Water Sensitive Urban Design in the Sydney Region

PRACTICE NOTE 4

Rainwater tanks

Contents

Water sensitive urban development involves simple design and management practices that take advantage of natural site features and minimise impacts on the water cycle. It is part of the contemporary trend towards more 'sustainable' solutions that protect the environment.

This **Water Sensitive Practice Note** explains how to design and configure domestic rainwater tanks.

Rainwater tanks

Introduction

This Practice Note describes how to design and configure various types of domestic rainwater tank systems, including gravity systems, pressure systems and dual supply systems. There is currently a resurgence of interest in using rainwater tanks to partially supply domestic water demand in urban areas. This has followed increasing recognition of their environmental, stormwater management and water conservation benefits, as well as recent government policies to address urban water shortages, such as the Building and Sustainability Index (BASIX).

Urban water demand is typically met by importing large volumes of treated water from rivers and aquifers in neighbouring catchments, often across long distances and at considerable cost. At the same time, similar volumes of roof water are discarded unused via stormwater drainage systems that contribute to pollution of urban waterways, erosion, sedimentation and flooding impacts.

Whilst all mains water is treated to drinking water standards, as little as 1% of domestic water consumption is actually used for drinking. Toilet flushing, laundry, outdoor uses and hot water represent the bulk of domestic water consumption (about 85%). In most cases, these uses do not require water to be treated to such a high standard and can often be supplied at required water quality standards via a rainwater treatment train. Benefits include significant reductions in mains water consumption and substantial reductions in stormwater discharges.

Figures 1 and 2 show the proportions of household water used for various purposes in Sydney during 2003. The Figures reveal that drinking water is a very small proportion of total household water use. An effective strategy for use of rainwater that targets household water consumption types with greater volumes and frequency of water use, such as outdoor, toilet, washing machine (laundry) or hot water uses will significantly reduce mains water consumption.

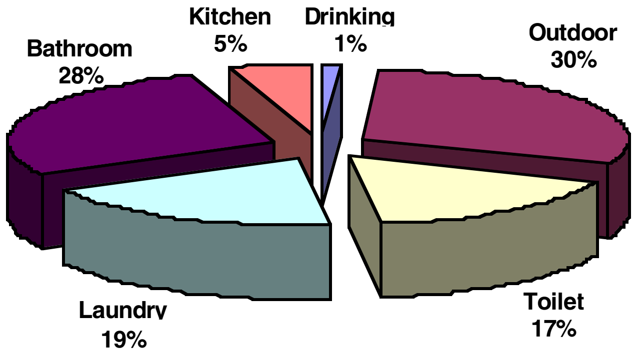

Fig 1: Single household water use categories

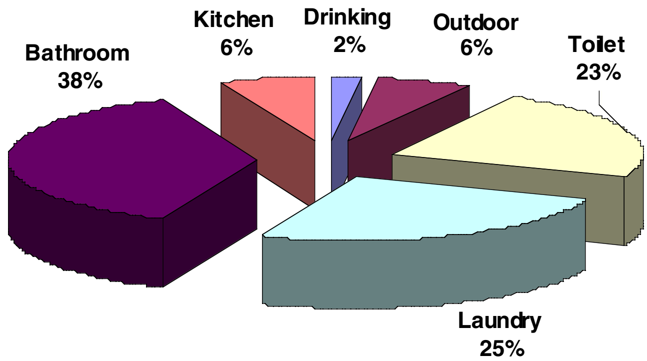

Fig 2: Multi-unit water use categories

It is incorrect to assume that using rainwater to supply outdoor uses alone will produce substantial mains water savings. The mismatch between seasonal rainfall and outdoor water use patterns often results in poor utilisation of rainwater resulting in long periods where rainwater tanks are full. This problem can be remedied by using rainwater to supply constant indoor uses such as toilet flushing, washing machines (laundry) and hot water that will consistently draw down the rainwater tank allowing rainwater to refill the tank more often. Combinations of different water use frequencies from rainwater tanks such as toilet flushing and outdoor uses can result in optimum mains water savings and large reductions in stormwater discharges.

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System overview

Rainwater harvesting systems and treatment trains can include a variety of elements that can be chosen to suit the desired domestic rainwater uses. Principal elements (as shown in Figure 3) include:

- roof gutters
- first flush device or filter sock
- rainwater tank
- leaf diverters
- pump
- inline filter or UV disinfection
- overflow to garden areas, infiltration trenches and street drainage system.

