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Water Cycle Management Study

Planning Proposal for Proposed Subdivision at: Lot 70, 73 & 77 DP 1006688 No. 407 Crookwell Road, Kingsdale

Prepared by:

Ciaran Bromhead and Jason Armstrong

Strategic Environmental and Engineering Consulting (SEEC) Pty Ltd
PO Box 1098, Bowral NSW 2576
Tel. 02 4862 1633
Fax. 02 4862 3088
Email reception@seec.com.au
Web www.seec.com.au

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Strategic Environmental and Engineering Consulting

PO Box 1098, Bowral, NSW, 2576
phone: (02) 4862 1633
fax: (02) 4862 3088
email: reception@seec.com.au
www.seec.com.au

Project Reference: 22000418-WCMS-0D
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Signed:

Document Certification

This report has been developed based on agreed requirements as understood by SEEC at the time of investigation. It applies only to a specific task on the nominated lands. Other interpretations should not be made, including changes in scale or application to other projects.
Any recommendations contained in this report are based on an honest appraisal of the opportunities and constraints that existed at the site at the time of investigation, subject to the limited scope and resources available. Within the confines of the above statements and to the best of my knowledge, this report does not contain any incomplete or misleading information.

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Document Issue Table

Version	Date	Author	Reviewed	Notes
DRAFT A	16/11/2022	CB & JA	JA	Draft Issue For Discussion
DRAFT B	16/12/2022	CB & JA	JA	Draft Issue – Minor Updates
FINAL C	22/12/2022	CB & JA	JA	Planning Proposal Issue
FINAL D	22/12/2022	JA	BJ	Minor Update Per Council Comments

SUMMARY

The following report is a Water Cycle Management Study (WCMS) focusing on storm water quality, designed to comply with the requirements of various consent authorities that require that new developments demonstrate a level of environmental responsibility by maintaining or improving water quality.

This report contains:

- a description of the proposed development., Refer to Section 2;
- a detailed site description. Refer to Section 3;
- an investigation into how the proposed development will affect the site. Refer to Section 4;
- a series of measures to offset the potential impacts of the development and any major existing issues. Refer to Section 5;
- modelling results to justify the proposed measures contained in Section 5. Refer to Section 6.

The most important component of this report for the developer is Section 5. It contains a series of measures to be implemented as part of the development that will minimise potential problems caused by the development. This is referred to as a Water Cycle Management Plan (WCMP). It takes into account the existing conditions (Section 3) and the likely impacts of the development (Section 4). Although this is currently a planning proposal in most cases, the planned measures in Section 5 of this report will become "conditions of consent" of any future DA approval.

TABLE OF CONTENTS

1 INTRODUCTION

SEEC have been commissioned by Southern Region Land Engineering, on behalf of the property owner, to prepare this WCMS. It is required to accompany a planning proposal to Goulburn-Mulwaree Council for the subdivision of Lot 70, 73 and 77 DP 1006688 No. 407 Crookwell Road, Kingsdale into 275 residential and rural/residential allotments and five (5) recreational allotments.

This study includes:

- an investigation into the existing storm water cycle;
- an assessment of how the proposed development will affect the management of the water cycle; and
- a plan for managing the water cycle to strive for a neutral or beneficial effect on the quality of water leaving the site.

The site is within the Sydney Drinking Water Catchment which is administered by WaterNSW who require all new developments to demonstrate a Neutral or Beneficial Effect (NorBE) on water quality.

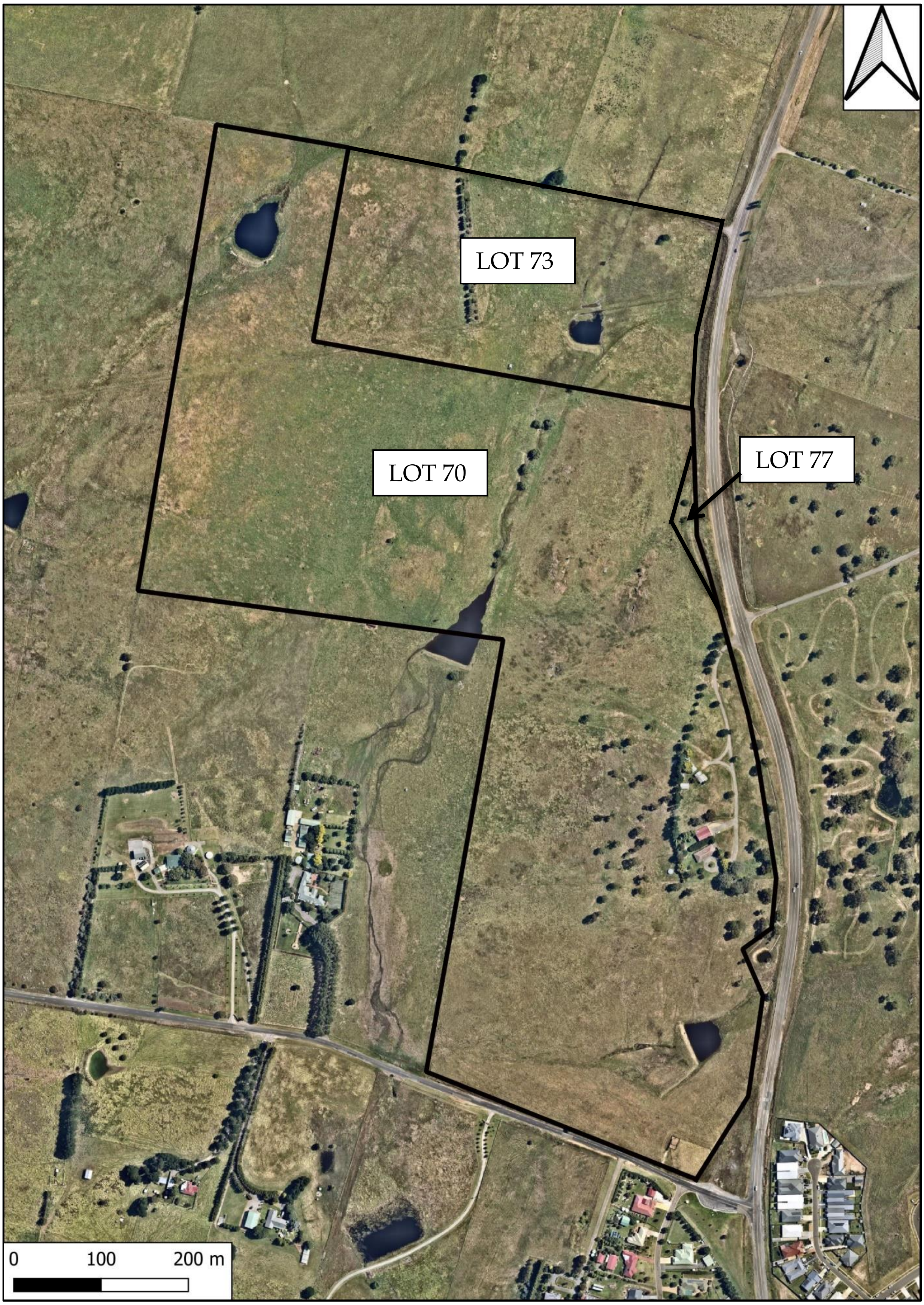

Figure 1: Lot 70, 73 and 73 DP 1006688 No. 407 Crookwell Road, Kingsdale. Underlying image taken by Nearmap 2022

2 PROPOSED DEVELOPMENT

The proposed development a planning proposal submission rezone and to subdivide Lot 70, 73 and 77 DP 1006688 into 280 new allotments with the proposed work to include the following:

- 265 residential allotments (Lots 1-265)
- 10 rural/residential allotments (Lots 1001-1010)
- 5 RE3 Allotments (Lots 501-503 and 505-506)
- Construction of new residential and rural roads. The total area of road reserve will be approximately 11.15 ha

It is proposed to connect all new lots except for Lots 1001-1005 to reticulated water however only the proposed lots 1-265 and lots 1006-1010 will have access to reticulated sewer. As such all wastewater generated on proposed Lots 1001-1005 will need to be managed on site and each of these lots would also require a suitably sized rainwater tank/roof water collection system for the supply of domestic drinking water. Details surrounding the on-site wastewater disposal system can be found in ACT Geotechnical Engineers Pty Ltd Report KA/C12356.

