STORM
Consulting

Water Sensitive Urban Design
Mary's Mount, Goulburn

Report Prepared For

Goulburn City Council

Prepared by:

STORM Consulting Pty Ltd

August 2003

Suite 3, 6 West Street Pymble NSW 2073 Australia
Tel: (02) 9499 4333 Fax: (02) 9499 4311
Website: www.stormconsulting.com.au

STORM Consulting Pty Ltd

Document Verification

Job title	Mary's Mount	Job number	G224
Document title	**Water Sensitive Urban Design at Mary's Mount, Goulburn**		

Revision	Date	Filename	WSUD Report 24 Sept Version 5		
4	24/09/03	Description	Final Report. Table 11 amended to show only top widths and drawings P01 and P02 amended for top widths.		
			Prepared by	Checked by	Approved by
		Name	L Dallmer Roach	Mark Liebman	Rod Wiese
		Signature			

Issue Document Verification with Document ✓

This report takes into account the particular instructions and requirements of our Client. It is not intended for and should not be relied upon by any third party and no responsibility is undertaken to any third party.

EXECUTIVE SUMMARY

Approximately 410 hectares of urban development is planned for Mary's Mount on the north west side of Goulburn. This area is within the Goulburn Local Government Area and is part of the SCA drinking water catchments defined by SEPP 58.

Goulburn Council (Council) has engaged Storm Consulting Pty Ltd (STORM) to undertake stormwater and water cycle investigations and make recommendations specific to developing the Mary's Mount area so that Council may prepare an appropriate Development Control Plan (DCP) that will satisfy its own requirements and those of the Sydney Catchment Authority (SCA).

STORM Consulting has undertaken a wholistic approach with the water sensitive urban design planned and documented in this report.

STORM developed a peak flow hydrological model (XP-RAFTS) to determine the changes to the peak flows that would arise after development of Mary's Mount. Due to partial area effects there is no significant or notable changes to the 100 year ARI post development peak flow except minor increases in two areas where communal detention may be required. These two areas include the proposed development adjacent to Crookwell and Mary's Mount Road (owned by Mr Toparis) and the proposed developments that will drain to the piped stormwater system that runs beneath the playing field of Mulwaree High School.

The flow assessment study is considered to be conservative as it ignores the effects that rainwater tanks have on peak storm flows. On a small scale (8 hectare) model constructed for a typical development within the whole DCP area, the effect of rainwater tanks on reducing peak flows was evident on all storms up to and including the 100 year ARI.

The flow assessment study has enabled minimum creek corridor widths to be determined. These minimum widths represent the minimum areas required for flood conveyance. The study assumes that formation of a "natural" trunk drainage system would occur in areas that currently do not have any identifiable drainage characteristics. STORM has recommended that these creek corridors be vegetated to ensure that long term erosion problems do not develop leading to a decline in water quality.

A Section 94 Contribution Plan will enable Council to revegetate these creek corridors. There is a nexus between the revegetation work and mitigation of water quality impacts arising from development everywhere in the catchment.

Some of the creek corridors will require earth works to form the channels to enable all developed land to remain flood free in a 100 year ARI storm event. Forming the creek channels will enable more land to be developed. These works are therefore to be undertaken by developers as there is no nexus between the channel formation work and the rest of the catchment.

The Department of Infrastructure Planning and Natural Resources have together with STORM and Council identified the extent of the creek corridors that will be administered by DIPNR. These areas are to be revegetated by Council through Section 94 Contributions. These areas can be revegetated as soon as possible along with the proposed creek corridors that are located within Mulwaree High School.

The stormwater treatment train that is recommended for adoption includes:

- Source controls, including plumbed rainwater tanks (and not infiltration).
- Conveyance Controls are to include grassed swales and bioretention trenches.
- There is no need for any end of pipe controls or communal detention systems however due to the relatively untested assumptions made in this planning study, contingent areas have been set aside that may be used for the construction of end of pipe treatment controls should they be required.

Estimates of the predevelopment and post development water quality have found that the post development water quality is likely to be slightly better than the predevelopment water quality. This statement is based on the assumption that all the recommendations included in this report are put into place. This should satisfy the development requirements of the SCA.

Further studies that need to be undertaken have also been identified in this report. The cost to upgrade three culverts under Mary's Mount Road has not been able to be assessed and nominal amounts of $100,000 per culvert has been included in the cost estimates for Section 94 purposes. The estimated costs for undertaking the additional studies ($120,000) have also been included in the estimates for the Section 94 Contributions plan.

The total estimated costs for Section 94 Contributions would be.$4,563,000. This may equate to a cost of about $2,535 per lot, assuming 1800 lots. Council may provide some reductions to the Water Service Charges for reductions to head works achievable when rain water tanks are adopted.

The development at Mary's Mount presents an exciting opportunity to undertake an excellent example of Water Sensitive Urban Design.

TABLE OF CONTENTS

Attachments

1.0 INTRODUCTION

1.1. PREAMBLE

Goulburn Council (Council) has engaged Storm Consulting Pty Ltd (STORM) to undertake investigations and make recommendations specific to developing Mary's Mount area so that Council may prepare an appropriate Development Control Plan (DCP) that will satisfy Sydney Catchment Authority (SCA).

1.2. BACKGROUND

Approximately 410 hectares of urban development is planned for Mary's Mount on the North West side of Goulburn. This area is within the Goulburn Local Government Area and is part of the SCA drinking water catchments defined by SEPP 58. Council is currently preparing a DCP for the Mary's Mount Release Area and to intends recover the cost of these works under a Section 94 Contribution Plan.

Given that the development is located within the highly sensitive SCA catchments there is a great need to protect those catchments from the impacts of urban development. It is well documented that urban development can lead to the degradation of water quality in receiving waters and have a dramatic effect on the hydrological regime. Construction of impervious surfaces reduces natural stores of water in the soil profile. This leads to significant increases in:

- the frequency of runoff (often by a factor of 10);
- the peak flows for runoff events; and
- the volume of runoff events.

Traditional approaches to stormwater management would implement either on-site or communal detention which reduces peak flows and, to some degree, improves water quality by limiting erosion related to high velocities. However, detention has no impact on reducing the volume and frequency of runoff which may result in unsustainable consequences for the downstream water environments. The impact of increased flows is likely to lead to an alteration of the stability of receiving waters and local creeks that convey flows toward the Sydney Water drinking water off-takes.

Another traditional approach may be to pipe and concrete various components. Although hydraulically efficient, these materials do not allow for the natural attenuation of pollution that occurs in both the soil and in natural creeks systems.

Clearly, if one wishes to address the issue of water management on new developments then a departure from the traditional response is required. A holistic water cycle management plan may help to mitigate the impacts of the urban development to acceptable levels. This report describes a holistic water cycle management plan that will identify mitigation measures to be put in place for the Mary's Mount Development.

It should also be understood that holistic water cycle management encompasses a policy that shifts some of the risk for water management from Council to the ultimate land user. This will have the secondary effect of reduced Section 94 Contributions and reduced development risk. Another major benefit of imposing a holistic water cycle management regime is that it reduces Council's maintenance burden and shares it equally with the land users.

1.3. SCOPE OF REPORT

STORM has been commissioned to undertake 4 key tasks associated with the strategic planning for water sensitive urban design at Mary's Mount. These include:

Task 1 – Rainwater Harvesting Analysis

Task 2 – Trunk Drainage Concept Development

Task 3 – Water Quality Planning and Modelling

Task 4 – Reporting

Each of these tasks are detailed below, however, it will culminate into a report describing the holistic water cycle management plan. It will identify mitigation measures to be put in place for the Mary's Mount Development and be supported by a design drawing. This information will then be incorporated into a DCP by Council.

1.4. CAUTIONARY NOTE ON THE USE OF DATA IN THIS REPORT

The flow rates shown in this report apply to specific sections of Mary's Mount and are based on a number of critical assumptions. At no point should these rates be adopted to guide a design in any way or reduce the responsibility to carefully undertake the requisite design calculations.

Every, individual, proposed development on Mary's Mount would still need to be supported with a detailed assessment of the flows based on the design conditions relevant to that proposed development.

Whilst this report does not recommend communal detention, the need to maintain post development flows the same as predevelopment flows in all flow events up to the 100 year ARI must be demonstrated by each developer for each development. In every case, different constraints will guide the design and in some cases, for example areas draining to existing pipe work at Mulwaree Shire High School, communal detention may well be required to ensure that flows do not exceed existing pipe or channel capacities. In such cases developers should be encouraged by Council to explore a range of alternatives, leading to an optimum response.

2.0 LOCAL CONDITIONS

2.1. HYDROLOGY

Rainfall data for Mary's Mount has been obtained from the Bureau of Meteorology and is summarised below in Table 1. Approximately 30 years of good quality data was used that extended from 1972 to 2002.

Table 1 - Rainfall statistics for Goulburn (Progress Street)
Source: the Bureau of Meteorology.

Statistic	Annual Average (mm)
Mean monthly rainfall – mm	672.7
Median (5th decile) monthly rainfall - mm	651.2
9th decile of monthly rainfall - mm	854.3
1st decile of monthly rainfall - mm	420.3
Mean no. of raindays	127.2

The average annual evaporation rate for Goulburn is 1289mm year. Clearly Goulburn is in a net evaporation area.

