APPENDIX G
Orchard Hills North: Supporting Technical Documents

G13 Stormwater and Flood Management Strategy

Stormwater and Flood Management Strategy

Legacy Property Group

Orchard Hills North Precinct

March 2022

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1. EXECUTIVE SUMMARY

Legacy Property is proposing to rezone a site in Orchard Hills North (OHN), located within the Penrith Local Government Area (LGA). The proposed Precinct is approximately 151.9 hectares (ha) with frontages to Caddens Road to the north, Kingswood Road to the west, the M4 Motorway to the south and Claremont Meadows residential lots to the east.

J. Wyndham Prince Pty Ltd (JWP) prepared the Orchard Hills North Rezoning Stormwater Management Strategy (SWMS) report in March 2018 for Legacy Property and to support the pre gateway submission and proposed proposal rezoning at Orchard Hills North. The SWMS report presented background and details the planning proposal for Orchard Hills North rezoning, hydrologic analysis, water quality analysis, Riparian Corridor assessment and ecological assessment.

Gateway approval determination for the proposed OHN precinct was achieved on 22 February 2019. A series of additional investigation/comments formed part of this approval, with these matters addressed throughout this report and various discussions with Council officers.

This report provides an update to the revised Gateway Stormwater Management Strategy and flood impact assessment, ensuring that both water quantity and water quality are managed prior to discharge to the neighbouring environment with no adverse impact in accordance with PCC feedback, guidelines and policy documents.

Results demonstrate that the proposed six (6) detention basins located throughout the site with a total storage of approximately 71,550 m^3 will ensure that peak post-development discharges from the storm events up to and including 1% AEP is restricted to less than the pre-development levels at all key comparison locations. The strategy includes two (2) online basins with open water bodies within the relocated Werrington Corridor and four (4) traditional detention basins at the major discharge point of the Precinct.

Water quality will be managed by a series of devices that include on-lot rainwater tanks, gross pollutant trap, ponds, and bioretention raingardens to deliver the required water quality outcomes. The one (1) bio-retention raingarden co-located within basin B6 is located 1m above the bed level of the detention basins, with the other four (4) bio-retention raingardens located outside the detention basins footprint. The total bio-retention raingarden area required to deliver PCC objectives is approximately 11,150 m^2.

The proposed stormwater management devices (basins and water quality treatment devices) are sized to consider the external catchments to the west of the Precinct, which will ultimately drain into the Precinct but currently is not part of the rezoning area.

The concept design plans of the proposed Water Management devices have been prepared along with an Opinion of Probable Development Cost for use in the preparation of a Section 7.11 Contribution Plan. Refer to Orchard Hills North Cost Estimate and Concept Design Plans report (JWP, May 2021).

The Flood and Stormwater Management Strategy also provides a flood impact assessment of the OHN precinct. The assessment defined the flood behaviour within the Precinct providing information on the flood depths, levels, and hazards for 0.5EY, 1% AEP and PMF events. The flood impact map found in Appendix D shows that in 1% AEP event, the development of OHN will improve flooding conditions on the north, south and eastern side of the Precinct and reduce flood depths. There are some small increases in flood levels along the southern boundary. Further discussion on the suitability of these impacts is provided in Section 6.4.

The Stormwater Management Strategy proposed for Orchard Hills North is therefore functional; delivers the required technical performance; lessens environmental degradation and pressure on downstream ecosystems and infrastructure, and provides for a ‘soft’ sustainable solution for stormwater management within the Precinct.

2. BACKGROUND

2.1. Site

Orchard Hills North (OHN) is well located being north of the Western Sydney Motorway, in close proximity to Western Sydney University (to the north), Nepean Hospital (to the north) and 6 km northwest from the Penrith City Centre. The proposed Precinct is approximately 151.9 hectares (ha) with frontages to Caddens Road to the north, Kingswood Road to the west, the M4 Motorway to the south and Claremont Meadows residential lots to the east. The location of the Precinct is shown on Plate 2-1.

South of the M4 Motorway is Orchard Hills rural lands and Defence Lands. To the south-west is Glenmore Park, and further south will be the new Badgerys Creek Airport. The overall site is bisected by a network of existing watercourses, with the College Creek running through the site towards Caddens Road and Claremont Creek bisecting the eastern portion of the site.

Legacy Property Group nominated the Orchard Hills North site under Council's Accelerated Housing Delivery Program (AHDP) in October 2017. In November 2017, the site was endorsed by Council as a short-term rezoning opportunity to provide for housing delivery over the next 3-5 years.

Plate 2-1 – Proposed Rezoning Area

2.2. Objective

The objective of this study is to support the rezoning application that addresses the items in gateway determination and includes an assessment of flooding within and surrounding the subject site. This assessment will ensure compliance or otherwise with PCC development standards. In addition, this report responds to Council's comments on the stormwater management strategy provided in June 2020.

2.3. Proposed Development

The Planning Proposal for Orchard Hills North aims to rezone the 151.9 ha site from rural land to mixed land uses, comprising approximately 1,729 residential lots, a neighbourhood centre and numerous areas of green open space. The development includes re-align / re-establishment of College Creek, a tributary of Werrington Creek through the centre of the Precinct and removal as agreed by Natural Resources Access Regulator (NRAR) to a series of 1st order watercourses that have little ecological or stormwater management value. The proposed realignment of College Creek provides improved connectivity to the recently realigned watercourse through Caddens Road development (to the North). The precinct plan will retain the full riparian corridor width of the 4th order watercourse in Claremont Creek. Full detail on riparian corridor assessment was undertaken as a part of the stormwater management strategy report in September 2018 with a summary of these findings provided in Section 3.

It is also noted that there have been some updates to the road layout as a part of the Strategic Road Network (wider traffic management requirements) and location of Basin B7 as a part of Council discussion. These changes are not anticipated to result in a significant change in the catchment assumptions that form part of this strategy. The latest OHN structure plan RevU dated 24 May 2021 supplied by Design Planning is provided in Appendix A and also in Pate 2-2.

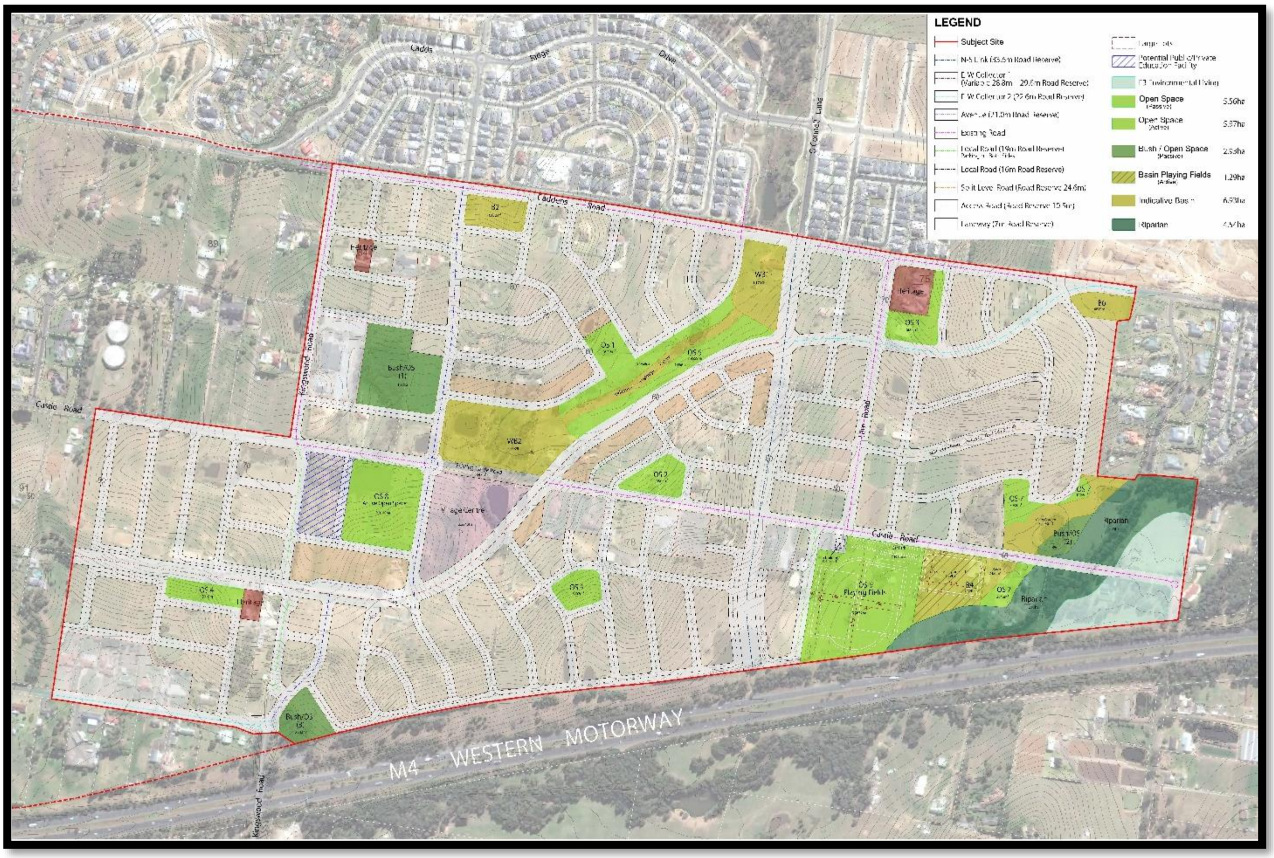

Plate 2-2 – OHN Indicative Master Plan

3. PREVIOUS STUDIES AND RELEVANT GUIDELINES

The following control documents have been considered in the development of the Stormwater Management Strategy for Orchard Hills North:

- Penrith City Council Water Sensitive Urban Design Policy (2015)
- Penrith City Council Development Control Plan (DCP) (2014)
- Penrith City Council Stormwater Drainage for Building Developments (2016)
- Penrith City Council Engineering design guidelines for subdivisions.
- Penrith City Council WSUD Technical Guidelines (2015)
- Penrith City Council Cooling the City Strategy (2015)

Previous studies have been undertaken in the vicinity of Orchard Hills North. A review of the following studies along with Council advice was undertaken as part of this study and are summarised in the following sections.

3.1. Orchard Hills North Rezoning SWMS (JWP, 2018)

J. Wyndham Prince Pty Ltd (JWP) have prepared the Orchard Hills North Rezoning Stormwater Management Strategy (SWMS) report in September 2018 for Legacy Property to support the proposed rezoning at Orchard Hills North. The SWMS report presented background and detail on planning proposal for Orchard Hills North rezoning, hydrologic analysis, water quality analysis and riparian Corridor assessment.

The report demonstrated that the proposed nine (9) detention basins would ensure that peak post-development flows are restricted to less than the existing levels at all key comparison locations. Whilst water quality would be managed by on-lot rainwater tanks, gross pollutant trap and fourteen (14) rain gardens co-located within detention basins in order the deliver the required water quality outcomes.

A riparian corridor assessment (including field investigations) has been undertaken to identify the significance of each mapped watercourse and provides additional information to support the proposed removal and/or realignment of the mapped watercourse within the indicative masterplan. It is noted that the riparian Corridor assessment did not include any stream order assessment or classification. The Natural Resources Access Regulator (then DPI Water) has been presented with the results of the riparian corridor assessment to enable an opportunity to review our documentation and provide some preliminary feedback prior to submitting the rezoning submission. The Natural Resources Access Regulator (NRAR) has reviewed the information presented and have provided a response on 22 August 2019 (provided in Appendix B). Response from NRAR states:

- NRAR is in agreement with the Orchard Hills North - Assessment of Riparian Corridors prepared by JWP and agrees to the proposed watercourses marked for removal in Figure 1.
- The remaining watercourses on the site are to be managed in accordance with the requirements of the NRAR Controlled Activity Guidelines for riparian corridors on waterfront land.
- Werrington Creek and tributaries
  - within the site are considered 1st order streams with a corresponding 10m wide Vegetated Riparian Zone (VRZ);
  - the watercourse/s can be realigned;
  - offsetting is allowable;
  - is to be maintained as a natural open channel including the establishment of riparian corridor; and
  - a low flow pipe design is not compliant with the Guidelines and will not be supported.
- Claremont Creek
  - within the site is considered a 4th order stream with a corresponding 40m wide Vegetated Riparian Zone (VRZ);
  - offsetting is allowable within the site; and

  – is to be maintained as a natural open channel including the establishment of riparian corridor.

An accompanying ecological (flora and fauna) assessment has also been undertaken by Cumberland Ecology which supports the removal of a number of watercourses.

The report was submitted for a gateway determination to PCC and as part of the feedback, PCC raised concern over the number of issues. These issues are discussed further in Section 3.2.

3.2. Orchard Hills North Rezoning Updated Basin Strategy (JWP, 2018)

As part of the Stormwater Management Strategy consultation, the basin strategy was updated to reflect PCC desire to consolidate the number of basins within the Precinct which included a hydrological assessment to consider the latest masterplan layout for the rezoning area. The strategy update to review stormwater quality management and undertake a flood impact assessment was pending further discussion with Penrith City Council on this consolidated basin assessment in order to support the next stage of the rezoning process.

The updated basin strategy minimised the number of proposed water treatment devices while still delivering stormwater management at the site boundary. This report was provided to the Council on December 2018. The updated strategy resulted in the removal of four (4) basins from the strategy and it was found that detention is not required at the site interface with Claremont Creek. Council reviewed the revised strategy and did not support the provision of the proposed developed catchments without the detention basin at the site interface with Claremont Creek. As water quality measures were still required for these catchments, Council prefers to retain detention basin and combine the original two (2) basins (B4 and B5) for these catchments to one (1) basin. This advice formed the basis for the current strategy development

3.3. O'Connell Street, Caddens Development SWMS (JWP, 2018)

J. Wyndham Prince Pty Ltd (JWP) was engaged by Legacy Property to prepare a Stormwater Management Strategy (SWMS) report to support the approval of the proposed subdivision at O'Connell Street, Caddens. The overall development includes approximately 550 lots across a total of six (6) stages.