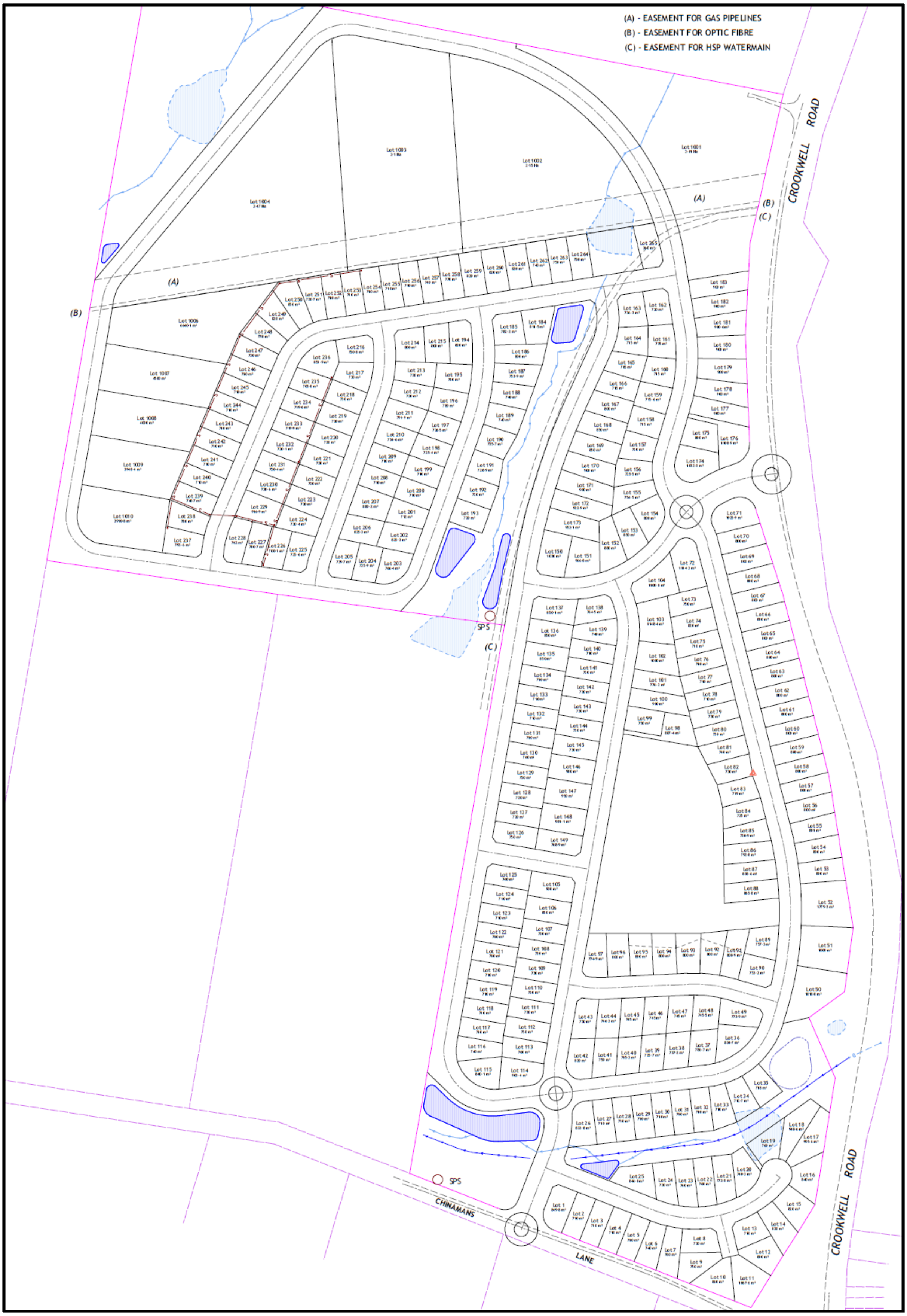

Figure 2: The proposed development. Image provided by Southern Region Land Engineering.

3 SITE DETAILS

3.1 Location and General Conditions

Lot 70, 73 and 77 DP 1006688 is a combined 50.78 ha (approx.) parcel of land zoned RU6, located on the western side of Crookwell Road and the Northern side of Chinamans Road, Kingsdale (Figure 1 and Figure 3).

At the time of assessment there was an existing dwelling, surrounding sheds and other associated infrastructure on site. Infrastructure was connected by several gravel access roads. We have been informed by the client that all existing infrastructure will be demolished to make way for the proposed development.

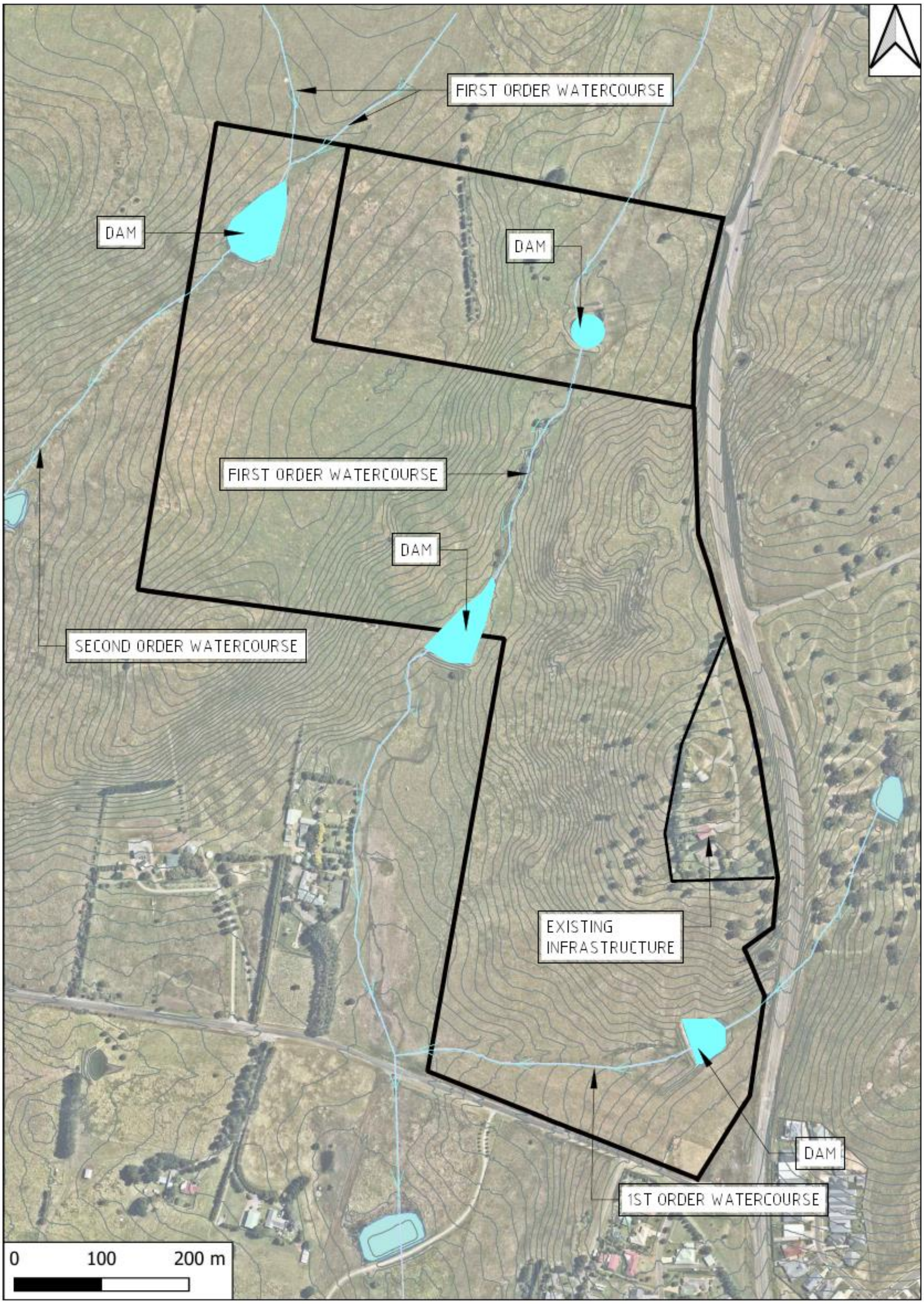

Figure 3: Existing site and drainage features at the time of assessment.

3.2 Topography

Topography across the site varies with crests, side slopes and depressions. The dominant slope is between 10-20% where land ultimately drains to the south.

3.3 Surface Drainage

At the time of assessment there were four dams located within the site. The site is drained by two first order watercourses and a second order watercourse which ultimately drains to the south and into the Wollondilly River which is located approximately 800 m from the southern boundary of the site.

3.4 Soils and Geology

Soil Landscape mapping (eSpade, 2022) identifies the site is located on the Sooley Soil Landscape. The Sooley SL occurs on a complex geological mixture of meta-sediments and intrusive volcanics in the hills around Goulburn. Slopes vary up to 10 percent, with local relief not exceeding 30m. Soils are generally poorly-drained, moderately deep and yellowish or grey in colour. According to SCA/DLWC (2002) the soil depth changes little with slope position and generally consists of a thin (150mm), weakly pedal silty loam topsoil (A1 horizon) over a variable thickness of weakly pedal silty clay loam (A2 horizon) and then a yellow to grey weakly pedal clay.

According to SCA/DLWC (2002) the soils are not dispersive but they are fine grained (Type F) and they are highly erodible (K-Factor for subsoil is 0.068). They are hydrological group C which means runoff will occur under moderate to heavy rainfall events.

3.5 Climate and Erosion Potential

Goulburn experiences a temperate climate, with warm to hot summers and cool winters. According to the Bureau of Meteorology (BoM), nearby Goulburn Tafe (Station No. 70263) receives 630.5 mm of mean annual rainfall and 1,241 mm of mean annual evaporation (Table 1). Evaporation is significantly greater in summer however mean rainfall exceeds mean evaporation for the month of June and July (Figure 4).

Table 1: Mean Monthly Rainfall and Mean Monthly Evaporation (Goulburn Tafe Station No. 70263).

