STORMWATER FLOW AND QUALITY MANAGEMENT PLAN

For a

PROPOSED LOW DENSITY RESIDENTIAL SUBDIVISION

At

Lot 217, DP 755242
18 Gosford Road
Wyee

On instruction from

Mr Chris Oliver – Optima Developments

Prepared by

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Document Registered By	Peter Bacon Principal Consultant

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1. INTRODUCTION

This section provides the background information to the plan.

This Stormwater Quality and Quantity Plan, hereafter referred to as the Stormwater Management Plan, was prepared to demonstrate sustainable management of stormwater within a proposed low density residential subdivision on lot 217 DP 755242, 18 Gosford Road, Wyee. The Stormwater Management Plan aims to be consistent with Lake Macquarie City Council's Water Sensitive Urban Design policies and objectives as identified in the MUSIC Link Output. .

The MUSIC-link software for Lake Macquarie City Council is used to demonstrate compliance with Council's requirements.

1.1 LOCATION

The subject site is in Wyee, which is within the Lake Macquarie City Council LGA.

The address is Lot 217, DP 755242, 18 Gosford Road, Wyee. Figure 1.1 shows the site.

Figure 1.1. The subject site is in Wyee. Access is off Gosford Road. (Image source: NSW Gov).

Figure 1.2. The subject Site is on the SW 'edge' of Wyee.

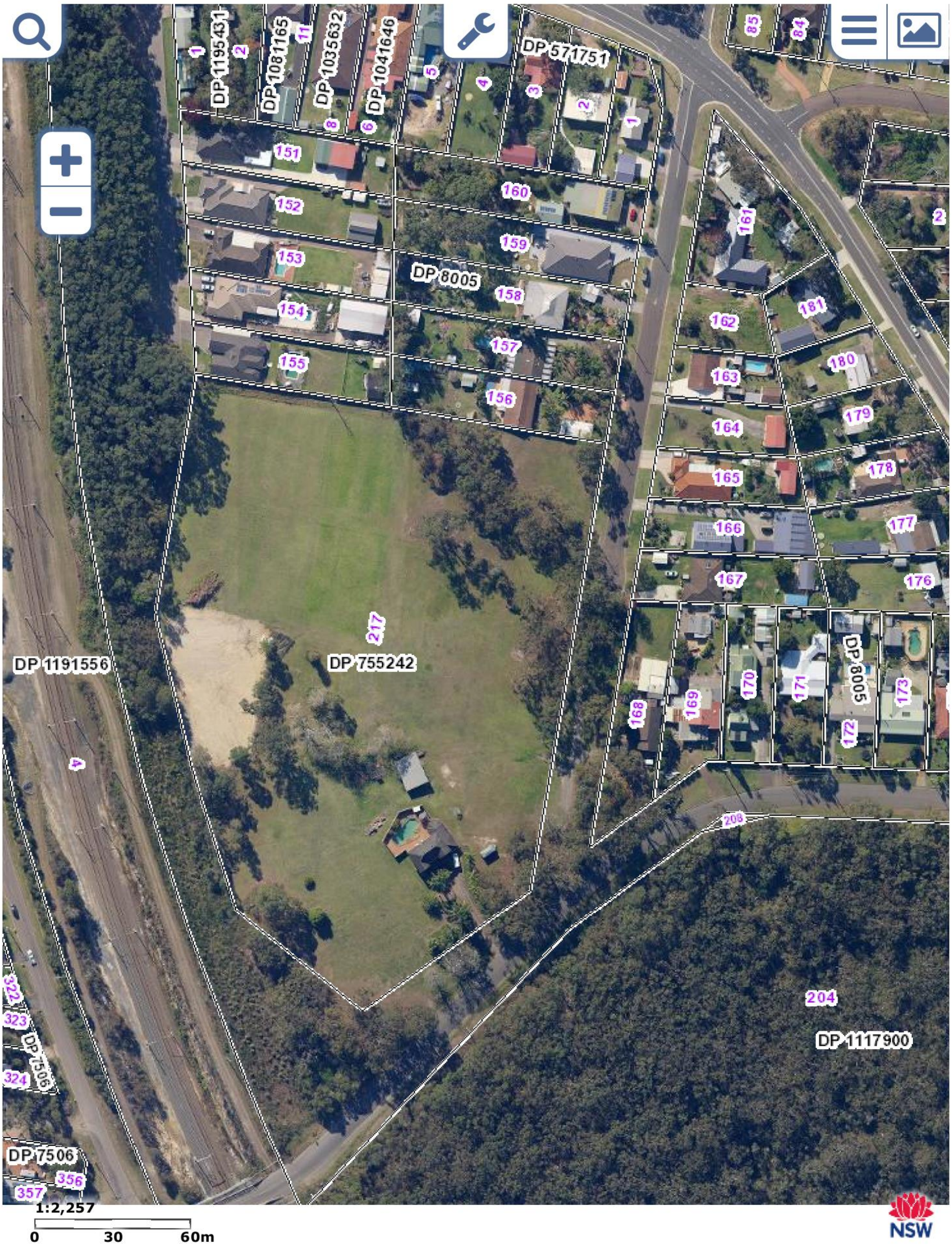


Figure 1.3. Close up of the subject site (Lot 217, DP 755242). Image source: NSW Gov.

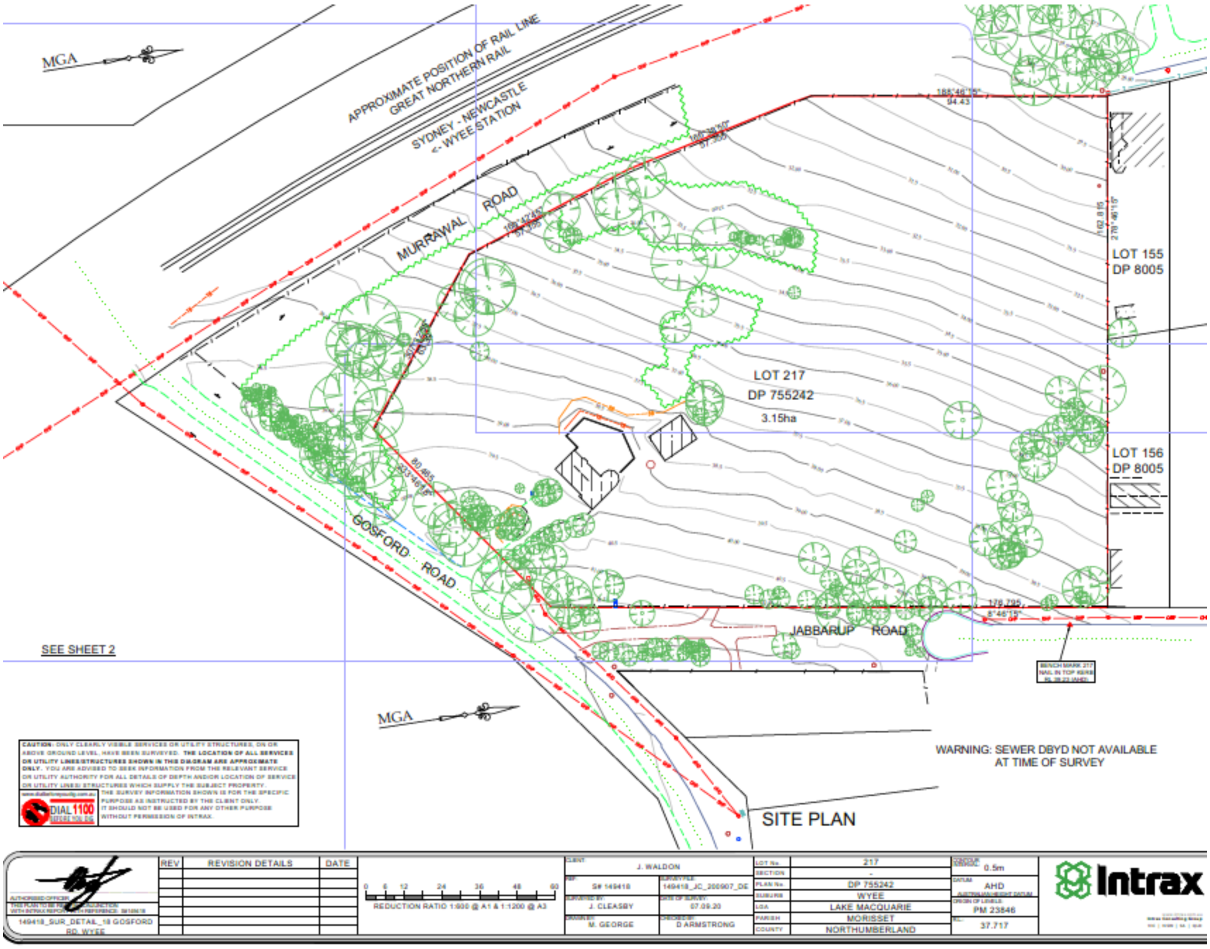


Figure 1.4. The contour map of the site (Source: INTRAX). The site drains to the north west.

1.2 EXTRACT OF COUNCIL'S INTIAL PLANNING ADVICE (FROM LETTER OF ADAM KENNEDY OF LMCC, DATED 20 AUG 2020.)

Water quality

The site is identified to be at the top of the local catchment, nevertheless, Gosford Road is a significant drainage line that delivers water to a larger patches of Ecological Endangered Communities (EEC) downstream. Maintaining existing hydrology is important for these downstream patches of EEC and they are also prone to significant flooding. The proposed rezoning has the potential to alter these flows affecting the EECs and downstream flooding. Water quantity, quality, frequency of inundation and height of inundation throughout this catchment is important and is likely to require a stormwater and water quality assessment including baseline surveys to establish the existing regime.

This stormwater Management Plan aims to demondstrate compliance with Council's WSUD objectives as well as responding to concerns with the EEC.

1.3 STORMWATER MANAGEMENT OBJECTIVES

The key aim of the stormwater management system is to ensure no increase in peak flow rates compared with current rates. This will be achieved by a combination of onsite rainwater detention and reuse, together with bioretention and wetland systems designed to attenuate stormwater peak flow.

The combination of detention, reuse and treatment within the wetland system will also reduce the contaminant load exiting the site. A key aim of Water Sensitive Urban Design (WSUD) is to reduce the impact of development on contaminant loads exiting the precinct. Typically, these targets are expressed as the percentage reduction compared with that expected from the same development but without WSUD elements.

The indicative targets used for this low density residential development are taken from the stormwater treatment objectives for Victoria and NSW (Engineers Australia, 2006)

- 80% reduction in mean annual load of total suspended solids (TSS) (kg/y)
- 45% reduction in mean annual load of total phosphorus (P) (kg/y)
- 45% reduction in mean annual load of total nitrogen (N) (kg/y)
- Retention of 100% of litter greater than 5mm for all flows up to the 3 month ARI peak flow
- No visible oils for flows up to the 3-month ARI peak flow.

Additionally, it was expected to have:

- No increase in peak outflow (cubic m/sec)
- 90% reduction in mean annual load of gross pollutants (kg/y)

MUSIC modelling was used to establish the extent to which these criteria were achieved.

Site specific objectives

The subject site has an Endangered Ecological Community between its western boundary and the Sydney-Newcastle Rail Corridor (LMC, pers comm).

Council has concern that residential development on the subject site will increase flooding into this EEC.

The subject site slopes towards the EEC, so it is important that the WSUD components reduce the peak outflows to rates that do not exceed the current peak rates.

Further, the outlet system should utilise existing stormwater outlets and infrastructure rather than develop new drainage systems into to corridor.

The current Stormwater Management Plan aims to ensure outflows are less than the current rates. The system will also ensure the reduction in contaminant loads meet the Council's WESU objectives.

2. THE REGULATORY REQUIREMENTS

Lake Macquarie City Council uses MUSIC-Link to examine the inputs and outputs of the site's MUSIC model. This data is then compared with Council's requirements.

These requirements and the MUSIC Guidelines for Version 6.3 have been used.

Key references

The key MUSIC reference used in developing the model are

- SCA (2012). Using MUSIC in Sydney's Drinking Water Catchment. A Sydney Catchment Authority Standard. Statewater, Parramatta.
- Using MUSIC-link for Lake Macquarie City Council

Objectives and permissible activities in R2 Low Density Residential Land (from 2014 LEP)

Zone R2 Low Density Residential

1 Objectives of zone

• To provide for the housing needs of the community within a low density residential environment.

• To enable other land uses that provide facilities or services to meet the day to day needs of residents.

• To encourage development that is sympathetic to the scenic, aesthetic and cultural heritage qualities of the built and natural environment.

2 Permitted without consent

Home-based child care; Home occupations

3 Permitted with consent

Bed and breakfast accommodation; Boarding houses; Boat sheds; Building identification signs; Business identification signs; Centre-based child care facilities; Community facilities; Dual occupancies; Dwelling houses; Emergency services facilities; Environmental facilities; Environmental protection works; Exhibition homes; Exhibition villages; Flood mitigation works; Group homes; Health consulting rooms; Home businesses; Home industries; Hostels; Kiosks; Neighbourhood shops; Oyster aquaculture; Places of public worship; Pond-based aquaculture; Recreation areas; Respite day care centres; Roads; Secondary dwellings; Semi-detached dwellings; Seniors housing; Sewage reticulation systems; Sewage treatment plants; Shop top housing; Tank-based aquaculture; Water recreation structures; Water recycling facilities; Water supply systems

4 Prohibited

Any other development not specified in item 2 or 3

Environmental facilities, environment protection and flood mitigation activities are all permitted with 'Consent' on R2 and E3 zoned land.

The table below shows the landuse matrix.

