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PRELIMINARY DOCUMENTATION

ATTACHMENT N STORM CONSULTING 2007 WATER CYCLE MANAGEMENT REPORT

STORM_CONSULTING

Water Cycle Management Report for Proposed Subdivision

Lot 172 DP 755923 and Lot 823 DP 247285 at Berringer Road and Cunjurong Point Road Manyana.

Report Prepared for:

Malbec Properties Pty Ltd

October 2007

Project No. 555

Prepared by:

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Organisation	Name
Allen Price and Associates	Matt Philpott
Department of Environment and Conservation	Craig Jones
Department of Natural Resources	David Zerafa

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1.0 INTRODUCTION

1.1. Background and Context

A 182 Lot subdivision is proposed at Berringer and Cunjurong Point Roads, Manyana. STORM_CONSULTING has been engaged to assess water quality and drainage resulting from the proposed development. This assessment involves addressing the requirements of the Department of Planning (DoP) with respect to environmental impacts on water quality and quantity. In summary, this report provides:

- Assessment of site constraints and opportunities
- Assessment of the proposed development layout
- Summary of the predicted or modelled water quality and flow impacts and the effectiveness of the measures proposed to mitigate the impacts
- Conclusions and recommendations for the subdivision.

The subdivision layout was modified in late August 2007 (layout version H), this report has been amended to incorporate these layout changes consisting of:

- Continuation of EEC area and associated riparian buffer to Berringer Road to provide habitat connectivity
- Increase in buffer size around the EEC area to protect the integrity of the EEC
- Associated reduction in size of the developed area within the catchment of the EEC area

The main impact of these changes in relation to this report is a reduction in impervious area and improved protection of the EEC zone.

1.2. Site locality

The proposed development is located in the northwest of residential Manyana (**Figure 1.1**). The property boundary borders Cunjurong Point Road to the west and Berringer Road to the north. To the south and east the boundary meets existing residential development adjacent to Sunset Strip and The Companionway respectively.

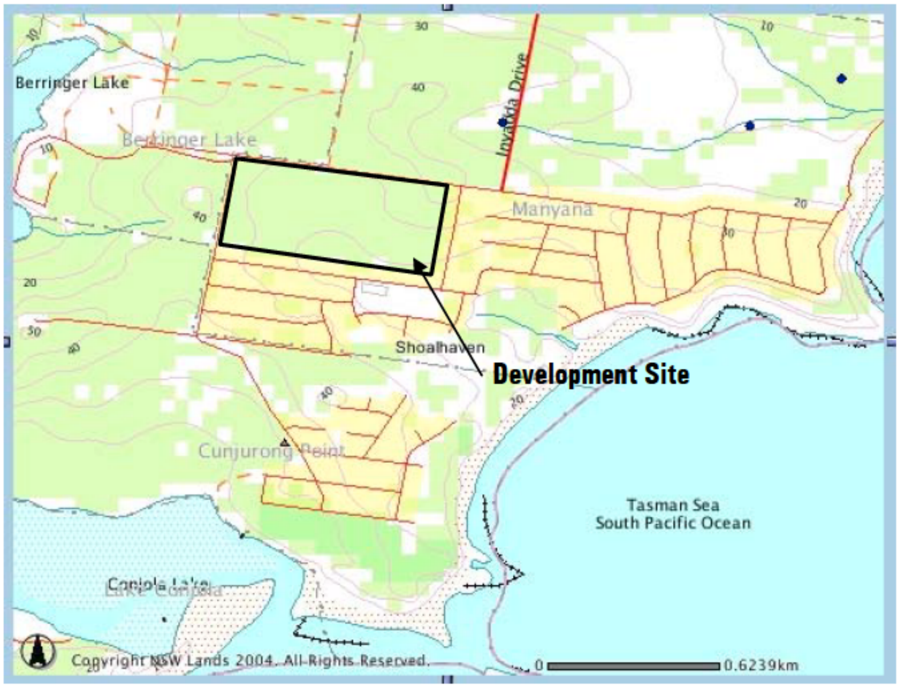


Figure 1.1: Site locality

1.3. Proposed development

It is proposed to subdivide Lot 172 DP 755923 and Lot 823 DP 247285 into a total of182 residential blocks. The proposed road layout servicing the new lots is shown in **Figure 1.2**.

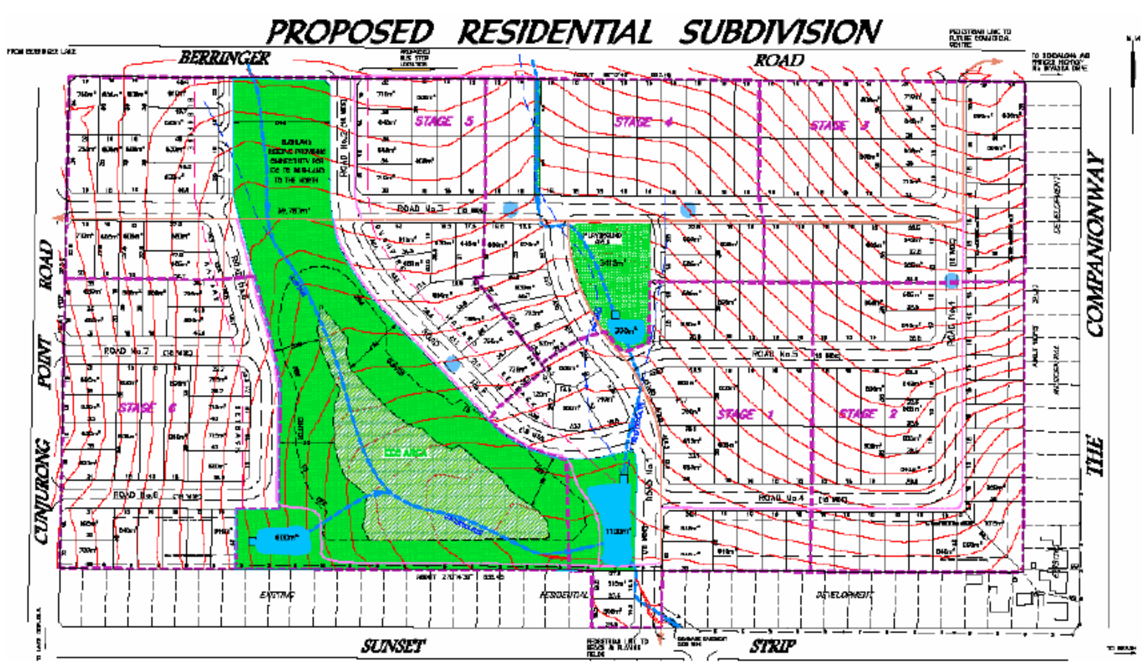


Figure 1.2: Proposed development layout.

1.4. Site Conditions

Topography

The western area of the site has an easterly aspect with the remainder having a southerly aspect. The slope of the site is generally between 5% and 7% (see contours in **Figure 1.2**).

Soils and Geology

The site is generally underlain by clay soils. Sections of lower slopes (near the drainage lines) have more clayey and silty soils, likely to have been washed down from the upper slopes.

Drainage

The proposed development is located at the upper reaches of a 57 Ha catchment which takes in a large portion of the developed portion of Manyana. Approximately 50% of the catchment draining to Manyana Beach is currently developed comprising the residential areas of Manyana.

Two intermittent drainage lines run through the subject property, meeting in the centre of the southern boundary where runoff will ultimately leave the site (**Figure 1.3**). At this location (near the intersection of The Barbette and Sunset Strip) runoff from the site is to be piped to another existing watercourse downstream of Manyana Drive. This creek meanders along the boundary of residential areas and extends to Manyana Beach, which drains to the ocean only after considerable periods of high rainfall (**Figure 1.4**).

The proposed subdivision layout retains the majority of the western drainage line.

Figure 1.3: Modified watercourse at the lower end of the site.

Figure 1.4: Receiving waters (downstream creek and Manyana Beach).

Vegetation

The main vegetation community on the site is sclerophyll forest including large *Eucalyptus* and *Angophora* species. Swamp sclerophyll forest on coastal floodplains has been identified in the lower areas of the western drainage line, this area is classified as an endangered ecological community (EEC) (**Figure 1.5**). The catchment for this drainage line is approximately 15.4 Ha, of which 0.8 Ha is currently road reserve.

Figure 1.5: Typical vegetation and habitat on site.

2.0 PLANNING MATTERS

The development constitutes a "Major Project" covered by Part 3A of the Environmental Planning and Assessment Act (EP&A Act).

The Director General of the Department of Planning has outlined a number of requirements for the proposed development. This report addresses the Director General's requirements for water cycle management for this development:

> *"Impacts on Water Quality and Drainage – Address potential impacts on quality of surface and groundwater; consistency with relevant Statement of Joint Intent established by the Healthy Rivers Commission; demonstrate an acceptable level of water quality protection with respect to Water Quality and River Flow Interim Environmental Objectives.*
>
> *Address Shoalhaven City Council's Integrated Water Cycle Management Plan, Water Sensitive Urban Design and cumulative stormwater runoff impacts from the site on downstream Endangered Ecological Community (EEC) of "Swamp Sclerophyll Forest on Coastal Floodplains".*
>
> *Riparian zones for drainage lines should also be addressed.".*

2.1. Development objectives

A summary of the key qualitative requirements for this development are listed in **Table 2.1.**

Table 2.1: Planning objectives summary

Planning Document	**Relevant Clause**
Statement of joint intent for NSW Coastal Lakes	- Key natural and/or highly valued modified ecosystem processes are rehabilitated and retained.
Clyde River and Jervis Bay water quality objectives	- Protection of aquatic ecosystems (ANZECC trigger value guidelines for phosphorous and nitrogen of 0.035mg/L and 0.25mg/L respectively). - Mimic natural drying in temporary waterways and - Maintain natural flow variability.
The objectives of the Subdivision DCP include:	- Interception and treatment of pollutants through the use of appropriate water quality control measures prior to discharge to receiving waters, including wetlands, lakes and ponds.

In addition to these qualitative objectives, the following Best Management Practice (BMP) objectives have been applied to provide a clear benchmark to assess the performance of the proposed development:

- Neutral Or Beneficial Effect (NORBE) for pollutant load
- 80% reduction in Total Suspended Solids (TSS) load; 45% reduction in Total Phosphorus (TP) and Total Nitrogen (TN) load from the development (Managing Urban Stormwater: Treatment Techniques, 1997)

NORBE refers to the post-development pollutant loads being equal or less than the pre-development pollutant loads. NORBE has been used as the primary objective for the assessment of impacts on the EEC area.

The 80% reduction in suspended solid and 45% reduction in nutrient load from the developed subdivision has been used as the primary objective for the assessment of water quality from the entire development.

Peak flows into the EEC area should be maintained for the 1 in 1 year ARI storm event to prevent erosion and modification to habitat. Peak flows leaving the entire site should not exceed current peak flows from the site to ensure downstream stormwater capacities are not exceeded

2.2. Consultation with Determining Authorities

The Department of Natural Resources (DNR) and the Department of Environment and Conservation (DEC) were contacted to discuss the scope and level of detail required in this assessment as well as the type of mitigation measures and water sensitive design techniques to be applied to the site were also discussed.

2.2.1. Department of Natural Resources

David Zerafa from DNR was consulted about the management of any drainage lines running through the site. DNR have undertaken mapping of a number of catchments along the south coast and have ranked the drainage lines into three categories. Neither of the drainage lines running through the site are recorded in watercourse management mapping undertaken in the area by DNR. However, it was suggested that where possible, the Category 2 objectives should be applied:

- Maintain the viability of native riparian vegetation
- Provide suitable habitat for terrestrial and aquatic fauna
- Protect water quality
- Protect in-stream aquatic vegetation

The majority of the western watercourse running through the site has been retained in order to preserve the EEC and native vegetation within that area meeting the category two objectives for riparian management.

2.2.2. Department of Environment and Conservation

Craig Jones from DEC was consulted to determine what level of reporting is required for the hydrologic modelling on the site, particularly for the EEC area. Concerns were conveyed about the viability of the EEC area due to multiple minor changes to the EEC zone. For example, minor changes to hydrologic regime, solar penetration and water quality.

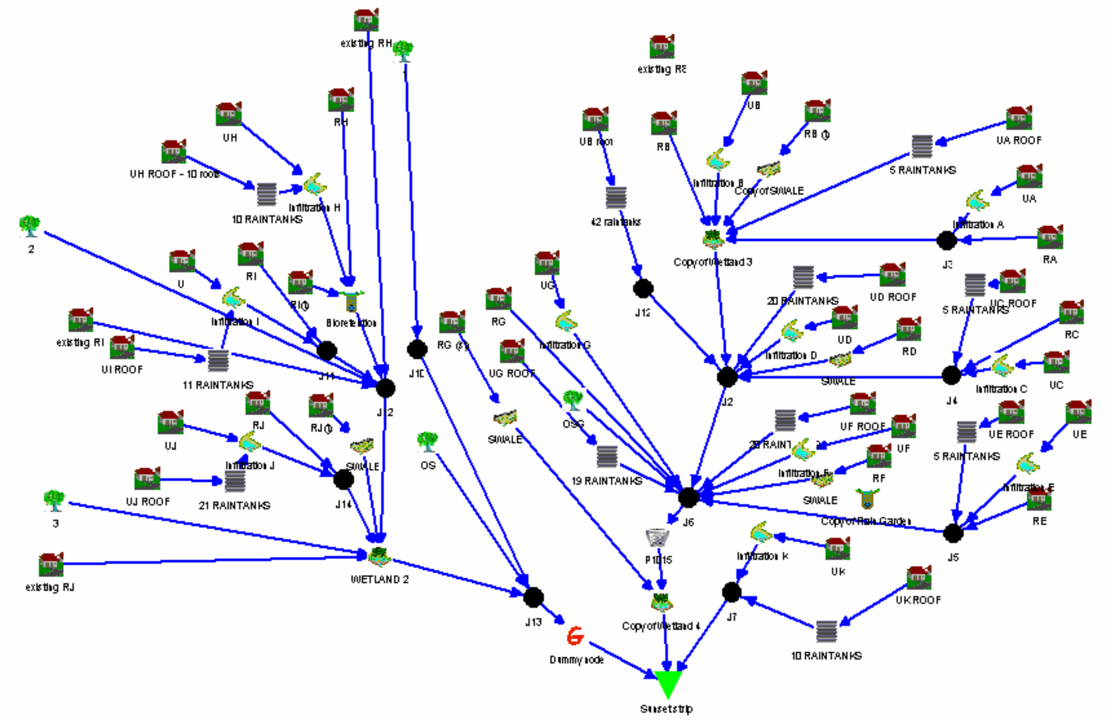
The type of reporting suggested for the hydrologic modelling was, at a minimum, the average annual volume of runoff, as well as pre- and post-development peak flows to demonstrate little or no change from the present hydrologic state.

