3. WATER CYCLE MANAGEMENT

3.1 DGR Item References

The following DGR items are addressed in this section:

RAINBOW BEACH CONCEPT PLAN (CP)

Item	Topic
CP3.2	Address and outline measures for Integrated Water Cycle Management (including stormwater) based on Water Sensitive Urban Design principles, including impacts on the surrounding environment.

PROJECT APPLICATION – OPEN SPACE CORRIDOR & CONSTRUCTED WETLAND (PA)

Item	Topic
PA5.1	Address and outline the measures for Integrated Water Cycle Management (including storm water) based on Water Sensitive Urban Design principles with reference to 'Area 14 Integrated Water Cycle Management Plan' (report to Hastings Council, 2006). Specifically describe the function of the constructed wetland within the larger IWCM plan for the site.

3.2 Water Cycle Strategies

The proposed development has been designed to comply with the policy requirements of Port Macquarie Hastings Council and the NSW State Government legislation.

3.3 IWCM Constraints (Area 14)

The Port Macquarie Hastings Council IWCM (Integrated Water Cycle Management) policy for Area 14, as amended on 5 November 2007, requires:

- Use of reclaimed water to dwellings for outdoor use, toilet flushing and laundry cold water.
- Irrigation of district sports fields with reclaimed water sourced from Port Macquarie-Hastings Council.
- Water sensitive urban design (WSUD) for stormwater management.

Reclaimed water sourced from Port Macquarie Hastings Council will be distributed to housing in the proposed residential areas via a dual-mains reticulation system.

Stormwater runoff from the residential and commercial areas within the proposed development will be fully treated in accordance with Council requirements to protect the water quality of receiving waters. This is discussed in detail in the following Section 3.4.

Although the use of rainwater tanks on dwellings for laundry and hot water uses is not mandatory under Council's policy it is anticipated at least 50% of premises within the proposed development will adopt the use of rainwater tanks.

3.4 Stormwater Management

3.4.1 Water-Sensitive Urban Design (WSUD)

The stormwater design for the proposed development complies with the key principles of WSUD from a stormwater management and planning perspective (CSIRO 1999), namely:

- Protect natural systems – protect and enhance natural water systems (creeks, rivers, wetlands) within urban developments.
- Protect water quality – improve the quality of water draining from urban development into creeks, rivers and bay environments.
- Integrate stormwater treatment into the landscape – use stormwater treatment systems in the landscape by incorporating multiple uses that will provide multiple benefits, such as water quality treatment, wildlife habitat, public open space, recreational and visual amenity for the community.
- Reduce runoff and peak flows – reduce peak flows from urban development by on site temporary storage measures (with potential for reuse) and minimise impervious areas.
- Add value while minimising development costs – minimise the drainage infrastructure cost of development.
- Reduce potable water demand – use stormwater as a resource through capture and reuse for non-potable purposes (e.g. toilet flushing, garden irrigation, laundry).

The proposed development using end-of-pipe wetlands for stormwater treatment was adopted as the most advantageous overall because it is the only option providing the required residential areas along with satisfactory WSUD solutions whilst remaining economically feasible in terms of minimizing total earthworks which avoids the necessity for imported fill.

WSUD stormwater treatment options using bioinfiltration treatment are not feasible because of the increased volume of earthworks required including large volumes of imported material (see Section 2.4).

3.4.2 Stormwater Treatment

3.4.2.1 Performance Criteria

Water quality objectives for stormwater runoff treatment from the development were adopted in accordance with:

- Port Macquarie Hastings Council adopted criteria in accordance with Council's IWCM policy of September 2006 as amended in November 2007 (see Section 3.3).
- Gold Coast City Council Stormwater Quality Management Guidelines 2006 Section 5.2.2.3 on Site Based Performance Criteria.

Port Macquarie-Hastings Council performance criteria, taken from Aus-Spec D7 Stormwater Management (AUS-SPEC 2003), are listed in Table 25.

Table 5.2 of the Gold Coast City Council publication *Stormwater Quality Management Guidelines* (2006) gives the performance criteria applicable to development during the operational phase which are also listed in Table 25.

Table 25 Operational Phase Stormwater Treatment Performance Criteria

PORT MACQUARIE-HASTINGS COUNCIL REQUIREMENTS

The following load reductions must be achieved when assessing the post development sites treatment train (Comparison of unmitigated developed case verses developed mitigated case).

- 80% Reduction in Coarse Sediment (particles <= 0.5 mm)
- 50% Reduction in Fine Sediment (particles <= 0.1 mm)
- 45% Reduction in Total Nitrogen (TN)
- 45% Reduction in Total Phosphorus (TP)
- 90% Reduction in Litter (sized 5mm or greater)
- 90% Reduction in Hydrocarbons, motor fuels, oils and greases

(All reductions are in terms of annual pollutant load)

GOLD COAST CITY COUNCIL REQUIREMENTS

Best Management Practices (BMP) are required to be demonstrated for all development applications with the City of Gold Coast. The following load reductions must be achieved when assessing the post development sites treatment train (Comparison of unmitigated developed case verses developed mitigated case).

- 80% Reduction in Total Suspended Sediment (TSS)
- 45% Reduction in Total Nitrogen (TN)
- 60% Reduction in Total Phosphorus (TP)
- 90% Reduction in litter (sized 5mm or greater)

Stormwater management measures have been identified for the treatment of runoff from the site to ensure that the performance criteria can be met. The proposed stormwater management measures for the site are described in Section 3.2 and Section 3.3.

3.4.2.2 Stormwater Management Practices

A wide range of stormwater management practices is available to achieve the principles of Water Sensitive Urban Design (CSIRO 1999, AUS-SPEC 2003). All have been shown to be successful when correctly designed, but selection of the most appropriate practices for a particular development is highly dependent on site conditions.

Table 26 lists the most common stormwater management practices currently used, along with opportunities and constraints for their use. This table forms the starting point for stormwater management for the site. Considering the site's topography and constraints, not all of the measures outlined in Table 26 are suitable. Each treatment option is therefore discussed in more detail and comment made on the suitability of each in the context of the development.

