WATER CYCLE MANAGEMENT PLAN

515 Crookwell Rd, Kingsdale

Site: Lot 103 & 104 DP 1007433

Project: 24 large lot Residential Subdivision

DA: TBA

LGA: Goulburn Mulwaree Council

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REFERENCEES:

- Goulburn Mulwaree Council – Development Control Plan 2009
- Goulburn Mulwaree Council – Design Specification 2013
- Australian Rainfall & Runoff – A Guide to Flood Estimation – 2019
- Landcom Managing Urban Stormwater Soil and Construction Volume 1 (4th Edition 2004) known as the "blue book".
- WaterNSW - NorBE Assessment Guidelines 2015
- WaterNSW - NorBE User Guide for Consultants 2015
- WaterNSW - Using MUSIC in Sydney's Drinking Water Catchments 2023
- WaterNSW - Development in the Sydney Drinking Water Catchment – Water Quality Information Requirements June 2018
- Civil Engineering Concept Design & Flood Impact Sheet Set, Red 23017 Revision P0 by CivPlan Pty Ltd dated 13th June 2024
- Goulburn Mulwaree Overland Flow Flood Study

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Nil

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1. Introduction

1.1 Purpose and Scope

The purpose of this Water Cycle Management Plan (WCMP) is to provide support for a planning proposal for the proposed 24 large lot residential subdivision at Lot 103 & 104 DP 1007433 at 515 Crookwell Rd, Kingsdale, NSW.

The scope of this WCMP includes assessment of the water cycle management requirements to support the proposed development and frame the implementation of Water Sensitive Urban Design (WSUD) best practise measures to the proposed development. This will include treatment measures implemented to address overland flow, water quality and quantity requirements calculated from various modelling analysis. The report will include the findings of the analysis and propose best practice strategies.

Furthermore, as the site is located inside of the WaterNSW Catchment Area, this assessment has been prepared in accordance with the standards and guidelines listed in the references on page 2 of this report. Stormwater quality analysis will be undertaken in accordance with WaterNSW guidelines to achieve a NorBE water quality outcome using the Model for Urban Stormwater Improvement Conceptualisation (MUSIC) software.

2. Project Overview & Hydrology

2.1 Site Description

The site is located Lot 103 & 104 DP 1007433 at 515 Crookwell Rd, Kingsdale, NSW and is within the Goulburn Mulwaree Council LGA and the WaterNSW catchment area. Access to the site is via an unpaved driveway from Crookwell Road which is aligned north to south along the site's eastern boundary. It's a rural residential area is mostly composed of farms and rural properties. The unpaved driveway from Crookwell Road leads to a dwelling and associated sheds in the centre along the eastern boundary of lot 103 DP 1007433.

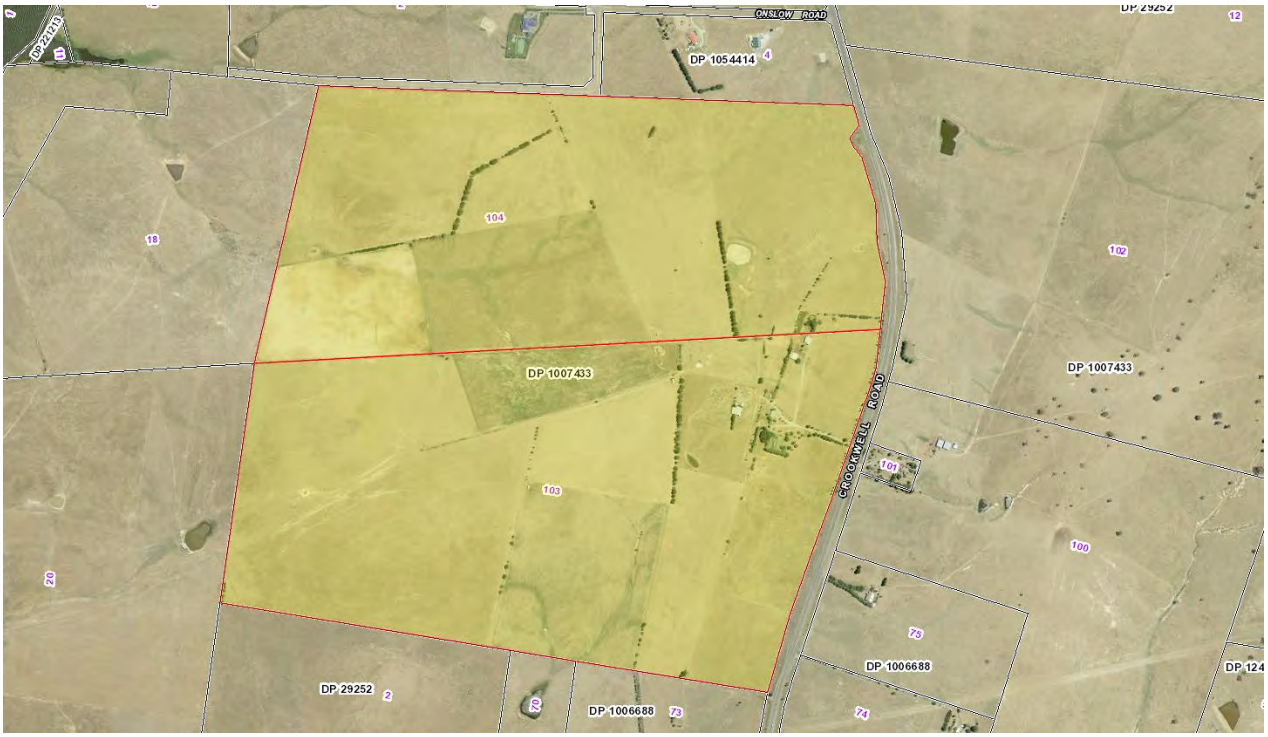

Figure 1: Site Location - NSW Imagery (SIX Maps)

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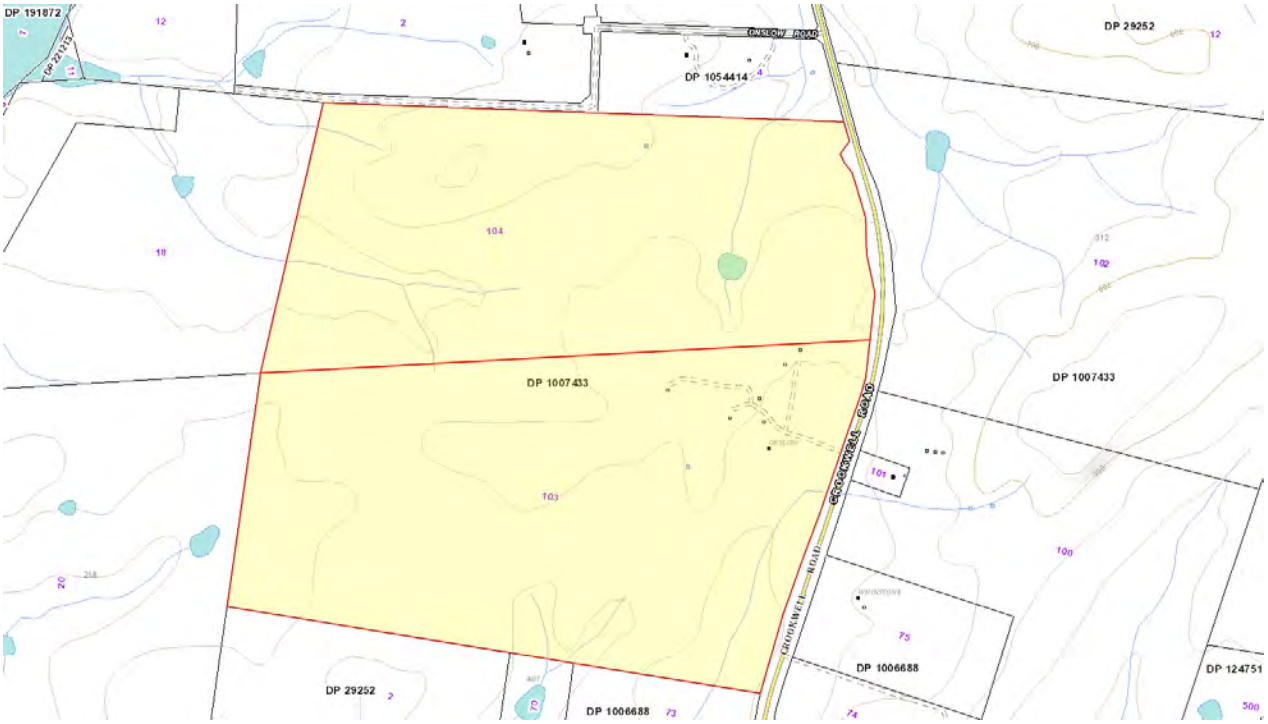

Figure 2: Site Location - NSW Topo (SIX Maps)

The total area of the site is approximately 195.71ha with lot 103 DP 1007433 making up approximately 90.97ha of the area and lot 104 at approximately 104.74ha. The developable land area of the site only (Figure 3) is being assessed for this report, which is 55.47ha. This area is being considered due to the catchment bypassing nearby Sooley Dam to the west and flowing directly towards the Wollondilly River, downstream of the dam. The area is generally undulating and dips at approximately 6-7% falling from the northern extent at approximately RL 685 to RL 670 approximately 760m to the south.

Currently there is a driveway that leads to the main dwelling and extensions of the driveway that lead to multiple large rural storage sheds and silos west and north of the dwelling. Further north, a gravel road leads to rural sheds and fenced stock yards. The remainder of the property is divided and fenced paddocks for different purposes, including sheep grazing and cropping. A paddock to the south of the dwelling contains a bore (ID: GW050231).

There are four mapped watercourses within the site, running to the south and north of the site. The watercourses to the north flows into nearby Sooley Dam and is considered undevelopable. The dam within the developable area is proposed to be retained as part of the subdivision works and all riparian buffers have been implemented as shown in Figure 3.

2.2 Proposed Development

The subject land is currently the subject of a proposed ongoing planning proposal. The current site is proposed to be subdivided into 24 large residential lots of minimum 2ha as shown in Figure 3.