The choice of elements used is optional, and is dependent on user choice and the intended use of rainwater. For example, a rainwater treatment train for supply to outdoor and toilet uses could comprise a leaf diverter (in areas with trees), a rainwater tank and a pump, whilst a treatment train for supply to laundry, toilet, hot water and outdoor uses could comprise a leaf diverter, a first flush device, a rainwater tank and a pump. However, a rainwater treatment train that supplies all household water demands might also include a first flush device to remove sediments, with an inline filter and UV disinfection on the drinking water supply line. Note that the NSW Department of Health does not prohibit the use of rainwater for any household purpose, but recommends that an adequately treated reticulated water supply should be used for drinking purposes where available.

Depending on site conditions, user requirements and budget, rainwater tank systems can be installed using a variety of different configurations, including:

- installation of tanks above or below ground
- using gravity or pressure systems
- using dual water supply systems
- including a detention volume inside the tank for additional stormwater management.

Dual supply systems

A dual water supply system utilises both rainwater and mains water. In this system, a rainwater tank can be topped up with mains water when the tank level is low (due to dry weather or high usage). This ensures a reliable water supply, whilst also providing significant mains water savings and stormwater management benefits.

Required tank capacity will depend on the number of persons in the household, water use, rainfall and roof area. In areas with mains water supply available, rainwater tanks with capacities of 1,000 – 5,000 litres are generally sufficient. Smaller tank sizes can also provide considerable benefits. When designing the tank system, provision should be made for each of the following storage components (see Figure 4):

- minimum storage (or mains water top up zone) to ensure that water supply is always available
- rainwater storage zone
- air gap for additional stormwater management and backflow prevention
- anaerobic zone (water is drawn from above this zone to ensure that it is free of sediment).

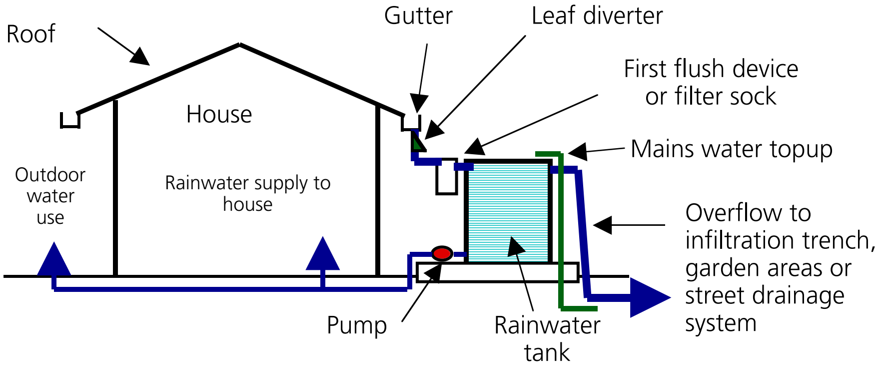

Fig 3: Elements of a domestic rainwater system (the rainwater treatment train)

Rainwater tanks

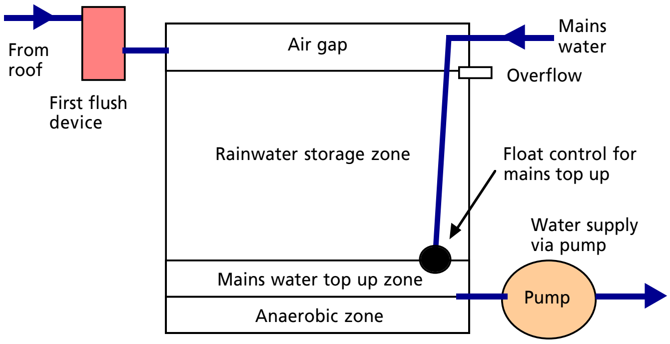

Fig 4: Storage components for a dual supply system

The minimum storage volume (mains water top up zone) is usually the maximum daily water use that is expected from the tank, less the potential daily top up volume of mains water (about 250-750 litres). If the volume of stored water falls below the minimum storage volume, the shortfall can be overcome by topping up the tank with mains water to the required level. A simple float valve system can be installed to do this automatically.

The rainwater storage zone comprises the total volume available in the tank to store rainwater below the overflow pipe. The air gap between the overflow pipe and the top of the tank can be used to provide 'stormwater detention', thereby delaying the delivery of excess roof water to the drainage system. The rainwater storage zone and the overlying air gap provide both stormwater retention and detention. Note that the air gap provides the highest level of backflow prevention in accordance with Australian Standard ASNZ3500.1.2.

