Leighton Properties Pty Ltd

Proposed Tourist Resort
Lot 490 on DP1095234
Part of Lot 489 on DP 47021
Part of Lot 500 on DP1095235

Casuarina Way, Kingscliff

Stormwater Management Plan

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BELLENG VDM

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Report Details:

Title:	Proposed Tourist Resort Lot 490 DP1095234 ,Part of Lot 489 DP47021, Part of Lot 500 DP1095235 Casuarina Way, Kingscliff Stormwater Management Plan
Author(s):	Anna Kleinschmidt
Status:	Issue 2
Client:	Leighton Properties Pty Ltd
Client Contact:	Andrew Mabin
Prećis:	This report presents the Stormwater Management Plan for the proposed Tourist Resort on Casuarina Way, Kingscliff. These works establish the site conditions and stormwater management controls upon which future development is planned.

Revision History:

Issue No	Date	Issued By	Approved By	Distributed To	No. of Copies
1	07/11/2008	Susan Dowling	 Signed: Derek Mackenzie B.Eng (Env), MIEAust, MSIA Senior Env Eng.	Leighton Properties Pty Ltd Burchill VDM Belleng VDM	1 1 1
2	23/04/2009	Anna Kleinschmidt Environmental Engineer/Scientist	Joshua Evans Senior Environmental Engineer	Leighton Properties Pty Ltd Belleng VDM	1 1

Executive Summary

Belleng VDM was commissioned by Leighton Properties Pty Ltd to prepare a detailed Stormwater Management Plan (SMP) for the proposed Tourist Resort at Lot 490 on DP1095234, and ancillary development on part of Lot 489 DP47021 and part of Lot 500 DP1095235 Casuarina Way, Kingscliff (the subject site). This specific SMP forms part of the planning application that seeks a Development Permit within the subject site.

The proposed development on the subject site consists of dwellings, a reception, interpretive centre, communal amenities, car parks, and an internal road network.

This Stormwater Management Plan (SMP) represents best water sensitive urban design practice and incorporates ecological sensitive design principles to reduce potential impacts on existing ecological communities and downstream receiving environments.

The SMP has been prepared in consultation with the landscape architect to ensure that the treatment methods selected are aesthetically designed, use appropriate materials sympathetic to the local environment and use endemic plant species to enhance the natural biodiversity of the site.

In keeping with the WSUD theme, minimal stormwater infrastructure or “hard” engineering solutions have been used resulting in minimal overall disruption to the site and minimising the need for ongoing maintenance.

The primary design intent of this SMP has been to avoid the removal of existing native trees as identified in the ecological assessment and is demonstrated in the creative use of swales and bioretention areas to meet the stormwater quality objectives of Tweed Shire Council.

The stormwater quality treatment measures proposed for this development will achieve Councils water quality objectives of:

- Suspended Solids – 300 kg/ha/yr;
- Total Phosphorous – 0.8 kg/ha/yr;
- Total Nitrogen – 4.5 kg/ha/yr;
- Litter 70% retention of annual litter load greater than 5mm;
- Coarse Sediment Retention of 90% of annual load of sediment greater than 0.125mm; and
- Oil and Grease (hydrocarbons) <10mg/Litre in flows up to 40% of Q_1 peak

Proposed measures for the residential site include:

- A stormwater retention and infiltration of the Q_{3mth} stormwater from roof areas;
- Vegetated swales; and
- Bioretention systems to capture pollutants and treat stormwater prior to discharge from the site.

MUSIC modelling indicates the percentage reduction will satisfy the nominated WQO. Required treatment areas are presented below:

Bioretention Areas	Filter Media Area (m²)
BIO 1	500
BIO 2	80
TOTAL	**580**

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1. Introduction

1.1. Background

Belleng VDM has been engaged by Leighton Properties Pty Ltd to prepare a detailed Stormwater Management Plan (SMP) for the proposed tourist resort at Lot 490 on DP1095234, and ancillary development on part of Lot 489 DP47021 and part of Lot 500 DP1095235 Casuarina Way, Kingscliff. In preparing this report, Belleng VDM has liaised with the Tweed Shire Council to ensure that the SMP meets the requirements of relevant Authorities.

This Stormwater Management Plan should be read in conjunction with the *Construction Management Plan, Belleng VDM 2009*.

1.2. Scope

Specifically, this report details the following:

1. Catchment Hydrology and Stormwater Conveyance including:
   a. topography;
   b. vegetation; and
   c. overland flow.

2. Water Quality Issues including:
   a. an estimate of sediment and nutrient transport from developed site; and
   b. the water quality objectives of the receiving waters.

3. Stormwater Management Controls for:
   a. construction phase; and
   b. operational phase.

4. Maintenance and Monitoring Program.

To minimise the impact of the development on the external environment the proponent shall implement this SMP. To avoid significant and/or sustained deterioration in downstream water quality this SMP may be amended as required, in response to the Monitoring and Maintenance Program described herein.

1.3. Objectives

The objective of this SMP is to ensure that there is no deterioration in stormwater quality or any reduction in the environmental values of the downstream receiving waters as a result of the proposed activities on the subject site.

This objective will be achieved through the implementation of:

- Infiltration of Q_{3mth} stormwater from all roof areas;
- Management strategies designed to minimise water pollution from the development of the subject site;
- Specific construction phase controls to minimise erosion and control sediment loss;
- Specific operational phase controls to minimise sediment and nutrient export from the subject site;

- A monitoring and maintenance program for the construction phase; and
- Defined performance criteria and actions to be taken if the criteria are not met.

1.4. Description of Subject Site

1.4.1 Location

The subject site is located on Lot 490 DP1095234, and ancillary development on Lot 489 DP47021 and Lot 500 DP1095235 Casuarina Way, in the suburb of Kingscliff in Tweed Shire. The site is bounded to the south by land identified in local zoning maps as tourist regions and to the northwest by Tweed Coast Way, Cudgen Creek and rural residential and agricultural properties. Refer to Figure 1.1 for the site locality plan.

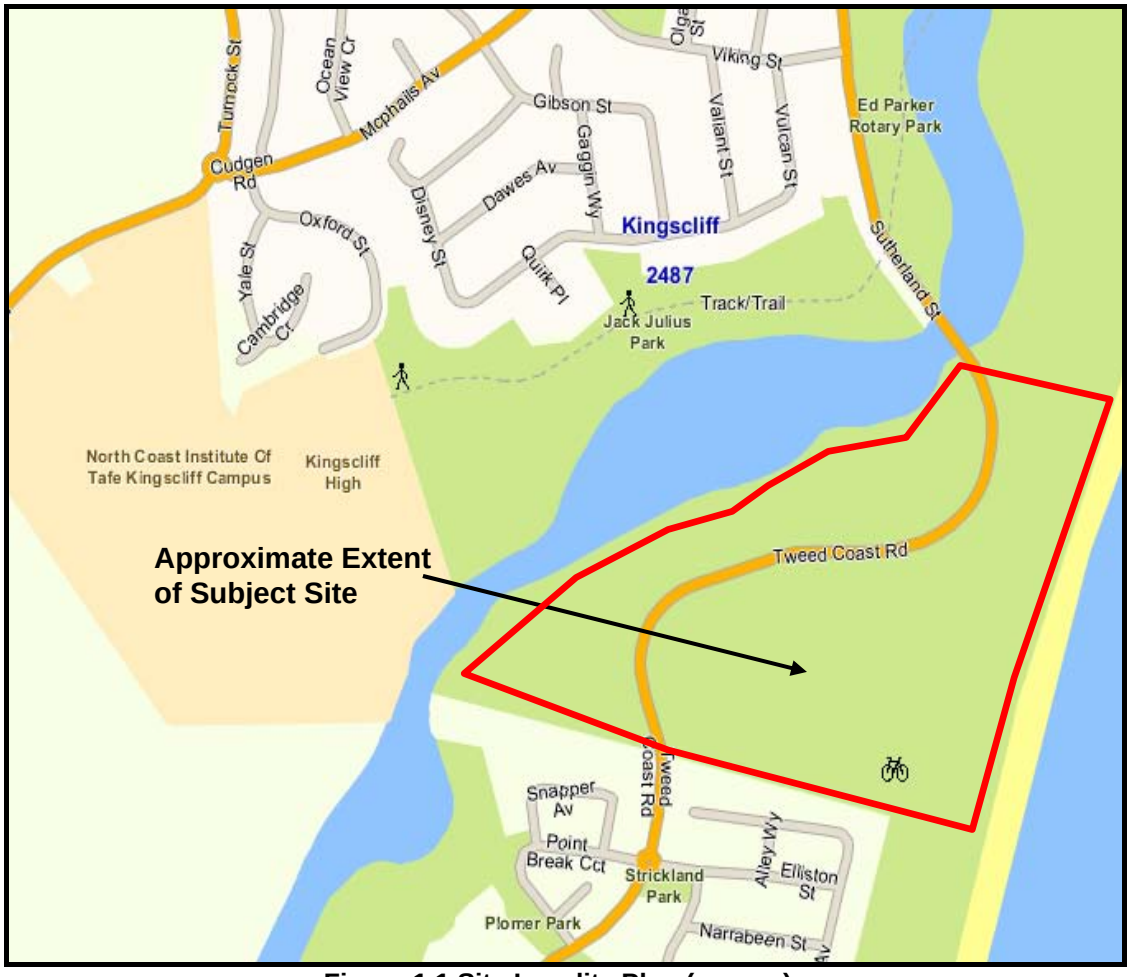

Figure 1.1.Site Locality Plan (approx)

1.4.2 Landuse and Vegetation

The subject site is currently undeveloped, with minor regrowth of coastal vegetation, introduced weed species, and identified vegetation areas of significance. These areas have been preserved in accordance with the ecologically sensitive principles of this report.

