Flood Impact and Risk Assessment

The Gables New Primary School

Prepared for SINSW on behalf of NSW Department of Education / 15 November 2024

241198

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Your Partner in Engineering

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Rev	Date	Prepared By	Approved By	Remarks
1	26/06/2024	RC	PM	DRAFT
2	27/09/2024	RC	MK	FINAL
3	08/11/2024	RC	MK	Updated following planning comments
4	15/11/2024	RC	MK	-

1.0 Introduction

This Flood Impact and Risk Assessment (FIRA) has been prepared by TTW (NSW) Pty Ltd on behalf of the NSW Department of Education (the Applicant) to assess the potential environmental impacts that could arise from the development of The Gables New Primary School at Lot 301 DP 1287967 on Fontana Drive, Gables (the site).

This report has been prepared to outline the existing constraints of flooding and overland flow paths at The Gables New Primary School alongside the post-development flood conditions, including likely flood impacts (if any) that the proposed school will cause to the surrounding properties. The details of this report are based on currently available information and correspondence undertaken at the time of writing.

This report accompanies a Review of Environment Factors that seeks approval for the construction and operation of a new primary school at the site, which involves the following works:

- Construction of school buildings, including learning hubs, a school hall and an administration and library building.
- Construction and operation of a public preschool.
- Delivery of a sports court and fields.
- Construction of car parking, waste storage and loading area.
- Associated site landscaping and open space improvements.
- Associated off-site infrastructure works to support the school, including (but not limited to) services, driveways and pedestrian crossings.

For a detailed project description, refer to the Review of Environmental Factors prepared by Ethos Urban.

1.1 Site Description

The site is located on Cataract Road, Gables, within The Hills Local Government Area (LGA), approximately 50km northwest of the Sydney CBD and 10km north of the Rouse Hill Town Centre. It comprises one lot, legally described as Lot 301 DP 1287967, that measures approximately 2.2ha in area. The site is bound by Pennant Way to the north, Cataract Road to the east, Fontana Drive to the west and a vacant lot to the south.

An aerial image of the site is shown at Figure 1.

Figure 1 - Site location and surrounding area (Source: Nearmap, dated 28th August 2024).

1.2 Statement of Significance

Based on the identification of potential issues, and an assessment of the nature and extent of the impacts of the proposed development, it is determined that:

- The flood impact assessment for the 1% AEP event confirms that changes to offsite flood levels are generally less than +/- 10mm, and therefore the proposed development is considered to result in negligible offsite impacts and will not have significant adverse effects on the locality, community and the environment;
- Potential impacts can be appropriately mitigated or managed to ensure that there is minimal effect on the locality, community.

1.3 REF Reporting Requirements

This report has been prepared in accordance with the REF deliverable requirements as presented in Table 1.

Table 1 - Relevant REF Requirements

Item No.	REF Requirement	Relevant Section of Report
15.1	Where the development could alter flood behaviour, affect flood risk to the existing community or expose its users to flood risk provide a flood impact and risk assessment (FIRA) prepared in accordance with the Flood Impact and Risk Assessment – Flood Risk Management Guide LU01, the Flood Risk Management Manual 2023, Support for Emergency Management Planning. The scope of the FIRA	Refer to Section 5.2 for analysis of post-development flood behaviour. The impact of the development is assessed in Section 7.0. As outlined in Section 1.4, this report was prepared in accordance with the Flood Risk Management Guide LU01.

	should be confirmed with the Department prior to undertaking the assessment.	
15.2	Prepare the assessment in accordance with the Standard DCCEEW Flooding Requirements.	In accordance with Standard DCCEEW Flooding Requirements, refer to Section 5.2 for analysis of post-development flood behaviour. DCCEEW latest advice on climate change is discussed in Section 5.3. The impact of the development is assessed in Section 7.0.
15.3	Detail design solutions and operation procedures to mitigate flood risk, where required.	Section 5.2.3 and 6.0 consider design solutions to mitigate flood risk.
15.4	Any proposed Emergency Management strategy for an area should be compatible with the evacuation strategies identified in The Hills Shire Flood Emergency Sub Plan.	A Flood Emergency Response Plan has been prepared by TTW and submitted alongside this report. This has been produced with reference to the Support for Emergency Management Planning Guide and The Hills Shire Flood Emergency Sub Plan.

The below table addresses the FERP-related advice raised by the NSW State Emergency Service (NSW SES) and Biodiversity Conservation and Science (BCS) Group on 17 April 2024 and 10th April 2024, respectively.

Table 2 – Agency Advice

Agency	Advice	Response
NSW SES	We recommend that the SEARs should include a flood assessment detailing: ▪ an assessment of the flood risk up to and including the Probable Maximum Flood (PMF), on the site and access/egress routes. ▪ climate change considerations ▪ time to onset, duration, depth, velocity and hydraulic hazard of any flooding ▪ an assessment of the impact of the proposed development on flood behaviour.	Flood behaviour in the 20% AEP, 1% AEP, 0.5% AEP and the PMF event has been assessed in this report. The 1% AEP and PMF event flood behaviour is discussed in Section 5.0 of this report, while 20% 0.5% AEP events are in Appendix A. The impact of climate change has been considered and discussed in Section 5.3 of this report. The Flood Emergency Response Plan prepared by TTW and submitted together with this report considers time to onset and the duration of flooding. The depth, velocity and hydraulic hazard of flooding is discussed in Section 5.0. The impact of the development on flood behaviour is discussed in Section 7.0.
BCS	BCS recommends that a flood impact and risk assessment (FIRA) be provided in accordance with the Flood Risk Management Manual Flood Impact and Risk Assessment Guideline (2023).	This report has been completed in accordance with the Flood Risk Management Manual Flood Impact and Risk Assessment Guideline (2023).
	As a minimum, the FIRA must: ▪ Identify any flood risk on-site having regard to adopted flood studies, the potential effects of climate change, and any relevant provisions of the NSW Flood Risk Management Manual (2023).	Existing flood information has been assessed and discussed in Section 3.0 and Section 5.1 of this report. The impact of climate change has been considered and discussed in Section 5.3 of this report.

	▪ Assess the impacts of the development, including any changes to flood risk on-site or off-site, and detail design solutions and operational procedures to mitigate flood risk where required. ▪ Identify flood behaviour, flood constraints and risks on the site and its surrounding including the potential impacts of climate change for the full range of events i.e., up to and including the probable maximum flood (PMF) event. ▪ Propose management measures required to minimise the impacts of flooding on the development and minimise flood risk to the community, including an Emergency Management Plan considering access to and from the site, and evacuation issues during significant flood events including the PMF, from both local catchments and/or regional catchments.	The impact of the school development on flood behaviour both onsite and to neighbouring properties is discussed in Section 7.0 of this report. Flood behaviour in the 20% AEP, 1% AEP, 0.5% AEP and the PMF event has been assessed and discussed in Section 5.0 and Appendix A of this report. Stormwater management measures have been discussed in Section 5.2.3 of this report, and a Flood Emergency Response Plan has been prepared by TTW and submitted together with this report.

1.4 Guidance Documents

The following documents have been reviewed and referenced in preparing this report:

- The Hills Development Control Plan (DCP) 2012;
- The Hills Local Environmental Plan (LEP) 2019;
- The Hills Shire Council Flood Modelling and Stormwater Design Guideline, Revision 1, February 2024;
- Flood Modelling and Dam Break Assessment for The Gables by Northrop (Revision 2, 20th November 2019);
- Box Hill North Precinct Water Cycle and Flood Management Strategy Report by J. Wyndham Prince, 2013;
- Structural and Civil Concept Plan Design Report by Meinhardt Bonacci, 2023;
- The Hills Section 7.11 Contributions Plan (CP) No. 16 – Gables Precinct, adopted May 2022;
- NSW Department of Planning and Environment (2023) Flood Impact and Risk Assessment – Flood Risk Management Guide LU01;
- NSW Department of Planning and Environment (2023) Flood Risk Management Manual https://www.environment.nsw.gov.au/topics/water/floodplains/floodplain-manual;
- NSW Department of Planning, Housing and Infrastructure – Planning Circular PS 24-001, Update on addressing flood risk in planning decisions, 1st March 2024;
- NSW Planning Portal Spatial Viewer (Spatial Collaboration Portal - Map Viewers (nsw.gov.au)); and
- School Infrastructure New South Wales (SINSW) Guidelines for School Site Selection and Master Planning, 2023.

1.5 Proposed Site Activity

The site is located with the Gables, a master planned community consisting of a town centre, retail facilities, public primary school, approximately 4,100 dwellings, recreational facilities and associated roads and infrastructure. At the centre of this master plan is a constructed lake and detention basin, providing visual amenity, water quality treatment and flood mitigation functions.

As part of the NSW Government's plan to rebuild essential services, the Gables new primary school will help meet growing enrolment demand for primary school students in Sydney’s northwest suburbs, accommodating up to 1,000 students in the Hills Shire LGA. The site was acquired in early 2023 by SINSW through a Voluntary Planning Agreement (VPA) by the developer, Stockland. The latest concept design plan of the proposed school is shown in Figure 2.

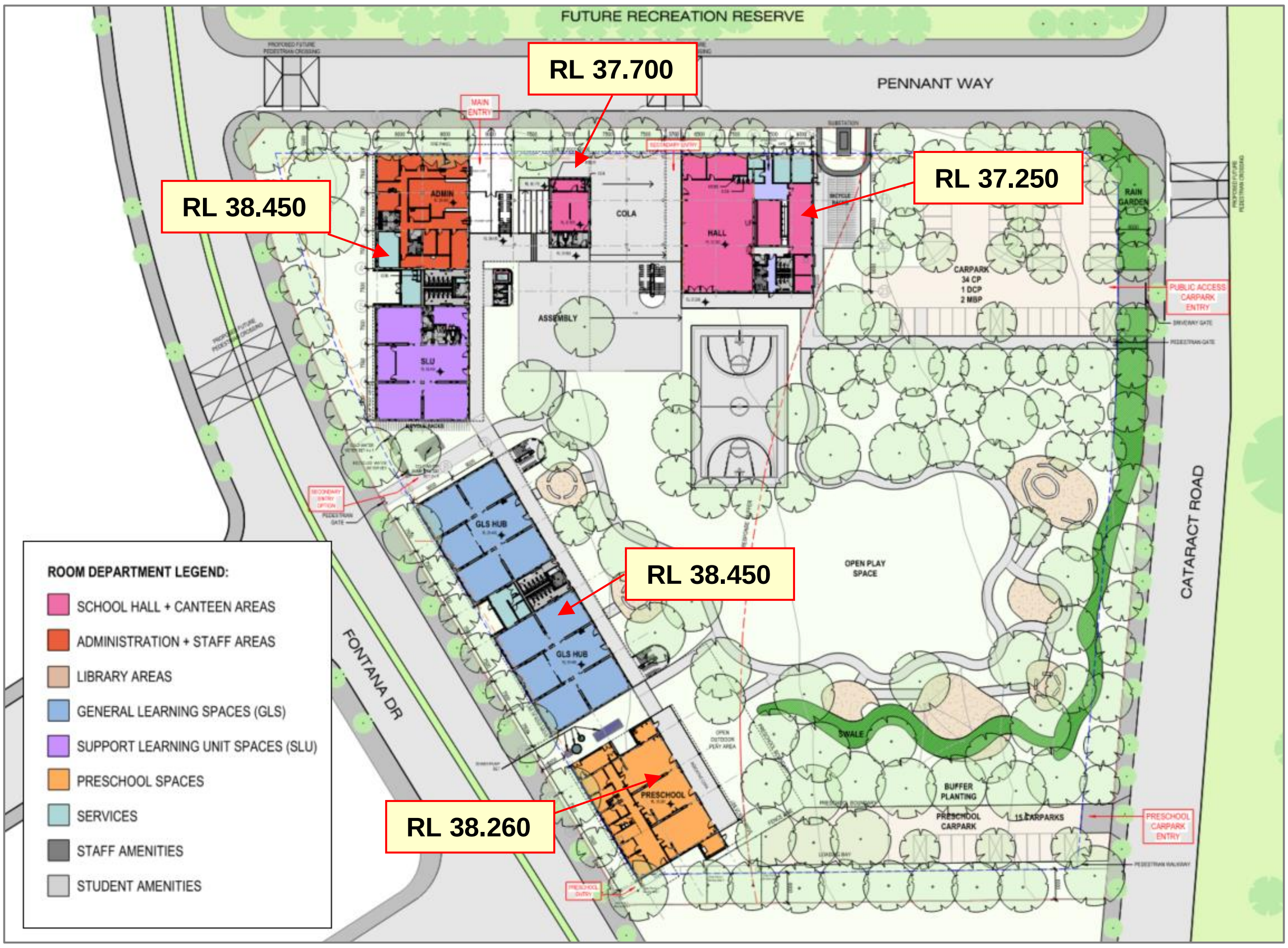

Figure 2 - Latest concept design plan and ground floor levels for the site, dated 16 October 2024 (Source: Architectus).

2.0 Site Characteristics

2.1 Site Location

The site is located at Lot 301 DP1287967, Fontana Drive, The Gables, NSW 2765, with a total area of approximately 2ha. The current site conditions and surrounding area is presented in Figure 1, with the site bounded by Fontana Drive at its western frontage, Pennant Way to the north, Cataract Road to the east and Lot 10 DP1286147 to the south. The site is currently zoned as R4 – High Density Residential.

2.2 Nearby Hydrological Features

A first-order stream lies just 50m east of the site, which drains northwards to Cataract Creek (eventually draining to Cattai Creek north-east of the site), as shown in Figure 1. The site is consequently close to a riparian corridor (Figure 3). The riparian corridors were designated as part of the Precinct Planning process in the Water Cycle and Flood Management Strategy Report (2013) to manage flood level increases and convey flood flows during flood events.

Similarly, a number of proposed detention basins lie downstream of the site, as denoted in the water cycle management plan, as shown in Figure 4.

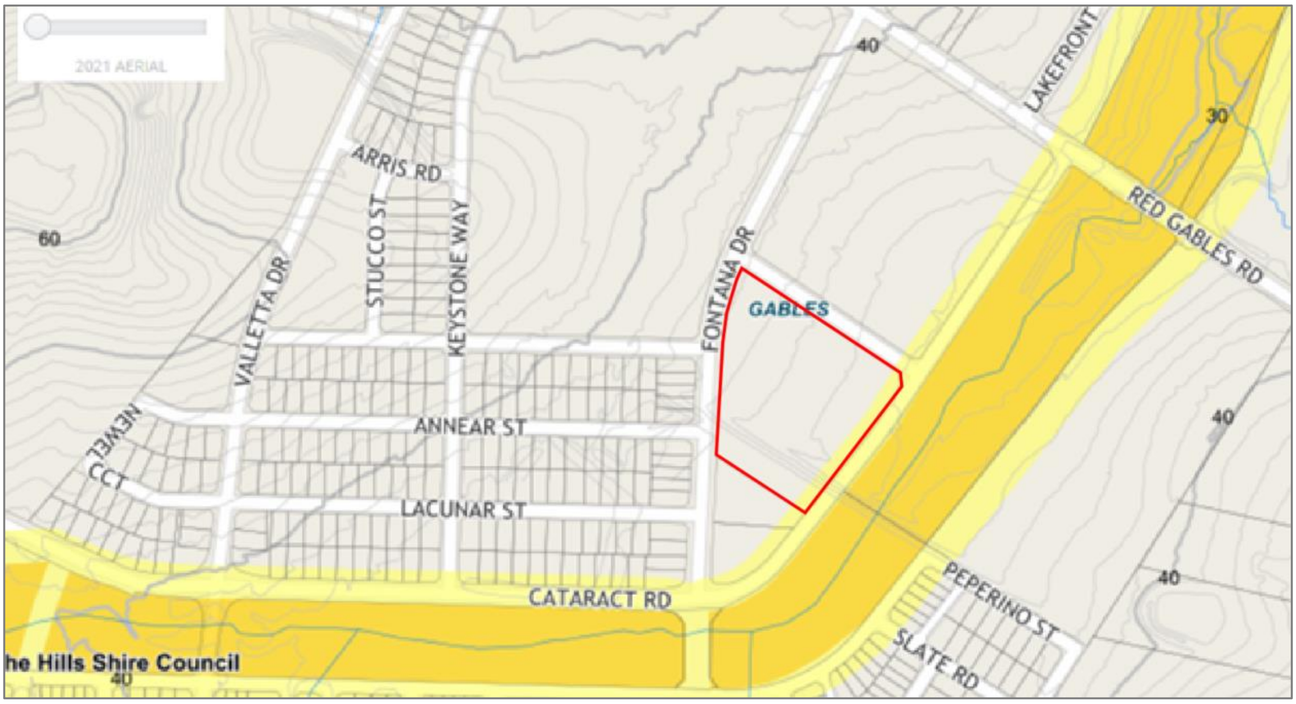

Figure 3 - Riparian corridor close to the site (Source: The Hills Shire Council Interactive Map, 2024).