Lake Macquarie Local Environmental Plan 2014	Rural						Residential					Business							Industrial				SP3	Recr'n		Env Prot'n			Waterways		
	RU1 Primary Production	RU2 Rural Landscapes	RU3 Forestry	RU4 Primary Production Small Lots	RU5 Village	RU6 Transition	R1 General Residential	R2 Low Density Residential	R3 Medium Density Residential	R4 High Density Residential	R5 Large Lot Residential	B1 Neighbourhood Centre	B2 Local Centre	B3 Commercial Core	B4 Mixed Use	B5 Business Development	B6 Enterprise Corridor	B7 Business Park	IN1 General Industrial	IN2 Light Industrial	IN3 Heavy Industrial	IN4 Working Waterfront	SP3 Tourist	RE1 Public Recreation	RE2 Private Recreation	E2 Environmental Conservation	E3 Environmental Management	E4 Environmental Living	W1 Natural Waterways	W2 Recreational Waterways	W3 Working Waterways
Is the zone used? [please select Y/N for each zone]	Y	Y	Y	N	Y	Y	Y	Y	Y	N	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	N	Y	Y	Y	Y	Y	Y	Y	Y	N
(LAND USE TERMS WITHIN AGRICULTURE GROUP TERM)																															
Agriculture	x	x	x		x	x	x	x	x		x	x	x	x	x	x	x	x	x	x			x	x	x	x	x	x	x	x	
Aquaculture	c	x	x		x	x	x	x	x		x	x	x	x	x	x	x	x	x	x			x	x	x	x	x	x	x	c	
Extensive agriculture	o	o	x		x	c	x	x	x		x	x	x	x	x	x	x	x	x	x			x	x	x	x	c	x	x	x	
Bee keeping	o	o	x		x	c	x	x	x		x	x	x	x	x	x	x	x	x	x			x	x	x	x	c	c	x	x	
Dairy (pasture based)	o	o	x		x	c	x	x	x		x	x	x	x	x	x	x	x	x	x			x	x	x	x	c	x	x	x	
Intensive livestock agriculture	c	x	x		x	x	x	x	x		x	x	x	x	x	x	x	x	x	x			x	x	x	x	x	x	x	x	
Feedlots	c	x	x		x	x	x	x	x		x	x	x	x	x	x	x	x	x	x			x	x	x	x	x	x	x	x	
Restricted dairies	c	x	x		x	x	x	x	x		x	x	x	x	x	x	x	x	x	x			x	x	x	x	x	x	x	x	
Intensive plant agriculture	c	c	x		x	x	x	x	x		x	x	x	x	x	x	x	x	x	x			x	x	x	x	x	x	x	x	
Horticulture	c	c	x		x	c	x	x	x		x	x	x	x	x	x	x	x	x	x			x	x	x	x	c	c	x	x	
Turf farming	c	c	x		x	x	x	x	x		x	x	x	x	x	x	x	x	x	x			x	x	x	x	x	x	x	x	
Viticulture	c	c	x		x	x	x	x	x		x	x	x	x	x	x	x	x	x	x			x	x	x	x	x	x	x	x	
(LAND USE TERMS OUTSIDE AGRICULTURE GROUP TERM)																															
Animal boarding or training establishment	c	c	x		x	c	x	x	x		c	x	x	x	x	x	x	x	c	c			x	x	x	x	x	c	x	x	
Farm buildings	c	c	x		x	c	x	x	x		x	x	x	x	x	x	x	x	x	x			x	x	x	x	c	c	x	x	
Forestry	c	c	o		x	x	x	x	x		x	x	x	x	x	x	x	x	x	x			x	x	x	x	x	x	x	x	
(LAND USE TERMS WITHIN RESIDENTIAL GROUP TERM)																															
Residential Accomodation	x	x	x		x	x	x	x	x		x	x	x	x	x	x	x	x	x	x			x	x	x	x	x	x	x	x	
Attached dwelling	x	x	x		x	x	c	x	c		x	x	x	x	x	x	x	x	x	x			c	x	x	x	x	x	x	x	
Boarding houses	x	x	x		x	x	c	c	c		x	c	c	c	c	x	x	x	x	x			x	x	x	x	x	x	x	x	
Dual occupancies	c	c	x		x	c	c	c	c		c	x	x	x	x	x	x	x	x	x			x	x	x	x	c	c	x	x	
Dual occupancy (attached)	c	c	x		x	c	c	c	c		c	x	x	x	x	x	x	x	x	x			x	x	x	x	c	c	x	x	
Dual occupancy (detached)	c	c	x		x	c	c	c	c		c	x	x	x	x	x	x	x	x	x			x	x	x	x	c	c	x	x	
Dwelling houses	c	c	x		c	c	c	c	c		c	x	x	x	x	x	x	x	x	x			c	x	x	x	c	c	x	x	
Group homes	x	x	x		x	x	c	c	c		c	x	x	x	x	x	x	x	x	x			x	x	x	x	x	c	x	x	
Group home (permanent)	x	x	x		x	x	c	c	c		c	x	x	x	x	x	x	x	x	x			x	x	x	x	x	c	x	x	
Group home (transitional)	x	x	x		x	x	c	c	c		c	x	x	x	x	x	x	x	x	x			x	x	x	x	x	c	x	x	
Hostels	x	x	x		x	x	c	x	c		x	x	x	x	x	x	x	x	x	x			x	x	x	x	x	x	x	x	
Multi dwelling housing	x	x	x		x	x	c	x	c		x	x	x	x	x	x	x	x	x	x			x	x	x	x	x	x	x	x	
Residential flat building	x	x	x		x	x	c	x	c		x	x	x	x	c	x	x	x	x	x			x	x	x	x	x	x	x	x	
Rural worker's dwelling	c	x	x		x	x	x	x	x		x	x	x	x	x	x	x	x	x	x			x	x	x	x	x	x	x	x	
Secondary dwellings	x	x	x		c	x	c	c	c		x	x	x	x	x	x	x	x	x	x			c	x	x	x	c	c	x	x	
Semi detached dwelling	x	x	x		x	x	c	c	c		x	x	x	x	x	x	x	x	x	x			c	x	x	x	x	x	x	x	
Seniors housing	x	x	x		x	x	c	x	c		x	x	x	x	c	x	x	x	x	x			x	x	x	x	x	x	x	x	
Residential Care facilities	x	x	x		c	x	c	x	c		x	x	x	x	c	x	x	x	x	x			x	x	x	x	x	x	x	x	
Shop top housing	x	x	x		c	x	c	c	c		x	c	c	c	c	c	c	c	x	x			c	x	x	x	x	x	x	x	
(LAND USE TERMS OUTSIDE RESIDENTIAL GROUP TERM)																															
Home based childcare	o	o	x		o	o	o	o	o		o	o	c	c	c	c	c	c	x	x			x	x	x	x	o	o	x	x	
Home business	c	c	x		c	c	c	c	c		c	c	c	c	c	c	c	c	x	x			c	x	x	x	c	c	x	x	
Home occupations	o	o	x		o	c	o	o	o		o	o	c	c	c	c	c	c	x	x			c	x	x	x	o	o	x	x	
Home occupations (sex services)	c	c	x		c	x	c	x	x		c	c	c	c	c	c	c	x	x	x			x	x	x	x	x	c	x	x	
(LAND USE TERMS WITHIN TOURIST AND VISITOR ACCOMODATION GROUP TERM)																															
Tourist and visitor accommodation	x	x	x		x	x	x	x	c		x	x	c	c	c	x	x	x	x	x			c	x	x	x	x	x	x	x	
Backpackers accommodation	x	x	x		c	x	x	x	c		x	x	c	c	c	x	x	x	x	x			c	x	x	x	x	x	x	x	
Bed and breakfast accommodation	c	c	x		c	c	c	c	c		c	c	c	c	c	x	x	x	x	x			c	x	x	x	c	c	x	x	
Farm stay accommodation	c	c	x		x	x	x	x	x		x	x	c	c	c	x	x	x	x	x			c	x	x	x	c	x	x	x	
Hotel or motel accommodation	x	x	x		c	x	c	x	c		x	x	c	c	c	c	c	c	x	x			c	x	x	x	x	x	x	x	
Serviced apartment	x	x	x		x	x	c	x	c		x	x	c	c	c	x	c	c	x	x			c	x	x	x	x	x	x	x	
(LAND USE TERMS OUTSIDE TOURIST AND VISITOR ACCOMODATION GROUP TERM)																															
Camping grounds	c	c	c		c	x	x	x	x		x	x	x	x	x	x	x	x	x	x			x	c	c	x	x	x	x	x	
Caravan parks	x	x	x		x	x	c	x	c		x	x	x	x	x	x	x	x	x	x			c	c	c	x	x	x	x	x	
Eco-tourist facilities	x	x	x		x	x	x	x	x		x	x	x	x	x	x	x	x	x	x			c	x	x	c	c	x	x	x	
(LAND USE TERMS WITHIN COMMERCIAL PREMISES GROUP TERM)																															
Commercial premises	x	x	x		x	x	x	x	x		x	c	c	c	c	c	c	x	x	x			x	x	x	x	x	x	x	x	
Business premises	x	x	x		c	x	x	x	x		x	c	c	c	c	c	c	x	x	x			x	x	x	x	x	x	x	x	
Funeral homes	x	x	x		c	x	x	x	x		x	c	c	c	c	c	c	x	x	x			x	x	x	x	x	x	x	x	
Office premises	x	x	x		c	x	x	x	x		x	x	c	c	c	c	c	c	x	x			x	x	x	x	x	x	x	x	
Retail premises	x	x	x		x	x	x	x	x		x	x	c	c	c	x	x	x	x	x			x	x	x	x	x	x	x	x	
Bulky goods premises	x	x	x		x	x	x	x	x		x	x	c	c	c	c	c	x	x	x			x	x	x	x	x	x	x	x	
Cellar door premises	c	c	x		c	x	x	x	x		x	x	c	c	c	x	x	x	x	x			x	x	x	x	x	x	x	x	
Food and drink premises	x	x	x		c	x	x	x	x		x	c	c	c	c	c	c	c	c	c			c	c	c	x	x	x	x	x	
Pubs	x	x	x		c	x	x	x	x		x	c	c	c	c	c	c	c	c	c			c	c	c	x	x	x	x	x	
Restaurants or cafes	x	x	x		c	x	x	x	x		x	c	c	c	c	c	c	c	c	c			c	c	c	x	x	x	x	x	
Take-away food and drink premises	x	x	x		c	x	x	x	c		x	c	c	c	c	c	c	c	c	c			c	c	c	x	x	x	x	c	
Garden centres	x	x	x		c	x	x	x	x		x	x	c	c	c	c	c	c	c	c			x	x	x	x	x	x	x	x	
Hardware and building supplies	x	x	x		c	x	x	x	x		x	c	c	c	c	c	c	c	c	c			x	x	x	x	x	x	x	x	
Kiosks	x	x	c		c	x	x	x	x		x	c	c	c	c	x	c	c	c	c			c	c	c	x	x	x	x	c	
Landscaping material supplies	x	x	x		x	x	x	x	x		x	x	c	c	c	c	c	x	c	c			x	x	x	x	x	x	x	x	
Markets	x	x	x		c	x	x	x	x		x	x	c	c	c	c	c	x	x	x			x	c	c	x	x	x	x	x	
Plant nurseries	x	x	x		c	x	x	x	x		x	x	c	c	c	c	c	x	c	c			x	x	x	x	x	x	x	x	
Roadside stalls	c	c	x		c	x	x	x	x		x	x	c	c	c	x	x	x	x	x			x	x	x	x	c	c	x	x	
Rural supplies	c	x	x		c	x	x	x	x		x	x	c	c	c	c	c	x	c	c			x	x	x	x	x	x	x	x	
Shops	x	x	x		c	x	x	x	x		x	c	c	c	c	x	x	x	x	x			x	x	x	x	x	x	x	x	
Neighbourhood shops	x	x	x		c	x	c	c	c		x	c	c	c	c	c	c	c	c	c			c	x	x	x	x	x	x	x	
Timber yards	x	x	x		x	x	x	x	x		x	x	c	c	c	c	c	x	c	c			x	x	x	x	x	x	x	x	
Vehicle sales or hire premises	x	x	x		x	x	x	x	x		x	x	c	c	c	c	c	x	c	c			x	x	x	x	x	x	x	x	
(LAND USE TERMS OUTSIDE COMMERCIAL PREMISES GROUP TERM)																															
Amusement centres	x	x	x		x	x	x	x	x		x	x	c	c	c	c	c	x	c	c			c	x	c	x	x	x	x	x	
Entertainment facilities	x	x	x		c	x	x	x	x		x	x	c	c	c	c	c	x	x	x			c	c	c	x	x	x	x	x	
Function centres	x	x	x		c	x	x	x	x		x	x	c	c	c	c	c	x	x	x			c	c	c	x	x	x	x	x	
Highway service centres	x	x	x		x	x	x	x	x		x	c	c	c	c	c	c	x	c	c			x	x	x	x	x	x	x	x	
Industrial retail outlets	x	x	x		x	x	x	x	x		x	x	c	x	x	x	x	x	c	c			x	x	x	x	x	x	x	x	
Registered clubs	x	x	x		c	x	x	x	x		x	c	c	c	c	x	c	x	x	x			c	c	c	x	x	x	x	x	
Restricted premises	x	x	x		x	x	x	x	x		x	x	c	c	c	c	c	x	c	c			x	x	x	x	x	x	x	x	
Service stations	x	x	x		c	x	x	x	x		x	c	c	c	c	c	c	c	c	c			x	x	x	x	x	x	x	x	
Sex service premises	x	x	x		x	x	x	x	x		x	x	c	c	x	x	c	c	c	c			x	x	x	x	x	x	x	x	
Veterinary hospitals	c	c	x		c	x	x	x	x		c	c	c	c	c	c	c	c	c	c			x	x	x	x	x	x	x	x	
Wholesale supplies	x	x	x		x	x	x	x	x		x	x	x	x	x	c	c	c	c	c			x	x	x	x	x	x	x	x	
(LAND USE TERMS WITHIN RURAL INDUSTRIES GROUP TERM)																															
Rural industries	c	c	x		x	x	x	x	x		x	x	x	x	x	x	x	x	c	x			x	x	x	x	x	x	x	x	
Agricultural produce industries	c	c	x		x	x	x	x	x		x	x	x	x	x	x	x	x	c	x			x	x	x	x	x	x	x	x	
Livestock processing industries	c	c	x		x	x	x	x	x		x	x	x	x	x	x	x	x	c	x			x	x	x	x	x	x	x	x	
Sawmill or log processing industries	c	c	x		x	x	x	x	x		x	x	x	x	x	x	x	x	c	x			x	x	x	x	x	x	x	x	
Stock and sale yards	c	c	x		x	x	x	x	x		x	x	x	x	x	x	x	x	c	x			x	x	x	x	x	x	x	x	
(LAND USE TERMS WITHIN INDUSTRIES GROUP TERM)																															
Industries	x	x	x		x	x	x	x	x		x	x	x	x	x	x	x	x	c	x			x	x	x	x	x	x	x	x	
Heavy industries	x	x	x		x	x	x	x	x		x	x	x	x	x	x	x	x	x	x			x	x	x	x	x	x	x	x	
Hazardous industry	x	x	x		x	x	x	x	x		x	x	x	x	x	x	x	x	x	x			x	x	x	x	x	x	x	x	
Offensive industry	x	x	x		x	x	x	x	x		x	x	x	x	x	x	x	x	x	x			x	x	x	x	x	x	x	x	
Light industries	x	x	x		x	x	x	x	x		x	x	x	x	x	c	c	c	c	c			x	x	x	x	x	x	x	x	
High technology industries	x	x	x		x	x	x	x	x		x	x	x	x	x	c	c	c	c	c			x	x	x	x	x	x	x	x	
Home Industry	c	c	x		c	c	c	c	x		c	x	x	x	x	c	c	c	c	c			x	x	x	x	c	c	x	x	

(OTHER LAND USE TERMS RELATING TO INFRASTRUCTURE)																										
Car parks	x	x	x	x	x	c	c	c	x	c	c	c	c	c	c	c	c	c	c	x	x	x	x	x	x	x
Electricity generating works	x	x	x	x	c	x	x	x	x	x	x	x	x	c	c	c	c	c	x	x	x	x	x	x	x	x
Freight transport facilities	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	c	c	x	x	x	x	x	x	x	x
Passenger transport facilities	x	x	x	x	x	x	x	x	x	x	c	c	c	c	c	c	x	x	c	x	x	x	x	x	c	c
Port facilities	x	x	x	x	x	x	x	x	x	c	c	c	c	c	c	c	x	x	x	x	x	x	x	x	x	x
Roads	c	c	c	c	c	c	c	c	c	c	c	c	c	c	c	c	c	c	c	c	c	c	c	c	x	x
Transport depots	x	x	x	x	x	x	x	x	x	x	x	x	x	c	c	c	c	c	x	x	x	x	x	x	x	x
Truck depots	x	x	x	x	x	x	x	x	x	x	x	x	x	c	c	x	c	c	x	x	x	x	x	x	x	x
Wharf or boating facilities	x	x	x	x	x	x	x	c	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	c
(LAND USE TERMS WITHIN EDUCATION ESTABLISHMENTS GROUP TERM)																										
Education establishments	x	x	x	x	x	c	x	x	x	c	c	c	c	c	c	c	x	x	x	x	x	x	x	x	x	x
Schools	x	x	x	c	c	c	x	x	x	c	c	c	c	c	c	c	x	x	x	x	x	x	x	x	x	x
(LAND USE TERMS WITHIN HEALTH SERVICES FACILITIES GROUP TERM)																										
Health services facilities	x	x	x	x	x	x	x	x	x	c	c	c	c	c	c	c	c	c	x	x	x	x	x	x	x	x
Hospitals	x	x	x	x	x	x	x	x	x	c	c	c	c	c	c	c	c	c	x	x	x	x	x	x	x	x
Medical centre	x	x	x	x	x	x	x	x	x	c	c	c	c	c	c	c	c	c	x	x	x	x	x	x	x	x
Health consulting rooms	x	x	x	x	x	x	c	x	x	c	c	c	c	c	c	c	c	c	x	x	x	x	x	x	x	x
(OTHER LAND USE TERMS RELATING TO COMMUNITY INFRASTRUCTURE)																										
Child care centres	x	x	x	c	x	c	c	c	c	c	c	c	c	c	c	c	c	c	x	c	x	x	x	c	x	x
Community facilities	c	c	x	c	c	c	c	c	c	c	c	c	c	c	c	c	c	c	c	c	c	x	c	c	x	x
Correctional centres	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Emergency services facilities	x	x	x	x	c	c	c	c	c	c	c	c	c	c	c	c	c	c	x	c	c	x	c	c	x	c
Industrial training facilities	x	x	x	x	x	x	x	x	x	x	x	x	x	c	c	c	c	c	x	x	x	x	x	x	x	x
Information and education facilities	c	c	c	c	c	c	c	c	c	c	c	c	c	c	c	c	x	x	c	c	c	x	c	c	x	c
Places of public worship	x	x	x	c	x	c	c	c	c	c	c	c	c	c	c	c	c	c	x	x	x	x	x	x	x	x
Public administration building	x	x	x	c	x	x	x	x	x	c	c	c	c	c	c	c	x	c	x	c	x	x	x	x	x	x
Research stations	x	x	x	x	c	x	x	x	c	x	x	x	c	c	c	c	c	c	x	x	x	c	c	c	c	x
Respite day care centres	x	x	x	c	x	c	c	c	c	c	c	c	c	c	c	c	x	x	x	c	x	x	x	c	x	x
(LAND USE TERMS WITHIN SIGNAGE GROUP TERM)																										
Signage	x	x	x	x	x	c	x	x	x	c	c	c	c	c	c	c	c	c	x	x	x	x	x	x	x	x
Advertising Structure	x	x	x	x	x	c	x	x	x	c	c	c	c	c	c	c	c	c	x	x	x	x	x	x	x	x
Building identification sign	c	c	x	c	c	c	c	c	c	c	c	c	c	c	c	c	c	c	c	c	c	x	c	c	x	c
Business identification sign	c	c	x	c	c	c	c	c	c	c	c	c	c	c	c	c	c	c	c	c	c	x	c	c	x	c
(LAND USE TERMS RELATING TO RECREATION)																										
Boat launching ramps	c	c	x	x	x	c	c	c	c	c	c	c	c	c	c	c	x	x	c	c	c	x	x	x	x	c
Boat sheds	x	x	x	x	x	c	c	c	c	c	c	c	c	c	c	c	x	x	c	c	c	x	x	x	x	c
Charter and tourism boating facilities	x	x	x	x	x	x	x	x	x	c	c	c	c	c	c	c	x	x	c	c	c	x	x	x	x	c
Environmental facilities	c	c	c	c	c	c	c	c	c	c	c	c	c	c	c	c	x	x	c	c	c	c	c	c	c	c
Jetties	x	x	x	x	x	c	c	c	c	c	c	c	c	c	c	c	x	x	c	c	c	x	x	x	c	c
Marinas	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	c	c	x	x	x	x	c
Mooring	x	x	x	x	x	x	x	x	x	c	c	c	c	c	c	c	x	x	x	c	c	x	x	x	x	c
Mooring pens	x	x	x	x	x	x	x	x	x	c	c	c	c	c	c	c	x	x	x	c	c	x	x	x	x	c
Recreation areas	c	c	c	c	c	c	c	c	c	c	c	c	c	c	c	c	c	c	c	c	c	c	c	c	x	x
Recreation facilities (indoor)	x	x	x	c	x	x	x	c	x	x	c	c	c	c	c	c	x	c	c	c	c	x	x	x	x	x
Recreation facilities (major)	x	x	x	x	x	x	x	x	x	x	c	c	c	c	c	c	c	x	c	c	c	x	x	x	x	x
Recreation facilities (outdoor)	c	c	c	c	c	x	x	c	x	x	x	c	c	c	c	c	x	c	c	c	c	x	x	x	x	x
Water recreation structures	c	c	x	x	c	x	x	x	c	c	c	c	c	c	c	c	x	x	c	c	c	x	c	x	x	c
(OTHER MISCELLANEOUS LAND USE TERMS)																										
Cemetery	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Crematorium	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	c	c	x	x	x	x	x	x	x	x
Environmental protection works	c	c	c	c	c	c	c	c	c	c	c	c	c	c	c	c	c	c	c	c	c	c	c	c	c	c
Exhibition home	x	x	x	x	x	c	c	x	x	x	x	x	x	x	x	x	x	x	c	x	x	x	x	x	x	x
Exhibition village	x	x	x	x	x	c	c	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Extractive industries	c	c	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Flood mitigation works	c	c	c	c	c	c	c	c	c	c	c	c	c	c	c	c	c	c	c	c	c	c	c	c	c	c
Mortuaries	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	c	c	x	x	x	x	x	x	x	x
Open cut mining	c	c	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x

3. CURRENT CONDITIONS

3.1 CURRENT LANDFORMS `

The subject site covers 3.15 ha. Figure 3.1 shows the highest point is in the SE corner. . The land slopes to the north and north west. The lowest point is in the NW corner.

The slope is even and is typically 7 to 8%.