2.2. SOILS

Soils were assessed on-site through the observation of exposed soil profiles (e.g. road-side cuttings, pits/trenches excavated in association with adjacent sub-division development). Soil dispersion properties were tested using a modified Emerson Aggregate Test and generally found not to be dispersive.

According to Goulburn City Council's Stormwater Management Plan (Goulburn Council, 2000), Goulburn's soil profiles generally have poor drainage characteristics. Soil properties are described as having moderate permeability, moderate topsoil erodibility, low subsoil erodibility and moderate shrink-swell potential.

Mary's Mount DCP Boundary

Bullallita Soils

Monastry Hill Soils

Sooley Soils

Figure 1 - Soil Landscape for Goulburn

Source: Goulburn Soil Landscape Series, Sheet S1 55-12, Soil Conservation Service of NSW.

Figure 1 shows the specific soil landscapes within the Mary's Mount DCP area taken from the Soil Landscape Series for Goulburn. The study area includes two types of soil landscapes which are classified as Sooley and Monastery Hill soil landscapes.

Both the Sooley and Monastery Hill soil landscapes have a complex soil distribution and associated undulating to rolling low hills landforms with slopes between 2-10%. Approximately 90% of the landscape has been cleared for rural activities eg cattle and sheep grazing and growing fodder crops. Vegetation in the area varies slightly between soil landscapes but generally consists of remnant Yellow Box, Blakely's Red Gum, Brittle Gum and Apple Box trees and introduced pastures as ground cover.

The Sooley soil landscape is characterised by SCA and DLWC (SCA and DLWC, 2002) as having localised poor drainage, water logging, high water table and shrink swell subsoils. This landscape is also characterised as having localised gully erosion, salinity and seepage scald hazards which has occurred as a result of vegetation clearing over the years.

Land management recommendations for this soil landscape suggest moderate limitations for urban development due to localised salinity and shrink swell subsoils. **Infiltration in this landscape may be limited in certain areas due to poor drainage, low permeability and salinity.**

The Monastery Hill soil landscape is characterised by SCA and DLWC as having localised shallow soils and shrink swell subsoils where rock outcrops occur. Topsoil in this landscape is a sandy clay loam with high permeability which is susceptible to structural decline, however the soils beneath the topsoil vary in permeability and acidity.

Land management recommendations for this soil landscape suggest low to moderate limitations to urban development due to localised rock outcrops and shrink swell soils. High groundcover is suggested to reduce the likelihood of the structural decline of the topsoil.

Disturbance of either of the soil landscape surfaces for urban development will create significant short term erosion problems which is of particular significance due to Mary's Mount's close proximity to the Wollondilly River. Sediment and erosion control will need to be rigorously managed in the area to prevent gullying and sheet erosion.

3.0 REGULATORY REQUIREMENTS & OBJECTIVES

3.1. COUNCIL REQUIREMENTS

Goulburn Council (2002) in its Stormwater Management Plan (SMP) outlines Council's broader objectives with regards to new developments and stormwater quality management. Relevant objectives contained in the SMP include:

- Urban development should only occur in areas where a land capability study has indicated that area is physically capable of supporting the proposed type of development without causing significant soil erosion, land slip or water pollution;
- Water-sensitive urban design principles should be incorporated in the development;
- A strong emphasis should be placed on the management of stormwater at or near the source. This applies to both the quantity and quality of stormwater;
- The reuse of stormwater for non-potable purposes should be encouraged. This should be undertaken in the context of total water cycle management;
- Where appropriate "Natural" channel designs should be adopted in preference to grass or concrete lined floodways, unless there are specific requirements for a lined channel;
- Site specific studies should be undertaken to identify the sustainable pollutant export from the development site. In the absence of these studies, there should be not net increase in the average annual load of pollutants critical to the health of receiving water ecosystems and human health, under post-development conditions. If this cannot be achieved, an 'offset' scheme could be developed where contributions are obtained from developers for rectifying existing problems affecting the 'health' of watercourse and water bodies within the catchment;
- Soil and water management practices should be implemented during the construction phase of the development to minimise soil erosion and sediment export;
- The applicable ANZECC water quality guidelines should be met for water bodies receiving stormwater runoff that is used for water supply purposes;
- The impact of urban stormwater on weed propagation and growth in bushland should be minimised;
- The impact of stormwater on public health and safety should be minimised;
- Opportunities for the multiple use of drainage facilities are to be encouraged, to the degree that they are compatible with other management objectives;
- The visual amenity and landscaping opportunities of stormwater systems are to be optimised;
- Peak flows from the development site should be attenuated so that there is no net increase in flows for event from the 1 year to 100 year average recurrence interval;

- The risk of property damage due to stormwater and groundwater should be minimised;
- The disruption to traffic and pedestrians during frequent storm events should be minimised;
- Protect and maintain natural wetlands, watercourses and riparian corridors; and
- Use of vegetated flow paths maximised.

Site-specific objectives detailed by Goulburn Council (2002) are as follows:

- stabilise creeks and prevent erosion;
- enhance biodiversity;
- improve user visual amenity;
- restore riparian ecosystems;
- employ practical state of the art stormwater management principles;
- provide multi-functional drainage and recreational areas.

Quantitative and qualitative stormwater management objectives that were generated for new development through the stormwater management planning process are presented in Tables 2 and 3 below.

Table 2 - Quantitative Stormwater Objectives for New Developments
Source: Goulburn's Stormwater Management Plan

Pollutant/Issue	Retention Criteria
Coarse Sediment	80% of average annual load for particles ≤ 0.5mm
Fine Particles	50% of average annual load for particles ≤0.1mm
Total Phosphorus	45% of average annual pollutant load
Total Nitrogen	45% of average annual pollutant load
Litter	90% of average annual litter load > 5mm
Hydrocarbons, motor fuels, oils and grease	90% average annual pollutant load

Table 3 - Qualitative Stormwater Objectives for New Developments
Source: Goulburn Council SMP (2002)

Pollutant/Issue	Management Objective
Runoff Volumes	Impervious areas connected to the stormwater drainage system are minimised.
	Reuse of stormwater for non-potable purposes maximised.
Stormwater Quality	Use of vegetated flow paths maximised.
	Use of stormwater infiltration 'at source' where appropriate.
Riparian Vegetation and Aquatic Habitat	Protect and maintain natural wetlands, watercourses and riparian corridors. All natural (or unmodified) drainage channels within the site which possess either: (a) base flow (b) defined bed and/or banks; or (c) riparian vegetation are to be protected and maintained. "Natural" channel design should be adopted in lieu of floodways in areas where there is no natural (or unmodified) channel.
Flow	Alterations to natural flow paths, discharge points and runoff volumes from the site to be minimised. The frequency of bank-full flows should not increase as a result of development. Generally, no increase in the 1.5 year and 100 year peak flows.
Amenity	Multiple use of stormwater facilities to the degree compatible with other management objectives.
Urban Bushland	Impact of stormwater discharges on urban bushland areas minimised.

3.2. SYDNEY CATCHMENT AUTHORITY REQUIREMENTS

SEPP 58 requires that the SCA assess and consent to development within the drinking water catchments. The SCA is required to assess the development proposal in relation to Clause 10 of SEPP 58 – matters for consideration, specifically:

(a) Whether the development or activity will have a neutral or beneficial effect on the water quality of rivers, streams or groundwater in the hydrological catchment, including during periods of wet weather;

(b) Whether the water quality management practices proposed to be carried out as part of the development/activity are sustainable over the long term; and

(c) Whether the development/activity is compatible with relevant environmental objectives and water quality standards for the hydrological catchment when these objectives and standards are established by Government.

Clearly there is an inconsistency between Goulburn Council (2002) objectives and the objectives of the SCA. Council's objectives are load based not outcome based. The SCA's objectives for new developments would override those of Council's and so it is suggested that Council objectives do not become the measure by which this water cycle management plan is to be measured.

The SCA does not have prescribed distances required to buffer natural watercourses from sewered urban developments.

3.3. DEPARTMENT OF INFRASTRUCTURE, PLANNING AND NATURAL RESOURCES.

Officers from the Department of Infrastructure Planning and Natural Resources (DIPNR) have advised that parts of the development at Mary's Mount would be subject to approval under the Rivers and Foreshores Improvement Act. DIPNR administers the RFIA Act.

All waterways require a 40m setback from the top of the bank, however under Part 3(a) a permit can be issued to build structures within the setback (ie. GPTs, stream rehabilitation).

STORM together with the DIPNR and Council have mapped the extents of the existing creek systems and required riparian zones and these are shown on the Water Sensitive Urban Design Plan.

The Water Management Act (2000) should not be applicable to the Mary's Mount area unless bores or water storage dams are installed.

4.0 ISSUES AND CONSTRAINTS

4.1. CONSTRAINTS MAPPING

Council has undertaken some constraints mapping some of which is included in the Water Sensitive urban Design Plan. This plan shows the following limitations:

- Reticulated water supply
- Drainage reserve
- Remnant Vegetation
- Creek lines and some existing farm dams.

4.2. SOIL LIMITATIONS TO WSUD

According to the SMP, Goulburn has no identified areas suffering from salinity at the time of dry land salinity mapping by the DLWC in the 1980's. There is evidence of small areas of salinity in Goulburn's South (near Bungonia Road) at the effluent Irrigation Farm and on Kenmore Land.

Salinity has been identified as a potential soil limitation for the Sooley Soils as detailed in Section 2.2. This means that caution will need to be exercised when attempting to infiltrate into these soils dues to the potential to increase salinity or scalding.