Figure 5 shows the configuration for a dual water supply system with mains water trickle top up.

Tank water is directed to indoor and/or outdoor fixtures via a small pump. When tank levels are low (such as during prolonged dry weather), the tank is topped up with mains water via a trickle system. This reduces peak demand on the mains water distribution network. The tank can be bypassed in the event of a pump or power failure. Australian Standards and national practice allows an internal top up arrangement for rainwater tanks, however Sydney Water Corporation currently requires an external top up system to be installed. Note that plumbing requirements for installation of dual water supply systems (rainwater and mains water) are subject to variation. The reader is advised to check the plumbing guidelines provided by Sydney Water Corporation (*Guidelines for Rainwater Tanks on Residential Properties*) and by the Committee on Uniformity of Plumbing and Drainage Regulation in NSW (*Guidelines for Plumbing Associated with Rainwater Tanks in Urban Areas Where a Reticulated Potable Water Supply is Installed*).

A dual water supply system may also include a mains water bypass system rather than a mains water trickle top up arrangement. In this system a solenoid valve is used to switch between mains and rainwater supplies. When the rainwater storage is empty or in the event of a pump or power failure, the solenoid valve is open allowing all household water demand to be supplied with mains water. If rainwater is available in the tank the solenoid valve is closed allowing the pump to deliver rainwater to the household (see Figure 6).

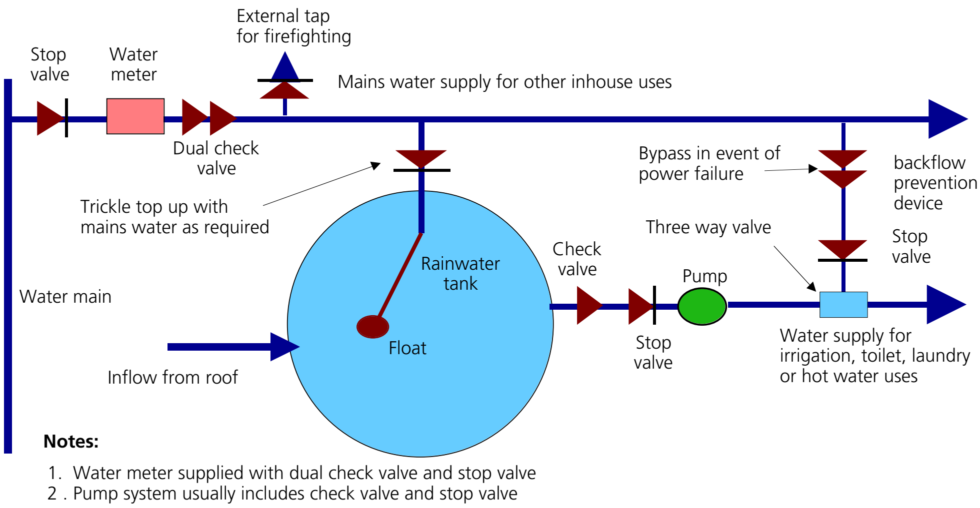

Fig 5: Configuration for a dual supply system with mains water trickle top up

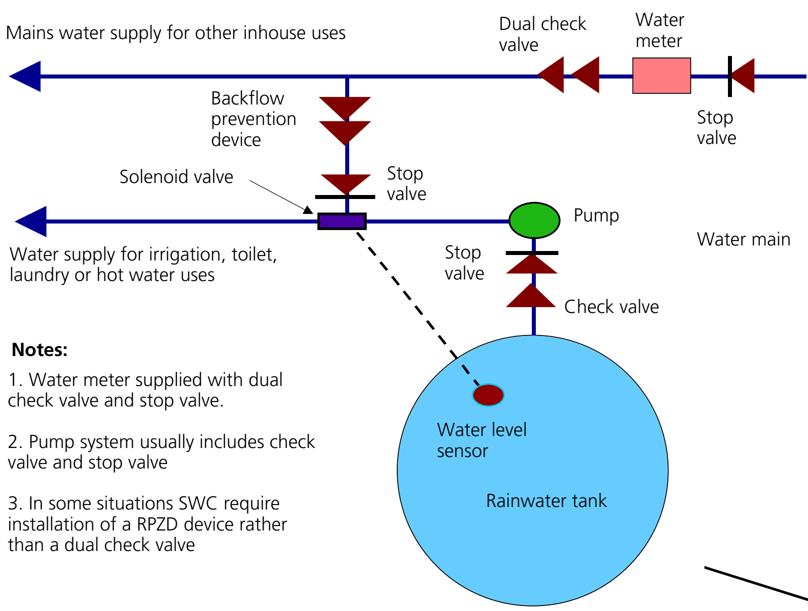

Fig 6: Configuration for a dual supply system with mains water bypass

Note that Figure 6 shows the use of two backflow prevention devices (as does Figure 5). In some cases Sydney Water Corporation may require the installation of a Reduced Pressure Zone Device (RPZD) for backflow prevention when the bypass configuration is employed. An RPZD will be required by Sydney Water for dual supply systems where an underground tank is installed.

