STORMWATER REPORT

471 CAMBRIDGE ROAD AND 528/540 PASS ROAD SUBDIVISION

MORNINGTON PARK ESTATE PTY LTD

JANUARY 2026

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1. Executive Summary

This report presents a stormwater assessment prepared as an extension to the Civil Concept Services Report for the proposed development at 471 Cambridge Road.

The stormwater component of the concept design has required detailed investigation and multiple technical discussions with Council due to downstream drainage constraints along Cambridge Road. To maintain clarity, the stormwater assessment has been documented as a standalone supporting document to the Concept Services Report, focusing specifically on minor drainage performance and overland flow behaviour under year 2100 climate change conditions (SSP2-4.5).

The stormwater modelling considers the site together with the existing downstream Council drainage system along Cambridge Road, reflecting how flows are conveyed through the piped network and how overland flow paths operate at the site boundary.

The assessment addresses the following design events as per Clarence Council's request:

- 10% AEP – minor drainage behaviour.
- 5% AEP – critical interaction between minor drainage and overland flow.
- 1% AEP – major overland flow paths and hazard identification.

Hydrology and hydraulics were modelled using ARR Data Hub, Book 9 – Runoff in Urban Areas and the software DRAINS (full unsteady hydraulic modelling). Where required, 2D hydraulic modelling (HEC-RAS) was used to assess overland flow behaviour and hazard classification, focusing on:

- Peak flows at the site boundary with full ensemble storms, classifying the worst scenario based on the duration and patterns.
- Distribution of flow between pipes and overland paths.
- Interaction between site runoff and the existing Cambridge Road drainage system.
- Identification of hydraulic bottlenecks and practical mitigation limits from site and Council's available infrastructure to be connected to.

The existing Cambridge Road drainage system comprises a DN900 pipe downstream, reducing upstream to DN525 and DN450 toward and across the site frontage. This reduction in pipe capacity limits conveyance and results in overland flow under existing pre-development conditions for the 10%, 5% and 1% AEP events.

These behaviours are independent of the proposed development and form the baseline condition for this assessment.

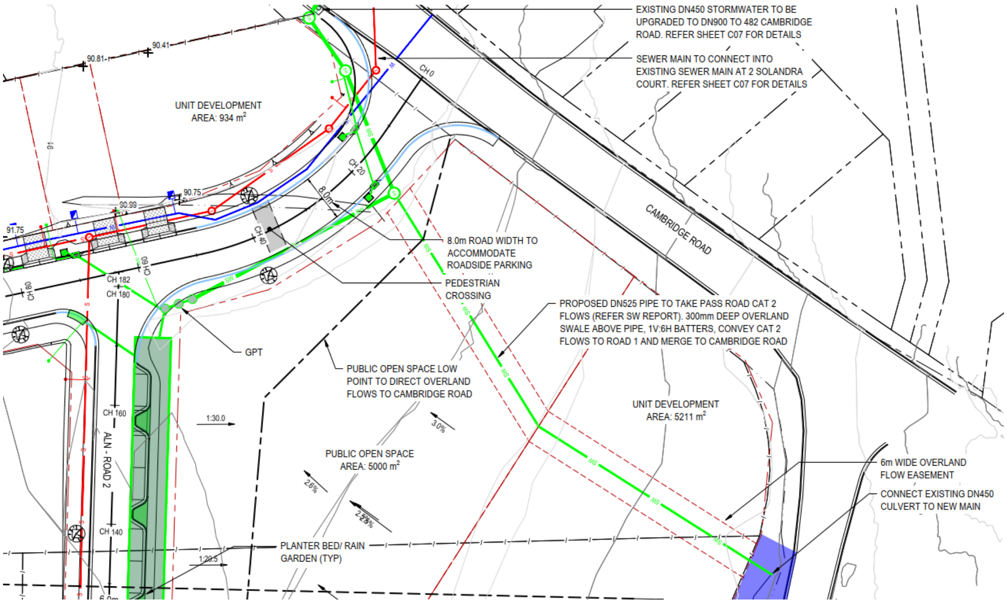


Figure 1 – Proposed Services at Road 1 and Discharge to Cambridge Road – Refer to Civil Drawings C01-DA3

To clearly demonstrate system behaviour and constraints, a series of progressive modelling scenarios were assessed. For clarity and efficiency, all scenarios are illustrated using the 5% AEP event, as this represents the controlling minor drainage case where both piped capacity and overland flow paths are active.

The 10% and 1% AEP events were then assessed using the final, preferred configuration only, as intermediate scenarios do not provide additional engineering insight for these events.

The assessed scenarios include:

1. Pre-development conditions with the existing Council's drainage system unchanged.
2. Post-development conditions without on-site detention and existing Council's drainage system unchanged.
3. Post-development conditions with practical on-site detention limited to approximately 80m length or ≈700m³ (available physical space on site dedicated for it along Road 2) and existing Council's drainage system unchanged.
4. Post-development conditions with the theoretical detention volumes (sensitivity test only to fully accommodate the flows within the pipe network) with existing Council's drainage system unchanged.
5. Post-development conditions with minimum practical detention (80m in length or ≈700m³) to ensure hazard rating is acceptable, and Council's drainage upsized continuously with DN900 up to the development boundary.

The assessment demonstrates that:

- Overland flow at the site boundary is primarily governed by downstream pipe capacity, not site-generated runoff.
- Attempting to resolve downstream capacity constraints solely through on-site detention would require unreasonable and impractical storage volumes.
- A balanced solution combining practical detention and improved downstream conveyance results in materially improved system performance.

For the 5% AEP event:

- Post-development total boundary flows are lower than pre-development when practical detention (700m^3) and DN900 conveyance are provided.
- When Council's system is upsized to DN900 and detention is provided (≈700m^3), overland flow is significantly reduced, with a portion of residual overland flow originating from upstream Pass Road catchments, not the site. A 2D hydraulic modelling confirms a maximum low hazard (H1) overland flow condition for the site and surrounds. (Refer to Topic 4 and Table 1).

For the 10% AEP event:

- Post-development boundary flows are lower than pre-development, with minimal overland flow. (Refer to Table 2).

For the 1% AEP event:

- While total boundary flow increases due to improved pipe conveyance, overland flow is reduced compared to pre-development, resulting in improved major system performance and safety outcomes. A series of level adjustments at the intersection of Road 1 and 2 partially divert the 1% AEP flow to the public open space, reducing the energy, depth, level and associated hazard rating of Road 1 between Road 2 and Cambridge Road. (Refer to Table 1).

Overall, the stormwater assessment confirms that the site is subject to significant overland flow under existing conditions, driven by downstream drainage capacity constraints along Cambridge Road. These conditions would occur irrespective of whether the proposed development proceeds.

The modelling demonstrates that existing overland flow is not caused by the site, but by limitations within the downstream Council drainage system. Under post-development conditions, the increase in site imperviousness is managed through practical on-site detention, such that peak discharges at the site boundary are controlled and, for the critical ensemble storms 10%, 5% and 1%AEP event, are either lower than pre-development or under controlled conditions.

Where overland flow remains, it is primarily associated with upstream catchments or rare storm events and is reduced in magnitude compared to existing conditions. As a result, the proposed development does not worsen existing stormwater behaviour and, where practicable, contributes to improved hydraulic performance and safety outcomes relative to the current scenario.

2. Catchment Context and Existing Overland Flow Behaviour

The site is influenced by runoff generated from multiple upstream catchments that interact with the Cambridge Road drainage system under existing conditions.

Catchment analysis and DRAINS modelling indicate that not all upstream runoff enters the site detention system (refer Figure 2). A portion of flow drains directly to Cambridge Road (Catchment 1), while another portion is conveyed toward a low point near the Pass Road intersection and bypasses the site detention (Catchment 2). Catchments 3, 4 and 5 are conveyed through the site drainage system (including the proposed detention system) before being discharged to Cambridge Road. These flow paths occur under existing conditions and are not created by the proposed development.

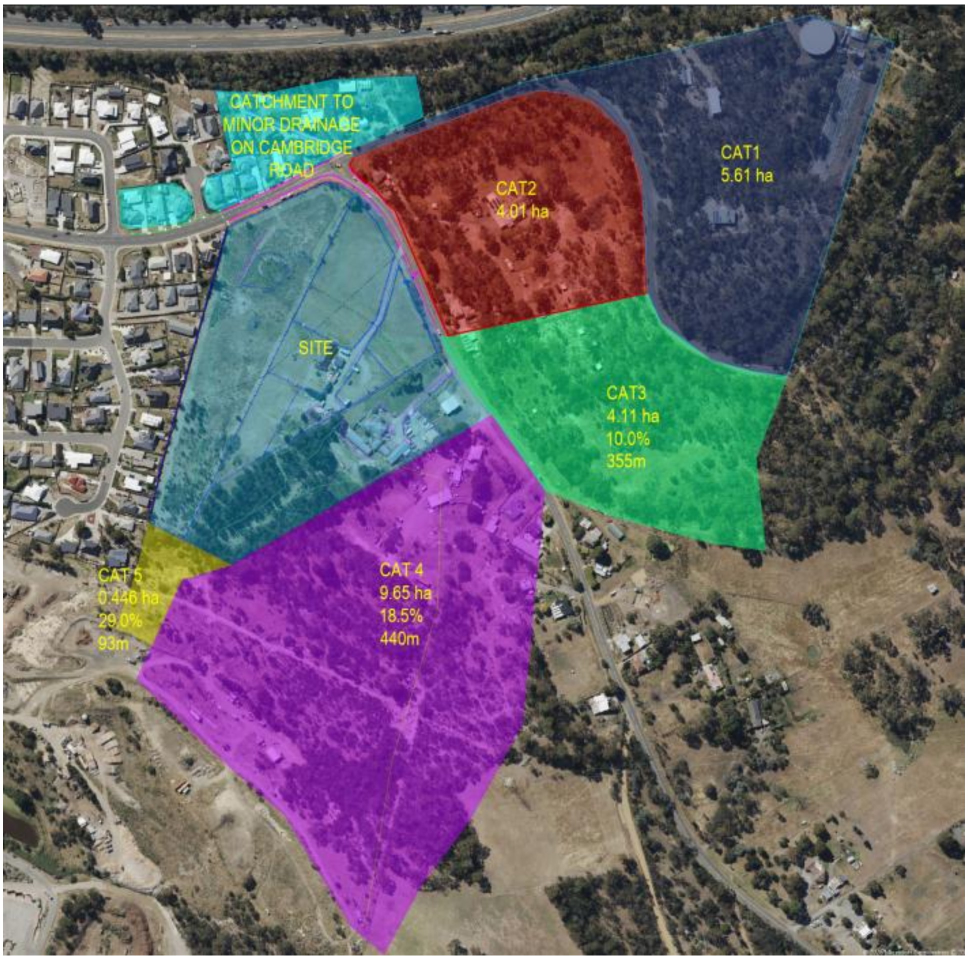


Figure 2 – Surrounding Catchment Scheme and Site

Council flood mapping (Figure 3) confirms that this area is already affected by flooding, particularly near the Pass Road and Cambridge Road intersection, indicating that overland flow in this location is an existing condition.

