La Vie Developments Pty Ltd

Concept Stormwater Management Strategy
Proposed Hospital and Health Care Campus

Corner Avondale Road and Huntley Road, Huntley, NSW

P0802279JR02_v2
May 2009

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All enquiries regarding this project are to be directed to the Project Manager.

Contents

1 Introduction

1.1 Scope of Work

This report details a concept stormwater management strategy prepared to support an application under part 3A of the EP&A Act for a proposed private hospital and health care campus at Lot 22 DP 607750 and Lot 4 DP 258024, corner Avondale Road and Huntley Road, Huntley, NSW. The strategy is developed on the basis that stormwater from the proposed development will have a neutral or beneficial impact on the local environment.

We note that development is to be undertaken in eight stages and that the approval sought is for project approval at Stage 1 (the 'Surgicentre') and concept approval for the remaining stages.

Detailed design has not yet been undertaken and there may therefore ultimately be some variations to the particulars of on-site stormwater management. Therefore, this concept stormwater management plan is preliminary and subject to refinement and possible change. Modelling results should not be interpreted as absolute and final but, rather, indicative of whether the site will be capable of sustainably managing stormwater flows and key stormwater pollutants (particularly nitrogen, phosphorous and suspended solids).

1.2 Development Proposal

We understood that the 'Illawarra International Health Precinct' hospital and health care campus is to include the following key components as shown on the proposed development plan (Attachment A):

- Specialist consultation suites and day surgery;
- 24 hour radiology and pathology;
- Hospital casualty and 24 hour medical centre;
- Stand alone obstetrics unit;
- 352 bed private tertiary referral hospital;
- Shopping plaza incorporating a range of specialist retailers including newsagency, convenience store, florist, café, restaurant and professional suites;
- Commercial laundry, dry cleaner and car washing facility;
- Accommodation for nursing staff, medical students, resident medical officers and registrar (30 one-bedroom and 20 two-bedroom serviced apartments, 4 meeting rooms and one training room);

- Further education facility including 80 one-bedroom serviced apartments, 4 meeting rooms and 2 conference rooms;
- Aged and disability centre; and
- 46 seniors independent living houses.

The proposal will be staged to develop over the next 8 – 12 years, matching growth in the adjacent West Dapto release area.

1.3 Relevant Policy and Guidelines

The following planning policies and design guidelines have been considered in the development of this concept stormwater management strategy:

- Wollongong City Council Local Environmental Plan 1990
- Wollongong City Council West Dapto DCP 23 (1993)
- Wollongong City Council Urban Drainage Design Manual 94-20 (1994)
- Wollongong City Council On-Site Stormwater Detention Code (2006)
- Australian and New Zealand Guidelines for Fresh and Marine Water Quality (2000)
- Southern Councils Group *Regional Water Sensitive Urban Design Policy* – Draft (2004)

1.4 Field Investigations

Site inspections were undertaken on the 3rd December 2008 and included the following:

- Walkover inspection of the site to assess existing conditions; and
- Excavation of 15 boreholes generally to 1 – 3 m depth using a hydraulic auger to allow for the characterisation of site soils and geology.

Detailed geotechnical information regarding the site, including borehole results, is contained in the *Geotechnical Investigation* report prepared by Martens & Associates (P0802279JR03_v1, March 2009).

2 Site Description

2.1 Location and Land Use

The subject site (Lot 22 DP 607750 and Lot 4 DP 258024) is located at the corner of Avondale Road and Huntley Road, Huntley, NSW, within the Wollongong City Council Local Government Area. It is located within the West Dapto Release Area and adjoins the existing suburb of Penrose. The site is bordered by Huntley Road to the south, Avondale Road to the west and north, and Goolagong Street to the east (Figure 1).

The site is currently pasture and has an area of approximately 10.5 ha. Refer to Attachment A for a site plan. Surrounding land use is generally medium density residential to the east and rural pastures west of the site.

Figure 1: Site location.

2.2 Topography and Drainage

Site topography is characterised by a knoll (RL 49 m) near the middle of the site with grades of up to approximately 15% to the east and west and shallower grades on the northern and southern hillsides. Elevation ranges between RL 49 m and RL 27 m. No surface drainage channels occur on the site, nor were there any indications of springs or seepage at the time of inspection. Runoff drains from the centre of the site towards the boundaries as sheet flow following natural contours.

Mullet Creek, which drains mostly north-east, passes by the site approximately 400 m to the north and downstream collects Dapto Creek, Forest Creek, Robins Creek and Reed Creek before discharging into Lake Illawarra approximately 5 km north-east of the site (Figure 2).

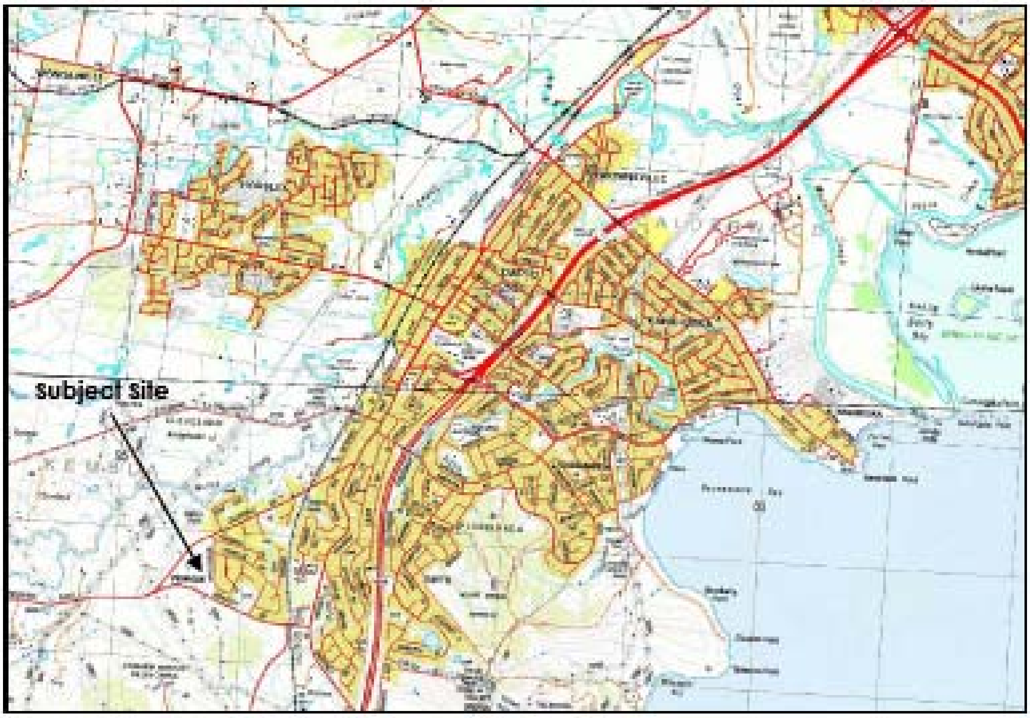


Figure 2: Local topography including creeks.

2.3 Rainfall

The Huntley area is characterised by moderate annual rainfall of 1,279 mm, distributed throughout the year as shown in Table 1.

Table 1: Mean monthly rainfall data from Port Kembla signal station (Source: BoM, 2009).

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Rainfall (mm)	116	158	183	93	89	140	63	88	55	108	94	90	1,278

2.4 Soils and Geology

The Kiama 1:100,000 Soil Landscape Sheet (Hazelton, 1992) identifies the site as having soils of the Shellharbour soil landscape group. The Shellharbour soil landscape group consists of deep Prairie soils on crests and upper slopes, Brown krasnozems on midslopes, and Red podzolic soils and Prairie soils on lower slopes and drainage plains.

Geological mapping (Wollongong 1:250,000, NSW Dept. Mines, 1966) indicates that the site is underlain by Budgong sandstones and also close to the influence of Illawarra Lake alluvium deposits.

On-site subsurface investigations indicated that the site is predominantly covered by silt topsoils underlain by clay with siltstone and shale bedrock. Soil depth was found to range between 0.15 m and 2.2 m.

2.5 Groundwater

Site subsurface investigations to maximum depth 3.0 m / into bedrock did not encounter groundwater. Ephemeral groundwater is likely to collect at the soil / rock interface after periods of substantial or prolonged rainfall.

2.6 Existing Water Quality

2.6.1 Mullet Creek

Water quality monitoring of local creeks and estuaries has been completed by Wollongong City Council as part of the *Wollongong Wide Water Quality Monitoring Program (2002 – 2006)* and a more specific *Monitoring of Water Quality in the West Dapto Release Area (2006)* study. Both projects included middle reaches of Mullet Creek, which passes by the subject site approximately 400 m to the north of the site.

