

URBAN RAINWATER HARVESTING

— HOW AND WHY

By Stan Abbott, Director of the Roof Water Research Centre at Massey University, Wellington

When properly installed and maintained, urban rainwater tanks are a safe, effective way of conserving water and supplementing the mains supply.

Using alternative water sources such as roof-collected rainwater can be part of the solution to diminishing water resources. Currently, more than 10 percent of New Zealanders rely on roof water for their drinking water - especially in rural areas that are not served by municipal town supplies.

Even in urban areas, local authorities are now encouraging householders to install domestic rainwater tanks, not only as a mains-water saving measure but also to reduce the adverse effects of stormwater runoff. Councils such as Kapiti, Waitakere, North Shore and Rodney offer rebates to householders who fit rainwater tanks to new or existing houses so that the rainwater can be used as a secondary source for toilet flushing, in washing machines, and outdoors for uses such as garden watering, car washing, and filling swimming pools.

In Australia, which has been plagued by worsening droughts, there is a huge demand for roof-collected rainwater and it is progressively becoming an important supplement to mains water supplies in many urban areas.

Authorities nationwide are encouraging more Australians to use rainwater, and 17 percent of households in Australia now source their water from rainwater tanks. In some parts of Australia building consents for renovations or new houses will now only be issued subject to the installation of rainwater tanks.

Feel the benefit

Rainwater tanks can provide a number of benefits to the householder and the community and they can be used to reinforce and promote water conservation policies and practices. Although rain tends to be seasonal, rainwater tanks can provide a convenient alternative water source when rains are abundant.

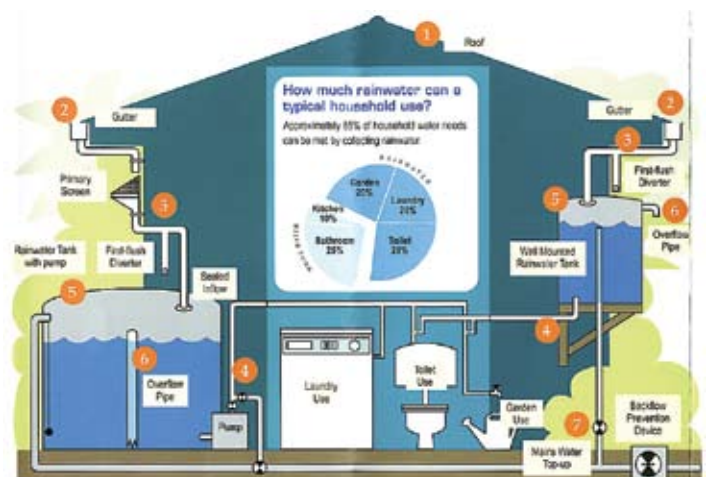
Rainwater tanks are used by households for the following reasons:

- In many rural and regional areas, and some fringe areas without access to mains water, rainwater tanks are essential for household water supply.
- In urban areas, rainwater can supplement mains water supply.
- Reduce the annual water bill in areas where water is metered.
- Improve the taste of water in areas of poor water quality.
- Improve water security of supply and consumer asset protection (eg lawns, gardens and motor vehicles) especially during times of water restrictions.
- Satisfaction of being environmentally friendly (eg easing the burden on the public water supply).

Increased central and local government support for the installation of rainwater tanks will result from the recognition of the community benefits of rainwater tanks, including:

- Reduce or delay the need to build and maintain other expensive water infrastructures such as storage dams, pipes, sewers and treatment facilities.

- Ease the load on stormwater systems by reducing stormwater runoff. This also reduces erosion, flooding and damage to local streams, beaches, dam infrastructure and roads.
- Collect runoff during summer storms in droughts that would not otherwise be collected in dry catchment areas.
- Government and local authorities are seen to be more environmentally conscious by introducing supporting policies.



Some components of dual rain water/mains water system. Reproduced with permission of Bruce Fulford, Rodney District Council.

Following the rules

In New Zealand, statutory control of an individual dwelling's water supply falls under the Health Act 1956, the Local Government Act 2002, and the Building Act 2004.

The Building Act requires premises to be provided with potable water for consumption, oral hygiene, utensil washing and food preparation. In accordance with section 4 of the Building Act, the main objective of Clause G12 of the Building Code is "...to safeguard people from illness caused by contaminated water". Under Section 39 of the Health Act, it is illegal to let or sell a house unless there is a supply of potable water.

