LANDCOM

MINTO URBAN RENEWAL PROJECT

WATER CYCLE MANAGEMENT

JULY 2005

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COMMERCIAL IN CONFIDENCE

1.0 EXECUTIVE SUMMARY

The redevelopment of the existing Department of Housing estate at Minto provides the opportunity to assess the water cycle management of the entire Minto Urban Renewal Project.

The entire spectrum of water management opportunities and constraints has been undertaken for the project. This assessment has evaluated all levels of storm intensity from the low flows created during minor storm events through to the Probable Maximum Flood (P.M.F.), an event that would occur once in every approximately 100,000 years. Similarly, the impacts on water management from the individual dwellings to the entire estate have been considered.

The opportunity for rainwater reuse and the requirements of the BASIX (Building Sustainability Index) Certificates were incorporated into the water cycle management appropriate for individual dwellings.

As part of the stormwater management the minor/major system and storm event detention opportunities and constraints have been evaluated using the Rafts model. The water cycle management proposed for the developed site includes a number of detention basins and overland flow paths. The concept designs and modelling have demonstrated that the peak flows for Council's flood planning level for the proposed development do not exceed those of the existing situation. As part of the stormwater management the minor and major system has also been evaluated and has highlighted any deficiencies in the system where upsizing of the minor piped system should be evaluated during detail design.

The proposed water quality treatment train for either the rainwater or stormwater has been assessed through the use of the MUSIC water quality model. The benefits of the rainwater reuse, bio-retention devices (swales and rain gardens) and Gross Pollutants Traps (GPT) have been assessed and incorporated in the future open space facilities. The proposal for numerous treatment facilities has enabled the system to be designed to ensure that the removal rate for pollutants is greater than the current benchmark industry standards.

INTRODUCTION

The Minto Urban Renewal Project (MURP) proposes the rejuvenation of the existing NSW Department of Housing (DOH) Minto Housing Estate. The MURP will create a new estate of 1,092 residential lots by altering the 1,030 existing cottages either by demolition (846 dwellings) or embellishment of retained cottages (184 dwellings) and creating an additional 908 residential lots.

This report details the procedures used and results obtained from analyses undertaken in developing the water cycle management to support the Master Planning Development Application (DA) for the MURP.

The purpose of the investigation is to:

- undertake a hydrologic, hydraulic and water quality assessment of the stormwater discharged from the site to demonstrate compliance with statutory requirements
- identify appropriate measures to achieve the water quality and quantity statutory requirements and determine their location and land area required to implement the recommendations
- identify existing localised flood 'hot spots' and provide recommendations to rectify the situation.

The following analyses have taken into consideration the economical, engineering, environmental and social aspects of the works. Particular emphasis has been placed on protecting the environment and enhancing the biodiversity of the receiving water bodies and environment by implementing water sensitive urban design and best management practices.

3.0 THE PHYSICAL ENVIRONMENT

3.1 THE SITE

The MURP area is approximately 94 hectares and is located about 35 km south west of the Sydney CBD and 5 km north of Campbelltown Post Office. The master plan study area is bounded by existing housing estates of Ingleburn, Bow Bowing, Minto Heights and Leumeah. The master plan area is defined between Benham Road and Durham Street to the north, the adjoining privately owned parcels to the south, Eagleview Road to the east and Pembroke Road and Townson Avenue to the west.

The site generally grades from east to west at grades varying between 0% and 18%. The eastern boundary of the master plan area, Eagleview Road follows a north-south orientated ridgeline.

The topography of the existing Department of Housing (DOH) cottage estates, with its troughs and ridges guides stormwater flows along defined overland flow paths. These overland flow paths, steep slopes and existing sub-standard stormwater system presently adversely impact upon a number of existing DOH dwellings.

The site consists of Blacktown soils over weathered shale bedrock. Typical characteristics of these soils include low fertility, tendency towards strongly acidic properties and prone to shrinkage and swelling. There are isolated pockets of filled land on the site. Most fill material is thought to have originated on the site and was deposited in an uncontrolled manner. Any site contamination is thought to be a result of activities including imported fill and herbicide use. Geotechnical investigations indicate that underground services associated with the development will be above the water table.

3.2 DATA

3.2.1 Topography

Topographic information for the catchments was obtained from aerial surveys undertaken by Quasco Pty. Ltd. in May, 2005. Portions of the site were also subject to detailed survey by Hard and Forrester Surveyors Pty. Ltd. in March, 2005.

