6. Water Management Strategy

6.1 General

Water cycle management is a holistic approach to the management of all water uses on a site. This philosophy incorporates the need to reduce the amount of water being imported from centralised storages through extensive water supply networks and the need to reduce overall water consumption on the site. A third component is the need to ensure that wastewater generation is minimised. With regard to stormwater, the philosophy of water cycle management is that water leaving the site should not lead to deterioration in water quality or an increase in water volume or peak flows.

A water management strategy has been developed for the proposed development and is illustrated in Figure 3. The water management strategy incorporates a treatment train of at-source and end-of-pipe controls.

At-source devices consist of a rainwater tank connected to roof drainage from the building and end-of-pipe devices consisting of bio-retention systems incorporated into the base of BASIN 1 and 2 and gross pollutant traps immediately upstream of each detention basin.

Landscaping provided around hardstand areas will also provide additional water quality control.

6.2 Proposed Treatment Devices

6.2.1 Potable Water Demand Management

Rainwater Tanks

A rainwater tank has been incorporated into the management strategy to simulate rainwater harvesting and reuse within the building. Captured water will be reused within the building for toilet flushing and garden/landscape watering.

As previously stated, TANK 1 has a permanent detention volume of 800m^3. It has been estimated that each employee will use 15L/day for toilet flushing. This is based on an annual demand of 95kL/year/person, 16% of which is used for toilet flushing (*Australian Runoff Quality,* Wong, 2006). The daily total water demand for toilet flushing for three shifts of 35 employees is 1.5kL/day.

Irrigation has been estimated to be an average of 21kL/day, based on a 10mm application/dry day over 3,000m^2 of landscaped area. Truck wash down has been estimated at 5 trucks/day with each wash using 1.0m^3 of water. This gives a total daily reuse of approximately 27.5kL/day.

Given the tank volume above, the tank (assuming it is empty) will fill in a rainfall event of approximately 26mm. Reuse rates as described above will empty the tank in approximately 29 days assuming no inflow during this period. The rainwater tank will be fitted with a 'trickle top-up' device to ensure water supply during extended dry periods.

6.2.2 Stormwater Quality Management

Bio-retention Structures

Bio-retention devices have been provided in the base of each detention basin. These devices comprise vegetated porous media that promotes infiltration to subsurface drains. This infiltration provides both water quality improvements and a reduction in peak discharge. Specifically, the vegetated filter media provides stormwater treatment through filtration, extended detention by promoting settling of suspended solids and biological uptake.

The vegetation that grows in the filter media enhances its function by preventing erosion of the filter medium, continuously breaking up the soil through plant growth to prevent clogging of the system and providing biofilms on plant roots that pollutants can absorb to.

It is noted that the bio-retention structures have been deliberately oversized in comparison to the stormwater quality treatment criteria (discussed in Section 6.3), sympathetic to the environmental sensitivity discussed in the HEZ WCMS.

The MUSIC model uses a decay equation and accounts for the actual geometry of the proposed system and bypass flows.. Model parameters were selected in accordance with the recommendations of the MUSIC model manual in accordance with best practice, and in the absence of available published data.

Gross Pollutant Traps

Gross pollutant traps (GPT's) are capable of removing suspended solids, and particulate-bound phosphorus and nitrogen. Some proprietary devices are also capable of removing floatable oils and grease.

A proprietary GPT has been nominated upstream of the detention basins. This device will be capable of treating the 3 month ARI flow rate and will contain a suitable bypass to cater for larger flows.

Typical documented removal efficiencies for a number of common proprietary gross pollutant traps are included in Table 6-1.

The following pollutant removal efficiencies, which are typical of those documented for common proprietary devices, have been adopted for the purposes of MUSIC modelling.

Suspended Solids	40% removal efficiency
Total Phosphorous	10% removal efficiency
Total Nitrogen	10% removal efficiency
Gross Pollutants	90% removal efficiency

Based on the following tables, it is recommended that the Humeceptor be selected as the GPT.

