Redleaf

Water Cycle Management Report

Wednesday 16th July 2025

Prepared for: Landcom

DOCUMENT CONTROL

Issue	Date	Purpose	Author	Approved
A	03/07/2025	DRAFT – Client Review	AT	LZ
B	07/07/2025	Development Application	AT	LZ
C	16/07/2025	Development Application	AT	LZ

This report has been prepared by Colliers International Engineering & Design (NSW) Pty Ltd and has undergone a quality assurance review. The signatures above confirm review completion.

Acknowledgement of Country

Colliers Engineering & Design (NSW) acknowledges the Wiradjuri people of the Wiradjuri Nation as the Traditional Custodians of the lands and waterways upon which this project is located in the Orange City Council LGA. We also acknowledge the Wangal people of the Eora national as the traditional custodians of the land upon which our Rhodes Office is located.

We pay our respects to the traditional owners for their care and stewardship of these lands for more than 40,000 years and to all Aboriginal and Torres Strait Islander Peoples and the elders past, present and emerging.

Abbreviations

AEP	Annual Exceedance Probability
ARI	Annual Recurrence Interval
CED	Colliers International Engineering & Design (NSW) Pty Ltd
DEM	Digital Elevation Model
GSDM	Generalised Short Duration Method
LGA	Local Government Area
LiDAR	Light Detection and Ranging
OCC	Orange City Council
PMF	Probable Maximum Flood
PMP	Probable Maximum Precipitation
QGIS	Quantum Geographic Information System
TIN	Triangulated Irregular Network
WCMS	Water Cycle Management Strategy

Table of Contents

Table of Figures

Table of Tables

1 Introduction

Colliers Engineering & Design (NSW) have been engaged by Landcom to prepare a Water Cycle Management Report including a Stormwater Management Plan, Water Balance assessment, and a Flood Impact & Risk Assessment and to support the development application submission for the proposed subdivision of Lot 1 DP153167, Lot 6 DP1031236, and Lot 200 DP1288388 at Redmond Place within the Orange City Council Local Government Area (LGA) (the subject site).

A full set of concept engineering drawings (24-1057C-DA-001 to 24-1057C-DA-0906, Revision A) prepared by Colliers will accompany this report and DA submission.

The flood assessment includes an analysis of the existing conditions flow regime and peak flood behaviour for the 10% Annual Exceedance Probability (AEP), 5% AEP 1% AEP, 1% AEP with climate change, and Probable Maximum Flood (PMF) storm events across the subject site. The analysis is undertaken in accordance with Orange City Council's (Council) policies and this report provides an overview of the background, methodology, key assumptions and results for the assessment undertaken in accordance with Orange City Council's Local Environmental Plan (LEP) (2011), Orange Development Control Plan (ODCP) (2004), the latest NSW Flood Risk Management Manual (2023), and Australian Rainfall & Runoff (AR&R) (2019).

The report aims to investigate and avoid any adverse impacts on the downstream properties, and to ensure flows throughout the site are managed during the interim and ultimate scenarios whilst maintaining an ecologically sustainable development.

1.1 Project Overview

1.1.1 Site Context

The site is located on the southeast fringe of Orange, adjacent to the Glenroi suburb and is the largest city in the Central West Region. It is 4.4km from Orange City Centre and approx. 3.2km from Orange train station.

The site has a significant frontage along Bathurst Road (MR705) (formerly known as Mitchell Highway) which runs from east to west from the M4 Motorway in Greater Sydney connecting through Penrith, Katoomba, Bathurst and to Orange. It is intended to be the first line of housing on entry to the Orange township.

The site is approximately 24.4Ha in size and is currently vacant, with the exception of a structure that previously housed an emergency services helicopter hangar. The site lies on the southern side of Redmond Place, bounded by Bathurst Road (on the northeast), Lone Pine Avenue and Brabham Way to the west and south respectively. It is surrounded by a mixture of land uses with low density residential to the west, retail and large format retail to the north, rural farmland to the south and east, as well as a motorsport racing track also on the opposite side of the A32 highway.

The site typically grades from northwest to southeast with levels ranging from 903 mAHD down to 886 mAHD and is bounded by the Mitchell Highway to the east, Redmond Place to the north, Brabham Way to the south and Lone Pine Avenue to the west.

Currently, the subject site is zoned R1 – General Residential Zone and is predominantly rural grass land, with one building footprint located in the north of the site along Redmond Place.

Dairy Creek is located south of the site and flows south to north and then east, where it confluences with Summerhill Creek. It is not anticipated that Dairy Creek will impact the subject site, as the site is located approximately 3-4m above the channel invert, however, along the eastern boundary of the site the terrain is low-lying with a culvert underneath the Mitchell Highway that brings flow into the site from the northeast and it was noted from a site visit that the terrain along the eastern boundary can be somewhat swampy.

The subject site is illustrated in Figure 1 below.

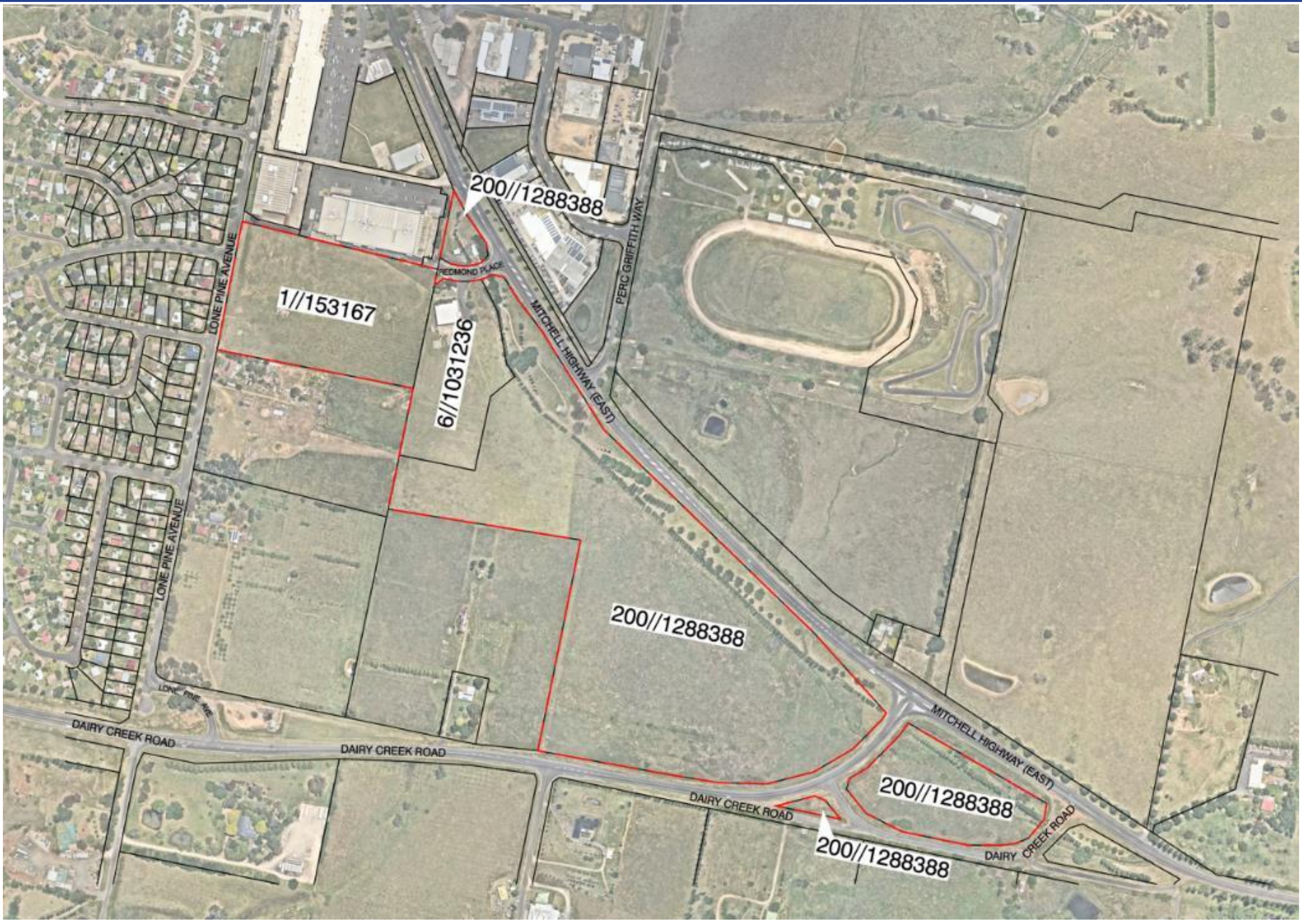

Figure 1 Subject Site (Source: Oculus)

The site comprises three lots identified in Table 1.

Table 1 Lots comprising the Site

Legal description	Address	Area
Lot 1 DP 153167	154 Lone Pine Avenue	4.10 ha
Lot 6 DP 1031236	3 Redmond Place	2.28 ha
Lot 200 DP 1288388	5255 Mitchell Highway	17.85 ha
Total		**24.23 ha**

The land is owned by Orange City Council, who will remain owners throughout the course of the project.

1.1.2 Background

Landcom and Orange City Council have signed a Project Delivery Agreement for the purposes of delivering the Redleaf project.

The site is owned by Orange City Council and Landcom are taking the lead in preparing the Development Application. A planning proposal to amend the Orange Local Environmental Plan 2011 (LEP) to rezone the site for residential use was approved in April 2025.

The Project Objectives are as follows:

1. Supply - increase the supply of land to facilitate housing through the creation of land lots to support a sustainable, innovative, and affordable community;
2. Diversity - promote housing diversity through master planning and rezoning to support a diverse mix of product, including houses and townhouses;
3. Affordable Housing - increase the supply of land for affordable housing by delivering at least 20% of all residential dwelling sites in the Project for Affordable Housing (CHP rental stock)
4. Sustainability - develop a climate resilient, healthy, and inclusive place, at the forefront of environmental and social sustainability.

The urban design approach for the project focuses on socio-economic activation, innovative sustainability solutions and urban vibrancy through place-making. The masterplan for the future new community of Redleaf will be based on a landscape-led approach to urban design, informed by the unique qualities of the site and Connecting with Country principles. A thorough community and stakeholder engagement process, including community workshops, a Walk on Country, and indigenous stakeholder interview, has also informed the urban design process.

The masterplan features approximately 330 dwellings that consist of low density, medium density, and low-rise apartments. The masterplan also features a water body, parks, and a walking loop with exercise equipment. The development will be delivered in four stages per the below staging plan.

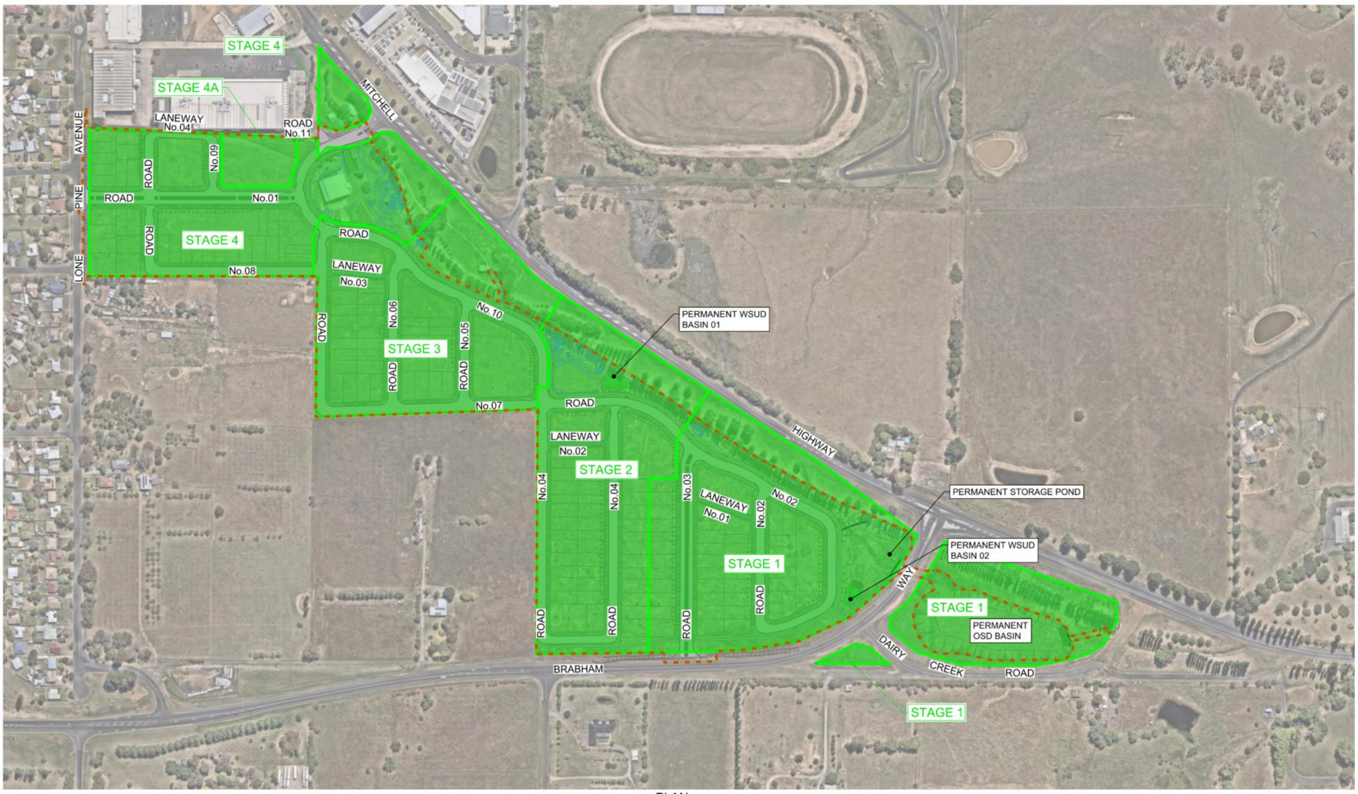

Figure 2 Staging Plan

1.2 Objective

The purpose of this report is to:

- Undertake hydrologic, hydraulic and water quality assessment of the development as an integrated approach to flood risk and water cycle management
- Identify and undertake detailed design for the proposed on-site detention basins, outlet configurations, and bio-retention basins for water quantity and quality management purposes
- Identify the flood behaviour for the proposed development for the specified 10% AEP, 5% AEP, 1% AEP, 1% AEP with climate change and Probably Maximum Flood (PMF) event

1.3 Guidelines and available data

1.3.1 Guidelines

The following Guidelines were reviewed as background information to this project:

1. DCP 04A Flood Affected Land 2004
2. DCP 07 Development in Residential Areas (2004) – Planning Outcome 7.7-18 Stormwater
3. NSW Government Floodplain Development Manual (2005)
4. NSW SES Orange City Local Flood Plan, 2005
5. Stormwater Management Plan for the City of Orange (2008)
6. Orange Local Environmental Plan 2011 (NSW legislation)
7. Australian Rainfall and Runoff (2019)
8. Blackmans Swamp Creek and Ploughmans Creek Flood Study (Lyall and Associates, 2019, Volumes 1 & 2)
9. Blackmans Swamp Creek and Ploughmans Creek Floodplain Risk Management Study and Plan (Lyall and Associates, 2020, Volumes 1 & 2)
10. State Environmental Planning Policy (Biodiversity & Conservation) (2021)
11. Neutral or Beneficial Effect on Water Quality Assessment Guideline (Water NSW) (2022)
12. Orange City Council Subdivision and Development Code (2024)

1.3.2 Data

The following data was reviewed and utilised for mapping:

1. LiDAR Data: 2019 2km x 2km 1 metre resolution digital elevation model produced using Triangular Irregular Network (TIN) method of averaging ground heights. The data is not hydrologically enforced. Vertical accuracy 0.3m, horizontal accuracy 0.8m.
2. NSW Government Spatial Services Topographic and Cadastral Data that included for example road and rail centrelines, hydrolines and hydro areas, cadastral lot boundaries, suburb, and LGA boundaries etc.
3. NearMap Imagery dated 27/02/2025
4. Detailed site survey by Premise dated 13/06/2025
5. Masterplan by Oculus dated 15/07/2025

2 Development Description

The total site is approximately 24.2 hectares. The development features approximately 330 dwellings that consist of low density, medium density, and low-rise apartments. The masterplan also features a water body, parks, and a walking loop with exercise equipment. Associated infrastructure including road, stormwater drainage and utility services are also featured to service the proposed development.

The proposed works for stormwater management within the site includes the construction of pit and pipe stormwater infrastructure beneath kerb & roads, two bio retention basins, drainage swales, a pond, and an OSD basin.

A masterplan provided by Landcom (prepared by Oculus) is illustrated in Figure 3 below.

Figure 3 Proposed Site Masterplan (Source: Oculus)

3 Stormwater Quantity Management

3.1 Objectives

Surface runoff is generally increased as a result of an increased impervious within development, which causes an increase in the peak flow rate exiting the site. This increased flow rate needs to be managed/mitigated to ensure the protection of downstream environments, habitats, and communities.

