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Stormwater Management Strategy

Project No: V200890		**Date:** 3 August 2021	
Project: 583 Ferntree Gully Road, Glen Waverley			
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Attachments:	☒ Stormwater Strategy Plan (pdf) ☒ Legal Point of Discharge Report	☒ Music Model (sqz)	☒ Stormwater Catchment Plan (pdf)

Introduction

Cardno has been engaged to provide a Stormwater Management Report to assist in the application for a planning permit for a medium density development at 583 Ferntree Gully Road Gen Waverley. This report will include a Stormwater Catchment Plan based on preliminary road gradings and a Stormwater Management Plan that incorporates Water Sensitive Urban Design Strategies to ensure the site meets best practice for stormwater quality. The development site grades from north to south, has an area of 2.45 ha and is occupied by a number of buildings along with associated roadways and car spaces. The northern most building is to be retained and separated from this parcel of land. The remaining 1.65 ha approximately is to be subdivided into 77 medium density townhouses. See below Figure 1 for an existing aerial image of the site

Figure 1: Site Area - Nearmap 8/11/2020

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Figure 2 details the proposed development site that shall contain 77 No. medium density houses.

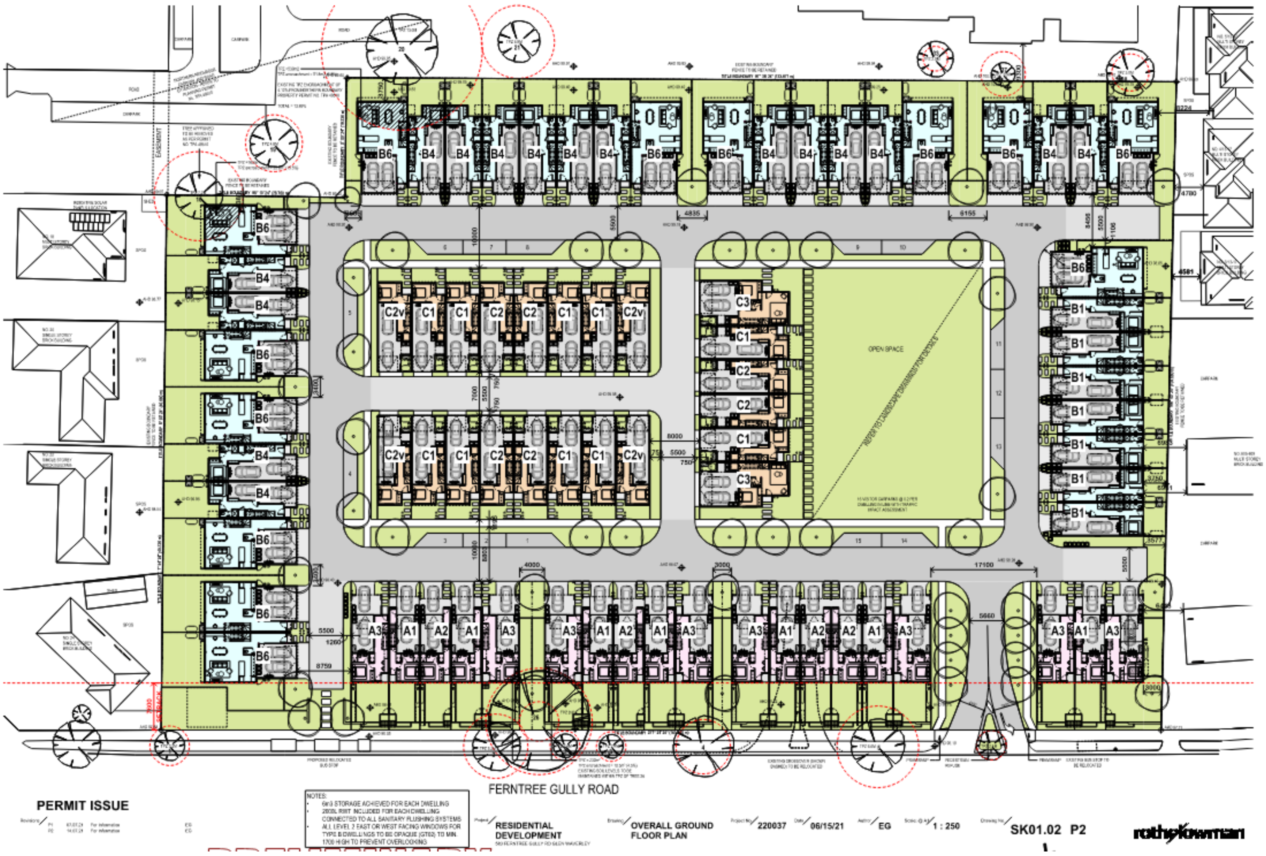

Figure 2: Proposed Development Site – Rothe Lowman

Pre-Development Flow

Monash City Council requires that there is no net increase in stormwater discharged into their drainage network caused by new developments. Each site has a Permissible Site Discharge (PSD) which is the maximum flow rate allowed to outfall to the legal point of discharge. In absence of PSD advice from council, this report has calculated the site's PSD based on current pre-development conditions.

The pre-development flow has been calculated based on the Rational Method Equation: $Q=\frac{CIA}{0.36}$

Where:

Q = Flow rate of water measured in litres per second (L/s)

C = Co-efficient of run-off -unitless

I = Rainfall intensity measured in millimetres per hour (mm/hr)

A = Area of catchment measured in hectares (Ha)

The rainfall intensity rate varies with location and is dependent on the Tc and design AEP values.