Table 26 Stormwater Management Practices

Practice	Opportunities			Constraints
	Pollutants removed	**Scale**	**Other**	
Litter baskets/racks	Litter and debris – M	Local	Pre-treatment for other practices	Require frequent maintenance
Sediment traps	Coarse sediment – H Suspended solids – L	Regional		Aesthetic and safety issues
Gross pollutant traps (GPTs)	Litter and debris – M Coarse sediment – H Suspended solids – L	Regional	Pre-treatment for other practices	Require regular maintenance
Filter strips/ buffer strips	Litter and debris – M Coarse sediment – H Suspended solids – H Nutrients – M	Lot/Local	Peak flow management	Require flat terrain
Grass swales	Litter and debris – M Coarse sediment – H Suspended solids – H Nutrients – M	Local	Peak flow management	Require flat terrain
Vegetated swales	Litter and debris – M Coarse sediment – H Suspended solids – H Nutrients – H	Local	Peak flow management	Require flat terrain
Extended detention basins	Coarse sediment – M Suspended solids – M Nutrients – L	Regional	Peak flow management	Requires pre-treatment Large land area required
Infiltration trenches (rock blanket)	Suspended solids – H Nutrients – M	Local	Peak flow management	Requires pre-treatment
Bioretention systems	Coarse sediment – H Suspended solids – H Nutrients – H	Local	Peak flow management	Requires pre-treatment
Porous pavements	Suspended solids – H Total phosphorus – M Total nitrogen – L	Local	Peak flow management	Not appropriate for steep sites
Constructed wetlands	Coarse sediment – H Suspended solids – H Total phosphorus – M Total nitrogen – L	Regional	Peak flow management	Requires pre-treatment Not appropriate for steep sites Requires large area of land
Rainwater tanks	N/A	Lot	Peak flow management	Requires community involvement
Community education	Litter and debris – L Nutrients – L	Regional	Other benefits include weed control, reduced water use	Community participation

Note: Data taken from NSW EPA "Managing Urban Stormwater – Treatment Techniques, 1997" and "Managing Urban Stormwater – Council Handbook, 1998".

L – 10 – 50% removal
M – 50 – 75% removal
H – 75 – 100% removal

Scales Lot less than 1 ha
Local 1 – 10 ha
Regional greater than 10 ha

3.4.2.3 Outline Suitability Assessment

Each of the techniques described in Table 26 is further assessed below, with regard to the site's specific opportunities and constraints.

Litter Baskets/racks

The primary purpose for litter baskets is to remove medium sized litter and debris from the site.

Sedimentation Pits

Sediment pits provide pretreatment of stormwater runoff for the removal of suspended solids before entering other treatment devices such as bioretention systems of wetland.

Gross Pollutant Traps

Gross pollutant traps are predominantly used for the removal of litter and debris – although they have been shown to effectively remove coarse sediment and suspended solids (Brisbane City Council, 1999).

Filter Strips/Buffer Strips

Buffer strips are areas of land left in their natural state which act to reduce peak runoff flows and improve the quality of stormwater runoff. This treatment improves the aesthetic and biodiversity value of the development and provides significant quality and quantity improvements. Buffer strips will be adopted as suitable opportunities arise within the development.

Grass Swales

Grass swales are considered a highly effective and aesthetic water quality control measure. However, in order to detain flow adequately, grass swales need to be placed on relatively flat slopes. Wherever slopes are sufficiently flat (or where they are able to follow contours), grass swales will be adopted to provide effective stormwater treatment.

Vegetated Swales

Vegetated swales require similar conditions as those outlined for grass swales above. Therefore, the use of vegetated swales is limited by slope. Wherever slopes are sufficiently low the use of a vegetated swale would provide effective stormwater treatment for the site.

Extended Detention (Sedimentation) Basin

Extended detention basins are designed to generally store runoff for 1-2 days. Their main purpose is the reduction of the peak discharge from the site during a storm event, and the retention of particulate matter.

Bioretention Systems

Bioretention systems effectively combine a grass or vegetated swale with an infiltration trench. They are considered to be extremely effective in removing sediment and nutrients. Although they require a flat area, they can be incorporated in steeper areas using a stepped system. They can also be located within a detention basin, thereby combining the stormwater quality and quantity functions into a smaller area. There are a number of suitable locations where bioretention systems will be adopted to provide stormwater treatment.

Infiltration Trenches

Infiltration trenches (rock blankets) allow pretreated stormwater runoff to infiltrate to into surrounding soils and groundwater. These devices were not considered in the stormwater treatment train.

Porous Pavements

Porous pavements are not appropriate for high traffic areas due to increased maintenance requirements. They are also less effective in steep areas. However, for relatively flat, low traffic roads they could be suitable for this development. Their perceived expense often leads to the preference of other measures in reaching quantity and quality objectives.

Constructed Wetlands

Wetlands require reasonably large flat areas of land. The lower part of the catchment consists of flat terrain and shallow lake systems and it is considered an ideal location for the inclusion of wetland systems. Wetlands will be included at the end of treatment train to provide final treatment of stormwater before entering the lake systems.

Rainwater Tanks

Tanks are an extremely useful aid to water conservation, and also have some effect in reducing nitrogen levels. The capacity of the tanks has been discounted in stormwater runoff calculations. Despite having a considerable effect in reducing runoff volumes, they cannot be assumed to be empty when needed.

The proposed treatment train for the development assumes that 50% of households will adopt the use of rainwater tanks. Port Macquarie Hastings Council IWCM policy does not mandate the use of rainwater tanks. Hence, a conservative estimate of 50% utilisation of tanks was adopted.

3.4.2.4 Adopted Treatment Measures

Based on the review of available options, the following treatment train is proposed for the treatment of runoff from the residential development areas of the site:

- Buffer strips for the removal of sediment and nutrients from impervious surfaces such as foot paths and driveways;
- Grassed swales to convey storm flow and provide adequate flow detention prior to downstream treatment devices such as wetlands and bioretention systems;
- Bio-retention systems to be utilised where possible (generally in upper reaches of catchment) for the removal of sediment and nutrients;
- Wetland systems to be utilised at the downstream end of the urban catchment immediately upstream of receiving water bodies;
- Rainwater tanks for capture of roof stormwater runoff installed on at least 50% of households.

