

*Guidance on the use
of rainwater tanks*

National Environmental Health Forum Monographs

Water Series No. 3

Guidance on the use of rainwater tanks

David A Cunliffe

National Environmental Health Forum Monographs

Water Series No. 3

National Environmental Health Forum



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Preface

The National Environmental Health Forum has been established by the Directors of Environmental Health from each State and Territory and the Commonwealth with a secretariat provided by the Commonwealth Department of Health and Family Services.

The National Environmental Health Forum is publishing a range of monographs to give expert advice and guidance on a variety of important and topical environmental health matters. This publication is the third in the water series. A list of published monographs is provided on page v.

The Directors of Environmental Health, in expediting publication of this document, have undertaken targeted consultation only.

Disclaimer

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Brochure

A brochure based on the monograph is available as a downloadable Adobe PDF. The brochure was designed for adoption and use by any agency.

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Results and reports were provided by the Communicable Diseases Branch, Queensland Department of Health; Victorian Department of Human Services; Victorian Department of Natural Resources and Environment; Northern Districts, Orana and Far West Region, and Western Region Public Health Units, New South Wales Health Department. This information was of inestimable value.

Literature and information searches were conducted using the Medline, Aqualine and Internet databases.

Published Monographs

Water Series

1. Guidance for the control of Legionella (1996)
2. Guidance on water quality for heated spas (1996)
3. Guidance on the use of rainwater tanks (1998)

Soil Series

1. Health-based soil investigation levels, 2nd edition (1998)
2. Exposure scenarios and exposure settings, 2nd edition (1998)
3. Composite sampling (1996)

Metal Series

1. Aluminium, 2nd edition (1998)
2. Zinc (1997)
3. Copper (1997)

Air Series

1. Ozone (1997)
2. Benzene (1997)
3. Nitrogen Dioxide (1997)
4. Sulfur dioxide (1999)

General Series

1. Pesticide use in schools and school grounds (1997)
2. Paint film components (1998)
3. Guidelines for the control of public health pests – Lice, fleas, scabies, bird mites, bedbugs and ticks (1999)
4. National standard for licensing pest management technicians (1999)

Indigenous Environmental Health Series

1. Indigenous Environmental Health No. 1 (1999)

Exposure Series

1. Child activity patterns for environmental exposure assessment in the home (1999)

Counter Disaster series

1. Floods: An environmental health practitioner's emergency management guide (1999)

1. Introduction

Australia has a generally hot, dry climate and outside the major towns and cities there are vast areas with very low population densities. Water is a valuable commodity and as distance from the major centres increases the supply of good quality reticulated water becomes increasingly more difficult. Many remote areas are not supplied with mains water. Rainwater tanks can provide a relatively safe, soft, clear and odourless source of water that can be used for a range of purposes including drinking, washing, bathing, laundry and gardening. Rainwater can be collected to supplement existing supplies or as the sole source of household water.

In Australia the use of domestic rainwater tanks has been a long standing and relatively common practice. In 1994 a survey by the Australian Bureau of Statistics showed that about 13% of all Australian households use rainwater tanks as a source of drinking water. The highest use was in South Australia (37%) and the lowest was in the Northern Territory (2%) and the Australian Capital Territory (0%) (Australian Bureau of Statistics, 1994).

Not surprisingly the 1994 survey also showed that the use of rainwater tanks was far more common outside the capital cities with 30.4% of rural Australians using rainwater compared to 6.5% in the capitals (Australian Bureau of Statistics, 1994). A survey conducted in South Australia in 1996 showed that 82% of the rural population used rainwater as the primary source of water for drinking compared to 28% of the population in metropolitan Adelaide (Heyworth *et al*, 1998).

Even in areas that receive good quality mains water there is some support for the use of rainwater based on conservation and a recognition of the limited fresh water resources in Australia. In addition some use is based on the concept of independently collecting a relatively pure product (at least as rain) and using it without treatment and in particular without the addition of any chemicals.

The perception is that rainwater is safe to drink and this is probably true if it is clear, has little taste or smell and importantly that the source of the rainwater is a well maintained tank and roof catchment system. However, while the use of rainwater might be common the application of maintenance procedures is far less common. In part, this may reflect the notion that rain is a relatively pure source of water and also it may be related to the fact that in many rural areas the availability of water is a bigger issue than quality.

The general lack of appropriate care by owners of rainwater systems occurs despite the fact that many water and health authorities provide pamphlets/brochures and advice to those that request information.

The aim of this monograph is to consolidate information and advice on rainwater tanks in one document. The monograph presents a description of the issues and provides guidance on the collection, care and storage of rainwater in domestic tanks in a manner that should maximise the quality of water supplied from these tanks.

2. Water quality

Rainwater as it falls on house roofs is soft, clear and largely free of micro-organisms and contaminating chemicals. During collection and storage however, there is a potential for chemical, physical and microbiological contamination. In most localities (exceptions are discussed below) chemical and physical quality is relatively easy to maintain but the risk of microbiological contamination is more difficult to control. This is supported by surveys and other sources of rainwater quality data, see **Section 2.1**.

It should be noted that inadequate maintenance was a common theme encountered in surveys of rainwater tanks. The adoption of a sensible maintenance program for catchment areas and rainwater tanks should improve water quality including microbiological quality.

Routine testing of rainwater collected in domestic tanks should not be necessary and in most cases is not recommended. If there are doubts about the quality of rainwater, particularly if used for drinking or cooking, testing may be necessary. If rainwater is made available for public use a limited testing program focusing on microbiological quality should be performed. Rainwater used for any commercial purpose will require more rigorous testing for potability.

Advice on testing and analytical laboratories should be sought from local water or environmental health authorities.

When testing is performed, results should be compared to the values contained in the Australian Drinking Water Guidelines (NHMRC/ARMCANZ, 1996) .

