



**A GUIDE TO SAFE
RAINWATER
HARVESTING
IN TONGA**

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Cover photo courtesy Mrs Audrey Pina Liti

1. Purpose of guide

This Guide to Safe Rainwater Harvesting for Tonga is designed as a training and reference resource for homeowners, village water committee and those installing and maintaining rainwater harvesting systems to enable them to identify risks to providing safe drinking-water and to plan appropriate improvements.

Drinking-water is sourced from groundwater or rainwater in Tonga. Rainwater harvesting is a preferred, and sometimes necessary, source of water for many households and businesses. Well installed and maintained rainwater harvesting systems can help ensure that safe drinking-water is available for all people who use it.



2. Safe drinking-water

Safe drinking-water, water that will not cause serious illness when consumed, is a basic human need and right, and a public health goal supported by international agreements and agencies.

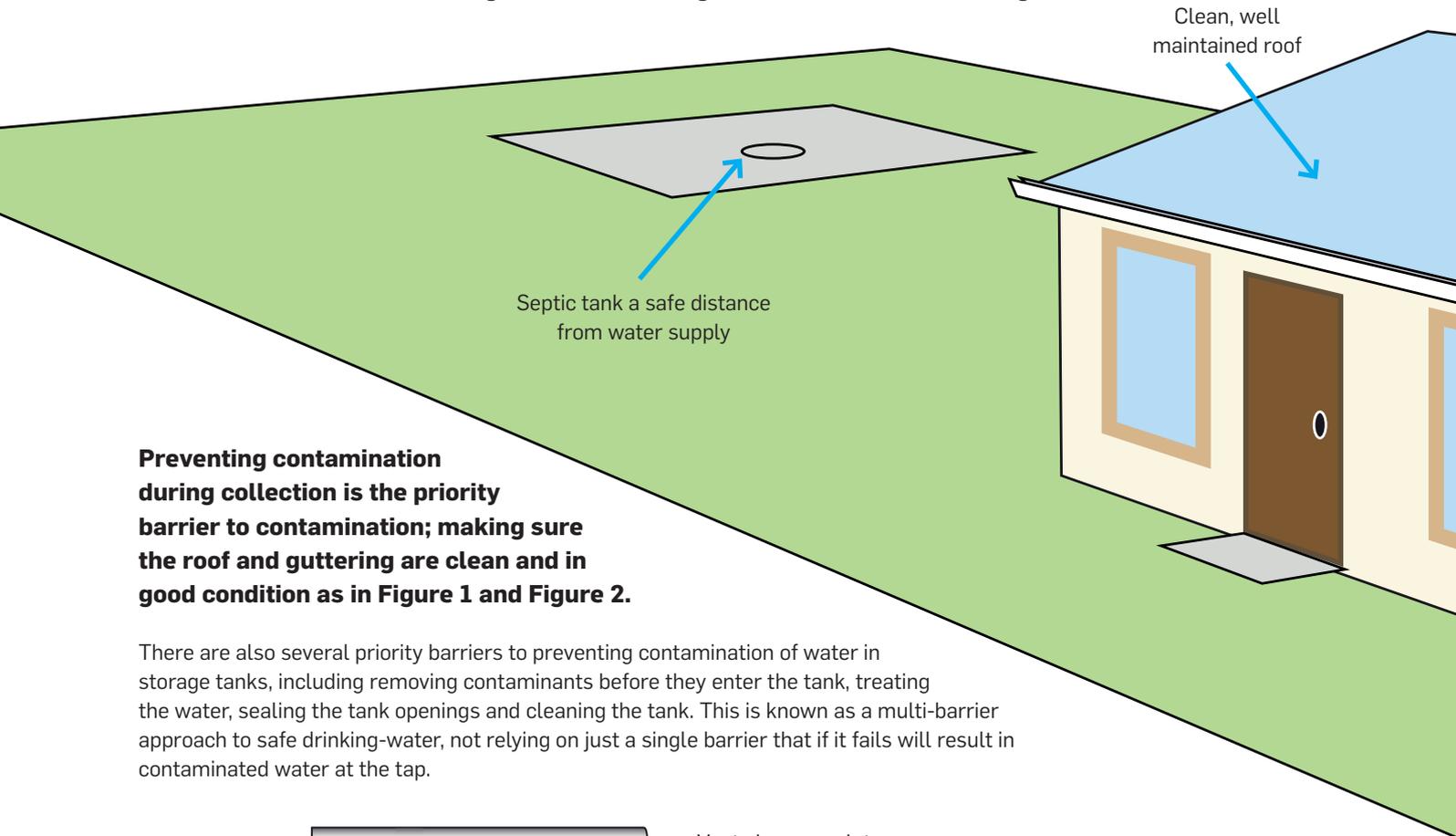
Ensuring drinking-water is safe requires effort because all types of water supply are susceptible to contamination. The contaminants of concern are pathogenic microorganisms (bacteria, protozoa, viruses and helminths), hazardous chemicals and physical (like turbidity or murkiness of the water).

