CONCEPTUAL STORMWATER MANAGEMENT PLAN

Future Residential Subdivision

DEVELOPMENT ADDRESS

14 Claret Ash Avenue
South Bowenfels, NSW 2790

LEGAL DESCRIPTION

Lot 1 DP933666

FOR

Ledger Enterprises Pty Ltd

ORIGINAL REPORT DATE
March 2020

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Site Address:	**Lot 1 DP933666 & Lot 24 DP1041700** **14 Claret Ash Avenue** **South Bowenfels, NSW 2790**
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1. INTRODUCTION

Developer	Ledger Enterprises Pty Ltd
Address	14 Claret Ash Avenue, South Bowenfels, NSW 2790
Local Authority	Lithgow Council
Property Description	Lot 1 DP933666 & Lot 24 DP1041700
Size of Development	Approx. 17.1619 ha
Type of Development	Future Residential Subdivision
Time to Undertake Works	12 - 18 Months
Existing Land Use	Vacant
Adjacent Land Use	Residential Dwellings
Engineering Consultant	Calare Civil Pty Ltd
Report Written By	Grant Lyons
Qualifications	Senior Civil Designer
Experience	25+ years civil engineering experience. 10 years New Zealand, 2 years England & 13+ years Australia, Prepared Stormwater Management Plans since 2004 (2006 Australia).
Report Checked By	Garth Dean
Qualifications	Engineer (BE CPEng.)
Experience	30+ Years Civil Engineering Experience
Purpose of Report	To ascertain the requirements to control stormwater exiting the site and ensure that it has no adverse effect on the downstream receiving waters. This report addresses the issue of: Quantity runoff in accordance with the relevant documents and local / regional authority regulations Quality runoff in accordance with the WATER NSW requirements.

2. SITE DESCRIPTION

2.1. Topography & Drainage

The proposed development is located at the northern end of Claret Ash Avenue in South Bowenfels with access to the site from the end of the existing formation.

Elevations range from 956m AHD to 1030m AHD.

The site has a ridgeline running from the west, approximately ¾ of the way along the western boundary, the ridge line heads in a south easterly direction for approximately 200m where it then runs generally south for the remaining site extents.

There is no external catchment running though the site.

The site itself is undulating with ridges and gullies throughout, there are two main discharge points from the site due to this topography.

Due to the slope of the site and its constant fall it is unlikely that this site will become inundated in a flood event and as such flooding and inundation issues will not be addressed in this report.

2.2. Soils

At this stage a Geotechnical investigation has not been undertaken, due to the nature of the site and its current use it is unlikely that there are extremely erosive soils on site.

For the purposes of this report a soil type of Light Clay has been adopted, this is a rather conservative assessment that gives moderate soil storage and field capacities.

2.3. Watercourses

There are no defined permanent watercourses from upstream catchments running through the site.

The receiving watercourse for this catchment is ultimately Farmers Creek some 2.5km away.

The runoff from the site will flow through various tributaries before entering Farmers Creek.

The existing water quality of the receiving waterway is unknown. It is assumed that the eco-system in this creek is moderate and mitigating works will be undertaken to ensure the water quality leaving the site will be to the neutral or beneficial effect requirements set by WATER NSW to minimise any environmental impact.

2.4. Flora & Fauna

From the survey information provided it is ascertained that there is no major or protected vegetation within the works area onsite.

No fauna survey has been undertaken. If any protected, threatened or endangered species of fauna are found to be inhabitant within the site prior to or during construction works the relevant authorities will be informed immediately.

3. DATA

3.1. Existing Stormwater Infrastructure

This is currently a vacant site and as such is devoid of hardstand areas or structures, there is no formal drainage system either on site or in the vicinity of the site.

As discussed previously the site is undulating with multiple discharge points.

There are two discharge points for the site.

The western discharge point is at the boundary of Lot 7 DP776529 where an existing drainage depression conveys the runoff to the existing drainage system at the Great Western Highway. This depression is deemed to be the legal point of discharge for the western side of the development.

The eastern discharge point is at the boundary of Lot 45 DP1109094. This block is Council owned and contains an existing detention basin where a piped system then conveys the runoff. This detention basin and the piped network is deemed to be the legal point of discharge for the eastern side of the development.

3.2. Stormwater Management Plans

The Site Based Stormwater Management Plan (SBSMP) described below is in accordance with the WATER NSW “Using MUSIC in Sydney’s Drinking Water Catchment” standard, dated December 2012 and Lithgow City Councils engineering guidelines.

3.3. Water Quality/Stream Health

No study has been undertaken to determine the water quality of the recipient creek. As discussed previously water quality leaving the site will be at least 10% better than the pre-developed levels to achieve NorBE.

4. OPPORTUNITIES AND CONSTRAINTS

4.1. Key Site Characteristics

In this preliminary assessment of the development no major constraints have been identified.

The site has suitable fall for drainage and satisfactory area to incorporate the proposed treatment devices as detailed in this report.

The site will require reshaping for the proposed road networks but the preliminary assessment indicates that all civil works can be designed using acceptable engineering techniques.

4.2. Previous Studies / Plans

This report consolidates the two previous Calare Civil reports that detailed the western and eastern discharge locations separately. This report will assess both locations as separate catchments with supporting information for each.
Previous reports

- Conceptual Stormwater Management Plan
  Rev. P1
  Dated 26/03/2020
- Existing Eastern Detention Basin Review and Capacity Check
  Rev. P1
  Dated 14/09/2020

5. STORMWATER QUANTITY

5.1. Existing Conditions

All stormwater currently flows to the natural gullies within the site and direct discharge to the previously described eastern & western discharge points.

To ultimately develop this site, an underground drainage system & overland flowpaths will need to be provided to manage stormwater and ensure that there is no net worsening on the downstream system.

5.2. Methodology

Hydrology

To undertake the hydrologic analysis of the development, the methodologies detailed in AR&R 2019 have been used. Flows and levels have been calculated using a rainfall depth chart developed using the Bureau of Meteorology IFD software (refer **Appendix A**) for the Lithgow area.

Watercom Drains

A hydrologic assessment of the proposed system has been undertaken using Watercom Drains, producing an Ilsax model to ensure that the development does not adversely affect the downstream system by decreasing the time of concentration and increasing the runoff.

This model has used the Central Slopes temporal pattern and the AR&R 2019 rainfall depths based on the co-ordinates of the site and obtained from the BoM.

The developed scenario will require onsite detention to mitigate the increase in flows, it is proposed to use a detention basin prior to the outlet discharge locations.

Section 3.7 of Councils Guidelines for Civil Engineering Design & Construction set the criteria to be met when designing the basins, the main parameters are;

- Floor Slope min 1% fall.
- Designed to ensure no increase in runoff when compared to the pre-developed 1% AEP event.
- Batters max 1:3
- Max 1.2m deep in 5% AEP, unless safety measures are proposed.
- 500mm freeboard from 1% AEP level.
- Max peak flow velocity 2m/s for grassed spillways in 5% AEP event
- Spillway to cater for 1% AEP

The design has checked the above parameters are met or mitigated and additionally ensured that storm events up to and including the 5% AEP event are discharged through the outlet pipes without overtopping to the spillway.

5.3. Watercom Drains Model Analysis

Western Discharge

For the western discharge point an assessment has been made to ensure that the runoff flowrate in the developed scenario is not in excess of that that is currently discharging from the site.

The model has been set up with two systems, the first being the pre-developed, unmitigated, site, the second is the developed mitigated site.

A catchment analysis has been undertaken for the western catchment that determines the total catchment area to be 5.453ha.

It has a total impervious area of 0% for the predeveloped site and 19% for the developed site, given that the majority of the site will be left undeveloped due to the steep terrain and existing bush areas. The impervious area is based on 100% imperviousness for the road formation and 40% imperviousness for the building envelopes.

The storm events assessed are the 20% & 1% AEP events, the table below shows the comparison between the pre and post developed site for the peak storm.

It should be noted that the western detention basin has been previously designed and constructed. These calculations are to confirm that the previous design is still valid for the proposal.

Table 5.1

Watercom Drains Results							
Storm Event (AEP)	Pre-Dev Site Flow (m^3/s)	Post Dev Site Unmitigated Flow (m^3/s)	Post Developed Site Mitigated Flow (m^3/s)	Peak Detention Volume (m3)	Outlet Pipe (No. / Dia / Orifice)	Pipe Outlet Velocity Mitigated (m/s)	Weir Outlet Velocity Mitigated (m/s)
20%	0.189	0.338	0.074	253.3	1 / 250 / -	1.64	-
10%	0.271	0.420	0.077	274.2		1.67	-
5%	0.321	0.506	0.082	336.4		1.77	-
2%	0.344	0.627	0.090	429.7		1.89	-
1%	0.401	0.715	0.095	498.5		1.98	-

It can be seen from the above results that in all storm events there is a reduction in runoff when compared to the existing site runoff.

Storm event	Reduction in Runoff
20% AEP	60%
10% AEP	71%
5% AEP	74%
2% AEP	74%
1% AEP	76%

It should also be noted that the maximum depth of water will be 1.4m in the 1% AEP event & 1.1m in the 5% AEP event.

For the full calculations please refer to the supplied Watercom Drains model file.

If not included in the package the Watercom drains file can be obtained by contacting the author.

Eastern Discharge

Only the 1% AEP event has been assessed as the intention is not so much to mitigate the flows but to ensure the existing system has capacity to convey the additional runoff.

Future Developed Capacity

The model has been set up only allowing for the developed scenario discharging to the basin, of which a small portion will bypass directly to the existing drainage system.

The existing piped system immediately downstream of the existing detention basin has been included in the modelling to ensure all flows running off the site are able to be conveyed.

A catchment analysis has been undertaken for the eastern catchment that determines the total catchment area to be 31.557ha.

It has a total impervious area of 0% for the predeveloped site and 3.5% for the developed site, given that the majority of the site will be left undeveloped due to the steep terrain and existing bush areas. The impervious area is based on 100% imperviousness for the road formation and 40% imperviousness for the building envelopes.

As stated above only the 1% AEP event has been assessed.

