Shoalhaven City Council
C/- Set Consulting Pty Ltd

Stormwater Management Assessment – Lot 1 DP 1021332 and Lot 458 DP 1063107 George Evans Road, Mundamia NSW

martens consulting engineers

ENVIRONMENTAL

WATER

WASTEWATER

GEOTECHNICAL

CIVIL

PROJECT MANAGEMENT

P1002863JR03V01
December 2012

Limitations Statement

The sole purpose of this report and the associated services performed by Martens & Associates Pty Ltd is to provide a stormwater management assessment in accordance with the scope of services set out in the contract / quotation between Martens & Associates Pty Ltd and Shoalhaven City Council (hereafter known as the Client). That scope of works and services were defined by the requests of the Client, by the time and budgetary constraints imposed by the Client, and by the availability of access to the site.

Martens & Associates Pty Ltd derived the data in this report primarily from a number of sources which may include for example site inspections, correspondence regarding the proposal, examination of records in the public domain, interviews with individuals with information about the site or the project, and field explorations conducted on the dates indicated. The passage of time, manifestation of latent conditions or impacts of future events may require further examination / exploration of the site and subsequent data analyses, together with a re-evaluation of the findings, observations and conclusions expressed in this report.

In preparing this report, Martens & Associates Pty Ltd may have relied upon and presumed accurate certain information (or absence thereof) relative to the site. Except as otherwise stated in the report, Martens & Associates Pty Ltd has not attempted to verify the accuracy of completeness of any such information (including for example survey data supplied by others).

The findings, observations and conclusions expressed by Martens & Associates Pty Ltd in this report are not, and should not be considered an opinion concerning the completeness and accuracy of information supplied by others. No warranty or guarantee, whether express or implied, is made with respect to the data reported or to the findings, observations and conclusions expressed in this report. Further, such data, findings and conclusions are based solely upon site conditions, information and drawings supplied by the Client *etc*. in existence at the time of the investigation.

This report has been prepared on behalf of and for the exclusive use of the Client, and is subject to and issued in connection with the provisions of the agreement between Martens & Associates Pty Ltd and the Client. Martens & Associates Pty Ltd accepts no liability or responsibility whatsoever for or in respect of any use of or reliance upon this report by any third party.

Head Office
6/37 Leighton Place
Hornsby, NSW 2077, Australia
ACN 070 240 890 ABN 85 070 240 890
Phone: +61-2-9476-9999
Fax: +61-2-9476-8767
Email: mail@martens.com.au
Web: www.martens.com.au

Document and Distribution Status

Author(s)	Reviewer(s)	Project Manager	Signature
Michael Dumas	Andrew Norris	Andrew Norris	

Revision No.	Description	Status	Release Date	Document Location			
				File Copy	MA Library	Set Consulting	
1	Draft Report	Draft	12.12.10	1E,1P,1H	1H	1P	
2	Final Report	Final	12.12.14	1E,1P,1H	1H	1P	

Distribution Types: F = Fax, H = hard copy, P = PDF document, E = Other electronic format. Digits indicate number of document copies.

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

Executive Summary

Overview

This stormwater assessment is prepared by Martens & Associates Pty Ltd (MA) on behalf of the Client to support an application to subdivide Lot 1, DP1021332 and Lot 458, DP1063107 (the 'site').

This report details an environmentally sustainable strategy for the management of stormwater generated from the site as well as detailing existing stormwater conditions at the site and likely impacts resulting from the proposed development.

Method

Assessment of water quality and quantity changes as a result of the proposed land release has been completed using the DRAINS and MUSIC hydrological and water quality models. Analysis included assessment of existing conditions and developed conditions.

An iterative approach was used to determine the requirements for site on-site detention as well as the need for, and preliminary dimensions / capacities of water quality structures to achieve adopted site objectives of 'no change' hydrological regime.

Results

Analysis concluded that a range of stormwater quality and quantity control solutions were required on the site. These systems were required to address requirements of the site hydrogeological assessment (that is to replace lost site groundwater recharge) and to achieve water quality treatment and flow detention following development.

The assessment concludes that the site requires the following stormwater structures to minimise the effects of the land's development on the local stormwater hydrology:

- Combined OSD basins and wetlands.
- Roadside bioremediation swales with groundwater recharge.
- Gross Pollutant Traps.
- Rainwater Tanks on all residential and commercial lots.

Implementation and Management

The implementation of the proposed water quality and quantity control measures would be through the development approval process. The design requirements for the OSD and water quality control systems should be made conditions of development consent.

To allow for ongoing maintenance of water quality (roadside bioremediation basins, wetlands and GPTs) and quantity (OSD tanks) systems, it is recommended that all such systems be located on Council allotments. This shall allow Council access and enforcement powers to ensure that these systems are maintained and operated in perpetuity.

'End of Pipe" systems such as OSD basins and wetlands would most likely be vested to Council for ongoing maintenance and operation.

Conclusions

The completed analysis indicates that, even with best practice water quality and quantity control solutions as developed in this assessment it is not feasible to achieve a post development surface water regime which mimics the pre-development condition exactly.

The proposed development does not have an adverse impact on downslope areas (in terms of increased peak discharge rates and pollutant loads) based on detailed hydrological and water quality modelling completed.

Site OSD basins are designed to mitigate peak discharges for critical duration storms for recurrence intervals from the 1 in 3 month ARI to the 1 in 100 year ARI.

Results indicate that post-development water quality objectives, in terms of pollutant retention and change in mean annual loads, will be met by the proposed stormwater treatment train.

Preliminary sizing of site water quality components are given in Section 3.5.1. Bioremediation components are to have a minimum infiltration area of 125 m^2/ha to ensure that site recharge requirements (as per the hydrogeological assessment) are met.

All site catchments are to include gross pollutant traps upslope of site wetlands.

Rainwater tanks are to be included on all lots for the purposes of non-potable re-use.

Contents

Tables

1 Overview

1.1 Study Overview

This stormwater assessment is prepared by Martens & Associates Pty Ltd (MA) to support an application to subdivide Lot 1, DP1021332 and Lot 458, DP1063107 (the 'site'). The report addresses the requirements of Shoalhaven City Council's DCP 100 (2002), Engineering Design Specification (1999) and Council's Sustainable Stormwater Guidelines.

This report details an environmentally sustainable strategy for the management of stormwater generated from the site as well as detailing existing stormwater conditions at the site and likely impacts resulting from the proposed development. The solutions and conceptual designs presented in this report draw from field inspections, modelling, relevant planning and engineering controls, policy objectives and guiding principles and represent a model for best practice management techniques for stormwater management.

1.2 Project Scope

The report addresses the following issues:

- Review of hydrogeological assessment findings from previous Martens and Associates stormwater management report (MA reference P1103064JR01V02, August 2011).
- Assessment of the existing and post-development peak stormwater discharges from the site for a range of average recurrence intervals.
- Assessment of likely changes to stormwater quality as a result of the proposed development to ensure a neutral or beneficial effect (NorBE) on post-development site stormwater discharge quality.
- Provide preliminary details of minimum requirements for stormwater management system components.

1.3 Proposed Development

We understand that the proposed works include:

- Proposed staged subdivision with residential, commercial and open space allotments and subsequent construction of dwellings, commercial buildings, *etc*.

- Internal road network with associated stormwater drainage infrastructure including stormwater quality and quantity control measures.

- Sewerage, water, power and gas infrastructure to service the development.

A site plan showing the proposed development and staging is provided in Attachment A.

1.4 Policy and Objectives

A number of planning controls and principles have been considered and implemented in the development of site stormwater management solutions. The objectives of these are summarised below:

1.4.1 Shoalhaven City Council DCP 100 (2002)

This document addresses minimum requirements for stormwater runoff quantity and quality management. Specific objectives of Council's DCP (2002) considered pertinent to this study include:

- To provide a stormwater system which adequately protects the natural and built environment at the acceptable level of risk.

- To provide a major system which is economically maintainable, taking account of life-cycle costs.

- To control flooding and maintain road access in accordance with accepted levels of service.

- To minimise the risk of traffic accidents related to flooded roads in accordance with accepted level of risk.

- To consider damage by stormwater to property such as houses.

- To provide a minor system that takes in account of the whole life-cycle costs and minimises nuisance flooding.

- To reduce localised flooding to a level which adequately protects the community.

- To minimise the risk of traffic accidents by reducing the contributing factor of water on roads in a minor storm event.

- To ensure that downstream systems are not adversely affected and ensure no net increase in pollution levels discharging from the development.

- The 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.

- The drainage system optimises control of any accumulation of silts and controls blockages by debris of inlet structures and pipes.

- The design and construction of water quality facilities will be undertaken to the requirements of Council and relevant authorities.

1.4.2 Shoalhaven City Council (1999) Engineering Design Specifications

This document summarises the objectives and technical specifications for developments to comply with Council's DCP 100 (2002). Specific objectives and specifications considered to be pertinent to this study include the following:

- To ensure that inundation of private and public buildings located in flood-prone areas occurs only on rare occasions and that, in such events, surface flow routes convey floodwaters below the prescribed velocity/depth limits.

- To provide conveyance and safety for pedestrians and traffic in frequent stormwater flows by controlling these flows within prescribed limits.

- Retain within each catchment as much incident rainfall and runoff as possible and appropriate for the planned use and the characteristics of the catchment.

1.4.3 Shoalhaven City Council Sustainable Stormwater Guideline.

This document provides specific performance objectives for stormwater quality and quantity control structures based on size of development and likely impacts on downslope properties.