Figure 1.2. Aerial View (approx)

1.4.3 Topography and Stormwater Conveyance

The subject site slopes from the southeast to the northwest at a grade of approximately 2%. Levels across the site range from a maximum of 8m AHD to a minimum of 1m AHD. Stormwater flows north through the centre of the site into an existing wetland and through culverts located under Tweed Coast Way to discharge into Cudgen Creek and finally into the Pacific Ocean.

1.4.4 Rainfall

The climate of Kingscliff is considered sub-tropical having relatively warm wet summers, mild winters and a high rainfall average. A rainfall study was undertaken for 6-minute interval data obtained from the Bureau of Meteorology (BOM) for station 058158 (Murwillumbah). A data set with rainfall recordings for the year 1978 (average rainfall year) was applied to the MUSIC modelling performed as part of this analysis and indicates the mean annual rainfall was 1648 mm.

1.5. Description of Development

The proposed development will include the following items:

- Dwellings;
- Reception;
- Conference Centre;
- Communal Amenities;
- Car Parks;
- An Internal Road Network;
- Recreational Facility
- Pontoon; and
- Foot Path.

Figure 1.3 (John Mainwaring & Associates) presents the Proposed Development Layout (Drawing No. 1040 MP-01-3 A).

LEGEND

	Resort internal circulation lanes	B2	2 Bedroom Bungalow
	On ground pedestrian and ciclyng pathways	B2A	2 Bedroom Fully Accessible Bungalow
	Suspended walkways	B3	3 Bedroom Bungalow
	Fully accessible bungalows	BSB	Beach Side Bungalow
	Asset Protection Zone	MA	Maintenance Area
UP	Unit Pod		
UPA	Fully Accessible Unit Pod		

Supply 10 upgraded car parks See Dwg MP 01-2

CUDGEN CREEK REHAB PRECINCT

LOT 490

LOT 500

Pontoon

Shelter

CREEKSIDE PATHWAY AS IDENTIFIED BY ECOLOGIST

Large Picnic Shelter

Car park

Tennis Court

1/2 Basket Ball Court

BOUNDARY LINE

APZ LINE

Bus Stop

Pedestrian crossing

Proposed Interpretive Centre

New roundabout

Primary access

Existing Conc. Bike Path

Signage

Wet Land

Retention Basin

Resort Facilities

Loading

Pool Area

Drop-off

Service / Loading

BBQ Area

Childrens Play Area

Maintenance Area

Maintenance area parking

Visual buffer

LANDSCAPED VISUAL BUFFER AREA

Fire Access

Existing Fire fighting track

Path to link with existing path to south

Beach side public parking

Play ground 500 m²

Community Amenities

Circuit Training Stations

Revegetation and Public Park

6.5m wide grassed path for Rural Fire Brigade Access

Existing Conc. Bike Path

0 50M 75M 100M 125M

AMENDMENTS

REV:	DATE:	DESCRIPTION:	ISSUED BY:
A	02.04.09	NSW DEPT OF PLANNING - DA	NK
B	25.08.09	RE LOCATE PONTOON	TK
C	07.10.09	ADJ. MAIN ROAD TO TRAFFIC ENG. REQ	TK
D	16.10.09	ADJ. ROAD TO MAINTENANCE AREA	TK
E	15.03.10	MP - UPDATE	PL

NOTES:
Verify all dimensions on site before the commencement of any new construction work, alterations or shop drawings - take measured dimensions in preference to any scaled dimensions

Comply to the following or any other relevant codes:
- Building Code of Australia
- Local Authorities Rules and Guidelines
- covenants manual
- Apply all applicable AUSTRALIAN STANDARDS where relevant, including:
- Termite Barrier AS 3660.1
- Access and Mobility Codes AS 1428.1 & 1428.2
Larger Scale Drawings Take Precedence to smaller scale

Kingscliff Resort DEVELOPMENT

LEIGHTON PROPERTIES

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Email: jma@jma-arch.com
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TEL: 07 3252 4400 FAX: 07 3252 2911

CLIENT.	LEIGHTON PROPERTIES
JOB	THE KINGSCLIFF RESORT
LOCATION	CASUARINA WAY KINGSCLIFF 2487
PROPERTY DESCRIPTION	

JOB No.	1040
DATE.	OCT 09
SCALE.	1:1000@A1 50%@A3
DRAWN.	NK
CHECKED	JMA Architects

DRAWING SET	MASTER PLAN
DRAWING TITLE	SITE PLAN
DRAWING No:	1040 MP-01-3
ISSUE	E
PRINT DATE	16/03/2010

FOR SUBMISSION

2. Hydrological and Hydraulic Assessment

2.1. Hydrologic Objectives

The objectives for this site are to infiltrate the Q_{3mth} rainfall event from all roof areas, and to undertake hydraulic calculations necessary to convey minor and major flows within the proposed drainage swales and spoon drains.

2.2. Catchment Definition

The pre development catchment is presented in Figure 2.1 and consists of one catchment, the subject site (11.67 ha).

In the post development scenario, the total site has been subdivided into 10 sub catchments for flow mitigation and stormwater quality treatment. These sub catchments are presented in Figure 2.2 and summarized below:

- Catchment A (2.39 ha);
- Catchment B (1.66 ha);
- Catchment C (1.14 ha);
- Catchment D (0.78 ha);
- Catchment E (0.88 ha);
- Catchment F (0.65 ha);
- Catchment G (0.30 ha)
- Catchment H (0.31 ha)
- Catchment I (2.39 ha);
- Catchment J (2.06 ha);
- Catchment K (1.08 ha); and
- Additional car parking spaces (Catchment L: 1.62 ha).

2.3. Hydrological Management Approach

No detailed hydrological and hydraulic assessment has been completed for this proposal due to the following considerations:

- The proposed site is located within the Council's OSD exemption area;
- The subject site directly discharges to tidally influenced receiving waters;
- The subject site discharges to a major waterway (Cudgen Creek); and
- All future roof runoff is to be discharged to infiltration trenches sized to accommodate the Q_{3month} storm (40% of Q_1). Infiltration systems reduce the volume and magnitude of peak discharges from impervious areas, predominantly for small storm events.

A detailed hydrological assessment of the proposed stormwater system will be undertaken as part of the Operational Works stage.

BOUNDARY LINE

BOUNDARY LINE

BOUNDARY LINE

BOUNDARY LINE

BOUNDARY LINE

BOUNDARY LINE

N

Catchment

Flow Path

SCALE 20 0 20 40 60 80 100 (metres)

1 : 2000 (FULL SIZE)

AMEND	DATE	DESCRIPTION	APPR.
1	22/04/09	New Layout	

AMENDMENTS

DO NOT SCALE FROM THIS DRAWING

FULL SIZE : A1

CLIENT :

LEIGHTON PROPERTIES PTY LTD

PROJECT :

LOT489 DP47021
LOT490 DP1095234
LOT500 DP1095235

CASUARINA WAY

AREA :

KINGSCLIFF

DRAWING TITLE :

FIGURE 2.1:

PRE DEVELOPMENT CATCHMENT DELINEATION PLAN

ASSOCIATED CONSULTANTS :

BELLENG VDM

LEVEL 3, EVANDALE PLACE
142 BUNDALL ROAD, BUNDALL, QLD, 4217
PO BOX 6788 GOLD COAST MAIL CENTRE, QLD 9726
PH: (07) 5510 3655 FAX: (07) 5510 3655