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Rain (mm)	64.3	62.3	62.2	43.4	41.5	52.1	40.3	55.2	48.0	53.3	65.2	62.4	630.5
Evap (mm)	192.2	145.6	120.9	75	49.6	33	37.2	58.9	84	120.9	147	186	1241

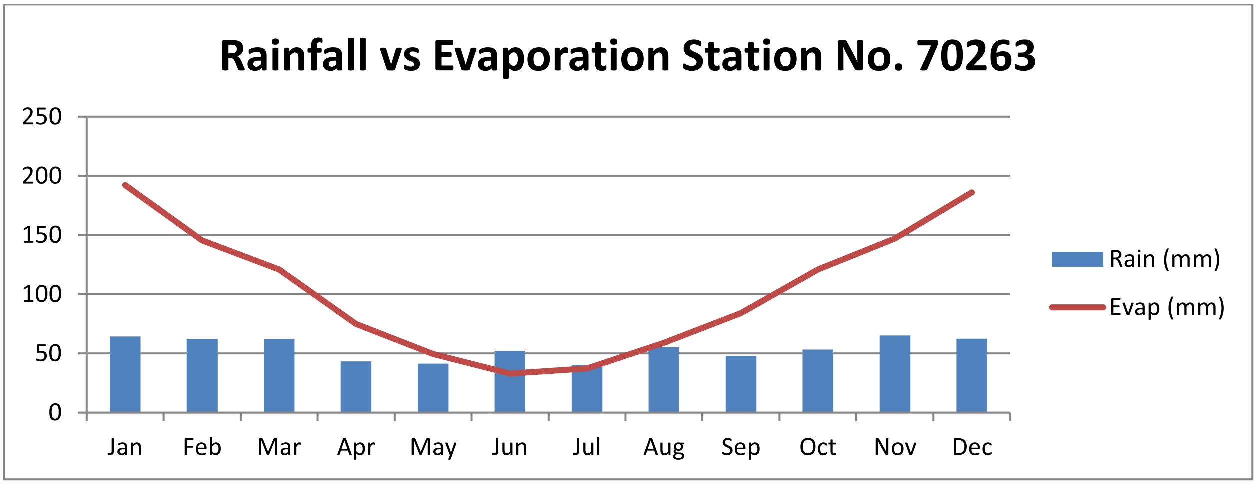

Figure 4: Graph showing Rainfall and Evaporation (from Bureau of Meteorology, 2022)

3.6 Biodiversity

The site is predominately grassed with gravel access tracks. Site observations observed several exotic and native trees in proximity to the existing infrastructure. According to the Department of Planning, Industry and Environment (DPIE) Biodiversity Values Map and Threshold tool (accessed, 2022) this site is unaffected by any threatened species or communities with potential for serious and irreversible impacts.

3.7 Salinity

No formal salinity investigations were undertaken but observations of available aerial imagery by SEEC staff did not identify any obvious surface indications of salinity (such vegetation die back, salt scars, etc.). Salinity is not expected to be a concern.

3.8 Governing Bodies Constraints and Opportunities

The site is within the Goulburn-Mulwaree Shire Council and Sydney Drinking Water Catchment area and must therefore accord with their Current Recommended Practices (CRPs), Local Environmental Plan (LEP) and Development Control Plans (DCPs).

4 IDENTIFYING FUTURE WATER QUALITY ISSUES

4.1 Soil and Water Management during Construction

During construction there will be some short to long-term soil disturbance. An Erosion and Sediment Control Plan as discussed in Section 5.1 will be required to manage soil disturbance during construction.

4.2 Production, Management and Disposal of Wastes

4.2.1 Domestic Waste

We anticipate that new residences would have access to Council's waste transfer stations (as part of annual rates). As such, we expect that no domestic waste would be disposed onsite.

4.2.2 Effluent Disposal

Lots 1001-1005 would not be serviced by reticulated sewer, so new houses would require onsite treatment and disposal systems for domestic effluent (see ACT Geotechnical Engineers Pty Ltd Report KA/C12356). All other residential lots would be serviced by reticulated sewer.

4.2.3 Other Pollutants

Due to an increase in impervious surfaces, the development may generate quantities of pollutants entrained in stormwater runoff. The measures outlined in Section 5 have been developed to ensure that the water quality of the site runoff is kept at a neutral or beneficial level when compared with the pre-development scenario.

4.3 Land Surface Changes

4.3.1 Land Use Change

There will be significant land surface changes as a result of this development. These changes will impact the overall level of impervious surfaces across the site and will lead to increased runoff. The proposed changes are:

4.3.1.1 Construction of a new home on each new lot together with associated driveways, patios, garden sheds etc.

4.3.1.2 Construction of sealed road pavements which would have kerb and gutter and footpaths. The estimated effective imperviousness of the road easement would be 60 percent.

4.3.2 Overland Flow/ Localised Flooding

A regional or localised flood assessment has not been undertaken as part of this water cycle management assessment. There are three major overland flow paths/intermittent watercourses located within the development area (Figure 3) but these would be retained within their own drainage reserves. A flood assessment would be undertaken and submitted with a future development application submission for the development.

4.4 Pre vs Post Assessment of Stormwater Quality

The proposed future land use at this site will lead to an increase in stormwater discharge and pollutant production due to increased runoff from impervious surfaces (roofs, paved areas, parking lots, etc.).

Section 5 of this report contains a Water Cycle Management Plan that shows how a neutral or beneficial effect on water quality can be achieved given the assumptions in Section 4. Section 6 contains modelling using a computer tool known as MUSIC to justify the effectiveness of that plan.

5 WATER CYCLE MANAGEMENT PLAN

5.1 Construction Soil and water Management Plan (SWMP)

5.1.1 Subdivision Construction

A construction-phase Soil and Water Management Plan (SWMP) would be prepared for the proposed construction works as parts of the site have been identified at high risk of erosion (because of the moderate slopes) and more than 2,500 m^2 would be disturbed when the new roads are built.

The implementation of the SWMP must adhere to the guidelines and recommendations in Landcom, 2004 (The "Blue Book") and should include the following *generic* principles:

- Sediment fencing is to be used downslope of any construction area until works are complete (Standard Drawing SD 6-8, Landcom, 2004).
- Construction of suitably sized sediment basins to capture sediment run-oof during the construction of the roads and disturbed lands during earthworks.
- Topsoil will be stripped from any construction areas and stockpiled following Standard Drawing SD 4-1 (Landcom, 2004) for later re-use.
- The upslope catchment length of exposed soil areas will be kept below 80m. Any slope length exceeding 80m will have a berm installed to direct overland flows onto well protected, vegetated lands.
- Construction traffic access is to be limited to the minimum required for efficient construction. Areas not essential for construction purposes are to be protected from traffic entry through the use of barrier and/or sediment fencing. Table 2 contains details of access limitations during construction in accordance with Landcom (2004).
- While C-factors[1] are likely to rise to 1.0 during the work's program, they will not exceed those given in Table 3.
- Diversion berms will be used to divert "clean" runoff from upslope of any construction areas away. Discharges are to be onto a stabilised, well-vegetated area, preferably using a level spreader or sill.
- Rapidly rehabilitate disturbed lands to bring C-factors down to acceptable levels (see Table 3) and minimise the risk of erosion.
- Areas of concentrated flow (e.g. drainage pathways, swales etc.) are to be protected using appropriate erosion control measures. We suggest a biodegradable Rolled Erosion Control Product (RECP) such as coconut fibre matting or jute matting to provide stable ground cover until vegetation regenerates.

[1] C-factor is a measure of ground cover. It is a value between 0.005 and 1, with lower values indicating better ground cover and higher values for exposed soil with no vegetation or erosion control measure in place. At a construction site, a C-factor of 0.1 can be achieved with 60% grass cover.

Table 2 – Limitations to access during construction works

Land use	Limitation	Comments
Construction areas	Limited to 5 (preferably 2) metres from the edge of any essential construction activity as shown on the engineering plans	All site workers should clearly recognise these areas that, where appropriate, are identified with barrier fencing (upslope) and sediment fencing (downslope) or similar materials.
Access areas	Limited to a maximum width of 5 metres	The site manager will determine and mark the location of these zones on site. They can vary in position so as to best conserve existing vegetation and protect downstream areas while being considerate of the needs of efficient works activities. All site workers will clearly recognise these boundaries
Remaining lands, including re-veg areas	Entry prohibited except for essential management works	Thinning of growth might be necessary, for example, for fire reduction or weed removal

Table 3 – Maximum acceptable C-factors at nominated times during works

Lands	Maximum C-factor	Remarks
Waterways and other areas subjected to concentrated flows (e.g. table drains), post construction	0.05	Applies after ten working days from completion of formation and before they are allowed to carry any concentrated flows. Flows will be limited to those shown in Table 5.2 of Landcom (2004). Foot and vehicular traffic will be prohibited in these areas
Stockpiles, post construction	0.10	Applies after ten working days from completion of formation. Maximum C-factor of 0.10 equals 60% ground cover
All lands, including waterways and stockpiles during construction	0.15	Applies after 20 working days of inactivity, even though works might continue later. Maximum C-factor of 0.15 equals 50% ground cover
All lands post construction	0.1/0.05	0.1 applies after 10 days of works finish and can be achieved by 60 percent ground cover. 0.05 applies after 60 days and can be achieved with 70 percent ground cover.

5.1.2 Single Lots

In the future, each development application on each new lot must be accompanied by an Erosion and Sediment Control Plan (ESCP) as described by Landcom, 2004. Chapter 9 of Landcom (2004) gives some generic examples.

5.3 Stormwater Management

5.3.1 Stormwater Management Plan

Site stormwater is to be managed in accordance with the Concept Surface Water Management Plans prepared by Southern Regional Land Engineering (SRLE) and as outlined in the following section.

5.3.2 Earthworks

It is envisaged that site earthworks and re-grading would be required for the installation of the new road and stormwater drainage infrastructure. All lots would drain to a road or interalottment drainage system.