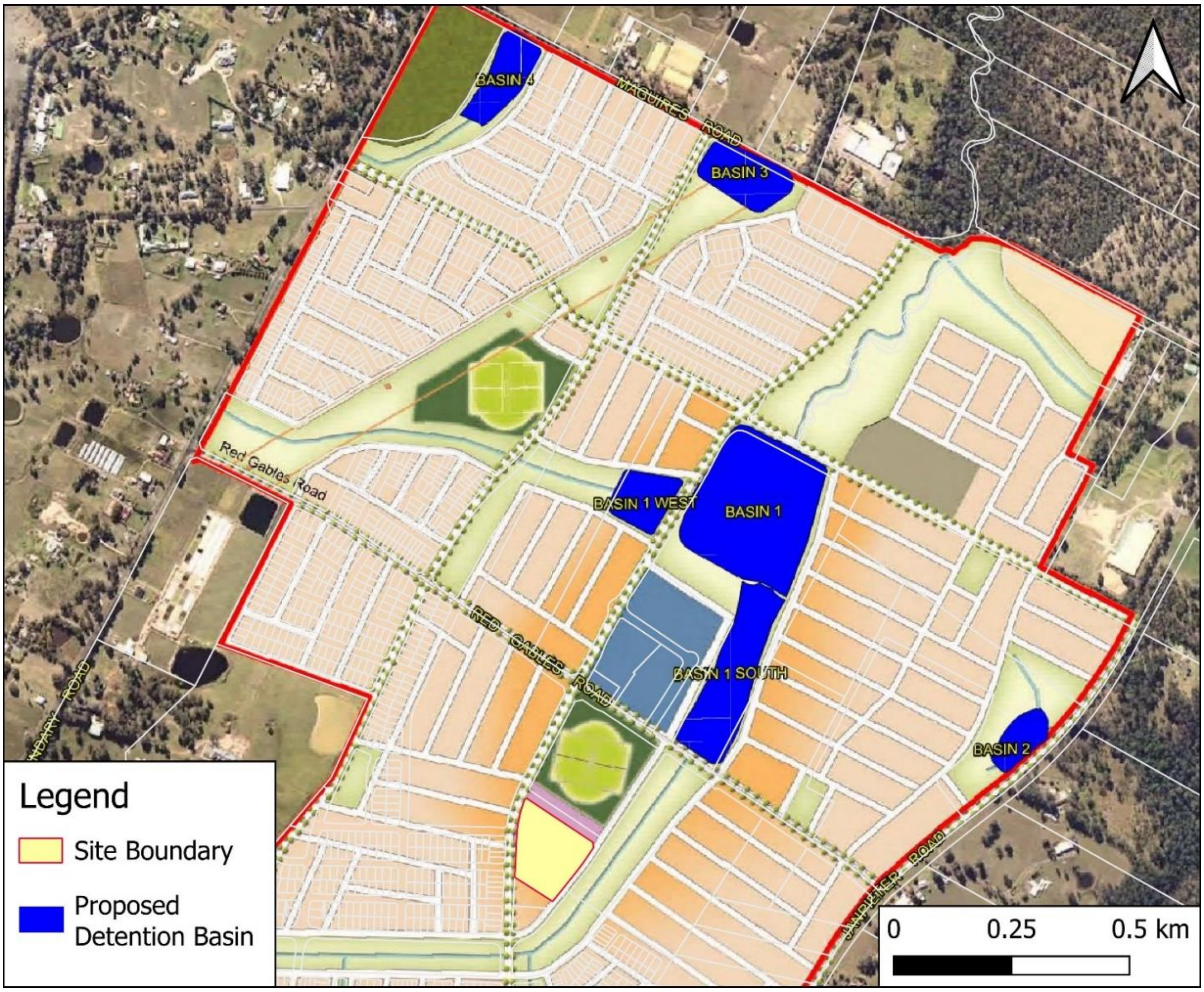

Figure 4 - Proposed detention basins in the Gables Precinct (Source: J. Wyndham Prince, 2013).

2.3 Site Topography

To assess the topography of wider area, the latest available elevation data (2017) was obtained from the Elevation Information System (ELVIS). As presented in the Digital Elevation Model (DEM) in Figure 5, the site is located in a low-lying area, with higher elevations to the west close to Valletta Drive (approximately 60m AHD) and to the east of the site (54m AHD). Elevation falls to around 30m AHD along the first-order creek east of the site.

However, it is important to note that the latest available elevation data covering the site is from 2017 – since which there has been significant development in the Gables area. Figure 6 shows the wider site in March 2017, in which most of the surrounding area is under construction and much of the road network, that exists today, not yet constructed. This consequently affects the accuracy of presumed flow routes through the site.

The 2023 *Structural and Civil Concept Plan Design Report* by Meinhardt Bonacci indicates that the northern part of the site, formerly occupied by a dam, has been extensively filled in excess of 5.0m depth since the LiDAR data was obtained. Topographical survey data of the site collected by Monteath and Powys in July 2022 is presented in Figure 7. Survey data indicates that there is a prevailing west to east slope within the site boundary, with a high of 39.7m AHD in the northwest (at the corner of Fontana Drive and Pennant Way) and a low of 34.2m AHD in the northeast (at a 3.2% gradient), with surface runoff collecting at the creek tributary.

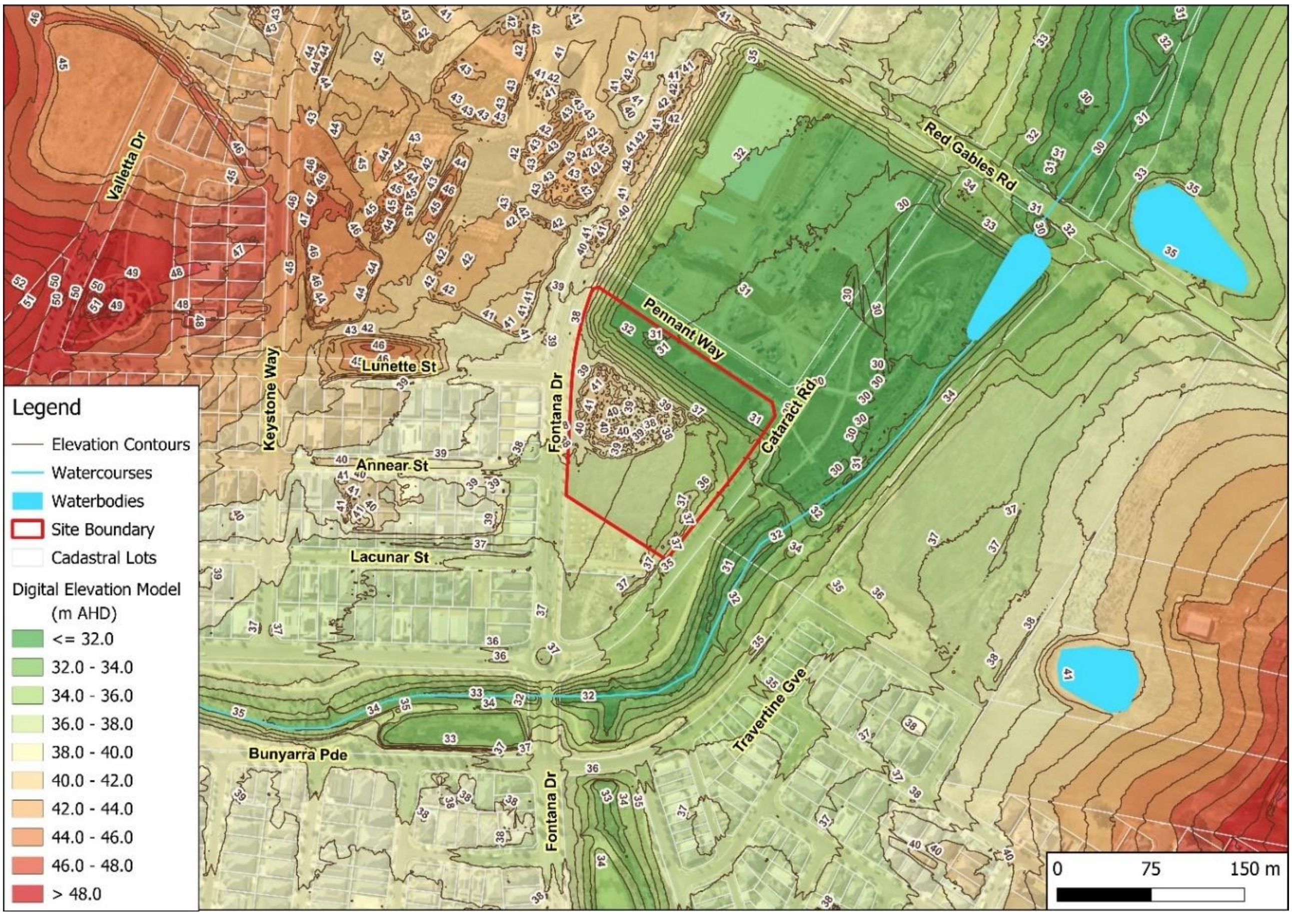

Figure 5 - Topography of the site and its surrounding area using 2017 LiDAR data (Source: ELVIS).

Figure 6 - Site and its surrounding area, captured in March 2017 (Source: Nearmap).

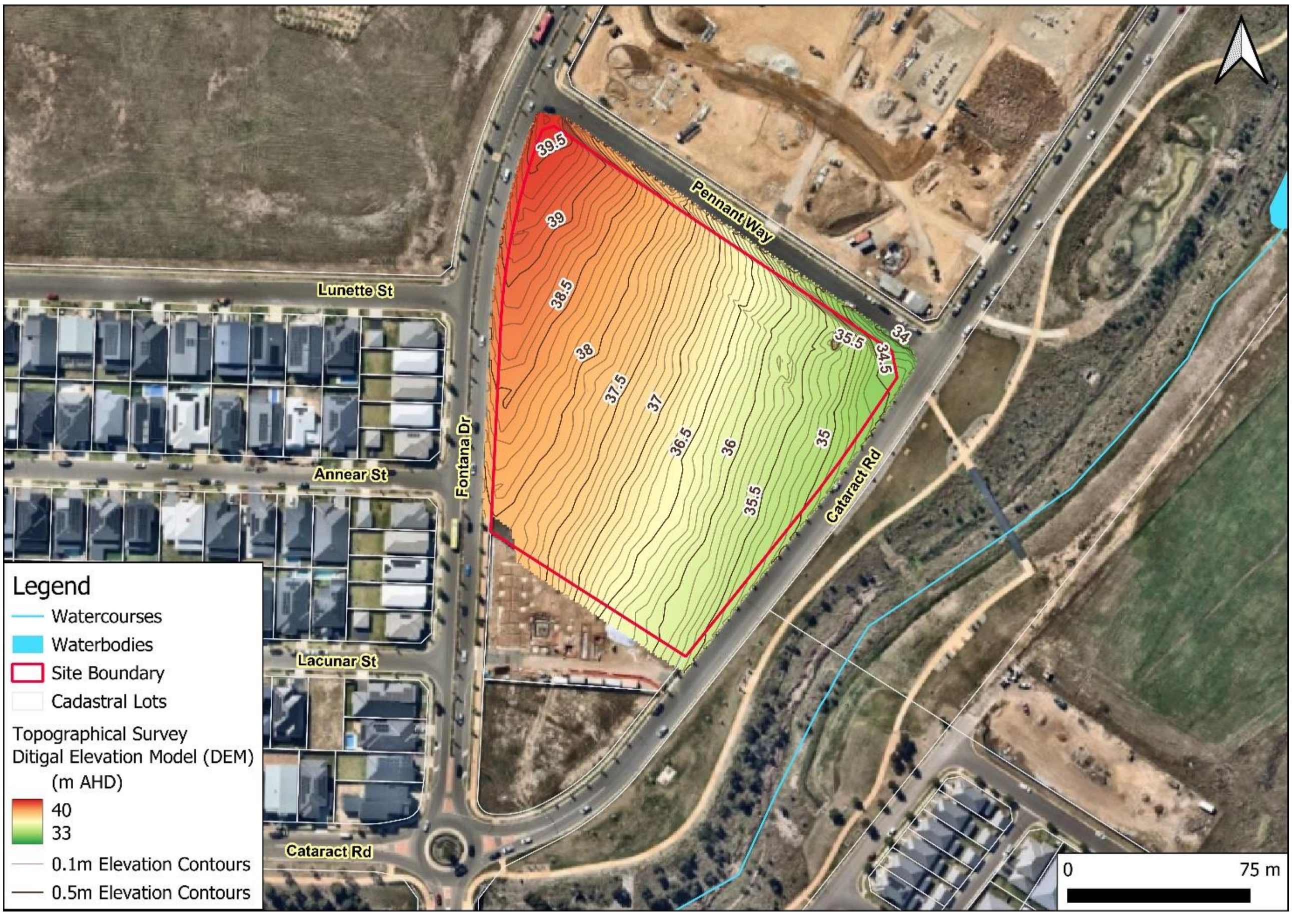

Figure 7 - Digital Elevation Model of the site based on 2022 topographical survey (Source: data obtained from Monteath and Powys, 2022).

3.0 Existing Flood Information

3.1 Water Cycle and Flood Management Strategy Report, 2013

J. Wyndham Prince completed the Water Cycle and Flood Management Strategy Report in July 2013 for Gables (formerly known as Box Hill North Precinct) to identify stormwater and flood management issues to be considered when catering for the future development requirements of the precinct.

A TUFLOW model was produced to assess flood risk in the Precinct both pre- and post-development for the 2-year Annual Recurrence Interval (ARI), 100-year ARI and the Probable Maximum Flood (PMF). While the report notes that flood levels can largely be accommodated within the Precinct's riparian corridors and drainage reserves, it acknowledges that the local PMF event affects a number of properties adjacent to the riparian corridor. Figure 8 and Figure 9 show the location of the site in relation to the estimated flood extent for the 100-year ARI and the PMF events, respectively.

It should be noted that the precinct layout shown in these results were a draft indicative layout plan. The layout has since been adjusted and the location of the school is therefore altered slightly to that shown on the plan.

In the 2013 strategy report, the site is not affected by flooding in the 100-year ARI event as flood waters are contained within the creek. By contrast, the site is shown to be flooded in the PMF event with a peak flood level of 36.5m AHD. Depths within the site boundary peak between 0.5 – 1.0m in the northeast, whilst the northwest remains flood immune.