Table 6-1: Typical Removal Efficiencies for Common Proprietary GPT's

Pollutant Type	Proprietary Treatment Unit			
	Ecosol	**Humeceptor**	**Cleansall**	**CDS**
Gross Pollutants	Very High (typically 95% removal of pollutants greater than 3mm)	Moderate-Low (gross pollutant removal recommended upstream of device)	Very High	Very High (95%-99% removal of pollutants greater than 2.4mm)
Sediment				
Coarse (0.5-5mm)	Very High	Very High	Very High	Very High
Medium (0.06-0.5mm)	Moderate	Moderate-High	Moderate	Moderate
Fine (<0.06mm)	Low	Low-Moderate	Low	Low
Nutrients and Metals	Low (bound to sediments)	Low-Moderate (bound to captured sediments)	Low (bound to captured sediment)	Low (attached to captured sediments only)
Oil and Grease	Moderate (if baffle fitted)	Moderate-High (bound to sediments and floating oils)	Low (bound to captured sediment)	Moderate-High (if baffle and/or oil sock fitted)

Low	10% - 30%
Moderate	30% - 50%
High	50% - 80%
Very High	80% - 100%

6.2.3 Wastewater Management

Wastewater management is to be undertaken through the use of best practice techniques such as 'dual-flush' toilet systems and water reducing bathroom, kitchen and shower appliances.

6.3 Water Quality Objectives

Australian Runoff Quality (2006) outlines treatment objectives expressed as mean annual reductions of developed pollutant loads. These objectives represent achievable targets using current best practice stormwater management techniques. The treatment objectives are listed below in Table 6-2.

Table 6-2: Stormwater Treatment Objectives for New South Wales

Pollutant	Stormwater Treatment Objective
Suspended Solids	80% retention of the average annual load
Total Phosphorous	45% retention of the average annual load
Total Nitrogen	45% retention of the average annual load
Litter	Retention of litter greater than 50mm for flows up to the 3 month ARI peak flow
Coarse Sediment	Retention of sediment courser than 0.125mm for flows up to the 3 month ARI peak flow
Oil and Grease	No visible oils for flows up to the 3 month ARI peak flow

Source: Australian Runoff Quality, A Guide to Water Sensitive Urban Design, 2006

The proposed treatment train has been modelled using MUSIC (the Model for Urban Stormwater Improvement Conceptualisation) and its performance assessed against these qualitative stormwater management objectives.

6.4 MUSIC Modelling

6.4.1 Rainfall and Evapotranspiration

Rainfall

Six minute rainfall data for Pokolbin (Somerset) was obtained from the BOM for input into the model. Pokolbin (Somerset) is approximately 5 kilometres from the site, and has a data length of 44 years and data completeness of 74%.

Significant gaps existed in the rainfall data prior to 1965 and following 1981. The MUSIC model was therefore run for 15.5 years of rainfall data in the period July 1965 to January 1981 with a six minute time step. The mean annual rainfall for this period was 735mm.

Evapotranspiration

Monthly average areal potential evapotranspiration values for the area were obtained from the Climatic Atlas of Australia – Evapotranspiration (Wang et al., 2001). Evapotranspiration values are given in Table 6-3. The total annual evapotranspiration was 1342mm.

Table 6-3: Monthly Average Areal Potential Evapotranspiration Values

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Evapo-transpiration (mm/month)	185	135	135	96	68	50	48	63	95	140	156	171

6.4.2 MUSIC Model Parameters

Landuse

The following land types were defined within the model:

- **Bushland** – This land type represents the existing usage across the site and was used to determine baseline pollutant loads.
- **Hardstand Area** – This land type includes all hardstand and pervious area that has been disturbed as a result of site works. This area excludes roof areas.
- **Roof** – This land type includes roof areas for the proposed building within the development. These areas were distinguished from other 'urban development' as roof areas would have significantly lower (if any) pollutant export rates.

Hydrology

MUSIC hydrology parameters for each land use are summarised in Table 6-4. The parameters are based on the default parameters for Sydney given in the MUSIC model manual (2003).