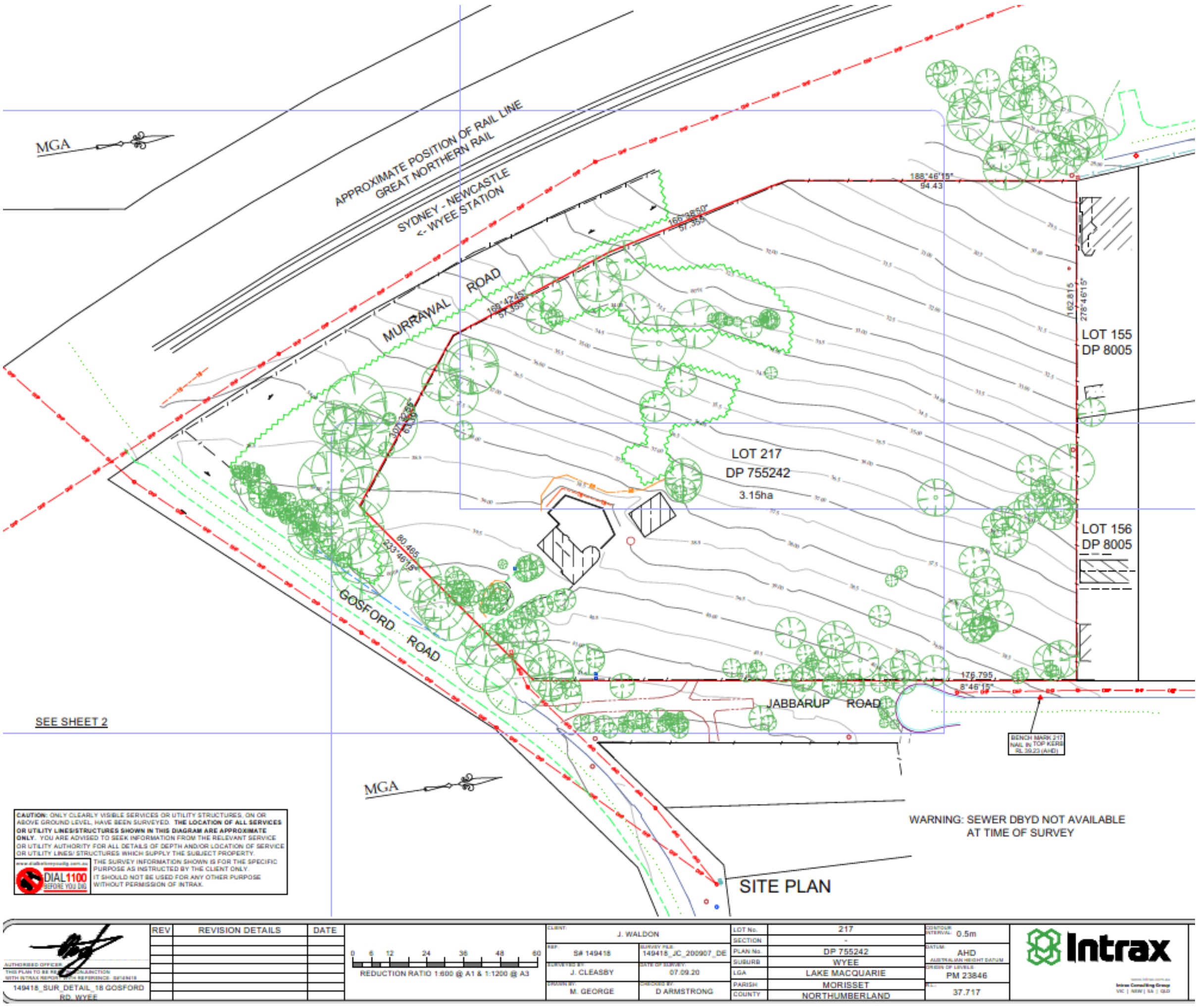


Figure 3.1. Extract of the site survey. NOTE north point (image source INTRAX).

Much of the lot is covered with exotic pasture grasses.

There is also some Endangered Ecological Community (EEC) vegetation to the west of the subject site. The site stormwater Management Plan is designed to ensure no increase in the peak flow into the EEC.

Figure 3.2. Looking upslope to the NE. The area is largely cleared pasture.

Figure 3.3. The surface soil is a sandy loam. The clay content increases below 45 to 50 cm.

Figure 3.4. The midslope soil has slightly more clay and organic matter in it , but the field texture is still sandy loam.


Figure 3.5. The soil in the lowest part of the site is a sandy loam over a sandy clay subsoil.

Figure 3.6. The EEC is thickly infested with weeds, especially blackberry.

3.2 Soils

The site is underlain by the Gorokan Soil Landscape (Murphy, 1993).

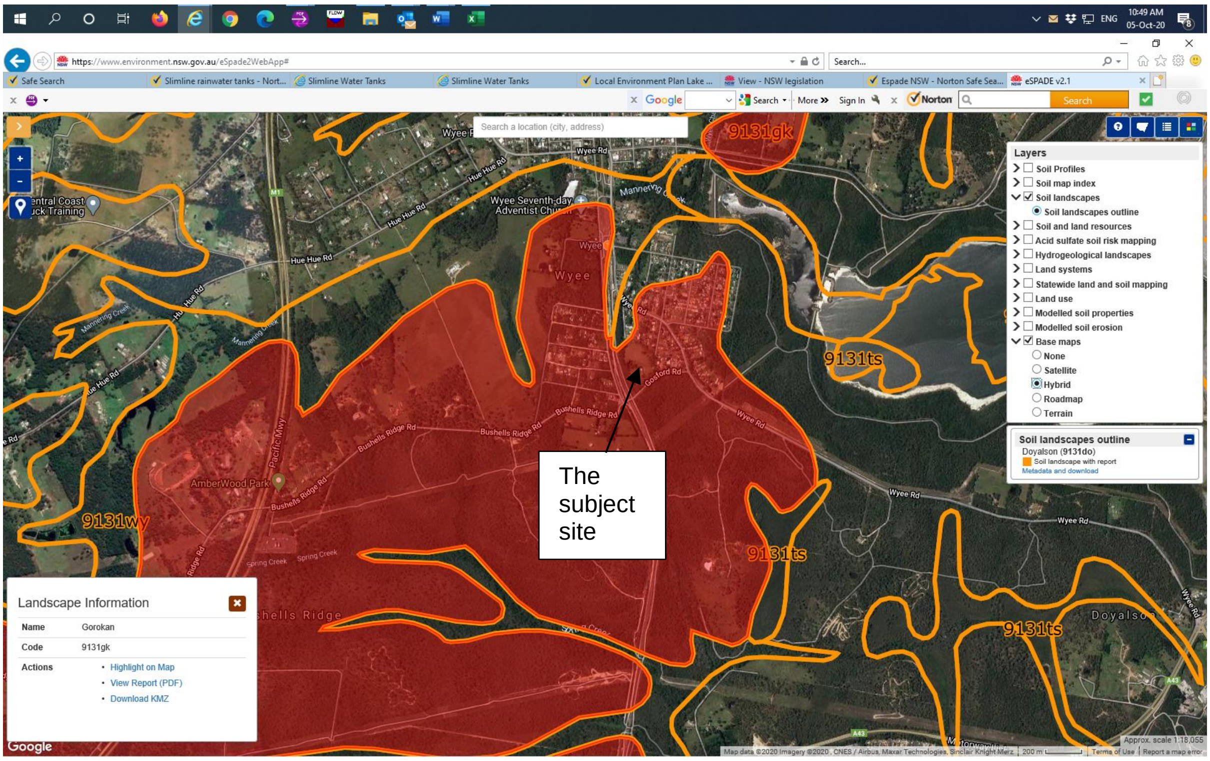


Figure 3.7. The subject site is on the Gorokan Soil Landscape (Murphy, 1993).

Table 3.1 shows some characteristics of the soil landscape.

Table 3.1. Attributes of the Gorokan Soil Landscape Group (Murphy, 1993).

Attribute	Gorokan	Comment
Landform	Undulating low rises	The site is sand dominant, so flow will be by both surface runoff and subsurface movement towards the NW.
Parent material	Sandstone	Low fertility soils. This is important because the typical 7 to 8% grades on erosive soil means that any swales will need erosion protection.
Soils	Moderately deep, with good internal drainage near the surface, but impermeable at depth.	Soils are free draining. " The site is at the top of the catchment, so there is minimal run-on. Figures 3.3 to 3.5 show the sand dominant topsoil extends to at least 0.45 m.
Fertility	Strongly acid and low fertility	Limited pasture growth unless fertilised. Liming would normally be required.
Topsoil	Loamy sand to sandy loam	Initial free drainage, but subsoil acts as throttle, minimising through drainage.
Subsoil	Varies from highly pedal to massive clay.	Impeded internal drainage in subsoil. This means that once the lower, relatively flat parts of the landscape become saturated, they will rely on runoff.

The soils have drainage limitations in the subsoil. This can result in waterlogging on lower slopes where run-on accumulates. This is an issue for the EEC downslope of the site. It is critical that peak flows are not increased by the development. Additionally, the site drainage should be via the existing drainage liens through the EEC, rather than developing new ones.

Table 3.2. The particle size distribution in two subsoil samples. WY-S1 was at the top of the slope. WY-S2 was approximately halfway down and in an area where there appeared to be more clay in the samples.

SAMPLE ID	Moisture content	Gravel (> 2 mm)	Sand (0.02-2.0 mm)	Silt (2-20 um)	Clay (< 2 µm)	Texture based on hydrometer measurement
	(% of water in air-dry sample)	(% of total oven-dry equivalent)				
WY S1 20-50	6.4%	2%	86%	6%	11%	Loamy sand
WY S2 20-40	16.1%	2%	59%	8%	13%	Sandy loam

In order to ensure a conservative design, the surface soil was assumed to be a sandy loam.

3.3 CLIMATE

Climate data was obtained from the Bureau of Meteorology web site. Norah Head is the nearest relevant meteorological station.

Table 3.3. Climate data for Norah Head AWS (061366). Rainfall and temperatures since 1995. Source: BoM.

Attributes	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
Mean maximum temperature (Degrees C)	26	26	25	23	20	18	18	19	21	23	24	25	22
Mean minimum temperature (Degrees C)	20	20	19	16	13	11	10	11	13	15	17	19	15
Mean rainfall (mm)	81	118	116	126	128	157	86	70	61	64	91	65	1154
Decile 1 monthly rainfall (mm)	13	27	51	39	16	31	10	9	14	10	21	28	905
Decile 5 (median) monthly rainfall (mm)	72	96	111	97	111	152	63	58	49	57	87	68	1130
Decile 9 monthly rainfall (mm)	172	208	176	266	236	273	181	143	133	96	147	108	1429
Mean number of days of rain >= 1 mm	8	8.6	9.3	9	8.8	10.2	7.3	5.9	7.2	6.8	8.4	6.8	96.3
Mean number of days of rain >= 10 mm	2.3	3.8	3.5	3.7	3.6	4.1	2.9	1.9	2	1.8	2.8	2.3	34.7
Mean number of days of rain >= 25 mm	0.9	1.3	1.5	1.5	1.6	1.9	0.8	0.7	0.5	0.6	0.8	0.4	12.5
Highest daily rainfall (mm)	89	95	130	97	113	235	112	115	61	89	120	79	235
Mean daily solar exposure (MJ/(m*m))	23.4	20.6	17.3	13.6	10.9	8.6	10.3	13.5	17.3	20	21.7	23.3	16.7

Mean daily temperatures range from an average maximum of 26 degrees in January to a mean minimum of 10 degrees in July[1]. The average daily range is 7 degrees. The annual average temperature is 18 degrees. The temperature data suggests a warm temperate climate which would allow year round growth of temperate climate vegetation. Heavy frosts are unlikely.

The mean monthly rainfall is highest in late autumn/ early winter and least in early spring. This is indicative of a humid temperate climate. Some moisture stress can occur in spring. This will increase demand for irrigation (and therefore more likely drawdown from the proposed rainwater tanks).

Rainfall in excess of 25 mm in a single day is most common in early winter. Flooding of the nearby Endangered Ecological Community (EEC) to the west of the subject site is most likely due to 'Eastern Lows' at this time of year.

[1] The subject site is some 10 km from the Pacific Ocean. However, there are several large coastal lakes between the site and the ocean. These would reduce daily temperature range.

There is little difference between the mean and the median annual rainfall. This suggests a relatively small range in variation in annual rainfall. Similarly, there is less than a two-fold variation between the 10 and the 90 percentile rainfall years. This is low compared with much of Australia, suggesting relatively reliable rainfall.

The highest daily total rainfall of 235 mm fell in June. Highest falls occur in winter. This season is when stormwater damage and runoff rate would be greatest.

Solar radiation has the expected annual variation, ranging from 23 MJ/ (m*m/day) in summer to 8 MJ/ (m*m/day) in mid-winter.

3.4 RAINFALL INTENSITY

Rainfall intensity duration data was obtained from the BoM website. The 1987 data method (1987 Australia Rainfall and Runoff, AR&R87), was used because the information is intended to calculate stormwater runoff based on the probabilistic method

Table 3.4. Rainfall intensity expressed in mm/hr. Based on IFD data for the subject site. Source: BoM.

Duration	Duration in min	Annual Exceedance Probability (AEP)						
		63.20%	50%	20%	10%	5%	2%	1%
1 min	1	133	151	214	262	313	388	452
2 min	2	112	128	182	223	267	330	382
3 min	3	104	118	168	205	246	304	352
4 min	4	97.4	111	157	192	229	284	329
5 min	5	91.9	104	148	181	216	267	311
10 min	10	72.3	82.2	116	142	170	211	246
15 min	15	60.3	68.5	96.9	119	142	176	206
20 min	20	52	59.2	83.8	103	123	153	178
25 min	25	46.1	52.4	74.3	91	109	135	158
30 min	30	41.5	47.2	67	82.1	98.3	122	142
45 min	45	32.5	37	52.6	64.4	77.2	95.8	112
1 hour	60	27.2	30.9	43.9	53.8	64.4	79.9	93
1.5 hour	90	21	23.9	33.9	41.5	49.6	61.4	71.3
2 hour	120	17.5	19.9	28.2	34.5	41.2	50.8	58.9
3 hour	180	13.5	15.4	21.7	26.5	31.6	38.9	45.1
4.5 hour	270	10.5	12	16.9	20.5	24.4	30	34.6
6 hour	360	8.83	10	14.1	17.1	20.3	25	28.8
9 hour	540	6.91	7.85	11	13.4	15.9	19.4	22.4
12 hour	720	5.81	6.6	9.27	11.3	13.3	16.3	18.8
18 hour	1080	4.53	5.16	7.27	8.83	10.5	12.8	14.8
24 hour	1440	3.78	4.31	6.1	7.42	8.8	10.8	12.5
30 hour	1800	3.28	3.74	5.31	6.47	7.69	9.44	10.9
36 hour	2160	2.9	3.32	4.73	5.77	6.86	8.44	9.72
48 hour	2880	2.38	2.73	3.91	4.79	5.71	7.02	8.08
72 hour	4320	1.78	2.04	2.94	3.61	4.32	5.3	6.09
96 hour	5760	1.43	1.64	2.36	2.9	3.48	4.25	4.87
120 hour	7200	1.19	1.37	1.97	2.42	2.9	3.52	4.03

Duration	Duration in min	Annual Exceedance Probability (AEP)						
		63.20%	50%	20%	10%	5%	2%	1%
144 hour	8640	1.03	1.18	1.69	2.07	2.47	2.98	3.41
168 hour	10080	0.908	1.04	1.47	1.8	2.14	2.57	2.92

The 50% AEP IFD **does not** correspond to the 2 year Average Recurrence Interval (ARI) IFD. Rather it corresponds to the 1.44 ARI.
* The 20% AEP IFD **does not** correspond to the 5 year Average Recurrence Interval (ARI) IFD. Rather it corresponds to the 4.48 ARI.

Table 3.5. Rainfall intensity expressed in mm. Based on IFD data for the subject site. Source: BoM.

Duration	Duration in min	Annual Exceedance Probability (AEP)						
		63.20%	50%	20%	10%	5%	2%	1%
1 min	1	2.22	2.52	3.56	4.36	5.22	6.47	7.53
2 min	2	3.75	4.27	6.06	7.43	8.9	11	12.7
3 min	3	5.19	5.91	8.38	10.3	12.3	15.2	17.6
4 min	4	6.49	7.38	10.5	12.8	15.3	18.9	22
5 min	5	7.66	8.7	12.3	15.1	18	22.3	25.9
10 min	10	12.1	13.7	19.4	23.7	28.3	35.2	41
15 min	15	15.1	17.1	24.2	29.7	35.5	44.1	51.4
20 min	20	17.3	19.7	27.9	34.2	41	50.9	59.4
25 min	25	19.2	21.8	31	37.9	45.4	56.4	65.8
30 min	30	20.7	23.6	33.5	41	49.2	61.1	71.2
45 min	45	24.4	27.8	39.4	48.3	57.9	71.9	83.7
1 hour	60	27.2	30.9	43.9	53.8	64.4	79.9	93
1.5 hour	90	31.5	35.9	50.9	62.3	74.5	92.1	107
2 hour	120	35	39.8	56.4	68.9	82.3	102	118
3 hour	180	40.6	46.2	65.2	79.6	94.8	117	135
4.5 hour	270	47.4	53.8	75.8	92.3	110	135	156
6 hour	360	53	60.2	84.6	103	122	150	173
9 hour	540	62.2	70.6	99.2	120	143	175	202
12 hour	720	69.7	79.2	111	135	160	196	226
18 hour	1080	81.6	92.9	131	159	188	231	266
24 hour	1440	90.8	104	146	178	211	259	299
30 hour	1800	98.3	112	159	194	231	283	327
36 hour	2160	105	120	170	208	247	304	350
48 hour	2880	114	131	188	230	274	337	388
72 hour	4320	128	147	212	260	311	382	439
96 hour	5760	137	157	227	279	334	408	468
120 hour	7200	143	165	237	291	348	423	484
144 hour	8640	148	170	243	298	356	430	491
168 hour	10080	153	174	248	302	360	431	491

4. THE PROPOSAL

4.1 Development configuration

It is proposed to subdivide the 3.15 ha site (figure 3.1) into 42 low density residential lots. There will be asset protection zones (APZ) along the southern boundary as a per the bushfire consultant's recommendations. There is an Endangered Ecological Community (EEC) between the western boundary of the subject site and the Sydney-Newcastle Rail Corridor. This will be protected from increased peak runoff flows via WSUD elements outlined in this current SMP. Drainage will be conveyed within an existing drainage line through the EEC. The road reserve will be 16m wide. It will have a 4.5m verge on the upper side (includes a 1.2m wide foot path) and a 3.5m verge without a foot path on the lower side.