QUALITY ASSURANCE SUPPLIER TO QLD. GOVT. – N 2961

DESIGNED : BC DRAWN : SD

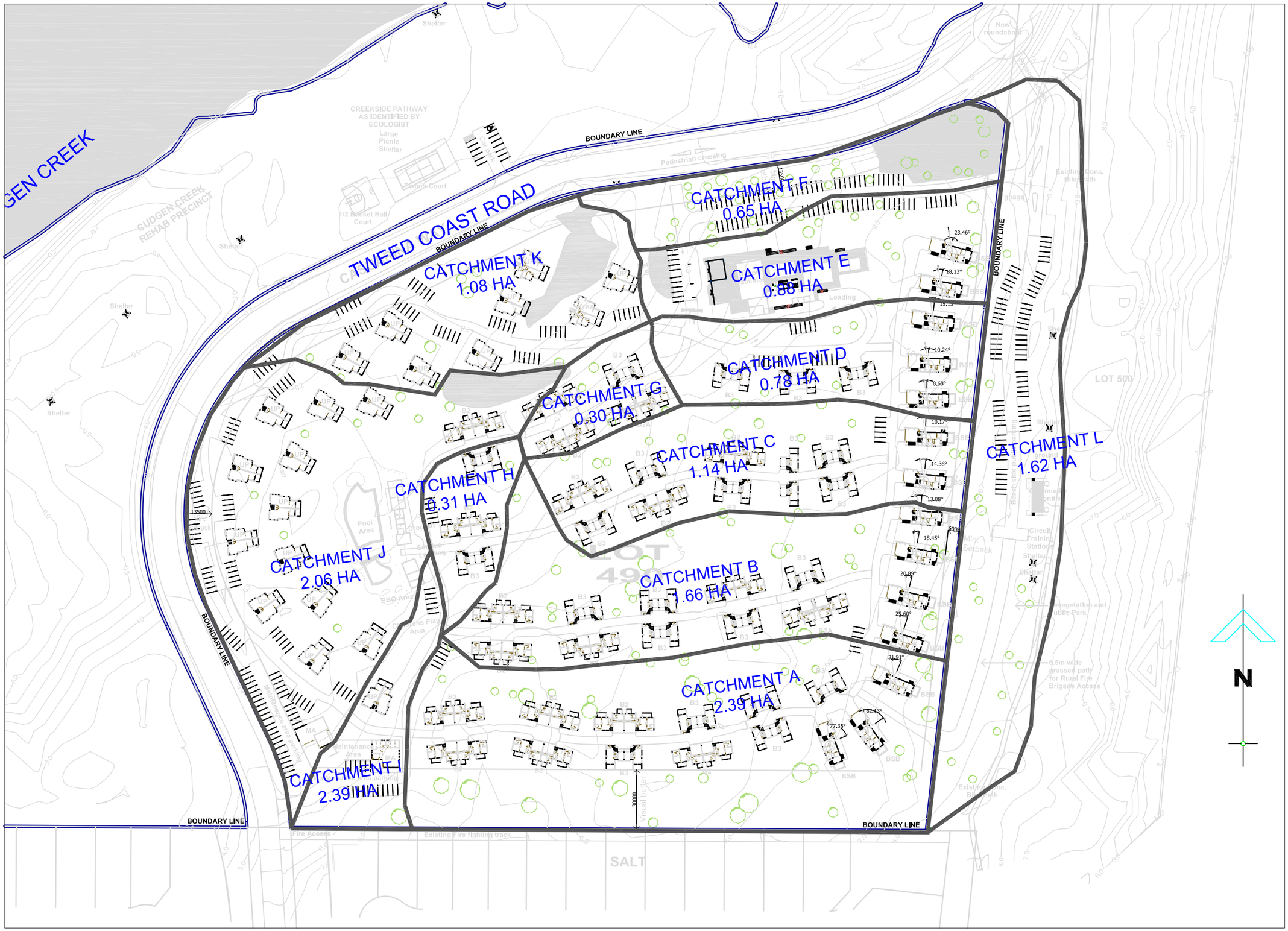
CHECKED : DM DATE : 03.10.08

FILENAME : I:\2000\08-3655_Lot 490 Casuarina Way\Environmental\ACAD\Water\GE0003655_SMP.dwg

APPROVED FOR AND ON BEHALF OF BELLENG VDM PTY LTD
R.P.E.Q. No. 1802 :

DRAWING No. : 2000-3655/Figure 2.1

AMENDMENT :



LEGEND

CATCHMENT

SCALE 20 0 20 40 60 80 100 (metres)

1 : 2000 (FULL SIZE)

1	22/04/09	New Layout	
AMEND	DATE	DESCRIPTION	APPR.

AMENDMENTS

DO NOT SCALE FROM THIS DRAWING

FULL SIZE : A1

CLIENT :

LEIGHTON PROPERTIES PTY LTD

PROJECT :

LOT489 DP47021
LOT490 DP1095234
LOT500 DP1095235

CASUARINA WAY

AREA :

KINGSCLIFF

DRAWING TITLE :

FIGURE 2.2:

POST DEVELOPMENT CATCHMENT DELINEATION PLAN

ASSOCIATED CONSULTANTS :

BELLENG VDM

LEVEL 3, EWINDALE PLACE
142 BUNDALL ROAD, BUNDALL, QLD, 4217
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QUALITY ASSURANCE SUPPLIER TO QLD. GOVT. – N 2961

DESIGNED : BC DRAWN : SD

CHECKED : DM DATE : 03.10.08

FILENAME : B:\2001\08-3655_Lot 490 Casuarina Way_Environmental\ACAD\Water\QE0003655_SMP.dwg

APPROVED FOR AND ON BEHALF OF BELLENG VDM PTY LTD
R.P.E.Q. No. 1802 :

DRAWING No. : 2000-3655/Figure 2.2

AMENDMENT :

3. Stormwater Management – Quality Controls

The selection and use of Stormwater Quality Improvement Devices (SQIDs) depends on the site conditions, and on management objectives. In many cases there may be multiple goals or needs for a particular area. In this case, there is often merit in combining SQIDs in series (or parallel) to achieve these multiple goals. Combining SQIDs in this manner will improve and better guarantee performance, or alternatively overcome site factors that limit the effectiveness of a single measure.

Based on the site characteristics, and the range of available SQIDs, this study has developed an overall concept that will satisfy the requirements of downstream environmental protection. The layout of the proposed treatment measures for the subject site is illustrated in Figure 3.1.

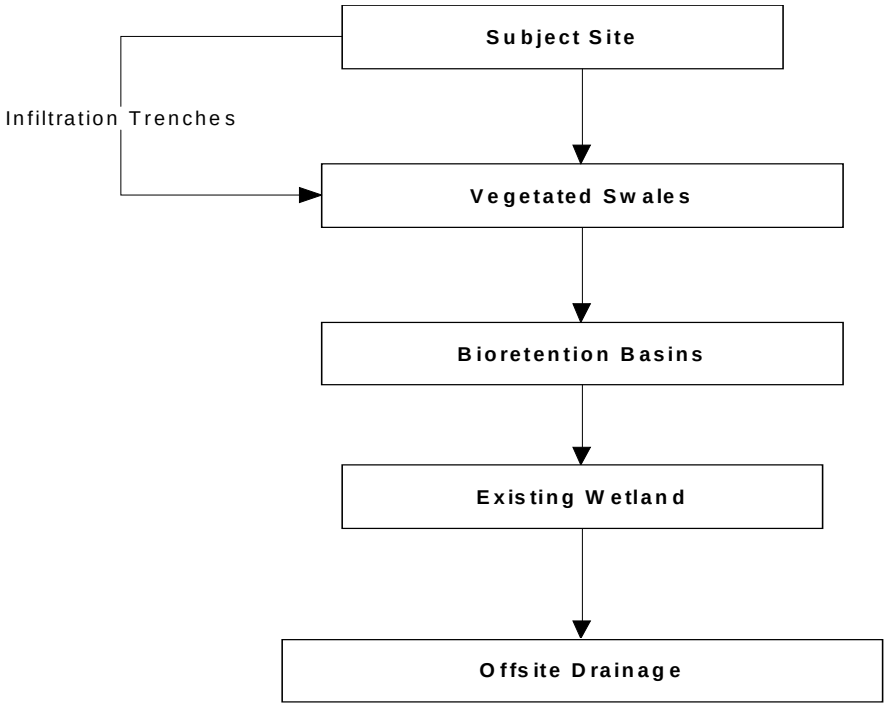


Figure 3.1. Proposed Stormwater Treatment Measures

3.1. Q_{3month} Infiltration from Roof Areas

Infiltration trenches promote the infiltration of stormwater into surrounding soils, hence reducing the volume and magnitude of peak discharges from impervious areas, especially for small storm events. Infiltration trenches also improve stormwater quality, particularly in the effective removal of sediments through pre-filtration. Accurate removal efficiency data is unavailable, and as such have not been included in the modelling of the proposed development.

All roof areas will be infiltrated for the 5 minute, Q_{3mth} event. The method used considers the maximum infiltration rate of 6 m/day infiltration for sand with a safety factor of 2 applied to account for blockage over time. The infiltration method will include a drainage trench to be directly connected to the roof areas of all proposed development. Table 3.1 lists the infiltration areas required for each development type. Each drainage trench to be back filled with coarse drainage gravel (minimum effective porosity of 30%) and lined with an appropriate geo-fabric.

Table 3-1 Infiltration Trench Volume Required

Development Type	Roof Area (m^2)	Trench Volume Required (m^3)
Small Pod	100	2.5
Medium Pod	150	4
Large Pod	230	7
Commercial Centre	2500	88

Refer to Appendix A for preliminary infiltration trench sizing method.

3.2. Vegetated Swales

Vegetated swales have been included in the treatment train to provide both stormwater treatment and conveyance. Swales provide pretreatment of stormwater by removing medium and coarse sediments. Indicative efficiency rates for vegetated swales are provided within the *Victorian Urban Stormwater – Best Practice Environmental Management Guidelines* and *A Manual for Managing Urban Stormwater Quality in Western Australia.* Design criteria for the swale drains include:

- Longitudinal slope of between 1% and 4%; and
- Minimum side slopes of 1 in 4.

Pollutant removal efficiency of swales has been calculated as follows:

- Suspended solids – medium efficiency (40% removal)
- Nutrients – low/medium (20% removal).

Anticipated maintenance work will include the following:

- Removal of debris and litter – Maintenance required when accumulation levels become unacceptable;
- Regular clearing of blockages to outlets – required whenever debris, coarse sediments and litter have accumulated to an unacceptable level;
- Mowing of turfed areas to preserve the optimal design height for vegetation; and
- Inspection after rainfall events to repair eroded areas – as required after storm events.

The proposed vegetated swales through the subject site have been designed to convey the full post development Q_{100} unmitigated flow as a conservative approach. Table 3.2 presents the calculated peak flow rates from the sub catchments depicted in Figure 2.2. Q_{3month} has been calculated based on information from the *Tweed Urban Stormwater Quality Management Plan* where Q_{3month} is deemed to be 40% of Q_1.