5.3.3 Road Drainage and Pre Treatment

All new urban roads would incorporate kerb and guttering with a pit and piped drainage system in accordance with Councils standards. The piped drainage system would either incorporate pit baskets to capture sediment to pre-treat stormwater prior to discharging into the proposed bioretention basins. Alternatively a suitably sized Gross Pollution Trap (GPT) would be installed immediately upstream of each bioretention basin.

Rural roads would be constructed with grass lined tables drains on each side that would provide some capture and pre-treatment of sediment and include mitre drains at regular intervals and therefore would not require a GPT, would be subject to detailed stormwater analysis with a future development application submission.

5.3.4 On-Site Detention

As discussed in Section 4.3.1, post development flows would increase due to increased impervious area without the inclusion of on-site detention. Post development flows from the development will be reduced by the provision of an above-ground on-site detention (OSD) basin as part of each Bioretention Basin located at the end of each catchment and located in a drainage reserve. These would limit post-development flows to no more than pre-development flows. Note that Basin 3A OSD volume would be designed to be included in combination within the rural road table drains and additional smaller dams/water quality ponds. This would be subject to detailed stormwater analysis with a future development application submission.

The required OSD storage volume and post development outflow for each stage (Stages 1 – 3) for the 100 Year ARI storm event have been summarised in Table 4 below.

Table 4 - On-Site Detention Basin Size Summary

Basin	Q100, Pre-Developed	Q100, Post-Developed	Reduction	OSD Volume
	m^3/s	m^3/s	%	m^3
1A	0.759	0.722	4.9%	305.1
1B	1.683	1.571	6.7%	1413.7
2A	0.948	0.884	6.8%	661.4
2B	1.23	1.134	7.8%	784.9
2C	1.233	1.149	6.8%	880.2
3A[2]	1.584	1.526	3.7%	1035.5

5.4 Bio-Retention Basins

There would be six bio-retention basins. All would be designed and built to the latest version of the *Adoption Guidelines for Stormwater Biofiltration Systems*. With care they would be made attractive landscape features in the drainage reserves. Each basin would:

- have a 50mm thick gravel mulch surface;
- be planted with spiky, native, moisture-tolerant, plants such as *Carex* sp. and *Juncus* sp.;
- have a 400 mm thick filtration zone;
- have a 300 mm thick, carbon/gravel anaerobic zone at the base;
- have a 100 mm thick transition layer between;
- have a grated high-flow outlet set 300 mm above the surface;
- drain via subsoil drainage pipes; and
- have signs erected informing the public of its purpose and the risk of rising water levels.

[2] Note that the required OSD volume for Basin 3A would be designed to be included as a combination within the rural road table drains and additional smaller dams/water quality ponds. This would be subject to detailed stormwater analysis with a future development application submission.

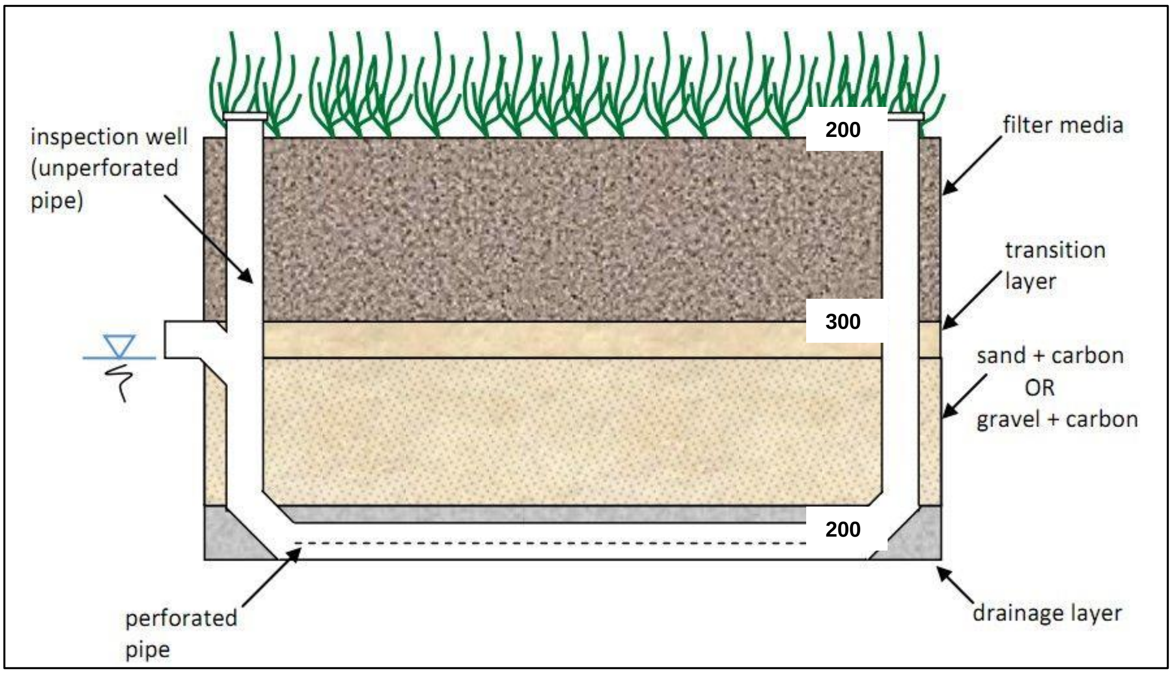

Figure 5 – Typical Section Bioretention Basin

5.4.2 Bio-retention Basin Media Specification

The filtration media will be well-graded loamy sand with:

- Hydraulic conductivity (ASTM F1815-06) between 250 and 300 mm/hour
- pH between 5.5 and 7.5
- Organic content less than 5%
- Electrical conductivity less than 1.2 dS/m
- Orthophosphate content less than 20 mg/kg
- Total nitrogen content <400 mg/kg

Subject to adequate hydraulic conductivity the following particle size distribution is a guide:

Clay and silt	< 3%	(<0.05 mm)
Very fine sand	5-30%	(0.05 - 0.15 mm)
Fine sand	10-30%	(0.15 - 0.25 mm)
Med-Coarse sand	40-60%	(0.25 - 1.0 mm)
Coarse sand	7-10%	(1.0 - 2.0 mm)
Fine gravel	<3%	(>2.0 mm)

The filtration media will be compacted with no more than one pass of a vibratory plate compacter or drum roller.

The transition layer shall be clean, well-graded sand containing little or no clay and silt (<2%). D15 of the transition layer must be <5 x D85 of the filter media.

The drainage layer shall be 2 - 7 mm washed screenings with <2% silt and clay

5.5 Monitoring and Maintenance

5.5.1 Construction Phase

5.5.1.1 The sediment basins and other construction-related soil and water management structures/products would be the responsibility of the developer.

5.5.1.2 The sediment basins would:

- Remain online until its catchment is at least 90 percent stabilised (by hard surfaces and/or a minimum 70 percent ground cover).
- Be maintained as per the directions of the SWMP. Note this would require regular flocculation after rainfall to ensure the design capacity is maintained.
- Be converted to bioretention/OSD basins when its catchment is stable/sufficient ground cover.

5.5.1.3 Other erosion and sediment control measures would be maintained as per the directions given in the SWMP.

5.5.2 Grassed Swales/Bioretention Basins

- The swales and the bioretention basins will be regularly checked for erosion and will involve checking the condition of grass cover and vegetation.
- Any choked areas will be cleaned up to ensure they maintain an effective runoff/ infiltration balance.
- Any bare areas or vegetative die-off will be rapidly rehabilitated.
- If water ponds on the surface of the bioretention basins for more than 24 hours after rainfall:
  - the subsoil drainage pipe will be inspected/cleared; and (if clear);
  - the permeability of the system will be checked by a geotechnical engineer or soil scientist. If the filter media is clogged it will require replacement.

5.5.3 Pits and Pipes

5.5.3.1 Enviropod Pit Baskets/ Gross Pollution Traps (GPT's)

The developer would be responsible for the maintenance of the inlet pit baskets and GPT's until transferred to Council.

5.5.3.2 The pipe network

The developer would be responsible for the maintenance of the pipes during the subdivision works. After that they would be transferred to Council. The pipes would require flushing to remove sediment prior to handing them over to Council.

5.5.4 Lot-Specific Erosion and Sediment Control

Each home should instigate its own Erosion and Sediment Control Plan during construction to prevent the trunk drainage pipes being over-loaded with sediment. Policing this would be the responsibility of Council.

5.5.5 Operational Environmental Management Plan

An Operational Environmental Management Plan (OEMP) will be provided at construction certificate stage detailing the proposed stormwater management maintenance schedule and actions.

6 MUSIC MODELLING

Pre and post development sediment and pollutant loads were modelled using MUSIC (Model for Urban Stormwater Improvement Conceptualisation), developed by eWater. MUSIC contains algorithms based on the known performance characteristics of common stormwater quality improvement structures used in Australia. These data are derived from research undertaken by eWater and others. The models are appropriately calibrated and all amendments to MUSIC defaults are noted in Section 6.2.

The modelling quantifies the loads of the principal pollutants before and after the development. Statistics are produced in MUSIC for the following parameters:

- Flow (ML/yr)
- Peak Flow (m^3/s) (although this is not used in a NorBE assessment)
- TSS - Total Suspended Solids (kg/yr)
- TP - Total Phosphorus (kg/yr)
- TN - Total Nitrogen (kg/yr)
- Gross Pollutants (kg/yr)

6.2 MUSIC Modelling Inputs

6.2.1 Climate Data

Creation of a MUSIC catchment file requires an associated meteorological data file. The data used here is "Zone 1" data supplied by WaterNSW. Basic rainfall and evapotranspiration statistics are in Table 5 and the time-series graph is in Figure 6.

