Marsden Park Industrial Precinct

Post Exhibition
Water Cycle Management Strategy Report
Including
Consideration of Climate Change Impacts

Prepared for:

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POST EXHIBITION WATER CYCLE MANAGEMENT STRATEGY INCLUDING CONSIDERATION OF CLIMATE CHANGE IMPACTS

- DOCUMENT CONTROL SHEET -

Issue No.	Amendment	Prepared By & Date	Checked By and Date	Approved By and Date
A	First Draft	GH, JC, ER (May 10)	PM (May 10)	PM (May 10)
B	Second Draft (internal issue only)	GH, JC, ER (May 10)	PM (May 10)	PM (May 10)
C	Third Draft	GH (May 10)	PM (May 10)	PM (May 10)
D	Final Draft	GH (May 10)	PM (May 10)	PM (May 10)
E	Amended Final Draft	GH (June 10)	PM (June 10)	PM (June 10)
F	Replaced Prelim Eng Concept Cover Sheet	GH (July 10)	PM (July 10)	PM (July 10)
G	Respond to additional BCC Comments	GH (October 10)		

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1 INTRODUCTION

This report details the procedures used and presents the results of investigations undertaken in developing a Water Cycle Management Strategy that incorporates an assessment of Climate Change Impacts on the hydrology of the proposed development of an Industrial Precinct adjacent to Richmond Road Marsden Park. It provides a refinement of the hydrological information, contained in *"Water Cycle Management Assessment (July 2009)"* prepared by Gutteridge Haskins and Davey (GHD) (Ref.1) to inform the exhibition of the Draft Indicative Layout Plan (ILP) in February 2010, and is intended to support the post-exhibition re-zoning process for the Marsden Park Industrial Precinct (MPIP).

The objective of this investigation is to prepare a Water Cycle Management Strategy for the site which takes into account the comments submitted on the previously exhibited ILP. This report details the components of an integrated approach to managing peak discharges and stormwater quality, generated by the proposed development. It also provides an assessment of the likely impact that predicted increases in rainfall intensities, as a consequence of Climate Change, may have on these hydrological investigations.

Reticulated sewerage and potable water systems will be provided for the site and there is the opportunity for recycled water to be supplied at some time in the future. This report only addresses the stormwater aspects of the water cycle, however the harvesting and reuse of roof water is included within the water quality assessment. Rainwater storage tanks used for this purpose will be provided with an alternative to using potable water for 'top up', which will be activated once a recycled water supply system becomes operational in the area, making the connection to the potable water supply redundant.

This strategy report details the outcomes from each of the following specific tasks:

- Hydrologic analysis which determines the peak 5 and 100-year Average Recurrence Intervals (ARI) pre development and post development flows;
- Consideration of the impact that increased rainfall intensities, due to altered rainfall patterns in anticipation of Climate Change, will have on the proposed stormwater strategy
- Determination of the minimum detention storage volumes required to restrict post development peak flows to pre development levels;
- A water quality analysis to determine a cost–effective stormwater treatment strategy that will comply with the Department of Planning's (DoP) and Blacktown City Council's (BCC) stormwater quality discharge criteria;
- A Stream Erosion Index (SEI) assessment was undertaken by GHD for the Marsden Park Industrial Precinct (Ref.1) and returned an SEI value of 4, which is within the acceptable range adopted by the DoP for Growth Centre Release Areas;
- Preparation of concept designs for the Detention Basins, Trunk Drainage Channels and Bio-filtration water quality control measures;
- Extraction of a Bill of Quantities and construction costs for the major stormwater management and conveyance components of the Strategy.

The proposed Water Cycle Management Strategy expands and refines the Water Cycle Management Assessment (Ref.1) prepared by GHD (July 2009), which provided background information for the exhibition of the Draft ILP.

2 PREVIOUS REPORTS / STUDIES

BCC has constructed an XP-RAFTS hydrological model for the Bells Creek catchment. This model has been adopted as the basis for the hydrological assessments in the proposed Water Cycle Management and the analysis of the impact that the MPIP would have on peak flows in Bells Creek.

GHD prepared *Water Cycle Management Assessment: Flooding Stormwater and Water Sensitive Urban Design (July 2009)*, (Ref.1) which provided the background hydrological and water quality information necessary to inform the exhibition process for the Indicative Layout Plan in early 2010.

The background parameters and coefficients used in the preparation of this Water Cycle Management Strategy have been based on the BCC *Draft Integrated Water Cycle Management Development Control Plan (June 2009)* (Ref.6) and discussion with BCC staff.

In the absence of specific guidelines from BCC and the Department of Environment Climate Change and Water (DECCW), the primary reference sources adopted for our assessment of the hydrological impacts associated with Climate Change, were:

1. *NSW Climate Change Action Plan: Summary of Climate Change Impacts Sydney Region, October 2008*, (Ref.2) prepared by the NSW Department of Environment and Climate Change;
2. *Practical Consideration of Climate Change – Floodplain Risk Management Guideline, October 2007*, (Ref.3) prepared by the NSW Department of Environment and Climate Change;
3. *Climate Change in the Hawkesbury-Nepean Catchment, 2007*, (Ref.4) prepared by the Commonwealth Scientific and Industrial Research Organisation, were adopted as the primary reference documents for this assessment; and
4. *Climate Change in Australia – Observed Changes and Projections, October 2007*, (Ref.5) prepared by Australian Government Bureau of Meteorology.

A sensitivity analysis of the impact that increased peak flows (resulting from the Climate Change assessment) would have on freeboard allowances was undertaken in accordance with *Draft Flood Risk Management Guide: Incorporating sea level rise benchmarks in flood risk assessments, October 2009* Department of Environment, Climate Change and Water as well as *Blacktown City Council Engineering Guide for Development – 2005.* (Ref.13)

3 THE EXISTING ENVIRONMENT

3.1 Site Description

The site is gently undulating and located on the western side of Bells Creek between South Street and the proposed Castlereagh Freeway, which separates it from the suburbs of Hassall Grove and Bidwill. It has an area of approximately 500 hectares which is made up of open grassland, a quarry, a caravan park and a mosque to the west of Richmond Road and a paintball centre, nursery, mini golf course and boarding kennels to the east of Richmond Road (see Plate 1).

Apart from some isolated remnant stands of trees, in the northwest and southeast of the site and along Bells Creek and its tributaries, the majority of the vegetation on the site is grassland. Consequently the vegetation cover was represented, for the purposes of the hydrologic assessments, by runoff coefficients ranging from 0.05 for grasslands through to 0.08 for a copse of trees.