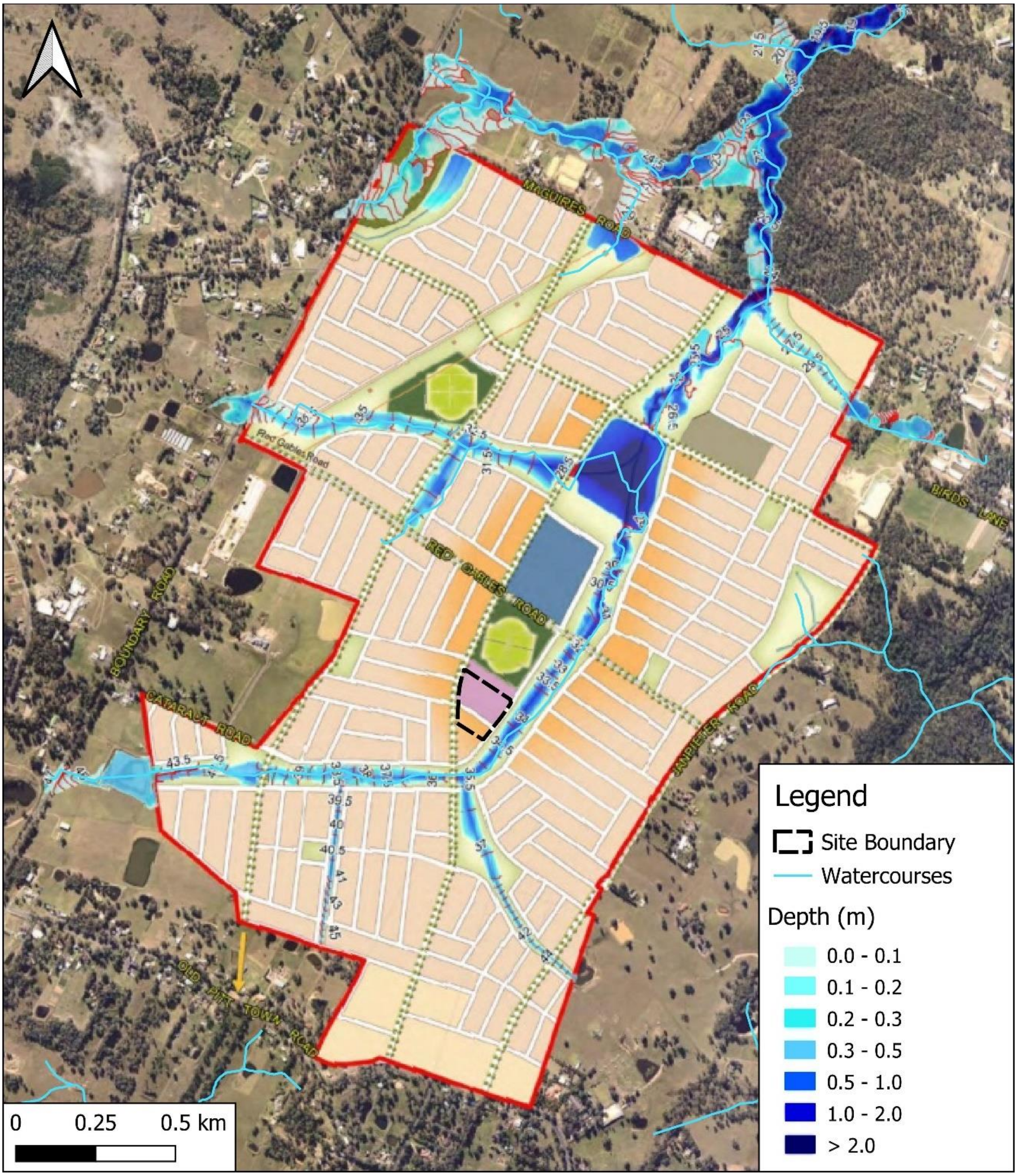

Figure 8 - 100-year ARI flood levels and depths in the Gables Precinct (Source: J. Wyndham Prince, 2013).

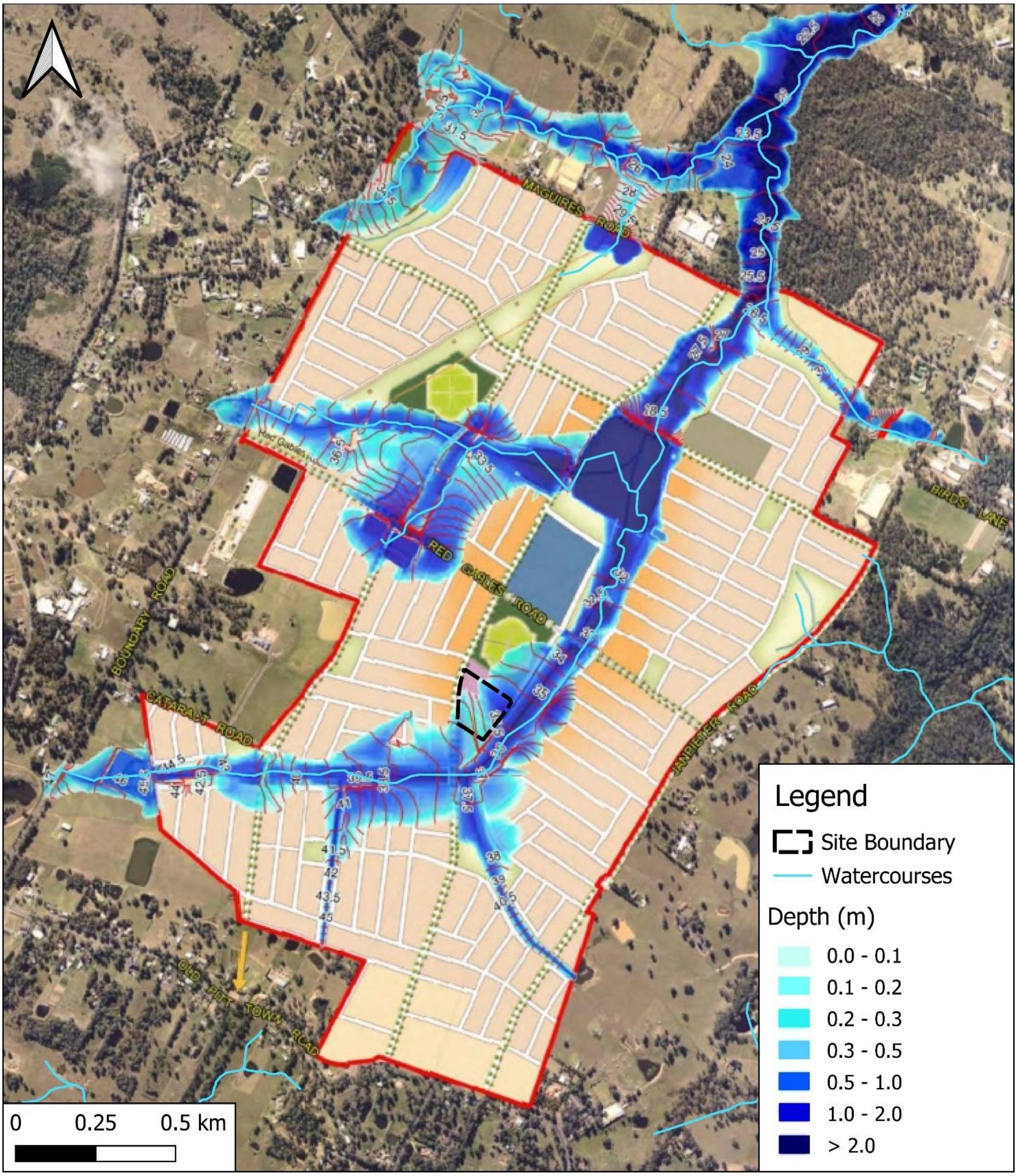

Figure 9 - PMF levels and depths in the Gables Precinct (Source: J. Wyndham Prince, 2013).

3.2 Flood Modelling and Dam Break Assessment for The Gables, Northrop, 2019

The latest and most up-to-date flood data available for the Gables is the Dam Break Assessment completed by Northrop Consulting Engineers, which was last revised in November 2019. Northrop Consulting Engineers were engaged to prepare a flood model and dam break assessment for The Gables Precinct. This built upon the Flood Impact Assessment previously completed by J. Wyndham Prince in 2015. The flood model was developed using TUFLOW software and a rainfall-on-grid hydrology approach.

Flood levels and depths during the 1% AEP (Annual Exceedance Probability) and Probable Maximum Flood

(PMF) events are shown in Figure 10 and Figure 11, respectively.

In the 1% AEP event, floodwaters are contained within the riparian corridor with a flood level of approximately RL 32.00m – 33.00m east of the site, leaving the site flood immune. As with J. Wyndham Prince's (2013) results, the site is shown to be flooded in the PMF, though depths are less than those simulated previously, ranging between 0.1m – 0.3m at the northeast of the site. Flood levels to the east of the site are between RL 34.00m – 35.00m, while levels reach RL 38.00m to the south and west. Hazard mapping of the PMF event, shown in Figure 12, indicates that hazard within the site is low at H1.

Though this study provides a good indication of flood behaviour on-site, further hydraulic modelling is required to give a full assessment of flood levels on-site during major flood events.

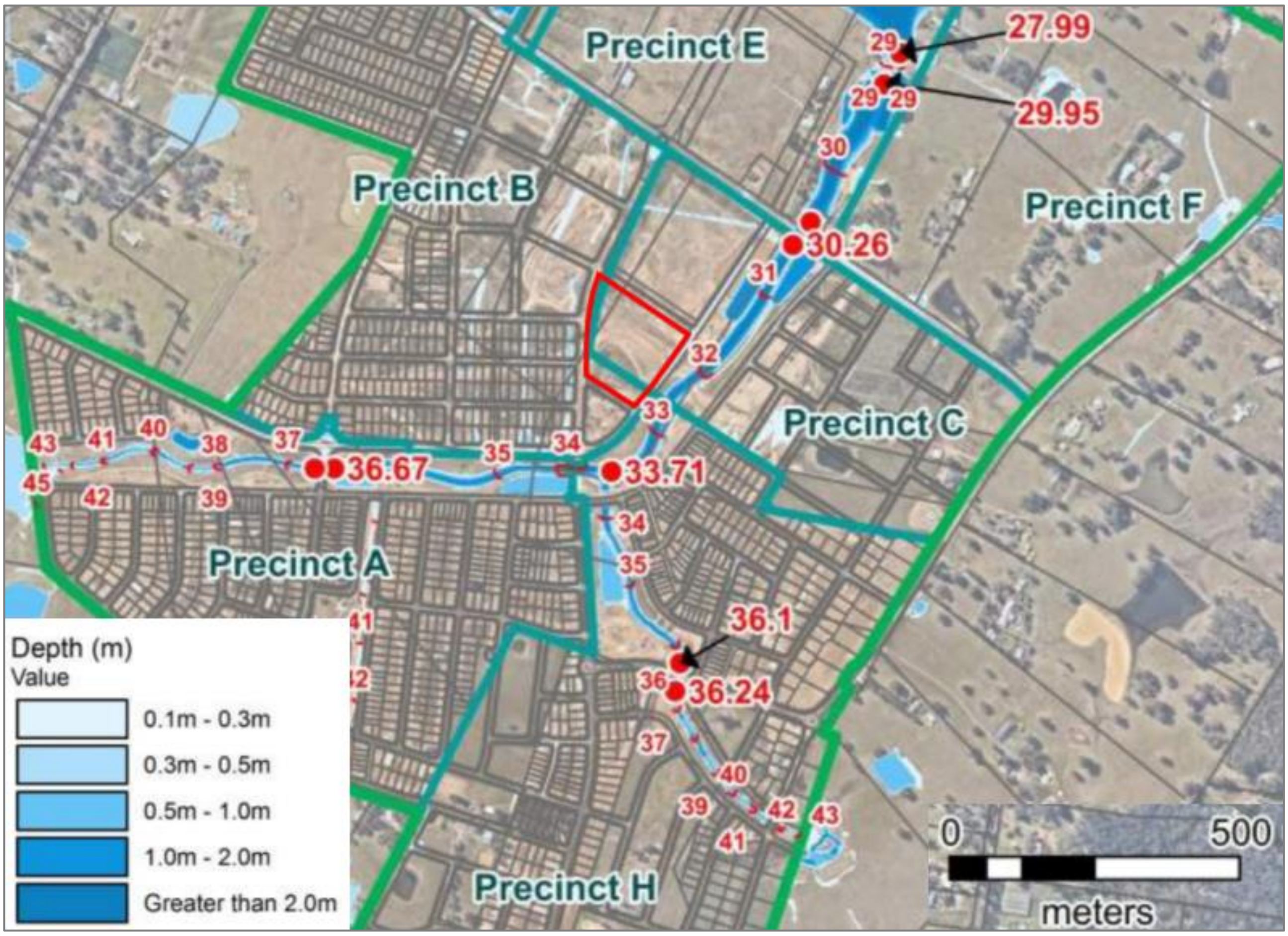

Figure 10 - 1% AEP flood levels and depths in the Gables Precinct (Source: Northrop Consulting Engineers, 2019).

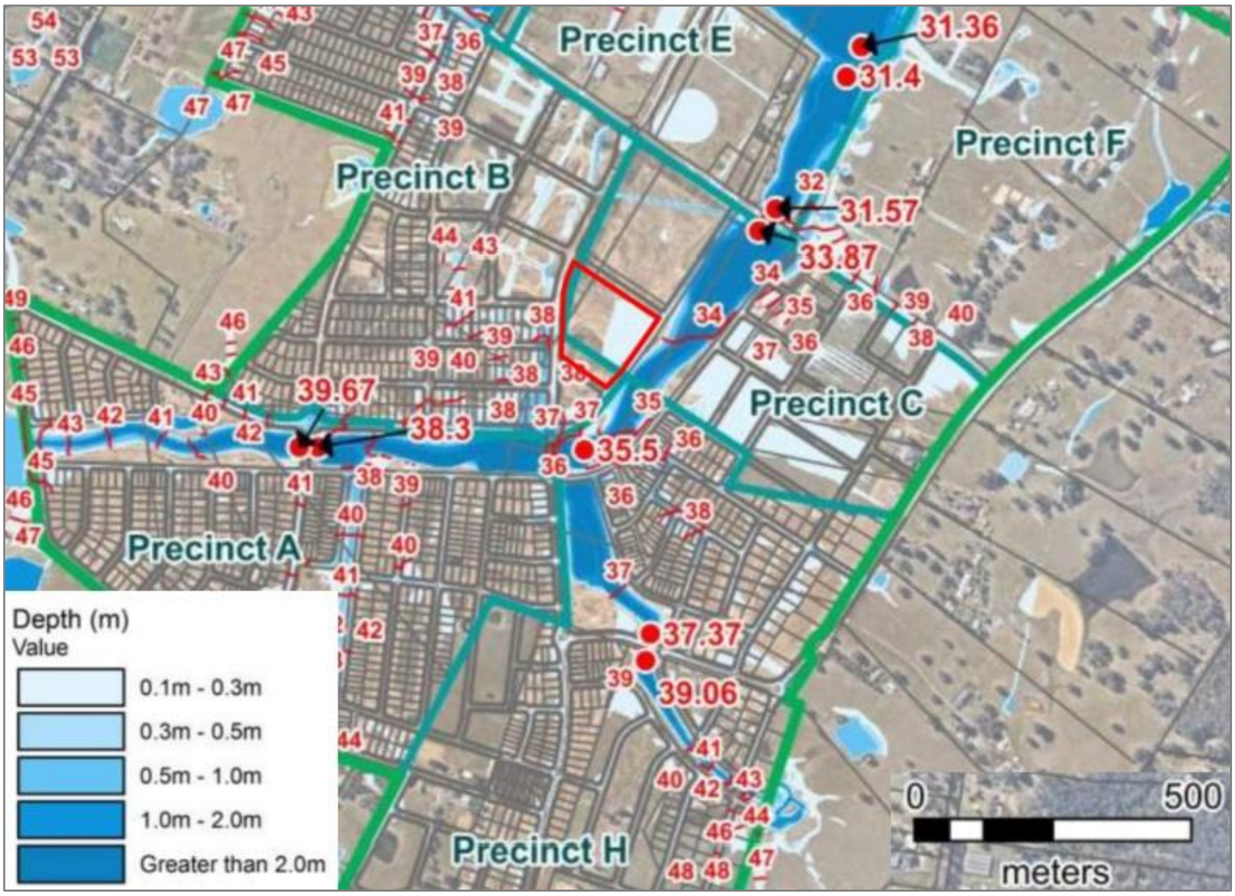

Figure 11 - PMF levels and depths in the Gables Precinct (Source: Northrop Consulting Engineers, 2019).

