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# EAST AFRICAN STANDARD

**Rain water harvesting — Code of practice**



**EAST AFRICAN COMMUNITY**



First Edition 2010

## Foreword

Development of the East African Standards has been necessitated by the need for harmonizing requirements governing quality of products and services in East Africa. It is envisaged that through harmonized standardization, trade barriers which are encountered when goods and services are exchanged within the Community will be removed.

In order to meet the above objectives, the EAC Partner States have enacted an East African Standardization, Quality Assurance, Metrology and Test Act, 2006 (EAC SQMT Act, 2006) to make provisions for ensuring standardization, quality assurance, metrology and testing of products produced or originating in a third country and traded in the Community in order to facilitate industrial development and trade as well as helping to protect the health and safety of society and the environment in the Community.

East African Standards are formulated in accordance with the procedures established by the East African Standards Committee. The East African Standards Committee is established under the provisions of Article 4 of the EAC SQMT Act, 2006. The Committee is composed of representatives of the National Standards Bodies in Partner States, together with the representatives from the private sectors and consumer organizations. Draft East African Standards are circulated to stakeholders through the National Standards Bodies in the Partner States. The comments received are discussed and incorporated before finalization of standards, in accordance with the procedures of the Community.

Article 15(1) of the EAC SQMT Act, 2006 provides that "Within six months of the declaration of an East African Standard, the Partner States shall adopt, without deviation from the approved text of the standard, the East African Standard as a national standard and withdraw any existing national standard with similar scope and purpose".

East African Standards are subject to review, to keep pace with technological advances. Users of the East African Standards are therefore expected to ensure that they always have the latest versions of the standards they are implementing.



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## Introduction

In the preparation of this East African Standard, the following source was consulted extensively:

BS 8515:2009, *Rain water harvesting — Code of practice*

Assistance derived from this source and others inadvertently not mentioned is hereby acknowledged.

BS 8515:2009

# BSI British Standards

## Rainwater harvesting systems – Code of practice



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British Standards

## Publishing and copyright information



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# Contents



**Summary of pages**

This document comprises a front cover, an inside front cover, pages i to ii, pages 1 to 44, an inside back cover and a back cover.

# Foreword

## Publishing information

This British Standard is published by BSI and came into effect on 31 January 2009. It was prepared by Technical Committee CB/506, *Water reuse*. A list of organizations represented on this committee can be obtained on request to its secretary.

## Use of this document

As a code of practice, this British Standard takes the form of guidance and recommendations. It should not be quoted as if it were a specification and particular care should be taken to ensure that claims of compliance are not misleading.

Any user claiming compliance with this British Standard is expected to be able to justify any course of action that deviates from its recommendations.

It has been assumed in the preparation of this British Standard that the execution of its provisions will be entrusted to appropriately qualified and experienced people, for whose use it has been produced.

## Presentational conventions

The provisions in this standard are presented in roman (i.e. upright) type. Its recommendations are expressed in sentences in which the principal auxiliary verb is "should".

*Commentary, explanation and general informative material is presented in smaller italic type, and does not constitute a normative element.*

## Contractual and legal considerations

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

**Compliance with a British Standard cannot confer immunity from legal obligations.**

In particular, attention is drawn to the following regulations:

- The Private Water Supplies Regulations 1991 [1];
- The Workplace (Health, Safety and Welfare) Regulations 1992 [2];
- The Confined Spaces Regulations 1997 [3];
- The Work at Height Regulations 2005 [4];
- The Private Water Supplies (Scotland) Regulations 2006 [5].

In this document, the following national regulations, which apply to plumbing systems in premises to which a supply of public mains water has been provided, are referred to as the "Water Fittings Regulations [6]":

- Water Supply (Water Fittings) Regulations 1999, in England & Wales;
- Water Byelaws 2004 (Scotland), in Scotland;
- Water Regulations (Northern Ireland) 1991, in Northern Ireland.

# 0 Introduction

## 0.1 General

On-site collection and use of rainwater is an alternative to public mains water supply for a variety of non-potable water uses in the home, workplace and garden. It can also provide benefits for the attenuation of surface water run-off.

As the rainwater harvesting sector expands, there is a need for standardization to protect the public and to ensure that reliable systems are designed, installed and maintained.

## 0.2 Types of rainwater harvesting

There are three basic types of rainwater harvesting systems (see Figure 1):

a) water collected in storage tank(s) and pumped directly to the points of use;

b) water collected in storage tank(s) and fed by gravity to the points of use;

c) water collected in storage tank(s), pumped to an elevated cistern and fed by gravity to the points of use.

Within these basic types, there are variations such as:

1) internal or external locations for tanks;

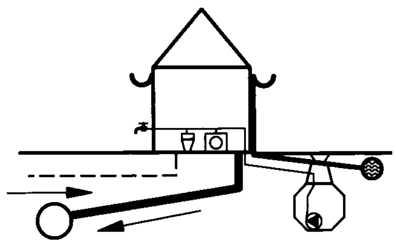
2) single or multiple linked tanks;

3) freestanding or fully or partially buried tanks;

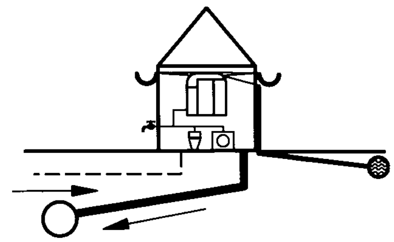
4) communal tanks supplying multiple properties;

5) packaged systems or components.

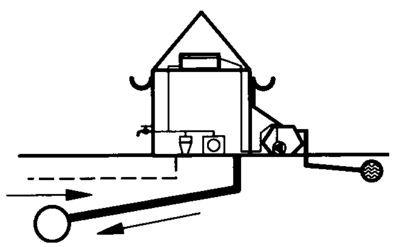
Figure 1 **Outline examples of rainwater harvesting systems**



a) Water pumped directly from storage tank (e.g. below ground)



b) Water fed by gravity from storage tank (e.g. elevated above ground)



c) Water pumped to intermediate cistern and fed by gravity from storage tank (e.g. above ground)

**Key**

Sewer

Surface water drainage e.g. soakaway

Public mains water supply

Pump

*NOTE Drawings are not to scale.*

## 1 Scope

This British Standard gives recommendations on the design, installation, testing and maintenance of rainwater harvesting systems supplying non-potable water in the UK.

It covers systems supplying water for domestic water uses (in residential, commercial, industrial or public premises) that do not require potable water quality such as laundry, WC flushing and garden watering. It does not cover systems supplying water for drinking, food preparation and cooking, dishwashing and personal hygiene.

*NOTE Although this Standard does not give specific recommendations relating to the use of rainwater for fire suppression or commercial irrigation, these applications are not excluded.*

It covers individual and communal systems, and those providing stormwater control. It does not cover water butts.

It also does not cover product design for specific system components.

It applies to retrofitting and new build.