3.0 WATER CYCLE MANAGEMENT MEASURES

3.1. Background

The traditional approach of the discharge of stormwater runoff from impervious surfaces directly into pits and pipes conveys pollutants directly to receiving waters. The traditional approach also increases the frequency, rate and volume of runoff to receiving waters. The modern approach is to intercept stormwater runoff as close to the source as possible, and then treat and infiltrate the runoff within the urban landscape. This is commonly known as Water Sensitive Urban Design (WSUD). WSUD also encourages the better use of water resources.

A range of water management systems are incorporated into this subdivision design in order to meet water quality and quantity objectives as well as provide benefits such as recreational spaces, habitat, improved vistas and reduction in mains water demand. The MUSIC model configuration for the site shows the arrangement of these systems.



3.2. Reclaimed water

It is recommended that reclaimed water from Shoalhaven City Council's northern wastewater treatment plant be used to supply outdoor uses and toilet flushing. The reclaimed water main currently runs adjacent to the site, providing a logical supply for non-potable uses. This will also dovetail with Council's proposed Integrated Water Cycle Management Strategy.

3.3. Rainwater Tanks

It is recommended that a minimum 5 KL rainwater tank be installed on each house with a minimum of 80% of the roof area draining to it. The tank should be plumbed to supply the hot water and laundry demands to regularly draw down the storage in the tank to retain runoff from the site (**Figure 3.1**).

Detention storage above the 5 KL may be used as part of On Site Detention (OSD) requirements, refer to section 3.4.

Figure 3.1:Typical Rainwater tank installation

3.4. On-site Detention

Detention of stormwater is required to ensure that the pre-development peak flows are not exceeded. A detention volume of 50 KL/Ha and permissible site discharge of 100 L/s/Ha is recommended. This will mean that for each house block approximately 3 to 5 kL of detention storage is required. Detention storage can be made up of air space above the retention storage volume in the rainwater tank, or in a separate tank, underground trench, or landscaped depression or a combination of these options.

3.5. Infiltration

Infiltration is recommended for all lots. Rainwater tank overflow, runoff from lot impervious surfaces and general backyard runoff should be collected and infiltrated. A collection volume of 2 m^3 in an appropriately sized gravel trench or equivalent landscaped depression (sometimes referred to as a raingarden), on the property is recommended to infiltrate frequent runoff (**Figure 3.2**). A conceptual infiltration area configuration is shown on the Stormwater Master Plan drawing (Appendix C). Promoting infiltration will assist with the maintenance of interflow (water flow through the soil profile, rather than the surface) thus helping to maintain the existing hydrological regime after development.

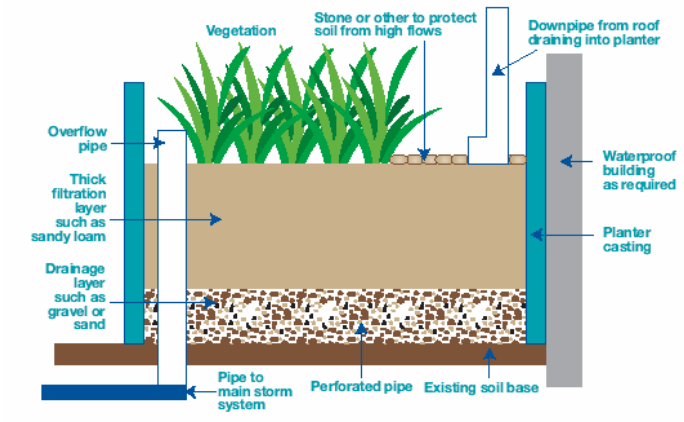


Figure 3.2: Examples of a Raingarden infiltration system
(http://library.melbournewater.com.au/content/wsud/sustainable_urban_design/Raingardens.pdf and http://www.rtbg.tas.gov.au/raingarden.html)

3.6. Road Side Swales and Biofiltration Trenches

Swales are recommended where the slope of the site permits the capture of road runoff (less than 5%). These swales will convey flows to the closest wetland while removing pollutants. It is recommended that bioretention trenches running adjacent to the EEC area are used to promote infiltration and interflow into the EEC area through the soil profile to maintain moisture to this sensitive community. A conceptual swale/biofiltration and road configuration is shown on the Stormwater Master Plan drawing (Appendix C). See **Figure 3.3** for an example of a typical roadside biofiltration system.

Figure 3.3: Typical biofiltration trench

3.7. Gross Pollutant Trap

A GPT that can achieve high levels of gross pollutant and coarse sediment removal is recommended to be located before the wetland on the southern boundary. The GPT will service a catchment of 17Ha and should be appropriately sized. An example of an appropriate product is a CDS unit, model P1015.

3.8. Wetlands

Wetlands will provide a high level of treatment of runoff from the proposed urban environment. Each wetland should contain the following key features:

- Open water inlet area to collect sediment;
- Maintenance access to allow for collection of accumulated sediment;
- Shallow water, reed bed area to provide surface area for pollutant filtration; and
- Water level control at the outlet.

A conceptual wetland configuration is shown on the Stormwater Master Plan drawing (Appendix D). The basic parameters of the wetland are outlined in **Table 3.1**.

Table 3.1: Wetland Design Parameters

Wetland	Inlet Pond volume (m^3)	Wetland Surface Area (m2)	Permanent Depth (m)	Extended Detention Depth (m)	Outlet orifice size (m)
1	200	600	0.3	0.6	0.04
2 (playground area)	150	300	0.3	0.6	0.03
3	200	900	0.3	0.6	0.03

4.0 DETERMINING SYSTEM PERFORMANCE

The previously discussed stormwater management systems form the Stormwater Master Plan and were developed to meet objectives for water quality and quantity outlined in Section 2. Modelling was used to optimise the location and size of these systems.

There are two broad aspects of the development on the water cycle to be assessed, the impact on water quality and the impact on water quantity.

Numerical modelling is used to simulate hydrologic and water quality conditions. Both the existing situation and proposed development are modelled to gain an understanding of the impacts of the development and the impact of water management systems. The Model for Urban Stormwater Improvement Conceptualisation (MUSIC) is used to simulate the water quality and hydrology[1].

4.1. Determining water quality performance

MUSIC is used to determine:

- the pre-development and post-development water quality into the EEC zone to determine whether a neutral or beneficial effect (NORBE) is achieved.
- the effectiveness of the treatment techniques proposed for the development to compare against the BMP of 80% retention of total suspended solids and 45% retention of nutrients.

4.2. Determining water quantity performance

The modification to runoff frequency, quantity and duration within the EEC area can increase the potential of threatening processes occurring in this area such as erosion of soils and modifications to the supply of moisture. MUSIC and RAFTS[2] are used to simulate long term hydrology as well as runoff from storm events into the EEC area.

To prevent exceeding the existing downstream stormwater system's capacity detention of flows is recommended to be incorporated into the design. RAFTS is used to determine the pre- and post-development peak flows for the 1 in 5 to the 1 in 100 year events leaving the site.

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[1] MUSIC is a stormwater modelling package that allows the user to determine likely water quality from a landscape. The software is useful as it allows the user to trial a range of stormwater treatment techniques such as wetlands and swales to determine the impact they have on the quality of stormwater. The model is able to simulate rainfall and runoff to a resolution of six minutes, allowing small sub-catchments such as housing blocks and roads to be modelled individually.

The software was developed by the Cooperative Research Centre for Catchment Hydrology (CRCCH) in Melbourne as a tool to improve the management of stormwater from urban environments. As with all modelling software, it is reliant on input data and assumptions inherent in the modelling of pollutant generation and treatment. Additionally, the software is a conceptual design tool, not a detailed design tool.

Engineering consultants around Australia have used MUSIC to design urban development proposal, which meet Water Sensitive Urban Design standards.

[2] Rafts utilises a non-linear runoff routing model used to determine the stormwater peak flow (Q) from a catchment in a prescribed storm event. XP-RAFTS is widely adopted by the engineering community to estimate peak stormwater flows.

4.3. MUSIC model assumptions

4.3.1. Climate Information

The closest continuous rainfall data gauge (6 minute) is located at Point Perpendicular (Bureau of Meteorology station no. 68151). The largest continuous record from 10/10/2001 to 1/1/2003 was used. The average annual rainfall from this period is 1,016mm. The annual average rainfall for the entire period of record for the site (daily rainfall) is 1,241mm. The continuous record used is drier than average, however, this is the best (closest) available source of continuous rainfall data. Because the analysis undertaken uses a comparative assessment, use of drier than average rainfall data is not considered to be an issue that would change the outcome or size of treatment measures.

4.3.2. Soil Information

The MUSIC model uses an impervious store, pervious store and groundwater store to calculate surface runoff and base flow (interflow). The same default values used to define the soil storage parameters, infiltration capacity, seepage and recharge rates were used for the pre- and post-development scenarios to provide an accurate comparison.

4.3.3. EEC Area

MUSIC is used to model both water quality and the long term wetting and drying of the EEC area. The pre-development model includes the forested catchments and existing roads (Berringer Rd and Cunjurong Point Road) that drain to the EEC area, a catchment of 15.4 Ha.

As part of the development strategy, it is proposed to divert some of the catchment, which will change from forest to urban, around part of the EEC through treatment systems, to be discharged midway along, or at the end of the EEC area.

Sub-catchments UH, UI and UJ (4.25 Ha) will be diverted to a wetland and discharged approximately midway through the EEC area. Part of sub-catchment UG (1.5 Ha) will be diverted around the EEC area and discharged downstream.

In summary, the catchment draining to the EEC area will reduce in size by 9.7%, and 37% of the existing catchment will change from forest to urban land use. (**Figure 4.1**).

Stormwater is collected and diverted to treatment systems to allow for the sufficient treatment of runoff and to divert a proportion of additional runoff volume due to the increase in impervious area

Details of areas, pervious percentages and pollution generation rates can be found in Appendix B.

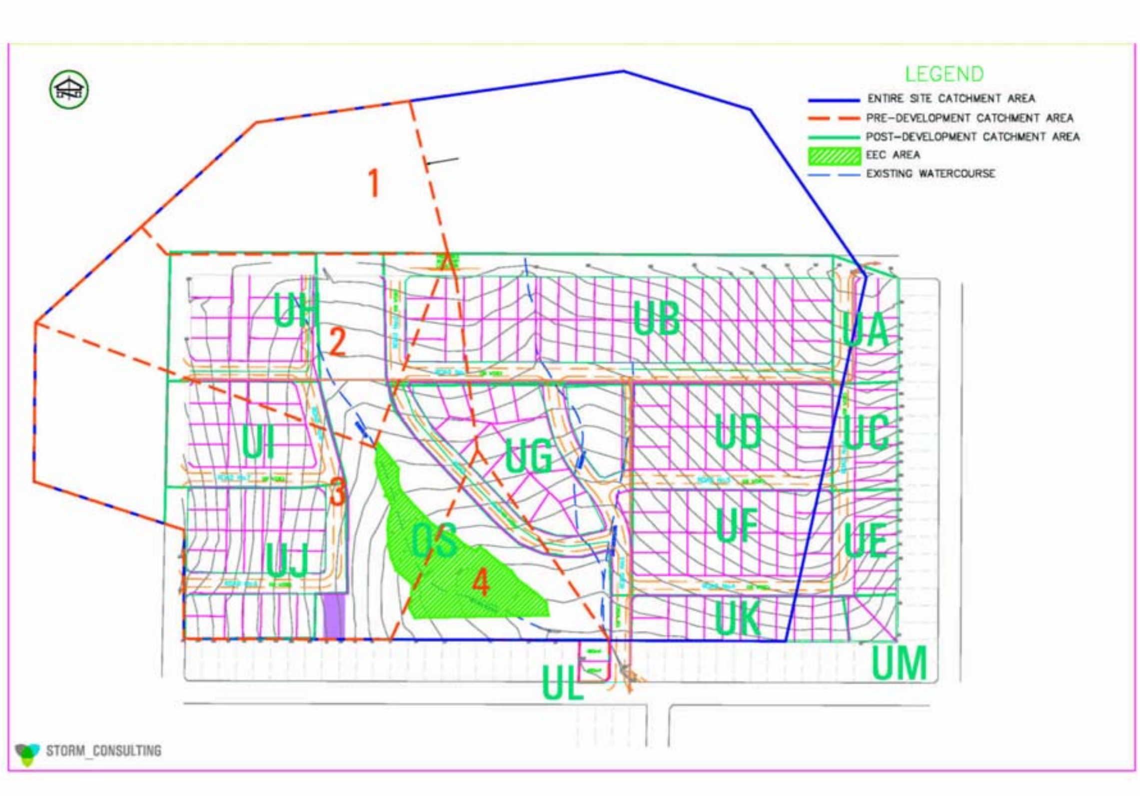


Figure 4.1: Pre and post-development catchment areas used in MUSIC.

4.3.4. Total development site

When modelling the entire development site, it is only necessary to model the areas that will change from forest landscape to urban residential development as the water quality objective relates to how effective the proposed treatment systems are at reducing pollution from the proposed development. Details such as actual areas, pervious percentages and pollution generation rates can be found in Appendix B.

4.4. RAFTS modelling assumptions

As discussed, the EEC area is sensitive to changes in the hydrologic regime, both from changes to base flows, (long term wetting and drying) as well as the erosive impact of storm events. The runoff routing modelling software XP RAFTS has been used to compare pre and post-development peak flows for the 1 in 1 yr event for the EEC area and the 1 in 5, 20 and 100 year events for the entire subdivision. Catchment layouts and key assumptions such as roughness values are contained in Appendix A.