A detention basin is proposed downstream of the development to attenuate peak flows and restrict discharge to below predevelopment rates. DRAINS modelling was used to size the site's internal minor drainage system and the detention basin, which is located downstream of Brabham Way and south of the Mitchell Highway.

The basin was designed to reduce outflow to below the predevelopment rate downstream of Brabham Way.

3.2 Methodology

An IL/CL model adopting AR&R 2019 procedure in DRAINS was prepared to design the proposed drainage network and stormwater detention basins for the proposed development. The relevant DRAINS files used for the design and assessment for the stormwater drainage are summarised in Table 2 below:

Table 2 DRAINS Model Files

Scenario	File Name
Pre and Post-Development	24-1057 DA REV01.drn

The following table is a summary of the inputs used within the model based on the findings of the hydrology assessment detailed in Section 6.3.1 and is consistent with the parameters used in the planning proposal.

Table 3 DRAINS IL/CL Model Parameters

Parameter	Value
Impervious Area Initial Loss (mm)	1
Impervious Area Continuing Loss (mm)	0
Pervious Area Initial Loss (mm)	25
Pervious Area Continuing Loss (mm)	1.96

3.2.1 Annual Exceedance Probabilities (AEP)

As per Orange City Council's Subdivision and Development Code, the internal site's minor drainage system was designed to the 10% AEP storm event for urban residential systems. Other major drainage items such as the On-Site Detention (OSD) basin were designed up to and including the 1% AEP storm event.

3.2.2 Rainfall

Rainfall intensities in the model were obtained from the Bureau of Meteorology Intensity-Frequency-Duration AR&R 2019 tool adopting the latitude and longitude of the site.

3.2.3 On-site Detention Basin

It is proposed to provide a detention basin to detain stormwater runoff from the proposed development. The detention basin will then release it at a lower flow rate such that it does not exceed the existing site flows for the catchments draining towards the south. DRAINS model was prepared to design the basin and the outlet structures.

The following table summarises the pre-development flows at the discharge location up to and including the 1% AEP storm event, and the post-development peak flows incorporating the onsite detention basin.

AEP (%)	Pre-Development Flow (m^3/s)	Post-Development Flow – Attenuated (m^3/s)	Basin Top Water Level (mAHD)
1	18.2	17.9	889.10
5	14.5	13.0	888.84
10	13.4	11.9	888.76
20	12.1	9.69	888.55
50	6.08	5.62	887.69

The results demonstrate that the attenuated post-developed peak flows are less than the pre-developed peak flow rates for the development.

The proposed basin and outlet control details have been included on the Civil Engineering drawings accompanying the Development Application package.

4 Stormwater Quality Management

4.1 Objectives

The targets for pollutant reduction and associated modelling methodology is consistent with the Orange City Council (OCC) Subdivision and Development Code (April 2024). The main objectives of the subdivision and development code of Orange City Council are listed below:

1. Targeting pre-development water quality for surface and ground waters.
2. Reducing demand on reticulated water supply by having alternative water sources.
3. Integration of water into the landscape for visual, ecological, and cultural amenity.

To achieve a zero impact and satisfy the requirements of the OCC Subdivision Code, the development will prepare a Water Cycle Management Plan in accordance with Neutral or Beneficial Effect (NorBE) guidelines, summarised as below:

- Post-development pollutant loads should aim for a reduction of at least 10% from pre-development for total suspended solids, total phosphorus and total nitrogen
- Post-development cumulative probability pollutant concentration curves should be better or equal to pre-development curves for total phosphorus and total nitrogen between the 50% and 98% percentile.

4.2 Methodology

The stormwater quality management modelling was prepared using the industry standard MUSIC Model (Model for Urban Stormwater Improvement Conceptualisation) Version 6.3 and was built upon the model used for the planning proposal. Blacktown City Council has a MUSIC template available for use and this template was adopted for modelling of the site, with the rainfall template and potential evapo-transpiraion (PET) data being changed to reflect the conditions within Orange more closely.

The MUSIC files used for the design and assessment for the stormwater quality are summarised in Table 4 below.

Table 4 MUSIC model files

Scenario	File Name
Ultimate	Redleaf_Orange__NorBE10p_v12.sqz

4.2.1 Hydrologic Data Inputs

Blacktown City Council has recommendations for using rainfall data provided through MUSIC-Link however, this data does not accurately portray what is happening within the development. Therefore, monthly Potential Evapo-Transpiration (PET) and rainfall data has been found from Rainfall Station No. 63253 – ORANGE Station. The data was based on a the time series 20/06/1963 12:00 AM to 30/06/1973 11:54 PM, with a mean annual rainfall value of 943mm/year.

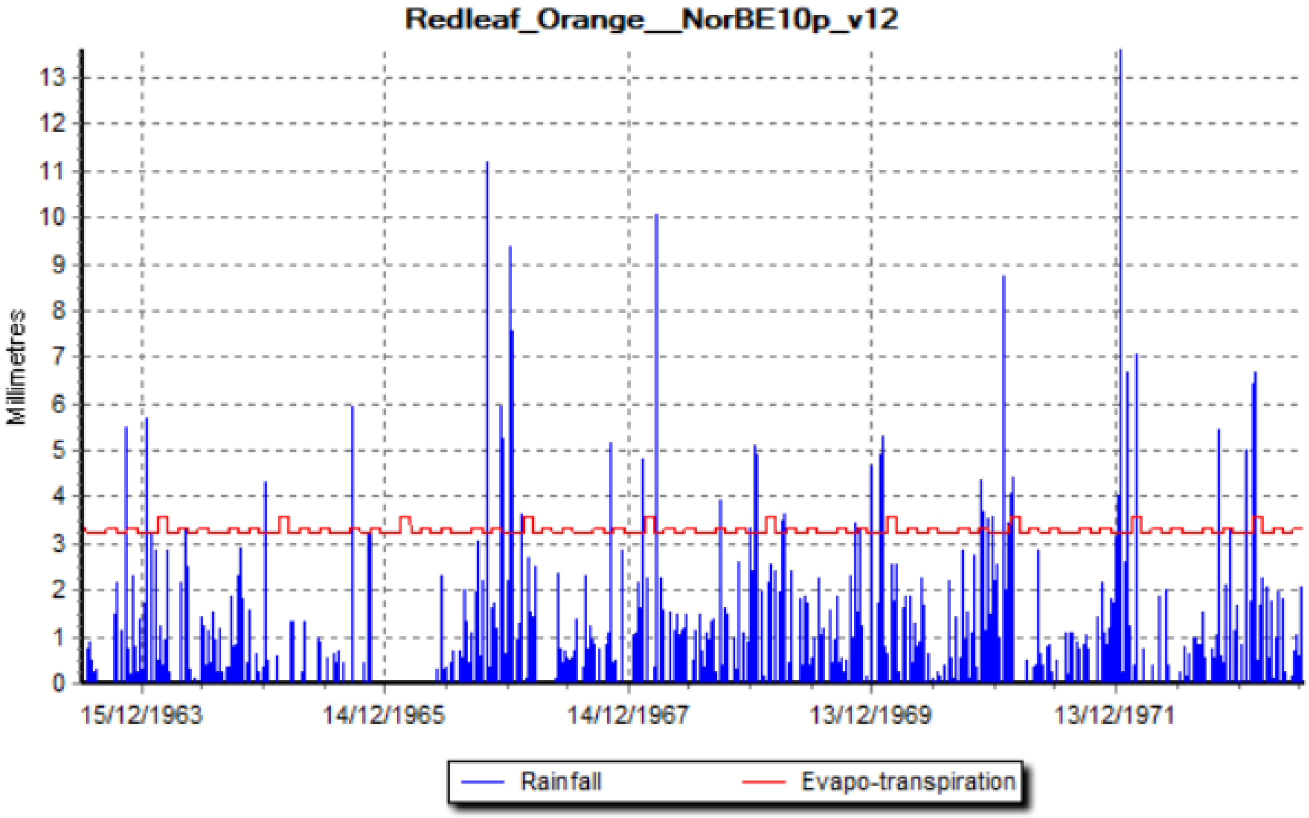

Figure 4 Rainfall and PET graph from Orange Rainfall Station

4.2.2 Source Node Data Inputs

Source Node parameters were adopted by Blacktown City MUSIC template. The following table summarises the source node inputs used within the MUSIC model.

Land-use category		Log10 TSS (mg/L)		Log10 TP (mm/L)		Log10 TN (mg/L)	
		Storm flow	Base flow*	Storm flow	Base flow*	Storm flow	Base flow*
BCC Roof areas (Roof)	Mean	1.30	1.20	-0.89	-0.85	0.30	0.11
	Std Dev	0.32	0.17	0.25	0.19	0.19	0.12
BCC Road Areas (Sealedroad)	Mean	2.43	1.20	-0.30	-0.85	0.34	0.11
	Std Dev	0.32	0.17	0.25	0.19	0.19	0.12
BCC Other Impervious areas (Unsealedroad)	Mean	2.15	1.20	-0.60	-0.85	0.30	0.11
	Std Dev	0.32	0.17	0.25	0.19	0.19	0.12
BCC Pervious Areas (Revegetatedland)	Mean	2.15	1.20	-0.60	-0.85	0.30	0.11
	Std Dev	0.32	0.17	0.25	0.19	0.19	0.12

Figure 5 Stormwater Quality Parameters - Source Nodes

4.2.3 Soil Parameters

MUSIC rainfall-runoff parameters were adopted from Blacktown City Council's MUSIC Template Data for all urban source nodes. See below table for rainfall-runoff parameters.

Parameter	Recommended values
Rainfall threshold (mm)	1.4
Soil capacity (mm)	170
Initial storage (percentage)	30
Field capacity (mm)	70
Infiltration capacity coefficient a	210
Infiltration capacity coefficient b	4.7
Initial depth (mm)	10
Daily recharge rate (percentage)	50
Daily baseflow rate (percentage)	4
Deep seepage (percentage)	0

Figure 6 Soil Parameters adopted in MUSIC

4.2.4 Catchment Details

The proposed development has been broken into two main sub-catchments primarily based on the lot layout and 1m LiDAR, see Figure 7 for catchment breakdown.

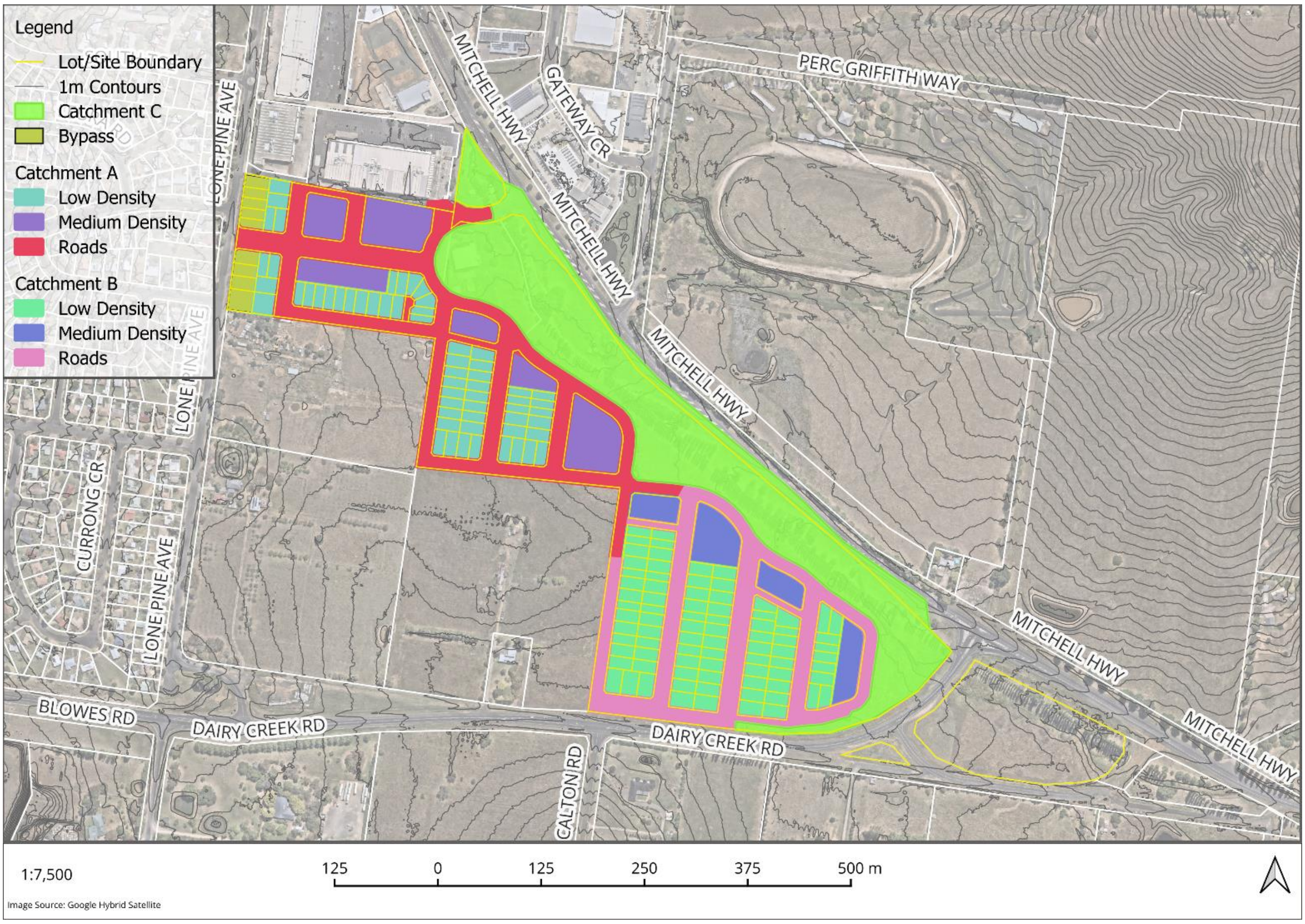

Figure 7 MUSIC Catchment Overview

Figure 8 summarises the assumed fraction impervious properties of the sub-catchments.

LOW DENSITY LOT			
IMPERVIOUS			PERVIOUS
ROOF	DRIVEWAY	OTHER	
60.00%	10.00%	0.00%	30.00%

MEDIUM DENSITY LOT			
IMPERVIOUS			PERVIOUS
ROOF	DRIVEWAY	OTHER	
60.00%	10.00%	10.00%	20.00%

ROAD		Other	
IMPERVIOUS	PERVIOUS	IMPERVIOUS	PERVIOUS
60.00%	40.00%	90.00%	10.00%

CATCHMENT ID	CATCHMENT TYPE	TOTAL AREA (Ha)
A1	Low Density Lots	2.3931
A1	Medium Density Lots	1.9434
A2	Road	3.7429
B1	Low Density Lots	3.4838
B1	Medium Density Lots	1.0462
B2	Road	2.8424
C	Pervious Areas	6.8332
D - Bypass	Low Density Lots	0.4205
TOTAL SITE	-	22.2851

CATCHMENT ID	IMPERVIOUS (Ha)				PERVIOUS (Ha)
	Roof (RWT)	ROOF	DRIVEWAY & ROAD	OTHER IMPERVIOUS	
A1	1.301	1.301	0.434	0.194	1.107
A2	0.000	0.000	2.246	0.000	1.497
B1	1.359	1.359	0.453	0.105	1.254
B2	0.000	0.000	1.705	0.000	1.137
C	0.000	0.000	0.000	0.000	6.833
D	0.000	0.252	0.042	0.000	0.126
TOTAL	2.660	2.660	4.838	0.299	11.828

Figure 8 Sub-catchment Properties

4.3 Treatment Train

The proposed stormwater treatment strategy begins with the installation of gross pollutant traps (Humegard) to capture gross pollutants before stormwater drains into the two bioretention basins. Each basin, integrated with a sediment forebay, is strategically located within the central parkland, and the other adjacent to the southern pond, as shown in Figure 9. These basins are designed to treat low-flow stormwater prior to its final discharge into the pond.

The proposed bioretention basins will require 300m^2 of filtration area in the central basin and 250m^2 in the southern basin, with an extended detention depth of 300mm. The design parameters adopted for the bioretention systems are shown below in Table 5.