Tc = Time of concentration, time taken for stormwater to flow from upstream point of the catchment to the outfall point, measured in minutes

AEP = Annual Exceedance Probability, the chance that a flood event will occur in any one year, expressed as a percentage. An AEP of 10% has been adopted as per table 5.4.3 of AS3500.3.

Inputting Tc and AEP into the Bureau of Metrology's data for a specific location computes the rainfall intensity. Refer to appendix for Intensity-Frequency Diagram taken for the Glen Waverley region.

The Co-efficient of run-off is calculated in accordance with the Australian Rainfall and Runoff (AR&R) Volume 1 (May 2003), Book VIII, Section 1.5.5(iii). The full calculations have been included in the appendix and summarised below.

Pre-development	Pervious	Impervious	Total	Fraction impervious (*f*)	Co-efficient of run-off (C)
Area (m^2)	5850	10628	16478	0.645	0.634

Table 1: Pre-development Co-efficient of Run-off

Acquiring these parameters and inputting them into the Rational Formula the pre-development flow for the Total Site can be calculated (10% AEP, C=0.634, A= 1.648 Ha, 8 min Tc, I = 92.8mm/hr).

$$Q = \frac{0.634\ X\ 92.8\ X\ 1.648}{0.36} = 269\ L/s$$ => pre-development flow - PSD for development

Post-Development Flow

Post-development flow is the expected amount of stormwater to be generated during a specific storm event. Developments tend to increase impervious areas by adding hard scapes such as roads and roofs which reduce the amount of stormwater infiltrating into softscape areas such as grass and garden beds. The post-development flow for this development will now be calculated utilising the rational method with parameters reflective of completed construction based on the latest available architectural layout.

Post-development	Pervious	Impervious	Total	Fraction impervious (*f*)	Co-efficient of run-off (C)
Area (m^2)	4303	12175	16478	0.738	0.704

Table 2: Post-development Co-efficient of Run-off

Acquiring these parameters and inputting them into the Rational Formula the post-development flow for the Total Site can be calculated (10% AEP, C=0.704., A= 1.648 Ha, 9 min Tc, I = 88.1mm/hr).

$$Q = \frac{0.704\ X\ 88.1\ X\ 1.648}{0.36} = 284\ L/s$$ post development flow

On-Site Detention

Due to the post-development flow being higher than the pre-development flow there is a need for on-site detention. This is to throttle flows in excess of the PSD to ensure the Council network is not overburdened during a storm event. OSD4 software has been used to calculate the volume of on-site storage required for the site based on calculated permissible site discharge flow and simulated post-development flow computed using the rational method.

With a PSD of 269 L/sec, a post-development coefficient of runoff of 0.704 and rainfall data taken from the Mount Waverley rain gauge; the OSD volume for a 1 in 20-year storm event can be calculated using OSD4 software. The required amount of storage is 78.49m³ as shown in figure 3 below.

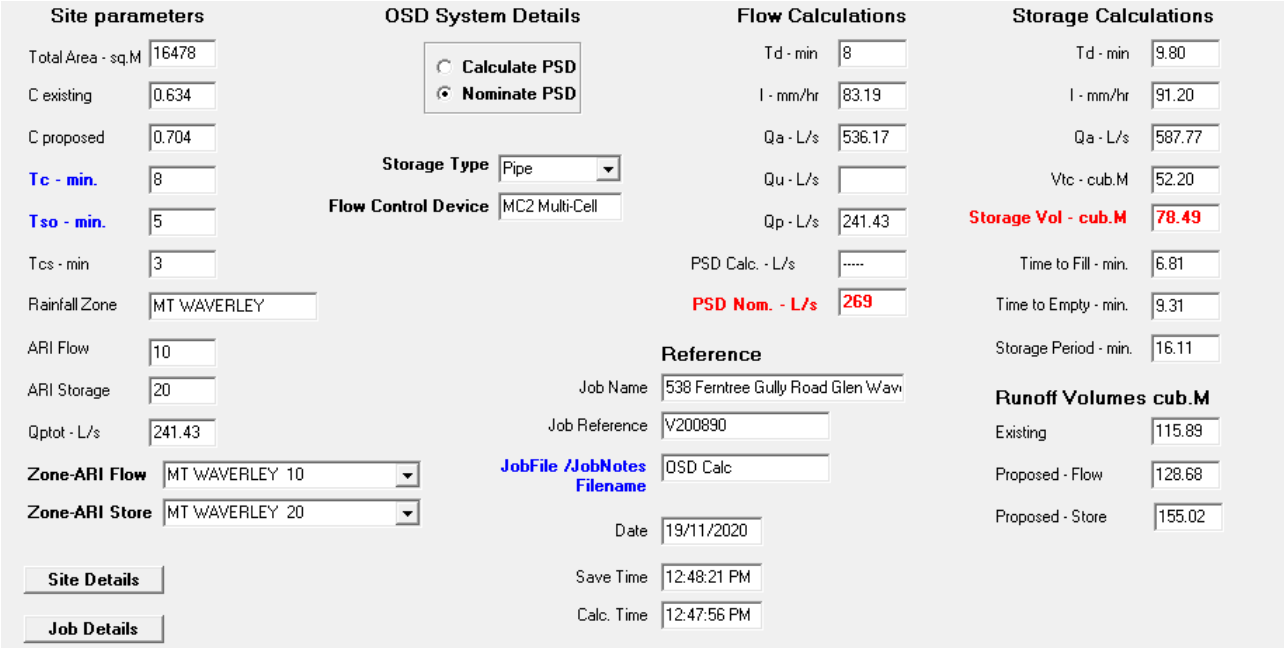

Figure 3: Detention Requirement – OSD4 Software

It is proposed to implement oversized underground stormwater pipes to store the necessary volume required for detention. The sizing and locations of these pipes shall be finalised during detailed design.