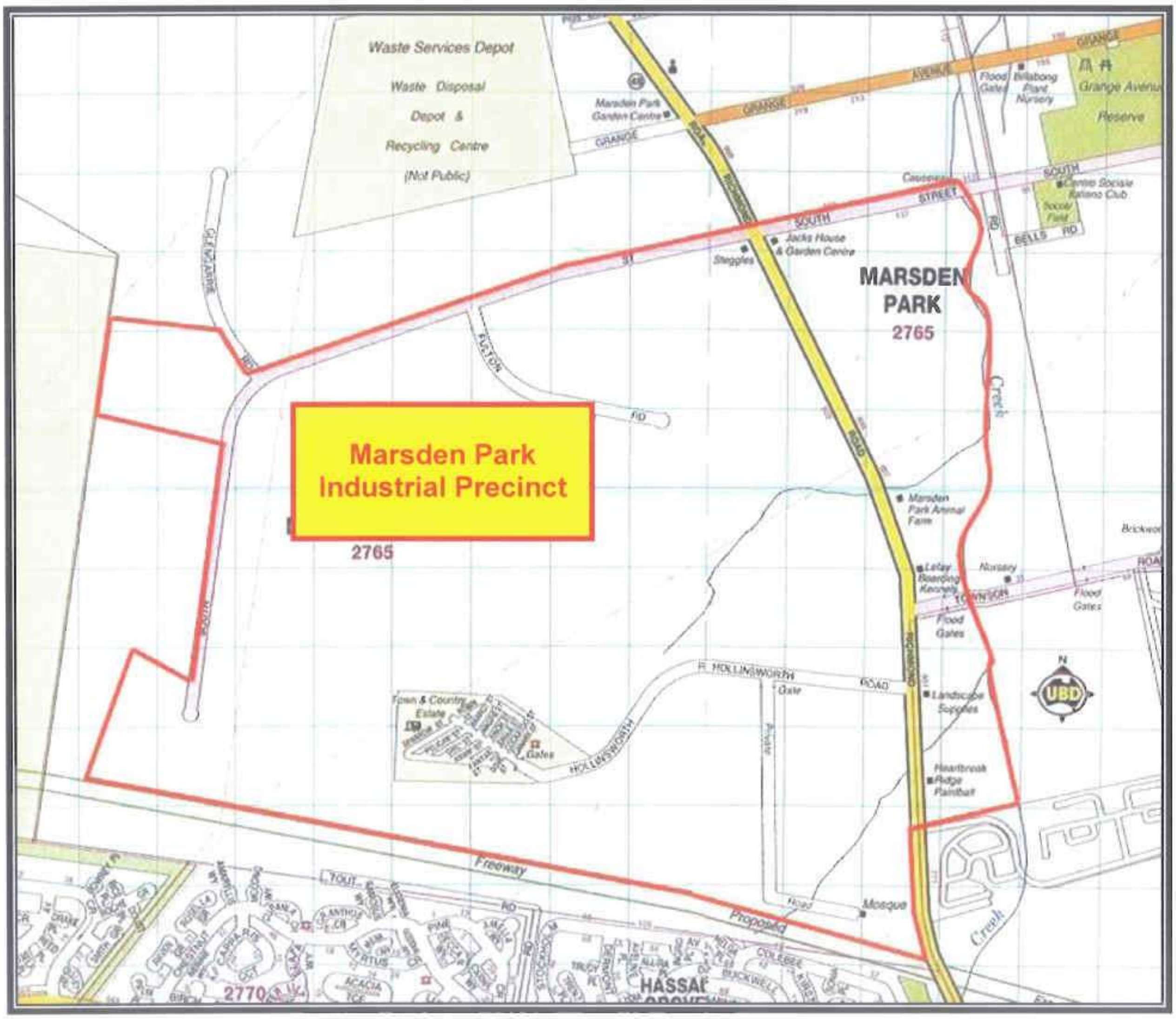

Plate 1: Location of the Marsden Park Industrial Precinct

3.2 Existing Drainage Configuration

Farm Dams with interconnecting depressions have been strategically located along the natural overland flowpaths through the site. Although the landform has been significantly modified for agricultural and quarrying pursuits: the western section of the site still generally drains in a north westerly direction into Little Creek within Shanes Park; the centre of the site drains to the north into an unnamed watercourse through Marsden Park; and the eastern areas drain through culverts under Richmond Road into tributaries of Bells Creek (see Plate 2 and Figure 2 Catchment Layout Plan Pre-developed Conditions).

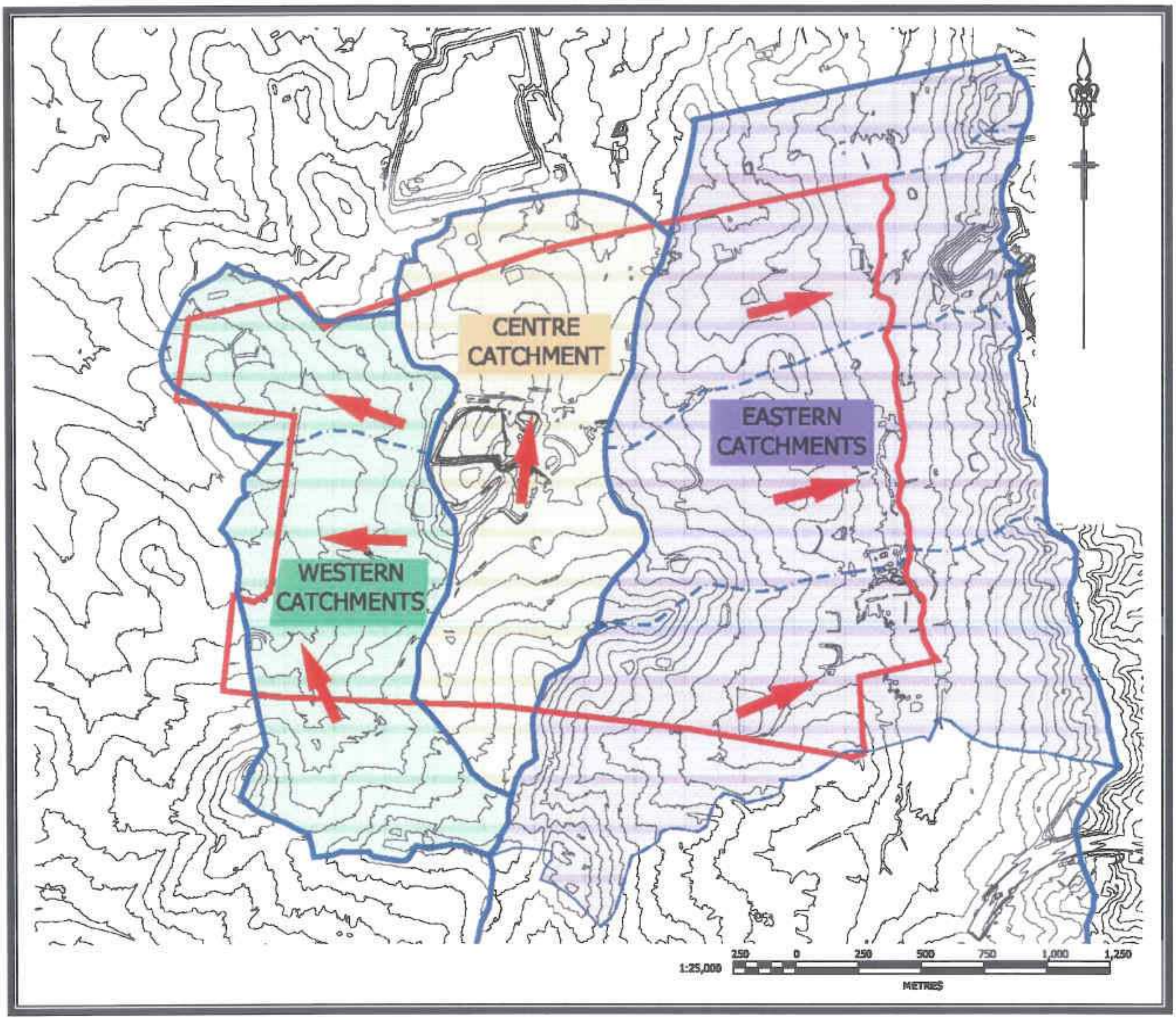

Plate 2: Existing Site Drainage Patterns

3.3 Mitigation Description

The Draft Indicative Layout Plan (ILP) at Plate 3 provides an indication of the type and extent of the various land uses proposed for the Marsden Park Industrial Precinct. This plan formed the basis for determining the impervious percentages for each sub-catchment within the developed hydrological model.

To represent the change in runoff characteristics once the site is developed the following fractions were used to denote the impervious portions of the catchments:

- Existing (pre-development) 0.05;
- Future (post-development) 0.85 for residential and 0.9 for all other urban land uses, with 0.05 in the riparian corridors and 0.8 in areas nominated as Detention Basin.

Once developed the runoff from the site will impact on the hydrologic response of the local sub-catchments as well as the quality of the stormwater leaving the site. The following sections of this report describe the strategies to be employed to mitigate these impacts.

- Chapter 6 "Hydrologic Analysis" sets out in detail the estimated differences between the pre-development and post-development peak flows and the strategy to be employed to mitigate the post-development peak flows.
- Chapter 8 "Water Quality Analysis" sets out the stormwater treatment strategy to be employed at a lot level (industrial and commercial allotments only) and at a regional level (runoff from the public domain infrastructure in combination with the already treated runoff from the industrial/commercial catchments). Additional treatment is included in the regional treatment strategy to compensate for the lack of treatment in the residential catchments. This chapter also includes the calculations for the stormwater harvesting and reuse components of the strategy.
- Chapter 9 "Trunk Drainage Channel Analysis" describes the design of the Trunk Drainage Channel and road crossings which are intended to control runoff through the site from major storm events and prevent flooding of allotments up to the 100-year Average Recurrence Interval (ARI) storm events.

The goal of this Water Cycle Management Strategy is to mitigate the impacts of the increased peak discharges and reduced water quality in stormwater runoff generated by the development on downstream watercourses. Consequently the points of comparison, for the pre and post-development impacts, have been determined as the point where the discharge outlets meet with the existing watercourses, i.e. immediately downstream of each of the six (6) sub-catchments.

