland flow crossing the pipelines without significant impedance on the approaching flows in 1% AEP or smaller events. Sensitivity tests considering an average gap of 0.3m to 0.5m indicated that there would be no change in flood levels the flood level in the proximity of the project site for events up to PMF. Refer to **Appendix J** for details of the sensitivity results.

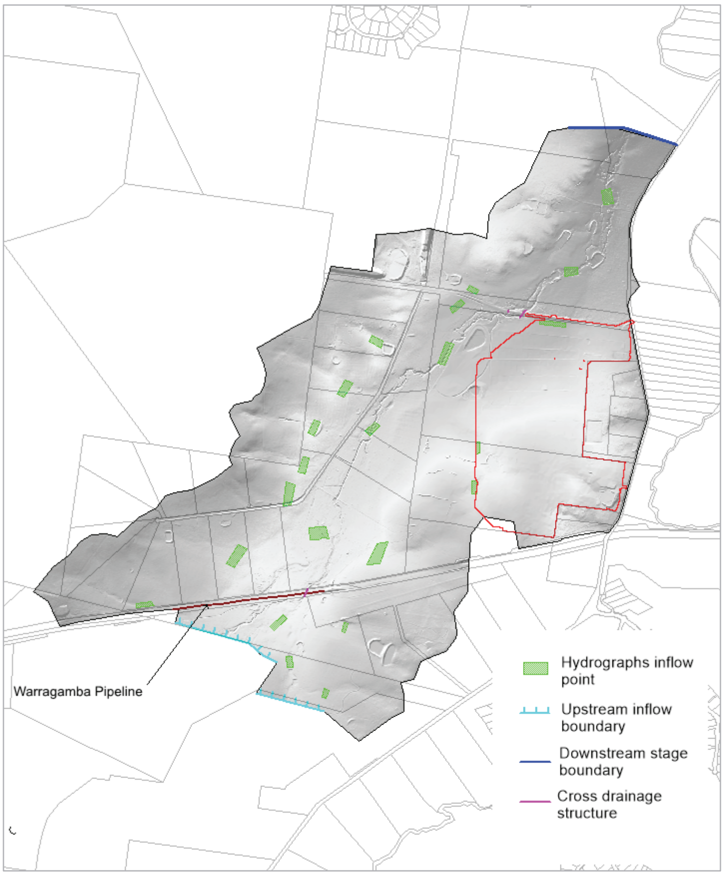

Figure 5 – Tuflow Model Structure

6.2 TUFLOW Modelling Scenarios

In the current flood assessment, for each AEP event, three storm events would be selected. The events represent the critical duration event for the main creek, the critical duration events from the project site for the pre-development and the post-development.

Table 7 presents the selected combinations of the critical durations for both the main creek and the site flowpaths under the pre- and post- development scenarios. The main creek duration and median temporal pattern has been selected basing on **Table 3**, XP-RAFTS Node 1J, the critical durations from the project site are from the DRAINS with modelling results listed in **Table 4**.

Table 7 - Adopted TUFLOW Modelling Scenarios

Event	Scenario 1 Critical duration Main Creek (Pre & Post development conditions)	Scenario 2 Critical duration Project site (Pre-development conditions)	Scenario 2 Critical duration Project site (Post-development conditions)
5% AEP	6 hr (4591)	3 hr (4663)	1 hr (4565)
1% AEP	6 hr (4722)	1.5 hr (4585)	1 hr (4463)
0.5% AEP	6 hr (4722)	1.5 hr (4585)	45 min (4528)
PMF	2 hr.	1 hr	15 min

Note: () represents ARR median temporal pattern ID

6.3 Base Case Conditions Modelling Results

6.3.1 Flood Level and Depth

Figures AA.1-AA.4 in **Appendix A** present the flood depths and levels of the existing conditions for the 5%, 1%, 0.5% and PMF events. The flood depth and level shown are the enveloped maximum values of the selected durations for each AEP events. Analysis indicated that the main creek critical duration flood events generally produces the highest flood level amongst the selected scenarios.