Legal Point of Discharge

Legal Point of Discharge (LPOD) advice has been provided by Monash City Council dated 1st December 2020 and attached to this report. Council have declared the LPOD to be the southern boundary of the site along Ferntree Gully Road. Cardno nominates to connect into the two existing pits along Ferntree Gully road as per existing conditions. The pit located midblock along the southern boundary is near the existence of a mature tree which is proposed to be retained. By implementing two legal points of discharge outlets ensures the site to be broken up into two internal catchments which discharge to their respective outfall point while protecting this existing tree.

Stormwater Catchment Strategy

Based on the natural fall of the land, Council nominated legal point of discharge and proposed internal road layout, a catchment plan shown in figure 4 over page illustrates how flows generated by the site will be safely conveyed downstream.

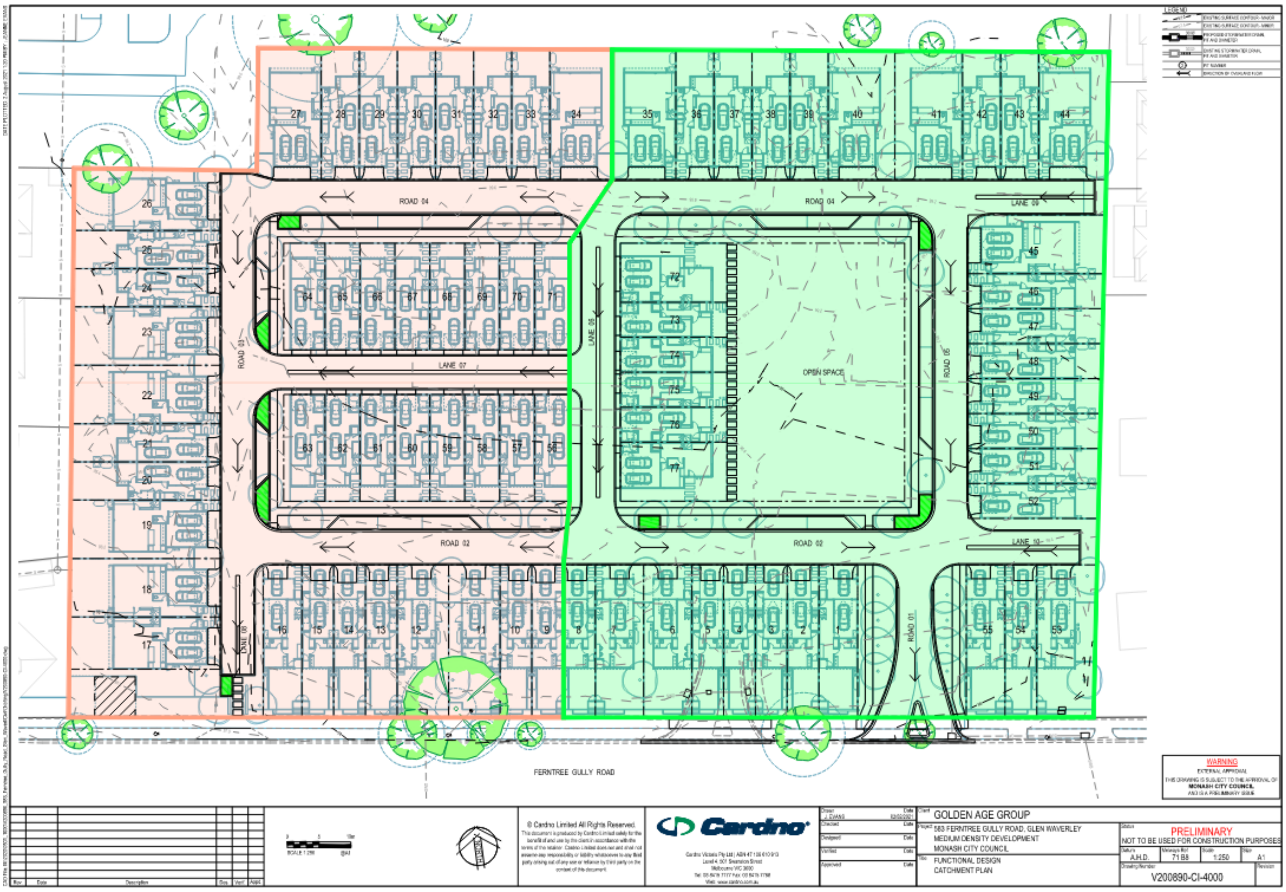

Figure 4: Stormwater Catchment Plan

Based on preliminary road gradings of internal high points and flow paths and development has been divided into two catchments and tabulated below.

	West Catchment	East Catchment	Total
Area	7854 sqm	8624 sqm 8636	16478 sqm
Percentage	47.6%	52.4%	100%

Table 3: Internal Catchments

Water Sensitive Urban Design

The objective of the treatment is to meet best practice Water Sensitive Urban Design as per Clause 53.18 – Stormwater Management in Urban Development planning scheme set down by the Department of Environment, Land, Water and Planning. This is in accordance with Melbourne Water's publication "WSUD Engineering Procedures" which stipulates the following water quality standards as tabulated below.