A major impediment to the increased uptake of rainwater harvesting is the fact that the policies of councils regarding the specific requirements for rainwater tank design and installation is not consistent and varies significantly across the country.

For the connection of rainwater tanks to the mains water supply, some councils have relaxed requirements in order to make the purchase of a rainwater tank more attractive. Because the quality of roof collected rainwater can be degraded by poor maintenance of the rainwater tank and can result in the transmission of pathogens from animal or bird faecal contamination, some regional health services put restrictions on possible indoor uses of rain tank water.

Cross-connection of the rainwater tank's plumbing to the mains water supply is usually only permitted if backflow prevention devices are installed to prevent the possibility of water from the rainwater tank entering the mains supply. However, some local authority regulations expressly forbid the connection of rainwater tanks to the drinking water supply if mains water is available, but do allow separate connections for other indoor uses such as using the rainwater to flush toilets.

Retention and detention

A rainwater retention tank is a tank that is used to collect rainwater that can be used for indoor purposes such as for toilet flushing and in laundries. A rainwater detention tank is one that is used for the slow release of rainwater run-off to the stormwater drain during and after rainfall events. Ideally dual (rainwater/mains water) systems should operate automatically and there should be no need for deliberate householder intervention.

Two systems are commercially available in New Zealand for integrating rain tank and mains water supplies. The first system is a trickle top-up system that uses a float in the tank to trigger the input of mains water in order to maintain a desired minimum level of water in the tank. During dry periods, the tank will contain a mixture of rainwater and mains water.

The second system uses a bypass valve that switches from the rainwater supply to the mains water supply whenever the rainwater is not available through the use of a pressure-triggered solenoid valve. In this system, mains water does not enter the tank but is diverted past the tank when required.

Regardless of the type of rainwater supply (stand-alone or connected to mains water), before householders purchase or install a rainwater tank it is important to establish whether there are any local health, building or planning regulations associated with rainwater tanks. The local council, public health service or regional authority with jurisdiction over these regulations should be consulted.

Sizing the tank

The size and placement of large rainwater tanks in dwellings with limited outdoor space for a tank can be another impediment to rainwater harvesting. However, a range of tank sizes (1,000–35,000 litres) and shapes are now available in New Zealand. Currently, the variety of tank types include tanks made from polyethylene, corrugated iron, concrete, timber and fibreglass.

Recently, too, smaller rectangular and round slim-line skinny tanks (ranging from 600 litres to 6,300 litres capacity) have come on to the New Zealand market. These are especially useful in situations where available space for locating a large tank is a problem because these smaller tanks can be installed (even two or more in series) up against the wall of a dwelling under the eaves of the house.

Many councils mandate a minimum and maximum size of rainwater storage tank for new buildings and only certain sizes are eligible for rebate and incentive schemes. It is advisable to check with the local plumbing or building authority for any rainwater storage tank size requirements. The yield of a rainwater tank is determined by both the volume and timing of rain runoff into the tank and, of course, the volume and timing of water usage specific to the individual property.



Health protection officers inspecting rainwater tanks at a school in rural Dunedin.

Water capture

Rainfall frequency in a particular region, specific tank sizes and rainwater use will influence the total rainfall available for use. In some instances, there will be overflow from the tanks during a rainfall event and in other cases rainwater will not be available (an empty tank) through lack of rainfall or overuse. Obviously, the ideal situation for rainwater harvesting is consistent rainfall and consistent water usage, preferably higher usage during times of higher rainfall.

Roof sizes across New Zealand vary widely and are based on factors such as land availability and income of the property owner. Unfortunately, not all of a particular roof area will be available for use and will depend on the location of downpipes and the location of the tank.

Ideally, the tank location and plumbing will be configured to ensure that all (or most) roof run-off is captured. However, considerations such as cost, site availability and aesthetic preference limit the actual roof area that can be used. Typically up to half of the roof area can be diverted into a rainwater tank.

A light rainfall event may not produce enough saturation of the roof to flush water into the tank. On the other hand, substantial rainfall events might result in overflow from the roof, particularly if debris has accumulated in gutters or screens. The proportion of rainfall run-off that can be captured ranges from 60 percent to over 90 percent depending on the condition of the gutters.