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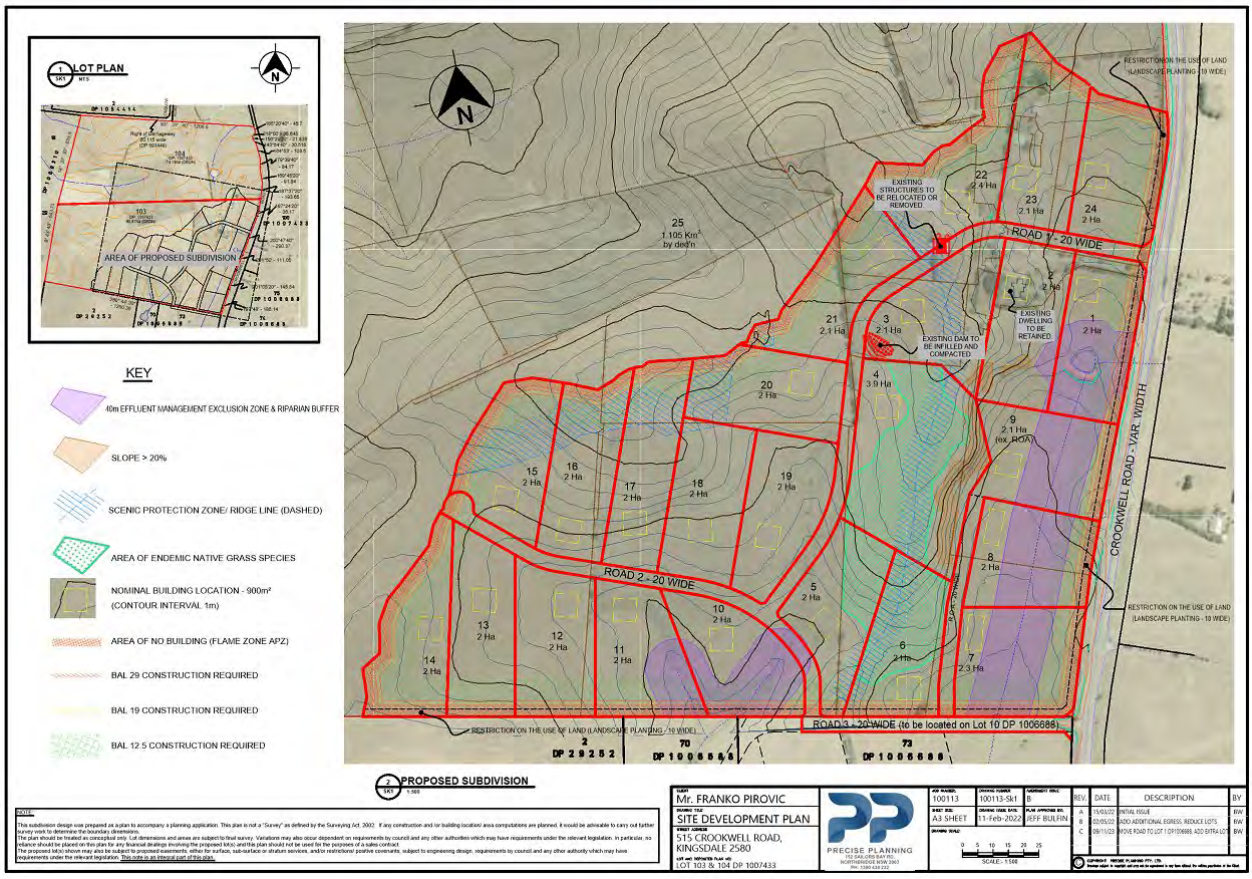

Figure 3: Proposed Development

2.3 Rainfall Data, Catchments & Hydrology

Rainfall on the site area considered to be developed will naturally flow towards the south of the site, and the associated pit and pipe network goes into the natural watercourse.

The rainfall data used to undertake the required modelling, analysis and design has been drawn from the ARR Data Hub and BoM using Australian Rainfall and Runoff 2019 (ARR19). The data drawn from the nearest point to the subject site was a Latitude 34.5625 South and Longitude 150.3625 East.

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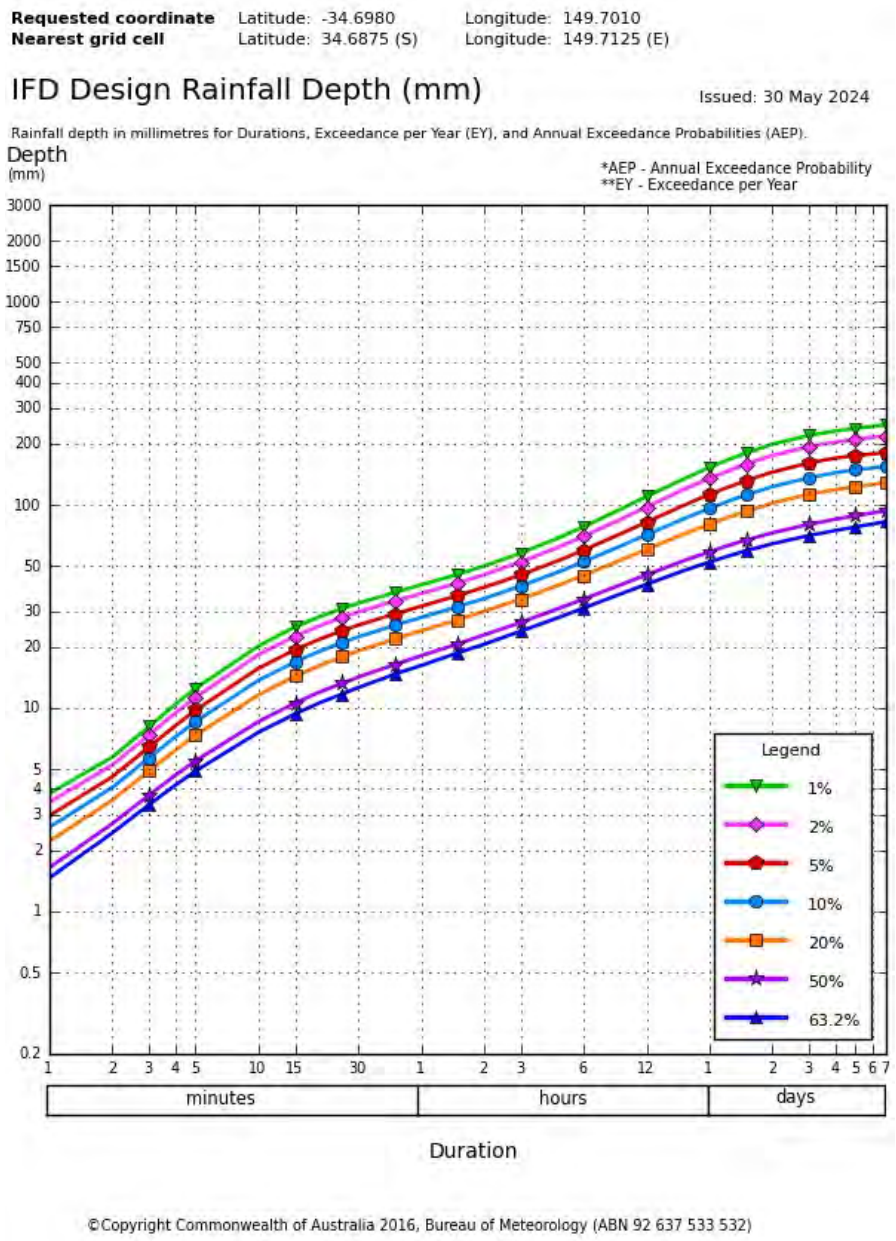

Figure 4: IFD Design Rainfall Intensity Data: Latitude 34.698 South and Longitude 149.701 East

The pre and post development catchment areas within the site, including impervious portions, are shown in Figure 5.

515 Crookwell Rd, Kingsdale, NSW				
Pre Development				
Site	55.47	ha	1%	Impervious
Post Development				
Site-Roads	4.31	ha	60%	Impervious
Site-Lots	51.16	ha	2.7%	Impervious
	55.47	**ha**		

Figure 5: Subject Site Catchments Pre & Post Development

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The current land is mainly farming/ rural residential and based on the observed overland flow surface condition from the inspection of the site, an average Manning's Roughness Coefficient of n=0.03 was applied for the pre and post development scenario. There are significant upstream catchments to consider for this development.

Surface Type	Suggested n Values
Concrete Pipes or Box Sections	0.012
Concrete (trowel finish)	0.012 - 0.015
Concrete (formed, without finishing)	0.013 - 0.018
Concrete (gunite)	0.016 - 0.020
Bricks	0.014 - 0.016
Pitchers or Dressed Stone in Mortar	0.015 - 0.017
Random Stones in Mortar or Rubble Masonry	0.020 - 0.035
Rock Lining or Rip-Rap	0.025 - 0.030
Earth (clear)	0.018 - 0.025
Earth (with weeds or gravel)	0.025 - 0.035
Rock Cut	0.035 - 0.040
Short Grass	0.030 - 0.035
Long Grass	0.035 - 0.050

Channels

Flow across Parks	0.35
Flow across Rural Residential land	0.30
Flow across Residential (2a)	0.21
Flow across Residential (2b)	0.11
Flow across Industrial	0.06
Flow across Commercial	0.04
Flow across Paved Areas	0.01
Flow across Asphalt Roads	0.02
Flow across Gravel Areas	0.02

Overland Flow Retardance

Land Use Type	Manning 'n'
Residential areas – high density	0.2 – 0.5
Residential areas – low density	0.1 – 0.2
Industrial/commercial	0.2 – 0.5
Open pervious areas, minimal vegetation (grassed)	0.03 – 0.05
Open pervious areas, moderate vegetation (shrubs)	0.05 – 0.07
Open pervious areas, thick vegetation (trees)	0.07 – 0.12

Land Use Type	Manning 'n'
Waterways/channels – minimal vegetation	0.02 - 0.04
Waterways/channels – vegetated	0.04 – 0.1
Concrete lined channels	0.015 – 0.02
Paved roads/car park/driveways	0.02 – 0.03
Lakes (no emergent vegetation)	0.015 – 0.35
Wetlands (emergent vegetation)	0.05 – 0.08
Estuaries/Oceans	0.02 – 0.04

Figure 6: Manning's 'n' Roughness Co-efficient (see ARR19 Book 6 Section 6.2.1 & 6.2.2)

The pre and post development conditions have been modelled using a RAFTs hydrological modelling for PSD/SSR purposes rather than ILSAX due to the size of the catchments, noting that some are more than 2ha. ILSAX or IL-CL hydrological modelling will be utilised for the drainage network which includes the grassed swales, to be refined as part of the detailed design. Impervious areas are contained to the existing gravel roads/driveways and dwelling/shed roofs.

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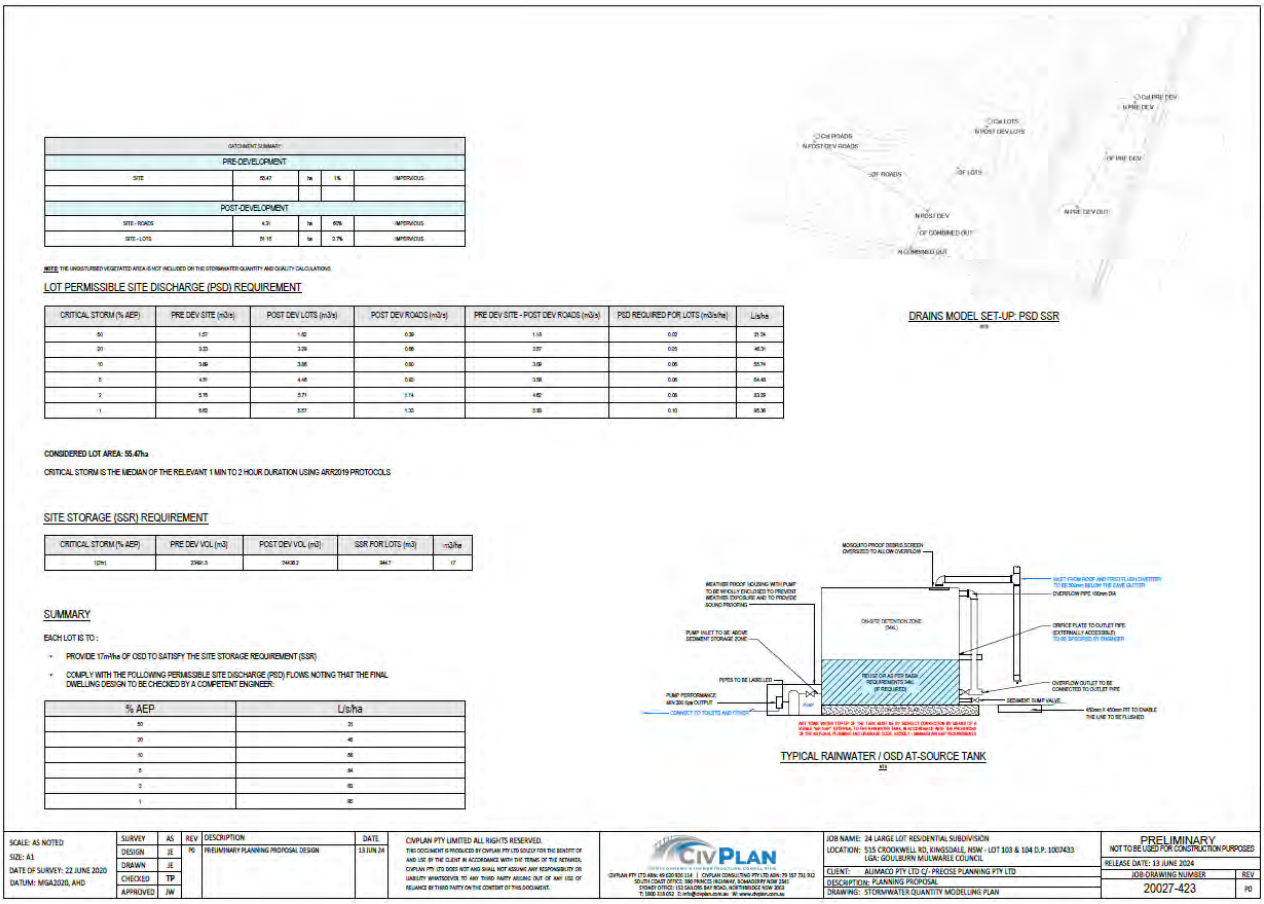