The current approach to ensuring safe drinking-water, promoted by the World Health Organization, is called *drinking-water safety planning*. It is a practical approach of assessing the entire water supply from its source to the tap for what could cause the water to become unsafe to drink, then planning improvements to eliminate, reduce or manage these causes. Plans are also made to deal with the emergency situation of unsafe drinking-water. A *drinking-water safety plan* guides day-to-day operation and maintenance of the water supply and guides investment in necessary improvements. A *drinking-water safety plan* is required for every water supply because every supply has slightly different features. A *drinking-water safety plan* is best prepared by the owner of the supply because they know best the supply features and have the responsibility for implementing the plan.

Periodic water quality testing is a check that the plan is working and the water is safe. Drinking-water standards or guidelines provide a list of contaminants and acceptable concentrations that are considered safe if not exceeded.

3. Rainwater harvesting

Rain straight from the heavens is typically safe, but as soon as it is harvested it is at risk of contamination during collection, storage, distribution and handling.



Preventing contamination during collection is the priority barrier to contamination; making sure the roof and guttering are clean and in good condition as in Figure 1 and Figure 2.

There are also several priority barriers to preventing contamination of water in storage tanks, including removing contaminants before they enter the tank, treating the water, sealing the tank openings and cleaning the tank. This is known as a multi-barrier approach to safe drinking-water, not relying on just a single barrier that if it fails will result in contaminated water at the tap.

