Discussion Paper

Project :	**Sapphire to Woolgoolga Upgrade**
Subject:	**Arrawarra Rest Area – Feasibility Assessment of Bioretention (Scenario 4)**
Design Lot No:	**S2W-20-6000-DR818B**
Document No:	**S2W-REP-20-6000-DR818B**
Phase:	**Detailed Design**
Revision:	**01**
Date:	**21-March 2012**

This discussion paper has been prepared to identify possible design amendments to improve surface water outflow quality at Arrawarra Rest Area.

A report S2W-REP-20-6000-DR818A-DD-02, issued 29/08/2011, identified that approved drainage arrangements proposed for the rest area will not meet the WQ targets set out in DECC NSW, Managing urban stormwater: environmental targets, Consultation draft – October 2007.

These targets are:

- 85% reduction in the average annual total suspended solids load
- 65% reduction in the average annual total phosphorus load
- 45% reduction in the average annual total nitrogen load

Report DR818A-DD-02 identified that these target levels will not be met as part of the sub catchment areas from the rest area are not treated and by-pass the bioretention treatment systems. Furthermore, this report provided a discussion and modelling of three potential runoff treatment arrangements. The most comprehensive of the three options was scenario 3, which proposed that a combination of swales and bioretention could be adopted to ensure that surface water outflow met all of the aforementioned WQ targets.

Subsequently, RMS has requested LFHJV investigate amendments to the design to meet the water quality criteria. To treat all drainage catchment areas with bio retention swales the following amendments, illustrated on S2W-IFD-20-6125-GE-120308-Plan, are proposed to the alignment design:

- Flush kerbs in-lieu of barrier kerbs in some locations to ensure surface water flows to drainage swales prior to entering the drainage network.
- Amended batter slope and drainage channel adjacent to the truck parking area.
- An additional drainage swale adjacent to the truck parking area in an area of previously retained vegetation.
- A proposed drainage channel adjacent the light vehicle parking area in the northwest corner of the site. This would require an amendment to the noise wall 6NW80-SB.

The modelling and discussion of this proposed design has been added to report DR818A-DD-02 as scenario 4.

Additional Clearing

One aim of the Arrawarra Rest Area Environmental Assessment was to minimise the impact of the rest area on existing vegetation. Previously 0.5 ha of existing vegetation was retained in the design; however the proposed design for scenario 4 would require approximately 200 m2 of additional clearing to achieve the design intent.

This change to the design would require approval from RMS.

The drainage design has been modified to suit the new MX design and is shown in the plan provided as Attachment 1. Stormwater water quality modelling has been undertaken to quantify the extent of mitigation that can be provided for the proposed arrangements (Scenario 4 in the attached water quality modelling report - S2W-REP-20-6000-DR818A-FD-01) and shows that the target levels will be met for the proposed design.

Conclusions

With the amendments detailed above the Arrawarra Rest Area design could be revised to meet the water treatment targets set out DECC NSW, Managing urban stormwater: environmental targets, Consultation draft – October 2007.

Approval would be required from RMS to reduce the area of retained vegetation, and the design of noise wall 6NW80-SB would need to be amended.

Attachments:

1. S2W-IFD-20-6125-GE-120308-PLAN – *Option 6125 Bioretention Plan*
2. S2W-REP-20-6000-DR818A-FD-01 – *Arrawarra Rest Area – Treatment of Stormwater Runoff*