Flood mapping shows the flow patterns of the main creek and the two main flowpaths draining from the project site to the unnamed creek. It is shown that Patons Lane would be inundated and there would be a significant ponding up to 1.4m immediate upstream, within the project site boundary. The ponding area has an estimated flood storage of about 33,000 m^3. The area is currently drained by a single 0.375m RCP and a twin 0.825m RCPs under Patons Lane. Refer to **Figure 6** for details.

Analysis of the modelling results indicated that the ponding area is currently functioning as “natural” detention basin, controlling the outflow downstream. The proposed filling of the ponding area would have a significant effect on flooding and would impact the neighbouring lots downstream of Patons Lane. The loss of the flood storage and the detention basin effect would need to be compensated under the developed conditions.

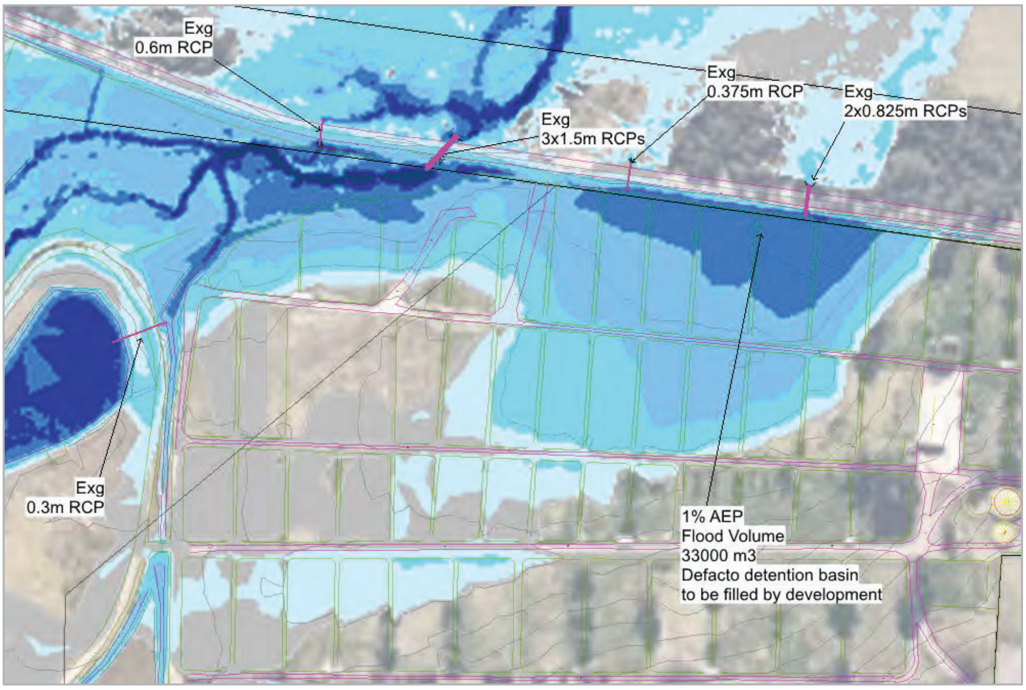

Figure 6 – Existing Ponding Area Within the Development Site

6.3.2 Flood Hazard

Figures AB.1-AB.4 in **Appendix A** present the flood hazard in proximity of the project site. The mapping has adopted Australian Institution for Disaster Resilience flood hazard category. Under the hazard framework depending on the combination of overland flow velocity and flood depth, inundated area can be classified into 6 different hazard categories from H1 to H6 with category with H6 being is the most hazardous. **Figure 7** explains the flood hazard categories.

Flood mapping indicates that Patons Lane would be overtopped in the 5% AEP events. The roadway, at the sag location is of low hazard category H1 and remains trafficable. In the 1% AEP event, the sag location would be in H3 hazard category, that is unsafe for vehicles and children and the elderly. Under PMF situation, the roadway would be highly hazardous over 400m of length and shown to be of hazard category H5.