5.0 MODELLED SYSTEM PERFORMANCE

5.1. Hydrologic regime in the EEC zone

5.1.1. Continuous Data

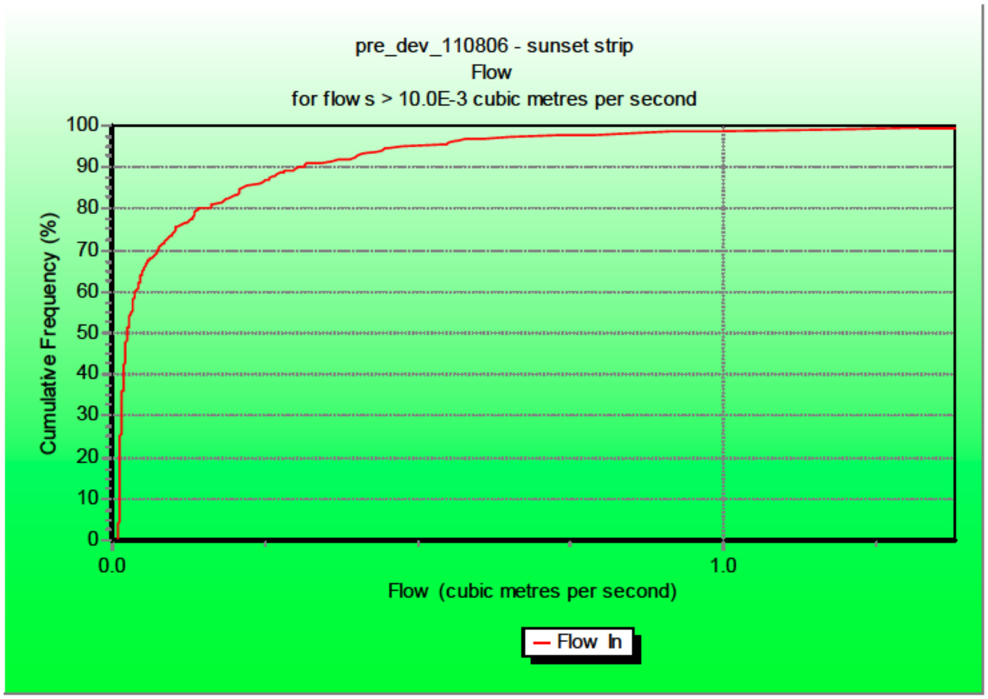
Using rainfall data obtained from the Point Perpendicular rainfall gauge, for the period from 10/10/2001 to 1/1/2003 the pre-development average annual volume of runoff through the EEC area is predicted to be 41.9 ML/y. Post-development, the average annual flow is 45.1/y.

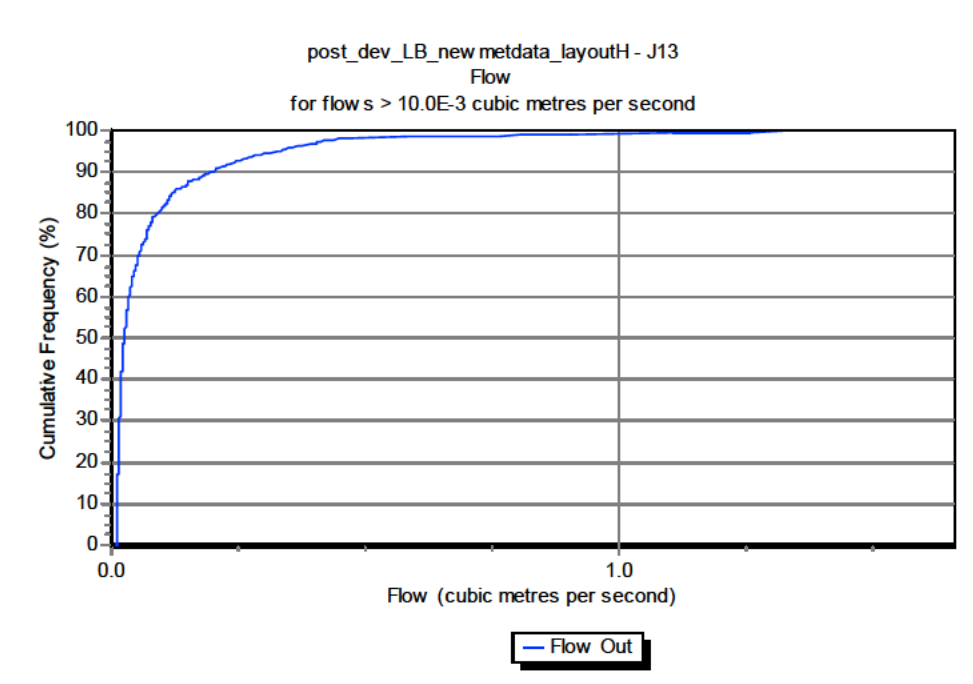
A time series graph for six months of data from 1/1/2001 to 30/6/2001 (Appendix C) shows the difference in flows over the period for the existing condition, the post-development condition with no mitigating measures and the post-development scenario with the mitigation measures proposed. Post-development with no mitigation measures significantly increases flow from the small frequent events. When treatment systems are included, flows from the small, frequent events are similar to the pre-development scenario. **Table 5.1** contains key statistics for flows for the modelled period. **Figure 5.1** contains a comparison of flows through the system greater than 10L/s. These are the “storm” type events. The statistics and cumulative frequency curves demonstrate a similarity between pre- and post- hydrologic regimes for the modelled period, suggesting the change in catchment characteristics is mitigated by the proposed layout and treatment systems and the impact of the development on storm hydrology is minimal.

Table 5.1 Hydrological Statistics for flows into EEC Area

	Pre-development (m^3/s)	**Post -development flows (m^3/s)**
90%ile	0.00237	0.00253
Mean	0.00133	0.00143
Standard deviation	0.00829	0.00790

Figure 5.1 Comparison of cumulative frequency for flows entering the EEC area for flows greater than 10L/s.





Gross Error Check - A comparison of average annual flows was carried out using a longer period of data from Nowra. The period used was from 5/8/1964 to 24/8/1974 and is on average drier than the Point Perpendicular gauge data. Pre-development average annual flow for this data is 28.1 ML/y, Post-development average annual flow for this data is 30.4 ML/y.

The difference in average annual flow is small, and the difference is similar in magnitude to the Point Perpendicular data suggesting that the climate period (Point Perpendicular) modelled is representative.

5.1.2.Peak flows

The RAFTS runoff routing model showed that peak flow from the 1 in 1 year ARI event into the EEC area is 0.942 m^3/s in the pre-development case and 0.72 m^3/s in the post-development.

5.2. Water quality in the EEC zone

Modelling results for pollutant loads and concentrations for the EEC area (**Table 5.2**) show that pollutant loads are reduced to below existing levels for suspended solids and phosphorous, however, nitrogen loads are slightly increased. Generally, phosphorous is the limiting growth factor for freshwater environments (ARQ, 2006). **Table 5.3** shows that average post-development pollutant concentrations are less than existing based on the modelling. However, both the pre- and post-development average concentrations exceed the default ANZECC trigger value for streams draining to the coast. The fact that the concentrations are exceeded in the pre-development model suggests that the trigger values set by ANZECC are conservative. The water quality guidelines themselves state (Clyde River and Jervis Bay River Flow and Water Quality Objectives, 2006):

> *"…default trigger values provided in ANZECC 2000 Guidelines are essentially conservative and precautionary. If they are not exceeded, a very low risk of environmental damage can be assumed."*

Table 5.2 Annual pollutant loads

	Pre-development (kg/y)	**Post-development (no mitigation measures) (kg/y)**	**Post-development (with mitigation measures) (kg/y)**	**Comment**
Total suspended solids	2350	4840	1220	Complies with quantitative objective
Total phosphorous	4.81	10.10	3.4	Complies with quantitative objective
Total nitrogen	34.3	70.2	36.4	*Higher than pre development conditions, however no significant impact

*Note: Effect that the increase of nitrogen has on the EEC area is discussed in the Threatened Species Assessment Report and is not considered to have a significant detrimental effect on the EEC area.

Table 5.3 Nutrient concentrations

	Pre-development (average concentration over period) mg/L	Post-development (average concentration over period) mg/L	Anzecc Trigger value (mg/L)
Total phosphorous	0.096	0.037	0.025
Total nitrogen	0.56	0.42	0.35

5.3. Water quality for the entire site

As mentioned in Section 3 current best practice for developments is a reduction in pollutant loads of 80% for suspended solids and 45% for phosphorous and nitrogen. That is, collection of 80% or more of suspended solids and 45% or more of the nutrient load before discharging from the site. Results for the entire subdivision, both the areas draining to the EEC zone and areas to the east, show that this best practice approach is met for suspended solids and nutrients for the stormwater management systems proposed for the site (**Table 5.4**).

Table 5.4 Treatment Train Effectiveness for whole site

	Development with no treatment (kg/y)	Development with treatment (kg/y)	Treatment train effectiveness (%)	Comment
Total suspended solids	12400	2260	80	Complies with water quality objective
Total phosphorous	26.7	8.26	66	Complies with water quality objective
Total nitrogen	194	83.5	53	Complies with water quality objective

5.4. Peak Flows for the entire site

A comparison of peak flows at the base of the development site (Sunset Strip) is listed in **Table 5.5.** Post-development peak flows are close to, or less than existing peak flows indicating the development will not impact on the capacity of the existing stormwater system.

Table 5.5 Pre- and Post-development comparison of peak flows

Average Recurrence Interval	Pre-development (m^3/s)	Post-development (m^3/s)	Comment
1	1.857	1.62	Post peak less than pre peak
2	2.720	2.52	Post peak less than pre peak
5	4.238	4.24	Post peak same as pre peak
20	6.422	6.73	Slight increase but not significant
100	9.113	9.56	Post peak close to pre peak

Gross Error Check

The rational method calculates the peak flow for the pre-development case for the 100 year ARI event at 11.76m^3/s which is slightly higher than the RAFTS calculation of 9.113m^3/s. The peak flows are close suggesting modelling assumptions are realistic.

6.0 CONCLUSIONS & RECOMMENDATIONS

6.1. EEC Area

6.1.1. Hydrologic regime

The EEC area is sensitive to changes to wetting and drying and changes to water quality. The proposed stormwater management systems mitigate the increases in runoff due to the increase in impervious area and maintain similar flow patterns into the EEC area.

The average annual flow is maintained at similar level to existing (42 ML/y pre, 45ML/y post) and the cumulative frequency distribution of flows greater than 10L/s (frequent storm flows) is similar. The results of the hydrological modelling indicate that objectives of maintaining close to existing flow behaviour to the EEC area will be achieved.

Peak flows for the 1 year ARI event into the EEC area are reduced from 0.942 m^3/s in the pre-development case, to 0.7 m^3/s in the post-development case. This has not changed with the change to the layout.

The change to the layout to increase the EEC buffer and provision of a link to the catchment upstream will provide an additional level of protection to the EEC area and facilitate a more "natural" hydrologic regime.

6.1.2. Water quality

The MUSIC modelling shows that the proposed stormwater treatment systems collect a large amount of pollutants contained in runoff from the site. Annual pollutant loads entering the EEC area for suspended solids and phosphorous are reduced to below pre-development levels, therefore complying with objectives and actually improving water quality compared to existing levels. Nitrogen loads are increased by a small amount (6%). This has been acknowledged in the ecologist's report (BES, 2006) and is not considered to have a significant detrimental effect on the EEC area.

Average concentrations for TSS, TP and TN are all less than pre-development levels indicating an overall improvement in water quality entering the EEC area.

6.2. Entire Site

6.2.1. Peak Flows

On site detention and detention volume available in the proposed wetlands provides sufficient detention to reduce peak flows to close to, or below existing peak flows. Therefore, the subdivision will not have a detrimental effect on the capacity of the existing stormwater infrastructure.

6.2.2. Water quality

Post-development water quality leaving the site meets the BMP guidelines for 80% reduction in TSS load, and 45% reduction in TP and TN load.

6.3. Compliance with general planning objectives

Table 6.1 summarises the impact of the development against the relevant planning controls.

Table 6.1 Cross reference with qualitative planning objectives

Planning Document	Relevant Clause	Comment
Clyde River and Jervis Bay water quality objectives	• Protection of aquatic ecosystems	Pollutant loads will generally decrease
Statement of joint intent for NSW Coastal Lakes	• Key natural and/or highly valued modified ecosystem processes are rehabilitated and retained.	The creek and pond area behind the dunes downstream of the development have been modified and is currently fed from a developed catchment with minimal water quality treatment. The proposed development includes a significant amount of water quality management features to protect the receiving waters. The EEC area is retained, and existing natural processes are protected by maintaining the hydrological regime as much as possible and filtering and collecting pollutants prior to discharge of stormwater to the EEC area.
Shoalhaven Council LEP	• protect water quality • ...protect aquatic habitats and riparian communities	The systems proposed provide a significant level of protection for the existing water quality, aquatic habitats and riparian communities.
Shoalhaven Council DCP	• ...interception and treatment of pollutants through the use of appropriate water quality control measures prior to discharge to receiving waters, including wetlands, lakes and ponds.	This is being undertaken throughout the site
Shoalhaven Council's IWCM strategy and WSUD policy.	• Policy does not exist	Rainwater tanks and recycled water are recommended for the site. A range of water sensitive design features are recommended for the site, including infiltration on site, grass swales and wetland ponds, rainwater tanks and use of reclaimed water, biofiltration.

6.4. Recommendations

Given that the modelling in this report demonstrates compliance with objectives, and that a neutral/beneficial effect has resulted, we recommend that all parts of the water cycle management strategy proposed be adopted.

REFERENCES

Bushfire Environmental Services (2006), *Threatened Species Assessment Report*

Department of Environment and Conservation (2006), *Clyde River and Jervis Bay River Flow and Water Quality Objectives (2006), http://www.environment.nsw.gov.au/ieo/clyde/report-02.htm#P182_17766*, Department of Environment and Conservation, accessed Sept 2006

Engineers Australia (2006), *Australian Runoff Quality*, Engineers Australia, Sydney.