Pollutant	Target Reduction (of typical urban annual load)
Suspended Solids	80%
Total Nitrogen (TN)	45%
Total Phosphorus (TP)	45%
Typical urban annual litter load	70%

Table 1: Best Practice Water Quality Targets

MUSIC Modelling

A MUSIC analysis (Model for Urban Stormwater Improvement Conceptualisation) was undertaken to estimate the residual pollutant loads generated by the site with the intention of meeting 'Best Practice' water quality objectives. The stormwater treatment devices include:

- Rainwater tanks from roof runoff to reuse onsite for toilet flushing and gardening/landscape irrigation.
- Raingardens to filter contaminants collected from road pavements areas before being discharged
- A proprietary filtration system to treat Total Nitrogen and Total Phosphorus before stormwater is discharged from the site

A typical section of a Raingarden is shown in Figure 5 below.

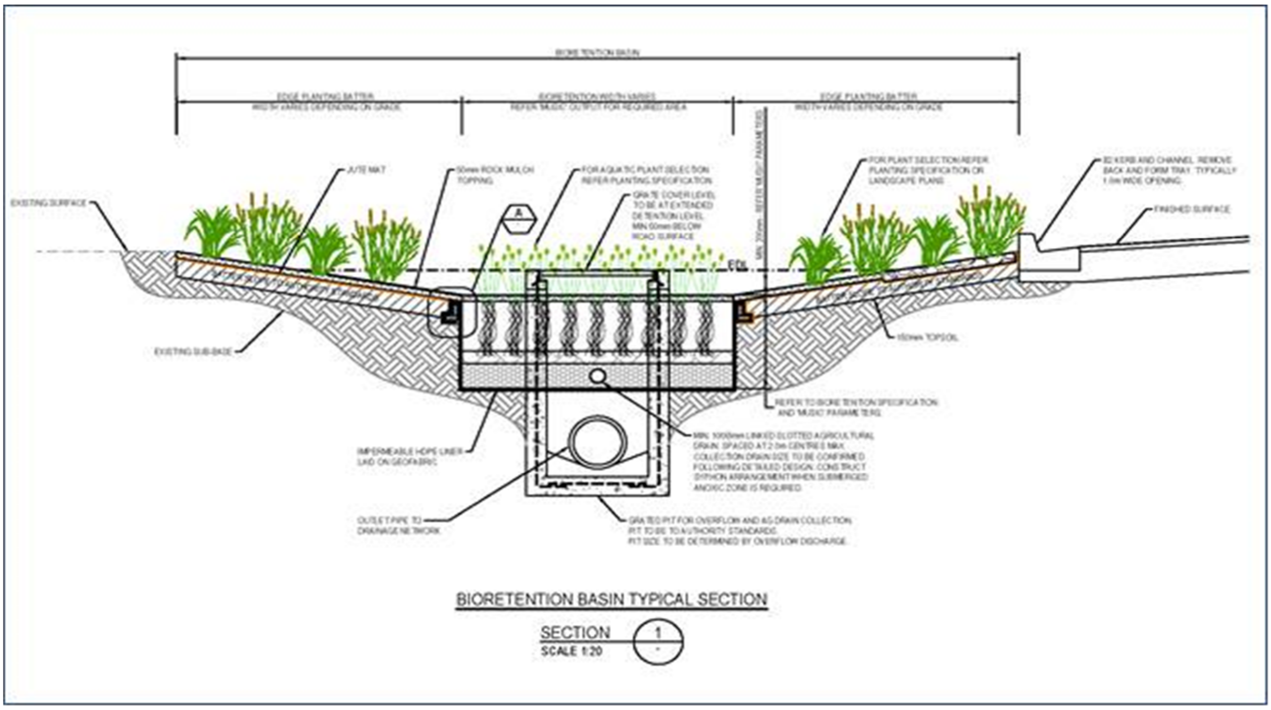

Figure 5: Raingarden Typical Section

The location and order of these proposed treatment devices are shown in the MUSIC model layout below. The model is a concept of the proposed strategy and the exact locations and alignment of these devices will be finalised during detailed design. The outfall node is for computation purposes only and is not reflective of the actual ultimate stormwater discharge point.