3.2.2 Proposed Layout

The proposed road (including cross sections), lot and open spaces layout have been taken from the current proposed Master Plan documentation.

3.2.3 Rainfall Data

3.2.3.1 Rainfall Records

The water quality analysis requires historical rainfall data recorded, by a pluviograph station . The closest pluviograph recording station is Lucas Heights, situated some 12km away from the development site. Historical rainfall records for the area were obtained from the Bureau of Meteorology from the following station:

Station No.	Location	Records	Data Interval
066078	Minto	Aug 1959 – Aug 1968	Daily

3.2.3.2 Intensity-Frequency-Duration (IFD)

The design IFD data for the site was obtained from Bureau of Meteorology Coefficients for Campbelltown listed in Council's *Engineering Design Guide for Development* (2004). Probable Maximum Precipitation (PMP) was derived using the Bureau of Meteorology's Generalised Short Duration Method (2003).

A summary of the rainfall intensities derived is shown in Table 3.1 below.

Table 3.1 – Minto Rainfall Intensities (mm/hr)

Storm Duration (minutes)	Annual Recurrence Interval (years)			
	0.25 (3-month)	5	20	100
10	34.7	103	132	171
15	29.1	86.3	111	143
20	25.4	75.4	96.9	125
25	22.7	67.4	86.7	112
30	20.7	61.3	78.9	102
45	16.5	49.0	63.1	81.4
60	13.9	41.4	53.3	68.9
90	10.8	32.2	41.6	53.9
120	9.0	26.8	34.7	45.0
180	6.8	20.6	26.7	34.7
270	5.2	15.7	20.5	26.7
360	4.3	13.0	17.0	22.2
720	2.7	8.3	10.9	14.3

3.2.4 Existing Utility Services

Existing utility service locations were derived from service utility plans and site survey information for gas, electricity, sewer, stormwater, telecommunications and water.

4.0 DESIGN CONTROLS

4.1 AUSTRALIAN RAINFALL AND RUNOFF – VOLUME 1 (1997)

Prepared by the Institution of Engineers, Australia *Australian Rainfall and Runoff – A Guide to Flood Estimation* was written to "provide Australian designers with the best available information on design flood estimation". It contains procedures for estimating stormwater runoff for a range of catchments and rainfall events and design methods for urban stormwater drainage systems.

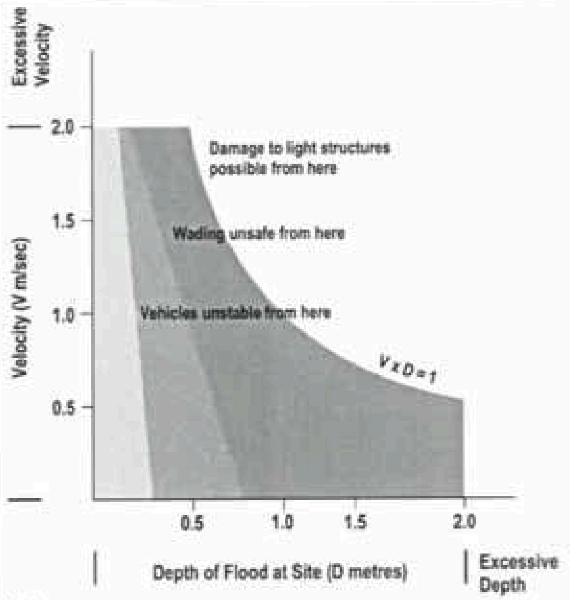
According to the document, good water management Master Planning should take into account:

- hydrological and hydraulic processes
- land capabilities
- present and future land uses
- public attitudes and concerns
- environmental matters
- costs and finances and
- legal obligations and other aspects.

4.2 NSW FLOODPLAIN DEVELOPMENT MANUAL (APRIL 2005)

The NSW Government's *Floodplain Development Manual – the Management of Flood Liable Land* (2005) is concerned with the management of the consequences of flooding as they relate to the human occupation of urban and rural developments. The manual outlines the floodplain risk management process and assigns roles and responsibilities for the various stakeholders.

The manual applies to the development, in particular in Appendix L – *Hydraulic and Hazard Categorisation* for ensuring safe overland flow paths are provided (see Figure L1 below).



Notes

1. At velocities in excess of 2.0 m/s, the stability of foundations and poles can be affected by scour. Also, grass and earth surfaces begin to scour and can become rough and unstable
2. The velocity of floodwaters passing between buildings can produce a hazard, which may not be apparent if only the average velocity is considered. For instance, the velocity of floodwaters in a model test has risen from an average of 1 m/sec to 3 m/sec between houses.
3. Vehicle instability is initially by buoyancy.
4. At floodwater depths in excess of 2.0 meters and even at low velocities, there can be damage to light-framed buildings from water pressure, flotation and debris impact.