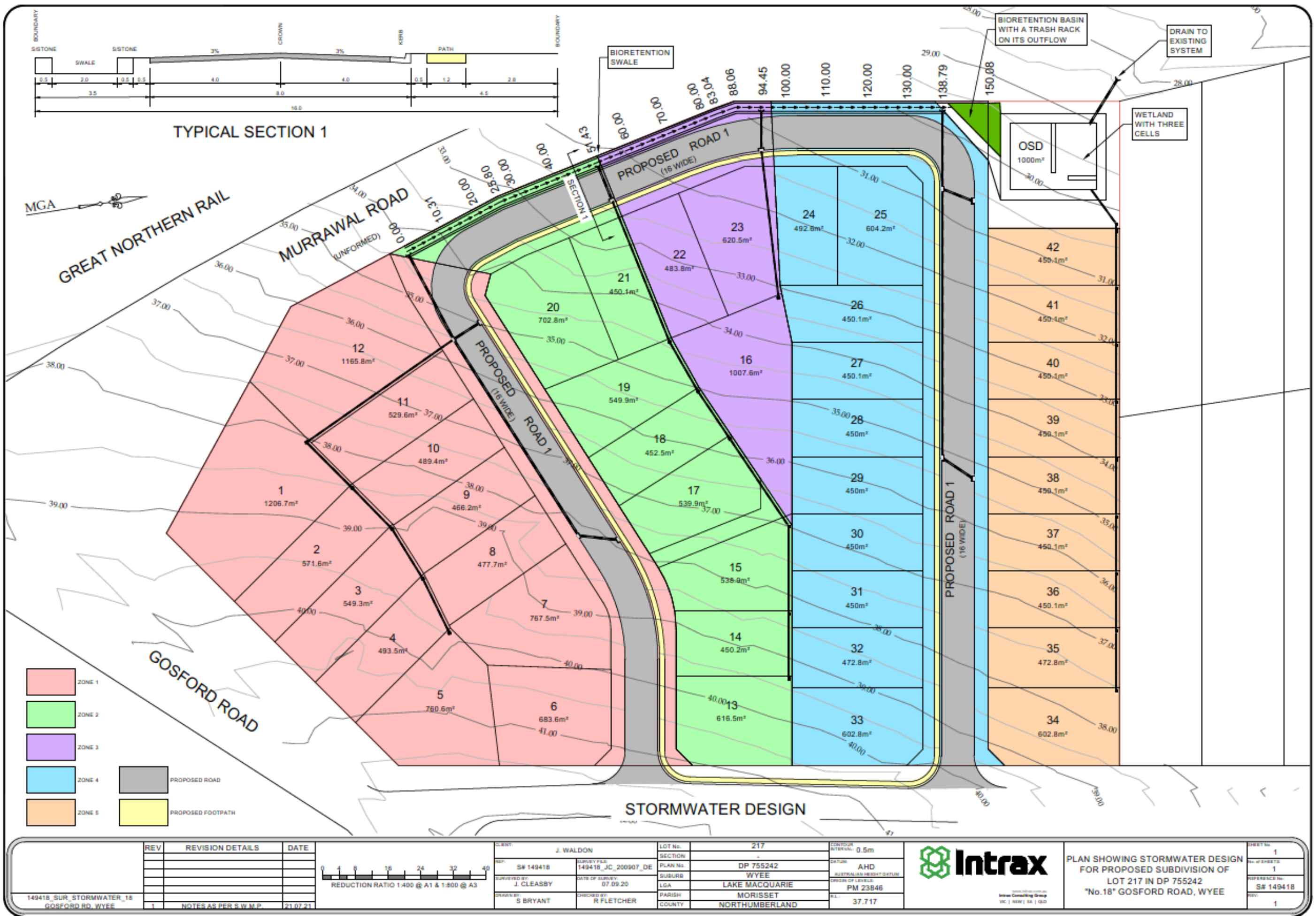
4.2 Subdivision components

Figure 4.1 shows the conceptual layout.

Figure 4.1. The proposed subdivision layout (Source: INTRAX).

Catchments 1 to 5 are shown in different colours. The black lines show the local stormwater system. The double lines show the bioretention swale, with different colours to reflect the adjacent catchments.

The bioretention basin and trash rack are shown in green.



The entire site drains to an OSD then to wetland. Outflow from the wetlands will drain to an existing drainage line. The drain outlet from the wetland joins an existing drain line.

- Total site area 3.15 ha
- 42 dwellings
- Large lots in southern corner include Asset Protection Zones (APZ) in them.
- Subsurface pipes drain each of 5 subcatchments within the development.
- Typical road reserve with 8 m wide pavement.
- 3.5 m verge on lower side and 4.5 m wide verge on upper side of the road.
- 1.2 m concrete path within the 4.5 m verge.
- A 2m wide bioretention swale, extending 139 m along the western side of the development (total area 287 m sq). The bioretention swale receives runoff from catchments 1, 2 and 3.
- A bioretention basin, 95 msq, with a trash rack on the exit point to an OSD
- An OSD receiving flows for all 5 catchments. Its primary role is to attenuate peak flows from the development.
- OSD outflow is regulated via a constant flow orifice.
- A 3 cell wetland receives discharge from the OSD.
- Baffles in the wetland are designed to maximise linear flow in the wetland.
- The wetland water surface will cover 450 msq.
- Wetland outflow is piped to an existing surface drain.

WSUD components

The WSUD components include:

- 42 dwellings
- Each dwelling connected to a rainwater tank , minimum capacity 5 cubic m.
- Each tank has a 50mm bleed pipe set to retain a minimum of 2.5 cubic m of dynamic roof runoff storage.
- Lot runoff ‘encouraged’ to move via overland flow to stormwater pipes. This is illustrated along the rear of lots 1 to 5. There will be pits with direct access to stormwater pipes at the lowest point of these properties.
- The stormwater pipes for catchments 1 , 2 and 3 are connected to a series of bioretention basins running along the western side of the site.
- This system discharges into a bioretention basin adjacent to the wetland.
- Catchment 4 also drains to the bioretention system.

- The bioretention basin will have a trash rack to capture gross pollutants.
- An OSD with orifice designed to attenuate low to moderate stormwater flows
- A 450 msq, 3 cell wetland with a dynamic storage component. This dynamic storage will attenuate storm flows rates, reducing peak outflow.
- The outflow from the wetland will be piped to an existing drainage line.

4.3 MUSIC MODEL PARAMETERS

Soil conditions

An examination of the soil during site inspection indicated that the soil typically had a loamy sand to a sandy loam texture in the surface 500 mm. The slope of the proposed development area is 6 to 7%.

The soil attributes, the anticipated contaminant concentrations and the reaction rate coefficients were taken from Fletcher et al (2004). Soils information and MUSIC model inputs were largely from SCA (2012) .

Table 4.1 shows the soil water storage capacity.

Table 4.1. Soil characteristics and site attributes (from table 4.5 SCA, 2012. Originally from Macleod, 2008).

Soil type	Assumed depth (m)	Soil water storage (surface 500 mm of soil)	Field capacity (soil type)
Sandy loam	0.5	98	70

The data in table 4.1 was combined into a MUSIC model which also included the parameters from table 4.2.

Table 4.2. Soil hydrological parameters (from SCA, 201 table 4.5, original source Macleod, 2008).

Parameter	Units	Result
Soil properties		
Rainfall runoff threshold from impervious surfaces	mm	1
Soil water storage capacity	mm in surface 500 mm	98
Initial storage	% of capacity	30
Infiltration coefficient -a		250
Infiltration coefficient-b		1.3
Groundwater properties		
Initial depth	mm	10

Parameter	Units	Result
Daily recharge	%	60
Daily baseflow rate	%	45
Daily deep seepage rate	%	0

Pollutant concentration parameters

Pollution management parameters were taken from MUSIC version 6.3, which was the current version in December, 2020[2].

These are shown in table 4.3. The pre-development landuse mode was 'rural residential' (coefficients from SCA, 2012). It was used in preference to 'agricultural mode' because unlike 'agricultural' landuse, there has been minimal soil disturbance, at least in recent years.

Table 4.3. Assumed contaminant parameters for rural residential lands (from SCA 2012, tables 4.6 and 4.7). Based on work of Fletcher et al, 2004).

Contaminant	Flow	Mean (log mg/L)	Std deviation (log mg/L)
Total Suspended Soilds (TSS)	Base flow	1.15	0.170
	Storm flow	1.95	0.320
Phosphorus	Base flow	-1.22	0.190
	Storm flow	-0.66	0.250
Nitrogen	Base flow	-0.05	0.120
	Storm flow	0.30	0.190

Table 4.4. Assumed contaminant parameters for residential (from SCA 2012, tables 4.6 and 4.7). Based on work of Fletcher et al, 2004). Note that the verges will be treated as residential lands in the MUSIC modelling.

Contaminant	Flow	Mean (log mg/L)	Std deviation (log mg/L)

[2] A new version of MUSIC will be released shortly, but it does not yet have MUSIC-link function. So, MUSIC 6.3 has been used below.

Total Suspended Soilds (TSS)	Base flow	1.2	0.170
	Storm flow	2.15	0.320
Phosphorus	Base flow	-0.85	0.190
	Storm flow	-0.60	0.250
Nitrogen	Base flow	0.11	0.120
	Storm flow	0.30	0.190

Table 4.5. Assumed contaminant parameters for roofs (from SCA (2012) Modelling Guidelines tables 4.6 and 4.7). No base flow runoff is assumed for the roofs.

Contaminant	Flow	Mean (log mg/L)	Std deviation (log mg/L)
Total Suspended Soilds (TSS)	Base flow	Not applicable	Not applicable
	Storm flow	1.30	0.320
Phosphorus	Base flow	Not applicable	Not applicable
	Storm flow	-0.89	0.25
Nitrogen	Base flow	Not applicable	Not applicable
	Storm flow	0.30	0.190

Table 4.6. Assumed contaminant parameters for sealed roads (from SCA (2012) MUSIC Modelling Guidelines tables 4.6 and 4.7). NOTE: The road sealed 'width' is set at 8 m.

Contaminant	Flow	Mean (log mg/L)	Std deviation (log mg/L)
Total Suspended Soilds (TSS)	Base flow	1.20	0.17
	Storm flow	2.43	0.32
Phosphorus	Base flow	-0.85	0.19
	Storm flow	-0.30	0.25
Nitrogen	Base flow	0.11	0.12
	Storm flow	0.34	0.19

The verges were treated as a separate source node in the MUSIC modelling. The parameters were based on residential land use.

Meteorological data

Meteorological data were obtained from the Bureau of Meteorology (2020) and from Ewater pluviograph data. The pluviograph data was from 1974 to 1993. The average annual rainfall in this period was 1290 mm.

The evapotranspiration data given in table 3 of Wyong Shire Council (2010a) used in MUSIC modelling. This is shown in table 4.6.

Table 4.7. Evapotranspiration data from table 3 of WSC, 2010a).

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Evapo transpiration	180	135	128	85	58	43	43	58	88	127	152	163

NOTE that the MUSIC-Link data for the Southern portion of the Lake Macquarie LGA was used.

Rainwater capture

It is assumed that each dwelling will have a 5 cubic m rainwater tank connected to a minimum of 70% of the roof area. The roof area is assumed to be 200 msq, so the catchment actually draining to the rainwater tank is 140 msq. The tank static capacity is assumed to be 2.5 cubic m. This is based on having a slow bleed pipe set at the height where 2.5 cubic m are retained in the tank. This outlet commences to outflow when the combination of rainfall less demand for rainwater results in more than 5 cubic m of rainwater in the tank.

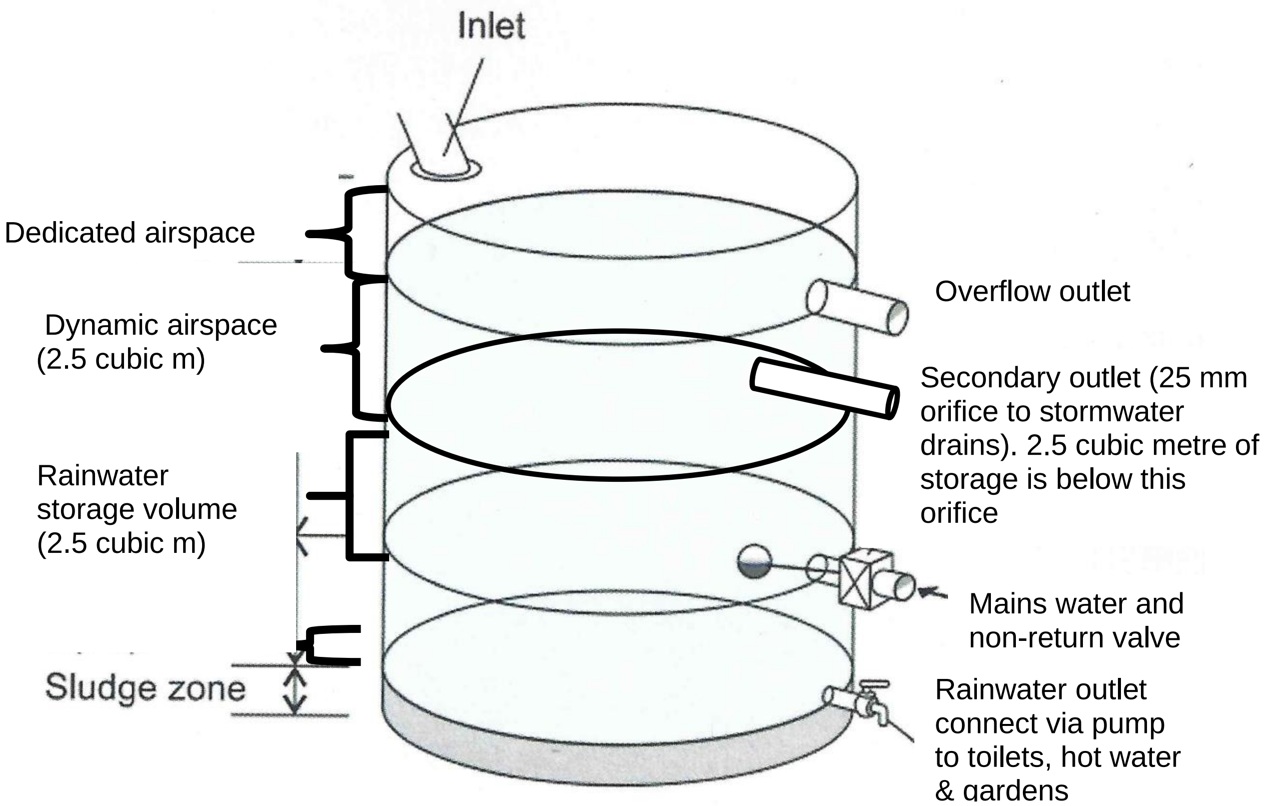


Figure 4.2. The tank design including OSD features (Sources: UPRCMT, 2005, SCA, 2012). The key issue is that it must have at least 5 cubic m of rainwater storage[3].

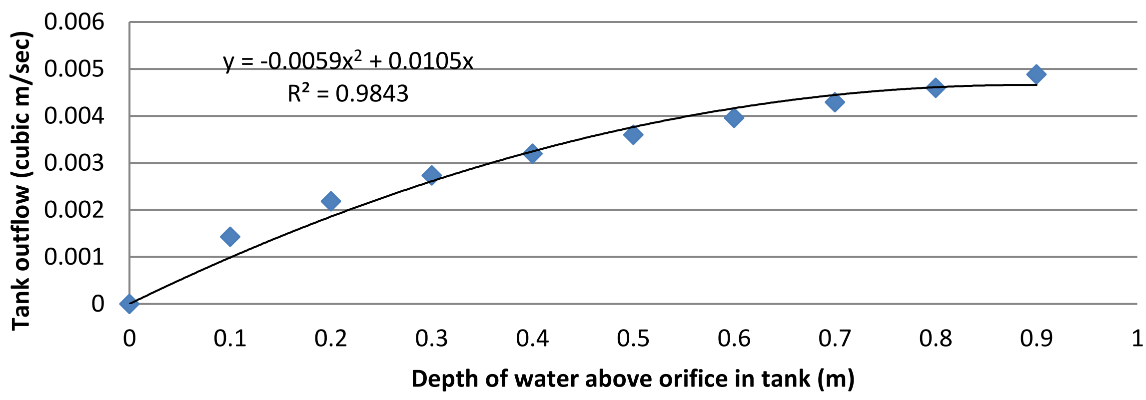
It is expected that the tank will have an inflow connected to the mains system. This will have a backflow prevention device as specified by the Council/ Hunter Water.

The inlet and outlet should be a 50 mm ID orifice connected to a stormwater pipe.

Figure 4.3 shows the relationship between outflow rate (cubic m/sec) and height above the 50 mm orifice.

[3] *NOTE that a separate OSD/ stormwater detention pond may be needed to treat road runoff prior to the commencement of home construction. This can be included in the erosion and sediment plan for the site. It should be based on Landcom (2004)-the BLUE Book. The requirements of Chapter 2, Chapter 9 section 9.4 and Appendix M must be incorporated in the site development plan.*
The proposed wetland footprint can be initially developed as a detention basin and then converted to a wetland once the roads and road drainage are installed.

Figure 4.3. Rate of outflow at various depths of water above the 50 mm ID orifice in the rainwater tank.



The height vs discharge curve in figure 4.3 was combined with the 100 Y ARI storm event to demonstrate the ability of small tanks to attenuate runoff even in major storms.

Rainwater reuse

Data from Coombes, et al (2003) is summarised in table 4.7.

Table 4.8. Water demands for urban dwellings assuming 4 bedrooms. Derived from Coombes, et al (2003). Presented in table 5.3 in SCA (2012).

Use component	Volume (kL/ 4 bedroom dwelling/day)[4]
Toilets	0.235
Toilets & Laundry	0.470
Toilets & laundry & hot water	0.845
Garden use (varies with current rainfall conditions)	0.15

Table 4.8 shows that the internal use for rainwater assuming 4 bedrooms and water being used in toilets, laundry and the hot water system is 0.845 cubic m/dwelling /day. It was decided to take a more conservative approach as assume the rainwater was only used for toilets and laundry. Based on 4 bedrooms, the average rate/day would be 0.47 cubic m/dwelling/day. For each catchment this use rate was multiplied by the number of dwellings

Additionally, there is an annualised average of 0.15 cubic m/dwelling/day used to irrigate dwelling surrounds. For each catchment this use rate was multiplied by the number of dwellings. This design only irrigated the lawns when the water was in storage and when there

[4] Each dwelling is assumed to have 4 bedrooms. Obviously, people rather than bedrooms determine flow. Coombs et al (2003), however was based on bedrooms

was no substantial rainfall. The rate applied per day was determined by the Potential Evapotranspiration (PET) as per MUSIC model parameters.

The rates and coefficients above were used in MUSIC modelling to determine the effectiveness of rainwater tanks in reducing contaminant export.