1.4.4 Martens and Associates Surface Water Hydrology Assessment (2011)

This document provided a previous assessment of surface water hydrology and hydrogeology and recommendations made in this document are considered pertinent to this study. Notably the following recommendations with respect to maintenance of existing surface stormwater and groundwater regimes:

- Stormwater runoff from site roofs to be directed to rainwater tanks on individual lots for non-potable re-use purposes. Minimum volume of rainwater tanks to be 3 KL.

- Stormwater runoff from lot areas be directed to bioremediation 'raingardens' located on each lot. Raingardens are to have a minimum filter area of 125 m^2/ha and a filter depth of 0.3 m.

- Stormwater runoff from site road reserves and lots is to be directed to bioremediation basins with a minimum filter area of 125 m^2/ha (with catchment area measured excluding lot areas) to ensure groundwater recharge for downslope ecosystems.

- That the stormwater system be designed to maintain existing stormwater flows and nutrient loads where possible to minimise possible adverse impacts on sensitive flora located downslope of the development site.

- That OSD basins / tanks be utilised to ensure that peak post-development stormwater flows are reduced to existing peak discharges, particularly for more frequent storm events.

2 Site Description

2.1 Location and Existing Landuse

The 12.5 ha (approx.) site is located at George Evans Road, Mundamia within the Shoalhaven Local Government Area (LGA) and is surrounded by predominantly underdeveloped bushland and rural land (Figure 1).

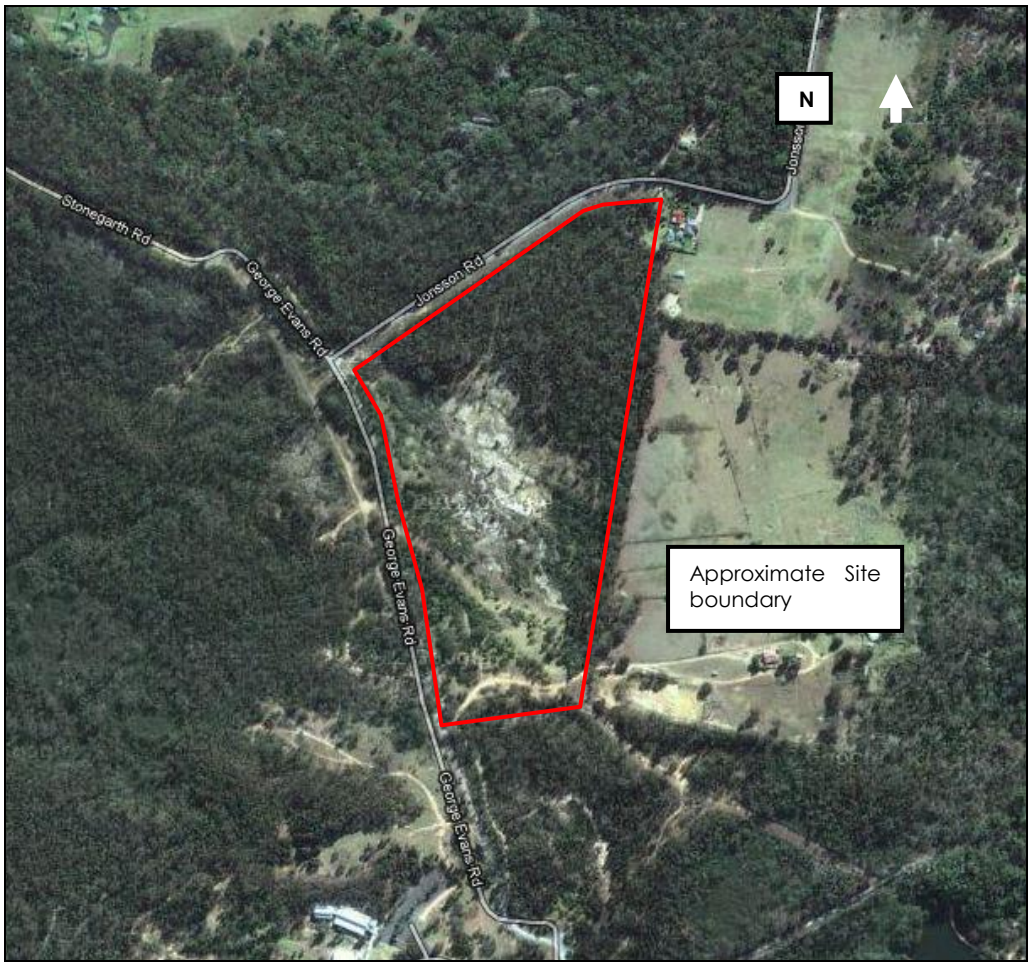


Figure 1: Site location

The site consists of a large area of disturbed land (towards the centre) primarily as the result of its past use as a quarry / gravel pit.

2.2 Topography and Drainage

Previous site use as a quarry / gravel pit has reshaped the natural site surface. The site falls to its centre which consists of a flat (slopes <5%) exposed sandstone surface. Drainage is facilitated by a manmade channel that runs north and exits the site under Jonsson Rd.

2.3 Groundwater

Site groundwater conditions are described as follows:

- Groundwater was observed in one test pit (TP108) and moist soil conditions reported in test pits located in the site's south.
- All other boreholes and test pits provided no indication of groundwater prior to termination depth.

A hydrogeological assessment for the Mundamia urban release area was completed by Martens and Associates in February 2011 (Martens ref: P1002761JR01V02). Two groundwater monitoring wells GMB2 (south) and GMB4 (north) were installed on the site as part of this study (Figure 2). The following is summarised from the 4 month well monitoring period:

- GMB2 was saturated above the soil/rock interface for the whole of the monitoring period.
- GMB4 remained dry above the soil/rock interface throughout the whole of the monitoring period. This is expected given that the silty gravely layer above the rock is highly permeable.

Given the site geological characteristics, ephemeral (temporary) groundwater is likely to occur in regions of the site's south in less permeable soils (sandy clay fill). A shallow (<2m) permanent groundwater table is not expected on site.

2.4 Geology and Soil Landscapes

Geological survey of NSW geology sheet (Wollongong 5609) maps the site being underlain by Nowra Sandstone, a subgroup of the Megalong Conglomerate Group geology.

3 Stormwater Management

3.1 Stormwater Management and Performance Objectives

Stormwater management objectives are broadly defined as:

- Provide comment and recommendation for likely on-site stormwater detention (OSD) requirements.
- Provide recommendations for on-site stormwater quality measures to ensure compliance with identified performance objectives.
- Provide preliminary details of stormwater infrastructure to drain the site via water quality controls and OSD basins.

Performance objectives are specified to generally comply with Shoalhaven City Council's (1999) Engineering Design Specification and Sustainable Stormwater Guideline. The principles of Water Sensitive Urban Design (WSUD) and Ecologically Sustainable Development (ESD) are also applied in the concept design with respect to sensitive flora downslope of the site. Objectives are summarised as follows:

- Post-development discharge rates are not to exceed the rate of discharge for existing conditions for a range of storms up to and including the 1 in 100 year ARI.
- Site OSD is designed to limit the post-development peak discharges to existing peak discharges for frequent events (1 in 3 month to 1 in 1 year ARI storm events) which have the greatest effect on vegetation.
- Site minor system (pit and pipe network) to convey 1 in 10 year ARI peak storm event. Site major system to convey 1 in 100 year ARI peak storm event.
- Site stormwater management system to achieve minimum target groundwater recharge rates to ensure existing seepage rates are maintained. Previous hydrogeological studies showed that a minimum of 125 m^2/ha of site recharge area is required.
- Post-development water quality outcomes are to be maintained as near as possible to pre-development condition to minimise impacts on native vegetation, whilst also adhering to the objectives for pollution retention listed in Table 1.

Table 1: Summary of pollution retention targets.

Pollutant	Post-development average annual load retention (%)
Total Suspended Solids	85
Total Phosphorus	65
Total Nitrogen	45
Gross Pollutants	90

3.2 Conceptual Stormwater Management System

Components of the site concept stormwater management system are:

- Rainwater tanks located on each lot (including medium density residential and commercial lots) to capture roof runoff for non-potable uses such as toilet flushing and irrigation.
- Roadside bioremediation swales located on one side of single cross-fall roads designed to treat stormwater flows from roads and lots, provides surface conveyance of flows to downslope treatment measures and provide areas for landscape planting.
- Site pit and pipe network pits and pipes designed to adequately convey the design peak storm event to site stormwater management measures.
- Gross pollutant traps located upstream of OSD and wetlands to capture gross pollutants.
- Wetlands located within OSD basins to further treat stormwater flows.
- OSD basins to capture stormwater flows from site areas and attenuate post-development peak discharges.

The above measures are sized through iterative hydrological, hydraulic and water quality modelling. Design takes account of requirements for groundwater recharge determined in the hydrogeological assessment (MA report P1103064JR01V02, August 2011).

3.3 Study Methodology and Assumptions

The study used the following computer models to assess OSD and water quality requirements:

- DRAINS (2012.15) hydrological modelling package to determine preliminary requirements for OSD sizing. Design rainfall intensity

data used in the model were consistent with figures given in Shoalhaven City Council's (1999) Engineering Design Specification. The DRAINS model layouts used are provided in Attachment B.

- MUSIC 5.1 water quality modelling package to determine requirements for water quality treatment measures for the site. The MUSIC model layouts used are provided in Attachment B.

