BESPOKE ENGINEERING SOLUTIONS

STORMWATER MANAGEMENT PLAN

Proposed Residential Subdivision

AT

Ebbw Vale Residential, Ebbw Vale, QLD, 4304

FOR

Queensland Property Group

Project No. B774

June 2025



REPORT CONTROL SHEET

Date:	10-06-2025					
Report Title:	Stormwater Management Plan					
Site address:	Ebbw Vale Residential, Ebbw Vale, QLD, 4304					
Our Ref No:	B774					
Author:	Idris Ahmad					
Certifier:	 Idris Ahmad (RPEQ 09127)					
Revision:	H	G	C	D	E	F
Date:	10.06.2025	07.03.2025	14.09.2023	09.08.2024	27.08.2024	08.11.2024

Disclaimer:
This report is a professional opinion based on the information available at the time of writing. It is not intended as a quote, guarantee or warranty and does not cover any latent defects.

This report will comment on the civil infrastructure to the project and may outline probable costs but the extent of the commission of Bespoke Engineering Solutions does not extend to detailed cost feasibility, as such the costs should not be relied on for financing arrangements.

This report has been prepared specifically for the aforementioned client, site and project. It has been written solely for the purpose of providing engineering advice on the above issues for Council for this development site. Please note that this report has been compiled based on the information that is current at the time of report printing, and that the recommendations supplied within this report are based solely on the above.

Also, no further analysis has been conducted beyond the nominated lawful point of discharge. Any existing drainage issues downstream from the analysed area shall be considered to remain the responsibility of the Council to investigate and maintain.

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1.0 INTRODUCTION

Bespoke Engineering Solutions have been commissioned by Queensland Property Group (referred to as the "Client" hereafter) to prepare a Site Based Stormwater Management Report for the proposed Residential Subdivision at Ebbw Vale Residential, Ebbw Vale. This document will address the management of stormwater quantity and quality, for submission to Ipswich City Council in support of the Development Application.

1.1 BASIS OF THE REPORT

The Stormwater Management Plan has been developed to assist in identifying acceptable stormwater management measures that incorporate the design fundamentals outlined within the local authorities' engineering planning scheme policies and Queensland Urban Drainage Manual's Fourth Edition August 2017 (QUDM).

This report has been compiled based on the following information:

- Discussions between Bespoke Engineering Solutions and the project team
- Site Plan provided by Queensland Property Group
- Proposed Site Plan provided by Queensland Property Group and Bespoke Engineering Solutions

1.2 SCOPE OF THE REPORT

This document will report on the following stormwater items:

- Identify the lawful point of discharge in accordance with the Local Authority requirements.
- Prepare a conceptual stormwater plan for the proposed development, which incorporates the recommendations made as part of the findings of this report.
- Identify any increases in stormwater runoff that will be generated by the development.
- Make the appropriate recommendations to ensure that stormwater discharge from the development is the same as pre-development discharge and that proposed stormwater discharge will not adversely affect surrounding properties and/or the drainage network.

2.0 SITE CHARACTERISTICS

2.1 LOCATION & DESCRIPTION

The development site exists as land described as Lot 25 SP220030 & 27 SP220033 freehold residential land. The development site has a total area of 29.06 ha and currently comprises heavy bushland. Furthermore, a power easement is adjacent the site on Lot 2 SP207444. The site is subjected to history of mining work operations; geotechnical reports indicate that underground mining had occurred on the site from the 1870's to 1960 with various open cut mining operations taking place into the late 1970's.

The development site has been proposed to create 387 residential lots along with local shopping amenities. The proposed development will be directly accessed through Whitwood Road & Railway Street via a new collector road heading in a southerly direction adjacent to the water corridor and an additional parallel access road is proposed on the western site boundary in front of benching lots. These roads then split into a series of access type roads into the 387 freehold lots.

Refer to **Appendix A** for **Proposed Site Layout**.

ICC interactive map shows the site currently under Conservation and SA30 Special Opportunity zoning.

Figure 1: Locality Plan (Source: Nearmap)

2.2 TOPOGRAPHY

The development site falls towards the North at RL 45m AHD and curved from South, West and East in a concaved fashion towards the Ebbw Vale memorial park along with the two parallel roads Railway Street & Jordan Street. The following illustrates the RL's located per side.

- South: RL 64m AHD to North of site with an approximate fall grade of 2.78%
- West: RL 77m AHD to North of site with an approximate fall grade of 6.76%
- East: RL 92m AHD to North of site with an approximate fall grade of 9.81%

The site has three entry/exit roads which includes Railway Street, Jordan Street & Whitwood Road.

2.3 SOILS

In accordance to the geotechnical report undertaken by Butler Partners, various surface layers of fill exist, including various composites of cohesive and non-cohesive materials throughout the site such as loose to very dense gravelly/clayey/silty sand/gravel and firm to hard silty/sandy/gravelly clay/silt. The depth of said fills range between 2.3m to 29m throughout numerous locations. Furthermore, weathered sedimentary rock of extremely low to medium strength was encountered underlying the soils along with interbedded layer of coals.

2.4 ACID SULPHATE SOILS

Acid Sulphate Soils (ASS), are normally found in Holocene sediments and are generally found at levels lower than 5.0m AHD. The minimum level of the site is approximately 45m AHD. It is not expected that ASS will be encountered, however in the event that ASSs are encountered on the site, a suitable Acid Sulphate Soils Management Plan will be developed by an appropriately qualified consultant. In addition, management of the acid sulphate soil will be required by the principal contractor in accordance with the requirements of the State Planning Policy involving ASS's.

2.5 EROSION AND SEDIMENT CONTROL

Erosion and sediment control (ESC) measures will be required to be established and maintained in accordance with Ipswich City Council's standards of best practice. Preparation of a detailed ESC plan showing how ESC will be managed during the construction phase of the project will be required. It will be the responsibility of the principal contractor to implement, and update as necessary, the requirements of the ESC plan during the construction phase.

2.6 FLOODING

The latest Ipswich City Council's Interactive Mapping (current at the time of this report) shows that the development site is not subjected to flooding. Furthermore, subject site was unaffected by historical flood events 2022, 2011 and/or 1974 as is mapped by Ipswich City Council on their Historical Flood Map. See section 3.1.2 below for further information.

3.0 STORMWATER QUANTITY

3.1 RUNOFF CHARACTERISTICS & LAWFUL POINT OF DISCHARGE

3.1.1 PRE-DEVELOPMENT CATCHMENTS

The existing site is considered to have two (2) catchment areas based on the preliminary site survey and LiDAR elevation data for contours outside of the development site. The two separate catchments are approximately 54.058ha flow towards north & 4.024ha flow towards north-east. The development site is seen impacted by external catchments due to the elevation of the site being lower than the immediate adjacent properties. There are two external catchment areas which are detailed as follows:

- Pre-development Catchment 01 (PRECA1) : 540,583 m^2 flows south-north on the development site
- Pre-development Catchment 02 (PRECA2) : 40,235 m^2 flows north-east on the development site

Total Pre-development Catchment Area = 540,583 m^2 + 40,235 m^2 = 580,818m^2
= 58.082 ha

Stormwater Catchment Plans are shown under **Appendix F** in addition to **Appendix B** under **Appendix J**.

3.1.2 FLOODING AND OVERLAND FLOW INUNDATION

The latest Ipswich City Council's Interactive Mapping (current at the time of this report) shows that the development site is not subject to flooding but conveys an overland flow path as illustrated by below **Figure 2** and further detailed under the **Flood Impact Assessment (March 2025)** attached to **Appendix J**.

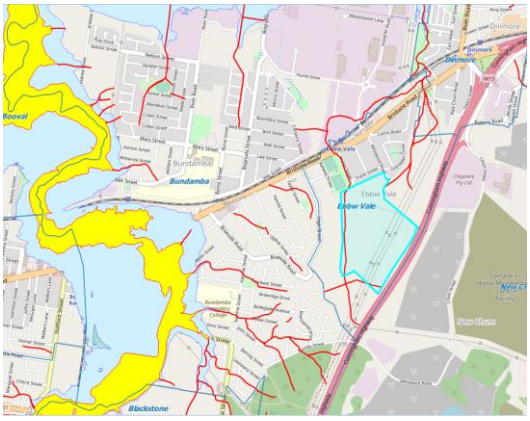

Figure 2: ICC Interactive Flood Map

Subject site was unaffected by historical flood events 2022, 2011 and/or 1974 as is mapped by Ipswich City Council on their Historical Flood Map as illustrated below in **Figure 3**.

Figure 3: ICC Historical Flood Map

3.1.3 EXISTING RUNOFF

Based on preliminary site surveys, LiDAR elevation data and Urban Catchment Flow Paths illustrated on ICC Interactive mapping and Appendix E of the **Flood Impact Assessment (March 2025)** attached to **Appendix J,** most of the stormwater that is captured on the existing site sheet overland flows towards the North portion of the site towards the Ebbw Vale Memorial Park.

3.1.4 PROPOSED RUNOFF AND LAWFUL POINT OF DISCHARGE

Under the post-development scenario, existing stormwater currently captured on subject site is allowed to overland sheet flow towards the North of the site and into the Ebbw Vale memorial park and to North East.

Runoff under post-development conditions is proposed to mimic or improve existing conditions. In other words, post-development discharges at the lawful point are similar to or lower than pre-development conditions.

This is shown by calculations and modelling in the following sections in addition to supporting **Flood Impact Assessment (March 2025)** provided under **Appendix J** of this report.

3.1.5 PROPOSED INFRASTRUCTURE

The total conveyance of overland flow across the site is divided into two distinct sections, following the ridge line that runs along the length of the property. Three detention basins (namely basin 1, basin 2 and basin 3) are proposed to manage the flow across the entire site, in addition to two in-stream devices, which are detained at downstream culverts. For details of culverts, further to this report, please refer to our **drawing series C200, C300** in conjunction with **CWD's flood impact assessment** under **Appendices B-E** and **Appendix J**.

1. **West of Ridge Line** - Approximately 75% of the overland flow to the west of the ridge line is directed into a proposed primary rock-lined channel (in-stream detention) located centrally within the corridor, acting as a basin of overland flow path. A detention basin is also proposed at the northwestern extremity of the site area, of the central rock-lined channel, at the north end. Two in-stream control devices are proposed in the rock-lined channel at locations where the cross-drainage structures are proposed due to road crossings.

2. **East of Ridge Line -** The remaining 25% of the overland flow is captured by a single, separate detention basin situated at the northeast corner of the site boundary.

In addition to the detention basins outlined above, four bio-basins are also proposed for water quality treatment. These bio-basins have a sediment forebay & trash rack on their upstream. Before entering the mainstream detention basins, the Q3-monthly discharge will be directed through the bio-basins for treatment by means of split-flows via weir arrangements inside dedicated maintenance holes. Once treated, the flow will be directed into the detention systems as previously described. Any other flows will bypass the bio-basins and enter the detention basins directly (refer to drawing series **C300, Appendix F).**

Stormwater Pit & Pipes are shown on C300, Quantity Catchments are shown on C300A and C300B, while C301 shows Stormwater Quality Catchments.

As mentioned, detention devices 1 and 2 correspond to the central rock-lined proposed channel. The outlet discharge from these systems is controlled by two-level reinforced concrete pipes (RCPs) at each device, with lower-level RCPs designed to accommodate stormwater flows from low ARI events and upper-level RCPs for major stormwater events (refer to drawings **C313 and C317, Appendix F**).

These two culvert locations serve as the control points for minor and major flow discharge stormwater ARI events. Detention system device 1 is proposed at the culvert crossing of Road 4, while detention system device 2 is located at the culvert crossing of Road 12 (refer to **drawing series C300 Appendix F**).

The culvert crossings on the primary water corridor (central rock-lined channel) will be equipped with headwalls, which will also support the maintenance of a 4-meter wide concrete path proposed on one side of the channel. The central rock-lined overland flow channel is designed with a 60-meter wide corridor to accommodate extreme stormwater events. These events will be captured via a large culvert opening positioned above the smaller opening of the bottom culvert. This design provides a comprehensive solution for managing post-development flow control across all stormwater events.

For details of infrastructure, further to and in conjunction with below sections, please refer **Appendix B and C** for **Earthworks Plans and Sections**, **Appendix D for Bio-Basin Plans and Sections**, and **Appendix E for Culvert Sections.**

Minor stormwater events from building lots, roads, and other areas will be managed through a combination of pit and pipe systems, which will be interconnected with the same bio-basins and detention basins. In major stormwater ARI events, the flow will overtop the existing infrastructure and fill and overflow the relevant proposed detention devices. In the case of extreme storm events, all the detention basins are provided with overflow regulatory devices such as weirs and/or pipe systems.

Please refer to the **Concept Stormwater Drainage Plans** in **Appendix F** and in conjunction with **CWD's flood impact assessment** under **Appendices B-E** and **Appendix J**. Basin sizing was done using DRAINS Lite as part of our reporting while a more comprehensive analysis was done in TuFLOW as part of CWD's reporting.

3.2 STORMWATER DISCHARGE (RATIONAL METHOD)

A preliminary assessment of stormwater discharge has been undertaken using The Rational Method in accordance with Council's engineering planning scheme policies and QUDM. The findings are presented in the below sections. **Node A** is referred to as the lawful point of discharge downstream of the central rock-lined channel, while **Node B** is referred to as the overland flow path at the lawful point of discharge North East of the site.