The *Wollongong Wide Water Quality Monitoring Program (2002 – 2006)* notes that the upper – middle Mullet Creek catchment includes 44% *Environmental Protection*, 42% *Non-urban* and 10% *Residential* land use, based on zoning patterns from the Wollongong LEP (1990), and is considered to be a moderately disturbed catchment. The program found that water quality in the Wollongong area was generally poor, with low dissolved oxygen, high nutrients and high faecal coliforms being the items of greatest concern. Total nitrogen and total phosphorous concentrations along Mullet Creek exceeded their respective ANZECC (2000) guideline values for protection of slightly – moderately disturbed aquatic ecosystems (lowland rivers) by a factor of 3 – 4.

The *Monitoring of Water Quality in the West Dapto Release Area (2006)* study completed monthly sampling between July 2004 and June 2005 at 29 sites including reaches of Mullet Creek and provides comparable results to the Wollongong wide program. The study found that nitrogen, phosphorous and dissolved oxygen concentrations frequently failed the ANZECC (2000) guidelines across the majority of the study area, as shown in Table 2, including at a sampling location along the middle reach of Mullet Creek, approximately 100 m downstream from the subject site.

2.6.2 Lake Illawarra

Water quality in Lake Illawarra is also poor, which is believed to be due to urban and industrial pollution (WCC, 2006).

Mullet Creek comprises approximately 32% of Lake Illawarra catchment and contributes large amounts of nutrients and suspended solids into the lake. The West Dapto release area water quality study (WCC, 2006) found that average total suspended solids were low at downstream sites along Mullet Creek (<11 mg/L) but total phosphorous and total nitrogen exceeded the ANZECC (2000) water quality guidelines for protection of slightly – moderately disturbed aquatic ecosystems (estuaries) as shown in Table 2.

Table 2: Water Quality Monitoring Results from *Monitoring of Water Quality in the West Dapto Release Area (2006)*. Units are in mg/L.

Location	Value	Dissolved Oxygen (DO)	Total Suspended Solids (TSS)	Total Phosphorous (TP)	Total Nitrogen (TN)
Middle reach of Mullet Creek near site[1]	Non-comply rate[3]	23%	8%	46%	62%
	Min	4.04	0.50	0.005	0.05
	Mean	7.15	5.12	0.038	0.44
	Max	10.15	24.00	0.170	1.20
	Guideline (Lowland Rivers)	**6**	**10[4]**	**0.025**	**0.35**
Downstream Mullet Creek before Lake Illawarra[2]	Non-comply rate[3]	46%	38%	92%	92%
	Min	4.03	2.00	0.030	0.05
	Mean	6.56	10.92	0.067	1.02
	Max	9.62	43.00	0.120	7.10
	Guideline (Estuaries)	**6**	**10[4]**	**0.030**	**0.30**

Notes: [1] Approx. 100 m downstream from the subject site. [2] Indicative of Mullet Creek contribution to Lake Illawarra water quality. [3] Percentage of occasions on which the water quality criteria were not met. [4] This is not an ANZECC (2000) guideline concentration. This value is considered the background guideline for the Wollongong area (WCC, 2006).

2.7 Local Catchments and Flooding

The subject site lies within the lower portion of the Mullet Creek catchment, which is approximately 72 km² located about 8 km south-west of the Wollongong CBD. The creek arises at the escarpment in the west at an elevation of approximately 600 mAHD and flows a distance of approximately 22 km before reaching Lake Illawarra. The headwaters are very steep with elevation falling from maximum 600 mAHD to only 50 mAHD in the foothills just 2.5 km to the east. The floodplain near Lake Illawarra is broad and flat, extending up to 2.8 km in width.

Given this small and steep catchment, the propensity for heavy rain, and progressive urbanisation, flooding is frequent and floods tend to be very flashy, with rapid rises and falls (Bewsher Consulting Pty Ltd, 2007). Mullet Creek has a long history of flooding.

The most recent Floodplain Risk Management Study completed in the Mullet Creek catchment (Bewsher Consulting Pty Ltd, 2007) confirms that the subject site is outside of the extent of the 1% AEP flood event (Figure 3).

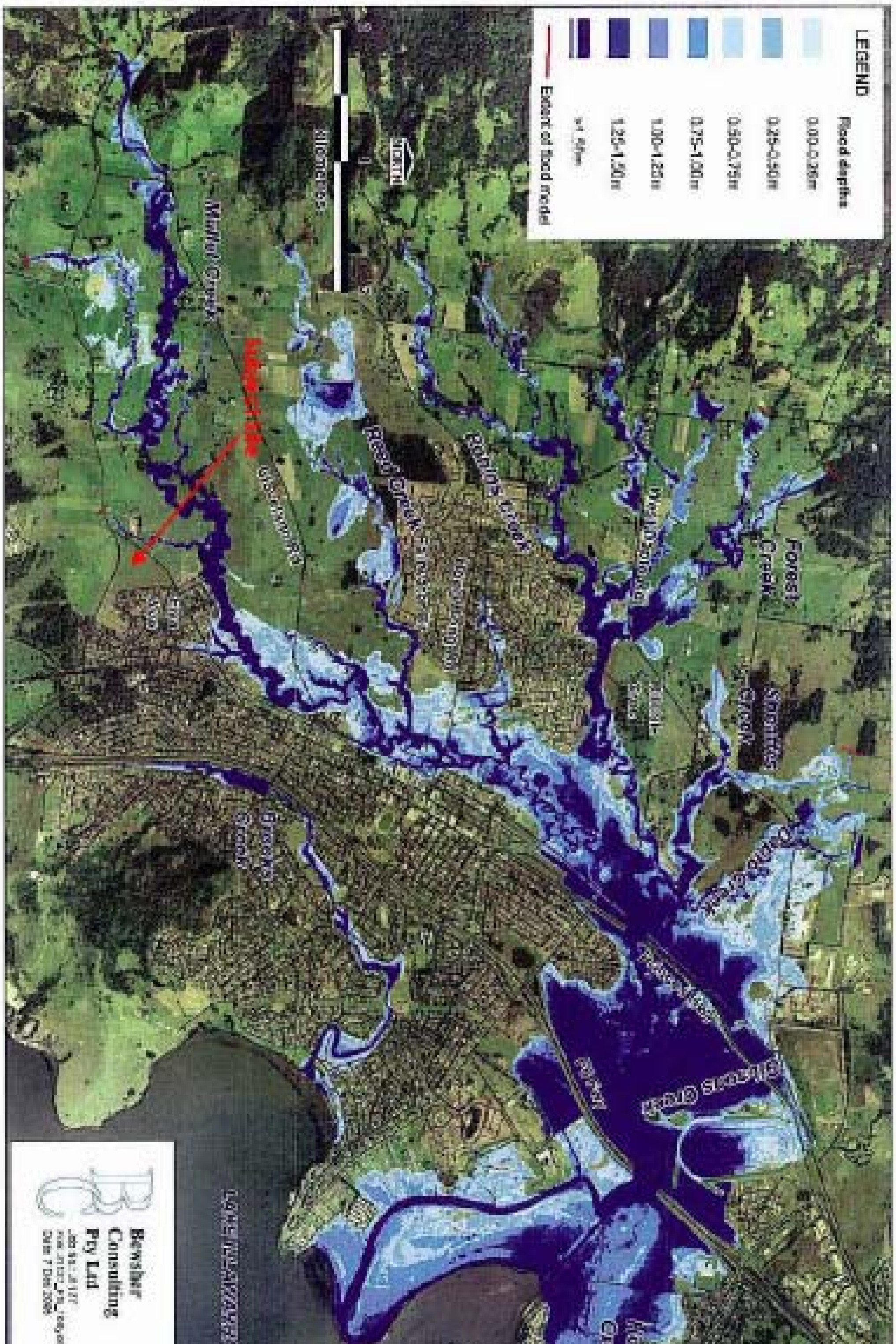


Figure 3: Mullet Creek flood study: 100 year ARI event extent and depths.

3 Stormwater Quantity Management

3.1 Stormwater Quantity Objectives

In accordance with Council's *Urban Drainage Design Manual (94 – 20)* and *On-site Stormwater Detention Code (2006)*, the concept stormwater management strategy has been designed to include infrastructure that meets the following objectives:

- Stormwater from the 10 year ARI design storm event is to be collected and conveyed by a piped drainage system (including gutters);
- Overland flow paths/drainage routes are to convey major storm flows when the capacity of the piped system is exceeded, up to the 100 year ARI design storm event; and
- For all design storm events up to the 100 year ARI event, post-development peak stormwater discharges should not exceed pre-development peak discharges in downstream areas.

3.2 Stormwater Quantity Modelling Approach

Stormwater flows at the site resulting from design storm events were modelled using the *DRAINS* hydraulic and hydrological analysis program. Input rainfall events were based on AR&R (1987) rainfall data.

Two scenarios were modelled:

1. Pre-development site conditions (existing rural land without formal drainage); and
2. Post-development site conditions based on the proposed site development with a concept formalised stormwater drainage system, including OSD structures.

Modelling scenario 2 was undertaken iteratively in order to ensure that the stormwater quantity objectives of the site (Section 3.1) were met.