ATTACHMENT 1 – S2W- IFD-20-6125-GE-120308-PLAN – *Option 6125*

Bioretention Plan

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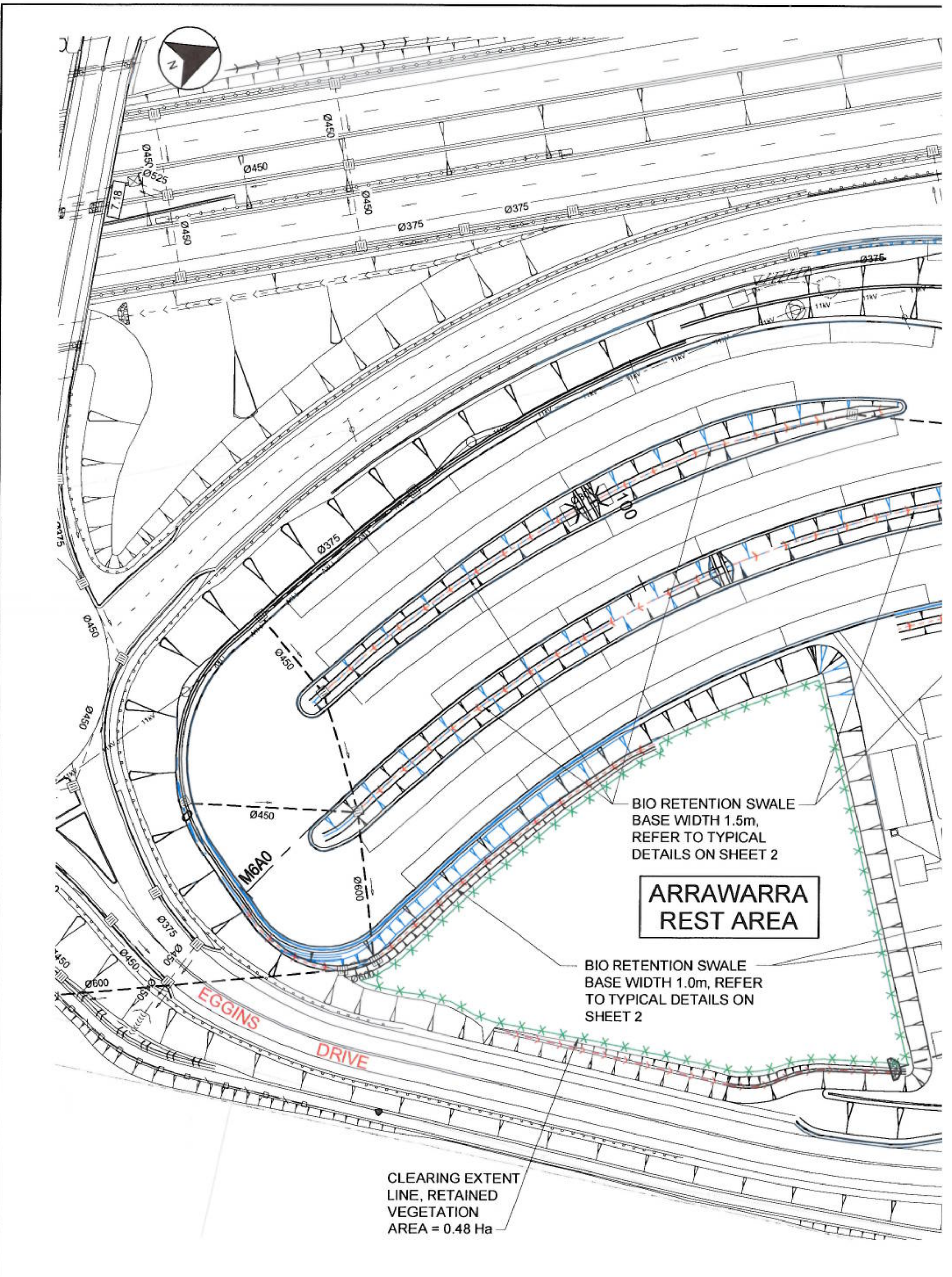


CONSORTIUM

CONTRACTOR

DESIGNER

SCALES

1:1000 FULL SIZE A3

ATTACHMENT 2 – S2W- -REP-20-6000-DR818A-FD-01 – *Arrawarra Rest Area*

Treatment of Stormwater Runoff

Discussion Paper

Project :	**Sapphire to Woolgoolga Upgrade**
Subject:	**Arrawarra Rest Area – Treatment of Stormwater runoff**
Design Lot No:	**S2W-20-6000-DR818A**
Document No:	**S2W-REP-20-6000-DR818A-FD-01**
Phase:	**Final Design**
Revision:	**01**
Date:	**21-March-2012**

1. Introduction

This discussion paper summarises the results and findings of the stormwater quality assessment undertaken for the Arrawarra Rest Area. To ensure the protection of downstream ecosystems from poor water quality associated with runoff from the Arrawarra Rest Area, stormwater quality modelling has been undertaken to quantify the extent of mitigation that can be provided.

2. Water quality

Stormwater runoff from impervious surfaces is typically of poorer quality than runoff from a natural or rural catchment. Therefore, it is proposed that stormwater treatment systems be provided to protect the downstream ecosystems from runoff of poor quality. Given the constraints of the site vegetated swales are proposed to provide stormwater treatment.

To ensure the protection of waterways in NSW, The Department of Environment and Climate Change NSW has derived draft environmental targets for the treatment of stormwater (DECC NSW, Managing urban stormwater: environmental targets, Consultation draft – October 2007).

These targets are:

- 85% reduction in the average annual total suspended solids load
- 65% reduction in the average annual total phosphorus load
- 45% reduction in the average annual total nitrogen load

Therefore, in assessing the impacts of urban runoff from the Arrawarra Rest Area, it is assumed that these targets are to be applied. The application of these targets requires that loads for these pollutants be estimated for the development. The stormwater quality modelling software MUSIC was used to estimate the pollutant loads generated by the site, and the effectiveness of the proposed treatment measures.

3. Proposed design and stormwater treatment measures

In assessing the pollutant loads generated by the Arrawarra Rest Area, the following assumptions were made.

- Only runoff from impervious surfaces was considered. Some areas of vegetation are part of the design and will drain to the drainage network; however these are a very small proportion, and generate few pollutants in comparison to impervious surfaces.
- The sizes of impervious catchments that comprise the Arrawarra Rest Area are listed in Table 1 and illustrated in Attachment A.

Table 1 Summary of Catchment Areas

Catchment Name	Area (m^2)
A	2065
B	1998
C	2369
D	1309
E	927
F	753
G	1268
H	1256

- Imperviousness for each catchment in the model was assumed to be 100%, other MUSIC parameters for source nodes were default values
- Meteorological data was 6 minute rainfall data from Coffs Harbour for 1998 to 2005. This period of data had a complete dataset with a mean annual rainfall reasonably close to the long term mean (1582 mm/year for the dataset, 1687 mm/year long term mean). Potential

evapotranspiration data was taken from the PET maps available from the Bureau of Meteorology)

The stormwater treatment currently proposed consists of swales. Swales remove coarse sediment runoff as it passes through the swale, and swales can also be designed as natural channels to reduce the maintenance burden of this landscape in addition to increasing the habitat value of these water conveyance corridors (see Figure 1).