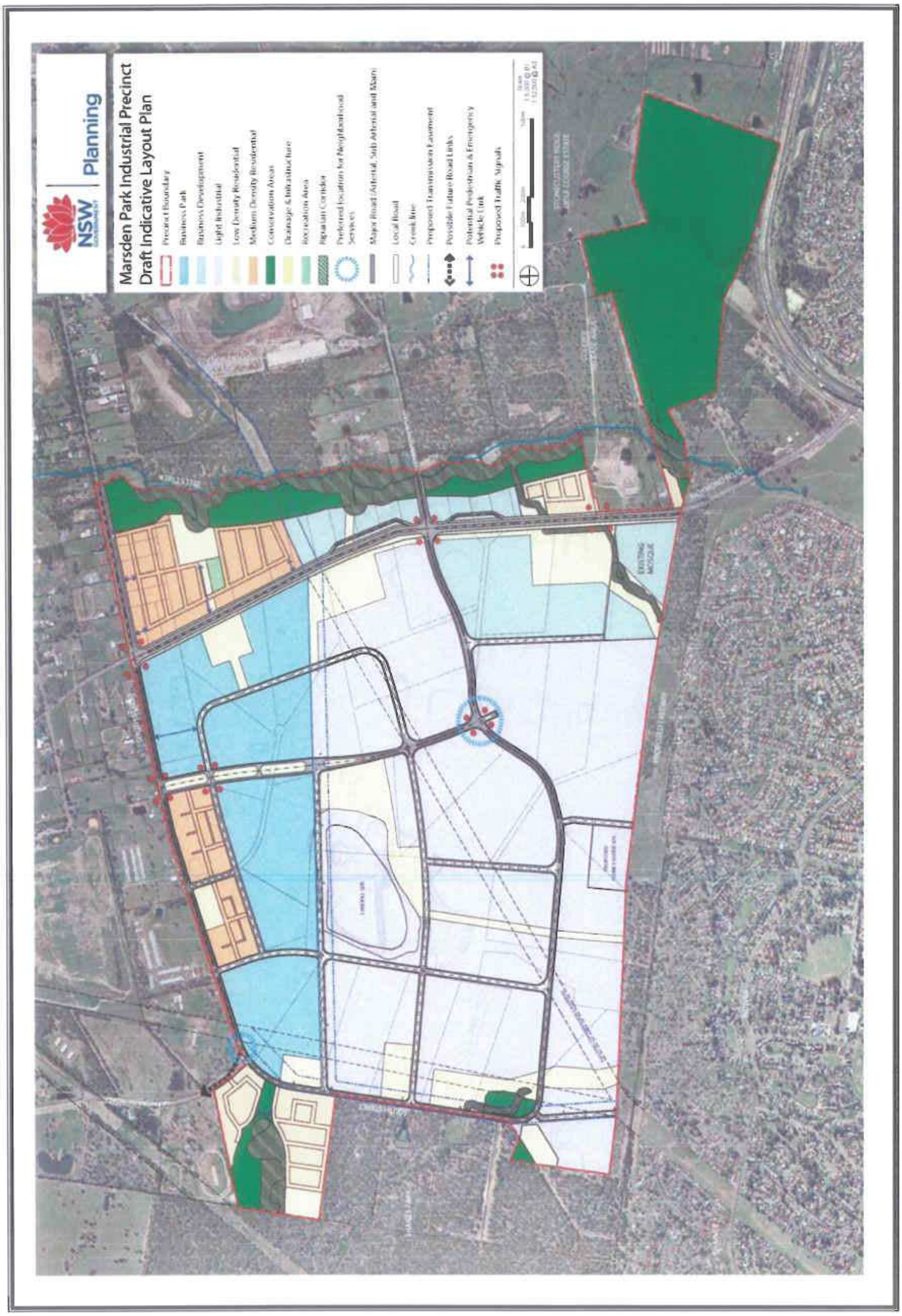

Plate 3: Draft Indicative Layout Plan

4 DEVELOPMENT GUIDELINES, OPPORTUNITIES AND CONSTRAINTS

The *Draft Blacktown City Council Growth Centre Precincts Development Control Plan 2009* prepared by the NSW Department of Planning, October 2009 (Ref.7) formed the principle reference document for assessing the performance of the mitigation measures proposed in this Water Cycle Management Strategy.

Where it was necessary to source specific criteria or targets from elsewhere, the following documents were used as secondary references:

- *Draft Integrated Water Cycle Management Development Control Plan(June 2009,* Blacktown City Council (Ref.6); and
- *Engineering Guide for Development – 2005,* Blacktown City Council (Ref.13).

4.1 Draft Blacktown City Council Growth Centre Precincts Development Control Plan

Heading *2.3.1 Flooding and water cycle management* establishes the stormwater management objectives for the new subdivisions as:

a. *to manage the flow of stormwater from urban parts of the Precinct to replicate, as closely as possible, pre-development flows;*

b. *to define the flood constraints and standards applicable to urban development in the Precinct;*

c. *to minimise the potential flooding impacts on development.*

In summary the key targets against which to measure the success of the Water Cycle Management Strategy are:

- *Where practical, development shall attenuate up to the 50% AEP peak flow for discharges in the local tributaries, particularly Category 1 and 2 creeks.* (Attenuation afforded by Detention Basins determined on basis of 20% and 100% AEP discharges. Optimisation of the Basin outlets to be undertaken as part of the more detailed designs required for individual Development Applications).
- *The developed 1% AEP peak flow is to be reduced to pre-development flows through the incorporation of stormwater detention and management devices.*
- *Achieve water quality targets set by the Department of Environment and Conservation* (Ref.16). (see table below).

	WATER QUALITY % reduction in pollutant loads				**ENVIRONMENTAL FLOWS Stream erosion control ratio**[1]
	Gross Pollutants (>5mm)	Total suspended solids	Total phosphorous	Total nitrogen	
Stormwater management Objective	90	85	65	45	3.5-5.0: 1
'Ideal' stormwater outcome	100	95	95	85	1:1

[1] *This ratio should be minimised to limit stream erosion to the minimum practicable. Development proposals should be designed to achieve a value as close to one as practicable, and values within the nominated range should not be exceeded. A specific target cannot be defined at this time.*

4.2 Blacktown City Council Draft Integrated Water Cycle Management DCP

Although the Integrated Water Cycle Management DCP is still in draft form and has not yet been adopted by Council, it has been considered in preparation of the MPIP Water Cycle Management Strategy.

Blacktown City Council's Draft Integrated Water Cycle Management DCP (Ref. 6) aims to:

- Protect and enhance natural river systems.
- Minimise potable water demand and wastewater generation.
- Match the natural water runoff regime as closely as possible.
- Mitigate the impacts of development on water quality.
- Mitigate the impacts of development on groundwater.
- Ensure any changes to the existing groundwater regime do not adversely impact upon adjoining properties.
- Integrate water cycle management measures into the landscape and urban design to maximise amenity.
- Minimise the potential impacts of development and other activity on the aesthetic, recreational and ecological values of receiving waters.
- Minimise soil erosion and sedimentation resulting from site disturbing activities.
- Ensure the principles of ecologically sustainable development are applied in consideration of economic, social and environmental values in water cycle management.

General requirements for the design of trunk drainage systems in new release areas, to achieve these aims are detailed in the BCC Engineering Guide for Development – 2005 (Ref.13). This document was the principle reference for the hydrological modelling referred to in this strategy.

4.3 Adopted Performance Targets for the MPIP

4.3.1 Water Conservation

- New residential dwellings, including a residential component within a mixed use building and serviced apartments intended to, or capable of being strata titled, are to demonstrate compliance with the NSW Government Building Sustainability Index initiative (BASIX).
- BCC require that all *industrial and commercial developments must install rainwater tanks to meet a minimum of 50 per cent of their own potable water demand for outdoor use, toilets, laundry or hot water.* (Ref.6)
- BCC require that water use within public open space (e.g. irrigation, water features, open water bodies / pools) should be supplied from non potable sources to meet a minimum of 80% of this demand. (Ref.6)

4.3.2 Stormwater Quality

- 90% reduction in the post development average annual gross pollutant (>5mm) load.
- 85% reduction in the post development average annual load of Total Suspended Solids (TSS) load.
- 65% reduction in the post development average annual load of Total Phosphorus (TP) load.
- 45% reduction in the post development average annual load of Total Nitrogen (TN) load.
- Environmental Flows - Stream Forming Flow Ratio 3.5-5.0: 1, where "the 'stream forming flow' is defined as 50% of the 2-year flow rate estimated for the catchment under natural conditions" (DECCW advice to GCC).

4.3.3 Peak Flow Management

- The developed 5-year and 100-year peak flows attenuated to match the pre-development peak flows where the discharge point from the MPIP meets the existing natural watercourses and creeks.
- Freeboard on the proposed Trunk Drainage system will comply with the values specified under Section 1.5 Design Freeboard (BCC 05), i.e. the finished floor level will be at least 0.5 m above the design 100-year top water level.

4.3.4 Consideration of Climate Change Impacts

An assessment, based on the guidelines outlined in the contemporary references identified in Heading 2 Previous Studies/Reports of this report, was undertaken and submitted to the DECCW for consideration (see Appendix A for a copy). The comments from DECCW were that the assessment undertaken "provides a pragmatic approach to the consideration of Climate Change impacts on the urban hydrology for the MPIP.

In summary the final parameters adopted as a consequence of the sensitivity analysis of the changes to the hydrology and freeboard allowances included:

- Increasing the rainfall intensities by 15%.
- A maximum reduction of 0.2 m in the 0.5 m freeboard allowance, based on the depth of flow in channels and the top water level in basins, generated by the existing 100-year ARI critical storm (i.e. existing freeboard allowance reduced from 0.5 m to 0.3 m as a consequence of increasing the existing 100-year rainfall intensities by 15%).
- Detention Basins to be provided with flexible outlet structures which can be adjusted on the basis of anticipated decadal changes to rainfall intensities. The design of these outlet structures is to be undertaken as part of the more detailed designs required for Development Approval and Construction Certification.

4.4 Salinity

Salinity mapping prepared by NSW Department of Infrastructure Planning and Natural Resources in 2002 (Ref.22) identifies the MPIP as having a *"Moderate Salinity Potential"*, increasing to *"High"* in watercourses and *"Known"* to the north of the site. GHD (Ref. 23) referred to groundwater salinity at >14,000 mg/L and generally relatively shallow saline groundwater is to be expected in soils overlying Wianamatta shales (Ref.24). However, much of the development falls within the area of *"Moderate Salinity Potential"* and measures designed to mitigate the impact of the MPIP on groundwater levels include:

- Minimisation of water infiltration;
- Inclusion of deep rooted vegetation;
- Minimisation of cut and fill operations which inappropriately alter natural drainage patterns;
- Design of impermeable liners on all measures that retain water for in excess of 24 hours.