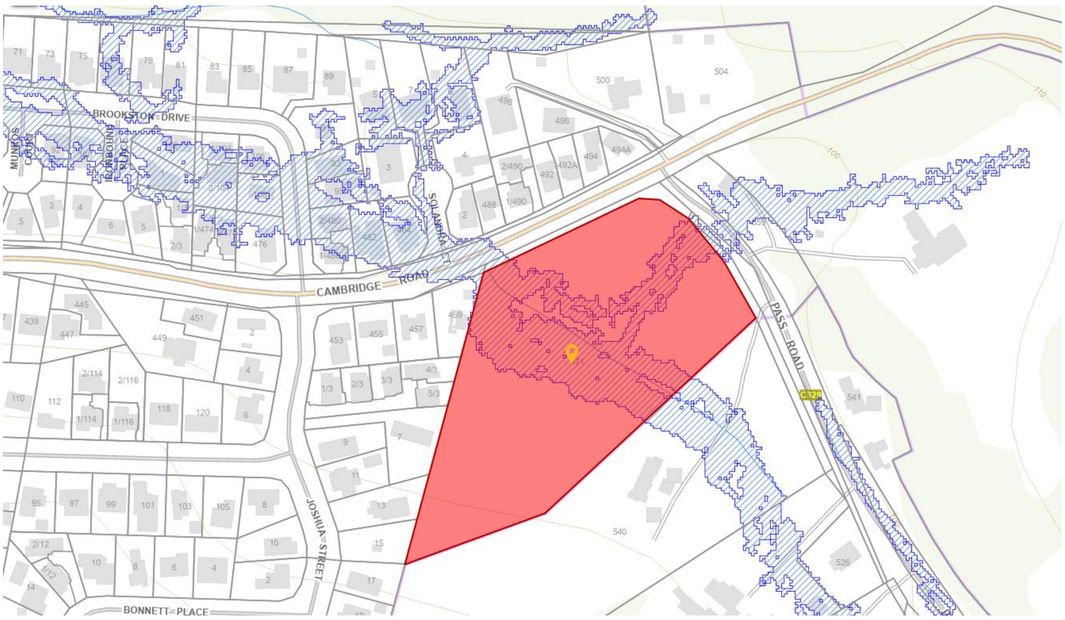


Figure 3 – Flood-prone Hazard Area (blue hatching), Development Area (red hatching)

It is proposed to convey the flows from Catchment 3 through a swale and piped drainage system directly to Cambridge Road rather than towards the detention system. This infrastructure does not increase discharge at the site boundary but reduces the frequency of uncontrolled overland flow across the site while maintaining existing downstream behaviour.

Downstream of the site, runoff is conveyed through the Cambridge Road drainage system, which is only a DN450/525 from the site boundary before transitioning to DN900 approximately 60m further down Cambridge Road. These small bore pipes govern system performance and result in overland flow during frequent-rare and rare storm events under existing conditions.

Figure 4 – Existing Clarance Council's Stormwater Pipe Network

3. Modelling Methodology

Stormwater modelling was undertaken using DRAINS, applying a full unsteady hydraulic model to represent the interaction between catchment runoff, piped drainage and overland flow paths across the site and the downstream Cambridge Road system.

Hydrologic parameters were derived in accordance with Australian Rainfall and Runoff (ARR 2019), with losses, routing and storm selection consistent with current Australian practice and Council expectations for concept-level stormwater assessment.

For each AEP (10%, 5% and 1%), ensemble temporal patterns were adopted in accordance with ARR 2019 to capture variability in storm hydrograph and peak timing. The critical storm duration was selected based on the duration producing the governing peak flow or storage demand at the site boundary.

For clarity and transparency, the detailed scenario comparison is presented using the 5% AEP event, as this represents the controlling case for the minor drainage system where both piped capacity and overland flow paths are active.

The 10% and 1% AEP events were then assessed using the final, preferred configuration only, as intermediate scenarios do not materially alter the engineering conclusions.

Overall, the rainfall runoff conversion was modelled using the Initial Loss – Continuing Loss (IL/CL) method, consistent with ARR 2019 guidance. The adopted loss parameters are summarised below:

- Impervious Areas (Initial Loss: 1 mm; Continuing Loss: 0 mm/hr)
- Pervious Areas (Initial Loss: 20 mm; Continuing Loss: 2 mm/hr)

These values are derived from Council's advice, being an approximate representation of local soil and surface conditions at concept stage and are consistent with typical ARR-based assumptions for urban and peri-urban catchments.

Hydraulic routing within the drainage network was modelled using full unsteady flow, allowing surcharge, backwater effects and flow redistribution between pipes and overland paths to be explicitly represented.

Overland flow was modelled using the kinematic wave formulation, enabling representation of shallow surface flow across roads and open areas where piped capacity is exceeded. This approach is appropriate for concept-level assessment of overland flow paths and aligns with ARR guidance for urban drainage systems, forming peak flows at the site boundary, with results separated into:

- Piped flow.
- Overland flow.

This separation allows the relative contribution of site-generated runoff and downstream system constraints to be clearly identified and provides a robust basis for assessing whether post-development conditions exceed pre-development behaviour.

4. Modelling Scenarios – 5% AEP (Controlling Case)

The following scenarios were developed to progressively assess existing conditions, development impacts, detention effectiveness, and downstream system constraints, allowing clear identification of hydraulic limitations and feasible mitigation measures.

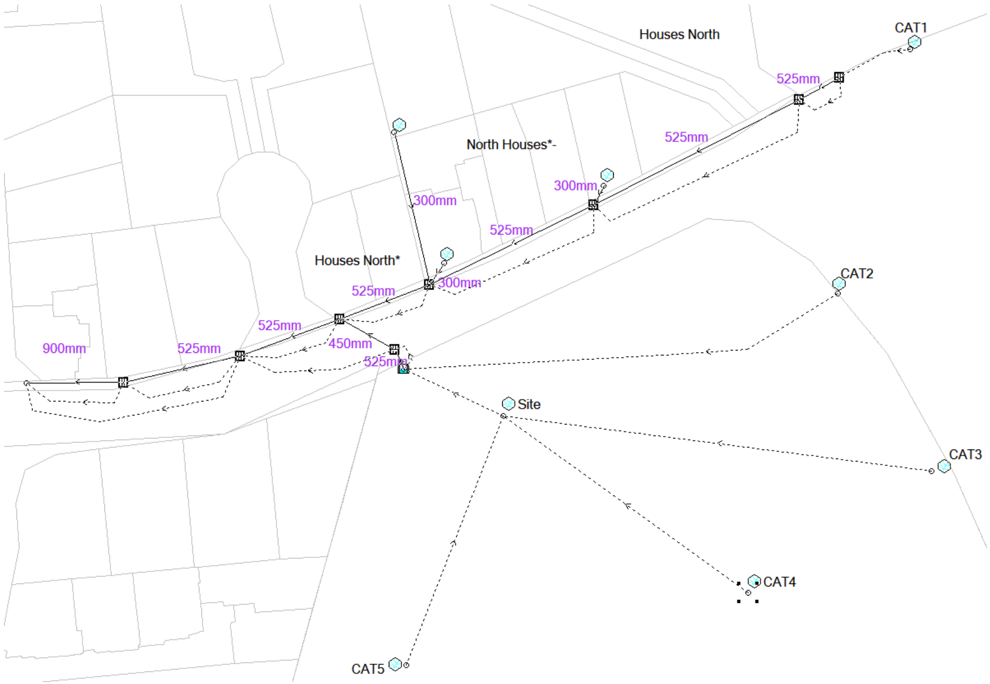


Figure 5 - Pre-development Scenario Scheme with Links and Nodes – Screenshot from DRAINS Software

Note, in the following Figures 9 to 17, blue labels represent peak flow conveyed within the pipe network, while red labels indicate peak overland flow occurring where hydraulic capacity is exceeded.

Scenario SC5%.1 – Pre-Development

This scenario represents existing conditions with the current Cambridge Road drainage system unchanged as per Figure 6. Overland flow occurs due to inlet constraints and limited downstream pipe capacity, with runoff generated by upstream catchments interacting with the site regardless of any future development.