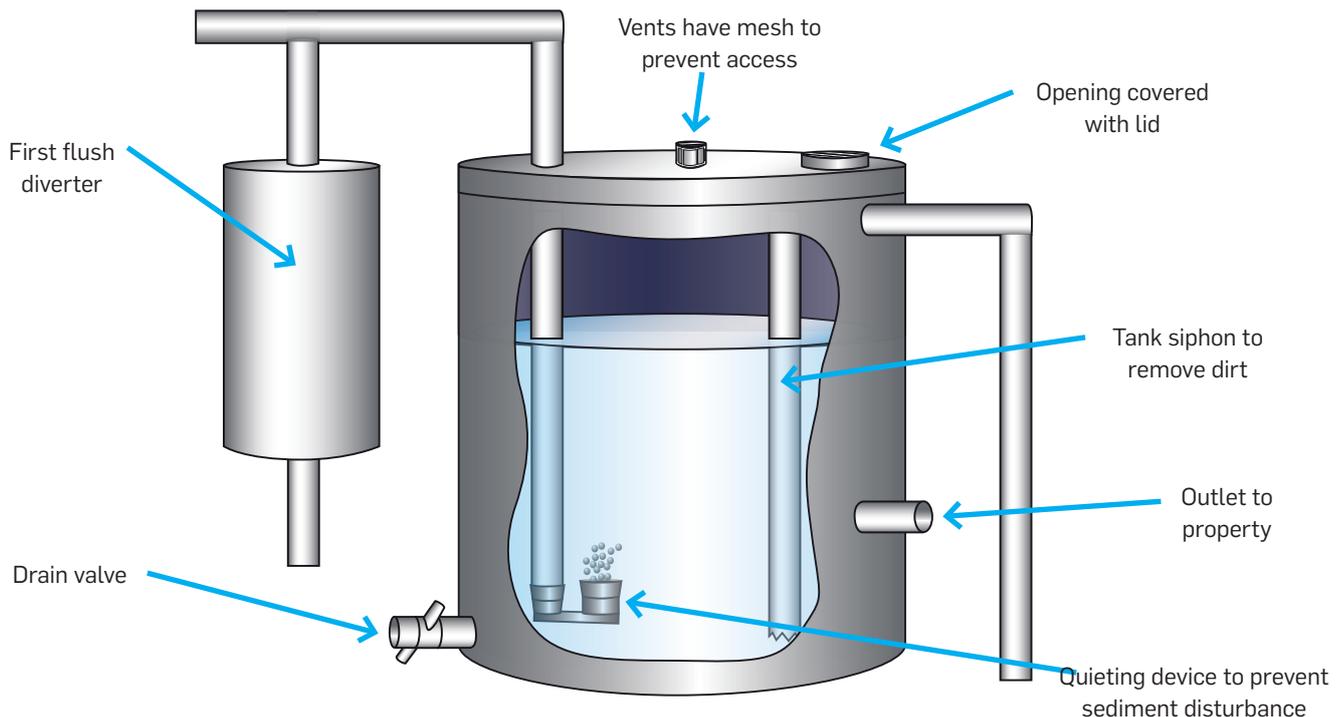


Figure 2 – specific mitigation points for maintaining a clean rainwater tank

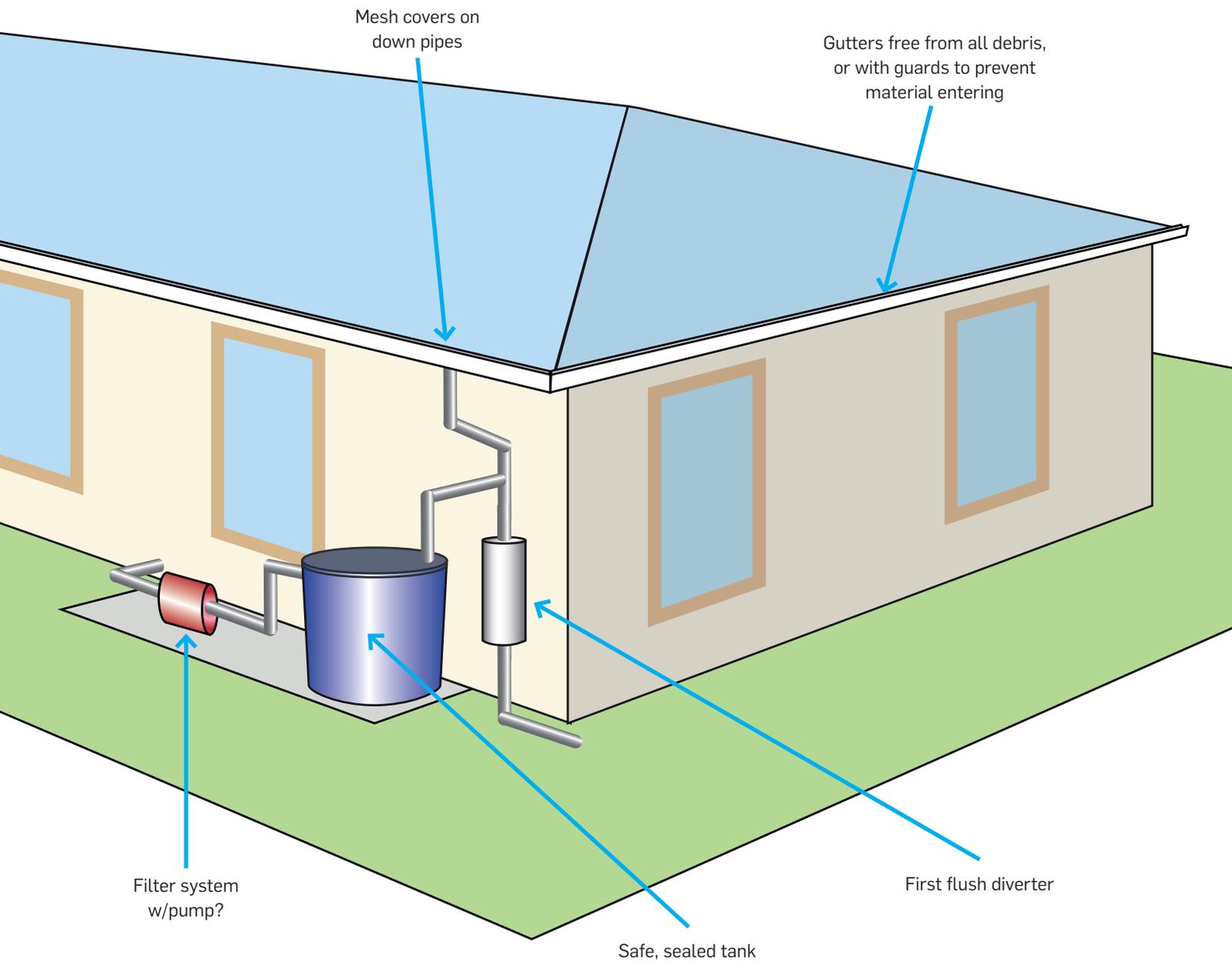


Figure 1 – diagram of house and rainwater collection system with points of attention for maintaining a safe supply

4. Safe rainwater supply checklist

To help focus attention on the most important barriers to contamination, a checklist has been developed, categorising elements of the physical rainwater supply and management practices into *Essential, Desirable and Optional for Safe Rainwater Supply*.

Other benefits of applying the checklist include:

- making transparent and explicit to accommodation business owners the Ministry of Health's expectations of a safe rainwater supply
- providing for consistency of inspection for all health inspectors
- providing a way to track improvements over time.

The one-page checklist (see Appendix 1) is a variation on checklists developed by the World Health Organization and one of the most widely used rainwater harvesting guidelines in the Pacific (*Harvesting the Heavens. Guidelines for Rainwater Harvesting in Pacific Island Countries*¹). This checklist varies in two respects. Firstly, it prioritises barriers to contamination, recognising that some risks are more

important to eliminate, reduce or manage than others. Second, it provides space for recording and tracking the status of the Essential elements, recommendations for improvements and improvements made over time.