Figure 1. An example of the use of swales for flow conveyance and water quality improvement.

Additional treatment measures such as bioretention systems could also be adopted. Bioretention systems are highly adaptable in form and therefore are suited to distributed or streetscape systems (see Figure 2A and Figure 2B).

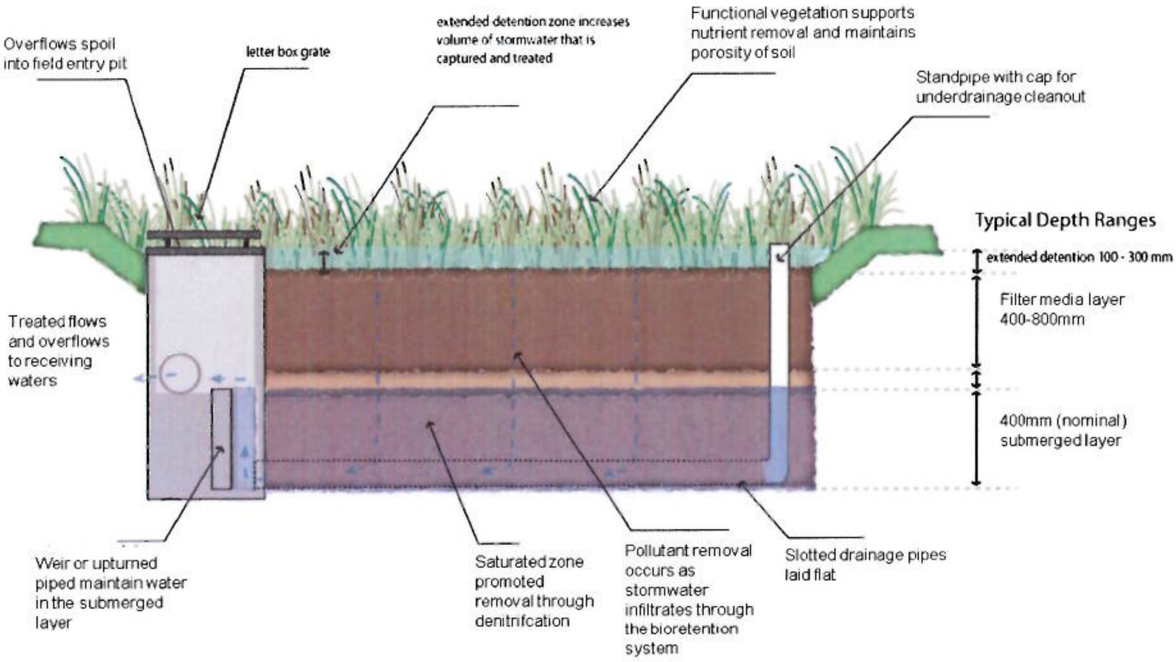


Figure 2A. Example section of a bioretention system for water quality improvement (above)

Figure 2B Example of a streetscape bioretention system at Bellvista on the Sunshine Coast, Queensland

4. Assessment of pollutant loads and pollutant removal

Initially, three scenarios were modelled for the purpose of assessing pollutant loads and pollutant removal. These are:

- Scenario 1 - The current drainage design that provides swale treatment
- Scenario 2 - The current drainage design that provides swale treatment with the addition of bioretention to treat runoff from catchments A, B, D and G
- Scenario 3 - The current drainage design that provides swale treatment with the addition of more vegetated swales and bioretention to treat runoff from catchments A, B, C, D, E, F and G.

Following this assessment, it was determined that the feasibility of adopting scenario 3 should be investigated further. However, this required the earthworks modelling and site drainage to be revisited to ensure that runoff from all catchments could be treated. Changes in the drainage design have altered the catchments that drain to each bioretention system, represented as scenario 4.

- Scenario 4 – As for Scenario 3 but the catchments have been redefined and the treatment systems adjusted to suit.

The parameters used to model the performance of swales and bioretention were as follows:

Swales

- Length varies depending on location
- Bed slope 1%
- Base width 0.5 to 10 m depending on location
- Batter slopes 1:3
- Vegetation height 0.25 m
- Swale depth 0.3 m
- Exfiltration rate 0.36mm/h (equivalent to heavy clay)

Bioretention Systems

- Extended detention 0.2 m
- Unlined filter media perimeter 0.01 m
- Saturated hydraulic conductivity 100mm/h
- Filter depth 0.5m
- TN content 800 mg/kg
- Organic material in filter <5%
- Orthophosphate content of filter media < 55mg/kg
- Base lined? – yes
- Vegetated with effective nutrient removal plants
- Underdrain present? – yes
- Submerged zone with carbon present? – yes
  - Depth 0.29m
- Exfiltration rate 0 mm/h

Other properties were the default settings.