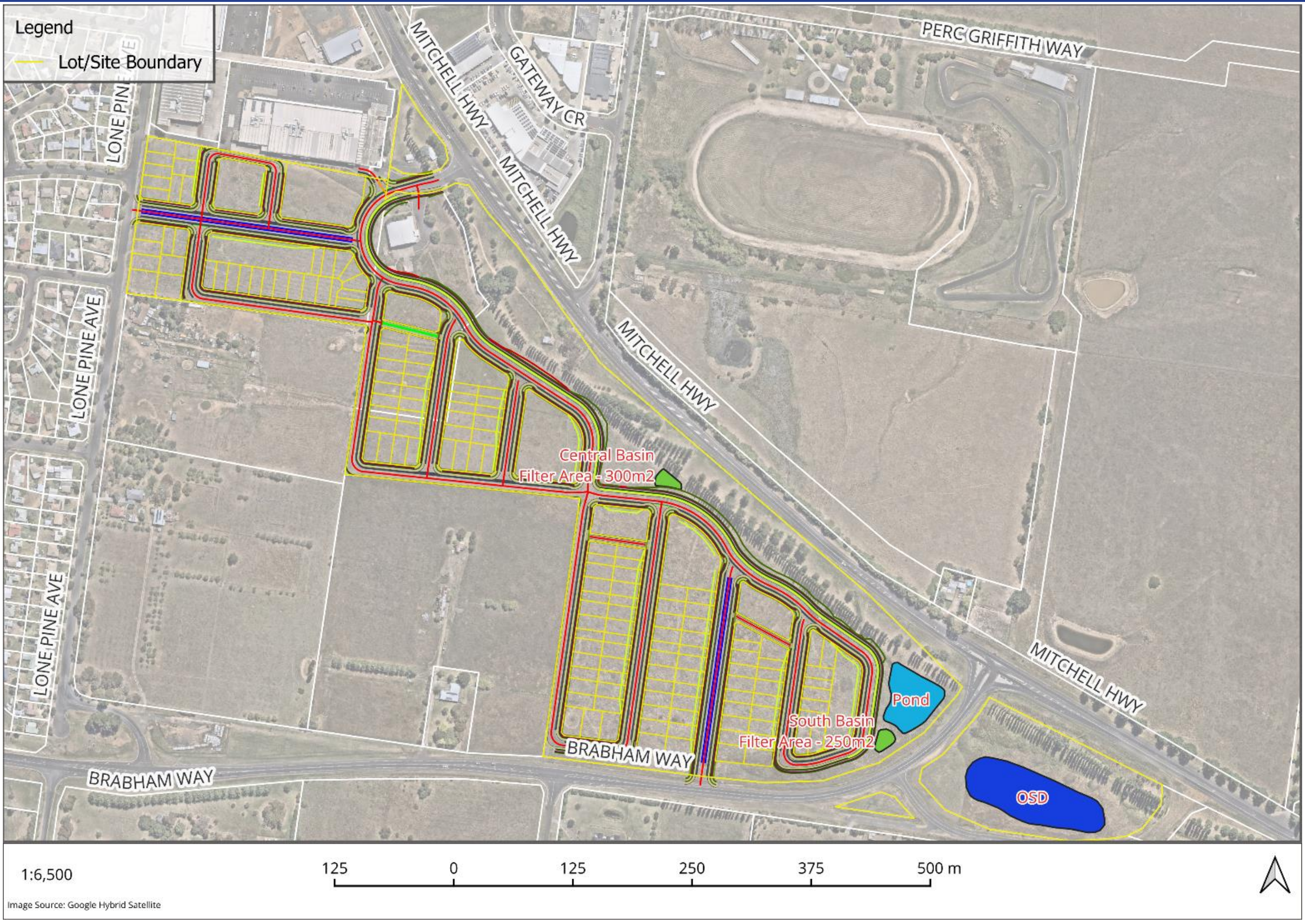

Figure 9 WSUD Features

Table 5 Bio Retention Basin Parameters Adopted in MUSIC

Parameter	Catchment A Value	Catchment B Value
Extended Detention Depth	0.3m	0.3m
Filter Layer Depths	0.4m	0.4m
Transition Layer	0.1m	0.1m
Drainage Layer	0.15m	0.15m
Filter Media	Loamy Sand	Loamy Sand
Filter Media Area	300m^2	250m^2
Filter Media Permeability Saturated Hydraulic Conductivity) (mm/hr)	180mm/Hr	180mm/Hr
TN Content (mg/kg)	800mg/kg	800mg/kg
Orthophosphate Content (mg/kg)	40mg/kg	40mg/kg
Exfiltration Rate (mm/hr)	0mm/hr	0mm/hr
Impervious Base Liner	Yes	Yes
Overflow Pit	Yes	Yes
Submerged Zone	No- With Carbon present	No- With Carbon present

Details of the proposed bio-retention profile are shown on the Civil Engineering Development application drawings.

The stormwater treatment is supplemented by a total of 135 2kL rainwater tanks distributed between low density lots within the northern and southern precincts for rainwater harvesting and re-use for internal usage such as toilet flushing, car washing, general wash down and irrigation. Furthermore, re-use from the storage pond for additional irrigation or other purposes have been allowed for with an annual demand of 1725 kL/yr as PET-rain. In the absence of water reuse rates in the Orange City Council guidelines, the Blacktown City Council WSUD Developer Handbook (2020) Section 11.14.3 Non-potable reuse rates for modelling reuse tanks in MUSIC have outlined the demand rates that was used in MUSIC for modelling purposes to ensure that demand can be met. See Figure 10.

Lots	Allowance
lots > 730 m^2	allow 0.1 kL/day internal use & 55.0 kL/year as PET- Rain
lots > 520 & < 730 m^2	allow 0.1 kL/day internal use & 45.0 kL/year as PET- Rain
lots > 320 & < 520 m^2	allow 0.1 kL/day internal use & 32.0 kL/year as PET- Rain
lots < 320 m^2	allow 0.1 kL/day internal use & 25.0 kL/year as PET- Rain
row houses, villas and townhouses	allow 0.1 kL/day internal use & 20.0 kL/year as PET- Rain
apartments or home units	allow 0.0 kL/day internal use (that is, zero daily demand) & 0.4 kL/year/m^2 of watered landscape areas (excluding turf) as PET- Rain (where used)

Figure 10 Water Demand allowance per lot size

4.4 MUSIC Model

The MUSIC model was built to assess the current masterplan allocation of treatment area is adequate to satisfy the NorBE guidelines. The configuration of which is shown in Figure 11 below.

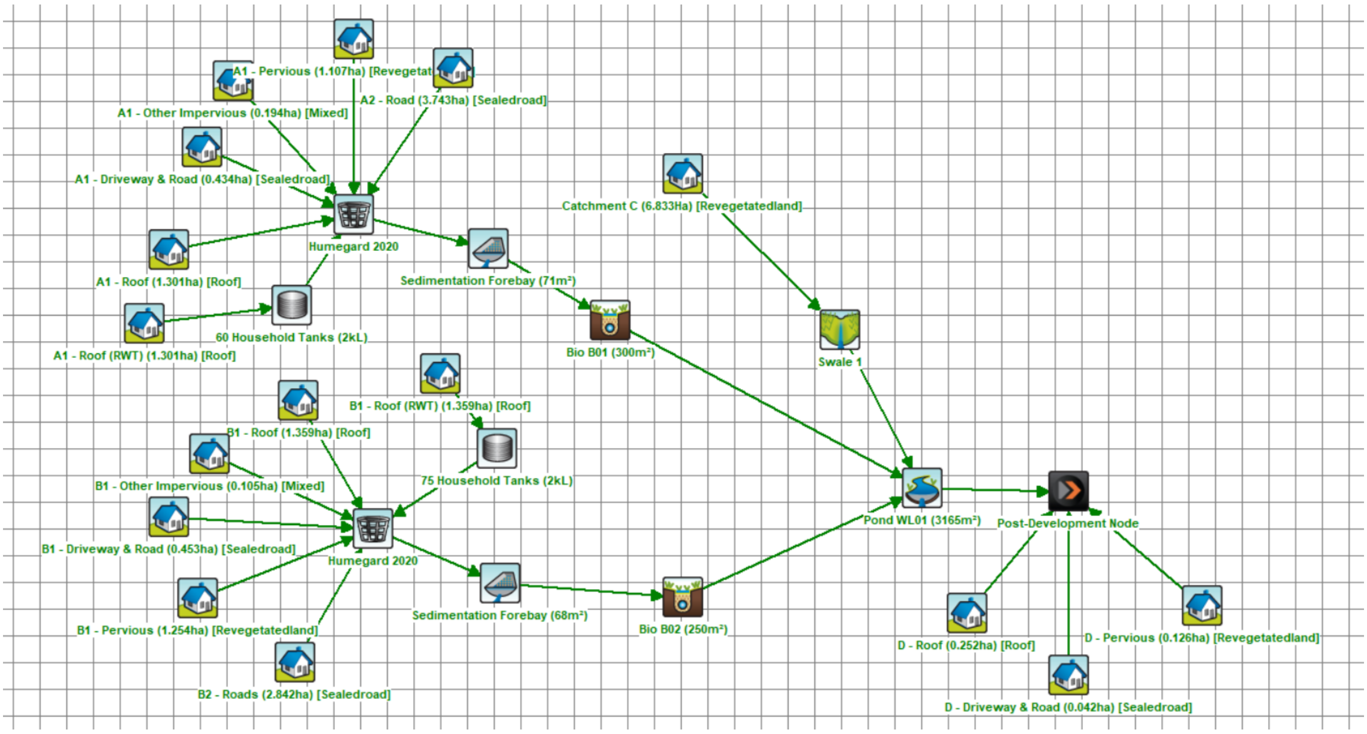

Figure 11 Post Development MUSIC Model

4.5 Water Quality Results

To determine if the treatment performance of the above treatment train is adequate, the proposed development pollutant loads are compared to those of the existing conditions of an agricultural node of the same size. The results demonstrate the mean annual loads have been reduced to satisfy the required targets, exceeding the requirements of NoRBE and NorBE +10% considerably. The analysis of the water quality results are outlined below in Table 6.

Table 6 MUSIC model results analysis

Pollutant	Predevelopment (kg/yr)	Post Development (kg/yr)	NorBE Met?	NorBE +10% Met?	% reduction from predevelopment levels
Total Suspended Solids	6520	2310	Yes	Yes	65%
Total Phosphorus	19.8	11.2	Yes	Yes	43%
Total Nitrogen	141	124	Yes	Yes	12%
Gross Pollutants	531	67.6	Yes	Yes	87%

Pollutant concentrations for Total Phosphorus (TP) and Total Nitrogen (TN) were compared in accordance with the assessment objectives. As can be seen from both TP and TN, the pollutant concentration (mg/L) for post development is generally reduced in comparison to the predevelopment concentration between the 50% and 98% cumulative frequency. Therefore, the results below show that the reductions have been achieved for the proposed Redleaf development.

The cumulative frequency graphs for TP and TN are shown in Figure 12 and Figure 13 below.

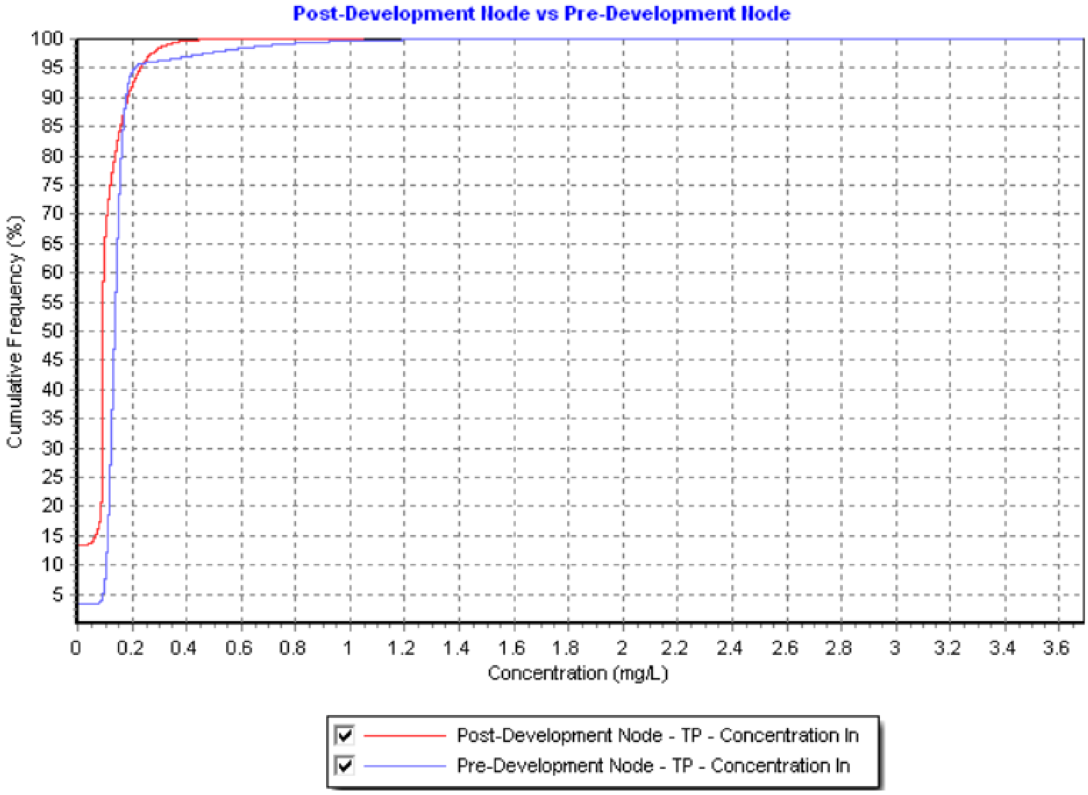

Figure 12 Cumulative frequency analysis of TP concentrations

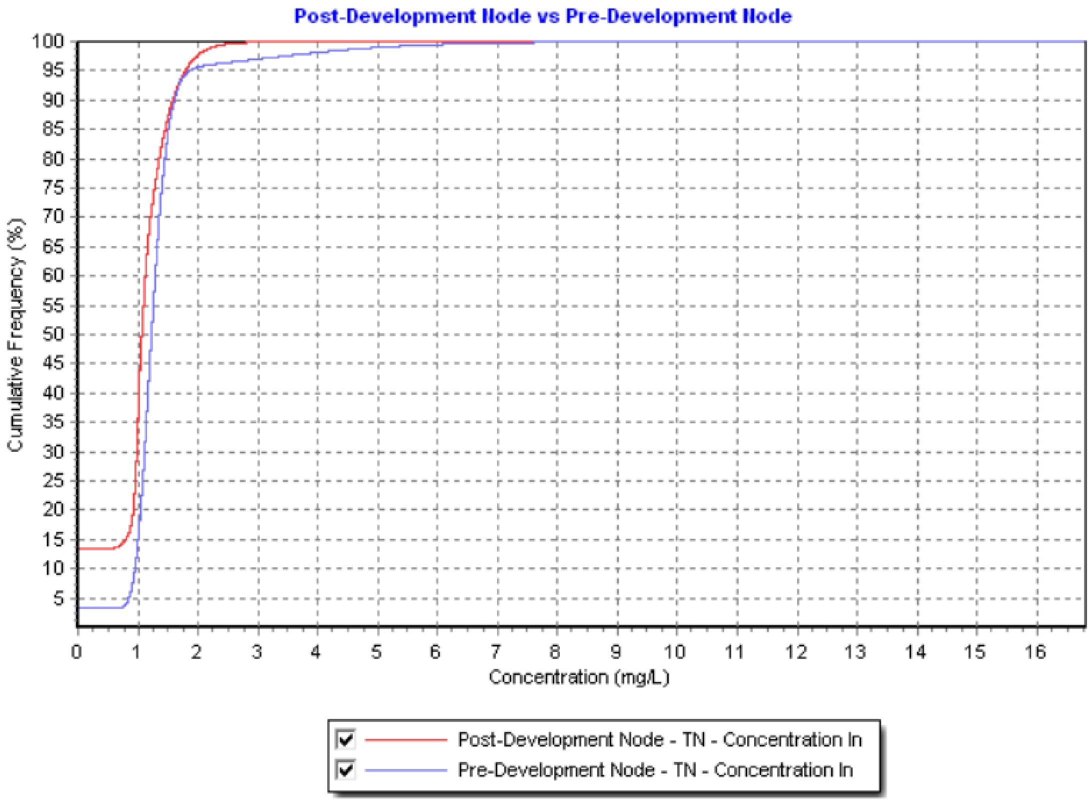

Figure 13 Cumulative frequency analysis of TN concentrations

5 Water Balance Assessment

5.1 Objectives

The Redleaf model aims to enhance water cycle management by establishing a visually appealing blue-green corridor alongside the Mitchell Highway. Central to this vision is a permanent pond located in the site's south-eastern corner, designed to be sustained with a combination of treated and untreated stormwater runoff. The pond's long-term viability depends on consistent regional rainfall, though extended droughts may affect water levels. This assessment evaluates the pond's performance over time, focusing on water level variability throughout its lifecycle.

5.2 Methodology

The water balance assessment was conducted using the Wetland Analysis Tool in MUSIC Auditor. This tool evaluates wetland performance by analysing water depths relative to vegetation height and residence time.

A daily flux file generated from the MUSIC model using the rainfall data based on the time series 20/06/1963 12:00 AM to 30/06/1973 11:54 PM was loaded into the tool. This data enabled a temporal review of pond inundation, helping assess how water levels respond to varying climatic conditions across the site during the 10-year assessment period.

5.3 Results

The analysis of the daily water balance data revealed that the standing water pond is capable of maintaining desirable water levels for much of the year under average rainfall conditions. The Wetland Analysis Tool highlighted that water depths generally remained relatively stable, which is essential for both ecological function and visual appeal.