Models used the design layout (Attachment A) provided by the Client. Key assumptions used in the modelling included:

3.3.1 DRAINS Model Assumptions

- Existing conditions modelling used the RAFTS component within DRAINS to calculate discharge.
- Post-development site levels are assumed to be altered through cut and fill to allow all site areas to drain to proposed stormwater management and treatment measures. Catchments are summarised in Table 4.
- Impervious and pervious areas for the site are summarised in Table 2. Figures are based on measured lot and road areas from the conceptual layout. Typical figures are based on Council's (1999) Engineering Design Specifications.
- Existing conditions assume that the centre of the site has reduced initial and continuing losses due to previous quarrying operations, losses are summarised in Table 3. Initial and continuing losses for proposed conditions include an additional 2.9 mm of depression storage to be provided in groundwater recharge system in accordance with the hydrogeological assessment (MA report P1002761JR01V01, June 2011).
- Rainwater tanks on individual lots are assumed to be 100% full at the commencement of rainfall events, do not contribute to site OSD and are not included in hydrological model.
- Site run-on flows are not considered in modelling as these areas are very small and are not anticipated to change from existing conditions.

3.3.2 MUSIC Model Assumptions

- MUSIC model used 6 minute pluviograph data from Nowra climate station available on the MUSIC website (www.toolkit.net.au/specials/). Data was for the period 1964 –

1982. Average monthly evapotranspiration rates for Nowra (BOM, 2001) were also used in the modelling.

- Sub-catchments used the stochastic pollutant generation method for determining pollutant loads as specified by SMCMA (2010) guidelines.
- Model used combined catchments based on sub-catchments calculated for the DRAINS hydrological model.
- Pollutant generation rates used in the model are from SMCMA (2010).
- Wetland nodes model the wetlands with exfiltration rates set to 0 mm/hr as wetland elements shall be lined.
- All stormwater runoff was assumed to go to proposed stormwater treatment measures with no areas bypassing.
- Proposed gross pollutant trap used in the model was the MUSIC node for a typical CDS unit.
- Site road bioremediation swales are assumed to be 2 m wide at the base, 3 m wide at the top and are modelled as a combined unit per catchment. Swales are assumed to have 3.5 m wide gaps at the front of each lot that they are adjacent to, to allow for a driveway crossing.
- Exfiltration rates for all roadside bioremediation swales were set at 10 mm/hr for required site groundwater recharge.
- Proposed rainwater tanks are combined for each catchment. All roof areas are assumed to drain to rainwater tanks. Stormwater re-use rates are based on typical potable water demand for residential lots from Shoalhaven Water of 548 L/day (200 KL/year) which is defined as 1 Equivalent Tenement (ET). 50% of this demand is assumed to be non-potable demand satisfied by rainwater tanks.
- Rainwater tanks are assumed to have a combined volume of 5 KL/ET, except for the commercial lot which is assumed to have a volume of 50 KL.
- Medium density lots in the sub-division have a demand rate of 1 ET/250 m^2 of lot area.

3.4 Site Hydrological Assessment

3.4.1 DRAINS Model Set-up

DRAINS model was set-up with the assumptions given above in Section 3.3.1. Model catchments, initial and continuing losses and pervious and impervious areas per catchment type are summarised in the following tables. Existing site utilizes three hydrological models to reflect the impact of reduced soil depth in the quarried portions of the site.

Table 2: Impervious and pervious fractions by land use.

Catchment Type	Impervious Fraction (%)	Pervious Fraction (%)	Supplementary Fraction (%)	Roof (% of total)
Road	95.0	5.0	0.0	0.0
Roof	100.0	0.0	0.0	100.0
Urban	30.0	60.0	10.0	30.0
Medium Density Residential	70.0	20.0	10.0	70.0
Commercial	90.0	10.0	0.0	50.0
Urban Parkland	25.0	75.0	0.0	0.0
Cleared Area	0.0	100.0	0.0	0.0
Forest	0.0	100.0	0.0	0.0

Table 3: Initial and continuing losses used in DRAINS modelling.

Component	Mundamia Proposed	Mundamia Existing	Mundamia Reduced Soil Depth
Paved area depression storage (mm)	3.9	-	-
Supplementary area depression storage (mm)	3.9	-	-
Pervious area depression storage (mm)	7.9	-	-
Impervious Initial Loss (mm)	-	1	1
Impervious Continuing Loss (mm/hr)	-	0	0
Pervious Initial Loss (mm)	-	15	2
Pervious Continuing Loss (mm/hr)	-	2	0

Table 4: DRAINS model catchments – existing and proposed conditions.

Scenario	Catchment	Area (ha)	Impervious Area (%)	Pervious Area (%)	Supplementary Area (%)	Hydrological Model
Existing Conditions	Cabbage Tree Flat – Cleared	2.00	5.2	94.8	0.0	Mundamia Existing
	Cabbage Tree Flat – Forest	5.95	0.0	100.0	0.0	Mundamia Existing
	Cabbage Tree Flat – Reduced	2.89	0.0	100.0	0.0	Mundamia Reduced
	Flat Rock Creek – Cleared	0.06	0.0	100.0	0.0	Mundamia Existing
	Flat Rock Creek – Forest	1.63	0.0	100.0	0.0	Mundamia Existing
Proposed Conditions	1/1	1.74	56.1	43.9	0.0	Mundamia Proposed
	2/1	0.67	73.6	18.0	8.7	Mundamia Proposed
	3/1	1.65	56.6	36.4	6.9	Mundamia Proposed
	4/1	0.93	70.9	23.8	5.3	Mundamia Proposed
	5/1	1.35	49.6	42.5	7.9	Mundamia Proposed
	6/1	1.12	78.2	15.0	6.7	Mundamia Proposed
	1/2	1.13	30.0	60.0	10.0	Mundamia Proposed
	2/2	1.98	47.3	45.0	7.7	Mundamia Proposed
	3/2	0.66	59.3	34.4	6.3	Mundamia Proposed
	4/2	0.32	30.0	60.0	10.0	Mundamia Proposed
	1/3	0.98	43.4	49.3	7.4	Mundamia Proposed

3.4.2 DRAINS Model Results

DRAINS modelling conducted for the study used sub-catchment data as summarised in Table 4. Catchment plans are provided in Attachment A. Results (peak flow discharged from the site for critical

duration storm events) are summarised in Table 5. General comments about the hydrological model are as follows:

- Results show that the proposed OSD basins reduce post-development peak flows for critical duration storms to existing conditions peak discharges.
- Critical duration storm event for the site is generally the 1.5 or 2 hour duration storm.
- Table 6 summarises the minimum OSD volume per catchment road area required.
- Post-development peak discharge rates for short duration storm events is generally higher than existing conditions for the site (in particular for the part of the site draining to Flat Rock Creek). Detailed design of OSD basins and modelling, including the effects of site rainwater tanks, at detailed design stage may mitigate these post-development flows.
- Peak flows from the site to Flat Rock Creek for existing conditions, more frequent storm events are very low. This is due to the existing catchments having no impervious area and high initial losses.

Table 5: Summary of critical duration site peak discharges.

Model	Average Recurrence Interval							
	1 in 3 month		1 in 1 year		1 in 10 year		1 in 100 year	
	Peak discharge (m^3/s)	Critical Storm Duration (minutes)	Peak discharge (m^3/s)	Critical Storm Duration (minutes)	Peak discharge (m^3/s)	Critical Storm Duration (minutes)	Peak discharge (m^3/s)	Critical Storm Duration (minutes)
Existing Conditions	0.16	90	0.51	120	1.58	120	2.96	120
Proposed Conditions	0.08	90	0.23	120	1.37	120	2.77	120
Change	-0.08	-	-0.28	-	-0.21	-	-0.19	-

Table 6: Summary of OSD basin requirements.

Catchment / Basin	Minimum volume (m^3/ha road)	OSD Volume (m^3)	Invert (mAHD)	Outlet Pipe Orifice (mm) and R.L. (mAHD)					
				Low-Flow		Mid-Level		High-Flow	
				Orifice	Level	Orifice	Level	Orifice	Level
1	600	4,475	66.0	150	66.0	400	66.25	2 x 490	66.745
2	550	2,250	61.2	200	61.2	450	61.45	2 x 290	61.845
3	225	220	61.7	180	61.7	275	61.9	290	62.245

3.5 Site Stormwater Quality

3.5.1 MUSIC Model Set-up

MUSIC model was set-up with sub-catchments and treatment nodes as detailed in the following tables and assumptions outlined in Section 3.3.2. Sub-catchments were assigned event mean and baseflow pollutant generation rates based on the catchment usage and soil parameters based on the site sub-surface investigations. Details of pollutant generation rates used are given in Table 8, soil parameters in Table 9. Rates and parameters adopted are based on SMCMA (2010).

Table 7: Catchments used in MUSIC modelling.