## 2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

BS 4800:1989, *Schedule of paint colours for building purposes*

BS 6700:2006, *Design, installation, testing and maintenance of services supplying water for domestic use within buildings and their curtilages*

BS 7592, *Sampling for Legionella bacteria in water systems – Code of practice*

BS 7671, *Requirements for electrical installations – IEE Wiring Regulations – Seventeenth edition*

BS EN 12056-3, *Gravity drainage systems inside buildings – Part 3: Roof drainage, layout and calculation*

BS EN 12056-4, *Gravity drainage systems inside buildings – Part 4: Wastewater lifting plants – Layout and calculation*

BS EN 13564 (all parts), *Anti-flooding devices for buildings*

## 3 Terms and definitions

For the purposes of this British Standard, the following terms and definitions apply.

**3.1 air gap**

physical break between the lowest level of the water inlet and the maximum fault level or critical level of an appliance or installation, a feed pipe, or an air inlet orifice incorporated into a hydraulic circuit

[BS EN 1717]

**3.2 anti-surcharge valve**
valved device, installed directly in the pipework of a drainage system intended to protect buildings from backflows and flooding from drains or sewers

**3.3 backflow**
movement of the fluid from downstream to upstream within an installation

[BS EN 1717]

**3.4 backflow prevention device**
device which is intended to prevent contamination of potable water by backflow in a water supply system

[BS EN 1717 (modified)]

**3.5 back-up supply**
supply of potable water, e.g. from the public mains water supply or private borehole, that can supplement the non-potable supply in times of drought and/or heavy demand

**3.6 break cistern**
cistern used to separate two plumbing systems of different pressures, water qualities or flow rates, where the water from one system flows through an air gap and into the storage cistern feeding the second system

**3.7 calmed inlet**
fitting on the end of the drainage pipe feeding the storage tank that minimizes turbulence and slows the water flow into the tank

*NOTE The calmed inlet is used to prevent disturbance of any sediments near the base of the tank.*

**3.8 cistern**
fixed container for holding water at atmospheric pressure for subsequent reuse as part of a plumbing system

**3.9 control unit**
unit which automatically controls and monitors the function of the rainwater harvesting system to facilitate effective operation

**3.10 cross-connection**
physical hydraulic link or a removable link between two separate systems, which can lead to cross-contamination

**3.11 dead leg**
section of pipework through which no water flows, usually created by closing a pipe after the removal of a terminal fitting

**3.12 depression storage**
volume of water lost from surfaces, e.g. by evaporation or absorption, before run-off commences

**3.13 dip sample**
sample of water collected by immersing a container into a body of water and withdrawing it

**3.14 domestic use**
use related to residential or similar dwellings

*NOTE Potable domestic use includes water for the kitchen sink, wash and hand basins, bath, shower and dishwasher. Non-potable domestic use includes water for WC flushing, domestic washing machines and garden watering.*

*In commercial, industrial or public premises, "domestic use" is limited to water used for those applications/appliances described above and excludes, for example, water used for fire fighting, central heating or irrigation systems.*

[BS EN 1717 (modified)]

**3.15 infiltration**
<into the ground> the movement of surface water or treated effluent into the ground

[BS EN 1085]

**3.16 green roof**
roof covered with vegetation

**3.17 nominal capacity**
dimensional volume of the maximum capacity of water that can be retained within the tank, e.g. up to the overflow

**3.18 non-potable water**
any water other than potable water

*NOTE Non-potable water can also be referred to as "unwholesome" water.*

**3.19 overflow**
device that relieves the system of excess volume

**3.20 point of use**
point where water is drawn by the user either directly or by connecting an apparatus

[BS EN 1717]

**3.21 potable water**
water suitable for human consumption that meets the requirements of Section 67 of the Water Industry Act 1991 [7]

*NOTE Potable water can also be referred to as "wholesome" water.*

**3.22 public mains water**
wholesome water supplied by a water undertaker, licensed water supplier, Scottish Water or the undertaker as specified in the Water Industry Act 1991 [7] in England & Wales, the Water (Scotland) Act 1980 [8] in Scotland, or the Water and Sewerage Services (Northern Ireland) Order 2006 [9] in Northern Ireland

**3.23 rainwater**
water arising from atmospheric precipitation

**3.24 rainwater butt**
cask set on end to store rainwater for garden watering

**3.25 return period**
average period of time within which the depth or intensity of rainfall for a given duration, e.g. 5 min, 24 hr, will be equalled or exceeded once

**3.26 soakaway**
pit or other drainage arrangement prepared in permeable ground to which surplus surface water is fed and from which it soaks into the ground

[BS EN 1085]

**3.27 spillover level**
level at which water will start to flow over the receiving vessel with all outlets closed

**3.28 stormwater control**
measures to control the rate and quantity of surface water run-off

**3.29 surface water**
water from precipitation, which has not seeped into the ground and which is discharged to the drain or sewer system directly from the ground or from exterior building surfaces

[BS EN 1085]

**3.30 tank**
closed, watertight, vented container for rainwater, which forms part of a drainage system

**3.31 working capacity**
maximum capacity of water that can be extracted from a tank in normal use, e.g. from the overflow to the lowest extraction point

# 4 Design

## 4.1 Sizing

### 4.1.1 General

As the optimum storage capacity for a rainwater harvesting system is a function of the rainwater availability and the non-potable water demand, the following factors should be identified in order to calculate the size of the system (see **4.1.2**):

a) the amount and intensity of rainfall;

b) the size and type of the collection surface;

c) the number and type of intended applications, both present and future.

*NOTE Annex A gives recommendations on the sizing of rainwater harvesting systems which provide additional storage for stormwater control.*

### 4.1.2 Calculation methods

*COMMENTARY ON **4.1.2***
*The three approaches to sizing recommended in **4.1.2** are based on methods given in DIN 1989-1.*

#### 4.1.2.1 General

The storage capacity of the rainwater harvesting system should be determined using one of the following methods:

a) a simplified approach for residential properties, where there is consistent daily demand, for which no calculations have to be carried out (see **4.1.2.2**);

b) an intermediate approach which uses simple formulae to calculate a more accurate estimation of storage capacity than the simplified approach (see **4.1.2.3**);

c) a detailed approach for non-standard systems, where there is variable demand through the year (see **4.1.2.4**).

*NOTE 1 The simplified approach is not suitable for commercial premises as the assumptions relating to demand are not applicable. The intermediate approach may be used for certain commercial and industrial premises, such as schools and offices.*

*NOTE 2 For larger rainwater harvesting systems, the size of the system needs to be analysed using a detailed approach to ensure a cost-effective solution is developed, as seasonal variations in rainfall can affect sizing requirements even where demand is relatively predictable and consistent.*

Once the storage capacity has been determined, storage tanks should be selected on the basis of working capacity, rather than the total capacity of the container.