The proposed Stormwater Management Strategy ensured that both water quantity and water quality are managed prior to discharge to the downstream environment in accordance with Penrith City Council's guidelines and policy documents. Results demonstrated that the proposed four (4) detention basins (refer to Plate 3-1) will ensure that peak post-development discharges are restricted to less than the pre-development levels at all key comparison locations. Water quality will be managed by on-lot rainwater tanks, gross pollutant trap and rain gardens co-located within detention basins. The proposed treatment train of water quality devices will also achieve Council's pollutant removal targets

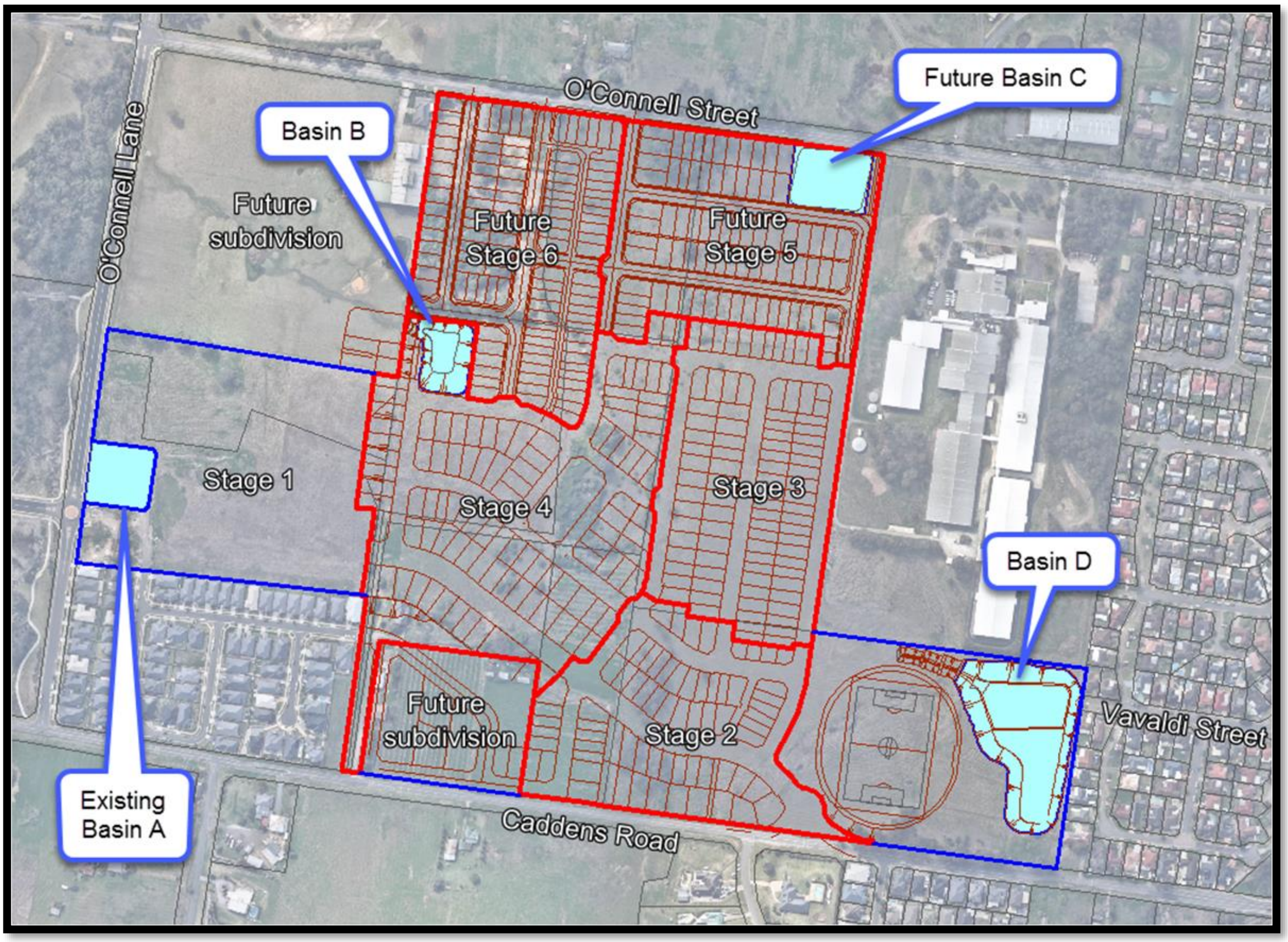

Plate 3-1 – O'Connell Street, Caddens Development (JWP, 2018)

It is noted that the Caddens development terrain and stormwater drainage network has been incorporated in the "Existing" conditions for this study at Orchard Hills North.

3.4. College, Orth and Werrington Creeks catchment Overland Flow Study (Catchment Simulation Solutions, 2017)

In June 2017, Council engaged Catchment Simulation Solutions (CSS) to prepare the College, Orth and Werrington Creeks Catchment Overland Flow Flood Study (COWFS). This flood study formed the first of four (4) stages which are set out under the NSW State Government's Flood Prone Land Policy.

The assessment covered a study area of approximately 12 km^2 which included suburbs of Werrington, Werrington County, Cambridge Park, Kingswood, Caddens and parts of Orchard Hills. Most notably, the study area included the central portion of the proposed Orchard Hills North site - which forms the uppermost reach of Werrington Creek.

One of the main objectives of the study (CSS, 2017) was to serve as a guide for future development across the catchment in a way that is cognisant of the flood risk.

The Flood Study provided information on flood discharges (flows), levels, depths and velocities, for a range of flood events under existing topographic and development conditions. This information can then be used as a basis for identifying those areas where the greatest flood damage is likely to occur, thereby allowing a targeted assessment of where flood mitigation measures would be best implemented as part of the subsequent Floodplain Risk Management Study and Plan."

Plates 3-1 and 3-2 shows extracts of Council's flood maps which shows the extents of 1% Annual Exceedance Probability (AEP) flooding across OHN. It is noted that there are numerous farm dams which have been included in the Council's model with existing flood storage being considered.

Importantly, the base hydrology (XP-RAFTS) models which underlined the abovementioned study have been obtained and adopted as the base case "Existing" conditions for this study at Orchard Hills North. Refer to Section 5 for modelling details and discussion.

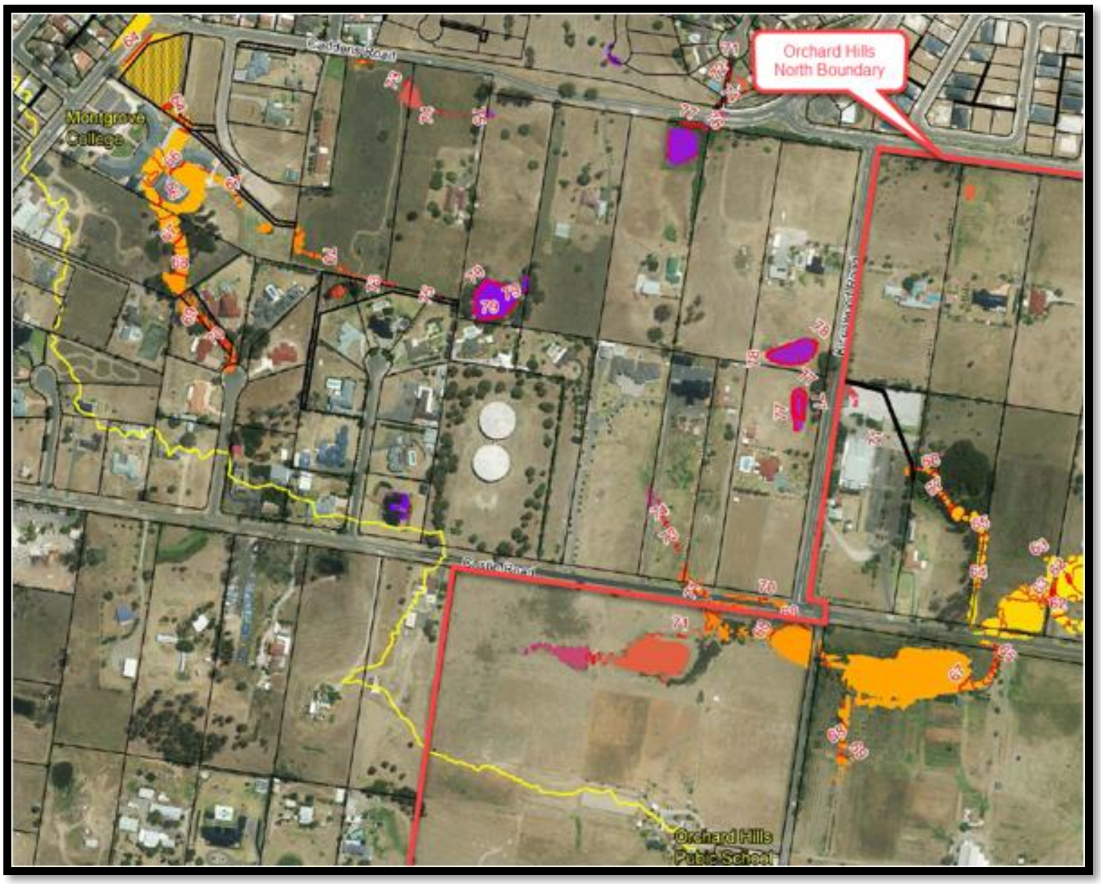

Plate 3-2 – 1% AEP Flood Map in vicinity of Orchard Hills North

(Source: Figure 28.1 CSS, 2017)

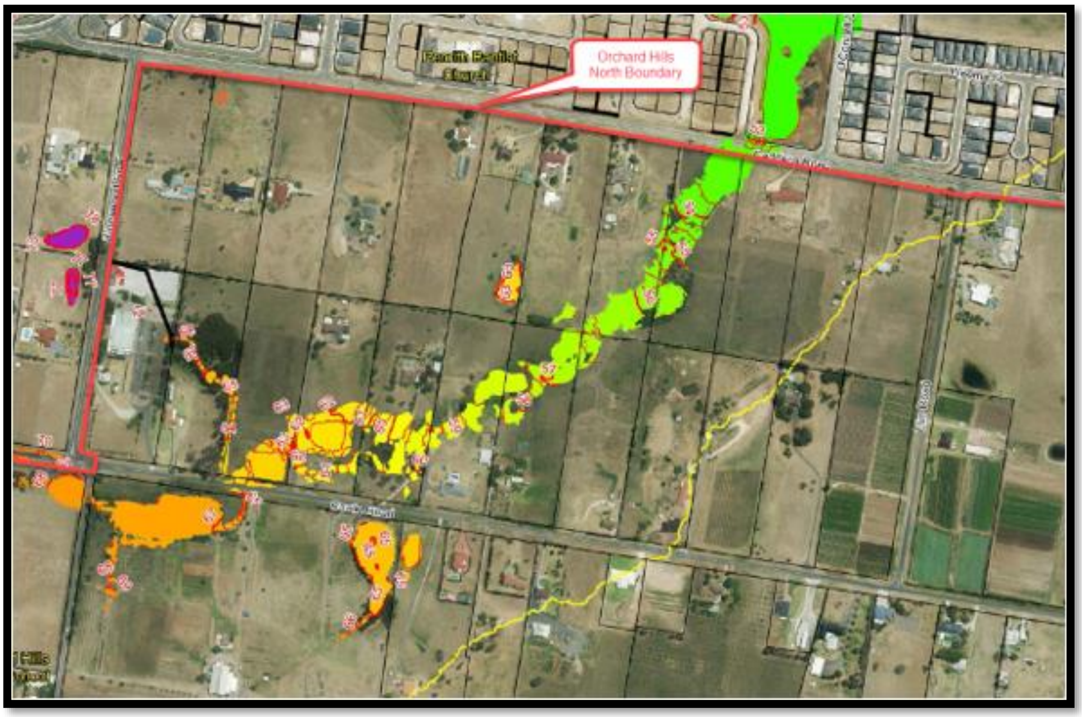

Plate 3-3 – 1% AEP Flood Map in vicinity of Orchard Hills North

(Source: Figure 28.2 CSS, 2017)

3.5. South Creek Flood Study (Worley Parsons, 2015)

In 2015, Worsley Parsons was commissioned by Council to prepare an updated flood study for South Creek. This assessment was built upon an earlier study (DWR, 1990) to also include several major developments, levees and earthworks across the floodplain to consider their potential to alter flood patterns.

The objective of the study was to provide the Council with a contemporary tool which can assess a range of standard design floods and provide more reliable estimates of planning flood levels. The new flood models would then assist any future floodplain management study that may be undertaken to assess options for reducing existing flood damages or in providing guidance to regional planning.

Hydrology updates were undertaken within XP-RAFTS to be consistent with the latest version. In particular, updates included:

- Redefining catchments based on the latest topography,
- Reassigning roughness parameters based on aerial imagery,
- Inclusion of several recent developments at the ADI Site, St Marys and Erskine Park
- Inclusion of a number of measures recommended in the South Creek Floodplain Management Study (1991), including works upstream of Elizabeth Drive, at Overett Avenue, and at South St. Marys.

The hydrologic model was calibrated against the 1990 study (and the 1986 and 1988 floods) mainly through the adjustment of the 'Bx' factor, with minor adjustments to the initial and continuing loss parameters.

A two-dimensional flood model was undertaken within RMA-2 software to assess South Creek and the tributaries. Flood mapping, velocities and hazards were provided for the 20, 100 and 200-year ARI events along with the Probable Maximum Flood (PMF).

The South Creek Flood Study included a part of Claremont Creek which bisects the eastern side of the Orchard Hills North site. Plates 3.3 is an extract from the Worley Parsons, 2015 report and show the predicted flood extents in the 1% AEP and PMF under "existing" conditions. It should be noted that this 2015 study is a mainstream flood study and do not represent the peak overland flood levels at the Claremont Creek within the Precinct.

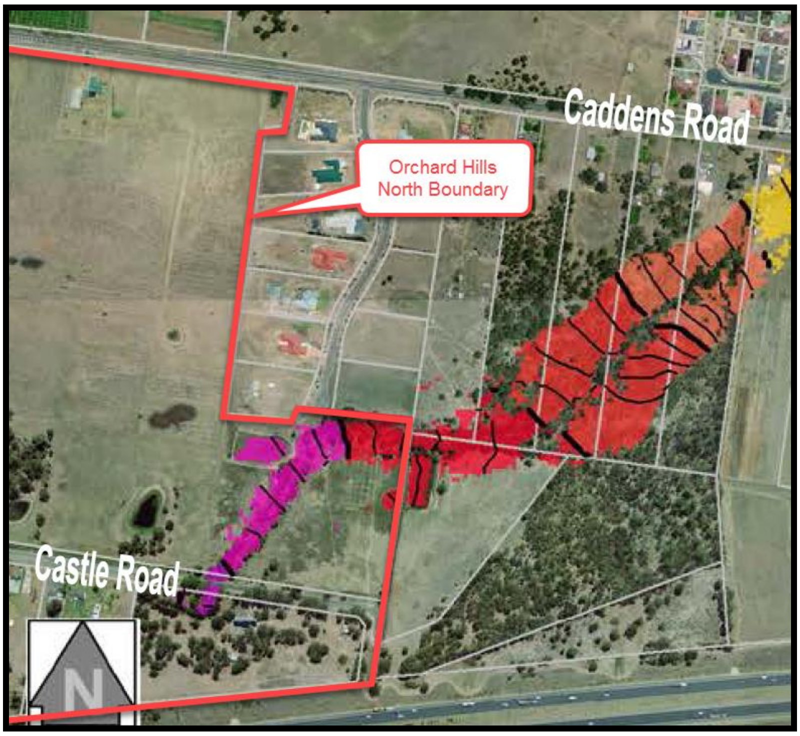

Plate 3-4 – 1% AEP Flood Map in the vicinity of Orchard Hills North

(Source: Figure 6.45 WP, 2015)

3.6. Cooling the City Strategy (PCC, 2015)

Penrith City Council has developed the Cooling the City Strategy, in 2015 that identifies strategies to cool the city and region in a way that improves liveability and prioritises protection from heat for people and communities based on the research undertaken within Penrith LGA. This strategy identified a range of opportunities that could be considered to cool the city to have the greatest impact and includes:

- Green Infrastructure;
- Water Sensitive Urban Design (WSUD);
- Increased Albedo / Reflectivity;
- Policy & Planning
- Community Engagement.