During wetter periods, the model predicted a slight increase in water level for approximately 2% of the time. However, during extended dry periods, particularly under drought scenarios, the model predicted a small drop in water level. These fluctuations occur only less than 5% of the time. This can be seen in the inundation frequency graph generated from the Wetland Analysis tool, shown in Figure 14 below, which presents the percentage of time levels exceed levels above and below the normal water level.

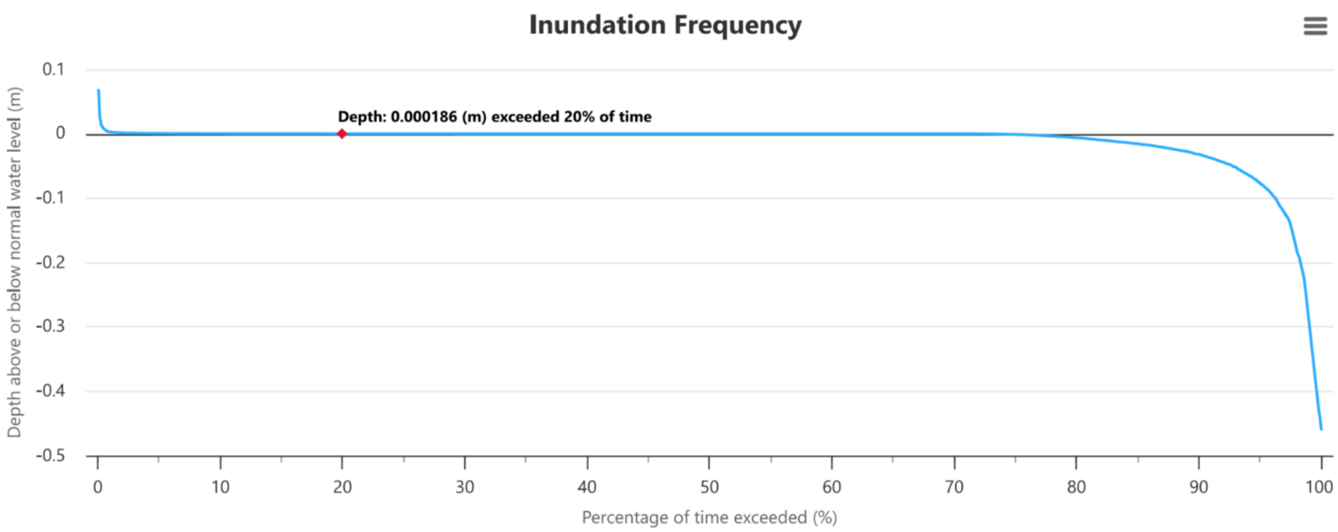

Figure 14 Inundation Frequency

Overall, the assessment affirms that the design is robust under typical conditions and the pond should remain within normal water levels for the majority of its lifecycle.

6 Hydrology Assessment

6.1 Study Area

The Redleaf development does not lie within the catchment of any previously undertaken flood study that is fit for purpose for the assessment of this rezoning application. The closest study in proximity for reference is the Flood Study (Lyall and Associates, 2020) for Blackmans Swamp Creek which was used to validate approaches to modelling in the region. The Redleaf Development Proposal Area and the extent of the hydrological and hydraulic assessment can be seen below in Figure 15.

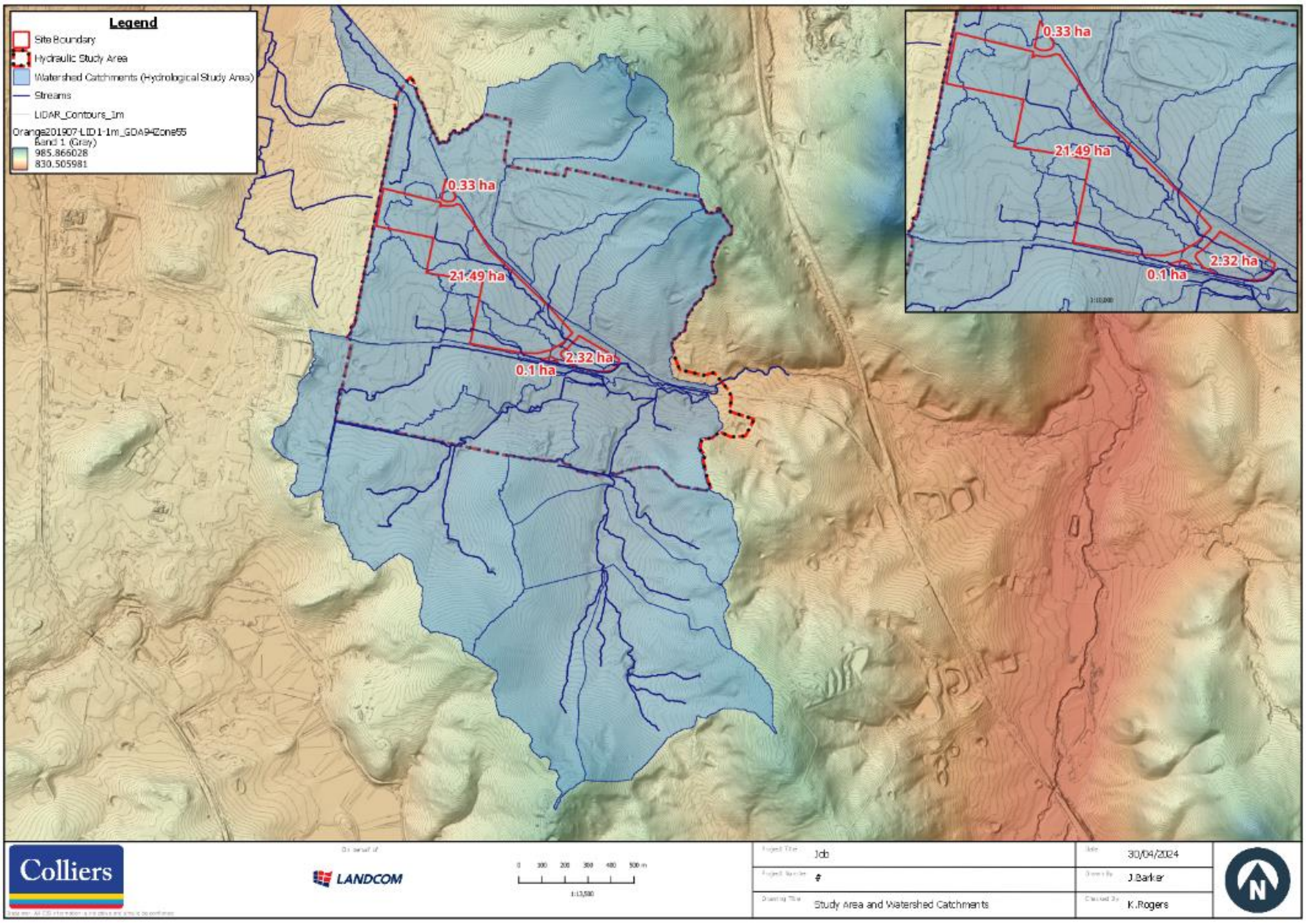

Figure 15 Study Area and Watershed Catchments

6.2 Data Collation and Review

The general data collated for this flood study included cadastral, topographic and LiDAR data. Additional data collated specifically for the flood study is outlined below.

- Rainfall data was downloaded from the ARR2019 Data Hub and utilised with due consideration for the NSW jurisdiction guidelines.
- Streamflow data was not utilised for calibration of this model. A search was undertaken for nearby streamflow gauges utilising the NSW government data available via the Water Data Online on the Bureau of Meteorology website (2023), with the closest gauges catchment being the Bell River at Malong, a poor-quality gauge, significantly downstream from Orange.
- A 1m resolution design surface was developed by Colliers Engineering & Design (NSW) Civil Engineering Department (250711 DESIGN DEM REV01.asc).

The gauging stations that are in proximity to the site can be seen below in Figure 16.

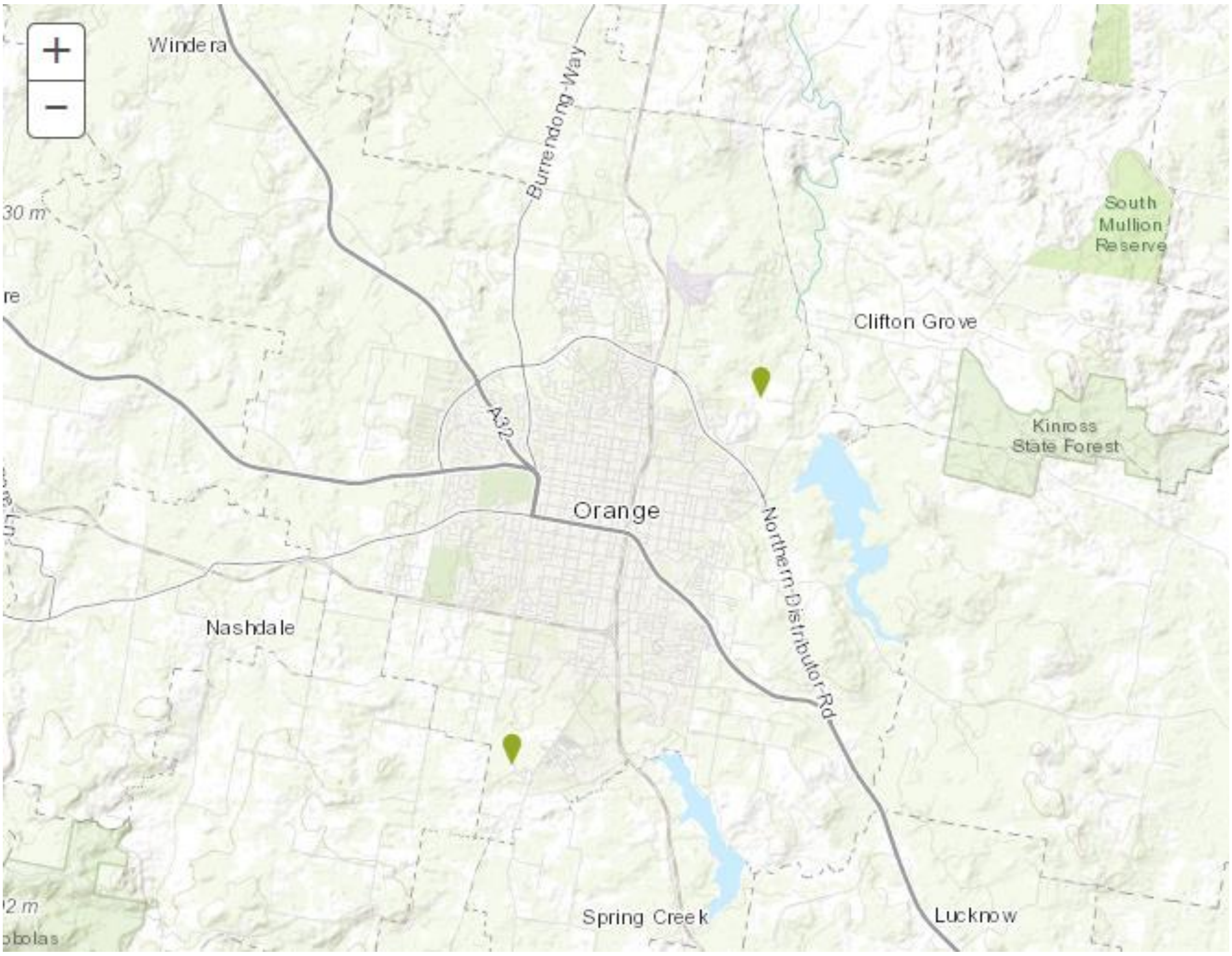

Figure 16 Water Data Online Gauging Stations

6.2.1 Digital Elevation Model

A digital elevation model was prepared from the 1m LiDAR obtained from Elvis (GeoScience Australia, 2021). A detailed site survey was conducted by Premise with the data surveyed provided to Colliers on the 13th of June 2025. The data obtained from the survey was overlaid on the LiDAR DEM to further refine the terrain information for analysis.

The resultant Digital Elevation model is illustrated below in Figure 17 below.

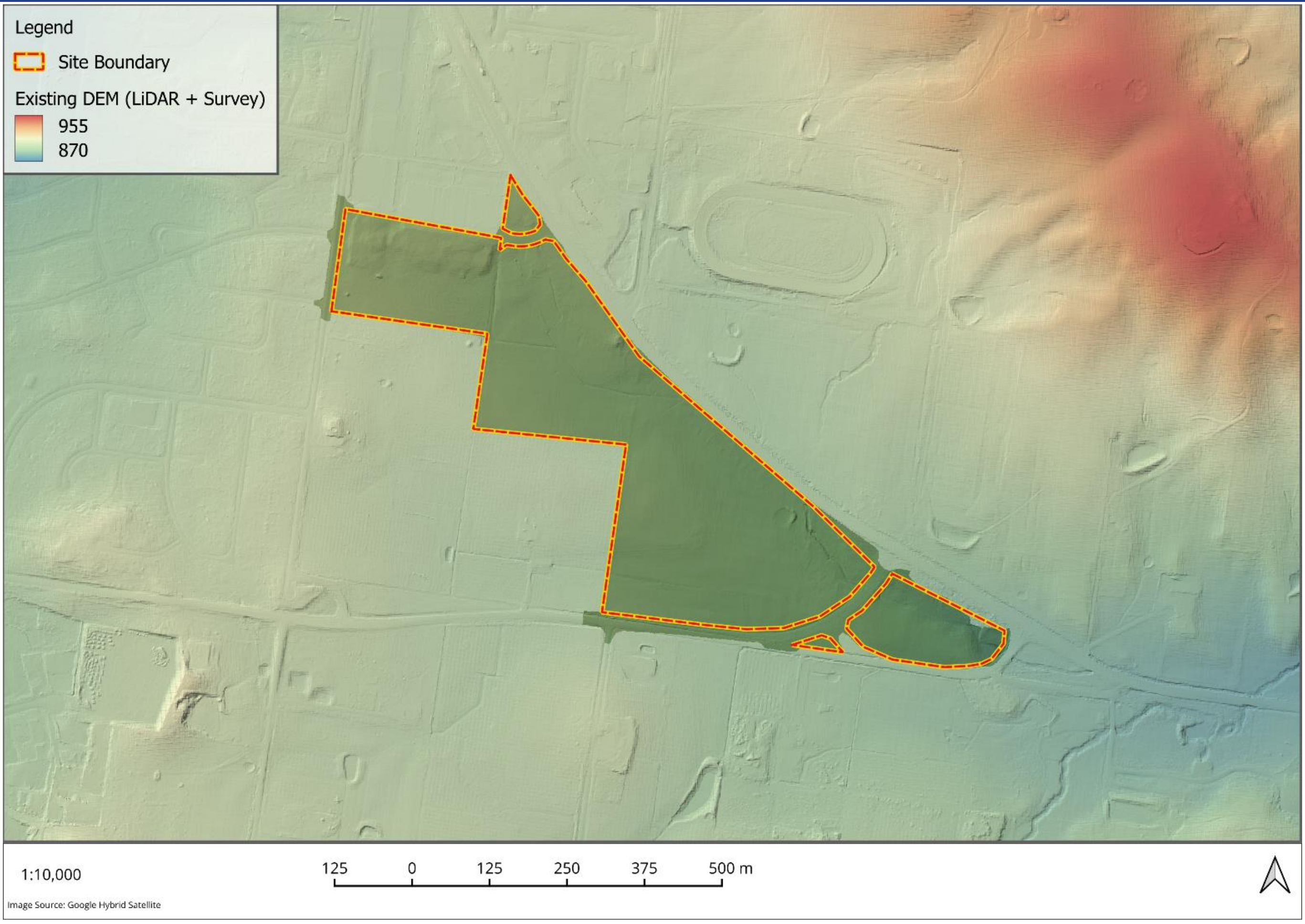

Figure 17 Digital Elevation Model – Existing Conditions.

6.2.2 Existing Farm Dams

Existing farm dams present within the study area were assumed to not function as detention basins and as such, were filled to the dam spillway level. This approach is conservative and ensures that dams do not unnecessarily act to attenuate overland flows. This was done by prewetting the catchment within the hydraulic (TULFOW) model.

6.3 Hydrologic Model

RORB modelling software was used to perform the hydrological analysis of the Site area and external catchment. RORB modelling is a modelling tool used for hydrological modelling and flood prediction. It simulates the hydrological processes of a catchment via rainfall patterns, catchment characteristics and land use information.

The hydrologic model was built upon the model used for the planning proposal and has been developed in accordance with the latest Australian Rainfall and Runoff (ARR2019) methodology and guidelines. The purpose of the model is to estimate the magnitude of the flows acting on the site in existing conditions and assess the impact of the post development flow rates.

ARR19 datahub extracted rainfall depths, temporal patterns (10-minutes to 168-hours) and areal factors have been utilised within the model.

