



RAINWATER HARVESTING

RESIDENTIAL DESIGN
SPECIFICATION



A DIVISION OF IRRIGATION AUSTRALIA



Independent research and consulting



User Guide

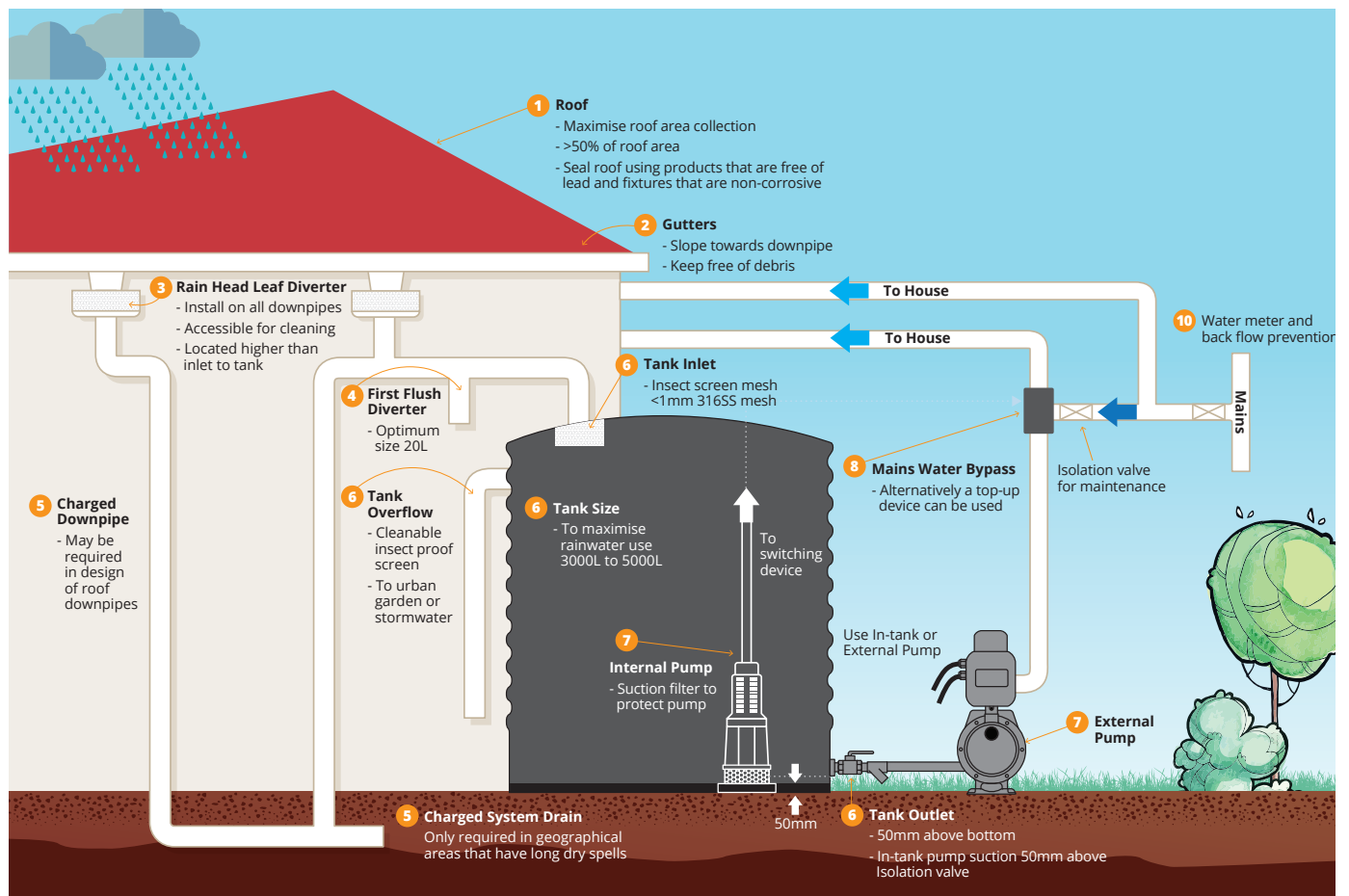
Congratulations on your decision to harvest rainwater. This guideline is provided by the Rainwater Harvesting Association of Australia (RHAA) and Urban Water Cycle Solutions (UWCS) for above ground rainwater harvesting systems connected to residential dwellings in urban areas. The specification is for a dual water supply, using mains water and rainwater sourced from roof catchments. The dual water supply system sources rainwater first, when stored rainwater is available, for outdoor, toilet, laundry and hot water supply. When stored rainwater is not available, all household water demands are supplied with mains water. The household is encouraged to choose the highest level of water efficiency.

Correctly installed rainwater harvesting systems develop a natural treatment train that addresses many of the potential contamination issues that may be associated with a roof catchment. This is an important reason why rainwater harvesting is so widely used in Australia and rainwater users remain healthy. Australian health data indicates drinking untreated rainwater provides health outcomes similar to mains water. One in four households use rainwater harvesting in Australia. The householder is responsible for the quality of the water in their house for all water uses.

The RHAA, through Professor PJ Coombes from UWCS and other independent scientists, have extensively monitored the inputs and outputs of residential rainwater harvesting systems and used that data to inform this design specification. This evidence provides a perspective that is independent of the traditional water industry and the centralized distribution paradigm.

The RHAA and UWCS trains Rainwater Harvesting Technicians and a list of local practitioners is available on the Rainwater Harvesting website. www.rainwaterharvesting.org.au. Additional rainwater harvesting information is available at www.urbanwatercyclesolutions.com

Rainwater Harvesting Design Specifications (for above ground tanks)





What are the elements of the design and how do they interact?

The elements of the rainwater harvesting system are shown on the Rainwater Harvesting Design Specification diagram. The ongoing efficiency and maintenance of the system is dependent on good design choices at the start of the process.