Adopted developed parameters;

Table 5.2

Catchments	Area (ha)	Fi	Tc (impervious)	Tc (pervious)
East to Detention	30.615	0.035	7	15
East Bypass	0.942	0.196	5	7

Detention Basin Results Summary

Table 5.3

Max WL	Max Volume	Discharge Flowrate
RL 963.13m	1150m^3	4.01m^3/s

Table 5.4

	Watercom Drains Results					
Storm Event (AEP)	Post Developed Site to Detention Flow (m^3/s)	Post Developed Site Bypass Flow (m^3/s)	Peak Detention Volume (m3)	Outlet Pipe (No. / Dia / Orifice)	Pipe Outlet Velocity Mitigated (m/s)	Pipe Freeboard Upstream (m)
1%	2.52	0.187	37.3	2/750/-	8.00	2.8m

An additional assessment has been undertaken for the 5% AEP event to assess the depth of ponding is in accordance with Council requirements. The modelling shows the maximum level of storage in the 5% AEP event will be RL962.39m, with a base level of 962.30 the peak depth will be 90mm.

For Watercom Drains results refer to **Appendix B**.

For the full calculations please refer to the supplied Watercom Drains model file.

If not included in the package the Watercom drains file can be obtained by contacting the author.

5.4. Proposed Mitigation Measures

The following is proposed as a best practice site specific solution for both the eastern & western catchments.

1. All roof areas are to drain to the proposed drainage system as designed in conjunction with the full civil works design and are to comply with the NSW BASIX requirements.

2. The road network is to incorporate a drainage system design in accordance with the relevant standards.

3. The piped drainage system is to discharge to the top of the filter media of a proposed bio-retention basin. Discussed in further detail later in this document.

4. The bio-retention basin is to discharge to the detention basin.

5. The drainage network is to discharge to the existing detention basin in lot 45 DP1109094 excepting the nominated bypass for the eastern catchment and to the existing gully in Lot 7 DP776529 with mitigation to ensure that the velocities when the outflow reaches the natural gully are no more than 2m/s. Additionally the outfall dissipation/protection is to be designed as such that the outflow is converted as best as practically possible to a sheet flow or in a similar shape to the receiving natural gully in accordance with the design plans.

Refer to the drawings supplied in the **Figures** section of this report for further details.

6. STORMWATER QUALITY

Existing Conditions

The site is currently vacant with some vegetation present.

There are no stormwater quality mitigation measures being implemented in its current state.

Receiving Waters

The existing condition of the receiving waterway is unknown so it is intended to keep the post development runoff levels to at least 10% less than the pre-developed state.

Due to the nature of this development there is a high probability that the increase of nutrient pollutants could be significant, any increase in litter, nutrients or suspended solids entering the receiving body of water can impact on the ecosystem therefore all runoff will be treated to ensure a neutral or beneficial effect (NorBE) on water quality.

Objectives

The use of stormwater quality improvement devices (SQUIDs) will address the NorBE objectives as detailed below.

10% reduction in Total Suspended Sediment (TSS)
10% reduction in Total Nitrogen
10% reduction in total Phosphorus

6.1. Methodology

The eastern and western catchments have been assessed separately with the results tabulated below.

The pollutant impact assessment has been carried out using the MUSIC model system.

The pollutant assessment considered two scenarios as follows:

Pre Development
Post Development treated.

The pre development site has been modelled as one catchment, the adopted catchment land uses are tabulated below.

Only the areas that are to be disturbed have been evaluated, this includes the road network and 40% of the nominated building envelopes.

The sub-catchment trains are shown in **Appendix B**:

Table 6.1 – Catchment Areas and Land Uses – Pre Development

PRE-DEVELOPED CATCHMENT TABLE					
CATCHMENT NAME	USAGE TYPE	MUSIC USAGE TYPE	CATCHMENT AREA (Ha)	EFFECTIVE IMPERVIOUS AREA	POLLUTANT INPUT PARAMETERS
Western Catchment	Vacant Rural Lot	Agricultural	1.474	0	Agricultural
Eastern Catchment	Vacant Rural Lot	Agricultural	2.201	0	Agricultural

It should be noted that;

- the soil type “light clay” was adopted for the modelling.

The post development model has numerous catchments, the adopted catchment land uses are tabulated below.

- The effective impervious area, for the bulk of the development, adopted is 0.55xTIA = 0.55x0.40 = 0.22
- There is a portion of the development, some 4610m^2 for the eastern catchment and 4170m^2 for the western catchment, that cannot drain to the bio-retention basin so will bypass the system, the equivalent impervious area fractions adopted are 0.101 & 0.206 for the respective catchments.

The sub-catchment trains are shown in **Appendix B**:

Table 6.2 – Catchment Areas and Land Uses – Post Development

POST DEVELOPMENT CATCHMENT TABLE					
CATCHMENT NAME	USAGE TYPE	MUSIC USAGE TYPE	CATCHMENT AREA (Ha)	EFFECTIVE IMPERVIOUS AREA (Ha)	BASEFLOW PARAMETERS
Eastern Catchment	Residental	Residental	1.740	0.866	Residental
Eastern Catchment – Bypass	Residental	Residental	0.461	0.101	Residental
Western Catchment	Residental	Residental	1.507	0.565	Residental
Western Catchment - Bypass	Residental	Residental	0.417	0.206	Residental

The land fall data used in the modelling was the Zone 4 rainfall data obtained from WATER NSW. Five year, six minute time step rainfall data was used from 01 January 1997 to 31 December 2001 to run the MUSIC model.

The daily values for average areal potential evapotranspiration for the site were calculated within the MUSIC software from the same data source as the rainfall data.

The proposed treatment train for the sub-catchments is as follows:

- Runoff from the allotments & road reserves are to be captured within the subdivisions piped system, to be designed.
- The piped system is to be directed to the relevant road side swale drain.
- The three main swale drains are to include a bio-retention swale as detailed on the plans.
- The seepage flow from each bio-retention basin is to discharge via a 100 dia

low flow pipe to the detention basin or the outlet pit as appropriate.

The treatment trains and catchment have been set up in accordance with the WATER NSW MUSIC Standards.

The predeveloped and post developed scenarios are tabulated below.
It should be noted that the drainage links were modelled with no routing as each catchment has not been confirmed by full design at time of author.

6.2. MUSIC Model Analysis

The modelling resulted in the following:

Eastern Catchment

Table 6.3

	Mean Annual Loads			
	Flow (ml/yr)	TSS (kg/yr)	TP (kg/yr)	TN (kg/yr)
Pre development (untreated)	5.18	893	3.88	17.4
Post development (treated)	10.1	617	1.60	15.2
% Reduction	-51%	31%	59%	13%

A review of the MUSIC model results shows that the proposed stormwater treatment train through the use of the bio-retention basin will reduce the expectant pollutant export loads leaving the site. The comparison of results between Pre Development (untreated) and Post Development (treated) models shows that the inclusion of the proposed stormwater treatment train will reduce the TSS loads by 31%, the TP loads by 59% and the TN loads by 13%.

The pollutant loads are shown to be at least 10% less than the Pre-developed site and therefore complies with the WATER NSW requirements for NorBE.

Western Catchment

Table 6.4

	Mean Annual Loads			
	Flow (ml/yr)	TSS (kg/yr)	TP (kg/yr)	TN (kg/yr)
Pre development (untreated)	4.48	789	3.23	16.0
Post development (treated)	8.46	702	1.53	13.9
% Reduction	-53%	11%	53%	13%

A review of the MUSIC model results shows that the proposed stormwater treatment train through the use of the bio-retention basin will reduce the expectant pollutant export loads leaving the site. The comparison of results between Pre Development (untreated) and Post Development (treated) models shows that the inclusion of the proposed stormwater treatment train will reduce the TSS loads by 11%, the TP loads by 53% and the TN loads by 13%.

The pollutant loads are shown to be at least 10% less than the Pre-developed site and therefore complies with the WATER NSW requirements for NorBE.

6.3. Impact of Development

The development of this site will increase loadings on the stormwater quality which is to be minimised by the implementation of primary and secondary treatment devices as detailed in this report and will be monitored as detailed in **Appendix B**.

6.4. Proposed Management Strategies

The objective is to provide a stormwater drainage system that reduces the impact of the development compared with the existing pre-development loads. Management practices to assist in the reduction of the reliance on the primary treatment structures will be implemented.

Provision of long term water quality monitoring for this development is considered impractical. Hence, the operational monitoring will consist of event samplings only if requested by the relevant local authority and will involve collecting stormwater prior to it leaving the site. Monitoring shall be for the following:

Table 6.5 – Operational Phase Water Quality Parameters

Insitu	Laboratory Parameters
pH	Suspended Solids
Turbidity	Total Nitrogen
Temperature	Total Phosphorus
Dissolved Oxygen	
Salinity	
Specific Conductance	

Further details can be found in **Appendix C**.

7. CONCLUSION

7.1. Stormwater Runoff Mitigation Options

Onsite detention is proposed to mitigate the anticipated increase in runoff due to the development. The development in its current state incorporates two detention basins, one for each catchment. A review of these basins show that they are both suitably sized to ensure there is no adverse impact on the downstream system. There is no proposal to alter either of these in regard to size and outlet systems.

7.2. Selection & Assessment of Stormwater Quality Controls.

The treatment proposed to address the stormwater quality runoff from the site will be in the form of bio-retention basins. These are to be included in the overall stormwater system at the downstream end, either prior to or within the existing detention basins as deemed appropriate.

The overall treatment train is as follows;

- All roofwater is to discharge to a piped system.
- All road runoff to be directed to a piped system.
- The combined runoff is to be directed to a bio-retention system sized as per the plans incorporated in the figures section of this report.
- Discharge from these basins to be via the detention system and then to the legal point of discharge.

These are to be installed and maintained in accordance with **Appendix D**.

7.3. Integration with Waterway Corridor

The catchment will ultimately drain into the neighbouring proposed piped system that then will discharge to the receiving waterway (Farmers Creek to the west and Good Luck Hollow to the East).

8. ASSET HANDOVER

Both of these systems will be dedicated to Council and following an on-maintenance period will become a Council asset and as such the sole responsibility of Council in regard to the ongoing maintenance.