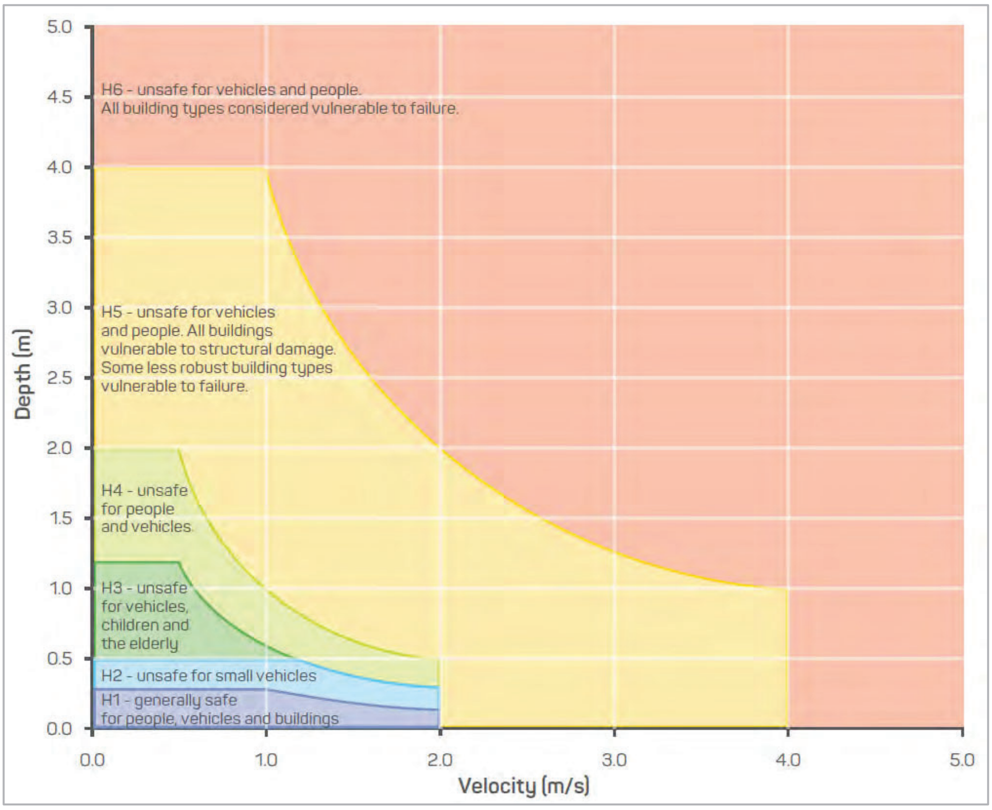

Figure 7 - General flood hazard vulnerability curve (extracted from Australian Disaster Resilience Handbook Collection, Guideline 7-3)

6.3.3 Flood Velocity

Figures AC.1-AC.4 in Appendix A present the flood velocity distribution in proximity of the project site for the 5%, 1%, 0.5% AEP and PMF events. It is noted that the flood velocity pattern across Patons Lane sag for the 5%, 1% and 0.5% AEP floods are quite similar as the overtopping flow "weirs" over the road embankment which is about 1m above the downstream flood level. Predicted maximum velocity is about 2.5m/s to 3.0m/s. With the PMF, the flood velocity is significantly higher (exceeding 3.0m/s) for 300m length of roadway. This is corresponding to the high hazard category H5 observed in flood hazard mapping.

6.4 Developed Conditions Model Setup

The pre-development flood model has included the proposed development filling represented by a design surface provided by H&H. The pre-development DRAINS inflows have been replaced with the post-development inflows. The Basin 1 outflow hydrograph has been applied directly to the upstream of the proposed outlet pipeline 3 x 2.44(W) x 1.21(H) RCBCs connecting to the creek immediately upstream of the main cross drainage structure under Patons Lane. An approximate 1.5 ha catchment flow bypassing the Basin 1 has been assumed draining directly to the nearest existing culvert 2x0.825m RCPs.