2.1 Microbiological

Rainwater collected and stored in domestic tanks is likely to contain micro-organisms from one or a number of sources. While most will be harmless the microbiological safety of rainwater will depend on the exclusion of organisms that can cause infections of the gastrointestinal tract (enteric pathogens). The enteric pathogens include types of bacteria, viruses and protozoa. These organisms are typically introduced into drinking water supplies by contamination with faecal material from humans, animals and birds, with human enteric pathogens more frequently carried in human waste.

The majority of domestic rainwater tanks are installed above ground and collect run-off from roofs via guttering. Likely sources of micro-organisms include:

- soil and leaf litter accumulated in gutters particularly if kept damp for long periods due to poor drainage,
- faecal material deposited by birds, lizards, mice, rats, possums etc.,
- dead animals and insects either in gutters or in the tank itself.

Less commonly, rainwater is collected in underground tanks. If these tanks are not fully sealed or protected against ground run-off then micro-organisms associated with human and animal excreta may also contaminate stored rainwater. In one instance 89 people supplied with drinking water from an underground tank became ill with giardiasis/cryptosporidiosis (Lester, 1992). Investigations showed that the tank had been contaminated by an overflow from a septic tank.

The microbiological quality of drinking water is traditionally measured in terms of the presence or absence of coliform and thermotolerant (or faecal) coliform bacteria as indicators of faecal pollution and accordingly the possible presence of enteric pathogens.

Analyses of rainwater from domestic tanks have shown that the presence of coliform and thermotolerant coliforms is fairly common (Edwards, 1994; Fuller *et al*, 1981; Thurman, 1995; Victorian Department of Natural Resources and Environment, 1997; Western Sector Public Health Unit, 1993; unpublished results SA Water and Victorian Department of Human Services). However, the significance of these results is not clear. The probable source of indicator bacteria detected in most rainwater tanks is faecal material from small animals and birds. The rate of carriage of enteric pathogens from these sources is uncertain but it would be expected to be less than that of human faeces. Sludges and deposits in poorly maintained guttering or tanks could support the growth or survival of coliform bacteria and again it would be expected that such bacteria are less likely to indicate the presence of human pathogens.

Excluding specific and unusual events (as above), limited testing in Australia has generally failed to detect pathogens such as *Salmonella*, *Shigella*, *Cryptosporidium* and *Giardia* in water from domestic tanks (Fuller *et al*, 1981; Thurman, 1995; Victorian Department of Natural Resources and Environment, 1997; unpublished results, Victorian Department of Human Services). However, *Campylobacter* has been detected in a few samples (Victorian Department of Natural Resources and Environment, 1997) and there have been isolated reports of human infections associated with rainwater. In the one published report an elderly immunocompromised woman was subject to recurrent infections by *Campylobacter fetus* (Brodrigg *et al*, 1995). *C. fetus* was also isolated from the patients' rainwater tank which served as the sole source of drinking water. No further infections occurred after the patient started boiling the tank water before consumption and it was suggested that clinicians may wish to recommend this as a general practice to immunocompromised patients (Brodrigg *et al*, 1995).

The occasional detection of *Campylobacter* is not surprising as many birds are known to carry and excrete this organism (Koenraad *et al*, 1997; Whelan *et al*, 1983). Maintenance procedures that reduce potential contamination from bird droppings would reduce the risk of *Campylobacter* being present in collected rainwater.

2.2 Chemical

2.2.1 Roof materials

Roofs may be constructed from a variety of materials such as cement or terracotta tiles; Colorbond™, zincalume and galvanised steel sheeting; asbestos/fibro cement; polycarbonate or fibreglass sheeting; and slate. Regardless of the roofing material used, with new roofs it is advisable to divert the first few substantial run-offs away from the rainwater tank. This is done to allow dust and other debris left on the roof after construction to be washed away.

NOTE: Under AS 2180 - 1986; Section 1.11 - "on completion of the installation of all guttering and roofing, all debris such as cement mortar and in particular, metal clippings and filings shall be removed".

Where concerns exist about the suitability of a roofing material for use as a rainwater catchment surface, advice on the matter should be sought from the manufacturer.

Asbestos/fibro-cement roofing

Although no longer used in new houses, asbestos in a cement matrix may be present in some older type roofs (pre 1970s). Although asbestos fibres are dangerous to health when inhaled in sufficient quantities, it is not believed that asbestos in drinking water poses a risk

(NHMRC/ARMCANZ, 1996). Asbestos fibres have been detected in drinking water throughout the world with no known health effects.

Roofing material should be left undisturbed as far as practicable since asbestos fibres, while bound securely in fibro-cement sheeting, can be released into the air by actions such as cutting, grinding or drilling. High pressure roof cleaning methods should also be avoided.

Where the roof catchment area has deteriorated badly it should be replaced with asbestos-free substitutes.

Cement based or terracotta tiles

The coloured surface of cement based or terracotta tiles will oxidise over time through natural weathering. This oxidised coating may break down slowly and be washed into rainwater tanks, thus colouring the water.

The coating has been found to be non-toxic and, if left undisturbed, will settle to the bottom of the tank. The colour may reappear after rain if settled material is stirred up by water flowing into the tank. If this becomes a problem the tank should be drained and cleaned and roof and gutters washed down and cleaned to prevent oxidised material entering the rainwater tank.

It is possible to purchase *colour-through* tiles that have colour impregnated throughout the tile and which may be subject to less oxidation.

Paints and coatings

Before purchasing materials or paint to be used on roofs that will be used to collect rainwater for drinking, read and observe the manufacturer's recommendations on labels and brochures. Look for warnings. If in doubt check with the manufacturer.

Lead-based paints (including primers) - are toxic and not suitable for use in association with the collection of rainwater for human consumption.