The target status for all elements should be **GREEN** (= acceptable). For elements where risks have been identified that need to be eliminated, reduced or managed, there is an option of **ORANGE** status (meaning improvements are underway) or **RED** (meaning improvements are needed).

The following three sections provide guidance to assist with completing the checklist and developing plans to eliminate, reduce or manage risks.



¹ *Harvesting the Heavens. Guidelines for Rainwater Harvesting in Pacific Island Countries, 2004*. SOPAC Joint Contribution Report 178. SPC-SOPAC, Suva, Fiji.

5. Essential elements of a safe rainwater supply

The elements of a safe rainwater supply considered to be *essential* are discussed in this section.

These elements focus on preventing contamination in the first instance, during collection and during storage. The discussions pay particular attention to microbial contamination because pathogenic microorganisms cause illness rapidly, whereas illness from chemical contamination is more likely only after many years of drinking the contaminated water.

Roof in clean and good condition

Problems

Vermin having access to roof from overhanging trees, leaving excreta on roof that is washed into storage tank, causing microbial contamination. Vermin also gain access to storage tank from roof.



Solutions

- Cut back overhanging trees.
- Sweep and wash roof at least once a month, diverting wash water away from storage tank.
- Install a first-flush device on down pipes (see section 6).
- Keep the property free of rubbish that could attract vermin.