The research also demonstrated water either on the surface or stored in the soil profile, tree cover, and ground cover that is permeable and grassed are significantly cooler than others. The foundation of urban heat mitigation is the retention of water in the landscape. WSUD includes technologies such as water efficient fittings and appliances, rainwater tanks to reduce potable water consumption and costs, bio retention systems (rain gardens), swales, wetlands, proprietary devices and other approved site-specific measures to reduce pollution from stormwater entering local waterways which together can influence air temperature and surface temperature.

4. WATER QUALITY ASSESSMENT

4.1. Modelling Inputs and Assumptions

MUSIC modelling for the OHN precinct has been undertaken using MUSIC Version 6.3. We have considered Penrith City Council WSUD Design Policy (PCC, 2015) and Technical Guidelines (PCC, 2015) in the development of the water quality assessment.

The MUSIC model catchments have been split into the roof, road, urban previous and urban impervious. The details on catchment area and land use assumptions are provided in Appendix C.

It is noted that the water quality treatment devices have been sized considering the external catchment to the west of Precinct in its developed condition which will ultimately drain into the Precinct. MUSIC model catchment plan is shown in Figure 4-01 in Appendix D. An overview of the model layout is shown in Plate 4-1.

The target pollutant removal rates for this development as set out in the Council's WSUD Policy (PCC, 2015), shown in Table 4-1.

Table 4-1 – Pollutant Reduction Targets

Pollutant	Reduction Target
Total Suspended Solids (TSS)	85%
Total Phosphorus (TP)	60%
Total Nitrogen (TN)	45%
Gross Pollutants (GP)	90%

The MUSIC Modelling has assumed the following in the determination of results:

- The proposed development has a lot mix of normal residential to large-lot residential including medium density residential, as such, lot area with an average of 75% impervious overall with the Precinct;
- Commercial Areas 100% impervious;
- Road reserve 95% impervious;
- Open Space 10% impervious as the proposed concept plan for the Precinct shows open space and playing fields which are not anticipated to be more than 10% Impervious;
- Roof areas assumed to cover 60% of lot area;
- Only 50% of the lots within the OHN development are considered to have rainwater tank within the Precinct. This approach is based on PCC post-gateway advice (6a) which confirmed that stormwater management strategy for the Precinct must not rely on individual rainwater tanks on individual lots unless required by the BASIX provisions.

  As such, for the lots sizes within the Precinct smaller than 320 m^2 are assumed to have no rainwater tank. This lot size accounts for approximately 50% of lots within the Precinct; and
- Given that there is no information on the development plan of external catchment draining to the study area, external catchments were modelled with 80% impervious and with no rainwater tanks.

Further details on assumed parameters are provided in Appendix C.

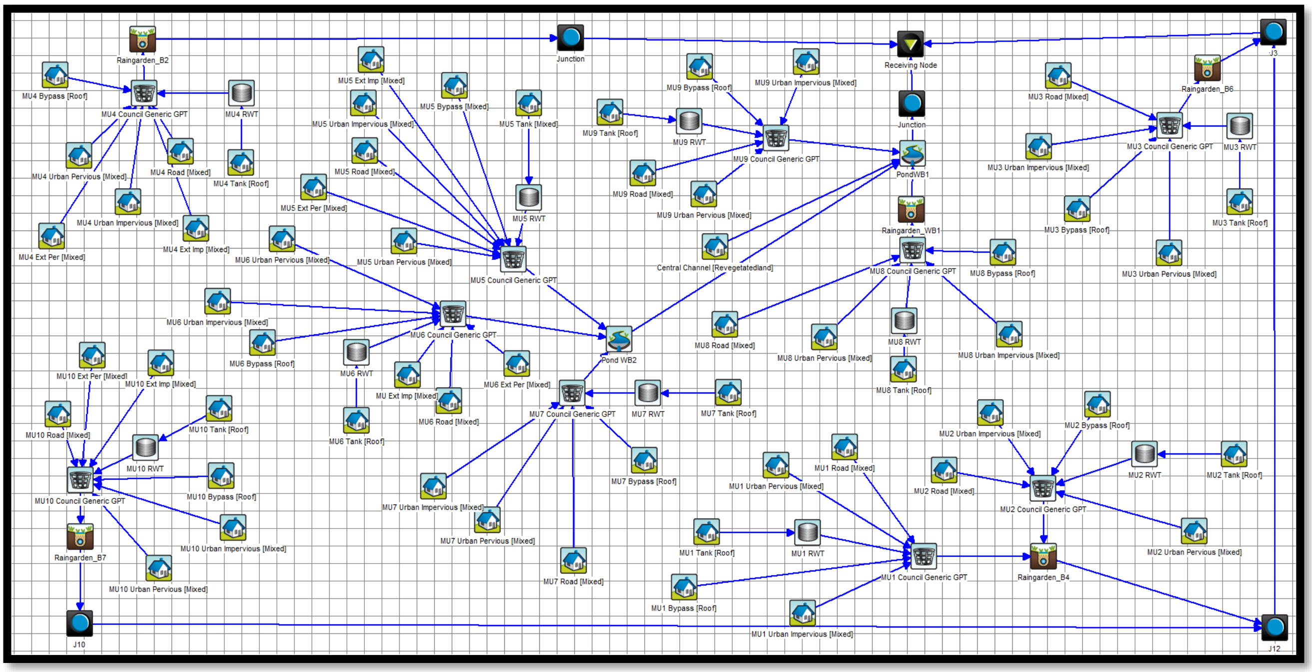

Plate 4-1 – MUSIC Model Overview

4.2. Water Quality Management Measures

It is proposed that stormwater quality in the OHN precinct be managed using a treatment train approach. A proposed treatment train of water quality devices has been identified to achieve the target pollutant removals. This includes a combined system of rainwater tanks, Gross Pollutant Traps (GPT), bio-retention raingardens and permanent water bodies (ponds). The proposed treatment train consists of:

- Rainwater harvesting and re-use of residential roof runoff of by utilising rainwater tanks;
- Gross Pollutant Traps (GPT) to pre-treat runoff prior to discharge into bioretention gardens; and
- Bioretention Raingarden which will receive flows from the GPTs.
- Permanent water bodies (ponds) which will receive flows from the GPTs.

The indicative location of bioretention raingarden and ponds are shown in Figure 4-01 in Appendix D.

4.2.1 Rainwater Tank

Rainwater tanks were modelled for the Study Area based on the following design assumptions:

- Only 50% of the lots within the Orchard Hills North development are considered to have rainwater tank;
- 50% of the roof areas from these lots will be directly connected to rainwater tanks;
- 3.0 kL rainwater tanks on each lot, 2.4 kL re-usable storage above top-up; and
- Rainwater tank re-use of 0.10 kL/day internal use & 50 kL/year as PET- Rain. (PCC WSUD Technical Guidelines, 2015)

Further detail on rainwater tank sizing is provided in Appendix D.It is noted that any OSD that the rainwater tanks may provide has been ignored in the OSD modelling assessment.

4.2.2 Gross Pollutant Traps

GPTs have been provided to filter stormwater prior to discharge into the drainage system, bioretention raingardens and ponds. The expected pollutant removal rates adopted within the model is provided in Table 4-2. A generic GPT node has conservatively been adopted in MUSIC to provide flexibility in detailed design. The generic node has adopted no TSS, TP or TN removal. Such devices may include proprietary GPTs such as a Humeceptor or CDS unit (or equivalent). For the purposes of MUSIC modelling it was assumed that the GPTs will be located upstream of bioretention raingarden and ponds.

Table 4-2 – GPT Input Parameters

Pollutant	Input	Output
TSS (mg/L)	0	0
	1000	1000
TP (mg/L)	0	0
	1	1
TN (mg/L)	0	0
	5	5
Gross Pollutant (kg/ML)	0	0
	15	1.5

4.2.3 Pond

Permanent water bodies (ponds) can provide an aesthetic feature to subdivisions. The water bodies are designed to have permanent water storage that promotes a Hydraulic Residence Time (HRT) of sufficient length to promote the appropriate pollutant removal mechanisms. The design parameters adopted for the pond are shown in Table 4-3. The catchment MU5, MU6 and MU7 (see MUSIC Catchment Plan in Figure 4-01) are treated by WB2 pond which drains downstream through the constructed drainage channel (central corridor) to WB1 pond. The WB1 pond provides the water quality treatment to MU8 and MU9. The pond receives flows having firstly being treated by the GPT at each outlet.

Table 4-3 – Pond Input Parameters

Parameters	WB2	WB1
Surface Area(sq.m)	19549	10457
Extended Detention Depth (m)	0.3	0.3
Permanent pool volume (cu.m)	32302	15754
Initial Volume (cu.m)	32302	15754
Exfiltration Rate (mm/hr)	0.03	0.03

Ponds are proposed to comprise part of the two (2) detention basins (WB1 and WB2) within the OHN precinct. Each of these water bodies will be located online within the re-established 2nd order riparian corridor.

Fringing vegetation is typically strategically planted to help promote the pollutant removal mechanisms and to inhibit public access to the deeper water zone.

Importantly, PCC has raised concern on algae management and unwanted vegetation management issues on the proposed ponds on the post-gateway advice 7(h) as such aerators and mixers are proposed as underwater infrastructure to assist with the control of Blue-Green Algae and breakdown thermal stratification within the water column. Concept designs will be undertaken to show measures relating to aerating of water to minimise the growth of algae. Details of mechanical infrastructure, water quality monitoring and reporting program will be detailed at the DA / CC stage.

4.2.4 Bioretention Raingarden

The design parameters adopted for the bioretention raingarden are shown in Table 4-4. The filter media receives flow having firstly being treated by the GPT at each outlet. Bioretention raingarden systems are proposed in five (5) locations across the OHN precinct in order to achieve the nutrient reduction targets outlined in the Council's WSUD Policy (PCC, 2015).

The bioretention raingarden within basin B6 is 1 m above the bed of the detention basin, and four (4) bioretention raingardens are located outside the detention basins B2, B4, B7 and WB1 (see MUSIC Catchment Plan in Figure 4-01). The one (1) co-located raingarden within Basin B6 is also preached at a higher level and only become inundated in larger storm events greater than 2% AEP event. Further details on the impact of larger storm event on these devices are provided in Section 6.5. The bio-retention raingardens will also attenuate first flush flows to reduce the risk of stream erosion within the watercourses.

Table 4-4 – Bioretention Raingarden Input Parameters

Parameters	Raingarden Catchment				
	MU1 +MU2	MU3	MU4	MU8	MU10
	RainGarden_B4	RainGarden_B6	RainGarden_B2	RainGarden_WB1	Raingarden_B7
Low flow by-pass (cu.m/s)	0	0	0	0	0
High Flow by-pass (cu.m/s)	3.67	0.59	0.64	0.95	3.03
Extended Detion Depth (m)	0.3	0.3	0.3	0.3	0.3
Surface Area (sq.m)	4100	800	1000	1250	4000
Saturated Hydraulic Conductivity (mm/hr)	125	125	125	125	125
Filter Depth (m)	0.5	0.5	0.5	0.5	0.5
TN Content (mg/kg)	800	800	800	800	800
Orthophosphate Content (mg/kg)	40	40	40	40	40
Exfiltration Rate (mm/hr)	0	0	0	0	0
Base Lined	Yes	Yes	Yes	Yes	Yes
Underdrain Present	Yes	Yes	Yes	Yes	Yes
Submerged Zone	No	No	No	No	No

4.3. Modelling Results

The pollutant reductions achieved for the proposed water quality treatment measures is provided in Table 4-5. The proposed measures have helped achieve the water quality targets set out in the Penrith City Council WSUD Policy (PCC, 2015).

Table 4-5 – Summary of MUSIC Model Results

Pollutant	Total Developed Source Nodes	Total Residual Load from Site	Total Reduction Achieved	Target Reduction Required	Total Reduction Achieved
	(kg/yr)	(kg/yr)	(kg/yr)	(%)	(%)
TSS	162000	22300	139700	85.0%	86.2%
TP	279	83.6	195.4	60.0%	70.0%
TN	1800	880	920.0	45.0%	51.1%
Gross Pollutants	21600	77.6	21522	90.0%	99.6%

4.4. Stream Erosion Index

As set out in Penrith City Council DCP, Water Sensitive Urban Design Policy 2013 and Water Sensitive Urban Design Technical Guidelines 2015, a Stream Erosion Index (SEI) assessment must be undertaken. The SEI assessment is to ensure that the duration of post-development stream forming flows is no greater than 3.5 times the duration of pre-development stream forming flows. The methodology to determine the SEI complies with the NSW MUSIC Modelling Guide (2015) and is set out in Table 1 of the Council's Technical Guidelines.

A rural residential urban node has been used to represent the site under existing conditions and the rainfall-runoff/soil parameters remain consistent with Table 4 – MUSIC Rainfall-Runoff Parameters for Penrith in the Council's Technical Guidelines.

The MUSIC modelling guidelines require the stream forming flow for the site to be determined using either the Probabilistic Rational Method (PRM) or Flood Frequency Analysis. As there are no stream gauge records available for the site, the PRM method has been adopted. We note that the Rational method is no longer considered valid under the Australian Rainfall and Runoff (ARR 2016) guideline, however, we have utilised this method in accordance with Council's WSUD Policy (PCC, 2013). A summary table of the SEI assessment and results is provided in Table 4-6.

The flow for the site has been calculated and a SEI at each discharge location was determined. The storm erosion index assessment reference locations are shown in Figure 4-01 in Appendix D.

Table 4-6 – SEI Assessment

	Determination of Critical Flow							Stream Erosion Index		
Assessment Location	Area (km^2)	$t_c = 0.76A^{0.38}$ (hour)	t_c (minutes)	I_2 (mm/hr)	C_2	Q_2 (m^3/s)	Q_{crit} (m^3/s)	Pre Dev Outflow (ML/yr)	Post Dev Outflow (ML/yr)	SEI
L1	0.46	0.57	34	39.9	0.44	2.28	0.57	15.80	36.40	2.3
L2	0.06	0.27	16	59.7	0.44	0.48	0.12	1.58	3.63	2.3
L3	0.07	0.28	17	58.0	0.44	0.52	0.13	1.85	4.10	2.2
L4	0.75	0.68	41	37.1	0.44	3.45	0.86	27.80	9.31	0.3
L5	0.37	0.52	31	73.4	0.44	3.34	0.84	8.55	21.00	2.5

4.5. Permanent Water Body Management Strategy

The permanent water bodies have been designed considering the Royal Life Saving guidelines and now includes shallow water zones to manage the safety risk.