Further to the above, we note that at the time of preparing this report, final design surface levels were not available and it was therefore not possible to undertake a detailed assessment of drainage design (i.e. individual pit and pipe layout requirements).

3.3 Concept Stormwater Drainage System

3.3.1 Overview

On the basis of available information, a concept stormwater drainage layout has been prepared for the proposed development to meet the site's flow control objectives (Section 3.1). A discussion of the essential elements of the concept layout is contained in the following sections. Schematic diagrams of the assumed pre- and post-development stormwater drainage layouts and complete details of the input data used in DRAINS modelling are provided in Attachment B.

At this stage, several proposed water *quality* treatment devices, or structures, have not been included in the DRAINS model. These devices will provide some further stormwater detention and, therefore, the post-development OSD results provided here are conservative. Details of water *quality* treatment structures are contained in Section 3.5.

3.3.2 Catchments

In its current state as 10.5 ha of pasture, prior to any development, there is a knoll near the middle of the property and so the site consists of one 10.5 ha naturally draining catchment with two primary sub-catchments. There are no upslope catchments affecting the site.

Post-development, we see that the site can be divided into three catchments, each with area available for an OSD structure at its low point. Catchment areas are determined by estimated finished surface levels and forecasted drainage infrastructure (gutters, pits, pipes, swales and the like). However, detailed design of the drainage system is outside the scope of this concept plan. The concept plan seeks to ensure that effective, sustainable stormwater management that meets the site objectives can be achieved. Detailed design of the stormwater drainage layout will be required at the CC stage of development.

Post-development catchment areas are shown in Table 3 and on the site plan (Attachment A).

Table 3: Conceptual post-development stormwater catchments, assumed for preliminary design and modelling.

Sub-catchment	Area (ha)	Post-Development Impervious (%)
C1 – North	2.69	90
C2 – South-west	4.58	80
C3 – South-east	3.16	35

3.3.3 Stormwater Detention Structures

An on-site detention structure per catchment area is the primary mechanism for control of peak stormwater discharge from the site post-development. Basic, preliminary design specifications, which have been assumed for modelling purposes, are given in Table 4. In addition to peak storm flow attenuation, the proposed structures will also provide some water quality treatment (Section 3.5).

Table 4: Preliminary OSD design specifications per post-development catchment.

	OSD 1	OSD 2	OSD 3
Type	Underground tank	Underground tank	Underground tank
Surface Area (m^2)	1,200	628	500
Max. Storage Depth (m)	1.3	1.65	1.5
Total OSD Capacity (m^3)	1,560	1,022	750
Outlet Pipe (Diameter, mm)	600	2 x 750	2 x 525

3.4 Modelling Results

DRAINS modelling indicates that a peak stormwater discharge of 5.23 m^3/sec occurs at the site in its current state, prior to any development, during the 100 year ARI storm event. Under post-development site conditions, with the proposed stormwater detention structures in place, peak stormwater discharges during the design storm event (100 year ARI) can be limited to less than 5.23 m^3/sec, as summarised in Table 5. That is, the on-site detention objective for the site (see Section 3.1) can be met using a practical stormwater drainage layout.

More detailed DRAINS modelling results are made available in Attachment B.

Further detailed design will be necessary at the construction certificate stage to configure the OSD structures for effective operation during lesser storm events (i.e. 5 and 10 year ARI storm events).

Table 5: DRAINS flow model results – peak discharge (m^3/sec) during 100 yr ARI storm.

Channel	C1	C2	C3	OSD objective achieved?
Pre-Development	1.35	2.3	1.58	5.23
Post-Development Piped discharge	0.72	2.55	1.51	Yes
Post-Development Overland flow discharges	0	0.38	0.02	
Total	0.72	2.93	1.53	5.18

3.5 Stage 1 (Project Approval) OSD Requirements

Additional DRAINS modelling was completed specifically for Stage 1 of the proposed development to confirm that adequate OSD could be provided at the onset of the development. The results are provided in Table 6 and Table 7 and indicate that post-development peak stormwater flows during the design storm event (100 year ARI) can be limited to less than pre-development rates by installing a 420 m^3 capacity underground OSD tank within the confines of the Stage 1 portion of the site. An indicative Stage 1 OSD tank location is shown on the site plan (Attachment A). Final sizing will be required at CC stage.

Table 6: Preliminary OSD design specifications for Stage 1.

Parameter	OSD Specs.
Type	Underground tank
Surface Area (m^2)	600
Max. Storage Depth (m)	0.7
Total OSD Capacity (m^3)	420
Outlet Pipe (Diameter, mm)	600

Table 7: Stage 1 DRAINS results – peak discharge (m^3/sec) during 100 yr ARI storm.

Channel	Pre-Development	Post-Development	OSD objective achieved?
Piped discharge	0	0.41	
Overland flow discharges	0.45	0	Yes
Total	0.45	0.41	

3.6 Summary and Site Discharge Locations

Total on-site detention (OSD) required for the proposed development is 3.33 ML. We recommend that construction of the three detention structures is implemented in phases as shown in Table 8.

The existing drainage system in Avondale Road and Goolagong Street will need to be surveyed in detail so that final connection to the existing street drainage can be determined. Recommended sub-catchment discharge locations are also noted in Table 8.

Table 8: Preliminary OSD structure construction phases and discharge locations.

Stage	OSD Structure	Discharge Location
1	Construct OSD 1 to serve Stages 1 – 4.	Avondale Road drainage system
2	Use OSD 1.	Avondale Road drainage system
3	Use OSD 1.	Avondale Road drainage system
4	Use OSD 1.	Avondale Road drainage system
5	Construct OSD 2 to serve Stage 5 and ultimately 8A.	Avondale Road drainage system
6	Construct OSD 3 to serve Stages 6, 7 and 8B.	Goolagong Street drainage system
7	Use OSD 3.	Goolagong Street drainage system
8A	Use OSD 2.	Goolagong Street drainage system
8B	Use OSD 3.	Avondale Road drainage system

4 Stormwater Quality Management

4.1 Stormwater Quality Objectives

The concept stormwater management strategy has been designed to include measures that deliver the following objectives, as summarised in Table 9.

i. Council has adopted a guideline concentration of 10 mg/L total suspended solids (TSS) for water courses based on background levels from the Wollongong area and Hornsby Shire Council policy (WCC, 2006).

ii. In order to assist in improving or maintaining the water quality in downstream reaches of Mullets Creek and in Lake Illawarra, median pollutant loads should not exceed pre-development levels.

iii. Southern Councils Group (SCG) *Regional Water Sensitive Urban Design Policy* – Draft (2004) is a policy to ensure that building design and development in the Wollongong LGA and other south-east regions of NSW incorporate effective water and soil management measures, including quality control of stormwater discharge.

Table 9: Stormwater quality criteria for the proposed Illawarra International Health Precinct development: Huntley Road, Huntley.

Criteria	Total Suspended Solids (TSS)	Total Phosphorous (TP)	Total Nitrogen (TN)
(i) Council's adopted TSS target	10 mg/L	-	-
(ii) Protection of receiving environment	Less than or equal to pre-development loads.		
(iii) SCG WSUD Draft Policy (2004)	80% retention of baseline annual load or improve existing	45% retention of baseline annual load or improve existing	45% retention of baseline annual load or improve existing

These objectives are considered to be adequate to ensure that stormwater ultimately released from the site does not affect receiving waters.

Further to the above, and in accordance with the SCG WSUD Draft Policy (2004), the proposed strategy aims to incorporate Water Sensitive Urban Design (WSUD) principles wherever possible.

4.2 Stormwater Quality Modelling Approach

4.2.1 MUSIC 3.0

The Model for Urban Stormwater Improvement Conceptualisation computer modelling application (*MUSIC* version 3.0) developed by the Cooperative Research Centre (CRC) for Catchment Hydrology was utilised to evaluate pre- and post-development key pollutant loads and concentrations emanating from the site. Although the model is not a precise engineering tool, it provides a useful mechanism for investigating and refining the performance of a stormwater management scheme so that best management practices are achieved at a site.

4.2.2 Modelling Scenarios

Three site scenarios were modelled:

1. Pre-development conditions including existing rural land;
2. Post-development untreated stormwater conditions based on the proposed site development without any stormwater treatment structures; and
3. Post-development treated stormwater conditions based on the proposed site development with stormwater treatment measures.

Modelling scenario 3 was undertaken iteratively in order to ensure that the stormwater quality objectives of the site (Section 4.1) were met. Comparison of results from scenario 2 and scenario 3 allow for evaluation of the effectiveness of the proposed stormwater treatment structures.

The site layout details used in modelling are provided in Attachment C and MUSIC output files are provided as Attachment D.

4.2.3 Pollutant Generation Rates

Pollutant Event Mean Concentrations (EMC's) adopted for site modelling are as shown in Table 10. They are mostly in accordance with Australian Runoff Quality (2006).