Scenario 1

The existing scenario was modelled as providing the treatment listed in Table 2.

Table 2. Swale dimensions provided in the MUSIC model for Scenario 1 (current design).

Catchments	Impervious area (m^2)	Bioretention size (m^2)	Swale dimensions (m)
A	2065		40 x 2
B	1998		40 x 2
C	2369		
D	1309		10 x 2
E	927		
F	753		
G	1268		
H	1256		
Downstream of site			50 x 2
	Total Bioretention Size (m^2)	0	

Scenario 2

The model for scenario 2 incorporated only those areas that are treatable within the current design. Within the current design it will not be possible to drain all catchments to a treatment device. Table 3 lists the catchments and footprints of treatment areas incorporated into the MUSIC model for scenario 2.

Table 3. Swale dimensions and bioretention system areas provided in the MUSIC model for Scenario 2 (areas treatable within the current design).

Catchments	Impervious area (m^2)	Bioretention size (m^2)	Swale dimensions (m)
A	2065	29	40 x 2
B	1998	38	40 x 2
C	2369		
D	1309	10	10 x 2
E	927		
F	753		
G	1268	26	15 x 2
H	1256		
Downstream of site			50 x 2
	Total Bioretention Size (m^2)	103	

Scenario 3

In striving to meet the treatment targets for the site, further analysis was undertaken to identify opportunities for the incorporation of additional stormwater treatment. These opportunities are not confirmed and would be subject to design development. These opportunities would necessitate reshaping some of the terrain and reconfiguring parts of the drainage network. There may be opportunities to provide some swale and bioretention treatment for catchments C, E, and F. Table 4 includes the additional swale and bioretention areas that were included in this assessment of all potential treatment opportunities

Table 4. Swale dimensions and bioretention system areas provided in the MUSIC model for scenario 3 (all potential treatment opportunities).

Catchments	Impervious area (m^2)	Bioretention size (m^2)	Swale dimensions (m)
A	2065	29	40 x 2
B	1998	38	40 x 2
C	2369	35	10 x 10
D	1309	10	10 x 2
E	927	10	10 x 10
F	753	12	15 x 2
G	1268	26	15 x 2
H	1256		
Downstream of site			50 x 2
	Total Bioretention Size (m^2)	160	

Scenario 4

Following the initial investigations for Scenario 3, the earthworks and stormwater drainage designs were revisited to determine if it would be possible to treat all catchments. This investigation revealed that it is feasible to treat all catchments; however the catchment boundaries and subsequent water quality modelling needed to be updated. Table 5 includes the swale and bioretention areas that were included in this assessment of all potential treatment opportunities. The updated catchments are illustrated in Attachment B and Figure 4.

Table 5. Swale lengths and bioretention system areas provided in the MUSIC model for scenario 4 (runoff from all surfaces treated).

Catchments	Impervious area m2	Details	Bioretention size m2	Swale dimensions m
C1	1504	100% impervious	19	40 x 5.5
C2	1593	100% impervious	22	40 x 5.5
C3	2729	100% impervious	45	No swale
C4	541	100% impervious	7	15 x 5.5
C5	1877	100% impervious	26	15 x 5.5
C6	1147 (Car park) 1240 Future amenities area	100% impervious car park, half of future amenities area at 50% imperviousness	24	15 x 5.5
C7	799 (Car park) 1240 Future amenities area	100% impervious car park, half of future amenities area at 50% imperviousness	18	15 x 5.5
C8	2253	100% impervious	36	10 x 6 (2 swales)
		Total Bioretention Size (m^2)	197	

5. Results from stormwater quality modelling

Scenario 1

The MUSIC modelling results for the treatment provided by scenario 1 (the current design, Table 6) indicate that the swales do provide some treatment, but the removal of each of the pollutants falls short of the targets.

Table 6. MUSIC modelling results for the areas treatable within the current design

Scenario 1	Source	Residual	% removal	NSW Target (% removal)
Total Suspended Solids (kg/yr)	3730	843	77.4	85
Total Phosphorus (kg/yr)	7.28	3.27	55.1	65
Total Nitrogen (kg/yr)	50.8	42.3	16.7	45

Scenario 2

The MUSIC modelling results for scenario 2 (the areas treatable within the current design, Table 7) indicate that the removal of total suspended solids falls slightly short of the targets, and the removal of total phosphorus nearly reaches the target. The removal of total nitrogen falls substantially below the target.

Table 7. MUSIC modelling results for the areas treatable within the current design

Scenario 2	Source	Residual	% removal	NSW Target (% removal)
Total Suspended Solids (kg/yr)	3560	583	83.6	85
Total Phosphorus (kg/yr)	7.42	2.61	64.8	65
Total Nitrogen (kg/yr)	51.4	34	33.8	45

Scenario 3

The MUSIC modelling results for scenario 3 (all the opportunities for treatment used, (Table 8) indicated that if all the opportunities for treatment were realised, the removal of all of the pollutants modelled would exceed the treatment targets set for NSW. These results were further refined in Scenario 4.