Acrylic paint - will leach dissolved chemicals including detergents in the first few run-offs after application and these run-offs should not be collected.

Bitumen-based (tar) materials - are generally not recommended as they may leach hazardous substances or cause taste problems.

Pesticide-treated wood

The use of pesticide-treated wood should be avoided where it may come into contact with rainwater to be collected in a domestic tank. Chemicals used in the preservation process may be washed from the treated wood into the tank. Examples of timber preservatives used in Australia are:

- water-based preservatives such as copper chrome arsenate compounds and boron compounds
- oil-type or oil-based preservatives such as creosote
- light organic solvent preservatives such as solutions containing pentachlorophenol.

If wooden shingles have been used it will be necessary to ensure they have not been treated with chemicals that may taint the water.

Lead flashing

Lead is a cumulative poison that can have a number of adverse effects including serious impacts on the central nervous system. *In utero* exposure of fetuses and exposure of infants are of greatest concern (NHMRC/ARMCANZ, 1996).

As a precaution lead flashing should not be used on those parts of a roof used as a rainwater catchment area. In the case of an existing roof, lead flashing should be replaced if possible. Where small quantities of lead flashing are used or retained it can be painted over with a suitable roof paint. Coated lead flashing is also available.

Leaching of lead into roof run-off may be more of a problem on poorly maintained roofs and gutters where the process may be increased by the acidic action of water containing organic substances leached from materials such as leaf litter.

2.2.2 Industrial pollution

There is an increased risk of pollution by airborne contaminants in major urban centres and industrial areas. Collection of rainwater for human consumption (drinking and cooking) in areas affected by heavy traffic, industry, incinerators and smelters is not recommended.

In Port Pirie (South Australia), for example, there is a long history of smelting with associated airborne lead pollution and analyses of rainwater collected in domestic tanks have detected concentrations of lead exceeding drinking water guidelines (Fuller *et al*, 1981; Body, 1986).

When in doubt about the possible impact of local industry advice should be sought from the local authority, environmental health authority or environment protection authority.

2.2.3 Agricultural pollution - pesticides

Although the use of pesticides is coming under increasing scrutiny and control, rainwater collected in some agricultural areas may be subject to contamination by pesticides or other chemicals. Aerial spraying provides a greater potential for contamination.

In surveys of rainwater quality in rural areas pesticides were not detected in most samples (Victorian Department of Natural Resources and Environment, 1997; Fuller *et al*, 1981; NSW Environment Protection Authority and Northern Districts Public Health Unit, 1996; Orana and Far West Region Public Health Unit, 1992). Endosulfan, profenofos, chlorpyrifos and dieldrin have been detected in some samples but all at concentrations below Australian Drinking Water Guidelines (NHMRC/ARMCANZ, 1996). There was evidence that tanks included in the surveys were poorly maintained. The risk of pesticide contamination could be reduced by appropriate maintenance and by the use of first flush diversion devices.

If in doubt about the use of pesticides in the general area, advice should be sought from the local authority, Department of Agriculture, environmental health authority or environment protection authority.

2.2.4 Wood burners

There have been consumer reports of contamination, including tainting with creosote, of rainwater collected from roofs that incorporate flues from wood burners. While a range of hydrocarbons could be deposited on roofs in the vicinity of such flues limited testing in one survey (Victorian Department of Natural Resources and Environment, 1997) did not detect concentrations exceeding guideline values in the Australian Drinking Water Guidelines (NHMRC/ARMCANZ, 1996). Nevertheless, it is suggested that where possible rainwater

should not be collected from that part of a roof that incorporates a flue from a wood burner. In addition extra care should be taken to operate wood burners correctly and to only use appropriate fuel.

2.3 Fluoride

Many mains water supplies are dosed with fluoride to provide protection against dental caries. This practice is supported by the NHMRC (1991). Rainwater collected in domestic tanks will not contain fluoride but it is not recommended that tank water should be dosed. Alternative sources of fluoride include fluoridated toothpastes and the use of fluoride supplements. Where rainwater is used as a major source of water for drinking and cooking, advice concerning fluoride should be sought from the local dentist, school or community dental service or from the Australian Dental Association.

3. Construction of tanks

Rainwater tanks are available in a range of suitable materials including galvanised, Aquaplate™ or zincalume steel; fibreglass; plastic; and concrete. Australian and Australian/New Zealand Standards that apply to tanks and their associated fixtures and fittings are:

- AS 2070, “Plastics materials for food contact use”;
- AS/NZS 2179-1994, “Specifications for rainwater goods, accessories and fasteners”;
- AS 2180 - 1986, “Metal rainwater goods - selection and installation”;
- AS 3500.1 - 1992, “National plumbing and drainage code. Part 1: Water supply”
- AS 3855 - 1994, “Suitability of plumbing and water distribution systems products for contact with potable water”;
- AS 4020 (Int)-1994, “Products for use in contact with water intended for human consumption with regard to their effect on the quality of water”.

Wherever possible materials complying with the appropriate Australian or Australian/New Zealand Standard should be used. In selecting a rainwater tank, requirements relating to installation as per **Section 5** and maintenance as per **Section 7** should be considered.

3.1 Steel tanks

The most common material used in the manufacture of rainwater tanks is galvanised steel. Galvanised steel is not inherently resistant to corrosion but it is available with rust resistant coatings such as zincalume or Aquaplate™ (see below).

The initial corrosion of galvanised steel normally leads to the production of a thin adherent film that coats the surface of the tank and provides protection against further corrosion. It is important when cleaning such tanks not to disturb this film.

New tanks may leach excess concentrations of zinc which could affect the taste of stored rainwater. These tanks may need to be flushed before use.

Aquaplate™ steel has a food-grade polymer skin complying with the requirements of Australian Standard, AS 2070, bonded to a corrosion resistant galvanised steel base.