The treatment train will allow runoff from the development to be treated to meet the adopted water quality objectives. The constructed water bodies proposed for the site will, by virtue of long residence times, provide for additional removal of sediment and nutrients from the water column.

Treatment devices will be designed and constructed in accordance with Port Macquarie-Hastings Council recommendations, taken from Aus-Spec-1 D7 "Development Design Specification - Stormwater Management" (see AUS-SPEC 2003).

Stormwater treatment wetlands will also be designed and constructed in accordance with the NSW Department of Land and Water Conservation "Constructed Wetlands Design Manual" (DLWC 1998). Typical proposed details are shown in Figure 13.

3.4.3 MUSIC modelling of Stormwater Treatment

The quality of runoff from the development was modelled using the MUSIC software package in combination with the CRC-FE Pond model. MUSIC was used to complete initial modelling of the development to confirm that the water quality objectives defined by Port Macquarie Hastings Council and Gold Coast City Council (refer Section 3.1) for runoff from the site (to the water bodies) could be achieved. MUSIC was then used to derive the runoff, sediment, and nutrient inputs to the Pond model from each of the three water bodies.

The MUSIC model (Model for Urban Stormwater Improvement Conceptualisation), was developed by the Cooperative Research Centre for Catchment Hydrology. MUSIC simulates both the quantity and quality of runoff from catchments together with the improvement in quality afforded by a wide range of treatment devices. Version 3.01 of the model was used for the study.

3.4.3.1 MUSIC Model Parameters

Model input fraction impervious parameters for various land uses within the MUSIC model were obtained from the *Melbourne Water MUSIC Input Parameters* (March 2004). Separate parameter sets were available for the following land use areas:

Table 27 Fraction Impervious Parameters for Various Land Uses

Landuse	Node Type	% Impervious	% Pervious
Urban	Urban	45%	55%
Urban Roof	Urban	100%	0%
Parkland	Urban	10%	90%
School	Urban	70%	30%
Playing Fields	Urban	10%	90%
Medium Density	Urban	60%	40%
Medium Density (roof)	Urban	100%	0%
Commercial	Urban	90%	10%
Forest	Forest	10%	90%

* Source – MUSIC Input Parameters – Melbourne Water – March 2004

3.4.3.2 MUSIC Model Network Configurations

The MUSIC model network configurations for the existing conditions and development conditions respectively are shown in Figure 22 and Figure 23.

The contributing areas from each catchment and configuration details are shown in Table 28.

Table 28 MUSIC Model Configuration Details and Input Parameter Values

Source Nodes

Catchment	Landuse	MUSIC Node	Area (Ha)	% Impervious	% Pervious
1	School	Urban	5.98	70%	30%
2	Residential	Urban	10.944	45%	55%
3	Residential	Urban	0.951	45%	55%
4	Residential	Urban	0.43	45%	55%
5	Residential	Urban	0.575	45%	55%
6	Residential	Urban	0.314	45%	55%
7	Playing Fields	Urban	8.495	10%	90%
9	Residential	Urban	0.779	45%	55%
10	Residential	Urban	1.587	45%	55%
11	Residential	Urban	3.048	45%	55%
12	Residential	Urban	3.481	45%	55%
13	Residential	Urban	4.086	45%	55%
14	Residential	Urban	2.831	45%	55%
15	Residential	Urban	0.535	45%	55%
16	Residential	Urban	2.057	45%	55%
25	Residential	Urban	1.602	45%	55%
26	Residential	Urban	1.319	45%	55%
27	Residential	Urban	0.797	45%	55%
28	Residential	Urban	1.824	45%	55%
29	Residential	Urban	2.934	45%	55%
30	Residential	Urban	0.393	45%	55%
31	Residential	Urban	3.151	45%	55%
32	Residential	Urban	0.29	45%	55%
33	Residential	Urban	0.858	45%	55%
34	Residential	Urban	0.906	45%	55%
35	Residential	Urban	0.564	45%	55%
36	Urban Open Space	Urban	0.77	10%	90%
37	Residential	Urban	0.9	45%	55%
38	Residential	Urban	1.855	45%	55%
39	Residential	Urban	1.801	45%	55%
40	Residential	Urban	6.425	45%	55%
41	Residential	Urban	3.93	45%	55%
42	Residential	Urban	0.561	45%	55%
43	Urban Open Space	Urban	4.882	10%	90%
44	Residential	Urban	6.626	45%	55%
Total			88.481		

Buffer Parameters

Catchment	% of Upstream Area Buffered	Buffer Area (% of Upstream Impervious Area.)	Seepage Loss (mm/hr)
1	N/A	N/A	N/A
2	20.0	5%	0.00
3	20.0	5%	0.00
4	20.0	5%	0.00
5	20.0	5%	0.00
6	20.0	5%	0.00
7	N/A	N/A	N/A
9	20.0	5%	0.00
10	20.0	5%	0.00
11	20.0	5%	0.00
12	20.0	5%	0.00
13	20.0	5%	0.00
14	20.0	5%	0.00
15	20.0	5%	0.00
16	20.0	5%	0.00
25	20.0	5%	0.00
26	20.0	5%	0.00
27	20.0	5%	0.00
28	20.0	5%	0.00
29	20.0	5%	0.00
30	20.0	5%	0.00
31	20.0	5%	0.00
32	20.0	5%	0.00
33	20.0	5%	0.00
34	20.0	5%	0.00
35	20.0	5%	0.00
36	N/A	N/A	N/A
37	20.0	5%	0.00
38	20.0	5%	0.00
39	20.0	5%	0.00
40	20.0	5%	0.00
41	20.0	5%	0.00
42	20.0	5%	0.00
43	N/A	N/A	N/A
44	20.0	5%	0.00

Swales

Swale	Length (m)	Bed Slope	Base Width	Top Width	Depth	Vegetation Height	Seepage Loss
A	282.8	0.50%	1	12	1	0.100	0.00
B	351	0.50%	1	20	2	0.1	0.00
C	355	0.50%	1	20	2	0.1	0.00
D	100	3%	1	5	0.5	0.25	0.00

Wetland Nodes.