The size of the tank should allow for rainfall variation; however, it should be noted that construction above a certain size based on rainfall for that area provides very limited additional benefit unless stormwater attenuation is intended.

*NOTE 3 The size of the tank will also affect how often the stored water overflows. Occasional overflowing can be useful for maintenance and might have benefits for water quality.*

#### 4.1.2.2 The simplified approach

To apply the simplified approach to sizing the rainwater harvesting system for non-potable domestic use, storage capacity should be estimated using the following method.

First, the roof plan area draining to the storage tank should be established in accordance with BS EN 12056-3, and the annual average rainfall depth for the location of the site should be determined from Figure 2.

In most cases, the storage capacity should then be read from the Y axis of Figure 3, using the appropriate diagonal line for the rainfall depth. However, where the site has a large roof plan area and/or is in a region with high annual rainfall, the storage capacity should be determined in relation to the population in the house.

Where the system is to provide both non-potable water for domestic use and stormwater control, the integrated sizing approach given in **A.1** should be used to estimate the additional storage capacity needed.

*COMMENTARY ON **4.1.2.2***
*The simplified approach is based on the following assumptions:*

*a) relatively constant daily domestic use through the year of 50 litres per day per person for WC flushing and clothes washing;*

*b) annual average rainfall depth for the site location;*

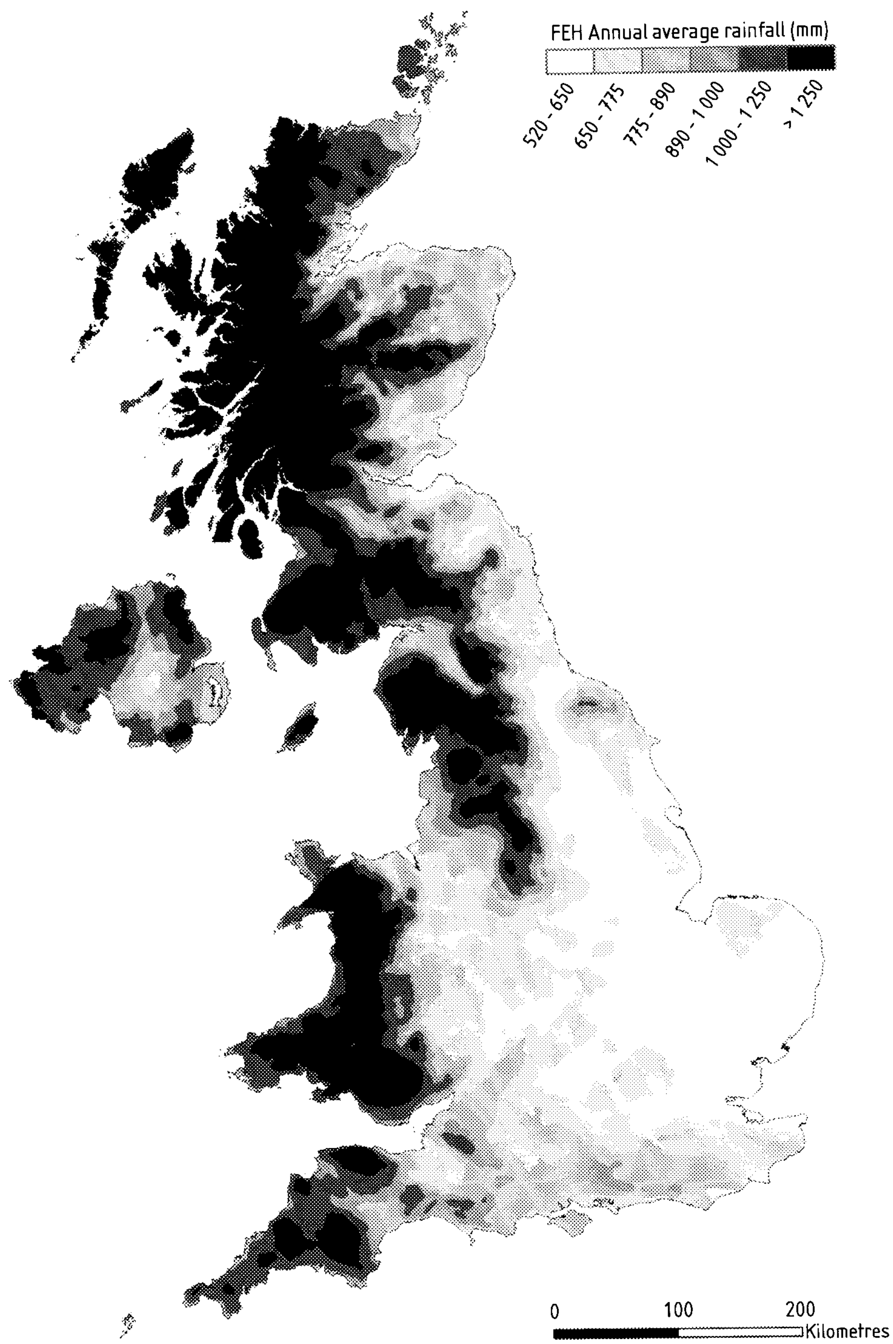
*c) the use of standard tiled pitched roofs for the collection surface.*

*The storage is based on the general rule of 18 days of average rainfall, which caters for the variability of rainfall that occurs in the UK. Provision of greater storage capacity offers very little additional benefit. Around 80% of all the effective run-off from the collection surface in the year will be utilized. Where the storage capacity is dictated by the number of users and not the roof plan area/rainfall, the storage capacity can be reduced by up to 30% due to the supply being significantly greater than the demand.*

*It is noted that sizing for non-potable supply alone provides a limited beneficial element for stormwater control. However, as this volume is relatively small, it is normally ignored when designing for stormwater control.*

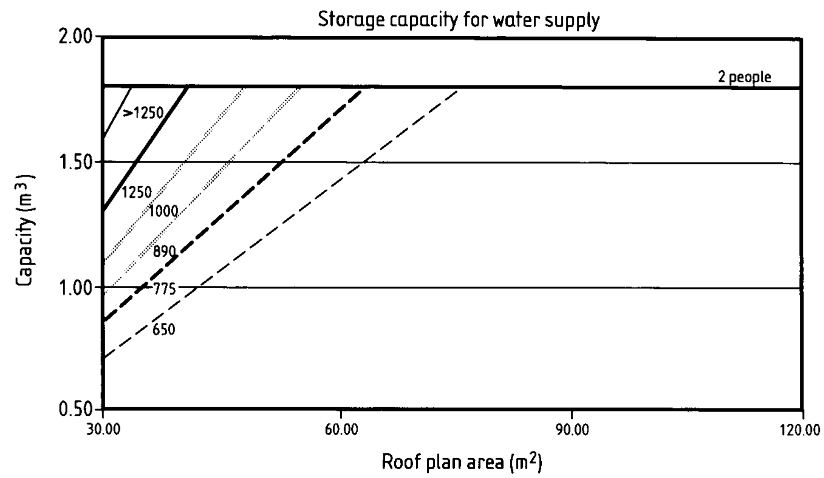
*The integrated sizing approach (see **A.1**) may only be applied in situations where the average run-off yield is more than the average non-potable demand. This is because of the low likelihood of significant spare storage in the tank occurring at the time of a large storm and, if the demand is greater than the yield, the back-up supply could be used excessively.*