The development scenario also has included an underground conduit connecting the existing 2x0.825m RCPs and the 0.375m RCPs to the main creek. This allows the two existing culvert systems could be fully utilised during flood, that would reduce flood impact associated with concentration of overland flows across the Patons Lane sag under the main creek flooding situation. **Figure 8** illustrates the proposed stormwater concept.

As discussed in the previous section, it is anticipated a loss of about 33,000 m^3 flood storage under the developed conditions. Two excavation areas with proposed levees within the floodplain area are proposed to compensate the would-be lost floodplain storage and to control the water level increase downstream of Patons Lane. **Figure 8** illustrates the proposed ground shaping concept to form the required detention. The proposed scheme has aimed to minimise works within the 40m wide riparian corridor zone and avoid the 30m exclusion zone for pylon structures within the electricity easement.

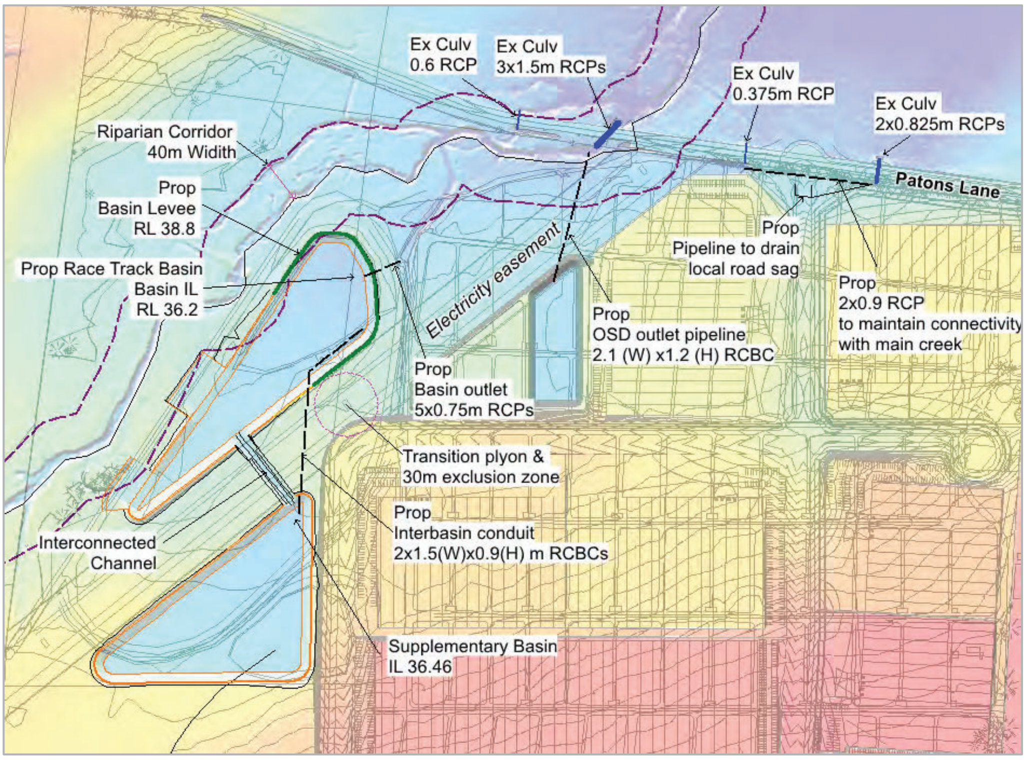

Figure 8 - Proposed mitigate measures

6.5 Developed Conditions Modelling Results

6.5.1 Flood Level and Depth

Figures BA.1-BA.4 in **Appendix B** present the flood depths and levels of for the 5%, 1% and 0.5% AEPs, and PMF events. The flood depths and levels are the enveloping maximum values for the selected storm duration events.

Table 8 - Comparison of Flood Volume (m3) within the Development Lot

Event	Pre-development	Post-development	Difference
5% AEP	83300	73200	-10100
1% AEP	109700	115600	+5900
0.5% AEP	113100	120100	+7000
PMF	299900	298800	-1100

Note – Post-development flood volume does not include Basin 1.