Refer to **Appendix G** for Rational Method Calculations.

3.2.1 PRE-DEVELOPMENT STORMWATER DISCHARGE

Refer **Appendix F Drawing C301** for illustration of **Pre-Development Catchments**

Table 1: Pre-Development Catchment 1 **(PRECA1) - NODE A**

Development Site Area (m^2)	Pre-Development Impervious Area (m^2) (%)	Pre-Development Pervious Area (m^2) (%)
540,580m^2	**0.000m^2 (0%)**	**540,580m^2 (100%)**

Time of Concentration Node A = 30.0 Minutes,
Calculated using Friend's Equation; QUDM V3 Section 4.6.6 (c)

C_{10} Runoff Coefficient = 0.70
QUDM V3, Table 4.5.3 – Table of C_{10} Values

ARI (yr)	AEP	I (mm/hr)	Pre-Development Discharge (m^3/s)
1	63%	48.1	4.045
2	39%	62.2	5.559
5	18%	78.3	7.817
10	10%	89.7	9.429
20	5%	103.0	11.368
50	2%	121.0	14.626
100	1%	135.0	17.028

Table 2: Pre-Development Catchment 2 **(PRECA2) – NODE B**

Development Site Area (m^2)	Pre-Development Impervious Area (m^2) (%)	Pre-Development Pervious Area (m^2) (%)
40,240m^2	**0.000m^2 (0%)**	**40,240m^2 (100%)**

Time of Concentration Node Bx = 20.0 Minutes,
Calculated using Friend's Equation; QUDM V3 Section 4.6.6 (c)

C_{10} Runoff Coefficient = 0.70
QUDM V3, Table 4.5.3 – Table of C_{10} Values

ARI (yr)	AEP	I (mm/hr)	Pre-Development Discharge (m^3/s)
1	63%	60.6	0.379
2	39%	78.3	0.521
5	18%	98.6	0.733
10	10%	113.0	0.884
20	5%	129.0	1.060
50	2%	152.0	1.368
100	1%	168.0	1.577

3.2.2 POST-DEVELOPMENT STORMWATER DISCHARGE

Refer **Appendix F Drawing C300A** for illustration of **Post-Development Catchments**

3.2.2.1 Site External Catchments - Undisturbed Water (Quality Treatment Not Required)

Table 3: Post-Development External Catchment **(POST EXTCA1)** - Unmitigated

Development Site Area (m^2)	Post-Development Impervious Area (m^2) (%)	Post-Development Pervious Area (m^2) (%)
42,010m^2	**20,000m^2 (48%)**	**22,010m^2 (52%)**

Time of Concentration Node A = 20.0 Minutes,
Calculated using Friend's Equation; QUDM V3 Section 4.6.6 (c)
C_{10} Runoff Coefficient = 0.7
QUDM V3, Table 4.5.3 – Table of C_{10} Values

ARI (yr)	AEP	I (mm/hr)	Post-Development Discharge (m^3/s)
1	63%	60.6	0.396
2	39%	78.3	0.544
5	18%	98.6	0.765
10	10%	113.0	0.923
20	5%	129.0	1.106
50	2%	152.0	1.428
100	1%	168.0	1.647

Table 4: Post-Development External Catchment **(POST EXTCA2)** – Unmitigated

Development Site Area (m^2)	Post-Development Impervious Area (m^2) (%)	Post-Development Pervious Area (m^2) (%)
71,880m^2	**5,300m^2 (7%)**	**66,580m^2 (93%)**

Time of Concentration Node A = 18 Minutes,
Calculated using Friend's Equation; QUDM V3 Section 4.6.6 (c)
C_{10} Runoff Coefficient = 0.7
QUDM V3, Table 4.5.3 – Table of C_{10} Values

ARI (yr)	AEP	I (mm/hr)	Post-Development Discharge (m^3/s)
1	63%	64.3	0.719
2	39%	83.2	0.988
5	18%	104.7	1.390
10	10%	119.8	1.674
20	5%	137.0	2.011
50	2%	160.8	2.585
100	1%	178.0	2.985

Table 5: Post-Development External Catchment 3 (**POST EXTCA3)** – Unmitigated

Development Site Area (m^2)	Post-Development Impervious Area (m^2) (%)	Post-Development Pervious Area (m^2) (%)
11,9360m^2	**4,700 m^2 (4%)**	**114,660 m^2 (96%)**

Time of Concentration Node A = 20 Minutes,
Calculated using Friend's Equation; QUDM V3 Section 4.6.6 (c)
C_{10} Runoff Coefficient = 0.7
QUDM V3, Table 4.5.3 – Table of C_{10} Values

ARI (yr)	AEP	I (mm/hr)	Post-Development Discharge (m^3/s)
1	63%	60.6	1.125
2	39%	78.3	1.546
5	18%	98.6	2.174
10	10%	113.0	2.623
20	5%	129.0	3.144
50	2%	152.0	4.057
100	1%	168.0	4.679

Table 6: Post-Development External Catchment 4 **(POST EXTCA4)** - Unmitigated

Development Site Area (m^2)	Post-Development Impervious Area (m^2) (%)	Post-Development Pervious Area (m^2) (%)
27,510m^2	**0 m^2 (0%)**	**27,510 m^2 (100%)**

Time of Concentration Node A = 20 Minutes,
Calculated using Friend's Equation; QUDM V3 Section 4.6.6 (c)
C_{10} Runoff Coefficient = 0.7
QUDM V3, Table 4.5.3 – Table of C_{10} Values

ARI (yr)	AEP	I (mm/hr)	Post-Development Discharge (m^3/s)
1	63%	60.6	0.259
2	39%	78.3	0.356
5	18%	98.6	0.501
10	10%	113.0	0.604
20	5%	129.0	0.725
50	2%	152.0	0.935
100	1%	168.0	1.078

Table 7: Post-Development External Catchment 5 **(POST EXTCA5)- NODE B** – Unmitigated

Development Site Area (m^2)	Post-Development Impervious Area (m^2) (%)	Post-Development Pervious Area (m^2) (%)
30,800m^2	**0m^2 (0%)**	**30,800m^2 (100%)**

Time of Concentration Node A = 19 Minutes,
Calculated using Friend's Equation; QUDM V3 Section 4.6.6 (c)
C_{10} Runoff Coefficient = 0.7
QUDM V3, Table 4.5.3 – Table of C_{10} Values

ARI (yr)	AEP	I (mm/hr)	Post-Development Discharge (m^3/s)
1	63%	62.5	0.299
2	39%	80.8	0.411
5	18%	101.6	0.578
10	10%	116.4	0.697
20	5%	133.0	0.836
50	2%	156.4	1.077
100	1%	173.0	1.243

Table 8: Post-Development External Catchment 6 **(POST EXTCA6)- NODE B** – Unmitigated

Development Site Area (m^2)	Post-Development Impervious Area (m^2) (%)	Post-Development Pervious Area (m^2) (%)
1,210m^2	**0m^2 (0%)**	**1,210m^2 (100%)**

Time of Concentration Node A = 5 Minutes,
Calculated using Friend's Equation; QUDM V3 Section 4.6.6 (c)
C_{10} Runoff Coefficient = 0.7
QUDM V3, Table 4.5.3 – Table of C_{10} Values

ARI (yr)	AEP	I (mm/hr)	Post-Development Discharge (m^3/s)
1	63%	100	0.019
2	39%	129	0.026
5	18%	163	0.036
10	10%	187	0.044
20	5%	215	0.053
50	2%	253	0.068
100	1%	281	0.079

3.2.2.2 Site Internal Catchments - DIRTY WATER (Water Quality Treatment Required)

Table 9: Post-Development Internal Catchment 1 **(POST INTCA1)** – Unmitigated

Development Site Area (m^2)	Post-Development Impervious Area (m^2) (%)	Post-Development Pervious Area (m^2) (%)
56,660m^2	**22,664m^2 (40%)**	**33,996m^2 (60%)**

Time of Concentration Node A = 7 Minutes,
Calculated using Friend's Equation; QUDM V3 Section 4.6.6 (c)
C_{10} Runoff Coefficient = 0.78
QUDM V3, Table 4.5.3 – Table of C_{10} Values

ARI (yr)	AEP	I (mm/hr)	Post-Development Discharge (m^3/s)
1	63%	93.1	0.914
2	39%	120.4	1.256
5	18%	151.4	1.765
10	10%	173.4	2.129
20	5%	199.4	2.570
50	2%	234.2	3.306
100	1%	259.8	3.827

Table 10: Post-Development Internal Catchment 2 **(POST INTCA2)** – Unmitigated

Development Site Area (m^2)	Post-Development Impervious Area (m^2) (%)	Post-Development Pervious Area (m^2) (%)
144,900m^2	**57,960m^2 (40%)**	**86,940m^2 (60%)**

Time of Concentration Node A = 8.0 Minutes,
Calculated using Friend's Equation; QUDM V3 Section 4.6.6 (c)
C_{10} Runoff Coefficient = 0.78
QUDM V3, Table 4.5.3 – Table of C_{10} Values

ARI (yr)	AEP	I (mm/hr)	Post-Development Discharge (m^3/s)
1	63%	89.6	2.251
2	39%	115.9	3.093
5	18%	145.7	4.346
10	10%	166.6	5.230
20	5%	191.6	6.316
50	2%	224.8	8.116
100	1%	249.2	9.388

Table 11: Post-Development Internal Catchment 3 **(POST INTCA3)** – Unmitigated

Development Site Area (m^2)	Post-Development Impervious Area (m^2) (%)	Post-Development Pervious Area (m^2) (%)
17,200m^2	**6,880m^2 (40%)**	**10,320m^2 (60%)**

Time of Concentration Node A = 5.0 Minutes,
Calculated using Friend's Equation; QUDM V3 Section 4.6.6 (c)
C_{10} Runoff Coefficient = 0.78
QUDM V3, Table 4.5.3 – Table of C_{10} Values

ARI (yr)	AEP	I (mm/hr)	Post-Development Discharge (m^3/s)
1	63%	100.0	0.298
2	39%	129.3	0.410
5	18%	162.7	0.576
10	10%	187.0	0.697
20	5%	215.0	0.841
50	2%	253.0	1.084
100	1%	281.0	1.257

Table 12: Post-Development Internal Catchment 4 **(POST INTCA4)** – Unmitigated

Development Site Area (m^2)	Post-Development Impervious Area (m^2) (%)	Post-Development Pervious Area (m^2) (%)
29,590m^2	**11,836m^2 (40%)**	**17,754m^2 (60%)**

Time of Concentration Node A = 7.0 Minutes,
Calculated using Friend's Equation; QUDM V3 Section 4.6.6 (c)
C_{10} Runoff Coefficient = 0.78
QUDM V3, Table 4.5.3 – Table of C_{10} Values

ARI (yr)	AEP	I (mm/hr)	Post-Development Discharge (m^3/s)
1	63%	93.1	0.477
2	39%	120.4	0.656
5	18%	151.4	0.922
10	10%	173.4	1.112
20	5%	199.4	1.342
50	2%	234.2	1.727
100	1%	259.8	1.999

Table 13: Post-Development Internal Catchment 5 **(POST INTCA5)** – Unmitigated

Development Site Area (m^2)	Post-Development Impervious Area (m^2) (%)	Post-Development Pervious Area (m^2) (%)
39,710m^2	**19,855m^2 (50%)**	**19,855m^2 (50%)**

Time of Concentration Node A = 16 Minutes,
Calculated using Friend's Equation; QUDM V3 Section 4.6.6 (c)
C_{10} Runoff Coefficient = 0.8
QUDM V3, Table 4.5.3 – Table of C_{10} Values

ARI (yr)	AEP	I (mm/hr)	Post-Development Discharge (m^3/s)
1	63%	68.0	0.480
2	39%	88.0	0.660
5	18%	110.8	0.928
10	10%	126.6	1.117
20	5%	145.0	1.344
50	2%	169.6	1.721
100	1%	188.0	1.991

3.2.3 PRE VS POST COMPARISON

Below is a summary of catchment areas and stormwater contributions in Pre & Post development scenarios:

Pre-Development Scenario :

- Pre-development Catchment 01 (PRECA1) = 54.058ha flows from south to north direction of the site
- Pre-development Catchment 02 (PRECA2) = 4.024ha flows in the east-to-north direction of the site

Total Pre-development Catchment Area = 58.082ha – **refer Appendix F Drawing C300B**

Post-Development Scenario :

- All except external catchment EXTCA5 area 3.080ha clean stormwater sheet flows in a north-east direction away from the proposed site. This flow does not contribute to a detention basin design.
- Internal catchment INTCA5 area 4.092ha dirty stormwater sheet flows east-north direction to Biobasin-(East) and contributes to Detention Basin-2 design – **refer Appendix F Drawing C300A**

External Catchments:

POST EXTCA1 = 4.201 ha
POST EXTCA2 = 7.188 ha
POST EXTCA3 = 11.936 ha
POST EXTCA4 = 2.751 ha
POST EXTCA5 = 3.080 ha (north-east separate catchment area – sheet flow, clean water)
POST EXTCA5 = 0.121 ha (north-east separate catchment area – not contributing to NE detention basin, sheet flow, clean water flow out to property boundary)

TOTAL POST-DEVELOPMENT (EXTERNAL CATCHMENT AREA) = 29.277 ha

Internal Catchments:

POST INTCA1 = 5.665 ha
POST INTCA2 = 14.490 ha
POST INTCA3 = 1.720 ha
POST INTCA4 = 2.959 ha
POST INTCA5 = 3.971 ha (north-east separate CATCHMENT AREA - DIRTY WATER TO BIO BASIN (EAST)
TOTAL POST-DEVEVELOPMENT (INTERNAL CATCHMENT AREA) = 28.805 ha

TOTAL SUM POST-DEVELOPMENT CATCHMENT AREA = 29.277 + 28.805 = 58.082 ha

Based on the calculations undertaken, Table 13 (NODE A—CENTRAL DRAINAGE) and Table 13A (NODE B - NORTH-EAST DRAINAGE) below compare pre-development and post-development stormwater discharge.