Table 5 - Rainfall and PET Statistics for MUSIC Climate Zone 1.

Measure	Statistics						
	mean	median	maximum	minimum	10%ile	90%ile	mean annual (mm)
Rainfall (mm/6 minute steps)	0.008	0	12.5	0	0	0	721
Potential evapotranspiration (mm/day)	2.966	2.60	4.81	1.23	1.29	4.52	1083

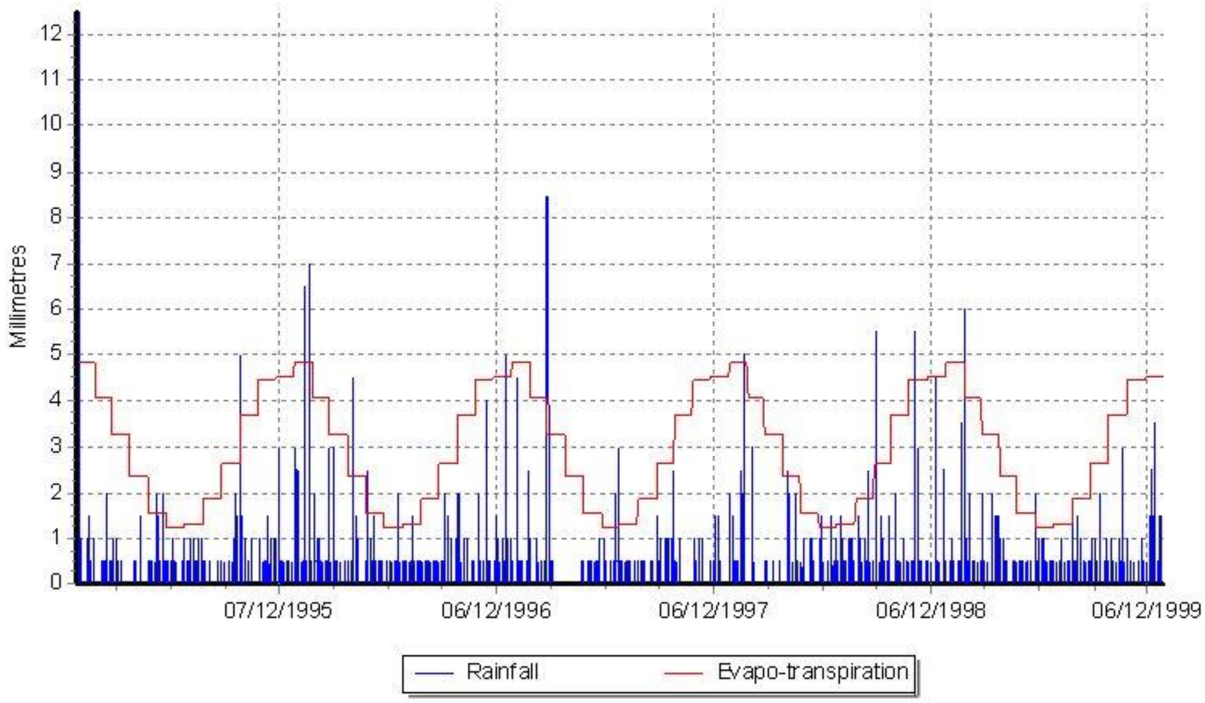

Figure 6 - Time Series Graph for WaterNSW Zone 1 data set

6.2.2 *Calibration*

Table 6 presents the event mean concentrations (EMCs) of various surfaces and land uses. These are the defaults in MUSIC for the various land uses represented as source nodes.

Table 6 - Event Mean Concentrations (Storm Flow)

Source Node	TSS mean (log mean)	TSS std dev (log std dev)	TP mean (log mean)	TP std dev (log std dev)	TN mean (log mean)	TN std dev (log std dev)
Road (sealed)	269 (2.43)	2.1 (0.32)	0.5 (-0.30)	1.8 (0.25)	2.19 (0.34)	1.55 (0.19)
Agricultural land	141 (2.15)	2 (0.31)	0.6 (-0.22)	2 (0.3)	3.02 (0.48)	1.82 (0.26)
Residential	141 (2.15)	2.09 (0.32)	0.251 (-0.6)	1.78 (0.25)	2 (0.3)	1.55 (0.19)

The pervious area characteristics for each source node have been calibrated based on a silty clay loam soil with a 0.5 m rooting depth (WaterNSW, 2019). Calibration is shown in Table 7. The MUSIC schematic for development is shown in Figure 7 to Figure 9.

Table 7 - Pervious area calibrations used in MUSIC

Parameter	Value
Soil storage capacity	88 mm
Initial storage	30 mm
Field capacity	70 mm
Infiltration capacity coefficient	180
Infiltration capacity exponent	3
Groundwater initial depth	30 mm
Daily recharge rate	25%
Daily baseflow rate	25%
Daily deep seepage rate	0%

6.2.3 Pre-development Modelling Assumptions

Pre-development MUSIC modelling for Stage 1 assumes a total area of 11.26 ha modelled using a single agricultural source node, 100% pervious.

Pre-development MUSIC modelling for Stage 1 and 2 assumes a total area of 22.28 ha modelled using a single agricultural source node, 100% pervious.

Pre-development MUSIC modelling for Stage 1-3 assumes a total area of 50.78 ha modelled using a single agricultural source node, 100% pervious