Environmental Protection Authority (1997), *Managing Urban Stormwater: Treatment Techniques,*

APPENDIX A
RAFTS Model input

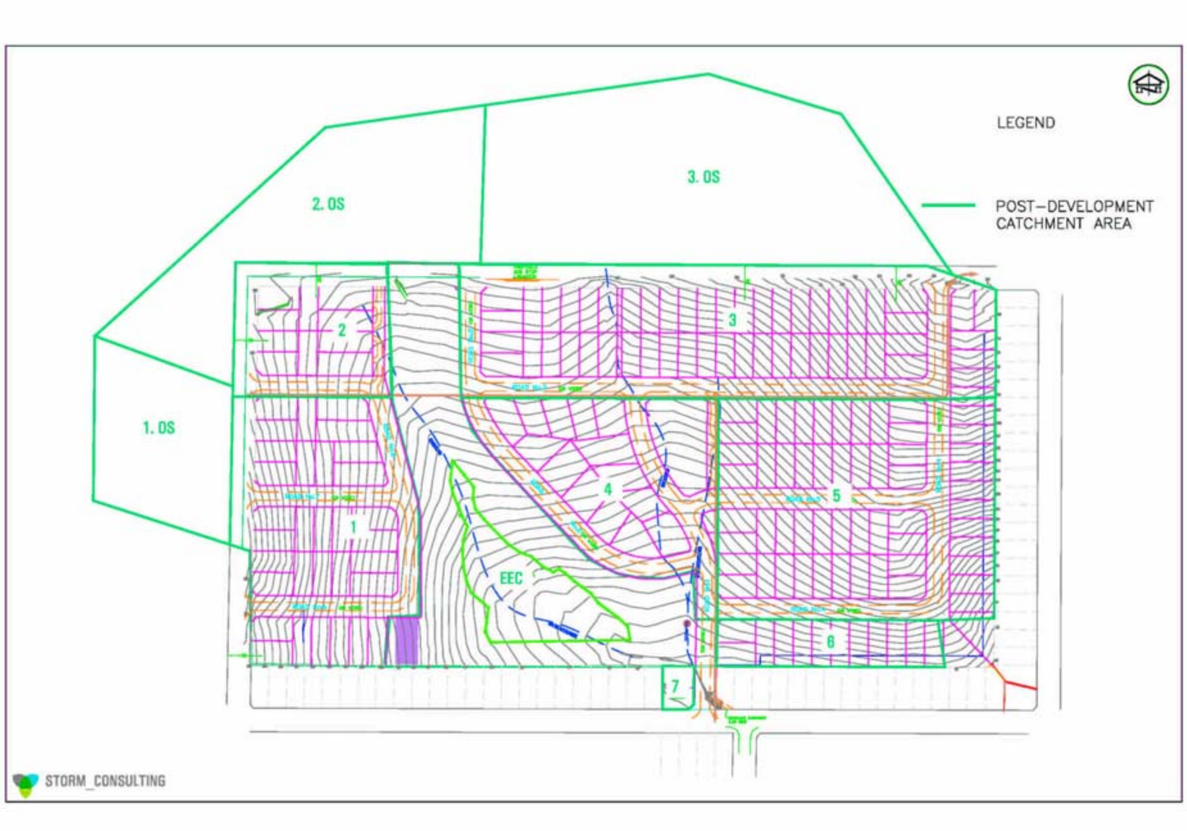
Pre-Development Subcatchments and Pern values

Sub Catchment	Pervious Catchment Area [ha]	Pervious Catchment Mannings 'n' [n value]	Impervious Catchment Area [ha]	Impervious Catchment Mannings 'n' [n value]
1	5.238	0.08	0.683	0.015
2	5.238	0.08	0.256	0.015
3 (EEC)	2.3	0.08	0	
4	1.88	0.08	0	
5	15.7	0.08	0.723	0.015
6	0.098	0.08	0	

Post-Development Subcatchments and Pern values

Sub Catchment	Pervious Area [ha]	Pervious Catchment Mannings 'n' [n value]	Impervious Area [ha]	Impervious Catchment Mannings 'n' [n value]
1. OS	1.616	0.08	0	
2. OS	3.198	0.08	0.683	0.015
3. OS	4.83	0.08	0	
(EEC)	2.3	0.08	0	
1	1.894	0.035	1.95	0.015
2	0.95	0.035	1.45	0.015
3	1.63	0.035	2.57	0.015
4	1.57	0.035	1.62	0.015
5	2.389	0.035	2.04	0.015
6	0.564	0.035	0.2	0.015
7	0.058	0.025	0.04	0.015

Pre-development subcatchment schematic



Post-development subcatchment schematic

APPENDIX B
MUSIC Model input

Pre-development MUSIC Summary

Source nodes						
Location	C1	C2	C3	C4	R2	R3
ID	2	5	6	7	8	9
Node Type	ForestSourceNode	ForestSourceNode	ForestSourceNode	ForestSourceNode	UrbanSourceNode	UrbanSourceNode
Total Area (ha)	2.64	3.3	6.64	1.62	0.6	0.3
Area Impervious (ha)	0	0	0	0	0.363789	0.179237
Area Pervious (ha)	2.64	3.3	6.64	1.62	0.236211	0.120763
Field Capacity (mm)	170	170	170	170	170	170
Pervious Area Infiltration Capacity coefficient - a	200	200	200	200	200	200
Pervious Area Infiltration Capacity exponent - b	1	1	1	1	1	1
Impervious Area Rainfall Threshold (mm/day)	1	1	1	1	1	1
Pervious Area Soil Storage Capacity (mm)	200	200	200	200	200	200
Pervious Area Soil Initial Storage (% of Capacity)	30	30	30	30	30	30
Groundwater Initial Depth (mm)	10	10	10	10	10	10
Groundwater Daily Recharge Rate (%)	25	25	25	25	25	25
Groundwater Daily Baseflow Rate (%)	5	5	5	5	5	5
Groundwater Daily Deep Seepage Rate (%)	0	0	0	0	0	0
Stormflow Total Suspended Solids Mean (log mg/L)	1.602	1.602	1.602	1.602	2.43	2.43
Stormflow Total Suspended Solids Standard Deviation (log mg/L)	0.2	0.2	0.2	0.2	0.32	0.32
Stormflow Total Suspended Solids Estimation Method	Mean	Mean	Mean	Mean	Mean	Mean
Stormflow Total Suspended Solids Serial Correlation	0	0	0	0	0	0
Stormflow Total Phosphorus Mean (log mg/L)	-1.097	-1.097	-1.097	-1.097	-0.3	-0.3
Stormflow Total Phosphorus Standard Deviation (log mg/L)	0.22	0.22	0.22	0.22	0.25	0.25
Stormflow Total Phosphorus Estimation Method	Mean	Mean	Mean	Mean	Mean	Mean
Stormflow Total Phosphorus Serial Correlation	0	0	0	0	0	0
Stormflow Total Nitrogen Mean (log mg/L)	-0.046	-0.046	-0.046	-0.046	0.34	0.34
Stormflow Total Nitrogen Standard Deviation (log mg/L)	0.24	0.24	0.24	0.24	0.19	0.19
Stormflow Total Nitrogen Estimation Method	Mean	Mean	Mean	Mean	Mean	Mean
Stormflow Total Nitrogen Serial Correlation	0	0	0	0	0	0
Baseflow Total Suspended Solids Mean (log mg/L)	0.778	0.778	0.778	0.778	-2	-2
Baseflow Total Suspended Solids Standard Deviation (log mg/L)	0.13	0.13	0.13	0.13	0.17	0.17
Baseflow Total Suspended Solids Estimation Method	Mean	Mean	Mean	Mean	Mean	Mean
Baseflow Total Suspended Solids Serial Correlation	0	0	0	0	0	0
Baseflow Total Phosphorus Mean (log mg/L)	-1.523	-1.523	-1.523	-1.523	-2	-2
Baseflow Total Phosphorus Standard Deviation (log mg/L)	0.13	0.13	0.13	0.13	0.19	0.19
Baseflow Total Phosphorus Estimation Method	Mean	Mean	Mean	Mean	Mean	Mean
Baseflow Total Phosphorus Serial Correlation	0	0	0	0	0	0
Baseflow Total Nitrogen Mean (log mg/L)	-0.523	-0.523	-0.523	-0.523	-2	-2
Baseflow Total Nitrogen Standard Deviation (log mg/L)	0.13	0.13	0.13	0.13	0.12	0.12
Baseflow Total Nitrogen Estimation Method	Mean	Mean	Mean	Mean	Mean	Mean
Baseflow Total Nitrogen Serial Correlation	0	0	0	0	0	0
OUT - Mean Annual Flow (ML/yr)	6.69	8.36	16.8	4.1	3.97	1.97
OUT - TSS Mean Annual Load (kg/yr)	161	201	405	98.8	995	491
OUT - TP Mean Annual Load (kg/yr)	0.378	0.473	0.952	0.232	1.86	0.916
OUT - TN Mean Annual Load (kg/yr)	4.14	5.17	10.4	2.54	8.09	3.99
OUT - Gross Pollutant Mean Annual Load (kg/yr)	0	0	0	0	109	53.8
Other nodes						
Location	sunset strip	j1	j2			

ID	1	3	4			
Node Type	ReceivingNode	JunctionNode	JunctionNode			
IN - Mean Annual Flow (ML/yr)	41.9	19	37.8			
IN - TSS Mean Annual Load (kg/yr)	2.35E+03	1.36E+03	2.25E+03			
IN - TP Mean Annual Load (kg/yr)	4.81	2.71	4.57			
IN - TN Mean Annual Load (kg/yr)	34.3	17.4	31.8			
IN - Gross Pollutant Mean Annual Load (kg/yr)	162	109	162			
OUT - Mean Annual Flow (ML/yr)	0	19	37.8			
OUT - TSS Mean Annual Load (kg/yr)	0	1.36E+03	2.25E+03			
OUT - TP Mean Annual Load (kg/yr)	0	2.71	4.57			
OUT - TN Mean Annual Load (kg/yr)	0	17.4	31.8			
OUT - Gross Pollutant Mean Annual Load (kg/yr)	0	109	162			

Post-development MUSIC Summary

Source nodes																			
Location	UB roof	UB	R8	Landscaped	1	6	UA	UA ROOF	RA	RC	UC	UC ROOF	RE	UE	UE ROOF	UH ROOF	UH	RH	RD
Node Type	UrbanSourceNode	UrbanSourceNode	UrbanSourceNode	ForestSourceNode	ForestSourceNode	ForestSourceNode	UrbanSourceNode	UrbanSourceNode	UrbanSourceNode	UrbanSourceNode	UrbanSourceNode	UrbanSourceNode	UrbanSourceNode	UrbanSourceNode	UrbanSourceNode	UrbanSourceNode	UrbanSourceNode	UrbanSourceNode	UrbanSourceNode
Total Area (ha)	0.84	2.12	0.658	0.157	2.64	2.38	0.25	0.1	0.25	0.2	0.25	0.1	0.2	0.25	0.1	0.34	0.95	0.51	0.32
Area Impervious (ha)	0.84	0.42	0.39	0.08	0.00	0.00	0.05	0.10	0.15	0.12	0.05	0.10	0.12	0.05	0.10	0.34	0.19	0.31	0.19
Area Pervious (ha)	0.00	1.70	0.26	0.08	2.64	2.38	0.20	0.00	0.10	0.08	0.20	0.00	0.08	0.20	0.00	0.00	0.76	0.20	0.13
Field Capacity (mm)	170	170	170	80	170	170	170	170	170	170	170	170	170	170	170	170	170	170	170
Pervious Area Infiltration Capacity coefficient - a	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200
Pervious Area Infiltration Capacity exponent - b	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Impervious Area Rainfall Threshold (mm/day)	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Pervious Area Soil Storage Capacity (mm)	200	200	200	120	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200
Pervious Area Soil Initial Storage (% of Capacity)	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30
Groundwater Initial Depth (mm)	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
Groundwater Daily Recharge Rate (%)	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25
Groundwater Daily Baseflow Rate (%)	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
Groundwater Daily Deep Seepage Rate (%)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stormflow Total Suspended Solids Mean (log mg/L)	1.3	2.146	2.43	1.9	1.602	1.602	2.146	1.3	2.43	2.43	2.146	1.3	2.43	2.146	1.3	1.3	2.146	2.43	2.43
Stormflow Total Suspended Solids Standard Deviation (log mg/L)	0.32	0.32	0.32	0.2	0.2	0.2	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32
Stormflow Total Suspended Solids Estimation Method	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean
Stormflow Total Suspended Solids Serial Correlation	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stormflow Total Phosphorus Mean (log mg/L)	-0.886	-0.602	-0.3	-1.1	-1.097	-1.097	-0.602	-0.886	-0.3	-0.3	-0.602	-0.886	-0.3	-0.602	-0.886	-0.886	-0.602	-0.3	-0.3
Stormflow Total Phosphorus Standard Deviation (log mg/L)	0.25	0.25	0.25	0.22	0.22	0.22	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Stormflow Total Phosphorus Estimation Method	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean
Stormflow Total Phosphorus Serial Correlation	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stormflow Total Nitrogen Mean (log mg/L)	0.301	0.301	0.34	-0.075	-0.046	-0.046	0.301	0.301	0.34	0.34	0.301	0.301	0.34	0.301	0.301	0.301	0.301	0.34	0.34
Stormflow Total Nitrogen Standard Deviation (log mg/L)	0.19	0.19	0.19	0.24	0.24	0.24	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19
Stormflow Total Nitrogen Estimation Method	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean
Stormflow Total Nitrogen Serial Correlation	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Baseflow Total Suspended Solids Mean (log mg/L)	-5	1.204	-5	0.9	0.778	0.778	1.204	-5	-5	-5	1.204	-2	-5	1.204	-5	-5	1.204	-5	-5

Baseflow Total Suspended Solids Standard Deviation (log mg/L)	0.17	0.17	0.17	0.13	0.13	0.13	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17
Baseflow Total Suspended Solids Estimation Method	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean
Baseflow Total Suspended Solids Serial Correlation	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Baseflow Total Phosphorus Mean (log mg/L)	-5	-0.854	-5	-1.5	-1.523	-1.523	-0.854	-5	-5	-5	-0.854	-2	-5	-0.854	-5	-5	-0.854	-5	-5
Baseflow Total Phosphorus Standard Deviation (log mg/L)	0.19	0.19	0.19	0.13	0.13	0.13	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19
Baseflow Total Phosphorus Estimation Method	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean
Baseflow Total Phosphorus Serial Correlation	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Baseflow Total Nitrogen Mean (log mg/L)	-5	0.113	-5	-0.14	-0.523	-0.523	0.113	-5	-5	-5	0.113	-2	-5	0.113	-5	-5	0.113	-5	-5
Baseflow Total Nitrogen Standard Deviation (log mg/L)	0.12	0.12	0.12	0.13	0.13	0.13	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12
Baseflow Total Nitrogen Estimation Method	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean
Baseflow Total Nitrogen Serial Correlation	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
OUT - Mean Annual Flow (ML/yr)	7.76	8.19	4.31	0.965	6.64	5.99	0.965	0.924	1.64	1.3	0.965	0.924	1.32	0.965	0.924	3.14	3.67	3.34	2.1
OUT - TSS Mean Annual Load (kg/yr)	155	900	1.08E+03	67.7	161	145	106	18.4	409	323	106	18.4	332	106	18.4	62.7	403	835	524
OUT - TP Mean Annual Load (kg/yr)	1.01	1.83	2.01	7.07E-02	0.377	0.34	0.216	0.12	0.762	0.602	0.216	0.12	0.618	0.216	0.12	0.409	0.819	1.55	0.976
OUT - TN Mean Annual Load (kg/yr)	15.5	15	8.76	0.797	4.12	3.72	1.77	1.85	3.33	2.63	1.77	1.85	2.7	1.77	1.85	6.28	6.71	6.79	4.26
OUT - Gross Pollutant Mean Annual Load (kg/yr)	191	194	118	25.7	0	0	22.9	22.8	44.9	35.6	22.9	22.8	36.2	22.9	22.8	77.4	86.9	91.5	57.4