4.5 Stormwater Management Objectives

The Water Cycle Management Strategy proposed for the MPIP has been prepared in accordance with the principles of Ecologically Sustainable Development (ESD). To comply with these principles, the final form of the structural stormwater control elements must be designed, developed and maintained in accordance with the following objectives:

- *Precautionary Principle* – although there is uncertainty with respect to the magnitude of climate change impacts, the drainage system must be designed with sufficient redundancy to accommodate the changes to rainfall intensities considered in the Climate Change Impact assessment. Restriction of urban development to 0.5 m above the estimated 100-year flood levels provides a safe guard against uncertainty in Flood Level estimations.
- *Inter-generational Equity* – incorporation of Water Sensitive Urban Design principles within the development such that the post-development water quality discharges comply with the DECCW advice. The targets, included in this advice, were intended as minimum standards required to maintain the environmental integrity of receiving water bodies.
- *Conservation of Biological Diversity and Ecological Integrity* – achieved through the conservation of existing riparian areas, the use of vegetated 'naturalised' Trunk Drainage networks and compliance with the DECCW Environment Flow advice.
- *Improved Pricing and Valuation of Assets* – the Water Cycle Management Strategy has been prepared as a cost-effective control measure, for inclusion in a S94 Contributions Plan, to reduce the impacts of stormwater discharges on the receiving environment. It includes consideration of the costs associated with viability of the public domain infrastructure, in particular: ease of access to the open space areas; vegetation management; removal of litter and gross pollutants; and the control of sediment and nutrients.

4.6 Response to Blacktown City Council Comments

BCC made comment on the original submission of the GHD Water Cycle Management Assessment in August 2009. The following table contains a brief explanation of each BCC comment and the proposed element(s) within the Water Cycle Management Strategy (WCMS) which will address each comment.

BCC Comment	Response
a) RTA concurrence with the Stormwater Strategy proposed in Richmond Road.	Proposal for spill containment within the road reserve and compensatory storage and treatment within the MPIP. Still awaiting written concurrence fro RTA.
b) Assessment of the durations used in the TUFLOW model to determine peak flows in the Little Creek catchment.	Copy of the existing GHD models were provided by BCC. The 100 yr ARI Storm duration which currently produces peak flows in this catchment has been confirmed as 120 mins for both the existing and developed conditions. (Refer Table 6.3 for the 5 yr and Table 6.4 for the 100 yr – Link Label W-1.1.03)
c) Water quality options analysis for the Little Creek catchment.	See Section 7 "Water Quality Analysis."
d) Water quality model to include bypass of high flows at the GPTs.	See Section 7 "Water Quality Analysis."
e) TUFLOW modelling to account for existing Bells Creek Flood Models and downstream boundary conditions.	Copy of the existing GHD TUFLOW model for Bells Creek was provided by BCC.
f) Climate Change Impacts to be identified across the MPIP.	See Section 6.10 "Climate Change Sensitivity Assessment."
g) Report on the Stream Erosion Index at each discharge location.	See Section 9 "Stream Erosion Index."
h) Determination of Flood Planning Levels throughout the MPIP	To be identified as a constraint for the determination of individual DAs in accordance with Section 6 "Hydrologic Analysis" and Section 8 "Trunk Drainage Channel Analysis."
i) Locate each modelling node to allow a comparison of pre and post development conditions.	See Section 6 "Hydrologic Analysis" and Section 7 "Water Quality Analysis."
j) Hydraulic assessment of the Riparian corridors adjacent to Basins A, C and G as well as TC1 and TC8.	No longer applicable as the Basins are located on line. See Section 6 "Hydrologic Analysis" and Section 8 "Trunk Drainage Channel Analysis.
k) Identify local overland flowpaths and match with final road and drainage alignments.	Adjustments to ILP will address this issue. Each DA to be constrained by the nominated flowpaths. See attached Figures.
l) Assess options to locate TC7 outside of the road median	Still to be resolved.
m) Include options to use recycled water within the rainwater harvesting and reuse scheme	See Section 1 "Introduction."
n) Estimation of bulk earthworks to include dewatering and desilting of existing farm dams and disposal of unsound material.	See Section 10 "Costing of Detention Basin Major Works" and the attached Bill of Quantities.
o) Water Cycle Management Report detailing the parameters used and the assessment outcomes.	Addressed by the final "Water Cycle Management Strategy" report.

5 STORMWATER MANAGEMENT CONCEPT

The proposed Water Cycle Management Strategy for the MPIP has been prepared with consideration of the statutory requirements and guidelines listed under Heading 4 Development Guidelines, Opportunities and Constraints.

In summary it consists of three (3) integrated components:

1. On Lot water quality controls for the industrial/commercial areas.
   A rainwater tank or tanks will be strategically placed within each allotment to harvest, store and allow roof runoff to be reused for toilet flushing, hot water and external irrigation. All external hardstand areas will be directed to a Gross Pollutant Trap (GPT), which will pre-treat the runoff before it is discharged into a raingarden (bio-retention/filtration) system representing at least 1% of the allotment. The remaining pervious areas of the allotment, where elevations permit, will be directed into the raingarden, which will be connected to the formal drainage network.

2. Roof water harvesting and reuse on all residential allotments.
   The roof runoff will be collected in the roof guttering and collected in rainwater tanks connected to a BASIX compliant reuse system. There will be no other on lot treatment or on site detention of runoff from the residential catchments. All runoff will drain to the formal drainage network where it will be discharged into the precinct based Detention Basins and their co-located raingardens.

3. Water quality control raingardens co-located within the Precinct Based Detention Basins.
   The formal drainage network, consisting of underground pipes and densely vegetated channels, has been sized to convey the runoff from the public domain infrastructure, residential catchments and the pre-treated site runoff from the industrial/commercial catchments into the precinct based Detention Basins and their co-located raingardens.

Runoff from external catchments within Hassall Grove and Bidwill, which drain through the MPIP, are detained within the internal precinct based Detention Basins. However their low flows are diverted around the water quality control systems, co-located within the Basins, and 'shandied' with the treated runoff from the MPIP before being discharged downstream.

A more detailed description of the peak flow management and water quality control elements of the Strategy can be found in Headings 6 "Hydrologic Analysis" and Heading 8 "Water Quality Analysis".

6 HYDROLOGIC ANALYSIS

The hydrologic analyses for this study were undertaken using the rainfall - runoff flood routing model XP-RAFTS (Runoff and Flow Training Simulation with XP Graphical Interface) (Ref. 11 & 12).

6.1 Sub-Catchments (Pre and Post Development)

Sub-catchment areas contributing to this drainage system were established through site investigations, detail survey and Aerial Laser Scan (ALS) survey covering the catchment and consideration of the Masterplan for the site. Catchment boundaries for the existing and developed areas contributing to the drainage system are shown on Figure 3 and the catchment details are provided in Tables 6.3 and 6.4.

NOTE Developed catchment boundaries have been determined on the best information available with regard to final site grading and levels. Final catchment boundaries and areas contributing to each Detention Basin must be confirmed as part of the Development Approval process for each stage of the development.

6.2 Rainfall Data

6.2.1 Intensity-Frequency-Duration (I.F.D.)

Design rainfall intensity-frequency-duration (I.F.D.) data for the site were obtained from *Blacktown City Council's Engineering Guide for Development 2005* (Ref. 13). A summary of the rainfall intensities adopted in this study is provided in Table 6.1. The critical storm durations were determined using these values for each sub-catchment.

Table 6.1

BLACKTOWN RAINFALL INTENSITIES (mm/hr)

Storm Duration (min.)	Rainfall Intensities (mm/hr) ARI	
	5	100
5	129	219
10	98	167
15	82	139
20	71	121
25	64	108
30	58	98
45	46.2	78
60	39.2	66
90	30.7	52
120	25.7	43.4
180	20.0	33.8
270	15.5	26.2
360	13.0	21.9
540	10.1	17.1
720	8.45	14.3
1080	6.61	11.4
1440	5.54	9.66

The models used to examine the catchment rainfall/runoff relationships incorporated temporal patterns for synthetic design storms determined using procedures detailed in *Australian Rainfall and Runoff, Engineers Australia (1987)* (Ref. 14).

6.3 XP-Rafts Parameters

The Pern (n) values and losses adopted for the catchments in the XP-RAFTS modelling are listed in Table 6.2.

Table 6.2

ADOPTED XP-RAFTS PARAMETERS (BCC Standard Parameters)

Parameter	Catchment Condition	Adopted Value
Pern		
	Existing Pervious	0.05 - 0.08
	Urban Pervious	0.025
	Urban Impervious	0.015
Initial/Continuing Losses - Adopted in Undeveloped Subcatchments		
Initial Loss	Pervious Catchment	15.0
Continuing Loss	Pervious Catchment	2.5
Initial Loss	Impervious Catchment	1.0
Continuing Loss	Impervious Catchment	0.0
ARBM - Adopted in Developed Subcatchments		
ARBM Loss Process	Routing Time Step (min)	1
Storage Capacities		
Impervious Zone	Capacity (mm)	1.5
	Initial (mm)	0.5
Interception Zone	Capacity (mm)	1.5
	Initial (mm)	0.5
Depression Zone	Capacity (mm)	5
	Initial (mm)	0
Upper Soil	Capacity (mm)	25
	Initial (mm)	20
Lower Soil	Capacity (mm)	100
	Initial (mm)	80
Groundwater	Initial (mm)	0
Infiltration		
Upper Soil	Dry Sorpivity (mm/min^0.5)	3
	Hydraulic Conductivity (mm/min)	0.33
Lower Soil	Drainage Factor	0.05
	Constant Rate	0.94
	Variable Rate	1
Evapotranspiration		
Proportion of Rainfall Intercepted by Vegetation		0.7
Max Potential Evapotranspiration	Upper Soil (mm/day)	10
	Lower Soil (mm/day)	10
Proportion of Evapotranspiration from Upper Soil		0.7
Ratio of Potential Evaporation to A Class Pan		0.7

6.4 Calibration

It is normal practice for flood routing models such as XP-RAFTS to be calibrated with historical rainfall and streamflow data for the catchment being investigated in order to produce the most reliable results. The model parameter values (in particular Bx) are adjusted so that the model adequately reproduces observed hydrographs. However, no streamflow records were available for the site and a Bx value of 1.00, which is consistent with the value used in the BCC XP-RAFTS model for Bells Creek, was adopted for the hydrologic analysis of the MPIP.