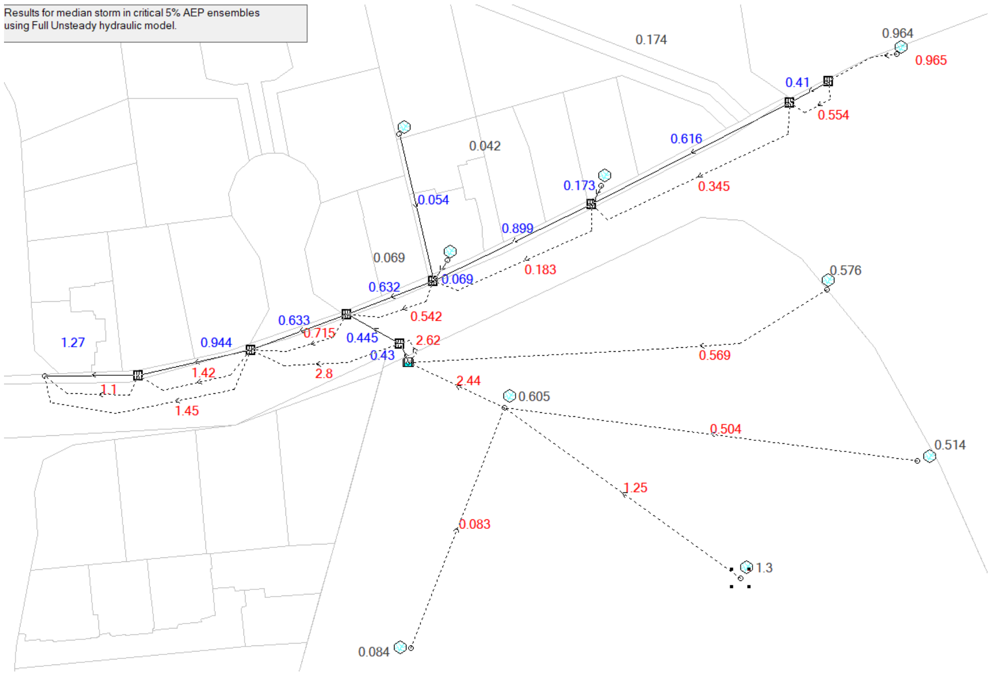


Figure 6 – 5% AEP Pre-development Flows. Note that the 5% AEP pre-development overland flow at the boundary is 2.62m^3/s (red text).

Figure 7 below illustrates the base point of post-development stormwater network modelling, including links and nodes adopted for the hydraulic assessment.

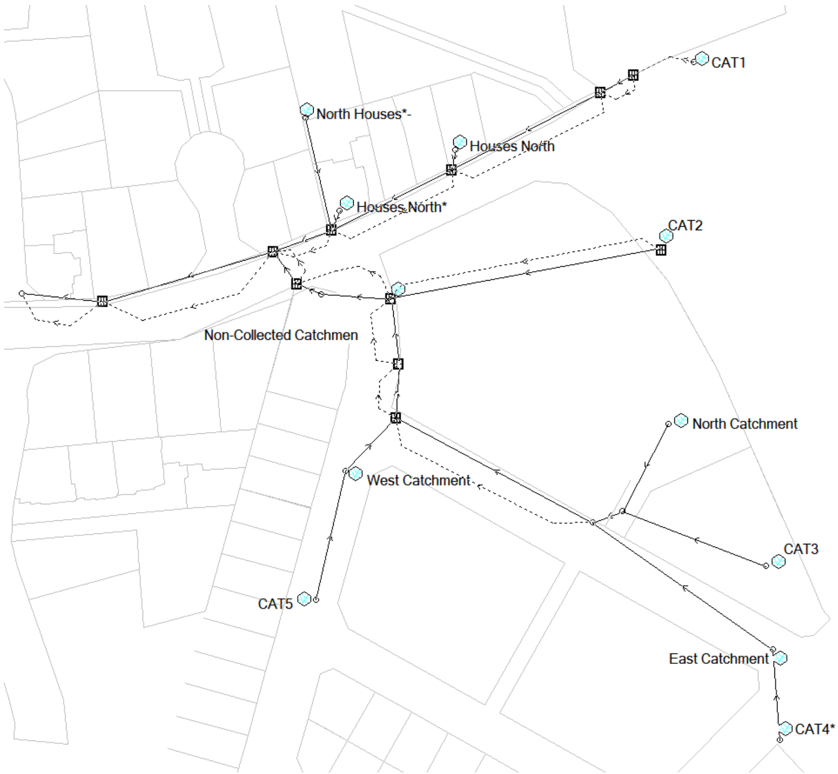


Figure 7 - Post-Development with no Detention Scheme - Links and Nodes (DRAINS)

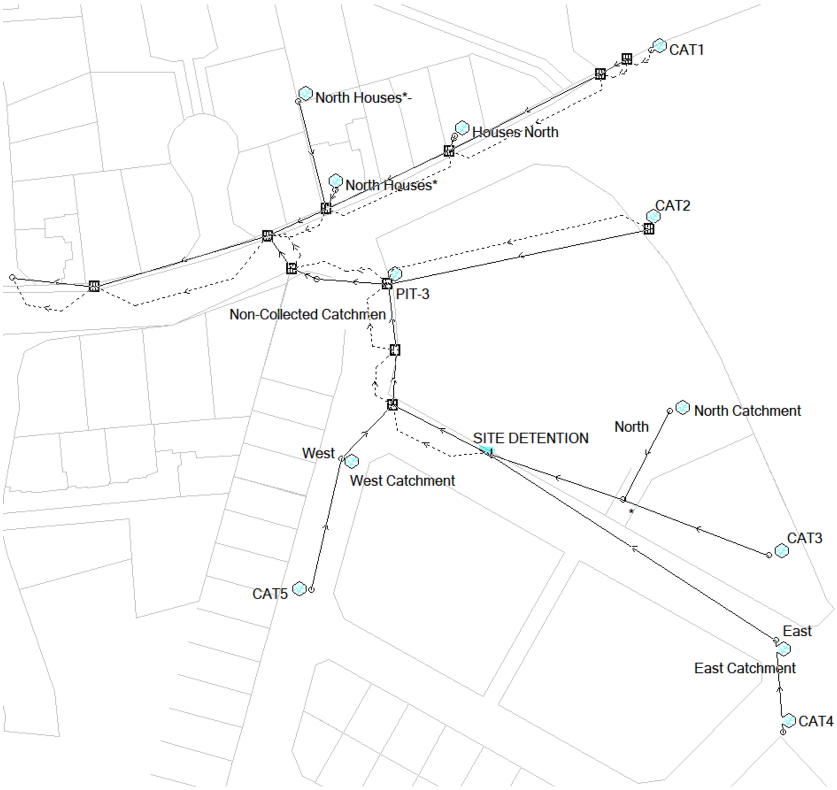


Figure 8 - Post-Development with Detention Scheme - Links and Nodes (DRAINS)

Scenario SC5%.2 – Post-Development (No Detention) and Council's System Unchanged

This scenario assesses the effect of increased site imperviousness without any on-site detention and Council's system unchanged. Boundary flows and overland flow increase, demonstrating that unmanaged development would exacerbate existing hydraulic constraints within the downstream drainage system.

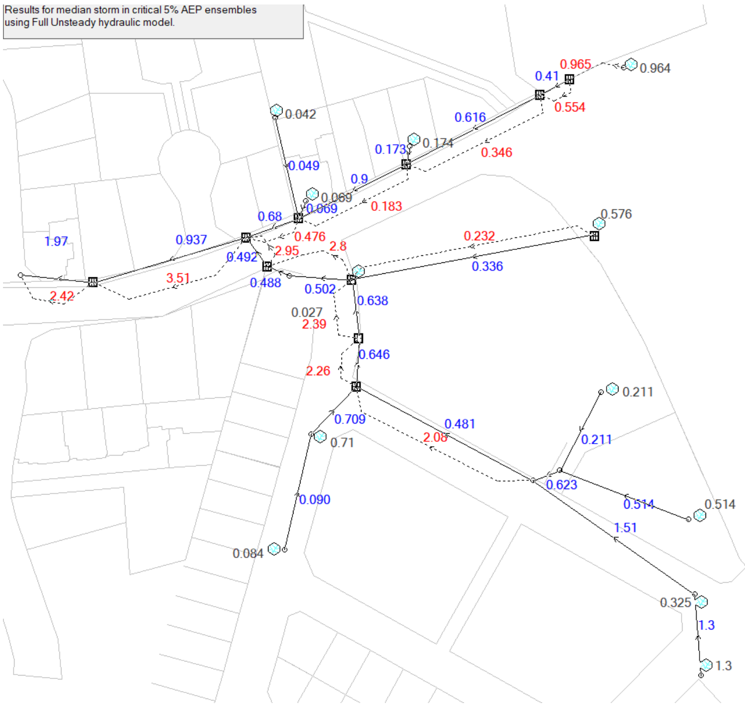


Figure 9 – Post-development 5% AEP Flows with no detention. Note that the overland flow at the boundary increases from 2.62m^3/s to 2.80m^3/s as a result of the proposed development.

Scenario SC5%.3 – Post-Development with Practical Detention and Council's System Unchanged

This scenario includes a practical on-site detention system limited to approximately 80m in length (≈700 m³), reflecting site constraints. While detention moderates peak discharge, downstream pipe capacity remains the controlling constraint, and overland flow is still generated.

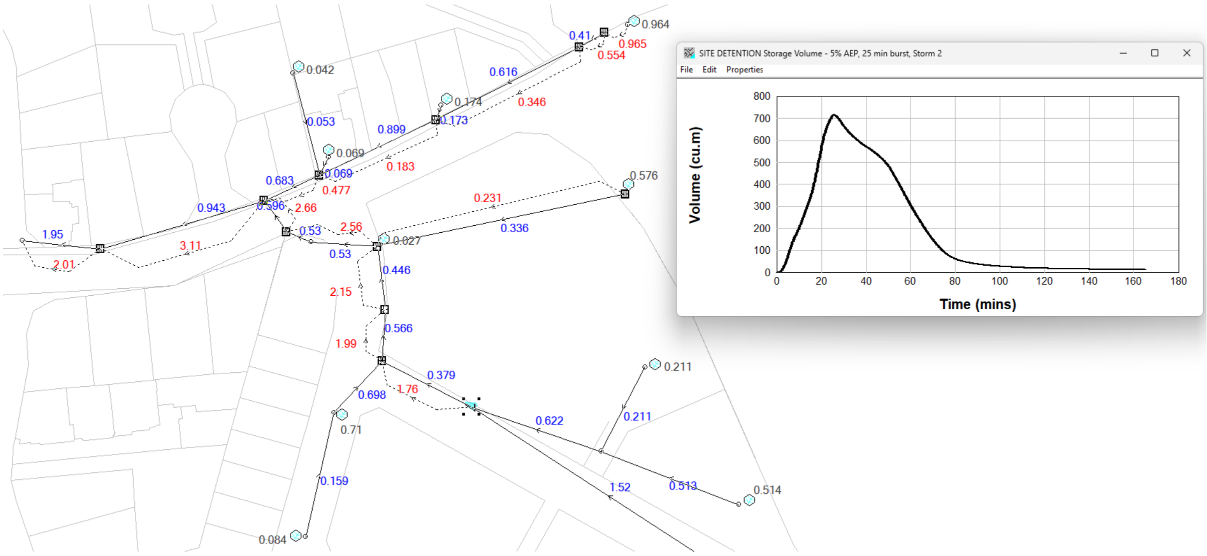


Figure 10 – Post-development 5% AEP flows with ~700m^3 detention. Note that the overland flow at the boundary is reduced from pre-development levels of 2.62m^3/s to 2.56m^3/s

Scenario SC5%.4 – Post-Development with Theoretical Detention for a Non-Overland Scenario and Council's System Unchanged

This sensitivity test increases detention volume to approximately 4,500-5,000 m³ to eliminate overland flow. While hydraulically effective, the required storage volume is disproportionate and not achievable within the site, demonstrating that over-compensation is not a reasonable solution.