Scenario	Model Catchment	Catchment Area (ha)	Impervious Area (% of Total Area)	Pervious Area (% of Total Area)	Adopted Catchment Usage
Existing Conditions	Cabbage Tree Flat - Cleared	4.89	0	100	Agricultural
	Cabbage Tree Flat – Road	0.11	100	0	Unsealed Road
	Cabbage Tree Flat - Forest	5.95	0	100	Forest
	Flat Rock Creek – Cleared	0.06	0	100	Agricultural
	Flat Rock Creek - Forest	1.63	0	100	Forest
Developed Conditions	Catchment 1 – Road	1.62	95	5	Road
	Catchment 1 – Roof	2.49	100	0	Roof
	Catchment 1 – Urban	2.37	69	31	Urban Residential
	Catchment 1 – Urban Park	0.97	25	75	Urban Residential
	Catchment 2 – Road	0.61	95	5	Road
	Catchment 2 – Roof	1.16	100	0	Roof
	Catchment 2 – Urban	2.23	85	15	Urban Residential
	Catchment 2 – Urban Park	0.09	25	75	Urban Residential
	Catchment 3 – Road	0.21	95	5	Road
	Catchment 3 – Roof	0.22	100	0	Roof
	Catchment 3 – Urban	0.51	14	86	Urban Residential
	Catchment 3 – Urban Park	0.05	25	75	Urban Residential

Table 8: Event mean and baseflow concentration of pollutants used in MUSIC modelling (SMCMA, 2010).

Land-use	Parameter	Storm Flow (SF) (mg/L)	Standard Deviation (log_{10})	Base Flow (BF) (mg/L)	Standard Deviation (log_{10})
Agricultural	Total suspended solids (mg/L)	141	0.31	20	0.13
	Total phosphorus (mg/L)	0.60	0.30	0.09	0.13
	Total nitrogen (mg/L)	3.02	0.26	1.10	0.13
Unsealed Road	Total suspended solids (mg/L)	1000	0.32	15.8	0.17
	Total phosphorus (mg/L)	0.50	0.25	0.14	0.19
	Total nitrogen (mg/L)	2.19	0.34	1.29	0.12
Forest	Total suspended solids (mg/L)	39.8	0.20	6.0	0.13
	Total phosphorus (mg/L)	0.08	0.22	0.03	0.13
	Total nitrogen (mg/L)	0.89	0.24	0.30	0.13
Urban Residential	Total suspended solids (mg/L)	141	0.32	15.8	0.17
	Total phosphorus (mg/L)	0.25	0.25	0.14	0.19
	Total nitrogen (mg/L)	2.00	0.19	1.30	0.12
Road	Total suspended solids (mg/L)	269	0.32	15.8	0.17
	Total phosphorus (mg/L)	0.50	0.25	0.14	0.19
	Total nitrogen (mg/L)	2.19	0.34	1.29	0.12
Roof	Total suspended solids (mg/L)	20	0.32	20	0.17
	Total phosphorus (mg/L)	0.13	0.25	0.13	0.19
	Total nitrogen (mg/L)	2.00	0.19		

Table 9: Soil parameters used in MUSIC modelling.

Modelling Parameter	Value Adopted
Rainfall Threshold (mm/day)	1.5
Soil Storage Capacity (mm)	142
Initial Storage (% of Capacity)	25
Field Capacity (mm)	94
Infiltration Capacity Coefficient - a	180
Infiltration Capacity Coefficient - b	3.0
Initial Depth – Groundwater (mm)	10
Daily Recharge Rate – Groundwater (%)	25
Daily Baseflow Rate – Groundwater (%)	25
Daily Deep Seepage Rate – Groundwater (%)	0

Table 10: General parameters used in treatment nodes for post-development conditions.

Treatment Node	Parameters Adopted for MUSIC model
Constructed wetlands	Low flow by-pass – 0 m^3/s
	High flow by-pass – 1 m^3/s
	Inlet pond volume – 20% of total wetland volume
	Extended detention depth – 1.5 m
	Exfiltration rate – 0 mm/hr
	Evaporative loss – 125% of potential evapotranspiration
	Daily demand rate for irrigation supply – 0 KL/ha/day
Gross pollutant trap	Total suspended solids retention rate – 70%
	Total phosphorus retention rate – 30%
	Total nitrogen retention rate – 0%
	Gross pollutant retention rate – 98%
Rainwater tank	Overflow pipe diameter – 300 mm
	Depth above tank outlet – 0.2 m
Road bioremediation swale	Low flow by-pass – 0 m^3/s
	High flow by-pass – 0.5 m^3/s
	Extended detention depth – 0.10 m
	Exfiltration rate – 10 mm/hr
	Filter depth – 0.72 m
	Saturated hydraulic conductivity – 100 mm/hr
	TN content of filter material – 500 mg/kg
	Orthophosphate content of filter material – 50 mg/kg
Park buffer	Percentage area buffered – 50%
	Percentage impervious area upslope buffered – 50%
	Exfiltration rate – 0 mm/hr

Table 11: Treatment node parameters by catchment.

Treatment Node	Parameter	Basin 1	Basin 2	Basin 3
Wetland	Volume wetland (m^3/road ha)	750	750	-
	Volume wetland (m^3)	608	229	-
	Total area (m^2)	1216	458	-
Roadside bioremediation swale	Length	455.7	288.1	136.8
	Swale area[1] (m^2)	1,139	720	342
	Filter area (m^2/ha)	562.3	942.7	1,329.9
	Filter area (m^2)	911.4	576.1	273.6
Rainwater tank	Volume (m^3)	644.2	265.0	70.0
	Demand (KL/day)	37.6	14.5	3.8

Notes: [1.] Measured as area at half the depth of the swale.

3.5.2 MUSIC Model Results

Results of the MUSIC model are summarised in Table 12 and Table 13. Results indicate that post-development water quality objectives, in terms of pollutant retention and change in mean annual loads, will be met by the proposed stormwater treatment train.

Further refinement of the model at detailed design stage of the development may slightly alter the size of proposed treatment structures.

Table 12: Results of MUSIC modelling – mean annual loads.

Catchment	Conditions	Total Suspended Solids (kg/year)	Total Phosphorus (kg/year)	Total Nitrogen (kg/year)
Flat Rock Creek	Existing	170.0	0.41	4.1
	Proposed	72.7	0.28	2.7
	Change	-97.3	-0.13	-1.4
Cabbage Tree Flat	Existing	3,540	9.17	53.8
	Proposed	888	3.65	53.6
	Change	-2,652	-5.52	-0.2
Total Site	Existing	3,710	9.59	57.8
	Proposed	961	3.93	56.3
	Change	-2,749	-5.66	-1.5

Table 13: Results of MUSIC modelling – pollution retention rates.

Catchment		Total Suspended Solids (kg/year)	Total Phosphorus (kg/year)	Total Nitrogen (kg/year)	Gross Pollutants
Flat Rock Creek	Generated	987	1.89	12.7	123
	Discharged	72.7	0.28	2.7	0.1
	Reduction (%)	92.6	85.1	79.1	99.9
Cabbage Tree Flat	Generated	11,400	23.0	168.0	1,770
	Discharged	888	3.7	53.6	0.3
	Reduction (%)	92.2	84.1	68.1	100.0
Total Site	Generated	12,400	24.9	180.0	1,890
	Discharged	961	3.9	56.3	0.4
	Reduction (%)	92.3	84.2	68.7	100.0

4 Recommendations Summary

4.1 Stormwater System Design

The following recommendations regarding system design, implementation and management are provided to detail the scope of future requirements. They are to be reviewed, finalised and developed as the development progresses with final solutions developed prior to the release of construction certificate.

4.1.1 Design Recommendations

The following design recommendations are made with respect to stormwater management for the site. These recommendations incorporate the findings of the hydrogeological assessment (MA report P1002761JR01V01, June 2011):

- Stormwater runoff from all site roofs is to be directed to rainwater tanks on individual lots for non-potable re-use purposes (e.g. irrigation, toilet flushing, laundry, *etc.*). Rainwater tanks are to have a minimum volume of 5 KL/lot for individual residential lots, 5 KL/dwelling for medium density and dual occupancy lots and 60.3 KL / ha for commercial lots.

- Stormwater runoff from lots and roads is to be directed to roadside bioremediation swales. Swales are to have a minimum top width of 3.0 m and a minimum base width of 2.0 m. Swales are to be a minimum of 0.1 m deep with 1V:2.5H side slopes. Bioremediation filters are to be a minimum depth of 0.72 m and are to be unlined to allow groundwater recharge. Filter areas as identified and assessed as adequate for catchment are: 562 m^2/ha (Catchment 1); 943 m^2/ha (Catchment 2); and 1,330 m^2/ha (Catchment 3). Swales are to have an underdrain and overflow system discharge pit and pipe drainage system.

- A stormwater system including pits, pipes and associated infrastructure is to be constructed within road reserves to direct flows from bioremediation swales to gross pollutant traps (GPTs) and site OSD basins and wetlands. Detailed sizing and location of all pits and pipes is to be completed prior to the issue of a construction certificate.

- GPTs are to be placed at the downstream end of the Council stormwater transfer system and upstream of OSD basins and

wetlands. GPTs are to be designed and constructed to meet the pollutant reduction performances given in Table 10.

- All runoff from site areas is to be directed to one of three combined OSD wetlands located as shown in Attachment A. These structures are to incorporate a lined wetland of 0.5 m minimum depth and vertical sides, surrounded by an OSD basin (excepting Catchment 3 where no wetland is required). Minimum filter areas, volumes and design exfiltration rates are given in Table 11.

- OSD basins are to have a minimum of 1.5 m depth to overflow spillways, with an additional 0.3 m of depth above the spillway level. Basin side slopes are assumed to be a minimum of 1V:3H (Basins 2 and 3) and 1V:6H (Basin 1) respectively. Basins are to be set at such a level as to allow free-draining of flows from the basins (and wetlands at the centre of basins) to the outlet downslope of the site.