The percentage impervious area assumed for each different category of land use is included as part of the additional MUSIC input data provided in Attachment D.

Table 10: MUSIC model EMC's adopted for Illawarra Health Care Precinct, Huntley.

Land Use	EMC (mg/L)		
	TSS	TP	TN
Rural (Pasture and livestock)	90	0.22	2
Roofs	20	0.11	1.1
Urban Roads	190	0.25	2.1
Commercial (Landscaping)	150	0.32	2.1

4.3 Stormwater Management Measures

A range of stormwater management devices or 'structures' which will contribute to improving stormwater quality have been incorporated into this concept stormwater management plan. These are detailed in the following sections.

4.3.1 Stormwater Runoff Collection

We understand that all future internal roads and pavements shall be kerb and gutter and all roof water is to drain first to rainwater tanks. Overflow from rainwater tanks will be directed to an appropriately sized pipe network. As discussed earlier in Section 3.3, the site is to be drained as three separate sub-catchments to aid stormwater treatment by three detention structures. In combination with the natural site topography, all site stormwater can be drained to proposed detention tanks positioned at low parts of the site. Detailed design of the stormwater drainage layout will be required at the CC stage of development.

4.3.2 Bio-Filtration Basins

The primary treatment structures for runoff from the proposed buildings, internal roads, car parking and landscaped areas are two proposed bio-filtration basins.

The approximate locations of the proposed bio-filtration basins are shown on the site plan (Attachment A) and basic, preliminary design specifications, which have been assumed for modelling purposes, are given in Table 11. Moderate slopes at the site will provide adequate fall for drainage and potential for modifications to the structures if later considered necessary. We note that the basins can be provided as a single or multiple systems located within each sub-catchment.

Table 11: Preliminary bio-filtration basin design specifications.

	Catchment 2	Catchment 3 (i)	Catchment 3 (ii)
Total Surface Area (m²)	280	480	675
Extended Detention Depth (m)	0.5	0.5	0.5
Filter Area (m²)	280	480	675
Filter Depth (m)	0.4	0.4	0.4
Overflow Weir Width (m)	2.0	2.0	2.0

4.3.3 Gross Pollutant Traps

Gross pollutant traps (GPT's) are to be installed upstream of each bio-filtration basin to capture any gross pollutants contained in site stormwater runoff and ensure that the effectiveness of the filtration basin is not diminished. At this stage, and for modelling purposes, we have assumed that proprietary available *Humeceptor* units will be installed. However, the type and location of GPT's is subject to detailed design closer to the CC stage of development.

4.3.4 Rainwater Tanks

Rainwater tanks are to be fitted to all proposed buildings. Preliminary work completed indicates that tank sizes to be used are as detailed in Table 12 such that total site rainwater storage of 1.6 ML is achieved. The tanks will provide some level of on-site stormwater detention (OSD) and some water quality treatment.

4.3.5 Summary

The recommended treatment process that applies to each stage of the proposed development is different for each of the assumed post-development catchments, as noted in Table 12.

Treatment Train 'A' (catchment 1) includes the following components:

1. All roof areas directed to rainwater tanks
2. Rainwater tanks are used for irrigation of site landscaping areas
3. Roads, above ground parking and landscaped areas directed to small gross pollutant trap (GPT)
4. All parking areas also to oil/water separator
5. Overflow from rainwater tanks and GPT and oil/water separator outlets to go to underground OSD tank
6. OSD outlet to Avondale Road drainage system.

Treatment Train 'B' (catchment 2) includes the following components:

1. All roof areas directed to rainwater tanks
2. Rainwater tanks are used for irrigation of site landscaping areas
3. Roads, above ground parking and landscaped areas directed to small gross pollutant trap (GPT)
4. All parking areas also to oil/water separator
5. Overflow from rainwater tanks and GPT and oil/water separator outlets to go to underground OSD tank
6. OSD outlet to Catchment 2 bio-filtration basin
7. Bio-filtration basin outlet to Avondale Road drainage system.

Treatment Train 'C' (catchment 3) includes the following components:

1. All roof areas directed to rainwater tanks
2. Rainwater tanks are used for irrigation of site landscaping areas
3. Roads, above ground parking and landscaped areas directed to small gross pollutant trap (GPT)
4. All parking areas also to oil/water separator
5. Overflow from rainwater tanks and GPT and oil/water separator outlets to go to underground OSD tank
6. OSD outlet to Catchment 3(i) and 3(ii) bio-filtration basins
7. Bio-filtration basin outlets to Goolagong Street drainage system.

Table 12: Summary of stormwater management measures per building at Illawarra IHP.

Stage	Treatment Train Type	Roof Area (m²)	Rainwater Tank Volume (kL)	Landscaping Area (ha)	Mean Daily Rainwater Demand (kL/day)
1	A	5,893	100	0.08	1.29
2	A	1,685	50	0.05	0.78
3	A	4,804	100	0.11	1.81
4	A	1,042	100	0.08	1.29
5	B	18,828	250	0.30	4.89
6	C	2,064	250	0.82	13.55
7	C	3,395	250	0.82	13.55
8A	B	4,751	250	0.59	9.78
8B	C	21 x 133 = 2,793	250	0.41	6.78

4.4 Performance of Stormwater Management System (Results)

MUSIC modelling results of the proposed stormwater management system are set out in Table 13 and Table 14.

Table 13: MUSIC water quality modelling results presented as mean annual pollutant loads at the receiving node.

Parameter (kg/yr)	Pre-Development	Post-Development Untreated	Post-Development Treated
TN	106	145	67
TP	14.10	17.10	5.56
TSS	4,860	7,610	723

Table 14: MUSIC water quality modelling results presented as flow-based concentrations at the receiving node.

Pollutant (mg/L)	Pre-Development	Post-Development Untreated	Post-Development Treated
TN	1.19	2.02	1.10
TP	0.13	0.125	0.09
TSS	25.1	17.4	8.01

The results of the MUSIC modelling demonstrate that, when managed appropriately through the implementation of water quality control structures/devices, the proposed development will lead to improved post-development stormwater pollutant loads coming from the site. Design objectives are revisited in Table 15.

Table 15: Stormwater Quality Criteria for 'Illawarra Int. Health Precinct', Huntley, NSW.

Source	Criteria	Expected Performance of Proposed System	Criteria Met
(i) Council's adopted TSS target	TSS – 10 mg/L in local watercourses/lakes.	Post-development TSS loads will be lower than current levels and TSS concentration is reduced from 25 (pre-development) to 8 mg/L. This means that Council's objective for downstream areas will not be compromised by the development.	Yes
(ii) Protection of receiving environment	Stormwater quality better than or equal to pre-development loads.	Pollutant loads have been reduced from pre-development levels by the following %: TN – 37 TP – 61 TSS - 85	Yes
(iii) SCG WSUD Draft Policy (2004)	Retention of average annual pollutant load as follows (%): TN – 45 TP – 45 TSS – 80 Or improve existing WQ	Average annual pollutant post-development loads have been retained by the following (%): TN – 54 TP – 67 TSS - 90	Yes

5 References

Bewsher Consulting Pty Ltd (2007), Mullet Creek and Brooks Creek Floodplain Risk Management Study and Plans Summary Report.

Hazelton (1992) Kiama 1:100,000 Soil Landscape Sheet, Soil Conservation Service of NSW.

NSW Dept. Mines (1966), Wollongong 1:250,000 Geological Sheet.

Wollongong City Council (1990) Wollongong Local Environmental Plan.

Wollongong City Council (2007) Draft West Dapto LEP

Wollongong City Council West Dapto DCP 23 (1993)