Wetland	Low Flow Bypass (m^3/s)	High Flow Bypass (m^3/s)	Inlet Pond Volume (m^3)	Surface Area (m^2)	Extended Detention (m)	Permanent Pool Volume (m^3)	Seepage Loss (mm/hr)	Evap Loss (% of PET)	Equival. Outlet Pipe Diameter	Overflow Weir (m)
W1A	0	100	0	1500	2	750	0	125	450	3
W1B	0	100	0	2000	2	1000	0	125	450	3
W1C	0	100	0	2800	2	1400	0	125	450	3
W1D	0	100	0	2250	2	1125	0	125	450	3
W1E	0	100	0	2085	2	1040	0	125	450	3
W2	0	1000	0	5500	1	2750	0	125	300	5
W3	0	1000	0	7500	1	3750	0	125	600	5
W4(A+B)	0	1000	0	5000	1	2500	0	125	450	5

The runoff generation parameters adopted for the various land-uses were taken from Gold Coast City Council Music Modelling Guidelines 2006. Runoff Generation parameters are listed in Table 29. The pollutant export relationships adopted for various land-uses are listed in Table 30.

Table 29 Runoff Generation Parameters

Rainfall-Runoff Parameters

	Forest	Urban	Roof	Rural Residential	Commercial	Industrial
Impervious Area Properties						
Rainfall Threshold (mm/day)	1	1	1	1	1	1
Pervious Area Properties						
Soil Storage Capacity (mm)	200	200	200	200	200	200
Initial Storage (% of Capacity)	25	10	10	25	25	25
Field Capacity (mm)	170	170	170	170	170	170
Infiltration Capacity Coefficient - a	200	50	50	200	200	200
Infiltration Capacity Coefficient - b	1	1	1	1	1	1
Groundwater Properties						
Initial Depth (mm)	50	50	50	50	50	50
Daily Recharge Rate (%)	25	25	25	25	25	25
Daily Baseflow Rate (%)	5	5	5	5	5	5
Daily Seepage Rate (%)	0	0	0	0	0	0

Notes: Parameters as per Table 4 of Gold Coast City Council *Guidelines for MUSIC modelling,* 2006.
Field Capacity Parameter as per default values used in MUSIC User Manual

Table 30 Pollutant Export Relationships

Stormwater Water Quality Parameters for MUSIC Source Nodes.

- Source: Gold Coast City Council MUSIC Modelling Guidelines 2006 - Table 5.
- Note: All Estimations are "Stochastically Generated.

Land-use Category		TSS (log_{10}mg/l)		TP (log_{10}mg/l)		TN (log_{10}mg/l)	
		Storm Flow	Base Flow	Storm Flow	Base Flow	Storm Flow	Base Flow
Forest	***Mean***	1.90	0.51	-1.10	-1.79	-0.08	-0.59
	Std. Dev.	0.20	0.28	0.22	0.28	0.24	0.22
Agriculture	***Mean***	2.30	1.40	-0.27	-0.88	0.59	0.07
	Std. Dev.	0.31	0.13	0.30	0.13	0.26	0.13
Rural Res	***Mean***	2.26	0.53	-0.56	-1.54	0.32	-0.52
	Std. Dev.	0.51	0.24	0.28	0.38	0.30	0.39
Urban	***Mean***	2.18	1.00	-0.47	-0.97	0.26	0.20
	Std. Dev.	0.39	0.34	0.31	0.31	0.23	0.20
Commercial	***Mean***	2.16	0.78	-0.39	-0.60	0.37	0.32
	Std. Dev.	0.38	0.39	0.34	0.50	0.34	0.30
Industrial	***Mean***	1.92	0.78	-0.59	-1.11	0.25	0.14
	Std. Dev.	0.44	0.45	0.36	0.48	0.32	0.20

The MUSIC Storm flow event mean concentrations for various land uses including the delineation of urban catchments to separate out roof water for incorporation of rainwater tanks have the following parameter sets shown in Table 31.

Table 31 MUSIC Storm Flow Mean Concentrations

MUSIC Storm Flow Mean Concentrations.

* Source: Gold Coast City Council MUSIC Modelling Guidelines 2006 - Table 6.

Land Use Category	TSS (mg/L)	Source	TP (mg/L)	Source	TN (mg/L)	Source
Urban Residential						
Roads	270	1	0.5	1	1.82	2
Roofs	20	1	0.13	1	1.82	2
Other Impervious Areas	151	2	0.34	2	1.82	2
Other Pervious Areas	151	2	0.34	2	1.82	2
Industrial						
Roads	270	1	0.5	1	1.78	2
Roofs	20	1	0.13	1	1.78	2
Other Impervious Areas	270 [A]	1	0.5 [A]	1	1.78	2
Other Pervious Areas	151 [B]	2	0.34 [B]	2	1.78	2

Land Use Category	TSS (mg/L)	Source	TP (mg/L)	Source	TN (mg/L)	Source
Commercial						
Roads	270	1	0.5	1	2.34	2
Roofs	20	1	0.13	1	2.34	2
Other Impervious Areas	270 [A]	1	0.5 [A]	1	2.34	2
Other Pervious Areas	151 [B]	2	0.34 [B]	2	2.34	2

Sources:

(1) - Fletcher et.al. 2004. Stormwater Flow and Quality, and the Effectiveness of Non-Proprietary Stormwater Treatment Measures - A Review and Gap Analysis. CRC for Catchment Hydrology Report 04/8.

(2) - Brisbane City Council - Guidelines for Pollutant Export Modelling in Brisbane Version 7 - Draft.

[A] - The TSS and TP Concentrations for roads have been applied to the "other pervious areas" For industrial and commercial uses because these areas are likely to largely comprise of Car parks and other heavy use areas.

[B] - It is considered appropriate to apply consistent TSS and TP concentrations to the "other pervious areas" (i.e. landscape areas, parklands) and the BCC concentrations for residential catchments are considered The most representative of "other pervious areas".

Note: All Estimations are "Stochastically Generated.

The MUSIC storm flow $\log_{10}$ concentrations for various land uses are presented in Table 32.

Table 32 Storm Flow Log_{10} Mean Concentrations for Various Land Uses

MUSIC Storm Flow Mean Concentrations (Log_{10} Values)

- Source: Gold Coast City Council MUSIC Modelling Guidelines 2006 - Table 6.
- Note: All Estimations are "Stochastically Generated.