Algal management is also seen as a key consideration to ensure the proposed pond water remains clean and clear. This has been raised by PCC on post-gateway advice 7(h) also. Waterbody particularly throughout Western Sydney can become thermally stratified when two (2) distinct temperature layers form.

During summer, algal blooms often occur in the warm stable conditions of the upper layer. Increasing the movement of water that circulates between the shallower and deeper layers of the pond reduces the differences in temperature, oxygen and nutrients between the top and bottom water. As such, the aerators (Otterbine) can be used in the pond as shown in Plate 4-2 that will add the aesthetic of the area. The high pumping rate/circulation rate of an aerator breaks down thermal stratification, mixing denser bottom waters with warmer surface water, distributing oxygen to all parts of the lake which aids in the breakdown of the algae chain. The general sizing guideline is 1.5 HP per 4,000 m2 - so there would be a 5HP and 3HP aeration unit recommended for WB1 and WB2 respectively.

Plate 4-2 – Aerator (Otterbine)
Source: www.clearpond.com.au

Plate 4-3 shows correct mooring installation and Plate 4-4 shows the water circulation of Otterbine respectively. Product illustration is provided in Appendix E.

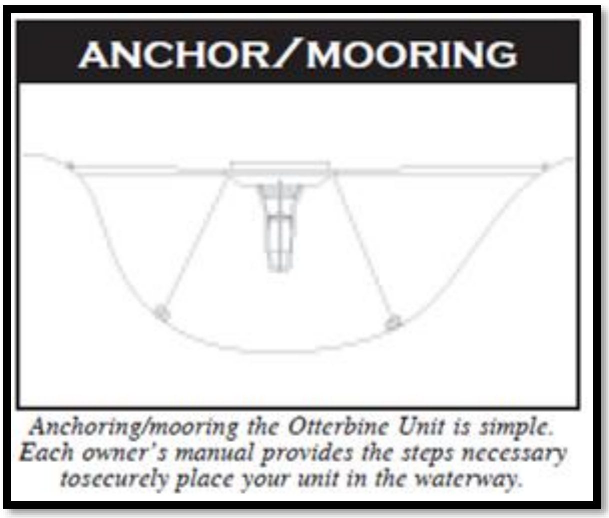	
Plate 4-3 – Mooring Installation of Otterbine	*Plate 4-4 – Water Circulation of Otterbine*

Alternatively, Aquarius Solar range of pumps is ideal for fountains and water features which provides operation when no power is available and with the option of power for pumps to keep the water flowing. This is an environmentally friendly solution which circulates the water from bottom to top. The function of Oase Aquarius Solar is illustrated in Plate 4-5.

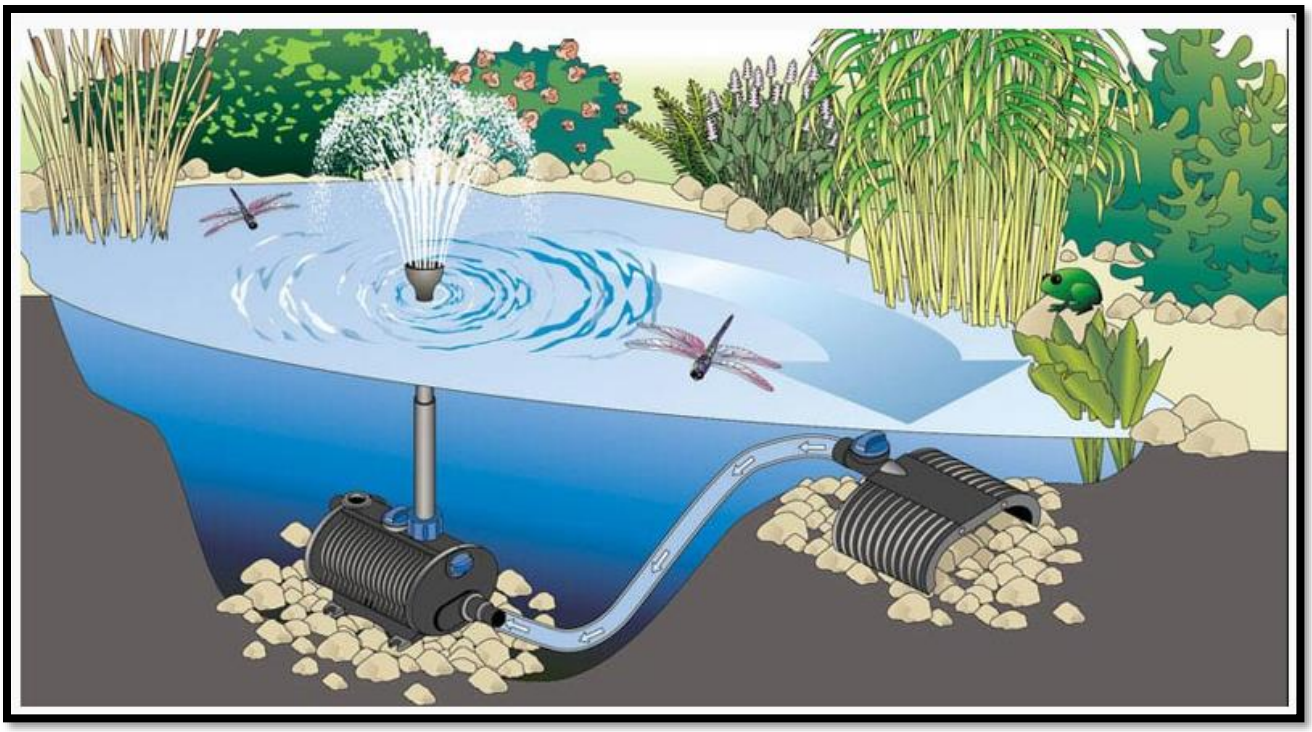

Plate 4-5 – Oase Aquarius Solar Illustration
Source: www.clearpond.com.au

The detailed management of the pond in terms of periodic de-silting, management of litter and unwanted vegetation including monitoring program will be provided at DA stage.

4.6. Stormwater Harvesting

The stormwater harvesting and reuse schemes will play an important role in improving water quality as well as reducing the adverse impacts of urbanisation on receiving waterways. The harvested stormwater can be reused to treat urban stormwater, reduce urban heat and reduces reliance on the portable water for irrigation.

As such, on-lot rainwater tank within the OHN Precinct are proposed to support stormwater harvesting and reuse strategy in this study. However, Council is of the view that the stormwater management strategy could be improved to include passive irrigation as well as harvesting and reuse of stormwater to irrigate open space.

The consideration will be undertaken during DA phase of the development of the sporting fields / open spaces to ensure that stormwater can be harvested and resed as required by Council control in the DCP.

4.7. Construction Stage

Erosion and sediment control measures are to be implemented during the construction phase in accordance with the requirements of Council and the guidelines set out by Landcom (the “Blue Book” 2004).

As the operation of “bio-retention” (raingarden) type water quality treatment systems are sensitive to the impact of sedimentation, construction phase controls should generally be maintained until the majority of site building works (approximately 80%) are complete

4.8. Long Term Management

Regular maintenance of the stormwater quality treatment devices is required to control weeds, remove rubbish, and monitor plant establishment and health. Some sediment build-up may occur on the surface of the raingardens and within the swales and may require removal to maintain the high standard of stormwater treatment. Regular management and maintenance of the water quality control systems will ensure long-term, functional stormwater treatment. It is strongly recommended that a site-specific Operation and Maintenance (O & M) Manual is prepared for the system as part of future Development Applications. The cost of preparing this manual could be a component of the Voluntary Planning Agreement. The O & M manual will provide information on the Best Management Practices (BMP’s) for the long-term operation of the treatment devices. The manual will provide site-specific management procedures for:

- Maintenance of the GPT structures including rubbish and sediment removal.
- Management of the raingarden including plant monitoring, replanting guidelines, monitoring and replacement of the filtration media and general maintenance (i.e. weed control, sediment removal).
- Management of permanent water systems including replanting guidelines. A separate algal control strategy may be needed in order to ensure the long-term viability of the waterbodies.
- Indicative costing of maintenance over the life of the device.

5. WATER QUANTITY ASSESSMENT

The hydrologic analysis for OHN precinct was undertaken using a non-linear runoff routing model XP-RAFTS that generates runoff hydrographs from rainfall data. The objective of the hydrologic analysis was to determine the requirement and size of detention basins needed to restrict peak post-development to existing flows at all key locations. It is noted that all proposed offline OSD and WSUD basins are to be located above the 1% AEP overland flow and mainstream flood levels. Basins must not be inundated in a 1% AEP overland flow and mainstream flood event.

XP-RAFTS models have been created to represent both “Existing” and “Developed” site conditions.

5.1. Existing Site Condition

As discussed in Section 3.1, XP-RAFTS modelling has previously been undertaken for Penrith City Council along Werrington Creek as part of the “College, Orth and Werrington Creeks Catchment Overland Flow Flood Study (COWFS) (CSS, 2017). This previous flood study assessed the “Existing” site conditions for the central portion of the Orchard Hills North site, which forms the catchment for College creek and uppermost reach of Werrington Creek.

The XP-RAFTS model used in this assessment (CSS, 2017) was adopted as the “base case” model for the hydrologic assessment. Refer to Plate 5-1 for model layout. The blue catchments denote sub-catchments within the vicinity of the site. Refer to Figure 5-01 for the existing catchment plan in Appendix D.

In order to make the model site-specific for OHN the “Existing” Site Conditions model was amended with the following minor changes:

- Node 5.01 has been split into two (2) nodes 5.01A and 5.01B at the intersection with Caddens Road to enable flow comparisons at the precinct boundary.
- Catchments downstream of Node 1.09 have been removed from the model to focus just around the subject site and to optimise modelling run times.
- The Claremont Creek catchments including the significant catchment upstream of the M4 have been added to enable flow comparisons to be made at the site boundary at Claremont Creek.
- A series of reporting nodes have been added for model connectivity and to ensure flows at the zoning boundary can be understood.
- Model parameters for all new catchments have been kept relatively consistent with the calibrated model from Council. This includes adopting existing farm dams modelled as a basin, similar initial and continuing loss and fraction imperviousness. However, the PERN values of 0.035 for pervious and 0.015 for impervious is adopted for additional Claremont Creek subcatchments.

Details of the model parameters adopted as part of this analysis: including Pern values, initial and continuing losses and rainfall data are provided in Appendix F.

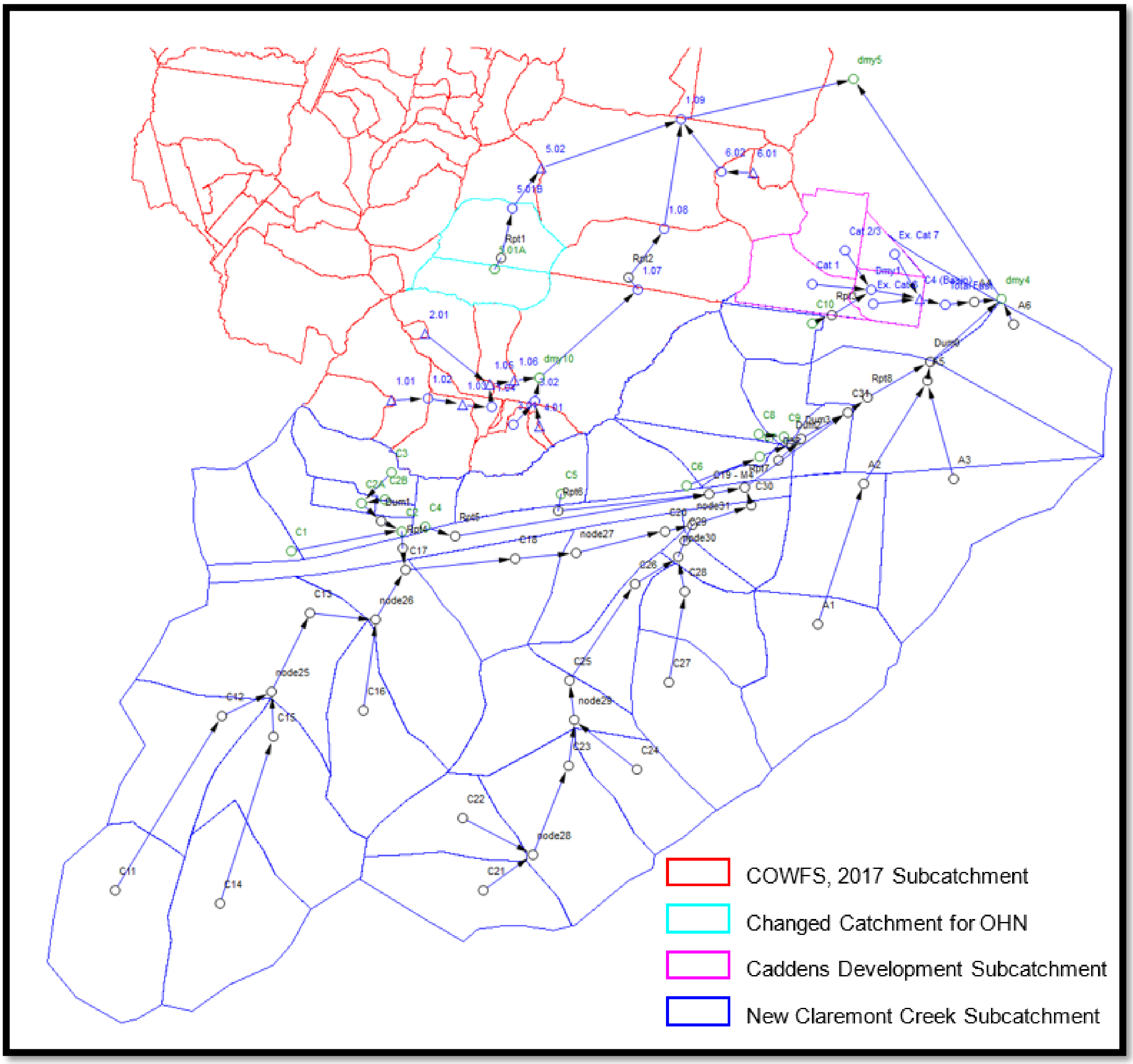

Plate 5-1 – XP-RAFTS Existing Layout

5.2. Developed Site Conditions

A “Developed” site conditions model has been created by updating the existing site conditions model to represent the proposed development plan within the Precinct. Refer to Plate 5-2 for model layout and Figure 5-02 for the developed catchment plan in Appendix D.

Developed site condition model development included the following updates:

- Sub-catchments within the site boundary were updated based on the indicative road network and grading of the site. The proposed catchment plan is shown in Figure 5-02.
- In accordance with Council guidelines, fraction impervious values were applied based on the proposed land-use zoning within the current masterplan (i.e. 75% residential, 85% medium density, 50% open space, 95% road reserve and 100% commercial). In addition, riparian areas have been assumed at 10%, low-density residential assumed at 60% and schools/heritage assumed at 50%.