A number of precautions need to be taken with tanks manufactured using Aquaplate™:

- the polymer coating is not resistant to prolonged exposure to sunlight and tanks made of Aquaplate™ must have a top cover in place at all times;
- kerosene or similar chemicals used as mosquito larvicides can lead to the degeneration of the polymer coating and should not be used in these tanks;
- the polymer coat should not be damaged when cleaning or installing the tank. If the coating is damaged, it should be repaired immediately using an appropriate sealant to prevent corrosion of the metal portions of the tank.

Copper or copper alloy fittings (brass and bronze) should not be connected directly to steel tanks as this causes corrosion. A minimum of two metres of plastic pipe suitable for potable water should be used between the tank and copper fittings.

3.2 Concrete tanks

Concrete and ferro-cement tanks are strong and long lasting and can be installed underground.

New tanks may impart tastes and may leach lime thereby increasing the pH of water. Accordingly these tanks may need to be flushed before use.

3.3 Fibreglass tanks

Fibreglass tanks suitable for the collection of rainwater are available. These tanks are manufactured with a food-grade coating on their interior surface. The coating is cured before the tanks are offered for sale. The tanks should also be manufactured in a manner to prevent the entry of light which could encourage algal growth.

3.4 Plastic tanks and tanks with plastic liners

Increasing ranges of tanks manufactured from synthetic polymers are becoming available. Plastic tanks and plastic liners should be constructed of materials that are at least of food-grade standard (AS 2070) and preferably that comply with the requirements of Australian Standards, AS 3855-1994 and AS 4020 (Interim)-1994. As with fibreglass tanks, the tanks should be manufactured in a manner to prevent the entry of light.

4. Size of tanks

In those cases where a rainwater tank is to represent a supplementary source of water, the size of the tank will depend on a balance of cost weighed against the range of uses required (drinking, cooking, bathroom, laundry, toilet etc).

If the rainwater tank is to represent the only source of potable or domestic water cost will be less important than the size of tank required to provide security of supply. In this circumstance the size of the tank will depend on:

- the volume of water needed,
- the amount and pattern of rainfall,
- the area of the roof catchment,
- the security of supply required.

The amount of rain combined with the area of the roof catchment will determine the maximum volumes of water that can be collected. If this is not sufficient then either a greater catchment area will be required (eg garage or shed) or alternatively water demand will need to be reduced. A number of water conservation measures could be applied including dual flush toilets, dry toilets (if permitted), water efficient devices, reduced flow shower heads, washing machines with suds savers etc. If necessary, a separate lower quality supply could be considered for uses such as toilet flushing.

If after the implementation of these measures the volume of rainwater that can be collected is not sufficient to meet demand, additional water will need to be obtained from another source.

Experience is always a useful guide and advice should be sought from neighbours particularly in areas where reliance on rainwater tanks is common.

It should be noted that in some areas local authorities specify minimum requirements for water storage and there may also be storage requirements associated with firefighting.

4.1 Volume of water needed

This may vary from one area to another. Water demand will depend on:

- the number of people using the water,
- average consumption per person,
- the range of uses (drinking, cooking, bathroom, laundry, toilet etc),
- the use of water conservation devices.

In areas supplied with reticulated water the average indoor use per household is estimated to be in the range of 400-740 litres per day or alternatively 100-200 litres per person per day. These volumes are being steadily decreased with the application of water conservation measures. Advice on water usage could be sought from the local water or water resources authority.

4.2 Average rainfall

In general the most accurate source of this information is the Bureau of Meteorology.

In addition to average rainfall (annual and monthly) it is important to determine the season of the rainfall and the occurrence and length of dry spells.

4.3 Size of the roof catchment

Calculate the area covered by the parts of the roof from which the water is to be collected. Note that it is the flat or plan area (including eaves) that should be determined. The slope or pitch of the roof and the actual number of square of metres of tiles or metal is not important.

The average roof area for a small house is about 100 m², for a medium house about 150 m², and for a large house about 200 m².

4.4 Security of supply

The size of the tank required will be influenced by the degree of security selected. As used in this document securities of 90% or 99% mean that the rainwater tank should supply the demand of water calculated for 90% or 99% of the time respectively.

The continued supply of water requirements under almost all conditions, including extended dry spells (high security), will require a larger tank than that required to supply demand under

normal or average conditions (lower security). Lower security will mean that water rationing or alternative sources of supply (see **Section 10**) may have to be used more frequently.

4.5 Information on tank size

Some State Government Departments have tables of calculated tank sizes based on rainfall data. In Queensland this information has been available from the Department of Natural Resources, in South Australia from the South Australian Water Corporation or the Department of Environment, Heritage and Aboriginal Affairs and in Western Australia from the Department of Agriculture. Other departments with responsibilities for water resources or water supply may also provide this information.

As a guide tank sizes for 99% and 90% security for a temperate climate are shown in the Appendix in Tables A.1 and A.2.

4.6 Calculation of tank size

Once the area of roof catchment has been determined and the average rainfall has been established the maximum amount of rain that can be collected can be calculated using the formula:

$$\text{Run-off (litres)} = A \times (\text{Rainfall} - B) \times \text{Roof Area}$$

A is the efficiency of collection and values of 0.8-0.85 (ie 80-85% efficiency) have been used (eg Martin, 1980).

B is the loss associated with adsorption and wetting of surfaces and a value of 2 mm per month (24 mm per year) has been used (eg Martin, 1980).

Rainfall should be expressed in mm and *Roof Area* in square metres (m²)

The maximum volumes of rainwater that can be collected from various areas of roof and at a range of average annual rainfalls are shown in the Appendix in Table A.3. These volumes were calculated using a value of 0.8 for *A* and 24 mm for *B*. Table A.3 should only be used as an initial guide. As stated earlier if the maximum volumes are less than the annual water demand then either the catchment area will need to be increased or water demand will need to be reduced.