Land Use Category	TSS Conc. (Log_{10} mg/L)	Source	TP Conc. (Log_{10} mg/L)	Source	TN Conc. (Log_{10} mg/L)	Source
Urban Residential						
Roads	2.43	1	-0.3	1	0.26	2
Roofs	1.3	1	-0.89	1	0.26	2
Other Impervious Areas	2.18	2	-0.47	2	0.26	2
Other Pervious Areas	2.18	2	-0.47	2	0.26	2
Industrial						
Roads	2.43	1	-0.3	1	0.25	2
Roofs	1.3	1	-0.89	1	0.25	2
Other Impervious Areas	2.43 [A]	1	-0.3 [A]	1	0.25	2
Other Pervious Areas	2.18 [B]	2	-0.47 [B]	2	0.25	2
Commercial						
Roads	2.43	1	-0.3	1	0.37	2
Roofs	1.3	1	-0.89	1	0.37	2
Other Impervious Areas	2.43 [A]	1	-0.3 [A]	1	0.37	2
Other Pervious Areas	2.18 [B]	2	-0.47 [B]	2	0.37	2

Sources:
1 - Fletcher et.al. 2004. Stormwater Flow and Quality, and the Effectiveness of Non-Proprietary Stormwater Treatment Measures - A Review and Gap Analysis. CRC for Catchment Hydrology Report 04/8.
2 - Brisbane City Council - Guidelines for Pollutant Export Modelling in Brisbane Version 7 - Draft.
[A] - The TSS and TP Concentrations for roads have been applied to the "other pervious areas" For industrial and commercial uses because these areas are likely to largely comprise of Car parks and other heavy use areas.
[B] - It is considered appropriate to apply consistent TSS and TP concentrations to the "other pervious areas" (i.e. landscape areas, parklands) and the BCC concentrations for residential catchments are considered the most representative of "other pervious areas".

3.4.3.3 Rainfall Evaporation and Runoff

A simulation period of 11 years from 25 December 1980 to 25 December 1991 was used. Simulations over this period produced an annual rainfall of 1124 mm with potential evapotranspiration (PET) of 1318mm.

A six (6) minute time step was utilised in the MUSIC model to allow for appropriate definition of storm hydrograph movement through the small-scale treatment processes of the bio-retention system. Six minute rainfall data was selected from the Port Macquarie Region. Monthly evapo-transpiration data for the Port Macquarie was also selected.

3.4.4 MUSIC Model Results

The results of the MUSIC modelling are shown in Table 33.

Table 33 Music Model Results for Rainwater Tanks Scenarios

100% Adoption of Rainwater Tanks:

			% Reduction					
Wetland No.	**Wetland Size (sq.m)**	**Flow**	**Total Suspended Solids**	**Total Phosphorous**	**Total Nitrogen**	**Gross Pollutants**	**Wetland Strip Length**	**Average Wetland Strip Width**
W1A	600	8.8%	87.5%	74.5%	45.8%	100.0%	*60*	*10*
W1B	500	8.8%	87.7%	75.2%	46.1%	100.0%	*50*	*10*
W1C	2500	5.9%	93.6%	78.7%	45.5%	100.0%	*210*	*12*
W1D	1000	8.5%	87.1%	74.5%	45.3%	100.0%	*100*	*10*
W1E	3000	8.5%	87.7%	74.8%	45.4%	100.0%	*170*	*18*
W2	6000	7.7%	91.9%	78.1%	45.5%	100.0%	*N/A*	*N/A*
W3	5500	5.0%	90.9%	76.0%	45.1%	100.0%	*N/A*	*N/A*
W4	4500	7.6%	89.4%	75.4%	45.7%	100.0%	*N/A*	*N/A*

50% Adoption of Rainwater Tanks:

			% Reduction					
Wetland No.	**Wetland Size (sq.m)**	**Flow**	**Total Suspended Solids**	**Total Phosphorous**	**Total Nitrogen**	**Gross Pollutants**	**Wetland Strip Length**	**Average Wetland Strip Width**
W1A	625	9.2%	86.9%	74.3%	45.5%	100.0%	*60*	*10.5*
W1B	525	9.3%	87.4%	74.8%	45.8%	100.0%	*50*	*10.5*
W1C	2750	6.2%	93.6%	78.8%	45.3%	100.0%	*210*	*13*
W1D	1075	9.2%	86.9%	74.4%	45.4%	100.0%	*100*	*11*
W1E	3250	9.2%	87.5%	74.8%	45.5%	100.0%	*170*	*19.5*
W2	6375	8.2%	91.9%	78.2%	45.4%	100.0%	*N/A*	*N/A*
W3	6000	5.5%	91.0%	76.2%	45.3%	100.0%	*N/A*	*N/A*
W4	4750	8.0%	89.3%	75.5%	45.6%	100.0%	*N/A*	*N/A*

No Adoption of Rainwater Tanks:

			% Reduction					
Wetland No.	**Wetland Size (sq.m)**	**Flow**	**Total Suspended Solids**	**Total Phosphorous**	**Total Nitrogen**	**Gross Pollutants**	**Wetland Strip Length**	**Average Wetland Strip Width**
W1A	650	9.5%	86.2%	74.1%	45.1%	100.0%	*60*	*11*
W1B	550	9.7%	87.1%	74.3%	45.5%	100.0%	*50*	*11*
W1C	3000	6.5%	93.6%	78.9%	45.0%	100.0%	*210*	*14*
W1D	1150	9.8%	86.6%	74.3%	45.4%	100.0%	*100*	*12*
W1E	3500	9.9%	87.3%	74.8%	45.5%	100.0%	*170*	*21*
W2	6750	8.7%	91.8%	78.3%	45.3%	100.0%	*N/A*	*N/A*
W3	6500	5.9%	91.0%	76.3%	45.5%	100.0%	*N/A*	*N/A*
W4	5000	8.4%	89.2%	75.5%	45.5%	100.0%	*N/A*	*N/A*

3.4.5 Existing Constructed Wetlands (E1)

The predictions from the MUSIC model were corroborated by the measured performance of existing wetlands constructed at the site in association with existing development to the south of the site (see Table 34).