Figure 2 **Hydrological regions of the UK for the sizing of rainwater harvesting systems**

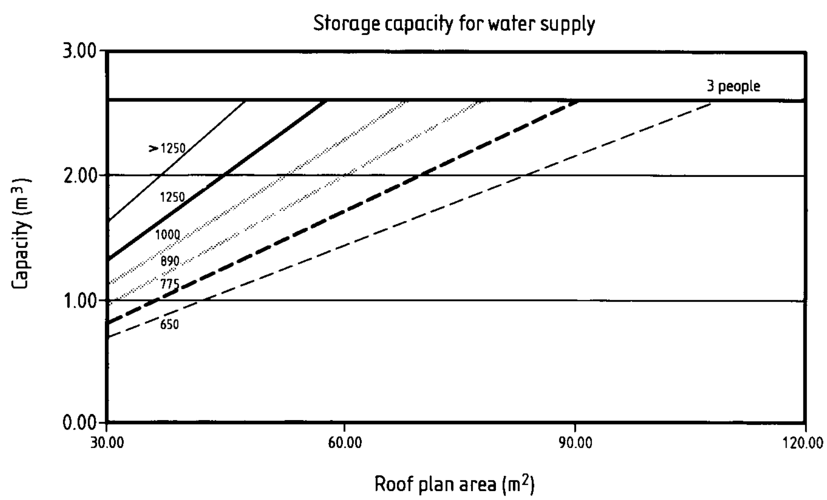



*NOTE Figure courtesy of UKWIR.*

Figure 3 **Storage capacities for non-potable domestic water based on maximum average annual rainfall and roof size for small populations (simplified approach)**

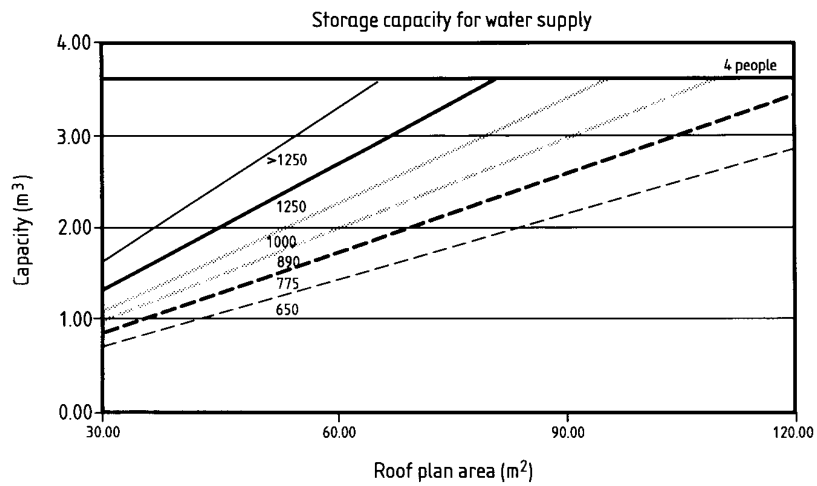



a) Storage capacity for a 2-person household

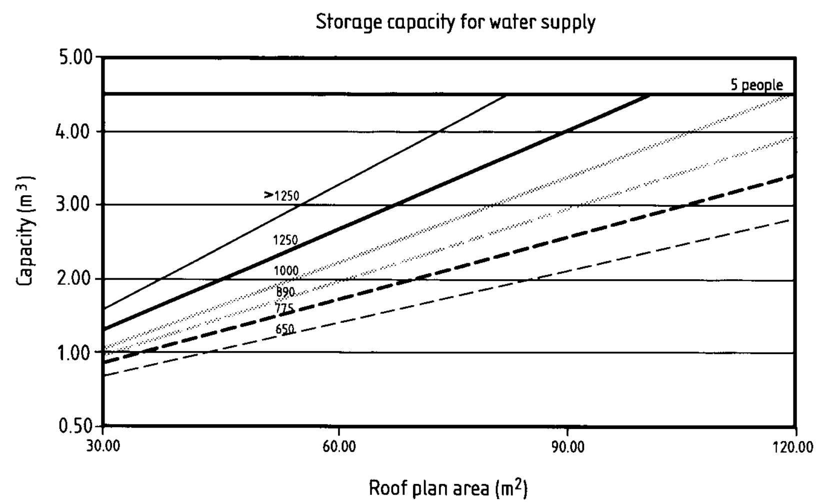



b) Storage capacity for a 3-person household

Figure 3 **Storage capacities for non-potable domestic water based on maximum average annual rainfall and roof size for small populations (simplified approach)** *(continued)*




c) Storage capacity for a 4-person household




d) Storage capacity of a 5-person household

*NOTE See Figure 2 for annual average rainfall data.*

*EXAMPLE*

*If a house has four residents, the maximum storage that might be useful is 3.6 $m^3$. However, if the house is in London, where the rainfall is up to 650 mm according to Figure 2 and the roof plan area draining to the tank is 90 $m^2$, the storage capacity ought to be reduced to around 2.1 $m^3$ in line with Figure 3c). It is not necessary to provide a 3.6 $m^3$ tank as the tank will rarely store more than 2.1 $m^3$ and thus very little extra water will be provided over the year.*

#### 4.1.2.3 The intermediate approach

*NOTE The intermediate approach is similar to the method described in **4.1.2.2** and thus the results obtained are likely to be similar. Equations are provided to allow a more flexible and accurate facility for calculating the storage needed. The advantage of this is the variables can be modified to reflect the situation being considered.*

To apply the intermediate approach to sizing the rainwater harvesting system for non-potable domestic use, storage capacity should be calculated from the following equations and should be the lesser of 5% of the annual rainwater yield or 5% of the annual non-potable water demand.

5% of the annual rainwater yield should be calculated using the equation:

$$Y_R = A \times e \times h \times \eta \times 0.05 \qquad (1)$$

where:

$Y_R$ is the annual rainwater yield (L);

$A$ is the collecting area ($m^2$);

$e$ is the yield coefficient (%);

$h$ is the depth of rainfall (mm);

$\eta$ is the hydraulic filter efficiency.

5% of the annual non-potable water demand should be calculated using the equation:

$$D_N = P_d \times n \times 365 \times 0.05 \qquad (2)$$

where:

$D_N$ is the annual non-potable water demand (L);

$P_d$ is the daily requirement per person (L);

$n$ is the number of persons.

Where the system is to provide both non-potable water for domestic use and stormwater control, the integrated sizing approach given in **A.2** should be used to estimate the additional storage capacity needed.