Vegetation falling on roof from overhanging trees, being washed into storage tank, rotting and adding sediment, causing bad taste and smell.



- Cut back overhanging trees.
- Use leaf screens on guttering and/or down pipes to storage tank.
- Sweep and wash roof at least once a month, diverting wash water away from storage tank.
- Install a first-flush device on down pipes.

Birds on roof leaving excreta on roof that is washed into storage tank, causing microbial contamination.



- Sweep and wash roof at least once a month, diverting wash water away from storage tank.
- Install a first-flush device on down pipes.

Problems

Poor condition or inappropriate roof materials being washed into storage tank, causing chemical contamination and bad taste and smell.



Solutions

- Sweep and wash roof at least once a month, diverting wash water away from storage tank.
- Install a first-flush device on down pipes.
- Repair rusted roof, fix holes, replace inappropriate materials, and paint with non-toxic paint.

Contaminants from atmosphere settling on roof and being washed into storage tank, causing chemical contamination and bad taste and smell. For example sea spray, ash from fires, agricultural chemical spray drift.



- Sweep and wash roof at least once a month, diverting wash water away from storage tank.
- Install a first-flush device on down pipes.

Guttering in clean and good condition

Problems

Vermin having access to guttering from overhanging trees, leaving excreta that is washed into storage tank, causing microbial contamination. Vermin also gain access to storage tank from guttering.



Solutions

- Cut back overhanging trees.
- Clean out gutter channel at least once a month, diverting wash water away from storage tank.
- Install a first-flush device on down pipes (see section 6).
- Keep the property free of rubbish that could attract vermin.

Problems

Vegetation falling in guttering from overhanging trees, being washed into storage tank, rotting and adding sediment, causing bad taste and smell.



Solutions

- Cut back overhanging trees.
- Use leaf screens on guttering and/or down pipes to storage tank.
- Clean out gutter channel at least once a month, diverting wash water away from storage tank.
- Install a first-flush device on down pipes.

Poor condition or inappropriate guttering materials being washed into storage tank, causing chemical contamination and bad taste and smell.

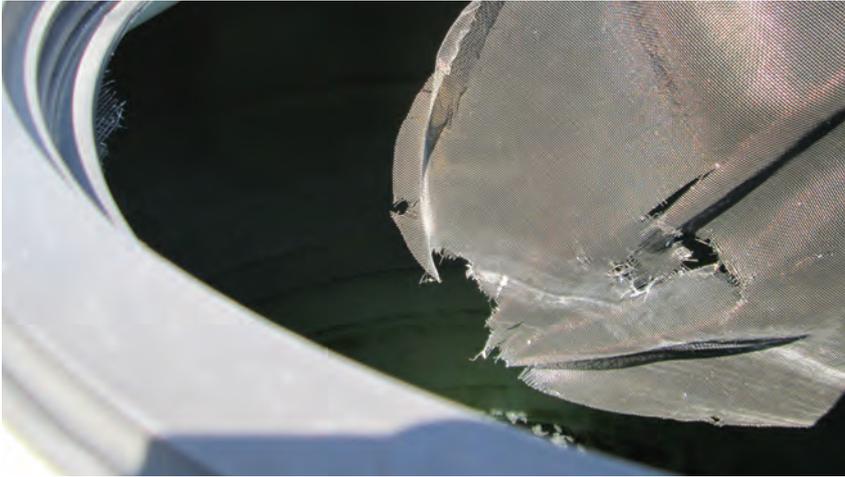


- Clean out gutter channel at least once a month, diverting wash water away from storage tank.
- Install a first-flush device on down pipes.
- Repair rusted guttering, fix holes, replace inappropriate materials.

All points of entry to storage tank fitted with sealed lids

Problems

Rain falling on the roof of the storage tank flows towards the opening/hatch, carrying with it microbial and chemical contaminants. If the opening/hatch is not securely sealed, contaminants will flow into the tank.