The soils on site were identified has having localised water logging, rock outcrops and shrink swell soils. The soils were also identified as having erosion potential. Development on the site may require geotechnical investigations to determine the extents of these constraints with regard to their impact on soil acidity, foundation hazard and foundation design.

5.0 WATER SENSITIVE URBAN DESIGN

Water Sensitive Urban Design involves the development of systems approach to the management of the water cycle on a new or existing development.

The stormwater cycle is generally broken down into three main phases or elements. They are:

1	Source Controls	At the lot scale of development, are paid for by the house owner and maintained by the house owner. Examples are rainwater tanks with plumbed reuse and infiltration trenches to infiltrate overflows from the raintanks.
2	Conveyance Controls	Between the lot and the end of pipe system. Examples are grassy swales, bioretention trenches, pipes and channels.
3	End of pipe controls	Lower down in the catchment and aim to treat large contributing areas. Typical examples are wetlands, sand filters, GPTs, vegetated uptake systems and the like.

Each of these stormwater cycle elements needs to be considered in combination with the trunk drainage requirements to ensure that the system is holistic and operates effectively, ie that traditional drainage requirements for flood immunity are satisfied simultaneously with water quality requirements. The relevant elements and their respective description locations in this report are given in Table 4.

Table 4 – Location and description of Stormwater Cycle Elements

Element	Section in this report	Description
Source Control	6.0	Source control justification, methodology, and results for rainwater tanks (task 1) and infiltration
Conveyance Control	7.0	Control measures, their applicability and recommended locations.
End of Pipe Control	8.0	Control measures, their applicability and recommended locations.
Trunk Drainage Corridor Assessment	9.0	Including RAFTS modelling and culverts assessment (task 2)
Water Quality Modelling	10.0	Demonstrated water quality benefit based on the recommendations within the Source Control, Conveyance Control and End of Pipe Control sections (task 3)

6.0 SOURCE CONTROLS

6.1. RAINWATER TANKS

6.1.1. Background

6.1.1.1. Performance

Goulburn Council has proposed to include the use of rainwater tanks on new developments in the Mary's Mount area. Recent research from the University of Newcastle (Coombes *et al* 2001) has shown that a rainwater tank which was used to supply water for in-house uses including toilet flushing, hot water and laundry would result in a decrease in dependence on mains water by as much as 50% or more depending on tanks size etc.

The environmental benefits of rainwater tanks are now better understood. The total volume of rainfall runoff that is conveyed off-site is reduced with the installation of rainwater tanks. This volume reduction correlates to a reduction in runoff days that begins to approach the pre-development rates.

When rainwater tanks are installed in combination with OSD tanks not only is the total volume of rainfall runoff reduced but also the peak rate of runoff. Research in this area by Coombes (2001) has demonstrated that up to 40% of the capacity of a rainwater tank can be used for OSD, and this amount increases when air space is provided in the tank. Over a 1000-year synthetic period, the tanks were predicted to be able to contribute to the reduction in peak flows during 90% of major storm events. This work has led to the acceptance of rainwater tanks as an OSD device in the Upper Parramatta River Catchment Trust (UPRCT) program.

It should be noted that only if the rainwater tank is used to supply the significant in-house demands that you are able to derive a real environmental benefit from rainwater reuse.

6.1.1.2. Configuration

A typical tank configuration is shown in Figures 2 and 3. This configuration includes a top-up mechanism from the mains water supply for when the tank runs dry and a mains water bypass direct to the dwelling in the event of power failure.

The Standard *AS/NZS 3500.1.2: Water Supply - Acceptable Solutions* considers rainwater tanks as low risk as long as a non-testable backflow prevention device is installed. The configuration shown in Figure 2, specifically the height of water above the invert of the overflow should be in accordance with AS3500.1.2 and AS 2845.2. Sydney Water (presumably Goulburn Council too) is now able to install a backflow prevention device within its water meters and priority for these meters is given to customers who have a rain water tank.

Figure 2 - Schematic of a Combined OSD & Rainwater Tank
Source: Coombes P., Frost A. & Kuczera G. (2001), Draft Report *Impact of Rainwater Tank and On-site Detention Options on Stormwater management*, UPRCT.

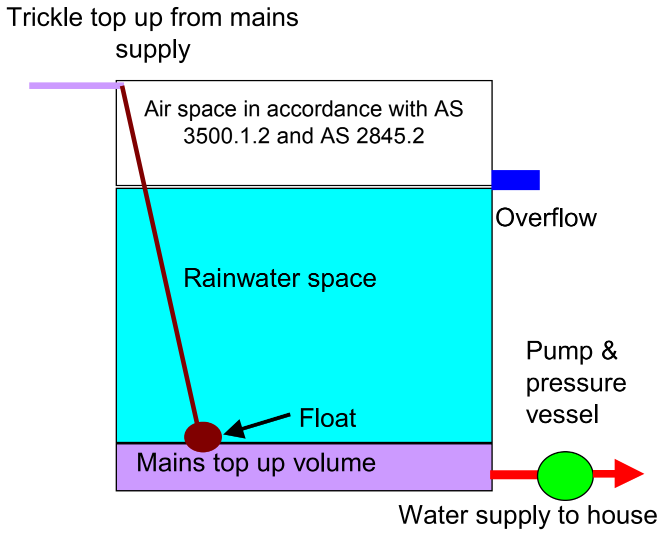
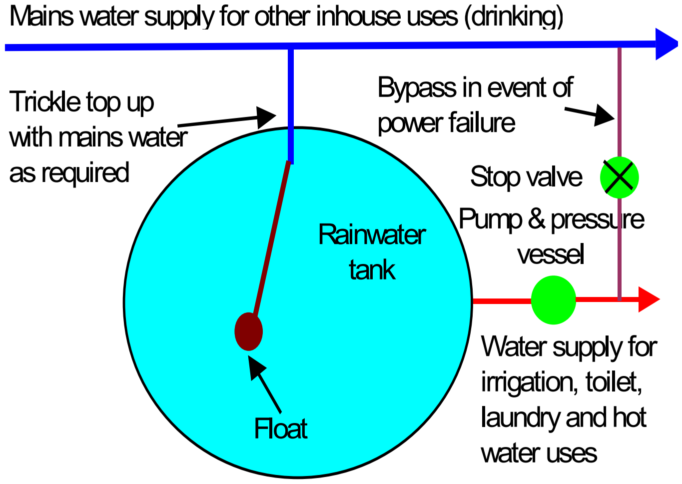


Figure 3 - Plan View of Rainwater Tank Configuration.
Source: Coombes P., Frost A. & Kuczera G. (2001), Draft Report *Impact of Rainwater Tank and On-site Detention Options on Stormwater management*, UPRCT.



6.1.1.3. Good Practice for Rainwater Tanks

After any extended dry period it is good practice to let the first run-off of rain bypass the tank. This first rain will wash or flush the roof catchment and usually contains higher amounts of accumulated dust, bird droppings, leaves and other debris.
Diversion of the first 0.2 – 0.5mm is considered sufficient and devices should be sized accordingly.

Regular maintenance of the rainwater tanks is critical. Studies by Newcastle University have shown that any incidence of health related effects of drinking water from a rain water tank are usually related to a lack of maintenance. Reference should be made to *Guidance on the Use of Rainwater Tanks* for maintenance procedures. The catchment area should be kept clear of debris.

6.1.1.4. Rainwater for Drinking Water Purposes

The use of rainwater for drinking purposes (where potable water is available) is not recommended by the Department of Health or the University of Newcastle and it is not recommended in this report. While it is not prohibited, if rainwater is planned to be used for drinking purposes, then reference should be made to the monograph *Guidance on the Use of Rainwater Tanks* (National Environmental Health Forum 1998).

6.1.2. Methodology

Two different models (of differing complexities) were used to derive a water balance for a typical "developed" lot at Mary's Mount. The first model consist of a daily time step model developed by STORM Consulting to estimate the number of runoff days and tank yield. The second, more complex model is the PURRS model, developed by Newcastle University to defines the starting condition of a rain tank at the beginning of storms of various duration, rather than simply and incorrectly assuming that a rain tank is full at the start of a storm event. Both of these models rely on a number of assumptions and factors related to the water demand.

Both models give yield information (similar to each other) but the PURRS model is ultimately used to derive peak flow rates for storms of various duration.

6.1.2.1. Estimating Daily Water Demand

Water demand is affected by a number of factors and varies widely across the state. Factors such as householder wealth, temperature, average rainfall, the size of gardens, the perceived availability of water, the number of days since the last rainfall event, the soil type and the type of rainfall experienced all affect the demand for water.

In order to get an accurate understanding of the likely average water demand, a representative sample of metered water usage was analysed. The sample was based on a new residential development including Crestwood Drive, Constantina Circuit, Green Valley Road and Endeavour Avenue. The sample development is a typical residential area with a level of affluence and attitude/behaviour likely to be found on

Mary's Mount. Block sizes on these developments were found to range in size between 700 to 1000 square metres – similar to that which is likely on Mary's Mount, with an average block size of 800 square metres used for estimating daily water demand.

Metered water usage was analysed over the longest period available from this area (from subdivision release until present) and then averaged across each street and for each house. Actual usage varied from high to average (compared with typical outdoor rates in NSW). As expected, larger blocks tended to use more water than smaller blocks. The average metered water consumption rate for each quarter is shown in Table 5. A sensitivity analysis was carried out on the average water consumption rates derived for this study. It was found that there is a very strong degree of confidence in the applicability of the water use data based on the relatively small differences between the 20% percentile and 80% percentile bands of metered household water consumption.