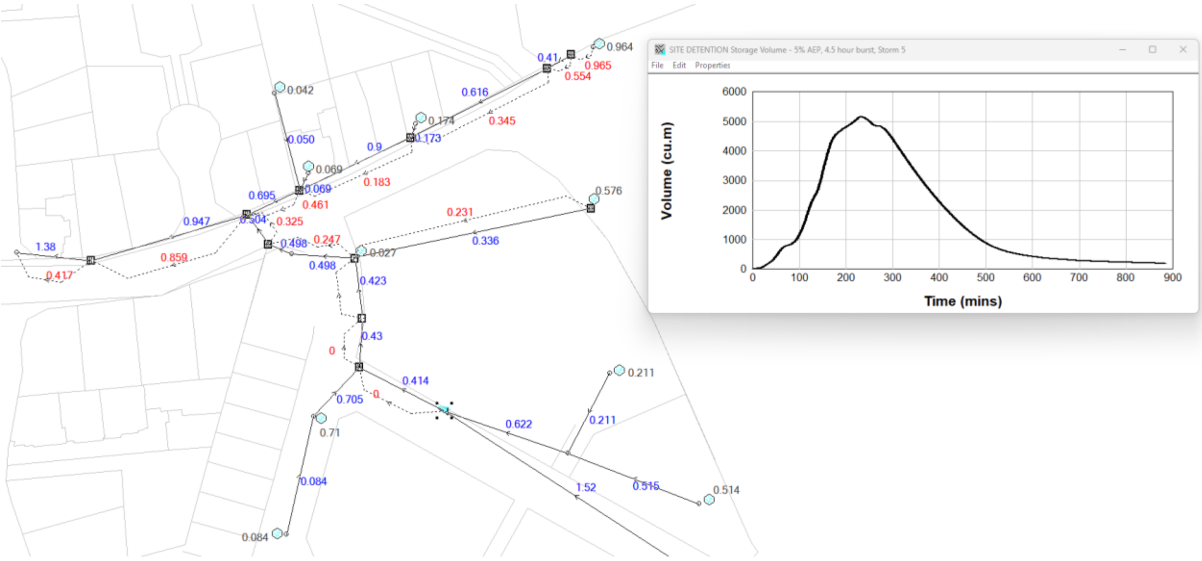


Figure 11 – Post-development 5% AEP flows with ~5,000m^3 detention. Note that the overland flow at the boundary is drastically reduced from pre-development levels of 2.62m^3/s to 0.247m^3/s, however, unfeasible.

Scenario SC5%.5 - Post-Development with Practical Detention (≈700 m³) and Council's System Upsized to DN900 pipes

This scenario combines practical on-site detention with continuous DN900 conveyance to the site connection. Improved pipe capacity allows more flow to be safely conveyed, substantially reducing overland flow and resulting in improved hydraulic performance relative to existing conditions.

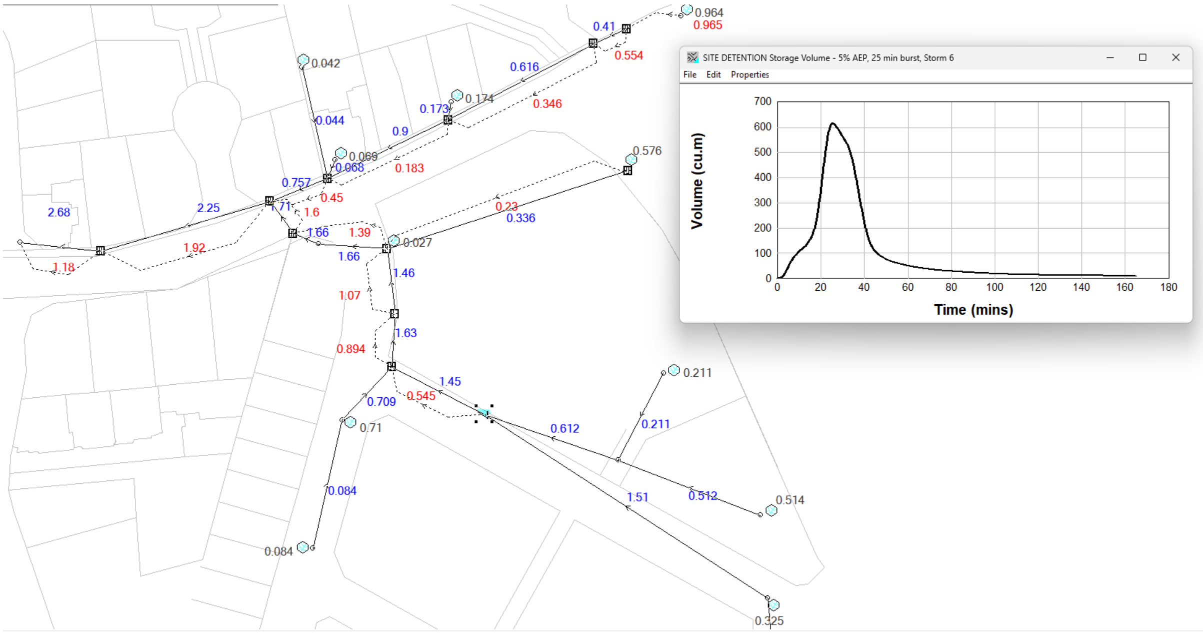


Figure 12 - Post-development 5% AEP flows with ~600m^3 detention. Note that the overland flow at the boundary is reduced from pre-development levels of 2.62m^3/s to 1.39m^3/s. Overland flow is further presented in the report with the hazard levels within the development boundary.

Table 1 - 5% AEP + SSP2-4.5 (YEAR 2100) Scenarios

5%AEP + SSP2-4.5 (YEAR 2100)				
Scenario	**Description**	**Peak Flow at Boundary (IN THE PIPE) (m³/s)**	**Peak Flow at Boundary (OVERLAND) (m³/s)**	**TOTAL @ the Boundary**
SC5%.1	Pre-Development - system as it is	0.430	2.62	3.05
SC5%.2	Post-Development (No Detention) and Council's System Unchanged	0.488	2.89	3.28
SC5%.3	Post-Development with Practical Detention and Council's System Unchanged	0.530	2.56	3.09
SC5%.4	Post-Development with Theoretical Detention for a Non-Overland Scenario and Council's System Unchanged	0.498	0.247	0.745
SC5%.5	Post-Development with Practical Detention (≈700 m³) and Council's System Upsized to DN900 pipes	1.66	1.39*	3.05

*Post-development at the boundary not greater than Pre-Development scenario and 47% reduction in overland flow to Cambridge Road. (2D Unsteady flow and hazard band results are presented on Topic 5.)

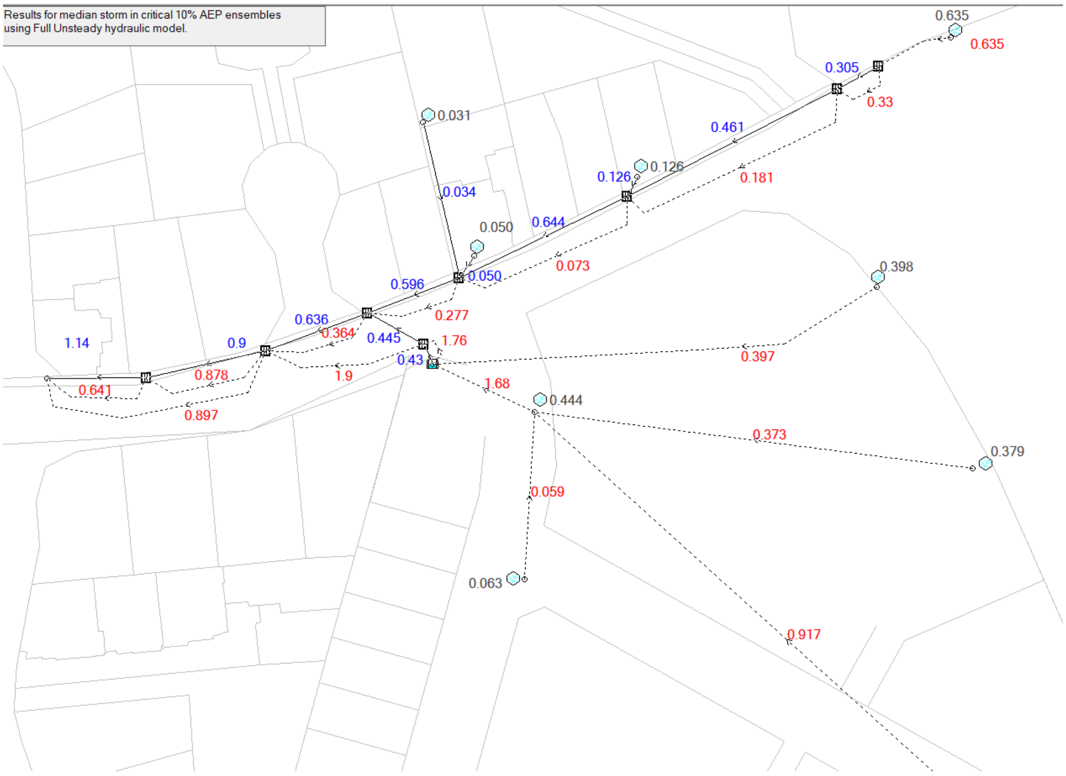


Figure 13 – 13% AEP Pre-development flows. Note that the 10% AEP pre-development overland flow at the boundary is 1.76m³/s (red text).