The next step is to calculate the size of the tank. The tank needs to be large enough to ensure that:

1. the required volume of water can be collected by the tank.
2. the volume of water in the tank will be sufficient to meet demand during the drier months or through periods of low or no rainfall.

The simplest way of checking a tank size estimated to provide water throughout an average year is to use monthly rainfall data and to assume that at the start of the wetter months the tank is empty. The following formula should then be used for each month:

$$V_t = V_{t-1} + (\text{Run-off} - \text{Demand})$$

V_t = theoretical volume of water remaining in the tank at the end of the month

V_{t-1} = volume of water left in the tank from the previous month.

Run-off should be calculated as discussed above (*A* = 0.8, *B* = 2 mm).

Starting with the tank empty then $V_{t-1} = 0$. If after any month V_t exceeds the volume of the tank then water will be lost to overflow. If V_t is ever a negative figure then demand exceeds

the available water. Providing the calculated annual run-off exceeds the annual water demand, V_t will only be negative if periodical overflows reduce the amount of water collected so that it is less than the demand.

Tank size is not necessarily based on collecting total roof run-off. For example, from Table A.3 the maximum water that can be collected from a roof area of 200 m² with an annual rainfall of 1000 mm is about 156 kL. If the water demand is less than this some overflow may occur while demand is still met. If water demand is to be met throughout the year the tank should be large enough so that V_t is never negative.

Calculations should be repeated using various tank sizes until V_t is ≥ 0 at the end of every month. The greater the values of V_t over the whole year, the greater the security of meeting water demand when rainfalls are below average or when dry periods are longer than normal. The greater the security, the higher the cost of the tank.

5. Installation

Before purchasing or installing 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 or regional authority(ies) with jurisdiction over these regulations should be consulted. In some areas there may be requirements associated with supply of water for firefighting.

Water authorities usually do not allow direct connection of rainwater systems with reticulated water supplies or alternatively require the use of backflow prevention devices to stop rainwater siphoning back into the reticulated supply. If in doubt information should be sought from the local water authority.

Rainwater tanks should be installed in a manner that will minimise the risk of contamination from industrial pollutants, dust, leaves, pollens, pesticide sprays, fertilisers, debris, vermin, birds, small animals and insects. Tanks should not be allowed to provide breeding sites for mosquitoes (see **Section 9**).

Underground tanks require additional protection against entry of surface run-off or groundwater, animal or human faecal material and soils. These tanks need to be properly sealed and access points need to be protected against ingress of surface run-off. Maintenance and cleaning of underground tanks may be more difficult.

5.1 Covers and lids

Tanks should have impervious covers and all access points except for the inlet and overflow should be provided with close fitting lids which should be kept shut unless in use. The inlet to the tank should incorporate a mesh covering and/or strainer to prevent the access of mosquitoes and other insects and to prevent material such as leaves etc that may have collected on the roof or in gutters from being washed into the tank. The overflow should also be covered with an insect-proof mesh.

Tanks should be light proof to minimise algal growth. Most algae will not make water unsafe for human consumption but can adversely affect the taste, odour and appearance of the water.

5.2 First flush and bypass devices

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 the roof catchment and may contain higher than average amounts of accumulated dust, bird and animal droppings, leaves and other debris. It has been shown for small roofs that the water quality improves once the first 5 litres of water has

passed through the down-pipe from the roof guttering (Yaziz *et al*, 1989). For an average roof catchment it is suggested that the first 20-25 litres should be diverted/discarded.

First flush diversion devices are commercially available and the installation of such a device should be considered as a means of improving water quality collected in tanks.

The inlet pipe to all rainwater tanks should be easily detachable so that when required the tank can be bypassed.

5.3 Bypass or overflow water

Run-off that is not collected in the tank or that overflows should be diverted away from tank foundations, buildings or other structures. This water should be directed onto gardens or into the stormwater drain; it should not be allowed to pool or to cause nuisance to neighbouring properties or to areas of public access. Local authorities may have regulations or requirements that apply to diverted or excess rainwater flows.

5.4 Inlet pipes

Wherever possible all sections of inlet pipes should be directed down and rainwater should flow into the top of the tank. The inclusion of rising sections will provide potential traps for sediments, biofilms and stagnant water and these should be avoided. Modifications to existing downpipes should not restrict existing water flows from roof gutters. To maximise the collection of rainwater the downpipes should be of sufficient diameter to accept all of the water flow from roof gutters, even in heavy rains.

6. Catchment

Roof catchment areas should be kept clear of overhanging vegetation to reduce the amount of leaves and debris falling onto the catchment area. Overhanging branches also provide access to the roof for rodents, cats and possums and can provide roosting points for birds.

Gutters can be shielded from large debris (bark, larger leaves, etc) with plastic mesh but smaller particles will still accumulate and require regular removal.

Gutters should have sufficient and continuous fall to downpipes to prevent pooling of water which could increase accumulation of material, lead to algal growth and possibly provide a site for mosquito breeding. A fall of one in a hundred to one in five hundred should be sufficient.

Overflow, discharge or bleed-off pipes from roof-mounted appliances such as evaporative air conditioners, hot water services, and solar heaters should not discharge onto the rainwater catchment area.

7. Maintenance and repairs

The primary focus of maintenance procedures should be to keep all components clean and to minimise the risk of contamination/rubbish either entering or remaining in rainwater tanks

7.1 Catchment

As per **Section 6** the catchment area should be kept clear of debris. The roof should be washed clean once or twice a year and in particular should be cleaned toward the end of the dry season. Gutters should be cleaned regularly to remove leaves, collected dirt etc.

In areas subject to large amounts of wind-borne dust the roof and gutters may need to be cleaned more frequently.