Table 8. MUSIC modelling results for the areas representing all potential treatment opportunities

Scenario 3	Source	Residual	% removal	NSW Target (% removal)
Total Suspended Solids (kg/yr)	3570	308	91.4	85
Total Phosphorus (kg/yr)	7.39	1.91	74.1	65
Total Nitrogen (kg/yr)	51.8	27	47.9	45

Scenario 4

The MUSIC modelling results for scenario 4 (all the opportunities for treatment used, Table 9) indicated that if all the opportunities for treatment were realised, the removal of all of the pollutants modelled would exceed the treatment targets set for NSW.

Table 9. MUSIC modelling results for the areas representing all potential treatment opportunities

Catchments C1, C2, C3 (draining to the south)				
Scenario 4	**Source**	**Residual**	**% removal**	**NSW Target (% removal)**
Total Suspended Solids (kg/yr)	1740.0	213.0	87.7	85
Total Phosphorus (kg/yr)	3.52	1.02	70.9	65
Total Nitrogen (kg/yr)	25.0	12.7	49.2	45
Catchments C4, C5, C6, C7 and C8 (draining to the north)				
Total Suspended Solids (kg/yr)	2450.0	248.0	89.9	85
Total Phosphorus (kg/yr)	5.11	1.41	72.4	65
Total Nitrogen (kg/yr)	36.5	19.4	46.7	45

6. Design Considerations

Due to the constrained nature of the site, submerged zone bioretention systems have been used in the modelling of pollutant removal. Submerged zone systems have the advantage of higher rates of total nitrogen removal, however they are more complicated to build and require more specific materials. If more space for treatment is provided, conventional bioretention systems without submerged zones can be used. These have a slightly larger footprint, but are easier to build.

7. Removal of hydrocarbons

Swales provide some removal of hydrocarbons through the process of sedimentation of particles that may have hydrocarbons adsorbed to them. There is also the potential for hydrocarbons to adsorb directly to the soil as water moves through the swale. However, hydrocarbon removal may be limited in many instances because a substantial proportion of hydrocarbons are likely to be transported as a thin floating film on the water surface. The water in the swale therefore acts as a separating phase between the floating hydrocarbons and the soil.

To overcome this separation, it is recommended that treatment devices that include infiltration be employed. Infiltrating water into a soil filter media ensures that there is good contact between water-borne hydrocarbons and the soil, providing opportunities for the adsorption and thus removal of hydrocarbons from the water. Bioretention systems are suited to this purpose.

Bioretention systems remove stormwater pollutants through physical, biological and chemical processes that occur on the surface and within the filter media. Treatment of petroleum hydrocarbons occurs primarily through sorption and filtration. These processes include:

- sorption of hydrophobic hydrocarbon compounds to the surface of the soil profile where they can subsequently biodegrade (occurring on the surface of filter media)
- filtration of petroleum compounds associated with fine sediments by the filter media
- filtration of hydrophilic hydrocarbon compounds and through the soil/ microbial filter matrix, and subsequent biodegradation of the hydrocarbons by the soil microbes.

Bioretention systems can be designed to be freely draining, promoting an aerobic environment appropriate for the respiration/ biodegradation of carbon rich organic compounds. If hydrocarbons are a pollutant of concern then it is recommended that bioretention systems be constructed without submerged zones.

Bioretention systems have been shown to remove between 80 and 95% of total petroleum hydrocarbons (Hong et al. 2006). Studies by Hong et al. (2006) showed that biodegradation of petroleum hydrocarbons took place in a thin layer of mulch placed on the surface of bioretention media. Most of the petroleum hydrocarbons were biodegraded within two to eight days after a runoff event (depending on the particular compound). A summary of the results are presented in Table 10.

Table 10 Petroleum Hydrocarbon Treatment Performance of Bioretention Systems (Source: Hong et al. 2006)

Petroleum Hydrocarbon Compound	Inflow Concentration (mg/L)	Discharge Concentration (mg/L)	Petroleum Hydrocarbon Removal
Napthalene	1.6	0.2	88%
Toluene	2.7	0.1 - 0.6	78 – 96%
Motor Oil	30	3.4 - 5.4	82 – 89%

Bioretention systems have also been shown to be effective at removing polycyclic aromatic hydrocarbons (PAH) from urban runoff. DiBlasi *et al.* (2009) studied PAH removal in a field system that receives runoff from a university car park. Results showed that the polycyclic aromatic hydrocarbons are affiliated with suspended solids and were primarily treated by the top few centimetres of the soil media near the bioretention system inflow location. PAH removal by the bioretention system ranged from 60 to 99%, resulting in discharge concentrations of 0.05 to 0.37ug/L (based on inflow concentrations of 0.98 to 5 ug/L).

To ensure a reasonable level of protection from hydrocarbons for the receiving environment, it is recommended that stormwater treatment systems include bioretention, and that these systems be sized to meet the treatment targets of the Department of Environment and Climate Change NSW (now the Office of Environment and Heritage NSW).

8. Plant selection for swales and bioretention systems

The following plant lists are indicative only and are intended to indicate the type of plant material that can be used successfully in swales and bioretention systems. The final species chosen should be refined in collaboration with the landscape architect during detailed design.