Although it is commonly perceived that a rainwater tank will take up a large amount of allotment area, the reality is quite different with a 1,000 litre tank occupying an area less than 2 square metres and a 5,000 litre tank occupying an area of about 2 - 3 square metres.

Pressure systems

A pressure system involves using a pump to deliver rainwater to household or garden fixtures. Pressure systems are required where the tank cannot be installed at a sufficient height to provide acceptable pressure (see Figure 3), or if the tank is installed underground (see Figure 7).

Gravity systems

The installation of a rainwater tank system that relies on gravity to supply rainwater to the household and the garden will involve placing the rainwater tank on a stand or at a height greater than intended end uses as shown in Figure 8. The use of gravity to supply rainwater at low pressure to the household is common in rural areas and for the use of small rainwater tanks that supply outdoor and/or indoor water uses in urban areas.

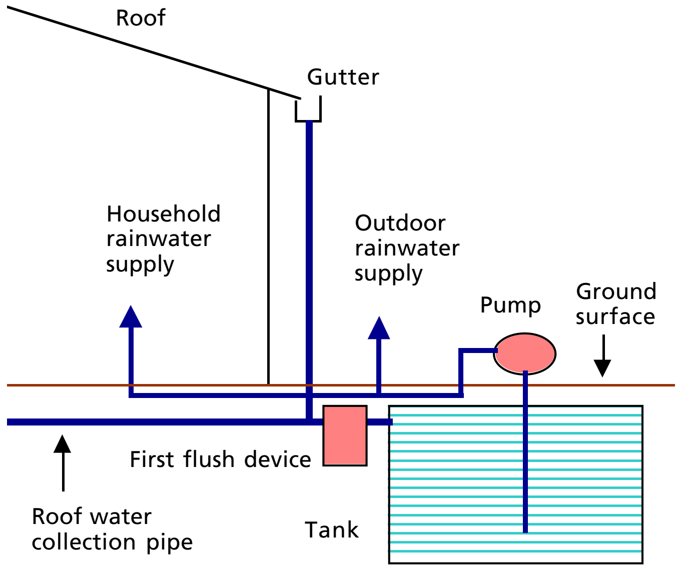

Fig 7: Configuration for a pressure system on an underground rainwater tank

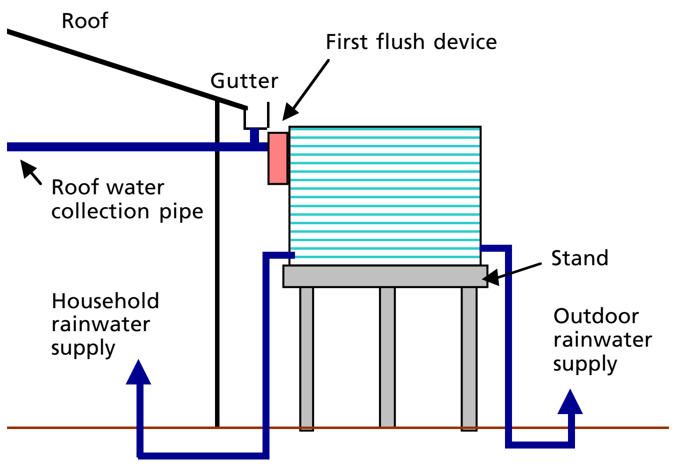

Fig 8: Configuration for a gravity system

Rainwater tanks

In a gravity system, rainwater is collected from the roof and directed to the tank. All connections to outdoor and household fixtures depend on gravity alone. Water pressure at each fixture is governed by the difference in height between the tank and the fixture.

To achieve a water pressure similar to that of normal mains water, the tank needs to be positioned at least 20 metres vertically above fixtures. This is generally not practicable. However, many household water uses such as toilets, laundry tubs and garden hoses do not require such high water pressures. Gravity systems are often adequate for these purposes.