Table 14: Comparison of Pre & Post-Development – (CENTRAL STORMWATER FLOW) at **Node A,** the Lawful Point of Discharge (calculated using Rational Method)

Catchment	ARI (yr)	AEP	Total Site Discharge			
			Pre-Development Discharge (m^3/s)	Post-Development Discharge (m^3/s)	Difference + / - (m^3/s)	Difference + / - (%)
Pre vs Post Development Discharge Contributing to Node						
Site	1	63%	4.045	6.439	2.394	59.18%
	2	39%	5.559	8.849	3.290	59.18%
	5	18%	7.817	12.439	4.622	59.12%
	10	10%	9.429	14.992	5.563	59.00%
	20	5%	11.368	18.055	6.687	58.83%
	50	2%	14.626	23.239	8.613	58.88%
	100	1%	17.028	26.860	9.832	57.74%

Table 15**:** Comparison of Pre & Post-Development – (NORTH-EAST STORMWATER FLOW) at **Node B,** the Lawful Point of Discharge (calculated using Rational Method)

Catchment	ARI (yr)	AEP	Total Site Discharge			
			Pre-Development Discharge (m^3/s)	Post-Development Discharge (m^3/s)	Difference + / - (m^3/s)	Difference + / - (%)
Pre vs Post Development Discharge Contributing to Node						
Site	1	63%	0.379	0.514	0.135	35.56%
	2	39%	0.521	0.706	0.185	35.55%
	5	18%	0.733	0.993	0.260	35.49%
	10	10%	0.884	1.195	0.311	35.21%
	20	5%	1.060	1.438	0.378	35.62%
	50	2%	1.368	1.842	0.474	34.65%
	100	1%	1.577	2.131	0.554	35.12%

3.2.4 CATCHMENT EXCLUSION ZONES

In the predevelopment stage, there is a designated catchment named above as PRECA2, which contributes a total of 4.024 hectares that flows towards the east of the site boundary on the north. Under existing conditions, a portion of the PRECA2 area has been excluded from the primary catchment area. This is due to the natural drainage pattern in this location, which directs surface runoff toward the east and then along the Cunningham Highway towards the north, rather than into the proposed central instream detention and rock-lined channel.

Similarly, in the post-development scenario, the external catchment area EXTCA5, encompassing 3.080 hectares of clean stormwater runoff, does not discharge into the central channel (which acts as an in-stream detention basin) designed for mainstream stormwater flows. Instead, this catchment contributes to overland sheet flow exiting at the northeastern boundary of the site. The flow is then conveyed via a DN600 reinforced concrete pipe (RCP) through an underground drainage system, initiated at a pit inlet located at the upstream collection point. Refer to **Appendix F** for detailed catchment delineation and flow path illustrations.

3.2.5 SUMMARY OF PRELIMINARY ASSESSMENT

As can be identified in **Table 13** and **Table 13A**, there are increases in post-development stormwater discharges from the development site.

3.3 HYDROLOGICAL AND HYDRAULIC MODELLING

Hydrological and Hydraulic analyses have been undertaken using DRAINS software.

DRAINS is a hydrological and hydraulic modelling software package developed for the design and analysis of urban stormwater drainage systems. It utilises either the “Extended Rational Method” or the “ILSAX method” hydrological loss model to convert Australian Rainfall and Runoff temporal patterns and rainfall data into runoff hydrographs.

Rainfall is modelled for catchment in equal time intervals under each storm event, and the subsequent runoff is routed through a drainage system. To establish the most likely rain event that would require the highest volume of detention. A summary of critical storm events analysed in DRAINS for each model is presented under Tables 15 and 16 series below**,** and some of the modelling parameters outlined under **Table 17.**

Table 16: Critical Storm Events for **Pre-development (PRE CA1) – NODE A (CENTRAL CHANNEL FLOW)**

Storm (ARI)	Duration (minutes)	Description
Q1	30	AR&R 1 year, 33 minutes storm, average 48 mm/h
Q2	30	AR&R 2 year, 33 minutes storm, average 62 mm/h
Q5	30	AR&R 5 year, 33 minutes storm, average 78 mm/h
Q10	30	AR&R 10 year, 33 minutes storm, average 90 mm/h
Q20	30	AR&R 20 year, 33 minutes storm, average 103 mm/h
Q50	30	AR&R 50 year, 33 minutes storm, average 121 mm/h
Q100	30	AR&R 100 year, 33 minutes storm, average 135 mm/h

Table 17: Critical Storm Events for **Pre-development (PRE CA2) – NODE B (NORTHEAST FLOW)**

Storm (ARI)	Duration (minutes)	Description
Q1	20	AR&R 1 year, 20 minutes storm, average 61 mm/h
Q2	20	AR&R 2 year, 20 minutes storm, average 78 mm/h
Q5	20	AR&R 5 year, 20 minutes storm, average 99 mm/h
Q10	20	AR&R 10 year, 20 minutes storm, average 113 mm/h
Q20	20	AR&R 20 year, 20 minutes storm, average 129 mm/h
Q50	20	AR&R 50 year, 20 minutes storm, average 152 mm/h
Q100	20	AR&R 100 year, 20 minutes storm, average 168 mm/h

The following catchments in the post-development stage are contributing to the **Central Channel Flow:**

Table 18: Critical Storm Events for Post-development (POST EXTCA1) – NODE A (CENTRAL DRAIN)

Storm (ARI)	Duration (minutes)	Description
Q1	20	AR&R 1 year, 20 minutes storm, average 61 mm/h
Q2	20	AR&R 2 year, 20 minutes storm, average 78 mm/h
Q5	20	AR&R 5 year, 20 minutes storm, average 99 mm/h
Q10	20	AR&R 10 year, 20 minutes storm, average 113 mm/h
Q20	20	AR&R 20 year, 20 minutes storm, average 129 mm/h
Q50	20	AR&R 50 year, 20 minutes storm, average 152 mm/h
Q100	20	AR&R 100 year, 20 minutes storm, average 168 mm/h

Table 19: Critical Storm Events for **Post-development (POST EXTCA2) – NODE A (CENTRAL DRAIN)**

Storm (ARI)	Duration (minutes)	Description
Q1	18	AR&R 1 year, 18 minutes storm, average 64 mm/h
Q2	18	AR&R 2 year, 18 minutes storm, average 83 mm/h
Q5	18	AR&R 5 year, 18 minutes storm, average 105 mm/h
Q10	18	AR&R 10 year, 18 minutes storm, average 120 mm/h
Q20	18	AR&R 20 year, 18minutes storm, average 137 mm/h
Q50	18	AR&R 50 year, 18 minutes storm, average 161 mm/h
Q100	18	AR&R 100 year, 18 minutes storm, average 178 mm/h

Table 20: Critical Storm Events for **Post-development (POST EXTCA3) – NODE A (CENTRAL DRAIN)**

Storm (ARI)	Duration (minutes)	Description
Q1	20	AR&R 1 year, 20 minutes storm, average 61 mm/h
Q2	20	AR&R 2 year, 20 minutes storm, average 78 mm/h
Q5	20	AR&R 5 year, 20 minutes storm, average 99 mm/h
Q10	20	AR&R 10 year, 20 minutes storm, average 113 mm/h
Q20	20	AR&R 20 year, 20 minutes storm, average 129 mm/h
Q50	20	AR&R 50 year, 20 minutes storm, average 152 mm/h
Q100	20	AR&R 100 year, 20 minutes storm, average 168 mm/h

Table 21: Critical Storm Events for **Post-development (POST EXTCA4) – NODE A (CENTRAL DRAIN)**

Storm (ARI)	Duration (minutes)	Description
Q1	20	AR&R 1 year, 20 minutes storm, average 61 mm/h
Q2	20	AR&R 2 year, 20 minutes storm, average 78 mm/h
Q5	20	AR&R 5 year, 20 minutes storm, average 99 mm/h
Q10	20	AR&R 10 year, 20 minutes storm, average 113 mm/h
Q20	20	AR&R 20 year, 20 minutes storm, average 129 mm/h
Q50	20	AR&R 50 year, 20 minutes storm, average 152 mm/h
Q100	20	AR&R 100 year, 20 minutes storm, average 168 mm/h

Table 22: Critical Storm Events for **Post-development (POST EXTCA5) – NODE B**

(CLEAN WATER NORTH-EAST FLOW – NON-CONTRIBUTING FLOW TO DETENTION BASIN DESIGN)

Storm (ARI)	Duration (minutes)	Description
Q1	19	AR&R 1 year, 19 minutes storm, average 62 mm/h
Q2	19	AR&R 2 year, 19 minutes storm, average 81 mm/h
Q5	19	AR&R 5 year, 19 minutes storm, average 102 mm/h
Q10	19	AR&R 10 year, 19 minutes storm, average 116 mm/h
Q20	19	AR&R 20 year, 19 minutes storm, average 133 mm/h
Q50	19	AR&R 50 year, 19 minutes storm, average 156 mm/h
Q100	19	AR&R 100 year, 19 minutes storm, average 173 mm/h

Table 23: Critical Storm Events for **Post-development (POST EXTCA6) – NODE B**

(CLEAN WATER NORTH-EAST FLOW - CONTRIBUTING FLOW TO DETENTION BASIN DESIGN)

Storm (ARI)	Duration (minutes)	Description
Q1	5	AR&R 1 year, 5 minutes storm, average 100 mm/h
Q2	5	AR&R 2 year, 5 minutes storm, average 129 mm/h
Q5	5	AR&R 5 year, 5 minutes storm, average 163 mm/h
Q10	5	AR&R 10 year, 5 minutes storm, average 187 mm/h
Q20	5	AR&R 20 year, 5 minutes storm, average 215 mm/h
Q50	5	AR&R 50 year, 5 minutes storm, average 253 mm/h
Q100	5	AR&R 100 year, 5 minutes storm, average 281 mm/h

Table 24: Critical Storm Events for **Post-development (POST INTCA1) – NODE A (CENTRAL DRAIN)**

Storm (ARI)	Duration (minutes)	Description
Q1	7	AR&R 1 year, 7 minutes storm, average 93 mm/h
Q2	7	AR&R 2 year, 7 minutes storm, average 120 mm/h
Q5	7	AR&R 5 year, 7 minutes storm, average 151 mm/h
Q10	7	AR&R 10 year, 7 minutes storm, average 173 mm/h
Q20	7	AR&R 20 year, 7 minutes storm, average 199 mm/h
Q50	7	AR&R 50 year, 7 minutes storm, average 234 mm/h
Q100	7	AR&R 100 year, 7 minutes storm, average 260 mm/h

Table 25: Critical Storm Events for **Post-development (POST INTCA2) – NODE A (CENTRAL DRAIN)**

Storm (ARI)	Duration (minutes)	Description
Q1	8	AR&R 1 year, 8 minutes storm, average 90 mm/h
Q2	8	AR&R 2 year, 8 minutes storm, average 116 mm/h
Q5	8	AR&R 5 year, 8 minutes storm, average 146 mm/h
Q10	8	AR&R 10 year, 8 minutes storm, average 167 mm/h
Q20	8	AR&R 20 year, 8 minutes storm, average 192 mm/h
Q50	8	AR&R 50 year, 8 minutes storm, average 225 mm/h
Q100	8	AR&R 100 year, 8 minutes storm, average 249 mm/h

Table 26: Critical Storm Events for **Post-development (POST INTCA3) – NODE A (CENTRAL DRAIN)**

Storm (ARI)	Duration (minutes)	Description
Q1	5	AR&R 1 year, 5 minutes storm, average 100 mm/h
Q2	5	AR&R 2 year, 5 minutes storm, average 129 mm/h
Q5	5	AR&R 5 year, 5 minutes storm, average 163 mm/h
Q10	5	AR&R 10 year, 5 minutes storm, average 187 mm/h
Q20	5	AR&R 20 year, 5 minutes storm, average 215 mm/h
Q50	5	AR&R 50 year, 5 minutes storm, average 253 mm/h
Q100	5	AR&R 100 year, 5 minutes storm, average 281 mm/h

Table 27: Critical Storm Events for **Post-development (POST INTCA4) – NODE A (CENTRAL DRAIN)**

Storm (ARI)	Duration (minutes)	Description
Q1	7	AR&R 1 year, 7 minutes storm, average 93 mm/h
Q2	7	AR&R 2 year, 7 minutes storm, average 120 mm/h
Q5	7	AR&R 5 year, 7 minutes storm, average 151 mm/h
Q10	7	AR&R 10 year, 7 minutes storm, average 173 mm/h
Q20	7	AR&R 20 year, 7 minutes storm, average 199 mm/h
Q50	7	AR&R 50 year, 7 minutes storm, average 234 mm/h
Q100	7	AR&R 100 year, 7 minutes storm, average 260 mm/h

Table 28: Critical Storm Events for **Post-development (POST INTCA5) – NODE B (DIRTY WATER NORTH-EAST FLOW - CONTRIBUTING FLOW TO DETENTION BASIN DESIGN)**

Storm (ARI)	Duration (minutes)	Description
Q1	16	AR&R 1 year, 7 minutes storm, average 68 mm/h
Q2	16	AR&R 2 year, 7 minutes storm, average 88 mm/h
Q5	16	AR&R 5 year, 7 minutes storm, average 111 mm/h
Q10	16	AR&R 10 year, 7 minutes storm, average 127 mm/h
Q20	16	AR&R 20 year, 7 minutes storm, average 145 mm/h
Q50	16	AR&R 50 year, 7 minutes storm, average 170 mm/h
Q100	16	AR&R 100 year, 7 minutes storm, average 188 mm/h

The adopted hydrological modelling parameters are indicated in **Table 17** below:

Table 29: Software Parameters used in DRAINS Model

Key Criteria	Adopted Value
Hydrological Model	ILSAX
Paved (Impervious) are depression storage (mm)	1
Supplementary Area Depression Storage (mm)	1
Grassed (Pervious) area depressions storage (mm)	5
Soil Type	Normal
Antecedent rainfall depth for AMC	3mm

3.3.1 PRE-DEVELOPMENT DRAINS CATCHMENT (INCLUDING EXTERNAL CATCHMENT)

The breakdown of the pre-development catchment used in the DRAINS model is shown on **Figure 4 and Figure 5.** Refer to the **Catchment Plans under Appendix F** for the location of each of the analysed catchments.