Table 8 compares the flood storage within the developed lot boundary under the pre- and post-development conditions. There would be a net loss of total flood storage in the 5% AEP event, but in the 1% and the larger event the flood volume has been compensated with the proposed mitigation in place. The results demonstrated the proposed mitigation concept would achieve no loss of floodplain storage in the 1% AEP event. Increase in flood storage in 5% AEP event can be achieved by further excavation on the floodplain north of the race-track area or reducing outlet capacity from the "Race-track basin" and this will be considered in future design if required.

6.5.2 Flood Impact

Figures BB.1-BB.4 in **Appendix B** show the flood level changes relative to the existing conditions. It has been agreed in the pre-submission meeting with the Council that flood level increase less than 20mm is considered acceptable under the current development environment. Flood mapping shows that there would be no flood impact to the Patons Lane predicted for the 5% and 1% AEP floods. Therefore, the proposed development would not adversely affect the adjourning properties.

With the 0.5% AEP event, the model predicted a minor flood level increase between 20mm and 40mm within Patons Lane road corridor. PMF shows that there would be up to 0.1m increase in flood level north of the development boundary. Despite the increase in flood level, it would have little implication to Patons Lane as an emergency evacuation route for the properties to west of the road sag as the roadway would have already been highly hazardous under the pre-development conditions.

Table 9 tabulates the peak overland flows at Patons Lane and the downstream floodplain. The tabulation demonstrates that the proposed development would not increase the peak flows at Patons Lane and the downstream properties.

Table 9 – Overland flow at Patons Lane and downstream Pre and Post development

Event	Patons Lane *1 Existing	Patons Lane Downstream *2 Exsiting	Patons Lane *1 Developed	Patons Lane Downstream *2 Developed
5% AEP	23.5	40.4	23.4	40.4
1% AEP	49.5	66.1	48.5	64.9
0.5% AEP	55.0	71.5	54.6	71.1
PMF	509	513	494	515

Note: *1 flow line rough the Patons Lane road centre line
*2 flow line location approximately 100m downstream of Patons Lane

Figure BB.5 to **Figure BB.10** in **Appendix B** are flood impact maps for the individual selected duration events. **Figure BB.5** and **Figure BB.8** present the flood impact for the 5% AEP 1-hour and 1% AEP 1-hourr events relative to the base case for the same storm event. For these two cases, the post-development flows from the project site exceeds the pre-development flows according to DRAINS modelling output in **Table 4**. The two figures demonstrate the site flows effect may have on the overall flood regime.

Refer to **Figure BB.5**, for the 5% AEP 1-hour scenario, there would be a maximum increase of 22mm in flood level (marginally exceeds the acceptable limit) to the north of the Patons Lane. The impacted area is mainly confined within Patons Lane road carriageway and a small portion falling within the private property to the north. Given that there is no flood impact predicted for the more critical main creek flooding (6-hr duration event) for which the general flood level at the crossing is about 0.15m higher, the impact is considered immaterial.

Refer to **Figure BB.8**, for the 1% AEP 1-hour scenario, there is no adverse flood impact predicted to the north of the lot boundary, despite that the peak post-development outflow from the project site exceeds the pre-development outflow. As the main creek flow increases, the flow effect from the development site diminishes.

6.5.3 Flood Hazard

Figures BC.1-BC.4 present the flood hazard map for the 5%, 1%, 0.5% AEP and PMF events. There may have minor worsening in terms of flood hazard across Patons Lane sag as the development filling would cause more overtopping flood occurring over the sag to the west. It is noted that the flood hazard for Patons Lane in the 5% AEP flood remains Category H2, the roadway would be trafficable in the event similar to the pre-development conditions. The proposed development would unlikely affect the operation of Patons Lane.