7.2 Inlet screens and first flush/bypass devices

Inlet screens and first flush/bypass devices should be cleaned regularly and kept in good repair.

7.3 Tank desludging

All tanks should be examined for the accumulation of sludge every 2-3 years, or if sediment is evident in the water flow. Sludge can provide an environment for survival and/or growth of micro-organisms and in some cases relatively high concentrations of lead have been detected in sludge even though the body of stored rainwater complied with drinking water guidelines. Outlet taps are generally near the bottom of tanks and as sludge accumulates the likelihood of material being re-suspended and being removed with rainwater increases. Concentrations of lead exceeding the Australian Drinking Water Guidelines (NHMRC/ARMCANZ, 1996) have been detected in water containing barely visible particulates of sludge that were re-suspended by water flowing through the outlet tap.

Sludge may be removed by siphoning without emptying the tank. To do this, use an inverted funnel in the end of a hose and move it carefully across the bottom of the tank. The sludge plus the lower portion of water in the tank can then be released to waste. If leaves and coarser debris are present in the sludge, a siphon hose of approximately 50 mm diameter should be used.

Sludge may also be pumped from the tank with minimum loss of water by using a suitable motor operated pump and attachments.

Finally sludge can also be removed by draining and cleaning the tank. If a drain plug is provided at the base of the tank, water can be run to waste to discharge the sludge. Once the tank is empty, the remaining sludge can be scooped up and removed through the access opening. Care should be taken not to disturb the protective film on the inside surface of steel tanks.

Professional tank cleaners (generally listed in telephone directories) may also be available to de-sludge tanks.

Organic material removed from the tank may be disposed of in the garden by spreading and digging into garden beds. Alternatively sludge should be disposed of at a licensed waste depot.

7.4 Tank cleaning

Where cleaning necessitates entering the tank, care should be taken to ensure adequate ventilation is provided and an additional person is in attendance. Advice on working in confined spaces should be available from Occupational, Health, Safety and Welfare authorities in each State and Territory.

It is important to check the structural condition of the tank before choosing a method of cleaning. Harsh cleaning methods may accelerate deterioration. In the case of a steel tank, removal of the protective layer on the inside walls will lead to tank corrosion.

Cleaning agents that might release hazardous fumes or adversely affect water quality after cleaning should not be used. After cleaning it is recommended that the internal walls and floor of the tank be rinsed with clean water. Rinse water and sediment should be run to waste.

7.5 Disposal of discarded water

Discarded water should be diverted away from tank foundations, buildings and other structures (also see **Section 5.3**).

8. Disinfection

Regular disinfection of rainwater held in domestic tanks is not considered necessary in most cases and is generally only recommended as a remedial action. In the absence of any known problems and if the water is clear, essentially odourless and does not contain any suspended material it is unlikely to cause illness in most users. However, as indicated in **Section 2.1** the microbiological quality at times may not be as good as reticulated water supplies.

For those with lower immune responses such as the very young or very old, cancer patients, people with diabetes, organ transplants or those who are HIV positive, boiling the water before consumption should be considered (see below). If gastric upsets are being experienced, boiling should also be considered. If the tank water is suspected as being a possible cause of gastric illness then the rainwater tank and catchment area should be inspected and any appropriate remedial action should be taken.

If the water is coloured or smells the catchment area and tank should be inspected and appropriate remedial action should be taken to remove the source of any problems. If the rainwater is the only source of water it should be chlorinated (see below). The tank should be drained and cleaned at the first opportunity. Where rainwater is the secondary source of water, the tank should be drained and cleaned prior to the next rainfall.

8.1 Boiling

Rainwater can be disinfected by heating and holding at a rolling boil for one minute or more (CDC, 1995, 1997; WHO, 1994). This will kill any harmful bacteria, viruses or protozoa including *Giardia* and *Cryptosporidium*. The water can then be cooled and stored in a clean container until use. To improve the taste of boiled water, pour it back and forth from one clean container to another, or let it stand for a few hours to increase the dissolved oxygen concentration.

8.2 Chlorination

Chlorination is effective against harmful bacteria and many viruses but it has limited effect against protozoa such as *Giardia* and *Cryptosporidium*. Chlorination can also remove odours from rainwater by oxidising the responsible chemicals. The effectiveness of chlorine is shortlived and it will only act on what is in the tank at the time of dosing. Fresh run-off into the tank after chlorination will probably not be disinfected.

When chlorine is added to water, it reacts with organic matter and other impurities in the water and the amount of chlorine required for disinfection will depend on the concentrations of these impurities. In general, concentrations will be low in rainwater.

To achieve effective disinfection it is necessary to add sufficient chlorine to provide a free chlorine residual of 0.5 mg per litre after a contact time of 30 minutes. This can be measured using a suitable chlorine test kit if available. Such kits are used to test chlorine residuals in swimming pools.

As a general guide, the addition of 40 mL of liquid sodium hypochlorite (12.5% available chlorine) per 1000 litres of water or 7 grams of granular calcium hypochlorite (75% available

chlorine) per 1000 litres of water will give a reasonable assurance of effective disinfection. Both of these methods will provide chlorine doses of approximately 5 mg/L. Sodium and calcium hypochlorite can be purchased from large supermarkets, hardware stores or swimming pool stockists. Stabilised chlorine (chlorinated cyanurates) should not be used.

When using calcium hypochlorite this should be dissolved in a *clean* plastic bucket - *in the open air* - before adding it to the tank. Always add the disinfectant to the water rather than *vice versa*. After pouring the concentrated chemical mixture into the tank, stir the tank water thoroughly to provide as much mixing as possible and let it stand for at least one hour before use.

The chlorine will not make the water unsafe to drink but it could impart a distinct taste and odour that should dissipate in one to a few days. Boiling the water will remove most of the taste and odour associated with chlorination.