Figure 7: Pre/Post Development PSD/SSR – Water Quantity

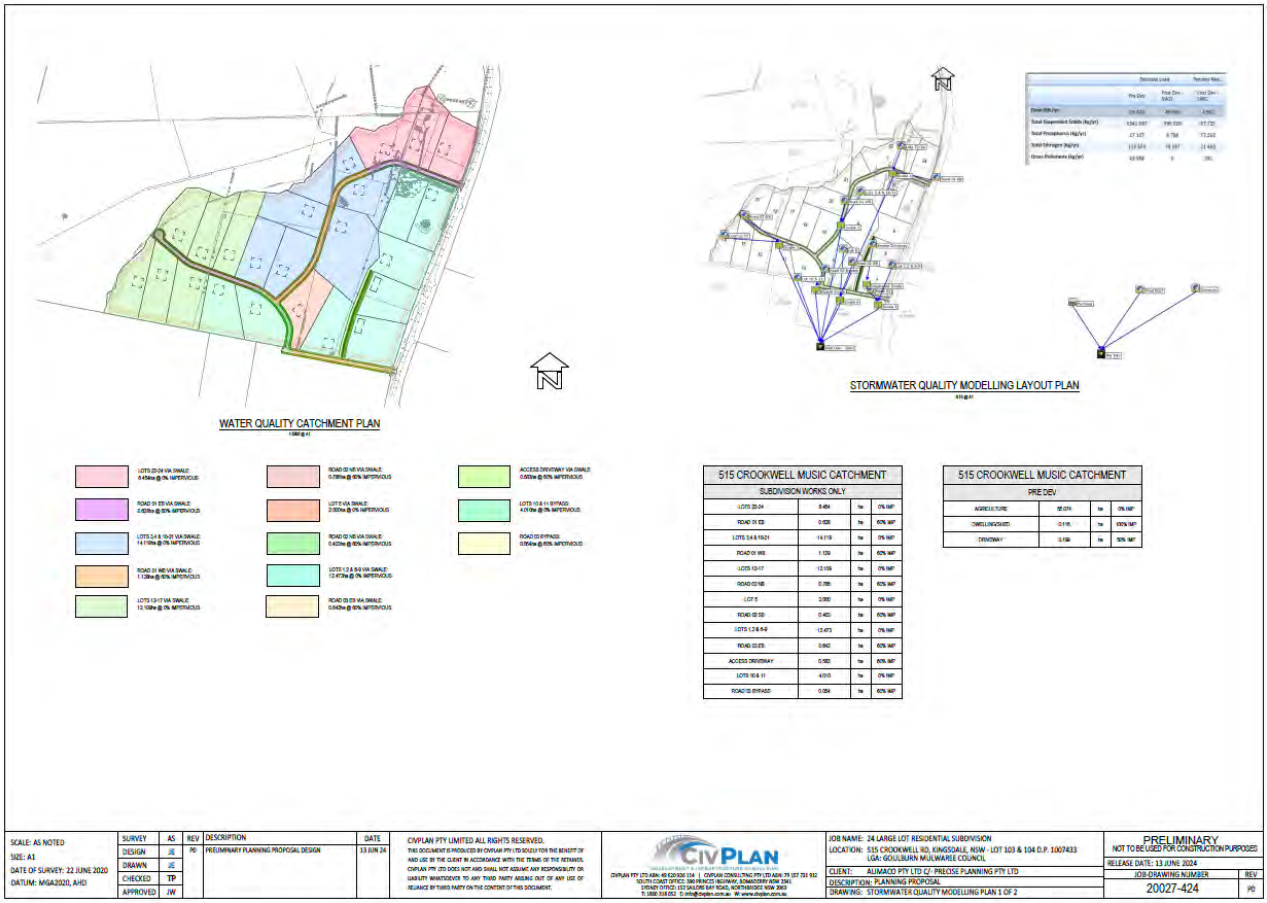

Figure 8*: Pre/Post Development (Subdivision Works Only) Catchment Plan – Water Quality*

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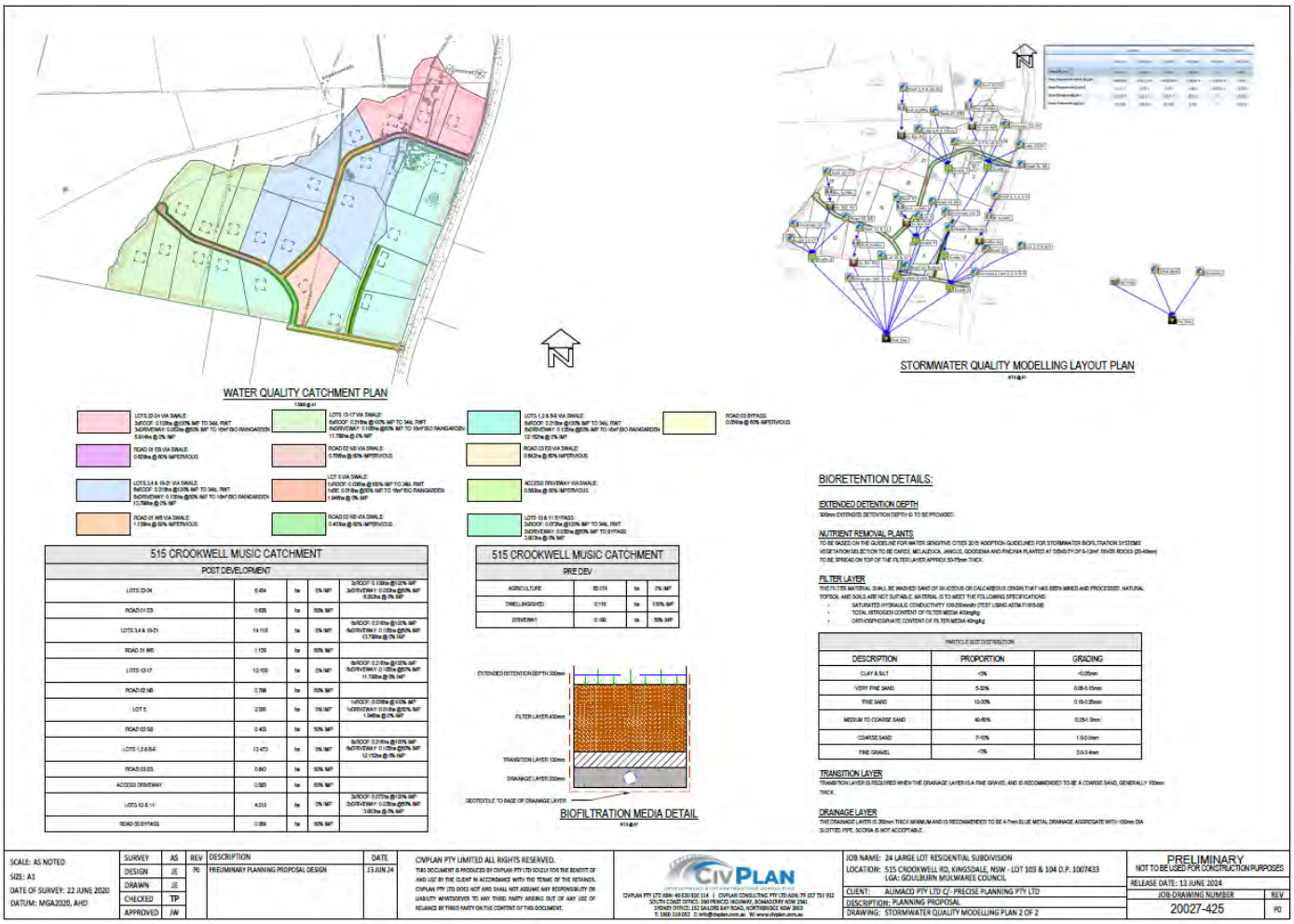

Figure 9: Pre/Post Development Catchment Plan – Water Quality

3. Stormwater Quantity Analysis

3.1 DRAINS Modelling

A model was set up using DRAINS with RAFTs modelling to analyse the pre and post development flows of the site and the on-site detention (OSD) requirements like: Permissible Site Discharge (PSD) and Site Storage Requirements (SSR) calculations for attenuation. The model simulated the 1%, 2%, 5%, 10%, 20% and 50% Annual Exceedance Probability (AEP) storm events with duration up to and including 2 hours, also noting that the 4EY and 1EY events were analysed to assist with water quality modelling and implementation of the WSUD strategy. A conceptual model (figures 10) was set up for both the pre and post development conditions to analyse OSD requirements (PSD/SSR) for the proposed development.

Below are the following parameters for Kingsdale and the subject site:

RAFTS:

- Impervious Area Initial Loss (mm): 1mm
- Impervious Area Continuing Loss (mm/h): 0mm
- Pervious Area Initial Loss (mm): 9.6mm
- Pervious Area Continuing Loss (mm): 2.7
- BX:1

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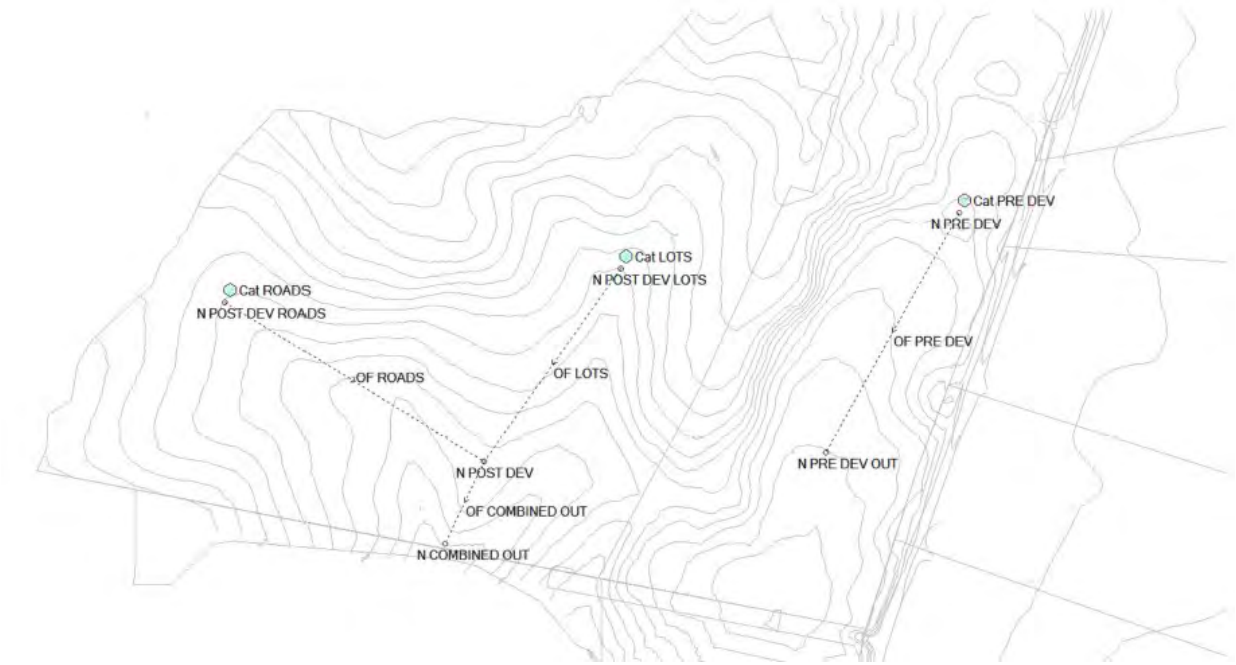

Figure 10: DRAINS Pre-Development and Post Development Model Set-Up for OSD Analysis

Due to the development type being a large lot residential land use, at source OSD can be adopted, rather than a dedicated OSD basin. To achieve this, each dwelling will need to have a dedicated OSD rainwater tank (RWT) connected to 100% of the roof gutter, with a suitably sized and positioned orifice plate to control the stormwater outflow. The exact size, level and details need to be confirmed by a competent civil engineering once each dwelling design is finalised.