Derived from laboratory testing and flood conditions which caused damage.

FIGURE L1 - Velocity & Depth Relationships

Source: *NSW Floodplain Development Manual, 2005* (Dept. of Infrastructure Planning & Natural Resources)

4.3 NSW DEPARTMENT OF ENVIRONMENTAL CONSERVATION

The NSW Department of Environmental Conservation (DEC), formerly the NSW Environment Protection Authority (EPA) has developed a set of guidelines known as the *Managing Urban Stormwater* (MUS) series. The set of guidelines includes:

- *Managing Urban Stormwater: Council Handbook*
- *Managing Urban Stormwater: Source Control*
- *Managing Urban Stormwater: Soils & Construction*

4.2.1 Managing Urban Stormwater: Council Handbook

The NSW Department of Environmental Conservation (DEC) encourages the principle of no net deterioration of water quality. Under its former name, the NSWEPA the DEC published *Managing Urban Stormwater: Council Handbook*, a guideline for stormwater quality from urban developments. Among its recommendations are the following pollutant removal criteria:

Table 4.1– Pollutant Removal Criteria form *Managing Urban Stormwater: Council Handbook*

Total Phosphorous	45% of the annual average load
Total Nitrogen	45% of the annual average load
Fine Particles	80% of the annual average load for particles 0.5mm or less
Suspended Solids	50% of the annual average load for particles 0.1mm or less
Litter	Retention of litter greater than 50mm for flows up to 25% of the 1 year ARI peak flow
Coarse Sediment	Retention of sediment greater than 50mm for 0.125 flows up to 25% of the 1 year ARI peak flow
Oils & Greases	For areas of concentrated hydrocarbon deposition, no visible oils or greases for flows up to 25% of the 1 year ARI peak flow

4.2.2 Managing Urban Stormwater: Source Control

The DEC guide *Managing Urban Stormwater: Source Control* recommends the control of stormwater pollution at the source, rather than more traditional "end of line" systems that are unsightly and require high levels of ongoing maintenance. In this document, Water Sensitive Urban Design (WSUD) is described as "minimising the impacts of development on the total water cycle and maximising the multiple benefits of a stormwater system". It lists the main objectives of WSUD as:

- preservation of existing topographic and natural features, including watercourses and wetlands
- protection of surface water and groundwater sources
- integration of public open space with stormwater drainage corridors, maximising public access and
- passive recreational activities and visual amenity.

The broad principles of WSUD are listed as:

- minimising impervious area
- minimising use of formal drainage systems (eg. pipes)
- encouraging infiltration (where appropriate) and
- encouraging stormwater re-use.

4.2.3 Managing Urban Stormwater: Soils and Construction

Managing Urban Stormwater – Soils and Construction (4th edition, March 2004) are guidelines produced by the NSW Department of Housing to help mitigate the impacts of land disturbance activities on landforms and receiving waters by focusing on the removal of suspended solids in stormwater runoff from construction sites.

According to the guide, effective soil and water management during construction involves the following key principles:

- assess the soil and water implications of development at the subdivision or site planning stage (including salinity and acid sulphate soils)
- plan for erosion and sediment control concurrently with engineering design and before the land disturbance begins
- minimise the area of soil disturbed
- conserve topsoil for subsequent rehabilitation/revegetation
- control surface runoff from upstream areas, as well as through the development site;
- rehabilitate disturbed lands as quickly as possible and
- maintain soil and water management measures appropriately during, and after the construction phase until the disturbed land is fully stabilised.

4.4 WSROC SALINITY CODE OF PRACTICE

The Western Sydney Salinity Code of Practice was produced by the Western Sydney Regional Organisation of Councils (WSROC) to provide information on the current best management practice for salinity management in the Western Sydney region. The document illustrates the methods used for assessing the salinity risk, recommended investigation methods and best management practices for managing salinity.

The guide lists the following key principles for salinity management:

- maintain natural water balance
- maintain good drainage
- avoid disturbance or exposure of sensitive soils
- retain or increase vegetation in strategic areas and
- implement building controls and/or engineering responses where appropriate.

4.5 BASIX REQUIREMENTS

The Building Sustainability Index (BASIX) is a web-based planning tool introduced by DIPNR to measure the performance of new residential dwellings against the sustainability indices of energy, thermal comfort and water.