Stormwater generation sources within the lot

The assumed site components are set of below

- There is a total of 42 dwellings
- The average roof area, including eves is 200 msq
- An average of 70% of the roof area drains to a rainwater tank
- The rainwater tank has 2.5 cubic m of dynamic storage above the 25 mm drain, 2.5 cubic m of dynamic rainwater storage and 2.5 cubic m of fixed reserve storage topped up by rainwater.
- Excess roof runoff is conveyed by pipe to local stormwater pipes.
- Yard drainage is lot size (msq)-roof area) (msq)* 50% pervious*runoff model output in catchment 1 where there are relatively large areas of APZ[5]
- Verges are 4.5m wide on the upper side (includes 1.2m concrete path) and 3.5 m wide on the lower side of the road.
- The road is 8m wide and 100% sealed surface. It is assumed that the road had a centre crown with 50% drainage to the upper catchment and 50% to the lower catchment.
- The bioretention swale consists of 5 sub swales corresponding with the length of the swale between stormwater pipe inflow points.
- The wetland lot covers 1000 msq. Allowing for boundary bunds with 2m inner and 2m outer slopes, the wetland area is 450 msq.
- APZ s are included in individual lot areas.

Table 4.8 sets out the stormwater generation areas within the lot.

[5] APZ –Asset Protection Zone . Lots 1 to 7 and 12 are larger than the standard 450 msq. Therefore, it is assumed that it is reasonable to increase the perviousness % from 50% to 60% in catchment 1.

Table 4.9. The areas within individual subdivision components.

Lot No	Area	Road pavement	Verges	Bioretention swale 3m wide	wetland lot	Catchment number
1	1207					1
2	572					1
3	549					1
4	494					1
5	761					1
6	684					1
7	758					1
8	478					1
9	466					1
10	489					1
11	530					1
12	1165					1
Total (C1)	**8152**	**989**	**1197**			**1**
13	617					2
14	450					2
15	539					2
17	540					2
18	452					2
19	550					2
20	703					2
21	450					2
Total (C2)	**4301**	**441**	**200**	**103 msq (treats C1)**		**2**
16	1008					3
22	484					3
23	583					3
Total (C3)	**2075**	**322**	**206**	**869 msq (treats C2)**		**3**
24	456					4
25	604					4
26	450					4
27	450					4
28	450					4
29	450					4
30	450					4

Lot No	**Area**	**Road pavement**	**Verges**	**Bioretention swale 3m wide**	**wetland lot**	**Catchment number**
31	450					4
32	472					4
33	603					4
Total (C4)	**4856**	**1223**	**1801**	**89 (treats C3)**		**4**
Additional						
Bio retention basin.				**95** (treats C4)		
Below pipe outlet C4.				Widens out to a bioretention basin and trash rack		
34	603					5
35	473					5
36	450					5
37	450					5
38	450					5
39	450					5
40	450					5
41	450					5
42	450					5
Total (C5)	4226					5
wetland					1000	
Totals	23610	2975	3404	511	1000	3.15 ha

Table 4.10. Components used to estimate impact of stormwater management strategies.

Component	Catchment 1	Catchment 2	Catchment 3	Catchment 4	Catchment 5	Total
Lot area	8153	4301	2075	4835	4226	23590
Number of roofs and tanks	12	8	3	10	9	42
Average roof area (msq)	200	200	200	200	200	
Roof area/ catchment (msq)	2400	1600	600	2000	1800	8400
Drainage to rainwater tank (% of roof area)	70	70	70	70	70	
Roof drainage to tanks (msq)	1680	1120	420	1400	1260	5880
Roof drainage directly to stormwater system (msq)	720	480	180	600	540	2520
Yards draining to catchment (msq)	5753	2701	1475	2835	2426	15190
Verges (msq)	1197	200	206	1801	0	3404
Bioretention swale (msq)		103	86	89	95	373
Road (msq)	989	441	322	1223	0	2975
Wetland msq						1000
Total (msq)	3628	5936	6444	9017	6508	31533

The site had 500 msq of impervious area prior to development (2% imperviousness)

Figure 4.4 shows a screen shot of the proposed system.

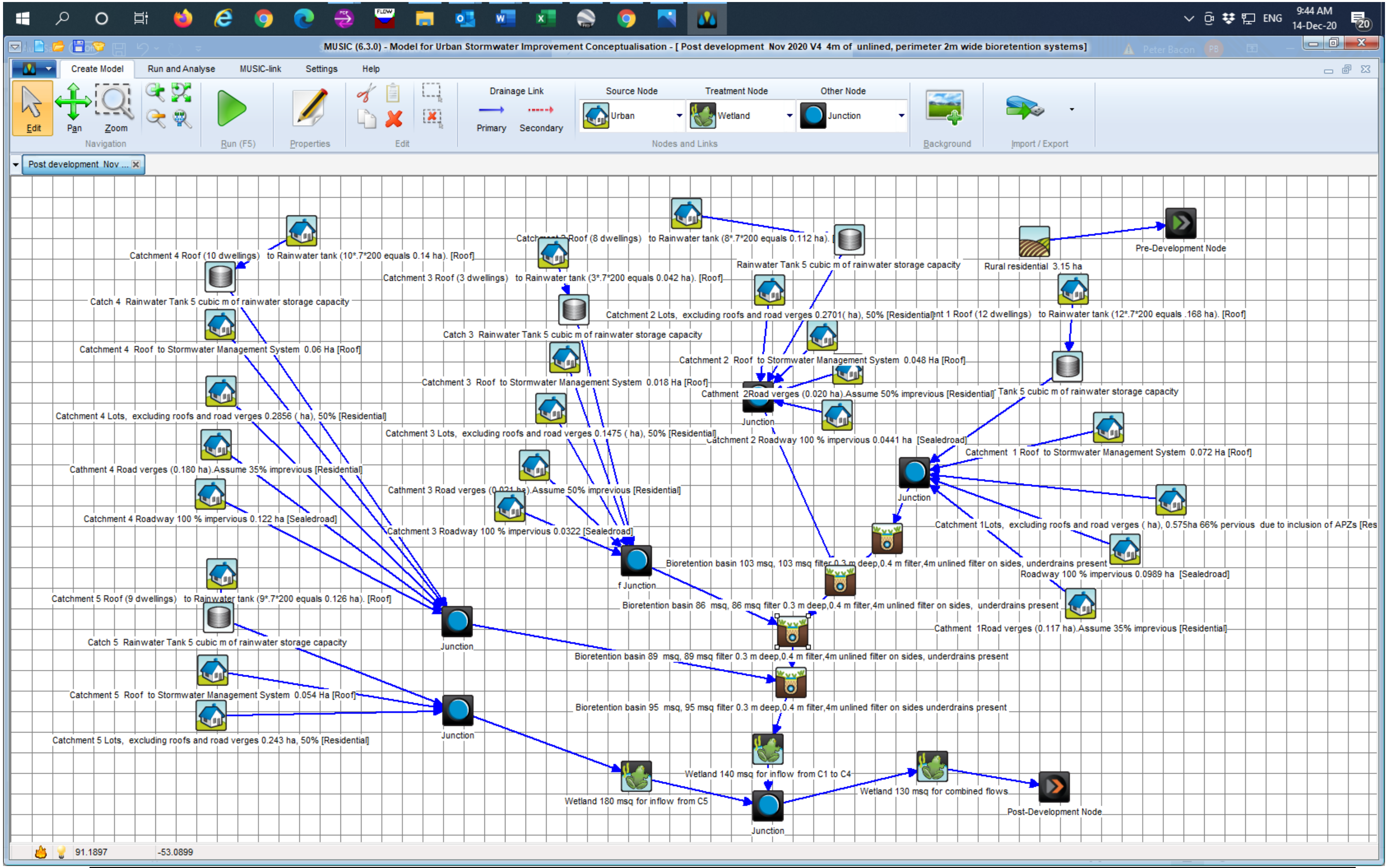


Figure 4.4. Screen print of the MUSIC model.

The MUSIC Model contains information of design components of each of the water quality devices.

Rainwater tanks

Figure 4.5 shows the properties of the roof runoff tanks

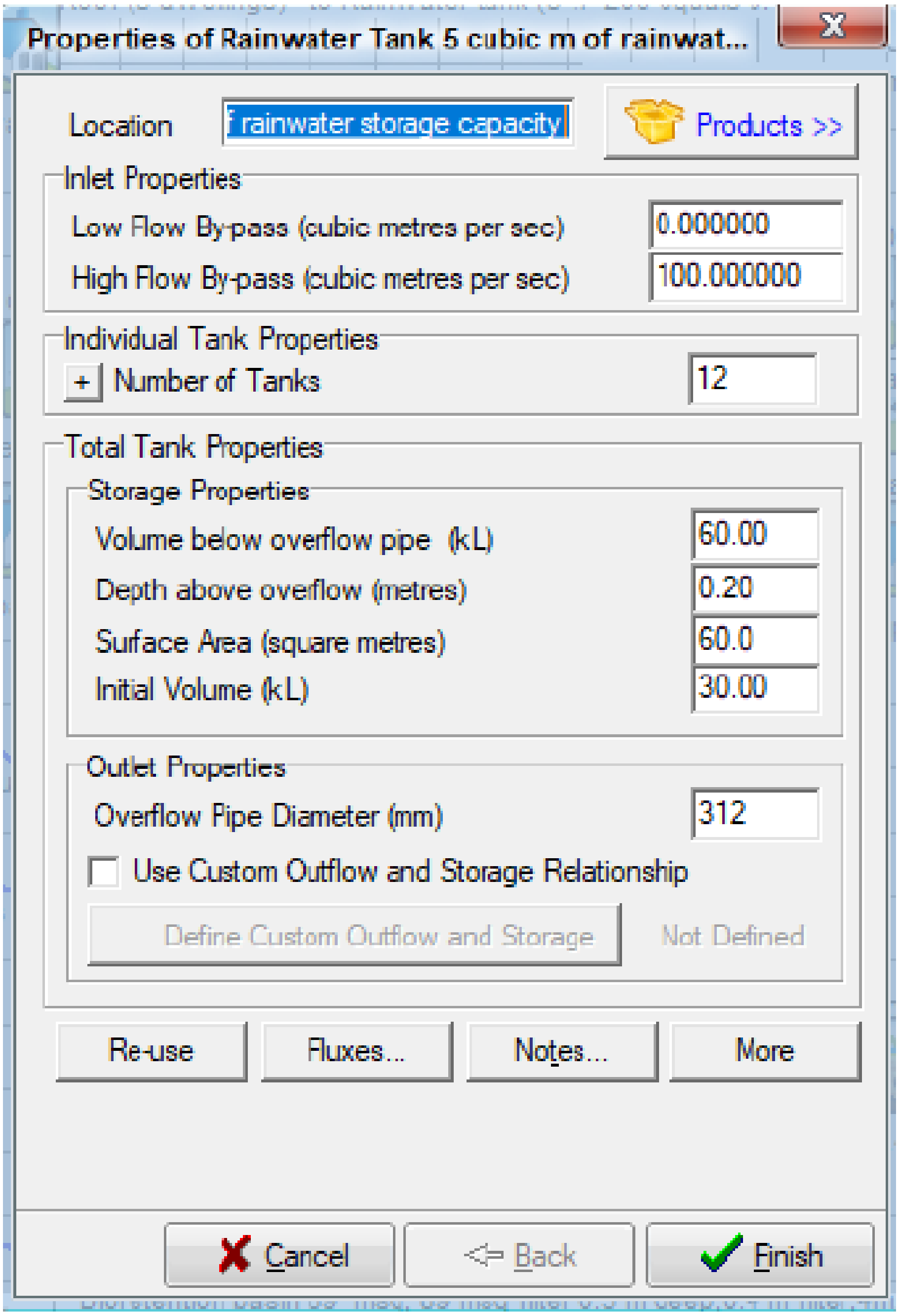


Figure 4.6. The properties of the rainwater tank system in catchment 1. This catchment has 12 dwellings in it. A similar system is used in each catchment.

Each of the 42 dwellings has a 5 cubic m rainwater tank. Only 2.5 cubic m is retained, with the volume in excess of this discharged via a 50 mm orifice as figure 4.2 shows.

Bioretention basins

A series of 4 elongated bioretention basins were used to treat and convey stormwater runoff from the stormwater pipes catchment in catchments 1 to 4.

An issue was the need or otherwise to line the bioretention systems. The proposed design is for vertical rock walls 0.5m high on each side of the basin. The filter system will be 2m wide. It will have a subsurface pipe to convey water from the subsurface towards the final basin then into the wetland.

Do the bases of the bioretention systems need lining?

Table 4.11 shows the effectiveness of the treatment system with and without bioretention system lining.

Table 4.11. Comparison between lined and unlined bioretention basins on the subject site.

Entire development	**Pre**	**Post no WSUD**	**Post with WSUD**	**Percent reduction due to WSUD**
System performance when bioretention basins, lined sides, do not have a lined base				
Flow (ML/yr)	16	28	23	21
Total Suspended Solids (kg/yr)	1040	3690	696	81
Total Phosphorus (kg/yr)	2.6	7.5	2.4	66
Total Nitrogen (kg/yr)	25	61	27	55
Gross Pollutants (kg/yr)	13.6	671	0	100
System performance when bioretention basins do have lined floor				
Flow (ML/yr)	16	28	23	22
Total Suspended Solids (kg/yr)	1050	3700	692	81
Total Phosphorus (kg/yr)	2.6	7.5	2.6	66
Total Nitrogen (kg/yr)	25	61	27	56
Gross Pollutants (kg/yr)	14	671	0	100

The difference is trivial, and the unlined system is compliant with Lake Macquarie Council's stormwater quality objectives.

It is concluded that there was no advantage in lining the bioretention systems apart from the vertical rock walls on each side. Note that the vertical rock walls will largely prevent horizontal outflow of surface water through the sides of the basin. In figure 7, below there are a few msq of unlined perimeter to allow for seepage via joints between blocks of rock.

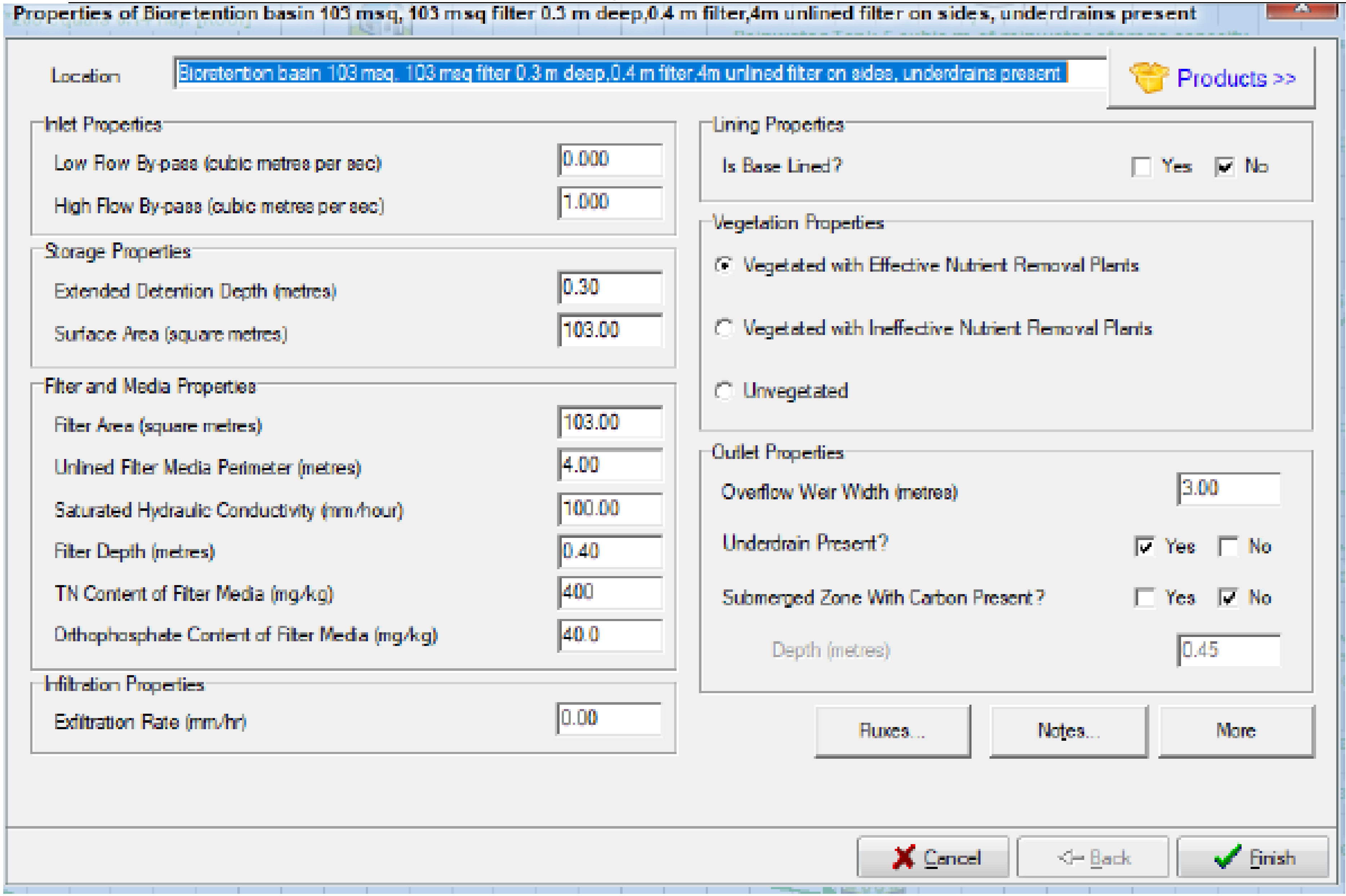


Figure 4.7. The properties of the first bioretention basin. Note that the basins have vertical sides, so surface area equals filter area.

The wetland

The wetland consists of three cells. One cell receives outflows from the bioretention basins. This flow joins flow from another cell receiving only water from catchment 5. The combined flows converge in cell 3.