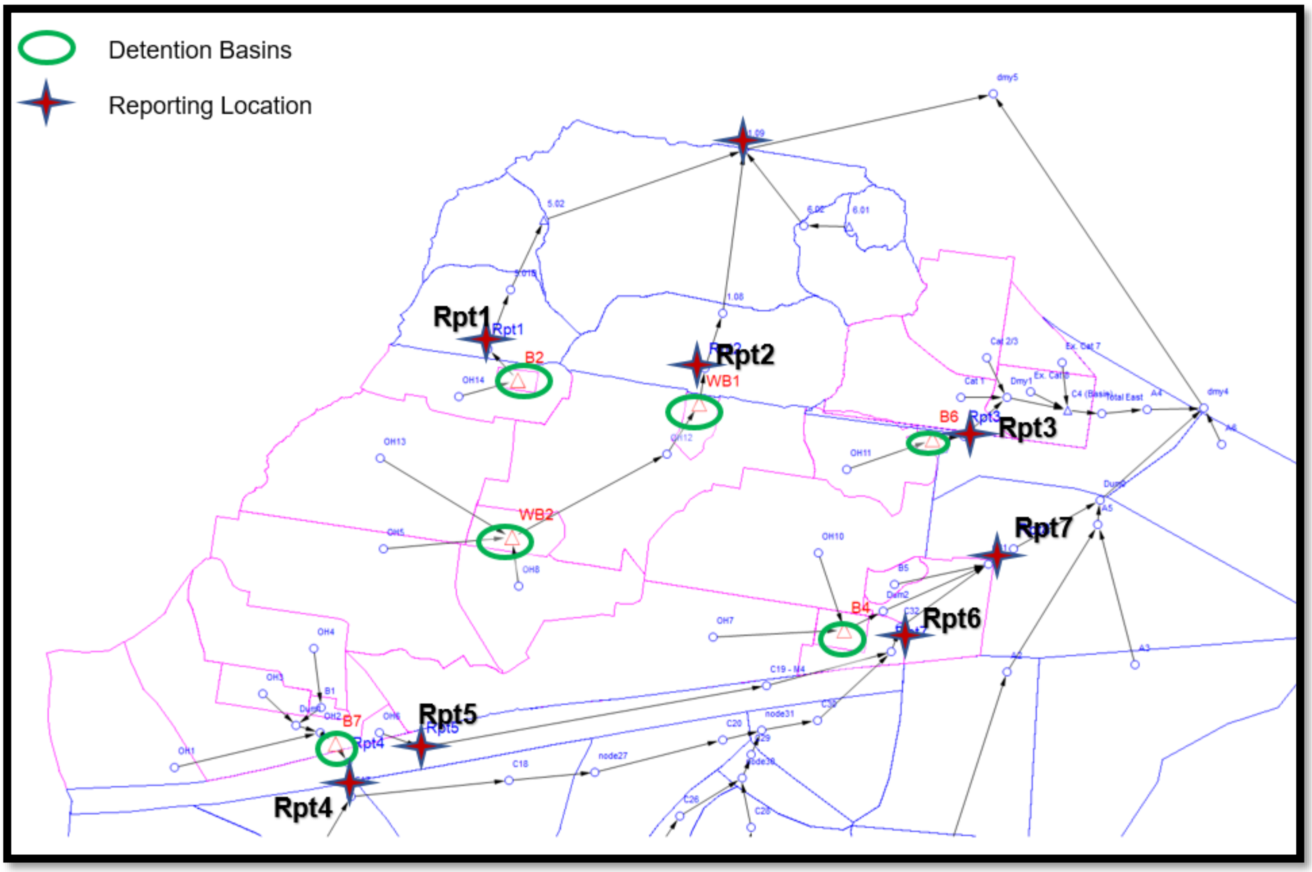

Plate 5-2 – XP-RAFTS Developed Layout

5.3. Detention Basins

The proposed stormwater management strategy encompasses a total of six (6) detention basins to manage stormwater runoff at all key locations across the OHN precinct. The detention basin is designed with a low flow outlet for smaller storm events up to 0.5 EY and a high flow spillway for storm event 1% AEP and greater. The key flow reporting locations along with the indicative location of all proposed detention basins are shown in Plate 5-2 and Figure 5-02. The reporting locations generally represent precinct boundary and locations where the existing terrain naturally grades into surrounding properties.

The central corridor (College Creek, a tributary of Werrington Creek) is proposed to be realigned and rehabilitated as part of the Orchard Hills North project to convey flows safely through the site. This realigned central drainage channel through the centre of the Precinct includes a central low flow channel to convey the 0.5 EY.

Two (2) online detention basins are proposed to manage a range of events up to and including the 1% AEP event. This includes WB1 and WB2 detention basin with a permanent water body (to provide aesthetic features for the development) at the floor of the basin. In addition, the WB1 detention basin is featured with raingarden to enhance water quality treatment and ensure water quality objectives for the PCC are achieved.

It was found that at the site interface with Claremont Creek, the detention is not required, due to the peak flow from the development (which is small in comparison) passing through Claremont Creek before the peak flow from the large rural catchment upstream arriving at the site boundary. However, based on the Council instructions 21 March 2019, one (1) offline detention basin (B4), at the future playing field is proposed to manage local flows prior to discharge to Claremont Creek to the east. This basin is located outside of the riparian corridor/vegetation constraints and manage a range of events from 0.5 EY to the 1% AEP such that the flow downstream of the site at Claremont Creek does not exceed the existing condition peak flow.

The remaining three (3) detention basins (B2, B6 and B7) are each located at natural low points along the boundary of the OHN precinct. The flow out from basin (B7) discharge to existing culverts under the M4 (west). This basin will also cater for catchments OH1 to OH4 which considers future development potential to the west of the Precinct.

In the short term, a temporary basin (orange symbol on Figure 5-02) will be required to manage stormwater runoff from catchment OH4 within the western portion of Legacy Property Group controlled land until such time that B7 is constructed. The size of this temporary device will be determined as part of the future Development Application phase once the Precinct is rezoned.

It is noted that the catchment assumption for the basin design is that the nearby road network to be designed to allow both minor (piped) and major (overland) flows to discharge to the basin. Basins B2, B6 and WB1 will need to include flows from the reconstructed Caddens Road. The flows from Basin B2 are restricted to match existing condition flows to ensure flow from the Precinct can be catered for within the existing street drainage network downstream of the Caddens Road.

It is also noted that the detention management has been sized ignoring any OSD benefit that rainwater tanks may provide within the Precinct.

5.4. Results

The flows for both the existing and developed catchments for the 0.5 EY and 1% AEP events were derived from XP-RAFTS model. A range of storm duration from 10 minutes to 24 hours were analysed to determine the critical storm duration. Table 5-1 shows a comparison between “existing” and “developed” peak flows with the proposed detention basin at each of the key comparison locations shown in Plate 5-2 and Figure 5-02 in Appendix D.

Table 5-1 – Comparison of Existing and Developed Flows

Comparison Node	Location	0.5 EY			1% AEP		
		Ex	Dev	Dev/Ex	Ex	Dev	Dev/Ex
Rpt1	Caddens Road Boundary (west)	0.51	0.29	0.56	2.00	1.70	0.85
Rpt2	Caddens Road Boundary (centre)	3.47	2.64	0.76	9.25	7.10	0.77
1.09	Downstream subdivision confluence	7.21	6.47	0.90	19.37	17.75	0.92
Rpt3	Caddens Road Boundary (east)	0.52	0.51	0.98	2.11	1.73	0.82
Rpt4	Culverts near Frogmore Road under M4	2.27	2.14	0.94	8.72	8.57	0.98
Rpt5	Southwest to M4	0.27	0.12	0.45	1.17	0.40	0.34
Rpt6	Confluence Claremont Creek and M4 U/S Site	21.44	20.76	0.97	62.54	60.38	0.97
Rpt7	Claremont Creek at D/S Site Boundary	23.16	23.16	1.00	66.49	65.36	0.98

The summary of the detention volumes required at each basin to ensure that 1% AEP post developed flows do not exceed 1% AEP pre-developed flows are provided in Table 5-2.

Table 5-2 – Summary of Proposed Detention Volumes

Basin	1% AEP Detention Volume (m^3)	1% AEP Detention Depth (m)
WB1	14,100	1.21
WB2	28,250	1.27
B2	3,000	1.40
B4	11,450	1.51
B6	2,500	1.44
B7	12,250	1.43

The hydrological modelling result shows that the proposed six (6) detention basins within the OHN precinct will ensure that post-development flows do not exceed existing flows at all key comparison locations for events up to and including the 1% AEP storm event. The modelling, therefore, demonstrates that the proposed basin strategy will ensure the flows are not increased as a result of the development of OHN.

6. FLOOD IMPACT ASSESSMENT

A fully dynamic one and two dimensional (1D/2D) hydraulic model prepared as a part of College, Orth and Werrington Creek Catchment Flood Study (COWFS) (CSS, 2017) has formed the basis for the flood impact assessment. The TUFLOW modelling is used to confirm the basin performance and ensure there are no impacts of the proposed development to the neighbouring environment. The 0.5 EY, 1% AEP events and PMF event were modelled for the critical duration storm. It is noted that all proposed OSD and WSUD basins are to be located above the 1% AEP overland flow and mainstream flood levels. Basins will not be inundated in a 1% AEP overland flow and mainstream flood event.

6.1. Available Data

The following data was used to inform the modelling:

- Hydrology model (XPRAFTS) used for stormwater management strategy (Section 5);
- Hydraulic model inputs from the College, Orth and Werrington Creeks Catchment Overland Flow Flood Study (COWFS) (CSS, 2017) flood model;
- Digital Elevation Model (DEM) on the NSW Government Spatial Services website (http://elevation.fsdf.org.au/);
- Existing road crossing information at Kingswood Road, Western Motorway and Caddens Road was obtained from a site inspection undertaken on 29 March 2019;
- The subdivision and lot mix plan by Design Planning (Appendix A);
- Preliminary site grading to inform developed condition catchments and basin.
- Aerial photography of the site recorded by Nearmap, 2019.

6.2. Existing Scenario Model

The COWFS TUFLOW (CSS, 2017) assessed the existing site conditions for the central portion of the Orchard Hills North site, which forms the uppermost reach of the College Creek, a tributary of Werrington Creek. To establish an existing condition model of OHN, the following amendments were made:

- Update the direct rainfall hydrology to traditional hydrology (lumped catchment rainfall-runoff routing);
- TUFLOW model version TUFLOW_2018-03-AD_isp was used for the assessment;
- Flow hydrographs from XPRAFTS model were applied in the 2D domain of the model to define the catchment flows;
- TUFLOW model boundary was extended to cover the Claremont Creek catchment south of M4;
- ALS data was obtained to define the terrain for those areas which were originally not covered by CSS study;
- The terrain and stormwater drainage network from Caddens development (JWP, 2018) has been incorporated to define the existing condition.
- The model was truncated nearly 850 m downstream from Caddens Road (the northern boundary of the site) at College Creek and nearly 750 m from the eastern boundary of the site at Claremont Creek.
- The downstream boundary at the College Creek and Claremont Creek is based on the automatically generated stage-discharge curve based on the slope of the existing terrain.
- The College Creek crossing culvert size at Caddens Road was updated from 0.6 m dia pipe to 2.30 m (w) x 0.60 m (h) culvert based on the 29 March 2019 site inspection.
- The Claremont Creek road crossing structures along M4 Western Motorway and Kingwoods Road were supplemented in the TUFLOW model based on the 29 March 2019 site inspection;
- Culverts are modelled with zero blockage scenario. The purpose of the flood assessment was to confirm the basin performance and ensure there are no impacts of the proposed development as such all culverts are modelled with zero blockage for consistency in both the existing and developed scenario;

- Existing building footprints are updated in the vicinity of the site which was originally not covered by COWFS (CSS, 2017);
- Model grid size (2 m x 2 m) and model parameters have been kept relatively consistent with COWFS (CSS, 2017).
- Model roughness parameters have been kept relatively consistent with the calibrated COWFS model from Council. Detail of adopted roughness from COWFS, 2017 report is provided in Table 6-1.

Table 6-1 – Depth Varying Roughness Values (extracted from COWFS, 2017)

Material Description	$Depth_1$ *(metres)*	n_1	$Depth_2$ *(metres)*	n_2	$Depth_3$ *(metres)*	n_3	$Depth_4$ *(metres)*	n_4
Building*	<0.01	0.025	>0.01	10.00	-	-	-	-
Water	0.035 for all depths	-	-	-	-	-	-	-
Trees	<0.30	0.133	0.50	0.078	>2.00	0.098	-	-
Grass	<0.03	0.107	0.05	0.077	0.07	0.052	>0.10	0.031
Concrete / roadways	<0.005	0.034	>0.005	0.015	-	-	-	-
Areas currently under construction	<0.005	0.054	0.03	0.039	0.05	0.033	0.07	0.028
Areas currently under construction *(continued)*	0.10	0.024	0.50	0.021	>2.00	0.022	-	-

In Appendix E, Figure 6-01 provides an insight into the existing TUFLOW model information. The existing terrain and roughness for the Precinct and its surrounds are shown in Figures 6-02 and 6-03, respectively.

6.2.1 Model Validation

The existing hydrology model (XP-RAFTS) and hydraulic model (TUFLOW) were updated as discussed in Section 5 and 6.2. As such, the existing XP-RAFTS and TUFLOW model were compared against the COWFS model to confirm that the revised modelling is suitable for the OHN assessment.

The downstream catchment node 1.09 from the OHN precinct hydrology model (see Plate 6-1 for location) was chosen to compare the hydrographs with COWFS, 2017. The reference location for node 1.09 is provided in Figure 6-04 in Appendix D. The 1% AEP storm event hydrograph from OHN precinct existing XP-RAFTS model was compared with COWFS, 2017. The hydrograph comparison is provided in Plate 6-2. The comparison shows a minor change in the hydrograph after the peak flow which may be due to the split of node 5.01 and minor change in catchment lag time. The change is considered minor compared to the flow. This suggests that the hydrology model for OHN assessment is similar to COWFS, 2017 model.