The BASIX system ensures that these developments meet the following performance-based targets:

- a 25% reduction in greenhouse gas emissions, compared with the average home and
- a 40% reduction in water consumption.

The following table shows the timeline for the staged introduction of the requirements and what types of developments must comply.

Table 4.2 – Summary of the Introduction of the BASIX system.

BASIX introduced	BASIX applies to
1st July 2004	▪ all new single dwellings and dual occupancy ▪ all new boarding houses, guest houses, hostels, lodging-houses and backpacker accommodation under 300m² in Sydney local government areas except Blue Mountains, Hawkesbury and Wollondilly.
1st July 2005	▪ all new residential dwellings, including single dwellings and multi-units (eg. villas, townhouses and low-rise, mid-rise and high-rise developments.
Oct 2005	▪ all residential alterations and additions throughout NSW.
July 2006	BASIX energy target is increased to 40% reduction in greenhouse gas emissions

4.6 ANZECC WATER QUALITY GUIDELINES

The Australian and New Zealand Environment and Conservation Council (ANZECC) Paper No. 4 - *Australian and New Zealand Guidelines for Fresh and Marine Water Quality (October 2000)* includes a series of default pollutant concentrations that "trigger" the need to implement strategies to improve the water quality of the discharge. These trigger values have been set to highlight the risk of adverse effects due to excess nutrients - eutrophication, low dissolved oxygen and pH in a number of varying ecosystems. They should be used in lieu of site specific data.

The relevant trigger values for this project (Sydney Basin) include:

- Total Phosphorous 0.025mg/L
- Total Nitrogen 0.35mg/L

4.7 DRAFT CAMPBELLTOWN (SUSTAINABLE CITY) DEVELOPMENT CONTROL PLAN 2004

An integral part of the Master Planning process for the MURP the *Draft Campbelltown (Sustainable City) DCP* 2004 provides the necessary controls for the redevelopment of the site. Particular water management requirements include:

- compliance with Council's Engineering Design Guide for Development
- compliance with the demands of the BASIX system

- adoption of the principles of WSUD (including a water cycle management plan).

4.8 CAMPBELLTOWN CITY COUNCIL ENGINEERING DESIGN GUIDE FOR DEVELOPMENT

Council's *Engineering Design Guide for Development* sets out their requirements for the design of stormwater drainage for urban and rural areas. The *Engineering Design Guide* outlines the broad objectives of the policy of:

- retention of the natural stormwater system where possible
- a high level of safety for all users
- acceptable levels of amenity and protection form the impact of flooding
- consideration given to the effect of floods greater than the design flood
- a controlled rate of discharge to reduce downstream flooding impacts
- protection of the environment from adverse impacts as a result of the development
- maintenance of and enhancement of the regional water quality
- sustainability of infrastructure
- economy of construction and maintenance.

The policy also provides detailed requirements for the hydrologic and hydraulic design and analyses of the proposed water management system including standard calculation factors and drawings.

5.0 WATER MANAGEMENT OPTIONS

5.1 WATER QUANTITY MANAGEMENT

5.2.1 Major/Minor Drainage System

The major/minor approach to street drainage is the recognised drainage concept for urban catchment within the Campbelltown City Council local government area.

"The minor system is the gutter and pipe network capable of carrying runoff from minor storms. The major system comprises the many planned and unplanned drainage routes which convey runoff from major storm to trunk drains, sometimes causing damage along the way." [1] The major system also exists to cater for minor system failures

The overall aim of the major/minor approach is to ensure that hazardous situations do not arise on streets and footpaths, and that all buildings in urban areas are protected against floodwaters."[1]

5.2.2 Detention Basins

Detention basins temporarily detain stormwater runoff from urbanised catchments with the aim of reducing and attenuating the peak discharge at the outlet to reduce the risk of flooding to downstream lands as a result of a development. The storage volume may be above, or below ground while discharges are accurately controlled via an orifice or throttled outlet pipe.

5.2.3 Rainwater Tanks

Rainwater tanks are sealed tanks designed to retain rainwater collected from roofs for subsequent re-use for toilet flushing, laundry or garden watering. Due to the uncertain nature of the rainwater supply, tanks are usually connected to mains water for "top-ups" in dry weather conditions.

5.2 WATER QUALITY MANAGEMENT

5.2.1 Infiltration Devices

Consisting of a gravel bed and usually greater than 600mm depth, an infiltration device primarily removes sediments and attached pollutants (including nutrients, metals and other soluble pollutants) by filtration. They may be installed as conventional below ground trenches backfilled with filter media or beneath permeable paving and are designed to capture and treat the "first flush" volume of a rainfall event.