The permissible site discharge (PSD) requirements were determined and are shown in Figure 11.

CRITICAL STORM	PRE DEV SITE	POST DEV LOTS	POST DEV ROAD	PRE DEV SITE - POST DEV ROAD	PSD REQUIREMENT FOR LOTS	
% AEP	m3/s	m3/s	m3/s	m3/s	m3/s/ha	L/s/ha
50	1.57	1.62	0.39	1.18	0.02	21.24
20	3.23	3.29	0.66	2.57	0.05	46.31
10	3.89	3.86	0.80	3.09	0.06	55.74
5	4.51	4.46	0.93	3.58	0.06	64.48
2	5.76	5.71	1.14	4.62	0.08	83.29
1	6.62	6.57	1.33	5.29	0.10	95.36

Figure 11: DRAINS Modelling Results – Permissible Site Discharge (PSD)

Then, in order to calculate the Site Storage Requirement (SSR), the critical storm event, which in this case is the 1% AEP for a 2-hour duration was analysed and the volume difference between pre and post development conditions compared. The results can be seen in figure 12.

CRITICAL STORM	PRE DEV VOL	POST DEV VOL	SSR FOR LOTS	
% AEP	m3	m3	m3	m3/ha
1_{2hr}	23491.5	24436.20	944.7	17

Figure 12: DRAINS Modelling Results – Site Storage Requirement (SSR)

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In summary,

- Each lot is to provide 17m3/ha of OSD to satisfy the Site Storage Requirements (SSR).
- Each lot is to have 34000L of capacity with a 65mm orifice plate, based on rainwater tank surface area of 70m^2.
- Each lot structure gutter entire must be plumbed to the inlet of the rainwater tank.
- Each lot is to Comply with the following Permissible Site Discharge (PSD) flows (final dwelling design to be check by a competent engineer):

% AEP	L/s/ha
50	21
20	46
10	56
5	64
2	83
1	95

3.2 Flood Impact

The Council have undertaken a flood study of the subject site and the site is subject to the impact of flooding. The current site flood study mapping is shown in figure 13. 1% flood planning levels to be confirmed in Flood Impact and Risk Assessment.

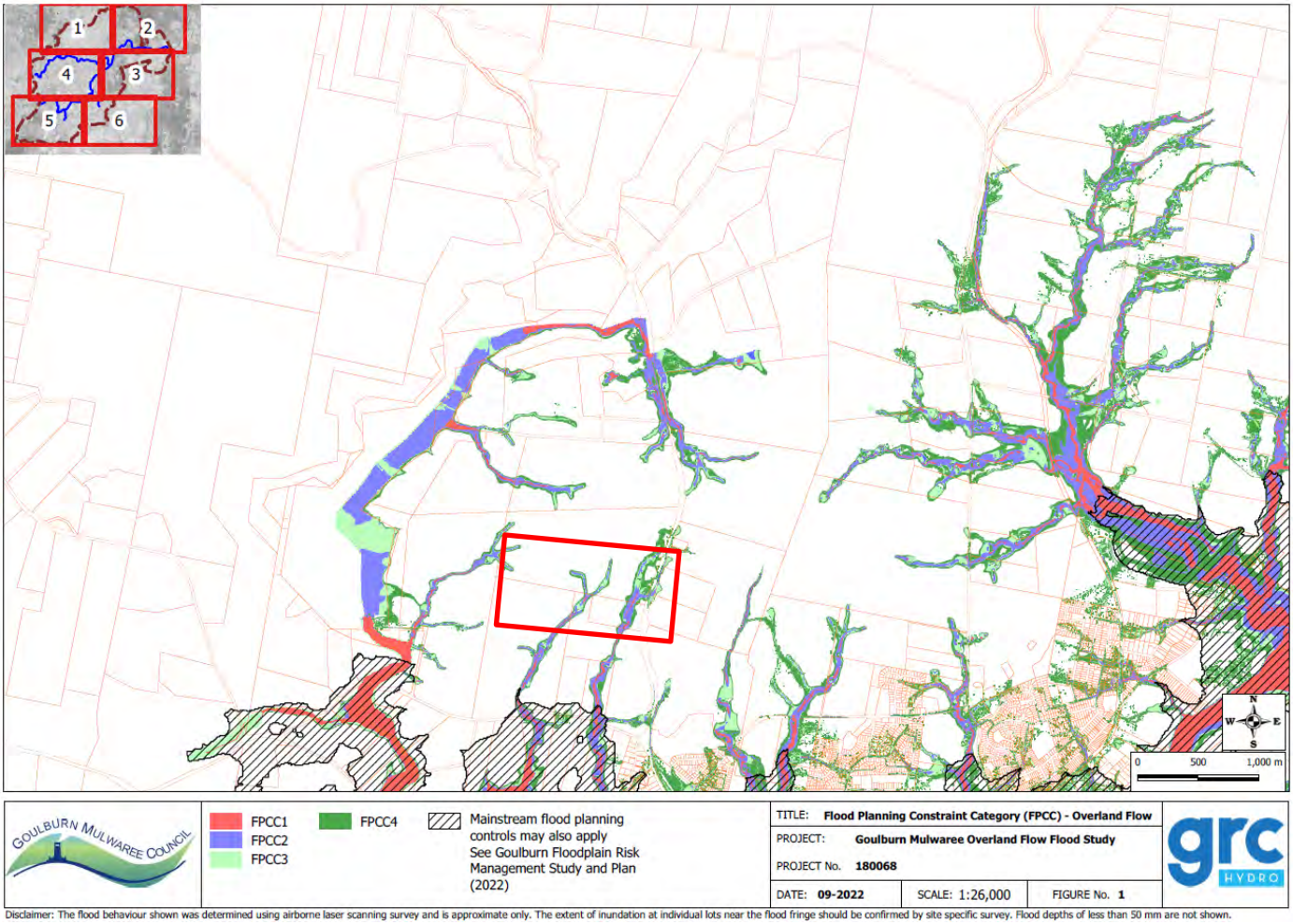

Figure 13: Flood Depths – (Floodplain Study)

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3.3 Interface and Tie in with Adjacent Properties

The attenuated stormwater outlet arrangement from the overall site will be via roadside swales which will outlet via surface runoff into the existing watercourses which run through the site.

4. Stormwater Quality Management

4.1 Objectives

The site is located within the Goulburn Mulwaree Council and the WaterNSW Catchment Area, and this assessment has been prepared in accordance with the standards and guidelines listed in the references on page 2 of this report.

Water quality modelling and analysis will be undertaken in accordance with WaterNSW guidelines to achieve a neutral or beneficial (NorBE) water quality outcome using MUSIC modelling software. The criteria to achieve NorBE are:

- Post-development **mean annual pollutant loads** for total phosphorus (TP), total nitrogen (TN) and total suspended solids (TSS) are to be a minimum of 10% less than the pre-developed conditions.
- Post-development **mean annual gross pollutant loads** are to be equal to or less than the pre-developed conditions.
- Post-development **pollutant concentrations** for total phosphorus (TP) and total nitrogen (TN) must be equal to or less than the pre-development concentrations between the 50th and 98th percentiles where runoff occurs.

4.2 Water Quality Modelling – MUSIC

The water quality modelling and analysis will be undertaken utilising Model for Urban Stormwater Improvement Conceptualisation (MUSIC) software using the WaterNSW guideline *"Using MUSIC in Sydney's Drinking Water Catchment"* and specific treatment node data provided by WaterNSW, specifically Zone 1. Figures 14, 15 and 16 show the climate zones, rainfall and evapotranspiration data source used on the model.

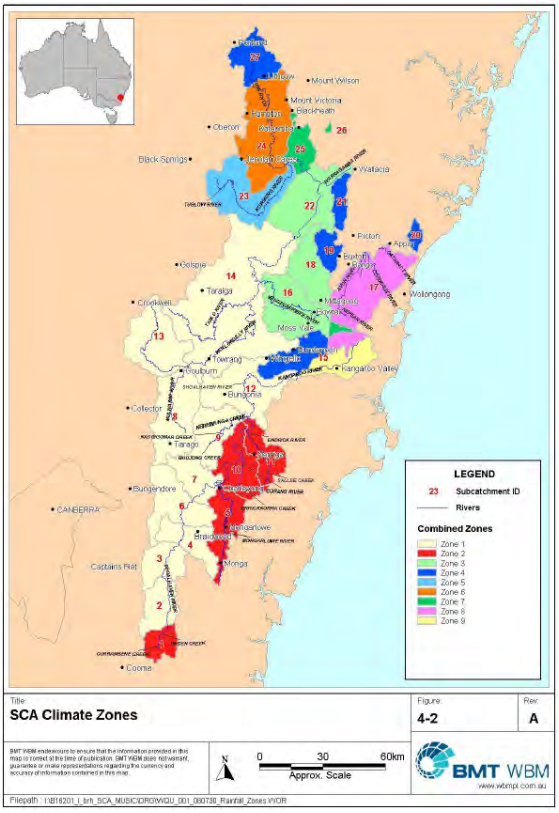

Figure 14: Climate Zones – Zone 1

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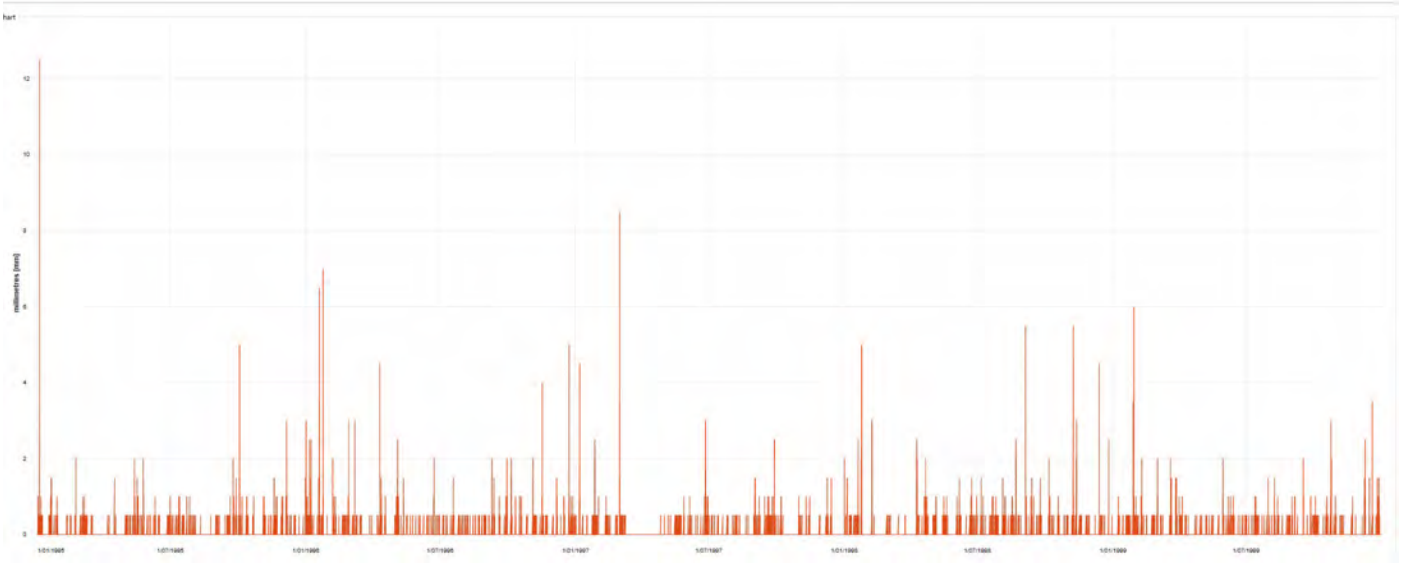