Table 5 - Average Monthly Usage and Percentile Bands

Quarter	20th Percentile Band	Average Metered Water Use (KL/day)	80th Percentile Band
Dec – Feb	0.92	1.17	1.38
March – May	0.60	0.68	0.76
June – Aug	0.49	0.53	0.63
Sept – Nov	0.56	0.66	0.80

Averaged metered water use was found to be higher during summer and lowest during the cooler winter months – as expected. Average summer usage rates determined for Mary's Mount are over 1.1 KL/day.

For the purpose of constructing a daily water balance model, the daily indoor and external house usage was disaggregated (Table 6). The disaggregation was based on typical indoor usage for a family of four living in a house (STORM Consulting 2002) with the difference between the metered readings and the typical indoor use considered to be external house uses.

However winter indoor consumption rates were found to exceed the actual metered water consumption in Goulburn and therefore outdoor use was assumed to be nil. Anecdotally this makes sense given that little watering and other ex-house usage occurring during winter in Goulburn.

Table 6 - Average Metered Water Use on a Residential Development
(with Indoor and External house disaggregation)

Month	(1) Indoor Disaggregated Use (KL/day)	(2) External House Disaggregated Use (KL/day)	(3) Average Metered Water Use (KL/day)
January	0.615	0.554	1.169
February	0.613	0.556	1.169
March	0.616	0.067	0.683
April	0.607	0.076	0.683
May	0.607	0.076	0.683
June	0.530	0.000	0.530
July	0.530	0.000	0.530
August	0.530	0.000	0.530
September	0.607	0.049	0.656
October	0.61	0.046	0.656
November	0.609	0.047	0.656
December	0.609	0.560	1.169

Note: (3) – (1) = (2)

6.1.2.2. Daily Water Balance

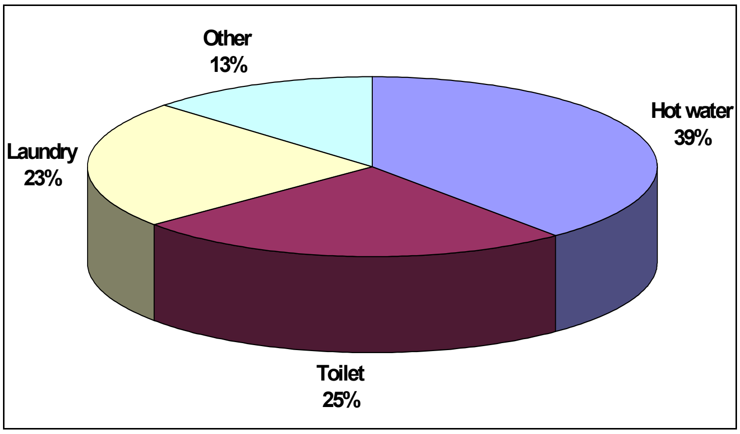
A daily water balance of a single, typical house was undertaken by STORM to determine the water usage for a typical household. The daily balance involved the construction of a spreadsheet with a daily accounting of rainfall runoff from the roof of a typical house into a tank followed by draw down of the tank through indoor and ex house consumption. Typical roof areas supplied by Council's planners were between 300m^2 and 350m^2, a roof area of 300m^2 was used in the daily water balance though a sensitivity analysis was also carried out.

The water consumption rates used in the balance were those shown in Table 6. Daily rainfall data was purchased from the Bureau of Meteorology from their weather station in Progress Street, Goulburn (station number 070263). Rainfall data from 1971 to 2002 was initially included in the water balance. The water balance was then shortened to include just the years of rainfall for which pluviograph data was also available. (The pluviograph data is in this case 5 minute rainfall data which was used to run a water balance with a 5 minute time step – see below.) These were the 10 years from 1991 to 2000 inclusive. These years are considered to be representative of a period of rainfall long enough to provide confidence in the results. This statement is based on the fact that the original 30 year water balance indicated very similar performance to the 10 year balance.

It was assumed that a simple top up mechanism of the tanks would be used to top up the tank when it was dry, as previously shown in Figures 2 and 3. The rainwater tank would need to be constructed with a mains water bypass to enable mains water to be supplied directly into the house during a power failure.

In order to further model indoor water use, the daily indoor demand was also disaggregated. The results of the disaggregation are shown graphically in Figure 4. Hot water, laundry and toilet make up 87 percent of indoor daily water use of a typical household.

Figure 4 - Percentage of daily water uses in a household
(ignores outdoor water use) Source: Coombes *et al*, 2001



Coombes *et al* (2001) have shown that when rainwater is used as a hot water supply, the pasteurising effect of a hot water heater on the rainwater resulted in water that consistently complied with ANZECC drinking water quality guidelines. Other uses of rainwater in the toilets and in laundries are believed to pose a minimal risk of exposure.

Initially, the daily water balance assumed that rainwater would be used for everything except drinking water. That is, rainwater would be used for hot water supply, laundry supply, toilet flushing (87 percent of indoor water use) and outdoor irrigation. However, due to concerns expressed by the Department of Public Health to Council regarding the use of rainwater for hot water, the daily water balance was determined for two situations – including and excluding hot water usage from indoor water use. In the latter instance, rainwater would be used for only 48 percent of indoor water use and not as a hot water supply.

The results of the daily water balance are shown below in Table 7.

Table 7 – 10-Year, Daily Rainfall Water Balance for a Single, Typical House in Goulburn with a Roof Area of 300m^2.

Tank Size (m^3)	Total Water Demand (KL/yr)	Volume drawn from Tank (no hot water) (KL)	Yield (%) without hot water	Spills/yr (no hot water use)	Volume drawn from Tank (with hot water) (KL)	Yield (%) with hot water	Spills/yr (with hot water use)
6	283	102	36	21	119	42	13
10	283	113	40	17	133	47	8
16	283	125	44	14	147	52	5
20	283	130	46	12	150	53	3

The daily rainfall water balance allows a number of conclusions to be drawn. These are:

- performance of a 10m^3 (10KL) tank appears to be marginally less than 20 m^3 tank in terms of yield. Therefore, at least a 10 m^3 tank is recommended as the minimum tank size for adoption.
- As expected, the larger the tank the greater the yield and lower number of spillages.
- Yield was lower when hot water was omitted. However, the greatest difference in yield that occurred was only 8%, and hence the inclusion or exclusion of hot water does not greatly impact water conservation.
- Whilst the yield did not vary greatly, the number of spills from a rain tank system that did not use rainwater for hot water was nearly twice the number of spills occurring each year from a system that did use rainwater for hot water. The stormwater treatment train is therefore affected by whether or not hot water is included for rainwater use. Greater volumes of water require management if rainwater is not used for hot water.
- Urban development alters stormwater runoff. Prior to urban development, the site may experience up to 6 days of runoff each year. Without any tank at all, 78 days of runoff would occur each year. Whilst any sized tank would result in less runoff days than the pre-development number of 78 runoff days, larger tanks obviously result in less runoff days. Including hot water in the uses for rainwater (together with toilet flushing, laundry and irrigation) will also contribute to decreasing the number of runoff days occurring, further reducing the impact of urban development on stormwater runoff.

6.1.2.3. Continuous Simulation Water Balance (PURRS modelling)

After undertaking the daily water balance, a continuous simulation of rainfall – runoff - storage and reuse was undertaken for a typical house in Goulburn. This work was undertaken using the latest version of the PURRS model produced by the University of Newcastle. PURRS is a complex model that operates not on a daily time step but on a 5 or 6 minute time step. Essentially PURRS is made up of a number of complex sub-models, including an outdoor water use model, a first flush model, a diurnal indoor water use model, an infiltration model and other complex sub-models.

The water demands as shown in Table 6 were used to estimate the "base" level of demand in the PURRS model. The same rain tank configuration as shown in Figures 2 and 3 and the same disaggregation of demand as shown in Figure 4 was adopted for the PURRS model.

Pluviograph data, covering the years 1991 to 2000 inclusive, was purchased from Sydney Water. The period of record was limited to just these years. The data was put into the correct format to be read by the PURRS model. The daily rainfall record was also required for the PURRS model (to simulate outdoor demand) and was put into the correct format. The model was run for a number of scenarios including roof areas of 300m^2 and 350m^2, 6m^3 and 10m^3 rain tank sizes and including/excluding hot water from rainwater usage.

The principle reason for undertaking the modelling of the water cycle on a typical house in 5 minute time steps is to be able to use actual rainfall events, as they were recorded in 5 minute intervals. This allows for the actual flux in the rain tank to be simulated accurately. In turn, this allows for the performance of the system to be estimated and the air space available for detention inside the rain tank also to be estimated. Note that this cannot be done using only daily rainfall.

The PURRS model was developed to dispel the myth that rain tanks are always full at the start of a storm event and that they could not be used to provide on site detention for this reason. By plumbing the rain tank into the "typical house" and continually drawing down the tank, the probability of the tank being full at the start of a storm event becomes very small and most definitely not "always"! By undertaking a continuous simulation of 10 years of rainfall at Goulburn it has been found that rain tanks would be able to contribute volumes of detention and provide not just a flow volume and frequency benefit but also a major peak flow reduction benefit. This apparent lot scale benefit has been shown to have catchment scale benefits.