Table 34 Performance of Existing Stormwater Treatment Constructed Wetlands

		DATE	**23 May 2007**	
Location	**Lab ID**	**Location (* See Note)**	**Total N (mg/L)**	**Total P (mg/L)**
A	"East-607"	Eastern headwall inlet to eastern cell of the constructed wetlands	2.31	0.55
		Contaminant reduction (Eastern Cell) (Reduction between locations "A" to "C")	90%	98%
B	"West-608"	West headwall inlet to western cell of constructed wetlands	0.87	0.2
		Contaminant reduction (Western Cell) (Reduction between locations "B" to "C")	73.6%	95%
C	"To Creek-610"	Outlet from Prototype (constructed) wetland to south arm of Duchess Gully, upstream of the existing lake (Existing Lagoon)	0.23	0.01
D	"East outlet from man lake - 609"	Outlet (S3) from large lake (Existing Lagoon) to Duchess Gully South	0.81	0.04

(Note: * Sampling locations are shown in Figure 5 and Figure 6)

Table 34 shows that:

- The existing wetlands provide good stormwater treatment efficiencies in terms of contaminant reduction percentages.
- Nutrient concentrations in the existing lagoon receiving water body were in any case higher than the concentrations in the wetlands outlet channel at the date of sampling.

3.5 Construction Phase Stormwater Management

The construction phase of the Project Application Open Space Corridor will be carried out in accordance with a comprehensive Construction Environment Management Plan (CMP) complying with Port Macquarie Hastings Council AUS-SPEC requirements. The CMP is fully described in Section 6.

The CEMP incorporates erosion and sediment control measures to ensure that water bodies and ecosystems adjacent to the construction area are not damaged during construction activity.

The CEMP also incorporates measures to control and divert runoff from catchments external to the construction area to prevent these flows entering the construction site.

The construction plans will incorporate revegetation and regrassing of all disturbed surfaces so that storm runoff from the completed work will achieve the same water quality standard as the existing grassed site.

3.6 DGR Item Responses

RAINBOW BEACH CONCEPT PLAN (CP)

Item	Topic
CP3.2	Address and outline measures for Integrated Water Cycle Management (including stormwater) based on Water Sensitive Urban Design principles, including impacts on the surrounding environment.

Response:
The proposed development complies fully with Council's IWCM (Integrated Water Cycle Management) policy for Area 14, as amended on 5 November 2007 by incorporating the following features (Section 3.3):

- Use of reclaimed water to dwellings for outdoor use, toilet flushing and laundry cold water.
- Irrigation of district sports fields with reclaimed water sourced from Port Macquarie-Hastings Council.
- Water sensitive urban design (WSUD) in residential areas by incorporating stormwater treatment using vegetated swales, bioinfiltration areas and treatment wetlands (Section 3.4).
- The proposed development using end-of-pipe wetlands for stormwater treatment was adopted as the most advantageous overall because it is the only option providing the required residential areas along with satisfactory WSUD solutions whilst remaining economically feasible in terms of minimizing total earthworks which avoids the necessity for imported fill (Section 2.4).
- WSUD stormwater treatment options using bioinfiltration treatment are not feasible because of the increased volume of earthworks required including large volumes of imported material (Section 2.4).

PROJECT APPLICATION – OPEN SPACE CORRIDOR & CONSTRUCTED WETLAND (PA)

Item	Topic
PA5.1	Address and outline the measures for Integrated Water Cycle Management (including storm water) based on Water Sensitive Urban Design principles with reference to 'Area 14 Integrated Water Cycle Management Plan' (report to Hastings Council, 2006). Specifically describe the function of the constructed wetland within the larger IWCM plan for the site.

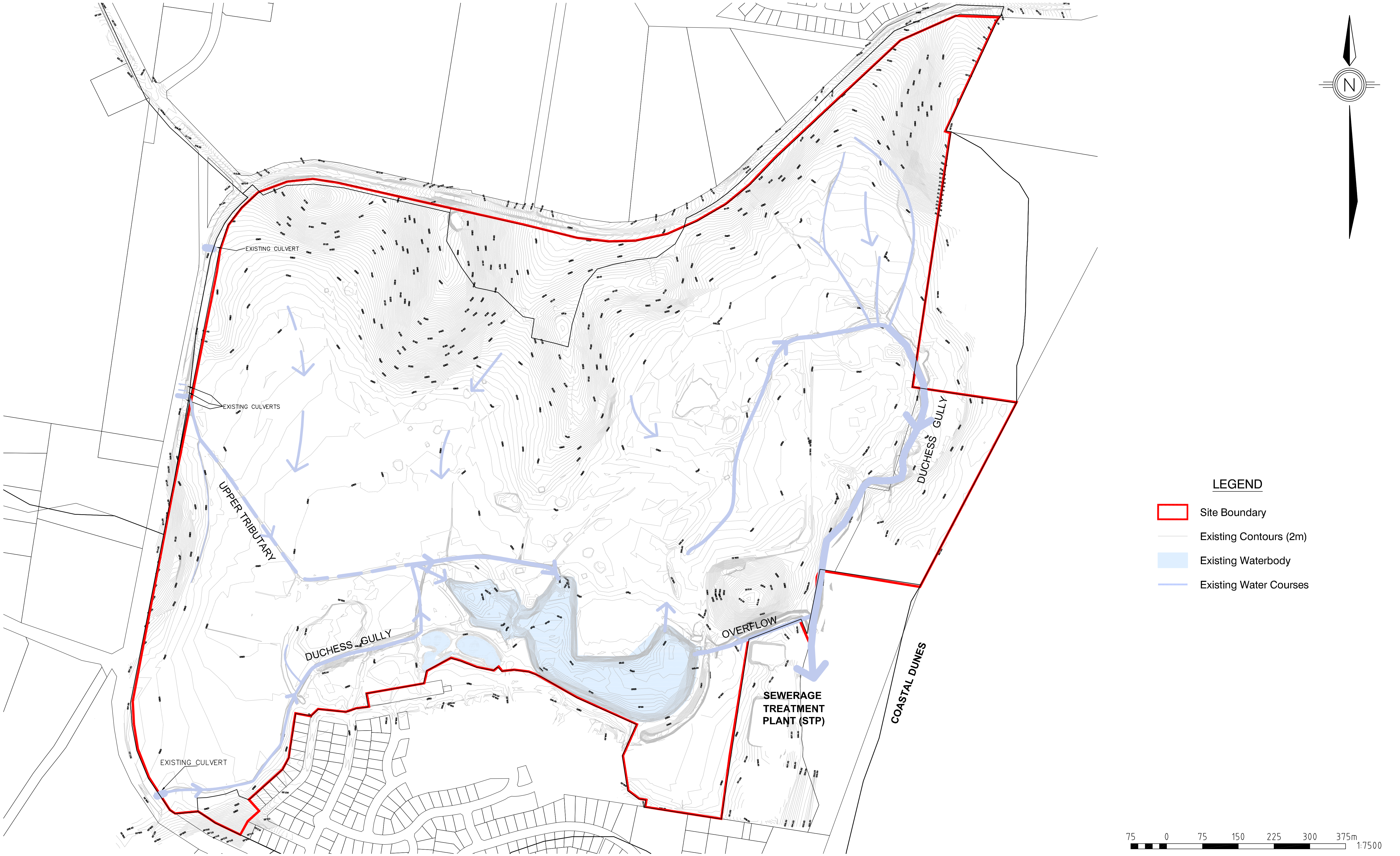
Response:
The proposed development complies fully with Council's IWCM (Integrated Water Cycle Management) policy for Area 14, as amended on 5 November 2007 by incorporating the following features (Section 3.3):