9. REFERENCES

1. Australian Rainfall & Runoff (AR&R) 2019.
    - Regional Flood Frequency Estimation Modelling
    - AR&R Data Hub
    - FFA-Reconciled Losses Map
    - WMA Water Review of AR&R Design Inputs for NSW - Appendix C
2. Bureau of Meteorology.
    - Design Rainfall Data System
3. NSW Water Management (General) Regulation 2018 Hydroline Spatial Data 1.0
4. Lyall & Associates
    - Lithgow Flood Study Review May 2017 Rev. 1.4 Volume 1 - Report
    - Lithgow Flood Study Review May 2017 Rev. 1.4 Volume 2 – Figures
5. Water NSW
    - Using MUSIC in Sydney Drinking Catchment

APPENDIX A

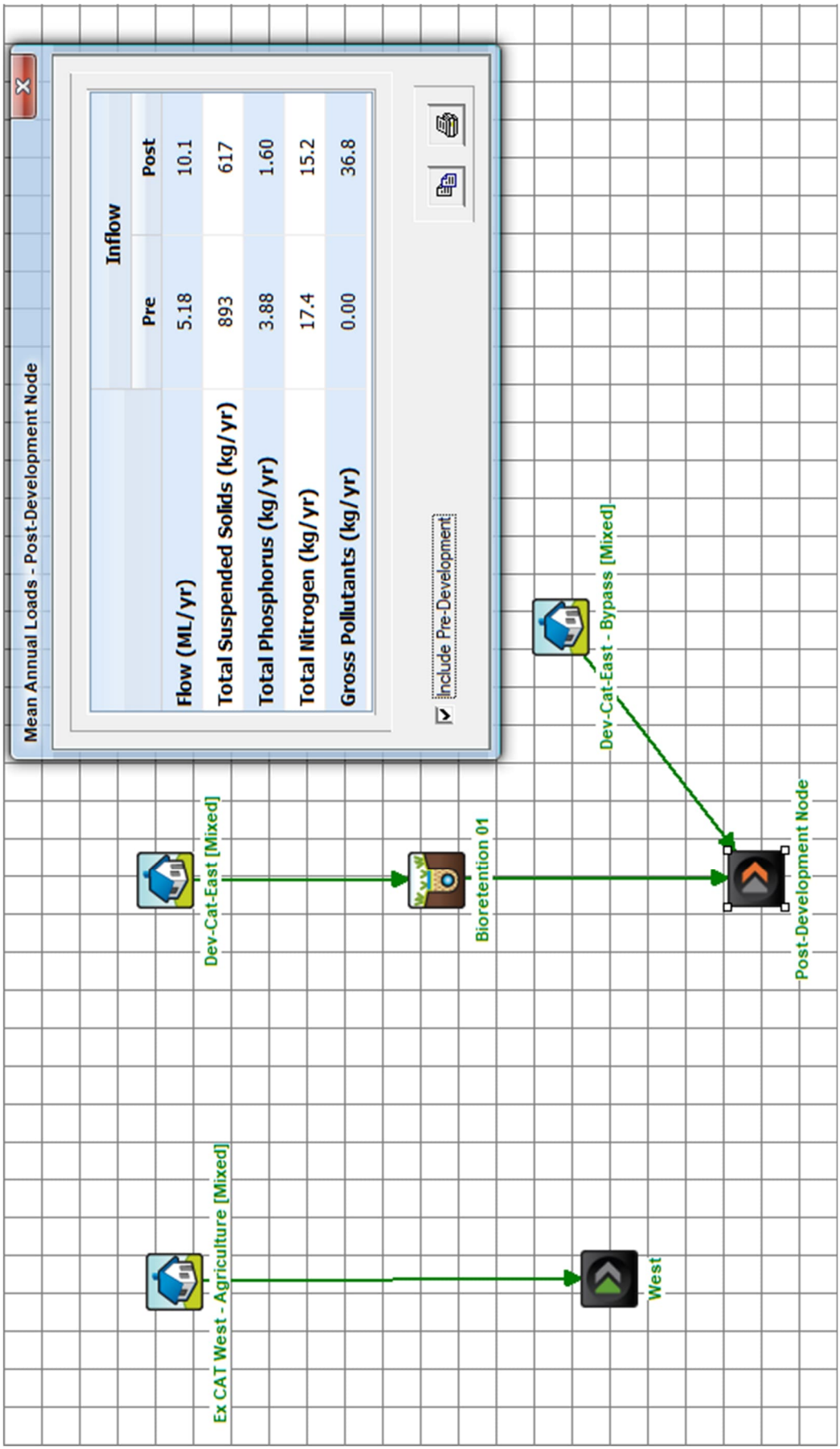
AR&R 2016 Rainfall Depths (IFD)

Copyright Commonwealth of Australia 2016 Bureau of Meteorology (ABN 92 637 533 532)								
IFD Design Rainfall Depth (mm)								
Issued:	25-Sep-17							
Location								
Requeste	Latitude	33.50663	Longitude	150.1256				
Nearest g	Latitude	33.5125(S)	Longitude	150.1375(E)				
		Annual Exceedance Probability (AEP)						
Duration	Duration in	63.20%	50%#	20%*	10%	5%	2%	1%
1 min	1	1.79	2.01	2.7	3.19	3.68	4.35	4.87
2 min	2	2.92	3.25	4.33	5.1	5.85	6.82	7.61
3 min	3	4.07	4.53	6.04	7.12	8.17	9.55	10.7
4 min	4	5.12	5.72	7.65	9.01	10.3	12.1	13.5
5 min	5	6.07	6.79	9.1	10.7	12.3	14.5	16.2
10 min	10	9.63	10.8	14.6	17.2	19.9	23.5	26.4
15 min	15	12	13.4	18.1	21.4	24.8	29.4	33
30 min	30	16	18	24.2	28.7	33.1	39.2	44.1
1 hour	60	20.3	22.6	30.2	35.7	41.1	48.5	54.4
2 hour	120	25.2	28	37.1	43.6	50	58.8	65.8
3 hour	180	28.8	32	42.3	49.5	56.7	66.5	74.4
6 hour	360	37	41.2	54.5	63.8	73.1	85.8	95.7
12 hour	720	48.9	54.7	73.4	86.4	99.6	117	131
24 hour	1440	64.9	73.3	101	120	141	166	186
48 hour	2880	83.8	95.2	134	164	195	231	259
72 hour	4320	94.8	108	153	189	227	270	302
96 hour	5760	102	116	165	204	246	292	327
120 hour	7200	107	122	172	212	256	304	341
144 hour	8640	111	126	176	215	260	309	346
168 hour	10080	114	129	179	216	260	310	346