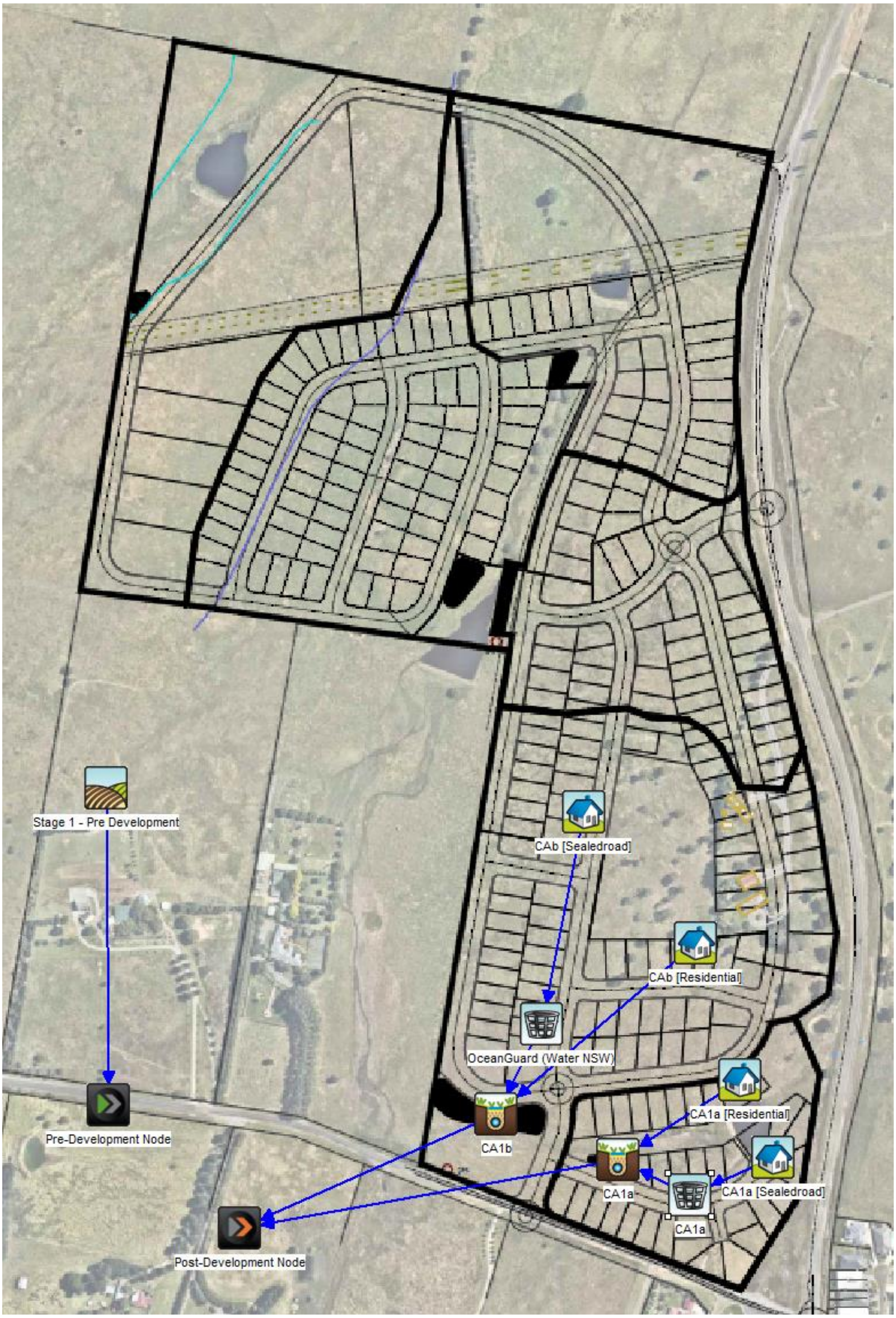

Figure 7: MUSIC Schematic – Stage 1

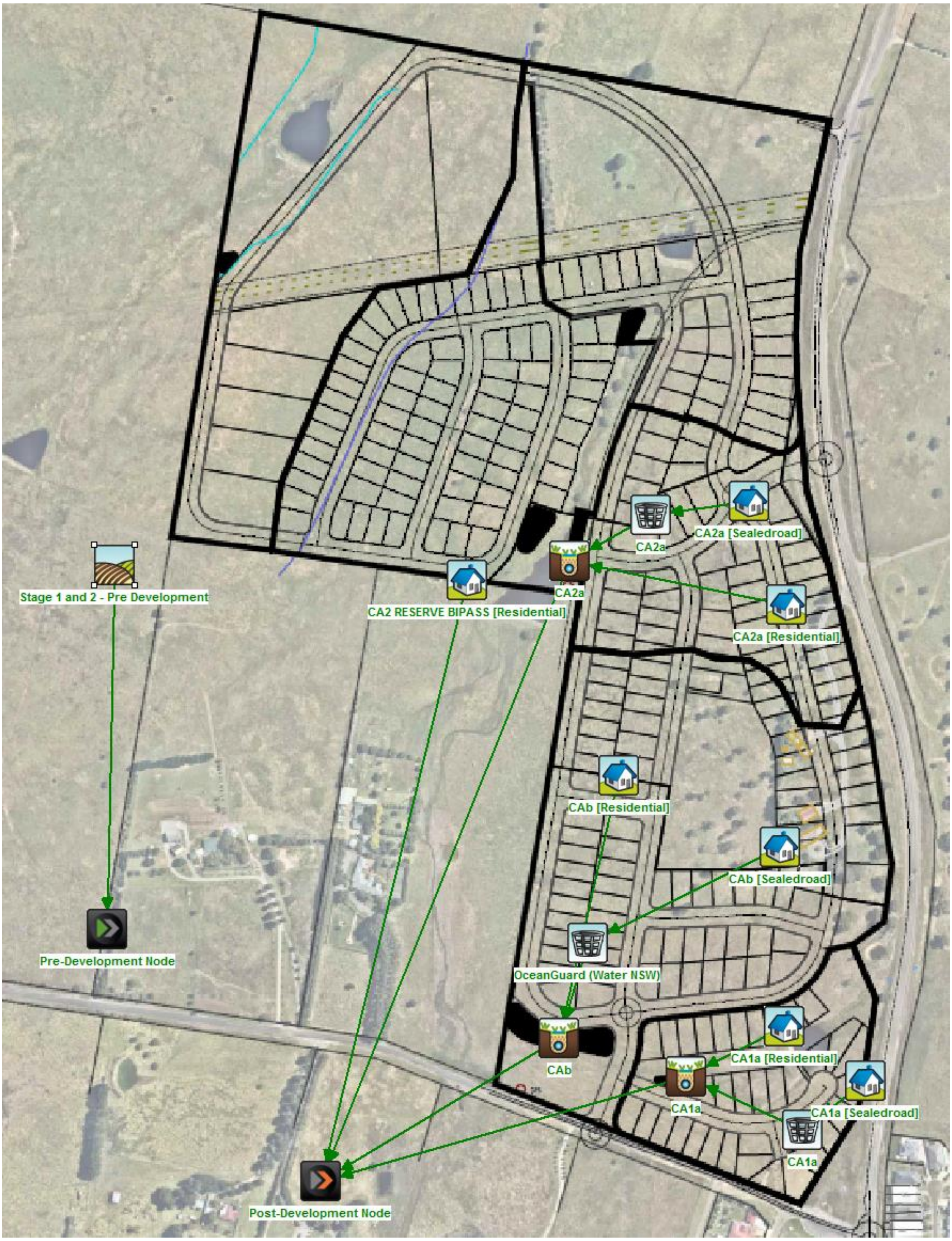

Figure 8: MUSIC Schematic – Stage 1 and 2

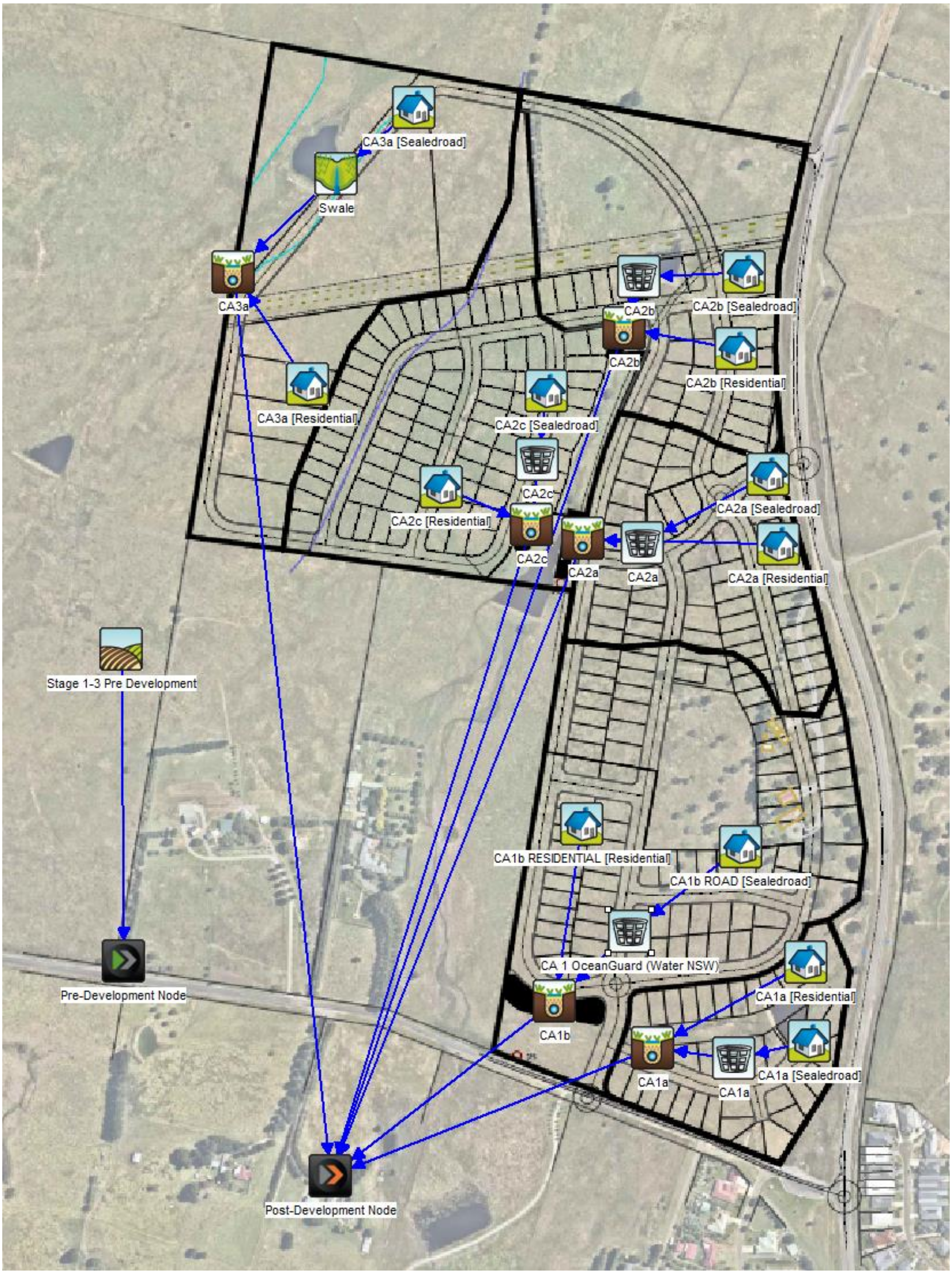

Figure 9: MUSIC Schematic – Full Development (All Stages)

6.2.4 Post-development Modelling Assumptions

Post-development modelling is based on the following assumptions:

- The plan described in Section 5 and attached is implemented
- The model is divided into six catchments as shown in Figure 10 and as described in Table 8 to Table 10.

All future lots have been modelling with a 0% impervious area as the water quality modelling has been undertaken for the proposed subdivision works only (roads and footpaths etc.). The owner of each future lot would need to undertake their own Neutral or Beneficial Assessment (NorBE) on water quality relating to the amount of impervious area proposed with the lot (i.e roof area, driveways and sheds etc.). All roads reserve areas have been modelling as 60% effective impervious. Tis calculation accounts for the road pavement width and concrete footpaths.