Table 3.2: Post-Development Hydrology

Catcht. ID	Ac = (ha)	tc (min)	I_{100} (mm/hr)	C	Q_{100} (cumec)	I_{20} (mm/hr)	C	Q_{20} (cumec)	I_{10} (mm/hr)	C	Q_{10} (cumec)	I_2 (mm/hr)	C	Q_2 (cumec)	I_1 (mm/hr)	C	Q_{3mth} (cumec)
A	2.39	5.00	311.00	0.96	**1.98**	246.00	0.84	**1.37**	218.00	0.80	**1.16**	160.00	0.68	**0.72**	126.00	0.64	**0.21**
B	1.66	5.00	311.00	0.96	**1.38**	246.00	0.84	**0.95**	218.00	0.80	**0.80**	160.00	0.68	**0.50**	126.00	0.64	**0.15**
C	1.14	5.00	311.00	0.96	**0.95**	246.00	0.84	**0.65**	218.00	0.80	**0.55**	160.00	0.68	**0.34**	126.00	0.64	**0.10**
D	0.78	5.00	311.00	0.96	**0.65**	246.00	0.84	**0.45**	218.00	0.80	**0.38**	160.00	0.68	**0.24**	126.00	0.64	**0.07**
E	0.88	5.00	311.00	0.96	**0.73**	246.00	0.84	**0.51**	218.00	0.80	**0.43**	160.00	0.68	**0.27**	126.00	0.64	**0.08**
F	0.65	5.00	311.00	0.96	**0.54**	246.00	0.84	**0.37**	218.00	0.80	**0.31**	160.00	0.68	**0.20**	126.00	0.64	**0.06**
G	0.30	5.00	311.00	0.96	**0.25**	246.00	0.84	**0.17**	218.00	0.80	**0.15**	160.00	0.68	**0.09**	126.00	0.64	**0.03**
H	0.31	5.00	311.00	0.96	**0.26**	246.00	0.84	**0.18**	218.00	0.80	**0.15**	160.00	0.68	**0.09**	126.00	0.64	**0.03**

I	0.42	5.00	311.00	0.96	**0.35**	246.00	0.84	**0.24**	218.00	0.80	**0.20**	160.00	0.68	**0.13**	126.00	0.64	**0.04**
J	2.06	5.00	311.00	0.96	**1.71**	246.00	0.84	**1.18**	218.00	0.80	**1.00**	160.00	0.68	**0.62**	126.00	0.64	**0.18**
K	1.08	5.00	311.00	0.96	**0.90**	246.00	0.84	**0.62**	218.00	0.80	**0.52**	160.00	0.68	**0.33**	126.00	0.64	**0.10**
L	1.62	6.00	311.00	0.96	**1.34**	246.00	0.84	**0.93**	218.00	0.80	**0.78**	160.00	0.68	**0.49**	126.00	0.64	**0.15**

Table 3.3 defines the grassed channel base width of 1.5 m for flows up to Q_{100} (no freeboard).

Table 3.3: Vegetated Swale Capacity

Item	Value
Manning n	0.035
Grade S	0.015
Width B	1.5
Side Slope G	4
Depth d	**0.4**
X	1.6
Effective B	**4.7**
Area A	1.24
Slope Length	1.65
Wetted Perimeter	4.8
Hydraulic Radius	0.258
Velocity V	**1.41**
Flow (m^3/sec)	**1.75**

Deeper channels (0.6 m) are required for downstream portions of the swales immediately discharging into the proposed bioretention basin and wetland.

3.3. Bioretention Systems

Bioretention systems are reported to operate best where input is derived from direct rainfall and sheet flow from surrounding allotments in a small catchment. Water captured in the ponding area should be no more than 40 cm deep for a maximum of 4 days to prevent anaerobic conditions, plant death and insect breeding.

Bioretention systems are required on the subject site to remove a significant portion of sediments and nutrients from the post-development stormwater runoff. Based on the guidelines listed above, this system may remove greater than 50% of suspended solids and 30% of nutrients from runoff received.

A typical cross section of a bioretention system illustrating the various layers is included as Figure 3.2.

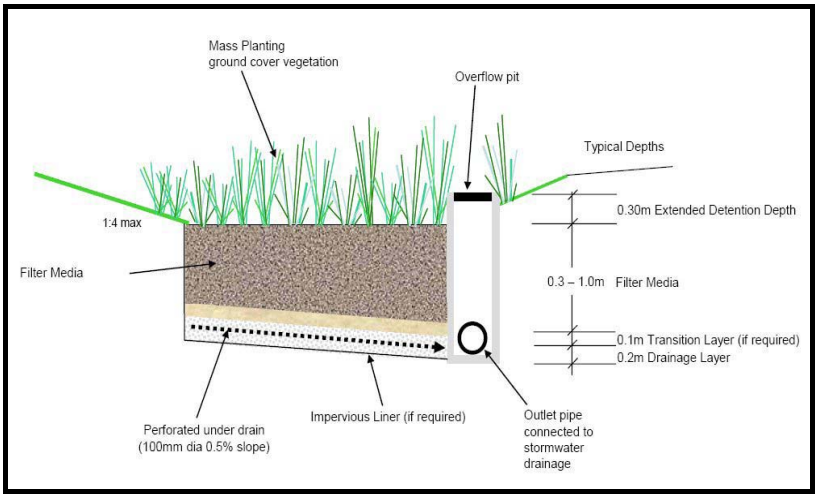


Figure 3.2. Typical Cross Section of Bioretention System
(Source: GCCC Land Development Guidelines: Water Sensitive Urban Design Guidelines)

3.4. Rainwater Tanks

Collection of roof runoff will reduce catchment stormwater quantities and provide increased infiltration and filtration through the irrigation of tank water on landscaped areas. Studies by the University of Newcastle have shown that provided storage volumes are available rainwater tanks can significantly reduce peak stormwater discharges, help to mitigate localised urban flooding, improve stormwater quality and minimise the influx of stormwater into the sewer system. Water collected within the tank can be reused for various non-potable uses.

Species List

The species list provided in Table 3.4 below shall be utilised as the basis for the selection of species for the proposed bioretention system.

Table 3.4: Suitable Species for Bioretention System

Zone	Botanical name:	Common name:	Wetland (W) or Bioretention System (B)	Depth Range:
1. Water-line/Edge	*Cyperus polystachyos*	Common Sedge	W/B	< 0.2m
	Juncus usitatus	Common Rush	W/B	< 0.2m
	Lomandra hystrix	Mat Rush	W/B	n/a
	Lomandra longifolia	Mat Rush	W/B	n/a
	Persicaria decipiens	Slender Knotweed	W/B	< 0.2m
	Philydrum lanuginosum	Woolly Frogmouth	W/B	< 0.2m
2. Adjacent shrubs/trees	*Acmena smithii*	Creek Lilly Pilly	W/B	n/a
	Allocasuarina littoralis	Black Sheoak	W/B	n/a
	Banskia robor	Swamp Banksia	W/B	n/a
	Glochidion sumatranum	Cheese Tree	W/B	n/a
	Hibiscus diversifolius	Swamp Hibiscus	W/B	n/a
	Lophostemon suaveolens	Swamp Box	W/B	n/a
	Melaleuca quinquinervia	Broad-leaved Paperbark	W/B	n/a
	Melaleuca irbyana	Bushhouse Paperbark	W/B	n/a
	Melastoma affine	Blue Tongue	W/B	n/a
	Syzygium australe	Scrub Cherry	W/B	n/a
	Waterhousia floribunda	Weeping Lilly Pilly	W/B	n/a

Maintenance

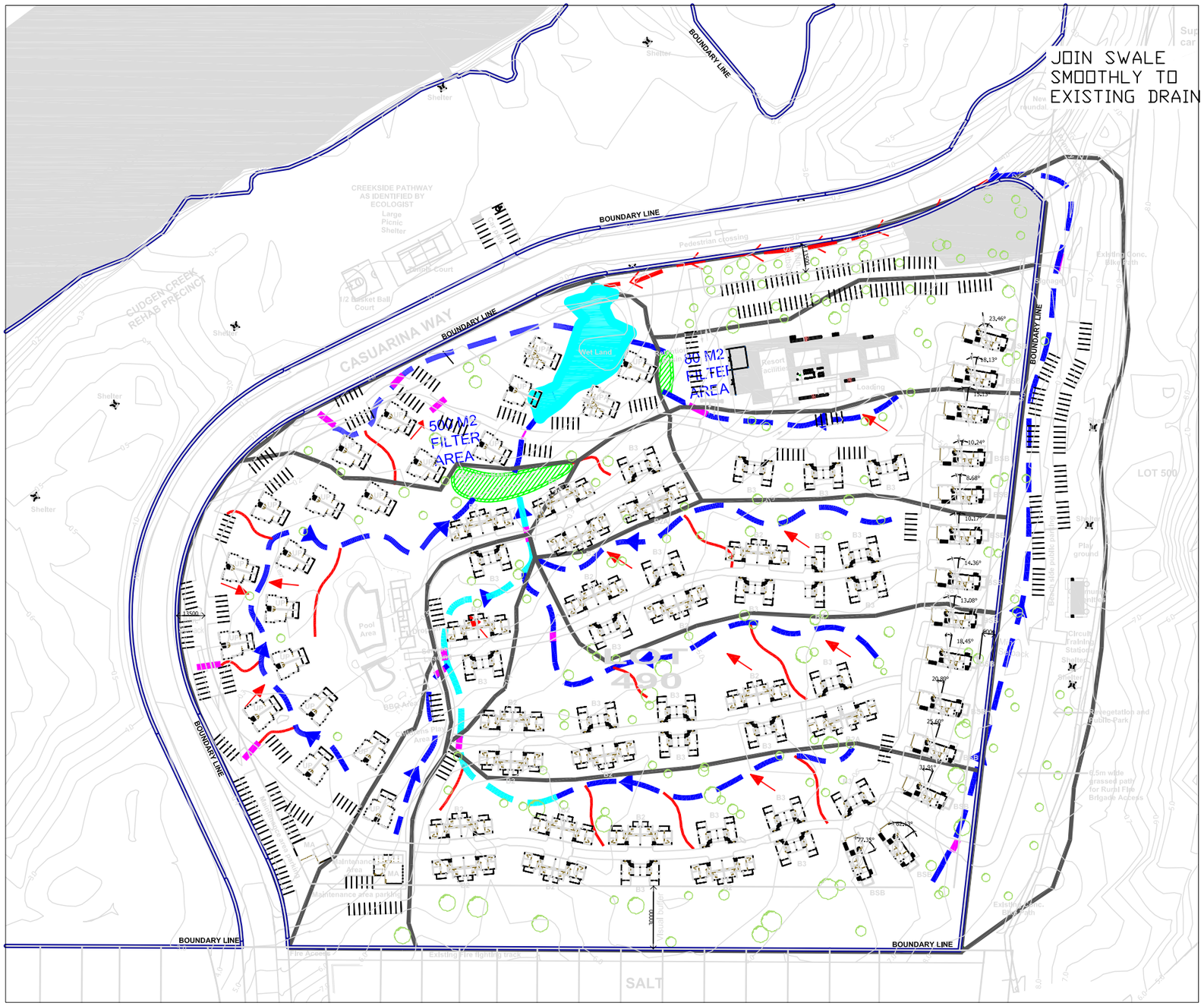
The stormwater treatment system may require regular maintenance, however, this will be the responsibility of the owner. Most maintenance requirements will be on an as needs basis. Anticipated maintenance work will include the following:

- Regular clearing of the inlet zone and outlet risers - required whenever debris and litter have accumulated to an unacceptable level or sufficient coarse sediments have accumulated in the infiltration area;
- Removal of debris and plant litter - required based on accumulation to unacceptable levels. Care must be taken to schedule periodic removal operations at times when vegetation may be routinely shedding leaves and foliage;
- Desilting of infiltration areas - this will be driven by monitoring of silt depth. It is expected that desilting, which will be achieved through removal by an excavator;
- Treatment/removal of diseased trees and shrubs – to be performed as required;
- Inspection after rainfall events to repair eroded areas – as required after storm events; and
- Mowing of turfed areas and pruning of trees and shrubs to maintain the appearance of the treatment system.