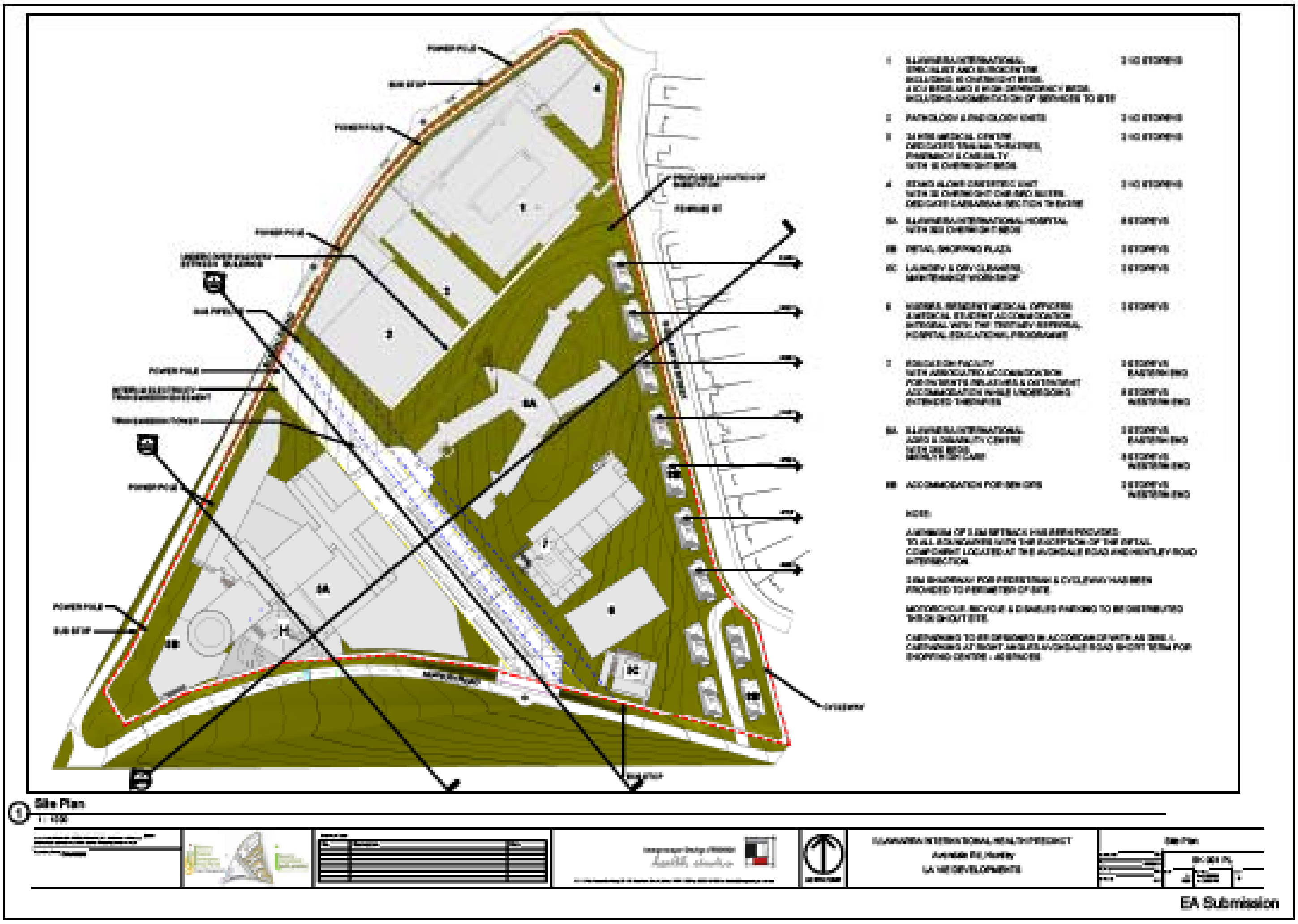
Wollongong City Council Urban Drainage Design Manual 94-20 (1994)

Wollongong City Council On-Site Stormwater Detention Code (2006)

Australian and New Zealand Guidelines for Fresh and Marine Water Quality (2000)

Southern Councils Group *Regional Water Sensitive Urban Design Policy* – Draft (2004

6 Attachment A – Site Plans



Site Plan

EA Submission

MARTENS & ASSOCIATES PTY LTD

Sustainable Solutions

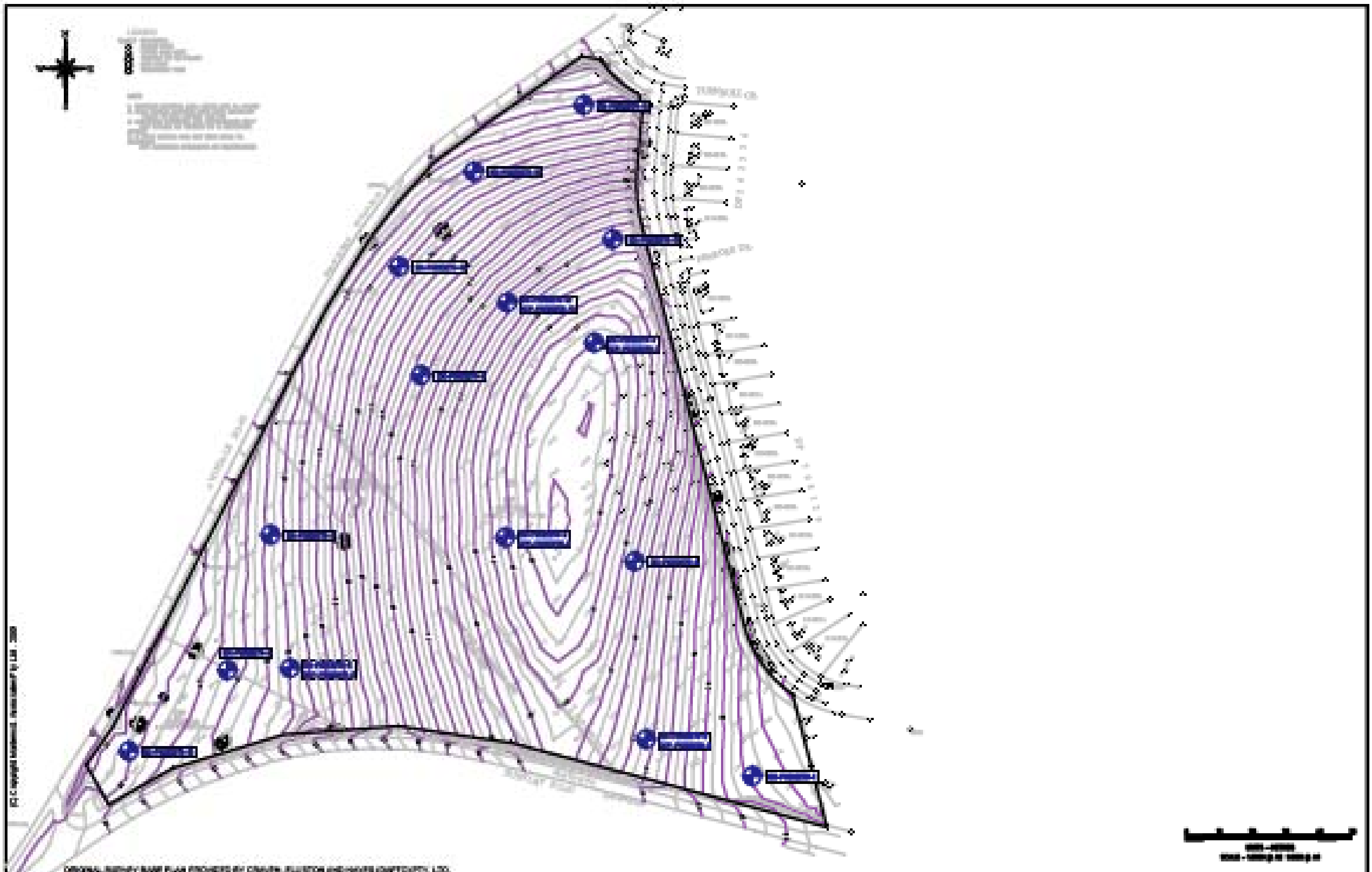
Environmental . Geotechnical . Civil

Hydraulic . Wastewater Engineers

ILLAWARRA INT. HEALTH PRECINCT / CONCEPT STORMWATER PLAN

SITE PLAN SHOWING PROPOSED STORMWATER MANAGEMENT STRUCTURES

SHEET 1



ORIGINAL SURVEY BASE PLAN PROVIDED BY CRAVEN, ELLISTON AND HAYES (KIAMA) PTY. LTD.

martens	MARTENS & ASSOCIATES PTY LTD Sustainable Solutions Environmental - Geotechnical - Civil Hydraulic - Wastewater Engineers	BRETT BOSLEY/ GEOTECHNICAL ASSESSMENT

SITE PLAN - CNR HUNTLEY AND AVONDALE ROAD (LOTS 22 DP 647750 AND 4 DP 258024)