Vermin and birds have access to the roof of the storage tank, leaving excreta on roof of the tank that is washed in when it rains, causing microbial contamination. Vermin and birds can also fall into storage tank and die, causing microbial contamination.



Solutions

- Keep the roof of the storage tank clean and do not store anything on the roof.
- Use storage tanks with domed roofs so rain easily flows off top to preventing ponding of water in the tank roof.
- Use storage tanks with raised lip around opening/hatch/lid that diverts rain away from opening.
- Ensure the opening/hatch on the roof of the storage tank is securely sealed with a fitting lid.

- Cut back overhanging trees.
- Install vermin guards around pipes to prevent the vermin using the pipes as a route to the top of the storage tank.
- Ensure the opening/hatch on the roof of the storage tank is securely sealed with a fitting lid.
- Keep the property free of rubbish that could attract vermin.

All inlet pipes and vents screened with fine mesh

Problems

Unscreened inlet pipes and vents allow leaves, dirt, insects and small vermin to enter the storage tank, causing sediment and microbial contaminants to build up.



Solutions

- Install fine mesh screens on all inlet pipes and vents.

Storage tank in clean and good condition

Problems

Sediment building up in bottom of tank will contain microbial contaminants that can be re-suspended in the water when it is disturbed during tank filling or using of water.



Solutions

- Regularly drain and clean the storage tank (see Appendix 2).
- Install a floating outlet device (see section 6).
- Install a quieting inlet device (see section 6).
- Install a second tank in series with the first. Fill through one tank and draw from the other. The first tank acts as a sedimentation tank.

Cracks in concrete tanks allow contaminants to enter the tank, causing microbial contamination of the water.



- Repair cracks with safe sealant. Check that the leaks have stopped.

For storage tanks at or below ground level, septic tanks are at least 5m away

Problems

Drain fields from septic tanks pass too close to storage tank, with the possibility of microbial contaminants from the septic tank effluent entering the tank through cracks or absorption through floor and walls of tank.



Solutions

- Raise storage tank off the ground.
- Move septic tank and its drain field much further away from the storage tank.
- Repair cracks in the storage tank.

6. Desirable elements of a safe rainwater supply

The elements of a safe rainwater supply considered to be *desirable* are discussed in this section. These elements mostly focus on removing or treating contamination that have slipped through the *essential* barriers. The elements are described in this section and refer to the diagram on page two.

Using preventative maintenance plans and checklists

A good preventative maintenance plan provides a reminder of what needs to be checked and how often. The checklist is a record of the maintenance and routine checks undertaken. The maintenance plan and checklist also act as guides for all staff who may be asked to look after the rainwater supply.

Regular (monthly) water quality monitoring

Periodic water quality testing is a check that the preventative maintenance plan is working and the water is safe. A minimum of one test a month should be carried out by a laboratory recommended by the health inspector.

Drinking-water standards or guidelines provide a list of contaminants and acceptable concentrations that are considered safe if not exceeded. In the absence of a country standard, the World Health Organization Guidelines are recommended.

Using first-flush device

A first-flush device is used to collect and divert away from the storage tank the initial few litres of rainwater from the roof after it starts to rain. This is the dirtiest water containing vermin and bird excreta, insects, dust, ash from fires etc. is washed off the roof. Once the diverter is full, the cleaner water flows to the storage tank. The dirty diverted water drains slowly to the surrounding environment.

Using quieting inlet pipe

A quieting inlet pipe is used in place of rainwater from the gutter and downpipe spilling directly into the top of the storage tank or being piped directly on to sediment in the bottom of the tank. It is a vertical pipe that runs down the inside of the tank to the tank floor and then turns upward so the water does not stir up the sediment in the bottom of the tank.

Using floating outlet pipe

A floating outlet pipe consists of an air-filled ball which suspends a flexible outlet just below the surface of the water in the cleanest water. The flexible outlet pipe is connected to the outlet tap at the bottom of the tank. This prevents re-suspending sediment from the bottom of the storage tank and sending dirty water into the reticulation.