3.5. Wetlands

The existing wetland will not be utilised as part of the overall water quality treatment train. All treatment to occur within proposed swales and bioretention areas, thus minimising any potential water quality impacts on the existing wetland system. This presents a conservative approach to water quality management. In reality a higher degree of water quality treatment may be expected due to the additional treatment effect provided by the existing wetland.

The location of the Stormwater Quality Treatment Devices (SQID) and stormwater control structures are illustrated in Figure 3.3 – Operational Control Concept Plan.

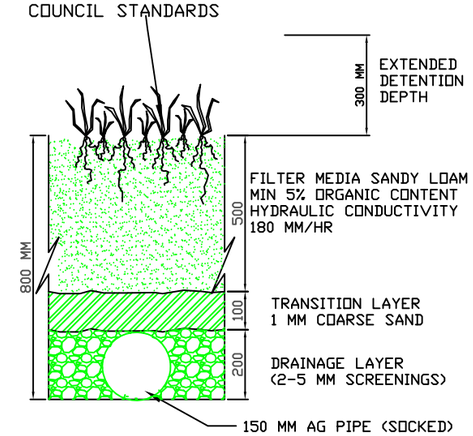


NOTES:

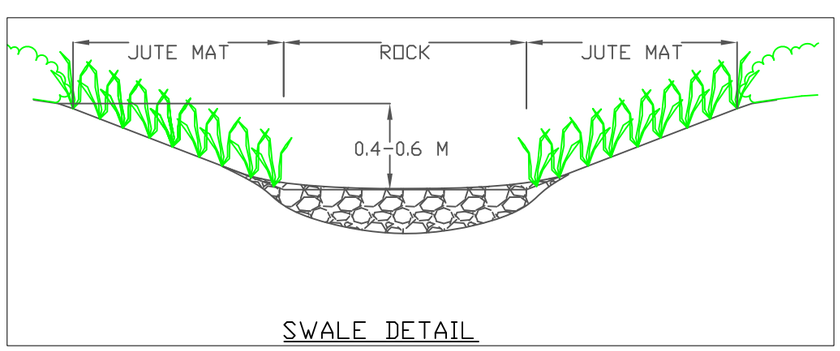
1. FINAL SWALE POSITION IS SUBJECT TO CONFIRMED ARCHITECTURAL LAYOUT & PEDESTRIAN PATH NETWORK.
2. SIZING OF BASINS IS INDICATIVE & SUBJECT TO DETAILED ENGINEERING DESIGN AT OPERATIONAL WORKS STAGE.
3.

DEVELOPMENT TYPE	ROOF AREA m^2	TRENCH VOLUME REQUIRED m^3
SMALL POD	100	2.5
MEDIUM POD	150	4
LARGE POD	230	7
COMMERCIAL	2500	88

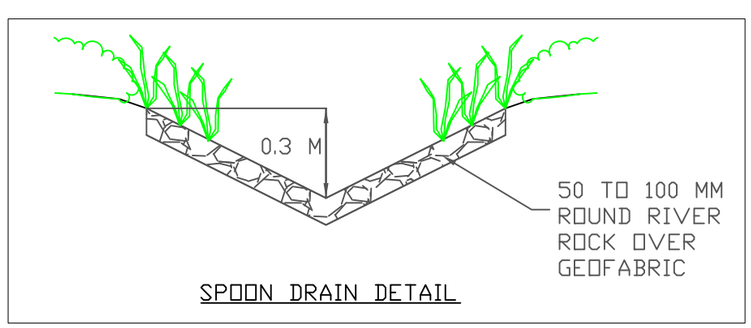
4. INFILTRATION DRAINAGE MEDIA TO BE COARSE GRAVEL MIN VOIDS 30%



BIORETENTION MEDIA CROSS SECTION



SWALE DETAIL



SPOON DRAIN DETAIL

LEGEND

- 0.4 M SWALE DEPTH (SEE DETAIL)
- 0.6 M SWALE DEPTH (SEE DETAIL)
- CULVERTS
- BIORETENTION BASINS
- SPOON DRAIN (SEE DETAIL)
- WETLAND
- EXISTING DRAIN

AMEND	DATE	DESCRIPTION	APPR.
1	22/04/09	New Layout	

AMENDMENTS

DO NOT SCALE FROM THIS DRAWING

FULL SIZE : A1

CLIENT :

LEIGHTON PROPERTIES PTY LTD

PROJECT :

LOT489 DP47021
LOT490 DP1095234
LOT500 DP1095235

CASUARINA WAY

AREA :

KINGSCLIFF

DRAWING TITLE :

FIGURE 3.3:

OPERATIONAL CONTROL CONCEPT PLAN

ASSOCIATED CONSULTANTS :

BELLENG VDM
LEVEL 3, EVANDALE PLACE
142 BUNDALL ROAD, BUNDALL, QLD, 4217
PO BOX 6788 GOLD COAST MAIL CENTRE, QLD 9726
PH: (07) 5510 3655 FAX: (07) 5510 3655
QUALITY ASSURANCE SUPPLIER TO QLD. GOVT. - N 2961

DESIGNED : –
DRAWN : SD
CHECKED : DM
DATE : 07.11.08
FILENAME : B:\007\08-3655_Lot 490 Casuarina Way\Environmental\ACAD\Water\Q8003655_SWP.dwg

APPROVED FOR AND ON BEHALF OF BELLENG VDM PTY LTD
R.P.E.Q. No. 1802 :

DRAWING No. : 2008-3655/Figure 3.3
AMENDMENT :

4. Water Quality Assessment

4.1. Key Performance Indicators

All development has the potential to affect many water quality parameters within stormwater. The key pollutants generated by various urban developments are listed in the Tweed Urban Stormwater Quality Management Plan for both the Operational (Post-Construction) and Construction phases.

Review of the proposed development layout and land uses indicates that suspended solids, nitrogen and phosphorus are the pollutants of greatest concern. This SMP will concentrate on the potential increase in pollutant values as a result of the proposed development, and in turn the required treatment to provide stormwater treatment to mitigate pollutant increases.

4.2. Water Quality Objectives

The Tweed Urban Stormwater Quality Management Plan defines acceptable performance criteria for post construction (occupational) phases of new developments. Stormwater treatment objectives are listed below:

Table 4.1: TSC Water Quality Objectives

Pollutant			
Nutrients	**Maximum permissible load that may be discharged (kg/ha/yr)**		
	Average Year (1719 mm)	**Wet Year (2185 mm)**	**Dry Year (929 mm)**
Suspended Solids (SS)	300	400	120
Total Phosphorus (TP)	0.8	1.1	0.35
Total Nitrogen (TN)	4.5	6	1.5
Litter	Retention 70% of annual litter load greater than 5 mm		
Coarse Sediment	Retention of 90% of annual load of sediment coarser than 0.125 mm		
Oil and grease (hydrocarbons)	<10 mg/litre in flows up to 40% of Q_1 peak.		

(Source: Tweed Urban Stormwater Quality Management Plan)

This will ensure the environmental values of the downstream receiving waters are maintained.

4.3. Pre- and Post-Development Water Quality

To determine the potential increase in pollutant export from the developed site without mitigating measures the Model for Urban Stormwater Improvement Conceptualisation (MUSIC) was used to analyse pre- and post-development conditions. Pre-development and post-development scenarios have been modelled based on the following assumptions:

- The pre-development catchments have been modelled as undeveloped catchments with an effective impervious percentage of 0%.
- The post-development catchments have been modelled as an urban node with an effective impervious percentage of 50%.
- Stochastically generated pollutant values have been used in the analysis.

4.4. MUSIC Modelling Parameters

4.4.1. Model Parameter Definition

The MUSIC modelling algorithm used to generate urban runoff is based on the data published by Tweed Shire Council in the Development Design Specification, D7. These values are contained in Table 4.2.

Table 4.2: Pollutant values applied by MUSIC

	Total Suspended Solids (log mg/L)		Total Phosphorous (log mg/L)		Total Nitrogen (log mg/L)	
Undeveloped Tweed	Mean	Std Dev.	Mean	Std Dev.	Mean	Std Dev.
Storm Flow Concentration	1.20	0.145	-1.47	0.30	-0.90	0.10
Base Flow Concentration	0.80	0.20	-1.00	0.34	-0.10	0.05
	Total Suspended Solids (log mg/L)		**Total Phosphorous (log mg/L)**		**Total Nitrogen (log mg/L)**	
Urban Tweed	Mean	Std Dev.	Mean	Std Dev.	Mean	Std Dev.
Storm Flow Concentration	2.00	0.145	-0.68	0.28	0.193	0.05
Base Flow Concentration	0.80	0.20	-1.00	0.34	-0.10	0.05

4.4.2. Bioretention System Input Parameters

The input parameters for the bioretention systems are summarised in Table 4.3.