Table 6-4: MUSIC Hydrology Parameters for Each Landuse

Parameter	Bushland	Hardstand Area	Roof
Impervious Area	0%	Variable	100%
Rainfall Threshold (mm)	1	1	n/a
Pervious Area Properties:			
Soil Storage Capacity (mm)	150	120	0
Initial Storage (%)	30	30	0
Field Capacity (mm)	80	80	0
Infiltration Capacity Coefficient, a	200	200	0
Infiltration Capacity Exponent, b	1	1	0
Groundwater Properties:			
Initial groundwater Depth (mm)	10	10	0
Daily Recharge Rate (%)	25	25	0
Daily Baseflow Rate (%)	5	5	0
Daily Deep Seepage Rate (%)	5	5	0

Pollutant Export

The MUSIC model requires the user to input pollutant parameters for baseflow and stormflow. Baseflow is derived from the groundwater store, which is recharged from the pervious soil store. Stormflow is generally generated from the impervious area, and under some conditions the pervious area as well.

Pollutant concentrations were derived from parameters outlined in *Urban Stormwater Quality: A Statistical Overview* (Duncan, February 1999) and default parameters for Sydney given in the MUSIC model manual (2003).

The parameters for ‘roof’ areas were set so that total phosphorous and total nitrogen were negligible in baseflow and stormflow, and total suspended solids were negligible in baseflow and minor in stormflow.

A summary of event mean concentrations adopted as water quality parameters are provided in Table 6-5.

Table 6-5: Water Quality Parameters

Flow	Land Type	Mean Concentration (mg/L)		
		Total Suspended Solids	Total Phosphorous	Total Nitrogen
Baseflow	Bushland	7.94	0.03	0.72
	Hardstand Area	12.59	0.15	2.09
	Roof	1×10^{-10}	1×10^{-10}	1×10^{-10}
Stormflow	Bushland	79.43	0.08	0.84
	Hardstand Area	158.49	0.35	2.63
	Roof	0.1	1×10^{-10}	1×10^{-10}

The model was run allowing for the stochastic generation of pollutant concentrations for suspended solids, nitrogen and phosphorus using the mean concentrations provided in Table 6-5, with a log-normal statistical distribution. This results in pollutant load estimates that are not reproducible between model runs but is considered to produce a more realistic interpretation of pollutant generation.

6.4.3 Model Calibration

Due to the absence of site specific runoff and pollutant data, accurate calibration of the MUSIC model could not be undertaken. Instead, the predicted volumetric runoff coefficients and export rates have been compared against typical volumetric runoff coefficients and export rates for similar land uses.

Hydrology

A comparison of model predicted and typical volumetric runoff coefficients is summarised in Table 6-6 for each land use. Predicted volumetric runoff coefficients were calculated using the predicted runoff volume and the average annual rainfall reported in the model for the analysed rainfall period.

Table 6-6: Comparison of Typical and Predicted Volumetric Runoff Coefficients

Landuse	Description	Volumetric Runoff Coefficient	
		Typical	MUSIC Predicted
Hardstand Area	Catchment modelled with 0% – 96% impervious surface	0.62[1]	0.11 – 0.85
Roof	Catchment modelled with 100% impervious surface[2]	1.00[2]	1.00

[1] From NSW Department of Environment and Conservation DRAFT Managing Urban Stormwater: Strategic Framework (April, 1997) for fully developed urban catchment with 70% impervious surface.
[2] Assumed.

Volumetric runoff coefficients predicted by the MUSIC model are generally within the range of volumetric runoff coefficients documented in *Managing Urban Stormwater: Strategy Framework* (DEC, 1997).

Pollutant Export

Predicted export rates for a 1 hectare catchment of each landuse are summarised in Table 6-7 and are based on the event mean concentrations provided in Table 6-5. Typical nutrient export rates were sourced from the *Constructed Wetlands Manual* (Department of Infrastructure, Planning and Natural Resources, 1998) and are also included in Table 6-7. It should be noted that the *Constructed Wetlands Manual* does not include typical export rates of total suspended solids or gross pollutants from urban catchments, nor does it include typical pollutant export rates for roof areas.

Table 6-7: Predicted Pollutant Export Rates for 1 Hectare Catchment

Landuse		Pollutant Export Rate (kg/ha/yr)			
		Total Nitrogen	Total Suspended Solids	Total Phosphorous	Gross Pollutants
Bushland	MUSIC Predicted	0.1	7.8	0.09	0
	Typical (range)^	1.1 (0.9 – 1.5)	-	0.06 (0.03 – 0.1)	-
Hardstand Area	MUSIC Predicted	18 – 22	1250 – 1470	2.6 – 3.0	196 – 218
	Typical (range)^	6.6 (3.2 – 22.4)	-	1.0 (0.4 – 3.6)	-
Roof	MUSIC Predicted	0	16	0	0

^Typical export rates for bushland/grassland and urban development/roads have been sourced from the Constructed Wetlands Manual (Department of Infrastructure, Planning and Natural Resources, 1998).