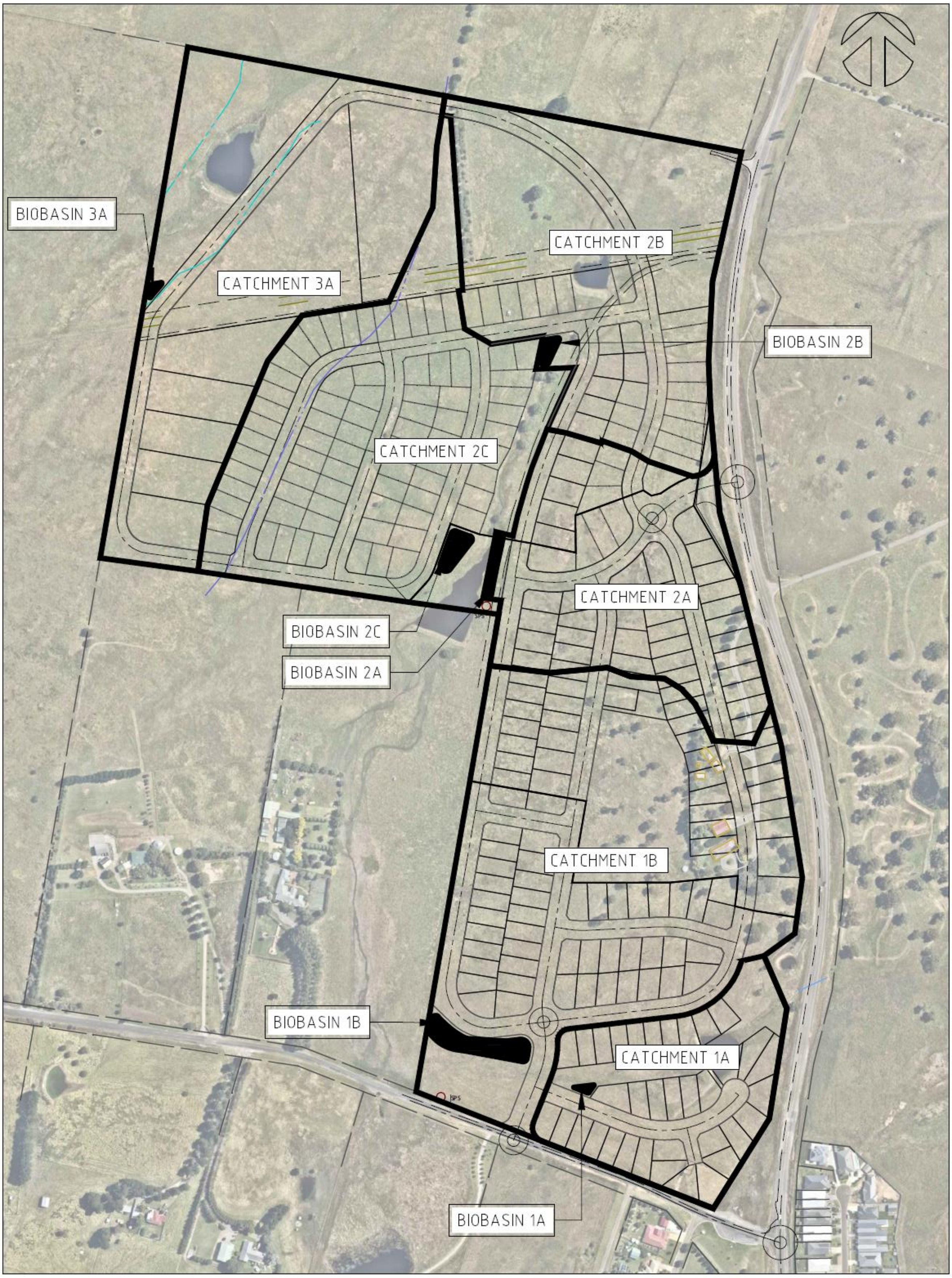

Figure 10: Catchment Plan and Bioretention Basins

Table 8: Catchments Post Development – Stage 1

Stage 1	Residential (ha)	Road (ha)	Total (ha)	Basin Area (m^2)	Filter Area (m^2)
1A	3.57	0.53	4.10	150	100.00
1B	4.6	2.56	7.16	2200	1500

Table 9: Catchments Post Development – Stage 1 and 2

Stage 2	Residential (ha)	Road (ha)	Total (ha)	Basin Area (m^2)	Filter Area (m^2)
1A	3.57	0.53	4.10	150	100
1B	9.35	3.46	12.81	2200	1500
2A	3.22	1.49	4.71	500	400
Catchment 2 BIPASS	0.49	N/A	0.49	N/A	N/A

Table 10: Catchments Post Development – Full Development (All Stages)

Catchment	Residential (ha)	Road (ha)	Total (ha)	Basin Area (m^2)	Filter Area (m^2)
1A	3.57	0.53	4.10	150	100
1B	9.35	3.46	12.81	2200	1500
2A	4.04	1.81	5.85	500	400
2B	6.57	1.56	8.13	380	300
2C	5.95	2.20	8.15	860	700
3A	9.87	1.61	11.48	150	100

6.3 Modelling Results

6.3.1 Mean Annual Loads

Table 11 to Table 13 presents the results of the modelling for the development. It shows the proposed treatment system would improve on the existing mean annual loads of sediment and nutrients in water leaving the site.

Table 11 – Stage 1 MUSIC results – Mean Annual Loads

	Inflow	
	Pre	Post
Flow (ML/yr)	9.54	15.9
Total Suspended Solids (kg/yr)	1.22E3	207
Total Phosphorus (kg/yr)	4.43	1.30
Total Nitrogen (kg/yr)	26.3	13.0
Gross Pollutants (kg/yr)	0.00	94.8E-3

Table 12 - Stage 1 and 2 MUSIC results – Mean Annual Loads

	Inflow	
	Pre	Post
Flow (ML/yr)	18.9	31.6
Total Suspended Solids (kg/yr)	2.24E3	472
Total Phosphorus (kg/yr)	8.78	2.79
Total Nitrogen (kg/yr)	48.1	27.1
Gross Pollutants (kg/yr)	0.00	0.404

Table 13- Stage 1-3 MUSIC results – Mean Annual Loads

	Inflow	
	Pre	Post
Flow (ML/yr)	43.0	70.2
Total Suspended Solids (kg/yr)	5.04E3	1.42E3
Total Phosphorus (kg/yr)	22.6	6.58
Total Nitrogen (kg/yr)	116	65.6
Gross Pollutants (kg/yr)	0.00	0.453

6.3.2 Pollutant Concentrations

To demonstrate neutral or beneficial effect, the post-development pollutant concentrations need to be less than or equal to the pre-development concentrations between (at least) 50 and 98 percent of the time. Figure 11 to Figure 16 show the TP and TN graphs for pollutant concentrations in both pre and post (treated) development scenarios. NorBE is met in all cases.