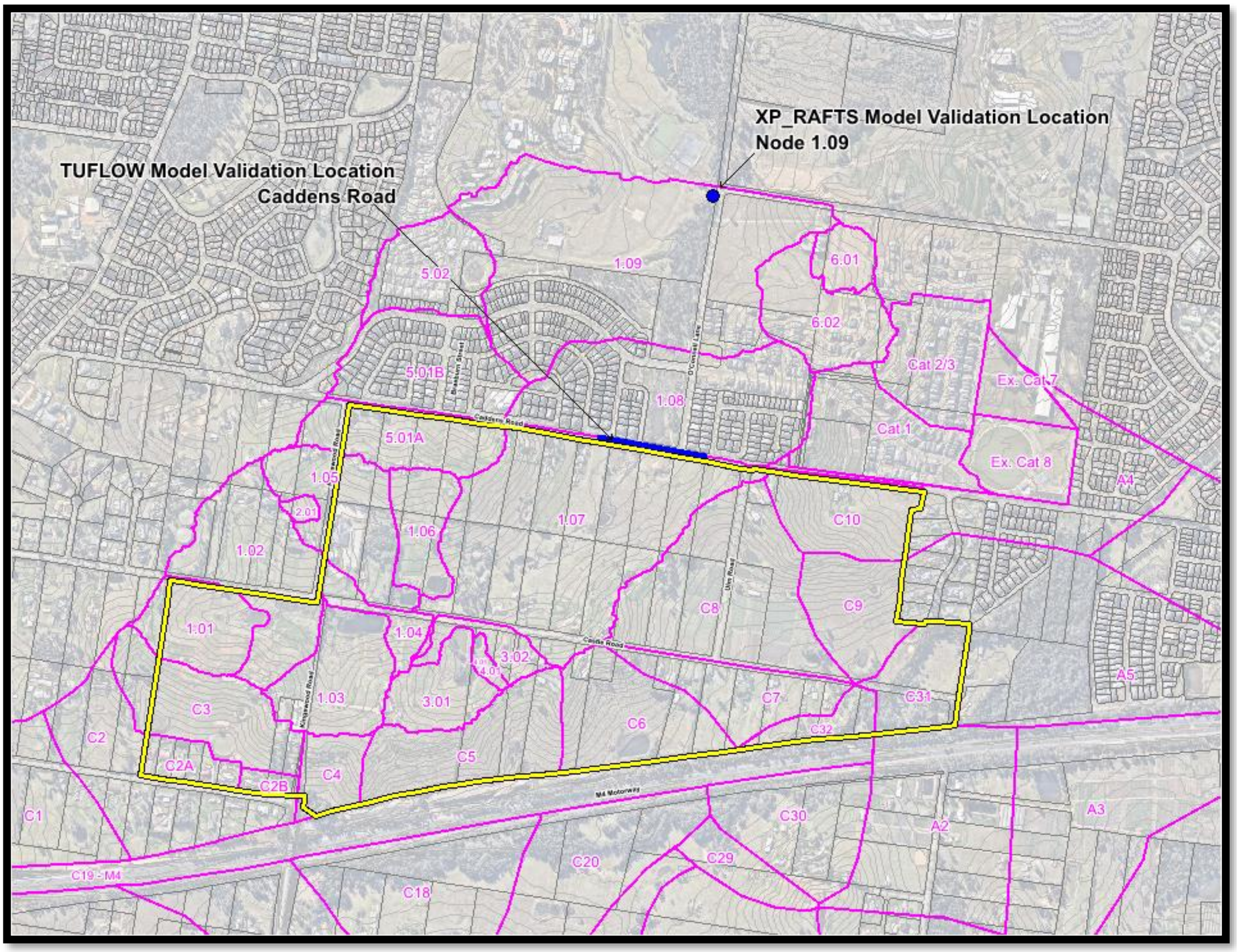

Plate 6-1 – Flow Comparison Location

The peak flow in the 1% AEP event in both the OHN Existing Condition model and the COWFS, 2017 modelling is provided in Table 6-2 with the hydrograph from both models provided in Plate 6-2.

Table 6-2 – XP-RAFTS Flow Comparison

Node ID	COWFS, 2017 (cu.m)	OHN Existing (cu.m)
1.09	19.34	19.33

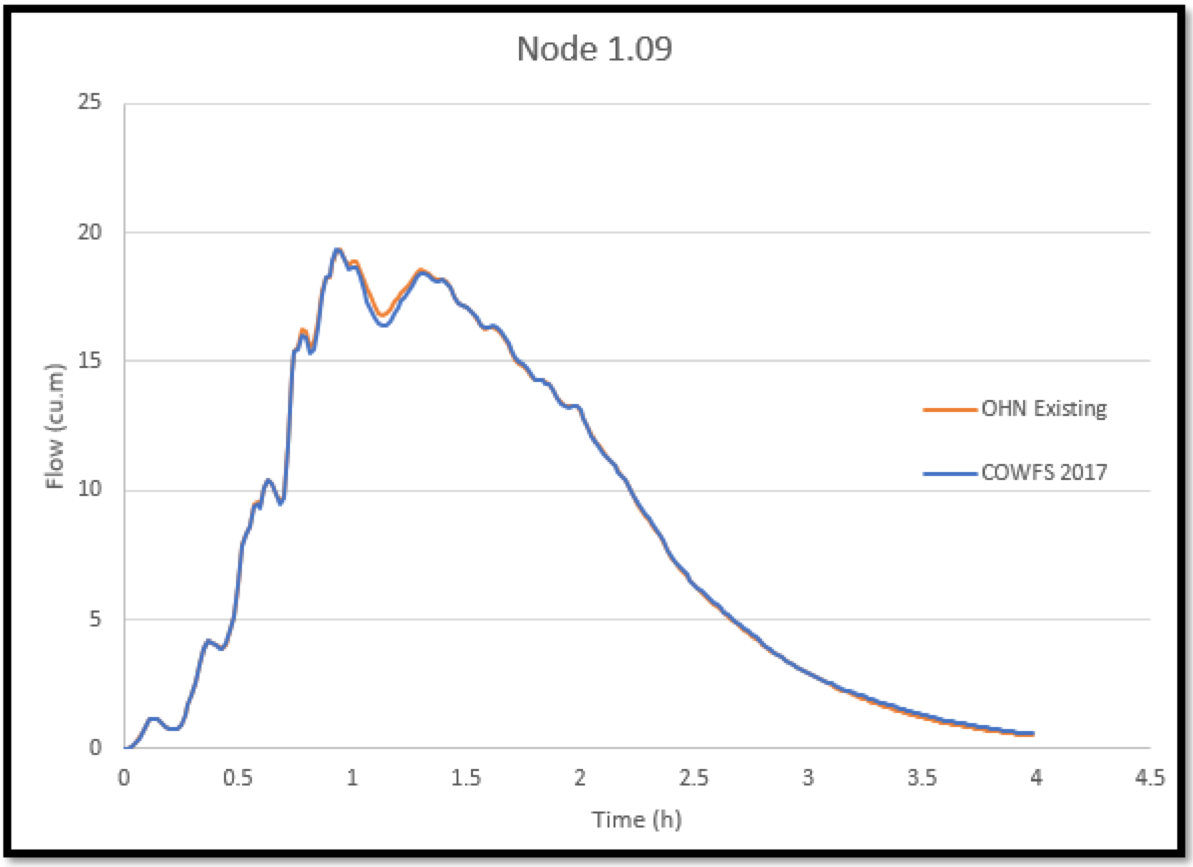

Plate 6-2 – XP-RAFTS Hydrograph Comparison

The 1% AEP storm event overland flow at Caddens Road (see Plate 6.1 for location and Figure 6-04) at College Creek crossing from OHN precinct existing TUFLOW model was compared with COWFS, 2017 at the same location. It was found that the COWFS, 2017 had modelled incorrect culvert size at Caddens Road. The College Creek crossing culvert size at Caddens Road was updated from 0.6 m dia pipe in COWFS, 2017 to 2.30 m (w) x 0.60 m (h) culvert (based on the 29 March 2019 site inspection) for this study. As such, the COWFS was rerun with an update in culvert size at Caddens Road.

The OHN TUFLOW model shows overland flow at Caddens Road of 8.53 m^3/s which is 3.63 m^3/s lower than the overland flow approaching at the same location in COWFS, 2017. This is due to an increase in the culvert at Caddens Road in OHN study which has reduced the overland flooding at Caddens Road. The updated COWFS, 2017 with modification on culvert size shows that the overland flow at Caddens Road is 8.94 m^3/s. The OHN existing condition model shows that the overland flow is 0.41 m3/s lower than updated COWFS, 2017 at Caddens Road. The 1% AEP event peak flow in both the OHN existing condition model and the COWFS, 2017 modelling is provided in Table 6-3.

Table 6-3 – TUFLOW Flow Comparison

Location	COWFS, 2017 (cu.m)	Updated COWFS, 2017 (cu.m)	OHN Existing (cu.m)
Caddens Rd	12.17	8.94	8.53

This suggests that the hydraulic model (TUFLOW) for OHN assessment is similar to revised COWFS, 2017 model and suitable to support OHN development.

6.3. Developed Scenario Model

An assessment of the developed scenario was undertaken by amending the existing scenario model with an indicative landform, revised land uses and proposed detention basins. The developed (unmitigated) flows from XP-RAFTS model was applied to the basin to assess the basin performance. The subdivision and lot mix plan by Design Planning was used to update the land use for the proposed development model (Appendix A). The roughness value adopted for the proposed land use are provided in Table 6-4, however, the proposed open space roughness parameters are kept consistent with the parameter adopted for grass in the existing scenario.

Table 6-4 – Roughness Value

Roughness	
Material Type	**Value**
Basin	0.05
Channel	0.05
Channel Embankment	0.07
Lot	0.1

The indicative developed terrain and roughness of the Precinct are provided in Figure 6-05 and 6-06 respectively in Appendix D.

The TUFLOW model was run for a series of AEP's and storm durations to understand the impacts of the proposed development on the surrounding neighbourhood.

6.4. Discussion of Results

6.4.1 Existing Scenario Flood Behaviour

Substantial changes have been made to the COWFS, 2017 model and, as such, the present results may differ somewhat from the previous COWFS,2017 results (refer to Section 6.2.2). The existing scenario flood model defined the flood behaviour within the OHN Precinct.

The existing scenario model results have been mapped for peak flood level, peak depth and provisional hazard for 0.5 EY, 1 % AEP and PMF events and are shown in Figures 6-07 to 6-12 in Appendix D. The result shows in 1% AEP event, approximately 51 m^3/s is within Claremont Creek at OHN Southern body. The 1% AEP overland flow from the North West portion of OHN precinct discharges in a northerly direction through a number of existing properties to Braeburn Street as a result of limit culvert capacity in Caddens Road. The flood depth through the properties is up to 0.30 m.

The 1% AEP flow downstream of Caddens Road through the central portion of OHN via the existing riparian corridor of College creek, which has recently been reconstructed.

6.4.2 Developed Scenario Flood Behaviour

The developed scenario flood result shows that the proposed development will significantly improve flood conditions in the north, south, and eastern portions of the Precinct and reduce flood depth by 0.30 m. Developed scenario results have been mapped for peak water level, peak flood depth and a provisional hazard across the 0.5 EY, 1% AEP and PMF events. These maps are shown in Figures 6-13 to 6-18 in Appendix D. The number of properties in Bradebun Street that were affected in 1% AEP event in existing condition has reduced due to the flow being better managed by Basin B2 (green areas in Figure 6-19).

6.5. Post-Development Impact Assessment

The flood impact as a result of the development of the OHN in the 1% AEP event are shown in Figure 6-19 in Appendix D demonstrates an improved flooding situation downstream to the north, south and eastern side of the Precinct which includes both College Creek and Claremont Creek.

However, there is a localised increase in the water level of up to 0.05 m south of the OHN Precinct border with the M4 Motorway corridor. This location is within an existing overland flow path of the Motorway corridor. Also, future development would not be possible in this location. As such, these impacts are considered acceptable. Council agrees that further refinement of the flood model to manage these minor flood impacts outside the Precinct may be undertaken as part of the future Development Application (DA) of the Precinct with a view of reducing the off-site impacts to zero if possible.

There is also a minor increase in water level in Braeburn street up to 0.1 m, downstream of Caddens Road. This is due to the changes in a flow regime from the OHN precinct in this area, and a managed overland flow from the OHN resulted in a 0.2 m reduction in flood depth in the 1% AEP event. Further discussion on Braeburn Street is provided in Sections 6.5 and 6.6. Both the existing and developed condition flood hazard in Braeburn Street is relatively unchanged and considered an acceptable minor change. Figure 6-13 in Appendix D demonstrates that in the 0.5 EY, 18 properties are flood free, which were flood-affected in existing conditions and during the 1% AEP event, eight (8) properties are flood free. However, further refinement of the flood impacts off-site will be undertaken at DA stage of the development with a view of reducing the off-site impacts to zero if possible.

6.6. Stormwater System Capacity Assessment at Caddens

As discussed in Section 6.4 there are some changes in the flood regime in Braeburn Street.Council has raised a query regarding the capacity of the existing stormwater drainage system and the impact on the drainage network.

We understand that Caddens Release area (downstream of OHN) drainage network had allowed for Catchment Ex1 (3.83 ha) and Ex2 (1.85 ha), a total of 5.68 ha to drain through Braeburn Street and Catchment Ex3 (1.9 ha) to drain through the Ruby Street as shown in Plate 6-3 which is catchment plan sheet 2 dated July 2010, Dwg no. 210018-CC1-551 Rev C prepared by Cardno to support this development approval. However, OHN Precinct developed flow from a total area of 8.01 ha is now managed within the Basin B2, and flow restricted to existing condition flow is conveyed through the existing Braeburn Street drainage network. Braeburn Street also acts as an overland flow path in the existing condition.

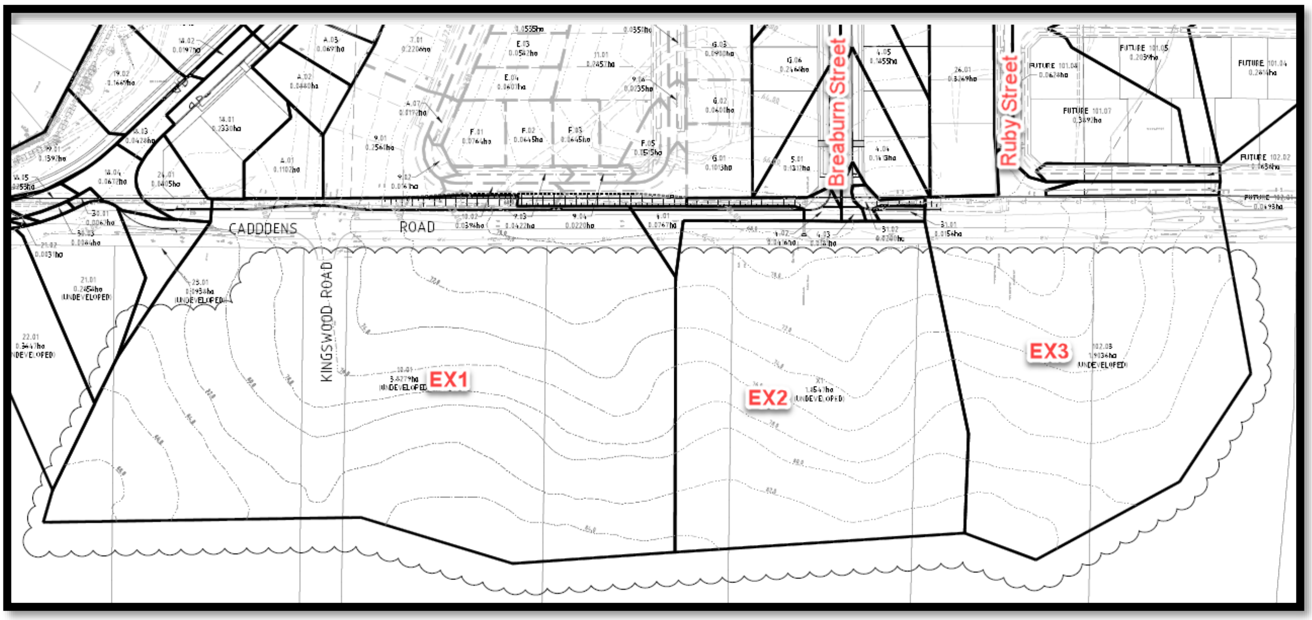

Plate 6-3 – Caddens Release Area Catchment Plan

We have reviewed the Caddens Release Stage 1 Roadworks and Stormwater Drainage Plan Sheet 10 (Dwg no. 210018-CC1-209 Fev F) prepared by Cardno. The pipe in which the Basin B2 is proposed drain to a 450 mm RCP. The 450 mm pipe has a capacity of 842 l/s. Given that the majority of the catchment that drains to this 450 mm pipe is from OHN. The flows from OHN Precinct development in 0.5 EY and 1% AEP storm event is provided in Plate 6-4. The comparison shows that the flow through the pipe in 0.5 EY storm event is 28% of the pipe capacity and during 1% AEP event it is running on 80% capacity. It is noted that the developed condition flow from OHN precinct downstream of Caddens Road at Braeburn Street is 32% lower than the existing condition flow of 355 l/s from OHN Precinct in 0.5 EY.