Predicted export rates from the MUSIC model are generally within the range of export rates recommended in the Constructed Wetlands Manual for urban catchments.

6.4.4 Existing Catchment Model

The predicted average annual pollutant loads leaving the study area under existing conditions are provided in Table 6-8. Pollutant load estimates are provided for suspended solids, total phosphorous, total nitrogen and gross pollutants. The pollutant load estimates provided in Table 6-8 form the baseline for assessing the performance of the proposed stormwater management strategy.

Table 6-8: Predicted Average Annual Pollutant Loads Leaving the Study Area for Existing Conditions

Runoff Volume (ML/yr)	Average Annual Pollutant Load (kg/yr)			
	Total Suspended Solids	Total Phosphorous	Total Nitrogen	Gross Pollutants
4.16	367	0.4	4	0

6.4.5 Mitigated Catchment Model

A summary of average annual runoff volume and pollutant loads from the proposed development following implementation of the proposed treatment train is provided in Table 6-9. Also provided is the percentage reduction in the developed pollutant load resulting from stormwater treatment train.

Table 6-9: Mitigated Pollutant Loads and Treatment Performance

Parameter	Developed Pollutant Load	Mitigated Pollutant Load	Percentage Difference
Flow (ML/yr)	35.6	9.7	-73%
Total Suspended Solids (kg/yr)	2920	43.8	-99%
Total Phosphorous (kg/yr)	5.9	0.5	-91%
Total Nitrogen (kg/yr)	40.2	7.1	-82%
Gross Pollutants (kg/yr)	1090	0	-100%

As can be seen from Table 6-9, the proposed treatment train for the development area achieves pollutant retention rates generally in excess of the adopted objectives documented in Table 6-2 (ARQ, 2006). Additionally, the model-predicted treatment efficiencies are generally higher than the treatment criteria given that the bio-retention structures were deliberately oversized.

It is noted that there is typically some uncertainty in model-predicted treatment efficiency, particularly for nutrients such as Nitrogen and Phosphorus. This is not unique to this development scenario, but is a result of the nature of biological treatment systems and inherent variability of rainfall and related pollutographs. However, it is considered unlikely that model-predicted treatment efficiency and actual treatment efficiency would vary to an extent such that the water quality criteria (80%SS, 45% N and P) would not be met. Accordingly, it is considered unreasonable to propose contingency measures for the proposed industrial development.

A summary of bio-retention structure characteristics incorporated into the base of each dry detention basin is provided in Table 6-10.

Table 6-10: Bio-retention Structure Characteristics

BASIN	Surface Storage Properties			Infiltration Dimensions		Infiltration Media Properties		
	Area (m^2)	Extended Detention Depth (m)	Seepage Loss Rate (mm/hr)	Area (m^2)	Media Depth (m)	Material Type	Particle Diameter (mm)	Saturated Hydraulic Conductivity (mm/hr)
1	430	0.5	36	300	0.6	Sandy Loam	0.2	180
2	1560	0.65	36	1260	0.6	Sandy Loam	0.2	180

7. Conclusions and Recommendations

The proposed drainage and stormwater management strategy for the site will comprise:

- Stormwater harvesting using a rainwater tank.
- Construction of two dry detention basins incorporating bio-retention media in the base of each and gross pollutant trap upstream of the inlet.
- A local drainage pipe conveyance system to be designed as part of construction certificate detailed design process.
- The construction of a 900mm diameter stormwater pipe underneath the BASIN 1 access road.

Numerical modelling using XP-SWMM has demonstrated that the proposed detention structures will attenuate developed flows for the 1, 10 and 100 year ARI events to below existing conditions.

Storage across the site is to comprise:

- Two dry detention basins with storage totalling 1750m^3 (BASIN 1 and 2).
- One 800m^3 rainwater tank (TANK 1) with an additional 400m^3 of surcharge storage.