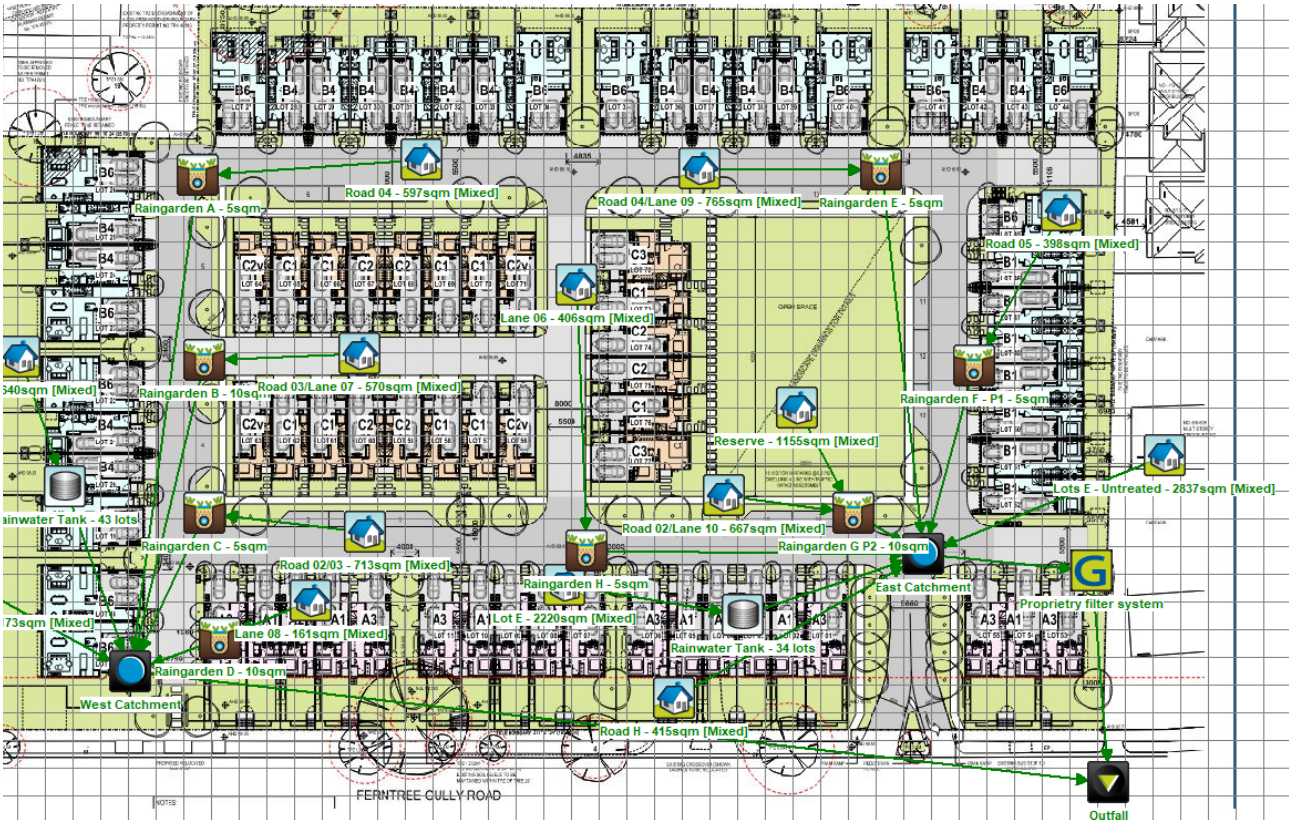

Figure 6: MUSIC Model

In an effort to reduce the demand placed upon mains supply, improve water reuse and reduce outbound pollutant loads, rainwater storage tanks are proposed to capture roof runoff from 77 dwellings. The harvested rainwater shall be used to supplement potable water supply for toilet flushing and irrigation.

The predicted overall annual pollutant residual loading and reduction that will be achieved is shown in figure 7. The MUSIC model confirms that best practice stormwater treatment objectives can be achieved with the proposed stormwater treatment measures described and analysed in this report.

Treatment Train Effectiveness - Outfall

	Sources	Residual Load	% Reduction
Flow (ML/yr)	9.95	8.46	15
Total Suspended Solids (kg/yr)	1420	206	85.4
Total Phosphorus (kg/yr)	3.33	1.36	59
Total Nitrogen (kg/yr)	26.4	9.67	63.4
Gross Pollutants (kg/yr)	258	14.3	94.4

Figure 7: MUSIC Treatment Train Effectiveness

The main parameters used in the MUSIC model are described below:

> Rainfall and Evaporation - A 1990-1999 6 minute time-step data from the Croydon rainfall gauge was used for the model.

> Rainfall Runoff Parameters – The standard rainfall-runoff parameters associated with urban commercial nodes were used in the MUSIC model setup.

> Contributing Catchment Areas inputted as source nodes in MUSIC are as follows:
East Catchment Lot area – 2220m^2
East Catchment Road area – 2412m^2
East Catchment Untreated area - 2837m^2
East Catchment Reserve area - 1155m^2
West Catchment Lot Area – 2640m^2
West Catchment Road area – 2041m^2
West Catchment untreated area - 3173m^2

> Rainwater tank Demand Loads – Annual rainwater usage calculated at 22750 litres per dwelling
Monthly dwelling rainwater demand for MUSIC model

Jan	16%	Jul	6%
Feb	13%	Aug	6%
Mar	10%	Sep	6%
Apr	6%	Oct	6%
May	6%	Nov	8%
Jun	6%	Dec	11%

To meet these objectives while adhering to space and logistical limitations of the proposed development, a Stormwater Strategy Plan has been procured to illustrate the proposed treatment devices and locations within the subject site. The stormwater strategy plan incorporates a range of WSUD treatment devices to capture, reuse and treat stormwater run-off. This includes the implementation of a 2kL rainwater tank for each allotment, eight raingardens with a combined surface area of 55m^2 and on-site stormwater detention. The Plan has been included below in Figure 8.