Figure 15: Rainfall Meteorological Data Statistics (Zone 1)

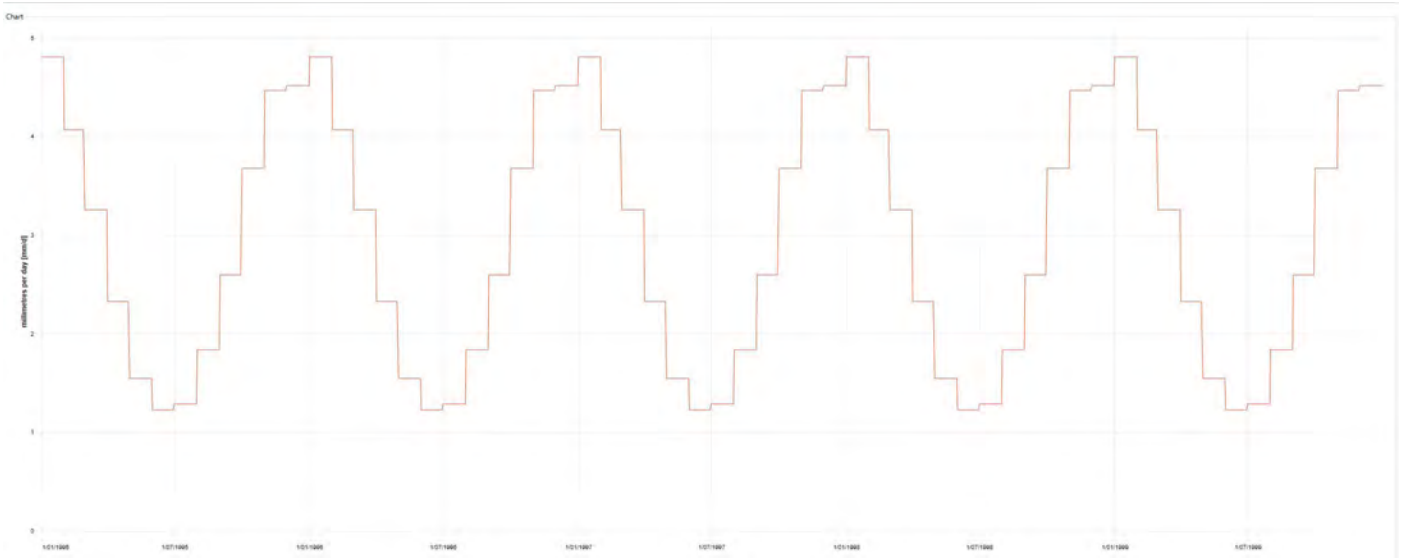

Figure 16: Evapotranspiration Meteorological Data Statistics (Zone 1)

The details below show the pre and post development land use, catchment sizing, effective impervious areas, assumptions, and applications for the matter of water quality treatment. Note that Post-Development (Subdivision Works Only) – refer to figure 17 - only refers to the works to be carried out during the subdivision process, before the construction of the dwellings, as required by WaterNSW according to the most recent guidelines *"Using MUSIC in Sydney's Drinking Water Catchment (February 2023)"*. In this case, only the access driveway composes the impervious area of the Post-Development (Subdivision Works Only), as all the existing structures will be demolished as part of the proposed subdivision. And Post-Development (Dwellings) – refer to figure 18 – is the final development, considering an imperviousness of 2.7% for each lot.

515 Crookwell Rd, Kingsdale			
Pre Devlopment CATCHMENTS			
CATCHMENT 01			
Name	Description	Area (ha)	% Impervious
Farming	Agriculture	55.074	0%

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CATCHMENT 02			
Name	Description	Area (ha)	% Impervious
Dwelling/Shed	Roof	0.116	100%
CATCHMENT 03			
Name	Description	Area (ha)	% Impervious
Driveway	Unsealed Road	0.199	50%

515 Crookwell Rd, Kingsdale			
POST-DEVELOPMENT (SUBDIVISION WORKS ONLY) CATCHMENTS			
CATCHMENT 01			
Name	Description	Area (ha)	% Impervious
Lots 22-23	Via Swale	6.454	0%
CATCHMENT 02			
Name	Description	Area (ha)	% Impervious
Road 01 EB	Via Swale	0.628	60%
CATCHMENT 03			
Name	Description	Area (ha)	% Impervious
Lot 3,4 & 18-21	Via Swale	14.119	0%
CATCHMENT 04			
Name	Description	Area (ha)	% Impervious
Road 01 WB	Via Swale	1.129	60%
CATCHMENT 05			
Name	Description	Area (ha)	% Impervious
Lot 12-17	Via Swale	12.109	0%
CATCHMENT 06			
Name	Description	Area (ha)	% Impervious
Road 02 EB	Via Swale	0.786	60%
CATCHMENT 07			
Name	Description	Area (ha)	% Impervious
Lot 5	Via Swale	2.000	0%
CATCHMENT 08			
Name	Description	Area (ha)	% Impervious
Road 02 WB	Via Swale	0.403	60%
CATCHMENT 09			
Name	Description	Area (ha)	% Impervious
Lot 1,2 & 6-9	Via Swale	12.473	0%
CATCHMENT 10			
Name	Description	Area (ha)	% Impervious
Road 03	Via Swale	0.642	60%
CATCHMENT 11			
Name	Description	Area (ha)	% Impervious
Access driveway	Via Swale	0.583	60%
CATCHMENT 12			
Name	Description	Area (ha)	% Impervious
Lot 10 & 11	Bypass	4.010	0%

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CATCHMENT 13			
Name	Description	Area (ha)	% Impervious
Road 03 Bypass	Bypass	0.054	60%

TOTAL CATCHMENT	55.389	ha

Requirements for Subdivision Works Only to meet NorBE

All roads including access roads to be constructed with roadside swales as part of the subdivision works in order to meet NorBE requirements.

Figure 17: Site Post-Dev (Subdivision Works Only) MUSIC Catchments

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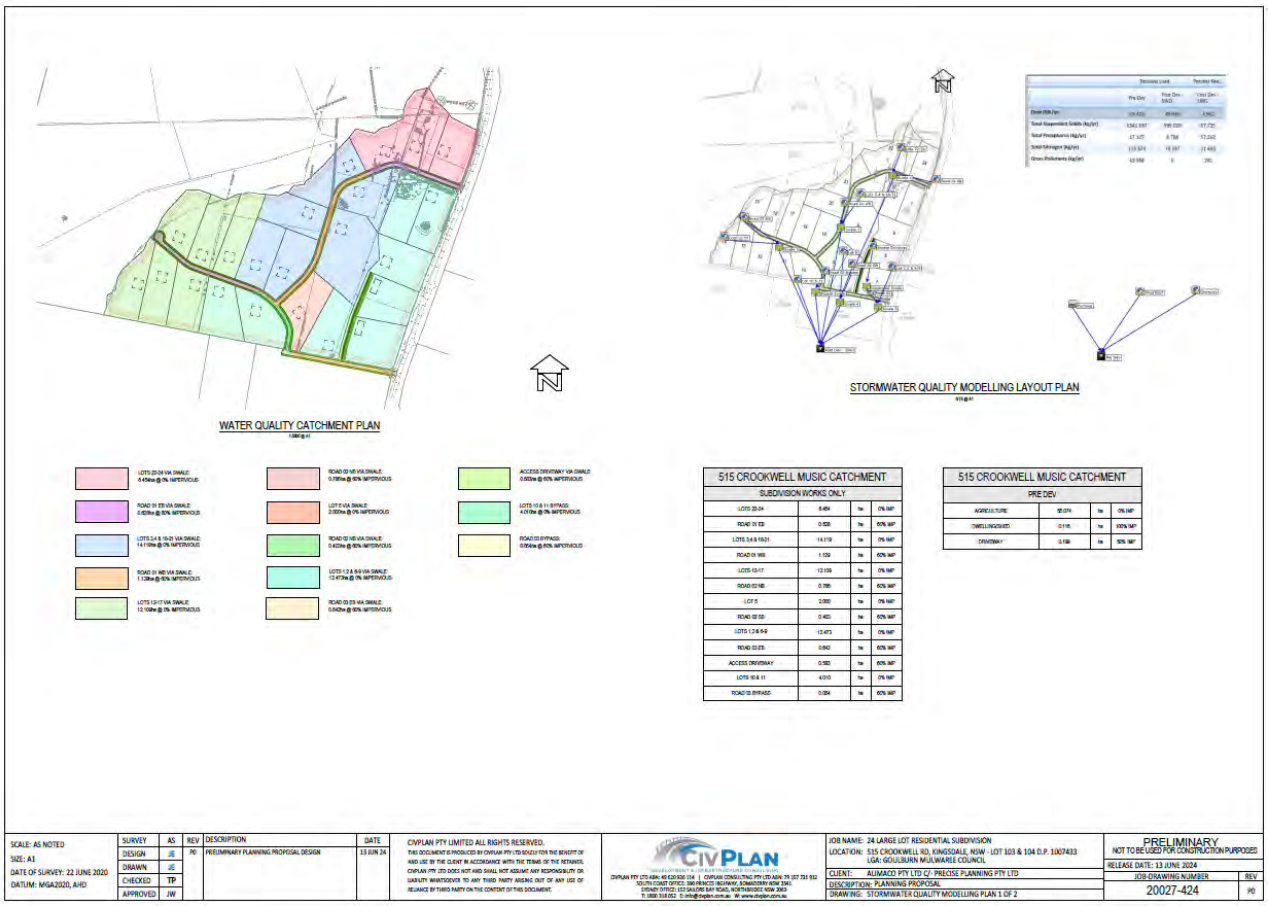

Figure 18: Site MUSIC Catchment Plan (Subdivision Works Only)