- Use of reclaimed water to dwellings for outdoor use, toilet flushing and laundry cold water.
- Irrigation of district sports fields with reclaimed water sourced from Port Macquarie-Hastings Council.
- Water sensitive urban design (WSUD) in residential areas by incorporating stormwater treatment using vegetated swales, bioinfiltration areas and treatment wetlands (Section 3.4).

The adequacy of the proposed residential area stormwater treatment systems is demonstrated using MUSIC modelling to show that these systems comply with Port Macquarie Hastings Council's adopted criteria in accordance with Council's IWCM policy of September 2006 as amended in November 2007 (Section 3.3)

The integrated functioning of the proposed constructed wetland as part of an appropriate overall freshwater ecosystem with protection and enhancement of aquatic habitat values within the existing and constructed wetlands in the Open Space Corridor is described (Section 2.12).

FIGURES SECTION 3



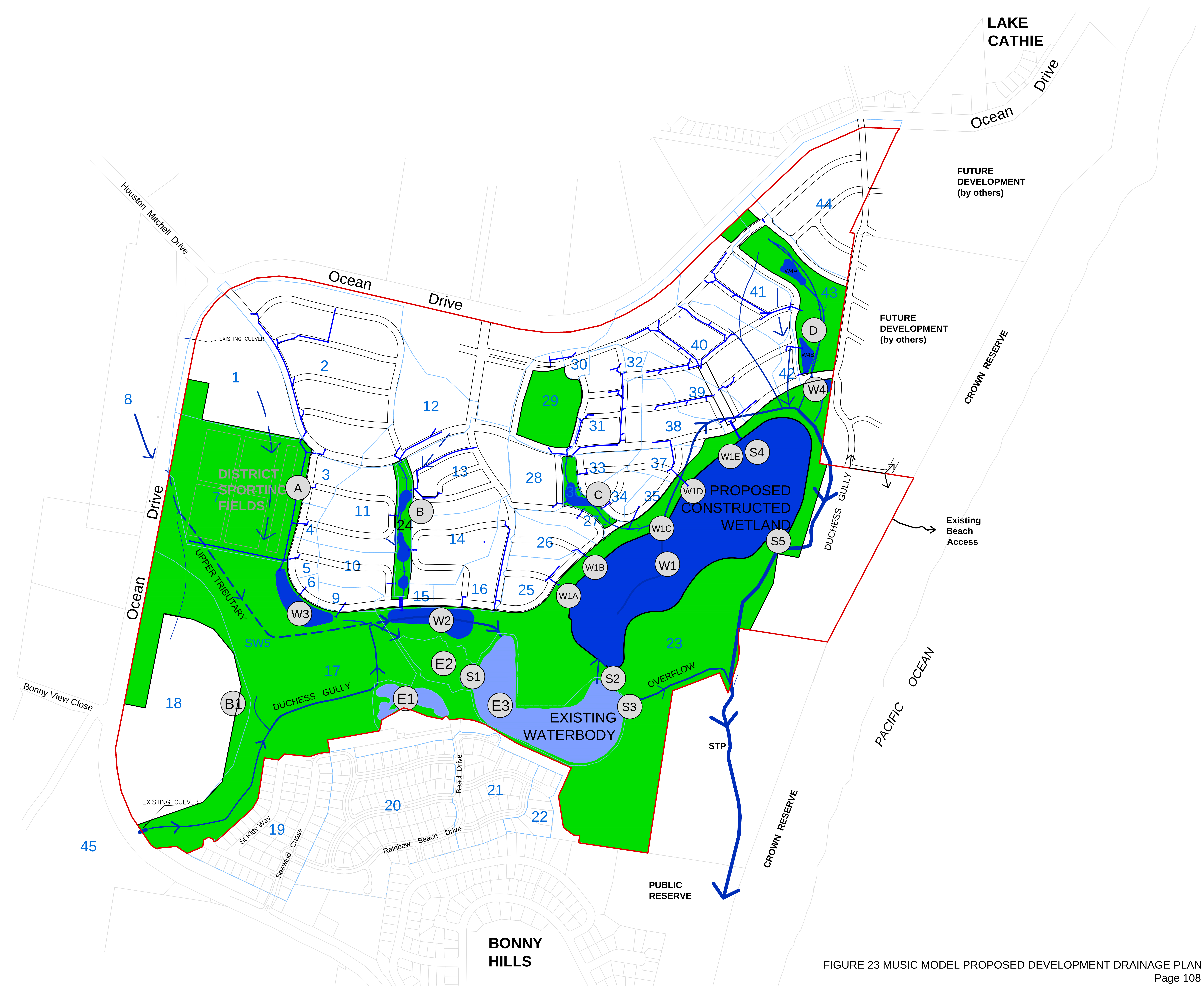
Scale 1:7500 (A3)