Table 30: Pre-Development Catchment Summary (DRAINS)

	Paved	Supplementary	Grassed
Discharge Contributing to Node A – Catchment 1 – 540,580m^2			
Percentage of area (%)	0	0	100
Time of concentration (minutes)	0	0	30
Discharge Contributing to Node B – Catchment 2 – 40,240m2			
Percentage of area (%)	0	0	100
Time of concentration (minutes)	0	0	20

3.3.2 POST-DEVELOPMENT DRAINS INTERNAL CATCHMENT

The breakdown of the post-development catchments (contributing to discharge nodes) used in the DRAINS model is shown on **Figure 4 and Figure 5**. Refer to the **Catchment Plans under Appendix F** for the location of each of the analysed catchments.

Table 31: Post Development **Internal** Catchment Summary (DRAINS)

	Paved	Supplementary	Grassed
Discharge Contributing to Node A – Internal Catchment 1 (POST INTCA1) – 56,650m^2			
Percentage of area (%)	40	0	60
Time of concentration (minutes)	7	0	10
Discharge Contributing to Node A – Internal Catchment 2 (POST INTCA2 – 150,270m^2			
Percentage of area (%)	40	0	60
Time of concentration (minutes)	8	0	12
Discharge Contributing to Node A – Internal Catchment 3 (POST INTCA3) – 11,820m^2			
Percentage of area (%)	40	0	60
Time of concentration (minutes)	5	0	7
Discharge Contributing to Node A – Internal Catchment 4 (POST INTCA4) – 29,590m^2			
Percentage of area (%)	40	0	60
Time of concentration (minutes)	7	0	10
Discharge Contributing to Node B – Internal Catchment 5 (POST INTCA5) – 40,920m2			
Percentage of area (%)	50	0	50
Time of concentration (minutes)	16	0	16

3.3.3 POST-DEVELOPMENT DRAINS EXTERNAL CATCHMENT

Table 32: Post Development **External** Catchment Summary

	Paved	Supplementary	Grassed
Discharge Contributing to Node A – External Catchment 1 (POST EXTCA1) – 42,010m2			
Percentage of area (%)	48	0	52
Time of concentration (minutes)	10	0	20
Discharge Contributing to Node A – External Catchment 2 (POST EXTCA2) – 71,880m2			
Percentage of area (%)	0	0	100
Time of concentration (minutes)	0	0	18
Discharge Contributing to Node A – External Catchment 3 (POST EXTCA3) – 119,360m2			
Percentage of area (%)	0	0	100
Time of concentration (minutes)	0	0	20
Discharge Contributing to Node A – External Catchment 4 (POST EXTCA4) – 27,510m2			
Percentage of area (%)	0	0	100
Time of concentration (minutes)	0	0	20
Discharge Contributing to Node B – External Catchment 5 (POST EXTCA5) – 30,800m2			
Percentage of area (%)	0	0	100
Time of concentration (minutes)	0	0	19

3.3.4 DRAINS MODEL

Detention basins have been modelled using the DRAINS software to ensure that post-development runoff discharge is equal to or less than pre-development levels, thereby demonstrating compliance with the non-worsening requirement. Three detention systems are proposed on the site, as outlined below:

- **In-stream Detention and Channel Combined System** – Refer to the CWD Flood Report for comprehensive details on stormwater detention and integrated flood analysis.
- **West Detention Tank with Bio-basin** – This system has been modelled using DRAINS, with results and analysis presented in the following section.
- **East Detention Tank with Bio-basin** – Designed to manage north-eastern flow, this system has also been analysed using DRAINS, with findings detailed in the following section

3.3.5 WEST DETENTION TANK WITH BIO-BASIN

The contributing catchments used in this analysis are **POST EXTCA1 (4.201ha)** and **POST INTCA3 (1.720ha)**, and the equivalent catchments are compared with pre- and post-development scenarios. The DRAINS model is presented below.

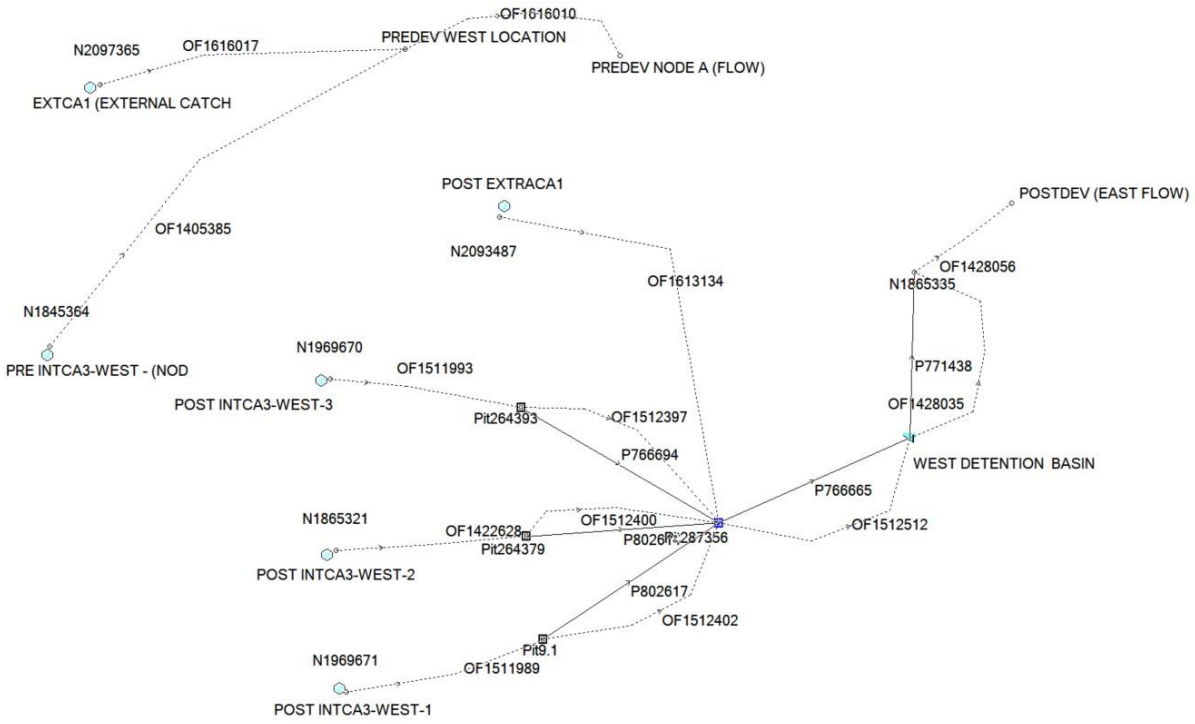

Figure 4: DRAINS Network Model Node A – West Detention Tank

3.3.6 EAST DETENTION TANK WITH BIO-BASIN

The contributing catchments considered in this analysis are as follows:

- **PRECA1: 4.024 ha** (pre-development) is compared with the sum of the two of the following;
- **POST INTCA5: 3.971 ha** (post-development internal catchment)
- **POST EXTCA6: 0.121 ha** (post-development external catchment)

It should be noted that, under this configuration, the Q10 flow has been diverted to the central channel located on the western side via a pit and pipe network. Consequently, the required detention tank volume has been reduced to optimise the design while ensuring compliance with the State Government's guidelines for "no worsening" and "no adverse impact" on downstream flow conditions on the north-east flow.

The corresponding DRAINS model is provided below.

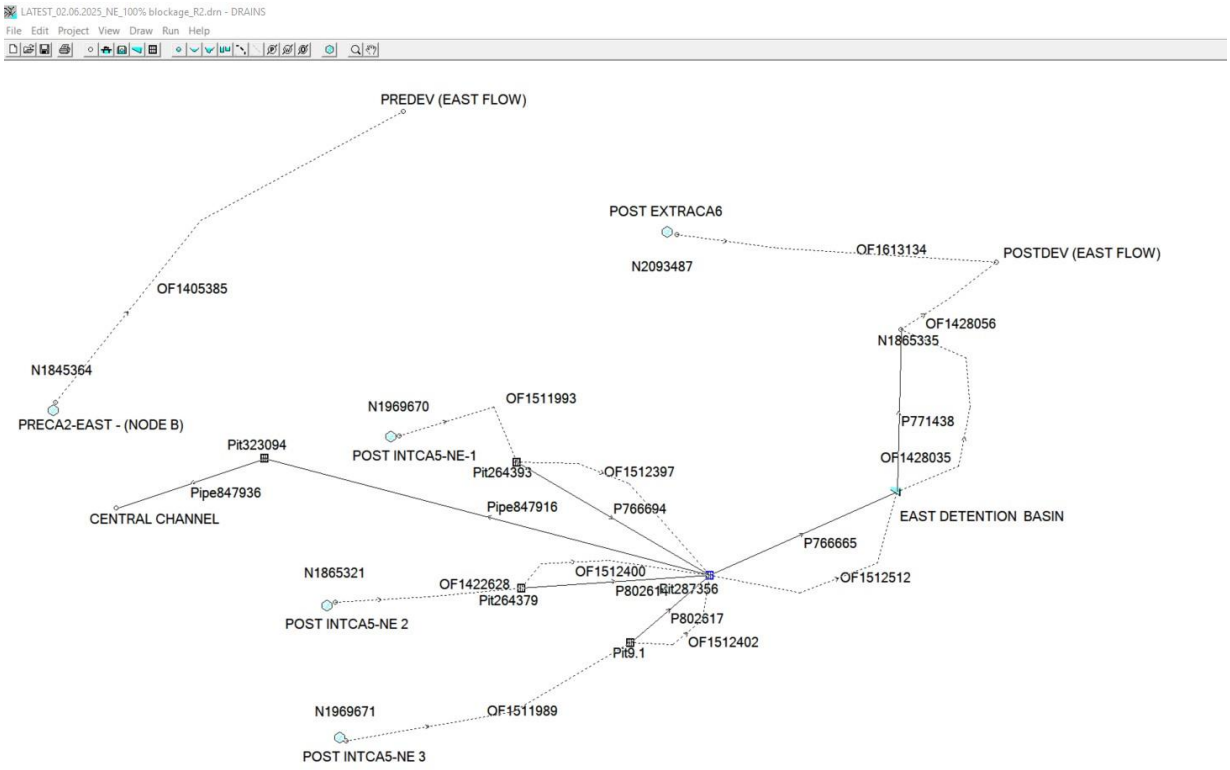

Figure 5: DRAINS Network Model Node B– East Detention Tank – North-East Flow

3.3.7 DETENTION DEVICES

The post development catchments and site constraints have been analysed to determine the optimum detention arrangement for the development (**Table 33**). A DRAINS model of this post development scenario has been prepared to determine and simulate the required detention device arrangement. This opportunity will ensure the peak stormwater runoff from the development is mitigated to pre-development levels or less.

Table 33: Detention Devices Design Summary

Stormwater Detention Device Detail	
Detention Type	1. The central rock-lined channel functions as an in-stream detention device, with control points located at the two culvert crossings. For detailed information on the detention device and associated flood analysis, refer to the CWD Flood Report. 2. A detention basin is located at the northern end on the **west side** (Node A), of the rock-lined channel, which discharges into the central channel and conveys flow towards the north. 3. Another detention basin is situated on the **north-east** side (Node B), capturing flow from a separate catchment area that drains toward the east.
Stages Serviced per Detention Device	In-stream Device 1 = refer CWD flood report In-stream Device 2 = refer CWD flood report Basin (WEST) = Stages 6 and 7 Basin (EAST) = Stages 1 and 2
Detention Device Volume (Total m^3)	In-stream Device 1 = In-stream detention, refer CWD report In-stream Device 2 = In-stream detention, refer CWD report Basin (WEST) = 1,963m^3 Basin (EAST) = 725m^3
Detention Peak Storage Depth (Q100)	In-stream Device 1 = refer CWD flood report In-stream Device 2 = refer CWD flood report Basin (WEST) =2m Basin (EAST) =2m

Base RL	In-stream Device 1 = refer CWD flood report In-stream Device 2 = refer CWD flood report Basin (WEST) = RL 45.50m Basin (EAST) = RL 50.00m
Outlet Configuration	In-stream Device 1 - Refer CWD Flood Report In-stream Device 2 - Refer CWD Flood Report <u>Basin (WEST)</u> Bottom Orifice – DN500 Top Weir – Crest Length=8m, Crest Level=47m <u>Basin (EAST)</u> Bottom Orifice – DN100 Top Weir – Crest Length=4m, Crest Level=51.5m
Additional Note Regarding Detention:	The majority of stormwater on the site will be detained within the proposed central rock-lined channel located at the centre of the site.