- Each OSD is to have three outlet pipes consisting of a low-level pipe, mid-level pipe and high flow pipe, connected to a sealed pit downstream of the basin with combined pipe(s) to an outlet headwall. Pipe outlets are summarised in Table 6. Basin 1 is to have a separate outlet pipe connected to a headwall downslope of Jonsson Road, separate to the stormwater drainage network for Catchments 1 and 2 as shown on the attached site plan. Discharge from Basin 3 is to be directed to the stormwater drainage network for the adjacent site to the east of the subject site.

- Site stormwater outlets will require an appropriate level spreader / energy dissipater to replicate existing flow conditions. A nominal 20 m setback should be established between site stormwater outlets and areas of sensitive vegetation.

4.1.2 System Implementation Recommendations

The proposed solution includes works both in future public lands (road side swales and majority of basin / wetland structures within road reserves and public open space to be vested to Council) and on private lands (rainwater tanks and basin / wetland 2 on ALC land). The following section provides initial comments on matter to be considered to ensure the solution is appropriately implemented on the site.

The construction of end of pipe and roadside structures would be undertaken as a condition of future sub-division consent and would occur as the development road system in constructed. On

completion, these systems may be maintained for a period by the developer or be transferred to Council for their management. It is anticipated that the specifications for the system shall form a condition of future sub-division consent.

Future allotments shall be burdened with the need for stormwater management infrastructure to achieve the objectives of this study. The infrastructure required shall include a rainwater tank (as is generally required throughout NSW due to BASIX), with minimum volume as detailed in this report.

4.1.3 System Management Recommendations

To ensure that the proposed stormwater systems continue to perform as designed, the following management and maintenance measures are required:

- Road side swales, GPTs, OSD basins and wetlands should be inspected and cleaned routinely to ensure that litter accumulation does not become excessive.

- Periodic removal of accumulated silts from GPTs, road side swales, wetlands and OSD basin may be required to ensure ongoing hydraulic performance. System monitoring is to be undertaken to ensure that adequate infiltration into the filter media is maintained. Where infiltration deteriorates, the owner of the infrastructure shall be required to replace filter media.

- Vegetation management is required to ensure that systems do not become clogged with dead and decaying vegetation and to ensure that vegetation does not block water flow through the systems. Maintenance requirements for vegetation shall depend on the nature of the plants and is to be developed in detail as part of the final project landscape management plan.

5 Conclusions

The following recommendations and conclusions are made based on the hydrological and water quality assessments:

- The completed analysis indicates that, even with best practice water quality and quantity control solutions as developed in this assessment it is not feasible to achieve a post development surface water regime which exactly mimics the pre-development condition.

- The proposed development does not have an adverse impact on downslope areas (in terms of increased peak discharge rates and pollutant loads) based on detailed hydrological and water quality modelling completed.

- Site OSD basins are designed to mitigate peak discharges for critical duration storms for recurrence intervals from the 1 in 3 month ARI to the 1 in 100 year ARI.

- Results indicate that post-development water quality objectives, in terms of pollutant retention and change in mean annual loads, will be met by the proposed stormwater treatment train.

- Site wetlands are to be located within the footprint of OSD basins. Preliminary sizing of site wetlands are given in Section 3.5.1.

- Selected site roads as shown in SK002 (Attachment B) are to be designed as single cross-fall pavements with bioremediation swales located adjacent to roads. Road bioremediation swales are sized with end of pipe structures to achieve site's minimum infiltration area (125 m^2/ha) as per the hydrogeological assessment.

- All site catchments are to include gross pollutant traps upslope of site wetlands.

- Rainwater tanks are to be included on all lots for the purposes of non-potable re-use. Tanks are to be sized in accordance with parameters listed in Section 3.5.1.

6 References

Bureau of Meteorology (2001) *Climatic Atlas of Australia – Evapotranspiration.*

Institute of Engineer's Australia (1987) *Australian Rainfall and Runoff.*

Shoalhaven City Council (2002) *Development Control Plan 100.*

Shoalhaven City Council (1999) *Engineering Design Specifications.*

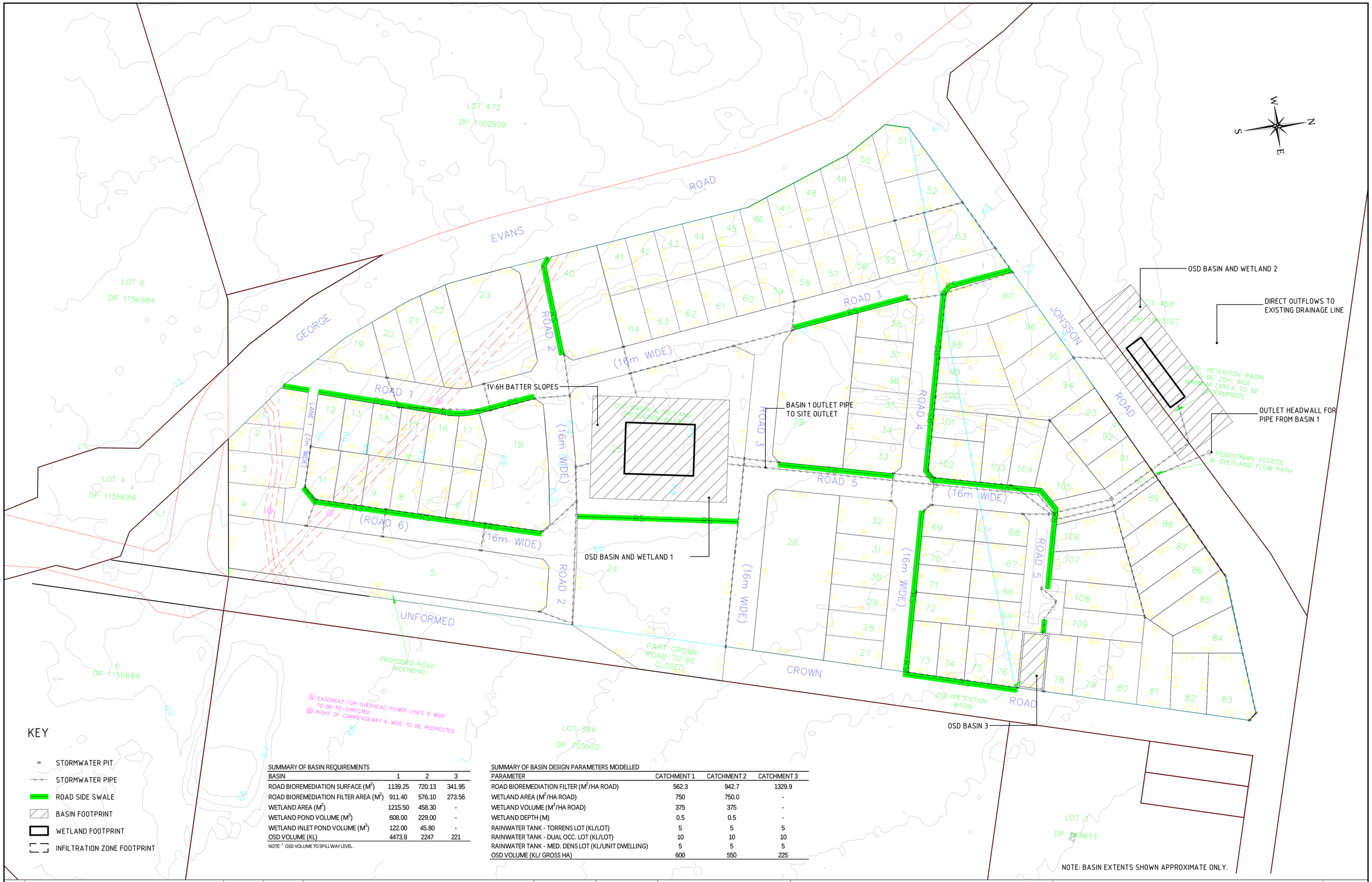
Shoalhaven City Council *Sustainable Stormwater Guidelines.*

Sydney Metropolitan Catchment Management Authority (2010) *Draft MUSIC Modelling Guidelines.*

www.toolkit.net.au/specials/

http://training.ewater.com.au/file.php/1/HTML/index.html?gross_pollutent_traps.htm

7 Attachment A – Site Plan



KEY

- STORMWATER PIT
- STORMWATER PIPE
- ROAD SIDE SWALE
- BASIN FOOTPRINT
- WETLAND FOOTPRINT
- INFILTRATION ZONE FOOTPRINT

SUMMARY OF BASIN REQUIREMENTS

BASIN	1	2	3
ROAD BIOREMEDIATION SURFACE (M^2)	1139.25	720.13	341.95
ROAD BIOREMEDIATION FILTER AREA (M^2)	911.40	576.10	273.56
WETLAND AREA (M^2)	1215.50	458.30	-
WETLAND POND VOLUME (M^3)	608.00	229.00	-
WETLAND INLET POND VOLUME (M^3)	122.00	45.80	-
OSD VOLUME (KL)	4473.8	2247	221

NOTE: [1] OSD VOLUME TO SPILLWAY LEVEL.

SUMMARY OF BASIN DESIGN PARAMETERS MODELLED

PARAMETER	CATCHMENT 1	CATCHMENT 2	CATCHMENT 3
ROAD BIOREMEDIATION FILTER (M^2/HA ROAD)	562.3	942.7	1329.9
WETLAND AREA (M^2/HA ROAD)	750	750.0	-
WETLAND VOLUME (M^3/HA ROAD)	375	375	-
WETLAND DEPTH (M)	0.5	0.5	-
RAINWATER TANK - TORRENS LOT (KL/LOT)	5	5	5
RAINWATER TANK - DUAL OCC. LOT (KL/LOT)	10	10	10
RAINWATER TANK - MED. DENS LOT (KL/UNIT DWELLING)	5	5	5
OSD VOLUME (KL/ GROSS HA)	600	550	225

NOTE: BASIN EXTENTS SHOWN APPROXIMATE ONLY.