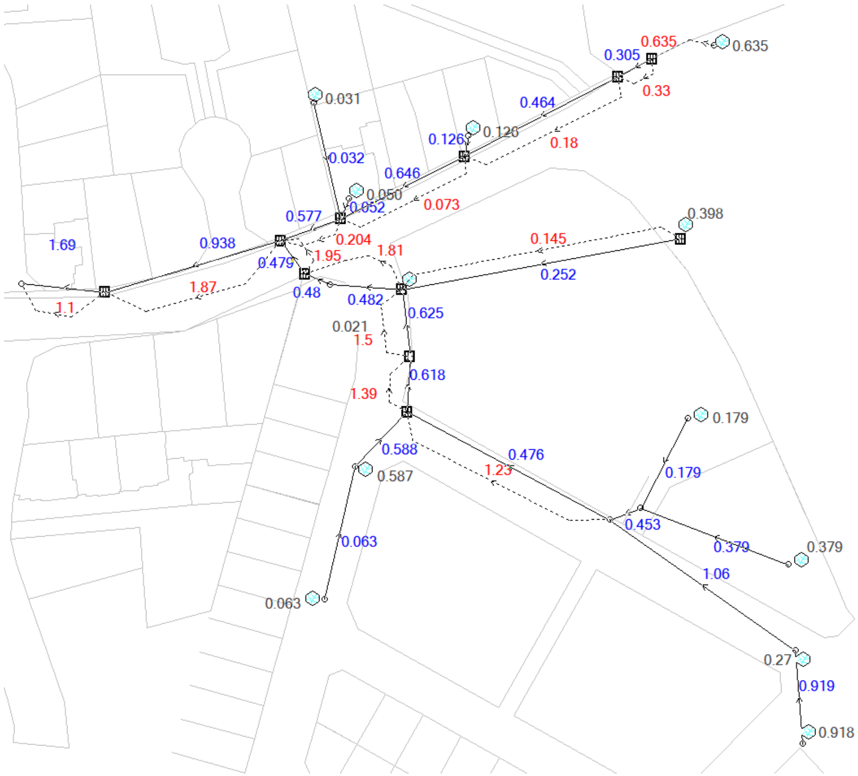


Figure 14 – Post-development 10% AEP flows with no detention. Note that the overland flow at the boundary increases from 1.76m³/s to 1.81m³/s as a result of the proposed development.

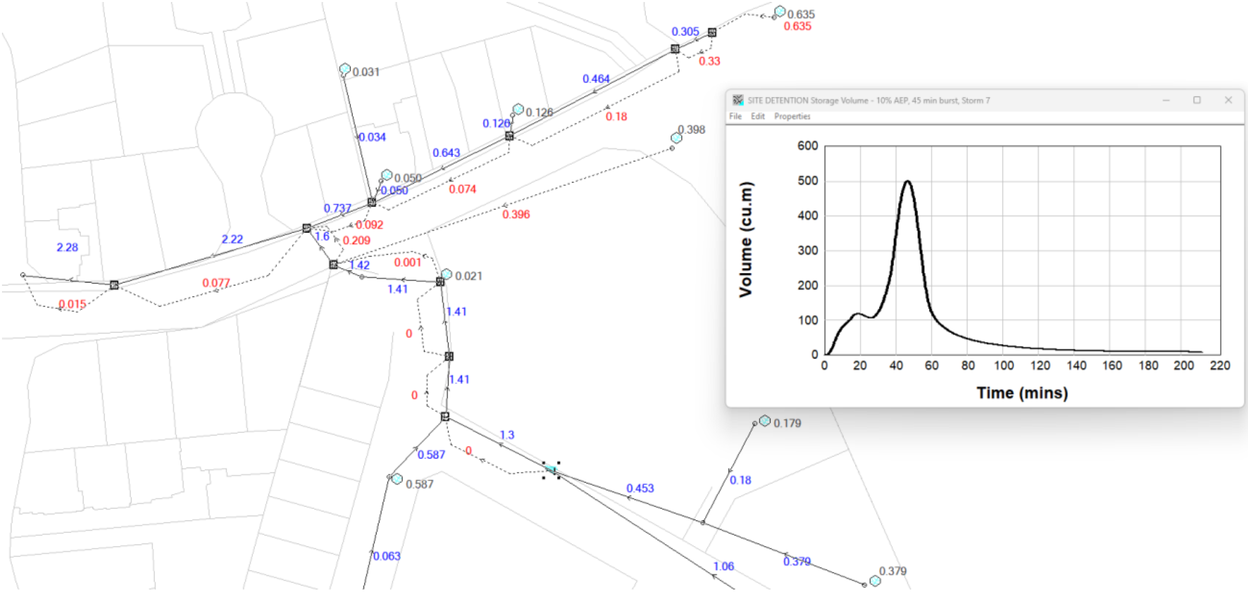


Figure 15 – Post-development 10% AEP flows with ~600m^3 detention. Note that the overland flow at the boundary is reduced from pre-development levels of 1.76m^3/s to 0.001m^3/s.

Table 2 - 10% AEP + SSP2-4.5 (YEAR 2100) Scenarios

10%AEP + SSP2-4.5 (YEAR 2100)				
Scenario	**Description**	**Peak Flow at Boundary (IN THE PIPE) (m^3/s)**	**Peak Flow at Boundary (OVERLAND) (m^3/s)**	**TOTAL @ the Boundary**
C10.1	Pre-Development – system as it is	0.43	1.76	2.19
C10.2	Post-Development – no detention	0.475	1.89	2.36
C10.3	Post-Development with Practical Detention (≈700 m^3) and Council's System Upsized to DN900 pipes	1.42	0.40	1.82

For the 1% AEP event, the assessment extends beyond pipe capacity and considers major overland flow behaviour, flow paths and hazard. While DRAINS is used to quantify peak discharges at the site boundary, a 2D unsteady hydraulic analysis using HEC-RAS was undertaken to assess the spatial distribution of overland flow, flow depths, velocities and associated hazard across roads and adjacent areas.

This combined approach provides a more appropriate representation of major system performance for rare events.

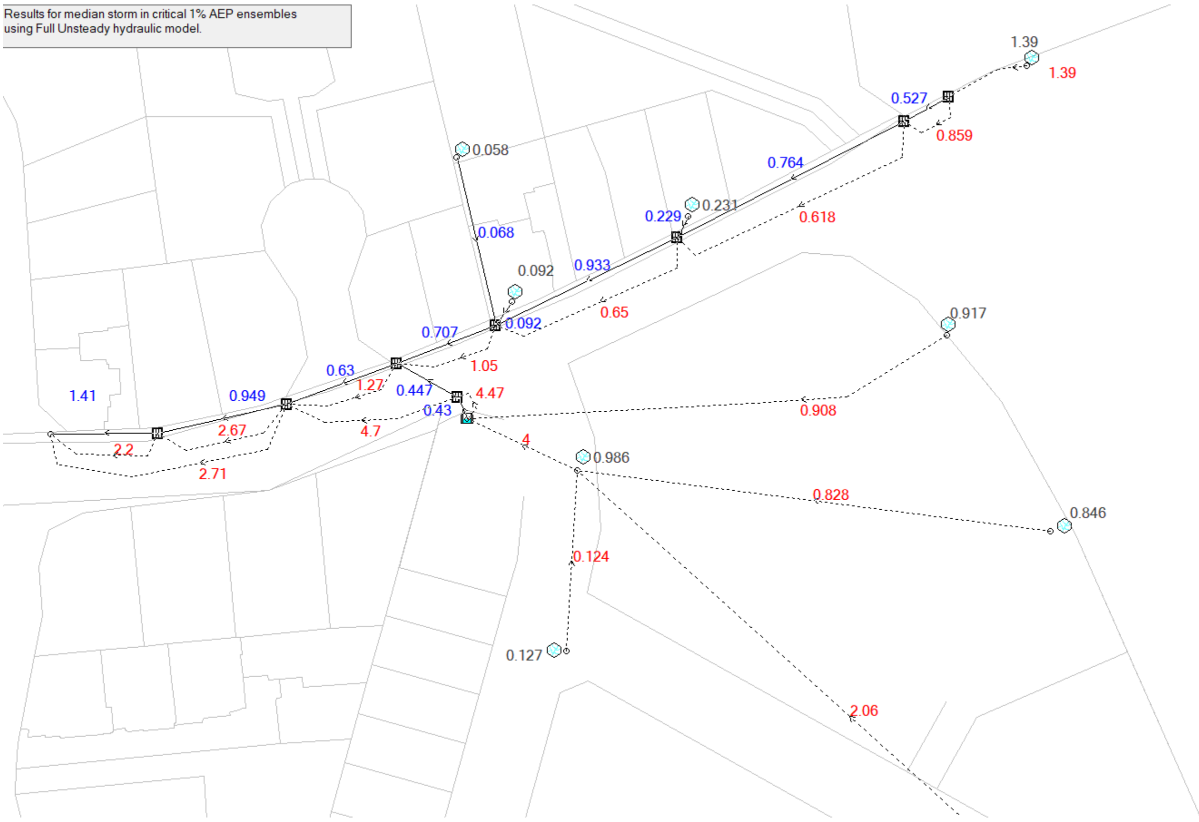


Figure 16 – 1% AEP Pre-development flows. Note that the 1% AEP pre-development overland flow at the boundary is 4.47m³/s (red text).