Water quality modelling has indicated that the proposed treatment train of a rainwater tank, a gross pollutant trap and bio-retention structures will achieve pollutant reduction rates in excess of those recommended in Australian Runoff Quality. The GPT should be maintained in accordance with the manufacturer's recommendations and the basins should be inspected regularly and maintained appropriately to ensure optimum performance.

Accordingly, it is assessed that the objectives of the Hunter Economic Zone Water Cycle Management Strategy Development Study are satisfied for the proposed development.

8. References

- Parsons Brinckerhoff, Hunter Economic Zone Water Cycle Management Strategy Development Study, September 2004.
- Department of Infrastructure, Planning and Natural Resources, Constructed Wetlands Manual, 1998.
- Duncan, H.P., Urban Stormwater Quality: A Statistical Overview, CRC for Catchment Hydrology, February 1999.
- Hunter Water Corporation, Hunter Water Corporation Water and Sewer Design Manual, December 2005.
- MUSIC Development Team, CRC for Catchment Hydrology, MUSIC User Guide, May 2005
- NSW Environmental Protection Authority, DRAFT Managing Urban Stormwater: Strategic Framework, April, 1997.
- Pilgrim, D.H., Australian Rainfall and Runoff: A Guide to Flood Estimation, Volume 1 and Volume 2, Institution of Engineers Australia, 1987.
- Wang, Q.J., McConachy, F.L.N., Chiew, F.H.S., James, R., de Hoedt, G.C., and Wright, W.J., Climatic Atlas of Australia: Maps of Evapotranspiration, CRC for Catchment Hydrology, 2001.
- Wong, THF, Australian Runoff Quality: A Guide to Water Sensitive Urban Design, Engineers Australia, 2006

Figures

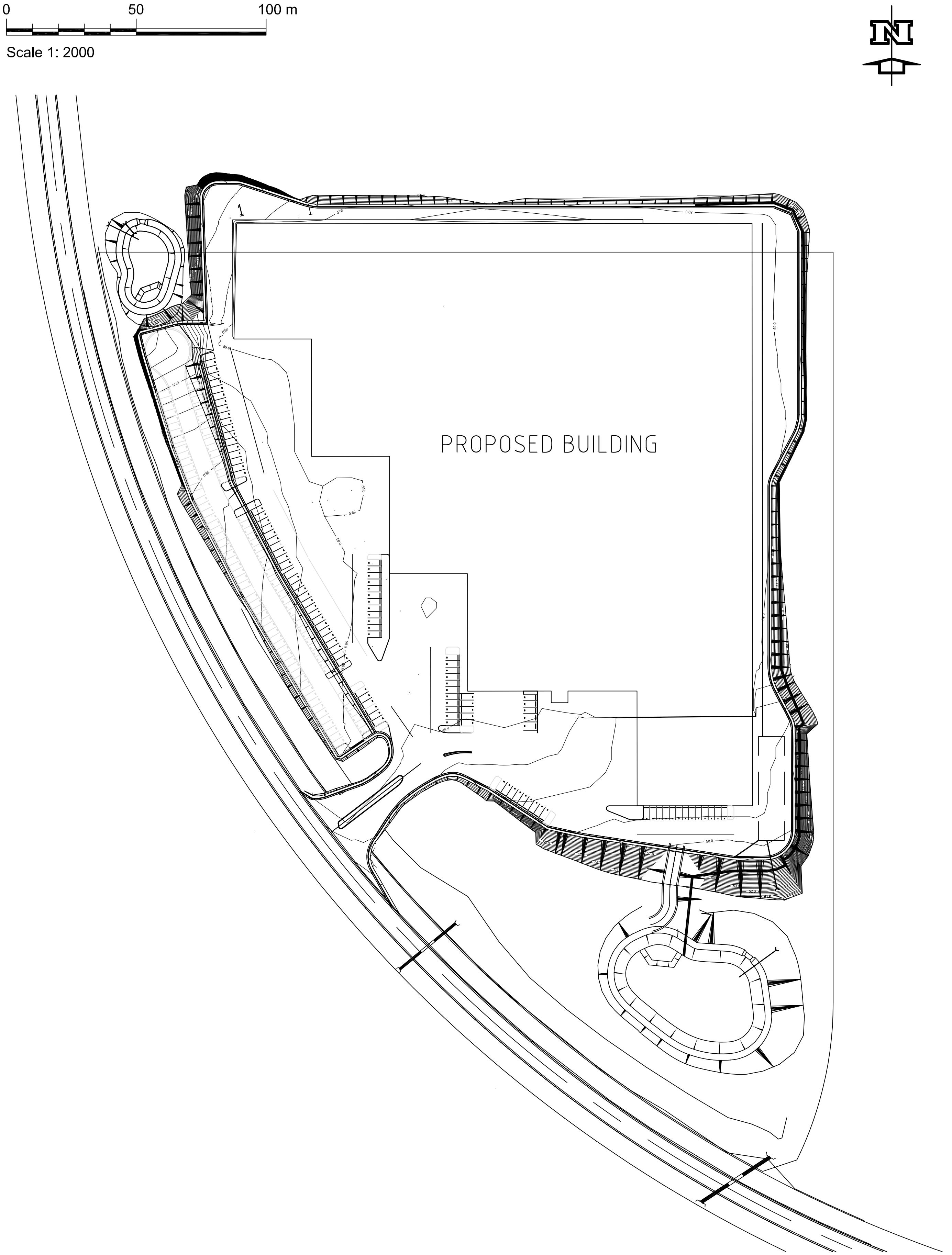
Client: WIPS Management
Project: Drainage & Stormwater Management Strategy
Location: Hunter Economic Zone, Kurri Kurri