The results of the PURRS model are summarised below in Table 8 and show the expected yields from the tanks.

Table 8 - PURRS model results for a typical house in Goulburn

	Tank Size	Roof Size	Tank supply	Annual Tank Supply	Total top up	Annual top up	Yield
Units	m^3	m^2	(KL)	(KL/yr)	(KL)	(KL/yr)	%
Including hot water in daily water use	6	300	948	94.8	1448	144.8	39.57
		350	1025	102.5	1371	137.1	42.78
	10	300	1063	106.3	1333	133.3	44.37
		350	1174	117.4	1222	122.2	49.00
Excluding hot water from daily water use	6	300	861	86.1	1535	153.5	35.93
		350	914	91.4	1482	148.2	38.15
	10	300	965	96.5	1431	143.1	40.28
		350	1030	103.0	1366	136.6	42.99

The PURRS model allows a number of conclusions to be drawn regarding the use of rainwater tanks on new developments areas. The following points can be drawn from the above table:

- The yields indicated from the PURRS model are higher than those estimated using a daily water balance. However the volumes of water yielded in absolute terms are still significant.
- Again, yields are slightly lower when hot water is excluded from rainwater indoor usage, but not enough to greatly influence water conservation on-site.
- Similar to results of the daily water balance, it appears that a 10 m^3 tank is the optimal tank size, giving greater yields and air space. A 10 m^3 tank is recommended for adoption. The incremental cost of using a 15 m^3 is not considered worth the extra yield. In summary, tank sizes beyond the 10 m^3 tank result in diminishing returns.
- Obviously, a larger roof area gives greater yield. Similarly, bigger tanks also give greater yields. However the air space available at the start of a storm event diminishes with increases in roof area.
- The model found the following starting conditions for a $10m^3$ rainwater tank plumbed into the house for maximum nonpotable use with a $300m^2$ roof catchment:
    - 3 month ARI: 60% full at the start of the 3 month ARI storm
    - 1 year ARI: 72.5% full at the start of the 1 year ARI storm
    - 5 year ARI: 60% full at the start of the 5 year ARI storm
    - 100 year ARI: not modelled due to a 10 year limit of pluviograph data but conservatively assumed to be 60% as for a 5 year ARI.
- The implications to the whole catchment of the large volumes of air space inside the tanks is commented on below. These large volumes of air space are expected

to at least result in significantly smaller end of pipe treatment solutions. The cost savings here are likely to off set the cost of the rain tanks. When these savings are considered in parallel with the cost of water saved, the economic benefits of rain tanks can become significant.

6.1.2.4. WUFFS Sub-catchment modelling

In order to determine the benefit of rainwater tanks across the whole site, a third model was constructed. This model is a WUFFS model. WUFFS is another modelling software package available from the University of Newcastle and includes the effect of rainwater tanks and swales and other WSUD treatments.

In order to assess how the rain water tanks would affect the flows of the whole catchment, an 8 hectare typical development was modelled. The basis for this was the plan prepared by Flood and Poidevin for the land to be developed by Mr Toparis adjacent to Crookwell Road.

This sub-catchment scale model included typical lots with a raintank, each with a 300 m^2 roof area and other impervious areas with the remainder of the lot as pervious area. The roads were considered to have grassy swales.

The model was run for the various starting conditions of the rainwater tanks for the 3 month, 1 year and 5 year ARI storm events.

Significant benefits of rainwater tanks were found for Mary's Mount. This is commented on below.

6.1.3. Results

Approximately 47% of the total demand could be met by a 10 KL rainwater tank. This is based on a daily balance only where average annual demand is about 280 KL and the yield from the tank is about 133 KL. Obviously, the yield from the tank will decrease if hot water is not included in rainwater usage.

Based on this modelling, it is likely that the number of runoff days from the site would be reduced from approximately 77 down to approximately 8 per year. This rate is close to that of the pre-development runoff rate of about 6 days per year.

The differences in peak flow rates for each hectare of developed land with 10 m^3 rainwater tanks on each lot and grassy swales is summarised in Table 9 below:

Table 9 – WUFFS Sub-catchment model results

Design Storm event (ARI)	Flow post development per hectare of development without tanks (L/s/Ha)	Flow post development per hectare of development with tanks (L/s/Ha)
3 month	28	20
1 year	54	30
5 year	150	100
100 year	352	268

Clearly Table 9 shows that there are significant benefits to be gained in terms of detaining peak flows from the development for the whole range of storm events.

In summary it is recommended that a 10KL minimum rain tank is plumbed into each dwelling, effecting compulsory reuse to ensure that the environmental impacts of development are minimised and also to supply a meaningful volume of water demand.

6.2. INFILTRATION TRENCHES

Infiltration trenches are shallow trenches filled with a gravel or rock matrix. Stormwater run-off is directed into the trench for treatment. Suspended sediments and some dissolved pollutants are trapped within the gravel/rock matrix while the cleaned run-off water can percolate into the subsoil and water table. Excess water can be directed into grassed swales for further treatment or off-site disposal.

Infiltration trenches are best:

- Located in sandy soils (infiltration greater than 36 mm/hr).
- Located in flat terrain (less than 2%).
- Located where there is a deep groundwater table.
- Where the area available is restricted.

Generally, infiltration trenches:

- Have moderate maintenance costs.
- Require backwashing of gravel/sand matrix once every one to two years to prevent clogging.
- Have a low initial capital outlay.

- Are located underground, so minimal negative impact on visual appeal of area.
- Can be planted with indigenous vegetation to provide aesthetic and biodiversity improvements.

Infiltration trenches have not been included in the modelling for this development. Individual developers may include them on a site however this should be subject to geotechnical investigations and also consider salinity.

Refer to Section 2.2 and Section 4.2 for sol limitations.

7.0 CONVEYANCE CONTROLS

Grass swales, bio-retention systems and naturals channels treatments often used as conveyance controls for new developments. These are described below.

7.1. GRASS SWALES

Grass swales provide a system to control, treat and dispose of stormwater run-off. They are often used as an alternative to the traditional kerb and gutter systems. Grassed swales can reduce run-off volumes and peak flows as well as allow infiltration. Grassed swales also provide an area for treatment of car-based pollutants (such as hydrocarbons) by trapping and storing these pollutants for breakdown by soil microorganisms.

Grass swales are best:

- Located in open sunny areas to promote vegetation growth.
- In flat areas that have slopes between 2-4%.
- Vegetated with local species suitable for local climatic conditions.

Generally, grass swales:

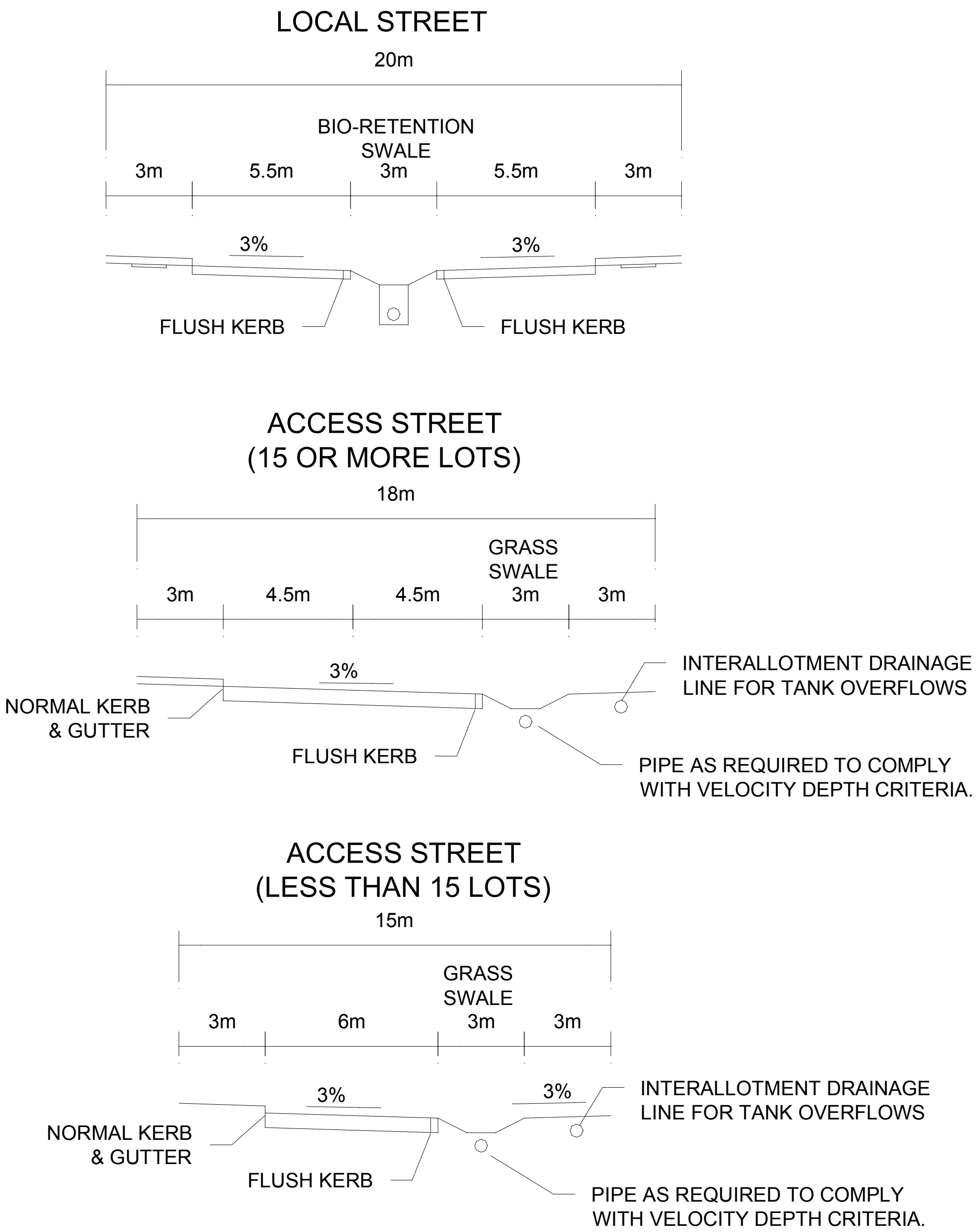
- Are low maintenance (dependant on vegetation species).
- Have low capital costs.
- Are an attractive alternative to traditional kerb and gutter systems.