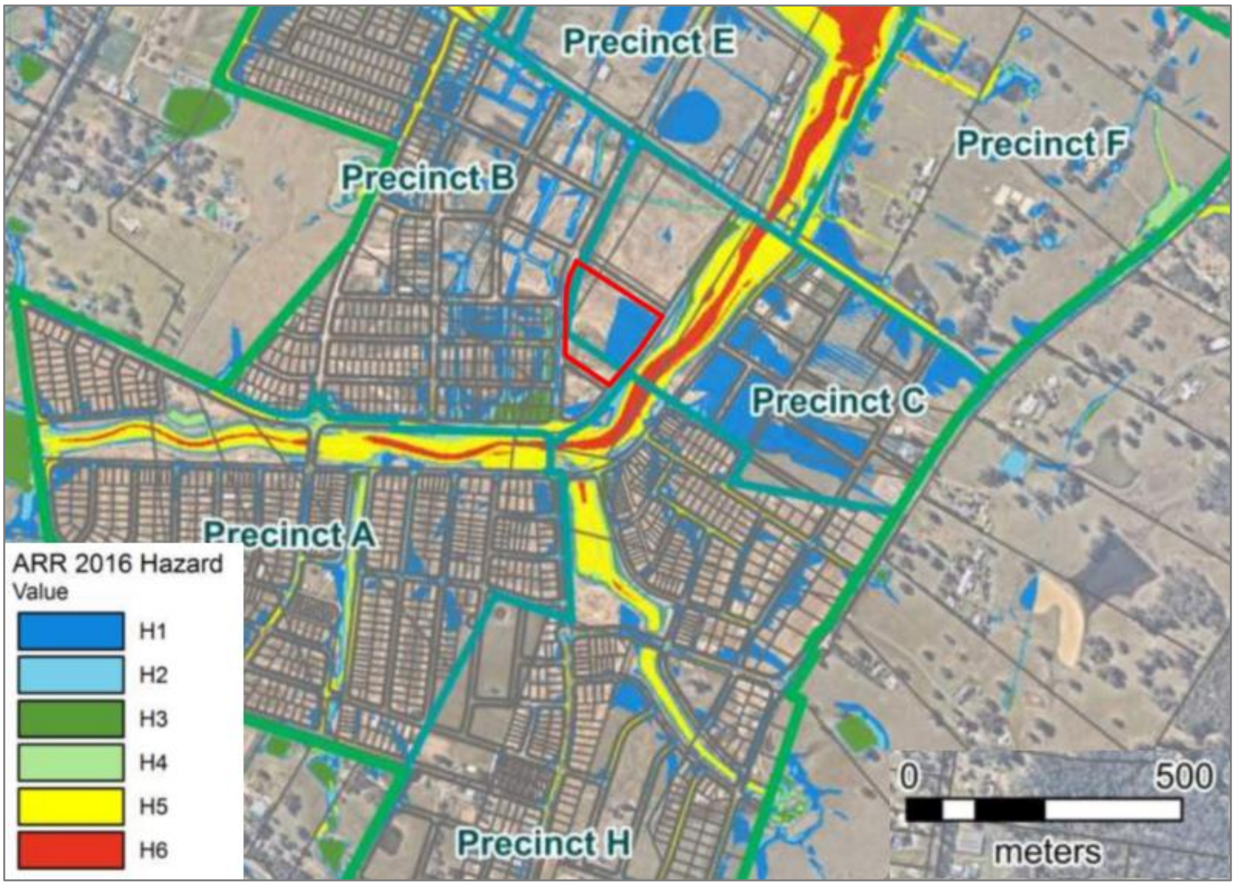

Figure 12 - PMF hazard in the Gables Precinct (Source: Northrop Consulting Engineers, 2019).

4.0 Methodology

4.1 The Gables Lake CC TUFLOW Model, Northrop, 2019

Stockland, the developer, provided TTW with the latest TUFLOW hydraulic model for The Gables, prepared by Northrop Consulting Engineers as part of their Dam Break Assessment Report (2019). This has been used as a basis for the flood modelling completed as part of this report. The model boundary is shown against the site location in Figure 13. The modelling methodology used by Northrop can be summarised as follows:

- The model was developed using TUFLOW software and a rainfall on grid hydrology approach.
- Rainfall depths and temporal patterns from Australian Rainfall and Runoff (ARR) 1987 have been adopted.
- Probable Maximum Precipitation (PMP) has been estimated using the Generalised Short Duration Method (GSDM).

Northrop's assessment includes an 'Existing' scenario, in which the Gables area is still in development, and an 'Ultimate Developed' scenario which accounts for the future development according to the master plan design of the community. This developed scenario provides a more accurate representation of future flood behaviour in the area as it accounts for increases to the total impervious area and subsequent increases in the discharge rate to the downstream drainage network and waterways that future Gables development may produce.

The 'Ultimate Developed' model is therefore used as the basis in this flood assessment.

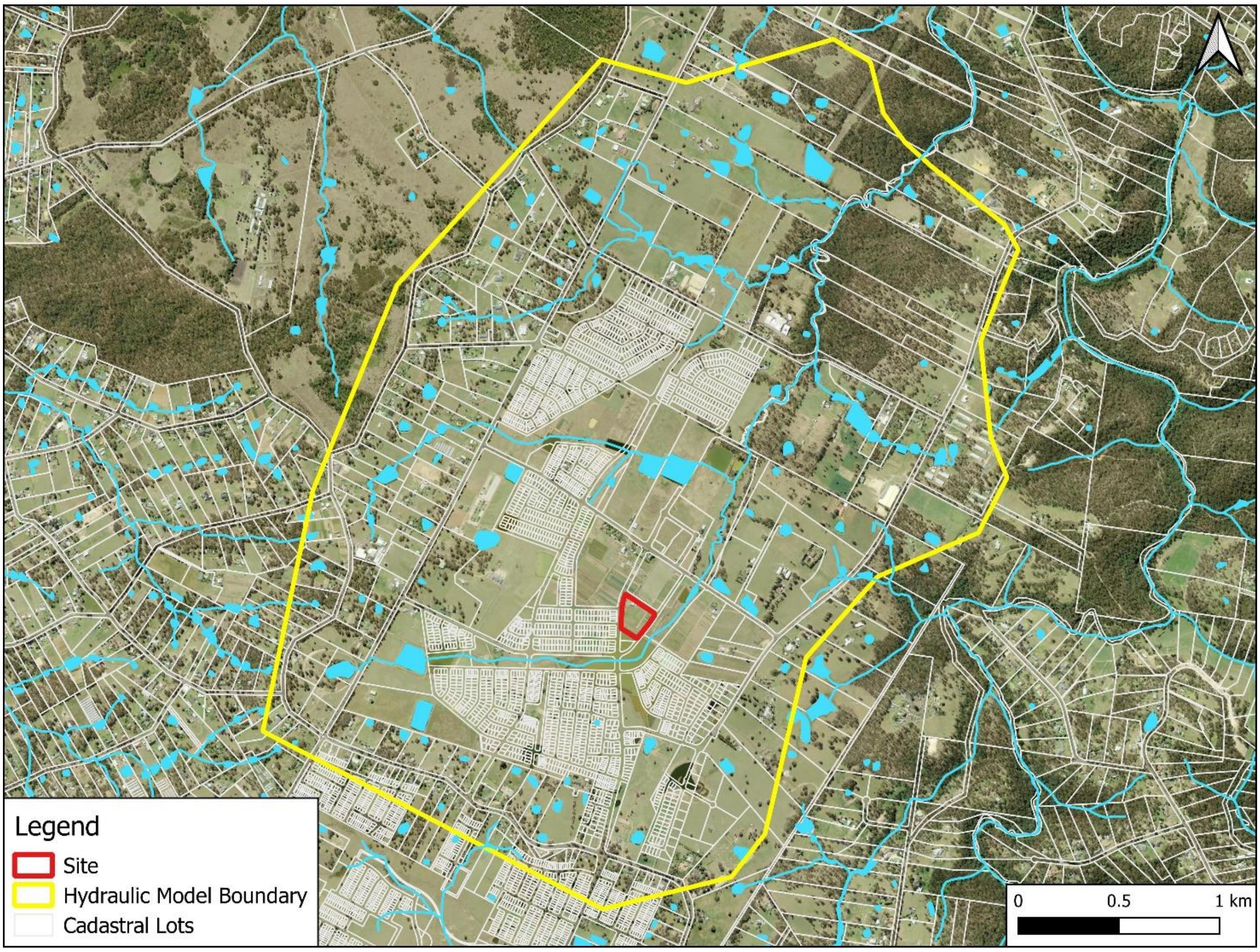

Figure 13 - TUFLOW Hydraulic model boundary

4.2 TTW Hydraulic Model Updates

As of September 2017, TUFLOW offers HPC (Heavily Parallelised Compute) as an alternative 2D Shallow Water Equation (SWE) solver to TUFLOW Classic. While TUFLOW Classic is limited to running a simulation on a single CPU core, HPC can run a single TUFLOW model across multiple CPU cores or GPU graphics cards, providing significantly quicker run times.

Using TUFLOW Classic, model run times were upwards of 10 hours for the 1% AEP event. To reduce the amount of simulation time required for this assessment, sensitivity tests were conducted using the HPC engine (with the 2018-03-AE-iDP-w64 TUFLOW executable). Comparison of the 1% AEP event results between the Classic and HPC runs showed the difference in flood levels were typically +/- 10mm within the site and surrounding area, as depicted in the afflux map in Figure 14. Given that the level differences are within acceptable limits and hence considered appropriate for the purpose of this study, the HPC solution scheme was adopted and used in all model runs.

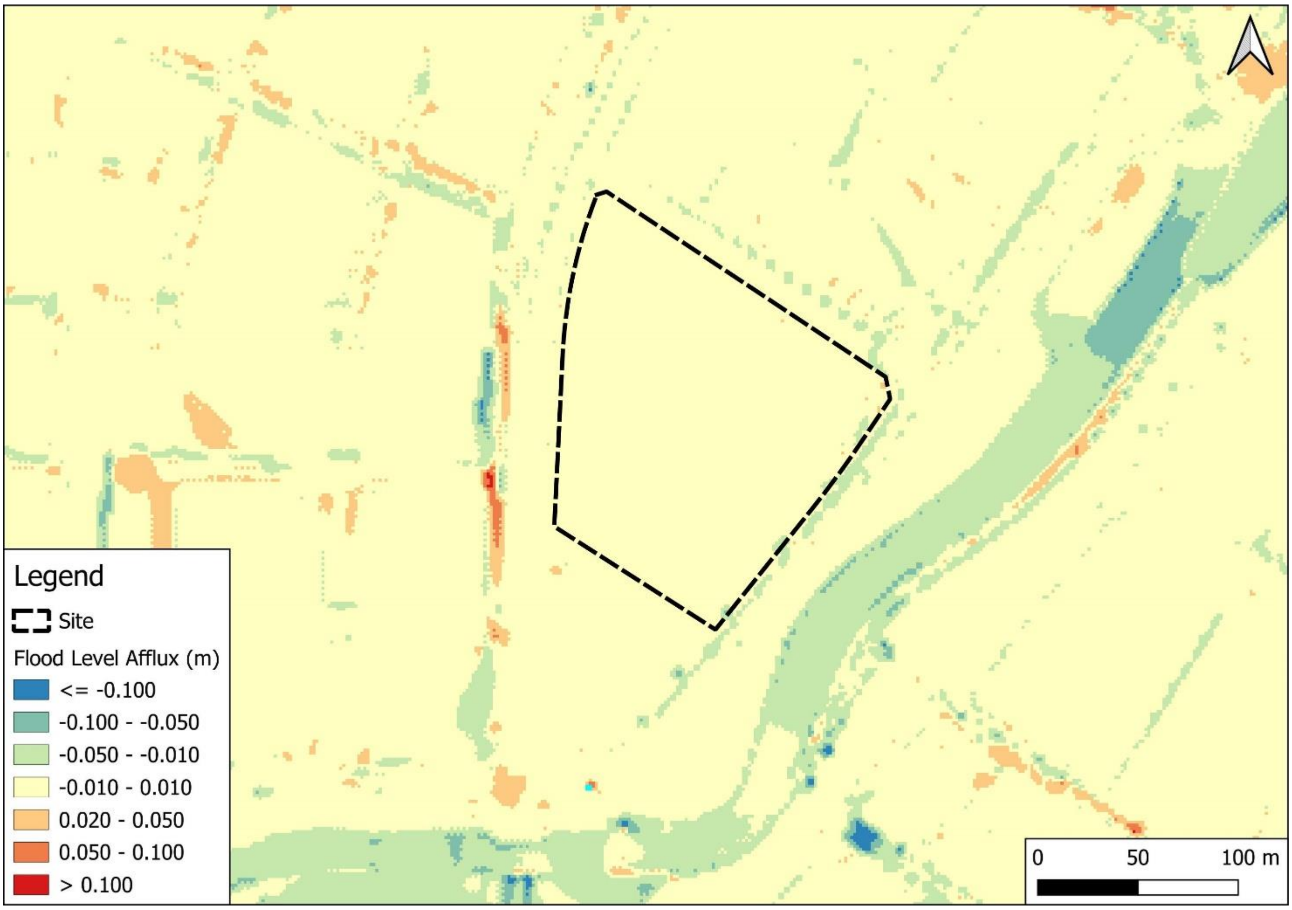

Figure 14 - 1% AEP event flood level afflux between the HPC and Classic runs

As part of this assessment, the Northrop's Ultimate Developed model was updated as follows:

- Digital elevation model updated to include the topographical survey data of the site collected by Monteath and Powys in July 2022.
- Manning's n of site refined using aerial imagery to reflect the current undeveloped conditions at the site for the existing scenario. For the post developed scenario, the Manning's n was adjusted to account for the additional hardstand areas within the site.
- Building footprints around the site (specifically, the block of residential buildings at Lunette Street, Annear Street, Lacunar Street and Cataract Road west of the site) were incorporated based on aerial imagery.
- The central traffic strip along Fontana Drive was incorporated into the model, assuming a height of 150mm.
- The civil design TIN (dwg format) provided by Meinhardt on 3rd September was added to the model in the post-development scenario to represent the proposed development.

4.3 Flood Hazard Categories

The relative vulnerability of the site to flood hazard has been assessed by using the flood hazard vulnerability curves set out in 'Handbook 7 – Managing the Floodplain: A Guide to Best Practice in Flood Risk Management in Australia' of the Australian Disaster Resilience Handbook Collection (2017).

These curves assess the vulnerability of people, vehicles and buildings to flooding based on the velocity and depth of flood flows. The flood hazard categories are outlined in Figure 15, ranging from a level of H1 (generally safe for people, vehicles and buildings) to H6 (unsafe for vehicles and people, with all buildings considered vulnerable to failure). Table 3 outlines the threshold limits for each hazard category.