Table 4.3. Bioretention Parameters Applied to MUSIC Model

Storage properties				Infiltration Properties			
Bioretention System	**Extended Detention Depth (m)**	**Surface Area (m²)**	**Seepage Loss (mm/hr)**	**Filter Area (m²)**	**Filter Depth (m)**	**Filter Median Particle Diameter (mm)**	**Saturated Hydraulic Conductivity (mm/hr)**
Subject Site	0.3	790	0	580	0.5	0.45	180

4.4.3. Vegetated Swale Input Parameters

The input parameters for the vegetated swales are summarised in Table 4.4.

Table 4.4. Vegetated Swale Parameters Applied to MUSIC Model

Vegetated Swales	Length (m)	Bed Slope (%)	Base Width (m)	Top Width (m)	Depth (m)	Veg Height (m)	Seepage Loss (mm/hr)
Subject Site	1800	2	1.5	4.7	0.4	0.25	90*

*The seepage loss adopted is conservative and well below the maximum infiltration rate of 6m/day (250mm/hr) allowed for by Council.

4.4.4. Rainwater Tank Input Parameters

Rainwater Tanks have not been included within MUSIC modelling. It is recommended that each dwelling install a minimum 2000 L rainwater tank to be

internally plumbed for non-potable uses such as toilet flushing. The rainwater tank overflow will discharge to the proposed infiltration trenches.

4.5. Pre- & Post-Development MUSIC Results

The modelled net pollutant loads prior to Stormwater Best Management Practices for the proposed development are summarised in Table 4.5. The table gives total pollutant loads exiting the site for the pre and post-development cases without inclusion of Stormwater Quality Improvement Devices (SQIDS).

Table 4.5: Modelled Median Pollutant Loadings (kg/yr)

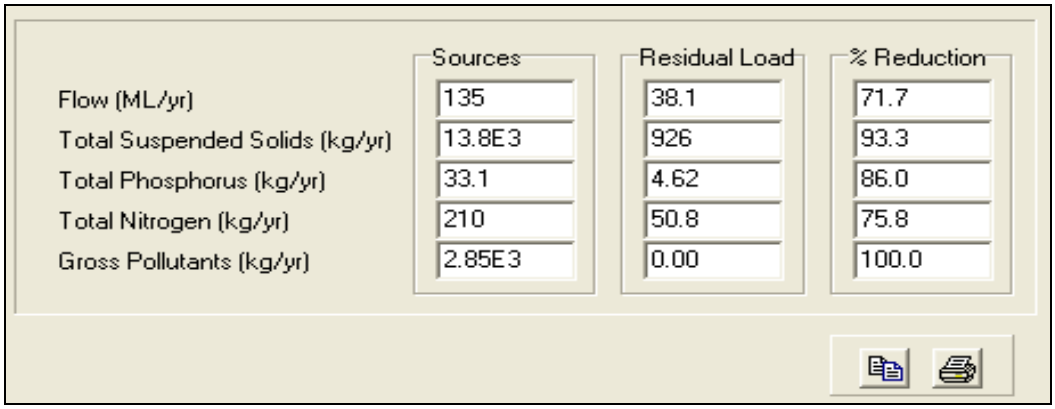
Catchment	Runoff (ML/yr)	Sediment (kg/yr)	TP (kg/yr)	TN (kg/yr)
Pre Development	12.6	1710	2.01	16.8
Post Development	135	13800	33.1	210

The modelling shows that without mitigation, TSS, TP, TN and gross pollutant loads in the subject sites watercourses will be increased. Consistent with Water Sensitive Urban Design principles, SQIDs will be incorporated into the development layout to mitigate the effect of the proposed development on both runoff and diffuse pollution.

4.6. Stormwater Management Assessment

Results of the MUSIC modelling in accordance with the Tweed Urban Stormwater Quality Management Plan WQO's are summarised in Table 4.6 for the proposed development.

Table 4.6: Treatment Train Effectiveness



A summary of the residual pollutant concentrations exiting the site and comparison to the specified Tweed Shire Council `WQO's is contained in Table 4.7.

Table 4.7: Pollutant Concentration & Targets

Pollutant	Residual Concentration (kg/yr)	Residual Concentration (kg/ha/year)	Target (kg/ha/year)	Target Achieved
TSS	926	79.3	300	✓
TP	4.62	0.40	0.8	✓
TN	50.8	4.35	4.5	✓

Results of this analysis indicate that the WQOs are met for all pollutants under consideration.

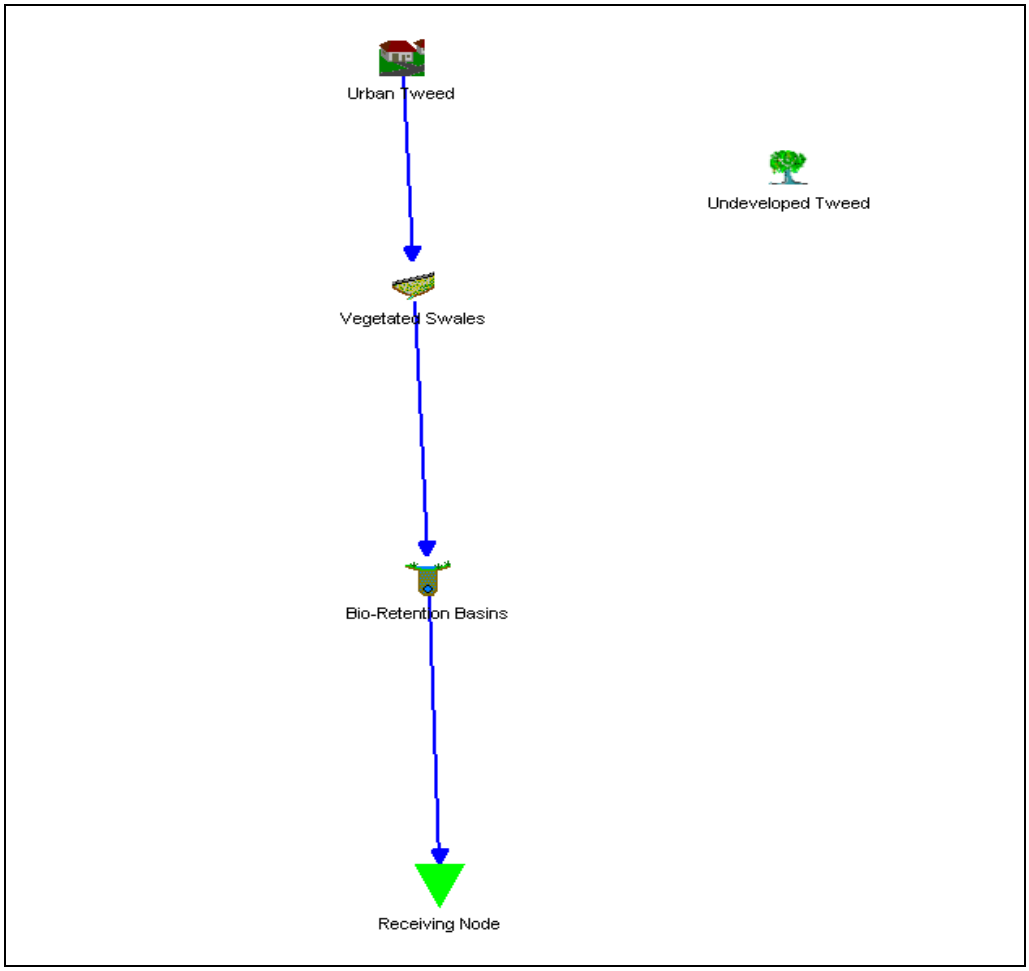


Figure 4.1. Music Model Screen Capture

Refer to Figure 3.3 for vegetated swale and bioretention basin locations. Respective filter media areas at each location are provided in Table 4.8 below:

Table 4.8: Bioretention Sizing Table

Bioretention Areas	Filter Media (m²)
BIO 1	500
BIO 2	80
TOTAL	**580**

The proposed arrangement provides an opportunity for treatment at the source. Belleng VDM has liased with the landscape architect to ensure that the above proposed treatment measures are aesthetically designed, use appropriate materials and are planted with endemic ephemeral species. The proposed layout avoids as much as possible, the removal of native vegetation.

5. Erosion & Sediment Control Measures

Comprehensive review of all available SQIDs and BMPs was undertaken as part of this investigation. The following sections provide a summary of the construction and operational phase management plans.

5.1. Construction Controls

During the construction phase of the development the following sediment and erosion control devices and stormwater management controls will be implemented; in accordance with IEAust Guidelines and Tweed Shire Council's Development Design Specifications, D7. The location of control devices is presented in Figure 5.1.

5.1.1. Sediment Basin Requirements

Sedimentation basins are generally required where:

- The disturbed area is greater than 1 hectare;
- The disturbed soils are dispersive; and/or
- Where there is a need to control runoff suspended solids/turbidity.

As the disturbed area within the subject site is greater than 1 hectare, sedimentation basins will be required. Sediment basins are to be located and constructed prior to bulk earthworks. Sediment basin sizing has been calculated using the standard approach recommended in IEAust Sediment and Erosion Control Guidelines for Queensland, which is the use of the Universal Soil Loss Equation (USLE) and the CALM Method. The results of each are provided in the tables below, which show volume, area and configuration of the basins.

Table 5.1: Annual Sediment Loss Prediction From the Subject Site

Basin ID	Area (ha)	Slope Length	Slope Grade	Intensity $^{6}I_2$	R	K	LS	C	P	A (t/ha/yr)	Yield (m^3)
1	9.06	>100	2%	16.8	6047	0.015	0.36	1	1.3	42.45	256
2	1.53	>100	2%	16.8	6047	0.015	0.36	1	1.3	42.45	43
3	1.08	>100	2%	16.8	6047	0.015	0.36	1	1.3	42.45	31
4	1.62	>100	2%	16.8	6047	0.015	0.36	1	1.3	42.45	46

Artificial flocculation will be applied on retained runoff to assist in the settling process. This will be completed via the application of Gypsum within 24 hours of the conclusion of each storm event and before any pumping out of the basin. Application of the Gypsum (or approved equivalent) will occur by simply broadcasting it over the surface by hand ensuring an even spread over the basin surface at a rate of 32 kg per 100 m^3 of water.