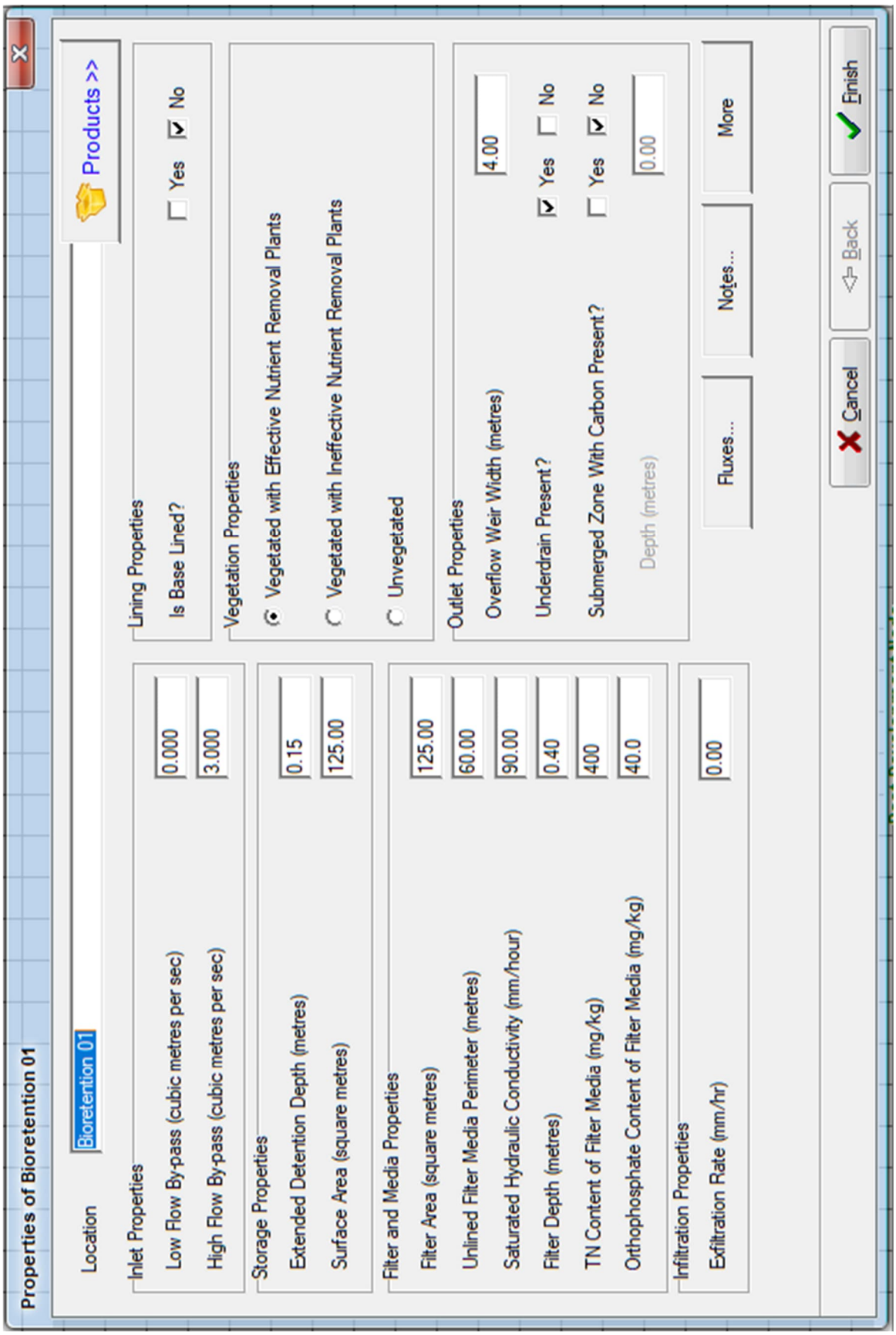
APPENDIX B

Stormwater Quality Treatment Trains

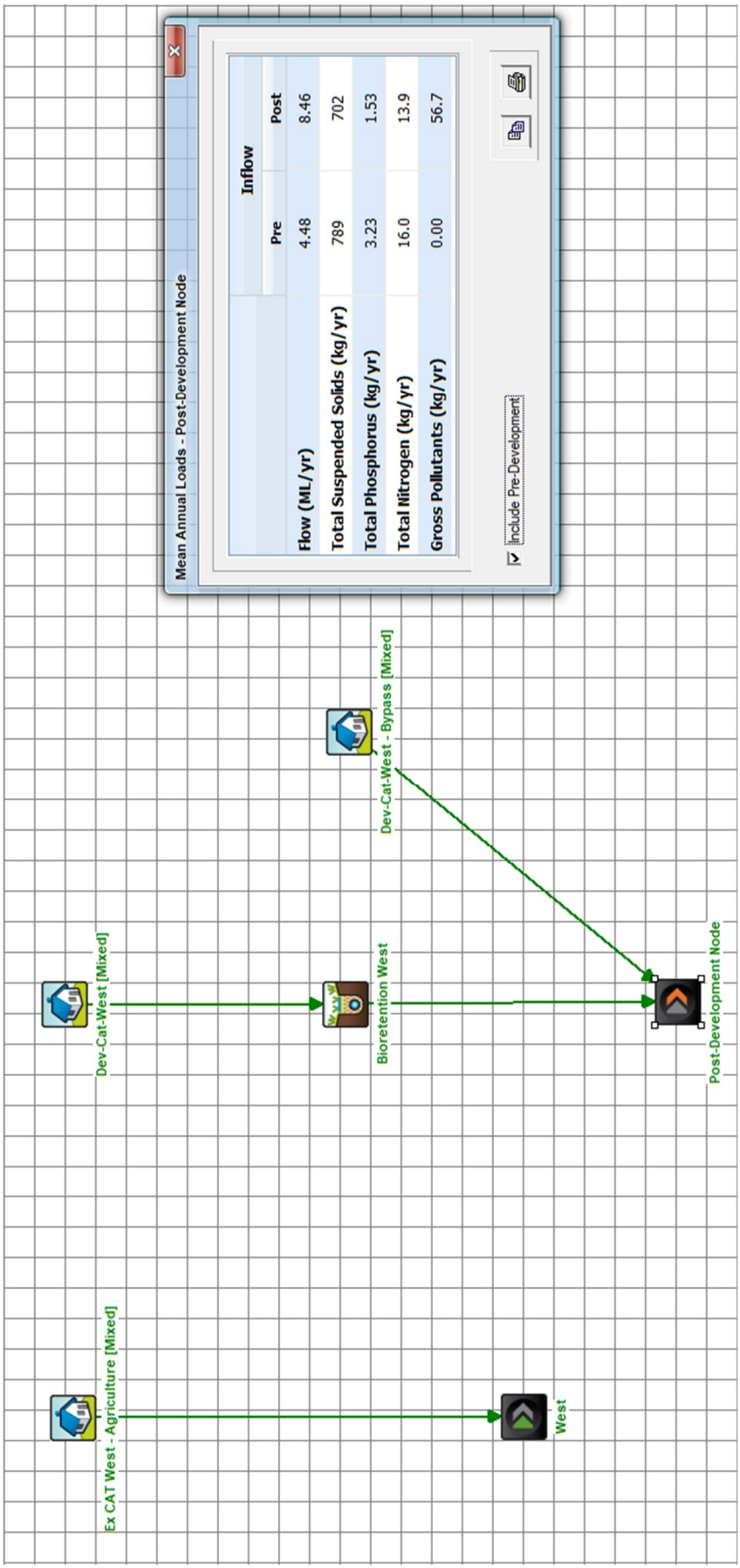
Eastern Catchment



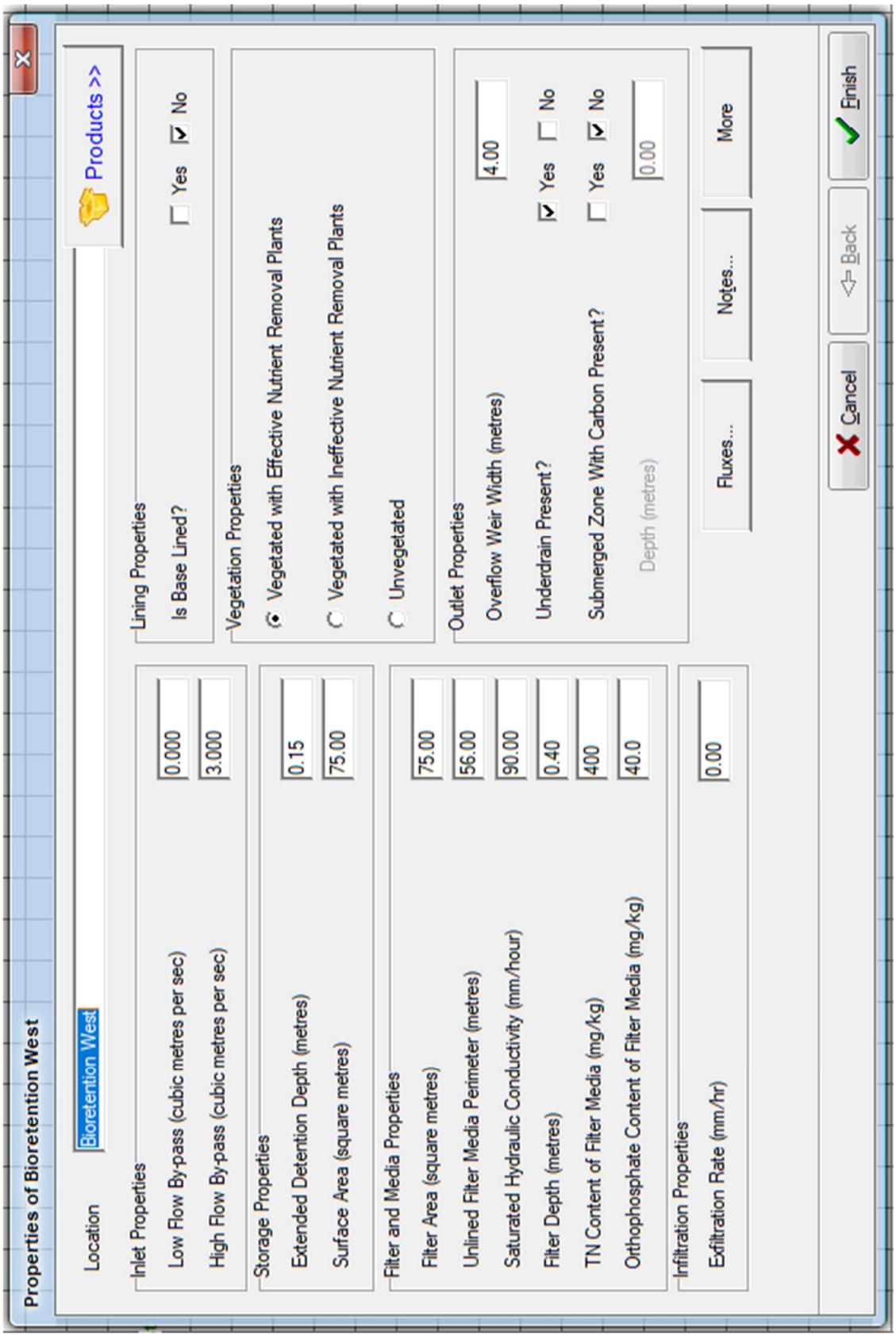
Eastern Basin Details



Western Catchment



Western Basin Details



APPENDIX C

Stormwater Quality Monitoring Program

STORMWATER MANAGEMENT PLAN

Water Quality Management – Operational Phase

Issue:	Water Quality Management – Operational Phase
Operational Policy:	To provide a concise plan to ensure that the water quality in the waterways remain at an acceptable level as specified in the water quality objectives (WQO) for the site at all times and to ensure that any water discharged from the site is of an acceptable quality.
Performance Criteria:	Water discharges off the site should be of a quality, which ensures there is no detriment to the downstream environment. The quality of discharge from the site should achieve the following long term WQO's: Release Criteria $ pH – 6.5-8.0. (range). $ Dissolved Oxygen -80 – 105% (range). $ Total P – 0.07mg/L. (median). $ Total N – 0.65mg/L (median). $ Turbidity-20NTU (median). $ Suspended Solids - <15mg/L (median). $ Faecal Coliforms – <1000/organisms/100mL. $ Litter/Gross Pollutants – No man made materials >5mm in any dimension. WQO's are upper limits for median values or ranges in which medians should lie, unless otherwise stated
Responsibility:	Lithgow City Council
Implementation Strategy:	A comprehensive conceptual stormwater runoff management system is proposed for the development, comprising local runoff water quality control. Local catchment runoff water quality control is achieved by: $ Bio-Retention Basins

Implementation Strategy (Cont'd):	These controls will:
	
	$ trap trash;
	$ trap coarse sediment and attached nutrients and heavy metals;
	$ remove nutrients;
	$ contain surfactants
	
	Periodical monitoring of erosion or sediment deposition within treatment devices.
	
	Periodic maintenance of vegetation within the treatment devices.

Monitoring:	Inspect outflow points from the stormwater outlets and

	treatment trains to ensure that there are no signs of erosive activity or significant sediment deposits. Monitoring shall include inspection of all treatment devices to ensure they are operating efficiently. During the first year of the operational phase of the development water quality monitoring shall include 2 event samplings. The parameters tested shall include: $ Surface Waters: Event Based Monitoring Parameters: temperature, dissolved oxygen, pH, specific conductance, salinity, turbidity, suspended solids, total nitrogen, total phosphorous and faecal coliforms. Note that additional water quality monitoring may be required if the WQO's are not being met.
Auditing & Reporting:	Reviews are to be carried out on a quarterly basis to assess the implementation strategy. A checklist is to be completed which assesses the strategy against each of the monitoring points above. A combined completed checklist for each quarter is to be provided to the relevant authority within Council on an annual basis and is to include any remediation measures implemented including description of measure, dated rectified/implemented and by whom.