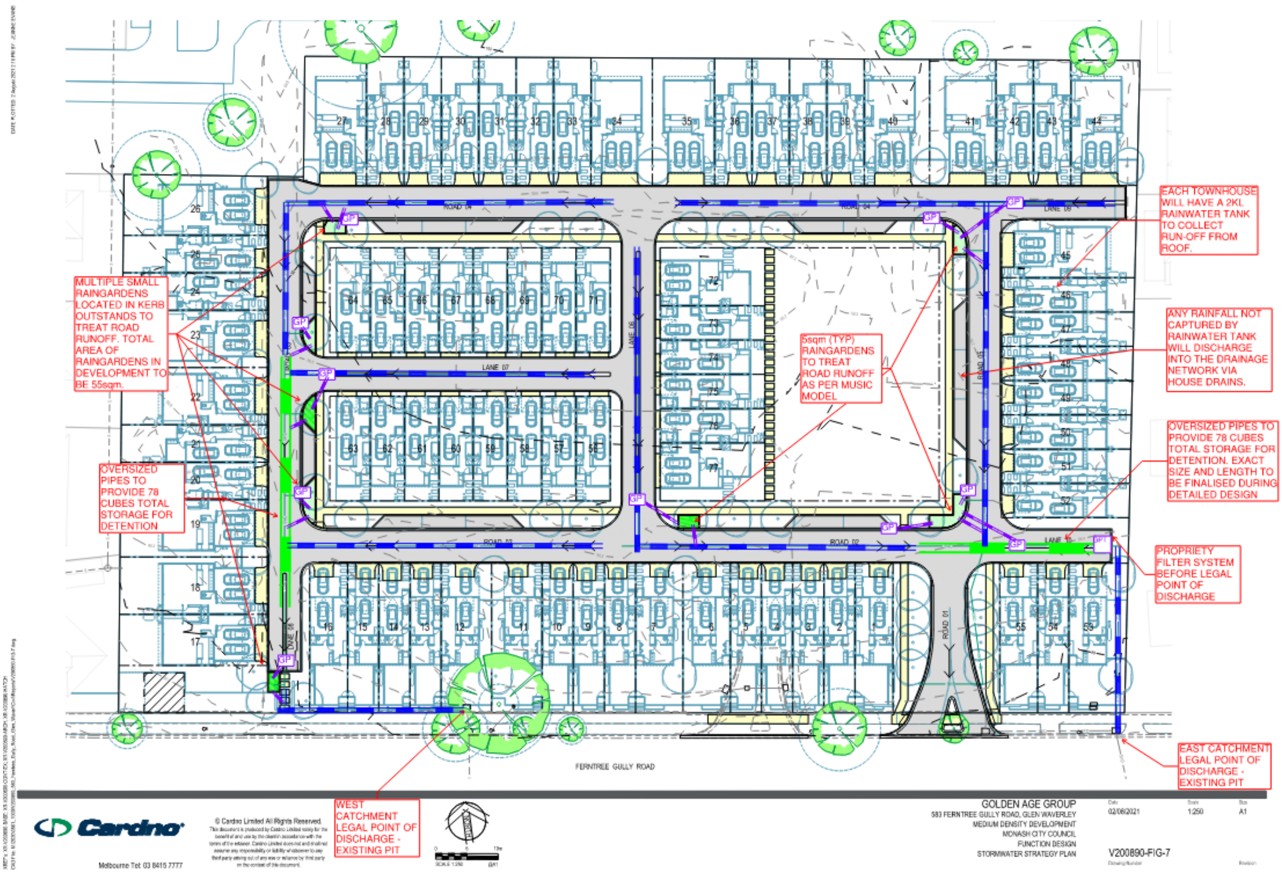

Figure 8: Stormwater Strategy Plan

Rainwater Tanks

A 2kL tank is proposed for each of the 77 townhouses. The ESD consultant Co-Perform has undertaken analysis to determine the level of the tank throughout the year based on typical rainfall. Based on the full roof area (approx. 60sqm) being captured into a 2,000-litre tank, with 1.1 people per bedroom, four toilet flushes per day and also assuming landscape watering the tank annual profile looks like the graph in figure 9 which has been provided by Co-Perform.

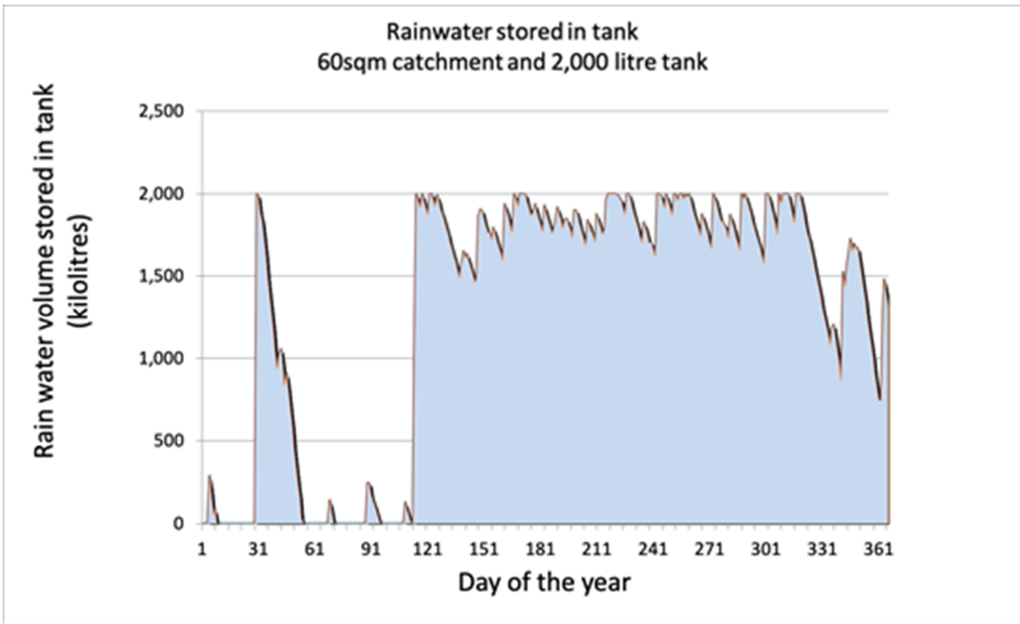

Figure 9: Graph of storage volume in Rainwater tank over a year – Co-Perform Consultants

This indicates that the tank is drained down quickly during periods of low rainfall and especially during the summer months when there is also a demand for landscape watering. This indicates that it is not appropriate to utilise the rainwater tanks for detention system as they are fully utilised for the retention and reuse requirement. The entire detention volume required (78 cubes) will be provided by oversized pipes and not the rainwater tanks.