Locality Plan
Figure 1

REPORT: 2122647A\PR_0330
CAD REFERENCE: J:\2122647a_HEZ_WALLTECH\09_Drafting\003\ACAD\DRAWINGS\2122647A-003-CIV-F001.dwg

Client: WIPS Management
Project: Drainage & Stormwater Management Strategy
Location: Hunter Economic Zone, Kurri Kurri

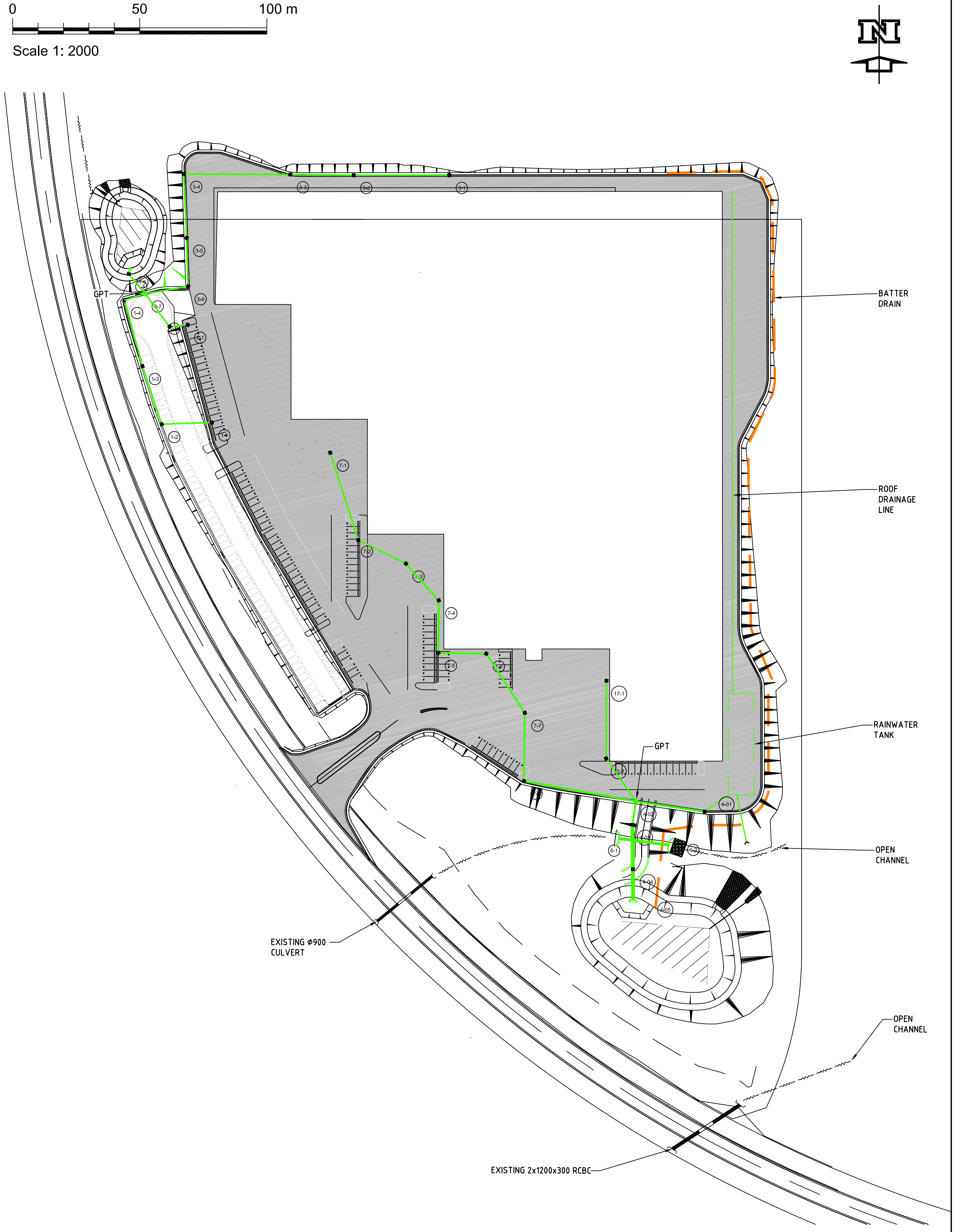
PARSONS BRINCKERHOFF



Proposed Development Layout
Figure 2

Client: WIPS Management