Table 7 ARR 2016 Data Hub Co-Ordinates

Parameter	Value
Latitude	-33.310
Longitude	149.134
Zone	55
Date Accessed	20/02/2024

6.3.1 Losses

The AR&R Datahub recommends a five-step hierarchy for determination of catchment losses. Steps 1 through 3 rely on available calibration data from either the actual study area or similar adjacent catchments. Step four of the hierarchy uses NSW Flood Frequency Analysis reconciled losses available through the Data Hub.

A review of the Flood Study (Lyall and Associates, 2020) for Blackmans Swamp Creek showed that they utilised a combined hydrologic / hydraulic calibration / validation and validated the hydrology model to rational method. The adopted losses were IL 18mm and CL2.5mm/hr. The study found a better fit to downstream gauge using 0mm IL and 2.5mm/hr for CL. This was considered inappropriate to adopt these losses within the RORB model, as the study used XP RAFTS and the modelling was undertaken in 1987 IFD rainfall.

Therefore, the losses were adopted from datahub with the continuing loss multiplied by 0.4 of the DataHub value, as per the DataHub recommendation Hierarchy Level 5. The adopted losses are consistent with the values used in the planning proposal and can be seen below in Table 8.

Table 8 ARR 2016 Data Hub Adopted Losses

Parameter	Value
Initial Loss	25mm
Continuing Loss	1.96 mm/hr

6.3.2 Pre-development Hydrologic Model

The pre-development conditions catchment delineation was undertaken using GRASS GIS, following the methodology outlined by Hans van der Kwast (2019). The GRASS GIS tools automate the delineation of catchments and streams usings the underlying 1m LiDAR data. The assessment generated set of maps indicating local drainage direction and streams from which the catchments and sub-catchments were derived.

Sub-catchments were connected by reaches of type 1, 2 or 3, depending on land use and slope. The land use fraction impervious was based on the OCC Subdivision Code (2024). The RORB model can be seen below in Figure 18.

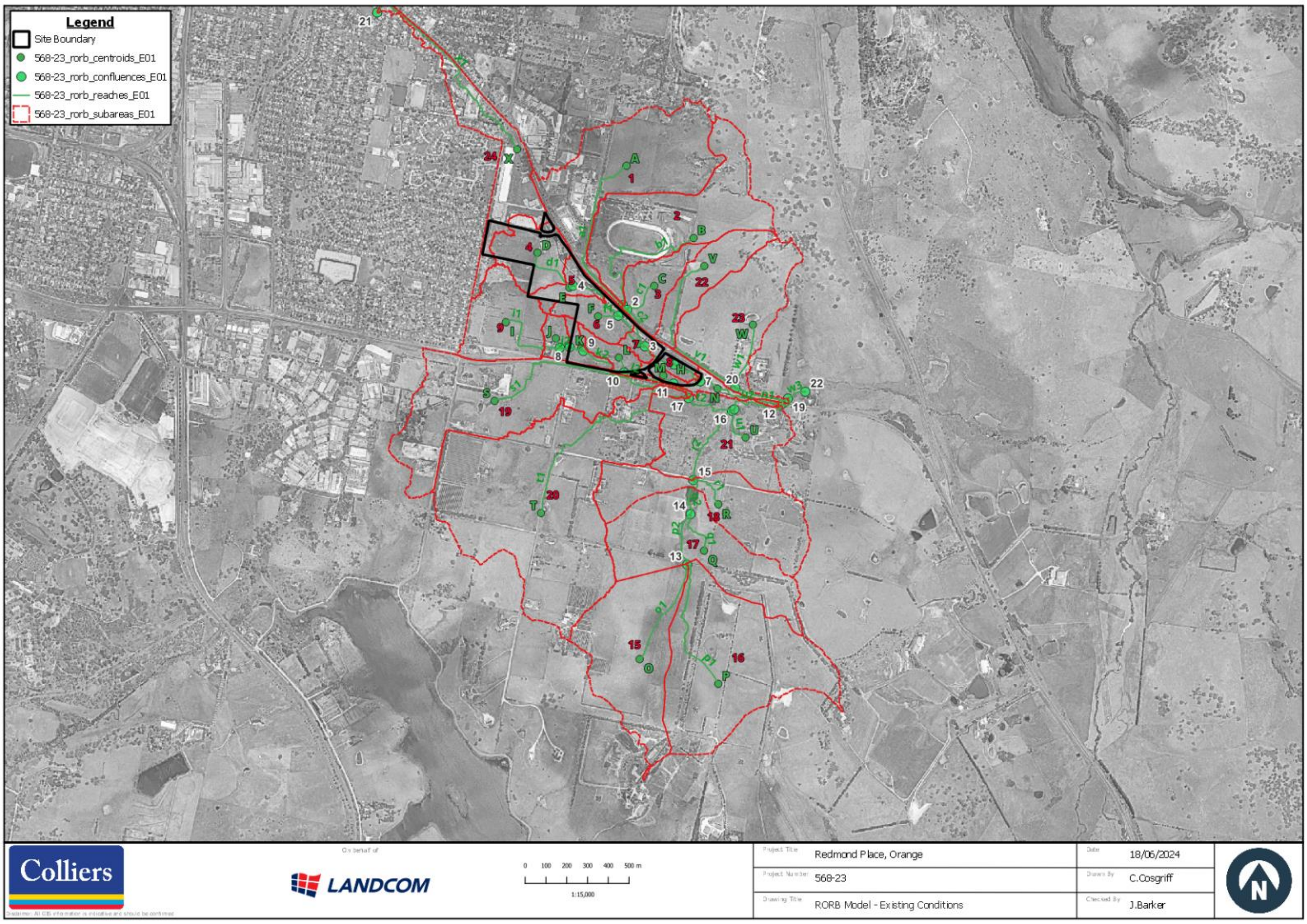

Figure 18 RORB – Existing

6.3.3 Kc Calibration

The routing factor Kc was determined by applying each of the relevant equations as listed below and utilising other flow determination methods to validate the chosen equation in accordance with AR&R2019. The equation for the entirety of NSW was firstly adopted for further calibration / investigation against sanity check methods including RFFE and rational calculations.

Table 9 Kc Calibration

Equation	Kc	Flow
NSW	2.26	23.97
NSW West of Great Dividing Range	1.64	32.22
RFFE		71.60
NSW Rational Method		24.70

The RORB results, indicating a flow ranging from ~24 – 32 m³/s are on the lower end of the results, but coincides reasonably with the rational value using an average FI from the FI map informing the RORB sub-catchments. The Kc for catchments west of the Great Dividing Range in NSW was selected given the comparison to sanity check flow methods and to ensure a conservative calculation given the results from the RFFE assessment. The RORB parameters are summarised in Table 10 below.

Table 10 RORB Parameters

Parameter	Value
Kc	1.64
Kc (Sub Area X)	0.33
m	0.80
Initial Loss (IL)	25.00
Continuing Loss (CL)	1.96

6.3.4 Simulated Storm Events

An initial assessment of all storm durations (ranging from 10min to 168hours, for all temporal patterns) was run for the 1% AEP storm event to assess the critical durations throughout the site and relevant catchment in order to assess the critical storm duration at critical locations throughout and downstream of the site. The results were then analysed following the process outlined in Figure 19.

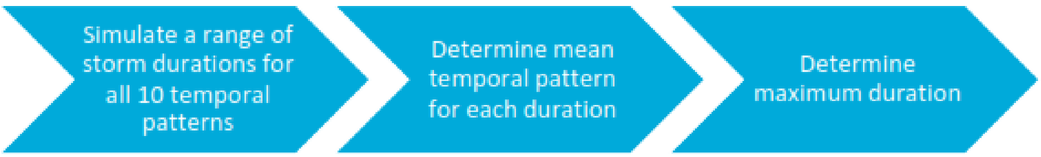

Figure 19 Process for determination of critical storm

The analysis illustrated that the critical storm durations ranged from 15-minutes to 90-minutes. From subsequent simulations five key storm durations and critical temporal patterns were adopted to perform the existing conditions flood impact assessment. The storms which were adopted are outlined below in Table 11.

Table 11 Critical Storm Durations and Mean Temporal Patterns – Existing Conditions.

Storm Duration	Mean Temporal Pattern
15 min	TP10
30 min	TP6
45 min	TP7
60 min	TP4
90 min	TP10

6.3.5 Post-Development Hydrologic Model

The model was updated with appropriate routing to represent the impact of development. Kc was updated as a function of D_{av} and land use fraction impervious was updated to represent the various land use and parcel densities through the proposed development. Updated RORB parameters are shown below in Table *12*. The parameters were consistent with the existing model due to a negligible change in D_{av} between scenarios.

Table 12 RORB Parameters – Developed

Parameter	Value
Kc	1.64
Kc (Sub Area X)	0.33
m	0.80
Initial Loss (IL)	25.00
Continuing Loss (CL)	1.96

The developed model can be seen below in Figure 20 with land use fraction impervious values shown in Table 13.

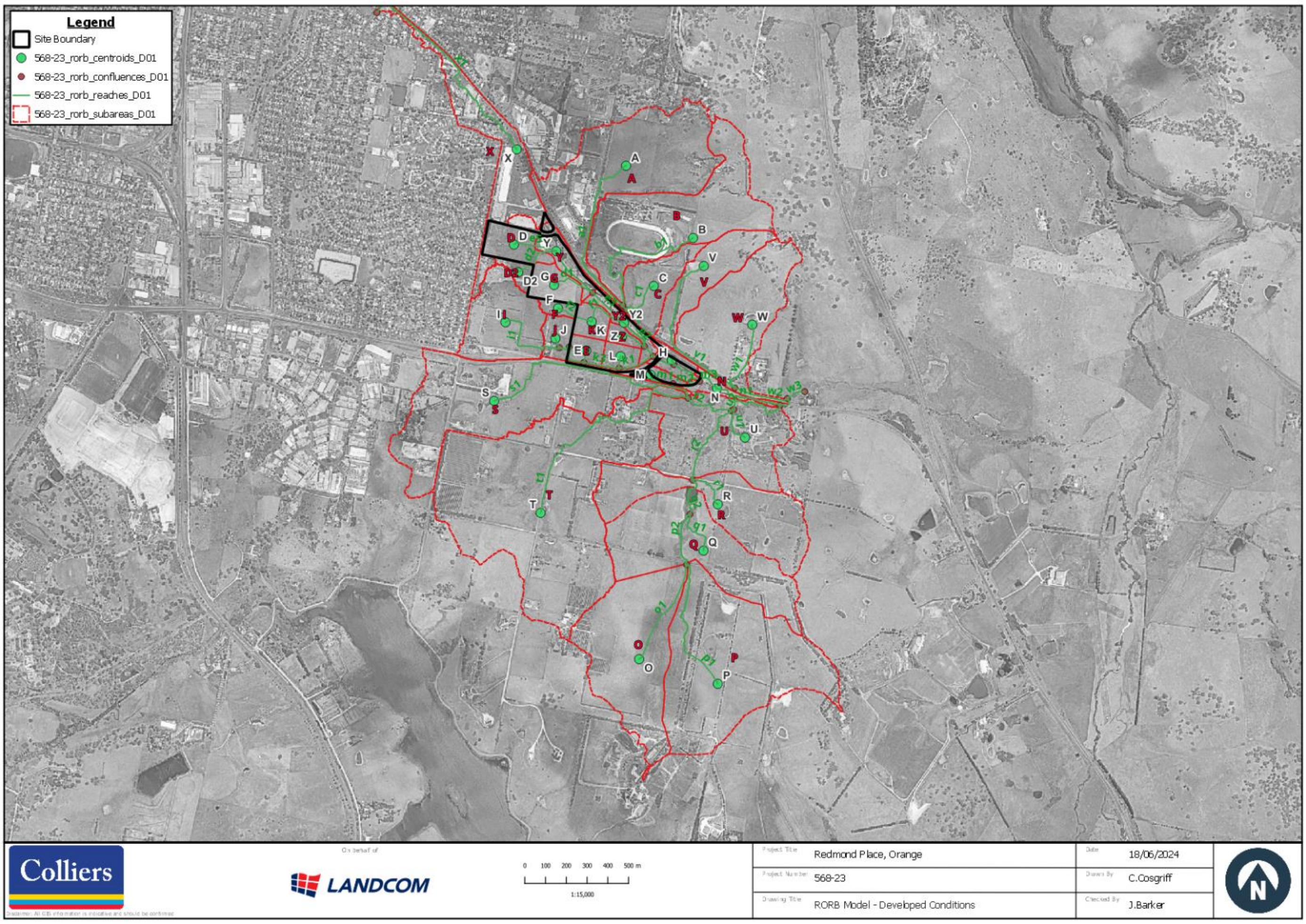

Figure 20 RORB – Developed

Table 13 Land Use Fraction Impervious.

Parameter	Value
Low Density Residential	0.70
Medium Density Residential	0.80
Apartments	0.90
Industrial	0.95
Rural	0.05
Open Space	0.10
Commercial Road	0.98
Subdivisional Road	0.60
Drainage Reserve	0.10

The simulated storm events were analysed as per existing conditions detailed in section 6.3.4.

6.4 Climate Change

Climate change factors were adopted based on Orange City Council's Subdivision and Development Code. The adopted increase of 20% in rainfall due to climate change were applied to the 1% AEP rainfall data.

7 Hydraulic Assessment

7.1 Approach and Methodology

The site's flood behaviour for the 10% AEP, 5% AEP, 1% AEP, 1% AEP with climate change and PMF design storm events under pre and post developed conditions have been modelled using a two-dimensional TUFLOW hydraulic model. TUFLOW is a computational engine that provides one dimensional (1D) and two dimensional (2D) solutions for free-surface flow equations to simulate flood and tidal wave propagation.

The model introduces flow in the form of RORB excess hydrographs via "SA" polygon for each sub-catchment internal and external to the proposed development.

7.2 Pre-development Hydraulic Model

The TUFLOW modelling for the pre-development study was built upon the model used for the planning proposal and was undertaken using the following model parameters:

- TUFLOW version 2023-03-AC was adopted using the HPC explicit solver. This remains consistent with the version used within the planning proposal.
- A 1m topographic grid was used in the model construction based on available LiDAR (2019) data sourced from ELVIS. Detailed site survey obtained from Premise was overlayed on top of the LiDAR data to refine the topographic layer
- The 2D cell size remained consistent with the planning proposal at 2m
- The model domain was defined from ridge line south of Dairy Creek approximately 2km south of the site's southern boundary. At the downstream end, the domain has been set approximately 400m west of the eastern boundary at the Dairy Creek culvert underneath Mitchell Highway.
- PO lines were placed at the site downstream boundary and within the development to assess flows leaving the site and flows contributing the overland flow paths, respectively.
- Mannings n roughness values for watercourses were updated from the planning proposal to reflect the latest design. The adopted values are specified in Section 7.2.2.
- Blockage factor of 50% for sag pits, and 20% for on-grade pits were adopted based on Orange City Council's Subdivision and Development Code

7.2.1 Boundary Conditions

The hydrological model was developed to inform the inflows with a rainfall excess approach taken to input flows to the model. Sub-catchments derived from the hydrological analysis and loaded into RORB were used to extract excess flows after losses are accounted for and applied in the form of a hydrograph applied across the full area of the sub-catchment.

A singular hydrograph has been included as an external flow boundary to capture this inflow from Dairy Creek. There are three outflow boundaries represented to allow flows to exit the site, which have been placed a significant distance downstream as to not impact upon flood condition in the area of analysis. The applied slopes have been measured at each location to give an accurate representation of outflow. All external flow boundaries can be seen below in Table 14.

Table 14 External Boundaries

Type	Name	Slope
HQ	DairyCreek_Out	0.1667
HQ	LonePineAve_Out	0.025
HQ	Eastmodel_outflow	0.05
QT	DairyCreek_Inflow	NA (hydrograph inflow)

7.2.2 Mannings 'n' Roughness (Materials Definition File)

A materials definition file was used to define the mannings roughness of the terrain surface. Aerial imagery and SixMaps cadastral data was used to delineate the specific roughness regions. Depth varying mannings 'n' values were adopted due to the distributed rainfall input approach, with defined mannings coefficients outlined below in Table 15.