3.3.8 PRE VS POST DEVELOPMENT (MITIGATED) RUNOFF COMPARISON

Through mitigation methods described above, the post development flows have been reduced to less than pre-development peak flow rates in the worst case scenario. Below are outline the resultant flows as calculated in the DRAINS model presented above. These results indicate peak flows for each event; however, detention of lesser storms has determined the detention device volume and outlet configuration.

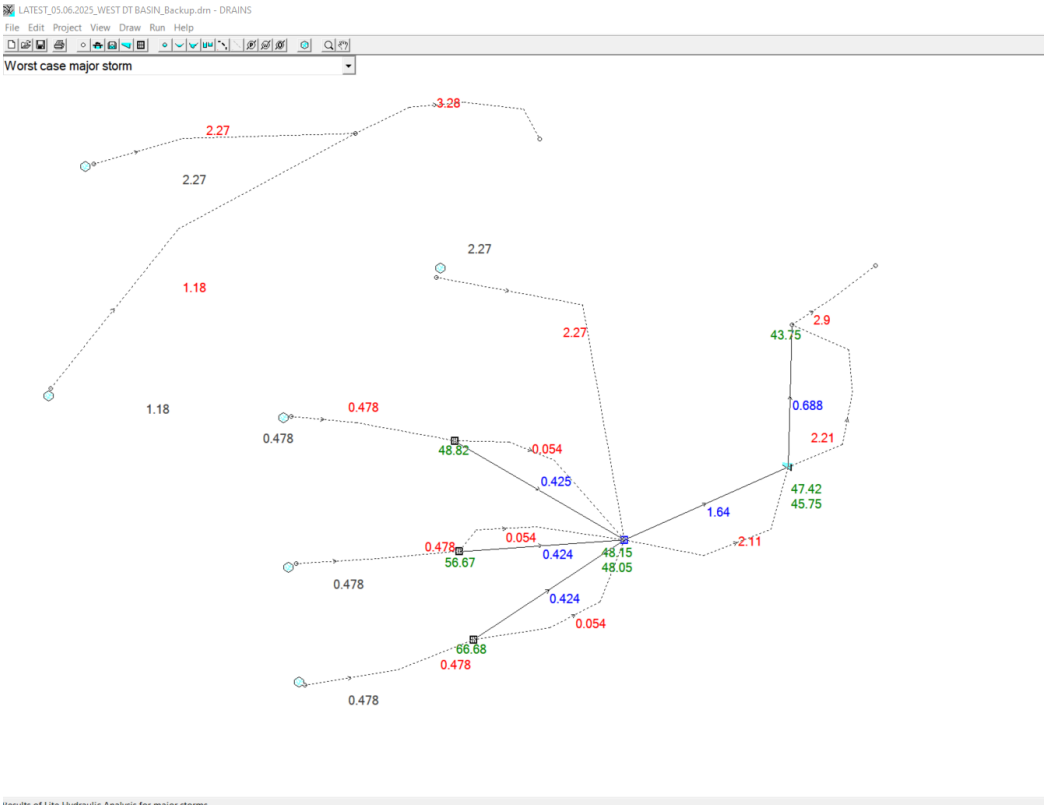

Figure 6: Basin West DRAINS Model Results (Node A) – (Worst Case Major Storm 1% AEP)

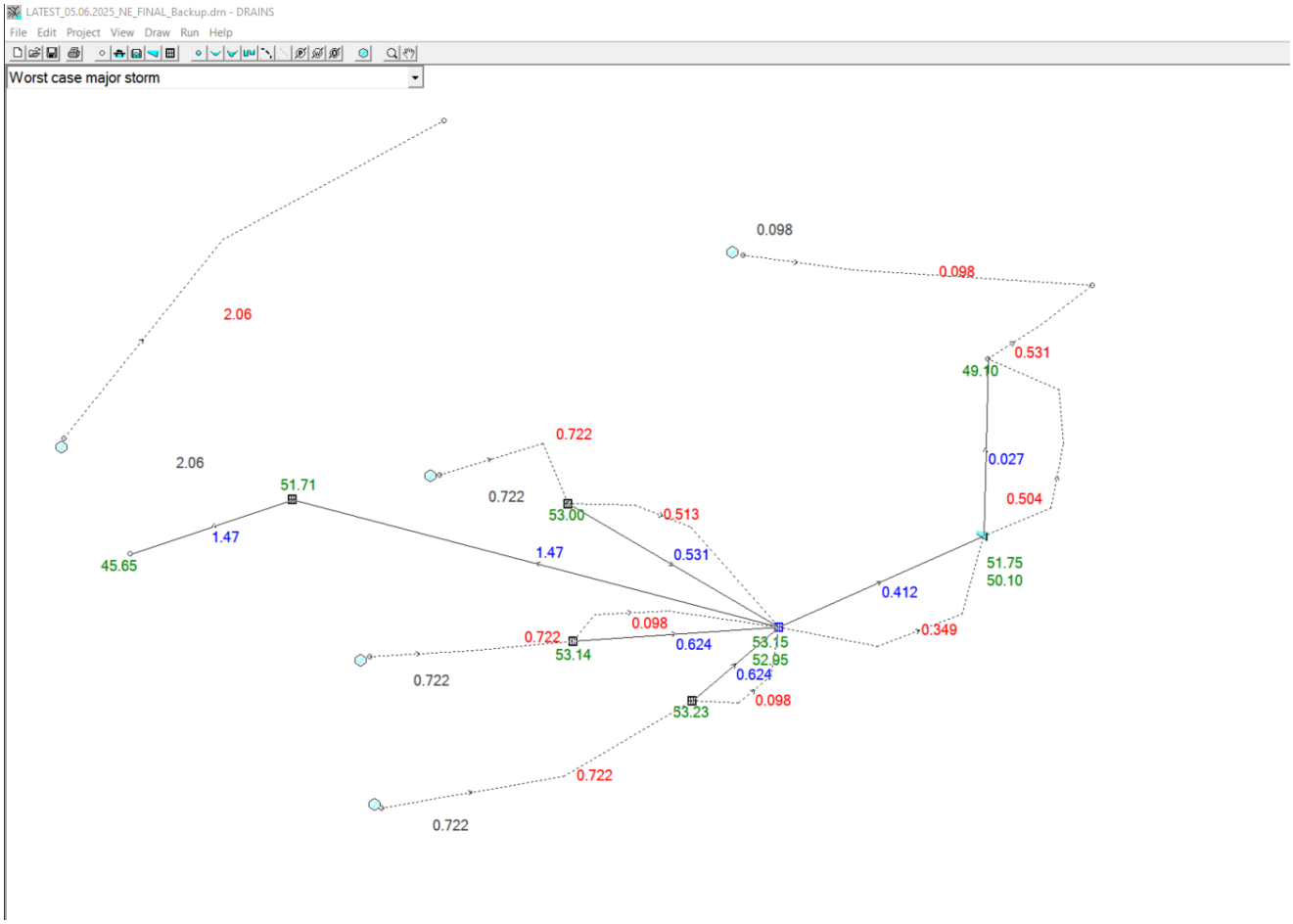

Figure 7: East Basin DRAINS Model Results (Node B) - (Worst Case Major Storm 1% AEP)

Table 34: Pre vs. Post Development Discharge **Basin West -** Node A

ARI (yr)	AEP	Pre-Development Discharge (m^3/s)	Post-Development Discharge (m^3/s)	Difference + / - (m^3/s)	Difference + / - (%)
		@ Node A	@ Node A	@ Node A	@ Node A
1	63%	0.509	0.348	-0.161	-31.63%
2	39%	0.869	0.462	-0.407	-46.84%
5	18%	1.280	0.562	-0.718	-56.09%
10	10%	1.610	0.818	-0.792	-49.19%
20	5%	2.100	1.430	-0.670	-31.90%
50	2%	2.690	2.110	-0.580	-21.56%
100	1%	3.280	2.900	-0.380	-11.59%

Table 35: Pre vs. Post Development Discharge **Basin East -** Node B

ARI (yr)	AEP	Pre-Development Discharge (m^3/s)	Post-Development Discharge (m^3/s)	Difference + / - (m^3/s)	Difference + / - (%)
		@ Node B	@ Node B	@ Node B	@ Node B
1	63%	0.203	0.022+0.018	-0.163	-80.30%
2	39%	0.442	0.026+0.030	-0.386	-87.33%
5	18%	0.725	0.136+0.042	-0.547	-75.45%
10	10%	0.941	0.175+0.051	-0.715	-75.98%
20	5%	1.260	0.211+0.065	-0.984	-78.10%
50	2%	1.660	0.280+0.080	-1.300	-78.31%
100	1%	2.060	0.531+0.098	-1.431	-69.47%

3.3.9 SUMMARY OF MITIGATION

As can be seen in **Tables 22 and 23**, post development flows are reduced in the worst-case scenario for each storm year. The maximum of stormwater water discharges into the Ebbw Vale Memorial Park in the northern end of the development site and rest of it to the north-eastern side.

The proposed water corridor, consisting of a meandering channel integrated with culverts, will function as the primary detention system. It includes two in-stream detention devices located at the northern and central sections of the site, which may also be referred to as downstream culverts in accordance with QUDM (2017) guidelines. For detailed design and analysis of these in-stream detention devices, refer to the CWD Flood Report.

As above mentioned, there are 2 additional detention basins proposed on the either side of the site, the one on the north west end, west to the side of the primary rock lined channel and the second one on the north-east end of the site to compensate and reduce the post development discharges into the natural streams. Furthermore, a detention basin on the north-east side has been proposed to cater for the stormwater within surrounding lots that fall away from site towards the eastern boundary.

The proposed detention allocation is successful in mitigating post development flows such that no adverse effects occur to existing council stormwater infrastructure and/or adjacent properties.

We can therefore conclude that the mitigation of peak flows are deemed to represent an acceptable solution for this development.

3.4 DRAINS MODEL AND RATIONAL METHOD CALCULATIONS CORRELATIONS

The below tables are prepared to compare results that are obtained using rational method as illustrated in QUDM against results obtained using a DRAINS model which utilises hydrographs.

As can be seen in **Tables 24-25** below, the DRAINS model utilises the same time of concentration and rainfall intensity as rational method in order to reflect the same scenarios. Subsequent results obtained are found competitive.

3.4.1 PRE-DEVELOPMENT STORMWATER DISCHARGE COMPARED WITH DRAINS SOFTWARE

Refer **Appendix F Drawing C301** for illustration of **Pre-Development Catchments.**

Table 36: West Detention Basin (Node A)- Pre-Development Equivalent Catchments **(POST INTCA3 + POST EXTCA1))** – Rational Method – Discharge Contributing Catchments

Catch ID	Development Site Area (m^2)	Pre-Development Impervious Area (m^2) (%)	Pre-Development Pervious Area (m^2) (%)
POST INTCA3	**56,650m^2**	**0.000m^2 (0%)**	**56,650m^2 (100%)**
POST EXTCA1	**40,201m^2**	**20,000m^2 (48%)**	**22,010m^2 (52%)**

POSTINTCA3
Time of Concentration Node A = 5.0 Minutes,
Calculated using Friend's Equation; QUDM V3 Section 4.6.6 (c)
C_{10} Runoff Coefficient = 0.7
QUDM V3, Table 4.5.3 – Table of C_{10} Values

POST EXTCA1
Time of Concentration Node A = 20.0 Minutes,
Calculated using Friend's Equation; QUDM V3 Section 4.6.6 (c)
C_{10} Runoff Coefficient = 0.7
QUDM V3, Table 4.5.3 – Table of C_{10} Values

ARI (yr)	AEP	I (mm/hr)	RATIONAL METHOD – Q (m^3/s)	DRAINS OUTPUT – Q (m^3/s)
1	63%	NA	0.664	0.348
2	39%	NA	0.912	0.462
5	18%	NA	1.282	0.562
10	10%	NA	1.548	0.818
20	5%	NA	1.861	1.430
50	2%	NA	2.401	2.110
100	1%	NA	2.775	2.900

Table 37: East Detention Basin (Node B)- Pre-Development Equivalent Catchments **(PRECA2)** – Rational Method – Discharge Contributing Catchments

Development Site Area (m^2)	Pre-Development Impervious Area (m^2) (%)	Pre-Development Pervious Area (m^2) (%)
40,240m^2	**0.000m^2 (0%)**	**40,240m^2 (100%)**

