An Introduction to Rainwater Harvesting Systems

A UK Rainwater Management Association Briefing Guide

Preface

This Guide has been produced for specifiers and buyers of rainwater harvesting (RWH) systems for use in domestic and commercial properties.

It offers a broad generic explanation of the two broad principles on which domestic RWH systems work, ie “direct-pressure”, and gravity fed via “header-tanks”.

It also explains the advantages and disadvantages of these operating principles, from a user’s perspective.

Introduction

Mains-water supplies throughout large areas of England are under serious stress, a position predicted to deteriorate in the future due to population growth and the need to build a large number of new homes. Apart from economising methods, rainwater harvesting (RWH) is one of the most straightforward ways of helping to mitigate this problem.

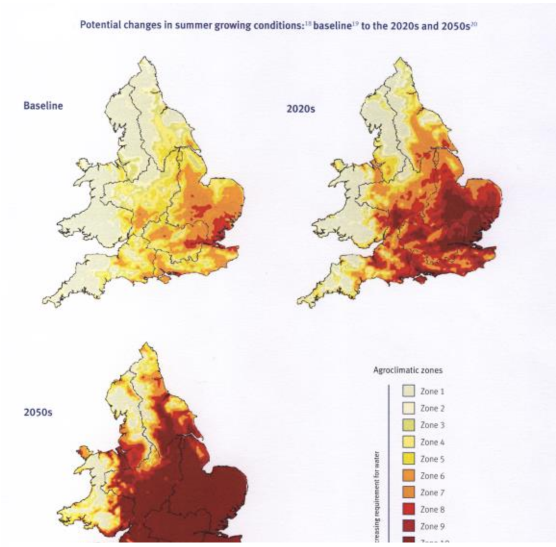
RWH is the collection and storage for subsequent use of rainwater that otherwise would have been lost to soak-aways or the surface water drain.

Harvested rainwater is naturally soft, and compared to mains water is also slightly acidic; collection is usually from the roof of a building, being passed through a particle filter before entering a storage tank. Leaf-guards are also recommended at the top of rainwater down-pipes.

Harvested rainwater can be substituted for mains water for most applications not requiring wholesome water, such as toilet flushing, clothes washing, vehicle washing and garden irrigation.

Water from other hard-standings such as car-parks and driveway surfaces can also be used for this purpose if first filtered to remove hydrocarbons and other impurities.

Other sources of non-wholesome water, such as re-using bath-water (known as “greywater” recycling) should not be confused with RWH, and are therefore not covered by this guide but are generally much more expensive.



Environment Agency projections of deteriorating conditions for farming due to stresses on water supplies

General Principles

Rainwater harvesting systems must be properly designed (to BS 8515) and be properly installed in accordance with the manufacturer’s instructions.

It is advised that systems be installed by fully qualified personnel, the main trades involved being ground-works (for installation of the storage tank and associated connections to underground pipe-work), and plumbing (nearly all of the remaining work); a professional

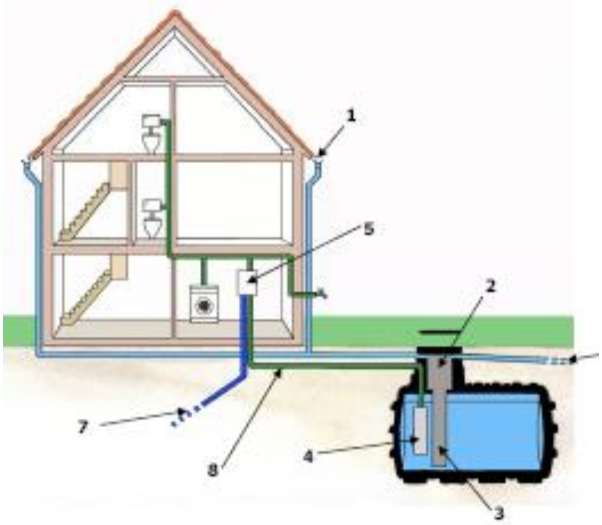
electrician is also required to provide a power supply and make electrical connections.
Prior to installation a risk assessment is to be carried out and if, as is usual, an underground storage tank is to be installed, it is good practice (and may be a local byelaw) to contact the local authority building regulations department for advice and approval (if needed).

Warning

No connection of a RWH system is to be made to the mains water supply, other than as specified by the manufacturer. In particular, no cross-connection is to be made between the rainwater and mains water as this is prohibited by Water Regulations, and a public health hazard could result.