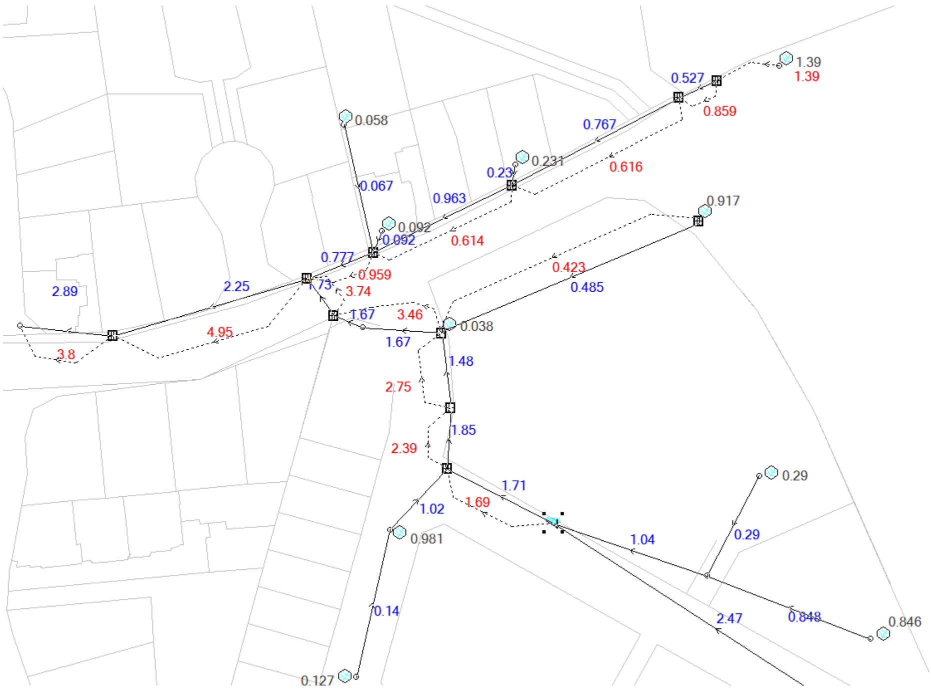


Figure 17- Post-development 1% AEP flows with ~600m³ detention. Note that the overland flow at the boundary is reduced from pre-development levels of 4.47m³/s to 3.46m³/s.

Table 3 - 1% AEP + SSP2-4.5 (YEAR 2100) Scenarios

1%AEP + SSP2-4.5 (YEAR 2100)				
Scenario	**Description**	**Peak Flow at Boundary (IN THE PIPE) (m^3/s)**	**Peak Flow at Boundary (OVERLAND) (m^3/s)**	**TOTAL @ the Boundary**
C1.1	Pre-Development – system as it is	0.43	4.47	4.90
C1.3	Post-Development with Practical Detention (≈700 m^3) and Council's System Upsized to DN900 pipes	1.67	3.46	5.13**

** Although total flow increases, the increase occurs within the piped system. Overland flow is reduced by 22.5%, which is the controlling safety criterion for the major system. (2D Unsteady flow and hazard band results are presented on Topic 5.)

5. HEC RAS and Overland Flow Verification

For major storm events, stormwater behaviour is governed by overland flow paths rather than pipe capacity alone. Accordingly, a combined DRAINS and 2D hydraulic modelling approach has been adopted to assess overland flow paths, depths, velocities and associated hazard under higher magnitude events.

5% AEP - Overland Flows from Detention Verification

Although the 5% AEP event is primarily a minor drainage design case, overland flow is generated where downstream drainage capacity is constrained. A 2D unsteady HEC-RAS analysis was undertaken to verify that overland flows resulting from this event are safely conveyed, with acceptable depths, velocities and hazard classification.

- 5% AEP flows (for the peak 1% AEP storm duration) from within the development area were removed, assuming that these are conveyed in the underground pipe work.
- All inflow from outside the development area is assumed overland (i.e. the 5% AEP flow has not been removed), with CAT 1 as an exception. This is conservative given that a proportion of flow will enter the underground pipework at these inflow locations.
- Inflow and outflow boundaries are positioned at suitable distances upstream and downstream to ensure that the model stabilises before reaching the area of interest and that downstream results are not impacted by backwater effects. Boundary inflows include flows from within the development area, which is also conservative.
- Manning's roughness coefficients have been applied for different surface types to ensure an accurate representation of flow behaviour:
    - Developed Areas (e.g. Houses and Buildings): 0.30
    - Hardstand Surfaces (e.g. Driveways and Pavement): 0.018
    - Vegetated Zones and Landscaping: 0.035

Figure 18 – Post-development 5% AEP+CC Maximum Depths from Figure 12 Flow Scheme

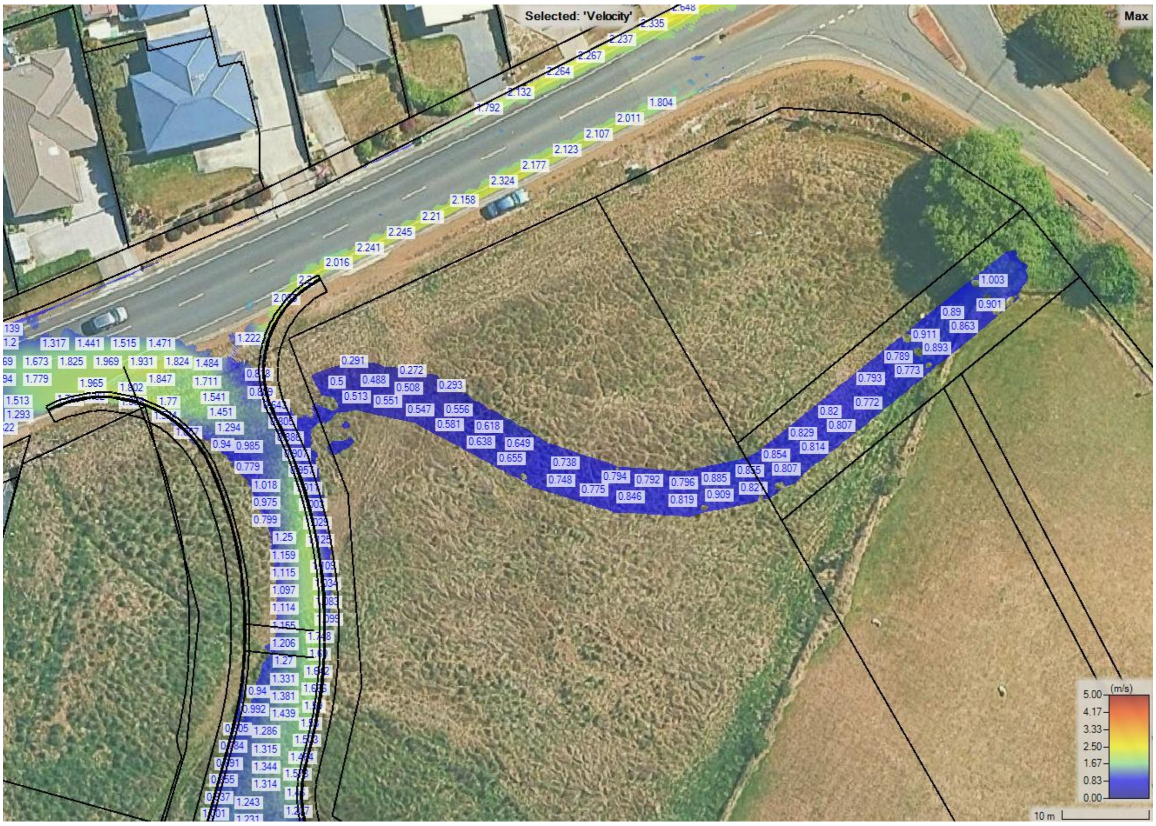


Figure 19 – Post-development 5%+CC AEP Maximum Velocity from Figure 12 Flow Scheme

Figure 20 – Post-development 5% AEP+CC Hazard Bands Figure 12 Flow Scheme (H1 Hazard Level within the Development Boundaries) – Generally safe for people, vehicles and buildings

1% AEP – Major Overland Flow Assessment

For the 1% AEP event, the assessment focuses on major overland flow behaviour rather than peak discharge alone. A 2D unsteady HEC-RAS model was used to define flow paths, quantify depths and velocities, and confirm that overland flow remains within acceptable hazard limits across the site and adjoining road network.