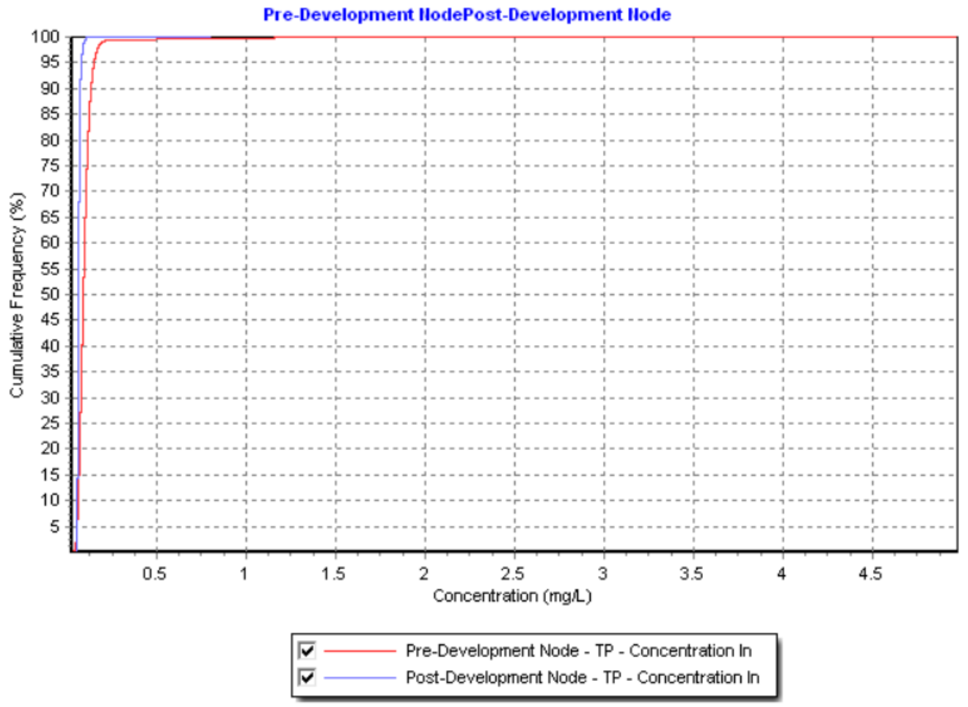

Figure 11: Stage 1 Total Phosphorous Concentration Graph

Figure 12: Stage 1 Total Nitrogen Concentration Graph

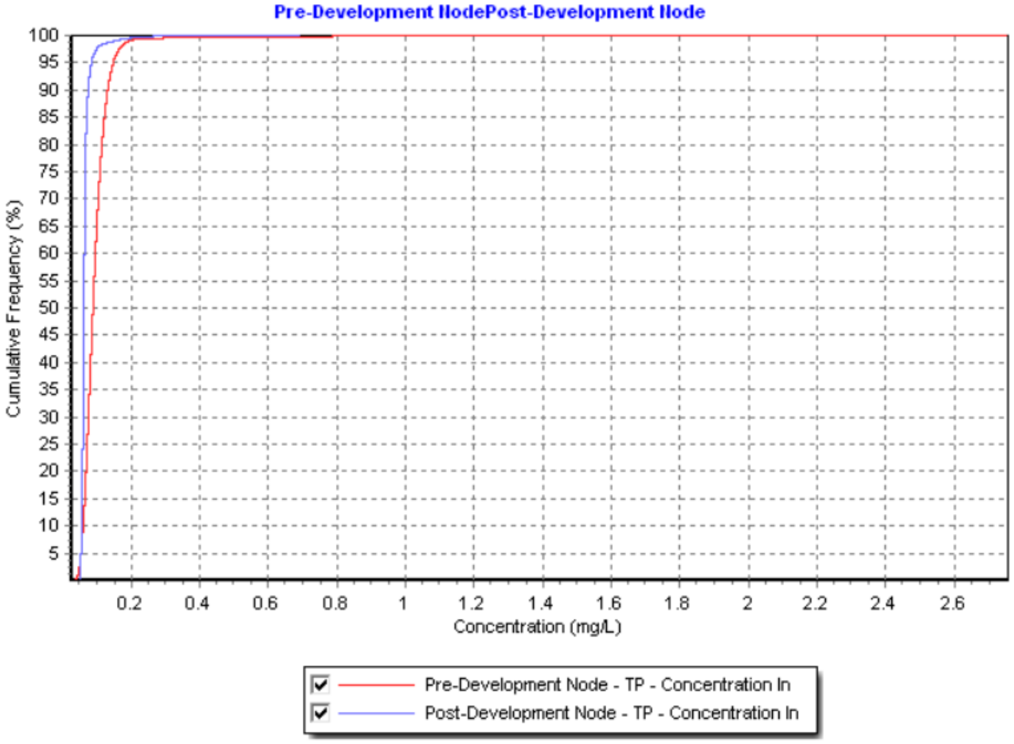

Figure 13: Stage 1 and 2 Total Phosphorous Concentration Graph

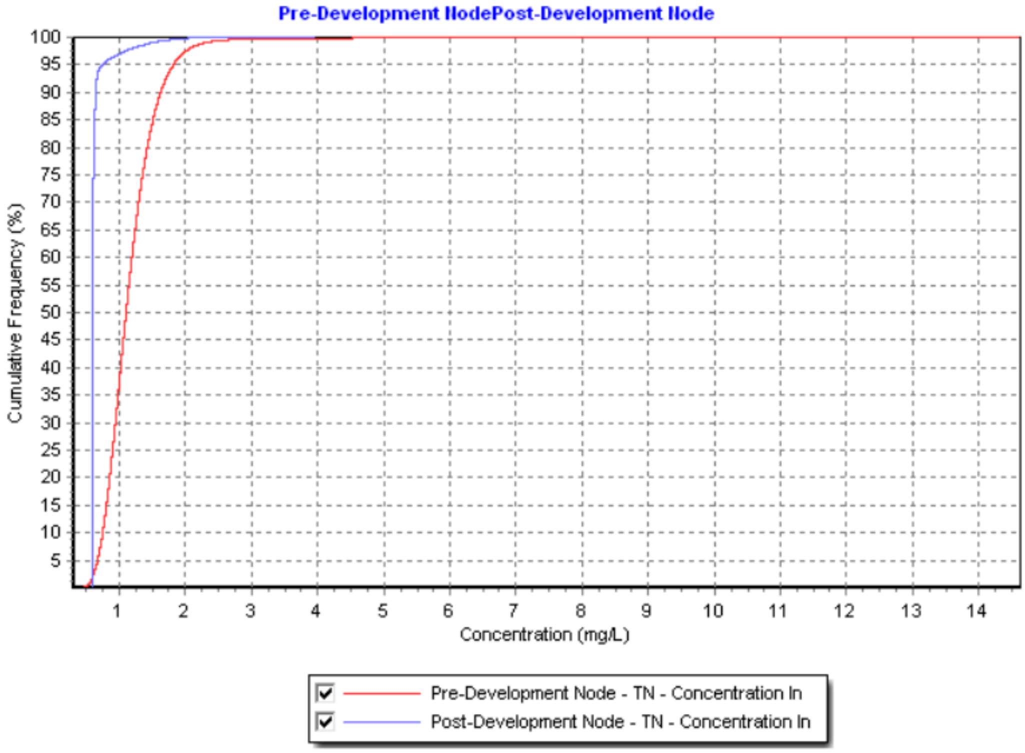

Figure 14: Stage 1 and 2 Total Nitrogen Concentration Graph

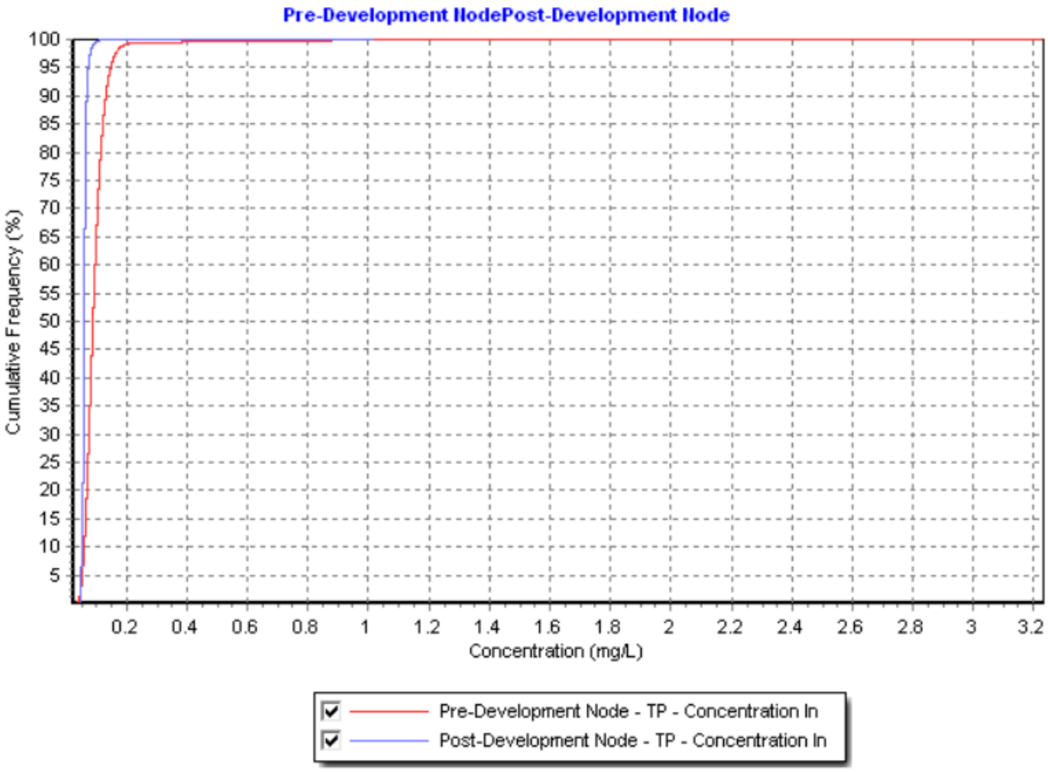

Figure 15 – Stage 1-3 Total Phosphorous Concentration Graph

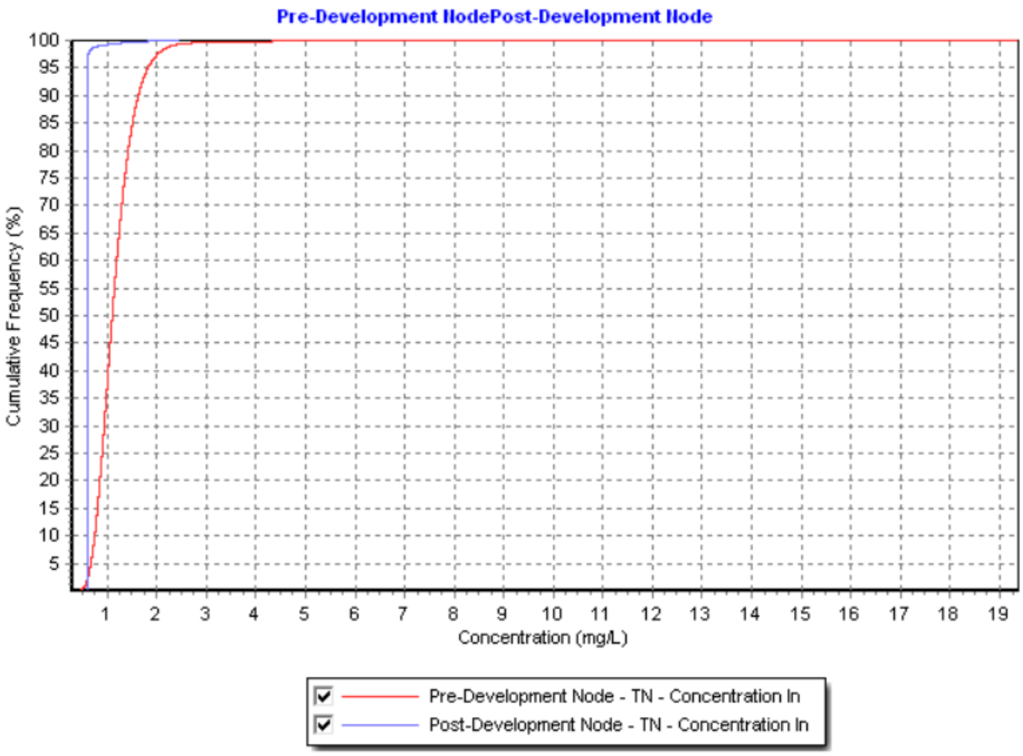

Figure 16 – Stage 1-3 Total Nitrogen Concentration Graph

7 CONCLUSIONS

The results of the MUSIC modelling demonstrate that a beneficial effect can be achieved, providing the proposed Water Cycle Management Plan (Section 5) is implemented. Therefore future detailed designs are to incorporate concepts listed in this report. Without these specific measures, the development could potentially have a negative impact on water quality. The plan includes a set of long-term maintenance strategies to ensure that the effectiveness of the proposed measures provides ongoing benefits for water quality.

Section 5 of this report details the measures required to achieve a neutral or beneficial effect. We recommend that this plan be implemented in full, as it provides an integrated management strategy for water quality control.

8 REFERRENCES

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