Recommendations

> To meet the Best Practice Environmental Guidelines (BPEG), bio retention systems totalling 65m² along with a 2kL rainwater tank for every townhouse must be used to provide water quality treatment.

> Incorporate over-sized underground pipes to store 78 cubic metres of volume for on-site detention beneath the road pavement to maintain the pre-development flow into Council's drainage network.

> Council adopts this report as part of the planning permit and accepts the strategy of using two pits as discharge points along the southern boundary to assist in stormwater conveyance and avoid removing a mature tree in the frontage of Ferntree Gully Road.

Conclusion

This report is to support the application for a planning permit with Council to facilitate the development at 583 Ferntree Gully Road for seventy seven medium density townhouses. These dwellings will each have a 2000L rainwater tank for toilet flushing and irrigation but is not suitable for detention storage. The detention volume has been calculated as 78 cubic metres based on the pre-development and post-development flows which have been calculated using OSD4 software and the rational method. Run off from road surfaces shall mainly be treated via raingardens. The stormwater from the eastern portion of the site will also pass through a proprietary filtration system to treat total nitrogen and total phosphorus.

The site falls from north to the south and preliminary road gradings shows no trapped low points within the development, and the strategy is to split the site into two catchments which safely conveys stormwater downstream to the two existing pits nominated as the LPOD.

Appendix

Rational Method Full Calculation Formulas

The pre-development flow has been calculated based on the Rational Method Equation: $Q = \frac{CIA}{0.36}$

Q = Flow rate of water measured in litres per second (L/s)

C = Coefficient of run-off -unitless

I = Rainfall intensity measured in millimetres per hour (mm/hr)

A = Area of catchment measured in hectares (Ha)

The rainfall intensity rate (I) varies with location and is dependent on the Tc and design AEP values.

Tc = Time of concentration, time taken for stormwater to flow from upstream point of the catchment to the outfall point, measured in minutes

Tc = To + Ti where;

Ti = Initial time from roof to lot's discharge point (minutes)

To = time stormwater takes to flow from lot discharge point to site discharge point (minutes)

To = L / V where;

L = longest reach stormwater has to travel internally (meters)

V = velocity of stormwater in pipe (m/sec)

AEP = Annual Exceedance Probability, the chance that a flood event will occur in any one year, expressed as a percentage.

The Co-efficient of run-off is calculated in accordance with the Australian Rainfall and Runoff (AR&R) Volume 1 (May 2003), Book VIII, Section 1.5.5(iii). The coefficient of run-off is a product of the site's fraction impervious, frequency factor and rainfall intensity as set out by the following formula

$C_{10} = 0.9f + C'_{10}\,(1-f)$ where;

C_{10} = 10-year AEP runoff coefficient

f = fraction impervious – portion of site where infiltration of stormwater can not occur (range from 0 to 1)

C'_{10} = pervious runoff coefficient which has the formula

$C'_{10} = 0.1 + 0.0133\,({}^{10}I_1 - 25)$ where;

${}^{10}I_1$ = the 10 year AEP, 1 hour duration rainfall intensity

To convert C_{10} to C, a frequency factor is applied as per the below

$C = Fy * C_{10}$ where;

Fy = frequency factor needed to obtain desired design AEP coefficient of runoff

Pre-development Flow

The design C equals C_{10} so no need for a frequency factor due to 10% AEP

$C = 0.9f + C'_{10}(1-f)$

f = 0.645 taken from measuring the area of pre-development impervious area and dividing by total site area

$C'_{10} = 0.1 + 0.0133\ ({}^{10}I_1 - 25)$

${}^{10}I_1 = 28.8$ - as per BOM IFD table included below

	Annual Exceedance Probability (AEP)						
Duration	**63.2%**	**50%#**	**20%***	**10%**	**5%**	**2%**	**1%**
1 hour	16.2	18.1	24.3	28.8	33.5	39.8	44.9
1.5 hour	12.5	13.9	18.5	21.8	25.1	29.7	33.3

Therefore C'10 = 0.1504

C = 0.9 * 0.645 + 0.1504(1-0.645) = 0.634

Tc = Ti + To

Ti = 5 minutes as per table 15 of EDCM

Table 15 Times of Concentration

Development Category	Maximum Time of Concentration (t_c) For flow to enter system (minutes)
MINOR SYSTEM	-
Road Reserves:	
Access Lane	5
Access Place	5
Access Street	6
Connector Street	6
Trunk Connector Street	6
Secondary Arterial Road	6
Primary Arterial Road	6
Parklands	Calculated
Residential:	
Block Area (m^2) < 300	5
300 – 450	5
450 – 600	7
600-1000	7

To = L / V

L = 155m V = 0.8 m/s (assumed)

To = 155 / 0.8 / 60 = 3 minutes (rounded down)

Tc = 5 + 3 = 8 minutes

Inputting Tc and AEP into the Bureau of Metrology's data for the specific location computes the rainfall intensity of 92.8 mm/hr. See below for Intensity-Frequency Diagram taken for the Glen Waverley region.