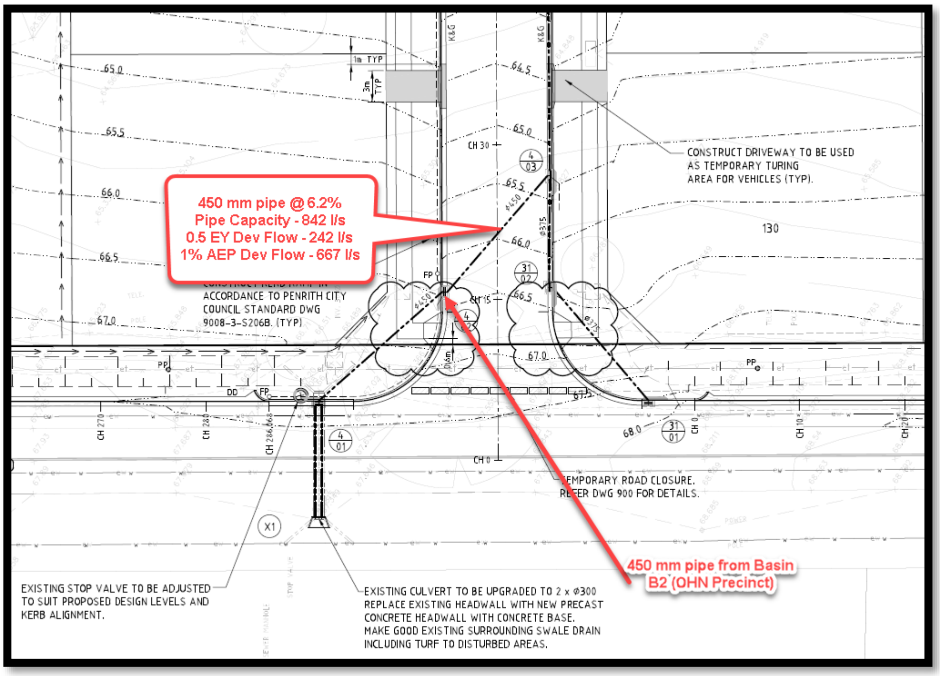

Plate 6-4 – Stormwater Drainage Network Capacity

As a part of the future Basin B2 design and as a part of the future DA design, Basin B2 can consider two (2) low flow outlets as shown in Plate 6-5, one connected to Braeburn Street stormwater network and the other at Ruby Street drainage network.

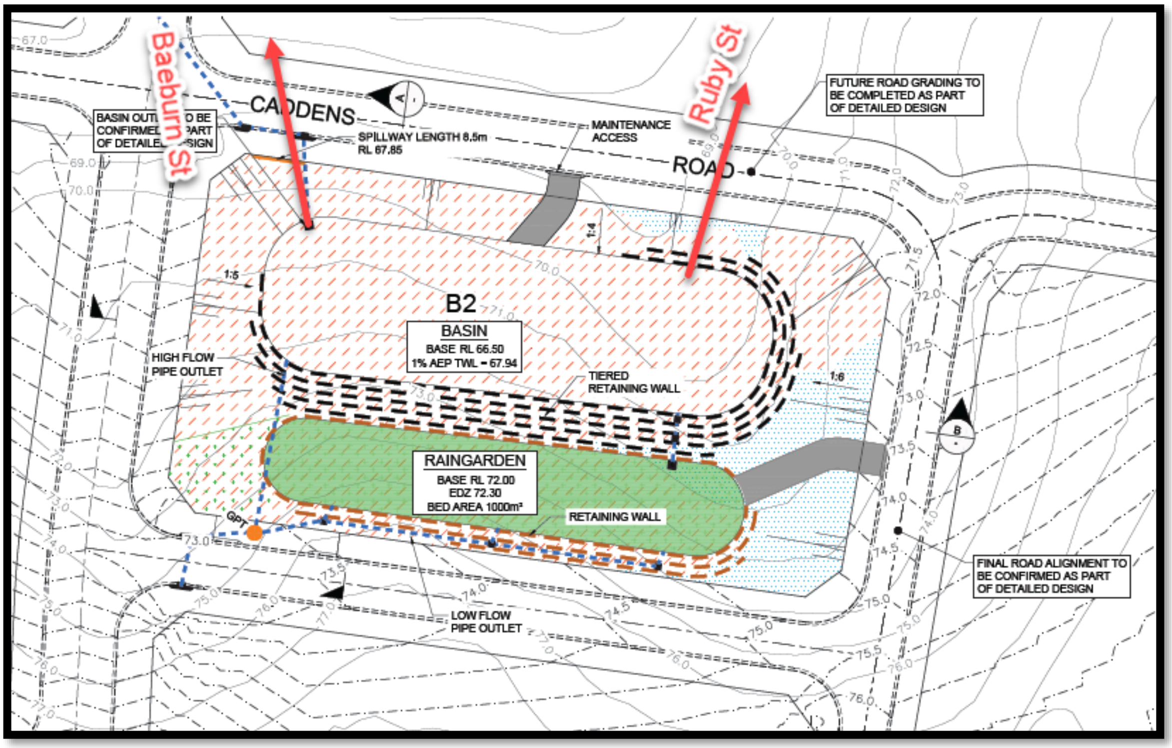

Plate 6-5 – Future Arrangement of Basin B2

Further refinement of basin outlet arrangement and local changes in the local flood regime in Braeburn Street and Ruby Streets will be further considered as DAs for this area are proposed.

This study reviews the pipe lengths in Breaburn Street only in the vicinity of Caddens Road. Further refinement of the existing drainage system will be undertaken as part DA stages of the development. Any DA that drains to this catchment must analyse the existing road drainage system from Caddens Road to the receiving waters for both Breaburn Street and Ruby Street for all storms up to and including the 1% AEP event. Any changes to Basin B2 and the existing street drainage system downstream as a part of DA must be detailed accordingly.

6.7. Basin B2 and B6 - Full System Failure

Given that Basin B2 is “cut” below existing ground levels within the OHN precinct, and its embankment is similar to the existing Caddens Road. This configuration has the least probability of basin embankment failure, however, there may be a scenario of outlet structure being blocked in Basin B2, resulting in overtopping of the basin embankment.

While we have not completed a hydraulic assessment of a low flow blockage scenario, a developed condition PMF storm event has been used to assess the impact of this extreme flood on the downstream propetries to emulate a “basin system failure”. During a PMF event, flow through the low flow pipe is negligible (i.e. minimal flow similar to a blockage scenario) and is considered a suitable system failure assessment.

The flood level difference of the PMF storm event is provided in Figures 6-19 and 6-20 in Appendix D, comparing developed conditions to existing condition 1% AeEP and PMF storm event, respectively. The result shows no significant flood level increase impact downstream of the Basin B2 or Basin B6, however, there is an increase in water level at Braeburn street road reserve up to 0.1 m, downstream of Caddens Road. The overland runoff from the OHN precinct is now being managed through Braeburn Street as compared to the existing condition where these flows entered the adjoining properties overland. Water level through the properties, to the west of Braeburn Street, is reduced by up to 0.20 m eliminating the potential damage to a significant number of properties in this area.

Therefore, even during a system failure, the development of OHN will improve the flood situation for the existing Caddens development downstream of the OHN.

However, to provide Council with certainty that the flood impacts will be managed as part of the further redevelopment of OHN, we have recommended that the controls be included in the site-specific Development Control Plan (DCP) for OHN in our letter dated 24 November 2020. These controls will ensure that additional assessments are submitted and approved by Council prior to the subdivision of the land surrounding both basin B2 and B6. This will ensure that all required management of flood impacts will be undertaken within the OHN rezoning area and will not require any additional land from the Caddens Hills Stage 2 release area in order to deliver the necessary flood management outcomes for this locality.

Given the location of the proposed basin B2 and B6 upstream of Caddens Road, additional flood impacts assessment will be required to ensure that no detrimental impact occurs downstream on the Orchard Hills North (OHN) rezoning Area in the design event (i.e. the peak 1% AEP Event), Therefore any application to subdivide land within Basin B2 or Basin B6 Catchments must include the following:

- Updated Hydraulic modelling (TUFLOW) to demonstrate that in the 1% AEP event, no detrimental impact as a result of this development occurs in the existing downstream areas.
- A “System Failure” assessment, i.e. all outlet structures for Basin B2 and Basin B6 are 100% blocked and that flood impacts downstream are not unsafe, consistent with the latest industry practice during the peak 1% AEP event.
- The “System Failure” model shall also test a “rare flood event,” i.e. 0.2% AEP event, to assess how a system failure can be managed in the downstream development.

If the design and/or land required to deliver either Basin B2 or Basin B6 need to be amended or if, as part of the management approach for this area, a drainage system upgrade downstream of OHN is required, this will be the responsibility of the applicant to undertake the necessary amendments to ensure compliance with Council’s existing flood-related controls listed in the relevant guideline/DCP or as an outcome of the additional assessments prior to the release of the development consent.

6.8. Flood Affectation on Raingarden

Council has raised a question regarding their desire for the water quality management devices and stormwater detention management to be separated. There is one (1) bioretention raingarden co-located within the basin B6 that will be impacted by detained flood water in the 1% AEP event. The 2% and 1% AEP flood level and depth information on the raingarden adjacent to the basins are provided in Table 6-5.

Table 6-5 – Flood Level at Raingarden

Basin ID	Basin Invert Level (m AHD)	Raingarden EDZ Level (m AHD)	2% AEP Flood Level (m AHD)	1% AEP Flood Level (m AHD)	2% AEP Flood Depth in Raingarden (m)	1% AEP Flood Depth in Raingarden (m)
B2	66.50	72.30	67.88	67.95	0.0	0.00
B6	45.50	46.80	46.75	46.86	0.0	0.06
B7	55.85	57.64	57.24	57.30	0.0	0.00
WB1	52.15	55.30	52.28	52.33	0.0	0.00

The result demonstrates that even in the rare flooding event (1% AEP) the raingarden in the co-located device (B6) will be inundated by a maximum of 60 mm. All other raingardens will not be impacted by the detention function of the adjoining basins for all design storm events.

An assessment of the time of inundation has also been completed for Basin B6. The peak flood level hydrographs from within the basin B6 is presented in Plate 6-6 for the range of storm events.

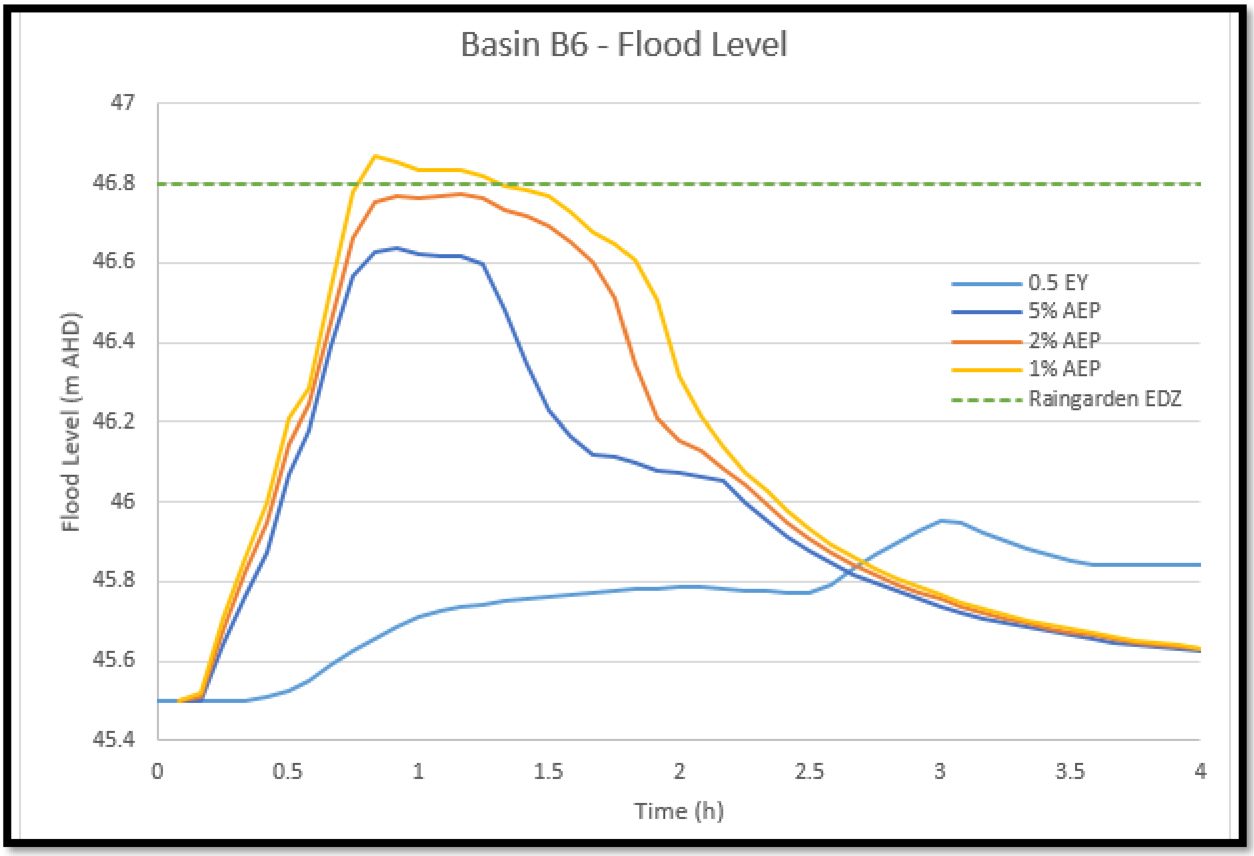

Plate 6-6 – Basin B6 Flood Level Hydrograph

The result showed that the raingarden within Basin B6 is inundated for a maximum period of 30 min to a depth above the EDZ of only 60mm in the peak 1 % AEP event. The assessment demonstrated that the current concept design and configuration of both basin B6 will not increase the maintenance requirements for these devices over that which is normally required for stormwater management devices.