515 Crookwell Rd, Kingsdale			
POST-DEVELOPMENT CATCHMENTS			
CATCHMENT 01			
Name	Description	Area (ha)	% Impervious
Lots 22-23	Via Swale	6.293	0%
Roof	Via Rwt	0.108	100%
Driveway	Via Swale	0.053	50%
CATCHMENT 02			
Name	Description	Area (ha)	% Impervious
Road 01 EB	Via Swale	0.628	60%
CATCHMENT 03			
Name	Description	Area (ha)	% Impervious
Lot 3,4 & 18-21	Via Swale	13.798	0%
Roof	Via Rwt	0.216	100%
Driveway	Via Swale	0.105	50%
CATCHMENT 04			
Name	Description	Area (ha)	% Impervious
Road 01 WB	Via Swale	1.129	60%
CATCHMENT 05			
Name	Description	Area (ha)	% Impervious
Lot 12-17	Via Swale	11.788	0%
Roof	Via Rwt	0.216	100%

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Driveway	Via Swale	0.105	50%
CATCHMENT 06			
Name	Description	Area (ha)	% Impervious
Road 02 EB	Via Swale	0.786	60%
CATCHMENT 07			
Name	Description	Area (ha)	% Impervious
Lot 5	Via Swale	1.946	0%
Roof	Via Rwt	0.036	100%
Driveway	Via Swale	0.018	50%
CATCHMENT 08			
Name	Description	Area (ha)	% Impervious
Road 02 WB	Via Swale	0.403	60%
CATCHMENT 09			
Name	Description	Area (ha)	% Impervious
Lot 1,2 & 6-9	Via Swale	12.152	0%
Roof	Via Rwt	0.216	100%
Driveway	Via Swale	0.105	50%
CATCHMENT 10			
Name	Description	Area (ha)	% Impervious
Road 03	Via Swale	0.642	60%
CATCHMENT 11			
Name	Description	Area (ha)	% Impervious
Access driveway	Via Swale	0.583	60%
CATCHMENT 12			
Name	Description	Area (ha)	% Impervious
Lot 10 & 11	Bypass	3.903	0%
Roof	Via Rwt	0.072	100%
Driveway	Bypass	0.035	50%
CATCHMENT 13			
Name	Description	Area (ha)	% Impervious
Road 03 Bypass	Bypass	0.054	60%

TOTAL CATCHMENT	**55.389**	**ha**

Requirements for Subdivision Works Only to meet NorBE

All roads including access roads to be constructed with roadside swales as part of the subdivision works in order to meet NorBE requirements.

All lots are to have a 16m2 Bioretention rain garden

All lots are to have a 34kL RWT for reuse

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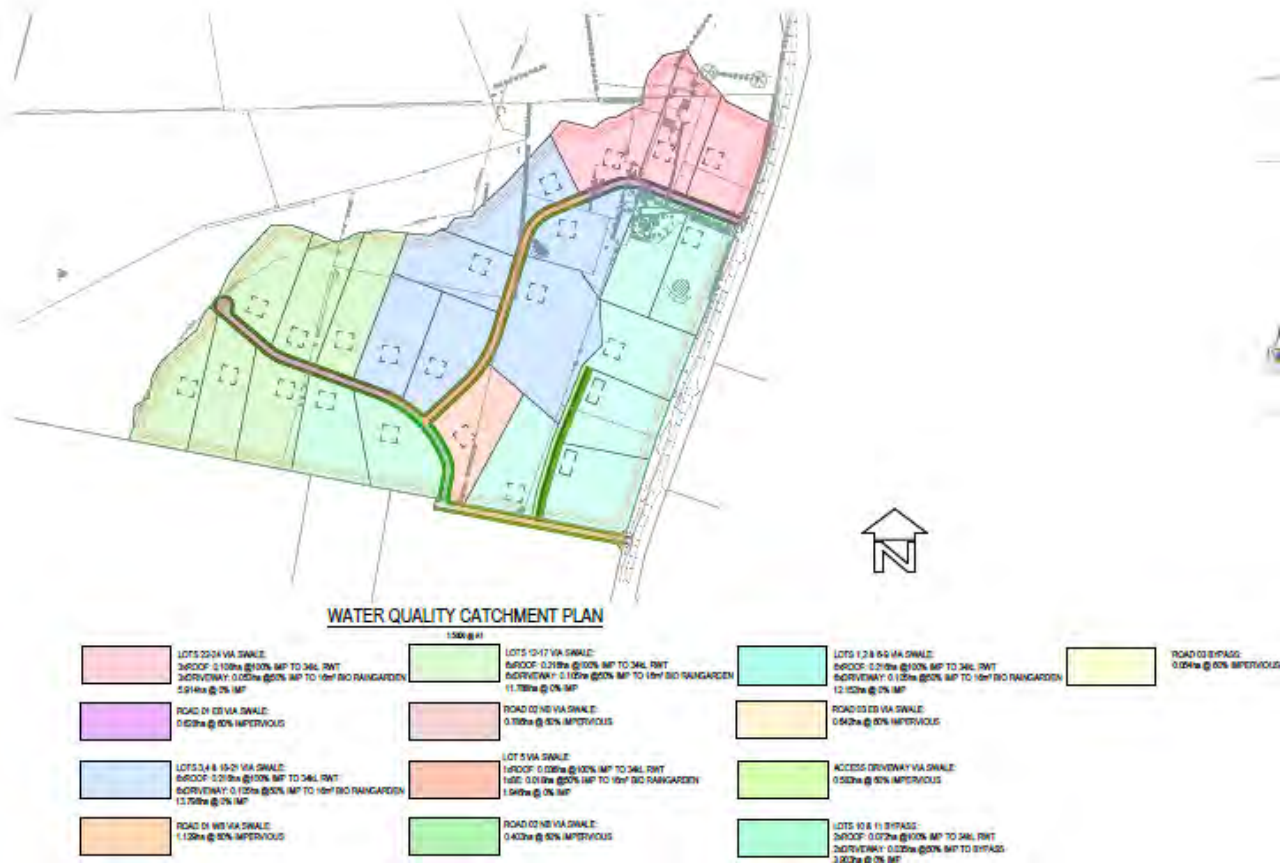

Figure 19: Site Post-Dev (Dwellings) MUSIC Catchments

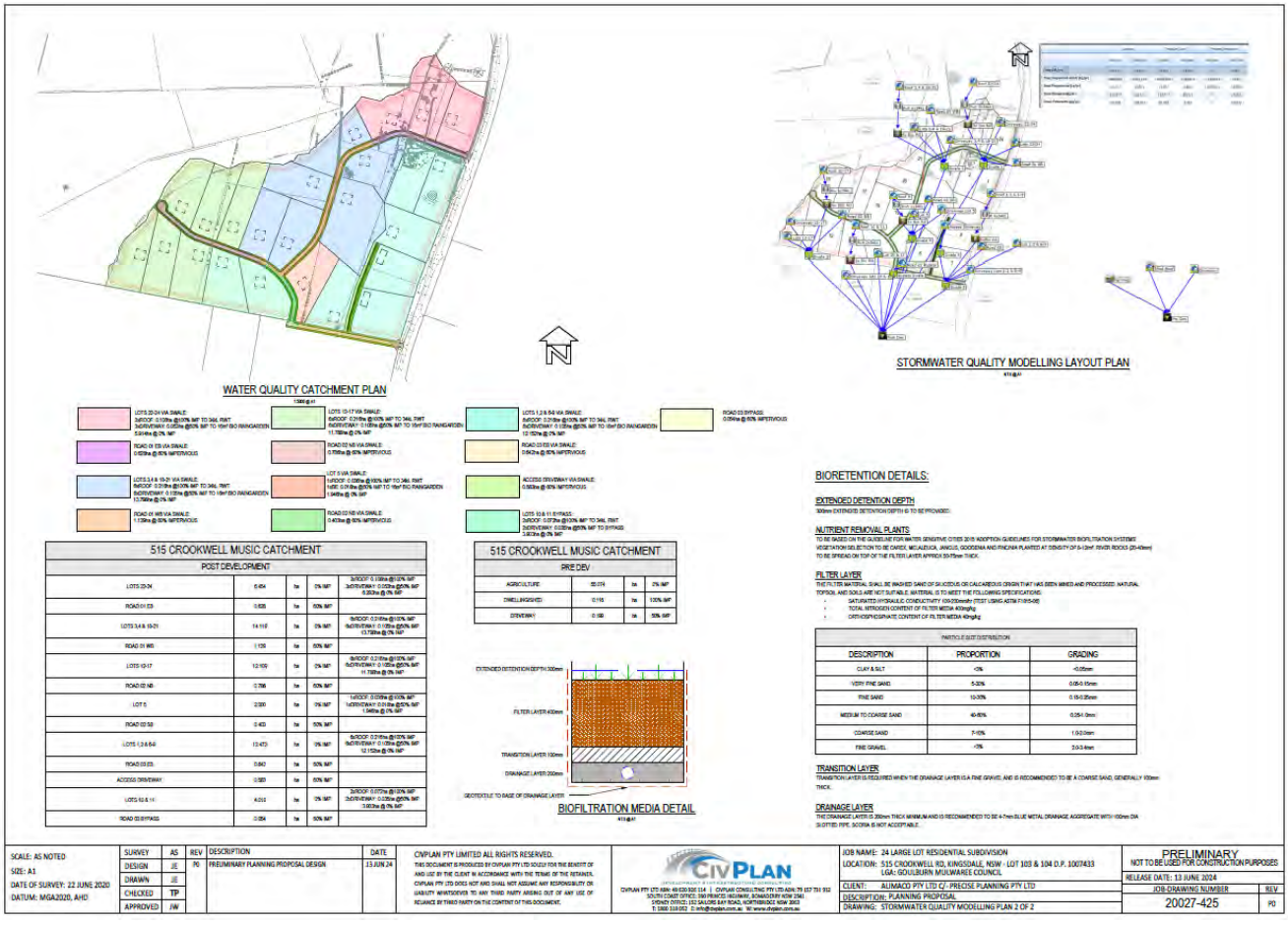

Figure 20: Site MUSIC Catchment Plan (Post Development)

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Note that the default MUSIC stormflow concentration parameters have been used for the modelling of the quality measures and are in accordance with WaterNSW guidelines. The catchments are in accordance with the water quality catchments detailed in section 2.3 of this report and refined as per figures 17 and 19.

4.3 Treatment Measures

The treatment measures for the proposed development are:

Post-Development (Subdivision Works Only – no dwellings) – Refer to Figure 21:

- Swale
    - Initially, for the Subdivision Works Only, it's proposed roadside swales to treat the stormwater runoff as indicated in the Civil Engineering Concept Design Sheet Set reference 20027 dated 5th June 2024, and as listed below:
        - Roadside Swales for the full length of the sides of the proposed roads to be constructed during the subdivision works in order to meet the NorBE requirements in terms of water quality.

Post-Development (dwellings) – Refer to Figure 22:

- Rainwater Tanks for Lots / Dwellings
    - 34kL of RWT dedicated to reuse/BASIX in addition to the OSD requirements (PSD/SSR) for each dwelling. This sizing is based on a roof area of 360m^2 per lot.
    - Reuse rates for external use are 55kL/year/dwelling and 0.845kL/day/dwelling for internal use. This is based on the WaterNSW guidelines and average dwelling size of 4 bedrooms.
    - The roof systems are to be connected via the gutter drainage network to the rainwater reuse tank (RWT) with an overflow to the pit and pipe network that will discharge the stormwater to the road.