The Rainwater Harvesting system also interacts with the local rainfall, climate, the house and the residents. Regular small rain events are very significant for rainwater harvesting systems, even in dry periods most capital cities experience regular rain events - an average of less than 6 days between rain events. Using efficient water use appliances (such as front loading clothes washers, low flow showers and low flush toilets) within the house will reduce the capital and operating costs of the system. The behaviour of the residents will influence the design and operation of the rainwater harvesting system.

The following sections list the elements of the system and how they should be designed and implemented.

1. ROOF

1.1. Maximise roof area collection

Research shows better yield outcomes from specifying the minimum roof area. It is important to maximise the roof area that is being directed to the rainwater harvesting system. The minimum roof area that needs to be connected is whichever is the greater of:

- > 100 square metres, or
- > 50% of the roof area

A properly installed roof guttering system on a standard roof will connect approximately 100 square metres of roof catchment to the rainwater tank via two downpipes. A choice to connect more roof area may involve the use of a charged downpipe connection to the rainwater tank. See the notes about Charged pipes in section 5.

1.2. Use lead free roof sealing materials

It is important to understand if lead flashing is present on roofs where rainwater is being used for kitchen, hot water or drinking water uses then it must be identified and removed.

Where rainwater is only used as a supplementary water source, such as for toilet flushing or irrigation, lead flashing is not a concern but we would still recommend that it is removed so that the rainwater is available for other uses if required.

1.3. Use non-corrosive materials

In new homes and properly installed roofs, corrosive materials (that rust) should not be present.

They may occur where galvanised roofs have been installed and react with screws and fittings from other fixtures that have been installed on the roof.

Ensure that any fixtures installed on the roof use non-corrosive materials.

2. ROOF GUTTERS

2.1. Designed to Australian Standard AS3500 and slope towards downpipes

To maximise rainwater collection, roof gutters must be installed to the Building Code and Australian Standard AS3500 - the Plumbing and Drainage standard. All roof guttering systems should meet these standards as a part of the building design.

A design based on Australian Standard AS3500 will ensure that your roof gutters flow towards your downpipes.

The direction of gutter fall can be checked by putting a hose in the gutter to see if the water flows towards downpipes. If water ponds in the gutters the installation will need to be corrected.



2.2. Keep your gutters free of debris

Roof gutters need to be kept free of leaves and debris to maximise rainwater yield. Clogged roof gutters will prevent water from flowing to the tank and can reduce water quality through leaves and debris breaking down in the gutter.

If you have overhanging trees, you may need to pay more attention to the cleaning of your gutters.

For safety and convenience, you could consider looking at options to minimise your maintenance of roof gutters, such as gutter guards.

2.3. Gutters can be specifically designed to maximise rainwater collection

There are gutters and associated products that are purpose built to improve rainwater collection. These products that connect all gutters together for easy diversion to the tank, or simple in-gutter options for diverting downpipes to the tank.

3. RAIN HEAD LEAF DIVERTERS

3.1. Installed on all downpipes collecting rainwater

Rain Head Leaf Diverters must be installed on all downpipes connected to the rainwater system to remove leaves and debris.

3.2. In an accessible position and higher than the inlet of the tank

Rain Head Leaf Diverters must be installed on downpipes at a height greater than the tank inlet. This is to ensure there is downward flow to the tank.

It is important Rain Head Leaf Diverters are accessible so that maintenance can be performed easily and safely.

3.3. 316 stainless steel mesh sized <1mm

Rain Head Leaf Diverters must have stainless steel mesh for longevity.

Mesh sized <1mm on the diverter will prevent the entry of mosquitoes and minimise debris entering the system.

4. FIRST FLUSH DIVERTERS

4.1. Install at the tank prior to the inlet

A single first flush diverter should be installed just prior to the point of entry into the tank.

4.2. 20 litre first flush size

For a typical household roof, the optimum capacity of a first flush device is 20 litres.

5. CHARGED DOWNPIPE DRAIN

Charged pipes are created when the downpipe is not near the tank and the downpipe is directed underground and then up again into the tank. Rainwater remains in the pipes and the pipes are 'charged' with this rainwater.

For charged pipes, it is essential that Rain Head Leaf Diverters are installed to keep the line clear of leaves, debris, small animals and insects (for example: frogs and mosquitoes).

5.1. Allow charged downpipes to be flushed

Because charged systems have a low point below the tank inlet there is a risk of debris building up in the system. By placing a drain at the lowest point of the charged pipe, the pipe can be flushed if required. Charged pipes may need to be flushed if they are holding water for an extended period of time (for example more than 20 - 30 days).

5.2. Recommended for areas with prolonged dry periods

It is more likely in areas with prolonged dry periods that any water sitting in a charged line will have poorer quality. A charged pipe drain should be used to drain the pipe at the end of the wet season and at the end of the dry season. Areas with prolonged dry periods are South Australia and Western Australia.



6. WATER TANK

A minimum standard of quality is recommended for all rainwater tanks to ensure tanks are structurally sound, safe and reliable for long term rainwater storage. Following are the minimum requirements for different types of rain water tanks:

- Polyethylene Tanks - Certified to AS/NZS4766 (Australian Standard - Polyethylene Storage Tanks for Water)
- Steel Tanks - Tank designed by suitably qualified Engineer and constructed using materials certified to AS/NZS2180
- Concrete Tanks - Certified to AS/NZS3735 (Australian Standard - Concrete Structures Retaining Liquids). The rainwater tank must be installed on a base that is constructed according to tank manufacturers guidelines.
- Bladder Tanks - Made from material certified to AS/NZS4020 (Australian Standard - Testing of products for use in contact with drinking water) with seams tested in accordance with AS/NZS2001 (Australian Standard - Methods of Tests)

6.1. Rainwater Tank Inlet

An Inlet Strainer must be installed on all rainwater tanks incorporating 316 stainless steel mesh with less than 1 mm openings to ensure no entry point to the tank for mosquitoes and other vermin.

Where possible the rainwater pump should draw water from the opposite side of the tank to the inlet from the roof catchment.