Plate 1 – Grassed Swales at East Bowral

Plate 2 – Grassy Swales near Brisbane

7.1.1. Swale Modelling and Typical Road Cross Sections

As part of the WUFFs subcatchment modelling grass swales were modelled on a section of the proposed Ganter Construction development. The swales were based on a 3 m top width, side slopes of 1 to 3 and a depth of 0.5m. This assumes that crossings would be of the type shown in Plate 1 above rather than the crossing shown in Plate 2.



MARY'S MOUNT DCP - WSUD PLAN

TYPICAL ROAD CROSS SECTIONS

STORM CONSULTING
SUITE 3, 6 WEST STREET,
PYMBLE NSW 2073 AUSTRALIA
PH: +612 9499 4333
FAX: +612 9499 4311
www.stormconsulting.com.au

FIGURE 6

The results of the swale modelling indicate that a typical street could convey all the flows within the defined velocity depth criteria.

Figure 6 includes typical road cross sections developed for Mary's Mount. These are not to be adopted for design purposes. Standard Council drawings/details incorporating swale crossings needs to be developed as part of further work.

One way cross falls on roads together with flush kerb is required where swales are to be adopted. Alternatively, wider road reserves with two way cross falls and swales on each side of the road would be feasible.

One also needs to consider that the frequency of roof overflows will be reduced to about 8 days per annum.

Interallotment style drainage lines could be placed along side the low side of the road in the footpath reserve to pick up overflows from the rainwater tanks. This limits the stormwater load on the swales and would result in improved water quality.

Roads generally need to be aligned along the contours to achieve desirable grades of between 1% and 5%. Where roads are graded more steeply check dams can be constructed within the swale to slow velocities.

The maximum depth of flow in the swales were found to be less than 0.5m for all events including the 100 year ARI. During detailed design it will become apparent that pipe sizes are able to be reduced considerably – which will help to off set the cost of constructing the swales.

It is recommended that grass swales be adopted in the design of the subdivision and the made a requirement in the DCP.

7.2. BIORETENTION SYSTEMS

Bioretention systems combine a grass swale with an infiltration trench to provide a treatment, flow control, and flow reduction system. The infiltration trench is overlain with a grass swale that is vegetated with plants. Stormwater flows are directed onto the grassed swale to control flows and remove pollutants before percolating through to the infiltration trench for father flow attenuation, and pollutant removal through the biofilms attached to the filter media.

We recommend that Bioretention trenches are adopted on Mary's Mount for use on Local Access streets that carry higher traffic loads. The Cooperative Research Centre (CRC) for Catchment Hydrology has found that Bioretention trenches can achieve very high rates of sediment removal and nutrient removal though Nitrogen removal processes require further clarification.

Bioretention trenches also provide the opportunity to develop "grand roads" with central planting that in time will form complete canopies over the roads. Such a philosophy if adopted would enhance the grand aesthetic of many parts of Goulburn.

Plate 3: Bioretention Trenches at Victoria Park, Sydney

Bio-retention trenches are best:

- In open sunny areas to promote vegetation growth.
- In flat areas that have slopes less than 2%.
- Vegetated with local species suitable for local climatic conditions.

Generally, bioretention trenches:

- Require yearly inspections to ensure they are operating effectively.
- Require regular maintenance of vegetation cover.
- Require backwashing of gravel once every 1-2 year.
- Have moderate capital costs.
- Have increased biodiversity and aesthetic values.

Bioretention trenches were not modelled even though we are proposing to adopt them on all local access streets.

7.3. NATURAL CREEK FORMATION/REHABILITATION

Healthy natural channels prevent erosion by providing bank protection, flow control and flow velocity reductions. They provide habitat for a range of organisms and a place for children and adults to recreate.

We recommend that creeks at Mary's Mount be retained, revegetated and used as trunk drainage corridors.

This is commented on in detail in Section 9.1.

Despite the best efforts at Water Sensitive Urban Design it is still likely that minor changes to flow regimes will occur. These changes while "minor" in gross terms may be sufficient to change the highly sensitive land forms in the local area. Failure to comply with the recommendations in this section would result in a high hazard of erosion and the potential for major morphological changes to the creeks.

Natural channels are best vegetated with local species suitable for the local climatic conditions.

Generally, natural channels:

- Require annual inspection of vegetation cover and weed removal.
- Have moderate capital costs.
- Have increased biodiversity and aesthetic values.

Plate 3 natural channel in Brisbane

Plate 4 Natural Channel in Brisbane

8.0 END OF PIPE CONTROLS

The combination of source controls, conveyance controls and creek rehabilitation has been assessed in a water quality model developed by STORM.

Moreover, Goulburn with its lack of rainfall and dispersive soils is not conducive to constructed wetlands. Other end of pipe controls should be used in preference to wetlands if it is later found that end of pipe controls are required.

The result of the water quality assessment by STORM is that end of pipe controls are not required. Refer to Section 10 which documents the water quality assessment undertaken for this study.

However a contingency planning approach has been adopted and areas that are suitable for the construction of end of pipe controls such as sand and vegetative filters have been identified and included in the Water Sensitive Urban Design Plan.

The apparent lack of need for end of pipe controls is likely to result in significant cost savings to Council in the long term through diminished maintenance and to the developers in terms of capital cost reductions.

9.0 TRUNK DRAINAGE CORRIDOR DEVELOPMENT

9.1. BACKGROUND

In order to determine minimum corridor widths to allow for flood flows to be safely conveyed without the risk of damage to property or person a basic flood corridor assessment has been undertaken. This assessment did not consider flood flows from the Wollondilly or backwater effects form the Wollondilly - it only considered flood flows generated on the Mary's Mount site itself.

The flood assessment has assumed that highly vegetated, relatively narrow, low maintenance channels would convey flood flows rather than the current regime which can be described as one with broad, low, sheet flow. Some of the existing catchments would have sheet flow at shallow depth (less than 300 mm) and with a width of flow of about 80m to 100m. It is recommended that this flow can be concentrated in a narrower channel, generally up to 30m width (Refer to Table 11 for widths) to increase the land yield in the catchments.

The recommended channels are comprised of side slopes of about 1 in 6 for public safety, depths up to 1.0m depending on where the channel is and with velocity depth (vd) multiples generally kept to about 0.4 except toward the major tributary outlets at the confluence with the Wollondilly. The Manning 'n' adopted for these creeks was 0.15 which allows for mass planting to occur with a low maintenance requirement. This would also satisfy riparian corridor requirements.

The DIPNR has also stipulated a 40m set back from creeks that have defined beds and banks and these have been adopted and recommended by STORM. Refer to Section 3.3 and the Mary's Mount Water Sensitive Urban Design Plan which shows the areas required for flood conveyance (which are also to be revegetated) and the areas identified by DIPNR required for riparian corridors. Note that the areas to be revegetated include the areas required for flood conveyance plus an additional 5m either side as a contingency and for bank stability purposes.

The trunk drainage corridor assessment has identified two types of work to be carried out by Council and developers.

That is:

1. We have identified existing creeks that are mostly stable (they have some minor evidence of erosion) but which would be subject to erosive stresses should development proceed. These areas need to be stabilised by revegetation and in some cases very minor regrading. The revegetation is to be undertaken by Council, after any channel formation works (see 2 below) have been undertaken by potential developers.

   It should be noted that there are two major areas that may never be developed and that do not require any channel formation works and so can be revegetated as soon as possible. These are the areas inside Mulwaree Shire High School and areas that are within 40m of the top bank (on the western side of Mary's Mount) as shown on the Water Sensitive Urban Design Plan for Mary's Mount.

2. There are areas at Mary's Mount that are currently "unformed" drainage corridors. These areas will require formation as a "naturalised" drainage system (trunk drainage corridor). This formation work is to be undertaken by developers when they develop their respective landholdings. The developers will need to fill adjacent to the channels and or excavate the channels to ensure that the lots are constructed above the estimated 100 year ARI water levels. This work does not benefit or arise from development elsewhere in the catchment and so a nexus between the Section 94 and the work required can not be demonstrated. By way of further explanation, the channels could be left as they are today, and then revegetated for stability purposes.

   Vegetating the whole channel system on the other hand would provide a common water quality and environmental benefit that should therefore be funded under Section 94 works. Further as developers would be undertaking earth works to develop their subdivisions they would be in the best position to determine how to construct the requisite channel shape.