REV.	DESCRIPTION	DATE	ISSUED
A	DA LAYOUT	12.12.10	ASN

BAR SCALE
PAGE BAR SCALE
0 20 40 60 80 100
UNITS - METRES
SCALE - 1:1000 @ A1 1:2000 @ A3

DESIGNED: MGD
DATUM: mAHD
REVIEWED: ASN
HORIZONTAL RATIO: 1:1000
PAPER SIZE: A1
VERTICAL RATIO: 1:1000

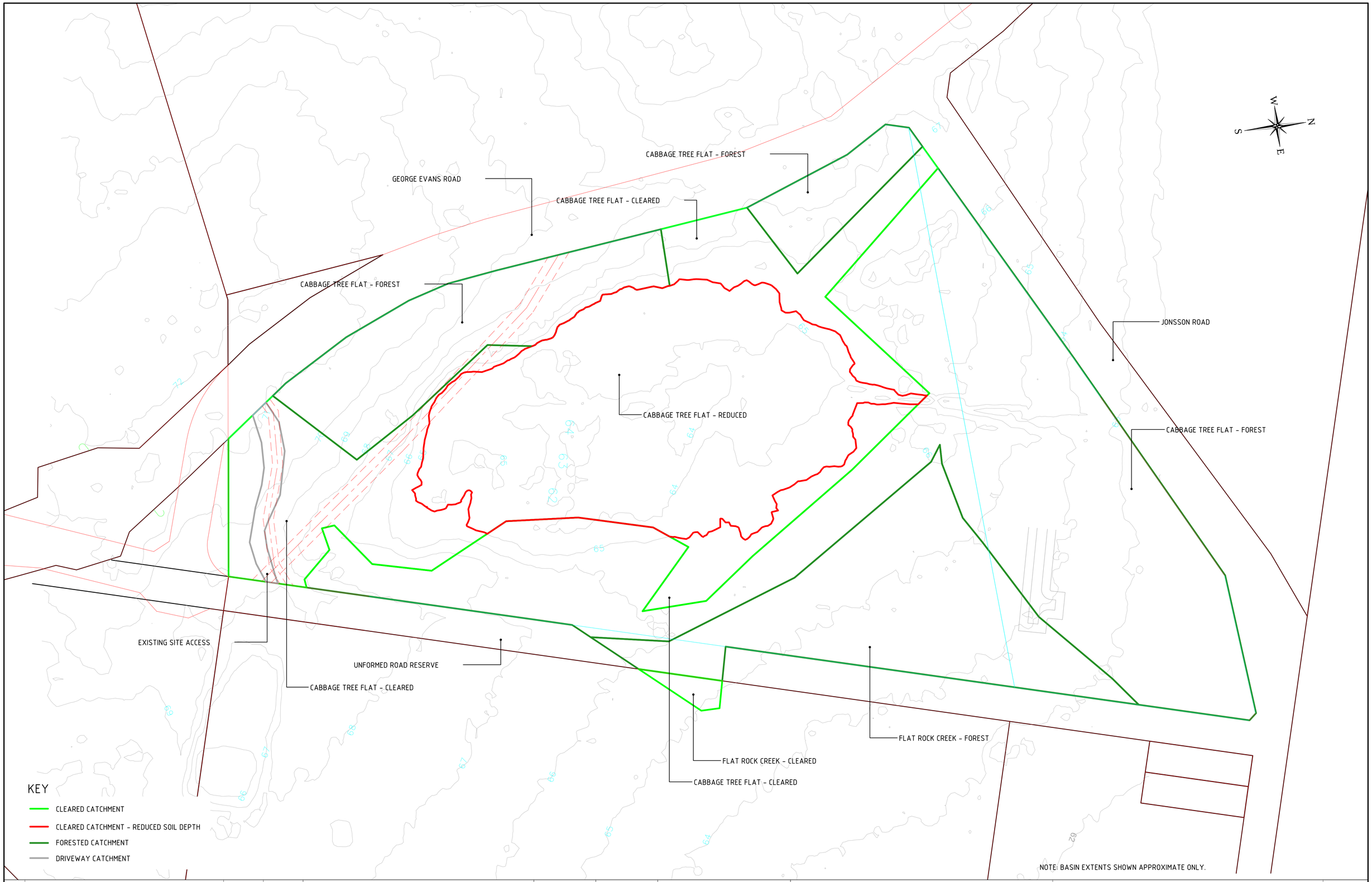
CLIENT / PROJECT
MUNDAMIA SUBDIVISION
SCC AND NALC

THIS PLAN MUST NOT BE USED FOR CONSTRUCTION UNLESS SIGNED AS APPROVED BY PRINCIPAL CERTIFYING AUTHORITY
All measurements in mm unless otherwise specified

martens & Associates Pty Ltd
Consulting Engineers
Environment
Water
Geotechnical
Civil
6/37 Leighton Place, Hornsby, NSW 2077 Australia Phone: (02) 9476 9999 Fax: (02) 9476 8767
Email: mail@martens.com.au Internet: http://www.martens.com.au

TITLE: CONCEPT STORMWATER LAYOUT
DRAWING ID: SK002
PROJECT MANAGER: A. NORRIS
PROJECT NO.: P1002863
FILE: JD02V03
REVISION: A

8 Attachment B – Model Sub-Catchment Plans and Set-ups



REV.	DESCRIPTION	DATE	ISSUED
A	DA LAYOUT	12.12.10	ASN

BAR SCALE

PAGE BAR SCALE

0 20 40 60 80 100

UNITS - METRES

SCALE - 1:1000 @ A1 1:2000 @ A3

DESIGNED: MGD	DATUM: mAHD
REVIEWED: ASN	HORIZONTAL RATIO: 1:1000
PAPER SIZE: A1	VERTICAL RATIO: 1:1000

CLIENT / PROJECT

MUNDAMIA SUBDIVISION

SCC AND NALC

THIS PLAN MUST NOT BE USED FOR CONSTRUCTION UNLESS SIGNED AS APPROVED BY PRINCIPAL CERTIFYING AUTHORITY
All measurements in mm unless otherwise specified

martens & Associates Pty Ltd

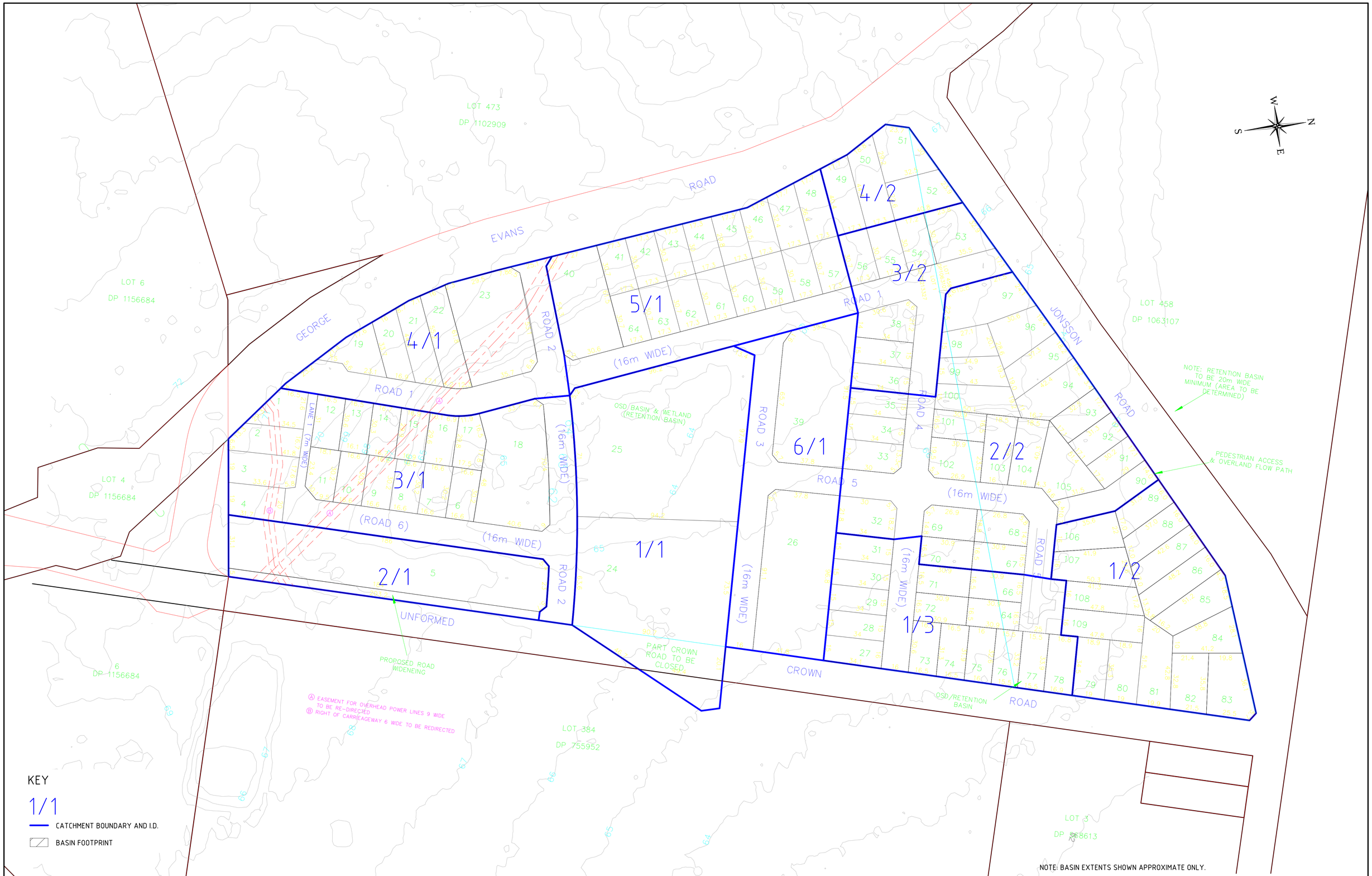
Consulting Engineers
Environment
Water
Geotechnical
Civil

6/37 Leighton Place, Hornsby, NSW 2077 Australia Phone: (02) 9476 9999 Fax: (02) 9476 8767
Email: mail@martens.com.au Internet: http://www.martens.com.au

TITLE: STORMWATER CATCHMENTS - EXISTING CONDITIONS

DRAWING ID: **SK003**

PROJECT MANAGER:	PROJECT NO.:	FILE:	REVISION:
A. NORRIS	P1002863	JD02V03	A



KEY

1/1 — CATCHMENT BOUNDARY AND I.D.