Whilst the use of a light guard or solar shield can be used to reduce the effect of algae growth, a well-designed rainwater tank system that minimises the build-up of sediment and nutrients in the tank is sufficient.

6.2. Rainwater Tank Overflow

An overflow incorporating 316 stainless steel mesh with less than 1 mm openings that can be cleaned must be installed on all tanks to ensure that there is no entry point to the tank for mosquitoes and other vermin.

The tank overflow capacity must be equal to or greater than the capacity of the inflow.

Overflow water can be directed to the yard or a ground area or gardens that are able to absorb the overflow rainwater. This minimises the rainfall impact on stormwater infrastructure and downstream waterways, and improves soil qualities. Note: Ensure rainwater overflow does not affect neighbouring properties and any excess rainwater must flow to the municipal stormwater system (usually in the street or at the back of properties).

6.3. Rainwater Tank Size

The optimum size for a household rainwater tank with a mains water back up system is between 3000 Litres and 5000 Litres.

6.4. Rainwater Tank Outlet to Household Supply

The rainwater tank outlet is to be 50 mm or higher from the base of the tank to ensure the outlet does not access material that may have built up on the bottom of the tank. This material plays an important role in the natural water treatment train of a water tank.

In areas where a high level of dust or other fine particles are common (such as near farm land) the tank outlet is to be located a minimum of 100 mm from the base of the tank.

In the case where a submersible pump is used in the rain harvesting system, the inlet to the submersible pump should be located in the tank at either 50 mm or 100 mm above the base of the tank, for the same reasons.

6.5. Notes:

For optimal water quality ensure the rainwater from the tank is regularly used.



7. RAINWATER TANK PUMP SYSTEMS

In order to estimate pump size we need to understand the flow rates required for house use. The flow rate guide below provides an indication of the flow rate that the pump may need to supply.

Table 1.

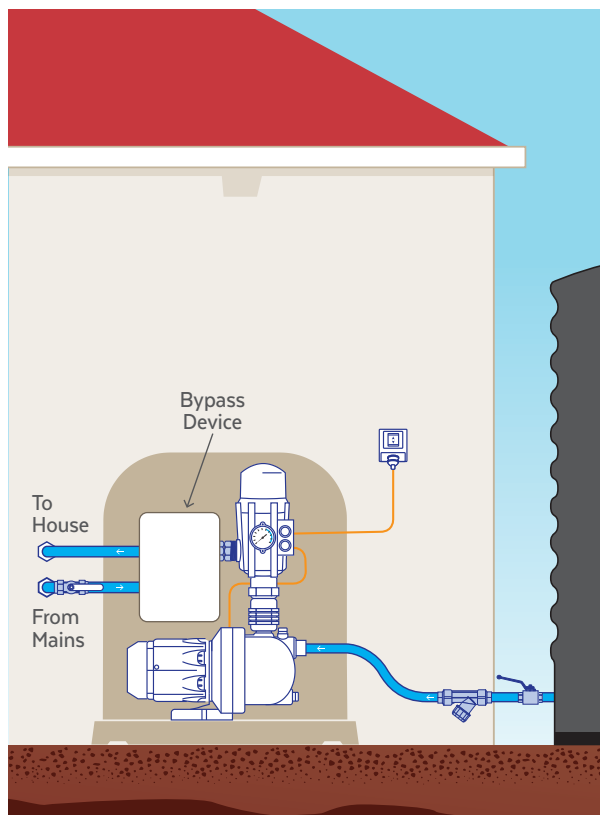
Toilet	5 litres/minute
Washing Machine	< 12 litres/minute
Hot Water (Shower)	< 9 litres/minute
Garden Hose	15 litres/minute
Garden Sprinkler	15 litres/minute

As a guide you should assume two appliances could be operating at the one time. An industry standard for the pressure provided by the pump should be greater than 300 KPa.

A pumping system can be installed on a rainwater tank to increase the water pressure to be used for garden watering and inside the house for the toilet, washing machine, or whole of house. Some water appliances will not work unless there is pressure produced by the pump. The pump can be installed outside (external pump) or inside (in-tank pump) the rainwater tank (See Diagram 1 for typical installations). A guide to the benefits of an external pump and an in-tank pump are listed in Table 1.

Diagram 1: Typical Installation

EXTERNAL OPTION



IN TANK OPTION

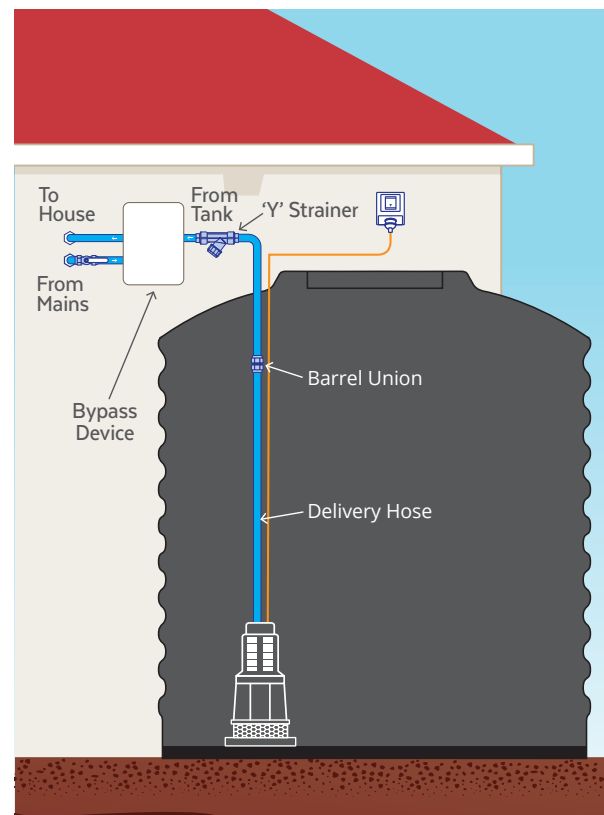




Table 2 : Benefits of Pumping Systems

Characteristic	External Pump	In-tank Pump
Performance	Ensure correctly installed suction line	Ensure inlet screen of pump is located 50mm above bottom of tank
Noise	May require positioning away from bedrooms or install pump cover.	Water in tank will minimise noise
Electrical cabling	Ensure electrical cables are protected from children and animals	Power point should be installed on wall at level of top of tank so cabling is out of reach
Weather protection	Ensure protection from sun and rain by using pump cover	No protection required

7.1. Pump Selection

The pump is a key component of a rainwater harvesting system and an investment in quality and reliability from a reputable supplier and brand is recommended (for guidance refer www.rainwaterharvesting.org.au). Choose the smallest pump size (measured in Power Absorbed) for the required household flow rate. This will minimise electricity usage. Variable speed pumps are preferred over fixed speed pumps because they minimise electricity costs and greenhouse gas emissions. Do not select a pump where cast iron is in contact with the rainwater.