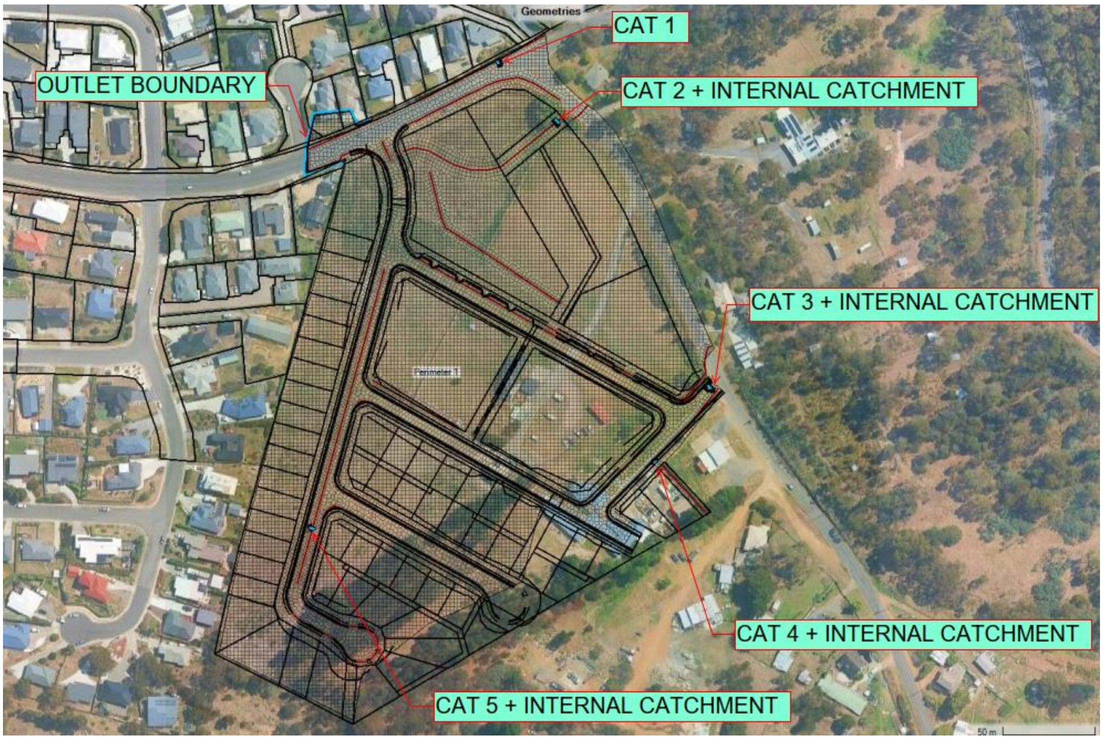


Figure 21 – HEC-RAS Geometry with Inflows

Figure 22 – HEC-RAS – Site Layout and Overland Flow Extent

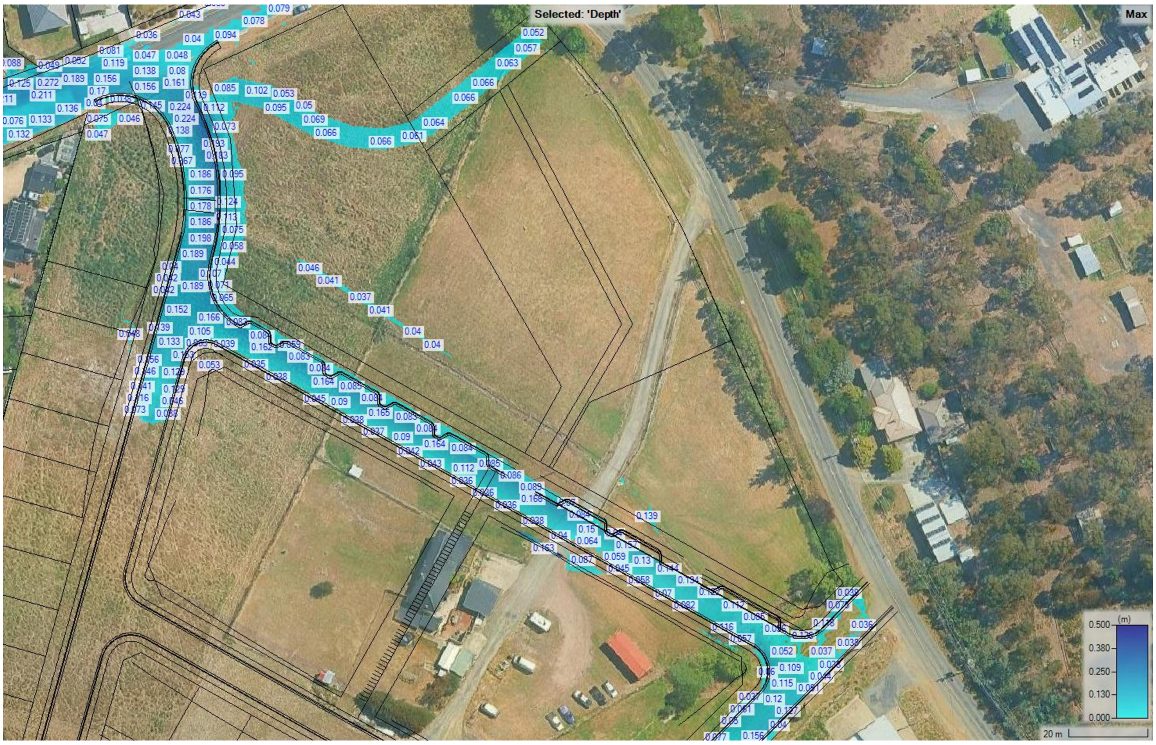


Figure 23 – Post-development 1% AEP+CC Maximum Depths

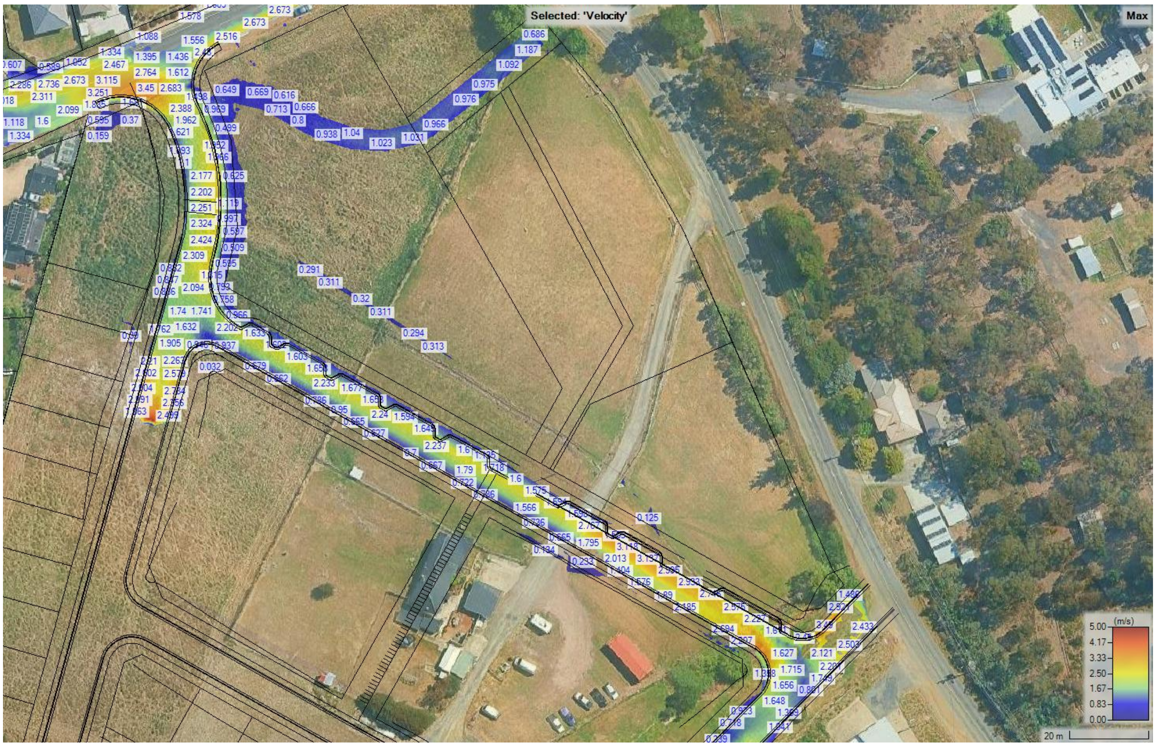


Figure 24 – Post-development 1% AEP+CC Maximum Velocity

Flood hazard within the study area has been assessed using nationally recognised depth–velocity (D×V) criteria, which provide an objective measure of flood risk to people, vehicles and built form. These criteria are widely adopted in Australian floodplain management practice and are documented in the Australian Institute for Disaster Resilience (AIDR) guidelines, with thresholds derived from experimental testing and full-scale flood behaviour observations.

The D×V framework allows flood hazard to be classified according to the vulnerability of different receptors, recognising that acceptable thresholds vary between pedestrians, vehicles and buildings. As a result, separate stability criteria are applied depending on land use, exposure and the likely presence of people or vehicles during flood events.

Figures 25 to 28 presented below summarise the adopted hazard classification thresholds for general flood vulnerability, pedestrian stability, and vehicle stability. These references form the basis for interpreting the hydraulic modelling results presented in subsequent sections of this report.

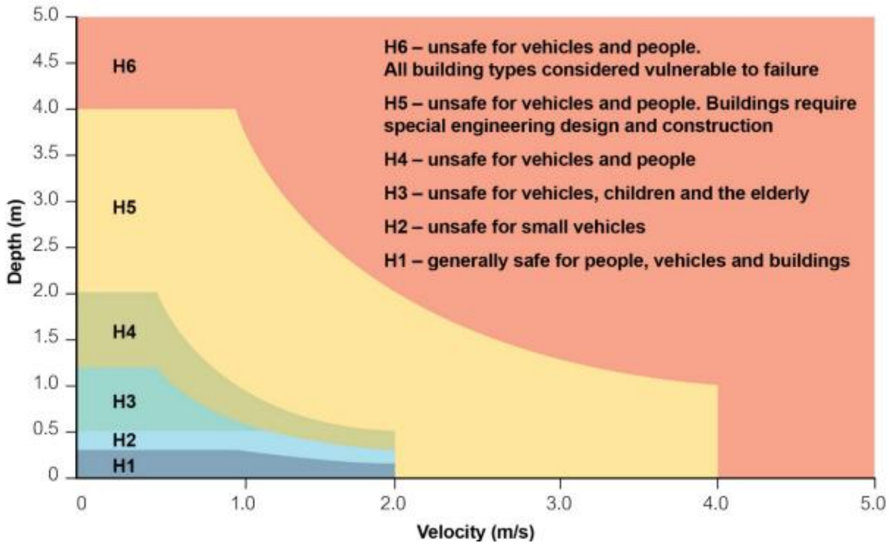


Figure 25- Depth-velocity (D×V) relationship defining hazard categories H1 to H6, from generally safe conditions to extreme hazard for people, vehicles and buildings.

Hazard vulnerability classification	Description	Classification limit (D and V in combination) m^2/s	Limiting still water depth (D) m	Limiting velocity (V) m/s
H1	Generally safe for vehicles, people and buildings	VxD ≤ 0.3	0.3	2.0
H2	Unsafe for small vehicles	VxD ≤ 0.6	0.5	2.0
H3	Unsafe for vehicles, children and the elderly	VxD ≤ 0.6	1.2	2.0
H4	Unsafe for vehicles and people	VxD ≤ 1.0	2.0	2.0
H5	Unsafe for vehicles and people. All building types vulnerable to structural damage. Some less robust building types vulnerable to failure	VxD ≤ 4.0	4.0	4.0
H6	Unsafe for vehicles and people. All building types considered vulnerable to failure	VxD > 4.0	–	–

Figure 26- Quantitative depth, velocity, and D×V limits used to classify flood hazard levels (H1–H6) for hydraulic modelling assessment.