Time of Concentration = 20.0 Minutes,
Calculated using Friend's Equation; QUDM V3 Section 4.6.6 (c)
C_{10} Runoff Coefficient = 0.70
QUDM V3, Table 4.5.3 – Table of C_{10} Values

ARI (yr)	AEP	I (mm/hr)	RATIONAL METHOD – Q (m^3/s)	DRAINS OUTPUT – Q (m^3/s)
1	63%	60.6	0.379	0.203
2	39%	78.3	0.521	0.442
5	18%	98.6	0.733	0.725
10	10%	113.0	0.884	0.941
20	5%	129.0	1.060	1.260
50	2%	152.0	1.368	1.660
100	1%	168.0	1.577	2.060

3.4.2 POST-DEVELOPMENT STORMWATER DISCHARGE COMPARED WITH DRAINS SOFTWARE

Refer **Appendix F Drawing C300A** for illustration of **Post-Development Catchments**

3.4.2.1 Site External Catchments - Undisturbed Water (Quality Treatment Not Required)

Table 38: Post-Development External Catchment 1 **(EXTCA1)** – Unmitigated – Rational Method

Development Site Area (m^2)	Post-Development Impervious Area (m^2) (%)	Post-Development Pervious Area (m^2) (%)
42,010m^2	**20,000m^2 (48%)**	**22,010m^2 (52%)**

Time of Concentration Node A = 20.0 Minutes,
Calculated using Friend's Equation; QUDM V3 Section 4.6.6 (c)
C_{10} Runoff Coefficient = 0.7
QUDM V3, Table 4.5.3 – Table of C_{10} Values

ARI (yr)	AEP	I (mm/hr)	RATIONAL METHOD – Q (m^3/s)	DRAINS OUTPUT – Q (m^3/s)
1	63%	60.6	0.396	0.374
2	39%	78.3	0.544	0.587
5	18%	98.6	0.765	0.874
10	10%	113.0	0.923	1.100
20	5%	129.0	1.106	1.430
50	2%	152.0	1.428	1.850
100	1%	168.0	1.647	2.27

Table 39: Post-Development External Catchment 2 **(POST EXTCA2)** – Unmitigated – Rational Method - Refer CWD Flood Report for Central Channel Inundation

Development Site Area (m^2)	Post-Development Impervious Area (m^2) (%)	Post-Development Pervious Area (m^2) (%)
71,880m^2	**5,300m^2 (7%)**	**66,580m^2 (93%)**

Time of Concentration Node A = 18 Minutes,
Calculated using Friend's Equation; QUDM V3 Section 4.6.6 (c)
C_{10} Runoff Coefficient = 0.7
QUDM V3, Table 4.5.3 – Table of C_{10} Values

ARI (yr)	AEP	I (mm/hr)	RATIONAL METHOD – Q (m^3/s)	DRAINS OUTPUT – Q (m^3/s)
1	63%	64.3	0.719	0.105
2	39%	83.2	0.988	0.386
5	18%	104.7	1.390	0.794
10	10%	119.8	1.674	1.130
20	5%	137.0	2.011	1.610
50	2%	160.8	2.585	2.370
100	1%	178.0	2.985	3.070

Table 40: Post-Development External Catchment 3 **(EXTCA3)** – Unmitigated – Rational Method - Refer CWD Flood Report for Central Channel Inundation

Development Site Area (m^2)	Post-Development Impervious Area (m^2) (%)	Post-Development Pervious Area (m^2) (%)
11,9360m^2	**4,700 m^2 (4%)**	**114,660 m^2 (96%)**

Time of Concentration Node A = 20 Minutes,
Calculated using Friend's Equation; QUDM V3 Section 4.6.6 (c)
C_{10} Runoff Coefficient = 0.7
QUDM V3, Table 4.5.3 – Table of C_{10} Values

ARI (yr)	AEP	I (mm/hr)	RATIONAL METHOD – Q (m^3/s)	DRAINS OUTPUT – Q (m^3/s)
1	63%	60.6	1.125	0.139
2	39%	78.3	1.546	0.513
5	18%	98.6	2.174	1.050
10	10%	113.0	2.623	1.510
20	5%	129.0	3.144	2.140
50	2%	152.0	4.057	3.150
100	1%	168.0	4.679	5.520

Table 41: Post-Development External Catchment 4 **(EXTCA4)** – Unmitigated – Rational Method - Refer CWD Flood Report for Central Channel Inundation

Development Site Area (m^2)	Post-Development Impervious Area (m^2) (%)	Post-Development Pervious Area (m^2) (%)
27,510m^2	**0 m^2 (0%)**	**27,510 m^2 (100%)**

Time of Concentration Node A = 20 Minutes,
Calculated using Friend's Equation; QUDM V3 Section 4.6.6 (c)
C_{10} Runoff Coefficient = 0.7
QUDM V3, Table 4.5.3 – Table of C_{10} Values

ARI (yr)	AEP	I (mm/hr)	RATIONAL METHOD – Q (m^3/s)	DRAINS OUTPUT – Q (m^3/s)
1	63%	60.6	0.259	0.040
2	39%	78.3	0.356	0.148
5	18%	98.6	0.501	0.304
10	10%	113.0	0.604	0.434
20	5%	129.0	0.725	0.617
50	2%	152.0	0.935	0.907
100	1%	168.0	1.078	1.170

Table 42: Post-Development External Catchment 5 **(EXTCA5)** – Unmitigated – Rational Method - Refer CWD Flood Report for Central Channel Inundation

Development Site Area (m^2)	Post-Development Impervious Area (m^2) (%)	Post-Development Pervious Area (m^2) (%)
30,800m^2	**0m^2 (0%)**	**30,800m^2 (100%)**

Time of Concentration Node A = 19 Minutes,
Calculated using Friend's Equation; QUDM V3 Section 4.6.6 (c)
C_{10} Runoff Coefficient = 0.7
QUDM V3, Table 4.5.3 – Table of C_{10} Values

ARI (yr)	AEP	I (mm/hr)	RATIONAL METHOD – Q (m^3/s)	DRAINS OUTPUT – Q (m^3/s)
1	63%	62.5	0.299	0.045
2	39%	80.8	0.411	0.165
5	18%	101.6	0.578	0.340
10	10%	116.4	0.697	0.486
20	5%	133.0	0.836	0.691
50	2%	156.4	1.077	1.020
100	1%	173.0	1.243	1.320

3.4.2.2 Site Internal Catchments - Dirty Water (Require Water Quality Treatment)

Refer **Appendix F Drawing C300A** for illustration of **Post-Development Catchments**

Table 43: Post-Development Internal Catchment 1 **(INTCA1)** – Unmitigated – Rational Method - Refer CWD Flood Report for Central Channel Inundation

Development Site Area (m^2)	Post-Development Impervious Area (m^2) (%)	Post-Development Pervious Area (m^2) (%)
56,650m^2	**22,660m^2 (40%)**	**33,990m^2 (60%)**

Time of Concentration Node A = 7 Minutes,
Calculated using Friend's Equation; QUDM V3 Section 4.6.6 (c)
C_{10} Runoff Coefficient = 0.78
QUDM V3, Table 4.5.3 – Table of C_{10} Values

ARI (yr)	AEP	I (mm/hr)	RATIONAL METHOD – Q (m^3/s)	DRAINS OUTPUT – Q (m^3/s)
1	63%	93.1	0.914	0.352
2	39%	120.4	1.256	0.531
5	18%	151.4	1.765	0.847
10	10%	173.4	2.129	1.077
20	5%	199.4	2.570	1.750
50	2%	234.2	3.306	1.995
100	1%	259.8	3.827	2.933

Table 44: Post-Development Internal Catchment 2 **(INTCA2)** – Unmitigated – Rational Method - Refer CWD Flood Report for Central Channel Inundation

Development Site Area (m^2)	Post-Development Impervious Area (m^2) (%)	Post-Development Pervious Area (m^2) (%)
144,900m^2	**57,960m^2 (40%)**	**86,940m^2 (60%)**

Time of Concentration Node A = 8.0 Minutes,
Calculated using Friend's Equation; QUDM V3 Section 4.6.6 (c)
C_{10} Runoff Coefficient = 0.78
QUDM V3, Table 4.5.3 – Table of C_{10} Values

ARI (yr)	AEP	I (mm/hr)	RATIONAL METHOD – Q (m^3/s)	DRAINS OUTPUT – Q (m^3/s)
1	63%	89.6	2.251	0.567
2	39%	115.9	3.093	1.033
5	18%	145.7	4.346	1.718
10	10%	166.6	5.230	2.250
20	5%	191.6	6.316	3.024
50	2%	224.8	8.116	4.270
100	1%	249.2	9.388	5.407

Table 45: Post-Development Internal Catchment 3 **(INTCA3)** – Unmitigated – Rational Method

Development Site Area (m^2)	Post-Development Impervious Area (m^2) (%)	Post-Development Pervious Area (m^2) (%)
17,200m^2	**6,880m^2 (40%)**	**10,320m^2 (60%)**

Time of Concentration Node A = 5.0 Minutes,
Calculated using Friend's Equation; QUDM V3 Section 4.6.6 (c)
C_{10} Runoff Coefficient = 0.78
QUDM V3, Table 4.5.3 – Table of C_{10} Values

ARI (yr)	AEP	I (mm/hr)	RATIONAL METHOD – Q (m^3/s)	DRAINS OUTPUT – Q (m^3/s)
1	63%	100.0	0.298	0.318
2	39%	129.3	0.410	0.465
5	18%	162.7	0.576	0.636
10	10%	187.0	0.697	0.771
20	5%	215.0	0.841	0.969
50	2%	253.0	1.084	1.182
100	1%	281.0	1.257	1.434

Table 46: Post-Development Internal Catchment 4 **(INTCA4)** – Unmitigated – Rational Method - Refer CWD Flood Report for Central Channel Inundation

Development Site Area (m^2)	Post-Development Impervious Area (m^2) (%)	Post-Development Pervious Area (m^2) (%)
29,590m^2	**11,836m^2 (40%)**	**17,754m^2 (60%)**

Time of Concentration Node A = 7.0 Minutes,
Calculated using Friend's Equation; QUDM V3 Section 4.6.6 (c)
C_{10} Runoff Coefficient = 0.78
QUDM V3, Table 4.5.3 – Table of C_{10} Values

ARI (yr)	AEP	I (mm/hr)	RATIONAL METHOD–Q (m^3/s)	DRAINS OUTPUT – Q (m^3/s)
1	63%	93.1	0.457	0.130
2	39%	120.4	0.628	0.214
5	18%	151.4	0.882	0.347
10	10%	173.4	1.064	0.452
20	5%	199.4	1.284	0.604
50	2%	234.2	1.652	0.858
100	1%	259.8	1.912	1.081

Table 47: Post-Development Internal Catchment 5 **(INTCA5)** – Unmitigated – Rational Method – North-East Catchment

Development Site Area (m^2)	Post-Development Impervious Area (m^2) (%)	Post-Development Pervious Area (m^2) (%)
39,710m^2	**19,855m^2 (50%)**	**19,855m^2 (50%)**

Time of Concentration Node A = 6.0 Minutes,
Calculated using Friend's Equation; QUDM V3 Section 4.6.6 (c)
C_{10} Runoff Coefficient = 0.8
QUDM V3, Table 4.5.3 – Table of C_{10} Values

ARI (yr)	AEP	I (mm/hr)	RATIONAL METHOD – Q (m^3/s)	DRAINS OUTPUT – Q (m^3/s)
1	63%	96.5	0.480	0.355
2	39%	124.9	0.660	0.512
5	18%	157.0	0.928	0.743
10	10%	180.2	1.117	0.942
20	5%	207.2	1.344	1.217
50	2%	243.6	1.721	1.659
100	1%	270.4	1.991	2.166

4.0 STORMWATER QUALITY

The proposed development will result in an increase in the pollutants conveyed off the site by stormwater runoff. This report has been prepared to identify acceptable stormwater treatment measures to meet water quality objectives identified for the site.

4.1 CONSTRUCTION PHASE POLLUTANT GENERATION

The following pollutants are typically generated during the construction phase of the project.

Table 48: Construction Phase Pollutants (Source: BCC Subdivision and Development Guidelines-Table C4.1)

Pollutant	Sources
Litter	Paper, construction packaging, food packaging, cement bags, of-cuts
Sediment	Unprotected exposed soils and stockpiles during earthworks and building
Hydrocarbons	Fuel and oil spills, leaks from construction equipment
Toxic materials	Cement slurry, asphalt prime, solvents, cleaning agents, wash waters (e.g. from tile works)
pH Altering Substances	Acid sulphate soils, cement slurry and wash waters

4.2 OPERATIONAL PHASE POLLUTANT GENERATION

The pollutants that are likely to be generated by the proposed development are listed in the table below.

Table 49: Construction Phase Pollutants

Pollutant	Possibility
Litter	**YES**
Sediment	**YES**
Oxygen Demanding Substances (organise & chemical matter)	**Possibly**
Nutrients (N & P)	**YES**
Pathogens/Faecal coliforms (bacteria and viruses)	**Possibly**
Hydrocarbons (incl. oil & grease)	**Possibly**
Heavy Materials (often associated with sediment)	**Possibly**
Surfactants (e.g detergents from car washing)	**Possibly**
Organochlorines & Organophosphates (e.g pesticides, herbicides)	**Possibly**
Thermal Pollution (heat)	**YES**
pH Altering Substances	**Possibly**

4.3 RISK CATEGORY

State planning policy SPP 4-10 states that a development may be classified as “High Risk” with respect to storm water quality if it falls within one of the following categories:

- Any development proposal located within a waterway corridor, or River corridor, or a wetland area as indicated on Council planning scheme maps.
- Multi-unit dwellings or commercial uses with an area in excess of 2500 m^2 or greater than 6 units.
- Subdivision where greater than 6 lots are involved or site area in excess of 2500m^2.
- Industrial activities that are not impact assessable (under Council’s City Plan) and have at least 1,000m^2 in uncovered storage / working space.
- Industrial activities that are impact assessable (under Council’s City Plan).
- Uncovered car parks with at least 100 spaces.