Source nodes

Location	UD	UD ROOF	RF	UF	UF ROOF	UK ROOF	UK	UI ROOF	UI	RI	UJ ROOF	UJ	RJ	RG	UG ROOF	UG	OSG	5	2
Node Type	UrbanSourceNode	UrbanSourceNode	UrbanSourceNode	UrbanSourceNode	UrbanSourceNode	UrbanSourceNode	UrbanSourceNode	UrbanSourceNode	UrbanSourceNode	UrbanSourceNode	UrbanSourceNode	UrbanSourceNode	UrbanSourceNode	UrbanSourceNode	UrbanSourceNode	UrbanSourceNode	ForestSourceNode	ForestSourceNode	ForestSourceNode
Total Area (ha)	0.95	0.4	0.32	0.95	0.4	0.2	0.56	0.22	0.87	0.067	0.42	0.87	0.384	0.167	0.38	1.2	0.33	2.46	0.836
Area Impervious (ha)	0.19	0.40	0.19	0.19	0.40	0.20	0.11	0.22	0.17	0.04	0.42	0.17	0.23	0.10	0.38	0.24	0.00	0.00	0.00
Area Pervious (ha)	0.76	0.00	0.13	0.76	0.00	0.00	0.45	0.00	0.70	0.03	0.00	0.70	0.15	0.07	0.00	0.96	0.33	2.46	0.84
Field Capacity (mm)	170	170	170	170	170	170	170	170	170	170	170	170	170	170	170	170	170	170	170
Pervious Area Infiltration Capacity coefficient - a	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200
Pervious Area Infiltration Capacity exponent - b	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Impervious Area Rainfall Threshold (mm/day)	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Pervious Area Soil Storage Capacity (mm)	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200
Pervious Area Soil Initial Storage (% of Capacity)	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30
Groundwater Initial Depth (mm)	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
Groundwater Daily Recharge Rate (%)	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25
Groundwater Daily Baseflow Rate (%)	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
Groundwater Daily Deep Seepage Rate (%)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stormflow Total Suspended Solids Mean (log mg/L)	2.146	1.3	2.43	2.146	1.3	1.3	2.146	1.3	2.146	2.43	1.3	2.146	2.43	2.43	1.3	2.146	1.602	1.6	1.602
Stormflow Total Suspended Solids Standard Deviation (log mg/L)	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.2	0.2	0.2
Stormflow Total Suspended Solids Estimation Method	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean
Stormflow Total Suspended Solids Serial Correlation	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stormflow Total Phosphorus Mean (log mg/L)	-0.602	-0.886	-0.3	-0.602	-0.886	-0.886	-0.602	-0.886	-0.6	-0.3	-0.886	-0.602	-0.3	-0.3	-0.886	-0.602	-1.097	-1.1	-1.1
Stormflow Total Phosphorus Standard Deviation (log mg/L)	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.22	0.22	0.22
Stormflow Total Phosphorus Estimation Method	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean
Stormflow Total Phosphorus Serial Correlation	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stormflow Total Nitrogen Mean (log mg/L)	0.301	0.301	0.34	0.301	0.301	0.301	0.301	0.301	0.301	0.34	0.301	0.301	0.34	0.34	0.301	0.301	-0.046	-0.05	-0.05
Stormflow Total Nitrogen Standard Deviation (log mg/L)	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.24	0.24	0.24
Stormflow Total Nitrogen Estimation Method	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean
Stormflow Total Nitrogen Serial Correlation	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Baseflow Total Suspended Solids Mean (log mg/L)	1.204	-5	-5	1.204	-5	-5	1.204	-5	1.204	-5	-5	1.204	-5	-5	-5	1.204	0.778	0.78	0.778

Baseflow Total Suspended Solids Standard Deviation (log mg/L)	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.13	0.13	0.13
Baseflow Total Suspended Solids Estimation Method	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean
Baseflow Total Suspended Solids Serial Correlation	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Baseflow Total Phosphorus Mean (log mg/L)	-0.854	-5	-5	-0.854	-5	-5	-0.854	-5	-0.85	-5	-5	-0.854	-5	-5	-5	-0.854	-1.523	-1.52	-1.52
Baseflow Total Phosphorus Standard Deviation (log mg/L)	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.13	0.13	0.13
Baseflow Total Phosphorus Estimation Method	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean
Baseflow Total Phosphorus Serial Correlation	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Baseflow Total Nitrogen Mean (log mg/L)	0.113	-5	-5	0.113	-5	-5	0.113	-5	0.113	-5	-5	0.113	-5	-5	-5	0.113	-0.523	-0.52	-0.52
Baseflow Total Nitrogen Standard Deviation (log mg/L)	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.13	0.13	0.13
Baseflow Total Nitrogen Estimation Method	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean
Baseflow Total Nitrogen Serial Correlation	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
OUT - Mean Annual Flow (ML/yr)	3.67	3.7	2.1	3.67	3.7	1.85	2.16	2.03	3.36	0.443	3.88	3.36	2.52	1.09	3.51	4.63	0.83	6.19	2.1
OUT - TSS Mean Annual Load (kg/yr)	403	73.8	524	403	73.8	36.9	238	40.6	369	111	77.4	369	629	273	70.1	509	20.1	150	50.9
OUT - TP Mean Annual Load (kg/yr)	0.819	0.481	0.976	0.819	0.481	0.24	0.483	0.264	0.75	0.207	0.505	0.75	1.17	0.509	0.457	1.03	4.71E-02	0.35	0.119
OUT - TN Mean Annual Load (kg/yr)	6.71	7.39	4.26	6.71	7.39	3.7	3.96	4.07	6.15	0.903	7.76	6.15	5.11	2.22	7.02	8.48	0.515	3.84	1.31
OUT - Gross Pollutant Mean Annual Load (kg/yr)	86.9	91.1	57.4	86.9	91.1	45.5	51.2	50.1	79.5	12.1	95.6	79.5	68.9	30	86.5	110	0	0	0

Source nodes	3	RI(t)	RJ(t)	RG(nt)	RG (st)	RG(et)	OS	existing RJ	existing RI	existing RH	existing R8
Location	ForestSourceNode	UrbanSourceNode	UrbanSourceNode	UrbanSourceNode	UrbanSourceNode	UrbanSourceNode	ForestSourceNode	UrbanSourceNode	UrbanSourceNode	UrbanSourceNode	UrbanSourceNode
Node Type	1.616	0.162	0.25	0.216	0.688	0.17	2.3	0.066	0.191	0.61	0.722
Total Area (ha)	0.00	0.10	0.15	0.13	0.41	0.10	0.00	0.04	0.11	0.37	0.43
Area Impervious (ha)	1.62	0.06	0.10	0.09	0.28	0.07	2.30	0.03	0.08	0.24	0.29
Area Pervious (ha)	170	170	170	170	170	170	170	170	170	170	170
Field Capacity (mm)	200	200	200	200	200	200	200	200	200	200	200
Pervious Area Infiltration Capacity coefficient - a	1	1	1	1	1	1	1	1	1	1	1
Pervious Area Infiltration Capacity exponent - b	1	1	1	1	1	1	1	1	1	1	1
Impervious Area Rainfall Threshold (mm/day)	200	200	200	200	200	200	200	200	200	200	200
Pervious Area Soil Storage Capacity (mm)	30	30	30	30	30	30	30	30	30	30	30
Pervious Area Soil Initial Storage (% of Capacity)	10	10	10	10	10	10	10	10	10	10	10
Groundwater Initial Depth (mm)	25	25	25	25	25	25	25	25	25	25	25
Groundwater Daily Recharge Rate (%)	5	5	5	5	5	5	5	5	5	5	5
Groundwater Daily Baseflow Rate (%)	0	0	0	0	0	0	0	0	0	0	0
Groundwater Daily Deep Seepage Rate (%)	1.602	2.43	2.43	2.43	2.43	2.43	1.602	2.43	2.43	2.43	2.43
Stormflow Total Suspended Solids Mean (log mg/L)	0.2	0.32	0.32	0.32	0.32	0.32	0.2	0.32	0.32	0.32	0.32
Stormflow Total Suspended Solids Standard Deviation (log mg/L)	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean
Stormflow Total Suspended Solids Estimation Method	0	0	0	0	0	0	0	0	0	0	0
Stormflow Total Suspended Solids Serial Correlation	-1.097	-0.3	-0.3	-0.3	-0.3	-0.3	-1.097	-0.3	-0.3	-0.3	-0.3
Stormflow Total Phosphorus Mean (log mg/L)	0.22	0.25	0.25	0.25	0.25	0.25	0.22	0.25	0.25	0.25	0.25
Stormflow Total Phosphorus Standard Deviation (log mg/L)	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean
Stormflow Total Phosphorus Estimation Method	0	0	0	0	0	0	0	0	0	0	0
Stormflow Total Phosphorus Serial Correlation	-0.046	0.34	0.34	0.34	0.34	0.34	-0.046	0.34	0.34	0.34	0.34
Stormflow Total Nitrogen Mean (log mg/L)	0.24	0.19	0.19	0.19	0.19	0.19	0.24	0.19	0.19	0.19	0.19
Stormflow Total Nitrogen Standard Deviation (log mg/L)	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean
Stormflow Total Nitrogen Estimation Method	0	0	0	0	0	0	0	0	0	0	0
Stormflow Total Nitrogen Serial Correlation	0.778	-5	-5	-5	-5	-5	0.778	-2	-2	-2	-2

Baseflow Total Suspended Solids Mean (log mg/L)	0.13	0.17	0.17	0.17	0.17	0.17	0.13	0.17	0.17	0.17	0.17
Baseflow Total Suspended Solids Standard Deviation (log mg/L)	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean
Baseflow Total Suspended Solids Estimation Method	0	0	0	0	0	0	0	0	0	0	0
Baseflow Total Suspended Solids Serial Correlation	-1.523	-5	-5	-5	-5	-5	-1.523	-2	-2	-2	-2
Baseflow Total Phosphorus Mean (log mg/L)	0.13	0.19	0.19	0.19	0.19	0.19	0.13	0.19	0.19	0.19	0.19
Baseflow Total Phosphorus Standard Deviation (log mg/L)	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean
Baseflow Total Phosphorus Estimation Method	0	0	0	0	0	0	0	0	0	0	0
Baseflow Total Phosphorus Serial Correlation	-0.523	-5	-5	-5	-5	-5	-0.523	-2	-2	-2	-2
Baseflow Total Nitrogen Mean (log mg/L)	0.13	0.12	0.12	0.12	0.12	0.12	0.13	0.12	0.12	0.12	0.12
Baseflow Total Nitrogen Standard Deviation (log mg/L)	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean
Baseflow Total Nitrogen Estimation Method	0	0	0	0	0	0	0	0	0	0	0
Baseflow Total Nitrogen Serial Correlation	4.07	1.06	1.64	1.42	4.51	1.11	5.79	0.432	1.25	4	4.68
OUT - Mean Annual Flow (ML/yr)	98.4	265	409	354	1.13E+03	278	140	108	313	999	1.17E+03
OUT - TSS Mean Annual Load (kg/yr)	0.231	0.494	0.762	0.659	2.1	0.518	0.328	0.202	0.583	1.86	2.18
OUT - TP Mean Annual Load (kg/yr)	2.52	2.16	3.33	2.87	9.16	2.26	3.59	0.879	2.54	8.12	9.49
OUT - TN Mean Annual Load (kg/yr)	0	29.1	44.9	38.8	123	30.5	0	11.8	34.3	109	128
OUT - Gross Pollutant Mean Annual Load (kg/yr)											

USTM treatment nodes

Location	42 raintanks	Swale	Pond	Wetland	RW Tank	Bio-Retention	Swale	Rain Garden	Perm Pavement	creek	5 RAINTANKS	5 RAINTANKS
ID	2	7	8	9	10	14	15	16	17	20	24	28
Node Type	RainWaterTankNode	SwaleNode	PondNode	WetlandNode	RainWaterTankNode	BioRetentionNode	SwaleNode	BioRetentionNode	BioRetentionNode	SwaleNode	RainWaterTankNode	RainWaterTankNode
Lo-flow bypass rate (cum/sec)	0	0	0	0	0	0	0	0	0	0	0	0
Hi-flow bypass rate (cum/sec)	6.8		10	10	100	100		100	100		6.8	6.8
Inlet pond volume	0		0	50	0						0	0
Area (sqm)	210		300	50	50	95		11.5	18		25	25
Extended detention depth (m)	0.6	0.3	0.5	0.2	0.1	0.1	0.5	0.15	0.2	0.3	0.6	0.6
Permanent pool volume (cum)	210		225	15	100						25	25
Proportion vegetated	0		0.1	0.5	0						0	0
Equivalent pipe diameter (mm)	50		100	50	50						50	50
Overflow weir width (m)	10		2	3	10	1		0.6	2		10	10
Notional Detention Time (hrs)	7.76		2.53	1.07	0.754						0.923	0.923
Orifice discharge coefficient	0.6		0.6	0.6	0.6						0.6	0.6
Weir coefficient	1.7		1.7	1.7	1.7	1.7		1.7	1.7		1.7	1.7
Number of CSTR cells	2	10	2	5	2	3	10	3	3	10	2	2
Total Suspended Solids k (m/yr)	400	8000	400	1500	400	8000	8000	8000	8000	8000	400	400
Total Suspended Solids C* (mg/L)	12	20	12	6	12	20	20	20	20	20	12	12
Total Suspended Solids C** (mg/L)	12	14	12	6	12		14			14	12	12
Total Phosphorus k (m/yr)	300	6000	300	1000	300	6000	6000	6000	6000	6000	300	300
Total Phosphorus C* (mg/L)	0.13	0.13	0.09	0.06	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13
Total Phosphorus C** (mg/L)	0.13	0.13	0.09	0.06	0.13		0.13			0.13	0.13	0.13
Total Nitrogen k (m/yr)	40	500	40	150	40	500	500	500	500	500	40	40
Total Nitrogen C* (mg/L)	1.4	1.4	1	1	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4
Total Nitrogen C** (mg/L)	1.4	1.4	1	1	1.4		1.4			1.4	1.4	1.4
Threshold hydraulic loading for C** (m/yr)	3500	3500	3500	3500	3500		3500			3500	3500	3500
Extraction for Re-use	On	Off	Off	Off	On	Off	Off	Off	Off	Off	On	On
Annual Re-use Demand - scaled by daily PET (ML)	0				1.262						0	0
Constant Daily Re-use Demand (kL)	1.26				0						0.05	0.05
User-defined Annual Re-use Demand (ML)	0				0						0	0
Percentage of User-defined Annual Re-use Demand Jan	8.333333333				8.3333333						8.3333333	8.3333333
Percentage of User-defined Annual Re-use Demand Feb	8.333333333				8.3333333						8.3333333	8.3333333
Percentage of User-defined Annual Re-use Demand Mar	8.333333333				8.3333333						8.3333333	8.3333333
Percentage of User-defined Annual Re-use Demand Apr	8.333333333				8.3333333						8.3333333	8.3333333
Percentage of User-defined Annual Re-use Demand May	8.333333333				8.3333333						8.3333333	8.3333333
Percentage of User-defined Annual Re-use Demand Jun	8.333333333				8.3333333						8.3333333	8.3333333
Percentage of User-defined Annual Re-use Demand Jul	8.333333333				8.3333333						8.3333333	8.3333333