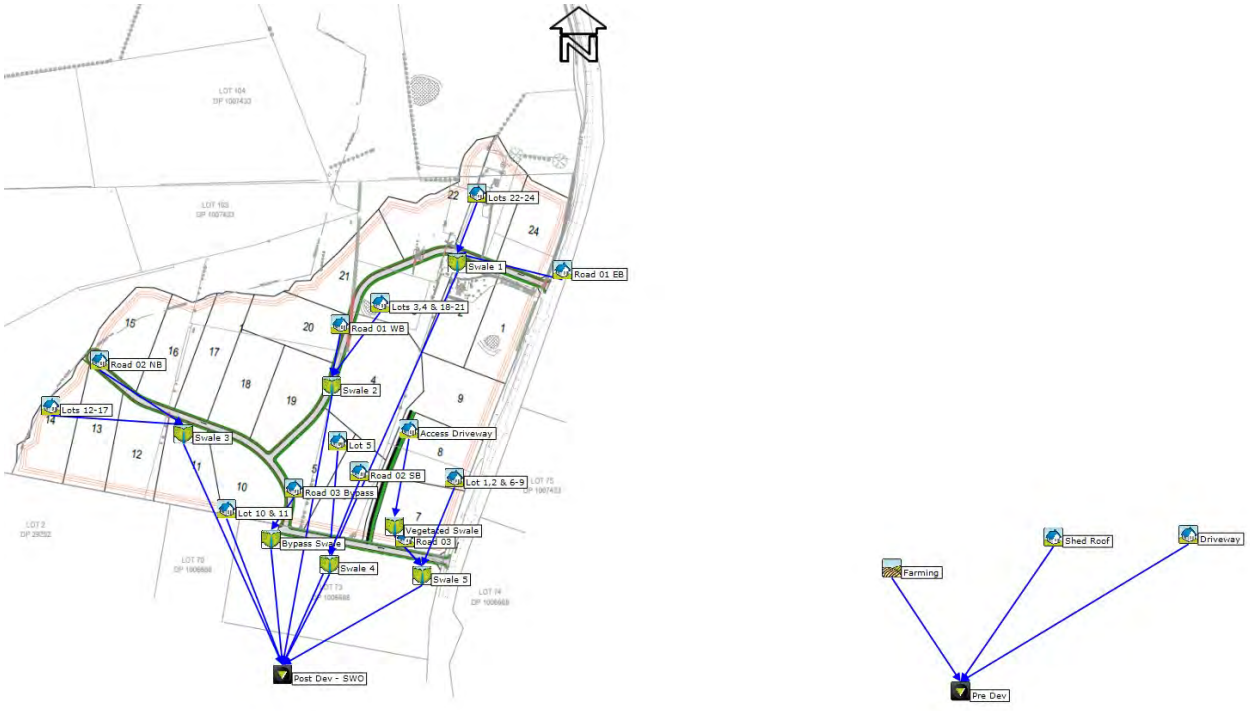

Figure 21: MUSIC Water Quality Model - Treatment Measures – Post-Dev (Subdivision Works Only)

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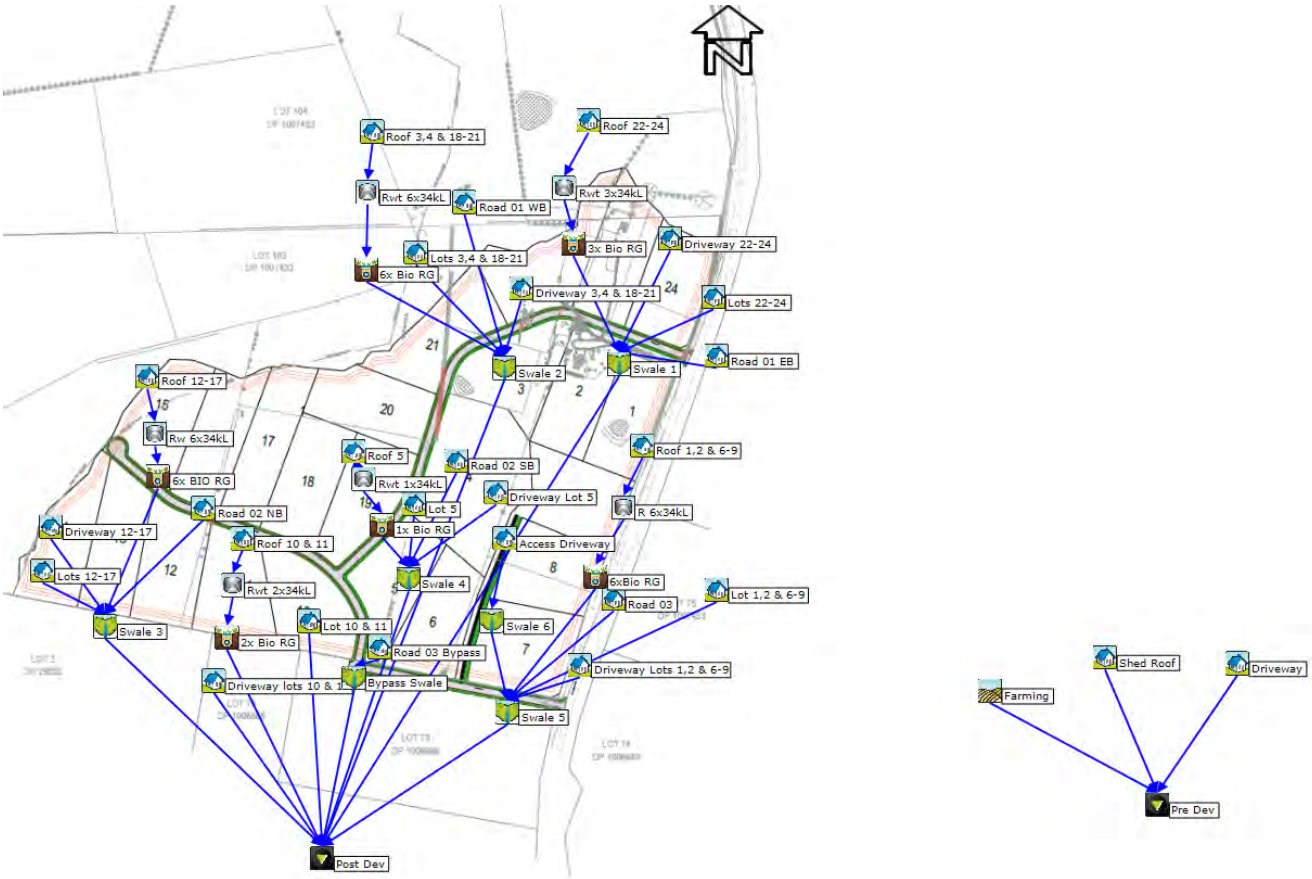

Figure 22: MUSIC Water Quality Model - Treatment Measures – Post-Development (Dwellings)

4.4 Treatment Effectiveness

The treatment measures and subsequent results have been compared to the requirements of NorBE as outlined in section 4.1 of this report. The results from the MUSIC modelling in accordance with the approach, catchment and treatment measures outlined are shown in figure 23 to 28 for both pre-development scenarios.

	Residual Load		Percent Red...
	Pre Dev	Post Dev - SWO	Post Dev - SWO
Flow (ML/yr)	35.425	49.936	4.562
Total Suspended Solids (kg/yr)	6341.697	995.029	87.725
Total Phosphorus (kg/yr)	17.107	6.786	57.262
Total Nitrogen (kg/yr)	115.624	79.247	21.483
Gross Pollutants (kg/yr)	45.968	0	100

Figure 23: MUSIC Water Quality Model – Mean Annual – Post-Development (Subdivision Works Only)

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	Sources		Residual Load		Percent Reduction	
	Pre Dev	Post Dev	Pre Dev	Post Dev	Pre Dev	Post Dev
Flow (ML/yr)	35.425	54.426	35.425	48.999	0	9.971
Total Suspended Solids (kg/yr)	6699.068	9563.144	6699.068	1183.914	-2.715E-14	87.62
Total Phosphorus (kg/yr)	17.057	16.501	17.057	6.847	2.083E-14	58.509
Total Nitrogen (kg/yr)	114.977	106.571	114.977	80.711	0	24.266
Gross Pollutants (kg/yr)	45.968	799.264	45.968	4.163	0	99.479

Figure 24: MUSIC Water Quality Model – Mean Annual Loads – Post-Development (Dwellings)

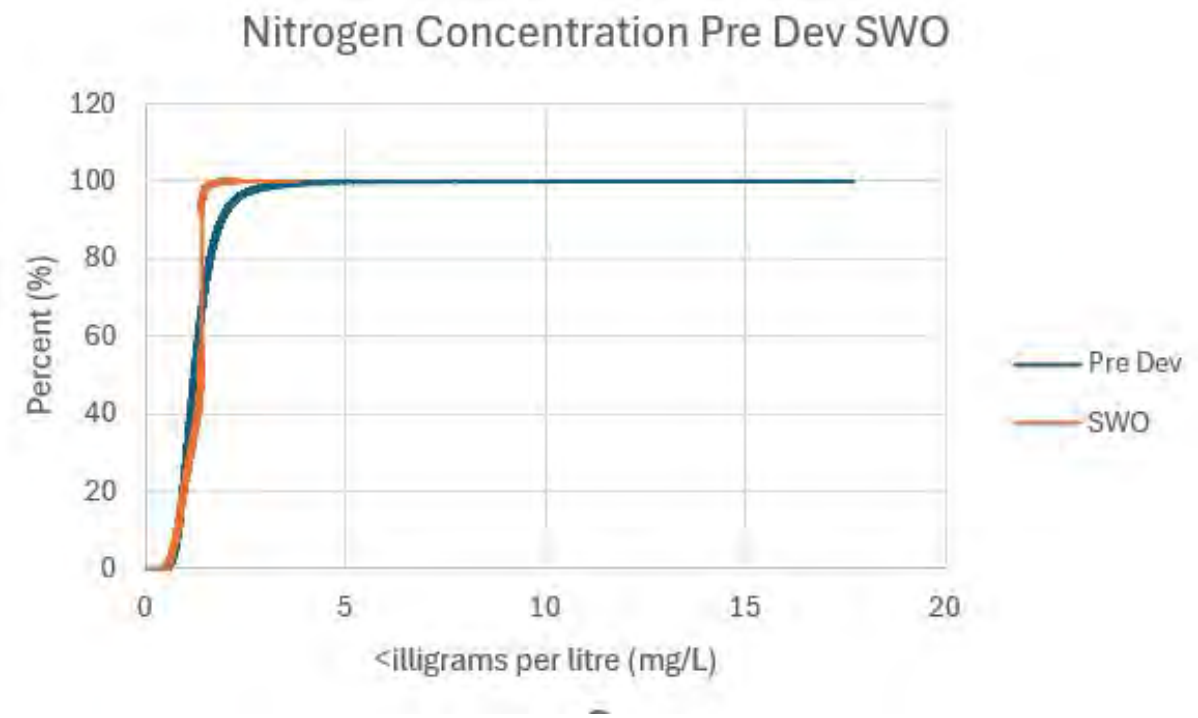

Figure 25: MUSIC Water Quality Model – Nitrogen Concentration (Flow Based Cumulative Frequency) - Post-Development (Subdivision Works Only)