Table 15 Mannings 'n' roughness values

Id	Material	'n' Value (y_1, n_1, y_2, n_2)
1	Impervious Area Rainfall Losses	IL = 1.0 mm CL = 0.0 mm/hr
2	Design ARR2016 Pervious Losses	Probability Neutral Burst Losses
3	Concrete Lined / Irrigation Channels	0.05, 0.04, 0.1, 0.02
4	Watercourses	0.5, 0.08, 0.1, 0.045
5	Waterbodies, no emergent vegetation [assume zero infiltration]	0.03, 0.08, 0.1, 0.03
6	Roads	0.05, 0.06, 0.1, 0.02
7	Gravel Roads	0.05, 0.08, 0.1, 0.03
8	Rail Corridor	0.1, 0.16, 0.2, 0.08
9	Open Space (e.g., Minimal vegetation (grassed))	0.05, 0.06, 0.15, 0.045
10	Moderate vegetation (shrubs)	0.15, 0.15, 0.3, 0.08
11	Heavy vegetation (trees)	0.15, 0.25, 0.4, 0.12
12	Building Footprints	0.1, 0.02, 0.3, 0.5
13	Large rural Lots	0.05, 0.06, 0.15, 0.04
14	Low density residential lots	0.1,0.12,0.2,0.06
15	Medium Density Residential	0.05, 0.2, 0.15, 0.15
16	High density lots	0.05, 0.25, 0.15, 0.3
17	Industrial/Commercial (Large significant buildings)	0.1, 0.02, 0.2, 0.5
18	Default Model 'n' value - Rural, generally unmaintained grass, lightly vegetated	0.05, 0.1, 0.15, 0.045
19	Developed Conditions - Parks, Open Space, Minimal Vegetation, neatly maintained grass [assumed pervious]	0.05, 0.05, 0.15, 0.03
20	Rock lined channel	0.05, 0.08, 0.1, 0.1

7.2.3 Pre-development Drainage Structures

Based on the detailed site survey, a number of existing drainage structures were included in the model.

The culvert underneath Brabham Way will need to be upgraded to convey the additional flows generated from post-development conditions on site, while maintaining existing conditions along Brabham Way. Pre-development flood modelling demonstrates that the road is partially inundated by low hazard flows in the minor 5% AEP storm event in its current state, and overtopped in the major 1% AEP storm event.

Each structure, input within the 1d_nwk files, can be seen below Figure 21 with attributes described in Table 16.

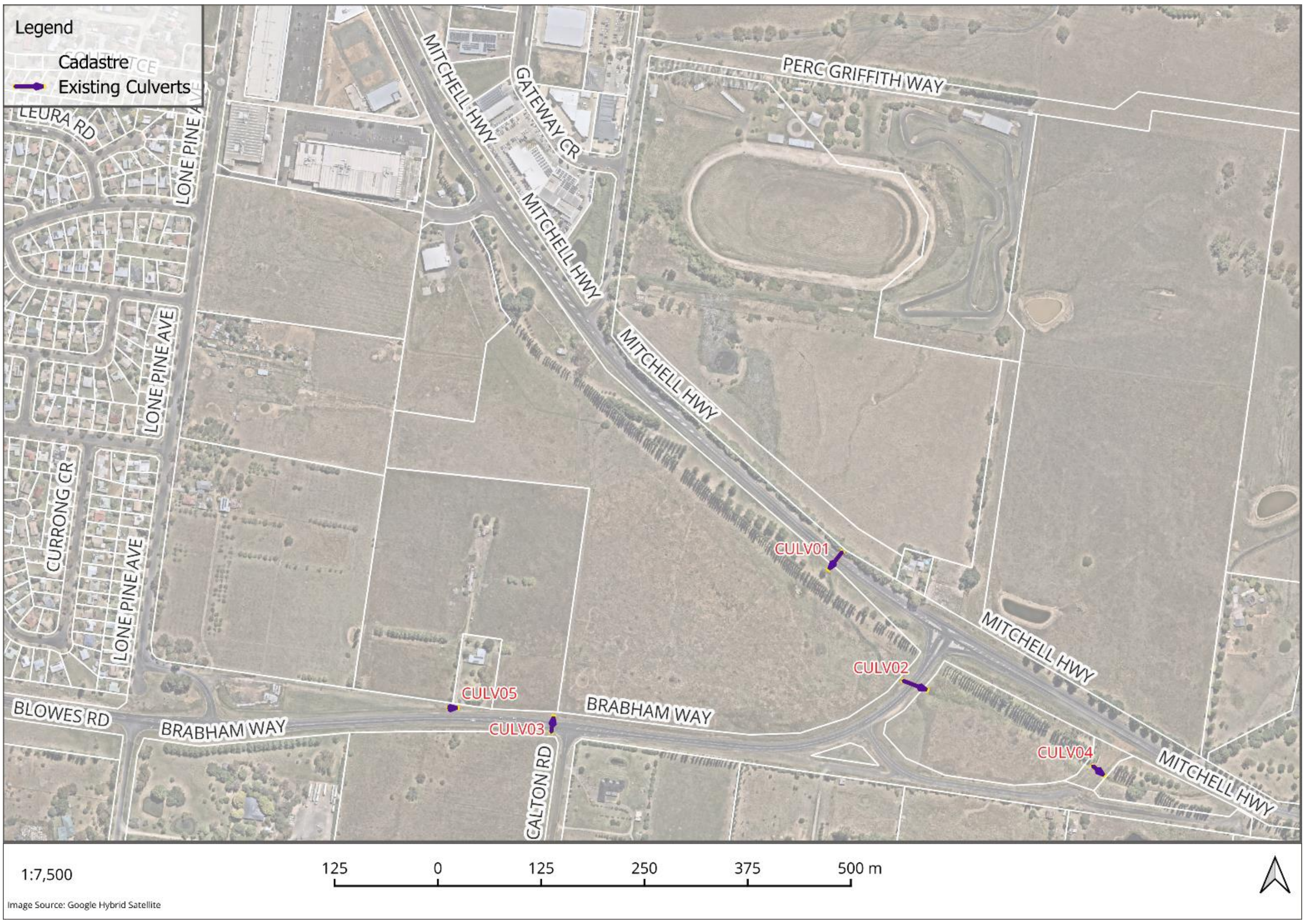

Figure 21 Existing Culverts

Table 16 Pre-development Scenario Structures

Type	ID	Length (m)	Size (mm)	US IL (m)	DS IL (m)	Location
R (Box Culvert)	CULV01	26	2x1500x600	893.25	892.912	Mitchell Hwy
C (RCP)	CULV02	30	3x1050Ø	890.989	890.598	Brabham Way
R (Box Culvert)	CULV03	19	1800x600	896.516	896.414	Brabham Way
C (RCP)	CULV04	17	2x1050Ø	884.806	884.491	Brabham Way
C (RCP)	CULV05	19	450Ø	897.363	897.147	Brabham Way

7.3 Post-development Hydraulic Model

The post-development hydraulic model was prepared to account for the proposed changes in land use under post-development conditions as per the masterplan. The following model elements were modified for proposed conditions:

- The post-development topographic surface developed by Colliers Civil Engineering department was layered on top of the LiDAR data and detailed site survey.
- The site's manning's roughness zones within the site were updated to present the proposed design surfaces as per the masterplan.
- The inflows for the SA boundary conditions for the proposed development sub-catchments were updated and modelled as 2D_SA_PITS to evenly distribute runoff into the urban stormwater system throughout the site.
- The proposed 1D-network of drainage pits and pipes, designed using DRAINS, have been incorporated into the model, including the on-site detention (OSD) basin to limit post-development outflows into Dairy Creek.
- Blockage factors of 50% for sag pits, and 20% for on-grade pits were applied to the proposed 1D-network based on Orange City Council's Subdivision and Development Code

All other modelling elements remained unchanged from the pre-development scenario model.

7.3.1 Boundary Conditions

The developed case inflows were updated to represent proposed land-use fraction impervious and routing.

The external outflow and inflow boundaries throughout the catchment remained the same as those adopted for existing conditions.

7.3.2 Post-development Drainage Structures

There are three additional major drainage structures required to service the proposed developments flood conditions. The proposed design solutions are listed below.

1. The upgrade of the Brabham Way culvert via additional adjacent culvert to convey the increased post-development flows from site
2. Underground pipeline to connect the external catchments from the west (sub-catchments I & J) to the pond
3. The retarding basin outlet, to ensure site discharge does not exceed predeveloped levels.

The updates to the 1d_nwk file can be seen below in Table 17 with the post-development 1d_nwk shown in Figure 22.

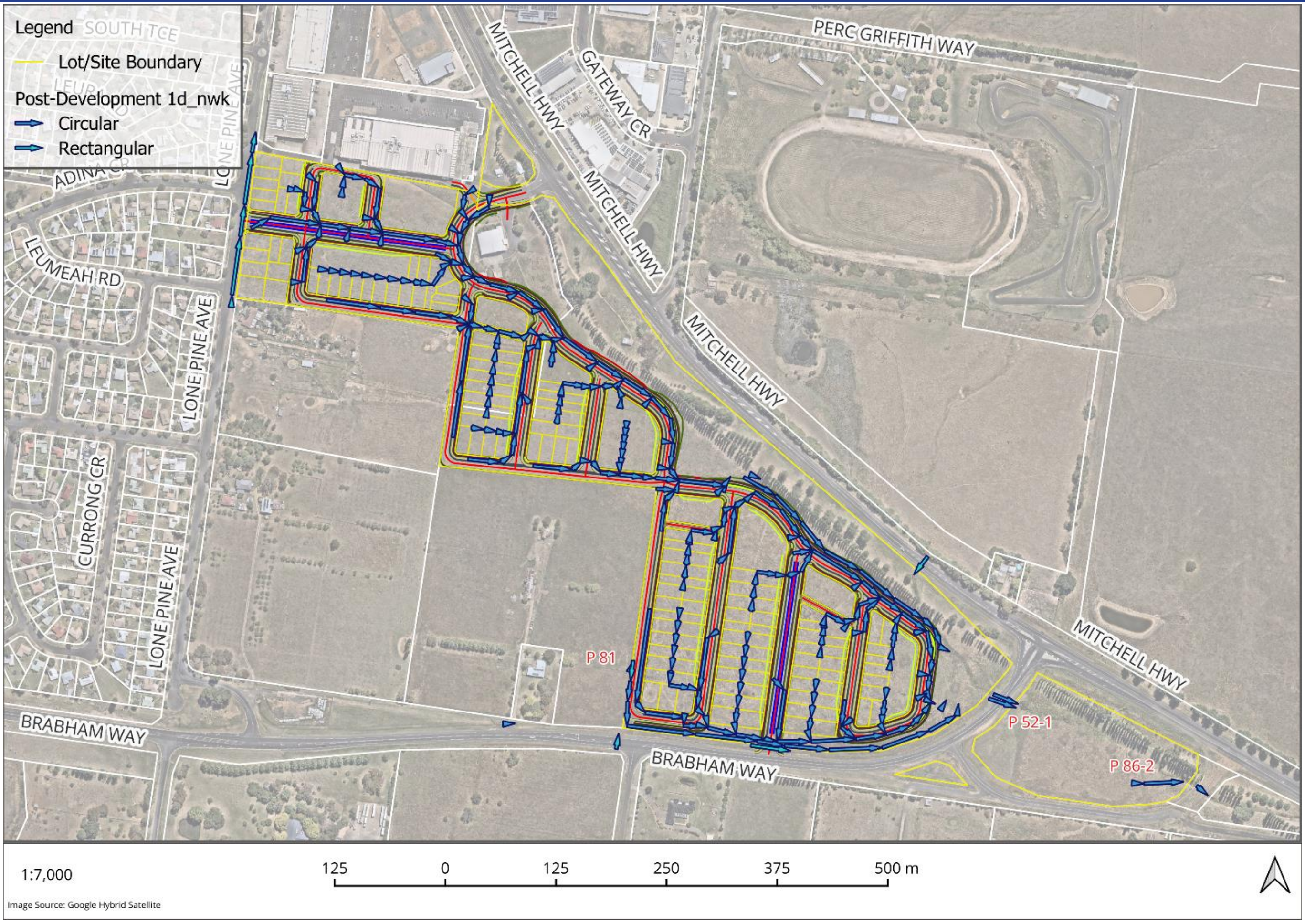

Figure 22 Post-development 1d_nwk

Table 17 Post-Development Drainage Structures

Type	ID	Length (m)	Size (mm)	US IL (m)	DS IL (m)	Location
C (RCP)	P 52-1	32	825Ø	890.989	890.598	Brabham Way
C (RCP)	P 81	446	2x1200Ø	895.010	890.989	Internal
C (RCP)	P 86-2	46	5x1050Ø	886.085	885.635	Retarding Basin

All other structures were consistent with the existing case scenario.

7.4 Hydraulic Modelling Results

The results of the existing case and developed case modelling are detailed in sections 7.4.1 & 7.4.2, with the impact of the proposed development on flood conditions discussed in section 7.4.4.

7.4.1 Pre-development Flooding Results

The pre-development TUFLOW modelling was undertaken to simulate the 10% AEP, 5% AEP, 1% AEP, 1% AEP with climate change and PMF events. Peak flood depths, levels, velocities, and hazard mapping for these results are presented in Appendix A.

The results of the 1% AEP pre-development conditions flood modelling are discussed below:

- The primary flood mechanism on the site is overland flooding.
- Being at the top of the catchment, the overland flow is generally restricted to sheet flow across rural areas in existing conditions, with flow directed towards defined gullies and eventually Dairy Creek. The deepest areas of flood depth for the 1% AEP event illustrated on the map are the farm dams, where the depth exceeds 1.5m in some areas, and upstream of the Brabham Way culvert, where depths exceed 2m and overtops the road.
- In the 1% AEP storm event, velocities are generally moderate (1 to 2m/s) throughout the majority of the site, with only some minor areas within major overland flow paths reaching up to 2.5m/s.
- Flood hazards based on the definitions in Flood Hazard Guidelines FB03, shown in Figure 26 below, are relatively low (generally H1 to H2) within the site and surrounding roads, with some areas reaching relatively high (generally H3 to H5) in the major overland flow paths and farm dams mainly due to depth of flooding in these areas. However, in its current undeveloped state, it is not expected that these hazardous areas will be trafficked by any people or vehicles, hence there is negligible risk to life or property

There are two major overland flow paths through the site which will need to be managed; the drainage spine along the southern side the Mitchell Highway, and the external catchment flows that travel along the northern side of Brabham Way.

The flood mapping representing the depths, velocities, and hazards experienced in a 1% AEP flood event in pre-development conditions can be seen in the figures below.