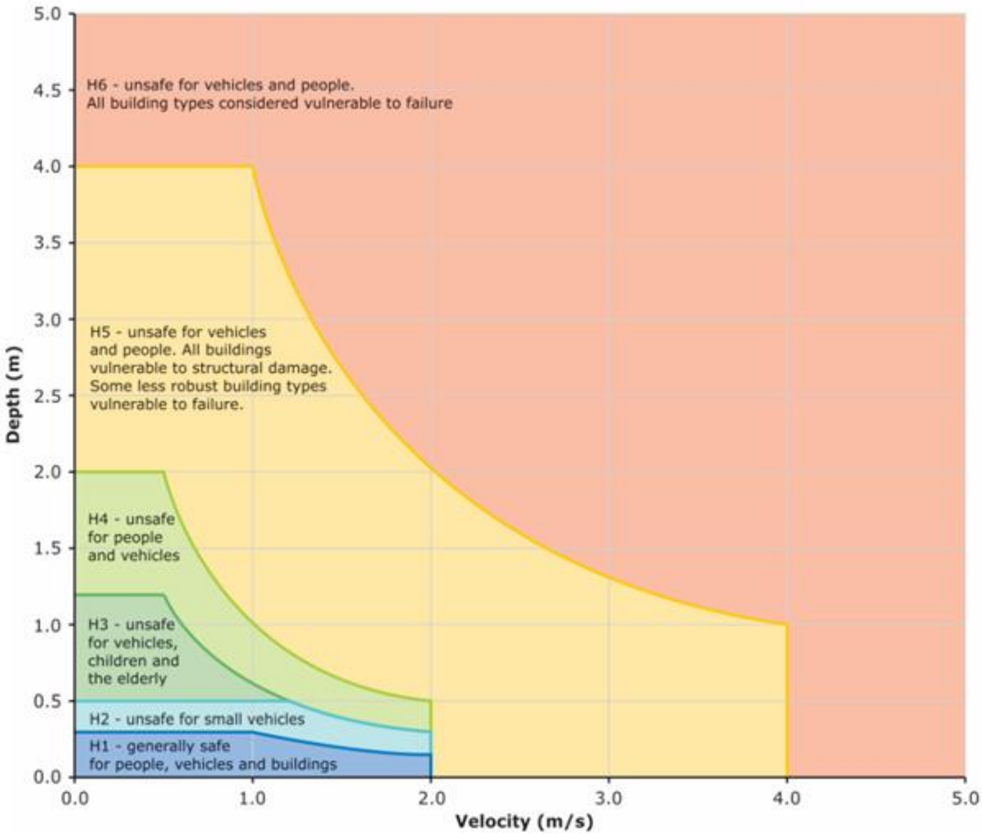

Figure 15 - Flood hazard vulnerability curve (Source: Flood Risk Management Guide FB03 - Flood Hazard, NSW Department of Planning and Environment, 2022)

Table 3: Hazard vulnerability threshold limits

Hazard	Description	Classification Limit (m2/s)	Limiting still water depth (D) (m)	Limiting velocity (V) (m/s)
H1	Generally safe for people, vehicles and buildings	D x V ≤ 0.3	0.3	2.0
H2	Unsafe for small vehicles	D x V ≤ 0.6	0.5	2.0
H3	Unsafe for vehicles, children and the elderly	D x V ≤ 0.6	1.2	2.0
H4	Unsafe for people and vehicles	D x V ≤ 1.0	2.0	2.0
H5	Unsafe for people and vehicles. All buildings vulnerable to structural damage.	D x V ≤ 4.0	4.0	4.0
H6	Unsafe for people and vehicles. All building types considered vulnerable to failure.	D x V > 4.0	No Limit	No Limit

4.4 Critical Durations

The Northrop Dam Break Report (2019) adopted the enveloped results for its assessment of the 1% AEP and PMF events. Numerous storm durations were assessed in this study to identify the critical storm duration across various events for the subject site. Table 4 outlines the model runs completed for each event, alongside the critical duration for the site. These critical duration storms have been adopted for the subsequent assessment as part of this study. Note that the Northrop study assessed only two storm durations for the 0.5% AEP event, and therefore there were no DRAINS hydrographs for storms shorter than 120-minutes for this event.

Table 4: Critical duration assessment for the proposed Gables school site

Event	Storm Durations Assessed (mins)	Critical Duration
20% AEP	30, 60, 90, 120	90 minutes
1% AEP	15, 30, 60, 90, 120, 180	30 minutes
0.5% AEP	120, 270	120 minutes
PMF	15, 30, 60, 90, 120, 180, 360	15 minutes

4.5 Flood Cut Off

In line with Northrop's model, a rainfall on grid (ROG) hydrology approach has been adopted, in which rainfall is applied to each cell in the 2D mesh. Hydrologic losses and runoff are therefore calculated for each cell and routed through downstream cells to evaluate flood depths and velocities. Modelling therefore reports flood behaviour at every grid cell, and the ROG method is typically associated with substantial shallow sheet flow. While depths of less than 0.005m have consequently been filtered out of the simulation outputs, results still indicate significant flood affectation across the entire model extent due to the ROG method.

Therefore, a cut off depth of 0.1m has been used for mapping all flood extents in line with The Hills Shire Council Flood Modelling and Stormwater Design Guideline (2024). The Northrop report also notes that for the purposes of their study, it was assumed (and agreed with The Hills Shire Council) that any flow under 100mm depth was classified as sheet flow and not reported in the figures.

Although this mapping approach has been adopted in this study, it is understood that the flood affectation of a property is subject to a site-specific assessment by Council.

5.0 Results

The existing and post-development flood conditions on-site during the critical 1% AEP and PMF events assessed are discussed in this section of the report.

In addition, flood maps for the existing and post-development site conditions for the 20% and 0.5% AEP events are presented in Appendix A.

5.1 Existing Scenario

5.1.1 1% AEP Event

The existing peak flood levels and depths, velocities, and hazards for the 1% AEP event assessed are shown in Figure 16, Figure 17 and Figure 18 respectively.

Flood depths within the school site are generally less than 0.1m and are thereby excluded from flood extent mapping. The majority of flood depths onsite are less than 50mm, reflective of the rainfall on grid methodology. While the site is subject to overland flow, this is mostly generated onsite. Shallow sheet flow is directed across the site to the southeast and towards the adjacent creek, at low velocities ranging between 0.1 – 0.3 m/s (Figure 17). The site is not subject to mainstream flooding from the adjacent eastern creek. Given the shallow depths onsite, the flood levels are only marginally higher than the existing ground level, peaking at 39.52m AHD to the northwest and dropping to 34.3m AHD to the northeast.

There is pooling in the 1% AEP event at the corner of Pennant Way and Cataract Road, with depths generally around 0.2 – 0.4m, but peaking at 0.50m close to the kerb and gutter system. As denoted in Figure 18, hazard here reaches H2 (unsafe for small vehicles), while the entire school site and surrounding roads are generally categorised as low hazard (H1 - generally safe for people, vehicles and buildings) in the 1% AEP event assessed.

Figure 16 - Peak flood levels and depths at the site in the 1% AEP event, pre-development of school

Figure 17 - Peak flood velocity at the site in the 1% AEP event, pre-development of school

Figure 18 - Peak flood hazard at the site in the 1% AEP event, pre-development of school

5.1.2 PMF Event

The existing peak flood levels and depths, velocities, and hazards for the PMF event assessed are shown in Figure 19, Figure 20 and Figure 21 respectively.

As in the 1% AEP event, PMF depths within the school site are less than 0.1m depth with the majority of flood depths onsite less than 50mm. Flood velocities within the site have increased somewhat, peaking between 0.5 – 0. 8 m/s in some areas to the east (Figure 20), though hazard within the site remains at H1. Flood hazard at the northeastern corner of the site along Pennant Way increases in the PMF event, reaching H5 along the road corridor. Hazard is also H5 at the western frontage of the site on Fontana Drive.

While depths within the creek system have increased, results show that flows are generally contained within the riparian corridor and the site is not affected by mainstream flooding in the PMF, even when a depth cutoff is not applied.

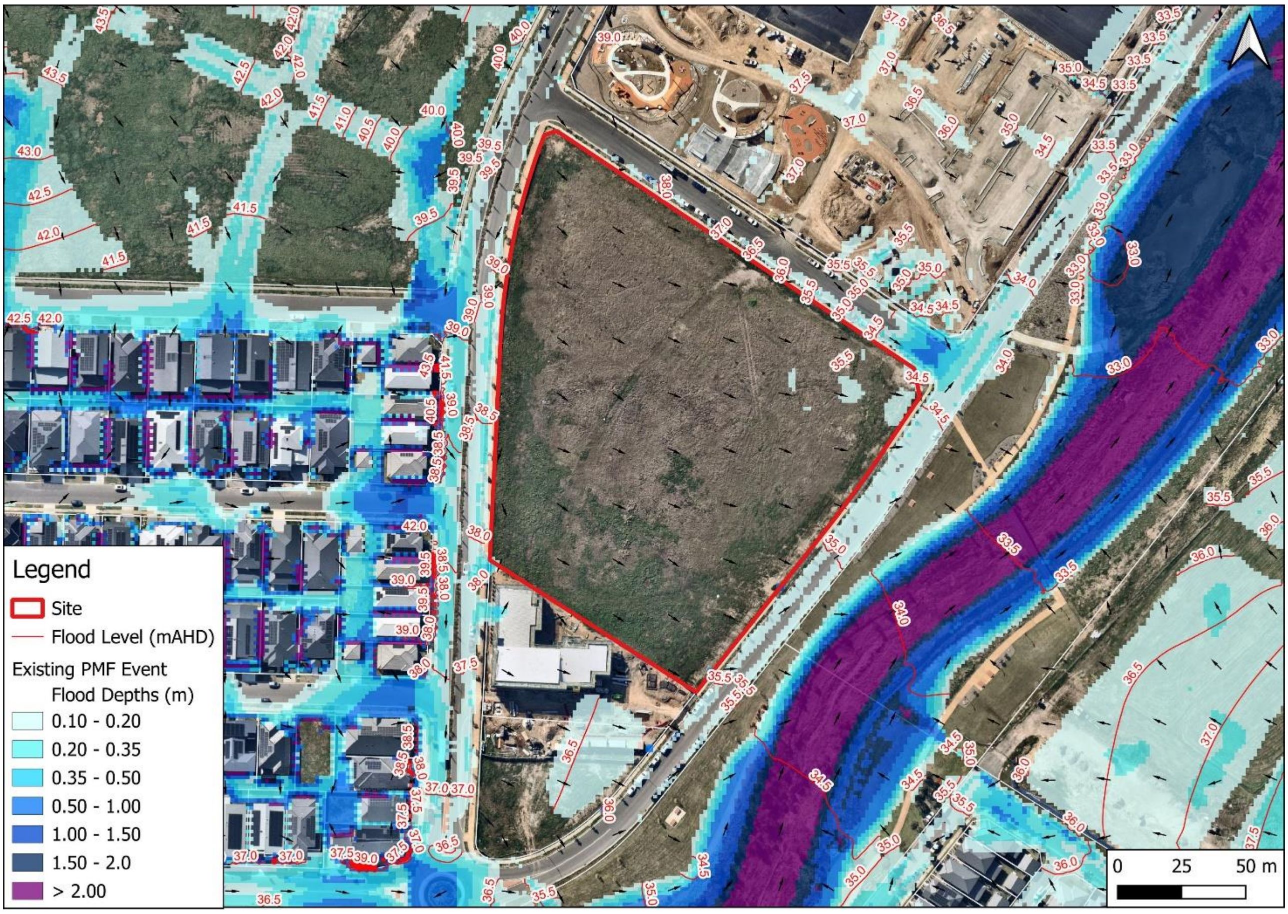

Figure 19 - Peak flood levels and depths at the site in the PMF event, pre-development of school

Figure 20 - Peak flood velocity at the site in the PMF event, pre-development of school

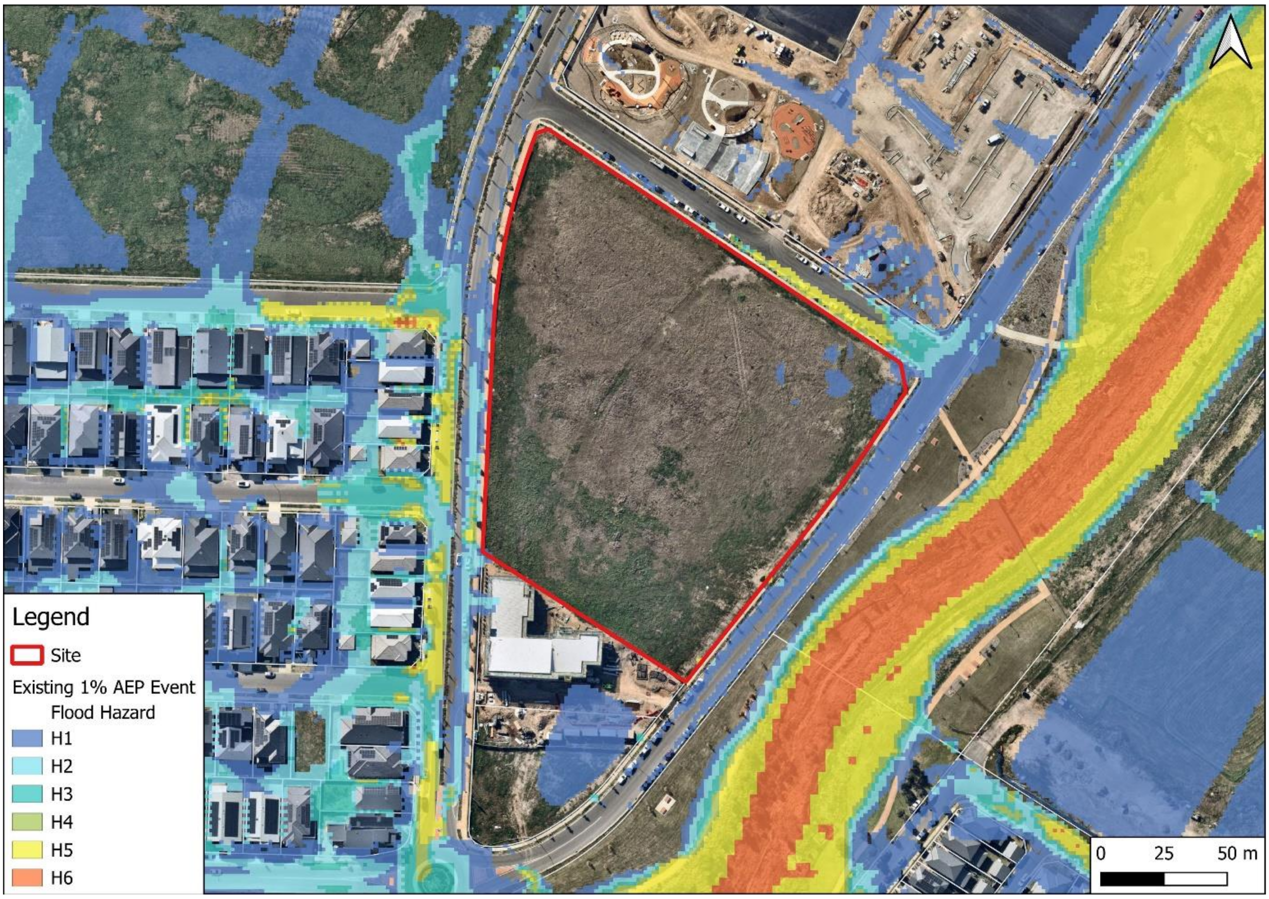

Figure 21 - Peak flood hazard at the site in the PMF event, pre-development of school

5.2 Post-Development Scenario

5.2.1 1% AEP Event

The peak post-development flood levels and depths, velocities, and hazards for the 1% AEP event assessed are shown in Figure 22, Figure 23 and Figure 24 respectively.

As in the existing scenario, the site is subject to some overland flow that is largely generated onsite as a result of the rainfall on grid modelling methodology. Shallow sheet flow is directed across the site to the southeast and towards the adjacent creek, at low velocities ranging between 0.1 – 0.3 m/s, though this increases in concrete areas such as the sports court and car park, peaking at approximately 1.0 m/s (Figure 23). The site is not subject to mainstream flooding from the eastern creek.

While across the wider school site flood depths are generally less than 0.05m, pooling of floodwaters is evident along the perimeter of the buildings in the 1% AEP event due to the proposed cut along the perimeter of the proposed school buildings (Figure 22). Depths around the buildings generally range between 0.2 – 0.9m, peaking at around 1.05m at the western perimeter of the northwest building currently designated as administration space (refer to Figure 2). While flood hazard across the site is generally low at H1, this rises to H2-H3 around the perimeter of the buildings, reaching H4 at the communal hall (Figure 24). It should be noted that this pooling is considered a site stormwater management issue that must be addressed as part of the site civil design as opposed to flooding.