Percentage of User-defined Annual Re-use Demand Aug	8.333333333				8.3333333						8.3333333	8.3333333
Percentage of User-defined Annual Re-use Demand Sep	8.333333333				8.3333333						8.3333333	8.3333333
Percentage of User-defined Annual Re-use Demand Oct	8.333333333				8.3333333						8.3333333	8.3333333
Percentage of User-defined Annual Re-use Demand Nov	8.333333333				8.3333333						8.3333333	8.3333333
Percentage of User-defined Annual Re-use Demand Dec	8.333333333				8.3333333						8.3333333	8.3333333
Filter area (sqm)						14		6	18			
Filter depth (m)						0.3		0.3	1			
Filter median particle diameter (mm)						1		1	1			
Saturated hydraulic conductivity (mm/hr)						360		360	360			
Voids ratio						0.3		0.3	0.3			
Length (m)		50					100			70		
Bed slope		0.04					0.03			0.015		
Base Width (m)		1					1			1		
Top width (m)		3					5			3		
Vegetation height (m)		0.25					0.25			0.25		
Proportion of upstream impervious area treated												
Seepage Rate (mm/hr)	0	5	5	36	0	1	0	1	3.6	5	0	0
Evap Loss as proportion of PET	0		1	1.25	0						0	0
Depth in metres below the drain pipe						0		0	0.5			
IN - Mean Annual Flow (ML/yr)	7.76	0	0	0	0	0	0	0	0	0	0.924	0.924
IN - TSS Mean Annual Load (kg/yr)	155	0	0	0	0	0	0	0	0	0	18.4	18.4
IN - TP Mean Annual Load (kg/yr)	1.01	0	0	0	0	0	0	0	0	0	0.12	0.12
IN - TN Mean Annual Load (kg/yr)	15.5	0	0	0	0	0	0	0	0	0	1.85	1.85
IN - Gross Pollutant Mean Annual Load (kg/yr)	191	0	0	0	0	0	0	0	0	0	22.8	22.8
OUT - Mean Annual Flow (ML/yr)	7.28	0	0	0	0	0	0	0	0	0	0.906	0.906
OUT - TSS Mean Annual Load (kg/yr)	109	0	0	0	0	0	0	0	0	0	13.5	13.5
OUT - TP Mean Annual Load (kg/yr)	0.947	0	0	0	0	0	0	0	0	0	0.118	0.118
OUT - TN Mean Annual Load (kg/yr)	13.1	0	0	0	0	0	0	0	0	0	1.61	1.61
OUT - Gross Pollutant Mean Annual Load (kg/yr)	0	0	0	0	0	0	0	0	0	0	0	0

USTM treatment nodes

Location	5 RAINTANKS	17 RAINTANKS	20 RAINTANKS	SWALE	20 RAINTANKS	10 RAINTANKS	11 RAINTANKS	SWALE	14 RAINTANKS	19 RAINTANKS	SWALE	SWALE
ID	32	39	46	47	51	52	59	62	67	72	77	82
Node Type	RainWaterTankNode	RainWaterTankNode	RainWaterTankNode	SwaleNode	RainWaterTankNode	RainWaterTankNode	RainWaterTankNode	SwaleNode	RainWaterTankNode	RainWaterTankNode	SwaleNode	SwaleNode
Lo-flow bypass rate (cum/sec)	0	0	0	0	0	0	0	0	0	0	0	0
Hi-flow bypass rate (cum/sec)	6.8	100	6.8		6.8	6.8	6.8		6.8	6.8		
Inlet pond volume	0	0	0		0	0	0		0	0		
Area (sqm)	25	85	100		100	50	55		70	95		
Extended detention depth (m)	0.6	0.6	0.6	0.3	0.6	0.6	0.6	0.3	0.6	0.6	0.3	0.3
Permanent pool volume (cum)	25	85	100		100	50	55		70	95		
Proportion vegetated	0	0	0		0	0	0		0	0		
Equivalent pipe diameter (mm)	50	50	50		50	50	50		50	50		
Overflow weir width (m)	10	10	10		10	10	10		10	10		
Notional Detention Time (hrs)	0.923	3.14	3.69		3.69	1.85	2.03		2.59	3.51		
Orifice discharge coefficient	0.6	0.6	0.6		0.6	0.6	0.6		0.6	0.6		
Weir coefficient	1.7	1.7	1.7		1.7	1.7	1.7		1.7	1.7		
Number of CSTR cells	2	2	2	10	2	2	2	10	2	2	10	10
Total Suspended Solids k (m/yr)	400	400	400	8000	400	400	400	8000	400	400	8000	8000
Total Suspended Solids C* (mg/L)	12	12	12	20	12	12	12	20	12	12	20	20
Total Suspended Solids C** (mg/L)	12	12	12	14	12	12	12	14	12	12	14	14
Total Phosphorus k (m/yr)	300	300	300	6000	300	300	300	6000	300	300	6000	6000
Total Phosphorus C* (mg/L)	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13
Total Phosphorus C** (mg/L)	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13
Total Nitrogen k (m/yr)	40	40	40	500	40	40	40	500	40	40	500	500
Total Nitrogen C* (mg/L)	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4
Total Nitrogen C** (mg/L)	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4

Threshold hydraulic loading for C** (m/yr)	3500	3500	3500	3500	3500	3500	3500	3500	3500	3500	3500	3500
Extraction for Re-use	On	On	On	Off	On	On	On	Off	On	On	Off	Off
Annual Re-use Demand - scaled by daily PET (ML)	0	0	0		0	0	0		0	0		
Constant Daily Re-use Demand (kL)	0.05	0.17	600		600	300	0.33		0.42	0.57		
User-defined Annual Re-use Demand (ML)	0	0	0		0	0	0		0	0		
Percentage of User-defined Annual Re-use Demand Jan	8.333333333	8.3333333	8.3333333		8.3333333	8.333333333	8.3333333		8.3333333	8.3333333		
Percentage of User-defined Annual Re-use Demand Feb	8.333333333	8.3333333	8.3333333		8.3333333	8.333333333	8.3333333		8.3333333	8.3333333		
Percentage of User-defined Annual Re-use Demand Mar	8.333333333	8.3333333	8.3333333		8.3333333	8.333333333	8.3333333		8.3333333	8.3333333		
Percentage of User-defined Annual Re-use Demand Apr	8.333333333	8.3333333	8.3333333		8.3333333	8.333333333	8.3333333		8.3333333	8.3333333		
Percentage of User-defined Annual Re-use Demand May	8.333333333	8.3333333	8.3333333		8.3333333	8.333333333	8.3333333		8.3333333	8.3333333		
Percentage of User-defined Annual Re-use Demand Jun	8.333333333	8.3333333	8.3333333		8.3333333	8.333333333	8.3333333		8.3333333	8.3333333		
Percentage of User-defined Annual Re-use Demand Jul	8.333333333	8.3333333	8.3333333		8.3333333	8.333333333	8.3333333		8.3333333	8.3333333		
Percentage of User-defined Annual Re-use Demand Aug	8.333333333	8.3333333	8.3333333		8.3333333	8.333333333	8.3333333		8.3333333	8.3333333		
Percentage of User-defined Annual Re-use Demand Sep	8.333333333	8.3333333	8.3333333		8.3333333	8.333333333	8.3333333		8.3333333	8.3333333		
Percentage of User-defined Annual Re-use Demand Oct	8.333333333	8.3333333	8.3333333		8.3333333	8.333333333	8.3333333		8.3333333	8.3333333		
Percentage of User-defined Annual Re-use Demand Nov	8.333333333	8.3333333	8.3333333		8.3333333	8.333333333	8.3333333		8.3333333	8.3333333		
Percentage of User-defined Annual Re-use Demand Dec	8.333333333	8.3333333	8.3333333		8.3333333	8.333333333	8.3333333		8.3333333	8.3333333		
Filter area (sqm)												
Filter depth (m)												
Filter median particle diameter (mm)												
Saturated hydraulic conductivity (mm/hr)												
Voids ratio												
Length (m)				100				50			45	137.5
Bed slope				0.03				0.01			0.01	0.01
Base Width (m)				1				1			1	1
Top width (m)				3				3			3	3
Vegetation height (m)				0.25				0.25			0.25	0.25
Proportion of upstream impervious area treated												
Seepage Rate (mm/hr)	0	0	0	5	0	0	0	1	0	0	1	2
Evap Loss as proportion of PET	0	0	0		0	0	0		0	0		
Depth in metres below the drain pipe												
IN - Mean Annual Flow (ML/yr)	0.924	3.14	3.7	0	3.7	1.85	2.03	1.64	3.88	3.51	1.06	4.51
IN - TSS Mean Annual Load (kg/yr)	18.4	62.7	73.8	0	73.8	36.9	40.6	409	77.4	70.1	265	1.13E+03
IN - TP Mean Annual Load (kg/yr)	0.12	0.409	0.481	0	0.481	0.24	0.264	0.762	0.505	0.457	0.494	2.1
IN - TN Mean Annual Load (kg/yr)	1.85	6.28	7.39	0	7.39	3.7	4.07	3.33	7.76	7.02	2.16	9.16
IN - Gross Pollutant Mean Annual Load (kg/yr)	22.8	77.4	91.1	0	91.1	45.5	50.1	44.9	95.6	86.5	29.1	123
OUT - Mean Annual Flow (ML/yr)	0.906	3.08	1.17E-02	0	1.17E-02	9.01E-03	1.91	1.51	3.73	3.3	0.96	3.93
OUT - TSS Mean Annual Load (kg/yr)	13.5	45.9	0.22	0	0.22	0.169	28.7	28.7	58.8	49.6	16.4	68
OUT - TP Mean Annual Load (kg/yr)	0.118	0.4	1.52E-03	0	1.52E-03	1.17E-03	0.249	0.213	0.485	0.43	0.132	0.542
OUT - TN Mean Annual Load (kg/yr)	1.61	5.49	2.32E-02	0	2.32E-02	1.79E-02	3.42	2.63	6.86	5.92	1.63	6.73
OUT - Gross Pollutant Mean Annual Load (kg/yr)	0	0	0	0	0	0	0	0	0	0	0	0

USTM treatment nodes

Location	SWALE	SWALE	SWALE	Wetland 1	WETLAND 2	Wetland 3	Infiltration H	Infiltration J	Infiltration I	Infiltration G	Infiltration B	Infiltration A
ID	83	85	86	88	89	90	91	93	94	95	96	101
Node Type	SwaleNode	SwaleNode	SwaleNode	WetlandNode	WetlandNode	WetlandNode	InfiltrationSystemNode	InfiltrationSystemNode	InfiltrationSystemNode	InfiltrationSystemNode	InfiltrationSystemNode	InfiltrationSystemNode
Lo-flow bypass rate (cum/sec)	0	0	0	0	0	0	0	0	0	0	0	0
Hi-flow bypass rate (cum/sec)				1	100	2	100	100	100	100	100	100
Inlet pond volume				50	84.2	46.1	0	0	0	0	0	0
Area (sqm)				857.5	900	568.6	34	28	22	38	84	10
Extended detention depth (m)	0.3	0.3	0.3	0.6	0.6	0.6	1	1	1	1	1	1
Permanent pool volume (cum)				175.1	178.6	102	0	0	0	0	0	0