As a general rule, the amount of rainfall that can be expected to be collected is calculated by multiplying the roof area by the annual rainfall in the location. For example, a 150 m² roof area in a location with an average annual rainfall of 1,200 mm per annum can expect to collect 180,000 litres per annum.

However, a number of other factors may need to be considered for more accurate calculations of the expected annual rainwater catchment from a particular roof. These include water losses through spillage, evaporation and pre-treatment devices such as first flush diverters that divert the contaminated rainwater away from the storage tank.

Water quality

Because the quality of rainwater collected in improperly maintained tanks and roof catchment systems is often poorer than that of many public mains water supplies, a number of health regulators and building authorities in New Zealand and Australia still do not actively encourage rainwater harvesting.

In a five-year Massey University study, we investigated the microbiological quality of roof-collected rainwater samples of 560 private dwellings in rural New Zealand. At least half of the samples analysed exceeded the acceptable standards for contamination and, in more than 40 percent of the samples, we found evidence of heavy faecal contamination.

The likely sources of the contamination were faecal material deposited by birds, frogs, rodents and possums, and dead animals and insects, either on the roofs or in the gutters, or in the water tank itself. Importantly, many of the roof water supplies surveyed revealed deficiencies in the use of rainwater catchment systems and components.

In a significant number of supplies where we found heavy faecal contamination, there was evidence of lack of maintenance; inadequate disinfection of the water; poorly designed delivery systems and storage tanks; and failure to adopt even simple physical measures to safeguard the water against microbiological contamination.

As can be seen, rainwater catchment areas and their management can impact on the quality of the rain tank water. However, there are a number of rainwater treatment devices commercially available now that can assist in cleaning and disinfecting roof-collected rainwater.

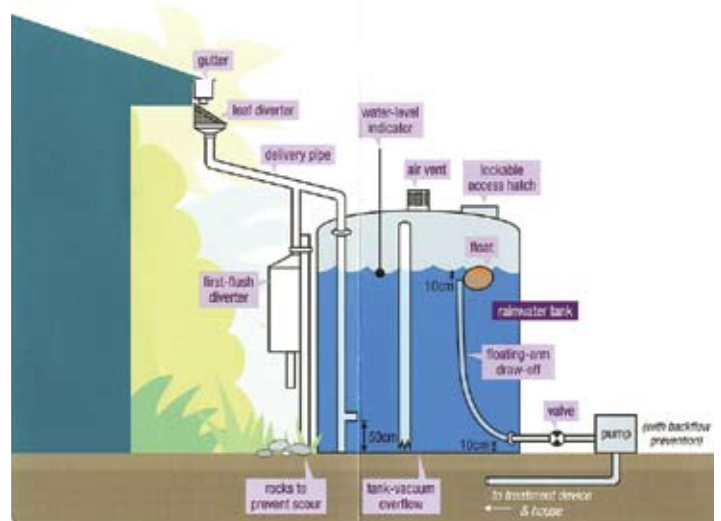
The Ministry of Health has also produced a number of excellent public information brochures, guides and books on how to prevent contamination of roof-collected rainwater. These, and other resources dealing with safe rainwater harvesting, can be found at the Plumbing Interest Group within the members' area at www.masterplumbers.org.nz.

Minimising contamination

The health risks of roof-collected rainwater can be minimised by sensible preventative management procedures. Some of the preventative measures are associated with design and installation while others are associated with ongoing maintenance. Well-designed systems are low maintenance and will generally prevent problems occurring, so that corrective action to restore safe rainwater quality will be needed infrequently.



Polyethylene rainwater tank at a school in rural Auckland.



Some essential requirements for safe rainwater harvesting. Reproduced with permission of Bruce Fulford, Rodney District Council

In a recent systematic evaluation of measures for improving the rainwater quality carried out at the Roof Water Research Centre in Wellington, we found spectacular improvements in the water quality in the rainwater tanks linked to first flush diverters. First flush diverters are devices that minimise contamination of the rain tank water by diverting the first amount of rain (which washes away the dust, debris, bird and animal droppings etc off the roof) away from the tank.

A first flush diverter will also minimise undesirable elements such as ash, heavy metals and chemical residues entering the tank. We recommend that, as a minimum, all roof water supplies should have a first flush diverter because the longer the dry period in between rainfall events, the greater the amount of pollutants deposited on the roof surfaces.