Issue:	Water Quality Management – Operational Phase
Identification of Incident or Failure:	Non-compliance with agreed performance criteria will be identified by: 1. Visual inspections identifying: $ Build-up of sediment & litter on and off the site. $ Excessive erosion on the site. $ Release of construction material from the site. $ Lack of vegetation establishment. 2. Poorly maintained, damaged or failed control devices. 3. Deteriorated water quality identified by the Environmental Consultant as being attributable to the site operations.
Corrective Action:	Harvesting of vegetation within the vegetated buffer & swales and re-establishment if vegetation is not healthy. If vegetation fails, new vegetation should be planted and established. Vegetation may require supplementary watering and replanting. If erosion occurs, fill, vegetated and/or install velocity dissipation. To be in accordance with the Institute of Engineers Erosion and Sediment Control Guidelines. If litter escapes from the site, clean up and inspect GPT operation. If poor water quality continues to occur, inspect all treatment techniques, revise designs and review different alternatives and install.
Reporting:	A Water Quality Report for all water quality monitoring results and assessments (as required) shall be maintained, following a monitoring campaign for up to 2 years after construction phase.

APPENDIX D

Maintenance Program

MAINTENANCE REQUIREMENTS FOR BIOFILTRATION SYSTEMS

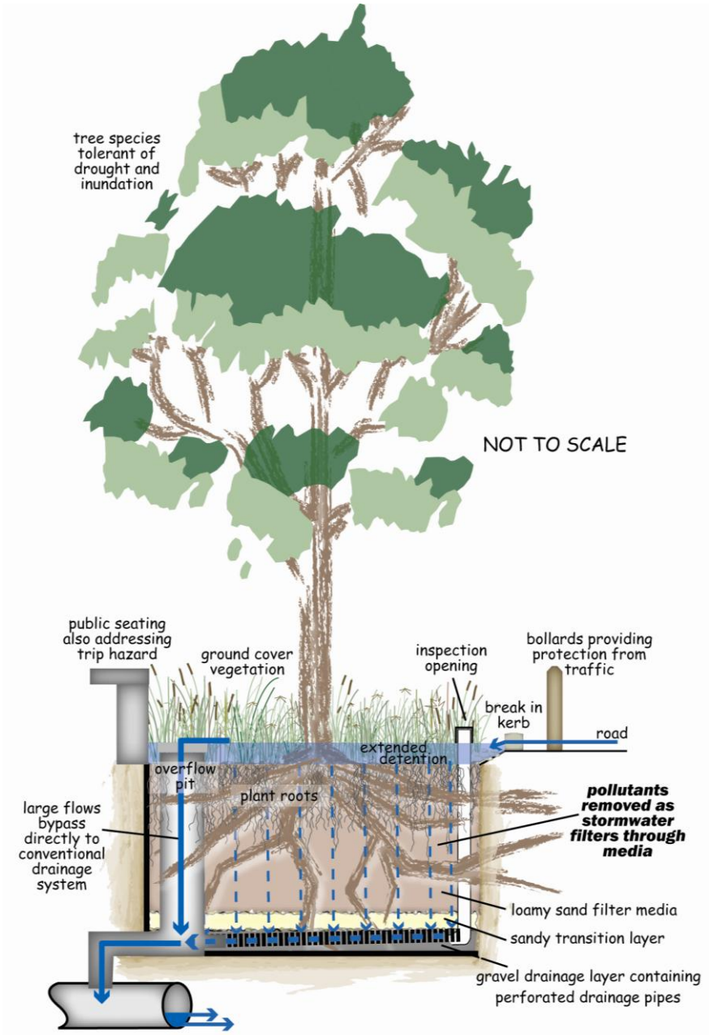


Figure 1. Conceptual drawing of a biofiltration system illustrating stormwater flow pathways and subsurface infrastructure.

Biofiltration systems (also known as biofilters, bioretention systems and rain gardens) are designed with the primary intent of removing pollutants from stormwater before the water is discharged to the local waterway or reused for other applications (e.g. irrigation). They are typically constructed as basins, trenches or tree pits (Figure 1). Stormwater runoff generally enters the biofiltration system through a break in a standard road kerb where it temporarily ponds on the surface before slowly filtering through the soil media. Treated stormwater is then collected at the base of the biofiltration system via perforated pipes located within a gravel drainage layer before being discharged to conventional stormwater pipes or collected for reuse. Note that, in some cases, the drainage pipe is upturned to create a permanent pool of water, or submerged zone, in the bottom of the biofiltration system. Conventional stormwater pipes also act as an overflow in most designs, taking flows that exceed the design capacity of the biofiltration system.

There are a number of maintenance activities that need to be carried out to ensure effective long-term function of biofiltration systems. Table 1 provides example illustrations of maintenance issues while Table 2 outlines inspection tasks, recommended frequencies and associated maintenance actions.

Table 1. Examples of issues requiring maintenance.

Build-up of fine sediments on the surface of the filter media reduces surface porosity and treatment capacity.		Holes, erosion and scour should be repaired and inflow controls provided or augmented.	
Anthropogenic and organic litter build-up is unsightly and can hinder flow paths and infiltration.		Anthropogenic and organic litter build-up is unsightly and can hinder flow paths and infiltration.	
Poor plant growth can be a sign of too much or too little water, or of poor filter function.		Vegetation die off can be a sign of too much or too little water, or of poor filter function.	
Weeds are unsightly and can reduce treatment capacity.		Blocked overflow grates can result in nuisance flooding.	
Overfilling of filters reduces the extended detention storage and treatment capacity.		Overflow levels that are set too low reduces the extended detention storage and treatment capacity.	

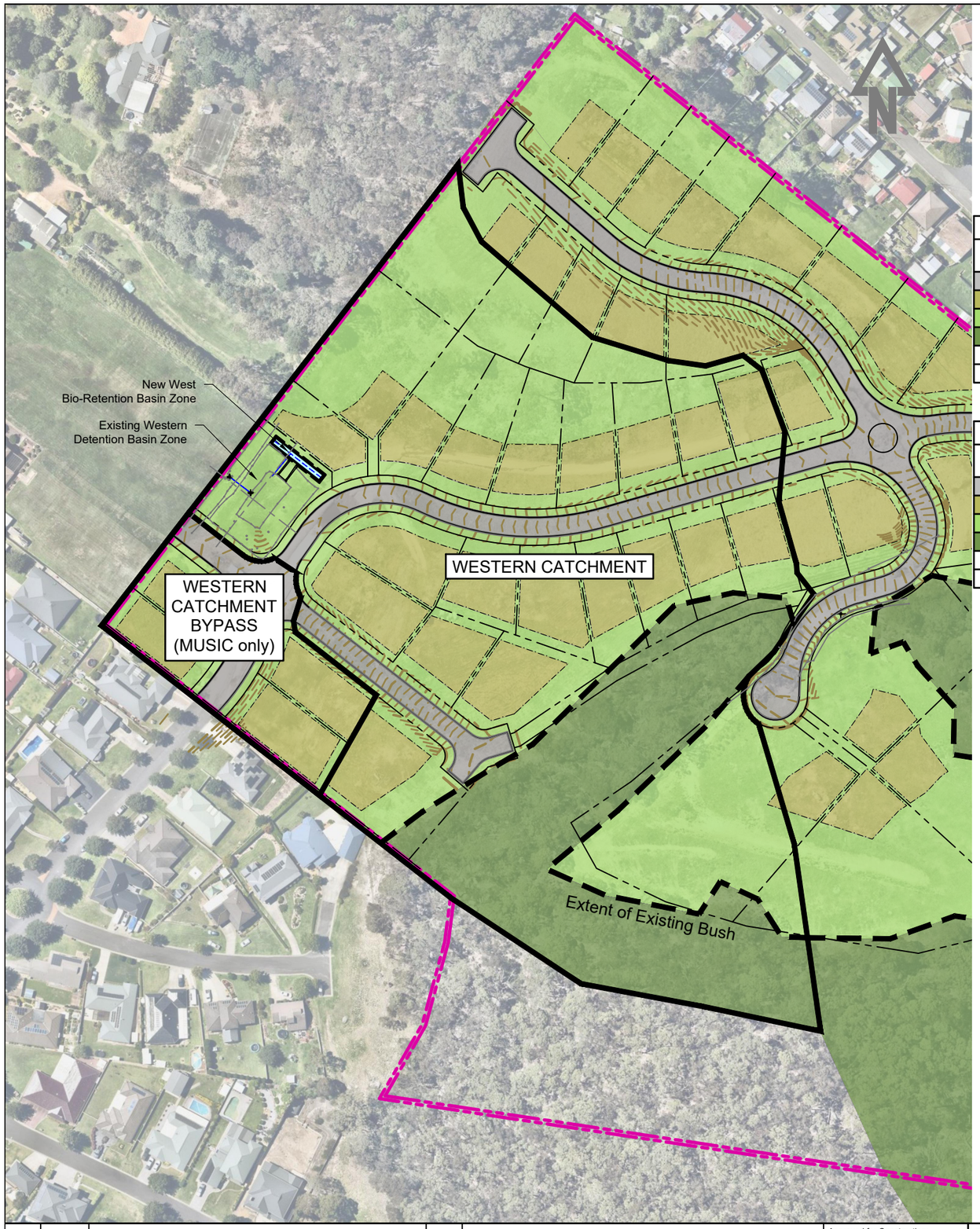
MAINTENANCE REQUIREMENTS FOR BIOFILTRATION SYSTEMS

Table 2. Inspection and maintenance tasks for biofiltration systems.