System Components

The diagram below shows the schematic layout of a typical "Direct Pressure" system; the diagram opposite shows the layout for a typical "Header-Tank" system.



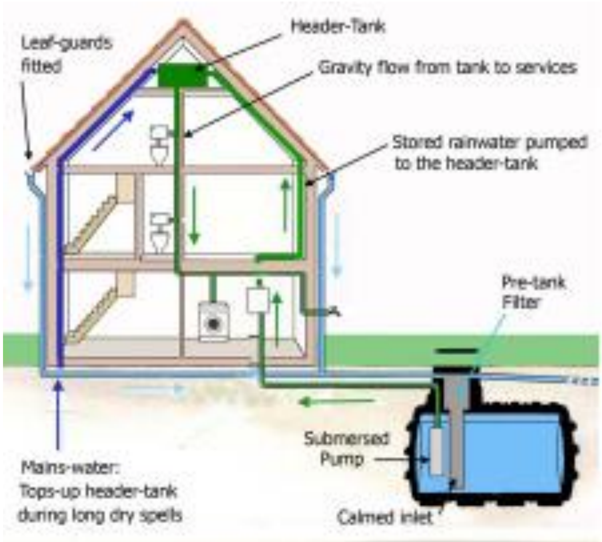
Key:

1. Leaf-guards at tops of down-pipes
2. Pre-tank filter prevents large solids from entering storage tank
3. Calmed inlet to minimise disturbance of water in the tank
4. Submersible pump to deliver water into the dwelling
5. Controls
6. Overflow to soak-away or storm-drain
7. Mains water supply to provide top-up, when needed, via Class-A air-gap
8. System supply to services via dedicated pipe-work; _which must not be cross-connected to the mains pipe-work_

Working Principles – Direct Pressure

Domestic systems generally use the property roof for collecting the rainwater which is then stored in an underground tank to provide non-wholesome water for toilet flushing, clothes washing machines, and the outside tap.

Collection from a conventional roof is recommended, avoiding "green" and sedum roofs wherever possible. The roof water is channelled through the normal guttering and down-pipe arrangements, before being brought into a single drainage pipe underground which feeds into the storage tank.



In accordance with the requirements of BS 8515, the water is filtered before entering the storage tank to remove solid particles, usually using a stainless-steel filter installed in the neck of the tank. This filter requires cleaning every 3 months to maintain its efficiency. Failure to do so will possibly lead to progressive clogging of the filter, causing incoming water to be lost direct to the overflow, rather than entering the tank.

Having passed through the filter, the water is introduced into the tank via a calmed inlet designed to smoothly introduce the fresh and highly oxygenated rainwater into the bottom of the tank. This helps to avoid stagnation at the lowest level, and assists maintenance of the quality of the water stored in the tank.

The stored water is then supplied to the non-wholesome services on-demand; this demand is sensed, by either a Control Unit or the pump itself, which activates the durable electric pump in the tank to meet the demand. When the demand for the water supply ends, this too is sensed and the pump stops. Under this "direct pressure" arrangement, the pump is effectively linked direct to the service concerned

In periods of prolonged rain, the storage tank will become full and overflow through the connection provided to the surface water management arrangements for the project (ie soak-away, storm drain or attenuation system) and be protected from back-filling by a back-flow prevention valve if connected to a sewer. As the water storage tank may already be full when a heavy downpour is experienced, the whole of the tank volume cannot be taken into account when making the attenuation calculations for the project.