As per the criteria listed above, the site has been assessed to be "High Risk" with respect to Water Quality. Council's SDG requires that appropriate pollutant export modelling be undertaken demonstrate that the proposed water quality treatment measures achieve the required water quality objectives.

4.4 WATER QUALITY OBJECTIVES

State Planning Policy 4/2010 —Healthy Waters design objectives refers to Chapter 2 of the "Urban Stormwater Quality Planning Guideline" (2010) for the recommended minimum stormwater design objectives with respect to water quality.

The following table summarises the identified minimum water quality objectives for the site as recommended in Chapter 2 of the "Urban Stormwater Quality Planning Guideline" (2010) South East Queensland. The below values are in consistent with SPP July-2017.

Table 50: Water Quality Objectives

Indicator	Reduction in average annual pollutant load discharging from site
Total Suspended Solids	80%
Total Nitrogen	45%
Total Phosphorous	60%
Gross Pollutants	90%

4.5 POLLUTANT MODELLING

To assess the discharge concentrations of key pollutants from the development, a treatment train has been developed and the results analysed using MUSIC software (Version 5).

MUSIC is the Model for Urban Stormwater Improvement Conceptualisation, developed by the MUSIC Development Team of the CRC for Catchment Hydrology. MUSIC provides the ability to simulate both quantity and quality of runoff from catchments ranging from a single house block up-to many square kilometres and the effect of a wide range of treatment facilities on the quantity and quality of runoff downstream. MUSIC will simulate the performance of a group of stormwater management measures, configured in series or in parallel to form a “treatment train”. MUSIC runs on an event or continuous basis, allowing rigorous analysis of the merit of proposed strategies over the short & long-term.

MUSIC Modelling Guidelines Version 6.3 Build 0.1908 - Water by Design (referred to as the "Water by Design Guideline" hereafter) has been used to obtain the various source and treatment node parameters for the **proposed treatment train** in **Figure 11**.

4.5.1 RAINFALL DATA AND SOURCE NODES

Table 51: Rainfall Data and Modelling Periods for SEQ

Council	Station ID	Station Name	Climate Period
ICC	40659	Greenbank Thompson Rd	1/1/1980 – 31/12/1989

Mean PET (mm)											
Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
181	139	137	102	72	62	63	81	108	138	159	184

Different source nodes have been used to model various catchment characteristics. The following tables summarise the recommended rainfall runoff parameters and pollutant export parameters for split catchment land use that have been used in the MUSIC model for the development site. These parameters have been used as per the recommendations made in Water by Design Guidelines Table 3.7.

Table 52: Rainfall Runoff Parameters (Residential)

Parameter	Urban Residential Land Use
Rainfall Threshold (mm)	1
Soil Storage Capacity (mm)	500
Initial Storage (% capacity)	10
Field Capacity (mm)	200
Infiltration capacity coefficient a	211
Infiltration capacity exponent b	5.0
Initial depth (mm)	50
Daily recharge rate (%)	28
Daily baseflow rate (%)	27
Daily deep seepage rate (%)	0

Table 53: Pollutant Export Parameters (MUSIC Modelling Guidelines 2018, Table 3.9)

Land Use	Surface Type	Flow Type	TSS Log 10 values (mg/L)		TP Log 10 values (mg/L)		TN Log 10 values (mg/L)	
			Mean	Std Dev	Mean	Std Dev	Mean	Std Dev
Residential	Roof	Baseflow	-	-	-	-	-	-
		Stormflow	1.30	0.39	-0.89	0.31	0.26	0.23
	Roads	Baseflow	1.00	0.34	-0.97	0.31	0.20	0.20
		Stormflow	2.43	0.39	-0.30	0.31	0.26	0.23
	Ground level	Baseflow	1.00	0.34	-0.97	0.31	0.2	0.2
		Stormflow	2.18	0.39	-0.47	0.31	0.26	0.23

Table 54: Fraction Impervious Summary

Catchment Type	Fraction Impervious
Roof Areas	100%
Roadways/Verge	60%
Landscaping Area	20%

4.5.2 PROPOSED TREATMENT TRAIN

A treatment train has been developed to meet the water quality objectives identified in **Table 48**. The following figures, represent the proposed treatment trains for the development site.

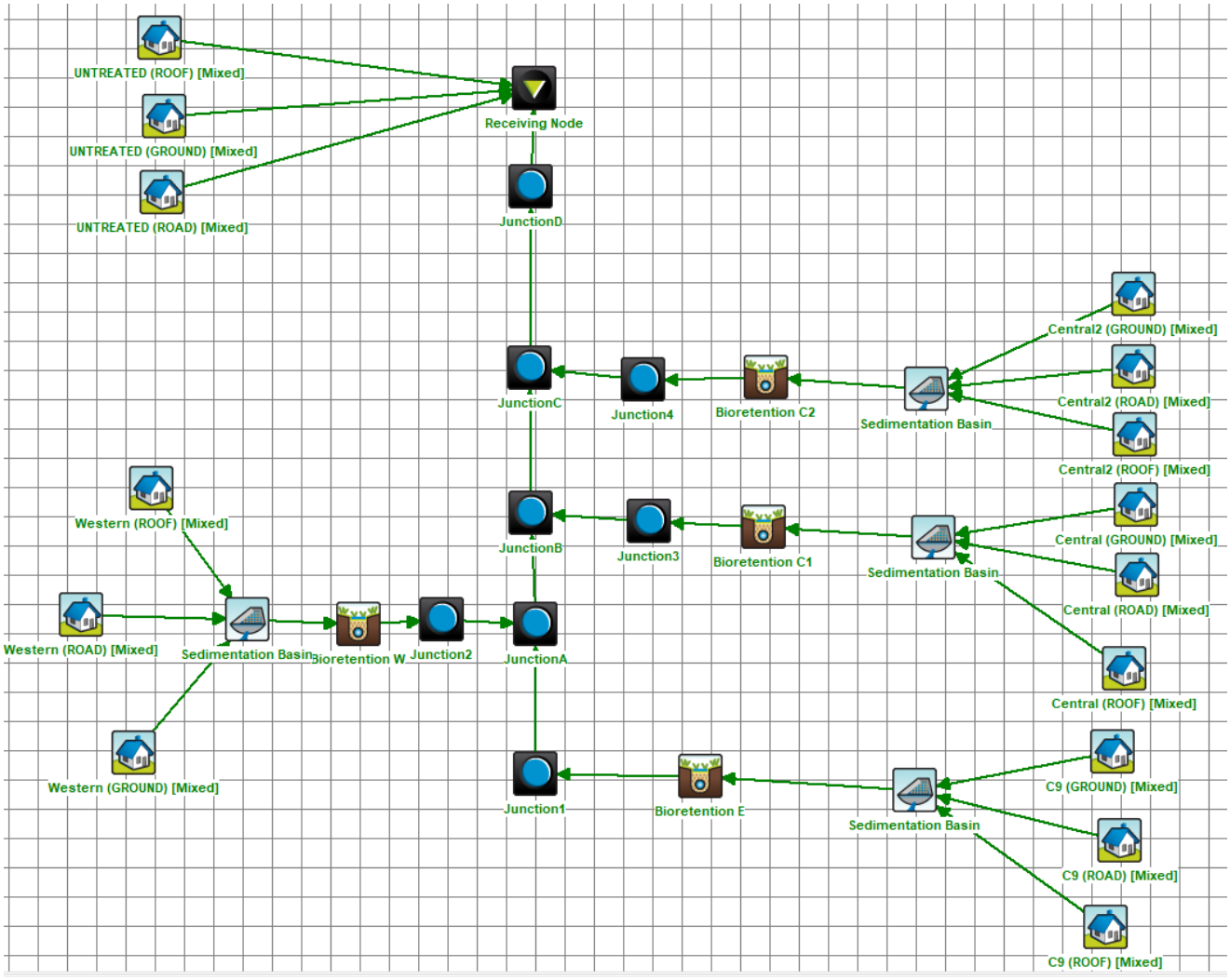

Figure 8: Treatment Train Effectiveness (MUSIC)

4.5.3 TRASH RACK AND COARSE SEDIMENT BAY

It is proposed to use a trash rack and coarse sediment bay per bio-basin, alongside maintenance footpaths in line with the Council's Implementation Guideline 24 and relevant standard drawings at appropriate slopes. See below the **Figure 11** for input parameters used for modelling the typical coarse sediment forebay nodes. Sediment forebay areas are 58.6, 119, 119 and 20.5 sqm adjacent the western bio basin, central basins each and eastern bio basin respectively.

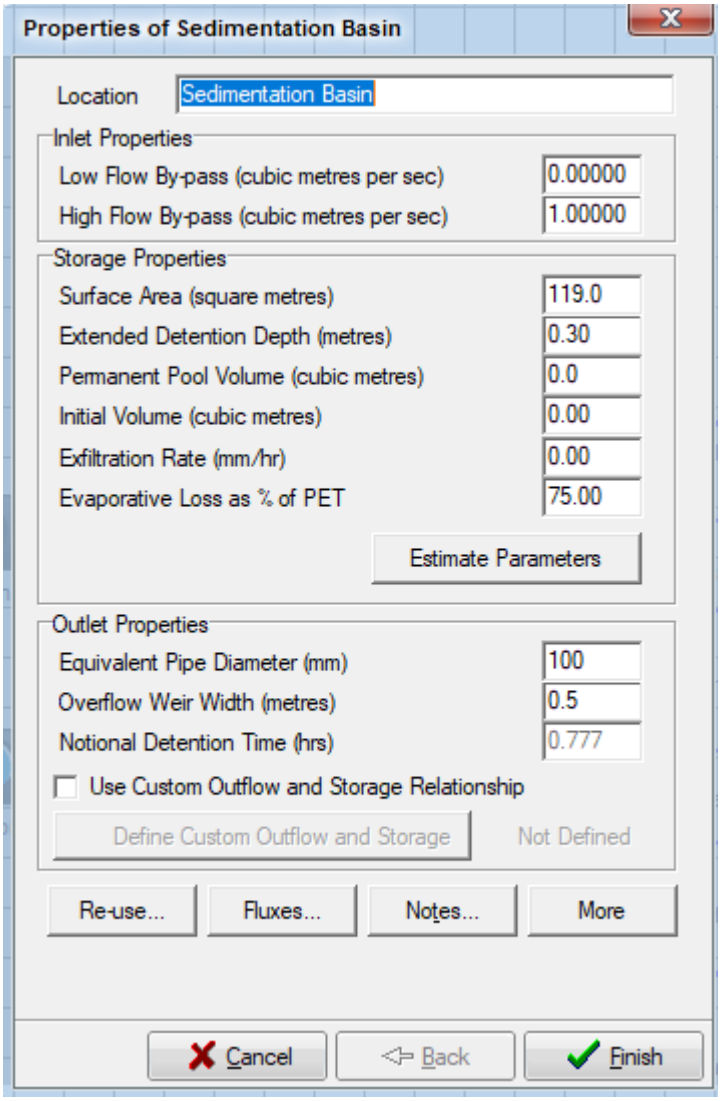

Figure 9: Input Parameters Used for Trash Rack and Sediment Forebay

4.5.4 BIO RETENTION BASIN

As per the guidelines outlined in the *MUSIC Modelling Guidelines (Version 3.0 – 2018)*, the total surface area of the bioretention basin for the development is modelled as a bio-retention basin in the treatment train.

It is proposed that detailed site grading during the Operational Works phase, be carried out to ensure that post development flows are conveyed as detailed in the stormwater management plan prior to discharging off the site. **Figure 10** below shows inputs made to the bio-retention node in MUSIC. These inputs are consistent for all basins except areas as which are enlisted below in **Table 55** in addition to other critical details relevant the bio basins.