[1] Australian Rainfall and Runoff 1987

5.2.2 Bio-Retention Systems

Bio-retention systems are similar to infiltration devices, but typically contain an extended detention zone above the gravel bed in the order of 100-300mm in depth and can contain water tolerant plant species to facilitate additional nutrient removal. Sediments and attached pollutants (including nutrients, metals and other soluble pollutants) are removed by filtration through the vegetative surface layer and filter media below.

They are often constructed as linear swales, but may also be designed as larger "raingardens" and are designed to capture and treat the first flush volume.

5.2.3 Vegetative Filter Strip

Vegetative filter strips are relatively flat, open landscaped areas upstream of stormwater inlets that promote "sheet flows" reducing velocities and removing litter, vegetative matter and sediments by filtration through the vegetation. Some nutrient and other pollutants that are bound onto sediment particles are also removed by this filtration process.

5.2.4 Constructed Wetlands

Constructed wetlands are permanent water bodies, typically consisting of a deep water zone for sedimentation and a shallow water zone containing macrophytes. Pollution removal is achieved via extended detention times, sedimentation, root filtration, nutrient uptake by the plants and nutrient stripping by bio-films that are cultivated within the root mass.

5.2.5 Gross Pollutant Traps

"Gross Pollutant Trap" is a term applied to either in-situ, or proprietary units that remove litter, vegetative matter and sediment. Although the numerous units fall under the under the one umbrella of gross pollutant traps, the actual mechanics of the different units vary, as do the achievable pollutant removal rates. GPTs come in a range of sizes, with the larger units able to effectively treat large catchment areas and high flow rates. They are usually sized based on their maximum treatable flow being equal to, or greater than the 3-month Annual Recurrence Interval (ARI) storm event (typically 50% of the 1-year ARI storm event) of the upstream catchment.

Table 5.1 – Typical Pollution Removal Rates of Water Quality Treatment Devices

Device	Coarse Sediment	Fine Sediment	Free Oil & Grease	Nutrients	Metals
Infiltration Devices*	50-80%	30-50%	30-50%	30-50%	30-50%
Bio-Retention Systems*	80-100%	30-50%	30-50%	30-50%	30-50%
Vegetative Filter Strips	50-80%	10-50%	10-50%	10-50%	10-50%
Pit Inserts	80-100%	40-60%	40-60%	40-60%	40-60%

Gross Pollutant Traps	60-90%	10-50%	-	10-50%	10-50%

* Assumes pre-treatment of stormwater runoff to remove gross pollutants and to minimise ongoing maintenance.

Source: WSUD – *Technical Guidelines for Western Sydney* (2004)

In January of 2004, the Cooperative Research Centre for Catchment Hydrology released *Structural Stormwater Quality BMP Cost – Size Relationship Information from the Literature* which compared the capital and ongoing costs of various water quality treatment devices. Table 5.2, below summarises the findings, which are nominated in cost per hectare of treated area unless noted otherwise.

Table 5.2 – Typical Costs of Water Quality Treatment Devices

Device	Capital Cost	Maintenance Cost (0-2yrs)	Maintenance Cost (+2yrs)	Land Take
Constructed Wetlands	$12,000 – $18,000	$250 - $400	$150 - $250	Large
Infiltration Devices	$100 - $140 [1]	$5 - $10 [1]	$5 - $10 [1]	Med. – Large
Bio-Retention Systems	$150 - $200 [1]	$2 - $5 [1]	$2 - $5 [1]	Med.
Vegetative Filter Strips	$20 - $50 [2]	$1 - $5 [2]	$1 - $5 [2]	Med.
Pit Inserts	$500 - $900 [3]	$200 - $300 [3]	$200 - $300 [3]	None
Gross Pollutant Traps	$4,500 – $7,000	$350 - $550	$350 - $550	Small

[1] Cost nominated is per linear metre of device (based on 1m wide x 1m deep) and does not include pre-treatment devices.

[2] Cost nominated is per square metre of area (costs vary, depending on type of vegetation selected)

[3] Cost nominated is per Insert.

6.0 WATER QUANTITY MODELLING

A hydrologic model of the catchment was formulated using the RAFTS software package and used to produce design discharges as discussed in the following sections. RAFTS is a non-linear runoff routing model that generates runoff hydrographs from rainfall.