SHEET 1

7 Attachment B – DRAINS Input and Output Files

Pre-development Scenario

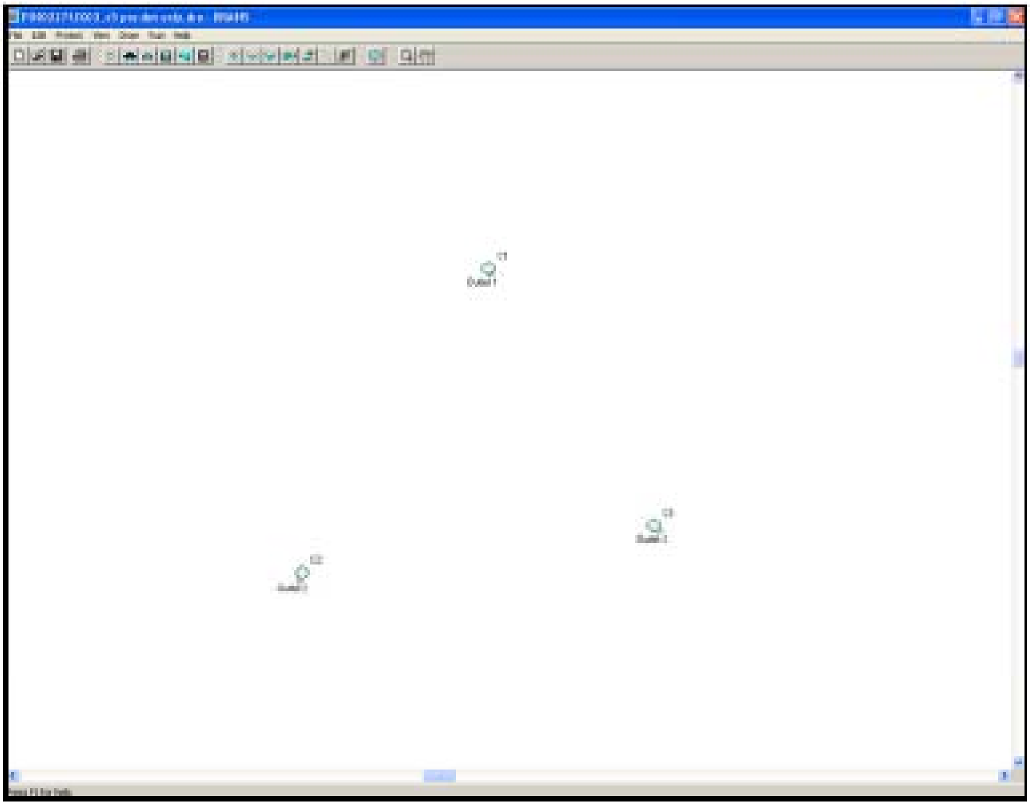


Figure 4: DRAINS pre-development stormwater drainage layout (three sub-catchments have been assumed to allow comparison with post-development modelling results).

PIT / NODE DETAILS Version 9

Name	Type	Family	Size	Ponding Volume (cu.m)	Pressure Change Coeff. Ku	Surface Elev (m)	Max Pond Depth (m)	Base Inflow (cu.m/s)
outlet	Node					24		0
N1058	Node					24		0
N1059	Node					24		0

SUB-CATCHMENT DETAILS

Name	Pit or Node	Total Area (ha)	Paved Area %	Grass Area %	Supp Area %	Paved Time (min)	Grass Time (min)	Supp Time (min)
C2	outlet	4.58	0	100	0	0	19.32	0
C3	N1058	3.16	0	100	0	0	19.32	0
C1	N1059	2.69	0	100	0	0	19.32	0

DRAINS results prepared 10 April, 2019 from Version 2018.07

PIT / NODE DETAILS

Name	Max HGL	Max Pond HGL	Max Surface Flow Arriving (cu.m/s)	Version 8 Max Pond Volume (cu.m)	Min Freeboard (m)	Overflow (cu.m/s)	Constraint

SUB-CATCHMENT DETAILS

Name	Max Flow Q (cu.m/s)	Paved Max Q (cu.m/s)	Grassed Max Q (cu.m/s)	Paved Tc (min)	Grassed Tc (min)	Supp. Tc (min)	Due to Storm
C1	2.504	0	2.504	0	19.52	0	AR&R 100 year, 1.5 hours storm, average 84 mm/h, Zone 1
C5	1.989	0	1.989	0	19.52	0	AR&R 100 year, 1.5 hours storm, average 84 mm/h, Zone 1
C3	1.355	0	1.355	0	19.52	0	AR&R 100 year, 1.5 hours storm, average 84 mm/h, Zone 1

Outflow Volumes for Total Catchment (0.00 impervious + 10.4 pervious = 10.4 total ha)

Storm	Total Rainfall cu.m	Total Runoff cu.m (Runoff %)	Impervious Runoff cu.m (Runoff %)	Pervious Runoff cu.m (Runoff %)
AR&R 100 year, 5 minutes storm, average 283 mm/h, Zone 1	2450.74	1960.33 (81.4%)	0.00 (0.0%)	1960.33 (81.4%)
AR&R 100 year, 10 minutes storm, average 227 mm/h, Zone 1	3940.02	2933.48 (74.5%)	0.00 (0.0%)	2933.48 (74.5%)
AR&R 100 year, 15 minutes storm, average 195 mm/h, Zone 1	5084.65	3960.14 (78.0%)	0.00 (0.0%)	3960.14 (78.0%)
AR&R 100 year, 20 minutes storm, average 174 mm/h, Zone 1	6032.4	4832.74 (80.0%)	0.00 (0.0%)	4832.74 (80.0%)
AR&R 100 year, 25 minutes storm, average 159 mm/h, Zone 1	6890.58	5587.45 (81.1%)	0.00 (0.0%)	5587.45 (81.1%)
AR&R 100 year, 30 minutes storm, average 147 mm/h, Zone 1	7666.05	6243.37 (81.4%)	0.00 (0.0%)	6243.37 (81.4%)
AR&R 100 year, 45 minutes storm, average 122 mm/h, Zone 1	9541.45	7840.61 (82.2%)	0.00 (0.0%)	7840.61 (82.2%)
AR&R 100 year, 1 hour storm, average 107 mm/h, Zone 1	11140.1	9205.08 (82.6%)	0.00 (0.0%)	9205.08 (82.6%)
AR&R 100 year, 1.5 hours storm, average 84 mm/h, Zone 1	13141.8	10684.44 (81.3%)	0.00 (0.0%)	10684.44 (81.3%)
AR&R 100 year, 2 hours storm, average 70 mm/h, Zone 1	14602	11658.12 (79.8%)	0.00 (0.0%)	11658.12 (79.8%)

PIPE DETAILS

Name	Max Q (cu.m/s)	Max V (m/s)	Max U/S HGL (m)	Max D/S HGL (m)	Due to Storm

CHANNEL DETAILS

Name	Max Q (cu.m/s)	Max V (m/s)	Chainage (m)	Max HGL (m)	Due to Storm

DETENTION BASIN DETAILS

Name	Max WL	MaxVol	Max Q Total	Max Q Low Level	Max Q High Level

CONTINUITY CHECK for AR&R 100 year, 1.5 hours storm, average 84 mm/h, Zone 1

Node	Inflow (cu.m)	Outflow (cu.m)	Storage Change (cu.m)	Difference %
outlet	4881.75	4881.75	0	0
N1032	5207.08	5207.08	0	0
N1030	2703.62	2703.62	0	0

Proposed Post-development Scenario

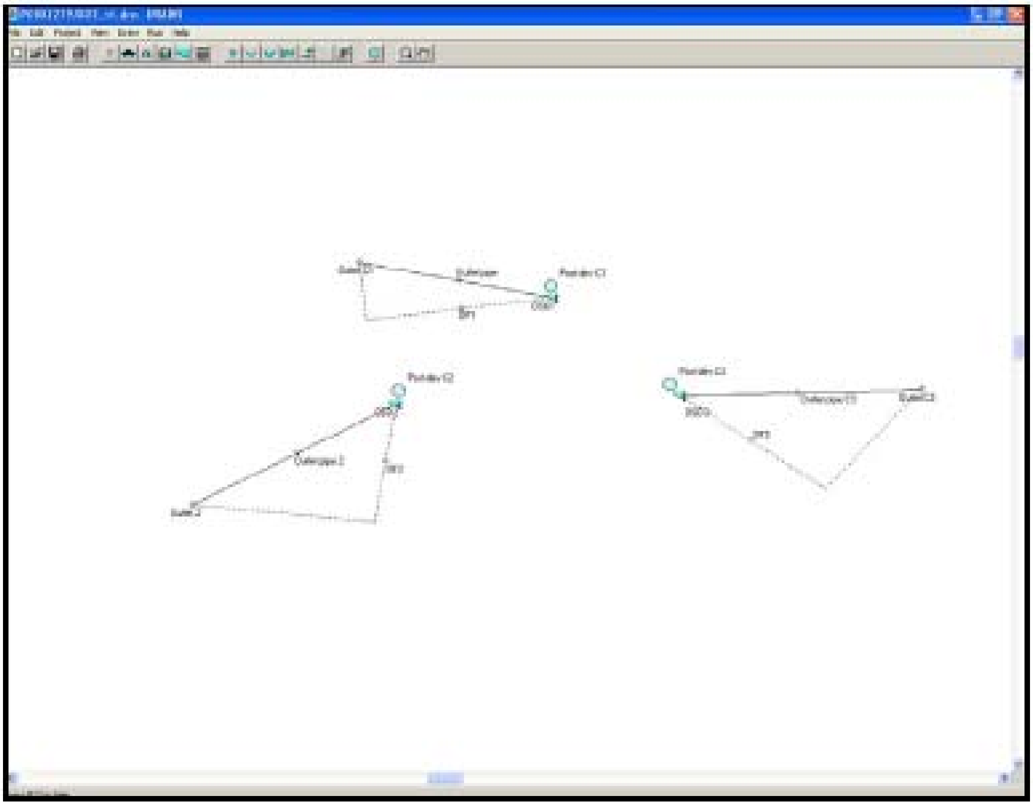


Figure 5: DRAINS post-development stormwater drainage layout (three sub-catchments each with OSD structure).