First-flush devices

A first-flush device separates the first part of rainfall from entering the rainwater tank (see Figure 9).

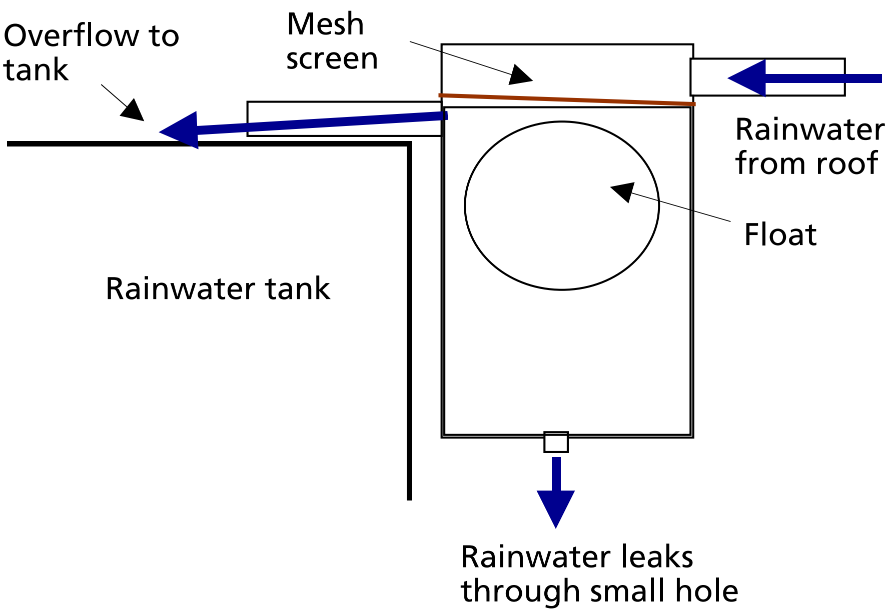

Fig 9: Basic design features of a first flush device

The use of a first flush device will prevent some of the sediment and debris from roofs or gutters from entering the rainwater tank. The device operates by filtering roof runoff through a mesh screen to capture leaves and debris. The first part of runoff is stored in the chamber to slowly trickle through a small hole whilst cleaner water at the top of the chamber passes into the rainwater tank.

The performance of first flush devices has often been misunderstood. Research from the University of Newcastle shows that first flush devices with capacities of up to 20 – 25 litres are successful at separating significant proportions of sediment and debris from rainwater. Larger first flush devices do not produce considerable additional improvement in rainwater quality. Indeed large first flush devices dramatically reduce the volume of rainwater that gets into a tank.

Note that a number of variations on the design shown in Figure 9 are available, as are alternative methods of removing sediment and debris from rainwater (such as filter socks).

Roofs & gutters

Rainwater collected from roofs painted with lead-based or tar-based paints, or from asbestos roofs should not be used for drinking water supplies. Galvanised iron, Colorbond™, Zincalume™, slate or ceramic tiles provide acceptable water quality. *Australian Standard AS4020 Products for use in Contact with Drinking Water* provides guidance on acceptable materials for roof catchments that supply drinking water. Special roof guttering is not required. Normal guttering is sufficient provided that gutters are kept clear of leaves and debris.

Rainwater tanks

Water quality

There is growing scientific evidence to confirm traditional knowledge and practice that water sourced from rainwater tanks is acceptable for most household uses. For example, research undertaken by the University of Newcastle has shown that domestic roof water stored in rainwater tanks is of acceptable quality for toilet, washing machine (laundry), hot water and outdoor uses. The processes improving rainwater quality in the rainwater treatment train include:

- exposure to ultra violet light, heat, and desiccation on the roof top destroy bacteria
- first flush devices or filter socks can limit the transfer of sediment and debris to rainwater tanks
- mesh screens on all inlets and outlets to rainwater tanks will exclude animals from entering tanks, thereby minimising the possibility of harmful bacteria entering tanks
- most bacteria in rainwater tanks are trapped at the water surface
- settlement processes remove sediments, metals and bacteria from rainwater
- biofilms (slime) and sludge in the tanks remove organics, bacteria and metals from rainwater
- hot water systems and pumps may also help eliminate bacteria from rainwater supplies.