The following plant species may be suitable for use in swales:

Cynodon dactylon	Couch grass
Dichantheum sericeum	Queensland bluegrass
Gahnia aspera	
Gahnia clarkei	
Gahnia sieberana	Red-fruit saw sedge
Imperata cylindrica	Blady grass
Lepidosperma laterale	Common sword sedge
Lomandra longifolia	Long-leaf lomandra
Lomandra multiflora	A lomandra
Paspalidium distans	A grass
Paspalum scrobiculatum	A grass
Poa labillardieri	Tussock poa

The following plant species may be suitable for use in bioretention systems

Angophora leiocarpa	Smooth-barked apple
Callistemon pachyphyllus	Wallum bottlebrush
Callistemon salignus	Willow bottlebrush
Callitris macleyanus (p)	Brush cypress pine
Carex appressa	
Dianella caerulea	Blue flax lily
Dianella revoluta	
Dodonaea triquetra	A hop bush
Exocarpus cupressiformis	Cherry ballart
Hakea florulenta	A hakea
Imperata cylindrica	Blady grass
Leptospermum juniperinum	Prickly teatree

Leptospermum polygalifolium	
Lomandra longifolia	Long-leaf lomandra
Lomandra multiflora	A lomandra
Lophostemon confertus	Brush box
Melaleuca quinquenervia	Broad-leaved paperbark
Melaleuca sieberi	A paperbark
Melaleuca stypheloides	
Melaleuca thymifolia	
Poa labillardieri	Tussock poa
Pteridium esculentum	Bracken fern
Themeda australis	Kangaroo grass

9. Maintenance Costs

In order to maintain the bioretention systems in a densely vegetated, stable and weed-free condition, maintenance is recommended for 2 years at a rate of approximately 64 hours per year (2 workers for one day every three months). Thereafter, ongoing maintenance of 48 hours per year is recommended (2 workers for one day every four months). This maintenance schedule accommodates weeding, plant replacement where required, stabilisation works where required and checks and clearing of the pit and pipe network.

The lifecycle of bioretention systems is not accurately understood, as these systems have only been in existence in Australia for 10 to 12 years. Experience with these older existing systems (such as Victoria Park Bioretention Systems in Zetland, Sydney, and Hoyland Street in Bracken Ridge in Brisbane) indicates that there is no apparent reduction in performance after 10 years. It is expected that bioretention systems could have a lifecycle of 25 to 50 years if appropriately designed. Appropriate design includes provision for:

- Ensuring that the filter media of bioretention systems is protected from high sediment loads such as those associated with construction activity
- Protection from vehicular or pedestrian activity that could result in media compaction
- Flow controls to ensure energy dissipation and even distribution of water across the filter surface.
- Healthy and dense vegetation growth.

10. Conclusions

Opportunities exist to treat stormwater within the Arrawarra Rest Area. Within the current design, it is estimated that the implementation of stormwater treatment devices could provide substantial pollutant removal. Further, if opportunities to include additional treatment areas can be realised through design development, then the treatment targets set for NSW could be met.

As seen in table 7, Scenario 2 with an assumed total bioretention treatment area of 103 m^2 falls short of the target for total suspended solids, and the removal of total phosphorus. However, the removal of total nitrogen falls substantially below the target.

Giving consideration to the way in which these pollutants are removed from water highlights the reason for this. A substantial proportion of the removal of total suspended solids and total phosphorus occurs in the vegetated swales modelled for the site. Treatment devices such as swales rely on the sedimentation of particles, and are effective devices for the treatment of particulate-bound pollutants like total suspended solids and total phosphorus.

However, nitrogen is one of the most difficult pollutants to remove from water as a large proportion of total nitrogen occurs in dissolved, non-reactive forms. This means that treatment devices such as swales provide only limited removal of total nitrogen. The effective removal of nitrogen requires that water passes through a treatment system that allows for removal through biological uptake and transformation. These processes occur in treatment devices such as constructed wetlands or bioretention systems.

Therefore in order to provide treatment of runoff sufficient to meet the NSW guideline targets, a comparatively larger total surface area of bioretention systems is required for Scenario 4 compared to Scenario 2. Scenario 4 demonstrates that a total bioretention surface area of $197m^2$ is required to provide sufficient nitrogen removal to reach the treatment targets.

11. References

DiBlasi et al. (2009). C. J. DiBlasi, H. Li, A. P. Davis and U. Ghosh. Removal and Fate of Polycyclic Aromatic Hydrocarbon Pollutants in an Urban Stormwater Bioretention Facility. Environmental Science & Technology 43(2): 494-502.

Hong *et al.* (2006). Hong, E. Y., E. A. Seagren and A. P. Davis. Sustainable oil and grease removal from synthetic stormwater runoff using bench-scale bioretention studies. Water Environment Research **78**(2): 141-155.