POST-DEV INPUTS. ✓

PIT / NODE DETAILS — Version 5

Name	Type	Family	Size	Ponding Volume (cu.m)	Pressure Change Coeff. Ku	Surface Elev (m)	Max Pond Depth (m)	Base Inflow (cu.m/s)	Blocking Factor	x	y	Bolt-down lid	id	Part Full Shock Loss
Outlet 2	Node					26.3			0	612.624	-232.073		102364328	
Outlet C1	Node					31			0	622.17	-218.867		102364334	
Outlet C3	Node					35			0	654.39	-233.125		102364335	

DETENTION BASIN DETAILS

Name	Elev	Volume	Init Vol. (cu.m)	Outlet Type	K	Dia(mm)	Centre RL	Pit Family	Pit Type	x	y	HED	Crest RL	Crest Length(m)	id
OSD2	27	0	216	Culvert	0.5					609.263	-236.973	No			102364336
	27.5	216													
	29	1822													
	29.3	2216													
OSD1	31.2	0	0	Culvert	0.5					600.281	-220.892	No			102364337
	32.5	1580													
	32.8	1565													
OSD3	35.5	0	0	Culvert	0.5					648.513	-226.48	No			102364338
	37.5	780													
	37.8	963													

SUB-CATCHMENT DETAILS

Name	Pit or Node	Total Area (ha)	Paved Area %	Grass Area %	Supp Area %	Paved Time (min)	Grass Time (min)	Supp Time (min)	Paved Length (m)	Grass Length (m)	Supp Length (m)	Paved Slope(%)	Grass Slope %	Supp Slope %	Paved Rough	Grass Rough	Supp Rough	Lag Time or Factor
Post-dev C2	OSD2	0.6780	60	40	0	2	2	0	30	20	-1	6	6	-1	0.015	0.033	-1	0
Post-dev C1	OSD1	2.1900	100	0	0	1	8	0	50	-1	-1	6	-1	-1	0.014	-1	-1	0
Post-dev C3	OSD3	0.1100	44	56	0	1.4	1.4	0	25	35	-1	6	6	-1	0.014	0.033	-1	0

PIPE DETAILS

Name	From	To	Length (m)	U/S IL (m)	D/S IL (m)	Slope (%)	Type	Dia (mm)	I.D. (mm)	Rough	Pipe Is	No. Pipes	Chg From	At Chg	Chg (m)	RI (m)	Chg (m)	RL (m)
Outlet pipe 2	OSD2	Outlet 2	15	27.5	26.3	8	Concrete, under roads	750	750	0.3	NewFixed	2	OSD2	0				
Outlet pipe	OSD1	Outlet C1	20	31.2	31	1	Concrete, under roads	600	600	0.3	NewFixed	1	OSD1	0				
Outlet pipe C3	OSD3	Outlet C3	30	35.5	35	1.67	Concrete, under roads	525	525	0.3	NewFixed	2	OSD3	0				

OVERFLOW ROUTE DETAILS

Name	From	To	Travel Time (min)	Spill Level (m)	Crest Length (m)	Weir Coeff. C	Cross Section	Safe Depth Major Storms (m)	Safe Depth Minor Storms (m)	Safe DxV (sq.m/sec)	Bed Slope (%)	D/S Area Contributing %	id
OF2	OSD2	Outlet 2	0.5	28	7	1.7	[illegible]	0.3	0.05	0.6	1	0	104333294
OF1	OSD1	Outlet C1	0.5	33	14.4	1.7	[illegible]	0.3	0.05	0.6	1	0	102810846
OF3	OSD3	Outlet C3	0.5	37.5	4	1.7	[illegible]	0.3	0.05	0.6	1	0	102392087

POST -DEV RESULTS ✓

PIT / NODE DETAILS

SUB-CATCHMENT DETAILS

8 Attachment C – MUSIC Model Layouts and Catchment Area Details

Pre-development Site Conditions

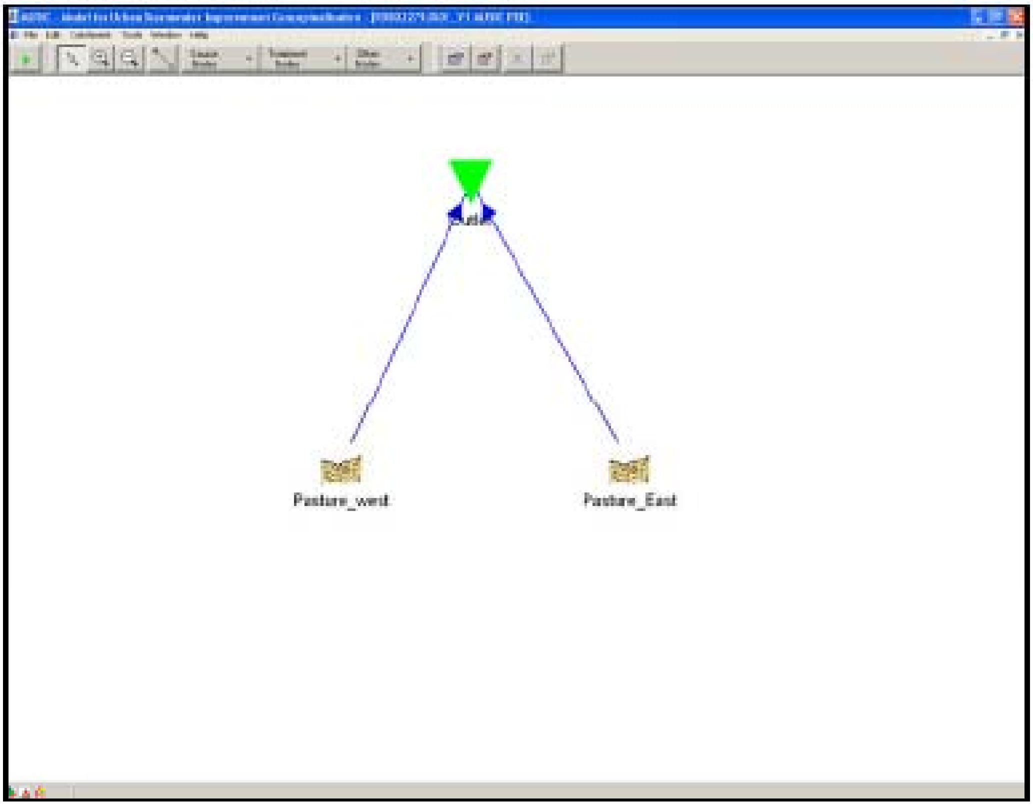


Figure 6: MUSIC pre-development layout.

Table 16: Catchment area details used for pre-development MUSIC modelling.

Total Area	**10.43 ha**
Pasture (Agricultural)	10.43 ha

Proposed Post-development Site Conditions

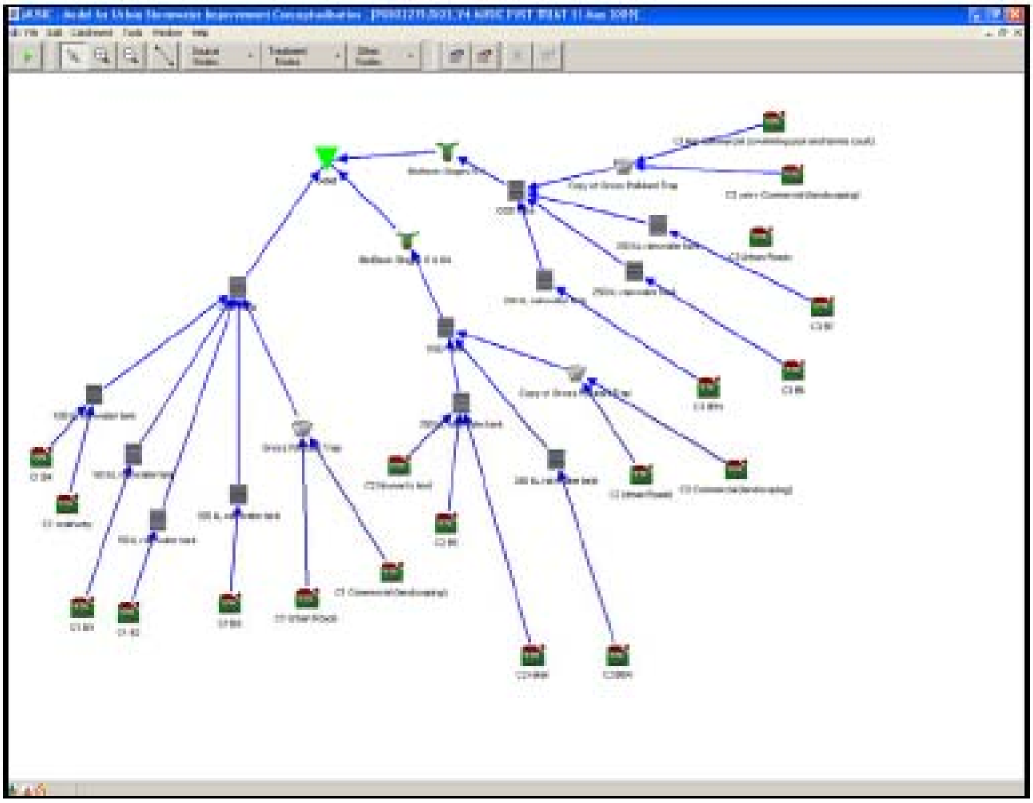


Figure 7: MUSIC post-development layout.