It should be noted that the proposed swale and rain garden along the south and east of the site have not been incorporated into the model as part of this assessment, as these changes have been incorporated into the design after the completion of the hydraulic modelling and assessment works. However, these additions are not expected to have any impact on the flood regimes estimated around the proposed buildings as presented in this report. Nonetheless, it is anticipated that the swale would lead to a slight increase in flood depth (and potentially flood hazard) along the length of the swale as overland flow would concentrate and be funnelled offsite.

Figure 22 - Peak flood levels and depths at the site in the 1% AEP event, post-development of school

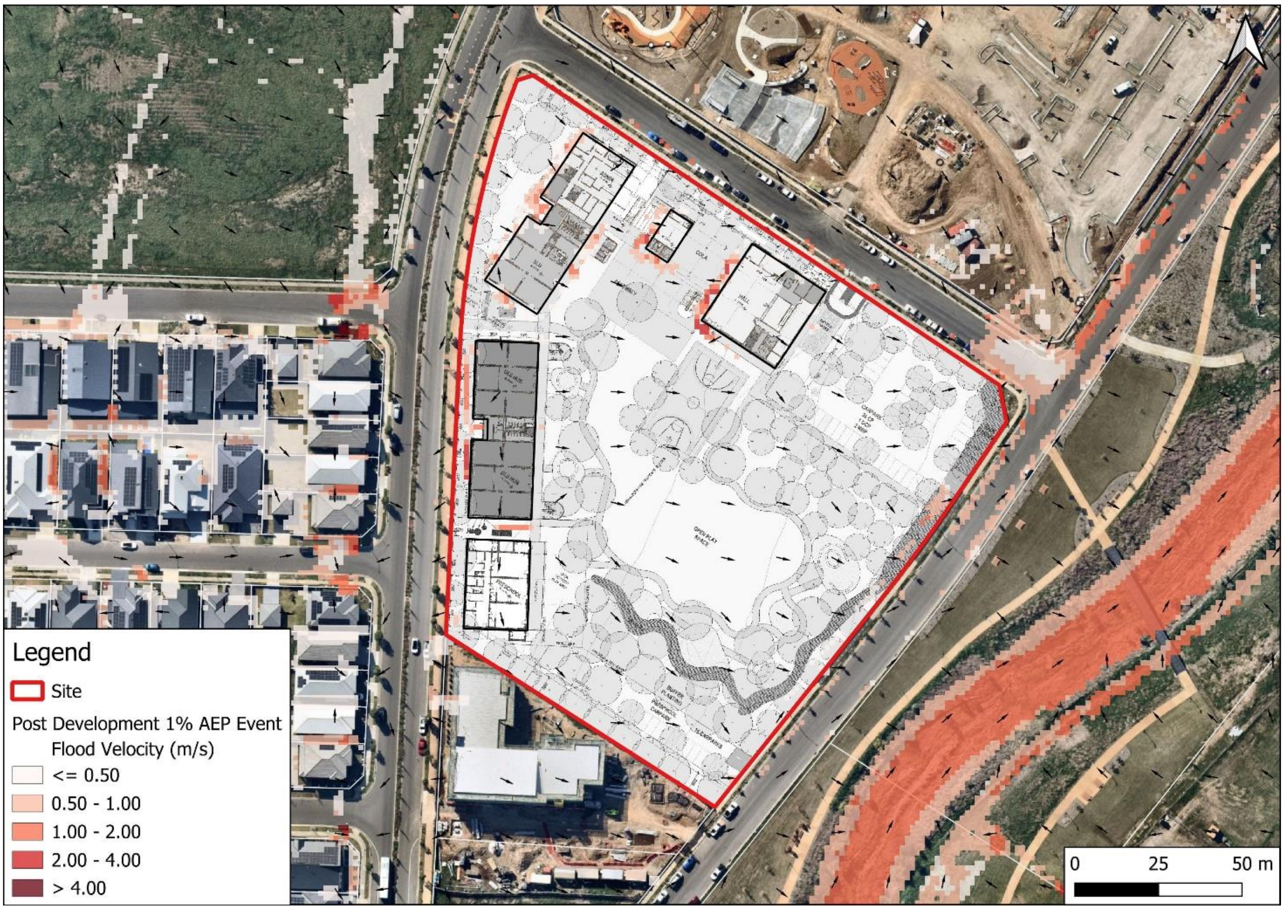

Figure 23 - Peak flood velocity at the site in the 1% AEP event, post-development of school

Figure 24 - Peak flood hazard at the site in the 1% AEP event, post-development of school

5.2.2 PMF Event

The peak post-development flood levels and depths, velocities, and hazards for the 1% AEP event assessed are shown in Figure 25, Figure 26 and Figure 27 respectively. Flood levels and depths onsite with no depth cutoff applied are shown in Appendix B.

As in the 1% AEP event, PMF depths within the wider school site are generally less than 0.05m, while the pooling floodwaters around the perimeter of the proposed buildings are of a similar depth, ranging generally between 0.2 – 0.8m but peaking around 1.5m at the southwest building (Figure 25). Flood hazard in the PMF has increased from the 1% AEP event, with hazard ranging from H2-H5 along the building perimeters (Figure 27), reaching H6 at the northeastern building.

Flood velocities within the site have increased in the PMF event, peaking between 1.0 – 1.8 m/s in the proposed car park to the east of the site (Figure 26), though hazard at this area remains as H1 due to the shallow nature of the sheet flow.

While depths within the creek system have increased, flows are contained within the riparian corridor and the site is not affected by mainstream flooding in the PMF.

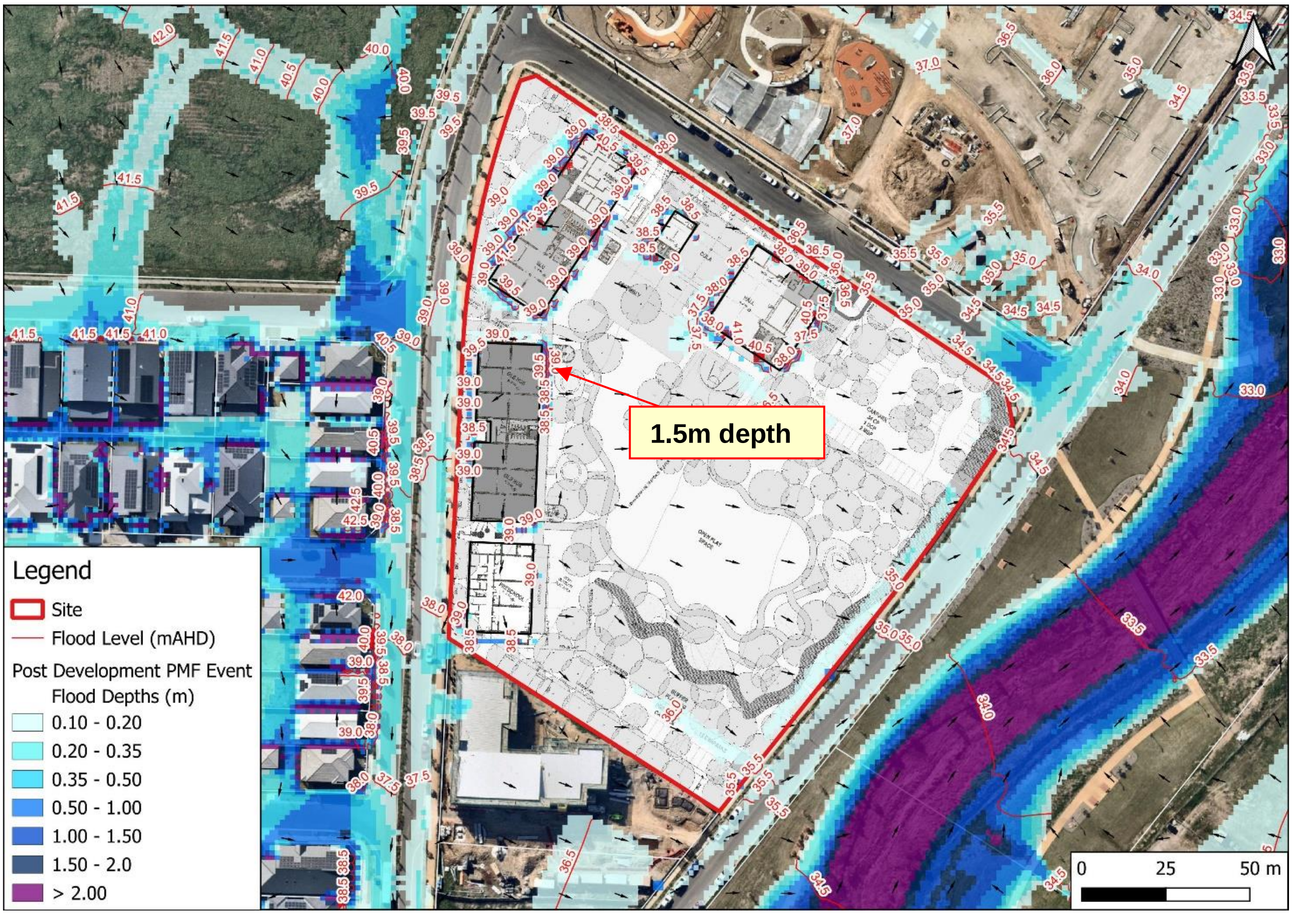

Figure 25 - Peak flood levels and depths at the site in the PMF event, post-development of school

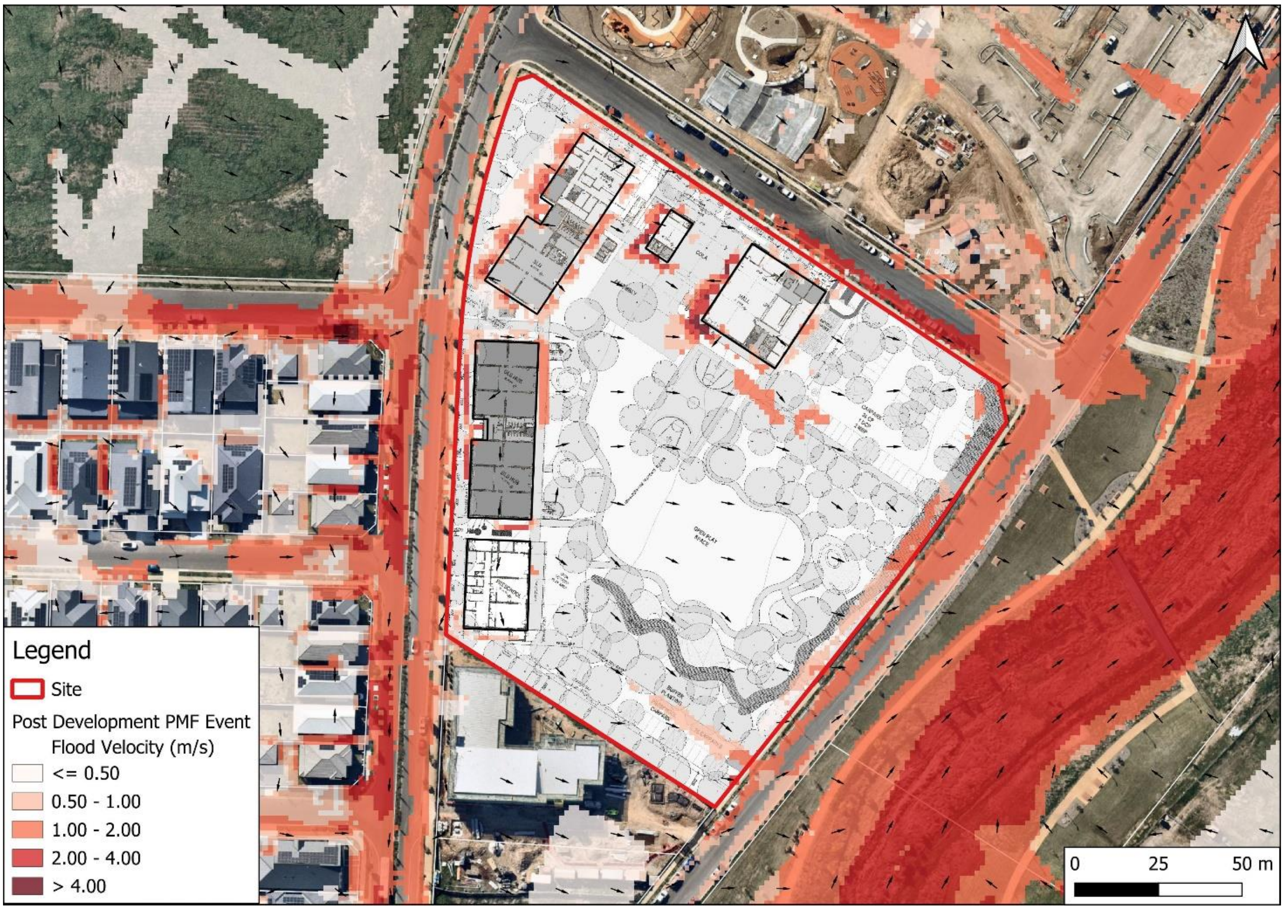

Figure 26 - Peak flood velocity at the site in the PMF event, post-development of school

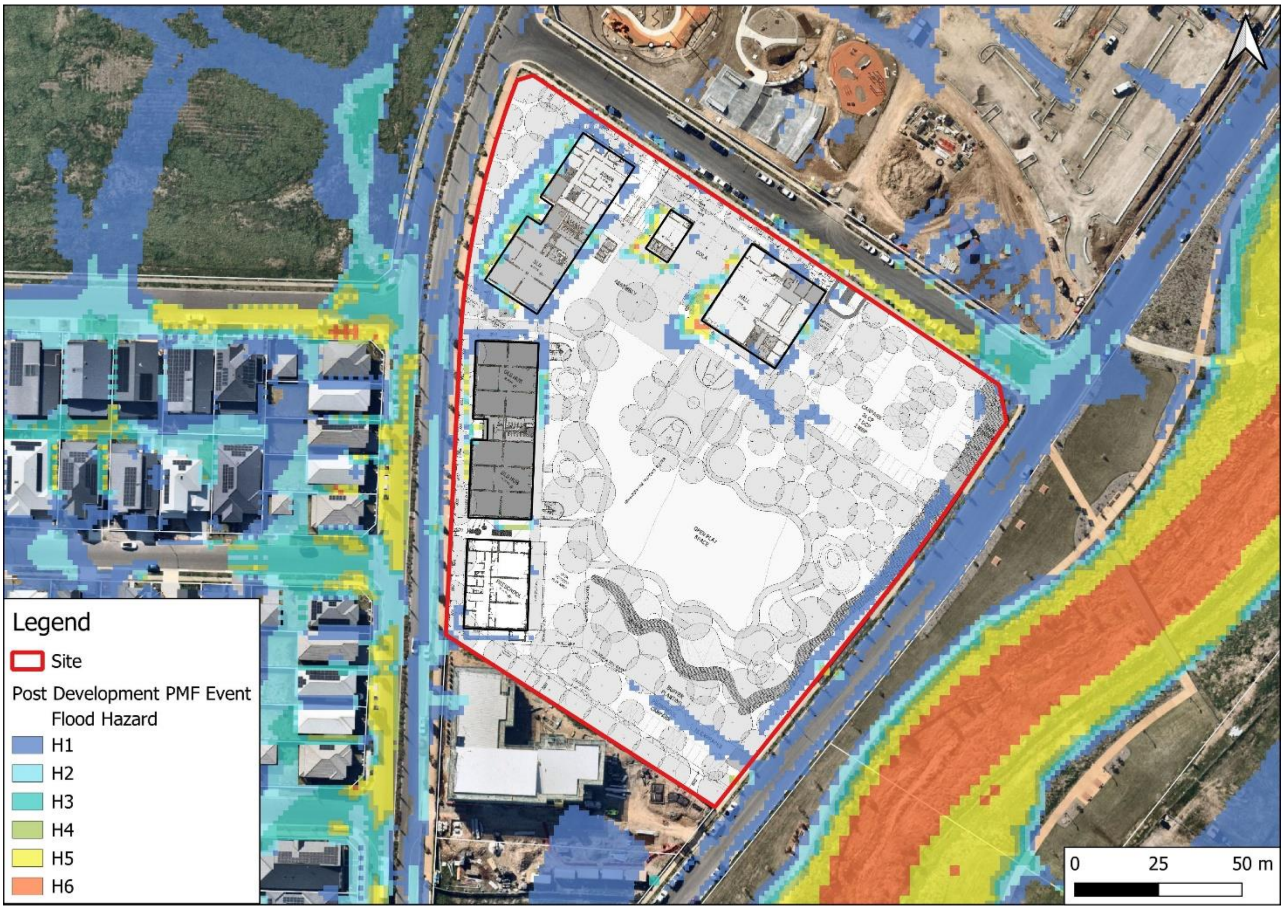

Figure 27 - Peak flood hazard at the site in the PMF event, post-development of school

5.2.3 Stormwater Management

As aforementioned, there is notable ponding of flows around the proposed school buildings in both the 1% AEP and PMF events. This is due to a combination of the coarse model resolution adopted and the proposed cut around the building perimeters. This is resulting in increased flood levels around the proposed buildings which exceed the proposed Finished Floor Levels (FFL) across the site, as indicated in Figure 28. However, these areas of ponding around the school are considered a stormwater management issue and are not considered flooding. These flows should be collected, contained and diverted around the proposed buildings as part of the more detailed civil site grading and stormwater design, to prevent flooding on the individual building within the site.