6.1 MODEL PARAMETERS

The user data inputs required by RAFTS include catchment areas and slopes, pervious and impervious areas, IFD rainfall statistics and hydrological losses.

Rainfall intensities provided by Campbelltown City Council (2004) were used as described in Section 3.2.3.2. Other hydrologic parameters were adopted as specified in Appendix B of Council's *Engineering Guide for Development* (2004) and are listed in Table 6.1 below.

Table 6.1 – RAFTS Model Parameters

Parameter	Value
Pervious Area Initial Loss	15 mm
Pervious Area Continuing Loss	2.5 mm/hour
Impervious Area Initial Loss	1.0 mm
Impervious Area Continuing Loss	0.0 mm/hour
B-multiplier (Bx)	1.0
PERN	0.025

6.2 RAFTS CATCHMENTS

6.2.1 Post-developed Catchment

The post-developed development area can be divided into 3 main catchments:

- The northern catchment, generally to the north of Ben Lomond Road, that drains towards the corner of Guernsey and Benham Roads;
- The small eastern catchment which drains towards Eagle View Road; and
- The southern catchment which drains towards the intersection of Pembroke Street and Ben Lomond Roads. This catchment consists of two main drainage systems; one which discharges from Townson Road into an open channel in Rose Park, and the other which generally follows Ben Lomond Road.

In developing the RAFTS model, the catchment was subdivided into 65 sub-catchments ranging in size from 0.21 to 5.96 hectares. Each sub-catchment was determined from the proposed Master Plan road layout and site grading. Figure 4 shows the sub-catchment and RAFTS node network. Catchment areas, slopes and percentage impervious portions are tabulated in Appendix B.

The sub-catchment in the vicinity of Rose Park, draining from Styles Crescent to Townson Avenue was not included in the model as no existing contour information was available to determine the sub-catchment boundary. This catchment is outside of the redevelopment area but contributes to the total flow in Townson Avenue.

The percentage impervious values of 75% and 35% for new residential and rural residential respectively were adopted from the recommended range of values in Council's *Engineering Guide for Development* (refer table 6.2). The split catchment option was used for separately modelling the pervious and impervious fractions of the catchment. Catchment details are provided in Appendix B.

Table 6.2 – Percentage Impervious Areas for Various Land Uses

Land Use	Recommended % Impervious	Adopted % Impervious
Rural Residential	20% - 60%	35%
New Residential	70% - 90%	75%

Source: Campbelltown City Council's *Engineering Design Guide for Development* (2004)

6.2.2 Existing Catchment

The pre-developed catchment RAFTS model was based on a model developed by Hyder (2003). Extra catchment area as added so that the existing model was consistent with the post-developed model as follows:

- A new catchment was added for Townson oval which had not been included in the existing model;
- A new catchment was added for the portion of the Campbellfield area that drains to Ben Lomond Road. Although this is not part of the redevelopment area, it does contribute to peak flows in the Ben Lomond Road drainage system.
- A new catchment was added for part of Campbellfield Primary School which drains towards Townson Road.
- Sub-catchment S29 and S30 were extended to included runoff from the western side of Townson Road.

Figure 2 shows the pre-developed sub-catchment division.

A comparison of the post-developed and existing sub-catchment areas in Appendix B shows that the total area of the southern catchment is about 5% smaller for existing model compared to the post-developed model. There is no obvious reason for this discrepancy. It also noted that the percentage impervious adopted for those parts of the catchment that are not being redeveloped is lower than that in the post-developed model. The net result of these discrepancies is that pre-developed flows will be under-estimated. This ensures a conservative assessment and will increase the size of detention basin required to reduce post-developed flows to pre-developed levels.

Some of the hydrologic parameters used in the Hyder model including rainfall intensities, B-multiplier, and PERN were inconsistent with Council's *Engineering Guide for Development* (2004). These values were changed to those specified by Council to enable an accurate comparison to the post-developed model for this proposal.

6.3 MANAGEMENT STRATEGIES

6.3.1 Major/Minor System

The proposed drainage system will be major/minor system. The (minor) piped drainage system is to be designed to control nuisance flooding and enable effective stormwater management for the site. Council's standard requires that the minor system be designed for a minimum 5 year ARI.

The major drainage system incorporates overland flow routes through proposed roads and has been assessed against the 100 year ARI design storm event, with general safety and flooding issues being addressed for events in excess of the 100 year ARI storm. If the major system cannot meet the safety and flooding criteria, the capacity of the minor system will need to be increased.