Project: Drainage & Stormwater Management Strategy
Location: Hunter Economic Zone, Kurri Kurri

PARSONS BRINCKERHOFF



Stormwater Management Plan

Figure 3

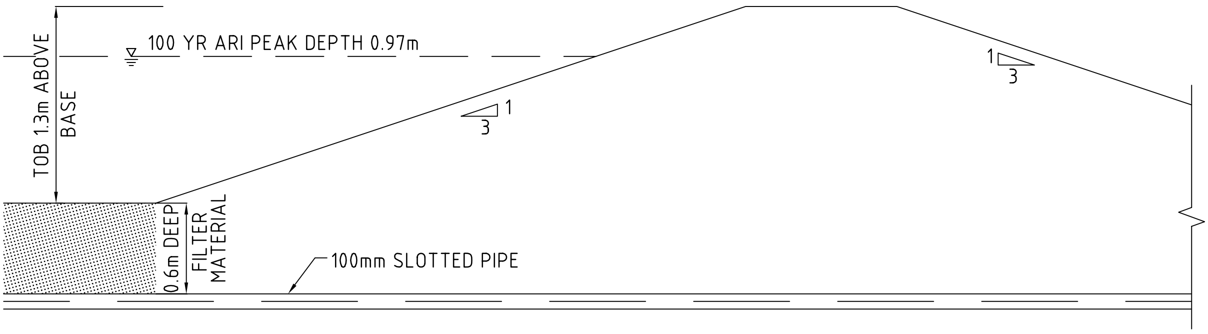
REPORT: 2122647A\PR_0330
CAD REFERENCE: J:\2122647a_HEZ_WALLTECH\09_Drafting\003\ACAD\DRAWINGS\2122647A-003-CIV-F003.dwg

Client: WIPS Management
Project: Drainage & Stormwater Management Strategy
Location: Hunter Economic Zone, Kurri Kurri