Location

Label: 583 Ferntree Gully Road

Latitude: -37.9021 [Nearest grid cell: 37.9125 (S)]

Longitude: 145.1589 [Nearest grid cell: 145.1625 (E)]

IFD Design Rainfall Intensity (mm/h)

Issued: 17 November 2020

Rainfall intensity for Durations, Exceedance per Year (EY), and Annual Exceedance Probabilities (AEP).
FAQ for New ARR probability terminology

Table | Chart

Unit: mm/h

	Annual Exceedance Probability (AEP)						
Duration	**63.2%**	**50%#**	**20%***	**10%**	**5%**	**2%**	**1%**
1 min	95.9	107	146	174	204	245	279
2 min	82.3	91.6	123	145	167	193	215
3 min	73.7	82.2	110	130	151	176	196
4 min	67.2	75.0	101	120	139	164	184
5 min	62.0	69.3	93.7	111	129	154	174
8 min	51.0	57.1	77.7	92.8	108	131	149
9 min	48.2	54.1	73.7	88.1	103	125	143
10 min	45.9	51.5	70.2	84.0	98.3	119	136
15 min	37.2	41.8	57.1	68.5	80.3	97.6	112
20 min	31.7	35.6	48.7	58.3	68.4	83.0	95.0
25 min	27.9	31.3	42.6	51.0	59.8	72.4	82.7
30 min	25.0	28.0	38.1	45.6	53.3	64.3	73.4
45 min	19.5	21.8	29.4	35.0	40.8	48.8	55.3

A = 1.648 hectares as per architectural plan

Acquiring these parameters and inputting them into the Rational Formula the pre-development flow for the Total Site can be calculated (10% AEP, C=0.634, A= 1.648 Ha, 8 min Tc, I = 92.8mm/hr).

$$Q = \frac{0.634\ X\ 92.8\ X\ 1.648}{0.36} = 269\ L/s$$ => pre-development flow - PSD for development

Post-development Flow

AEP, C'_{10} and $^{10}I_1$ remain unchanged from the pre-development scenario, only fraction impervious changes

$C = 0.9f + C'_{10}(1-f)$

f = 0.738 taken from measuring the area of post-development impervious area and dividing by total site area

C = 0.9 * 0.738 + 0.1504(1-0.738) = <u>0.704</u>

Tc = Ti + To

Ti = 5 minutes as per table 15 of EDCM

Table 15 Times of Concentration

Development Category	Maximum Time of Concentration (t_c) For flow to enter system (minutes)
MINOR SYSTEM	-
Road Reserves:	
Access Lane	5
Access Place	5
Access Street	6
Connector Street	6
Trunk Connector Street	6
Secondary Arterial Road	6
Primary Arterial Road	6
Parklands	Calculated
Residential:	
Block Area (m^2) < 300	5
300 – 450	5
450 – 600	7
600-1000	7

To = L / V

L = 180m V = 0.8 m/s (assumed)

To = 180 / 0.8 / 60 = 4 minutes (rounded up)

Tc = 5 + 4 = 9 minutes

Inputting Tc and AEP into the Bureau of Metrology's data for the specific location computes the rainfall intensity of 88.1 mm/hr. See below for Intensity-Frequency Diagram taken for the Glen Waverley region.

Location

Label: 583 Ferntree Gully Road

Latitude: -37.9021 [Nearest grid cell: 37.9125 (S)]

Longitude: 145.1589 [Nearest grid cell: 145.1625 (E)]

IFD Design Rainfall Intensity (mm/h)

Issued: 17 November 2020

Rainfall intensity for Durations, Exceedance per Year (EY), and Annual Exceedance Probabilities (AEP).
FAQ for New ARR probability terminology

Table Chart Unit: mm/h

	Annual Exceedance Probability (AEP)						
Duration	**63.2%**	**50%#**	**20%***	**10%**	**5%**	**2%**	**1%**
1 min	95.9	107	146	174	204	245	279
2 min	82.3	91.6	123	145	167	193	215
3 min	73.7	82.2	110	130	151	176	196
4 min	67.2	75.0	101	120	139	164	184
5 min	62.0	69.3	93.7	111	129	154	174
8 min	51.0	57.1	77.7	92.8	108	131	149
9 min	48.2	54.1	73.7	88.1	103	125	143
10 min	45.9	51.5	70.2	84.0	98.3	119	136
15 min	37.2	41.8	57.1	68.5	80.3	97.6	112
20 min	31.7	35.6	48.7	58.3	68.4	83.0	95.0
25 min	27.9	31.3	42.6	51.0	59.8	72.4	82.7
30 min	25.0	28.0	38.1	45.6	53.3	64.3	73.4
45 min	19.5	21.8	29.4	35.0	40.8	48.8	55.3

A = 1.648 hectares as per architectural plan

Acquiring these parameters and inputting them into the Rational Formula the pre-development flow for the Total Site can be calculated (10% AEP, C=0.704, A= 1.648 Ha, 9 min Tc, I = 88.1mm/hr).

$$Q = \frac{0.704 \ X\ 88.1\ X\ 1.648}{0.36} = 283\ L/s$$ => post-development flow