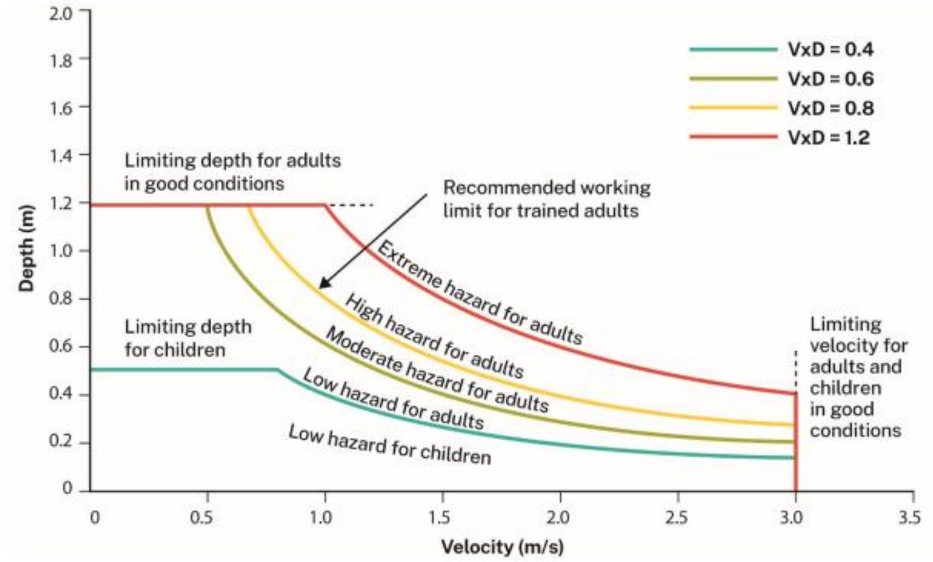


Figure 27- Depth-velocity criteria defining low to extreme hazard levels for pedestrian safety, including separate considerations for adults and children

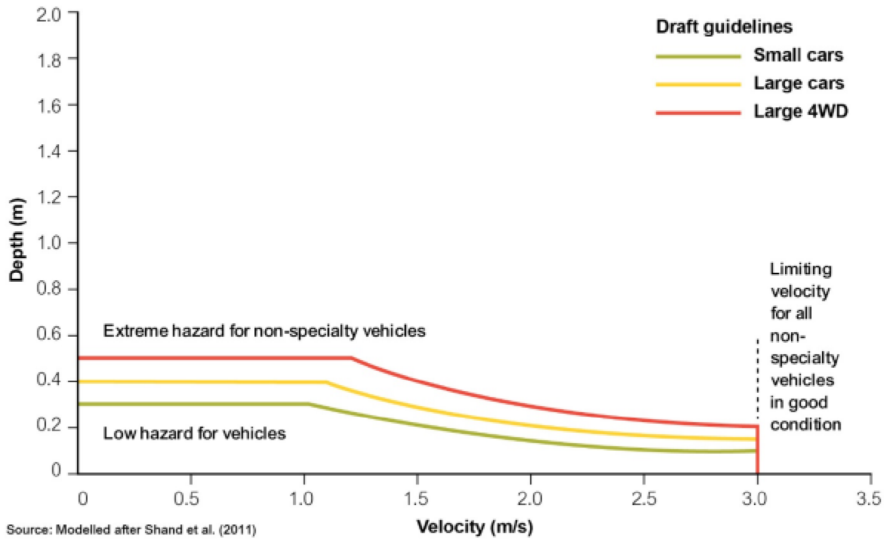


Figure 28- Depth-velocity limits for vehicle stability, distinguishing hazard levels for small cars, large cars and four-wheel-drive vehicles

Figure 29 - Spatial distribution of the D×V parameter across the site for the 1% AEP+CC event, highlighting variations between road environments and pedestrian-accessible areas

The results indicate that higher D×V values, ranging between approximately 0.50 and 0.75, are confined to internal road corridors, where the primary receptor is vehicles.

In contrast, areas accessible to pedestrians, including public open space and footpaths, exhibit significantly lower D×V values, typically between 0.055 and 0.25, which fall within the H1 hazard classification and are considered generally safe for people.

For road environments, vehicle stability was assessed separately using established vehicle stability threshold curves. Although D×V values within the road corridor exceed the H1 threshold for pedestrians, the combination of shallow flow depths, controlled velocities, and the vehicular-only nature of these areas indicates acceptable safety outcomes for vehicles during the 1% AEP event.

Overall, the assessment confirms that overland flow hazards remain low for pedestrian areas and manageable within road environments, with no unacceptable risk identified for the proposed development.

6. Conclusion

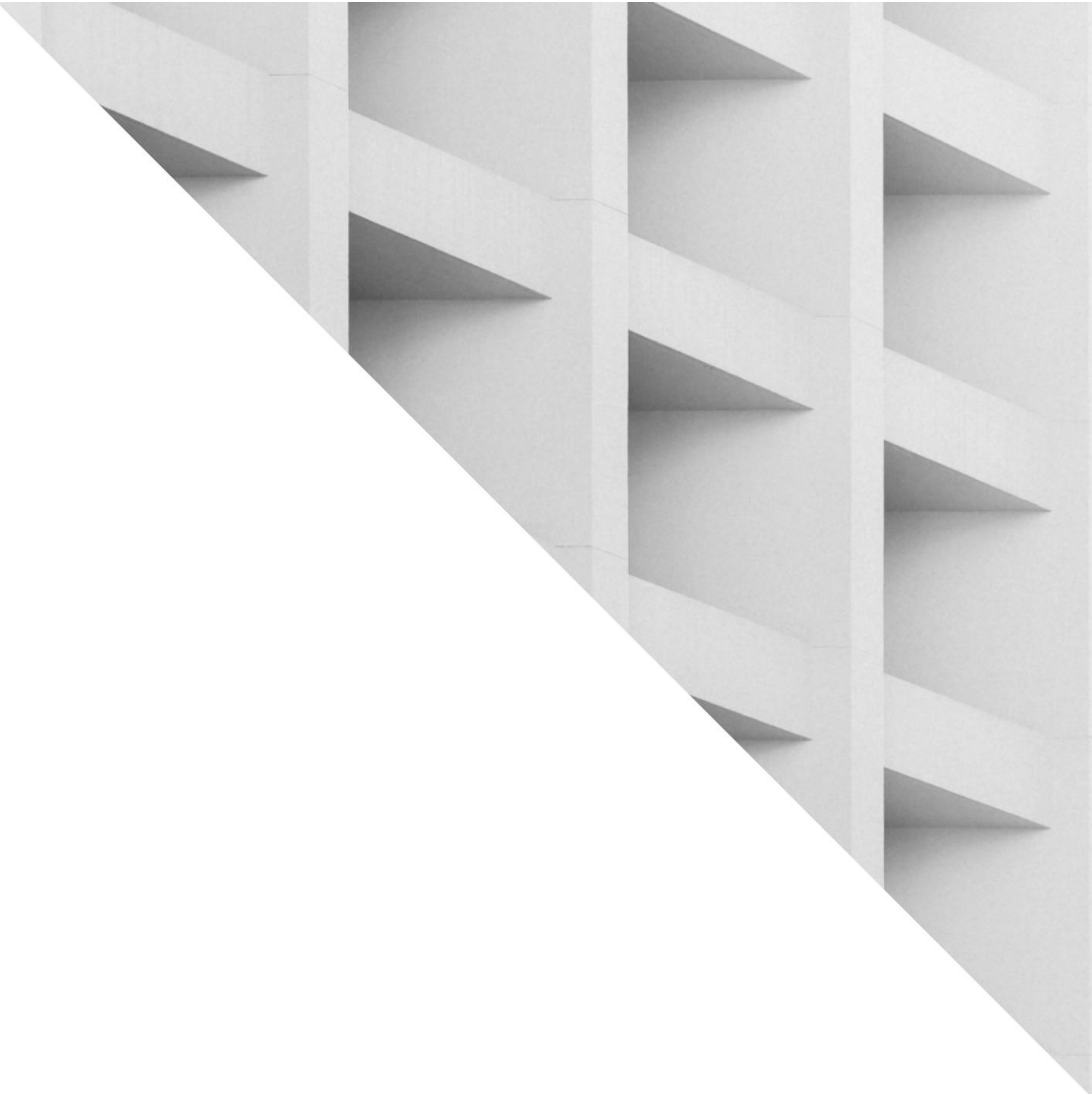
The stormwater assessment demonstrates that the existing flooding constraints affecting the site and the surrounding road network are primarily driven by limitations in the downstream Council drainage system along Cambridge Road, rather than by the proposed development itself. Pre-development modelling confirms that overland flow and flooding are already present under existing conditions for the 10%, 5%, and 1% AEP events, including under future climate change scenarios.

Post-development with CC modelling shows that the increase in site imperviousness is effectively managed through on-site controls, with runoff at the site boundary maintained at or below pre-development with CC conditions where feasible. A viable on-site detention system, constrained to the available footprint of approximately 80m in length, ≈700m^3, provides meaningful attenuation of peak flows without over-compensating for external system deficiencies.

Scenario testing confirms that attempting to fully offset the limited downstream pipe capacity through excessive on-site detention would require impractical storage volumes and does not represent a reasonable or proportionate engineering solution. In contrast, selective upsizing of the downstream drainage system to a continuous DN900 configuration, combined with on-site detention, significantly improves hydraulic performance, reduces overland flow magnitudes, and results in safe flood hazard outcomes for the 10% and 5% AEP event inclusive of Climate Change.

Two-dimensional hydraulic modelling undertaken for critical overland flow paths demonstrates that, under the adopted design scenario, Council's system upsized to DN900 and ≈700m^3 detention, flood hazard levels within internal roads and public open space are generally within H1 to H2 classifications, with pedestrian areas remaining at low hazard levels. Vehicle-related hazard levels are confined to road corridors only and remain consistent with accepted safety thresholds for minor storm events.

Overall, the proposed stormwater management strategy does not exacerbate existing flooding conditions and, where possible, contributes to improved flow management and safety outcomes relative to the current situation. The adopted approach is consistent with ARR guidance, Council requirements, and industry best practice, and provides a robust, defensible basis to support the proposed development.



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