   In summary the earthworks are to be developer funded.

By constructing channels with the same geometric and vegetative characteristics as those recommended in Table 11 (below) the 100 year ARI post development flows could be contained wholly within the channel. Council would also need to ensure that freeboard is allowed for in the final channel designs.

9.1.1. Flood Immunity

A desired level of flood immunity of 1 in 100 years has been assumed in accordance with Australian Rainfall and Runoff 1987.

9.2. FLOOD MODELLING USING RAFTS

9.2.1. Methodology

A RAFTS computer model was constructed to estimate the peak flows generated from the site for the 100 year ARI. This information was used to assess the need for detention and define the corridor width.

The subcatchments were determined by site contours and a node placed at the outlet of each subcatchment. This is described in the attached plan titled Mary's Mount WSUD – RAFTS Subcatchment Plan G224/P01.

Conservative loss rates of 1.5 mm for impervious and 5 mm for pervious areas was adopted in the RAFTS model. The percentages of impervious area that would result from development was estimated at 55% of the developable area. This value is consistent with similar developments.

9.2.2. Results

The peak flows, predevelopment and post development are shown at each node below in Table 10. Refer to Mary's Mount WSUD - Rafts Catchment plan Drawing P01 for the location of the subcatchments.

Table 10 Rafts 100 year ARI predevelopment and post development flows

Node	Max Flow (m^3/s)	
	PreDevelop	PostDevelop
A1	0.97	1.19
A2	1.75	2.08
**A3	4.40	6.17
A4	1.49	1.88
A5	7.38	8.69
A7	4.13	4.13
A8	1.26	1.44
A9	0.94	0.97
A10	0.88	0.93
A11	4.04	4.26
A12	6.99	7.37
A13	17.78	17.43
AS1	31.19	31.43
AS3	29.44	29.88
AS4	21.38	21.36
AS5	20.76	20.52
AS6	20.49	20.02
AS7	10.33	10.26
AS8	8.21	7.91
AS9	4.07	3.78
AS10	2.27	2.27
B4	2.95	3.26
B7	3.93	3.93
B8	1.06	1.06
BS1	51.86	48.38
BS2	29.88	27.92
BS3	29.62	27.50
BS4	27.94	26.03
BS5	24.94	22.81
BS5a	1.64	1.90
BS6	21.37	19.61
BS6a	2.15	2.59
BS7	16.96	15.43
BS8	15.56	14.02
BS8a	1.90	2.23
BS9	8.27	8.12
BS10	4.16	4.16
**C1	7.62	10.04
**C2	5.93	7.93
C6	0.61	0.65
CS1	56.92	53.30

CS2	52.29	49.00
CS3	21.25	19.71
CS4	21.05	19.45
CS5	20.76	19.15
CS6	18.42	16.72
CS7	17.98	16.24
CS8	15.07	14.59
CS9	12.57	12.06
CS10	5.77	5.77
CS11	2.69	2.69
D1	1.40	1.40
DS1	4.88	4.88
DS2	4.37	4.37
DS3	2.93	2.93
DS4	2.24	2.24
L	2.00	2.26

** denotes nodes where detention may be required due to increases in peak flows.

A contingent area has already been noted in the WSUD plan for C1 for water quality purposes anyway – this may also be used to provide detention if detailed modelling reveals that it is required. The catchment draining to A3 (near Mulwaree High School) may also require communal detention not only due to the limited pipe capacity in this area but also due to the predicted increase in peak flows. These developers may however provide Council with satisfactory alternatives, such as storage inside in the rain tanks to communal detention and Council should encourage innovation in this regard.

From the Rafts model it was generally observed that many of the nodes experience lower flood peaks post development. The increases in peak flows, where they occur except as noted above, are not expected to cause any change in flooding.

It is not unusual to find developments that actually result in post development peak flows that are similar to or lower than the predevelopment flows. Largely this could be due to the result of partial area effects. On Mary's Mount there are considerable parts of the upper catchment that will not be developed. As a result the lower parts will be developed and shed their runoff first. Then the runoff from the more pervious undeveloped rural areas begins to flow down through the creek system. This results in the smaller peak flows.

Provided that the recommended revegetation and rehabilitation is put in place the minor changes (if any) to the flow regimes are likely to have no adverse impacts except in the two areas noted above.

Should Council increase the proposed extent of development at Mary's Mount above the current limit of water supply these calculations and flood study would not be valid.

Table 11 - RAFTS post development estimated 100 year ARI flow rates and top widths (not including 5m buffer each side).

Node	Max Flow (m^3/s)	Top Width (m)
A1	1.19	8.0
A2	2.08	10.0
A3	6.17	16.6
A4	1.88	11.0
A5	8.69	21.2
A6	Node not used	
A7	4.13	13.0
A8	1.44	10.3
A9	0.97	7.7
A10	0.93	8.1
A11	4.26	14.5
A12	7.37	18.6
A13	17.43	31.8
AS1	31.43	52.3
AS2	Node not used	
AS3	29.88	40.8
AS4	21.36	41.6
AS5	20.52	39.2
AS6	20.02	45.8
AS7	10.26	27.4
AS8	7.91	22.4
AS9	3.78	14.0
AS10	2.27	13.0
B4	3.26	12.6
B7	3.93	13.6
B8	1.06	8.6
BS1	48.38	52.1
BS2	27.92	41.6
BS3	27.50	40.9
BS4	26.03	36.9
BS5a	1.90	9.3
BS5	22.81	36.5
BS6a	2.59	10.5
BS6	19.61	27.0
BS7	15.43	28.5
BS8a	2.23	8.5
BS8	14.02	23.4
BS9	8.12	19.7
BS10	4.16	13.5
C1	10.04	20.5
C2	7.93	18.2
C6	0.65	6.8
CS1	53.30	66.1
CS2	52.69	62.6

CS3	19.71	38.3
CS4	19.45	38.2
CS5	19.15	37.9
CS6	16.72	34.7
CS7	16.24	33.9
CS8	14.59	31.8
CS9	12.06	28.7
CS10	5.77	17.5
CS11	2.69	12.0
D1	1.40	9.6
DS1	4.88	22.5
DS2	4.37	16.2
DS3	2.93	12.7
DS4	2.24	10.8
L	2.26	22.6

Table 11 allows for the establishment of land take requirements for flood conveyance through the estate. The top widths shown in the table apply only to widths of flow. A contingency of 5m either side is recommended for the purpose of allowing for bank stability. The area at the top of the banks would need to be sown with vegetation to ensure that it remains stable hence the 5m allowance either side.

9.2.3. Recommendations

The minimum corridor widths required are shown in Table 11. Note that for costing and documentation purposes 5m has been added to either side of the channel to allow for a contingency and bank stability. As such if these corridors are adopted then all flows up to the 100 year ARI are estimated to be able to be conveyed safely within the proposed drainage and riparian corridors.

This does not mean that flood planning levels do not need to be determined.

The flow assessment undertaken as part of this study has identified that the flows do not differ significantly from the predevelopment condition. Importantly the RAFTS model is provides a suitably conservative flood estimation tool. It was demonstrated using the WUFFS model that significant detention benefits will arise from rainwater tanks even during the 100 year ARI storm event. It is considered that the use of rainwater tanks, swales and bioretention trenches and rehabilitated and revegetated creeks would be enough (except in the areas as noted above) to ensure healthy creek systems in terms of flow regime and water quality.

9.3. CULVERT ASSESSMENT AND THE FLOOD IMMUNITY OF MARY'S MOUNT ROAD.

9.3.1. Methodology

STORM attempted to determine the capacity of the culverts under Mary's Mount Road however detailed survey information is required to undertake this task.

Assessment of the existing culverts has therefore not been undertaken at this stage. It is recommended that this be undertaken as part of the assessment of the flood immunity of Mary's Mount Road.

9.3.2. Recommendations

It is recommended that an allowance for the upgrading of the culverts be included in the Section 94 Contributions plan and reviewed later if it is found that the culvert capacity is adequate.

The culvert capacity assessment should consider the potential in flow reductions arising from detention areas placed upstream of the culverts.

10.0 WATER QUALITY MODELLING

10.1. JUSTIFICATION

The SCA requires that the Mary's Mount development achieve a neutral or beneficial effect on the water quality leaving the site. In order to assess the water quality leaving the site a predevelopment and post development water quality model has been constructed.

10.2. LIMITATIONS OF WATER QUALITY MODELLING

Water quality modelling relies on a multitude of factors. There is a lack of calibrated data available within Australia and in the absence of calibrated data the best available information is used. This places limits on the accuracy of water quality modelling.

Water quality modelling is generally load based and to a lesser extent process based.

The water quality model adopted by STORM for this project is the MUSIC water quality model. The first addition of the model has some faults. However we accept those faults as the model is considered the best planning tool available at the current time.

10.3. MODELLING – MUSIC

As noted above pre and post development models were created in MUSIC.

The effect of rainwater tanks was entered into the model using the Generic node tool. We estimated the differences in flow that would arise from the use of rainwater tanks by using the WUFFS model as noted in Section 6.1.2.4.

We then estimated the water quality benefit achievable from the use of grassed swales. The best available data at this point remains an EPA publication titled Stormwater Treatment Techniques 1997 (EPA, 1997) which notes that grassed swales achieve retention rates of 50% to 75% for nutrients and 75% to 100% for sediment.