Tank sizes range from small modular tanks of 750 litres (~ 165 gallons) to over 50,000 litres (~11000 gallons). To convert a volume in gallons to a volume in litres multiply the number of gallons by 4.5.

To calculate the volume of a rectangular tank use the formula:

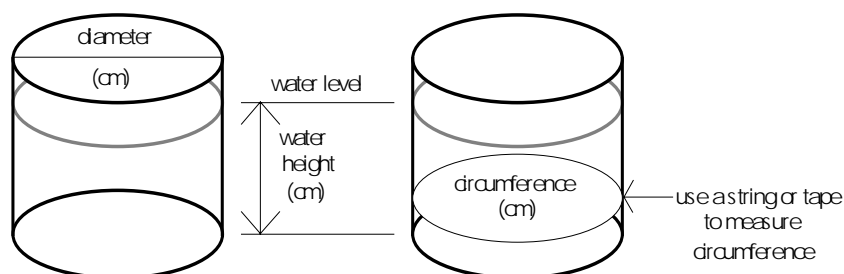
$$\text{Volume (in litres)} = \text{height (cm)} \times \text{width (cm)} \times \text{depth (cm)} \div 1000$$

To calculate the volume of a cylindrical tank use the formula:

$$\text{Volume (in litres)} = \pi \times \text{diameter}^2 \text{ (cm)} \times \text{height (cm)} \div 4000$$

$$(\pi = 22 \div 7)$$

or use one of the following methods:



Formula 1: Approximate volume (in litres) = $0.8 \times \text{water height} \times \text{diameter}^2 \div 1000$

Formula 2: Approximate volume (in litres) = $0.08 \times \text{water height} \times \text{circumference}^2 \div 1000$

Only calculate the volume of water in the tank and not the volume of the tank.

8.3 Handling chemicals

When handling and storing chemical compounds it is important to carefully read and follow safety directions given on the package label.

8.4 Ultraviolet light (UV) disinfection

In some cases UV disinfection has been used to treat rainwater supplied through internal house taps. While this form of disinfection could be quite effective for rainwater it should not be used as a replacement for proper maintenance procedures.

8.5 Water filters

Tap or outlet water filters should not be necessary for rainwater which should normally be soft, clear and free of any distinct odours. If water filters are installed they should be maintained exactly to manufacturers' specifications to avoid problems associated with microbial growths.

8.6 Dead animals in a tank

Where a rainwater tank has become contaminated by a dead animal such as a bird or rodent, carefully remove as much as possible of the animal carcass and then disinfect the water. If the animal is large such as a possum or cat and badly decayed, the taste of the water will probably be affected. It is recommended that the tank be drained and cleaned as soon as possible (see **Sections 7.4 and 7.5**).

The point of entry for the animal should be located and repaired/sealed.

9. Mosquito control

Rainwater tanks can provide very good habitats for mosquito breeding. The most effective control measure is to prevent access of adult mosquitoes. If access has occurred remedial action can be taken to prevent the release of mosquitoes.

9.1 Exclusion of adult mosquitoes

Ensure that unless in use all access points excluding the inlet and any overflows are kept shut with close fitting lids that will prevent access of mosquitoes. Inlets and overflows should be covered with closely fitting removable insect-proof screens. The screens should be made of non-rust material formed, typically, with 0.315 mm diameter material and 6x7 mesh openings per cm². The screens should be readily accessible for regular cleaning.

9.2 Control of mosquito larvae (wigglers)

Mosquito larvae (wigglers) found in rainwater tanks indicate the presence of an opening through which the female mosquito can enter and lay eggs on the water. The opening should be closed. This will prevent further entry and will also prevent the escape of any hatched mosquitoes.

Larvae present in rainwater can be treated by the addition of a small quantity of domestic kerosene (5 mL per 1000 litres). Commercial or industrial kerosenes (eg power kerosene for tractors etc) **should not** be used for mosquito control.

As described in **Section 3.1** kerosene should not be used in tanks coated with Aquaplate™. In addition, kerosene may not be suitable for use in tanks constructed or lined with plastic. If in doubt consult the manufacturer.

Used carefully kerosene will not provide any risk to human health but excessive amounts can taint the water and it is a human poison. Kerosene should not be added when water levels are low. Kerosene added to the surface will not mix through the body of rainwater in the tank and it will either be washed out of the tank by overflow or it will evaporate.

10. Other sources of water

In some cases it may be necessary to augment rainwater in tanks with water from other sources such as bores, dams, rivers and creeks or with carted water.

Only water that is suitable for drinking (possibly after chlorination) should be used. If there are any doubts about the suitability of a water source consult the local water or environmental health authority and if necessary have the water tested before adding to the tank.

10.1 Water from bores, dams, rivers, creeks, etc

Water should be added in one action and if from a surface supply such as a dam, river or creek the tank should be disinfected after addition is completed and the water let stand for at least one hour before use.

Chlorination should be performed as described in **Section 8** using a test kit to measure chlorine residuals. If a kit is not available use double the amount of chlorine recommended in **Section 8**.

Water from a deep and well maintained bore will generally not require disinfection after addition to a rainwater tank.

10.2 Carted water

Local authorities may be able to provide names of suitable water carriers/carters that they have approved or that they are satisfied will provide water that is suitable to drink. If local authorities cannot provide this information then only water carriers/carters that can provide evidence that water supplied will be safe to drink should be used. This evidence could include:

- any authorisations issued for the purpose of supplying drinking water,
- the identity and quality of the source water,
- evidence that tankers used are fit for the purpose of carrying drinking water.

11. Cost of rainwater

There have been a number of estimates of the cost of rainwater from domestic tanks. While costs will vary from one area to another they are generally much higher per kilolitre than the cost of mains water. In addition to the purchase price of the tank there are a number of other expenses to be considered:

- transportation,
- installation,
- alterations to gutters and downpipes,
- a tank stand or foundation,
- additional plumbing,
- a first flush device,
- insect-proof screening and gutter guard / screens,
- a pump if necessary,
- maintenance.