6.5 XP-RAFTS Model

There are a number of basins attenuating discharges from catchments upstream of Richmond Road, which drain tributaries of Bells Creek. To ensure consistency with existing hydrologic models BCC provided an XP-RAFTS model for the Bell Creek catchment, which was used as the basis for this assessment.

The BCC catchment information was altered to incorporate the MPIP catchment extents as determined by the ILP and recent survey information. Catchment areas upstream of the MPIP were left unaltered, whilst those catchments within and adjacent to the site, as far downstream as Grange Avenue, were updated to reflect the more recent survey information.

Applying estimated lag times between links in the model, rather than routing them by individual calculations was adopted for the MPIP XP-RAFTS model.

Basin O was originally required to attenuate and treat discharges from an 8.26 ha catchment in the south western corner of the MPIP. However, subsequent hydrologic modelling with respect to the preparation of this Water Cycle Management Strategy determined that the additional stormwater detention required could be accommodated within Detention Basin A with a slight increase in its storage volume (see Tables 6.5 and 6.6 – Basin O dimensions are redundant for detention purposes). Consequently the storage volume of Detention Basin A has been determined on the basis that the detention storage of Basin O is not required. Unfortunately, level constraints made it difficult to drain a raingarden co-located within Detention Basin O into the perched raingarden co-located within Detention Basin A, and the raingarden proposed within Basin O has been retained (see Plate 5 and Tables 7.6, 7.7 and 7.8).

Stage Storage relationships for each detention basin were developed using a graphical interpolation of each stage based on the total storage volume, basin layout, and the design levels. The final configuration of each basin, and its outlet, will be included within the detailed design information accompanying the Development Application for each basin.

6.6 Tailwater Effects

Invert levels for the floor of the Detention Basins storage zones have been determined on the basis that they will be at or above the downstream 100-year flood levels immediately downstream of the proposed basin location. However the hydraulic performance of the outlet arrangements for the basins has been modelled, in XP-STORM (Ref.20), with a submerged outlet during the 100-year ARI regional flood event. This should provide a conservative estimation of the hydraulic performance of the basins, in particular Basin G, I, J and M.

6.7 Discharge Estimates

Discharge estimates were derived for the existing and developed catchments for storms with ARI's of 5-years and 100-years. A range of storm durations from 25 minutes to 24 hours were analysed to determine the critical storm duration for each sub-catchment.

XP-RAFTS modelling was undertaken to determine the estimated peak discharges from the catchment for the following catchment conditions:

- Undeveloped Site under existing rural/quarry conditions.
- Site developed with detention systems provided.

The 5-year and 100-year ARI peak flows from the catchment are presented in Tables 6.3 and 6.4. XP-RAFTS outputs for the individual Basins are provided in Tables 6.5 and 6.6.

Table 6.3

SUMMARY OF PEAK FLOWS – 5 YEAR ARI

			Existing				Developed with Detention				Ratio
Link Label Exist	Link Label Dev	Location	Cum Area ha	Max Flow (m^3/s)	Storm Dur. (min)	Time to Peak	Cum Area ha	Max Flow (m^3/s)	Storm Dur. (min)	Time to Peak	Prop. / Exist
1.13	1.13	Bells Creek at Site Boundary	834.14	52.67	540	330	834.14	52.67	540	330	1.00
B-1.1.03	B-1.1.04	Tributary 1 at Richmond Road	118.34	13.86	25	15	116.66	9.63	120	53	0.70
B-1.1.04	B-1.1.06	Tributary 1 into Bells Creek (Basin G)	131.98	14.16	25	15	127.26	10.13	90	47	0.72
1.15	1.15	Bells Creek at Tributary 1	1003.75	63.77	90	35	999.03	63.51	540	330	1.00
B-2.1.01	B-2.1.02	Tributary 2 into Bells Creek (Undetained)	22.74	1.56	90	43	8.56	1.51	25	16	0.97
1.16	1.16	Bells Creek at Tributary 2	1045.09	66.29	120	101	1026.19	65.18	540	330	0.98
B-3.1.03d	B-3.1.04	Tributary 3 at Richmond Road	55.50	3.99	270	92	68.02	3.80	540	330	0.95
B-3.1.04	B-3.1.06	Tributary 3 into Bells Creek (Basin I)	62.17	4.26	360	145	75.52	4.25	540	330	1.00
1.17	1.17	Bells Creek at Tributary 3	1117.34	70.80	360	150	1111.79	70.09	540	335	0.99
B-3.3.00	B-3.8.02	Catchment north of Tributary 3 into Bells Ck	10.19	0.64	360	150	11.15	1.79	25	15	2.80
1.18	1.18	Bells Creek at d/s Tributary 3 Catchment	1144.07	72.26	360	155	1138.88	71.55	540	340	0.99
B-4.1.01	B-4.1.02	Tributary 4 at Richmond Road	31.04	2.07	540	330	43.30	2.98	270	90	1.44
B-4.1.02	B-4.1.05	Tributary 4 into Bells Creek (Basin M)	72.66	4.62	540	330	66.22	3.65	540	340	0.79
1.19	1.19	Bells Creek at Tributary 4	1213.98	75.87	540	330	1219.02	75.99	540	345	1.00
B-4.3.00	B-4.7.01	Catchment north of Tributary 4 into Bells Ck	16.67	0.89	270	94	9.46	1.61	25	17	1.81
1.20	1.20	Bells Creek at d/s Site Boundary (South St)	1249.49	77.64	540	330	1247.32	77.41	540	350	1.00
1.22	1.22	Bells Creek at Grange Avenue	1296.63	79.77	120	125	1294.46	79.78	540	360	1.00
N-2.01	N-8.02b	Minor Western Tributary of N/S Ck from Site	20.39	1.37	540	330	21.64	1.36	540	330	1.00
N-1.04	N-1.07	Main Tributary of N/S Ck from Site	118.21	7.69	90	30	119.17	7.69	90	30	1.00
N-S	N-S	Total Discharges from N/S Creek D/S of Site	163.61	10.69	540	330	162.25	9.54	540	330	0.89
W-1.1.03	W-1.1.05	Main Western Tributary 1 from Site	101.72	12.25	25	15	117.02	11.14	120	48	0.91
W-1.4.00	W-1.6.02	Minor Western Tributary 1 from Site	26.66	1.59	90	35	22.94	1.37	120	68	0.86
W-1	W-1	Main Western Tributary 1 D/S from Site	128.38	12.85	540	330	139.96	12.44	120	49	0.97
W-2	W-2	Main Western Tributary 2 D/S from Site	55.20	3.36	90	47	47.97	3.00	540	330	0.89

Table 6.4

SUMMARY OF PEAK FLOWS – 100 YEAR ARI

			Existing				Developed with Detention				Ratio
Link Label Exist	Link Label Dev	Location	Cum Area ha	Max Flow (m^3/s)	Storm Dur. (min)	Time to Peak	Cum Area ha	Max Flow (m^3/s)	Storm Dur. (min)	Time to Peak	Prop. / Exist
1.13	1.13	Bells Creek at Site Boundary	834.14	95.89	120	66	834.14	95.89	120	58	1.00
B-1.1.03	B-1.1.04	Tributary 1 at Richmond Road	118.34	25.60	25	15	116.66	21.78	120	50	0.85
B-1.1.04	B-1.1.06	Tributary 1 into Bells Creek (Basin G)	131.98	26.54	90	33	127.26	22.71	120	53	0.86
1.15	1.15	Bells Creek at Tributary 1	1003.75	121.32	90	35	999.03	120.85	120	61	1.00
B-2.1.01	B-2.1.02	Tributary 2 into Bells Creek (Undetained)	22.74	3.39	90	43	8.56	2.47	90	31	0.73
1.16	1.16	Bells Creek at Tributary 2	1045.09	126.25	120	101	1026.19	123.67	120	61	0.98
B-3.1.03d	B-3.1.04	Tributary 3 at Richmond Road	55.50	8.68	120	48	68.02	7.39	120	65	0.85
B-3.1.04	B-3.1.06	Tributary 3 into Bells Creek (Basin I)	62.17	9.21	120	58	75.52	8.13	120	67	0.88
1.17	1.17	Bells Creek at Tributary 3	1117.34	136.45	120	60	1111.79	133.07	120	66	0.98
B-3.3.00	B-3.8.02	Catchment north of Tributary 3 into Bells Ck	10.19	1.23	120	58	11.15	2.87	90	29	2.33
1.18	1.18	Bells Creek at d/s Tributary 3 Catchment	1144.07	139.67	120	63	1138.88	136.06	120	70	0.97
B-4.1.01	B-4.1.02	Tributary 4 at Richmond Road	31.04	4.22	120	68	43.30	6.62	120	41	1.57
B-4.1.02	B-4.1.05	Tributary 4 into Bells Creek (Basin M)	55.99	7.69	120	66	66.22	7.41	120	72	0.96
1.19	1.19	Bells Creek at Tributary 4	1213.98	148.65	120	65	1219.02	145.11	120	76	0.98
B-4.3.00	B-4.7.01	Catchment north of Tributary 4 into Bells Ck	16.67	1.64	120	53	9.46	2.60	90	32	1.59
1.20	1.20	Bells Creek at d/s Site Boundary (South St)	1249.49	151.91	120	67	1247.32	148.07	120	80	0.97
1.22	1.22	Bells Creek at Grange Avenue	1296.63	156.86	120	124	1294.46	153.16	120	87	0.98
N-2.01	N-8.02b	Minor Western Tributary of N/S Ck from Site	20.39	2.85	90	37	21.64	2.14	120	68	0.75
N-1.04	N-1.07	Main Tributary of N/S Ck from Site	118.21	14.83	90	30	119.17	14.14	120	61	0.95
N-S	N-S	Total Discharges from N/S Creek D/S of Site	163.61	20.55	120	65	162.25	19.38	120	63	0.94
W-1.1.03	W-1.1.05	Main Western Tributary 1 from Site	101.72	22.31	90	30	117.02	21.90	120	47	0.98
W-1.4.00	W-1.6.02	Minor Western Tributary 1 from Site	26.66	2.99	90	35	22.94	1.92	120	68	0.64
W-1	W-1	Main Western Tributary 1 D/S from Site	128.38	24.10	360	150	139.96	23.68	120	48	0.98
W-2	W-2	Main Western Tributary 2 D/S from Site	55.20	6.39	90	47	47.97	6.88	120	46	1.08