A rule of thumb is that the amount to be diverted should be the equivalent of 2 mm of rain over the area of roof. This means that for an average size roof area the amount to be diverted will be approximately 100 litres.

Keep it safe

Advice to give customers about safe rainwater harvesting include:

- Ensure the roof is appropriate for capturing rainfall; use a clean impervious roof made from non-toxic material.
- Remove and replace with approved materials any items containing lead products (eg paints, flashings, nails etc).
- Before purchasing materials or paint to be used on roof catchment areas, read and observe the manufacturer's recommendations on labels and brochures regarding the suitability of the products for rainwater collection.
- Keep roof catchments clean and clear of moss, lichen, debris and leaves.
- Keep roof catchments clear of overhanging vegetation as branches provide roosting points for birds and can provide access for small animals such as rodents, cats and possums.
- If appropriate, install gutter guards or screens as well.

- Install screened downpipe rainheads or other suitable leaf and debris protection devices on each downpipe. Recommended screen mesh size is 4-6 mm and these devices should be self-cleaning.
- Install a first foul flush diverter to prevent contaminated water entering the tank; first flush diverters must have automated diversion and drainage systems (ie no manual diversion or drainage); any roof water collection area, by virtue of its location, susceptibility to undue contamination with organic material, dust, ash, sand, salt or airborne chemical residue, should have a first flush diversion system installed.



Screened rainhead, first flush diverter, calmed inlet, floating out-take and tank vacuum device. Reproduced with permission of David Oliver, Marley New Zealand.

- Ensure that chimneys within or adjacent to roof water collection areas are of sufficient height to minimise the settlement of ash or residues on the roof and in the gutters.
- Exercise care when cleaning gutters; make sure the ladder is secure and avoid going anywhere near overhead power lines or better still have the power disconnected before cleaning the gutters.
- Inspect gutters regularly and clean if necessary. Disconnect the downpipe(s) that feed the water tank before cleaning the gutters or, better still, install downpipe debris diverters (ensure that the opened flaps have fully sealed off the downpipes before cleaning gutters).
- If installed, clean tank inlets and screens every three to four months.
- In the event of any weed or chemical spraying in an adjacent location, advise the contractor that the roof is used to collect drinking water, and that there must be no over-spraying. Obtain a guarantee from the contractor that persistent organochlorine pesticides will not be used.
- Install a 'calmed inlet' pipe into the rainwater tank so that the water enters the tank through a 'U' bend to avoid the disturbance of any sediment that may have accumulated in the bottom of the tank.
- Install a floating valve draw off pipe in the tank in order to extract water from near the top of the tank.



Corrugated iron rainwater tank at a Southland seaside bach.

- Prevent access by small animals, birds and mosquitoes into rainwater storage tanks by screening all tank inlets as well as overflows, and keep access hatches closed.
- Prevent entry of surface run-off from areas other than roof catchment into below-ground tanks. Tank roofs must be secure and the sides and bottom of the tank should be sealed to prevent egress.
- Inspect tanks annually and if necessary have tanks cleaned out professionally.
- Sediments can be removed by installing a tank vacuum system that automatically siphons off the sediment from the bottom of the tank if and when the tank overflows.
- A swimming pool vacuum cleaner can also be used for siphoning out sediments.
- If tank contamination is apparent the water should be chemically disinfected and/or boiled before the water is used for consumption and food and drink preparation.
- Depending on the circumstances, additional water purifying equipment may need to be installed. These include a 20 µm washable cartridge filter, a UV steriliser, and a 1 µm activated carbon under-bench filter.

About the author

Stan Abbott is a Senior Lecturer in Microbiology and Communicable Diseases at the Institute of Food Nutrition and Human Health at Massey University. He is also Director of the Roof Water Research Centre and is recognised as an expert in many aspects of rainwater harvesting at a national and international level. The Centre's aim is to address safe and sustainable rainwater harvesting activities through research, education and information. To find out more, visit <http://roofwater.massey.ac.nz> or email S.E.Abbott@massey.ac.nz.



A final word from MPGD Technical Manager Eric Palmer: It's important to note that concrete tanks have a buffering effect on water quality, which is not provided by tanks of other materials. Without the buffering, the pH of rainwater may be lower than recommended for use with copper pipe. This is particularly important in new installations. In old installations, a protective film may have built up on the inner surface of any copper pipes. ■