Inspection Task	Frequency	Comment	Maintenance Action
FILTER MEDIA			
Check for sediment deposition	3 monthly, after rain	Blocking of inlets and filter media reduces treatment capacity.	• Remove sediment from inlets, forebays and other pre-treatment measures, and the surface of biofiltration street trees
Check for holes, erosion or scour	3 monthly, after rain	Holes, erosion and scour can be a sign of excessive inflow velocities due to poor inflow control or inadequate provision for bypass of high flows.	• Infill any holes, repair erosion and scour • Provide/augment energy dissipation (e.g. rocks and pebbles at inlet) • Reconfigure inlet to bypass high flows • Relocate inlet
Inspect for the build-up of oily or clayey sediment on the surface of the filter media	3 monthly, after rain	Reduced surface porosity reduces treatment capacity.	• Clear away any mulch on the surface and lightly rake over the surface of the filter media between plants
Check for litter in and around treatment areas	3 monthly, after rain	Flow paths and infiltration through the filter media may be hindered.	• Remove both organic and anthropogenic litter
HORTICULTURAL			
Assess plants for disease or pest infection	3 monthly, or as desired for aesthetics		• Treat or replace as necessary
Check plants for signs of stunted growth or die off	3 monthly, or as desired for aesthetics	Poor plant health can be a sign of too much or too little water, or poor flow control.	• Check inlet and overflow levels are correct and reset as required For too much water: • Replace plants with species more tolerant of wet conditions OR • Replace filter media with that of a higher infiltration capacity For too little water: • Consider installing a choke on the outlet OR • Replant with species more tolerant of dry conditions
Check that original plant densities are maintained	3 monthly, or as desired for aesthetics	Plants are essential for pollutant removal and maintaining drainage capacity. Plants should be close enough that their roots touch each other; 6 – 10 plants/m^2 is generally adequate. A high plant density also helps prevent ingress of weeds.	• Carry out infill planting as required – plants should be evenly spaced to help prevent scouring due to a concentration of flow
Check for presence of weeds	3 monthly, or as desired for aesthetics	Weeds can reduce aesthetics and treatment capacity because some plants are more effective at pollutant removal than others.	• Manually remove weeds where possible – where this is not feasible, spot spray weeds with a herbicide appropriate for use near waterways
DRAINAGE			
Check that underdrain is not blocked with sediment or roots	6 monthly, after rain	Filter media and plants can become waterlogged if the underdrain is choked or blocked. Remote camera (CCTV) inspection of pipelines could be useful.	• Clear underdrain as required using a pipe snake or water jet • Water jets should be used with care in perforated pipes
Check that the water level in the submerged zone (if applicable) is at the design level	6 monthly, after rain	Drawdown during dry periods is expected.	• Check outflow level is correct and reset as required
Check that inflow areas, weirs and grates over pits are clear of litter and debris and in good and safe condition.	Monthly, and occasionally after rain	A blocked grate or inlet would cause nuisance flooding.	• Replace dislodged or damaged pit covers as required • Remove sediment from pits and entry sites (likely to be an irregular occurrence in mature catchments)
OTHER			
Observe biofiltration system after a rainfall event to check drainage	Twice a year, after rain	Ponding on the filter media surface for more than a few hours after rain is a sign of poor drainage	• Check catchment land use and assess whether it has altered from design capacity (e.g. unusually high sediment loads may require installation of a sediment forebay)

FIGURES

Western Stormwater Treatment Catchment Plan	2020.0047-C01
Eastern Stormwater Treatment Catchment Plan	2020.0047-C02
Western Stormwater Treatment Details	2020.0047-C03
Eastern Stormwater Treatment Details	2020.0047-C04
Bio-Retention Basin Details	2020.0047-C05



MUSIC CATCHMENTS

Western Catchment					
Catchment	Area (Ha)	fi	Effective Impervious Area (Ha)	Water NSW ***xTIA	Eq Impervious Area (Ha)
Road	0.299	1.000	0.299	1.00	0.299
Building Envelopes	1.208	0.400	0.483	0.55	0.266
Grassland	0.000	0	0.000	0.00	0.000
Bush	0.000	0	0.000	0.00	0.000
Total Area	1.507		0.782	0.375	0.565

Western Catchment Bypass					
Catchment	Area	fi	Effective Impervious Area (Ha)	Water NSW ***xTIA	Eq Impervious Area (Ha)
Road	0.147	1.000	0.147	1.00	0.147
Building Envelopes	0.270	0.400	0.108	0.55	0.059
Grassland	0.000	0	0.000	0.00	0.000
Bush	0.000	0	0.000	0.00	0.000
Total Area	0.417		0.255	0.495	0.206

WATERCOM DRAINS CATCHMENTS

Western Catchment - Existing			
Catchment	Area	fi	Effective Impervious Area (Ha)
Road	0.000	1.000	0.000
Building Envelopes	0.000	0.400	0.000
Grassland	4.134	0	0.000
Bush	1.319	0	0.000
Total Area	5.453		0.000

Western Catchment - Developed			
Catchment	Area (Ha)	fi	Effective Impervious Area (Ha)
Road	0.444	1.000	0.444
Building Envelopes	1.478	0.400	0.591
Grassland	2.212	0	0.000
Bush	1.319	0	0.000
Total Area	5.453	0.190	1.035

Amend	Date	Description	By
E	10/07/24	Redesigned based on proposed subdivision	GBL

FOR APPROVAL

Approved for Construction:

Garth Dean
B.E. GDSTT FIEAust CPEng NER APEC Engineer IntPE (Aus) RBP (Vic/NT)

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Lot 1 DP933666
14 CLARET ASH AVENUE
SOUTH BOWENFELS

WESTERN STORMWATER TREATMENT CATCHMENT PLAN

LEDGER ENTERPRISES PTY LTD

CALARE CIVIL CONSULTING ENGINEERS
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Job No. 2020.0047
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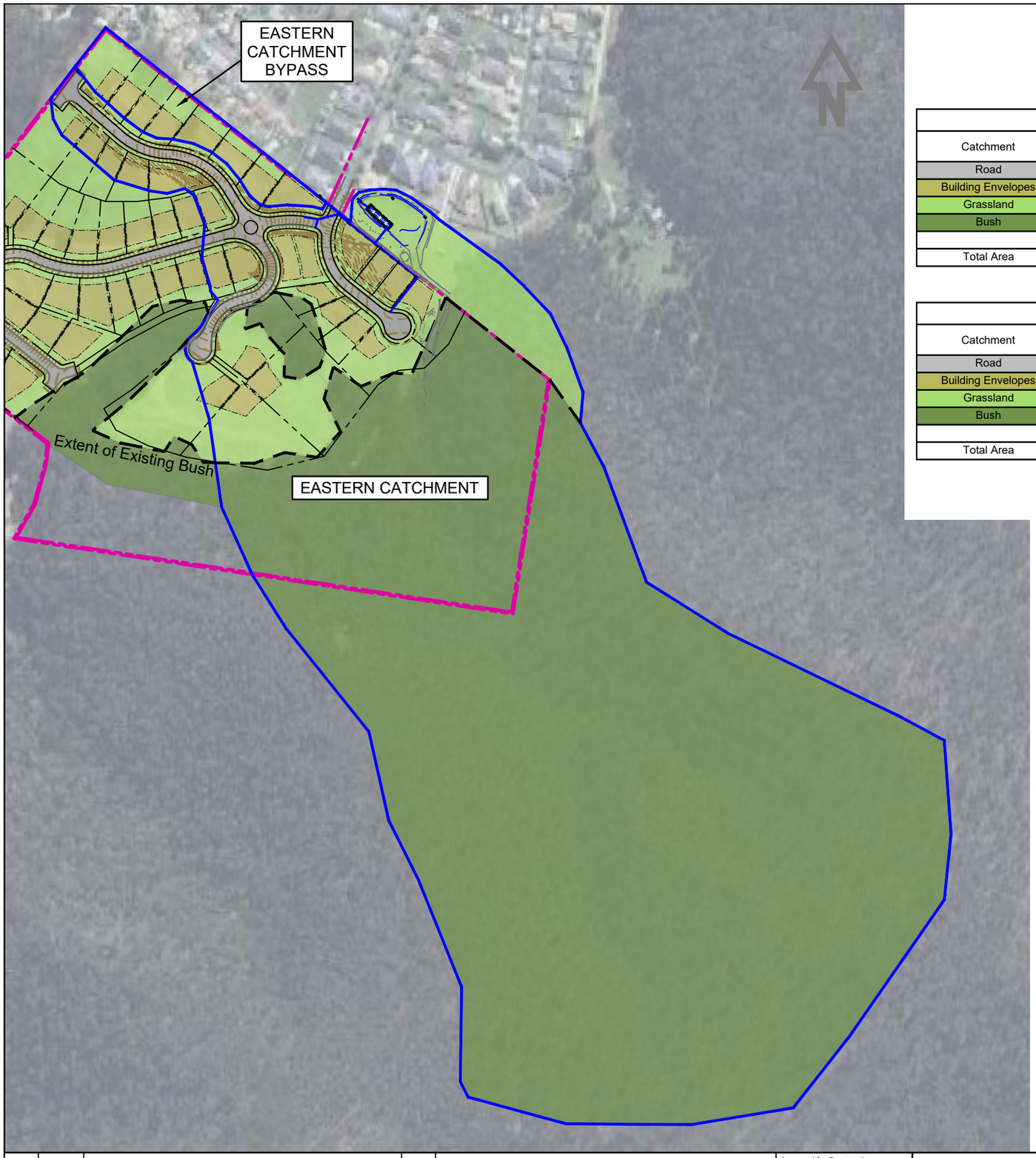

MUSIC CATCHMENTS

Eastern Catchment					
Catchment	Area	fi	Effective Impervious Area (Ha)	Water NSW ***xTIA	Eq Impervious Area (Ha)
Road	0.620	1.000	0.620	1.00	0.620
Building Envelopes	1.120	0.400	0.448	0.55	0.246
Grassland	0.000	0	0.000	0.00	0.000
Bush	0.000	0	0.000	0.00	0.000
Total Area	1.740		1.068	0.498	0.866

Eastern Catchment Bypass					
Catchment	Area	fi	Effective Impervious Area (Ha)	Water NSW ***xTIA	Eq Impervious Area (Ha)
Road	0.000	1.000	0.000	1.00	0.000
Building Envelopes	0.461	0.400	0.184	0.55	0.101
Grassland	0.000	0	0.000	0.00	0.000
Bush	0.000	0	0.000	0.00	0.000
Total Area	0.461		0.184	0.220	0.101

WATERCOM DRAINS CATCHMENTS

Eastern Catchment - Existing			
Catchment	Area	fi	Effective Impervious Area (Ha)
Road	0.000	1.000	0.000
Building Envelopes	0.000	0.400	0.000
Grassland	6.159	0	0.000
Bush	25.398	0	0.000
Total Area	31.557	0.000	0.000

Eastern Catchment - Developed			
Catchment	Area	fi	Effective Impervious Area (Ha)
Road	0.620	1.000	0.620
Building Envelopes	1.120	0.400	0.448
Grassland	3.477	0	0.000
Bush	25.398	0	0.000
Total Area	30.615	0.035	1.068

Eastern Catchment Developed - Bypass			
Catchment	Area	fi	Effective Impervious Area (Ha)
Road	0.000	1.000	0.000
Building Envelopes	0.461	0.400	0.184
Grassland	0.481	0	0.000
Bush	0.000	0	0.000
Total Area	0.942	0.196	0.184