NOTE: The increase in outflow from node B-4.1.02 results from the combination of external flows generated by Richmond Road and an existing external catchment, both of which discharge through cascading Detention Basins J and M. The outflow from detention Basin M is represented by node B-4.1.05.
Final Peak Flow values are to be determined upon completion of the detailed designs and preparation of the Development Application for each basin.

6.8 Basin Performance

The performance of the basins for the 5-year and 100-year ARI storm events are detailed in Tables 6.5 and 6.6, respectively.

Table 6.5

DETENTION BASIN PERFORMANCE – 5 YEAR ARI

	Basin Inflows			Basin Outflows				
Basin Label	Max Flow (m^3/s)	Storm Dur. (min)	Time to Peak (min)	Max Flow (m^3/s)	Storm Dur. (min)	Time to Peak (min)	Storage Used (m^3)	Storage Depth (m)
A*	30.89	25	15	10.99	120	46	18511	0.96
O	2.25	25	15	0.40	120	66	1550	0.84
B	6.31	25	15	1.21	120	66	4560	0.96
P	9.34	25	16	2.30	120	51	6983	1.00
E	25.07	25	15	5.64	540	335	30604	1.06
K	6.93	25	15	1.36	540	330	6275	1.02
G	24.72	25	19	9.13	120	53	21197	0.98
I	19.60	25	15	3.61	540	335	19045	0.97
J	11.54	25	15	2.33	270	92	9186	0.95
M	7.61	25	15	3.43	120	68	5220	0.84

* Basin A configured assuming that Basin O does not exist

Table 6.6

DETENTION BASIN PERFORMANCE – 100 YEAR ARI

	Basin Inflows			Basin Outflows				
Basin Label	Max Flow (m^3/s)	Storm Dur. (min)	Time to Peak (min)	Max Flow (m^3/s)	Storm Dur. (min)	Time to Peak (min)	Storage Used (m^3)	Storage Depth (m)
A*	48.42	25	15	21.47	120	45	30420	1.20
O	3.45	25	15	0.68	120	66	2855	1.17
B	9.79	25	15	1.53	120	82	8795	1.19
P	14.59	25	16	4.39	120	50	11548	1.18
E	39.94	25	15	11.66	270	94	39954	1.20
K	10.66	25	15	2.14	120	68	9453	1.20
G	39.71	25	19	20.83	120	51	32947	1.20
I	30.38	25	15	7.04	120	66	27616	1.19
J	17.82	25	15	5.07	120	46	13943	1.20
M	13.32	90	30	6.86	120	67	10074	1.17

6.9 Discussion of Modelling Results

The XP-RAFTS modelling undertaken, has determined that the proposed detention storages are adequate to restrict post development peak discharges from the site, to pre-development levels for the 5-year and 100-year ARI storm events. The results of this modelling have been reported in Tables 6.3 and 6.4 and demonstrate compliance with the "Blacktown City Council Growth Centres Precincts Development Control Plan 2009" flooding and water cycle management objectives.

6.9.1 Bells Creek Catchment (Eastern)

Detention Basins G, I and J discharge into culverts under Richmond Road before continuing on in an easterly direction towards Bells Creek within open channels (TC8B, TC13 and TC11 respectively). Apart from the residential sub-catchments draining to Detention Basin M, all other catchments east of Richmond Rd. discharge directly into Bells Creek without detention. These discharge points are shown on Figure 3 and denoted as Nodes B-1.1.06, B-2.1.02, B-3.1.06, B-3.8.02, B-4.1.05 and B-4.7.01.

To compensate for the sub-catchments without detention, the storage capacities of Basins G, I, J and M have been increased. The Existing and Developed with Detention peak flows in Bells Creek can be compared in Tables 6.3 and 6.4 at Nodes 1.15, 1.16, 1.17, 1.18. 1.19 and 1.20.

The results from the XP-RAFTS model generally exhibit a slight reduction in peak flows in Bells Creek at these Nodes. Consequently, the Hydrologic Analysis confirms that the goal for the Eastern Catchment of "not increasing peak flows in Bells Creek" has been demonstrated.

NOTE This strategy has been based on limiting the number of discharge points from the developed catchment into Bells Creek and its tributaries. The location of each discharge point shall be included with each Development Application for the relevant stage and the total number of discharge points identified in this strategy should not be exceeded without the approval of Blacktown City Council.

6.9.2 North-South Catchment (Centre)

The storage volume for Basin E has been increased to compensate for 20.66 ha which discharges directly into Marsden Park to the east of Basin K (see Nodes N-1.06 and N-1.07 on Figure 3). The point of comparison for peak flows from the Existing and Developed with Detention catchments is Node N-S (see Tables 6.3 and 6.4).

The slight decrease in peak flows determined at Node N-S demonstrates compliance with the goal for the North-South Catchment of "not increasing peak flows through Marsden Park."

6.9.3 Western Catchment (Little Creek)

Approximately 40 has of an external residential catchment from Bidwill drains into the Little Creek catchment through the southwest corner of the site. This catchment is denoted by Nodes W-1.1.00, W-1.2.00 and W-1.9.00 on Figure 3. Basins O and A treat and detain this external catchment as well as the internal catchments within the south western corner of the MPIP (Basin O is only required as a water quality control and is redundant as a Detention Basin) denoted by Node W-1.1.05. Basin B detains and treats a small internal catchment centrally located on the western fringe of the site. The catchment controlled by both Basins A and B cross South Street and join to the west of the MPIP in Shanes Park at Node W-1. See Tables G.3 and 6.4 for a comparison of Existing and Developed with Detention peak flows, which confirms compliance with "no increase in peak flows into the southern reach of Little Creek."

Detention Basin P controls runoff from the northwest corner of the site. A comparison of Existing and Developed with Detention peak flows can be found at Node W-2 in Tables 6.3 and 6.4, which identifies a slight reduction and confirms compliance with "no increase in peak flows into the north-eastern reach of Little Creek."

6.10 Climate Change Sensitivity Assessment

Preliminary assessments of hydrologic impacts, resulting from changes to rainfall patterns as a consequence of Climate Change, were undertaken to determine the impact of such changes on the performance of the proposed Trunk Drainage system. These assessments followed the sensitivity analysis procedures recommended in the *NSW Climate Change Action Plan, DECC (October 2008)* (Ref.2). A copy of the Climate Change assessment is provided in Appendix A.

In summary:

- Summer runoff depths are expected to increase by a maximum of 26%; and
- The 40-year 24-hour duration rainfall intensity is expected to increase by a maximum of 12%.
- The net average annual runoff is expected to fluctuate with an overall minor increase.

Consequently for the purposes of this assessment, the worst-case scenario of projected increased rainfall intensities (15% increase) and runoff depths (25% increase based on rainfall intensities increased by 15%), were adopted.

The hydrologic modelling determined that the volumes and surface areas for the Detention Basins could remain the same as those determined for existing conditions providing the pre and post development rainfall intensities are both increased by 15%. However it will be necessary, to account for the variability in the predicted decadal increases in rainfall intensities, to design a flexible outlet arrangement as part of the detailed engineering designs required for individual Development Applications.

This approach has been referred to DECCW for comment and has been confirmed as "a pragmatic approach to considering the impacts of Climate Change on urban drainage systems."

6.11 Summary of Release Area Detention Basins

A summary of the storage volumes and associated drainage reserve areas for each of the various detention basins proposed to service the Marsden Park Industrial Precinct is provided in Table 6.7. This table also summarises the changes in basin reserve areas that have occurred as a result of the refinement of the "pre-exhibition" basin strategy developed for the Precinct previously (Ref. 1).