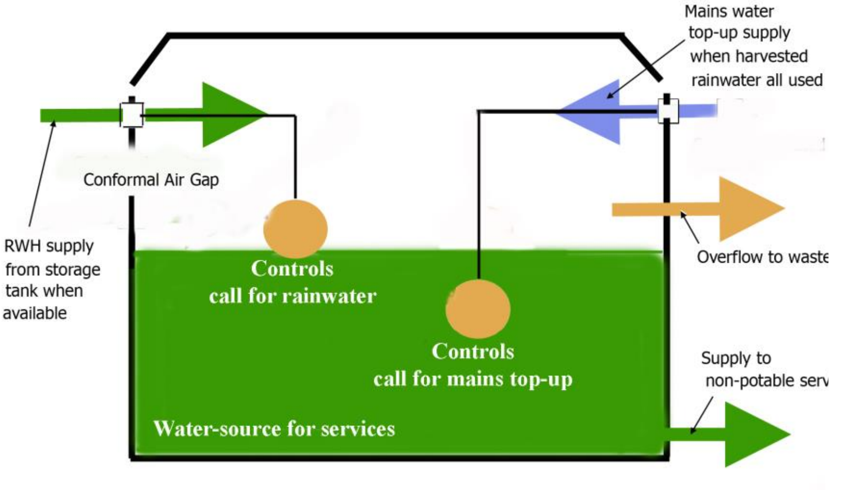
Conversely, in dry spells the tank contents may be in danger of becoming exhausted and need to be supplemented by mains water to ensure continuity of supply to the services. This too is sensed by the Control Unit which then activates a solenoid to allow mains water to enter the tank via a Class-AA air-gap; this prevents direct contact between the wholesome and non-wholesome pipe-work/water. Only a limited amount of water is introduced in this way, so leaving the maximum possible capacity available to harvest the next rainfall.

The principle reasons for using direct pressure systems, bearing in mind that they depend at all times on an available power-supply and an operational pump, are that they are usually cheaper than their header-tank counterparts, and in some buildings of modern design header-tanks cannot be accommodated.

Working Principles – Header-tanks

Many of the working principles of direct pressure systems apply equally to header-tank systems; the main differences between the systems being:

- The services are fed from the reservoir of water held in the header-tank, rather than direct from the pump in the main storage tank
- The water level in the header tank is maintained in one of two ways:
  - By the activation of the pump in the main storage tank
  - By direct top-up from the mains water supply if the tank has run dry



Schematic showing principles of header-tank operation

Top-up of the header-tank is achieved by a dual-level ball-valve arrangement (see diagram above), with the first level controlling the activation of the pump in the main underground storage tank; if the water in this tank is exhausted, then dry-run protection stops the pump working causing the water level in the header-tank to continue falling as water is consumed.

When the water level in the header-tanks falls below its second level, mains water is allowed to enter the tank direct, with direct contact between the mains water and the harvested rainwater already in the tank being prevented by a Class-AB air-gap between the two.

A very significant feature of header-tank systems is that they continue to provide water to the services they supply during temporary power-cuts, or if the pump is unserviceable.

Meeting Users Needs

When developing new properties, or refurbishing existing ones, builders and developers are required to build to the Code for Sustainable Homes (or BREEAM in the case of commercial buildings) and the associated mandatory mains water consumption limitations.

The recommended approach in this respect is to economise on water consumption by using water-efficient appliances, using reduced capacity/dual-flush toilet cisterns, installing smaller baths, basins and sinks, and by employing aerated tap and shower-heads. These measures alone, however, are unlikely to meet the whole requirements, leaving water substitution as the next available solution.

Building Regulations also now encourage the use of water substitution in new homes by allowing use of two types of water supply:

- “Wholesome” (ie mains water) for cooking, drinking, bathing, showering and dish-washing (broadly accounting for 50% of domestic water consumption)
- “Non-wholesome” (from a non-mains source) for toilet flushing, clothes-washing and the outside tap (broadly accounting for the other 50%)

The Regulations also very helpfully identify possible sources of non-wholesome water, the most common and cost-effective of which is harvested rainwater.

Once a decision has been reached to install RWH to meet the requirements of the Code for Sustainable Homes, or local planning requirements, the main choice to be made is between direct-pressure and header-tank systems; here, any cost-differential might come into account, along with consideration of needing to maintain the water supply to services under circumstances where maintenance of services during power-cuts or in the event of a pump failure is important.

The header-tank option may therefore be particularly relevant for social landlords, or in homes intended for the private rented sector.

Whichever system is chosen, the amount of mains water likely to be saved will vary from project to project, depending on the factors outlined earlier, but typical domestic and small commercial yields are illustrated in the table below:

Roof – m²	Local rainfall in mm per year				
	500	600	700	800	900
60	27,000	32,400	37,800	43,200	48,600
80	36,000	43,200	50,400	57,600	64,800
100	45,000	54,000	63,000	72,000	81,000
120	54,000	64,800	75,600	86,400	97,200
140	63,000	75,600	88,200	100,800	113,400
160	72,000	86,400	100,800	115,200	129,600
180	81,000	97,200	113,400	129,600	145,800
200	90,000	108,000	126,000	144,000	162,000

For further information or advice contact a UK-RHA member via www.ukrha.org or e-mail info@ukrha.org