BASIN FOOTPRINT

NOTE: BASIN EXTENTS SHOWN APPROXIMATE ONLY.

REV.	DESCRIPTION	DATE	ISSUED
A	DA LAYOUT	12.12.10	ASN

BAR SCALE

PAGE BAR SCALE

0 20 40 60 80 100

UNITS - METRES

SCALE - 1:1000 @ A1 1:2000 @ A3

DESIGNED: MGD	DATUM: mAHD	CLIENT / PROJECT: MUNDAMIA SUBDIVISION SCC AND NALC	
REVIEWED: ASN	HORIZONTAL RATIO: 1:1000		
PAPER SIZE: A1	VERTICAL RATIO: 1:1000	THIS PLAN MUST NOT BE USED FOR CONSTRUCTION UNLESS SIGNED AS APPROVED BY PRINCIPAL CERTIFYING AUTHORITY. All measurements in mm unless otherwise specified	

martens & Associates Pty Ltd
Consulting Engineers
Environment
Water
Geotechnical
Civil
6/37 Leighton Place, Hornsby, NSW 2077 Australia Phone: (02) 9476 9999 Fax: (02) 9476 8767
Email: mail@martens.com.au Internet: http://www.martens.com.au

TITLE:	DRAWING ID:
STORMWATER CATCHMENTS - DEVELOPED CONDITIONS	SK004

PROJECT MANAGER:	PROJECT NO.:	FILE:	REVISION:
A. NORRIS	P1002863	JD02V03	A

REV.	DESCRIPTION	DATE	ISSUED
A	DA LAYOUT	12.12.10	ASN

BAR SCALE

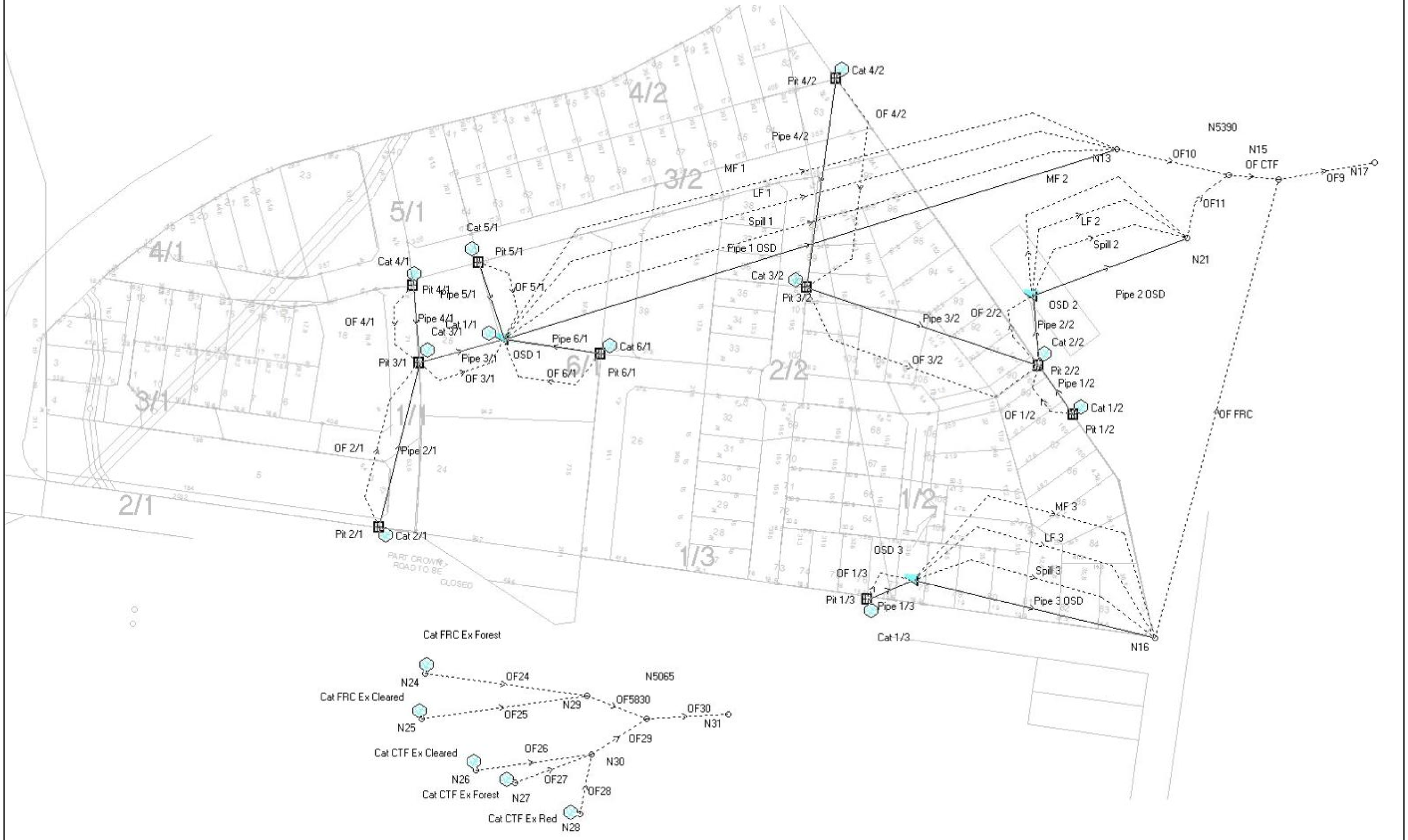
DESIGNED: MGD	DATUM: mAHD	CLIENT / PROJECT: MUNDAMIA SUBDIVISION SCC AND NALC
REVIEWED: ASN	HORIZONTAL RATIO: 1:1000	
PAPER SIZE: A1	VERTICAL RATIO: 1:1000	THIS PLAN MUST NOT BE USED FOR CONSTRUCTION UNLESS SIGNED AS APPROVED BY PRINCIPAL CERTIFYING AUTHORITY. All measurements in mm unless otherwise specified

martens & Associates Pty Ltd
Consulting Engineers
Environment
Water
Geotechnical
Civil
6/37 Leighton Place, Hornsby, NSW 2077 Australia Phone: (02) 9476 9999 Fax: (02) 9476 8767
Email: mail@martens.com.au Internet: http://www.martens.com.au

TITLE: MUSIC MODEL SET-UP

DRAWING ID: **SK005**

PROJECT MANAGER:	PROJECT NO.:	FILE:	REVISION:
A. NORRIS	P1002863	JD02V03	A



REV.	DESCRIPTION	DATE	ISSUED
A	DA LAYOUT	12.12.10	ASN

BAR SCALE

DESIGNED: MGD	DATUM: mAHD	
REVIEWED: ASN	HORIZONTAL RATIO: 1:1000	
PAPER SIZE: A1	VERTICAL RATIO: 1:1000	

CLIENT / PROJECT
MUNDAMIA SUBDIVISION
SCC AND NALC

THIS PLAN MUST NOT BE USED FOR CONSTRUCTION UNLESS SIGNED AS APPROVED BY PRINCIPAL CERTIFYING AUTHORITY
All measurements in mm unless otherwise specified