Using treatment, eg, filtration

Despite good management it is inevitable that some contamination will get into the stored water. This means that treatment is desirable. Of most importance are the microbial contaminants as they can make people ill very quickly. There are two types of treatment, removing visible contamination (where many of the microbes are found) by filtration and killing microbes by disinfection.

Filtration systems can be installed at points before or after the storage tank, or at dedicated drinking-water taps. Typically a system will include two or three decreasing mesh size filters. These serve to sequentially remove the largest size fractions. Unless a very fine mesh (1µm) is used not all microbes will be removed.

Disinfection, most commonly by chlorination, will kill the majority of microbes present. A disinfection process needs to be appropriately designed and operated to ensure it is effective. Businesses wishing to use chlorination should contact the local Health Inspector for advice. An alternative to chlorination is ultra-violet light treatment system, this needs to be appropriately designed and operated to deliver the best results.

Rainwater supply can be isolated from other water supplies

If other sources of water are used at the property and these sources are of unknown or poor quality, avoid the possibility of contaminating the stored rainwater by isolating the other sources from the rainwater supply.

If Tonga Water Board supply is used to supplement the rainwater supply ensure there is a backflow prevention device on the Tonga Water Board pipe. A simple mechanism would have the inlet pipe from Tonga Water Board situated above the level of the overflow pipe for the storage tank.

7. Optional elements of a safe rainwater supply

The elements of a safe rainwater supply considered to be *optional*, but good practice, are discussed in this section. They are mostly about providing the evidence that the supply's operation, maintenance and improvement plan is working.

Good record keeping of maintenance, checks, problems and fixes

A well maintained set of records demonstrates to the authorities that the rainwater supply is being actively managed to deliver consistently safe drinking-water

Review and update supply's operation, maintenance and improvement plan

In addition to records of preventative maintenance and routine checks, keeping a record of problems as they arise and their solutions can be used to identify recurring problems. This is an alert to revise the preventative maintenance plan, or add further maintenance to eliminate the problem; or make a more substantial improvement to the system.

8. Useful Contacts

Ministry of Health

Supervising Public Health Inspector
Vaiola Hospital
Tongatapu

Ministry of Land and Natural Resources

Ministry of Meteorology, Energy, Information, Disaster Management, Environment, Climate Change and Communications (MEIDECC)

Institute of Environmental Science and Research Limited (ESR)

esr.externalenquiries@esr.cri.nz
Tel: +64 3 351 6019



APPENDIX 1: Safe Rainwater Supply Checklist

Name: _____ Date _____ Assessed by _____

Safe rainwater supply checklist

| | Year (Quarter) | | | | Year (Quarter) | | | | Evidence of good management (MUST be doing active checks and maintenance) | Action required or in progress |
|---|---|----|----|----|----------------|----|----|----|--|--------------------------------|
| | Q1 | Q2 | Q3 | Q4 | Q1 | Q2 | Q3 | Q4 | | |
| | Indicate status as green (acceptable), orange (making improvement), red (improvement needed) | | | | | | | | | |
| 1. Essential for safe rainwater supply | | | | | | | | | | |
| Roof clean and in good condition | | | | | | | | | | |
| Guttering in clean and good condition | | | | | | | | | | |
| All points of entry to storage tank fitted with sealed lids | | | | | | | | | | |
| All inlet/outlet pipes and vents screened with fine mesh | | | | | | | | | | |
| Storage tank in clean and good condition | | | | | | | | | | |
| Storage tanks, at or below ground level, are at least 5 meters away from septic tanks | | | | | | | | | | |
| 2. Desirable for safe rainwater supply (indicate with ✓ or X) | | | | | | | | | | |
| Using preventative maintenance plans and checklists | | | | | | | | | | |
| Regular (monthly) water quality testing | | | | | | | | | | |
| Using first-flush device | | | | | | | | | | |
| Using quieting inlet pipe | | | | | | | | | | |
| Using floating outlet pipe | | | | | | | | | | |
| Using treatment, eg filtration | | | | | | | | | | |
| Rainwater supply can be isolated from other water supplies | | | | | | | | | | |
| 3. Optional for safe rainwater supply (indicate with ✓ or X) | | | | | | | | | | |
| Good record keeping of maintenance, checks, problems and fixes | | | | | | | | | | |
| Review update supply's operation, maintenance and improvement plan | | | | | | | | | | |