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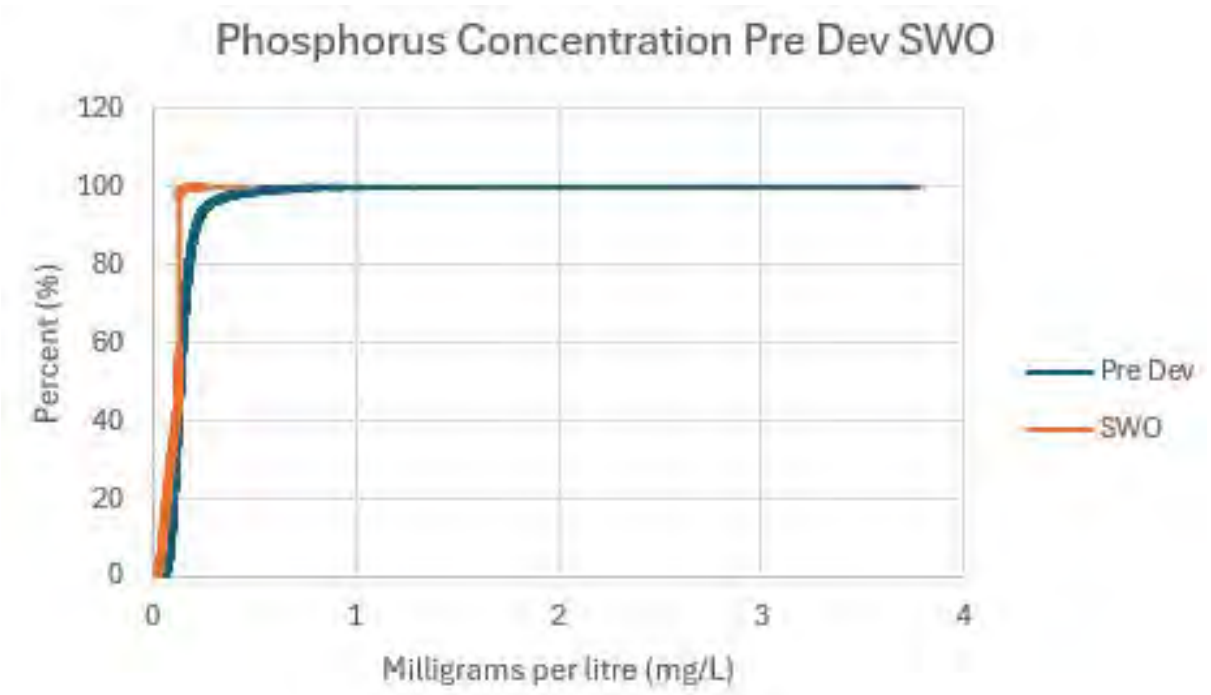

Figure 26: MUSIC Water Quality Model – Phosphorus Concentration (Flow Based Cumulative Frequency) - Post-Development (Subdivision Works Only)

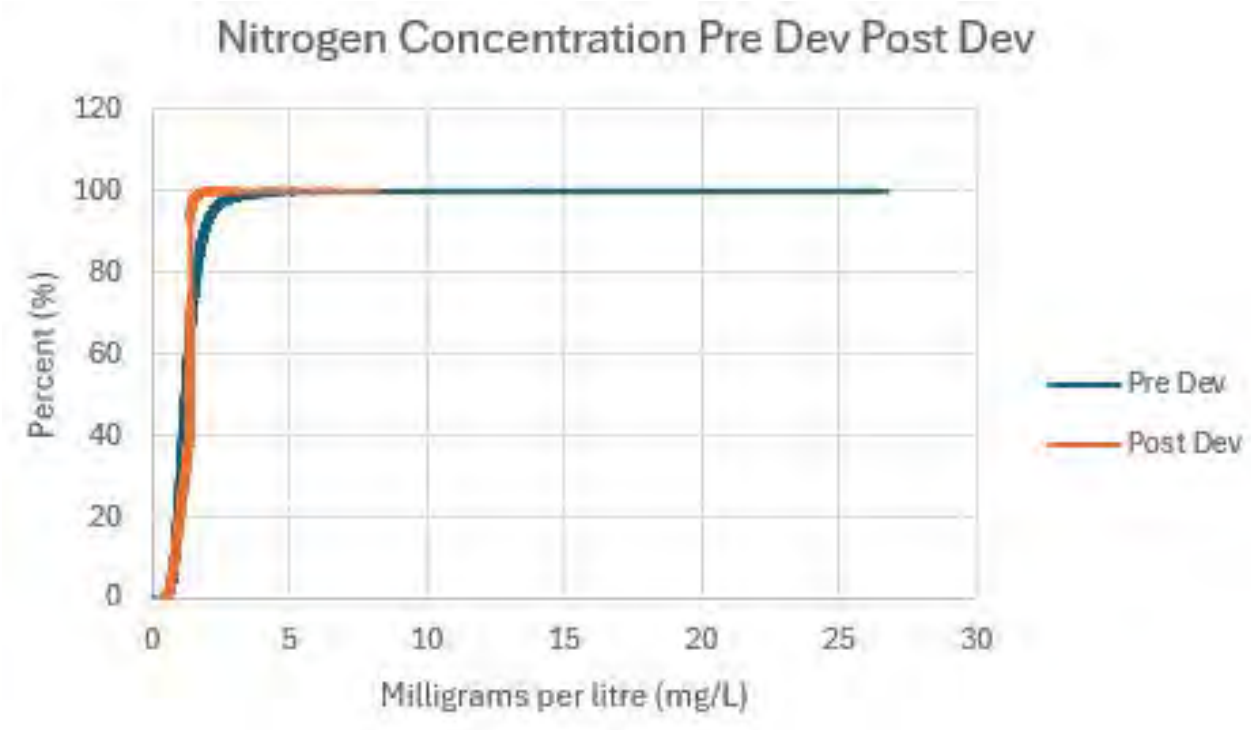

Figure 27: MUSIC Water Quality Model – Nitrogen Concentration (Flow Based Cumulative Frequency) - Post-Development (Dwellings)

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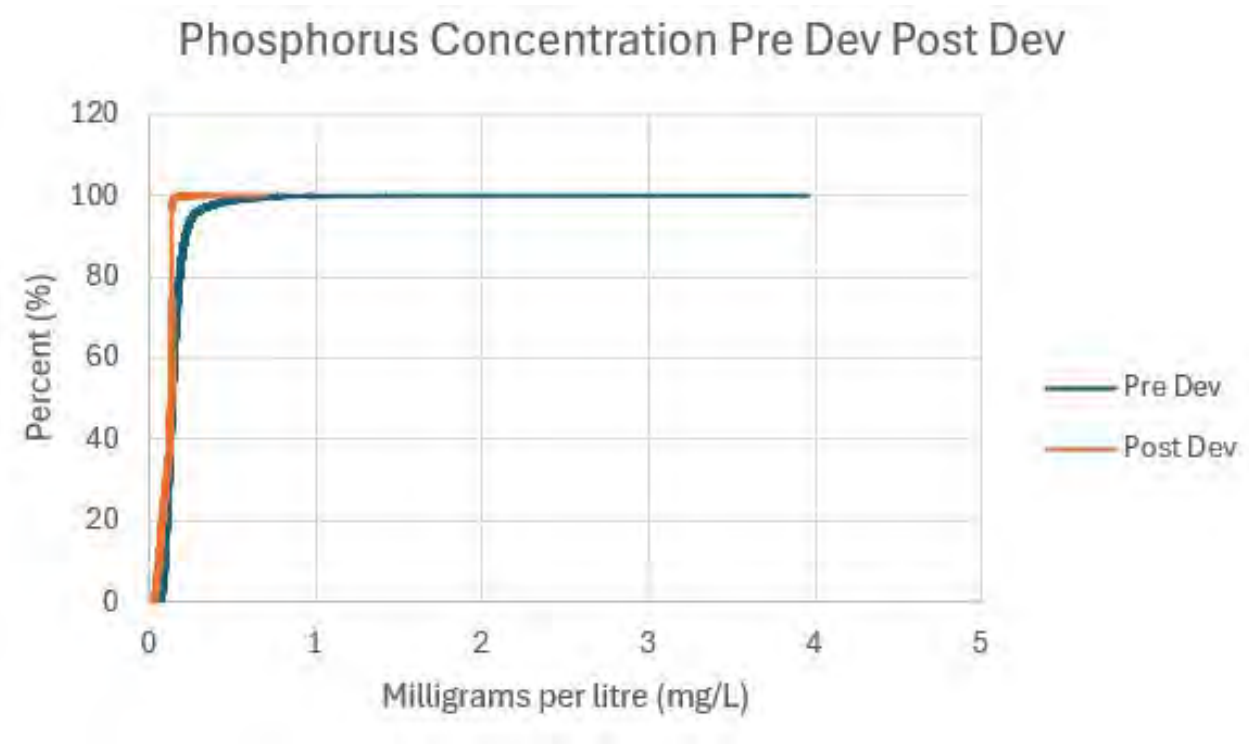

Figure 28: MUSIC Water Quality Model – Phosphorus Concentration (Flow Based Cumulative Frequency) - Post-Development (Dwellings)

Note that the new version of MUSIC (MUSICX) does not provide the tool to compare Flow Based Cumulative Frequency Charts between Pre and Post-Development . However, Excel tools were used to overlay the results exported from MUSICX and to draft a comparative chart between pre and post-development (both scenarios) nitrogen and phosphorus concentration. This clearly shows that Post-development (Subdivision Works Only) and Post-development (Dwellings) pollutant concentrations for total phosphorus (TP) are less than the pre-development concentrations between the 50th and 98th percentiles where runoff occurs, meeting the NorBE requirements for the proposed development. Post-development (Subdivision Works Only) and Post-development (Dwellings) pollutant concentrations for total nitrogen (TN) are less than pre-development concentrations between the 65th and 98th percentile where runoff occurs. Further investigation to allow the nitrogen concentration to be less for the entire required range will be undertaken at detailed design phase.

5. Maintenance

5.1 Privately Owned Assets

The rainwater tanks utilising Smart Tank Technology to each lot, incorporating the water quality treatment (reuse) and quantity (OSD capacity) to each dwelling are to be installed and maintained by each lot/dwelling owner.

The legal requirements are to be stipulated in the 88B Instrument for each lot.

6. Soil & Water Management

6.1 Concept Design Plan Set

For details relating to the soil & water management plan and associated measures please refer to the Civil Engineering

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Design Plan Set for the detailed design by CivPlan Pty Ltd. The measures have been designed in accordance with the Landcom Managing Urban Stormwater Soil and Construction Volume 1 (4th Edition 2004) known as the "blue book". Calculations for any temporary sedimentation basin(s) will be undertaken during the detail design.

7. Conclusion

Water quantity analysis was undertaken, and the proposed development was found to be able to achieve flow attenuation in the post development scenario through the use of OSD tanks provided that:

- Each lot is to provide 17m3/ha of OSD to satisfy the Site Storage Requirements (SSR).
- Each lot is to have 34000L of capacity with a 65mm orifice plate, based on rainwater tank surface area of 70m^2.
- Each lot structure gutter entire must be plumbed to the inlet of the rainwater tank.
- Each lot is to Comply with the following Permissible Site Discharge (PSD) flows (final dwelling design to be check by a competent engineer):

% AEP	L/s/ha
50	21
20	46
10	56
5	64
2	83
1	95

In accordance with the WaterNSW guideline, NorBE Assessment Guidelines 2015, it has been demonstrated that the NorBE criteria for water quality can be achieved through the use of treatment measures that are sympathetic to the nature of the planning proposal.

The following NorBE criteria have been met, and in the case of the treatment measures modelled and analysed,:

- The post-development mean annual pollutant loads for total nitrogen (TN), total phosphorus (TP) and total suspended solids (TSS) are to be a minimum of 10% less than the pre-developed conditions.
- Post-development mean annual gross pollutant loads are to be equal to or less than the pre-developed conditions.
- Post-development (Subdivision Works Only) and Post-development (Dwellings) pollutant concentrations for total phosphorus (TP) are less than the pre-development concentrations between the 50th and 98th percentiles where runoff occurs, meeting the NorBE requirements for the proposed development. Post-development (Subdivision Works Only) and Post-development (Dwellings) pollutant concentrations for total nitrogen (TN) are less than pre-development concentrations between the 60th and 98th percentile where runoff occurs. Further investigation to allow the nitrogen concentration to be less for the entire range will be undertaken at detailed design phase.
- It's been shown that all the NorBE requirements have been met for both post-development scenarios (Subdivision Works Only and after the construction of the dwellings for each lot), according to the WaterNSW Guidelines for water quality analysis and measures modelled using MUSIC.

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