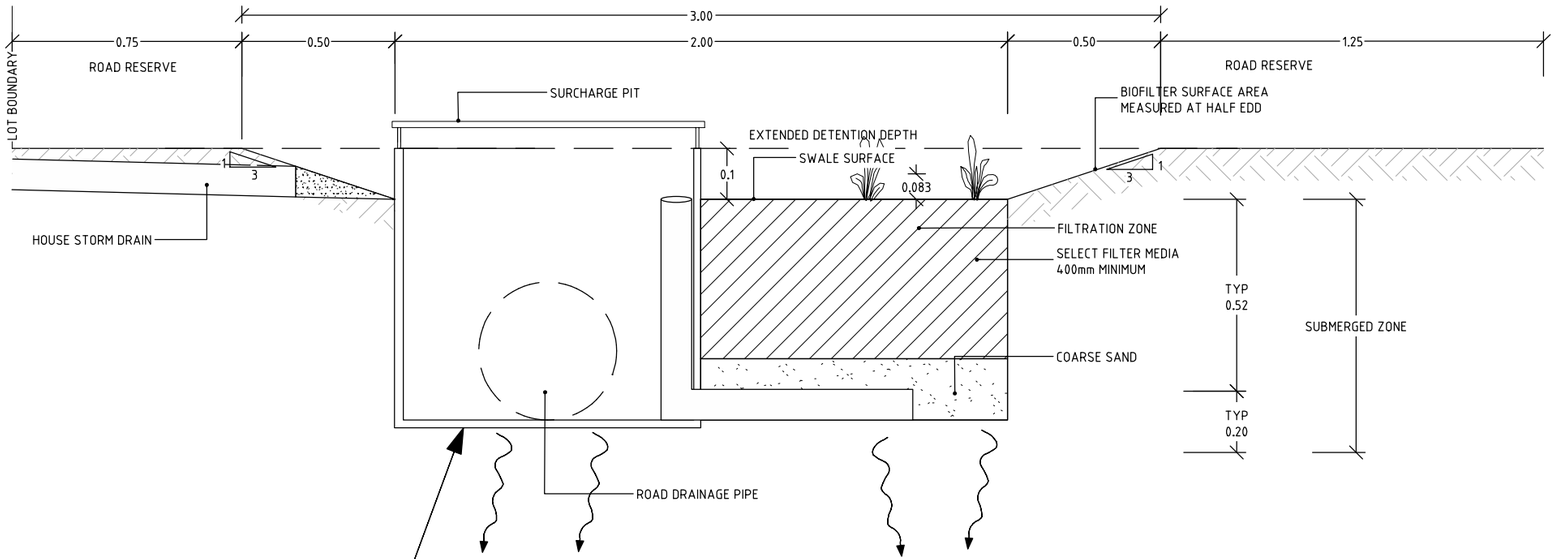
martens & Associates Pty Ltd
Consulting Engineers
Environment
Water
Geotechnical
Civil
6/37 Leighton Place, Hornsby, NSW 2077 Australia Phone: (02) 9476 9999 Fax: (02) 9476 8767
Email: mail@martens.com.au Internet: http://www.martens.com.au

TITLE: DRAINS MODEL SET-UP

DRAWING ID: **SK006**

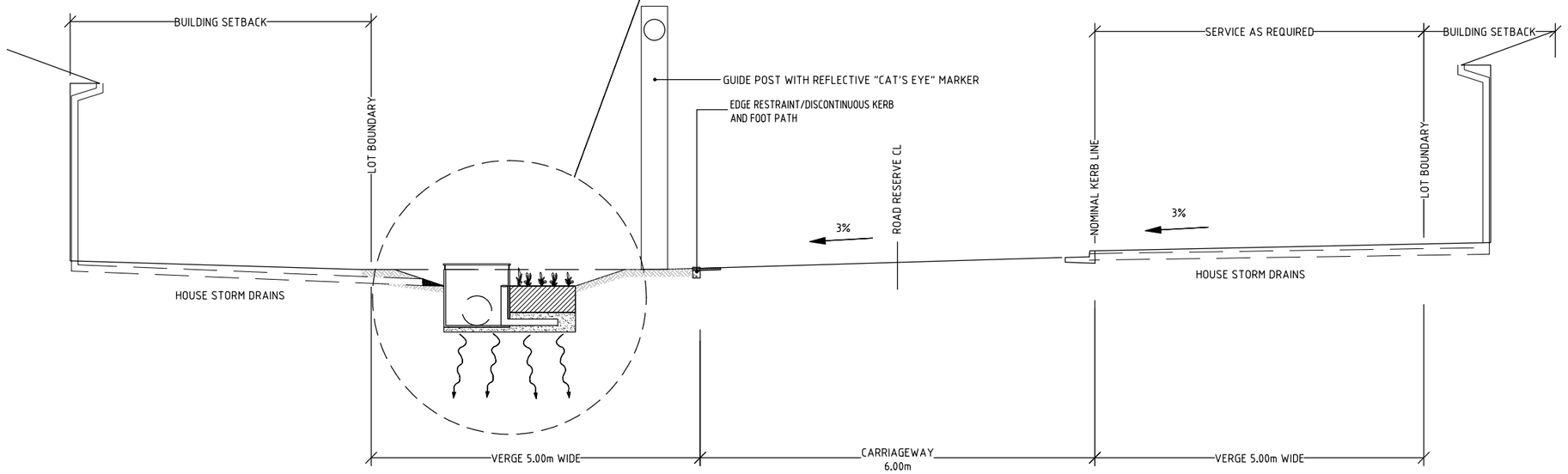
PROJECT MANAGER:	PROJECT NO.:	FILE:	REVISION:
A. NORRIS	P1002863	JD02V03	A

9 Attachment C – Typical Water Quality Treatment Structures



TYPICAL ROADSWALE SECTION

SCALE 1:20 @ A3



TYPICAL SECTION
ROAD 16m WIDE

SCALE 1:80 @ A3

NOTES: ROADSIDE SWALE SUBMERGED ZONE ACTS AS TEMPORARY STORE FOR STORMWATER TO ALLOW FOR INFILTRATION TO SATISFY GROUNDWATER RECHARGE REQUIREMENTS OF PROJECT.

0 0.2 0.4 0.6 0.8 1.0

UNITS - METRES

Martens & Associates Pty Ltd ABN 85 070 240 890

Environment | Water | Wastewater | Geotechnical | Civil | Management

Drawn:	MGD
Approved:	AN
Date:	12/12/07
Scale @A3:	1:20

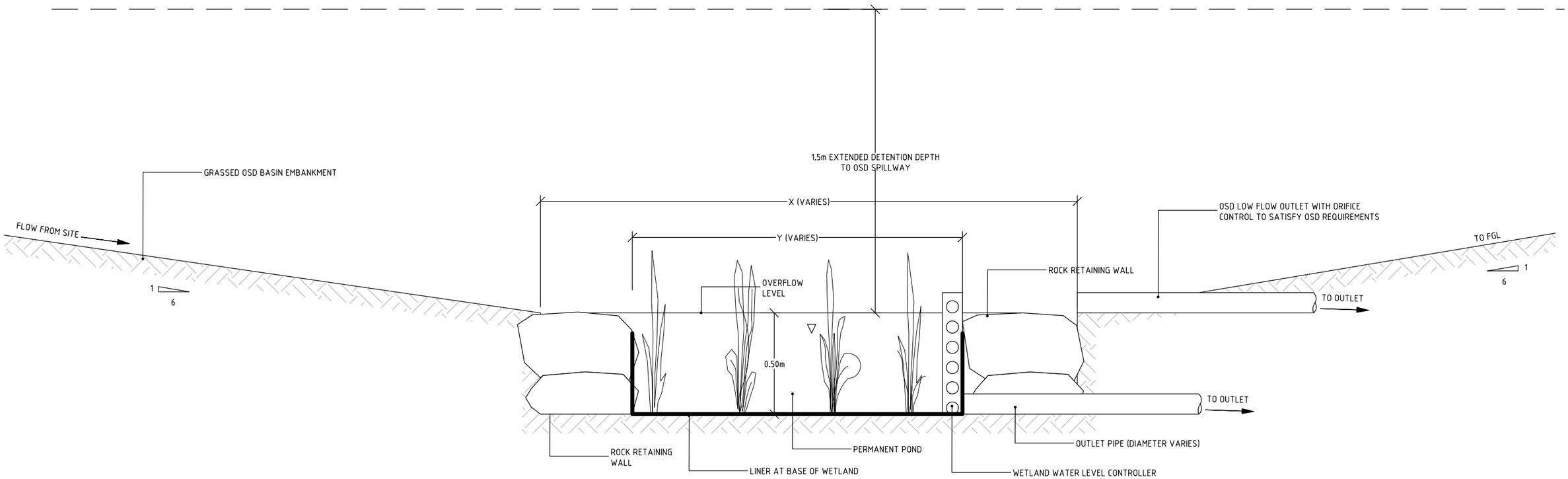
TYPICAL BIOSWALE SECTION
MUNDAMIA, NSW
MIXED USE SUBDIVISION

Drawing No./ID:
SK007

6/37 Leighton Place, Hornsby, NSW 2077 Australia Phone: (02) 9476 9999 Fax: (02) 9476 8767
Email: mail@martens.com.au Internet: http://www.martens.com.au

Project:	File:	Revision:
P1002863	JD03V01	A

martens



TYPICAL OSD WETLAND AND BIOREMEDIATION BASIN SECTION

SCALE 1:20 @ A3

NOTES: EXTENDED DETENTION DEPTH IN BASINS SIZED TO ALLOW TEMPORARY STORAGE OF STORMWATER TO SATISFY GROUNDWATER RECHARGE REQUIREMENTS OF PROJECT.

0 0.2 0.4 0.6 0.8 1.0

UNITS - METRES

Martens & Associates Pty Ltd ABN 85 070 240 890		**Environment | Water | Wastewater | Geotechnical | Civil | Management**	
Drawn:	MGD	**TYPICAL OSD, WETLAND AND BIOREMEDIATION BASIN SECTION MUNDAMIA, NSW MIXED USE SUBDIVISION**	Drawing No./ID: **SK008**
Approved:	AN		
Date:	12/12/07		
Scale @A3:	1:20	6/37 Leighton Place, Hornsby, NSW 2077 Australia Phone: (02) 9476 9999 Fax: (02) 9476 8767 Email: mail@martens.com.au Internet: http://www.martens.com.au	Project: P1002863 | File: JD03V01 | Revision: A