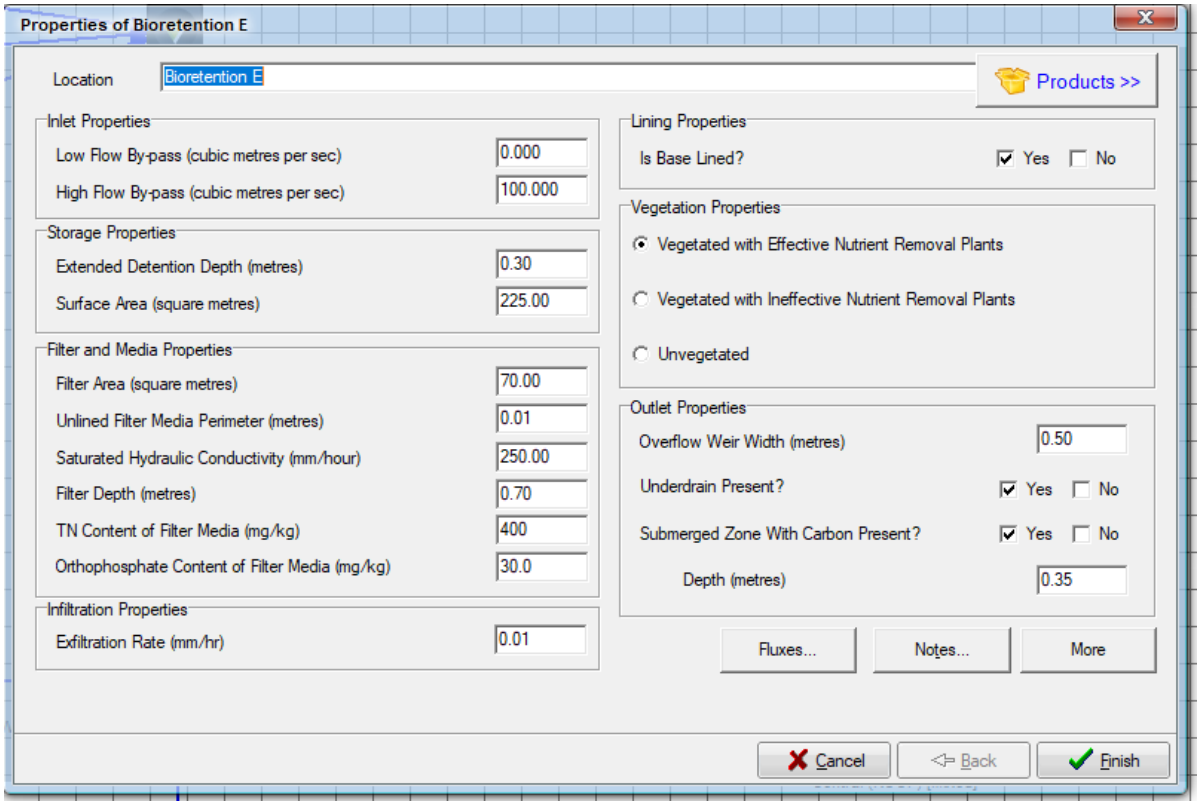

Figure 10: Bio-Retention Node Inputs

4.5.5 AREAS OF CATCHMENTS AND ALLOCATED STORMWATER QUALITY TREATMENTS

Catchment areas are derived by utilisation of the split catchment method are as summarised in below **Table 53**, in addition to information about relevant bio-basins and construction staging of the relevant bio basins.

Table 55: MUSIC Catchment Areas

Catchment	Pollutant Source			Stormwater Treatment		
Catchment #	Roof Area (ha)	Road Area (ha)	Landscaping Area (ha)	Receiving Bio Basin #	Bio Basin Filter Area (sqm)	Stages Serviced by Basin
1	1.960	2.320	1.960	W	329	6, 7 and 8
2	4.340	3.890	4.340	C1	650	3-5 and 9-13
3	0.550	0.380	0.550	C2	204	14
4	1.130	1.110	1.130	E	70	1 and 2
5	0.060	0.230	0.060	Untreated	-	-

4.5.6 TREATMENT TRAIN EFFECTIVENESS

Results from the MUSIC Model below on **Figure 11** show that the proposed treatment train, achieves the water quality objectives identified in **Table 50**. The following table summarises the proposed treatment train effectiveness as compared to the identified water quality objectives.

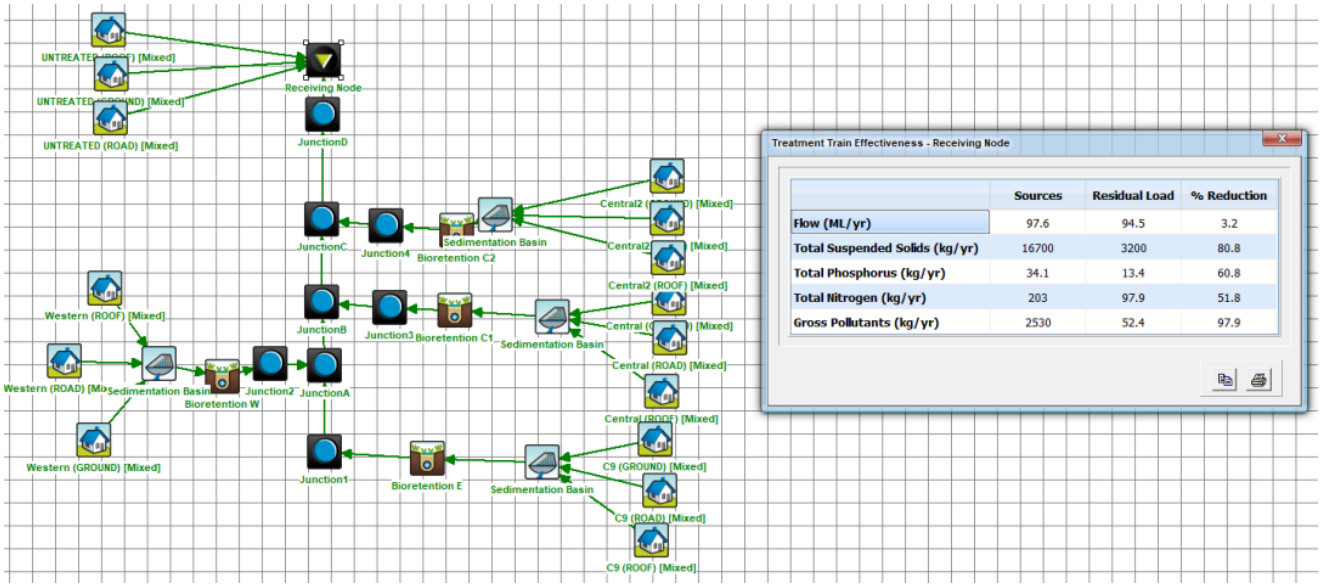

Figure 11: Treatment Train Effectiveness

5.0 LIFE CYCLE COST ASSESSMENT

The developer will fund the initial capital cost of a system to convey and treat stormwater runoff. The lifecycle of the above management options can be stated as relatively long (approximately up to 15 years). This is due to the use of structural devices with long design life and natural systems that are self-regulating. Maintenance costs associated with such management options will be high in the early stages of the life cycle but as the developed area stabilises the costs will decrease. Due to the long life of the devices, it can be stated that a very low lifecycle cost will be achieved. All maintenance of the proposed devices will be the responsibility of the Ipswich City Council.

6.0 WATER QUALITY MONITORING PROGRAM

A water-quality monitoring program may be required for the site under the conditions imposed by the Development Approval with the Local Government Area (LGA) Council. Below is a conceptual-phase monitoring program that will be updated to a detailed design level for inclusion with the Operational Works Application. The site has no base flow of water during dry periods and as such, the monitoring program will focus on stormwater discharge quality during construction and the quality of the ecological health during the maintenance period.

7.0 STORMWATER QUALITY MAINTENANCE

Key stormwater quality treatment devices requiring maintenance during the operational works phase of the project are the specified bio retention systems and the sediment pond.

Maintenance required for rain garden systems consists of:

- Regular and storm event inspections to insure:
- Sufficient vegetation is still established.
- No erosion has occurred: and
- Any clean-up required is undertaken.
- Regular mowing/ harvesting to ensure vegetation is maintained at acceptable levels.
- Removal of litter.

7.1 MAINTENANCE PLAN DETAILS FOR BIO-RETENTION SYSTEM

SCHEDULE OF SITE VISITS													
Purpose of Visit	**Frequency**	**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**
Routine inspection	Half /year	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔
Annual inspection	1/year				✔								
Routine maintenance	2/year				✔						✔		
Routine clean out of sediment	1/2 year				✔								

The above schedule is a guideline only. Routine clean out and maintenance should be scheduled based on the outcome of routine inspection.

INSPECTION
Routine Inspection
Routine inspection should be carried out on a regular monthly basis. The purpose of the inspection is to indicate when maintenance of the Bio retention system is required.
Inspections should consider erosion, condition of vegetation, and pond water.
Complete appropriate Maintenance Form. Maintenance is required if failure of the above sediment.
Annual Inspection
Once a year, the condition of the bio retention system should be closely inspected. Any damage or problems should be noted on the Maintenance Form for action.
ROUTINE MAINTENANCE
Purpose
Routine maintenance of the bio retention system involves weed control and the collection of any litter, removal of dead or diseased vegetation, and mulch replacement.
Weed Management
If weeds have been observed during routine inspection, these weeds should be removed from the bio retention system. Weeding generally involves manual removal of perennial species.
The aim is to remove the weed including the roots when the weeds are less than 3 months old; otherwise weeds infestation rapidly occurs and is difficult to control.
Herbicides should not be used, as they would contaminate the water in the creek.
The weed should be disposed offsite at appropriate waste management facility.
Replant appropriate plant species, where necessary, in areas that have been extensively weeded.
Litter Management
Remove and dispose of litter that may be visible around the bio retention system.
Dead or Diseased Vegetation
Remove or dispose of any dead or diseased vegetation within system
Mulch Replacement
Mulch replacement is recommended when erosion is evident or system looks unattractive.
CLEANOUT OF SEDIMENT
Setup and Prepare site for Cleanout
Notify adjacent residents at least three days prior to date of cleanout.
Setup equipment onsite
Cleanout of Sediment – Bio retention basin
The preferred method of cleanout of the bio retention system is replacing the clogged medium.
Position the equipment on the side of the system to allow easy access into the bio retention system and transfer of material into adjacent tipper truck. The truck should be positioned so that water from the truck body drains into the bio retention systems.
Drain waste in the truck thoroughly before proceeding to the disposals point.
Cleanout of Sediment – Sediment Fore bays
Cleanout of fore bays should be undertaken periodically by shovelling out accumulated sediment and conveying to maintenance truck via wheel barrow or by similar means.

7.2 NOISE & DUST MANAGEMENT

NOISE & DUST MANAGEMENT	
Element	To minimise the impact of noise and dust nuisance generated by earthworks and construction activities and maintain amenity for adjoining residents. Compliance with this objective is to meet the requirements set out in the Environmental Protection Reg. 1998 Part 2A Environmental Nuisance.
Policy	All works undertaken on site are to comply with the above documents.
Performance Requirements	**Noise** Bespoke Engineering Solutions Pty Ltd Engineering Works Specification included within the contract with the Principal Contractor nominates the following normal hours of onsite work: • 6.30am to 6.30pm Monday to Saturday or business days • No work on Sundays or Public Holidays • Any construction or earthworks activities outside of the hours nominated above will only be permitted with the prior written approval of both the Principal and the relevant Local Authority delegate. **Dust** Bespoke Engineering Solutions Pty Ltd Engineering Works Specification included within the Contract with the Principal Contractor specifies: • Dust generated from the site and from earthworks is to be controlled so as not to adversely affect adjoining properties, and to meet the requirements of the Environmental Protection Act. • No visible dust emissions must occur at the boundaries of the site during earthworks and construction activities on the site. • If at any time during the earthworks and construction activities, dust emissions exceed the levels specified above, dust-generating activities must cease until sufficient corrective actions have been implemented to reduce dust emissions to acceptable levels or wind conditions are such that acceptable levels are achieved. • In order to ensure minimal response times for implementation of corrective actions and continuity of the construction processes, watering equipment shall be available on site at all times during earthworks and construction activities to dampen down disturbed areas.
Monitoring	The monitoring and control of both noise and dust nuisance is to be a continuous process for the duration of the earthworks and construction activities at all times including non-working days.
Reporting	The superintendent is to take note of noise and dust levels: • During regular site inspections throughout the earthworks and construction activities; and • Immediately following receipt of any complaints.

Corrective Action	The superintendent in consultation with the Principal Contractor is to determine the source of the unacceptable noise and dust emissions and;
	• Devise a method to attenuate offending noise emissions either through maintenance of plant or revised work practices, and
	• Reduce dust emissions through either:
	  ○ Suspension of works until weather conditions are favourable;
	  ○ Damping down of work areas; or
	  ○ Revision of work practices.

8.0 CONCLUSION

This report has investigated the impacts of the proposed development on stormwater quality in the catchment. Bespoke Engineering Solutions Pty Ltd have performed analysis of all site catchments and conditions and have determined the best treatment for the catchments considering all aspects and constraints opposed on the development.

The site is classified as high risk in terms of pollutant generation due to the nature of the development. A MUSIC model was created for the site in the developed state to confirm what stormwater quality measures would be required. The results of the MUSIC model identified that the proposed treatment train is required to ensure the development meets the water quality objectives for flows generated from the entire site.

Bespoke Engineering Solutions Pty Ltd provides the above assessment and the information contained in the attached appendices based on the information outlined on Page 3 of this report. We trust that sufficient information has been provided to allow assessment and approval of the proposal with conditions.

9.0 REFERENCES

Ipswich City Council, Ipswich Planning Scheme, Implementation Guideline No.24 Stormwater Management – January 2016

Water-by-Design, MUSIC Modelling Guidelines Version 3.0 - 2018

Queensland Government, Department of Infrastructure, Local Government and Planning, State Planning Policy, July – 2017

Environmental Protection (Water and Wetland Biodiversity) Policy – 2019

Bureau of Meteorology, Meteorological Data

Water-By-Design Maintaining Vegetated Stormwater Assets - 2012

Water-By-Design Construction and Establishment Guidelines - 2019.

Water-By-Design Bioretention Technical Design Guidelines v1.1 - 2014