This research has also revealed that rainwater used in hot water systems is compliant with the *Australian Drinking Water Guidelines* provided that temperature settings greater than 50°C are maintained. Laboratory experiments also established that bacteria and pathogens are rapidly eliminated from water heated to 60°C. This result is consistent with the requirements of Australian Standard AS3500.2.4 that domestic hot water systems should be set at 60°C to eliminate bacteria from mains water systems, and that hot water should be delivered to the house at a non-scalding temperature of 50°C. Pathogens are not commonly found in rainwater tanks (Cunliffe, 2004).

It is not recommended that rainwater be used for drinking in high density urban areas unless it is passed through an approved filtration or disinfection system. Such a system should be sufficient to remove possible residual contamination from accumulated soil and leaves in gutters, faecal material (deposited by birds, lizards, rodents and possums) and dead animals on roofs or in gutters that may not be removed from the rainwater treatment train. Acceptable water quality can be maintained by:

- installing mesh screens over all inlets and outlets to prevent leaves, debris and mosquitoes from entering the tank
- installing a first-flush device or a filter sock to remove a proportion of sediment and debris from roof water
- regularly removing leaves and debris from roof gutters
- only cleaning rainwater tanks when sediment levels become unacceptably deep
- drawing water from the tank above the anaerobic/ sediment layer
- ensuring that the hot water service is set at 60°C (where rainwater is used in hot water system).

Regulatory issues

Health departments

State government health departments do not prohibit the use of rainwater for drinking or other purposes. However, they do recommend proper use and maintenance of rainwater tanks, and provide various guidelines, particularly on drinking water quality (see Cunliffe, 2004). No guidelines exist for outdoor, toilet, laundry and hot water uses. The NSW Health Department does not recommend the use of rainwater for drinking in urban areas where an adequately treated reticulated water supply exists. The Commonwealth Government's *EN Health Guidelines* provide advice on the management of rainwater tanks.

Rainwater tanks

Water supply authorities

Water supply authorities cannot prohibit the use of rainwater on private land. However, they do require the installation of an appropriate backflow prevention device to prevent possible contamination of mains water by rainwater. Sydney Water Corporation provides guidelines for plumbing configurations of rainwater tanks on residential properties (see www.sydneywater.com.au).

Local councils

Rainwater tanks and stormwater retention devices may require development consent if they exceed certain requirements relating to size, height, siting and other matters, as specified in the 'exempt development' provisions under State Environmental Planning Policy No.4. Local councils usually require that the plumbing configurations for rainwater tanks are consistent with the requirements of the Committee for Uniformity of Plumbing and Drainage Regulations (CUPDR). Note that CUPDR Circular 18 addresses the installation of rainwater tanks. If a development application is required (for example, for a tank with a capacity exceeding 10,000 litres), details should be provided as to:

- location and relationship to nearby buildings
- configuration of inlet, outlet and overflow pipes
- storage capacity, dimensions, structural details and proposed materials
- the purposes for which the stored water is intended to be used.

For further details, contact your local council.

Design standards

Chapter 7 of the *Australian Drinking Water Guidelines* (NHMRC, 2003) contains guidance on the management of small potable water supplies. Cunliffe (2004) provides a complete coverage of the topic. There are no recognised standards for the use of rainwater for secondary quality purposes.

Australian Standard *AS/NZ 3500.1.2-2003: National Plumbing and Drainage - Water Supply - Acceptable Solutions* provides guidance on the design of rainwater systems. The standard categorises cross connection between mains water supply and a domestic roof water tank as a low hazard connection. This requires a non-testable backflow prevention device (such as a dual check valve). If a higher level of backflow prevention is required for a greater hazard rating the following approaches can be used:

- no physical connection between the tank and the mains water system
- an air gap
- an approved backflow prevention device.

An air gap refers to a physical separation between the mains water and rainwater supplies within or above the tank. This is a simple, reliable and maintenance-free solution. Testable backflow prevention devices such as RPZDs are mechanical devices that separate mains and other water supplies. Testable devices require regular servicing. Australian Standard AS/NZ 3500.1.2-2003 provides guidance on the design of dual supply systems that utilise an air gap or a RPZD. An RPZD is required by Sydney Water for dual supply systems where an underground tank is installed. The CUPDR circular 18 and the Sydney Water Corporation *Guidelines for Rainwater Tanks on Residential Properties* also provides advice on plumbing configurations for rainwater tanks. *Australian Runoff Quality*, published by Engineers Australia, also provides guidance on the use of rainwater tanks.

Rainwater tanks

Materials & products

Concrete

Concrete tanks can be purchased in a ready-made form or constructed on-site. They can be placed above or below ground. Concrete tanks can be subject to cracking although careful construction techniques will minimise the potential.