Amend	Date	Description	By
E	10/07/24	Redesigned based on proposed subdivision	GBL

FOR APPROVAL

Approved for Construction:

Garth Dean
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14 CLARET ASH AVENUE
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EASTERN STORMWATER TREATMENT CATCHMENT PLAN

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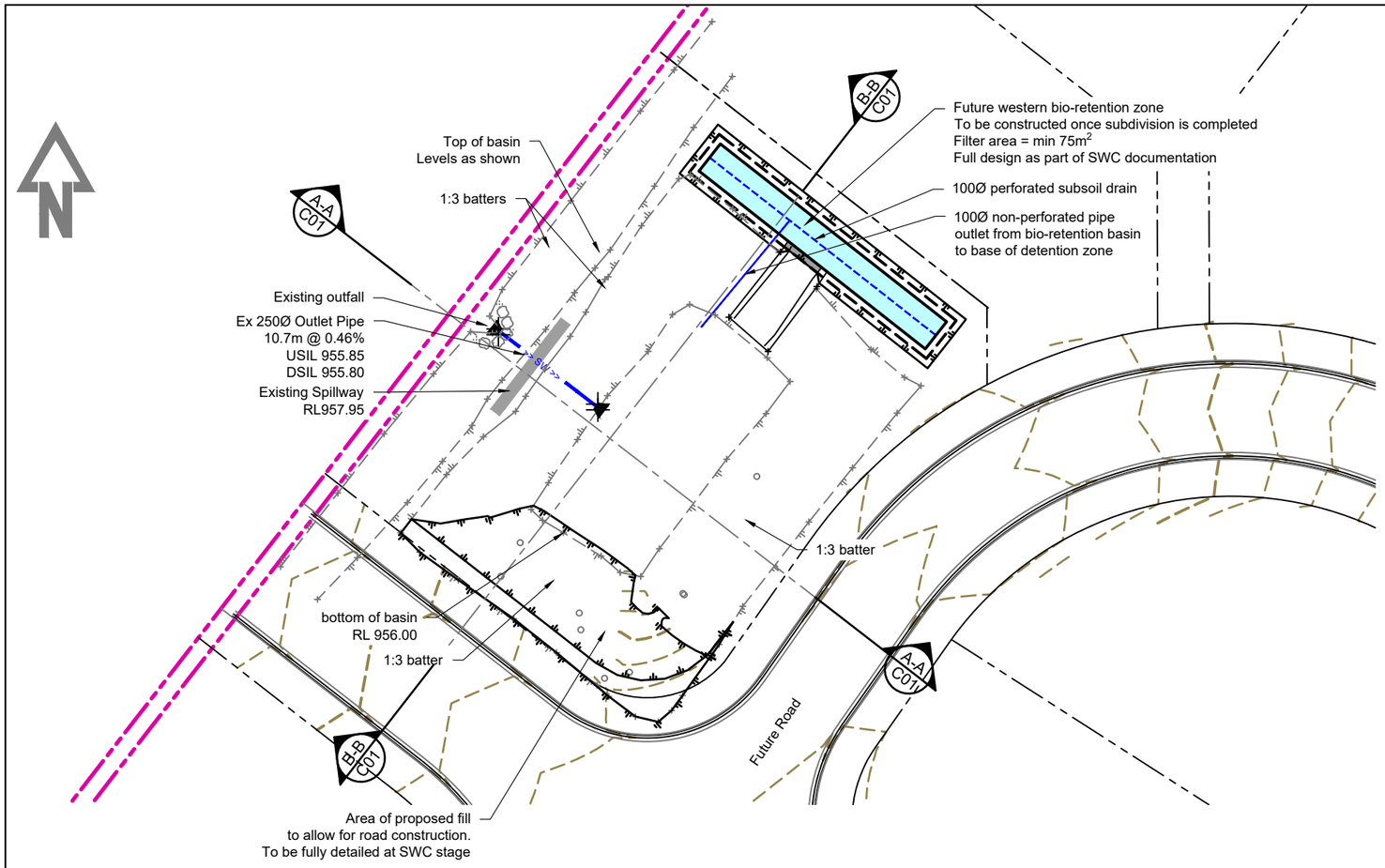

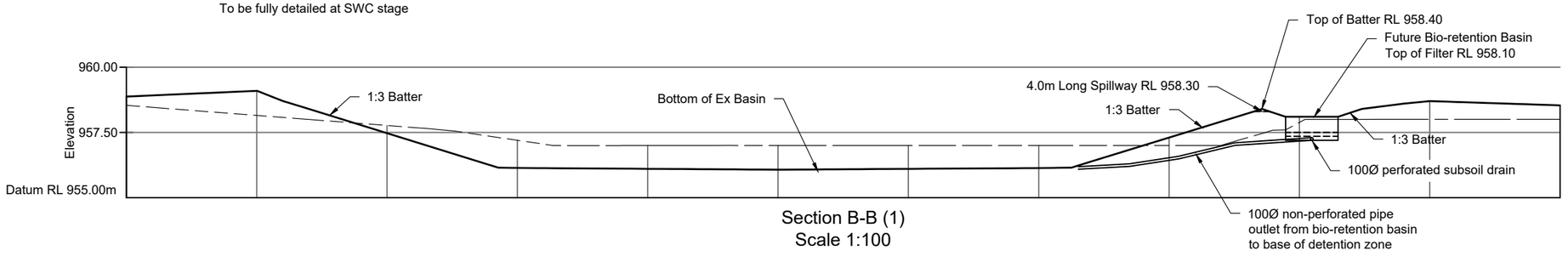

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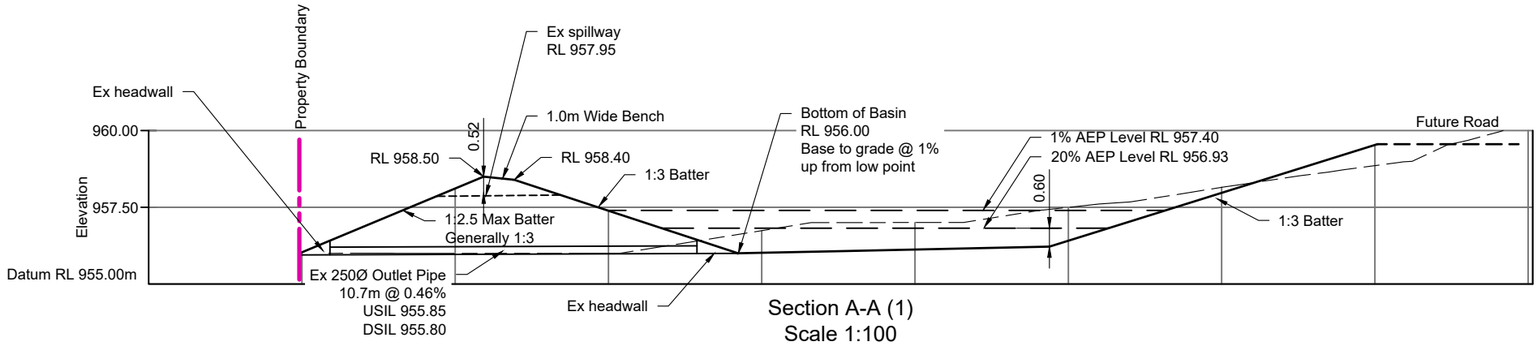

Section A-A (1)
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Notes

1. Detention basin shape can alter to suit final desired earthworks, total base area and wall depth/slope is to be preserved.
2. All levels if altered are to remain relative to each other.
3. Bio-retention basin is not to be constructed until all subdivision works have been undertaken and the remaining pervious areas have been stabilised. Basin can be constructed prior to individual lot development.

Amend	Date	Description	By
E	10/07/24	Redesigned based on proposed subdivision	GBL

FOR APPROVAL

Approved for Construction:

Garth Dean
B.E. GDSTT FIEAust CPEng NER APEC Engineer IntPE (Aus) RBP (Vic/NT)

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Lot 1 DP933666
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WESTERN STORMWATER TREATMENT DETAILS

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DWG. No. C03
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Ex Pit
SL 960.15
IL 957.90

Ex 2x750Ø

MUNBINGA ROAD

Ex Pit
SL 961.80
IL 959.65

Existing 2x900Ø

Existing Low point
RL 963.70 12m wide

Extent of 5% AEP detention level
Based on 3.5% impervious for developed scenario
RL 962.56
Max depth 260mm

Ex 1500Ø

Ex Pit
SL 962.35
IL 960.95

Extent of 1% AEP detention level
Based on 3.5% impervious for developed scenario
RL 962.85
Max Depth 550mm
Freeboard = 850mm to low point
Total Volume = 612.80m^3

Ex Pit
SL 963.50
IL 960.55

Ex 375Ø

Ex Pit
SL 962.30
IL 961.14

Ex 375Ø

Ex 375Ø

Ex 375Ø

Outlet pipe to ex detention outlet
to be sized in conjunction
with SWC design plans

overflow spillway to be 150mm
above top of pit level

Future eastern bio-retention zone
To be constructed once subdivision
is completed
Filter area = min 125m^2
Full design as part of SWC documentation

Top of existing basin wall

100Ø perforated subsoil drain

Ex Pit
SL 962.45
IL 961.46

Provide 0.50m high bund along
bio-retention basin to protect
from external high velocity flows

Base of detention basin

Piped network to capture all
of the eastern catchment
with the exception of the
nominated bypass catchment
Locations indicative only
to be confirmed with
SWC documentation

Ex 1:4 batter

Inlet pipe
to be sized in conjunction
with SWC design plans

Ex concrete channel capturing
flow from upstream bush area
approximately (25ha)

Piped network to capture all
of the eastern catchment
with the exception of the
nominated bypass catchment
Locations indicative only
to be confirmed with SWC documentation

Amend	Date	Description	By
E	10/07/24	Redesigned based on proposed subdivision	GBL

FOR APPROVAL

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APEC Engineer IntPE (Aus) RBP
(Vic/NT)

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EASTERN STORMWATER TREATMENT DETAILS