Table 5.2: Sedimentation Basin Configuration

Basin ID	Ac (ha)	Q_{10} (m^3/s)	Yield (m^3)	SA (m^2)	Length (m)	Width (m)	Total Depth (m)	Volume (m^3)
1	9.06	0.536	256	340.07	32	11	1.3	426
2	1.53	0.09	43	57.43	13	4	1.2	72
3	1.08	0.064	31	40.54	11	4	1.3	51
4	1.62	0.096	46	60.81	14	5	1.3	76

Note: Design particle size = 0.02 mm

Note: Further detailed investigation of the sedimentation basin requirements will be provided during the detailed design phase of the project.

5.1.2. Pre-Construction

Sediment erosion controls will be specifically tailored to meet the requirements for each development stage. Sediment and Erosion controls are illustrated in Figure 5.1. Before construction activities begin, the following sediment and erosion control measures will be implemented to minimise disturbance and ensure that the performance criteria for water quality are met:

- Construction of sediment basins;
- Maintain open space areas in a vegetated state to reduce soil disturbance and provide filter strip treatment of runoff;
- Install sediment fence along the northern and eastern site boundary;
- Install shake down grids and construction exits to remove sediment from vehicles prior to exiting the site; and
- Site personnel informed of the erosion and sediment controls.

5.1.3. During Construction

Measures to mitigate water quality impacts during the construction will include:

- Sediment fences to be erected at the base of all batters to prevent sediment laden stormwater from flowing onto road surface;
- Grass filter strips to be placed along all road verges;
- Progressive re-vegetation of filled and disturbed areas;
- Sediment fences to be erected around soil stockpiles;
- Regular inspections as soon as practicable after storm events to check and maintain controls;
- All inspections and maintenance to be recorded for review;
- Sediment to be removed from fences and basins when controls are 40% full and at the completion of construction. All material to be re-used or stored on-site in a controlled manner or taken off-site for re-use or disposal at a licensed waste disposal facility; and
- Monitoring of water quality to determine the effectiveness of the sediment and erosion control management practices (refer to Section 5).

Measures involving excavation of swales and trenches include:

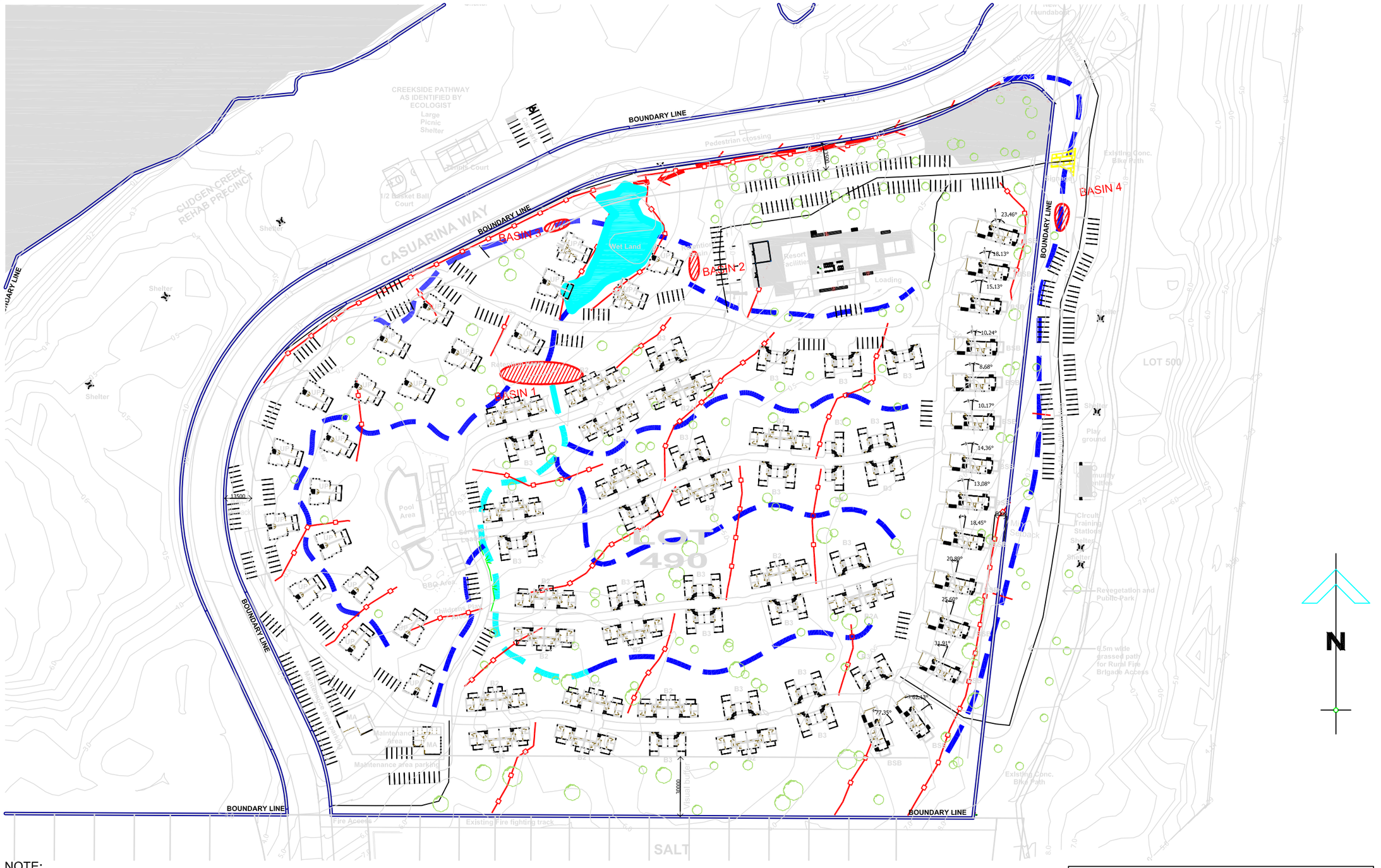
- Excavated material from swales and trenches will be reused onsite where possible; if this is not possible it will be removed from the site to an approved landfill by a licensed contractor.

5.1.4. ESC Device Description

The proposed ESC measures are detailed in Table 5.3.

Table 5.3: Erosion and Sediment Control Measures

Device Reference	Device Specification
Entry/Exit	Constructed using rock spread (150-200 mm dia) to a thickness no less than 500mm for the entire length and width as illustrated in Figure 5.1.
SF	All sediment fences must conform to the Soil Erosion and Sediment Control Engineering Guidelines for Queensland Construction Sites (IEAust 1996). All sediment fences will be constructed using an approved geo-textile fabric or other approved material.
TFS	Turf Filter Strips (TFS) are placed along all road reserves on the site to prevent sediment runoff. Flow attenuation also contributes to erosion minimisation.



NOTE:

1. ALL SILT FENCES TO BE CHECKED AFTER EVERY STORM & CLEANED WHEN AT 40% CAPACITY.
2. ALL SILT FENCES TO BE REMOVED FOLLOWING COMPLETION OF EARTHWORKS.
3. TEMPORARY SEDIMENT BASINS TO BE DESILTED/DREDGED OF CAPTURED SEDIMENT AND CONVERTED TO BIORETENTION BASINS FOLLOWING COMPLETION OF SITEWORKS.
4. TEMPORARY SEDIMENT BASINS TO BE FLOCCULATED AFTER STORM EVENTS >25MM.
5. SEDIMENT BASINS TO REMAIN RESPONSIBILITY OF CIVIL CONTRACTOR UNTIL "OFF MAINTENANCE" PERIOD COMMENCES.
6. FINISHED LOT SURFACES TO BE HYDROSEEDED/SOWN FOLLOWING COMPLETION OF EARTHWORKS.
7. LOCATIONS OF CONTROL DEVICES ARE INDICATIVE AND WILL BE REVISED AT OPERATIONAL WORKS STAGE AND ONSITE AS NECESSARY.
8. INSTALL SEDIMENT FENCE WEIRS AT ALL DRAINAGE AND SWALE CROSSINGS.
9.SWALES TO BE CONSTRUCTED AS PART OF PRELIMINARY EARTHWORKS.

SCALE 20 0 20 40 60 80 100 (metres)

1 : 2000 (FULL SIZE)

LEGEND

- EXISTING DRAIN
- SWALE DRAIN
- SEDIMENT FENCE
- CONSTRUCTION EXIT/ RUBBLE GRID
- SEDIMENT BASIN

AMEND	DATE	DESCRIPTION	APPR.
1	22/04/09	New Layout	

AMENDMENTS

DO NOT SCALE FROM THIS DRAWING

FULL SIZE : A1

CLIENT :

LEIGHTON PROPERTIES PTY LTD

PROJECT :

LOT489 DP47021
LOT490 DP1095234
LOT500 DP1095235

CASUARINA WAY

AREA :

KINGSCLIFF

DRAWING TITLE :

FIGURE 5.1:

SEDIMENT AND EROSION CONTROL PLAN

ASSOCIATED CONSULTANTS :

BELLENG VDM
LEVEL 3, EVANDALE PLACE
142 BUNDALL ROAD, BUNDALL, QLD, 4217
PO BOX 8788 GOLD COAST MAIL CENTRE, QLD 9726
PH: (07) 5510 3655 FAX: (07) 5510 3655
QUALITY ASSURANCE SUPPLIER TO QLD. GOVT. – N 2961

DESIGNED : –
DRAWN : SD
CHECKED : DM
DATE : 03.10.08
FILENAME : B:\000\08-3655_Lot 490 Casuarina Way_\Environmental\ACAD\Water\GE003655_SMP100308_D.dwg

APPROVED FOR AND ON BEHALF OF BELLENG VDM PTY LTD
R.P.E.Q. No. 1802 :

DRAWING No. : 2007-297/Figure 4.1
AMENDMENT : 1

6. Management Plan

To minimise the impact of the proposed changes on the external environment the proponent shall implement this SMP. This SMP shall be amended as required in response to the Monitoring and Maintenance Program described herein to avoid significant and/or sustained deterioration in existing water quality of waterways downstream, when operational works are approved.