FIGURE 22
EXISTING DRAINAGE PLAN

PRINT DATE: 17 March, 2010 - 8:34pm

Ver 2 Date: 15 March 2010

St. Vincents Foundation Pty Ltd
CAD FILE: L:\7135-01\Acad\Water Engineering & Env DGR Assessments\Figure 22 - Existing Drainage Plan.dwg
XREF's: x-contours



DRAINAGE CONCEPT PLAN
Plan D1

Drainage Catchment Area
1-45
Major Drainage Swales
A - D
Existing Waterbodies/Wetlands
E1 - Prototype wetland for Southern Residential Development
E2 - Western Lake
E3 - Eastern Lake
Proposed New Waterbodies/Wetlands
W1 - Large Waterbody
W2 - Constructed Wetland for Central Residential area
W3 - Constructed Wetland for Western Residential area
W1A - W1D - Stormwater Treatment Wetlands Cells
Stormwater System Connections
S1 - Low level Connection between northern & southern development
S2 - Connection to proposed wetlands high flow bypass to Duchess Gully
S3 - Water level control structure & low flow outlet
S4 - Overflow spillway for Constructed Wetland
S5 - High flow outlet to Duchess Gully

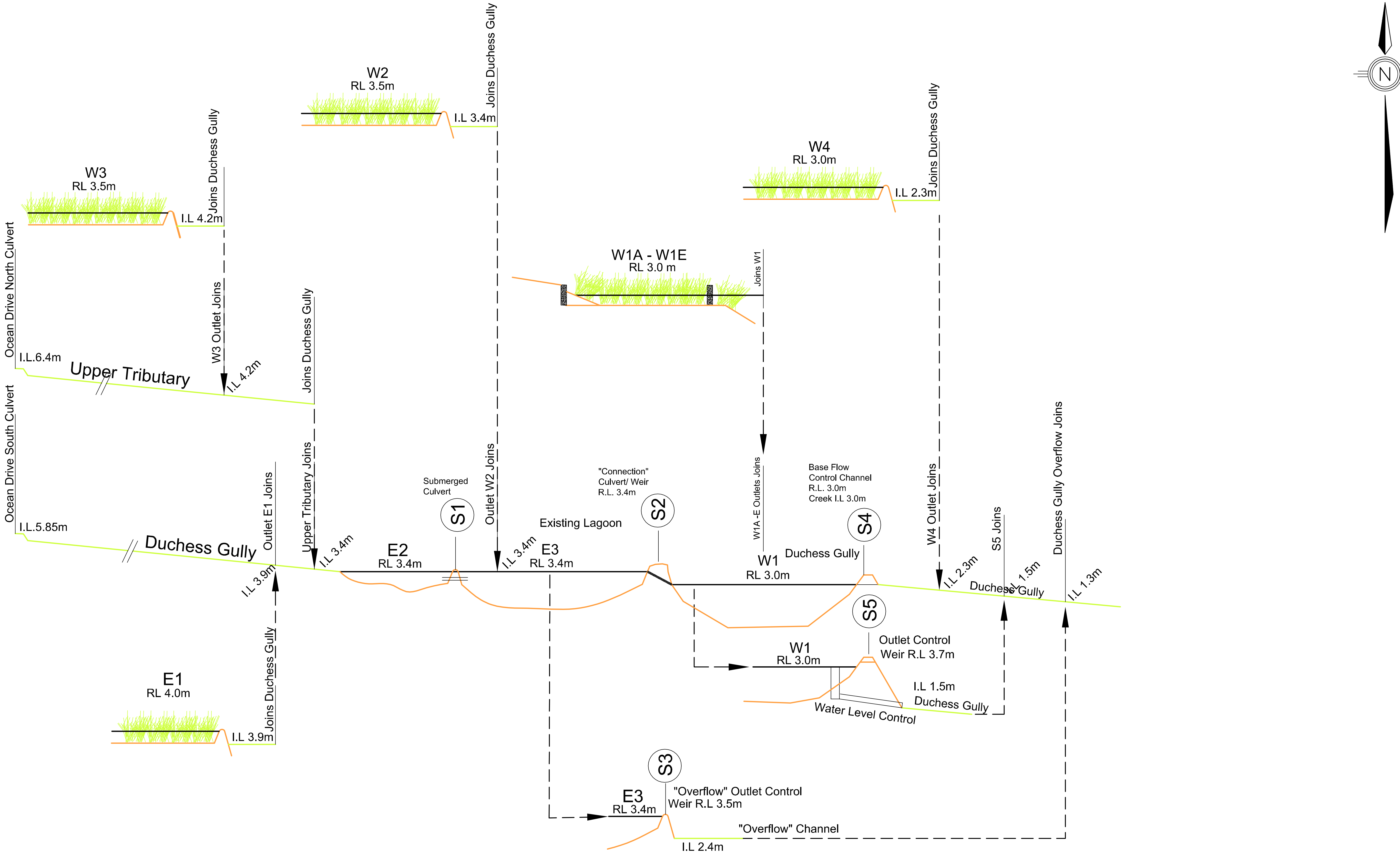
PROPOSED DRAINAGE CATCHMENT AREAS
PROPOSED INTEGRATED DRAINAGE AND CONSTRUCTED WETLAND SYSTEM
EXISTING WATER COURSES TO REMAIN

REVISIONS
A: 15.1.08
B: 18.9.09
C: 29.10.09

Rainbow Beach Estate
Concept Plan Application Set
Job. No. 4509:ND Dwn: CM
Luke and Company Pty Ltd

Scale:
1:8000@A3 1:4000@A1
The stated scale of this drawing maybe altered by copying. The scale should be verified prior to deriving measurements from this drawing
0 20 40 100 200 400(M)

FIGURE 23 MUSIC MODEL PROPOSED DEVELOPMENT DRAINAGE PLAN



PRINT DATE: 17 March, 2010 - 8:36pm

Ver 2 Date: 19 March 2010

St. Vincents Foundation Pty Ltd

CAD FILE: L:\7135-01\Acad\Water Engineering & Env DGR Assessments\Figure 24 - Drainage Hydraulic Gradients.dwg
XREF's: DrainageFlowDiagram_Sections_1.11.07

Scale NTS (A3)

FIGURE 24
DRAINAGE HYDRAULIC GRADIENTS