Table 6.7

SUMMARY OF RELEASE AREA DETENTION BASINS

Basin	Volume (m³)	Drainage Reserve Area (ha)	Reserve Area Difference to Pre-Exhibition (ha)	Remarks
A	30,500	2.93	-1.3	On-line Basin
B	9,000	1.35	-1.1	
C		0.00	-1.7	Replaced by Basin P
D		0.00	-2.5	Replaced by larger Basin E
E	40,000	6.04	0.8	
G	33,000	4.60	-2.7	On-line Basin
I	28,000	3.85	-1.8	
J	14,000	1.96	-0.2	
K	9,500	1.35	0.0	
L		0.00	-1.5	Replaced by Basin P
M	10,500	1.52	-0.9	
O		1.29	-0.3	Storage provided in new Basin A
P	12,000	1.66	1.7	Replaces Basins C and L
All Basins	186,500	26.55	-11.4	

7 STORMWATER QUALITY ANALYSIS

The stormwater quality analysis for this study was undertaken using the Model for Urban Stormwater Improvement Conceptualisation (MUSIC version 3.01) (Ref. 15). This water quality modelling software was developed by the Cooperative Research Centre (CRC) for Catchment Hydrology, which is based at Monash University and version 3.01 was released in May 2005.

MUSIC makes it possible to:

- estimate the potential nutrient reduction benefits of gross pollutant traps, constructed wetlands, grass swales, bio-retention systems, sedimentation basins, infiltration systems as well as model stormwater re-use as a treatment technique;
- evaluate compliance with water quality objectives; and
- assist in determining the Stream Erosion Index (refer to Section 9).

BCC and DECCW have established default parameters for use in MUSIC models to represent the generation of various pollutants by different land uses. A MUSIC model of the proposed MPIP development including the Water Cycle Management Strategy was constructed to demonstrate compliance with the adopted Environmental Stormwater Objectives adopted by the GCC and the post development annual load reductions in Part R of the Draft BCC DCP 2006.

7.1 Catchments

7.1.1 Generic On-Lot Treatment Layout for Commercial/Industrial Developments

A generic treatment node, representing a 2 ha commercial/industrial lot, was constructed and incorporated into a MUSIC model. The layout of the on-lot treatment proposed for the generic commercial/industrial lot is shown on Plate 4. The benefit provided through the use of a rainwater tank on each allotment was modelled using the following design assumptions:

- Half the roofed areas (representing 30% of the site area) will discharge to the rainwater tanks for re-use, with overflows discharging into the on-lot raingarden.
- Half the roofed areas (representing 30% of the site area) have been estimated to by-pass the rainwater tanks and discharge directly to the on-lot raingarden.
- All hardstand areas (representing 30% of the site area) will direct runoff, up to the 3-month ARI, into a generic vortex-type GPT, outflows from which will discharge directly into the on-lot raingarden.
- Landscaped areas (representing the remaining 10% of the site area) will discharge directly into the bio-retention device.
- For the purpose of estimating the pollutant load reduction achieved by the generic on-lot raingardens, a filter media depth of 0.6 m was assumed with an average particle size diameter of 0.5 mm and a hydraulic conductivity of 100 mm/hr.

For the purposes of estimating the pollutant load reduction achieved by the on-lot generic treatment, the GPT and raingarden were sized on basis of treating only the runoff from events less than the 3-month ARI with flows in excess of this bypassed directly to the formal drainage network.

The surface area of the on-lot generic raingarden was adjusted until the required water quality targets were achieved. Compliance with the targets occurred when the surface area of the raingarden was configured at 1.0% of the total catchment area of the commercial/industrial lot i.e. when the surface area of the raingarden reached 200 m^2 for a total contributing catchment area of 2 ha.

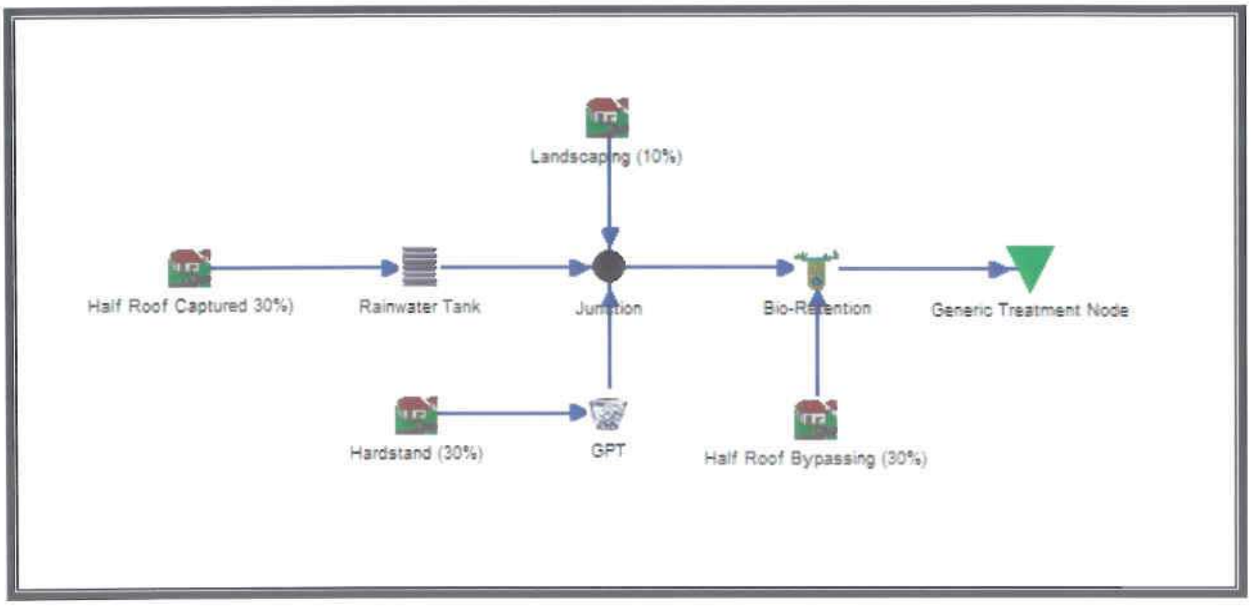

Plate 4: On-Lot MUSIC Model Layout (8955 JWP Lot Treatment.sqz)

Part R of the Draft BCC DCP 2006 contains information to assist with the design of individual on lot treatment elements based on achieving their pollutant load reduction criteria.

7.1.2 Overall Release Area Treatment Layout

A MUSIC model was also established for the proposed Water Cycle Management Strategy proposed to treat the runoff from the public domain infrastructure. Figure 3 shows the extent of the catchments used in this model and Plate 5 shows the general arrangement and construction of the MUSIC model to determine compliance with the required water quality targets.

A fraction impervious of 0.90 was adopted for commercial, industrial and new medium-density residential catchments (including half the road). A fraction of imperviousness of 0.85 was adopted for low-density residential developments (including half the road).

The runoff from all privately owned commercial/industrial catchments is intended to discharge through the on-lot water quality elements, as described earlier, before flowing into the formal drainage network. The public domain infrastructure, which includes the public roads, will be connected directly to formal drainage network before being treated in a vortex-type GPT prior to discharging into the either the downstream formal drainage network and/or the co-located raingardens and Detention Basins.

Where runoff, from the public domain infrastructure, bypasses the co-located raingardens and Detention Basins, the devices have been oversized to compensate by treating the runoff from the private sector to a higher standard. The point of comparison with the required treatment and peak flow reduction criteria is the point of connection with the existing watercourse for the respective catchment. Catchments that discharge directly into watercourses external to the MPIP have been minimised.