12. Further advice

12.1 Public Health Units

New South Wales

Environmental Health Unit,
 New South Wales Health Department,
 PO Box 798, Gladesville. NSW 2111.
 Phone: (02) 9816 0373 Facsimile: (02) 9816 0345

Victoria

Environmental Health Unit,
 Department of Human Services,
 GPO Box 4057, Melbourne. VIC 3001.
 Phone: (03) 9616 7777 (switchboard)

Queensland

Environmental Health Unit,
 Queensland Health,
 GPO Box 48, Brisbane. QLD 4001.
 Phone: (07) 3234 0938 Facsimile: (07) 3234 1480

Tasmania

Public and Environmental Health Branch,
 Department of Community and Health Services,
 GPO Box 125B, Hobart. TAS 7001.
 Phone: (03) 6233 3762 Facsimile: (03) 6233 6620

South Australia

Environmental Health Branch,
 Department of Human Services
 PO Box 6 Rundle Mall, Adelaide. SA 5000.
 Phone: (08) 8226 7100 Facsimile: (08) 8226 7102

Western Australia

Environmental Health Service,
 Health Department of Western Australia,
 PO Box 8172, Stirling Street, Perth. WA 6849.
 Phone: (08) 9388 4997 Facsimile: (08) 9388 4975

Northern Territory

Environmental Health Branch,
Territory Health Services,
PO Box 40596, Casuarina. NT 0811
Phone: (08) 8922 7340 Facsimile: (08) 8922 7200

ACT

Health Protection Service,
ACT Department of Health & Community Care,
Frewin Place, Scullin. ACT 2614.
Phone: (06) 205 1700 Facsimile: (06) 205 1705

12.2 Advice on water quality, testing or rates of use

Advice on water quality, testing or rates of use should be sought from the local water authority. This could be a government or local government agency or a water corporation.

12.3 Advice on tank size

Advice on determining the required size of rainwater tanks should be sought from the State or local agency responsible for management and control of water resources (see **Section 4.5**).

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14. Appendix A - Tank size and water demand data tables

Table A.1: Tank sizes to provide 99 % security of supply

		Tank size (kL)*						
Volume required (L/day)	Annual rainfall (mm)	Roof area (m ²)						
		100	150	200	300	400	500	600
60	150							43
	200				24			
	300		20	12	10			
	400	14	8	7				
	500	8	6	5				
	600	6	5	4				
	900	5	4	3				
100	200							40
	250				33	22		
	300				20	17		
	400			15	12			
	500		13	11	9			
	600	19	12	10	8			
	900	11	9	8				
	1200	10	8	7				
200	300							47
	350					40	29	26
	400					30	26	24
	500				28	24	22	20
	600			36	26	22	20	18
	900		29	23	18	16	14	
	1200	34	23	19	16	14		
400	500							51
	600							47
	700						49	44
	900					50	44	39
	1200				47	39	34	31

* The tank sizes shown were determined from summarised data provided by the South Australian Water Corporation and the Department of Environment, Heritage and Aboriginal Affairs. The original data was calculated using a computer simulation based on averaged rainfalls and rainfall patterns and using a value of 0.8 for A and 2 mm per month for B.

Table A.2: Tank sizes to provide 90 % security of supply

		Tank size (kL)*						
Volume required (L/day)	Annual rainfall (mm)	Roof area (m ²)						
		100	150	200	300	400	500	600
60	150				20	14		
	200			15	10			
	300	14	6	4				
	400	6	3	3				
	500	4						
	600	3	2					
100	150						34	27
	200				33	19	17	
	300			16	10	8		
	400		10	8	6			
	500	11	6	5	4			
	600	8	5	4	3			
200	900	6	4					
	250						26	21
	300					29	20	17
	350				26	17	13	12
	400				19	14	11	10
	500			20	12	10	8	
	600		25	15	10	8	7	
900	26	13	10	7				
400	1200	18	10	8	6			
	350							44
	500					42	30	24
	600					30	22	19
	700				39	27	21	18
	900				27	19	16	13
600	1200			34	21	16	13	12
	500							
	600							
	700							47
	800						50	40
	900						43	34
	1200				50	37	28	24

* The tank sizes shown were determined from summarised data provided by the South Australian Water Corporation and the Department of Environment, Heritage and Aboriginal Affairs. The original data was calculated using a computer simulation based on averaged rainfalls and rainfall patterns and using a value of 0.8 for A and 2 mm per month for B.

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Table A.3: *Maximum volumes of water that can be collected depending on roof size and annual rainfall*

<i>Maximum volumes of rainwater / year (litres)</i>							
<i>Annual Rainfall</i>	<i>Roof area (m²)</i>						
(mm)	100	150	200	250	300	400	500
150	10080	15120	20160	25200	30250	40320	50400
200	13250	21120	26500	35200	42240	53000	70390
250	18080	27120	36160	45200	54250	72320	90390
300	22080	33120	44160	55200	66230	88310	110400
400	30080	45120	60160	75190	90230	120300	150400
500	38080	57120	76150	95240	114200	152300	190500
600	46080	69110	92150	115200	138200	184300	230400
800	62080	93110	124200	155200	186200	248300	310400
1000	78070	117100	156100	195200	234100	312300	390400
1200	94070	141100	188100	235200	282100	377300	470400

Table A.4: *Water demand per day, month or year*

<i>Water demand (litres)</i>		
<i>Per day</i>	<i>= Per month</i>	<i>= Per year</i>
60	1830	21960
100	3050	36500
150	4575	54800
200	6100	73000
300	9150	109500
400	12200	146000
500	15250	182500
600	18300	219600
800	20500	292000