In order to assess the adequacy and safety of the major drainage system, channel routing links were used in RAFTS to model flowpaths along roads and pathways, while lagging links were used elsewhere. Although negligible attenuation is expected along the roadways, channel routing was used in order to assess flow depths and velocities in major storm events. The channel cross-sections were based on the proposed road cross-sections in the Master Plan. Low flow pipes capacities in the channel links were set to the 5 year ARI discharge, less 20% to account for pit blockage. The future post-developed pipe drainage system may be designed with greater capacity than this. As well, the report by Hyder (2003) suggests that the existing piped drainage in Guernsey Road and Townson may have a capacity in excess of the post-developed 5 year ARI flow. The capacity of the existing drainage system needs to be assessed at the detailed design stage.

6.3.2 Detention Basins

Detention Basins were included in the model to ensure that the development does not increase downstream flows, which could potentially have adverse impacts on downstream properties. All basins were designed to be a maximum of 1.2 metres deep to avoid safety fencing and thus retain the recreational value of the open spaces that they occupy. All basins were modelled with a linear stage-storage relationship and used the default discharge equations within RAFTS. More detailed modelling of the basins can be undertaken at the design stage when sufficient details are available to derive more accurate stage-storage and stage-discharge relationships.

The volumes required were refined by manual iteration until results showed that flows from the post-developed redevelopment did not exceed the pre-developed conditions. The proposed basins and their volumes are shown in Table 6.3.

Table 6.3 – Modelled Detention Basins

Location	RAFTS Node	Volume (m^3)
Scarborough Park	6.05	2,200
Redfern Park	2.06	1,900
Benham Oval	4.06	5,000

6.4 RESULTS

6.4.1 Design Discharges

Design discharges were produced for a range of ARIs including the 3-month, 2, 5, 20, 50, and 100-year ARI events and the Probable Maximum Precipitation (PMP). Storm durations ranging from 15 minutes to 3 hours were modelled for each ARI, using AR&R temporal patterns, in order to identify the peak flow for each sub-catchment node. The design discharges for all of these events are shown in Appendix C.

6.4.2 Comparison of Post-developed and Existing Flows

The 100-year ARI flows for the post-developed development are compared with pre-developed conditions in Table 6.4.

Table 6.4 - Comparison of Existing and Post-developed 100 year ARI Flows

Node		Location	Flow (m^3/s)	
Post-developed	Existing		Post-developed	Existing
4.07	N31	Outlet of Northern Catchment	19.35	22.7
4.61	N22	Guernsey Road near Mortimer St	10.0	11.3
5.03	S32	Intersection of Townson Avenue and Ben Lomond Road	8.5	7.8
6.07	S29	Townson Avenue near Footbridge	11.8	15.2
6.33	S28	Townson Avenue near Jenner Way	5.1	4.6
7.12	S31	Townson Avenue	12.6	16.4

		at Rose Park		
South	All South	Total of Southern Catchment	20.8	22.6

The results show that the total flows at the downstream nodes and along the Townson Avenue and Guernsey Road are generally lower in the post-developed scenario than for the pre-developed situation.

Although some isolated flows in the Ben Lomond Road drainage system have increased by up to 11%, the total flows for the southern catchment have decreased by 8%. It is also evident that the northern catchment flows have decreased by 15%.

The results proposed redevelopment will not have an adverse impact on downstream property as a result of increased flows.

6.4.3 Overland Flow Depths and Velocities

The 100-year ARI flow depths and velocities are tabulated in Table 6.5. These depths and velocities are based on the assumption that the minor, piped drainage system conveys 80% of the 5-year ARI flow (this allows for some pit blockage). Table 6.5 also compares the depths and velocities against the following criteria:

- A velocity-depth product of 0.4 m^2/s as recommended in AR&R
- Figure L1 of the *NSW Floodplain Development Manual*
- Campbelltown Council's *Engineering Design Guide for Developments* requirement that depths are less than 50mm above the top of kerb.

Generally, at the upstream end of the catchments the velocity-depth product is within the above mentioned limits, but as flows increase down catchments the safety limits are exceeded. Although flowpaths are adequate to convey major flows, they generally do not meet the safety criteria. The major constraint on conveyance of the roads is the narrow carriageway widths. To enable the overland flows to be reduced the piped drainage system will need to be designed to a higher ARI than the 5 year ARI for the flowpaths identified on Figure 5. The required ARI for the pipe drainage system at these locations will be confirmed at the detailed design stage.