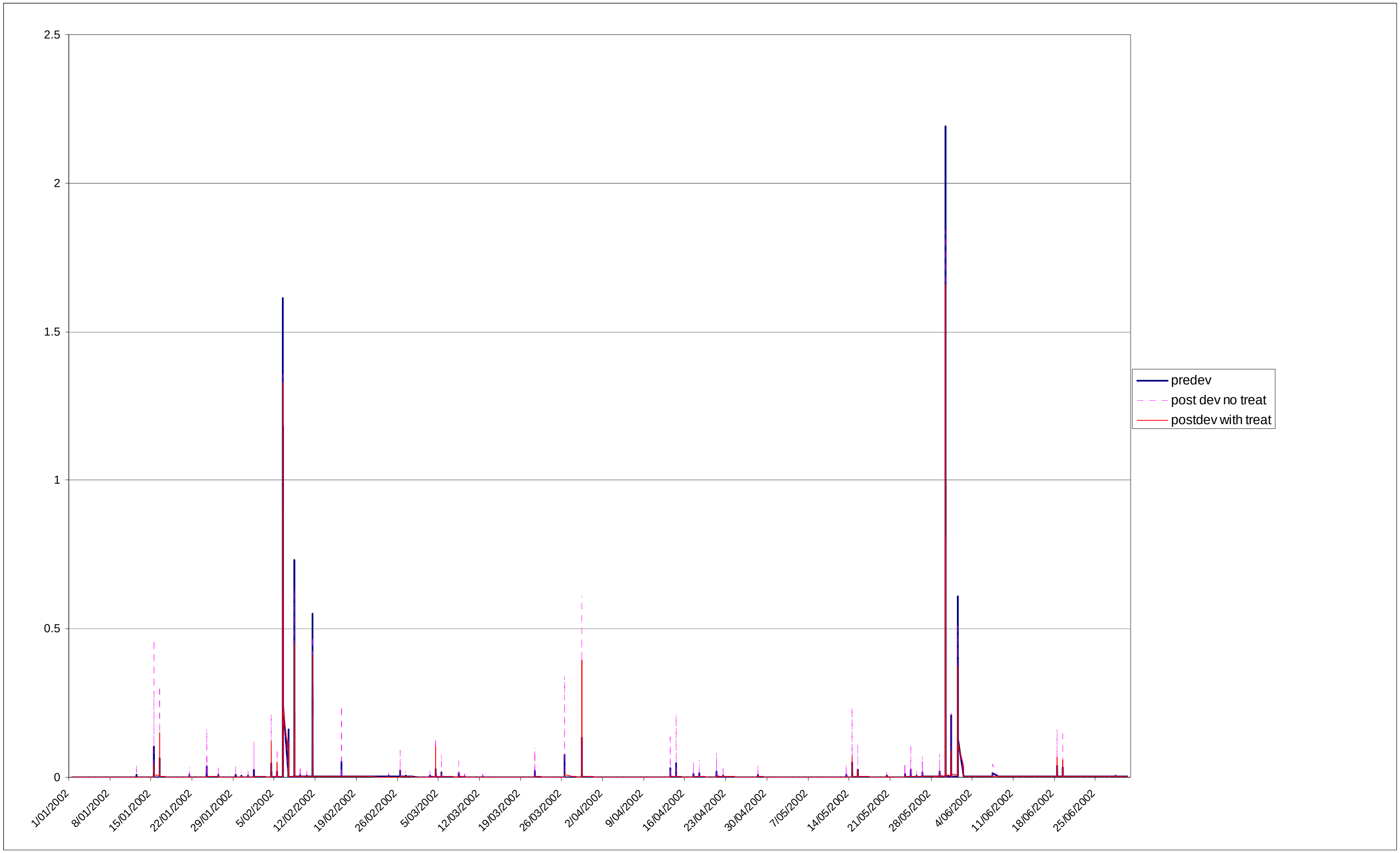
Proportion vegetated				0.5	0.5	0.5	0	0	0	0	0	0
Equivalent pipe diameter (mm)				40	40	30	0	0	0	0	0	0
Overflow weir width (m)				3	3	3	17	14	11	19	42	5
Notional Detention Time (hrs)				49.5	51.9	58.3	0	0	0	0	0	0
Orifice discharge coefficient				0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
Weir coefficient				1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7
Number of CSTR cells	10	10	10	5	5	5	1	1	1	1	1	1
Total Suspended Solids k (m/yr)	8000	8000	8000	1500	1500	1500	400	400	400	400	400	400
Total Suspended Solids C* (mg/L)	20	20	20	6	6	6	12	12	12	12	12	12
Total Suspended Solids C** (mg/L)	14	14	14	6	6	6	12	12	12	12	12	12
Total Phosphorus k (m/yr)	6000	6000	6000	1000	1000	1000	300	300	300	300	300	300
Total Phosphorus C* (mg/L)	0.13	0.13	0.13	0.06	0.06	0.06	0.09	0.09	0.09	0.09	0.09	0.09
Total Phosphorus C** (mg/L)	0.13	0.13	0.13	0.06	0.06	0.06	0.09	0.09	0.09	0.09	0.09	0.09
Total Nitrogen k (m/yr)	500	500	500	250	250	150	40	40	40	40	40	40
Total Nitrogen C* (mg/L)	1.4	1.4	1.4	0.9	0.9	1	1	1	1	1	1	1
Total Nitrogen C** (mg/L)	1.4	1.4	1.4	1	1	1	1	1	1	1	1	1
Threshold hydraulic loading for C** (m/yr)	3500	3500	3500	3500	3500	3500	3500	3500	3500	3500	3500	3500
Extraction for Re-use	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off
Annual Re-use Demand - scaled by daily PET (ML)												
Constant Daily Re-use Demand (kL)												
User-defined Annual Re-use Demand (ML)												
Percentage of User-defined Annual Re-use Demand Jan												
Percentage of User-defined Annual Re-use Demand Feb												
Percentage of User-defined Annual Re-use Demand Mar												
Percentage of User-defined Annual Re-use Demand Apr												
Percentage of User-defined Annual Re-use Demand May												
Percentage of User-defined Annual Re-use Demand Jun												
Percentage of User-defined Annual Re-use Demand Jul												
Percentage of User-defined Annual Re-use Demand Aug												
Percentage of User-defined Annual Re-use Demand Sep												
Percentage of User-defined Annual Re-use Demand Oct												
Percentage of User-defined Annual Re-use Demand Nov												
Percentage of User-defined Annual Re-use Demand Dec												
Filter area (sqm)												
Filter depth (m)												
Filter median particle diameter (mm)												
Saturated hydraulic conductivity (mm/hr)												
Voids ratio												
Length (m)	60	88.5	88.5									
Bed slope	0.01	0.01	0.01									
Base Width (m)	1	1	1									
Top width (m)	3	3	3									
Vegetation height (m)	0.25	0.25	0.25									
Proportion of upstream impervious area treated												
Seepage Rate (mm/hr)	2	1	2	1	1	2	1	1	1	2	2	2
Evap Loss as proportion of PET				1	1	1	1.25	1.25	1.25	1	1	1
Depth in metres below the drain pipe												
IN - Mean Annual Flow (ML/yr)	1.42	2.1	2.1	15.8	23	46.7	3.67	3.36	3.36	4.63	8.19	0.965
IN - TSS Mean Annual Load (kg/yr)	354	524	524	2.20E+03	1.91E+03	2.63E+03	403	369	369	509	900	106
IN - TP Mean Annual Load (kg/yr)	0.659	0.976	0.976	4.55	4.63	8.8	0.819	0.75	0.75	1.03	1.83	0.216
IN - TN Mean Annual Load (kg/yr)	2.87	4.26	4.26	27.4	37.2	73.8	6.71	6.15	6.15	8.48	15	1.77
IN - Gross Pollutant Mean Annual Load (kg/yr)	38.8	57.4	57.4	201	127	13.5	86.9	79.5	79.5	110	194	22.9
OUT - Mean Annual Flow (ML/yr)	1.23	1.88	1.81	10.4	16.9	40.3	3.31	3.06	3.12	3.98	6.78	0.798
OUT - TSS Mean Annual Load (kg/yr)	20.8	30.8	29.7	514	664	1.86E+03	270	254	267	343	573	67

OUT - TP Mean Annual Load (kg/yr)	0.169	0.256	0.246	1.42	2.04	6.54	0.608	0.567	0.59	0.755	1.27	0.149
OUT - TN Mean Annual Load (kg/yr)	2.09	3.17	3.05	13.5	22.1	61.6	5.7	5.29	5.43	6.96	11.8	1.39
OUT - Gross Pollutant Mean Annual Load (kg/yr)	0	0	0	0	0	0	0	0	0	0	0	0

USTM treatment nodes							
Location	Infiltration C	Infiltration E	Infiltration F	Infiltration K	Infiltration D	Wetland 4	Sandfilter
ID	102	103	104	105	106	107	108
Node Type	InfiltrationSystemNode	InfiltrationSystemNode	InfiltrationSystemNode	InfiltrationSystemNode	InfiltrationSystemNode	WetlandNode	BioRetentionNode
Lo-flow bypass rate (cum/sec)	0	0	0	0	0	0	0
Hi-flow bypass rate (cum/sec)	100	100	100	100	100	1	1
Inlet pond volume	0	0	0	0	0	52.1	
Area (sqm)	10	10	40	20	40	733.8	900
Extended detention depth (m)	1	1	1	1	1	0.6	0.6
Permanent pool volume (cum)	0	0	0	0	0	140.8	
Proportion vegetated	0	0	0	0	0	0.5	
Equivalent pipe diameter (mm)	0	0	0	0	0	30	
Overflow weir width (m)	5	5	20	10	20	3	0.6
Notional Detention Time (hrs)	0	0	0	0	0	75.3	
Orifice discharge coefficient	0.6	0.6	0.6	0.6	0.6	0.6	
Weir coefficient	1.7	1.7	1.7	1.7	1.7	1.7	1.7
Number of CSTR cells	1	1	1	1	1	5	3
Total Suspended Solids k (m/yr)	400	400	400	400	400	1500	8000
Total Suspended Solids C* (mg/L)	12	12	12	12	12	6	20
Total Suspended Solids C** (mg/L)	12	12	12	12	12	6	
Total Phosphorus k (m/yr)	300	300	300	300	300	1000	6000
Total Phosphorus C* (mg/L)	0.09	0.09	0.09	0.09	0.09	0.06	0.13
Total Phosphorus C** (mg/L)	0.09	0.09	0.09	0.09	0.09	0.06	
Total Nitrogen k (m/yr)	40	40	40	40	40	150	500
Total Nitrogen C* (mg/L)	1	1	1	1	1	1	1.4
Total Nitrogen C** (mg/L)	1	1	1	1	1	1	
Threshold hydraulic loading for C** (m/yr)	3500	3500	3500	3500	3500	3500	
Extraction for Re-use	Off	Off	Off	Off	Off	Off	Off
Annual Re-use Demand - scaled by daily PET (ML)							
Constant Daily Re-use Demand (kL)							
User-defined Annual Re-use Demand (ML)							
Percentage of User-defined Annual Re-use Demand Jan							
Percentage of User-defined Annual Re-use Demand Feb							
Percentage of User-defined Annual Re-use Demand Mar							
Percentage of User-defined Annual Re-use Demand Apr							
Percentage of User-defined Annual Re-use Demand May							
Percentage of User-defined Annual Re-use Demand Jun							
Percentage of User-defined Annual Re-use Demand Jul							
Percentage of User-defined Annual Re-use Demand Aug							
Percentage of User-defined Annual Re-use Demand Sep							
Percentage of User-defined Annual Re-use Demand Oct							
Percentage of User-defined Annual Re-use Demand Nov							
Percentage of User-defined Annual Re-use Demand Dec							
Filter area (sqm)							900
Filter depth (m)							0.3
Filter median particle diameter (mm)							1
Saturated hydraulic conductivity (mm/hr)							120
Voids ratio							0.3

Length (m)							
Bed slope							
Base Width (m)							
Top width (m)							
Vegetation height (m)							
Proportion of upstream impervious area treated							
Seepage Rate (mm/hr)	2	2	2	2	2	2	1
Evap Loss as proportion of PET	1	1	1	1	1	1	
Depth in metres below the drain pipe							0.0003
IN - Mean Annual Flow (ML/yr)	0.965	0.965	3.67	2.16	3.67	14.4	0
IN - TSS Mean Annual Load (kg/yr)	106	106	403	238	403	2.14E+03	0
IN - TP Mean Annual Load (kg/yr)	0.216	0.216	0.819	0.483	0.819	4.31	0
IN - TN Mean Annual Load (kg/yr)	1.77	1.77	6.71	3.96	6.71	26.9	0
IN - Gross Pollutant Mean Annual Load (kg/yr)	22.9	22.9	86.9	51.2	86.9	163	0
OUT - Mean Annual Flow (ML/yr)	0.798	0.798	3	1.82	3	8.22	0
OUT - TSS Mean Annual Load (kg/yr)	67	67	251	155	251	644	0
OUT - TP Mean Annual Load (kg/yr)	0.149	0.149	0.558	0.343	0.558	1.51	0
OUT - TN Mean Annual Load (kg/yr)	1.39	1.39	5.22	3.18	5.22	13.5	0
OUT - Gross Pollutant Mean Annual Load (kg/yr)	0	0	0	0	0	0	0

APPENDIX C
Comparison of 6 months rainfall


2.5
2
1.5
1
0.5
0
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8/01/2002
15/01/2002
22/01/2002
29/01/2002
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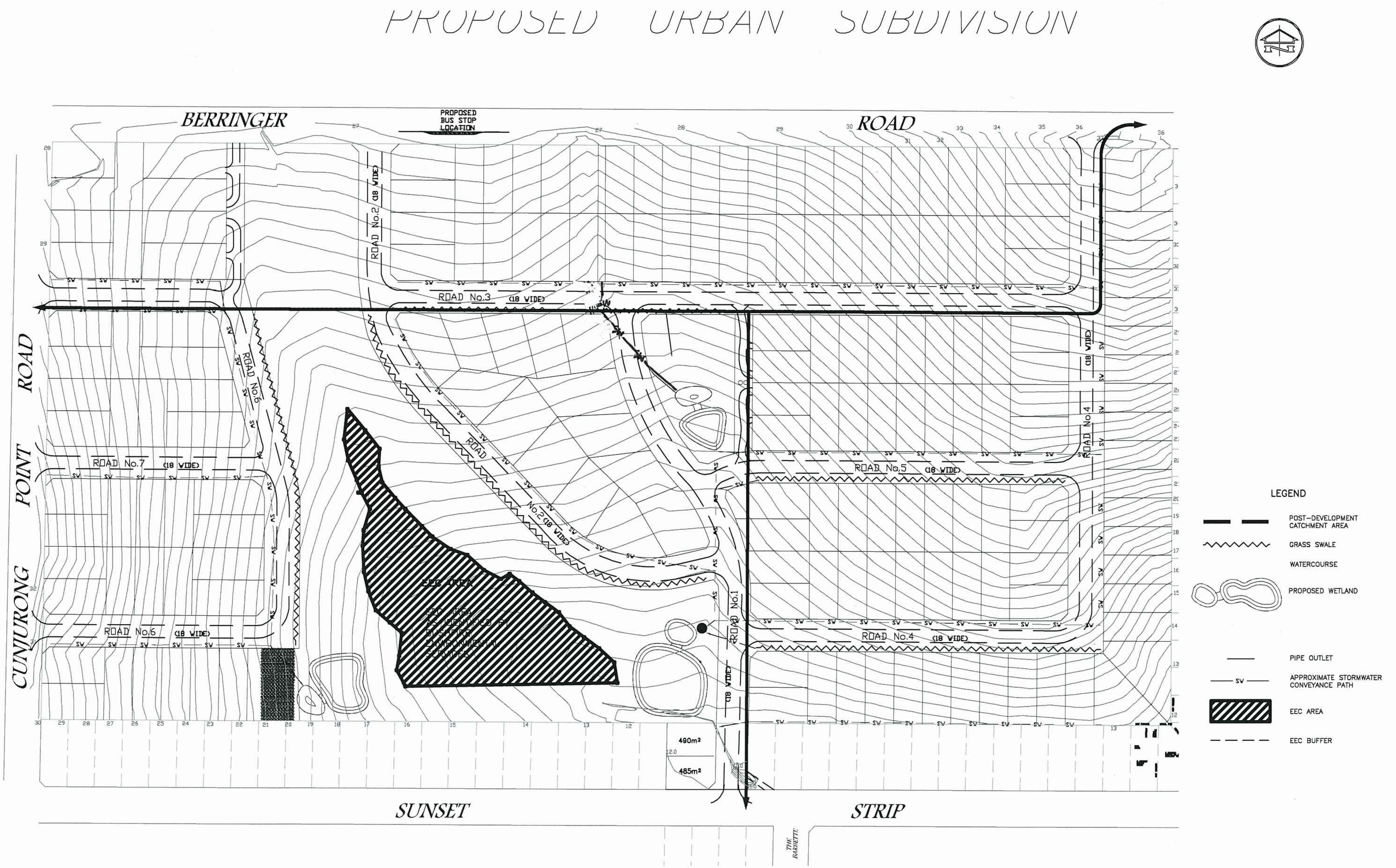
12/02/2002
19/02/2002
26/02/2002
5/03/2002
12/03/2002
19/03/2002
26/03/2002
2/04/2002
9/04/2002
16/04/2002
23/04/2002
30/04/2002
7/05/2002
14/05/2002
21/05/2002
28/05/2002
4/06/2002
11/06/2002
18/06/2002
25/06/2002
predev
post dev no treat
postdev with treat