Fibreglass & plastic

Fibreglass tanks are constructed from similar materials as fibreglass boats and can be used in above-ground installations. Plastic or poly tanks are constructed using food-grade polyethylene that is UV stabilised and impact modified. These tanks are strong and durable. They can be used above or below ground depending on their design.

Metal

Galvanised iron tanks are constructed from steel with a zinc coating, and can be used in above-ground installations. These tanks are strong and durable, but can be subject to corrosion if copper pipe for the household water service is directly connected to the tank. The first section of plumbing connected to the tank should be UPVC or other non-metallic material. Zincalume™ tanks are constructed from steel with zinc and aluminium coating. They are similar to galvanised iron tanks.

Aquaplate™ tanks are made from Colorbond™ lined with a food grade polymer. They can be used in above-ground installations. These tanks are strong, durable and corrosion resistant. When cleaning the tank, it is important to avoid damaging the polymer lining.

Maintenance

A rainwater tank system requires very little maintenance provided that the tank is correctly installed. Regular maintenance tasks are:

- cleaning the first flush device every 3-6 months
- removing leaves and debris from gutters and the inlet mesh on the tank every 3-6 months
- checking sediment level in the tank every 2 years.

Tanks require occasional cleaning. The frequency of cleaning will depend on the amount of sediment and debris that enters the tank. A first flush device and adequate mesh screens on all tank inlets and outlets will ensure that the majority of sediment and debris does not enter the tank. This will reduce the frequency of cleaning to every 10 years or so.

Costs & savings

Tank costs vary from place to place. Indicative 2004 prices (without installation) are as follows.

Material	Capacity (litres)					
	500	1,000	2,400	3,200	4,500	9,000
Aquaplate™ round	$250	$380	$670	$765	$795	$1,535
Aquaplate™ slimline	$285	$775	$1,466	$1,555	$1,685	-
Polymer	$340	$462	$530	$750	$950	$1,460
Concrete	-	-	-	-	$1,500 - $5,000	$2,300 - $7,500

Small household pumps with pressure control can be purchased for $340 to $620.

Installation costs for rainwater tanks can be highly variable. The cost to fully install a 4,500 litre above ground rainwater tank for indoor and outdoor use can range from $1300 to $3,500. Underground installation will usually add about at least $2000 to the cost. This system can provide the home owner with water savings of about $50 to $110 per year, reduce stormwater discharges to the environment, reduce water demand on rivers and dams, and improve water quality in downstream stormwater catchments.

Rainwater tanks

Rainwater tank performance

Some design considerations for a rainwater harvesting system are presented in this section. It is assumed that a home owner intends to build a new house that will have three occupants in the North Ryde area. Annual water demand in the household will be 225 kilolitres. The allotment has a land area of 450 m^2 with 70% of the area being impervious, and 150 m^2 of the roof catchment can be connected to a rainwater tank. The BASIX building sustainability index requires that water use in the new house be reduced by 40%. The performance of a variety of tank sizes and rainwater uses for the house has been simulated using the PURRS (Probabilistic Urban Rainwater and Wastewater Reuse Simulator) Model. The results are shown in Figure 10.

Figure 10 shows that mains water savings from use of rainwater tanks increases rapidly for small rainwater tanks and increases in mains water savings diminish with larger tank sizes. Larger rainwater tanks do not produce equally larger water savings. In this situation the optimum rainwater tank size for mains water savings appears to be between 2,000 and 5,000 litres. The annual reductions in stormwater runoff volumes are shown in Figure 11.

Figure 11 shows that the optimum sized rainwater tank for reducing stormwater runoff volumes is between 2 and 5 kilolitres. Reductions in stormwater runoff volumes at the allotment are the most significant factor for the reduction in catchment scale peak stormwater discharges that will help mitigate flooding impacts and improve in urban stormwater quality.

The optimum rainwater tank size for reductions in mains water savings and stormwater runoff is between 2 and 5 kilolitres. However the designer will also desire to reduce the installation costs of the rainwater tank and minimise the land area used by the rainwater tank. Specification of a rainwater tank with a capacity less than 4,000 litres will allow the installation of an above ground tank thereby significantly reducing installation costs. Use of a slimline tank will minimise the effective land area used by the rainwater harvesting solution.