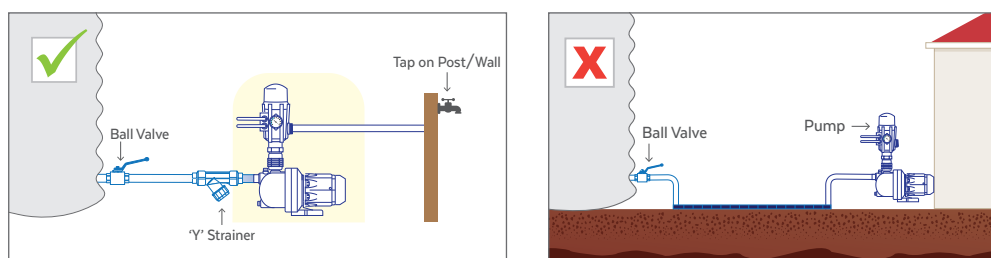
7.2. Pump suction for external pump (External Pump)

A critical component to successful pump performance is the pipework from the rainwater tank to the pump. This is called the suction line. This line shall be as short as possible and designed in such a manner to allow for expansion and contraction of the rainwater tank relative to the pump. This flexible line will prevent damage to the pump inlet fittings.

7.3. Use short suction lines

The use of short suction lines will prevent problems with air entrapment. This can cause the pump to lose prime and effect operation of the pump.

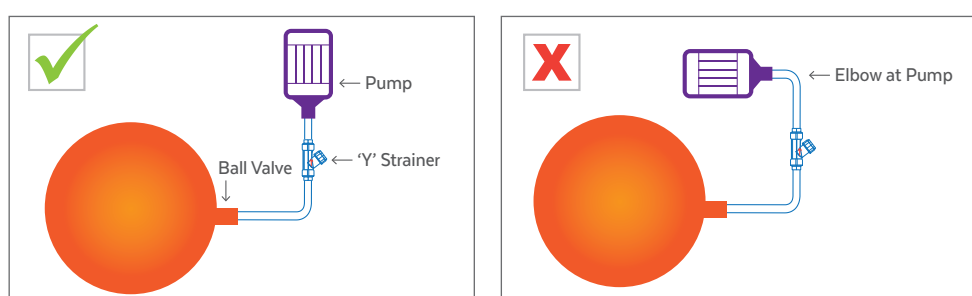
Diagram 2.1: The suction line



7.4. Minimise the use of elbows in suction pipework

Position the pump to use the least elbows possible in the suction line. It is best to have no elbows but where necessary have as few as possible. Try to prevent having an elbow directly onto the inlet of the pump. Elbows in the suction line cause performance and noise issues with the pump.

Diagram 2.2: Elbows in the Suction Line

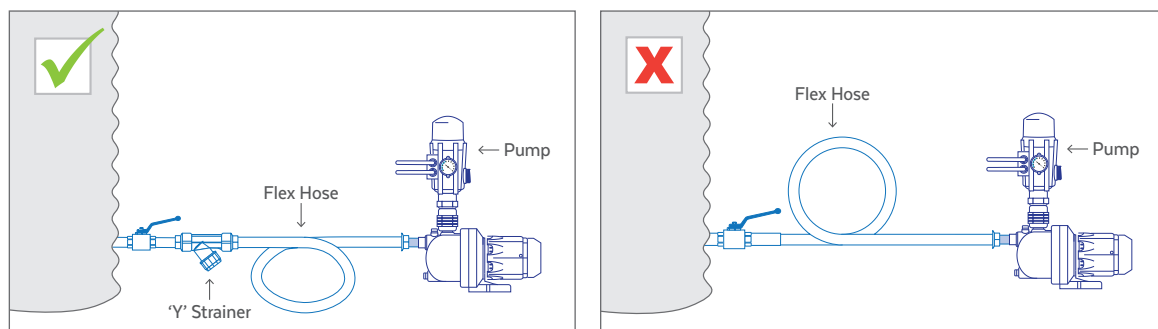




7.5. Use of Flexible Suction line

A flexible suction line is recommended because it does not have elbows and it allows for movement between the rainwater tank and the pump. If the flexible suction pipework needs to be looped ensure the loop goes downwards. This will prevent air from being trapped in the high point and causing priming and performance problems with the pump.