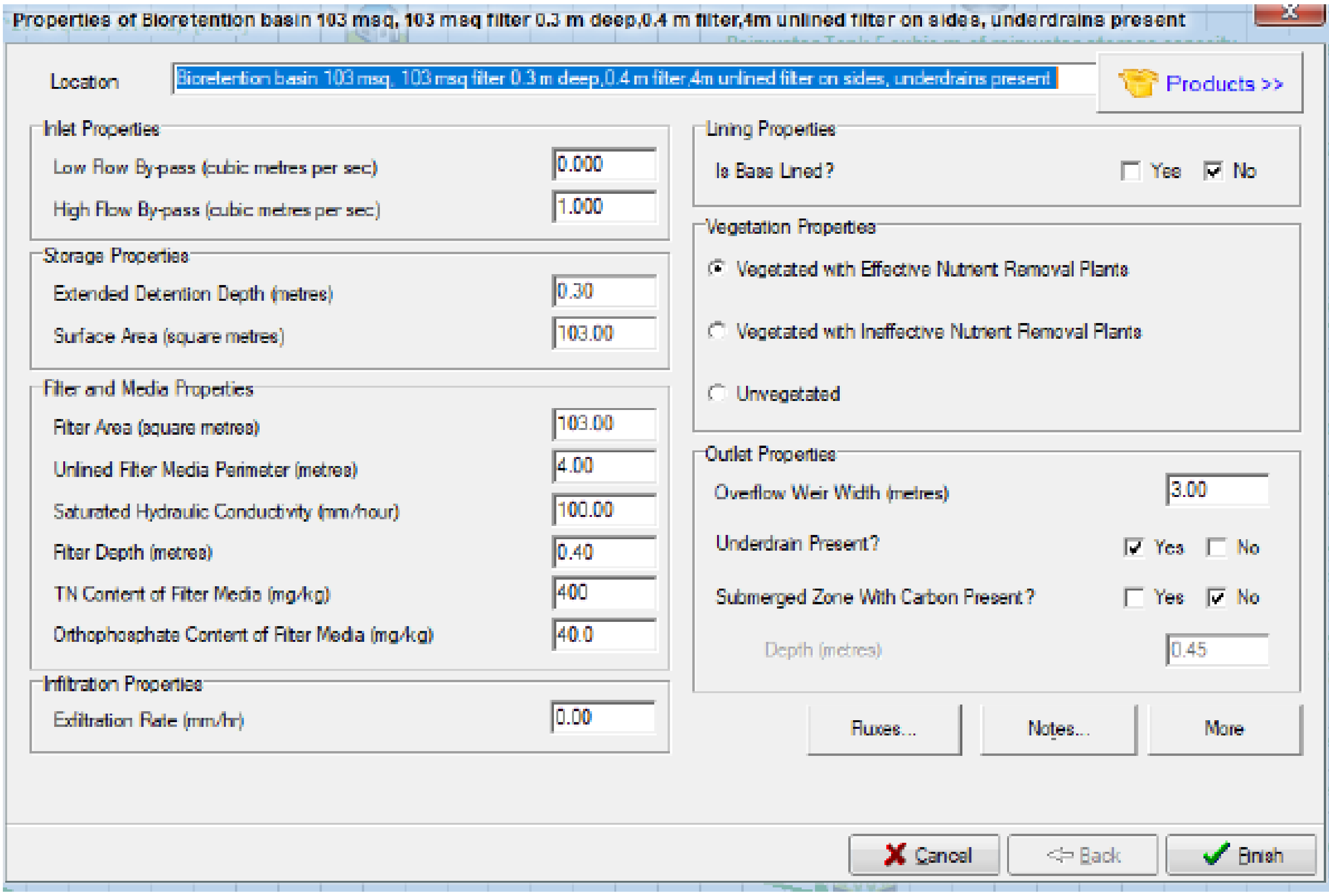


Figure 4.7. Properties of the wetland cell 3. Combined flow.

The wetland will be sited on the lowest point of the subject site and a close as possible to an existing drain.

5. RESULTS-effects of WSUD actions within the subdivision

Table 5.1 shows the effect of the development with and without WSUD elements.

Table 5.1. Average annual stormwater flows and contaminant loads with and without WSUD elements. The predicted impact of WSUD actions on the change in flow and contaminant loads prior to development and after development + WSUD are also tabulated. Note that the simulation had unlined bioretention basins (Based on MUSIC 6.3 version). The percentage reduction due to WSUD implementation is highlighted in yellow.

Entire site	Pre-development	Development, but no WSUD	Residual load due to WSUD	Percent reduction due to WSUD compared with no WSUD features	Difference: Pre development PERCENT CHANGE	LMC WSUD objectives	Compliance with LMC's WSUD objectives based on column 5.
	Pre	Post	Post	Post			
	UNLINED bioretention basins						
Column number	**1**	**2**	**3**	**4**	**6**	**7**	**8**
Flow (ML/yr)	16	28	23	21	-42	Not given	Not given
Total Suspended Solids (kg/yr)	1060	3690	691	81	32	80	YES
Total Phosphorus (kg/yr)	2.6	7.52	2.54	66	1	45	YES
Total Nitrogen (kg/yr)	25	61	27	55	-10	45	YES
Gross Pollutants (kg/yr)	14	671	0	100	100	70	YES

The key predictions from table 5.1

- Use of WSUD resulted in a fall of
  - 21% in annual outflow,
  - 81% in TSS
  - 66% in TP
  - 55% in TN, and
  - 100% in gross pollutant export from the site

  Compared with the development without WSUD.

- The percentage reduction in TSS, TP, TN and GP are all compliant with LMC stormwater quality objectives.

- The Development + WSUD result in the following percentage changes compared with the current rural residential landuses:
  - 42% rise in total water export
  - 32% reduction in TSS export

- 1% reduction in TP export
- 10% rise in TN export
- 100% reduction in gross pollutant export from the site

- Column 7 shows that the values in column 4 comply with Council's WSUD objectives.

It is concluded that the proposed WSUD elements will produce water quality outcomes compliant with Council's water quality objectives.

Tables 5.2 and 5.3 provide a summary of pre-development and post development (+WSUD) statistics.

Table 5.2. Pre-development stormwater statistics for flow and contaminant concentrations.

Pre-development Version 4							
Inflow	**mean**	**standard deviation**	**median**	**max**	**min**	**10 percentile**	**90 percentile**
Flow (cubic metres/sec)	0.00	0.01	0.00	2.5	0	0	7.90E-04
TSS Concentration (mg/L)	9.90	28.40	0.00	1510	0	0	2.11E+01
Log [TSS] (mg/L)	1.23	0.30	1.18	3.18	0.415	0.945	1.54
TP Concentration (mg/L)	0.03	0.064	0	2.43	0	0	9.19E-02
Log [TP] (mg/L)	-1.16	0.25	-1.190	0.39	-2.03	-1.45	-0.86
TN Concentration (mg/L)	0.42	0.61	0.00	12.00	0.00	0.00	1.15
Log [TN] (mg/L)	-1.54E-02	0.16	-3.23E-02	1.08	-0.541	-0.196	1.72E-01
TSS Load (kg/6 Minutes)	0.115	3.57E-01	0.00E+00	142	0	0	5.10E-03
TP Load (kg/6 Minutes)	2.92E-05	7.65E-04	0	0.406	0	0	2.01E-05
TN Load (kg/6 Minutes)	2.83E-04	7.25E-03	0	5.56	0	0	2.79E-04
Gross Pollutant Load (kg/6 Minutes)	1.55E-04	3.87E-03	0	1.02	0	0	0

Table 5.3. Post development stormwater statistics for flow and contaminant concentrations.

Post development V4							
Inflow	**mean**	**standard deviation**	**median**	**max**	**min**	**10 percentile**	**90 percentile**
Flow (cubic metres/sec)	7.14E-04	7.00E-03	1.41E-04	2.0	0	0	5.87E-04
TSS Concentration (mg/L)	3.94	4.68	6	239	0	0	6.01
Log [TSS] (mg/L)	0.77	0.12	0.78	2.38	0.344	0.72	7.79E-01
TP Concentration (mg/L)	0.04	0.03	0.06	0.314	0	0	6.01E-02
Log [TP] (mg/L)	-1.22	0.05	-1.22	-0.503	-1.31	-1.23	-1.22
TN Concentration (mg/L)	0.60	0.471	0.911	2.58	0	0	1.01
Log [TN] (mg/L)	-0.02	0.05	-0.001	0.41	-0.20	-0.09	0.01
TSS Load (kg/6 Minutes)	0.01	0.24	0.00	83.90	0.00	0.00	0.00
TP Load (kg/6 Minutes)	2.90E-05	5.51E-04	3.05E-06	0.196	0	0	1.27E-05
TN Load (kg/6 Minutes)	3.12E-04	4.86E-03	5.12E-05	1.4	0	0	1.98E-04
Gross Pollutant Load (kg/6 Minutes)	0	0	0	0	0	0	0
TSS Concentration (mg/L)	3.94	4.7	6	194	0	0	6.01
Log [TSS] (mg/L)	0.768	0.123	0.779	2.29	0.344	0.72	0.779
TP Concentration (mg/L)	3.84E-02	3.06E-02	6.00E-02	0.318	0	0	6.01E-02

Post development V4							
Inflow	**mean**	**standard deviation**	**median**	**max**	**min**	**10 percentile**	**90 percentile**
Log [TP] (mg/L)	-1.22	4.66E-02	-1.22	-0.50	-1.31	-1.23	-1.22
TN Concentration (mg/L)	0.604	0.471	0.91	2.32	0	0	1.01
Log [TN] (mg/L)	-2.08E-02	5.01E-02	-1.07E-03	0.366	-0.199	-8.52E-02	6.43E-03
TSS Load (kg/6 Minutes)	7.90E-03	0.243	3.05E-04	104	0	0	1.26E-03
TP Load (kg/6 Minutes)	2.90E-05	5.53E-04	3.05E-06	0.204	0	0	1.27E-05
TN Load (kg/6 Minutes)	3.11E-04	4.77E-03	5.12E-05	1.36	0	0	1.98E-04
Gross Pollutant Load (kg/6 Minutes)	0	0	0	0	0	0	0

Key predictions from tables 5.2 and 5.3

- Maximum outflow rate from the subdivision fell from 2.5 to 2.0 cubic m/sec when development + WSUD actions are implemented. Note that the post development flow will be to an existing drain.
- Maximum concentrations of contaminants in stormwater exiting the subject site are predicted to be up to 5 times less following subdivision + WSUD actions
- Maximum loads of contaminants (kg/6 minutes) exiting the 3.15 ha site are predicted to be typically less than the current export load following development plus WSUD.

A key finding is that the peak outflow rate will be substantially lower following a subdivision that includes WSUD elements. Unlike the current outflow, this flow is delivered to an established drain. Therefore, the extent of flooding in the EEC is likely to be slightly less under the proposed development (except in the existing drain).

The peak contaminant concentrations and peak contaminant are also substantially reduced.

6. MAINTENANCE

6.1 WSUD MAINTENANCE PROVISIONS (SOURCE: WSC, 2010C).

WSUD elements require maintenance in order to perform in accordance with their design intent. It is considered essential that provisions are made for maintenance of WSUD elements at the planning and design phase irrespective of Council or private ownership. This section outlines the necessary considerations and requirements in relation to operation and maintenance of WSUD elements.

For industrial and commercial development in the private realm WSUD elements will require a Positive Covenant and a Restriction on Use to be placed on the property title in order to bind all current and future owners to specific maintenance requirements.

6.2 MAINTENANCE REQUIREMENTS

a Maintenance requirements for vegetated stormwater treatment measures include:

- i during the plant establishment period (first two years): weed removal and replanting may be required.
- ii periodic maintenance should include: removal of accumulated sediments, litter and debris, weeding and replanting as required.
- iii three-monthly inspections are recommended for most stormwater treatment measures.

A defects liability period will apply to WSUD elements in accordance with Council’s requirements for landscaping projects. The developer and/or owner are then responsible for maintenance of the WSUD element(s) after practical completion is certified and prior to transfer of the asset into Council ownership.

b Operation and maintenance requirements of storage tanks, including rainwater tanks and treated stormwater storage tanks is as follows:

- i for rainwater tanks, inspect the roof and gutters, first flush device and inlet/overflow screens each 3-6 months. If necessary, roofs and gutters should be cleaned, overhanging vegetation should be pruned, first flush devices and screens should be cleaned.
- ii each 2-3 years, inspect all tanks for sludge accumulation. De-sludging may be periodically required.
- iii where pumps are used, consult the manufacturers for maintenance requirements.

c Operation and maintenance requirements of gross pollutants traps (GPTs) are as follows:

- i routine quarterly inspection and/or in accordance with manufacturer’s recommendations.
- ii cleaning and appropriate disposal of gross pollutants to ensure there is sufficient capacity to capture and retain pollutants in the next runoff event. Notwithstanding manufacturer’s recommendations, at least 50% capacity should be maintained within the GPT.

6.3 MAINTENANCE ACCESS AND SCHEDULES

a Access to WSUD elements is essential in order to perform routine inspection and maintenance activities. Consideration of maintenance and appropriate access is required at the concept design stage and is to be documented on DA plans . Council should be contacted to ascertain Council’s maintenance capability in respect to selection of appropriate WSUD elements and design considerations.

b A maintenance schedule(s) is to be provided at the time of Practical Completion (an indicative one is given below).

This schedule is to detail the necessary maintenance activities and intervention levels that are required for each WSUD element and it should cover at least a ten year period. The information should include but not be limited to the cleaning frequency of GPTs, subsoil line flushing, inspection for scour & erosion at key areas, capacity at key outlet and overflow points, plant health, vegetation maintenance for conveyance, weed management, filter media replacement etc.

6.4 POSITIVE COVENANT AND RESTRICTION OF USE ON WSUD ELEMENTS

For developments requiring a Positive Covenant and/or Restriction of Use, the applicant shall be responsible for the following:

a to ensure on-going future maintenance of WSUD elements applicants shall create a "Positive Covenant" and "Restriction on the Use of Land" under Section 88B of the Conveyancing Act 1919, burdening the property with the requirement to maintain the WSUD elements. The terms of the instruments are to be generally in accordance with the Council's "terms of Section 88B instrument for protection of WSUD elements" in accordance with Council's standard terms and definitions.

b create all required easements, rights-of-carriageway, positive covenants, restrictions-on-use or other burdens/benefits, the applicant must submit this with the plan of subdivision or transfer plan. This is to be completed prior to the issue of the Occupancy or Subdivision Certificate.

c a registered surveyor is to provide certification and a "Works-As-Executed drawing" to Council that all physical structures are fully contained within the lot and proposed easements.

6.5 WSUD ELEMENTS TO BE INCLUDED

The various types of WSUD elements located on private property that are to be included in the Positive Covenant are; rainwater tanks, bio-retention systems and constructed wetlands. Some of these WSUD elements will also require a Restriction on the Use of Land.

The maintenance plan below was derived from Landcom (2003).

6.6 MAINTENANCE ACTIVITIES

1. Inspection to identify areas of increased sediment deposition, rill erosion or damage to the surface
2. Inspection of the inlet points, surcharge pits and outlets to identify any scouring, litter accumulation or blockages.
3. Removal of sediments. Especially where the sediment is impeding flow and even distribution of water
4. Repair any damage due to vehicles being driven into the basin
5. Tillage of the basin surface if there are signs of the soil surface clogging.
6. Slashing if there is excessive vegetative growth.
7. Removal of invasive weeds
8. Replanting any bare areas (>10 msq)
9. Removal of litter and debris

Table 6.1 Routine monitoring components and required responses for the wetland system.

Structure	Purpose of monitoring	Performance target	Schedule maintenance or investigation trigger	Immediate action required	Maintenance action required
Land surrounding the basins	Identify wheel ruts, dead plants, overtopping and erosion	No evidence of erosion or damage to the structures, including the surrounding embankments.	Wheel tracks Evident	Evidence of overtopping	Revegetate small bare areas. Suggested vegetation is native couch grass. Contact cleaning contractor. Should be treated quarterly
Trash racks on inlet and outlet	Inlet and outlet trash racks to be cleared of litter	Trash racks cleared of litter	Up to 10% of the trash rack blocked with litter	>30% of the trash rack clogged with litter.	
Inlet structures	Inlets to be cleared of litter.	Clear inlets and downstream area	Partly blocked outlets Obvious sediment accumulation	Mostly blocked	
Underdrains	Ensure flows when basin has free water in it.	Flows obvious when free water is present. Flow ceases when there is no free water on the basin surface.	Minor outflow when water is ponded.	No outflow even after extended ponding	Schedule drain inspection
Sediment	Ensure even distribution of sediment on the basin floor.	Sediment absent	Some obvious accumulation of sediment.	Sediment accumulated to at least half the basin depth	Schedule immediate removal of sediment
Compaction	Ensure the majority of water exits the basin via deep percolation	Water depth falls by 100 mm/hr once inflow ceases	None evident	Water is still present 24 hr after inflows cease.	Check compaction
Plants	Identify is there is extensive plant die-off. Act to maintain plant health.	A healthy vigorous and reasonably even distribution of plants.	Plants are stressed	Lots of dead plants.	Identify cause of die-off. (some plants are seasonal and die-off in winter)

7. CONCLUSIONS

The proposed design for the 42 lot low density residential development aimed to meet Council's WSUD targets including:

- 70% of litter greater than 5mm for all flows up to the 1-year ARI peak flow (predicted result-100%)
- 80% reduction in mean annual load of Total Suspended Solids (kg/y) (predicted result-86 %)
- 45% reduction in mean annual load of total phosphorus (kg/y) (predicted result-66%)
- 45% reduction in mean annual load of total nitrogen (kg/y) (predicted result-55%)

An additional target of no increase in peak outflow (cubic m/sec) was added. The MUSIC model predicts a peak outflow of 2 cubic m/sec compared with the predevelopment estimate of 2.5 cubic m/sec. Its implementation will reduce downslope erosion risk.

It is concluded that the design will meet Council's stormwater objectives for the low density development.

8. REFERENCES

Coombes, P. J. and Kunczera, G. (2003). Analysis of the performance of rainwater tanks in Australian capital cities. 28th International Hydrology and Water Resources Symposium, Wollongong, Nov. 2003.

Fletcher, T., Duncan, H., Poelsma, P. and Lloyd, S. (2004). Stormwater flow and quality and the effectiveness of non-propriety stormwater treatment measures. CRCCH, Tech Rep. 04/8.

Macleod, A. (2008). MUSIC calibration based on soil conditions. Proc 2008 NSW and Qld joint SIA conference.

Murphy, C. L (1993). Soil Landscapes of the Gosford-Lake Macquarie 1:100 000 Sheet. Dept Conservation and Land Management. Parramatta, NSW.

NSW Gov (2010). Draft NSW MUSIC Modelling guidelines. Reference R.B17048.001.01

Sydney Catchment Authority (2012). Using MUSIC in Sydney's Drinking Water Catchment. NSW Gov/SCA.