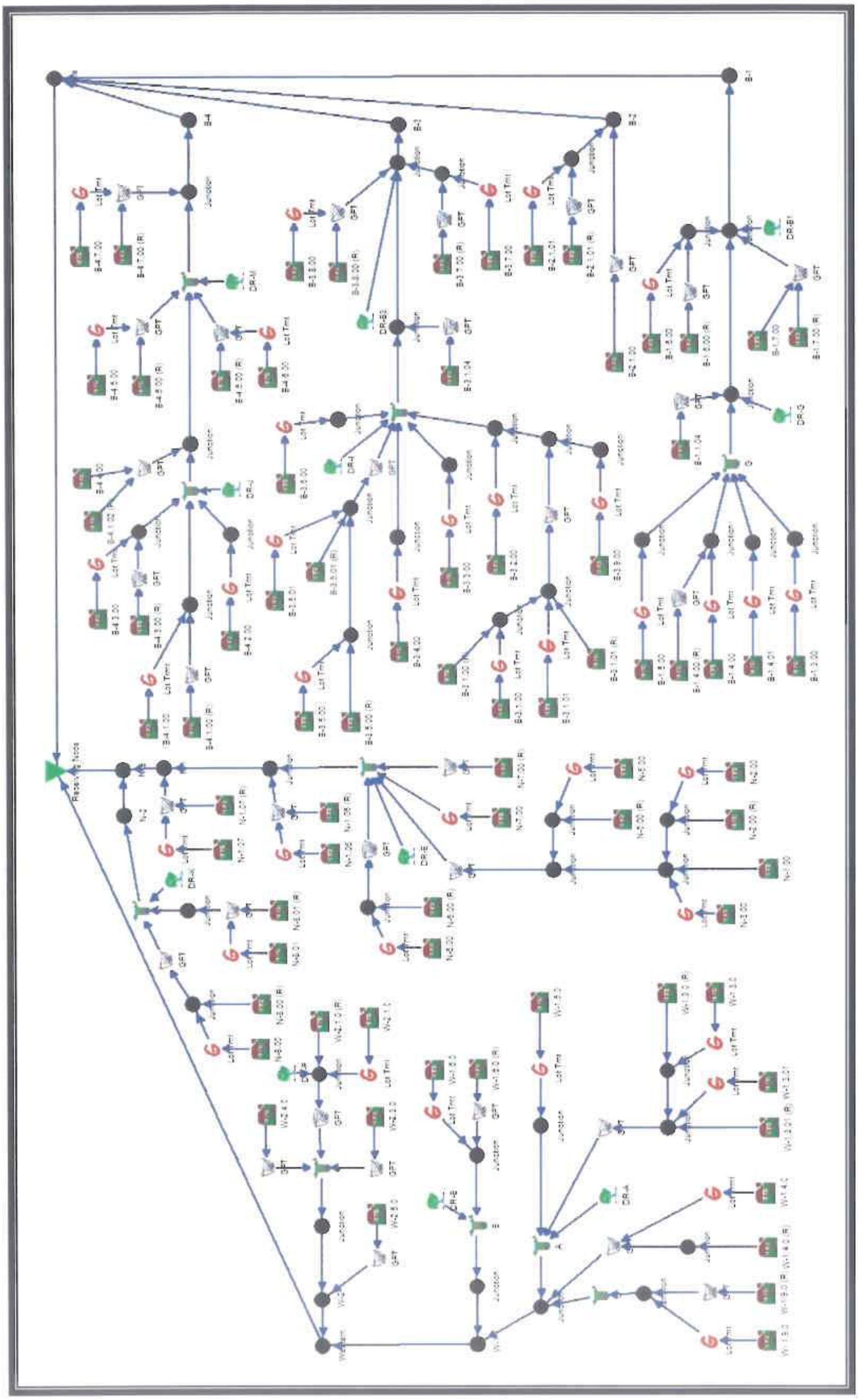

Plate 5: Overall Release Area MUSIC Model Layout (8955MU_05_Total.sqz)

7.2 Rainfall Data

The MUSIC model is able to utilise rainfall data based on 6 minute, hourly, 6 hourly and daily time steps. A 6 minute time step was chosen for this analysis, which is in accordance with the recommendations within the MUSIC Users Manual (Ref. 15).

Rainfall records for the area were obtained from Blacktown City Council. The station used and the years of record selected were determined by BCC and are tabulated below.

Station No	Location	Years of Record	Type of Data
67035	Liverpool (Whitlam Centre)	1967 - 1976	6 minute

Upon interrogation of the rainfall data provided by the Bureau of Meteorology for the Station No. 67035, it was noticed that a significant amount of data between 1974 and 1976 was missing. Consequently another data set was secured from BCC which included replacement rainfall data for this missing period. The amended 6 minute rainfall data was analysed and found to compare favourably with data from other local rainfall stations.

A summary of the amended rainfall data set (Liverpool 1967 – 1976) used in the MUSIC model for the MPIP and comparable rainfall data sets provided by the Bureau of Meteorology rainfall stations gauges in Seven Hills, Richmond and Orchard Hills (Penrith) is shown below in Table 7.1.

Table 7.1

SUMMARY OF RAINFALL DATA FOR THE SITE

Property	Bureau of Meteorology Data - Seven Hills (1950 - 2009)	Bureau of Meteorology Data - Orchard Hills (1971 - 2009)	Bureau of Meteorology Data - Richmond (1881 - 2009)	Bureau of Meteorology Data - Average Between Three BOM Stations	MUSIC Model Data Set - Liverpool (Whitlam Centre) (1967 - 1976)
Mean Yearly Rainfall (mm)	915	801	801	839	835
Decile 1 Rainfall (mm)	627	503	529	553	638
Decile 5 Rainfall (mm)	900	782	793	825	833
Decile 9 Rainfall (mm)	1178	1036	1070	1094	1119
Mean No. Rain Days	112	101	116	109	110
Mean No. Rain Days > 1mm	85	77	77	80	77
Mean No. Rain Days > 10mm	26	23	22	24	23
Mean No. Rain Days > 25mm	8.8	7.8	7.2	7.9	8.2

7.3 Soil / Groundwater Parameters and Pollutant Loading Rates

In the absence of site specific data, the soil / groundwater parameters, adopted for the urban catchments of the Marsden Park site, were based on the recommended parameters provided by the Department of Environment and Climate Change for areas within Western Sydney (Ref. 16). The adopted parameters are also consistent with the values recommended by BCC (Ref. 6) and are presented in Table 7.2.

Table 7.2

ADOPTED SOIL / GROUNDWATER PARAMETERS FOR THE SITE
(Source: DECC Technical Note – Ref. 16)

	Units	Urban	Non-Urban
Impervious Area Parameters			
Rainfall threshold (Roof 0.5, Road 1)	mm/day	1.4	1.4
Pervious Area Parameters			
Soil storage capacity	mm	170	210
Initial storage	% of capacity	30	30
Field capacity	mm	70	80
Infiltration capacity coefficient - a		210	175
Infiltration capacity coefficient - b		4.7	3.1
Groundwater Properties			
Initial depth	mm	10	10
Daily recharge rate	%	50	35
Daily baseflow rate	%	4	20
Daily deep seepage rate	%	0	0

The pollutant loading rates adopted for the urban catchments within the MPIP are based on the recommended parameters provided by the Cooperative Research Centre for Catchment Hydrology (Ref.17). These values are consistent with the values recommended for use by BCC (Ref. 6) and have been presented in Table 7.3.

Table 7.3

ADOPTED EVENT MEAN CONCENTRATIONS
(Source: CRCCH – Ref. 17)

	Roofs		Roads		Remaining Urban		Drainage Corridor	
Pollutant	Base Flow (mg/L)	Storm Flow (mg/L)	Base Flow (mg/L)	Storm Flow (mg/L)	Base Flow (mg/L)	Storm Flow (mg/L)	Base Flow (mg/L)	Storm Flow (mg/L)
TSS	-	20.0	-	269	15.8	141	6.03	39.8
TP	-	0.129	-	0.501	0.141	0.251	0.032	0.079
TN	-	2.00	-	2.19	1.29	2.00	0.302	0.891

7.4 Treatment Device Performance

Each element of the series of treatment practice (commonly referred to as a treatment train), as represented in the MUSIC model for the MPIP, is described below.

NOTE: *Part R Blacktown Development Control Plan 2006 (Draft)* requires that the post development average annual load of Total Hydrocarbons be reduced by 90%. MUSIC is unable to estimate load reductions for Total Hydrocarbons. However research suggests that Bio-retention systems are very effective at reducing Total Hydrocarbon loads and raingardens have been adopted as the preferred treatment strategy for hydrocarbons throughout the MPIP. However, final Total Hydrocarbon treatment shall be determined as part of the Development Approval process for each stage of the MPIP.

7.4.1 Rainwater Tanks

The impacts of the use of rainwater tanks, provided on each allotment, were modelled in the generic On-Lot Treatment strategy using the "Rainwater Tank" node with the following design assumptions:

Minimum Connected Roof Area

It has been assumed that 50% of all of the roofed areas will be directly connected to rainwater tanks. The remaining 50% of the roof area is assumed to by-pass the rainwater tanks and discharge directly to the on-lot raingarden.

Average Rainwater Tank Size

The nominal rainwater tank size adopted in the investigation was based on 100,000 litres for every 12,000 m² of site roof area. (Ref.1, GHD WCMA, July 2009)

Average Reuse

The average reuse amount adopted in the investigation was split into two components based on internal and external usage. The following amounts were based on a typical 2.0 hectare site with a 12,000 m² development:

- Average Annual Internal Water Usage (Daily Demand) 2.0 kl/day
- Outdoor (Annual Demand scaled by daily PET) 1,500 kl/yr

Consequently the average total daily reuse, adopted in the MUSIC model, has been estimated as 6.1 kilolitres per day per 2.0 ha industrial/commercial development.

7.4.2 Litter and Sediment Control Structures

Drainage systems collecting runoff from local roads and hardstand areas, throughout the MPIP, have been modelled with GPTs to remove litter and coarse sediment prior to discharge into the downstream drainage systems, bio-retention raingardens and riparian corridors. GPTs are available as inlet pit filter inserts, purpose built cast in situ systems or precast proprietary traps using either dry or wet sump storage chambers.

BCC has a preference for proprietary wet sump GPTs which use a vortex technology to separate the pollutants out of the water column. The criterion, used to assess the performance of the GPTs in the MUSIC model, was based on the credit given to vortex-type GPTs (Ref.6, p.81) i.e. Total Suspended Solids (TSS) - 70% for concentrations > 75 mg/L, and Total Phosphorus (TP) - 30% for concentrations > 0.5 mg/L. No credit was given to the GPTs capacity to remove oils, other nutrients or metals. However, if required it is possible to incorporate oil skimming or oil absorbent materials within a wet sump GPT for the purpose of removing non-emulsified, free floating oils. It is expected that the site drainage strategy would require approximately 40 major GPTs (at least one per bio-retention system and at road connections into trunk drainage systems). Wherever possible, dewatering systems should be provided to facilitate de-watering of the wet sumps. These dewatering lines must be discharged to the raingardens or some other appropriate filtration system to allow nutrients and fine particulates to be stripped out of the supernatant water. The approximate locations of the proposed GPT units are indicated on the MUSIC Model Layout at Plate 5 and included on the individual Preliminary Engineering Concept drawing for each Detention Basin.

Since the effectiveness of pollutant load removal varies between different GPT devices, the MUSIC modelling assumed the indicative pollutant removal as documented in Council's WSUD DCP for vortex-type GPT's.

7.4.3 Bio-Retention Systems (Raingardens)

Ten (10) co-located raingarden bio-retention/filtration systems are proposed throughout the MPIP. The proposed development layout facilitates the provision of co-located raingardens within the Detention Basins. Wherever possible the co-located raingardens are located off-line from the major inflows into the Detention