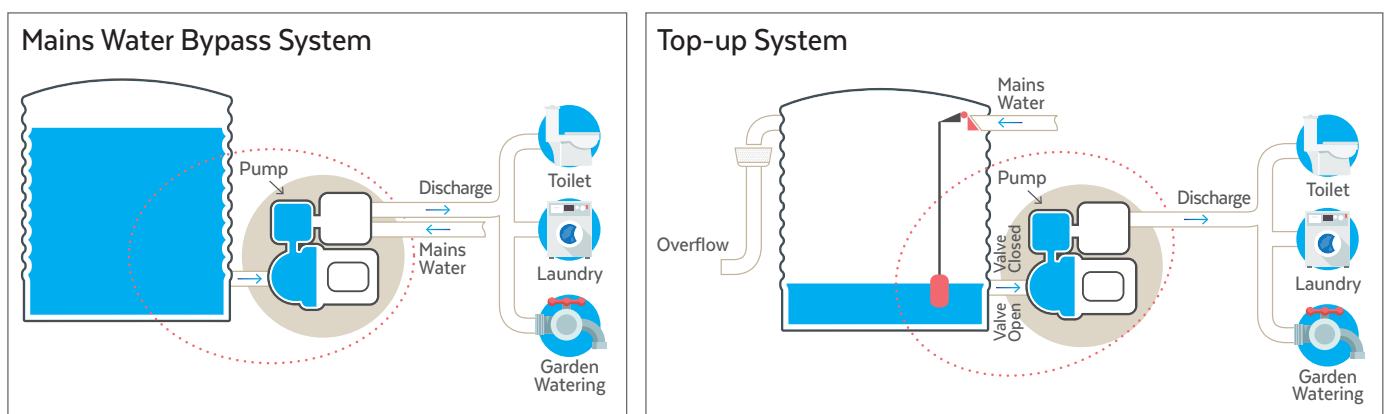
Diagram 2.3: Flexible Suction Lines



8. MAINS WATER BYPASS

To maximise the efficiency of rainwater harvesting, rainwater should be connected to all outside garden taps and inside the house (toilets, washing machine and/or whole of house). A connection to the mains supply can provide mains water bypass in times of dry weather (when there is no rainwater in the tank). The two main mechanisms for backing up rainwater supplies are a mains water bypass system or a mains water top up system. These two alternatives are shown in Diagram 3.

Diagram 3: Typical Pump Systems for inside house supply



8.1. Automatic Bypass Devices

A mains water bypass system is called a bypass system because the mains connection bypasses the rainwater tank and connects directly with the house. An automatic mains water bypass system is commonly referred to as a switching device. A mains water bypass system should only use mains water when there is no available rainwater supply (for example in times of dry weather). The bypass device should be certified to the standard ATS 5200.477. The device should allow full mains pressure to be available at times when the pump is not operating (typically this is above 300 KPa). A valve shall be installed on the mains pipe prior to the Bypass Device to allow maintenance of the device and pump system.

For many bypass systems you need to open the supply tap to the toilet wide open for the system to operate properly.



8.2. Automatic Tank Top-up Device

An automatic tank top-up device will always keep a certain level of water in the rainwater tank to ensure that the pumping system is always in operation. This system incorporates an air gap to prevent backflow. This system connects the mains water to a device at the top of the tank and maintains a certain level by an internal float in the tank. Limitation of this system is that there is always a reliance on the pump for water and it does not use the full capacity of the rainwater tank.

9. FILTRATION

Filtration should be considered in the context of the entire rainwater treatment train presented in these design guidelines. A correctly designed rainwater harvesting system is not entirely reliant on just one element to protect water quality.

For rainwater supply to in-house uses a sediment filtering system could be used. A cartridge system that includes 20–30 micron filter is commonly chosen to remove a range of organics and sediments.

A 0.2 micron filter with activated carbon could be selected for drinking water. This would remove a range of chemicals, minerals, organics and microbes. Water quality depends on using the whole treatment process outlined in these design guidelines and local conditions. The choice of water quality solution will also depend on the circumstances of people within a household.

10. BACKFLOW

Backflow is the unintended flow of water from a potentially polluted source into a mains water supply network. This is an issue for your water utility, they are keen to make sure that potentially contaminated water from a private property cannot flow back into and affect the water network. For this reason, there is a one-way valve (dual non-return valve) placed in all residential meters ensuring that water can only flow into your property and it is regularly checked and replaced by your water service provider.

In addition to the dual non-return valve at the meter, the Mains Water Bypass (as per ATS 5200.477) is fitted with a dual non-return valve to prevent backflow into the household plumbing system. In a Top-up System an air gap is provided as backflow prevention. There is no documented case in Australia where backflow from a household rainwater storage has caused an incident.

A combination of backflow prevention at the water utility meter and at the bypass device provides multiple barrier “zone protection” in accordance with Australian Drinking Water standards. No further backflow device is required in the dual water supply system.

11. TELLING MY BUILDER AND PLUMBER WHAT TO INSTALL

The homeowner should provide this design specification to the builder and plumber showing a simple diagram of the rainwater system. Because this is a national specification the homeowner will need to comply with local regulations. Your builder and plumber will help you with this. It is important to understand that this design specification is based on independent evidence, monitoring and extensive modelling.

12. HOW MY RAINWATER HARVESTING SYSTEM OPERATES AND STEPS I TAKE TO MANAGE THE SYSTEM

The rainwater harvesting system uses local rainwater first and switches to a mains water supply when rainwater is not available. This is an optimum outcome because it maximises the yield from the rain harvesting system without having to provide 100% water security. This solution also saves water utilities and government billions of dollars in capital investment and operating costs by reducing water demand and impacts on waterways across the community.

A correctly designed rainwater harvesting system fulfils its requirements without requiring daily supervision or extensive maintenance.



A visual check of leaf diverters and tank inflow during rain events is recommended

On a monthly basis the homeowner should run a hose or flush the toilet when there is rainwater in the tank and check that the pump switches on to make sure the system is not relying on mains water.

Empty and clean gutters, first flush diverters and rain heads at the start of each season (quarterly) or when filled with debris.

Remove, clean and check inlet, outlet and overflow strainers at the start of each season or when filled with debris.

Clean or replace water pump filters every six months or as directed by manufacturers

Water filtration maintenance (replace system components) – As directed by manufacturers

Charged downpipes should be drained at their lowest point at the end of the wet season and the end of the dry season.

Do not remove accumulated sediment or sludge from tank bottom unless necessary. This sludge actually performs valuable heavy metal capture and biological treatment train functions and should only be removed if it reaches a depth approaching the tank outlet point.