Appendix 1. MUSIC link report

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MUSIC-*link* Report

Project Details		Company Details	
Project:	A3.15 ha rural subdivision is proposed to be divided into 42 low density residential lots. A combination of rainwater tanks, bioretention systems and a wetland will result in the achievement of Council's WSUD objectives,	**Company:**	Woodlots and Wetlands Pty Ltd
Report Export Date:	14-Dec-20	**Contact:**	Dr Peter Bacon
Catchment Name:	for MUSIC link Post development Dec 2020 V5 4msq of unlined	**Address:**	220 Purchase Road Cherrybrook NSW 2126
Catchment Area:	3ha	**Phone:**	0427905440
Impervious Area*:	64.26%	**Email:**	woodlots3@bigpond.com
Rainfall Station:			
Modelling Time-step:	6 Minutes		
Modelling Period:	1-01-1999 - 31-12-2008 11:54:00 PM		
Mean Annual Rainfall:	1015mm		
Evapotranspiration:	1425mm		
MUSIC Version:	6.3.0		
MUSIC-link data Version:	6.33		
Study Area:	South Region		
Scenario:	South Region		

* takes into account area from all source nodes that link to the chosen reporting node, excluding Import Data Nodes

Treatment Train Effectiveness		Treatment Nodes		Source Nodes	
Node: Post-Development Node	**Reduction**	**Node Type**	**Number**	**Node Type**	**Number**
Flow	26.6%	Bio Retention Node	4	Agricultural Source Node	1
TSS	85.5%	Rain Water Tank Node	5	Urban Source Node	23
TP	71%	Wetland Node	3		
TN	60.8%				
GP	100%				

Comments

The proposed WSUD elements result in the Council's Stormwater management objectives being met.

The use of the SCA MUSIC guidelines resulted in some non compliance with Council's MUSIC-link input parameters. These were typically due to the use of a RURAL RESIDENTIAL predevelopment source instead of the AGRICULTURAL source. The rural residential source resulted in lower stormwater quality input coefficients, so the model we used is more conservative.

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Passing Parameters

Node Type	Node Name	Parameter	Min	Max	Actual
Agricultural	Rural residential 3.15 ha	Area Impervious (ha)	None	None	0.047
Agricultural	Rural residential 3.15 ha	Area Pervious (ha)	None	None	3.102
Agricultural	Rural residential 3.15 ha	Total Area (ha)	None	None	3.15
Bio	Bioretention basin 86 msq_ 86 msq filter 0.3 m deep_0.4 m filter_4m unlined filter on sides_ underdrains present	Hi-flow bypass rate (cum/sec)	None	None	1
Bio	Bioretention basin 86 msq_ 86 msq filter 0.3 m deep_0.4 m filter_4m unlined filter on sides_ underdrains present	PET Scaling Factor	2.1	2.1	2.1
Bio	Bioretention basin 95 msq_ 95 msq filter 0.3 m deep_0.4 m filter_4m unlined filter on sides underdrains present	Hi-flow bypass rate (cum/sec)	None	None	1
Bio	Bioretention basin 95 msq_ 95 msq filter 0.3 m deep_0.4 m filter_4m unlined filter on sides underdrains present	PET Scaling Factor	2.1	2.1	2.1
Bio	Bioretention basin 103 msq_ 103 msq filter 0.3 m deep_0.4 m filter_4m unlined filter on sides_ underdrains present	Hi-flow bypass rate (cum/sec)	None	None	1
Bio	Bioretention basin 103 msq_ 103 msq filter 0.3 m deep_0.4 m filter_4m unlined filter on sides_ underdrains present	PET Scaling Factor	2.1	2.1	2.1
Bio	Bioretention basin 89 msq_ 89 msq filter 0.3 m deep_0.4 m filter_4m unlined filter on sides_ underdrains present	Hi-flow bypass rate (cum/sec)	None	None	1
Bio	Bioretention basin 89 msq_ 89 msq filter 0.3 m deep_0.4 m filter_4m unlined filter on sides_ underdrains present	PET Scaling Factor	2.1	2.1	2.1
Post	Post-Development Node	% Load Reduction	None	None	26.6
Post	Post-Development Node	GP % Load Reduction	70	None	100
Post	Post-Development Node	TN % Load Reduction	45	None	60.8
Post	Post-Development Node	TP % Load Reduction	45	None	71
Post	Post-Development Node	TSS % Load Reduction	80	None	85.5
Pre	Pre-Development Node	% Load Reduction	None	None	0
Pre	Pre-Development Node	GP % Load Reduction	None	None	0
Pre	Pre-Development Node	TN % Load Reduction	None	None	0
Pre	Pre-Development Node	TP % Load Reduction	None	None	0
Pre	Pre-Development Node	TSS % Load Reduction	None	None	0
Urban	Catchment 1 Roof to Stormwater Management System 0.072 Ha	Area Impervious (ha)	None	None	0.072
Urban	Catchment 1 Roof to Stormwater Management System 0.072 Ha	Area Pervious (ha)	None	None	0
Urban	Catchment 1 Roof to Stormwater Management System 0.072 Ha	Total Area (ha)	None	None	0.072
Urban	Catchment 1 Roof (12 dwellings) to Rainwater tank (12*.7*200 equals .168 ha).	Area Impervious (ha)	None	None	0.168
Urban	Catchment 1 Roof (12 dwellings) to Rainwater tank (12*.7*200 equals .168 ha).	Area Pervious (ha)	None	None	0
Urban	Catchment 1 Roof (12 dwellings) to Rainwater tank (12*.7*200 equals .168 ha).	Total Area (ha)	None	None	0.168
Urban	Catchment 1Lots_ excluding roofs and road verges (ha)_ 0.575ha 66% pervious due to inclusion of APZs	Area Impervious (ha)	None	None	0.193
Urban	Catchment 1Lots_ excluding roofs and road verges (ha)_ 0.575ha 66% pervious due to inclusion of APZs	Area Pervious (ha)	None	None	0.381

NOTE: A successful self-validation check of your model does not constitute an approved model by Lake Macquarie City Council

MUSIC-*link* now in MUSIC by eWater – leading software for modelling stormwater solutions

Urban	Catchment 2 Roof to Stormwater Management System 0.048 Ha	Area Pervious (ha)	None	None	0
Urban	Catchment 2 Roof to Stormwater Management System 0.048 Ha	Total Area (ha)	None	None	0.048
Urban	Catchment 2 Lots_ excluding roofs and road verges 0.2701(ha)_ 50%	Area Impervious (ha)	None	None	0.134
Urban	Catchment 2 Lots_ excluding roofs and road verges 0.2701(ha)_ 50%	Area Pervious (ha)	None	None	0.135
Urban	Catchment 2 Lots_ excluding roofs and road verges 0.2701(ha)_ 50%	Total Area (ha)	None	None	0.27
Urban	Catchment 2 Roadway 100 % impervious 0.0441 ha	Area Impervious (ha)	None	None	0.044
Urban	Catchment 2 Roadway 100 % impervious 0.0441 ha	Area Pervious (ha)	None	None	0
Urban	Catchment 2 Roadway 100 % impervious 0.0441 ha	Total Area (ha)	None	None	0.044
Urban	Catchment 2 Roof (8 dwellings) to Rainwater tank (8*.7*200 equals 0.112 ha).	Area Impervious (ha)	None	None	0.112

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Node Type	Node Name	Parameter	Min	Max	Actual
Urban	Catchment 2 Roof (8 dwellings) to Rainwater tank (8*.7*200 equals 0.112 ha).	Area Pervious (ha)	None	None	0
Urban	Catchment 2 Roof (8 dwellings) to Rainwater tank (8*.7*200 equals 0.112 ha).	Total Area (ha)	None	None	0.112
Urban	Catchment 3 Roof to Stormwater Management System 0.018 Ha	Area Impervious (ha)	None	None	0.018
Urban	Catchment 3 Roof to Stormwater Management System 0.018 Ha	Area Pervious (ha)	None	None	0
Urban	Catchment 3 Roof to Stormwater Management System 0.018 Ha	Total Area (ha)	None	None	0.018
Urban	Catchment 3 Lots_ excluding roofs and road verges 0.1475 (ha)_ 50%	Area Impervious (ha)	None	None	0.073
Urban	Catchment 3 Lots_ excluding roofs and road verges 0.1475 (ha)_ 50%	Area Pervious (ha)	None	None	0.074
Urban	Catchment 3 Lots_ excluding roofs and road verges 0.1475 (ha)_ 50%	Total Area (ha)	None	None	0.148
Urban	Catchment 3 Roadway 100 % impervious 0.0322	Area Impervious (ha)	None	None	0.032
Urban	Catchment 3 Roadway 100 % impervious 0.0322	Area Pervious (ha)	None	None	0
Urban	Catchment 3 Roadway 100 % impervious 0.0322	Total Area (ha)	None	None	0.032
Urban	Catchment 3 Roof (3 dwellings) to Rainwater tank (3*.7*200 equals 0.042 ha).	Area Impervious (ha)	None	None	0.042
Urban	Catchment 3 Roof (3 dwellings) to Rainwater tank (3*.7*200 equals 0.042 ha).	Area Pervious (ha)	None	None	0
Urban	Catchment 3 Roof (3 dwellings) to Rainwater tank (3*.7*200 equals 0.042 ha).	Total Area (ha)	None	None	0.042
Urban	Catchment 4 Roof to Stormwater Management System 0.06 Ha	Area Impervious (ha)	None	None	0.06
Urban	Catchment 4 Roof to Stormwater Management System 0.06 Ha	Area Pervious (ha)	None	None	0
Urban	Catchment 4 Roof to Stormwater Management System 0.06 Ha	Total Area (ha)	None	None	0.06
Urban	Catchment 4 Lots_ excluding roofs and road verges 0.2856 (ha)_ 50%	Area Impervious (ha)	None	None	0.142
Urban	Catchment 4 Lots_ excluding roofs and road verges 0.2856 (ha)_ 50%	Area Pervious (ha)	None	None	0.143
Urban	Catchment 4 Lots_ excluding roofs and road verges 0.2856 (ha)_ 50%	Total Area (ha)	None	None	0.286
Urban	Catchment 4 Roadway 100 % impervious 0.122 ha	Area Impervious (ha)	None	None	0.122
Urban	Catchment 4 Roadway 100 % impervious 0.122 ha	Area Pervious (ha)	None	None	0
Urban	Catchment 4 Roadway 100 % impervious 0.122 ha	Total Area (ha)	None	None	0.122
Urban	Catchment 4 Roof (10 dwellings) to Rainwater tank (10*.7*200 equals 0.14 ha).	Area Impervious (ha)	None	None	0.14
Urban	Catchment 4 Roof (10 dwellings) to Rainwater tank (10*.7*200 equals 0.14 ha).	Area Pervious (ha)	None	None	0
Urban	Catchment 4 Roof (10 dwellings) to Rainwater tank (10*.7*200 equals 0.14 ha).	Total Area (ha)	None	None	0.14
Urban	Catchment 5 Roof to Stormwater Management System 0.054 Ha	Area Impervious (ha)	None	None	0.054
Urban	Catchment 5 Roof to Stormwater Management System 0.054 Ha	Area Pervious (ha)	None	None	0
Urban	Catchment 5 Roof to Stormwater Management System 0.054 Ha	Total Area (ha)	None	None	0.054
Urban	Catchment 5 Lots_ excluding roofs and road verges 0.243 ha_ 50%	Area Impervious (ha)	None	None	0.121
Urban	Catchment 5 Lots_ excluding roofs and road verges 0.243 ha_ 50%	Area Pervious (ha)	None	None	0.121
Urban	Catchment 5 Lots_ excluding roofs and road verges 0.243 ha_ 50%	Total Area (ha)	None	None	0.243
Urban	Catchment 5 Roof (9 dwellings) to Rainwater tank (9*.7*200 equals 0.126 ha).	Area Impervious (ha)	None	None	0.126
Urban	Catchment 5 Roof (9 dwellings) to Rainwater tank (9*.7*200 equals 0.126	Area Pervious (ha)	None	None	0

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musiclink

		(ha)			
Urban	Cathment 1Road verges (0.117 ha).Assume 35% imprevious	Area Pervious (ha)	None	None	0.078
Urban	Cathment 1Road verges (0.117 ha).Assume 35% imprevious	Total Area (ha)	None	None	0.12
Urban	Cathment 2Road verges (0.020 ha).Assume 50% imprevious	Area Impervious (ha)	None	None	0.009
Urban	Cathment 2Road verges (0.020 ha).Assume 50% imprevious	Area Pervious (ha)	None	None	0.010
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Node Type	Node Name	Parameter	Min	Max	Actual
Urban	Cathment 2Road verges (0.020 ha).Assume 50% imprevious	Total Area (ha)	None	None	0.02
Urban	Cathment 3 Road verges (0.021 ha).Assume 50% imprevious	Area Impervious (ha)	None	None	0.010
Urban	Cathment 3 Road verges (0.021 ha).Assume 50% imprevious	Area Pervious (ha)	None	None	0.010
Urban	Cathment 3 Road verges (0.021 ha).Assume 50% imprevious	Total Area (ha)	None	None	0.021
Urban	Cathment 4 Road verges (0.180 ha).Assume 35% imprevious	Area Impervious (ha)	None	None	0.062
Urban	Cathment 4 Road verges (0.180 ha).Assume 35% imprevious	Area Pervious (ha)	None	None	0.117
Urban	Cathment 4 Road verges (0.180 ha).Assume 35% imprevious	Total Area (ha)	None	None	0.18
Urban	Roadway 100 % impervious 0.0989 ha	Area Impervious (ha)	None	None	0.099
Urban	Roadway 100 % impervious 0.0989 ha	Area Pervious (ha)	None	None	0
Urban	Roadway 100 % impervious 0.0989 ha	Total Area (ha)	None	None	0.099
Wetland	Wetland 130 msq for combined flows	% Reuse Demand Met	None	None	0
Wetland	Wetland 140 msq for inflow from C1 to C4	% Reuse Demand Met	None	None	0
Wetland	Wetland 180 msq for inflow from C5	% Reuse Demand Met	None	None	0

Only certain parameters are reported when they pass validation

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Failing Parameters

Node Type	Node Name	Parameter	Min	Max	Actual
Agricultural	Rural residential 3.15 ha	Baseflow Total Nitrogen Mean (log mg/L)	0.04	0.04	-0.05
Agricultural	Rural residential 3.15 ha	Baseflow Total Nitrogen Standard Deviation (log mg/L)	0.13	0.13	0.12
Agricultural	Rural residential 3.15 ha	Baseflow Total Phosphorus Mean (log mg/L)	-1.05	-1.05	-1.22
Agricultural	Rural residential 3.15 ha	Baseflow Total Phosphorus Standard Deviation (log mg/L)	0.13	0.13	0.19
Agricultural	Rural residential 3.15 ha	Baseflow Total Suspended Solids Mean (log mg/L)	1.3	1.3	1.15
Agricultural	Rural residential 3.15 ha	Baseflow Total Suspended Solids Standard Deviation (log mg/L)	0.13	0.13	0.17
Agricultural	Rural residential 3.15 ha	Field Capacity (mm)	80	80	70
Agricultural	Rural residential 3.15 ha	Groundwater Daily Baseflow Rate (%)	22	22	45
Agricultural	Rural residential 3.15 ha	Groundwater Daily Recharge Rate (%)	100	100	60
Agricultural	Rural residential 3.15 ha	Groundwater Initial Depth (mm)	50	50	10
Agricultural	Rural residential 3.15 ha	Pervious Area Infiltration Capacity coefficient - a	84	84	250
Agricultural	Rural residential 3.15 ha	Pervious Area Infiltration Capacity exponent - b	3.3	3.3	1.3
Agricultural	Rural residential 3.15 ha	Pervious Area Soil Initial Storage (% of Capacity)	10	10	30
Agricultural	Rural residential 3.15 ha	Stormflow Total Nitrogen Mean (log mg/L)	0.48	0.48	0.3
Agricultural	Rural residential 3.15 ha	Stormflow Total Nitrogen Standard Deviation (log mg/L)	0.26	0.26	0.19
Agricultural	Rural residential 3.15 ha	Stormflow Total Phosphorus Mean (log mg/L)	-0.22	-0.22	-0.66
Agricultural	Rural residential 3.15 ha	Stormflow Total Phosphorus Standard Deviation (log mg/L)	0.3	0.3	0.25
Agricultural	Rural residential 3.15 ha	Stormflow Total Suspended Solids Mean (log mg/L)	2.15	2.15	1.95
Agricultural	Rural residential 3.15 ha	Stormflow Total Suspended Solids Standard Deviation (log mg/L)	0.31	0.31	0.32
Rain	Catch 4 Rainwater Tank 5 cubic m of rainwater storage capacity	% Reuse Demand Met	80	None	41.7137
Rain	Catch 4 Rainwater Tank 5 cubic m of rainwater storage capacity	Threshold Hydraulic Loading for C** (m/yr)	0	0	3500
Rain	Catch 4 Rainwater Tank 5 cubic m of rainwater storage capacity	Total Nitrogen - C** (mg/L)	0	0	1.4
Rain	Catch 4 Rainwater Tank 5 cubic m of rainwater storage capacity	Total Phosphorus - C** (mg/L)	0	0	0.13
Rain	Catch 4 Rainwater Tank 5 cubic m of rainwater storage capacity	Total Suspended Solids - C** (mg/L)	0	0	12
Rain	Catch 3 Rainwater Tank 5 cubic m of rainwater storage capacity	% Reuse Demand Met	80	None	41.6694
Rain	Catch 3 Rainwater Tank 5 cubic m of rainwater storage capacity	Threshold Hydraulic Loading for C** (m/yr)	0	0	3500
Rain	Catch 3 Rainwater Tank 5 cubic m of rainwater storage capacity	Total Nitrogen - C** (mg/L)	0	0	1.4
Rain	Catch 3 Rainwater Tank 5 cubic m of rainwater storage capacity	Total Phosphorus - C** (mg/L)	0	0	0.13
Rain	Catch 3 Rainwater Tank 5 cubic m of rainwater storage capacity	Total Suspended Solids - C** (mg/L)	0	0	12
Rain	Catch 5 Rainwater Tank 5 cubic m of rainwater storage capacity	% Reuse Demand Met	80	None	41.63
Rain	Catch 5 Rainwater Tank 5 cubic m of rainwater storage capacity	Threshold Hydraulic Loading for C** (m/yr)	0	0	3500

Rain	Catch 5 Rainwater Tank 5 cubic m of rainwater storage capacity	Total Suspended Solids - C** (mg/L)	0	0	12
Rain	Rainwater Tank 5 cubic m of rainwater storage capacity	% Reuse Demand Met	80	None	41.66
Rain	Rainwater Tank 5 cubic m of rainwater storage capacity	% Reuse Demand Met	80	None	41.84
Rain	Rainwater Tank 5 cubic m of rainwater storage capacity	Threshold Hydraulic Loading for C** (m/yr)	0	0	3500
Rain	Rainwater Tank 5 cubic m of rainwater storage capacity	Threshold Hydraulic Loading for C** (m/yr)	0	0	3500
Rain	Rainwater Tank 5 cubic m of rainwater storage capacity	Total Nitrogen - C** (mg/L)	0	0	1.4
Rain	Rainwater Tank 5 cubic m of rainwater storage capacity	Total Nitrogen - C** (mg/L)	0	0	1.4