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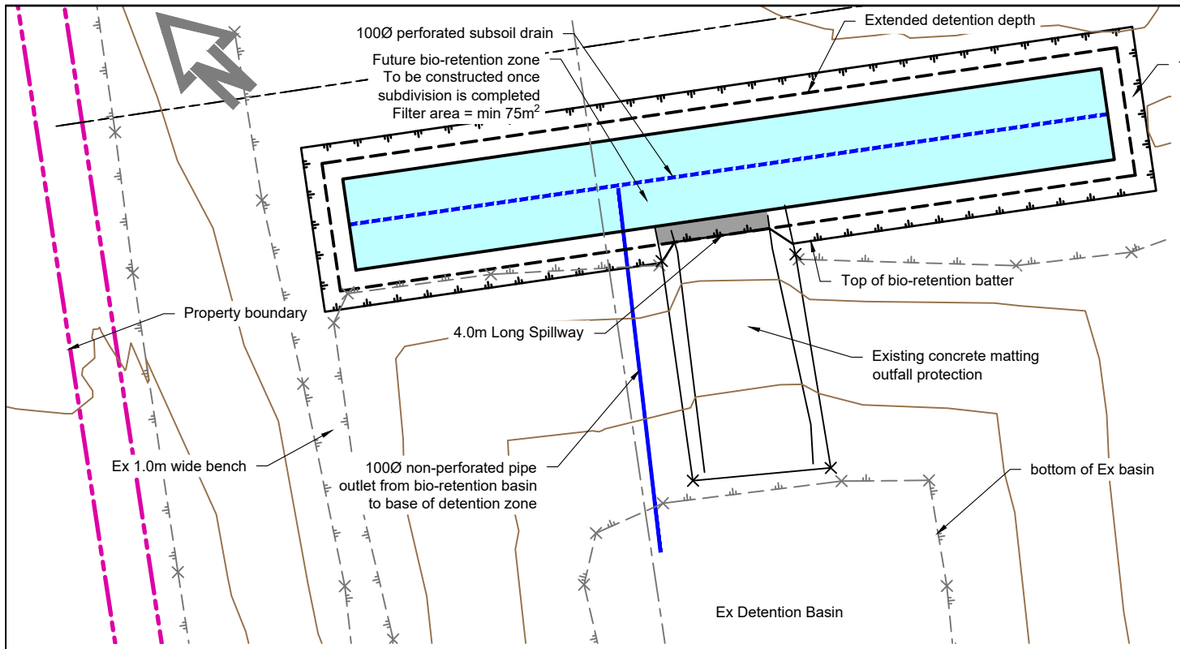
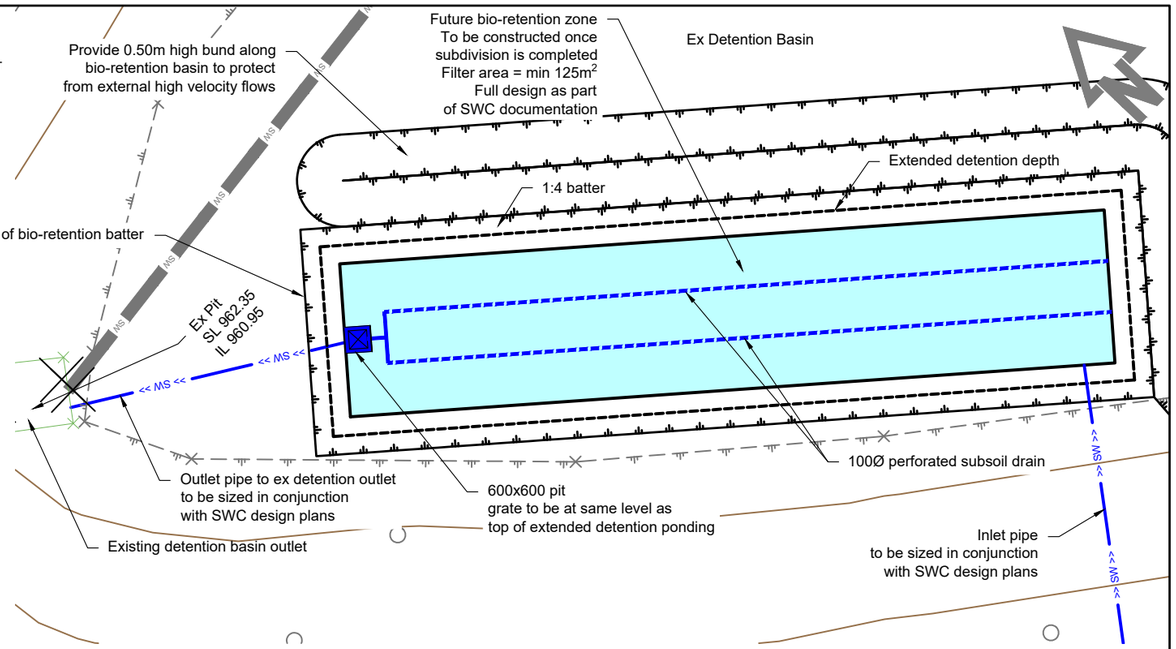


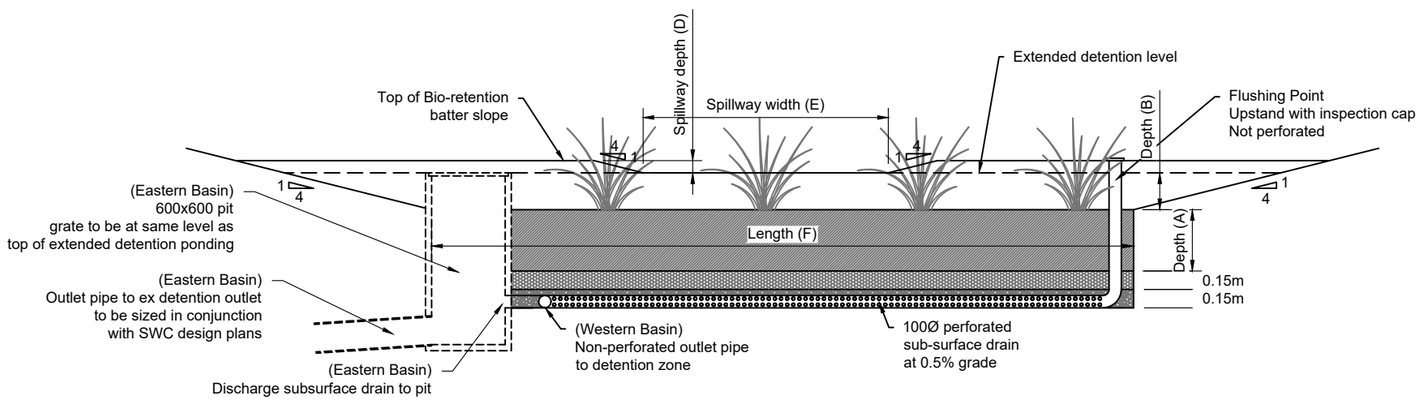
Western Bio-Retention Basin Plan View

Scale 1:100



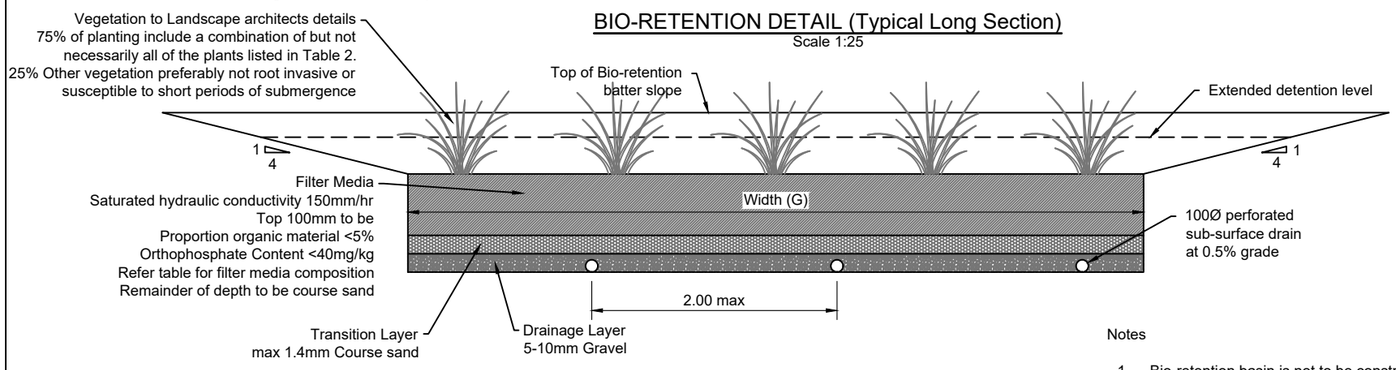
Eastern Bio-Retention Basin Plan View

Scale 1:100



BIO-RETENTION DETAIL (Typical Long Section)

Scale 1:25



BIO-RETENTION DETAIL (Typical Cross Section)

Scale 1:25

Table 1	
Name	Quantity (kg/100m2 filter area)
Granulated poultry manure fines	50
Superphosphate	2
Magnesium sulphate	3
Potassium sulphate	2
Trace element mix	1
Fertiliser NPK (16.4.14)	4
Lime	20
Total	82

Table 2
Plant name Listed in order of preference
Carex appressa
Melaleuca ericifolia
Goodenia ovata
Ficinia nodosa
Juncus amabilis
Juncus flavidus
For bio-retention swale use suitable deep rooting heavy mat grass eg. buffalo grass or Kasbah Cocksfoot- refer to local turf specialist recommendations

Filter Media

Structural Stability

Dispensability testing should be done if soil may be structurally unstable

Engineered filter media

Washed sand with appropriate Ks
Top 100mm should be ameliorated with organic material, fertiliser and trace elements as detailed in Table 1

Table 3							
Bioretention Area Name	A	B	C	D	E	Length F	Width G
Western Bio-Retention Basin	0.40m	0.15m	-	0.15m	4.0m	25.0m	3.0m
Eastern Bio-Retention Basin	0.40m	0.15m	-	0.15m	4.0m	25.0m	5.0m

Notes

1. Bio-retention basin is not to be constructed until all subdivision works have been undertaken and the remaining pervious areas have been stabilised. Basin can be constructed prior to individual lot development.

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FOR APPROVAL

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Lot 1 DP933666
14 CLARET ASH AVENUE
SOUTH BOWENFELS

BIO-RETENTION BASIN DETAILS

LEDGER ENTERPRISES PTY LTD

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