13. HOW DO I KNOW IF THE RAINWATER HARVESTING SYSTEM (OR HOUSEHOLD WATER SYSTEM) IS NOT WORKING WELL

If the pump doesn't switch on when water is required and there is rainwater in the tank there is a problem with the mains bypass device or the pump. If water is discoloured, smells or tastes strange attention is required and should be investigated. For guidance refer to www.rainwaterharvesting.org.au

The mains water use reported in your water utility bill can be used to see if expected rainwater yield is being achieved. As a guide the rainwater harvesting system and water efficient appliances will reduce the mains water use of a normal household up to 90,000 litres each year. If you are not achieving expected rainwater yields contact your rainwater harvesting technician for a discussion.

14. KEY POINTS FOR UNDERSTANDING RAIN HARVESTING

- Rainwater harvesting systems are inexpensive, easy to maintain, provide a reliable source of water and have greater benefits than costs for the majority of households.
- Rainwater harvesting saves water utilities and government billions of dollars in capital investment and operating costs by reducing demand for mains water and impacts on waterways across the community.
- Rainwater harvesting reduces stormwater management costs and reduces the environmental impact of water management in our cities and urban development
- Over 3 million Australians drink rainwater every day, drinking quality rain water is easily achieved
- Rainwater harvesting combined with mains water service provides water supply more efficiently than either system alone.

If you need help with your rainwater harvesting experience please visit the Rainwater Harvesting Association website or Urban Water Cycle Solutions website.

The Design Specification is a living document with a process for reviewing feedback on the Urban Water Cycle Solutions website and the Rainwater Harvesting Association websites.

Congratulations on your investment and welcome to many years of trouble free rainwater harvesting operation.



Bibliography on Rainwater Quality and Rainwater Harvesting considerations

- Heyworth J.S., Glonek G., Maynard E.J., Baghurst P.A., and Finlay-Jones J., (2006) *Consumption of untreated tank rainwater and gastroenteritis among young children in South Australia*. International Journal of Epidemiology. 35(4): 1051-58.
- Rodrigo S., Sinclair M., Forbes A., Cunliffe D., and Leder K., (2009). *Drinking Rainwater: A Double-Blinded, Randomized Controlled Study of Water Treatment Filters and Gastroenteritis Incidence*. American Journal of Public Health. 101(5). 842-7
- Cunliffe, D.A. (2010). *Guidance on use of rainwater tanks*. EN Health Council. Department of Health and Ageing. Australian Government.
- Australian Bureau of Statistics (2013). *4602 Environmental Issues: Water Use and Conservation*.
- Coombes P.J., Discussion on the "influence of roofing materials and lead flashing on rainwater tank contamination by metals" by M.I. Magyar, A.R. Ladson, C. Daiper, and V.G. Mitchell. Australian Journal of Water Resources. Vol 19: No 1. 86-90.
- Morrow A, Dunstan H, Coombes P. J., 'Elemental composition at different points of the rainwater harvesting system.' Science of the Total Environment; 408(20): 4542-4548. (2010)
- Dean, J. and Hunter, P.R. (2012). *Risk of gastrointestinal illness associated with the consumption of rainwater: A systematic review*. Environmental Science & Technology. 46; 2501- 2507"
- Martin Anthony, Coombes Peter J., Harrison Tracey Lee, Dunstan Richard Hugh, 'Changes in abundance of heterotrophic and coliform bacteria resident in stored water bodies in relation to incoming bacterial loads following rain events', Journal of Environmental Monitoring, 12: 255-260 (2010).
- Martin Anthony, Coombes Peter J., Dunstan Richard Hugh, 'Investigating the influences of season and coastal proximity on the elemental composition of harvested rainwater', Water Science and Technology, 61: 25-36 (2010)
- Lucas Steven Andrew, Coombes Peter J., Sharma A K, 'The impact of diurnal water use patterns, demand management and rainwater tanks on water supply network design', Water Science and Technology: Water Supply, 10: 69-80. (2010).
- Evans Craig Andrew, Coombes Peter J., Dunstan Richard Hugh, Harrison Tracey Lee, 'Extensive bacterial diversity indicates the potential operation of a dynamic micro-ecology within domestic rainwater storage systems', Science of the Total Environment, 407: 5206-5215. (2009).
- Lucas Steven Andrew, Coombes Peter J., Planner J, Welchman S, 'Rainfall harvesting and coal dust: The potential health impacts of trace elements in coal dust in rainwater', Air Quality and Climate Change, 43: 23-30. (2009).
- Evans Craig Andrew, Coombes Peter J., Dunstan Richard Hugh, Harrison Tracey Lee, Martin Anthony, Morrow Abigail Cecilia, 'Rainwater tanks and microbial water quality: Are the indications clear?', Australian Journal of Water Resources, 12: 143-152. (2008).
- Coombes P.J. *Energy and economic impacts of rainwater tanks on the operation of regional water systems*. Australian Journal of Water Resources. Vol. 11, No. 2. 177 - 192. (2008).
- Coombes Peter J., Barry M. E., 'The relative efficiency of water supply catchments and rainwater tanks in cities subject to variable climate and the potential for climate change', Australian Journal of Water Resources, 12: 85-100. (2008).
- Evans Craig Andrew, Coombes Peter J., Dunstan Richard Hugh, Harrison Tracey Lee, 'Identifying the major influences on the microbial composition of roof harvested rainwater and the implications for water quality', Water Science and Technology, 55: 245-253. (2007).
- Coombes Peter J., Barry M E, 'The effect of selection of time steps and average assumptions on the continuous simulation of rainwater harvesting strategies', Water Science and Technology, 55: 125-133. (2007).
- Barry M E, Coombes Peter J., 'Optimisation of Mains Trickle Top up Supply to Rainwater Tanks in an Urban Setting', Australian Journal of Water Resources, 10: 269-276. (2006).
- Lucas Steven Andrew, Coombes Peter J., Hardy Matthew James, Geary Phillip Milton, 'Rainwater Harvesting: Revealing the Detail', Water Journal of the Australian Water Association, 33: 50-55. (2006).
- Spinks Anthony T, Dunstan Richard Hugh, Harrison Tracey Lee, Coombes Peter J., Kuczera George Alfred, 'Thermal inactivation of water-borne pathogenic and indicator bacteria at sub-boiling temperatures', Water Research, 40: 1326-1332. (2006).
- Evans Craig Andrew, Coombes Peter J., Dunstan Richard Hugh, 'Wind, rain and bacteria: The effect of weather on the microbial composition of roof-harvested rainwater', Water Research, 40: 37-44. (2006).
- Coombes Peter John, 'Integrated Water Cycle Management: Analysis of Resource Security', Water, 32: 21-26. (2005).
- Coombes Peter J., Kuczera George Alfred, Kalma Jetse Daniel, 'Economic, Water Quantity And Quality Impacts From The Use Of A Rainwater Tank In The Inner City', Australian Journal of Water Resources, 7: 111-120. (2003).
- Coombes Peter J., Kuczera George Alfred, Frost Andrew James, Geoff O'Loughlin, Stephen Lees, 'The Impact of Rainwater Tanks In The Upper Parramatta River Catchment', Australian Journal Of Water Resources, 7: 121-129. (2003).
- Coombes Peter John, Kuczera George Alfred, Kalma Jetse Daniel, Argue J R, 'An Evaluation of the Benefits of Source Control Measures At The Regional Scale', Urban Water, 4: 307-320. (2002).
- Coombes Peter J., Argue J R, Kuczera George Alfred, 'Figtree Place: a case study in water sensitive urban development (WSUD)', Urban Water, 1(4): 335-343. (2000).
- Coombes Peter J., Mitchell Grace, 'Urban Water Harvesting and Reuse', Australian runoff quality: A guide to water sensitive urban design, Engineers Australia, Canberra, Australian Capital Territory, 6.1 - 6.15. (2006).
- Coombes P.J., *Insights into Household Water Use Behaviours Throughout South East Queensland During Drought*. 34th Hydrology and Water Resources Symposium, Sydney, NSW (2012)
- Lucas Steven Andrew, Coombes Peter John, 'Improving downpipe and gutter configuration on a residential dwelling to increase rainwater yield', H2009: Proceedings of H2009, the 32nd Hydrology and Water Resources Symposium, Newcastle, NSW (2009)
- Lucas Steven Andrew, Coombes Peter John, 'Mains water savings and stormwater management benefits from large architecturally-designed under-floor rainwater storages', H2009: Proceedings of H2009, the 32nd Hydrology and Water Resources Symposium, Newcastle, NSW (2009)
- Lucas Steven Andrew, Coombes Peter John, Sharma A K, 'Residential diurnal water use patterns and peak demands: Implications for integrated water infrastructure planning', H2009: Proceedings of H2009, the 32nd Hydrology and Water Resources Symposium, Newcastle, NSW (2009)
- Coombes Peter John, 'The use of rainwater tanks as a supplement or replacement for onsite stormwater detention (OSD) in the Knox area of Victoria', H2009: Proceedings of H2009, the 32nd Hydrology and Water Resources Symposium, Newcastle, NSW (2009)
- Morrow Abigail Cecilia, Coombes Peter John, Dunstan Richard Hugh, Evans Craig Andrew, Martin Anthony, 'Elements in tank water - Comparisons with mains water & effects of locality & roofing materials', Rainwater and Urban Design Conference 2007, Sydney (2007)
- Barton Andrew Frederick, Coombes Peter John, Sharma A, 'Impacts of innovative WSUD intervention strategies on infrastructure deterioration and evolving urban form', Rainwater and Urban Design Conference 2007, Sydney (2007)
- Barry M, Coombes Peter John, 'Optimisation of mains trickle topup volumes and rates supplying rainwater tanks in the Australian urban setting', Rainwater and Urban Design Conference 2007, Sydney (2007)
- Lucas Steven Andrew, Coombes Peter John, Geary Phillip Milton, Dunstan Richard Hugh, 'Rainwater harvesting and wastewater reuse in peri-urban areas', 13th International Rainwater Catchment Systems Conference and 5th Water Sensitive Urban Design Conference. Proceedings, Sydney (2007)
- Evans Craig Andrew, Coombes Peter John, Dunstan Richard Hugh, Harrison Tracey Lee, Martin Anthony, Morrow Abigail Cecilia, 'Roof harvested rainwater - Indicator organisms, water quality and risk assessment', Rainwater and Urban Design Conference 2007, Sydney (2007)