Nodes 2.02 to 2.04 represent a road with a central bio-retention swale. Flows within the swale do not meet the safety criteria, but depths and velocities on the vehicular pavement adjoining the swale do meet the safety criteria. Intermittent kerb will be provided along the swale to prevent vehicles from entering the swale while pedestrian access could be limited by the implementation of suitable traffic management measures.

6.4.4 Probable Maximum Flood

The 15 minute duration PMP storm produced the highest discharges. Estimated PMF discharges are up to 8 times the 100 year ARI flows. Detention Basin spillways will be designed at detailed construction certificated stage to convey half the PMF discharge.

The simple channel routing in the RAFTS model is inadequate to assess flood behaviour with such high flows.

While it is recognised that an appreciation of the impacts of the PMF must be considered during the development assessment stage the critical parameters are the provision for evacuation and the structural integrity and safety of houses or other buildings subjected to high depth and velocities. It is accepted that the SES regional evacuation plans would address any need for evacuation. The structural integrity of any building impacted upon by the PMF event, needs to be addressed as part of the development application for the individual buildings.

Table 6.5 - 100 year ARI Overland Flow Depths and Velocities

Node	Location	Velocity (m/s)	Depth (m)	CRITERIA		
				AR&R D x V < 0.4	Fig. L1 of FMM	<50mm above kerb
1.01	Proposed Road	3.07	0.110	Yes	No	Yes
2.01	Bio-Swale	1.61	0.177	Yes	Yes	Yes
2.02	Bio-Swale	1.59	0.419	Yes	Yes	Yes
2.03	Bio-Swale	1.12	0.483	Yes	Yes	Yes
2.04	Bio-Swale	1.42	0.465	Yes	Yes	Yes
2.06	Proposed Road	2.00	0.252	No	No	No
2.07	Proposed Road	2.04	0.253	No	No	No
2.08	Guernsey Ave	1.86	0.278	No	No	No
2.10	Proposed Road	2.13	0.079	Yes	Yes	Yes
2.11	Proposed Road	1.52	0.141	Yes	Yes	Yes
2.41	Proposed Road	1.69	0.081	Yes	Yes	Yes
2.42	Proposed Road	2.35	0.097	Yes	No	Yes
4.02	Proposed Road	2.17	0.214	No	No	No
4.03	Proposed Road	1.06	0.363	Yes	No	No
4.04	Proposed Road	1.78	0.288	No	No	No
4.12	Existing Footpath	2.28	0.264	No	No	N.A.
4.13	Proposed Road	3.38	0.176	No	No	Yes
4.20	Proposed Road	1.41	0.085	Yes	Yes	Yes
4.50	New Footpath	0.76	0.055	Yes	Yes	N.A.
4.60	Proposed Road	0.98	0.098	Yes	Yes	Yes

4.61	Guernsey Ave	1.47	0.302	No	No	No
4.70	Guernsey Ave	1.99	0.275	No	No	No
4.90	Guernsey Ave	1.51	0.306	No	No	No
5.01	Proposed Road	1.30	0.050	Yes	Yes	Yes
5.02	Townson Rd	1.22	0.062	Yes	Yes	Yes
6.01	Proposed Road	1.14	0.133	Yes	Yes	Yes
6.02	Proposed Road	1.89	0.140	Yes	No	Yes
6.03	Proposed Road	3.15	0.185	No	No	Yes
6.05	Proposed Road	3.00	0.250	No	No	No
6.06	Proposed Road	2.29	0.289	No	No	No
6.07	Townson Rd	1.85	0.323	No	No	No
6.11	Proposed Road	3.28	0.146	No	No	Yes
6.13	Proposed Road	1.42	0.256	Yes	No	No
6.30	Proposed Road	2.02	0.149	Yes	No	Yes
6.31	Proposed Road	2.96	0.144	No	No	Yes
6.32	Proposed Road	1.94	0.194	Yes	No	Yes
6.33	Townson Rd	2.77	0.185	No	No	Yes
6.34	Townson Rd	2.75	0.195	No	No	Yes
7.01	Proposed Road	1.31	0.085	Yes	Yes	Yes
7.02	Proposed Road	2.80	0.263	No	No	No
7.10	Townson Rd	2.00	0.308	No	No	No
7.11	Townson Rd	1.96	0.313	No	No	No
8.01	Proposed Road	2.43	0.124	Yes	No	Yes
8.20	Proposed Road	2.41	0.138	Yes	No	Yes
8.70	Proposed Road	2.30	0.107	Yes	No	Yes
8.71	Proposed Road	2.29	0.134	Yes	No	Yes