*COMMENTARY ON **4.1.2.3***
*The values normally used for each of the parameters in these equations are as follows.*

*a) 5% of annual demand or supply*

*This equates to 18 days a year and is needed to take account of daily rainfall variability. In practice there are diminishing returns for tank sizes designed using 7 or 8 days.*

*b) Collection area*

*This is the plan area of the roof or other collection surface which is to be drained to the rainwater harvesting system. Modification of this value to allow for pitch and alignment to the prevailing wind is not usually made.*

*c) Yield coefficient and hydraulic filter efficiency*

*Uncertainty in the yield from a collection surface is fairly small for a standard pitched roof. The loss of volume from rainfall through to stored run-off comprises both losses from wetting of the surface and also the filtering process.*

*In general the combination of these two factors results in a value of 0.7 to 0.8 being assumed. Where flat roofs, green roofs or paved surfaces are used for collection, it is advised that the more detailed approach given in **4.1.2.4** is used.*

*The filter efficiency in the region of 0.9 is commonly quoted and used. However where systems are designed for stormwater control, the filter performance during extreme events is important and information on this aspect needs to be explicitly obtained.*

d) *Non-potable demand*

*This is usually set at around 50 litres per person per day and comprises the demand for WC flushing and clothes washing. Where car washing and garden watering is included, demand can be much greater. In this case, supply is normally much less than the demand. Also, the daily variation of demand for external use of rainwater is such that the detailed approach for storage requirements ought to be used (see **4.1.2.4**).*

#### 4.1.2.4 The detailed approach

The detailed approach should be used to calculate the storage size more accurately for all situations and particularly where:

a) the demand is irregular (e.g. external use, non-residential use, tourism);

b) the yield is uncertain (e.g. due to the use of green roofs, permeable pavements);

c) costly, larger or complex rainwater harvesting systems are proposed.

*NOTE 1 Computer models may be used to simulate the performance of the rainwater harvesting system as accurately as possible. The uncertainty associated with both the demand and the supply needs to be considered using appropriate uncertainty methods.*

To apply the detailed approach to sizing the rainwater harvesting system for non-potable domestic use, storage capacity should be estimated by building a model of yield and demand, which is based on a continuous rainfall time series for a minimum of 3 years and preferably 5 years. This time series should use daily rainfall data for assessing non-potable system storage.

*NOTE 2 From an analysis of the results of using a time series for design, the frequency of overflowing can be found. Occasional overflowing allows any floating material to be discharged and offers potential benefits for water quality.*

*NOTE 3 The analysis also enables an assessment of how much water might be saved annually and the number of days that no rainwater is available, which is particularly useful if there is no back-up supply.*

Where the system is to provide both non-potable water for domestic use and stormwater control, the integrated sizing methods detailed in **A.3** should be used to estimate the additional storage capacity needed.

## 4.2 Collection

### 4.2.1 Surface

*COMMENTARY ON **4.2.1***
*Hard roof surfaces are considered the most suitable for rainwater collection, although many common roofing materials may also be used.*

*It is important to note that most collection surfaces are likely to be affected by some form of contamination, e.g. animal and bird faeces, soil, grit, hydrocarbons and various chemicals. These contaminants can have negative effects on the quality of the water collected. For further guidance, see **4.3**, Clause **6** and Clause **8**.*

When selecting a collection surface, the following factors should be taken into account, as these can affect the quality and quantity of the collected water:

a) the surface's materials and their drainage characteristics, e.g. run-off from a green roof will be significantly less than that from a hard roof and is also likely to be affected by a colouration caused by the soil or fertilizers;

b) the levels of pollution and the risk of contaminants entering the system.

Surfaces subject to as little pollution as possible should be used.

Ground level or trafficked surfaces can provide large areas for collection and may be used in areas where there is a high demand for non-potable water (e.g. commercial, industrial or public premises). As these surfaces carry a greater risk of pollutants entering the system, they should only be used once a specific risk assessment has been completed (see Clause **8**).

### 4.2.2 Guttering and collection pipework

Roof outlets, guttering and pipework should function as an integral part of the whole system, with access for routine maintenance and cleaning.

Collection pipework should allow the rainwater to flow from the collection surface to the storage tank by gravity or syphonic action.

Pipework should be free draining to avoid stagnation and should prevent contaminated water entering the system from other sources. In addition, sealed gullies should be used at ground level to minimize the risk of pollutants entering the system.

*NOTE Conventional rainwater goods and drainage pipes may be used.*

## 4.3 Filtration and treatment

*COMMENTARY ON **4.3***
*A rainwater harvesting system with filtration conforming to **4.3** provides water of a suitable quality for WC flushing, laundry and garden watering in most residential, commercial and industrial situations. However, readers might wish to note that some situations, e.g. where greater human exposure to the water is anticipated or where the water is to be used in public premises, could require higher water quality. In such cases, the system may incorporate treatment processes such as ultraviolet (UV) or chemical disinfection. For further guidance on disinfection, see the Market*

Filtration should be incorporated in the system before the collected rainwater enters the main body of stored water, to prevent debris accumulating in the tank e.g. a filter may be placed in the collection pipework upstream of the tank.

The filter system should include a filter which:

a) is water and weather resistant;

b) is removable and readily accessible for maintenance purposes;

c) has an efficiency of at least 90%;

d) passes a maximum particle size of <1.25 mm.

Additionally, to prevent any other floating debris from entering the distribution system, the storage tank should be fitted with a calmed inlet.

Where feasible, a floating extraction point from the tank should be used, which is approximately 100 mm to 150 mm below the surface of the water. If floating extraction is not practicable, a fixed extraction

*Transformation Programme (MTP) publication,* Rainwater and Grey Water: A guide for specifiers *[10].*

*The use of disinfection equipment is site and material specific depending on the user's requirements and therefore expert advice is to be taken if such treatment is deemed appropriate. Consideration also needs to be given to the environmental impact of disinfection treatments.*

point may be used but should be positioned approximately 150 mm above the base of the tank.

*NOTE An additional filter may also be fitted at the extraction point.*

## 4.4 Storage

### 4.4.1 General

The rainwater harvesting system should, as a minimum, include a tank for primary storage, which may be positioned either above or below ground. All tanks should be appropriate to the site (see **5.2.1**).

*NOTE 1 Tanks are normally prefabricated off site.*

The tank(s) used in the system should be constructed from materials that create watertight structures without encouraging microbial growth.

*NOTE 2 Suitable materials include concrete, glass reinforced plastic (GRP), polyethylene or polypropylene, and steel coated with non-corrodible materials, e.g. steel conforming to BS EN 10143. Guidance on the suitability of non-metallic products for use in contact with water is given in BS 6920.*

*NOTE 3 Storage may be accommodated in permeable pavement constructions or other structures, such as geo-cells.*

All tanks and cisterns, whether used separately or connected to each other in order to create greater capacity, should avoid stagnation, e.g. by ensuring that pipework connections allow the through-flow of water.