Conservative values were adopted by STORM assuming that 60% of nutrients would be retained and that 75% of sediments would be retained.

We did not include any end of pipe treatments in the water quality model and neither did we account for the water quality benefit of the revegetated and stabilised creek systems.

While we modelled only grassy swales we propose to include the use of bioretention trenches on local access roads. This would be likely to result in even better water quality than simply grassed swales.

Load rates generated by the models were benchmarked for comparison and included in Table 12 and 13 below.

10.4. RESULTS

Load rates were developed by the model are tabulated and benchmarked below.

Total Phosphorus (TP), Total Nitrogen (TN), and Total suspended solids were the principle pollutants modelled.

Table 12 - Predevelopment Pollutant Loads and Rates Generated by MUSIC

Pollutant	**(1) Area (Ha)**	**(2) Estimated Mean Annual export** (kg/a)	**Pollutant Load =(2)/(1)** (kg/ha/a)	**Benchmark*** (kg/ha/a)	**Benchmark**** (kg/ha/a)
TP	519.21	278	0.535	0.304	0.700
TN	519.21	1900	3.659	2.460	3.300
TSS	519.21	104000	200.304	43.400	40.000

* Loads taken from Goulburn catchment, grazing category within "Strategic Land and Water Capability Assessments" for SCA.
** Loads taken from rural (pasture) category within SKM 2000 based on Sydney data derived for the Clean Waterways Program.

Table 13 – Post development Pollutant Loads and Rates Generated by MUSIC

Pollutant	**(1) Area**	**(2) with WSUD & Creek Rehabilitation** (kg/a)	**Pollutant Load = (2)/(1)** (kg/ha/a)	**Benchmark^** (kg/ha/a)	**Benchmark^^** (kg/ha/a)
TP	519.21	268	0.516	0.347	0.7
TN	519.21	1800	3.46	2.78	4
TSS	519.21	94,000	181	59	200

^ Loads taken from Goulburn catchment, urban-residential category within "Strategic Land and Water Capability Assessments" for SCA.
^^ Loads taken from urban low density residential category within SKM 2000 based on Sydney data.

Table 12 and 13 demonstrate that a minor beneficial effect may result if this WSUD plan is to be adopted by Council.

The benchmarks indicate that the rates for suspended solids generation are high however they are high both predevelopment and post development. In the absence of better data they have been adopted. The benchmarks are simply to be considered as that and are not considered better data because one is based on an assessment of one catchment in Sydney and the other is based on an estimate of loads from an American EPA computer program.

In summary it appears that the SCA objectives can be meet provided that the recommendations in this report are adopted.

11.0 COSTS

11.1.1. Rainwater Tanks

Ecologically sustainable development should also be economically sustainable. The total cost of a rainwater tank and plumbing system is approximately to $2,230 (see Table 9). The cost is expected to increase by approximately $500 for a large dwelling.

Table 9 - Costs of Installing a Rainwater Tank (source from SIA Website 26/03/03)

Item	**10 kL Tank ($)**
Aquaplate Rainwater Tank	870
Pump + Pressure Controller	200* + 160
Plumber + Fittings	500
Float System	100
Concrete Base	200
GST	200
TOTAL	**$2,230**

* Pump price is likely to be $500 higher for large dwellings.

Rainwater reuse can provide substantial cost savings in new developments due to a reduction of stormwater drainage infrastructure required. Research at the Figtree Place development in Newcastle (Coombes 2001) has demonstrated a 1% cost saving in stormwater infrastructure. This research also found that a 3% cost saving was possible with rainwater reuse in new developments (based on the reduction of stormwater pipes and quality devices).

Based on the information presented and STORM Consulting's previous experience the following conclusions are drawn:

- Given the development's topography locating rainwater tanks underground for aesthetic reasons is not necessary. The site slopes away from the street and tanks are to be installed behind the dwelling so the tanks will not be seen from street level. Modern Australian architecture now often incorporates the use of rainwater tanks as a feature of the design moreover visible tanks bring the need for water conservation to mind when ever the tanks are seen.
- Above ground tanks are considerably cheaper than buried tanks, by as much as $2,500 for a 10KL tank.
- Rainwater tanks installed underground can be prone to groundwater ingress and degraded water quality as shown in recent research (Coombes 2001).

- The tank would need to be fitted with a pump and plumbed into the house. The total cost per dwelling of an above ground rainwater tank, pump and plumbing is approximately $2,230 or $2,730 for a large dwelling.
- Sydney Water currently offers a rebate for property owners who install a rainwater tank and is investigating the possibly of rebates at the point of sale for rainwater tanks. It is suggested that Goulburn Council could do the same.

11.1.2. Swales Indicative Costs

This information was obtained from the WSUD seminar 26th March 2003 (WSROC *et al* 2003).

Excavation & Soil	$ 40.00 /m^2
Irrigation	$ 12.00 /m^2
Bridge / Crossings	$ 30.00 /m^2
Planting	$ 32.00 /m^2
Maintenance	$ 6.00 /m^2
TOTAL	**$120 /$m^2$**

11.1.3. Bio-retention Systems Indicative Costs

Pits	$150.00 /m
Excavation	$ 24.00 /m
Pipe	$ 31.50 /m
Aggregate	$133.00 /m
Waterproof membrane	$ 11.50 /m
TOTAL	**$350 /m**

11.1.4. Creek Rehabilitation

Creek Revegetation	Quantity	Unit	Rate ($)	$
Revegetation	414,337	m^2	10	**$4,143,370**

11.1.5. Culverts

It is recommended to allow $300,000 for augmentation of the three waterway crossings under Mary's Mount Road. This may/not be required subject to a flood assessment of Mary's Mount road.

11.1.6. Additional Studies and Design Work

Further studies are required in order to ensure that this WSUD plan is implemented. Council is entitled to recover the costs of those studies under Section 94 Contribution Plans.

The work required is:

- WSUD guidelines to be developed for Mary's Mount. Estimated Cost including management by Council : $50,000.
- Vegetation Management plans are required for the creeks. Estimated cost about $30,000.
- Flood study to assess and derive flood planning levels and assess the flood immunity of Mary's Mount Road (culvert assessment). Costs including management by Council $40,000.

In total $120,000 for additional studies has been identified.

11.1.7. Summary of Costs for Section 94 Contributions

There are only three items for consideration:

•	Creek rehabilitation works:	$4,143,370
•	Further studies:	$ 120,000
•	Culvert upgrades	$ 300,000
	Total	$4,563,370

This equates to approximately $2,535 per lot based on a lot yield of 1800 lots.

12.0 RECOMMENDATIONS

12.1. SOURCE CONTROL

In conclusion, it is recommended that a 10m^3 (10 KL) tank be adopted as the minimum tank size. It is recommended that the water from the rainwater tank is used for laundry supply, external house uses, hot water supply and toilet flushing. Drinking of rainwater is not recommended. Encouraging but not enforcing the use of first flush water diversion devices (which bypass the first 0.5 mm of rainfall) is also recommended. In addition to this, the rainwater tank is to be topped up from the mains water supply to maintain the supply to the house during dry periods with a mains water bypass direct to the dwelling in the event of power failure.

12.2. CONVEYANCE CONTROL

It is recommended that grass swales are adopted for minor roads and bioretention trenches are adopted for local access roads in accordance with Figure 6.

It is recommended that trunk drainage corridor widths developed as part of this study are created around each of the existing creeks. The creeks are to be revegetated using approved revegetation and bed and bank stabilisation techniques.

It is recommended that some further studies are undertaken by Council.

12.3. END OF PIPE CONTROL

No end of pipe controls are recommended.

12.4. SUMMARY

It is recommended that Council, the SCA and DIPNR adopt this report and implement the proposed WSUD plan. The assessment work undertaken by STORM has found that the proposed plan is likely to achieve a minor beneficial effect on the drinking water catchments. This statement is based on the conservative modelling approach adopted by STORM.

13.0 REFERENCES

AS/NZS 3500.1.12: Water Supply – Acceptable Solutions

Australian Rainfall and Runoff (1987), Institution of Engineers, Australia.

Coombes P., Frost A. and Kuczera G., (2001), Draft report *Impact of Rainwater Tank and On-site Detention Options on Stormwater management for the UPRCT* by Newcastle University.

Department of Housing (1998), Managing Urban Stormwater – Soils and Construction (known as the Blue Book).

Department of Land and Water Conservation (1998), The Constructed Wetlands Manual.

Environmental Protection Authority (1997), Managing Urban Stormwater – Treatment Techniques.

Hairsine (1997), Industry Report – Report 97/9 Controlling Sediment and Nutrient Movement Within Catchments, Cooperative Research Centre for Catchment Hydrology.

Goulburn Council (2000), Stormwater Management Plan.

National Environmental Health Forum Monograph (1998) Guidance on the Use of Rainwater Tanks.

SCA and DLWC (2002), SCA Soil Landscapes as described by Michael Davey, printed 11/11/2002

Sydney Water (1995), Estimation of Stormwater and Sewer Load in the Sydney Illawarra Region Clean Waterways Program.

WSROC, Sydney Coastal Councils, UPRCT & Stormwater Trust, WSUD in the Sydney Region Part 1, 26th March 2003

ATTACHMENT A

RAFTS CATCHMENT PLAN
DRAWING G224/P01

ATTACHMENT B

MARY'S MOUNT
WATER SENSITIVE URBAN DESIGN PLAN
DRAWING G224/P02