To inform stormwater management design, approximate flow rates at each proposed building were derived from the model and are provided in Table 5. For location reference, refer to Figure 28. It is worth noting that the flows shown in Table 5 are extracted directly from the flood model to provide some design guidance. It is therefore anticipated that appropriate calculation of the contributing catchment at each building should be carried out as part of the subsequent civil design phases of the project, to confirm the flows that each perimeter of building within the site should be designed to.

Table 5 – Approximate flow rate at each building in the 1% AEP and PMF events. Building locations shown in Figure 28.

Building	1% AEP Flow (m^3/s)	PMF Flow (m^3/s)
A	0.05	0.15
B	0.02	0.10
C	0.03	0.18
D	0.03	0.15
E	0.10	0.50

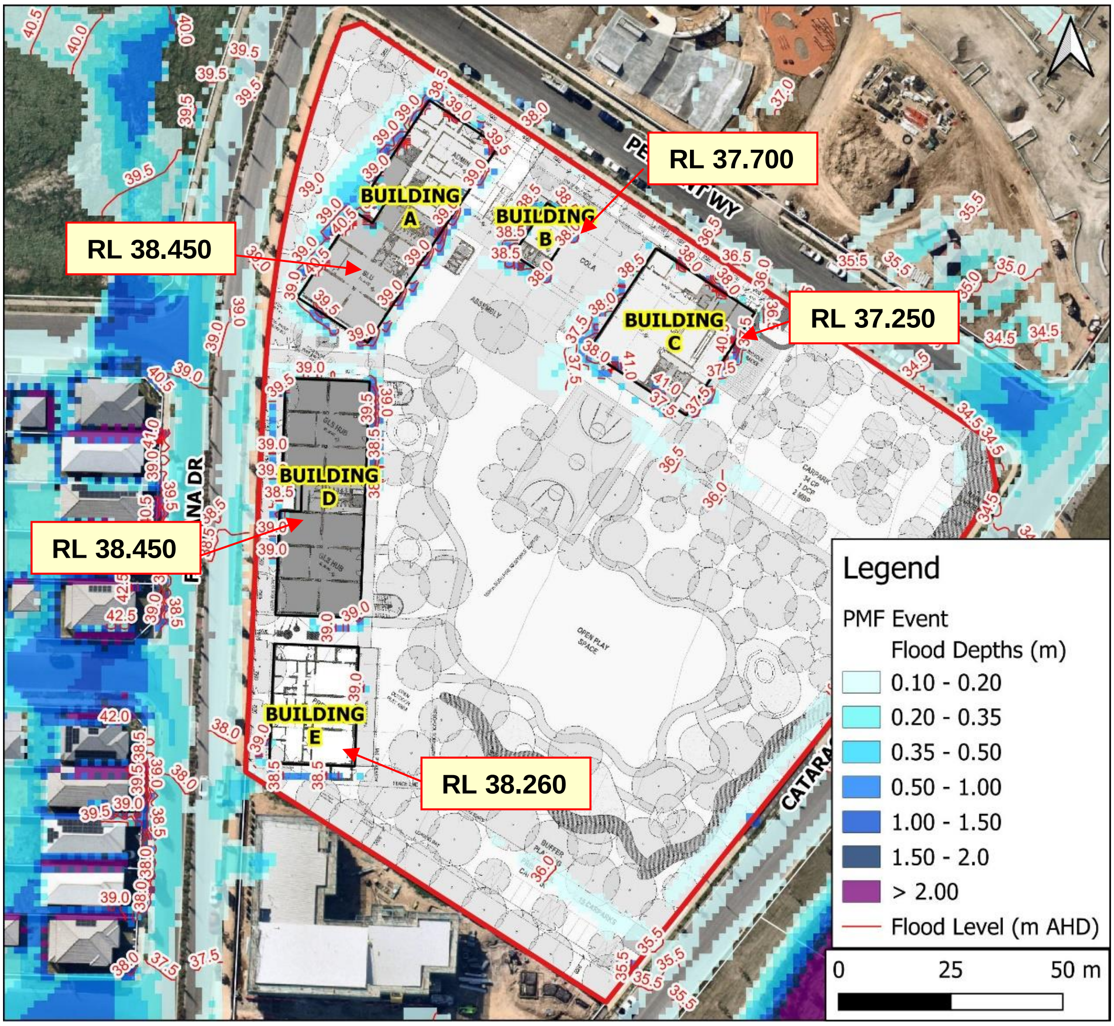

Figure 28 - PMF levels and depths shown against the proposed FFLs.

5.3 Climate Change

Climate change is expected to have an adverse impact on rainfall intensities, which has the potential to produce significant impacts on flood behaviour at specific locations.

For this study, a sensitivity analysis has been carried out to determine the impact of climate change on local flood conditions using the ARR2019 Interim Climate Change Factor for the site in the 2090 RCP8.5 scenario, which equates to a 19.7% increase in rainfall intensity.

Figure 29 presents the increase in 1% AEP flood depths and levels around the site with the addition of climate change. The results show limited impact across most of the site, with the largest increase adjacent to the northwestern proposed building (up to 53mm). Flood level increase is most notable within the eastern creek system (up to 260mm increase adjacent to the site). Nonetheless, there is still no mainstream flooding onsite.

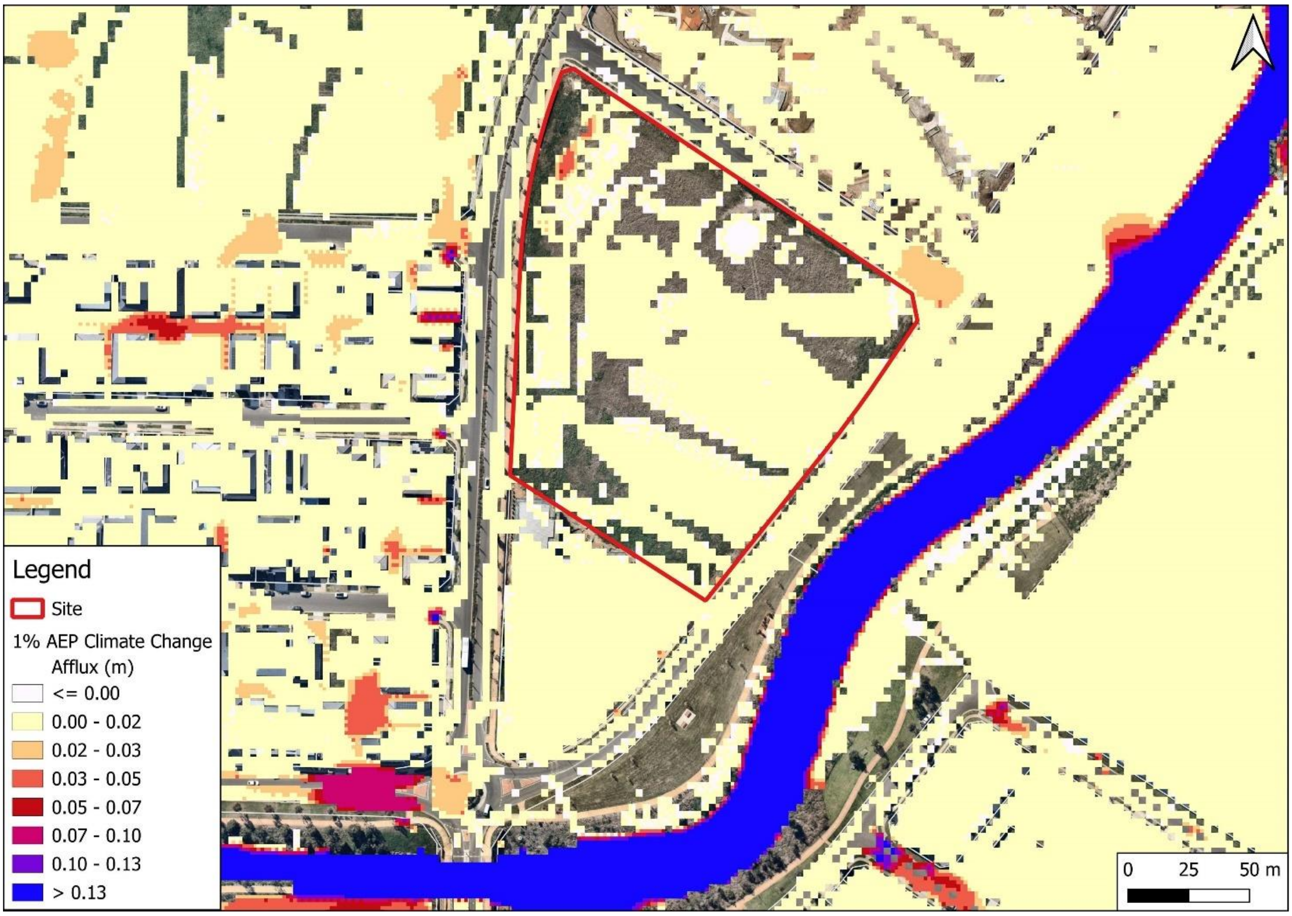

Figure 29 - Flood level afflux - Impact of climate change on 1% AEP flood levels

6.0 Flood Planning Requirements

6.1 The Hills Shire Development Control Plan

The current Development Control Plan (DCP) in place for the site is The Hills DCP (2012) which provides detailed planning and design guidelines to support the planning controls set out in The Hills Local Environmental Plan (LEP) 2019 when designing a development.

Under Section 4.15 of the Environmental Planning and Assessment Act 1979, the consent authority is required to take into consideration the relevant provisions of the DCP in determining a development application. Part C Section 6 of The Hills DCP provides a risk-based approach to planning and development in the flood prone lands of The Hills Shire LGA. The New South Wales State Government flood prone land policy is to reduce the impact of flooding and flood liability on individual owners and occupiers of flood prone property, and to reduce private and public losses resulting from floods, utilising ecologically positive methods wherever possible.

The aim of Part C Section 6 of The Hills DCP in relation to flood controlled lands is to provide development controls to guide the management of flood risks associated with development by:

- Increasing public awareness of the hazard and extent of land affected by all potential floods, including floods greater than the 100-year average recurrence interval (ARI) flood and to ensure essential services and land uses are planned in recognition of all potential floods;
- Informing the community of Council's policy for the use and development of flood controlled land;
- Managing the risk to human life and damage to property caused by flooding through controlling development on land affected by potential floods; and
- Minimising the potential impact of development and other activity upon the amenity, aesthetic, recreational and ecological value of the waterway corridors and the surrounding environment.

The Hills DCP outlines four distinct flood planning levels (FPLs) that are to be applied dependent on land use type and floor level, as presented in Table 6.

Table 6 - Flood Planning Levels laid out in the Hills DCP.

Reference	Flood Planning Level
FPL1	20 Year ARI (5% AEP)
FPL2	100 Year ARI (1% AEP)
FPL3	100 Year ARI (1% AEP) + 0.5m Freeboard
FPL4	PMF

Flood controls laid out in The Hills DCP are dependent on land use. As an educational facility, the site is categorised as a sensitive use or facility, and is therefore subject to the below controls:

- No development is to occur in or over a floodway area, a flowpath or high hazard area (as defined in the Floodplain Development Manual) generated by flooding up to FPL4 (PMF).
- Habitable floor levels to be no lower than FPL4 (PMF).
- Non-habitable floor levels to be no lower than FPL3 (1% AEP + 0.5m) unless justified by a site-specific assessment.
- All structures to have flood compatible building components below FPL4 (PMF).
- Applicant to demonstrate that any structure can withstand the forces of floodwater, debris and buoyancy up to and including FPL4 (PMF). An engineer's report may be required.
- The minimum surface level of open car parking spaces or carports shall be as high as practical, and not below FPL1 (5% AEP).
- Garages or enclosed car parking must be protected from inundation by flood waters up to FPL2 (1% AEP). Where 20 or more vehicles are potentially at risk, protection shall be provided to FPL3 (1% AEP + 0.5m AEP).

- Where the level of the driveway providing access between the road and parking space is lower than 0.3m below FPL2, the following condition must be satisfied - when the flood levels reach FPL2 (1% AEP), the depth of inundation on the driveway shall not exceed:
  - the depth at the road; or
  - the depth at the car parking space.
- Reliable access for pedestrians or vehicles is required from the building, commencing at a minimum level equal to the lowest habitable floor level to a refuge area above FPL4 (PMF). In the case of alterations or additions to an existing development, this may require retro-fitting the existing structures if required to support a refuge area above FPL4 (PMF).
- Applicant to demonstrate that area is available to store goods above FPL4 (PMF).
- Materials which may cause pollution or are potentially hazardous during any flood must not be stored externally below FPL4 (PMF).
- A Site Flood Emergency Response Plan is required when elements of the development, including vehicular and pedestrian access are below FPL4 (PMF).

Therefore, **The Hills DCP indicates that as a sensitive facility, the Gables proposed primary school must be protected to the PMF level.** Habitable floors must not be lower than the PMF level.

As denoted in Section 5.1.2, the site is affected by shallow overland sheet flow in the post-development scenario, with depths across the site mostly less than 0.05 – 0.1m in the PMF event. Though there is ponding around the perimeter of the proposed buildings, this is considered a stormwater management issue that should be addressed in the subsequent detailed civil design stages. Ideally, the FFL of each building within the site should be set at least 200mm above the surrounding ground levels together with drainage system around each building that is designed with sufficient capacity to fully contained the anticipated stormwater runoff for the PMF event.

As detailed civil design has not been incorporated into the hydraulic model, the pooling flood levels around the buildings are currently shown to be higher than the proposed FFLs. However, it is understood that appropriate internal stormwater design is required to provide PMF immunity to all proposed school buildings (e.g. sufficiently large catch drain to be provided around buildings). This will be further addressed in a later design stage of the project by the engaged civil consultant.

6.2 SINSW Guidelines

School Infrastructure New South Wales (SINSW) have their own framework and guidelines for educational site selection and development which should also be met. For flooding, the framework provides the following guidelines:

- Site must be located above the 1-in-200-year (0.5% AEP) flood level,
- Site must provide flood free access for pedestrians and vehicles (in particular, emergency vehicles during a flood event),
- Buildings must be located on land above the Flood Prone Land Contour (i.e., land susceptible to flooding in the PMF) where possible.

The site is not affected by mainstream flooding and is therefore located above the ‘flood prone land contour’. The 1-in-200-year flood event is depicted in Appendix A, with the site impacted mostly by negligible flood depths of less than 0.05m. As noted in Section 5.2.3, there is ponding of flows around the proposed school buildings across all modelled events due to a combination of the coarse model resolution and the proposed cut around the building perimeters. However, these areas of ponding around the school are considered a site stormwater management issue and are not considered flooding. These flows should be collected and diverted around the proposed buildings and should be considered as part of the subsequent detailed civil site grading and stormwater design phases of the project.