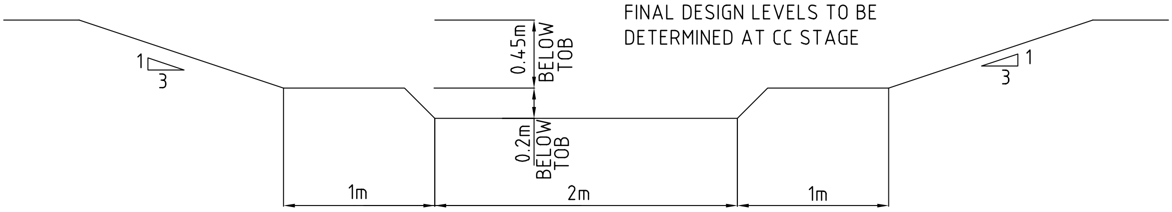
0 25 50 m
Scale 1: 1000

0.5 0 0.5 1 1.5 2 2.5 m
Scale 1: 50

PLAN
SCALE 1:1000



POND 1 TYPICAL SECTION
SCALE 1:50



OUTLET WEIR TYPICAL SECTION
SCALE 1:50

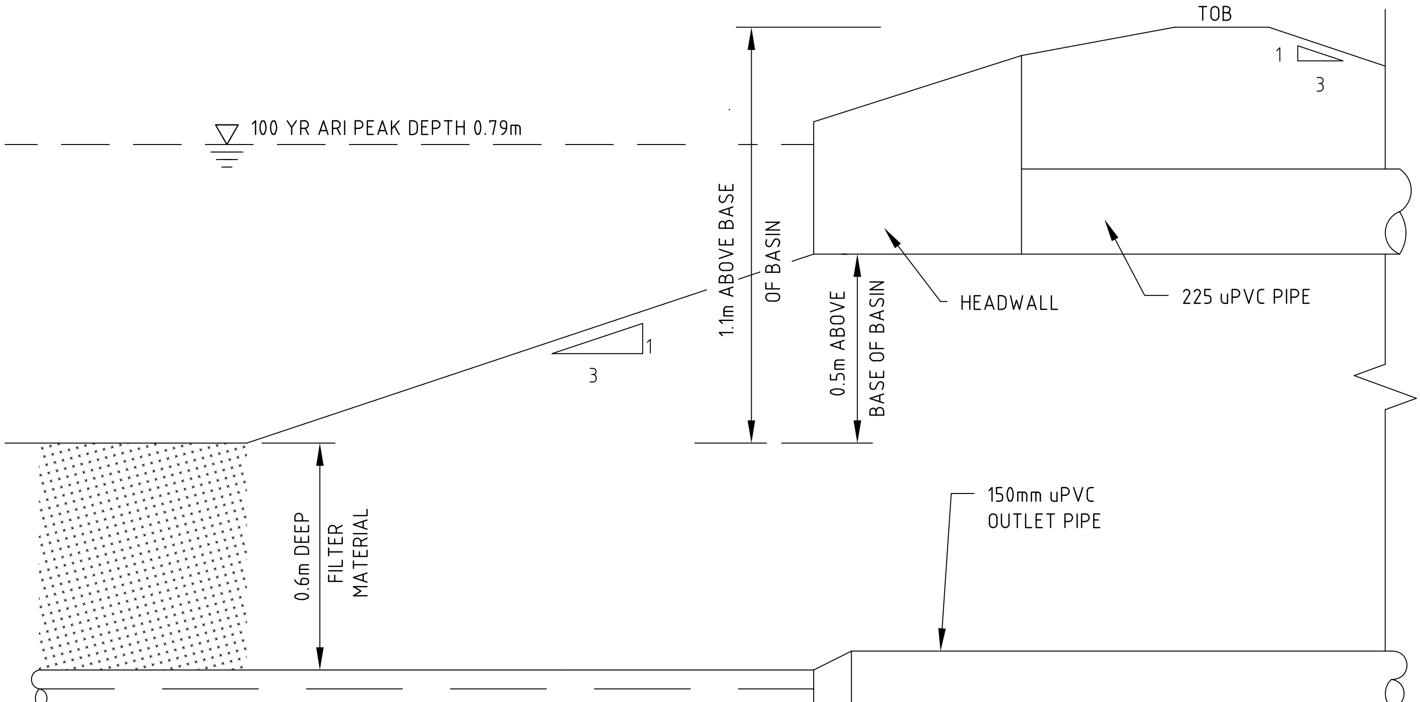
Conceptual Basin 1 Layout
Figure 4

REPORT: 2122647A\PR_0330
CAD REFERENCE: J:\2122647a_HEZ_WALLTECH\09_Drafting\003\ACAD\DRAWINGS\2122647A-003-CIV-F004.dwg

Client: WIPS Management
Project: Drainage & Stormwater Management Strategy
Location: Hunter Economic Zone, Kurri Kurri

PARSONS BRINCKERHOFF

PLAN
SCALE 1:500



POND 2 OUTLET TYPICAL SECTION
SCALE 1:20

Conceptual Basin 2 Layout
Figure 5