The inundation depths of 60 mm above the EDZ for basin B6 will not impact plant health. This is further supported by the expected mature plant height for all bio-retention plant species accepted by Penrith City Council will grow to be in the order of 1 m, far exceeding the total inundation depths basin B6.

7. SENSITIVITY ASSESSMENT OF WATER MANAGEMENT DEVICES

The OHN precinct development is at the stage of rezoning. As such it is highly likely that the grading within the Precinct may change as the individual DA's are progressed. This would result in a change in catchments and influence both the water quality and quantity management within the Precinct. A sensitivity assessment has therefore been undertaken to understand the basin performance if the catchment areas would be increased by 10% for each basin.

The basin performance with the increase in area by 10% has been summarised in Table 7-1. The result shows that the volume increase needed to cater for the increased catchment area would be below 5% for most of the basin except for basin WB2 at 5.2%. The corresponding water level change in the basin would be below 0.1 m.

Table 7-1 – Summary of 10% Increase in Area Assessment

			After 10% increase in Area			
Basin	1% AEP Detention Volume (m^3)	Detention Depth (m)	Detention Volume (m^3)	Detention Depth (m)	Increase in Detention Volume (%)	Increase in Detention Depth (m)
WB1	14,100	1.21	14,200	1.22	0.7	0.01
WB2	28,250	1.27	29,800	1.34	5.2	0.06
B2	3,000	1.40	3,150	1.45	4.8	0.05
B4	11,450	1.51	11,800	1.54	3.0	0.03
B6	2,500	1.44	2,600	1.48	3.8	0.04
B7	12,250	1.43	12,750	1.47	3.9	0.05

The minimal increase in detention storage which needs to manage a 10% increase in the catchment is likely to be managed in the refined proposed basin designs or managed in the freeboard requirement of the adjoining housing lots. No additional precinct wide assessment would be necessary if the catchment changes are limited to no greater than 10% of the assumed catchment areas.

It is noted that the water quality perspective device is based on the catchment that it is treating, thus a maximum increasing device size would be a further 1% of the catchment area. This change can be catered for in refined basin designs as the precincts develop in support of the future DA process.

8. REFERENCES

1. Penrith Local Environmental Plan (Caddens) 2016, Land zoning map – LZN 013, New South Wales Government, accessed 20 October 2016, <http://legislation.nsw.gov.au/maps/d2ce0fda-bb2c-4698-9313-323497471b21/6350_COM_LZN_013_020_20160914.pdf>
2. Penrith City Council (2015). Water Sensitive Urban Design Policy.
3. Penrith City Council (2015), Penrith Development Control Plan 2015.
4. Penrith City Council (2015). Water Sensitive Urban Design Technical Guidelines.
5. Penrith City Council (2015), Cooling the City Strategy 2015.
6. CRCCH, (2005) - CRC For Catchment Hydrology (2005). MUSIC Model for Urban Stormwater Improvement Conceptualisation, User Guide Version 3.
7. BMTWBM (2015). “Draft NSW MUSIC Modelling Guidelines”
8. Catchment Simulation Solutions (CSS,2015) “College, Orth and Werrington Creeks Catchment Overland Flow Study” – on behalf of Penrith City Council.
9. Worley Parsons (WP, 2015) South Creek Flood Study – on behalf of Penrith City Council.
10. Penrith Local Environmental Plan (Caddens) 2009, Land zoning map – LZN 00, New South Wales Government, accessed 14 February 2014, <http://www.legislation.nsw.gov.au/mapindex?type=epi&year=2009&no=485>
11. Penrith City Council (2013c), Design Guidelines for Engineering Works for Subdivisions and Developments, in force from 20 May 1997, amended 20 November 2013
12. Willing & Partners Pty. Ltd. (1996). Runoff Analysis & Flow Training Simulation. Addendum, Version 5.0
13. Willing & Partners Pty. Ltd. (1994). Runoff Analysis & Flow Training Simulation. Detailed Documentation and User Manual, Version 4.0

APPENDIX A
Orchard Hills North Master Plan

Indicative Master Plan

ORCHARD HILLS NORTH

NORTH

20 0 40 80 120 160 200 240 280 metres

Ref: LEGOH-2-001-4	Date: 24/05/2021	Revision: U	Scale: 1:2,000@A0

Note: All areas and dimensions subject to detailed survey

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APPENDIX B

NRAR Correspondence

Paul Isaac

From: Paul Isaac
Sent: Monday, 17 June 2019 11:07 AM
To: water.referrals@nrar.nsw.gov.au
Cc: Michael Johnson
Subject: [110265-08] Orchard Hills North Gateway determination Ref PP-2018-Penri-006-00
Attachments: Signed Gateway determination.pdf; Signed Gateway report.pdf

To Whom it May Concern

Please find attached a copy of the following documents relating to the proposed rezoning of Orchard Hills North:

- Signed Gateway Determination
- Signed Gateway Report

The following reports which may be of interest to NRAR are large and can be downloaded via the link below:

- Orchard Hills North Rezoning Stormwater Management Strategy dated March 2018 by JWP
- Orchard Hills North Planning Proposal Consolidate Basin Strategy dated December 2018 by JWP

https://ftp.jwprince.com.au/main.html?download&weblink=4884e1e2de9066e3db3aa2df6c6bc3ea&realfilename=NRAR$20Referral.zip

Additional reports lodged as part of the Planning Proposal are available from the NSW Government LEP Online System 9link below), or can be provided upon request.
http://leptracking.planning.nsw.gov.au/proposaldetails.php?rid=5624

Condition 7 of the Gateway Determination requires consultation with The NSW Office of Water under Section 3.34(2)(d) of the Act since the Office may be impacted by the proposal, and J Wyndham Prince is assisting Penrith City Council in this regard.

It would be appreciated if NRAR could provide comment on the proposal, and JWP requests that our David Crompton and I meet with the assessing officer in person in order to discuss the possible impacts of the planning proposal. The Gateway Determination allows a minimum period of 21 days for public authorities to provide comment on the proposal.

Kindly provide us with details of the assessing officer, possible dates and times for such a meeting, and advise us whether you require any additional information.

Please contact me should you require any additional information.

Paul Isaac – Senior Project Engineer/ Project Manager

J. WYNDHAM PRINCE
CONSULTING CIVIL INFRASTRUCTURE ENGINEERS
& PROJECT MANAGERS

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580 High Street, Penrith NSW
PO Box 4366 PENRITH WESTFIELD 2750

Paul Isaac

From: Jeremy Morice <jeremy.morice@nrar.nsw.gov.au>
Sent: Thursday, 22 August 2019 3:40 PM
To: Ellie Randall
Cc: Paul Isaac; Jeremy Morice
Subject: RE: [110265-08] Orchard Hills North Gateway determination Ref PP-2018-Penri-006-00

Hi Paul,

I apologise for the extended delay in responding to your enquires regarding the Orchard Hills site.

The Natural Resources Access Regulator (NRAR) has reviewed the information presented and the following requirements apply to the site.

- NRAR is in agreement with the Orchard Hills North - Assessment of Riparian Corridors prepared by JWP and agrees to the proposed watercourses marked for removal in Figure 1.
- The remaining watercourses on the site are to be managed in accordance with the requirements of the NRAR Controlled Activity Guidelines for riparian corridors on waterfront land
- Werrington Creek and tributaries
    - within the site are considered 1st order streams with a corresponding 10m wide Vegetated Riparian Zone (VRZ)
    - the watercourse/s can be realigned
    - offsetting is allowable
    - is to be maintained as a natural open channel including the establishment of riparian corridor
    - a low flow pipe design is not compliant with the Guidelines and will not be supported
- Claremont Creek
    - within the site is considered a 4th order stream with a corresponding 40m wide Vegetated Riparian Zone (VRZ)
    - offsetting is allowable within the site
    - is to be maintained as a natural open channel including the establishment of riparian corridor

Please give me a call if you require any clarification of the above comments.

Regards,

-

Jeremy Morice | Water Regulation Officer
Natural Resource Access Regulator | Water Regulation East
Level 0 | 84 Crown Street | Wollongong NSW 2500

PO Box 53 | Wollongong NSW 2520
T: 02 4275 9320 | E: jeremy.morice@nrar.nsw.gov.au
W: www.industry.nsw.gov.au

APPENDIX C

MUSIC Model input parameters

110265 - MUSIC MODELLING WORKSHEET
Orchard Hills

Catchment	Total Catchment Area (ha)	Catchment Division										
		Total Internal Catchment	School	Exting Lot	Openspace	Bushland	Local centre	Road	Lot Area	Lot area with RWT %	Lot Area with RWT (ha)	Lot Area with no RWT	External Catchment
MU1	25.57	25.57		1.21	4.28			6.40	13.68	60%	8.21	5.47	
MU2	20.75	20.75		0.16	0.75	1.17		6.28	12.38	60%	7.43	4.95	
MU3	6.45	6.45		0.18	0.20			2.521	3.55	90%	3.20	0.36	
MU4	7.30	6.00		0.22				2.32	3.47	90%	3.12	0.35	1.30
MU5	20.63	9.60		1.80		1.72		2.16	3.92	50%	1.96	1.96	11.03
MU6	19.16	17.28	2.11	0.04	1.22			4.40	9.52	50%	4.76	4.76	1.88
MU7	9.79	9.79		1.14	0.83		2.41	2.54	2.87	5%	0.14	2.72	
MU8	10.84	10.84		0.49	0.16			3.99	6.20	35%	2.17	4.03	
MU9	12.35	12.35			0.69			3.89	7.76	10%	0.78	6.99	
MU10	36.91	10.73		2.43	0.82			1.76	5.73	50%	2.86	2.86	26.18
Central Channel	2.60	2.60											
Total	172.35	131.96											

Catchment	Total Catchment Area (ha)	Node Inputs						
		Road (ha)	Standard (Normal) Residential Roof to Tank (ha)	Standard (Normal) Residential Roof Bypass (ha)	Urban Impervious (ha)	Urban Pervious (ha)	External Catchment Impervious	External Catchment Pervious
MU1	25.57	6.40	2.46	2.46	6.73	7.52	0.00	0.00
MU2	20.75	6.28	2.23	2.23	5.03	4.98	0.00	0.00
MU3	6.45	2.52	0.96	0.96	0.91	1.11	0.00	0.00
MU4	7.30	2.32	0.94	0.94	0.90	0.91	1.04	0.26
MU5	20.63	2.16	0.59	0.59	3.20	3.06	8.82	2.21
MU6	19.16	4.40	1.43	1.43	6.12	3.91	1.51	0.38
MU7	9.79	2.54	0.04	0.04	5.47	1.69	0.00	0.00
MU8	10.84	3.99	0.65	0.65	3.76	1.79	0.00	0.00
MU9	12.35	3.89	0.23	0.23	5.43	2.57	0.00	0.00
MU10	36.91	1.76	0.86	0.86	4.60	2.66	20.94	5.24
Central Channel	2.60	2.60	0	0	0	2.596	0	0
Total	172.35							

				RAINWATER TANK						
				Overflow Pipe Dia		High Flow By-pass	Daily Demand	PET - RAIN		Tank Surface Area
Catchment	Lots	Equivalent Pipe Area (m^2)	Equivalent Pipe radius (m)	Equivalent Pipe dia (mm)	Total Area of Roof to Tank (Ha)	1yr flow on roof (m^3/s)	Daily Demand (kL/day)	Annual Demand (kL/yr)	Total Tank Volume (m^3)	Tank Surface Area (m^2)
MU1	195	0.383	0.349	699	2.46	0.51	19.54	9770.21	468.97	366.38
MU2	177	0.347	0.333	665	2.23	0.46	17.69	8844.79	424.55	331.68
MU3	76	0.149	0.218	436	0.96	0.20	7.61	3804.47	182.61	142.67
MU4	74	0.146	0.215	431	0.94	0.19	7.43	3713.03	178.23	139.24
MU5	47	0.092	0.171	342	0.59	0.12	4.67	2333.87	112.03	87.52
MU6	113	0.222	0.266	532	1.43	0.30	11.33	5665.30	271.93	212.45
MU7	3	0.007	0.046	92	0.04	0.01	0.34	170.69	8.19	6.40
MU8	52	0.101	0.180	359	0.65	0.14	5.17	2584.13	124.04	96.90
MU9	18	0.036	0.107	215	0.23	0.05	1.85	924.19	44.36	34.66
MU10	68	0.134	0.206	413	0.86	0.18	6.82	3408.51	163.61	127.82

PET - Rain for landscape area	50	kL/year/dwelling
Assumed Daily Demand	100	L/day
Adopted Tank Size	3	kL
Assumed 80% is useable (w/o topups)	80	%
Useable tank	2.4	kL
Assumed Tank height	1.6	m
I5min/1yr	75	mm/hr

	FLOW DATA (m3/s)		
Catchment	4 EY	2 EY	1 EY
MU1	2.01	2.82	3.86
MU2	1.67	2.35	3.22
MU3	0.59	0.83	1.13
MU4	0.64	0.90	1.23
MU5	1.62	2.28	3.12
MU6	1.59	2.23	3.05
MU7	0.89	1.25	1.72
MU8	0.95	1.34	1.83
MU9	1.08	1.52	2.08
MU10	3.03	4.26	5.83

RAINWATER TANKS

Rainwater tanks are sealed tanks designed to contain rainwater collected from roofs. Rainwater tanks provide the following main functions:

- Allow the reuse of collected rainwater as a substitute for mains water supply, for use for toilet flushing, laundry, or garden watering (facilitate attainment of BASIX compliance).
- When designed with additional storage capacity above the overflow, provide some on-site detention, thus reducing peak flows and reducing downstream velocities.

The water collected can be reused as a substitute for mains water supply either indoors (toilet flushing and laundry) or outdoors (garden watering). Rainwater tanks can be either above ground or underground. Above ground tanks can be placed on stands to prevent the need of installing a pump to distribute the water. Such systems are referred to as gravity systems. Pressure systems require a pump and can be either above or below ground tanks.

Tanks can be constructed of various materials such as Colorbond, galvanised iron, polymer or concrete.

MUSIC Modelling Performance Criteria

The expected sediment and nutrient removal performance of the proposed devices was determined using the default equations and parameters provided in the MUSIC model. The water quality reduction mechanisms in MUSIC are based on an exponential decay equation referred to as the k -C* curve. The adopted MUSIC modelling parameters for Rainwater tanks are presented in the following table.

Table E-1 Stormwater Quality Parameters for Rainwater Tanks

	Rainwater Tanks	
Pollutant	k (m/yr)	C* (mg/L)
TSS	400	12
TP	300	0.13
TN	40	1.4