Thyer Mark Andrew, Hardy Matthew James, Coombes Peter John, Patterson C., 'The impact of end-use dynamics on urban water system design criteria'; Rainwater and Urban Design Conference 2007, Sydney (2007)

Martin Anthony, Coombes Peter John, Dunstan Richard Hugh, Evans Craig Andrew, Morrow Abigail Cecilia., 'The passage of direct precipitation to rainwater storage: A case study'; Rainwater and Urban Design Conference 2007, Sydney (2007)

Barton Andrew Frederick, Coombes Peter John, Rodriguez Jose Fernando., 'Understanding ecological response in urban catchments'; Rainwater and Urban Design Conference 2007, Sydney (2007)

Lucas Steven Andrew, Coombes Peter John, Hardy Matthew James, Geary Phillip Milton., 'A comparative study of common uses of selected modelling tools for evaluating rainwater harvesting strategies'; Proceedings, Melbourne (2006)

Lucas Steven Andrew, Coombes Peter John, Geary Phillip Milton., 'Continuous Simulation of Rainwater Tank, Wastewater Storage and Stormwater Runoff: The Influence of Climate Regimes, Water Demand and Diurnal Flow Patterns'; Conference Proceedings of Water 2006, Grand Hyatt Conference Centre, Auckland, NZ (2006)

Lucas Steven Andrew, Coombes Peter John, Hardy Matthew James, Geary Phillip Milton., 'Evaluating rainwater harvesting: Revealing the detail using a comparison of three models'; Conference Proceedings of Water 2006, Grand Hyatt Conference Centre, Auckland, NZ (2006)