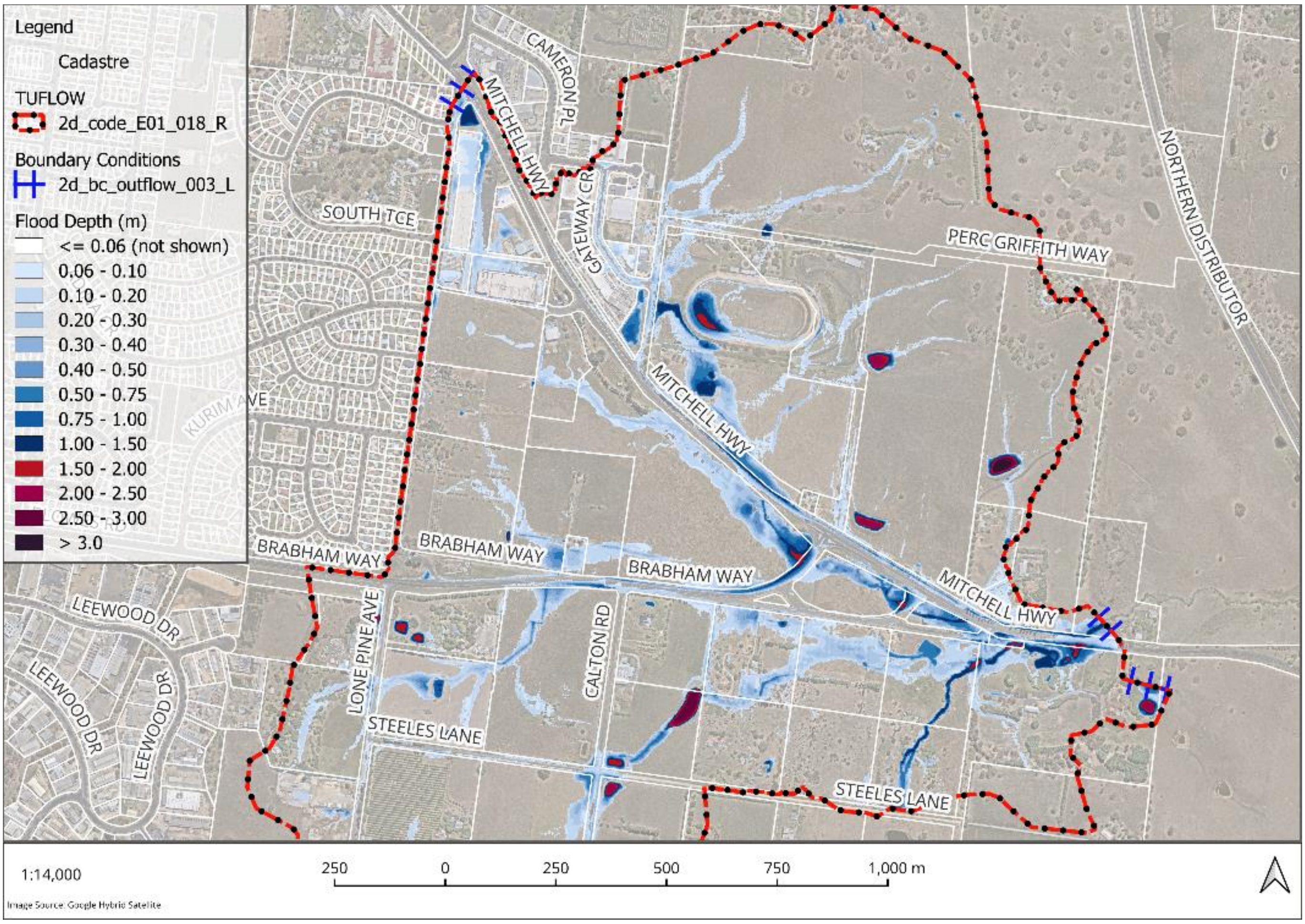

Figure 23 1% AEP Flood Depths – Pre-Development Scenario

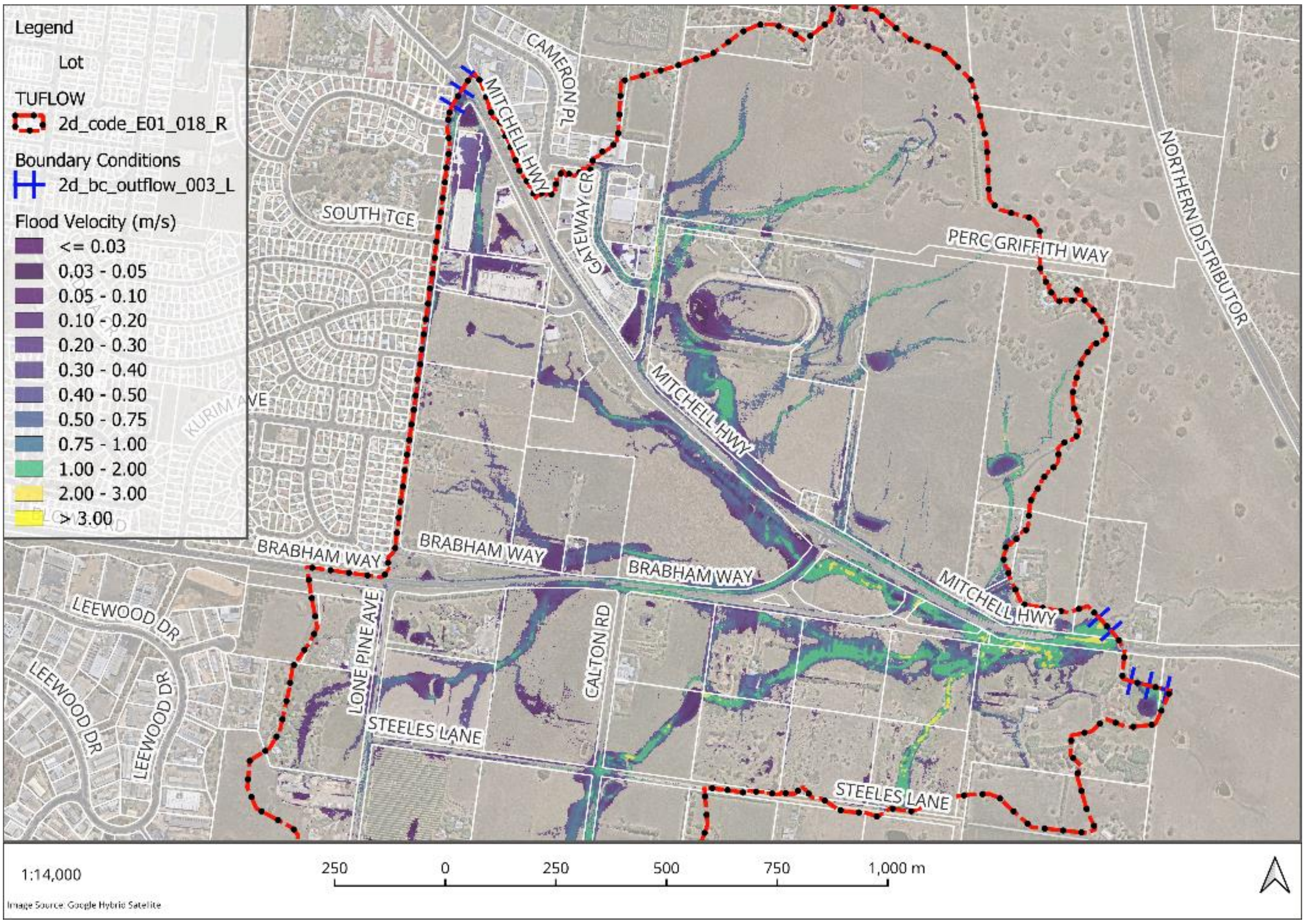

Figure 24 1% AEP Flood Velocities - Pre-development Scenario

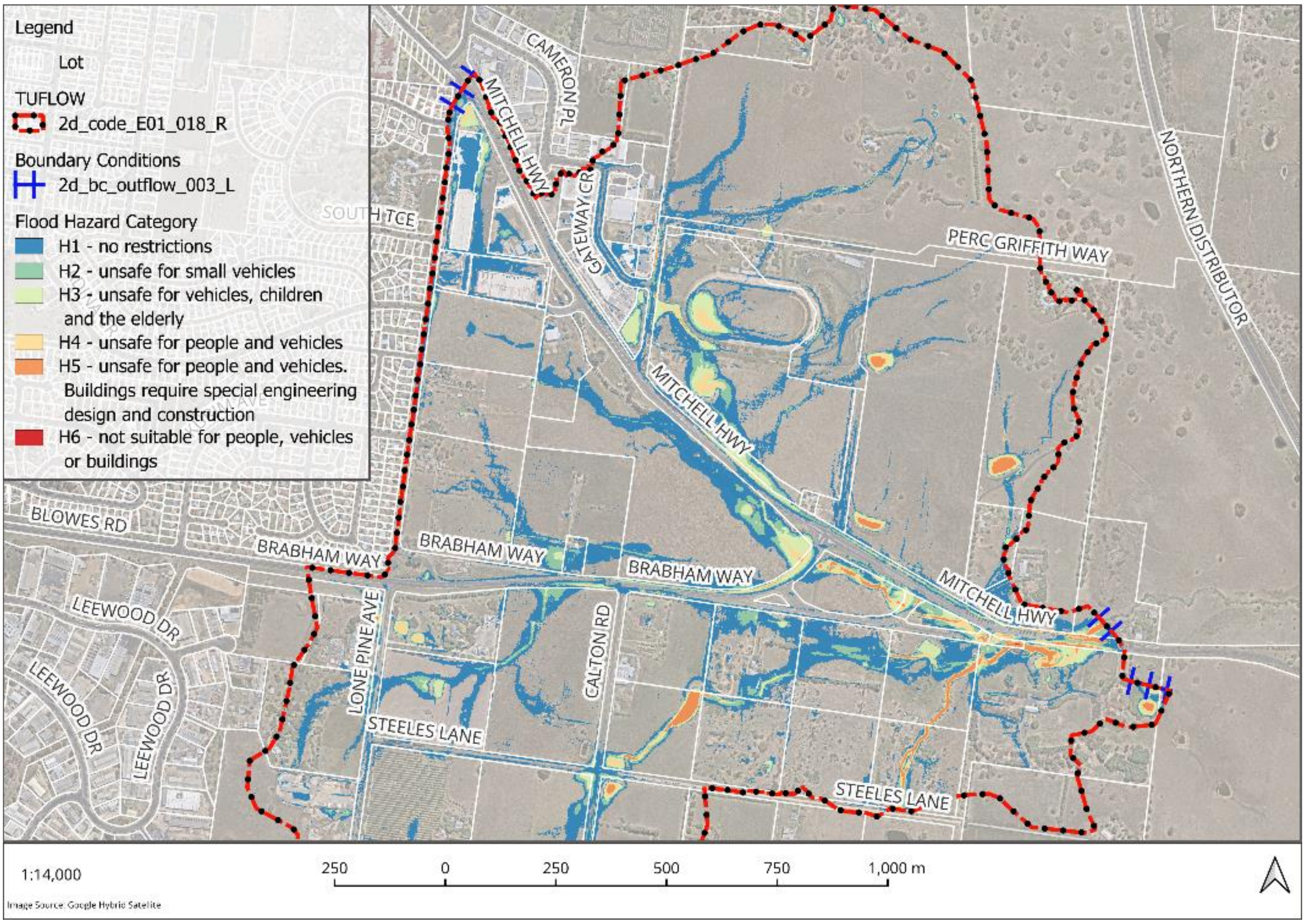

Figure 25 1% AEP Flood Hazards - Pre-development Scenario

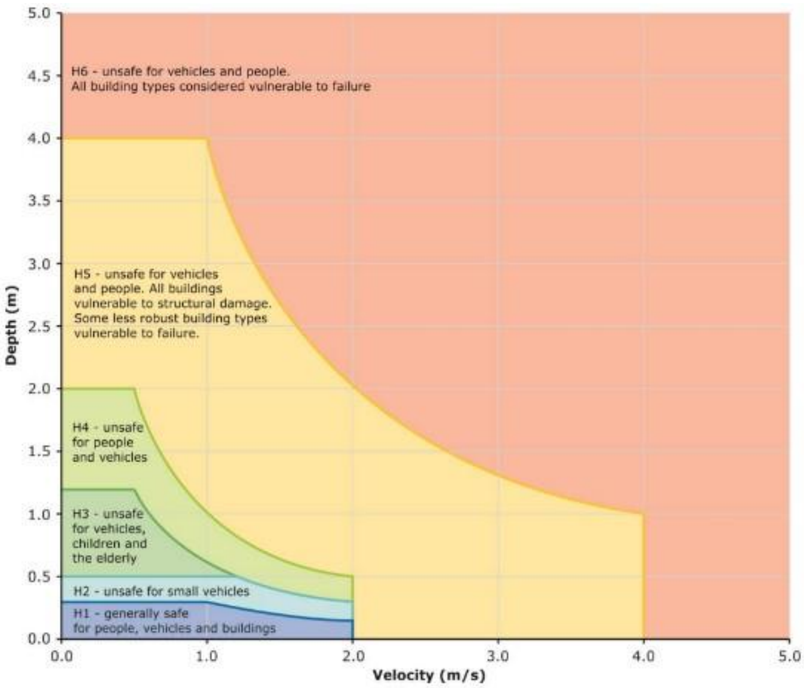

Figure 26 General Flood Hazard Curves (AR&R 2019)

7.4.2 Post-development Flood Results

The post-development TUFLOW modelling was undertaken to simulate the 10% AEP, 5% AEP, 1% AEP, 1% AEP with climate change and PMF events. Peak flood depths, levels, velocities, and hazard mapping for these results are presented in Appendix A.

The results of the 1% AEP post-development conditions flood modelling are discussed below

- In the 1% AEP storm event, the flood depths are generally moderate (60-300mm) around the road overland flow paths and sag locations. Flood depths within the swales around the site reach up to 1.4m with basins/pond flood depths reaching a maximum of approximately 3.7m. Nuisance stormwater flows of up to 60mm were filtered out from the site.
- Flood velocities are generally low (0.1 to 1m/s) within the site in the 1% AEP storm event, with only some areas within the swales reaching up to 1.5m/s
- In the 1% AEP storm event, the flood hazards are generally low (H1 to H2) within trafficable areas on the site. Areas reaching relatively high hazards (H3 to H5) are contained within the swales, basins, and ponds due to depth of flooding. However, it is not expected that these hazardous areas will be trafficked by any people or vehicles, hence there is negligible risk to life or property
- The proposed swales have sufficient freeboard (>300mm to the finished floor levels in the 1% AEP storm event.
- The peak flood level experienced in the detention basin is 889.06mAHD. The adjacent roads provide sufficient freeboard of over 500mm to this level (889.9 to 893.5mAHD)

The flood mapping representing the depths, velocities, and hazards experienced in a 1% AEP flood event in post-development conditions can be seen in the figures below.