6.1. Monitoring and Maintenance Program

6.1.1. Construction Phase Monitoring

Monitoring during the construction phase will be conducted to determine the impact of activities on the subject site. Runoff from the subject site will be monitored monthly during construction on an event basis for storm events in excess of 25 mm within a 24-hour period.

Parameters:	TSS, TN, TP, Turbidity, pH and DO.
Frequency:	Monthly following single rain events in excess of 25 mm per day during the construction phase.
Monitoring Procedures:	Sampling by the proponent in accordance with procedures set out in the Environmental Protection Authority's Water Quality Sampling Manual. Analysis by a NATA registered laboratory for all of the above parameters. Alternatively calibrated probes may be used.
Reporting:	Monthly reports are to be submitted to the Council for review, upon request, typically at Survey Plan Sealing.

6.1.2. On Maintenance Phase Monitoring

Monitoring during the operational phase will be to determine the impact of activities on the receiving waters. Surface water quality monitoring is to be undertaken at discharge points and within the receiving waters. Water quality monitoring will be completed following rainfall events of 25mm or greater in any 24 hour period and on a monthly basis for a minimum period of 12 months.

Monitoring sites:	Outlet of wetland and bioretention basins (Refer Figure 3.3).
Parameters:	pH, Turbidity, TSS, DO, Total-N and Total-P.
Frequency:	Monthly and following single rain events in excess of 25mm per day during the construction phase.
Monitoring Procedures:	Sampling by the proponent in accordance with procedures set out in the Environmental Protection Authority's Water Quality Sampling Manual. Alternatively calibrated probes may be used.
Reporting:	Monthly reports to be compiled and are to be available for Council Officers and other relevant authorities upon request. Council to be notified within 24hrs of non-complying test results

6.2. Investigation Indicators

The following indicators are used to identify if the objectives of the SMP are not being met:

1. Visible evidence of deterioration of downstream drainage that is directly attributable to the site;
2. Visible significant erosion; and/or
3. Failure of control measures.

The triggering of an investigation indicator will require the following remedial actions:

1. Locate source of water quality deterioration;
2. Prevent continuing deterioration with temporary controls;
3. Repair existing controls, construct additional controls or modify procedures to prevent future deterioration in water quality;
4. If, after new operation commences, there is an observed deterioration in water quality, the management plan and strategies will be reviewed in consultation with Tweed Shire Council.

6.3. Responsibilities and Timing

Table 6.1: Responsibilities and Timing

Item	Responsibility	Timing/Deadline
Operational Works Design	Environmental Consultant	TBA
Control Implementation	Site Manager	TBA
Water Quality Monitoring & Reporting	Environmental Consultant Tweed Shire Council	Monthly and following single rain events in excess of 25 mm per day during the construction phase. Monthly during the 'On Maintenance' period. Reports are to be available upon request by Council. Tweed Shire Council to be informed within 24hours of any non-complying test results.
Control Maintenance	Site Manager	Continuous until 'Off-Maintenance'.
Supervision on an as needs basis	Environmental Consultant	During Construction and 'On Maintenance' Phases.
Corrective action	Site Manager	Continuous until 'Off-Maintenance' for stormwater treatment system.
SWM Compliance Certification	Environmental Consultant	Prior to treatment system 'Off Maintenance'.

Where requested by the approving agency, Belleng VDM may agree to provide certification of the SMP provided the contractor and appointed consultant furnish the required information.

7. Summary

This Stormwater Management Plan (SMP) represents best water sensitive urban design practice and incorporates ecological sensitive design principles to reduce potential impacts on existing ecological communities and downstream receiving environments.

The SMP has been prepared in consultation with the landscape architect to ensure that the treatment methods selected are aesthetically designed, use appropriate materials sympathetic to the local environment and use endemic plant species to enhance the natural biodiversity of the site.

In keeping with the WSUD theme, minimal stormwater infrastructure or “hard” engineering solutions have been used resulting overall disruption to the site and minimising the need for ongoing maintenance.

The primary design intent of this SMP has been to avoid the removal of existing native trees as identified in the ecological assessment and is demonstrated in the creative use swales and bioretention areas to meet the stormwater quality objectives of Tweed Shire Council.

The stormwater quality treatment measures proposed for this development will achieve Councils water quality objectives of:

- Suspended Solids – 300 kg/ha/yr;
- Total Phosphorous – 0.8 kg/ha/yr;
- Total Nitrogen – 4.5 kg/ha/yr;
- Litter 70% retention of annual litter load greater than 5mm;
- Coarse Sediment Retention of 90% of annual load of sediment greater than 0.125mm;
- Oil and Grease (hydrocarbons) <10mg/Litre in flows up to 40% of Q_1 peak

Proposed measures for the residential site include:

- A stormwater retention and infiltration of the Q_{3month} stormwater from roof areas;
- Vegetated swales; and
- Bioretention systems to capture pollutants and treat stormwater prior to discharge from the site.

MUSIC modelling indicates the percentage reduction will satisfy the nominated WQO. Required treatment areas are presented below:

Bioretention Areas	Filter Media Area (m²)
BIO 1	500
BIO 2	80
TOTAL	**580**

8. References

The information presented herein has been prepared with reference to the following:

1. ANZECC, 2000, *Australian and New Zealand Guidelines for Fresh and Marine Water Quality 2000,* Australia and New Zealand Environment and Conservation Council (ANZECC), Agriculture and Resource Management Council of Australia and New Zealand.

2. Brisbane City Council 1999*, Urban Stormwater Management Strategy 1999-2000, Waterways Program.*

3. Brisbane City Council 2000*, Identifying and Applying Water Quality Objectives in Brisbane City, Waterways Program.*

4. Brisbane City Council 2000*, Draft Design Guidelines for Stormwater Quality Improvement Devices, Waterways Program (SQID)*

5. Brisbane City Council 2000*, Guidelines for Pollutant Export Modelling in Brisbane City (revised version 2000), Waterways Program.*

6. Brisbane City Council 2000*, Water Quality Management Guidelines, Waterways Program.*

7. Brisbane City Council 2000*, Stormwater Management Code, Town Plan*

8. Institution of Engineers, QLD Division, 1996. *Soil Erosion and Sediment Control-Engineering Guidelines for Queensland Construction Sites. IEAust. Brisbane.*

9. Gold Coast City Council, 2002. *Stormwater Management and Water Quality Guidelines,* Planning Policy.

10. Queensland Government 1997. *Environmental Protection (water) Policy. QLD Government Printer, Brisbane.*

11. Queensland Water Quality Guidelines, Draft For Comment, March 2001.

12. Queensland Government 1994. *Environmental Protection Act. QLD Government Printer, Brisbane.*

13. SEQ Regional Water Quality Strategy 1999. *Draft South East Queensland Regional Water Quality Management Strategy*, *Management Committee.*

14. Duncan H.P 1999, *Urban Stormwater Quality: A Statistical Overview.* CRC for Catchment Hydrology.

15. Victoria Stormwater Committee. 1999, *Urban Stormwater - Best Practice Environmental Management Guidelines.*

16. Water and Rivers Commission WA. 1998, *A Manual for Managing Urban Stormwater Quality in Western Australia.*

17. NSW EPA. 1997, *Managing Urban Stormwater - Treatment Techniques.*

18. Wong, T at el. CRC 1998, *Managing Urban Stormwater Using Constructed Wetland*.

9. Appendices

Appendix A – Infiltration Trench Sizing

Appendix A
Infiltration Trench Sizing

Infiltration Trench Sizing

Roof Area	230	m^2	Infiltration rate	6	m/day
Module Depth	0.880	m	FOS	2	
Module Width	0.408	m			
Module Length	0.685	m			
Module volume	0.246				
No. of Modules	29		**Infiltration Dimensions**		
No. of Modules (Width)	4		Excavation Width (m)	1.6	m
No. of Modules (Length)	5		Excavation Length (m)	3.4	m
Infiltration area	12.6	m^2	Perimeter (m)	10.11	m
Trench volume	7.1	m^3	Plan area (m^2)	5.6	m^2
Porosity	0.3	coarse gravel			

Duration (min)	Q_1 Intensity (,mm/hr)	Q_1 (m^3/s)	Q_{3mth} (0.4*Q_1) (m^3/s)	Vol runoff (m^3)	Infiltration rate (m^3/s)	Vol Infiltration (m^3)	Vol stored (m^3)	Total Vol (m^3)	CHECK
5	126	0.0081	0.0032	1.0	0.00044	0.1	2.1	2.3	PASS
6	118	0.0075	0.0030	1.1	0.00044	0.2	2.1	2.3	PASS
10	97	0.0062	0.0025	1.5	0.00044	0.3	2.1	2.4	PASS
20	71	0.0045	0.0018	2.2	0.00044	0.5	2.1	2.7	PASS
30	57	0.0036	0.0015	2.6	0.00044	0.8	2.1	2.9	PASS
60	39.2	0.0025	0.0010	3.6	0.00044	1.6	2.1	3.7	PASS
120	25.6	0.0016	0.0007	4.7	0.00044	3.1	2.1	5.3	PASS
180	19.8	0.0013	0.0005	5.5	0.00044	4.7	2.1	6.8	PASS
360	12.7	0.0008	0.0003	7.0	0.00044	9.4	2.1	11.6	PASS
720	8.22	0.0005	0.0002	9.1	0.00044	18.8	2.1	21.0	PASS
1440	5.61	0.0004	0.0001	12.4	0.00044	37.7	2.1	39.8	PASS