Evans Craig Andrew, Coombes Peter John, Dunstan Richard Hugh, Harrison Tracey Lee., 'Identifying the Main Influences on the Microbial Composition of Roof Harvested Rainwater and the Implications for Water Quality'; Book of Proceedings - 7th International Conference on Urban Drainage Modelling and the 4th International Conference on Water Sensitive Urban Design (7UDM + 4WSUD), Grand Hyatt Melbourne, Melbourne, Australia (2006)

Coombes Peter John, Dunstan Richard Hugh, Spinks Anthony T, Evans Craig Andrew, Harrison Tracey Lee., 'Key Messages from a Decade of Water Quality Research into Roof Collected Rainwater Supplies'; Hydropolis Conference, Burswood Entertainment Complex, Perth, Western Australia (2006)

Barry M E, Coombes Peter John., 'Optimisation of Mains Trickle Topup Supply to Rainwater Tanks in an Urban Setting'; Book of Proceedings, Grand Hyatt Melbourne, Melbourne, Australia (2006)

Lucas Steven Andrew, Coombes Peter John, Geary Phillip Milton., 'Realistic Simulation of Rainwater Tank Systems: Revealing the Detail'; Proceedings, Hyatt Regency Auckland, New Zealand (2006)

Coombes Peter John, Barry M E., 'The effect of selection of time steps and average assumption on the continuous simulation of rainwater harvesting strategies'; Book of Proceedings - 7th International Conference on Urban Drainage Modelling and the 4th International Conference on Water Sensitive Urban Design (7UDM + 4WSUD), Grand Hyatt Melbourne, Melbourne, Australia (2006)

Coombes Peter John, Dunstan Richard Hugh, Spinks Anthony T., 'An Overview of a Decade of Research into the Quality of Rainwater Supplies Collected from Roofs'; International Rainwater Harvesting Association, New Delhi, India (2005)

Coombes Peter John, Kozarovski P., 'Development of a regional model to understand the hydrological and economic benefits of rainwater tanks across New South Wales'; The 29th Hydrology and Water Resources Symposium, Engineers Australia, Canberra, Australia (2005)

Hardy Matthew James, Coombes Peter John, Kuczera George Alfred., 'An Investigation Of Estate Level Impacts Of Spatially Distributed Rainwater Tanks'; 2004 International Conference on Water Sensitive Urban Design, Engineers Australia, Adelaide, Australia (2004)

Spinks Anthony T, Dunstan Richard Hugh, Coombes Peter John, Kuczera George Alfred., 'Bacterial Water Quality of Rainwater Fed Domestic Hotwater Systems'; IWA Leading Edge Sustainability, Sydney, Australia (2004)

Coombes Peter John, Spinks Anthony T, Evans Craig Andrew, Dunstan Richard Hugh., 'Performance of Rainwater Tanks at an Inner City House in Carrington NSW During a Drought'; Cities as Catchments: WSUD2004, Adelaide, SA, Australia (2004)

Spinks Anthony T, Dunstan Richard Hugh, Coombes Peter John, Kuczera George Alfred., 'Urban rainwater harvesting: a comparative review of source water quality'; IWA State Conference, NSW (2004)

Coombes Peter John, Kuczera George Alfred., 'A Sensitivity Analysis Of An Investment Model Used To Determine The Economic Benefits Of Rainwater Tanks'; 28th International Hydrology And Water Resources Symposium, Wollongong, Australia (2003)

Coombes Peter John, Kuczera George Alfred., 'Analysis Of The Performance Of Rainwater Tanks In Australian Capital Cities'; 28th International Hydrology And Water Resources Symposium, Wollongong, Australia (2003)

Spinks Anthony T, Dunstan Richard Hugh, Coombes Peter John, Kuczera George Alfred., 'Thermal Destruction Analyses of Water Related Pathogens at Domestic Hot Water System Temperatures'; About Water, Wollongong (2003)

Coombes Peter John, Kuczera George Alfred, Kalma Jetse Daniel., 'Economic, Water Quantity And Quality Results From A House With A Rainwater Tank In The Inner City'; Hydrology And Water Resources Symposium 2002, Melbourne, Australia (2002)

Coombes Peter John, Frost Andrew James, Kuczera George Alfred, O'Loughlin G, Lees S., 'Rainwater Tank Options For Stormwater Management In The Upper Parramatta River Catchment'; Hydrology And Water Resources Symposium 2002, Melbourne, Australia (2002)

Kuczera George Alfred, Coombes Peter John., 'Towards Continuous Simulation: A Comparative Assessment Of Flood Performance Of Volume-Sensitive Systems'; Exploding The Myths: Stormwater Driving The Water Cycle Balance, Orange, New South Wales (2002)

Coombes Peter John, Kuczera George Alfred, Argue J R, Kalma Jetse Daniel., 'Costing of Water Cycle Infrastructure Savings Arising From Water Sensitive Urban Design Source Control'; Proceedings of the Second International Conference on Decision Making, Lyon, France (2000)

Coombes Peter John, Kuczera George Alfred, Kalma Jetse Daniel., 'Economic Benefits Arising From Use of Water Sensitive Urban Development Source Control Measures'; Hydro 2000 Proceedings Volume 1, Perth, Australia (2000)

Coombes Peter John, Kuczera George Alfred, Kalma Jetse Daniel, Dunstan H R., 'Rainwater Quality From Roofs, Tanks and Hot Water Systems at Figtree Place'; Hydro 2000 Proceedings Volume 1, Perth, Australia (2000)

Coombes Peter John, Kuczera George Alfred, Argue J R, Cosgrove F, Bridgeman D H, Enright K., 'Design, monitoring and performance of the sensitive urban redevelopment at figtree place in Newcastle'; Proceedings of the Eighth International Conference on Urban Storm Drainage, Sydney, Australia (1999)

Coombes Peter John, Kuczera George Alfred, Argue J J, Argue J R., 'Water Sensitive Urban Redevelopment: The Proceedings Hydra Storm '98'; Adelaide, Australia (1998)