APPENDIX D
Stormwater Masterplan

STORM_CONSULTING SUITE 3, 6 WEST STREET PYMBLE NSW, AUSTRALIA 2073 PH: +61 2 9499 4333 FAX: +61 2 9499 4311 www.stormconsulting.com.au



STORM_CONSULTING

ISSUE	REVISION	BY	CKD	DATE	ISSUE	REVISION	BY	CKD	DATE
A	layout H	LB	LB	12/10/07					

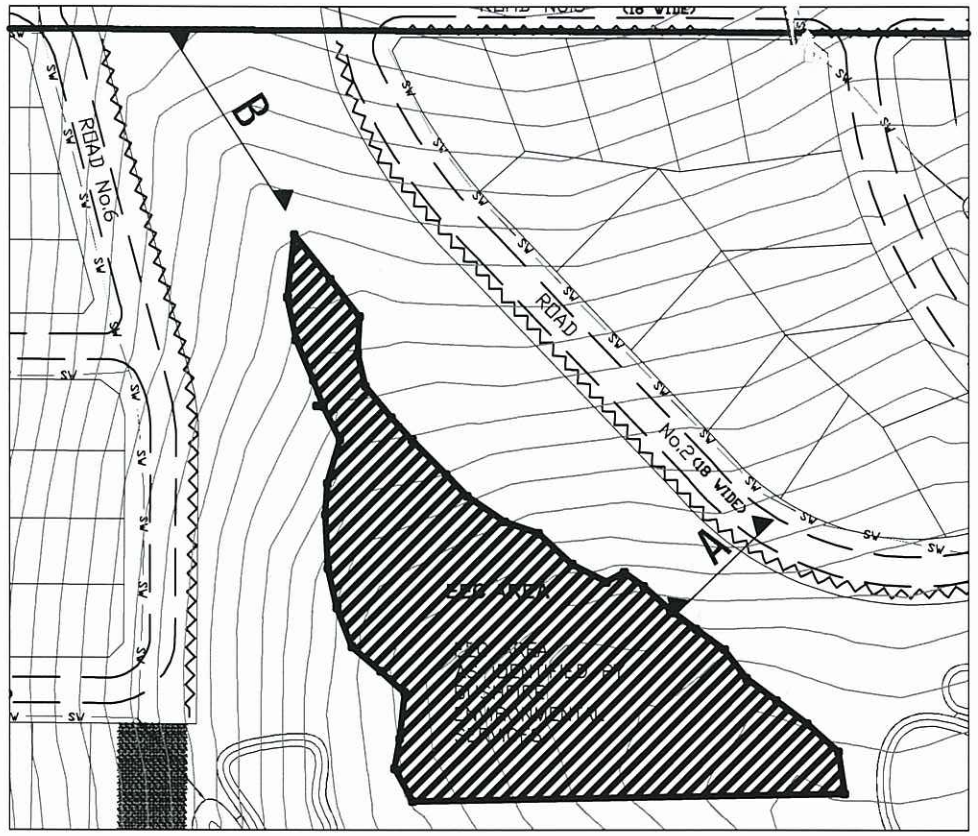
DOCUMENT PURPOSE: ADVANCED COPY: ☒ FOR CLIENT APPROVAL: ☐ FOR DA: ☐ FOR CC: ☐ FOR TENDER: ☐ FOR CONSTRUCTION: ☐

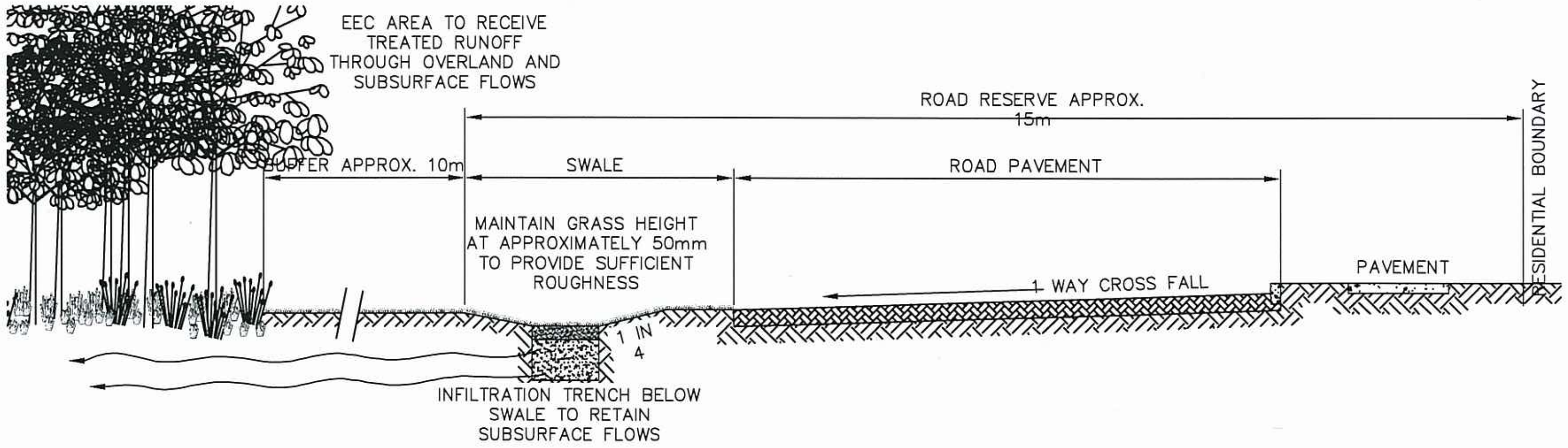
COORD. ORIGIN: N/A | SCALE: 1:2000 | DATUM: N/A | DATE: SEP 2006 | DRAWN: TC | DESIGNED: LB | CHECKED: LB

CLIENT: MALBEC PROPERTIES PTY LTD

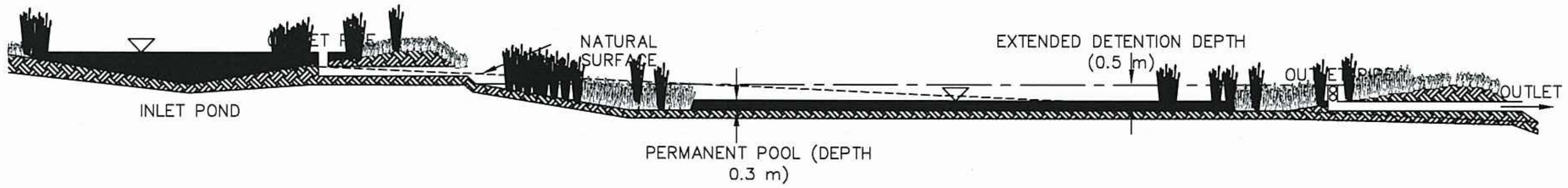
MANYANA SMP
POST DEVELOPMENT SUBCATCHMENTS & WS FEATURE LAYOUT

DRAWING: 555 P01
SHEET: 1 OF 2
A3

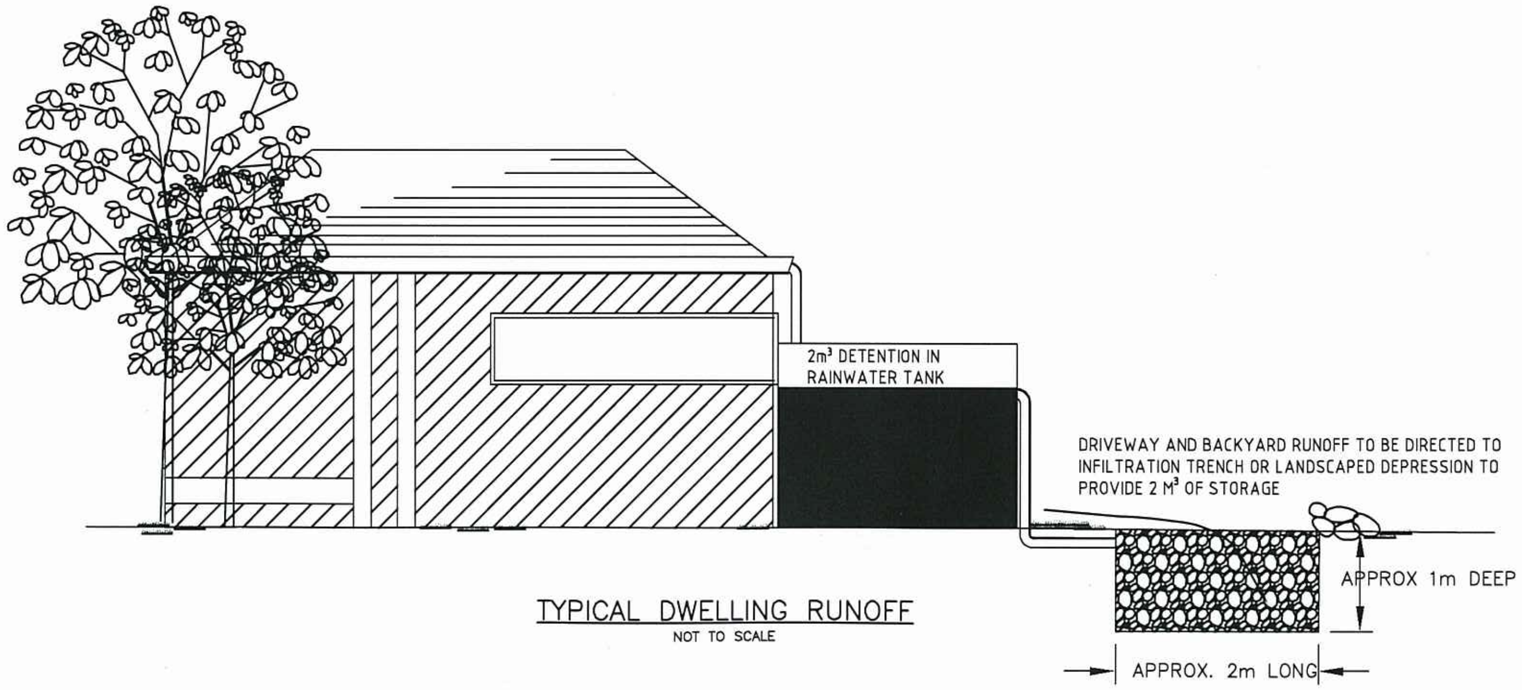




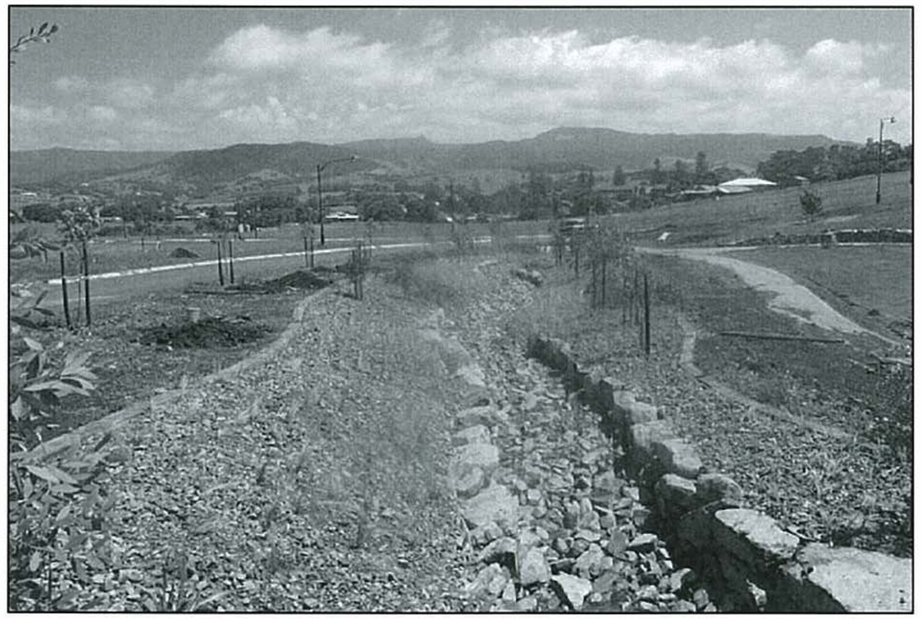
SECTION A
TYPICAL SWALE X–SECTION ADJACENT TO ROAD AND ECC AREA
NOT TO SCALE



SECTION B
TYPICAL WETLAND X–SECTION
NOT TO SCALE



TYPICAL DWELLING RUNOFF
NOT TO SCALE



EXAMPLE OF CONSTRUCTED ROCK LAND CREEK
NOT TO SCALE

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COORD. ORIGIN: N/A SCALE: NTS
DATUM: N/A DATE: SEP 2006
DRAWN: TC DESIGNED: LB CHECKED: LB

CLIENT: MALBEC PROPERTIES PTY LTD

MANYANA SMP
TYPICAL DETAIL OF WSD FEATURES ON THE SITE

DRAWING: 555 P02
SHEET: 2 OF 2
A3