APPENDIX 2: Cleaning a rainwater storage tank

Storage tanks need regular cleaning to remove accumulated sediment that will contain microbial contaminants and organic matter that taints the water. The frequency of cleaning will vary depending on the quality of the water entering the tank. Signs that the tank needs closer inspection and possibly cleaning include:

- dirty water in the tank or at the tap
- water that tastes or smells bad in the tank or at the tap
- the flow rate of the water is slower than normal.

Even if there are none of these signs, the tank should be inspected for a build-up of sediment every 2–3 years, and cleaned.

Consider using a professional service for storage tank cleaning. If it is necessary to clean the tank yourself, the following guidance will assist.



Photo courtesy Mrs Audrey Pina Liti

Plan for cleaning

People will still need to use water while the tank is being cleaned, so before starting:

- plan to clean the storage tank in the rainy season when there will be rainwater available for cleaning and refilling the tank
- having at least two storage tanks that can be isolated from each other will allow one tank at a time to be cleaned while still able to use the water from the other tank
- if you have only one storage tank, have a safe way of storing enough water for the time the storage tank will be out of action
- inform guests ahead of time that you will be cleaning the storage tank and access to water will be restricted for a time.

There are health and safety issues to consider when cleaning the storage tank, plan for these, including:

- having a second person around as an observer to raise an alarm if something goes wrong
- risks of falling off a ladder or roof of the storage tank, or slipping on wet surfaces
- one step of the cleaning process is using chlorine bleach to disinfect the inside of the tank. Inhaling the fumes, especially if inside the storage tank, is dangerous. Spilling bleach on the skin or in the eyes is also dangerous. **When the businesses need to clean the tank with chlorine they should contact the local Health Inspector for advice.**
- the waste from cleaning the tank (sediment, sludge and cleaning water) needs to be disposed of in such a way that it does not pond around the area of the tank and does not contaminate the surrounding environment.

Removing the sediment

Some tanks will have a tap at the bottom of the tank for the purpose of draining. If this tap is very close to the bottom and a large enough bore size, opening the tap will also drain most of the accumulated sediment.

Regardless of whether there is a drain tap close to the bottom, there will still be sediment which needs to be removed another way. For example, a siphon (eg, an inverted funnel on the end of a hose) slowly moved across the bottom of the tank will remove the sediment without the need to drain the tank of water. Alternatively, a pump can be used in place of the siphon, or a bucket. Sediment removal will be easier if the water level in the tank is low.

Cleaning and disinfecting the tank

If it is time to clean and disinfect the storage tank, the water will need to be drained and sediment removed as described in the previous section. By planning ahead, you can purposefully use the stored water until the water level is low to avoid having to dump precious water. Keep enough water aside for cleaning the tank.

- Take extreme care working inside the storage tank.
- Disconnect the tank from the downpipe and shut off the supply to the building.
- Once drained of water, the remaining water and sediment in the tank will need to be removed by hand, using a bucket.
- Before using a brush or broom to scrub the inside of the tank, soak it in a bucket of water which has a capful of non-perfumed household bleach added, and then rinse with clean water.
- Scrub the interior surfaces of the storage tank (bottom and sides) with water and the clean brush or broom.
- Remove the dirty water from the tank using a bucket. Rinse the interior of the tank with clean water, and remove this water also.
- Reconnect the storage tank and allow to refill with rainwater.
- Contact the local Health Inspector for advice on chlorinating the water.
- Once the water has been chlorinated, reopen the supply to the building.



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