However, Figure 10 shows that rainwater tanks at this site will not reduce mains water demand by the 40% required by BASIX. It is proposed to also install

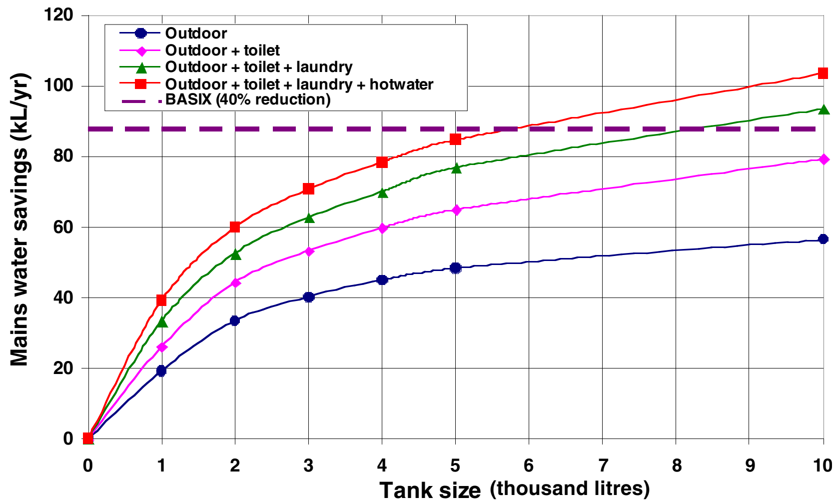

Fig 10: Mains water savings provided by rainwater tanks at North Ryde

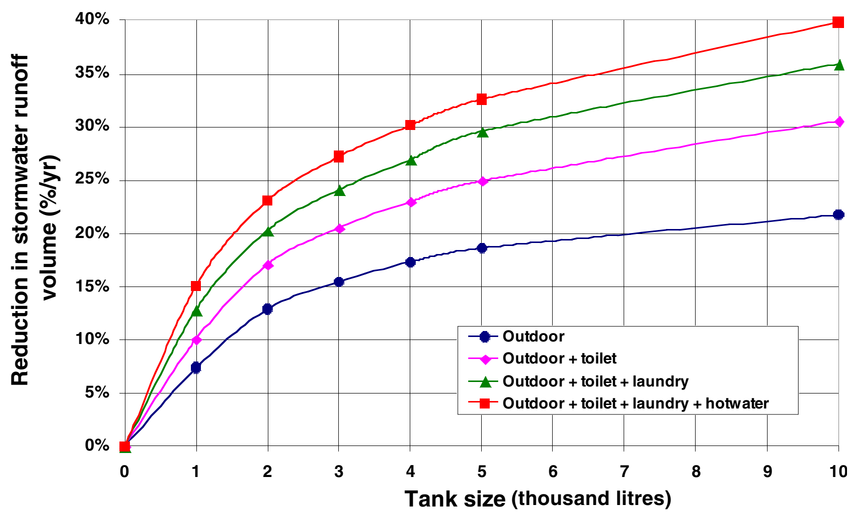

Fig 11: Reductions in annual stormwater runoff volumes provided by rainwater tanks at North Ryde for a 150 m^2 roof catchment

low flow showers, 6/3 dual flush toilets and tap flow restrictors that will reduce water use by 16%. Therefore, the rainwater harvesting system will need to reduce water use by at least 24%. Selection of a 3 kilolitre rainwater tank to supply outdoor, toilet and laundry (washing machine) uses will reduce water use by 29% and will also reduce stormwater runoff volumes by 24%. The designer should note that a wide range of rainwater harvesting solutions are possible, but performance of rainwater tanks will vary widely depending on water useage patterns, extent of roof area and the site's average rainfall.

Useful websites

Water Sensitive Urban Design in the Sydney Region Project: *www.wsud.org*

BASIX Sustainable Building Index: *www.basix.nsw.gov.au*

Peter Coombes, University of Newcastle: *www.eng.newcastle.edu.au/~cegak/Coombes*

Environment Australia: *www.greenhouse.gov.au/yourhome*

Michael Mobbs: *www.sustainablehouse.com.au*

BDP Environment Design Guide: The Royal Australian Institute of Architects

Sydney Water Corporation: *www.sydneywater.com.au*

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Other practice notes

Other Water Sensitive Practice Notes are available in this series:

To download copies, visit the Water Sensitive Urban Design in the Sydney Region website:

www.wsud.org

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Originally published 2002 by the Lower Hunter and Central Coast Regional Environmental Management Strategy (LHCCREMS) as *WaterSmart Practice Note No. 4*. Revised editions published 2003 and 2004 by the Water Sensitive Urban Design in the Sydney Region Project.