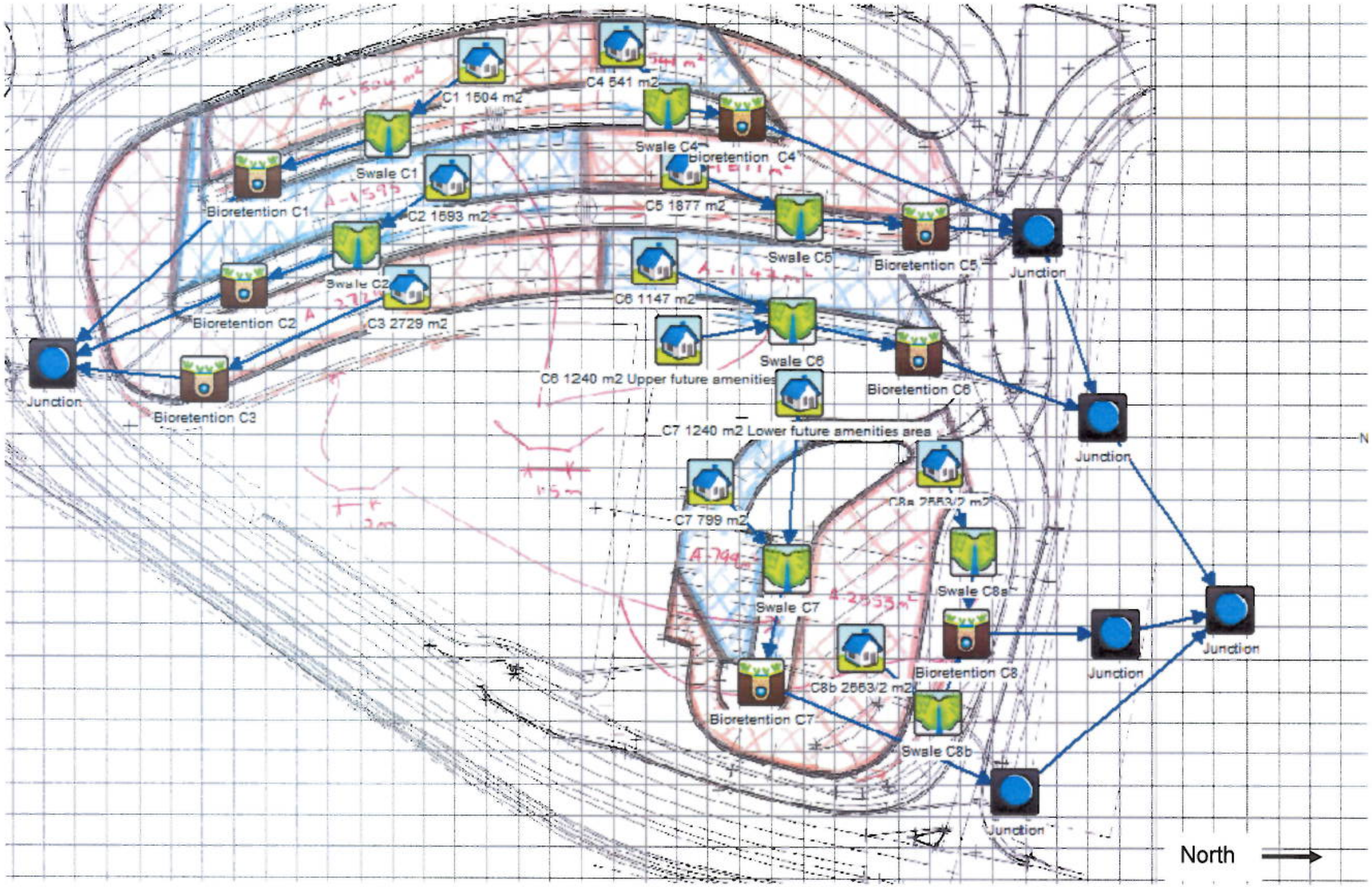
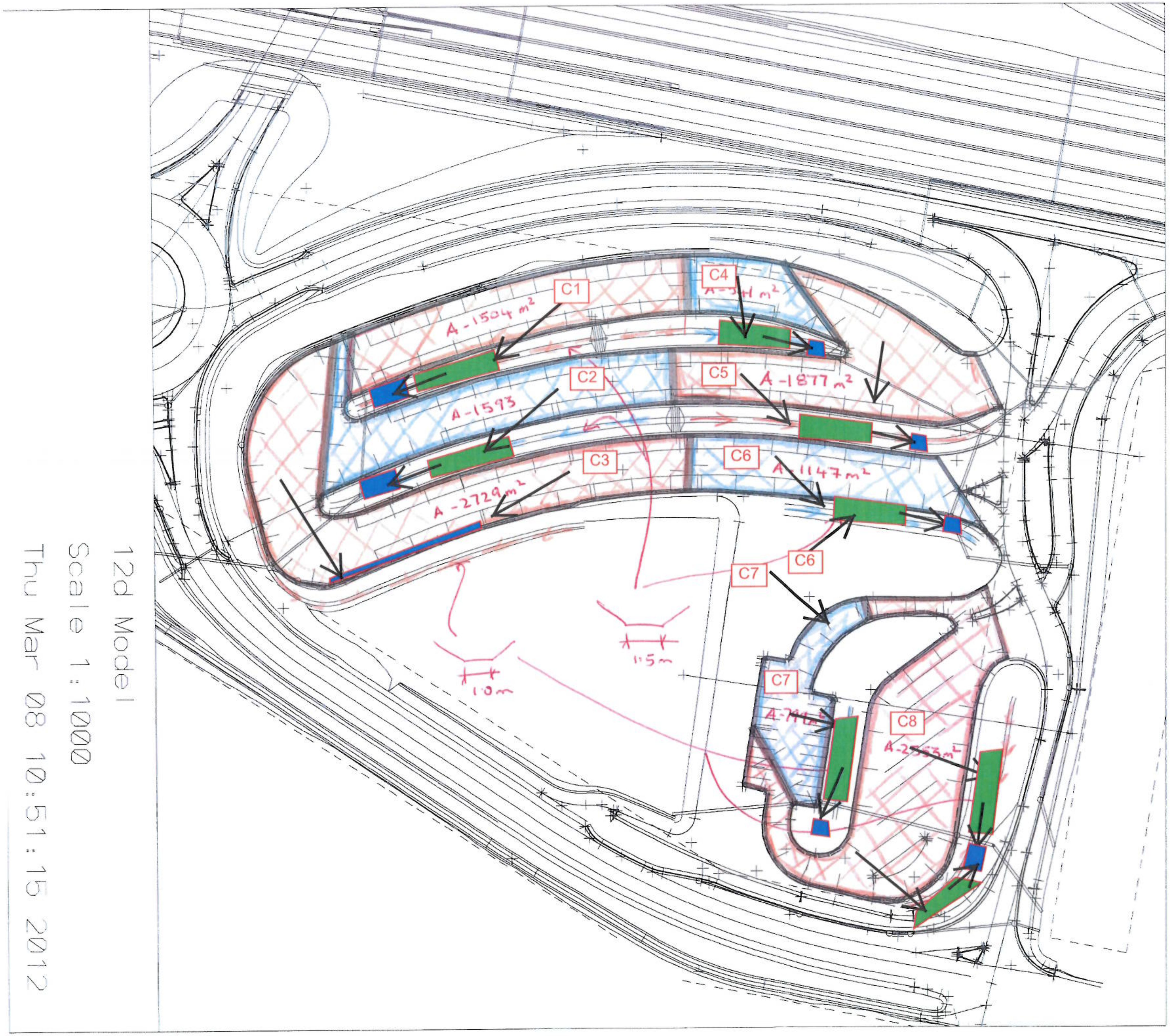