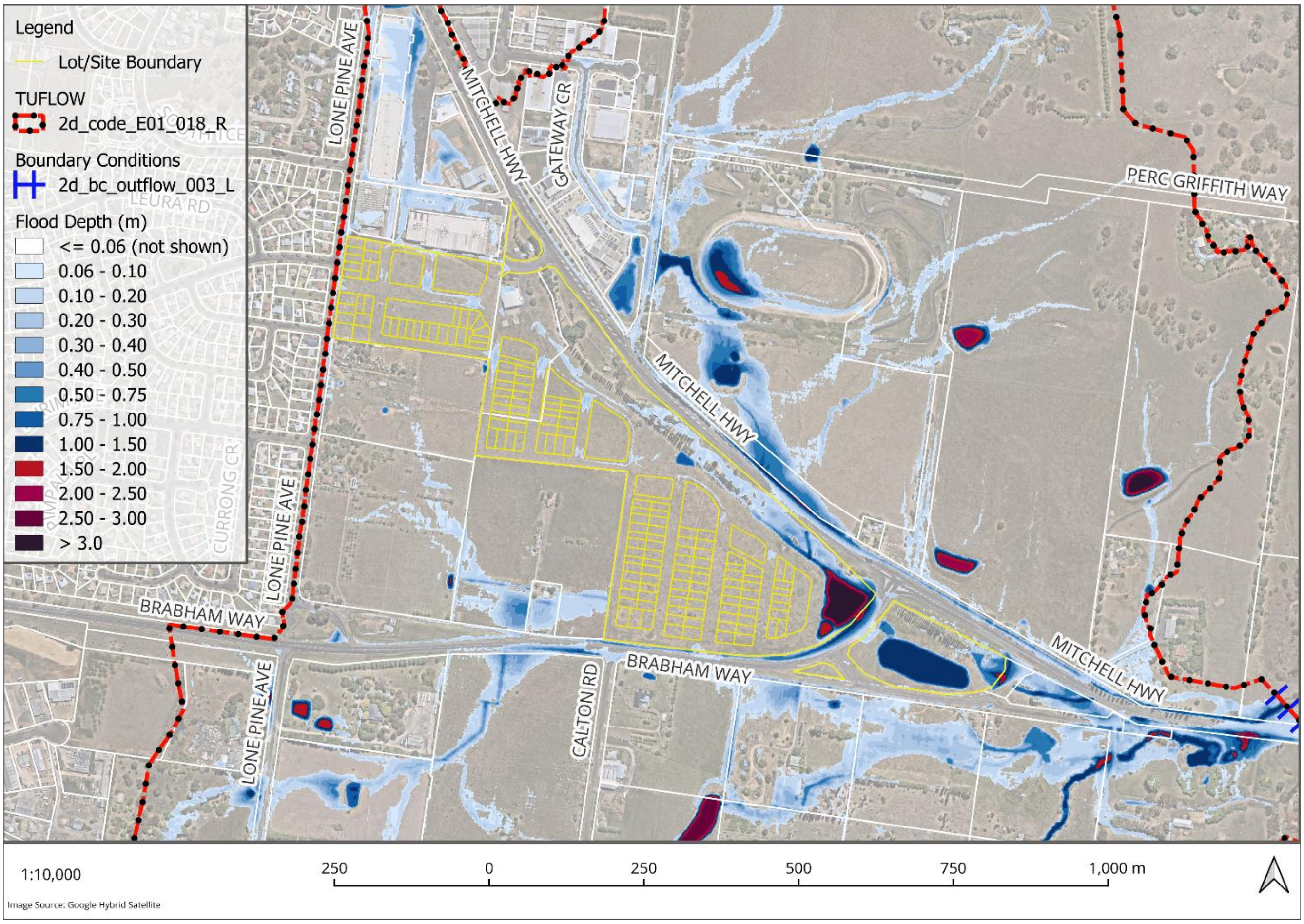

Figure 27 1% AEP Flood Depths – Post-Development Scenario

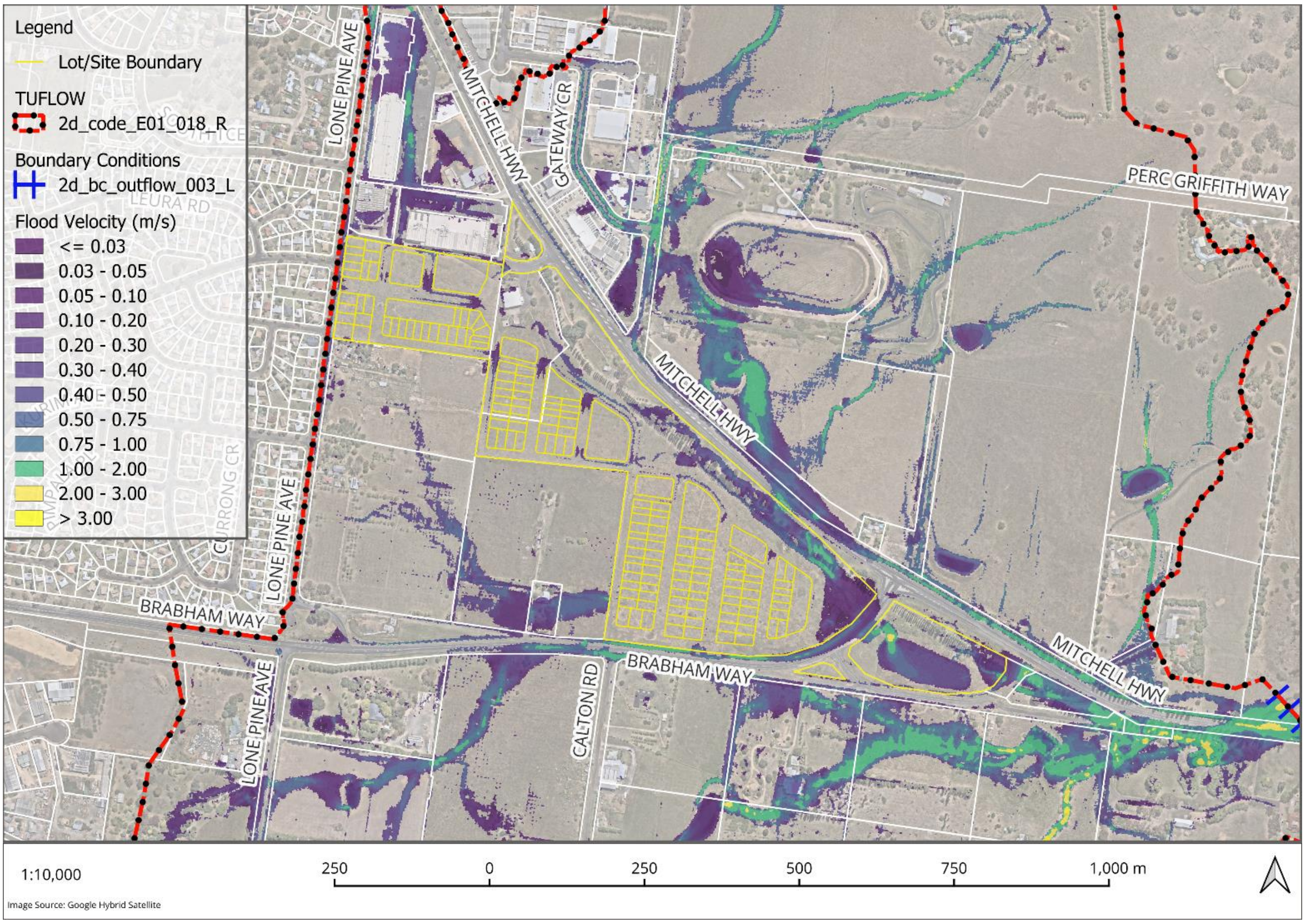

Figure 28 1% AEP Flood Velocities - Post-development Scenario

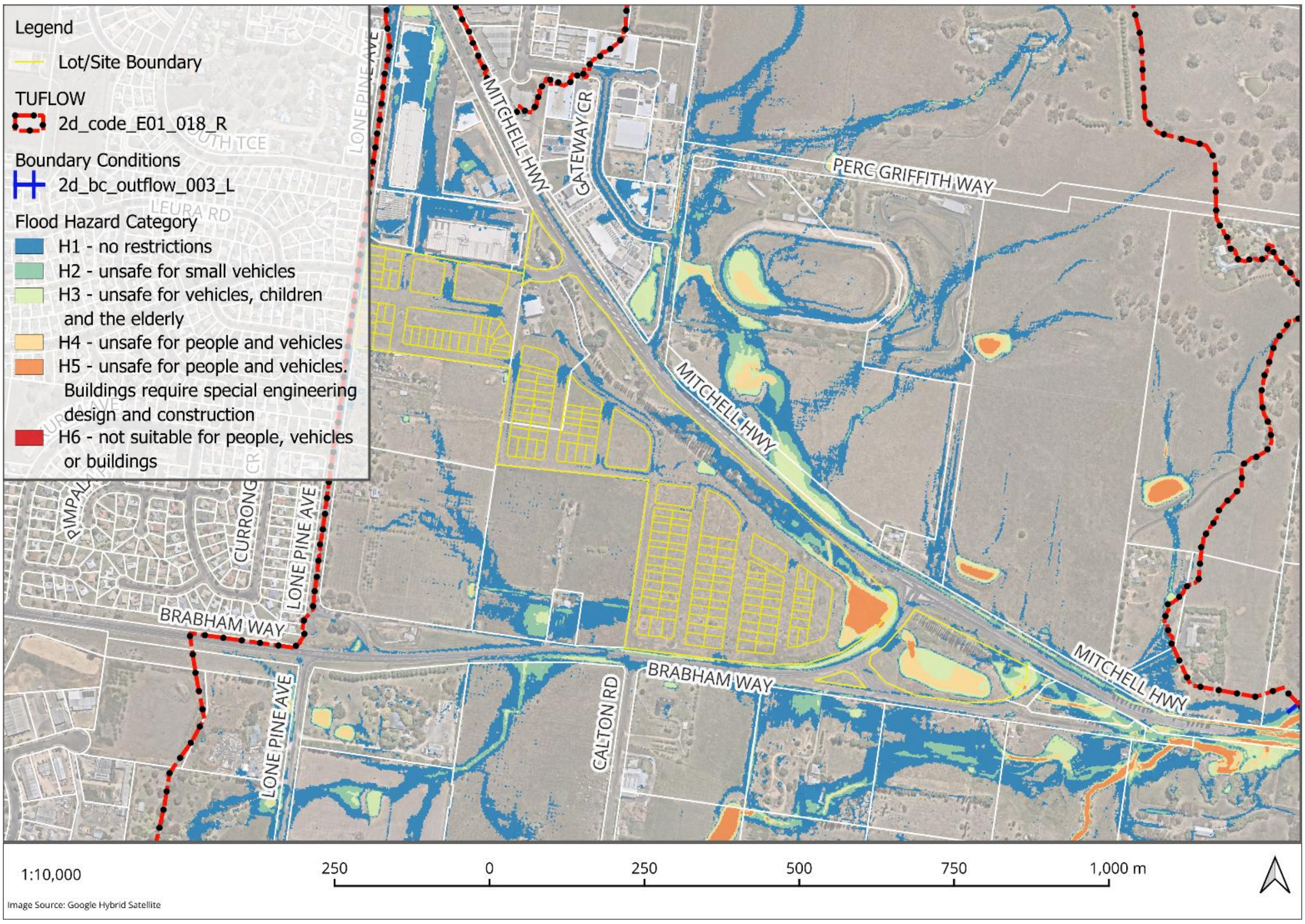

Figure 29 1% AEP Flood Hazards - Post-Development Scenario

7.4.3 Climate Change

A climate change scenario incorporating a 20% increase in rainfall intensity was modelled for the 1% AEP storm event. The resulting rise in water levels within road sags, swales, basins, and ponds does not lead to an unacceptable increase in flood inundation of the proposed development. No new roads are being overtopped by overflow from these features, and no previously unaffected or dry lots have been impacted by climate change flooding scenario. This indicates that freeboard for roads and lots have accounted for rises in water levels due to climate change.

Overland flow paths within the site still have sufficient space on the lot to construct the dwellings that are clear of the 1% AEP with climate change flood extents. Therefore, climate change is not considered to be a risk to the development.

7.4.4 Flood Impact Assessment

Afflux is the difference between water surface elevation levels from the developed case to the existing case. The 1% AEP developed flood impacts identified due to the development of Redleaf are as follows.

- Generally, the increased or reduced flood levels within the site and immediately adjacent of the site boundary, including north and south access roads, are due to changes within the topographic levels caused by filling of the site which elevates the water level on the surface. This does not represent any actual flood impacts and are considered to be acceptable.

- There are minor changes in flood levels adjacent to the site boundary. However, these changes are considered to be modelling artefacts and are not representative of any real adverse flood impacts. Thus, these changes are considered to be acceptable.
- There are no material adverse changes in flood levels downstream of the site, demonstrating the mitigation measures within the development are maintaining flood conditions downstream.

The 1% AEP post-development afflux mapping is illustrated below in Figure 30.

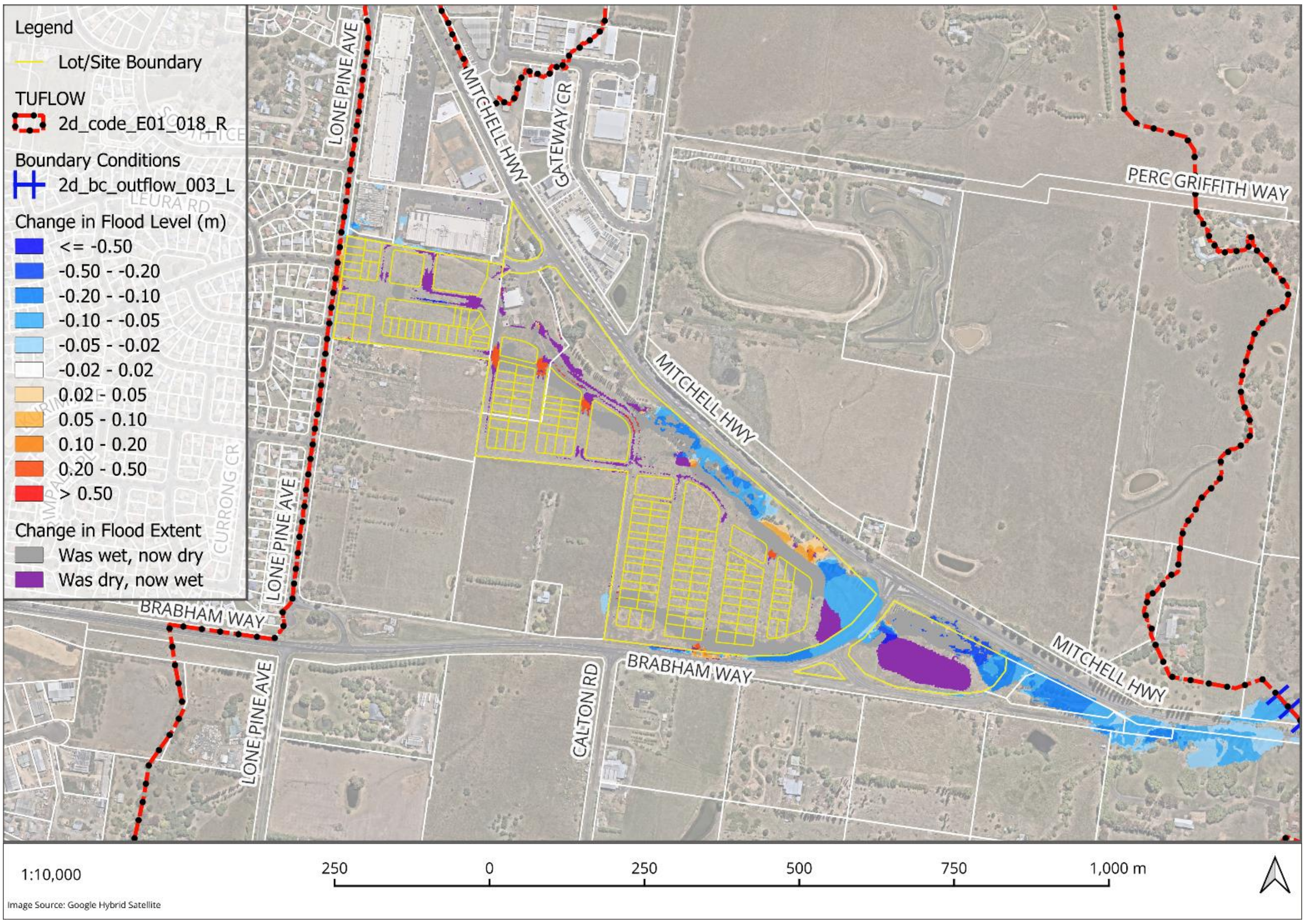

Figure 30 1% AEP Post-Development Afflux Map

Detailed 1% AEP flood modelling for the Redleaf project demonstrates that there are no material adverse offsite impacts due to the development of the site. Changes in flood behaviour within the site are due to the changed terrain which was designed to contain flooding within designated overland flow paths. The flood impacts have been managed through appropriate interventions such as infrastructure upgrades and detention systems. Thus, the proposed development is considered acceptable from a flood impact perspective.

7.5 Flood Emergency Management Response Strategy

Currently, the site topography in conjunction with the proposed earthworks grading locates the site within the overland PMF extent. Driveway and access road along Mitchell Highway and Brabham Way are subject to flash flooding and it is expected that the entry and exit vehicular routes will be inundated within the PMF extent for a short duration of time. Additionally, the internal roads also experience inundation with high hazard flooding. This is evident in the post-development flood results maps presented in Appendix A. As such, it is recommended that evacuation to be undertaken prior to the onset of the storm as it will be difficult to evacuate the from the site during the PMF storm event.

During a PMF storm event, Mitchell Highway and Lone Pine Avenue present relatively low flood hazards (H1 to H2) and could serve as potential evacuation routes, if conditions allow. In contrast, Brabham Way is subject to significantly higher flood hazards (up to H5) and should be avoided for evacuation purposes.

To access these potential evacuation points, half of the internal roads along the western interface boundary exhibit relatively low flood hazards (H1 to H2) on the high side of the road, as a result of its one-way crossfall, and may be used for evacuation. Caution should be undertaken when traversing these routes as flood hazards can reach up to H5 at internal road sag locations.

Evacuation may not always be possible. As such, lots inundated by the PMF storm will need to have habitable buildings with floor levels set above the PMF level. Future residents may then be able to shelter in place until the storm passes, and until emergency services can provide assistance. However, given the nature and sudden onset of flash flooding, and the critical duration of the PMF storm being 15-30min, residents are not expected to shelter in place for extended periods as conditions should improve quickly enough to allow safe passage.

8 Key Findings and Recommendations

The key findings of the stormwater management plan, water balance assessment, flood assessment and proposed recommendations are discussed below:

- The proposed development layout and associated civil design is found to be compatible with the existing floodplain environment and is adequate to support the DA from a stormwater and flooding perspective. The flood impact assessment demonstrates that the site can be developed in accordance with Council's flood planning requirements without causing adverse offsite impacts to water levels and peak discharge downstream of the site.
- The proposed stormwater detention infrastructure located downstream of the site is able to manage the increase in catchment runoff due to the proposed development in the 1% AEP storm event by reducing the post-development peak discharge from each sub-catchment to be less than pre-development peak discharge.
- The water feature pond will maintain its normal water level for a majority of its lifecycle, with some decrease in water level during dryer periods such as droughts.
- The proposed stormwater treatment train including rainwater tanks, gross-pollutant traps, sediment forebays and bioretention basins is capable of meeting the stormwater quality objective of NorBE + 10%.
- It is recommended that residents evacuate prior to the onset of the storm. The entry and exit vehicular routes will be inundated by flash flooding in the PMF storm event. Lone Pine Ave and Mitchell Hwy via half of the western interface roads may potentially be used as evacuation route. If residents are unable to evacuate in time, occupants of the site will need to either shelter-in-place within their properties for a short period of time until flood levels are safe to evacuate.

9 Conclusion

This water cycle management report for the development application for the Redleaf site has been undertaken in accordance with the requirements outlined in Council's LEP and DCP policies.

Based on the results of the study, it is concluded that the management measures proposed for the site, including its network of stormwater quantity and quality features, are effective in ensuring there would be no adverse impacts in the overall Dairy Creek catchment as a result of the proposed development.

Overall, the proposed development layout plan and civil design is deemed sufficient to support the development application from a stormwater and flooding perspective.

APPENDIX A

A.1. Flood Maps

Map Number	Map Title
1	10% AEP Existing Water Level
2	10% AEP Existing Depth
3	10% AEP Existing Velocity
4	10% AEP Existing Hazard
5	10% AEP Developed Water Level
6	10% AEP Developed Depth
7	10% AEP Developed Velocity
8	10% AEP Developed Hazard
9	5% AEP Existing Water Level
10	5% AEP Existing Depth
11	5% AEP Existing Velocity
12	5% AEP Existing Hazard
13	5% AEP Developed Water Level
14	5% AEP Developed Depth
15	5% AEP Developed Velocity
16	5% AEP Developed Hazard
17	1% AEP Existing Water Level
18	1% AEP Existing Depth
19	1% AEP Existing Velocity
20	1% AEP Existing Hazard

Map Number	Map Title
21	1% AEP Developed Water Level
22	1% AEP Developed Depth
23	1% AEP Developed Velocity
24	1% AEP Developed Hazard
25	1% AEP CC20 Existing Water Level
26	1% AEP CC20 Existing Depth
27	1% AEP CC20 Existing Velocity
28	1% AEP CC20 Existing Hazard
29	1% AEP CC20 Developed Water Level
30	1% AEP CC20 Developed Depth
31	1% AEP CC20 Developed Velocity
32	1% AEP CC20 Developed Hazard
33	PMF Existing Water Level
34	PMF Existing Depth
35	PMF Existing Velocity
36	PMF Existing Hazard
37	PMF Developed Water Level
38	PMF Developed Depth
39	PMF Developed Velocity
40	PMF Developed Hazard
41	1% AEP Developed Flood Afflux