6.5.4 Flood Velocity and Velocity Impact

Figures BD.1-BD.4 show the flood velocity distribution for the 5%, 1%, 0.5% AEP and PMF events. The predicted flow velocity distributions across Patons Lane have not been significantly different from the base case scenarios. **Figures BE.1-BE.4** show that the changes of flow velocity across Patons Lane are less than 20% relative to the existing conditions for all the modelled events. No significant impact on flood velocity is predicted for the proposed development.

6.6 Comparison of TUFLOW HPC and Classic

Figure CA.1 and **Figure CA.2** in **Appendix C** compare the 1% AEP 6-hour flood level TUFLOW Classic simulation results relative to the HPC computation results for the existing conditions and the developed conditions. The 6-hour duration event is the critical storm event for the unnamed creek. It is noted that the Classic flood surface is generally lower than the HPC surface by maximum 25mm over the floodplain. However Classic solution flood surface is higher locally at the downstream of Patons Lane roadway, given that 1-D flows hydrographs behaves similarly, the difference would likely be due to the differences in the way the computation method handles the weir (supercritical) flow calculation.

Figure CA.3 compares the flood impact pattern of the 1% AEP event calculated by Classic and HPC computation solutions. There is no significant difference in the afflux prediction. The choice of HPC and Classic solution may not be critical for the setting of this project site.

7 SUMMARY AND CONCLUSIONS

Arcadis has completed the flood assessment on the proposed development.

An XP-RAFTS hydrologic flood model has been developed to model the catchment hydrology of the unnamed creek. The XP-RAFTS model has been verified with the South Creek RAFTS model flow at the confluence with South Creek.

A separate DRAINS model has also been developed for the project site to configurate the design of the OSD Basin 1. The modelling indicates that Basin 1 would require a storage capacity of 26,000m^3.

A TUFLOW flood model has also been developed to simulate the pre- and post-development flow regime and to assess the effectiveness of the proposed flood mitigation measures. Hydrologic inputs are from the XP-RAFTS except for the development site area which are from the site-specific DRAINS model.

The existing condition flood modelling results show that there is a significant water ponding to the south of Patons Lane lying within the development area. The ponding area has a considerable size with maximum flood depth 1.4m in the 1% AEP event. The proposed filling of the area would lead to a loss of 33,000 m^3 floodplain storage. The ponding area behaves as a “natural” detention basin and help to reduce the flowrate to the downstream.

The developed condition flood modelling indicates that the proposed development would not lead to adverse flood impact to the adjourning properties. The proposed development would not significantly alter the flood hazard nor velocity distribution across the floodplain and would also unlikely affect the operation of Patons Lane over the tested flood events.

Apart from the inclusion of Basin 1, to achieve no impact to the downstream areas, two excavation areas together with surrounding levees are proposed on the floodplain to the west of the development site. The excavated areas have been configurated to function as a regional detention basin to replace the loss of the “natural” detention basin. Modelling demonstrated that there would be no loss of total floodplain storage in 1% AEP event relative to the existing condition.

REFERNCES

1. Penrith Overland Flow Flood "Overview Study", Cardno Lawson Treloar, August 2006.
2. Updated South Creek Flood Study, Volume 1 and 2, Worley Parsons, January 2015.
3. Australian Rainfall and Runoff, A Guide to Flood Estimation, Australian Government and Institution of Engineers, Australia, 2019
4. ARR Data Hub http://data.arr-software.org/
5. The Estimation of Probable Maximum Precipitation in Australia: Generalised Short Duration Method, Commonwealth Bureau of Meteorology, June 2013.
6. Australian Disaster Resilience Handbook Collection, Guideline 7-3, Flood Hazard, Australian Institute for Disaster Resilience, 2017.
7. XPRAFTS Reference Manual, XP Software, 2009
8. XPRAFTS User's Reference Manual Version 5.1, XP Software, 1996
9. Storm Injector, https://csse.com.au/storminjector_online_help/index.html, Catchment Simulation Solution
10. TUFLOW User Manual, Build 2018-03-AD, BMT, WBM, July 2019
11. DRAINS Help System
12. Preliminary Flood Assessment Technical Memo, Arcadis, October 2020