Table 17: Catchment area details used for post-development MUSIC modelling (hectares).

Catchment	C1	C2	C3
Total Area	2.69	4.58	3.16
Roofs	1.422	2.357	0.823
Urban Roads	0.636	0.986	0.306
Landscaping (Commercial)	0.629	1.202	2.118

9 Attachment D – MUSIC Input and Output Files

MUSIC Input Data (additional):

Table 18: Percentage impervious area assumed for MUSIC modelling.

Land Use	Percentage Impervious
Pasture (Agricultural)	0
Roofs	100
Urban Roads	100
Landscaping (Commercial)	50 (C1) – 25 (C2) – 3 (C3)

Table 19: Rainfall-runoff parameters.

Applicable Area	Parameter	Value
Impervious Area Properties	Rainfall Threshold (mm/day)	1.00
Pervious Area Properties	Soil Storage Capacity (mm)	150
	Initial Storage (% of capacity)	30
	Field Capacity (mm)	100
	Infiltration Capacity Coefficient – a	200
	Infiltration Capacity Exponent – b	1.00
Groundwater Properties	Initial Depth (mm)	2000
	Daily recharge rate (%)	25.00
	Daily base flow rate (%)	5.00
	Daily Deep Seepage Rate (%)	0.00

Table 20: Rainwater Tank properties.

Component	Property	Value
Rainwater Tank Inlet Properties	Low Flow By-pass (m^3/sec)	0.000
	High Flow By-pass (m^3/sec)	4.000
Rainwater Tank Storage Properties	Volume Below Overflow Pipe (kL)	50 – 250
	Depth Above Overflow (m)	0.3 – 0.4
	Surface Area (m^2)	25 – 100
Rainwater Tank Outlet Properties	Overflow Pipe Diameter (mm)	600
Rainwater Tank Re-use Properties	Annual Demand (kL/yr) scaled by daily PET	Daily demand x 365
	Daily Demand (kL/day)	0.78 – 13.55
	Monthly Distribution of Annual Demand (kL/yr)	Even

Table 21: OSD Tank properties.

Component	Property	Value
Inlet Properties	Low Flow By-pass (m^3/sec)	0.000
	High Flow By-pass (m^3/sec)	100.000
Storage Properties	Volume below overflow pipe (kL)	760.0
	Depth above overflow (m)	0.20
	Surface Area (m^2)	600.0
Outlet Properties	Overflow Pipe Diameter (mm)	742
Re-use Properties	Use stored water for irrigation or other purpose?	No

Table 22: Bio-filtration Basin properties.

Component	Property	Value
Inlet Properties	Low Flow By-pass (m^3/sec)	0.000
	High Flow By-pass (m^3/sec)	5.000
Storage Properties	Surface Area (m^2)	280 – 675
	Extended Detention Depth (estimate) (m)	0.50
	Seepage Loss (mm/hr)	3.60
Infiltration Properties	Filter Area (m^2)	280 – 675
	Filter Depth (m)	0.4
	Filter Median Particle Diameter (mm)	1.00
	Saturated Hydraulic Conductivity (mm/hr)	100.00
	Depth below underdrain pipe (% of Filter Depth)	0.0
Outlet Properties	Overflow Weir Width (m)	2.0

Table 23: Humeceptor properties.

Component	Property	Value
Inlet Properties	Low Flow By-pass (m^3/sec)	0.000
	High Flow By-pass (m^3/sec)	1.00
Pollutant Removal Efficiency	TSS (mg/L)	20%
	TP (mg/L)	20%
	TN (mg/L)	20%
	Gross Pollutants (kg/ML)	95%

MUSIC Results (additional):

P0802279JX01_V2 MUSIC PRE - Outlet

Flow-Based Sub-Sample Statistics

4/30/2009 12:09:30 PM

Inflow

	mean	stddev	median	maximum	minimum	10 %ile	90 %ile
Flow (cubic metres/sec)	1.21E-3	7.93E-3	85.5E-6	0.276	0.00	86.3E-9	1.71E-3
TSS Concentration (mg/L)	27.4	20.0	25.1	199	0.00	25.1	25.1
Log (TSS) (mg/L)	1.41	0.109	1.40	2.30	1.10	1.40	1.40
TP Concentration (mg/L)	0.137	47.5E-3	0.132	0.535	0.00	0.132	0.132
Log (TP) (mg/L)	-0.872	71.7E-3	-0.880	-0.272	-1.18	-0.880	-0.880
TN Concentration (mg/L)	1.22	0.324	1.19	3.88	0.00	1.19	1.19
Log (TN) (mg/L)	80.9E-3	62.5E-3	74.0E-3	0.588	-0.227	74.0E-3	74.0E-3
TSS Load (kg/Day)	11.3	134	0.186	4.73E3	0.00	187E-6	3.71
TP Load (kg/Day)	38.6E-3	0.362	974E-6	12.7	0.00	983E-9	19.5E-3
TN Load (kg/Day)	0.289	2.62	8.76E-3	92.4	0.00	8.85E-6	0.175
Gross Pollutant Load (kg/Day)	0.00	0.00	0.00	0.00	0.00	0.00	0.00

P0802279JX02_V3 MUSIC POST NO TREAT - Outlet

Flow-Based Sub-Sample Statistics

4/20/2009 12:07:30 PM

Inflow

	mean	stddev	median	maximum	minimum	10 %ile	90 %ile
Flow (cubic metres/sec)	2.93E-3	11.6E-3	57.2E-6	0.286	0.00	38.1E-9	6.35E-3
TSS Concentration (mg/L)	31.2	26.5	17.4	97.5	0.00	17.4	82.3
Log [TSS] (mg/L)	1.39	0.278	1.24	1.99	1.02	1.24	1.92
TP Concentration (mg/L)	0.135	28.3E-3	0.125	0.215	0.00	0.125	0.181
Log [TP] (mg/L)	-0.869	69.2E-3	-0.904	-0.668	-1.11	-0.904	-0.742
TN Concentration (mg/L)	1.88	0.300	2.02	2.02	0.00	1.52	2.02
Log [TN] (mg/L)	0.278	51.0E-3	0.306	0.306	84.2E-3	0.181	0.306
TSS Load (kg/Day)	20.8	89.8	86.1E-3	2.41E3	0.00	57.3E-6	43.0
TP Load (kg/Day)	46.9E-3	0.198	617E-6	5.31	0.00	410E-9	98.5E-3
TN Load (kg/Day)	0.398	1.60	10.0E-3	41.3	0.00	6.66E-6	0.845
Gross Pollutant Load (kg/Day)	5.49	12.8	0.00	70.7	0.00	0.00	26.5

P0802279JX03_V4 MUSIC POST TREAT 11 May 2009 - Outlet

Flow-Based Sub-Sample Statistics

12/05/2009 11:20:04 AM

Inflow

	mean	stddev	median	maximum	minimum	10 %ile	90 %ile
Flow (cubic metres/sec)	1.93E-3	9.33E-3	5.72E-6	0.291	0.00	0.00	3.47E-3
TSS Concentration (mg/L)	6.76	5.62	8.01	29.4	0.00	0.00	12.1
Log [TSS] (mg/L)	1.00	0.160	1.08	1.47	0.107	0.801	1.09
TP Concentration (mg/L)	73.0E-3	58.7E-3	88.3E-3	0.138	0.00	0.00	0.130
Log [TP] (mg/L)	-0.951	0.109	-0.886	-0.860	-1.36	-1.11	-0.885
TN Concentration (mg/L)	0.821	0.639	1.10	1.42	0.00	0.00	1.41
Log [TN] (mg/L)	0.108	61.7E-3	0.146	0.153	-0.123	10.3E-3	0.149
TSS Load (kg/Day)	1.98	16.0	5.88E-3	739	0.00	0.00	1.98
TP Load (kg/Day)	15.2E-3	84.4E-3	64.2E-6	2.98	0.00	0.00	24.8E-3
TN Load (kg/Day)	0.185	0.946	694E-6	31.2	0.00	0.00	0.317
Gross Pollutant Load (kg/Day)	0.00	0.00	0.00	0.00	0.00	0.00	0.00