Only certain parameters are reported when they pass validation

Node Type	Node Name	Parameter	Min	Max	Actua
Rain	Rainwater Tank 5 cubic m of rainwater storage capacity	Total Phosphorus - C** (mg/L)	0	0	0.13
Rain	Rainwater Tank 5 cubic m of rainwater storage capacity	Total Phosphorus - C** (mg/L)	0	0	0.13
Rain	Rainwater Tank 5 cubic m of rainwater storage capacity	Total Suspended Solids - C** (mg/L)	0	0	12
Rain	Rainwater Tank 5 cubic m of rainwater storage capacity	Total Suspended Solids - C** (mg/L)	0	0	12
Urban	Catchment 1 Roof to Stormwater Management System 0.072 Ha	Groundwater Daily Baseflow Rate (%)	5	20	45
Urban	Catchment 1 Roof to Stormwater Management System 0.072 Ha	Groundwater Daily Recharge Rate (%)	35	55	60
Urban	Catchment 1 Roof to Stormwater Management System 0.072 Ha	Pervious Area Infiltration Capacity coefficient - a	175	215	250
Urban	Catchment 1 Roof to Stormwater Management System 0.072 Ha	Pervious Area Infiltration Capacity exponent - b	2.4	4.7	1.3
Urban	Catchment 1 Roof to Stormwater Management System 0.072 Ha	Pervious Area Soil Storage Capacity (mm)	170	210	98
Urban	Catchment 1 Roof (12 dwellings) to Rainwater tank (12*.7*200 equals .168 ha).	Groundwater Daily Baseflow Rate (%)	5	20	45
Urban	Catchment 1 Roof (12 dwellings) to Rainwater tank (12*.7*200 equals .168 ha).	Groundwater Daily Recharge Rate (%)	35	55	60
Urban	Catchment 1 Roof (12 dwellings) to Rainwater tank (12*.7*200 equals .168 ha).	Pervious Area Infiltration Capacity coefficient - a	175	215	250
Urban	Catchment 1 Roof (12 dwellings) to Rainwater tank (12*.7*200 equals .168 ha).	Pervious Area Infiltration Capacity exponent - b	2.4	4.7	1.3
Urban	Catchment 1 Roof (12 dwellings) to Rainwater tank (12*.7*200 equals .168 ha).	Pervious Area Soil Storage Capacity (mm)	170	210	98
Urban	Catchment 1Lots_ excluding roofs and road verges (ha)_ 0.575ha 66% pervious due to inclusion of APZs	Groundwater Daily Baseflow Rate (%)	5	20	45
Urban	Catchment 1Lots_ excluding roofs and road verges (ha)_ 0.575ha 66% pervious due to inclusion of APZs	Groundwater Daily Recharge Rate (%)	35	55	60
Urban	Catchment 1Lots_ excluding roofs and road verges (ha)_ 0.575ha 66% pervious due to inclusion of APZs	Pervious Area Infiltration Capacity coefficient - a	175	215	250
Urban	Catchment 1Lots_ excluding roofs and road verges (ha)_ 0.575ha 66% pervious due to inclusion of APZs	Pervious Area Infiltration Capacity exponent - b	2.4	4.7	1.3
Urban	Catchment 1Lots_ excluding roofs and road verges (ha)_ 0.575ha 66% pervious due to inclusion of APZs	Pervious Area Soil Storage Capacity (mm)	170	210	98
Urban	Catchment 2 Roof to Stormwater Management System 0.048 Ha	Groundwater Daily Baseflow Rate (%)	5	20	45

[illegible]	[illegible]	Capacity exponent - b	[illegible]	[illegible]	[illegible]
Urban	Catchment 2 Roof to Stormwater Management System 0.048 Ha	Pervious Area Soil Storage Capacity (mm)	170	210	98
Urban	Catchment 2 Lots_ excluding roofs and road verges 0.2701(ha)_ 50%	Groundwater Daily Baseflow Rate (%)	5	20	45
Urban	Catchment 2 Lots_ excluding roofs and road verges 0.2701(ha)_ 50%	Groundwater Daily Recharge Rate (%)	35	55	60
Urban	Catchment 2 Lots_ excluding roofs and road verges 0.2701(ha)_ 50%	Pervious Area Infiltration Capacity coefficient - a	175	215	250
Urban	Catchment 2 Lots_ excluding roofs and road verges 0.2701(ha)_ 50%	Pervious Area Infiltration Capacity exponent - b	2.4	4.7	1.3
Urban	Catchment 2 Lots_ excluding roofs and road verges 0.2701(ha)_ 50%	Pervious Area Soil Storage Capacity (mm)	170	210	98
Urban	Catchment 2 Roadway 100 % impervious 0.0441 ha	Groundwater Daily Baseflow Rate (%)	5	20	45
Urban	Catchment 2 Roadway 100 % impervious 0.0441 ha	Groundwater Daily Recharge Rate (%)	35	55	60
Urban	Catchment 2 Roadway 100 % impervious 0.0441 ha	Pervious Area Infiltration Capacity coefficient - a	175	215	250
Urban	Catchment 2 Roadway 100 % impervious 0.0441 ha	Pervious Area Infiltration Capacity exponent - b	2.4	4.7	1.3
Urban	Catchment 2 Roadway 100 % impervious 0.0441 ha	Pervious Area Soil Storage Capacity (mm)	170	210	98
Urban	Catchment 2 Roof (8 dwellings) to Rainwater tank (8*.7*200 equals 0.112 ha).	Groundwater Daily Baseflow Rate (%)	5	20	45
Urban	Catchment 2 Roof (8 dwellings) to Rainwater tank (8*.7*200 equals 0.112 ha).	Groundwater Daily Recharge Rate (%)	35	55	60
Urban	Catchment 2 Roof (8 dwellings) to Rainwater tank (8*.7*200 equals 0.112 ha).	Pervious Area Infiltration Capacity coefficient - a	175	215	250
Urban	Catchment 2 Roof (8 dwellings) to Rainwater tank (8*.7*200 equals 0.112 ha).	Pervious Area Infiltration Capacity exponent - b	2.4	4.7	1.3
Urban	Catchment 2 Roof (8 dwellings) to Rainwater tank (8*.7*200 equals 0.112 ha).	Pervious Area Soil Storage Capacity (mm)	170	210	98
Urban	Catchment 3 Roof to Stormwater Management System 0.018 Ha	Groundwater Daily Baseflow Rate (%)	5	20	45

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Node Type	Node Name	Parameter	Min	Max	Actual
Urban	Catchment 3 Roof to Stormwater Management System 0.018 Ha	Groundwater Daily Recharge Rate (%)	35	55	60
Urban	Catchment 3 Roof to Stormwater Management System 0.018 Ha	Pervious Area Infiltration Capacity coefficient - a	175	215	250
Urban	Catchment 3 Roof to Stormwater Management System 0.018 Ha	Pervious Area Infiltration Capacity exponent - b	2.4	4.7	1.3
Urban	Catchment 3 Roof to Stormwater Management System 0.018 Ha	Pervious Area Soil Storage Capacity (mm)	170	210	98
Urban	Catchment 3 Lots_ excluding roofs and road verges 0.1475 (ha)_ 50%	Groundwater Daily Baseflow Rate (%)	5	20	45
Urban	Catchment 3 Lots_ excluding roofs and road verges 0.1475 (ha)_ 50%	Groundwater Daily Recharge Rate (%)	35	55	60
Urban	Catchment 3 Lots_ excluding roofs and road verges 0.1475 (ha)_ 50%	Pervious Area Infiltration Capacity coefficient - a	175	215	250
Urban	Catchment 3 Lots_ excluding roofs and road verges 0.1475 (ha)_ 50%	Pervious Area Infiltration Capacity exponent - b	2.4	4.7	1.3
Urban	Catchment 3 Lots_ excluding roofs and road verges 0.1475 (ha)_ 50%	Pervious Area Soil Storage Capacity (mm)	170	210	98

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Urban	Catchment 3 Roadway 100 % impervious 0.0322	Pervious Area Infiltration Capacity coefficient - a	175	215	250
Urban	Catchment 3 Roadway 100 % impervious 0.0322	Pervious Area Infiltration Capacity exponent - b	2.4	4.7	1.3
Urban	Catchment 3 Roadway 100 % impervious 0.0322	Pervious Area Soil Storage Capacity (mm)	170	210	98
Urban	Catchment 3 Roof (3 dwellings) to Rainwater tank (3*.7*200 equals 0.042 ha).	Groundwater Daily Baseflow Rate (%)	5	20	45
Urban	Catchment 3 Roof (3 dwellings) to Rainwater tank (3*.7*200 equals 0.042 ha).	Groundwater Daily Recharge Rate (%)	35	55	60
Urban	Catchment 3 Roof (3 dwellings) to Rainwater tank (3*.7*200 equals 0.042 ha).	Pervious Area Infiltration Capacity coefficient - a	175	215	250
Urban	Catchment 3 Roof (3 dwellings) to Rainwater tank (3*.7*200 equals 0.042 ha).	Pervious Area Infiltration Capacity exponent - b	2.4	4.7	1.3
Urban	Catchment 3 Roof (3 dwellings) to Rainwater tank (3*.7*200 equals 0.042 ha).	Pervious Area Soil Storage Capacity (mm)	170	210	98
Urban	Catchment 4 Roof to Stormwater Management System 0.06 Ha	Groundwater Daily Baseflow Rate (%)	5	20	45
Urban	Catchment 4 Roof to Stormwater Management System 0.06 Ha	Groundwater Daily Recharge Rate (%)	35	55	60
Urban	Catchment 4 Roof to Stormwater Management System 0.06 Ha	Pervious Area Infiltration Capacity coefficient - a	175	215	250
Urban	Catchment 4 Roof to Stormwater Management System 0.06 Ha	Pervious Area Infiltration Capacity exponent - b	2.4	4.7	1.3
Urban	Catchment 4 Roof to Stormwater Management System 0.06 Ha	Pervious Area Soil Storage Capacity (mm)	170	210	98
Urban	Catchment 4 Lots_ excluding roofs and road verges 0.2856 (ha)_ 50%	Groundwater Daily Baseflow Rate (%)	5	20	45
Urban	Catchment 4 Lots_ excluding roofs and road verges 0.2856 (ha)_ 50%	Groundwater Daily Recharge Rate (%)	35	55	60
Urban	Catchment 4 Lots_ excluding roofs and road verges 0.2856 (ha)_ 50%	Pervious Area Infiltration Capacity coefficient - a	175	215	250
Urban	Catchment 4 Lots_ excluding roofs and road verges 0.2856 (ha)_ 50%	Pervious Area Infiltration Capacity exponent - b	2.4	4.7	1.3
Urban	Catchment 4 Lots_ excluding roofs and road verges 0.2856 (ha)_ 50%	Pervious Area Soil Storage Capacity (mm)	170	210	98
Urban	Catchment 4 Roadway 100 % impervious 0.122 ha	Groundwater Daily Baseflow Rate (%)	5	20	45
Urban	Catchment 4 Roadway 100 % impervious 0.122 ha	Groundwater Daily Recharge Rate (%)	35	55	60
Urban	Catchment 4 Roadway 100 % impervious 0.122 ha	Pervious Area Infiltration Capacity coefficient - a	175	215	250
Urban	Catchment 4 Roadway 100 % impervious 0.122 ha	Pervious Area Infiltration Capacity exponent - b	2.4	4.7	1.3
Urban	Catchment 4 Roadway 100 % impervious 0.122 ha	Pervious Area Soil Storage Capacity (mm)	170	210	98
Urban	Catchment 4 Roof (10 dwellings) to Rainwater tank (10*.7*200 equals 0.14 ha).	Groundwater Daily Baseflow Rate (%)	5	20	45
Urban	Catchment 4 Roof (10 dwellings) to Rainwater tank (10*.7*200 equals 0.14 ha).	Groundwater Daily Recharge Rate (%)	35	55	60
Urban	Catchment 4 Roof (10 dwellings) to Rainwater tank (10*.7*200 equals 0.14 ha).	Pervious Area Infiltration Capacity coefficient - a	175	215	250
Urban	Catchment 4 Roof (10 dwellings) to Rainwater tank (10*.7*200 equals 0.14 ha).	Pervious Area Infiltration Capacity exponent - b	2.4	4.7	1.3
Urban	Catchment 4 Roof (10 dwellings) to Rainwater tank (10*.7*200 equals 0.14 ha).	Pervious Area Soil Storage Capacity (mm)	170	210	98
Urban	Catchment 5 Roof to Stormwater Management System 0.054 Ha	Groundwater Daily Baseflow Rate (%)	5	20	45

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Urban	Catchment 5 Roof to Stormwater Management System 0.054 Ha	Groundwater Daily Recharge Rate (%)	35	55	60
Urban	Catchment 5 Roof to Stormwater Management System 0.054 Ha	Pervious Area Infiltration Capacity coefficient - a	175	215	250
Urban	Catchment 5 Roof to Stormwater Management System 0.054 Ha	Pervious Area Infiltration Capacity exponent - b	2.4	4.7	1.3
Urban	Catchment 5 Roof to Stormwater Management System 0.054 Ha	Pervious Area Soil Storage Capacity (mm)	170	210	98
Urban	Catchment 5 Lots_ excluding roofs and road verges 0.243 ha_ 50%	Groundwater Daily Baseflow Rate (%)	5	20	45
Urban	Catchment 5 Lots_ excluding roofs and road verges 0.243 ha_ 50%	Groundwater Daily Recharge Rate (%)	35	55	60
Urban	Catchment 5 Lots_ excluding roofs and road verges 0.243 ha_ 50%	Pervious Area Infiltration Capacity coefficient - a	175	215	250
Urban	Catchment 5 Lots_ excluding roofs and road verges 0.243 ha_ 50%	Pervious Area Infiltration Capacity exponent - b	2.4	4.7	1.3
Urban	Catchment 5 Lots_ excluding roofs and road verges 0.243 ha_ 50%	Pervious Area Soil Storage Capacity (mm)	170	210	98
Urban	Catchment 5 Roof (9 dwellings) to Rainwater tank (9*.7*200 equals 0.126 ha).	Groundwater Daily Baseflow Rate (%)	5	20	45
Urban	Catchment 5 Roof (9 dwellings) to Rainwater tank (9*.7*200 equals 0.126 ha).	Groundwater Daily Recharge Rate (%)	35	55	60
Urban	Catchment 5 Roof (9 dwellings) to Rainwater tank (9*.7*200 equals 0.126 ha).	Pervious Area Infiltration Capacity coefficient - a	175	215	250
Urban	Catchment 5 Roof (9 dwellings) to Rainwater tank (9*.7*200 equals 0.126 ha).	Pervious Area Infiltration Capacity exponent - b	2.4	4.7	1.3
Urban	Catchment 5 Roof (9 dwellings) to Rainwater tank (9*.7*200 equals 0.126 ha).	Pervious Area Soil Storage Capacity (mm)	170	210	98
Urban	Cathment 1Road verges (0.117 ha).Assume 35% imprevious	Groundwater Daily Baseflow Rate (%)	5	20	45
Urban	Cathment 1Road verges (0.117 ha).Assume 35% imprevious	Groundwater Daily Recharge Rate (%)	35	55	60
Urban	Cathment 1Road verges (0.117 ha).Assume 35% imprevious	Pervious Area Infiltration Capacity coefficient - a	175	215	250
Urban	Cathment 1Road verges (0.117 ha).Assume 35% imprevious	Pervious Area Infiltration Capacity exponent - b	2.4	4.7	1.3
Urban	Cathment 1Road verges (0.117 ha).Assume 35% imprevious	Pervious Area Soil Storage Capacity (mm)	170	210	98
Urban	Cathment 2Road verges (0.020 ha).Assume 50% imprevious	Groundwater Daily Baseflow Rate (%)	5	20	45
Urban	Cathment 2Road verges (0.020 ha).Assume 50% imprevious	Groundwater Daily Recharge Rate (%)	35	55	60
Urban	Cathment 2Road verges (0.020 ha).Assume 50% imprevious	Pervious Area Infiltration Capacity coefficient - a	175	215	250
Urban	Cathment 2Road verges (0.020 ha).Assume 50% imprevious	Pervious Area Infiltration Capacity exponent - b	2.4	4.7	1.3
Urban	Cathment 2Road verges (0.020 ha).Assume 50% imprevious	Pervious Area Soil Storage Capacity (mm)	170	210	98
Urban	Cathment 3 Road verges (0.021 ha).Assume 50% imprevious	Groundwater Daily Baseflow Rate (%)	5	20	45
Urban	Cathment 3 Road verges (0.021 ha).Assume 50% imprevious	Groundwater Daily Recharge Rate (%)	35	55	60
Urban	Cathment 3 Road verges (0.021 ha).Assume 50% imprevious	Pervious Area Infiltration Capacity coefficient - a	175	215	250
Urban	Cathment 3 Road verges (0.021 ha).Assume 50% imprevious	Pervious Area Infiltration Capacity exponent - b	2.4	4.7	1.3
Urban	Cathment 3 Road verges (0.021 ha).Assume 50% imprevious	Pervious Area Soil Storage Capacity (mm)	170	210	98
Urban	Cathment 4 Road verges (0.180 ha).Assume 35% imprevious	Groundwater Daily Baseflow Rate (%)	5	20	45

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[illegible]	[illegible]	exponent - b	[illegible]	[illegible]	[illegible]
Urban	Cathment 4 Road verges (0.180 ha).Assume 35% imprevious	Pervious Area Soil Storage Capacity (mm)	170	210	98
Urban	Roadway 100 % impervious 0.0989 ha	Groundwater Daily Baseflow Rate (%)	5	20	45
Urban	Roadway 100 % impervious 0.0989 ha	Groundwater Daily Recharge Rate (%)	35	55	60
Urban	Roadway 100 % impervious 0.0989 ha	Pervious Area Infiltration Capacity coefficient - a	175	215	250
Urban	Roadway 100 % impervious 0.0989 ha	Pervious Area Infiltration Capacity exponent - b	2.4	4.7	1.3
Urban	Roadway 100 % impervious 0.0989 ha	Pervious Area Soil Storage Capacity (mm)	170	210	98
Wetland	Wetland 130 msq for combined flows	Hi-flow bypass rate (cum/sec)	None	99	100

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Node Type	Node Name	Parameter	Min	Max	Actual
Wetland	Wetland 140 msq for inflow from C1 to C4	Hi-flow bypass rate (cum/sec)	None	99	100
Wetland	Wetland 180 msq for inflow from C5	Hi-flow bypass rate (cum/sec)	None	99	100

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