The Flood Emergency Response Plan (TTW, 2024) prepared alongside this Flood Impact and Risk Assessment Report analyses access and egress for pedestrians and vehicles in the event of a flood event.

7.0 Impact of Development

A flood impact assessment has been undertaken to ensure the proposed development would not worsen flood conditions over the neighbouring properties in the 1% AEP event. Although not a requirement this study also considered the likely flood impacts that the proposed development will have to the neighbouring properties in the PMF flood event assessed. The flood level afflux mapping for the proposed development in the 1% AEP event is shown in Figure 30, and PMF event flood level afflux mapping in Figure 31.

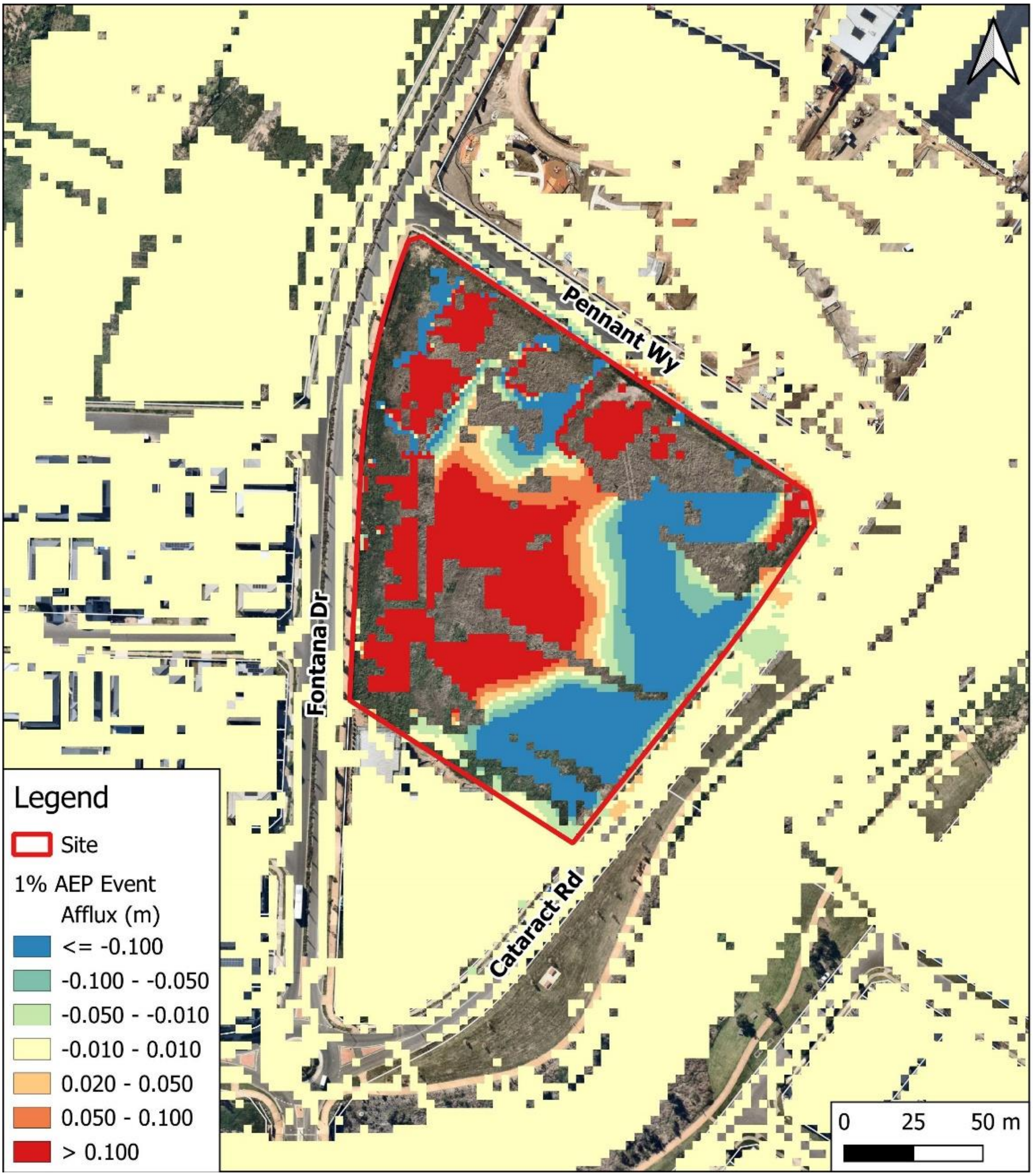

Figure 30 - Flood level afflux – Impact of proposed development on flood levels in the 1% AEP event

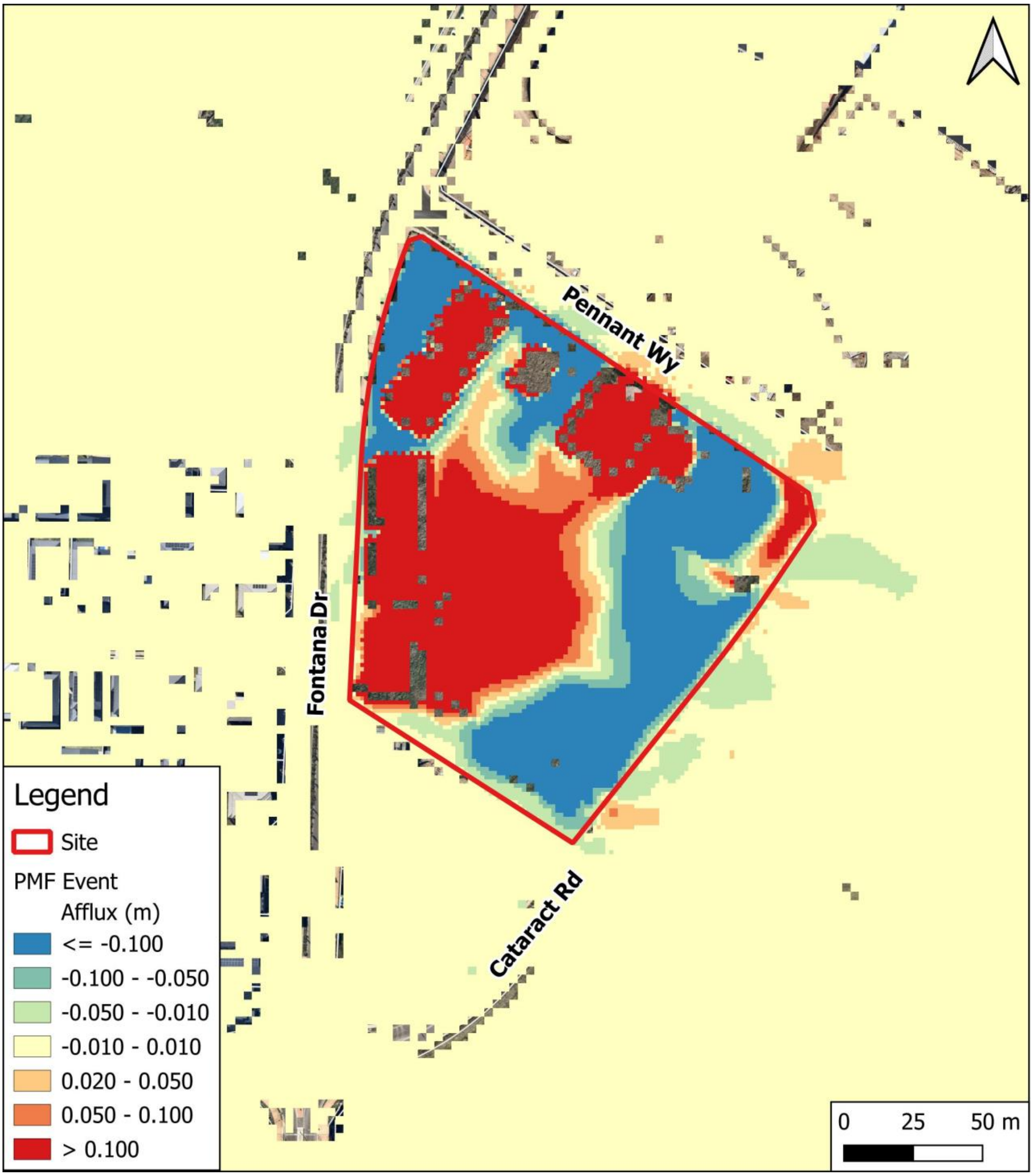

Figure 31 - Flood level afflux – Impact of proposed development on flood levels in the PMF event

There is significant change in flood levels within the site as a result of adjustments to the site grading and proposed cut and fill. As the site is largely affected by shallow sheet flow, the flood level is heavily dictated by the ground level. Decreases in flood level to the northwest and eastern frontage is due to the proposed cut, while increases in the centre of the site are due to the proposed fill. Apart from the accumulated pooling of flood waters, the results show that estimated flood depths generally remained similar to the existing conditions for both the 1% AEP and PMF events assessed.

The flood impact assessment for the 1% AEP event confirms that changes to offsite flood levels are generally less than +/- 10mm, and therefore the proposed development is considered to result in negligible offsite impacts in this event. Impacts are evident along Cataract Road, though this is largely a decrease in flood levels of around 20mm, with some small areas within the gutter showing a 20mm localised increase. The PMF event shows similarly negligible offsite impacts.

8.0 Conclusion

This report provides a summary of the flooding requirements to supplement the REF submission The Gables New Primary School.

As a sensitive facility, the proposed school site is subjected to flood controls laid out in Part C Section 6 of The Hills DCP and must be located above the PMF level.

The site is not impacted by mainstream flooding and is subject only to overland sheet flow. In the post-development scenario, flood depths within the proposed school site are generally less than 0.05 – 0.1m similar to that estimated for the pre-development scenario. With this said, there is notable ponding of flood waters around the perimeter of the proposed buildings, with the flood level here exceeding the proposed Finished Floor Levels. While this is considered a stormwater management issue as opposed to flooding, this must be addressed as part of the subsequent civil detailed design stages. Sufficient drainage provisions should be provided around each proposed building within the site to fully contain and divert anticipated stormwater runoff away from the building for all events up to and including the PMF event. In addition, the FFL of each proposed building should also be set at least 200mm above the surrounding ground levels to provide the flood immunity required.

As discussed in Section 7.0 of this report, the proposed development has a negligible impact on neighbouring properties in both the 1% AEP and PMF event. Therefore, the development is considered not to cause adverse flooding impacts to the area. Nonetheless, appropriate internal drainage and stormwater systems will need to be provided (i.e. as part of the subsequent design phase of the project by the engaged civil consultant) to ensure that all buildings within the school site will be flood free for all events up to and including the PMF event.

The findings in this statement are based on currently available information, regulations and correspondence undertaken at the time of writing.

9.0 Mitigation Measures and Recommendations

Project Stage *Design (D)* *Construction (C)* *Operation (O)*	**Mitigation Measures**	**Relevant Section of Report**
D	Sufficient drainage provisions should be provided around each proposed building within the site to fully contain and divert anticipated stormwater runoff away from the building for all events up to and including the PMF event.	*Section 5.2.3, Section 6.0*

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Associate (Flood)

Appendix A

20% AEP Event Flood Behaviour

Peak flood levels and depths at the site in the 20% AEP event, pre-development of school

Peak flood velocity at the site in the 20% AEP event, pre-development of school

Peak flood hazard at the site in the 20% AEP event, pre-development of school

Peak flood levels and depths at the site in the 20% AEP event, post-development of school

Peak flood velocity at the site in the 20% AEP event, post-development of school

Peak flood hazard at the site in the 20% AEP event, post-development of school

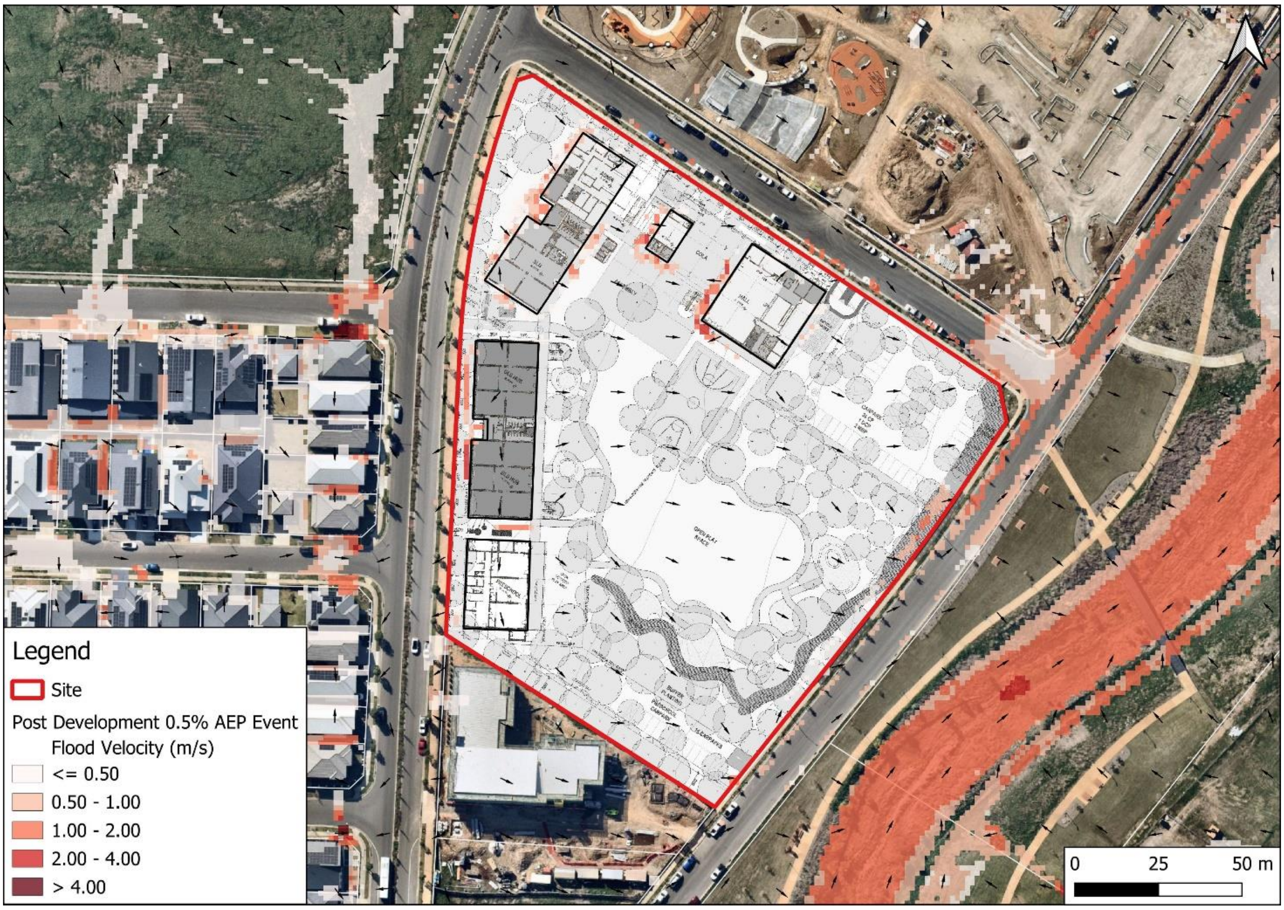
0.5% AEP Event Flood Behaviour

Peak flood levels and depths at the site in the 0.5% AEP event, pre-development of school

Peak flood velocity at the site in the 0.5% AEP event, pre-development of school

Peak flood hazard at the site in the 0.5% AEP event, pre-development of school

Peak flood levels and depths at the site in the 0.5% AEP event, post-development of school



Peak flood velocity at the site in the 0.5% AEP event, post-development of school

Peak flood hazard at the site in the 0.5% AEP event, post-development of school

Appendix B

PMF Event – Post development flood levels and depths