All tanks and cisterns should have screened ventilation and fitted lids to prevent contamination of the water.

All tanks and cisterns should be sited so that the stored water does not attain temperatures that could encourage multiplication of *Legionella*.

Where tanks are positioned above habitable or vulnerable areas, the risk of water leakage should be considered, e.g. bunding, additional drainage, sump pump.

The loading of the structure should be taken into account when locating tanks.

### 4.4.2 Above ground tanks and cisterns

*NOTE Above ground tanks are particularly cost effective for retrofit applications.*

Where they are used, above ground tanks and cisterns should be insulated and opaque to minimize the potential problems of freezing, warming and algal blooms.

### 4.4.3 Below ground tanks

*NOTE 1 Below ground tanks can provide frost protection, are cooler in the summer months and restrict algal growth due to the lack of sunlight.*

Below ground tanks (and their covers) should be sufficiently rigid to resist likely ground and traffic loadings (see BS EN 124). Tanks should be installed to resist flotation.

*NOTE 2 This might require the use of concrete for backfilling.*

## 4.5 Materials and fittings

The materials selected for the tank and other components should be suitable for the location and temperature ranges anticipated. All components of the system should be capable of withstanding pH levels as low as 5 for the lifetime of the products.

Consideration should be given to the environmental impact of materials used. Existing resources on site should be utilized, where appropriate, and materials re-used where possible to limit the environmental impacts of the system.

## 4.6 Power supply

The power supply of the rainwater harvesting system should be readily accessible but also guarded to ensure against the inadvertent isolation or disconnection of electricity.

## 4.7 Back-up water supply and backflow prevention

*NOTE Attention is drawn to the Water Fittings Regulations [6] which require adequate backflow prevention to be provided so that water supplied from the public mains water supply for domestic uses does not become contaminated.*

### 4.7.1 Back-up water supply

The rainwater harvesting system should incorporate a back-up water supply, which may be introduced into:

a) a purpose-designed module, incorporating a break cistern prior to its pump, for delivery to the distribution pipework;

b) an intermediate storage cistern, usually located at high level; or

c) the main collection tank, via a direct connection or discharging into the collection pipework, but not before filtration.

*NOTE 1 Annex B gives examples of typical systems with different back-up supply arrangements.*

The back-up supply should be fitted with a control mechanism which ensures that the amount of water supplied is minimized to that needed for immediate use. It is recommended that this is provided from a make-up module or an intermediate storage cistern.

The back-up supply should be sized to allow it to meet the full demand requirements in dry periods.

*NOTE 2 It is important to consider the implications of using a back-up supply derived from public mains water during extended dry periods. As the rainwater harvesting system is likely to rely on the back-up supply to satisfy much of the demand, certain applications will not be appropriate.*

*For instance, the use of the system for garden watering might be prohibited when water use restrictions (e.g. a hose pipe ban) are in place. In order to bring this to the user's attention, advice ought to be included in user instructions, wherever possible.*

If the back-up supply is to be fed into the main collection tank, careful consideration should be given to tank selection in order to minimize the amount of water needed for continued normal operation before the next rainfall event, e.g. it might be beneficial to use a tank with a small sump area.

### 4.7.2 Backflow prevention

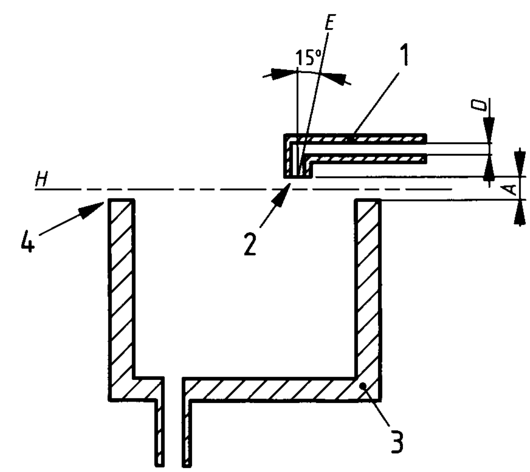
To prevent non-potable water entering the potable or public mains water supply, the back-up supply should be fitted with a backflow prevention device that is capable of providing category 5 protection (an air gap), such as:

a) a Type AA air gap conforming to BS EN 13076 (see Figure 4); or

b) a Type AB air gap conforming to BS EN 13077 (see Figure 5).

Flow rates, head loss and installation requirements should be taken into account when selecting the backflow prevention device.

Figure 4 **Unrestricted Type AA air gap (BS EN 13076)**

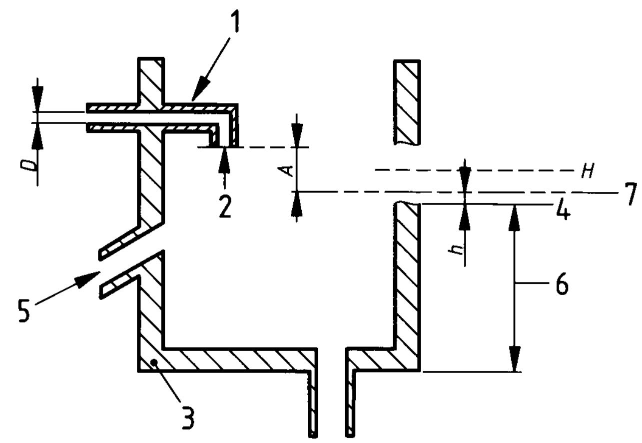



**Key**

1 Feed pipe
2 Feed orifice
3 Receiving vessel
4 Spillover level
*A* Air gap
*D* Internal diameter of feed pipe (bore)
*E* 15° maximum from the vertical
*H* Maximum water level

*NOTE This arrangement may be used where the discharge point from the public mains water supply can be placed above the spillover level of the rim of the storage cistern.*

Figure 5 **Unrestricted Type AB air gap with non-circular overflow (BS EN 13077)**




**Key**

1 Feed pipe

2 Feed orifice

3 Receiving vessel

4 Spillover level

5 Optional warning pipe

6 Upstream face of the overflow arrangement *Uw* (*Uw* ⩾ 5*h*)

7 Critical water level (distance *h*)

*A* Air gap

*D* Internal diameter of feed pipe (bore)

*H* Maximum water level

*NOTE This arrangement may be used where the discharge point from the public mains water supply is to be enclosed within the storage cistern. The slot that provides the spillover level is provided within the side of the cistern body and below the outlet of the inlet device. The size of the spill slot needs to conform to BS EN 13077 within critical limits. An online Type AB Air Gap Calculator is available from the Water Regulations Advisory Scheme (WRAS) website at www.wras.co.uk/publications_default.htm*

The backflow prevention device should be located upstream of, or at, the point of delivery where the two supplies come into contact with each other.

The impact that a sudden demand from the back-up mechanism might create in operation on the water supply, particularly in large communal systems, should be considered and it is important that supply infrastructure is capable of meeting this increase.