Figure 4: Structure of MUSIC modelling used for assessment of stormwater treatment performance of Scenario 4.

ATTACHMENT A

LEGEND
HEADWALL WITH ROCK MATRESS OR RIP-RAP ARPON
HEADWALL WITH CONCRETE APRON
HEADWALL WITH TYPE A DISSIPATOR U.N.O.
HEADWALL WITH ROCK VEGETATED APRON
PIPE/BOX CULVERT AND FLOW DIRECTION
EXISTING PIPE/BOX CULVERT
SWALE - VEGETATED
CATCH DRAIN - VEGETATED (TYPE 'A' UNO)
CATCH DRAIN - ENKAMAT (TYPE 'A' UNO)
CATCH DRAIN - CONCRETE (TYPE 'A' UNO)
CHANNEL - VEGETATED
CHANNEL - CONCRETE UNO
BERM DRAIN - VEGETATED UNO
BERM DRAIN - CONCRETE UNO
TABLE DRAIN - VEGETATED
TABLE DRAIN - CONCRETE UNO
PAVEMENT DRAINAGE TAG
STORMWATER PIT
NOTES
1. FOR GENERAL NOTES AND ADDITIONAL LEGEND REFER TO DRG GE6021.
KEYPLAN - ZONE 6000
Sheetflow in to median.
TRUCK PARKING
PARKING
No pavement flows to this area.
50% vegetated.
culvert
A - 2065m2
B - 1998m2
C - 2369m2
D - 1309m2
E - 927m2
F - 753m2
G - 1268m2
H - 1256m2
'V' SHAPED VEGETATED SWALE DRAIN
SIDE SLOPE - 10:1 (H:V)
DEPTH - VARIES (0.3 MIN)
ARRAWARRA REST AREA
SWALE DRAIN
BASE WIDTH - 0.5m
DEPTH - 0.5m (MIN)
BATTER SLOPE - 1.5:1 (H:V)
HOLD
PENDING DETAIL SURVEY
EGGINS DRIVE
Legend
Vegetated Swale
Bioretention System
NOT FOR CONSTRUCTION
S2W-DRG-20-6000-GE6201
01
HIGHWAY No 10 SAPPHIRE TO WOOLGOOLGA UPGRADE CITY OF COFFS HARBOUR
ZONE 6000
ARRAWARRA REST AREA
DRAINAGE
PLAN
0010.110RC4207
PRELIMINARY DETAILED DESIGN
S2W-MOD-20-6002-RD_DES_20110909-DD-01.TXT
S2W-MOD-20-6002-DR_DES_20110915-DD-01.12da
01 16.09.2011 ISSUED FOR PRELIMINARY DETAILED DESIGN
DESIGNERS SITE NOTE
LEIGHTON
Fulton Hogan
AECOM
SMEC

ATTACHMENT B



LEGEND

Bioretention System

Vegetated Swale

NOTE - not drawn to scale. Locations and sizes are indicative only

Annotated by AECOM, Courtney Henderson.
2012.03.08

ATTACHMENT B