The design of the system should ensure that there are no dead legs and suitable turnover of water is achieved, reducing the opportunity for water to become stagnant when not required. Where this is unavoidable, additional backflow prevention in the form of a single check valve should be provided at the branch of the pipework supplying the back-up mechanism to protect the potable water supply.

*NOTE Where the backflow prevention device is to be provided by a tundish arrangement and there is a risk of odours venting back into the premises, the use of a waterless trap may be considered downstream of the tundish.*

When designing for backflow prevention, the appliances to be connected to the system should also be taken into account. Where an appliance with a single fill connection, e.g. washing machine, is to be supplied solely with rainwater, additional backflow prevention might not be required. However, if the appliance needs a supplementary potable source of water, e.g. public mains water (hot or cold), category 5 backflow prevention will be required for the potable supply. In such cases, the manufacturer should be consulted to establish whether suitable category 5 backflow prevention has been incorporated within the appliance.

## 4.8 Pumping

### 4.8.1 General

For most systems, other than those which distribute the collected rainwater by gravity, a pump(s) should be used to ensure its continual availability.

*NOTE 1 The operational safety and hydraulic demand will dictate whether a single pump or multiple-pump systems are needed.*

The flow rate and the required pressure head of the pump should be determined in accordance with BS EN 12056-4.

The pump should be selected and arranged such that:

a) energy use and noise are minimized;

b) cavitation is prevented;

c) air is not introduced into the system.

The pump should be equipped with dry-run protection, which may be either integral to the pump or provided by an external control device (see **4.8.5**).

Surges, water hammer and hunting from the pump should be absorbed and prevented from causing undue high pressures, e.g. by the incorporation of expansion vessels or pressure controls, in order to prevent bursting and excessive draw off.

*NOTE 2 Where a pumped non-potable supply to WCs is used, an alternative back-up supply to the WC might be needed for hygiene purposes in case of pump or control failure. Attention is drawn to the Water Fittings Regulations which require that, in such cases, backflow protection is provided (see* ***4.7.2****).*

### 4.8.2 Pumps outside the tank

If installed outside the tank, the pump should have its own self-priming mechanism or a control system which ensures a constant fully primed condition. The suction line to the pump should be laid with a steady gradient upwards towards the pump.

The pump should be placed in a well-ventilated location and protected from extremes of temperature, with sound and vibration-free mountings.

A non-return valve should be provided in the suction line to the pump in order to prevent the water column from draining down. The pressure line of the pump should be supplied with an isolating valve.

#### 4.8.3 Pumps inside the tank

*NOTE A minimum level of water needs to be maintained above the pump inlet in order to prevent damage by sucking in air, sediment or debris.*

The immersion depth should be in accordance with the pump manufacturer's instructions.

The pump should be removable for maintenance purposes.

A non-return valve should be provided, with an isolating valve to enable the non-return valve to be maintained.

#### 4.8.4 Multiple pump systems

Multiple pump systems should conform to BS EN 12056-4, with a standby pump as necessary.

#### 4.8.5 Pump control unit

The pump control unit should:

a) operate the pump(s) to match demand;

b) protect the pumps from running dry;

c) protect the motor from over-heating and electric overload.

The pump control unit should permit manual override.

### 4.9 Overflow and drainage

An overflow should be fitted to all tanks/cisterns to allow excess water to be discharged during extreme rainfall events. The overflow should be such that any backflow is prevented and vermin are unable to enter the tank/cistern. Overflows fitted to above ground tanks/cisterns should be screened.

The capacity of outlet pipe on the overflow should be equal to or greater than the capacity of the inlet pipe.

Where appropriate, the overflow to a drain or sewer should be fitted with an anti-surcharge valve conforming to BS EN 13564 (all parts).

For the majority of systems, it is recommended that the overflow is connected to a soakaway.

*NOTE 1 For some systems, it might be more appropriate to either pass the flow into the surface water drainage system or allow it to flood. The choice of drainage is dependent on factors such as ground conditions and the consequences of the performance being exceeded. For example, in locations where soils have very low permeability, a soakaway might overfill as a result of large rainfall events although this will result in minimal consequences like infrequent temporary local wet areas and run-off in most instances.*

*NOTE 2 Where the tank is likely to be full on a regular basis, due to high regional rainfall, the overflow may be located at a lower level and designed to throttle and attenuate the flow. However, if the throttle takes the form of a small orifice, it will be liable to blockage from floating material.*

The overflow from the primary storage tank or cistern is likely to contain a small amount of floating material such as leaves washed from filters so, if the water is to be passed to a soakaway, appropriate trapping of the material should be provided.

*NOTE 3 Additional information on soakaways and infiltration drainage systems is given in BS EN 752.*

## 4.10 Controls and metering

A control unit should be incorporated in the rainwater harvesting system to ensure, as a minimum, that users are aware of whether the system is operating effectively.

The control unit should:

a) control pumps and minimize operational wear and energy use;

b) activate the back-up water supply automatically when the minimum water volume in the tank is reached;

c) provide a volt-free output to enable the system to be linked to a building management system (BMS), where appropriate.

*NOTE Guidance on the design of a suitable control unit is given in BS 6739.*

In order to prevent waste, storage tanks/cisterns with valve-controlled water inputs should have a warning system so any failure is readily noticeable.

*COMMENTARY ON **4.10***
*In addition to the control unit, system status monitoring may be incorporated that informs the user of:*

*a) whether rainwater or back-up supply water is being used;*

*b) the volume of rainwater used and the volume of water used from the back-up supply. This can be logged and displayed;*

*c) how full the tank is;*

*d) any malfunctions. These should relate to the specific fault, e.g. pump failure, back-up supply failure.*

*Additional monitoring of the overflow, water quality, tank temperature and other parameters may also be included.*

## 4.11 Distribution

### 4.11.1 General

*COMMENTARY ON **4.11***
*It is noted that the requirements specified for potable water systems in BS 6700 and BS EN 806 are considered good plumbing practice for all systems, regardless of the source of water.*

*Attention is also drawn to the Water Fittings Regulations [6]. These apply to pipes and fittings that are supplied, or are to be supplied, with public mains water.*

*In premises where a public mains water supply exists, or is to be provided, notification needs to be given to the local water supplier prior to work commencing, with a plan, schematic diagram and details of what is proposed.*

The system should distribute the collected rainwater by:

a) pumping it from the storage tank directly to the point of use; or

b) pumping it from the storage tank to intermediate cisterns near the point of use; or

c) using a gravity distribution tank, where practicable; or

d) using a full gravity system, without pumps.

Consideration should be given to minimizing the energy used to distribute rainwater.

### 4.11.2 Distribution pipework and fittings

*COMMENTARY ON **4.11.2***
*A variety of materials may be used for the distribution pipework, including:*

*a) polybutylene conforming to BS 7291-2;*

*b) cross-linked polyethylene (PE-X) conforming to BS 7291-3;*

*c) copper conforming to BS EN 1057;*

*d) stainless steel containing molybdenum (Mo) and conforming to either BS EN 10216-5 for seamless pipes or BS EN 10217-7 for welded pipes;*

*e) multi-layer barrier pipes conforming to WRAS guidance.*

*It is important to note that, where polybutylene or cross-linked polyethylene pipes are to be installed below ground, ducting is required.*

*Specific guidance on the types of pipe suitable for contaminated ground is given in WRAS Information and Guidance Note No. 9-04-03 [11].*

Where practicable, to differentiate rainwater pipework from potable water pipework, a contrasting type or colour of pipe material should be used. The pipework of the rainwater harvesting system, including any below ground back-up supply pipes, should not be blue, as this is the recognized standard used for the potable water supply. It is recommended that pipes are either green, or black and green, in accordance with WRAS Information and Guidance Note No. 9-02-05 [12] (see also BS 1710).

In addition, all pipework and fittings should be marked and/or labelled in accordance with Annex C (see also **5.4.2**).

Pipework should be sized to provide adequate flow and pressure, e.g. oversized pipes can cause water quality issues from low flows and excessive pressures can cause undue consumption or leakage.

Pipework and fittings should be arranged in such a way as to:

a) be sufficiently strong to resist bursting from the pressure they are to be subjected to in operation (see **6.1** for hydraulic testing);

b) prevent cross-connections with any public mains water or potable water supply;

c) prevent the trapping of air during filling, and the formation of air locks during operation, that would cause water to be unduly drawn off to clear the system.

# 5 Installation

## 5.1 General

*NOTE Attention is drawn to local planning and national building regulations, including the Water Fittings Regulations [6]. Guidance on the Water Fittings Regulations is available from the local water supplier, WRAS or the UK Rainwater Harvesting Association (UKRHA).*

Installation should be carried out in accordance with instructions given by the manufacturer or supplier.

Installation should ensure that all components, including tanks, are accessible for future maintenance and/or replacement of consumable parts. In particular, consideration should be given to the following points:

a) access to below ground tanks;

b) access for personnel to above ground tanks and cisterns, e.g. those located in lofts and roofs;

c) the location of access covers and filters (avoiding the need for access equipment wherever possible);

d) vehicular access to the site.

## 5.2 Tank installation

### 5.2.1 General

Prior to installation, any site specific factors that might affect the installation process should be taken into account. Such factors include:

a) groundwater levels;

b) ground strength and stability;

c) land contamination;

d) proximity to trees;

e) proximity to utilities and foundations;

f) shading and temperature;

g) access routes.

All tanks should be fitted with lids that protect the water from contamination and prevent inadvertent human entry.

All tanks should be installed so that the stored water does not attain temperatures that could encourage multiplication of *Legionella*.

Any holes that have been cut in a tank, other than those provided by the manufacturer, should be round, so as to not cause any additional stress on the tank that might result in a split. Where non-circular apertures are unavoidable, stress relief should be applied to the aperture to minimize any risk of splitting.

### 5.2.2 Above ground tanks

Above ground tanks should be securely mounted and supported on a firm level base capable of withstanding the weight of the tank when filled with water to the rim.

Tanks that are to be installed within a building should be able to withstand any temporary deformation that is required during installation, e.g. when being squeezed through a doorway or loft-hatch. Tanks, when installed and correctly supported, should not deform as the water level in the tank changes.

Tanks should not be supported by pipework.

### 5.2.3 Below ground tanks

Below ground or partially buried tanks should be installed so that they are not deformed or damaged.

Measures, such as concrete surrounds or backfilling and/or controlled filling with water, should be taken to ensure the structural stability of these tanks.

*NOTE Issues relating to structural stability include: avoiding flotation, resisting ground pressures and water table fluctuations (structural deformation), resisting vehicle loadings and accommodating differential movement.*

The area around the access covers of any below ground tank should be impervious and free draining away from the covers to avoid contamination during maintenance and inspection.

## 5.3 Cistern installation

Where storage cisterns are needed within buildings, these should be installed as for any cold water cistern with appropriate support, insulation and means to prevent contamination. The cistern should be supported on a firm level base capable of withstanding the weight of the cistern when filled with water to the rim. Flexible cisterns should be supported on a flat rigid platform fully supporting the bottom of the cistern over the whole of its area, e.g. close boarding.

Overflows fitted to storage cisterns should be capable of discharging all inflows into the cistern.

*NOTE In addition, an automatic supply cut-off device activated by an overflow may be installed to minimize the waste of water.*

## 5.4 Pipework installation

### 5.4.1 General

The pipework connecting the collection surface to the tank should be installed so that water losses are minimized. Pipes should not discharge into open gullies where splashing or additional contamination could occur.

Where specified in the design, it should be ensured that an anti-surcharge valve conforming to BS EN 13564 is fitted to the overflow to prevent wastewater backflow.

### 5.4.2 Labelling and identification

Where two or more water systems, i.e. potable and non-potable, supply one property, all pipework, fittings and points of use for the rainwater harvesting system should be marked and/or labelled in accordance with Annex C, in order to facilitate identification, to prevent inadvertent consumption or cross-connection between the systems, and to avoid operating errors.

## 5.5 Testing and commissioning

The system should be flushed and tested prior to handover to ensure that pipework and containers are watertight and that there are no cross-connections in accordance with BS 6700 and the manufacturer's recommendations.

*NOTE Running coloured dye through the system and carrying out a visual inspection is regarded as a suitable test.*

All pipework and fittings should be tested in accordance with, and meet the requirements of, BS 6700:2006, **6.1.12.3**, at a minimum of 1½ times the normal operating pressure.

The system should also be tested in accordance with BS 7671 to ensure that wiring is electrically safe and that there is no interference to or from other electrical or electronic equipment, or wiring in the vicinity.

Where the installation conforms to this code of practice, a certificate(s) of installation/commissioning should be provided.

# 6 Water quality

*COMMENTARY ON CLAUSE **6***
*It is essential that rainwater harvesting systems are designed in a way that ensures the water produced is fit for purpose and presents no undue risk to health, although there are currently no specific regulatory requirements for water quality that apply to systems which re-use rainwater for non-potable water use.*

Frequent water sample testing is not necessary; however, observations for water quality should be made during maintenance visits to check the performance of the system. Tests should then be undertaken to investigate the cause of any system that is not operating satisfactorily and any complaints of illness associated with water use from the system. Sampling for tests should be carried out in accordance with Annex D.

Testing immediately following the commissioning of systems is not recommended as systems are generally filled with public mains water in order to facilitate the testing of components, and water quality is therefore not representative of the normal rainfall collection.

*The MTP has undertaken a review of rainwater and greywater systems and made recommendations for quality guidelines and monitoring arrangements.*[1] *The recommendations and tables given in Clause **6** have been adapted from this MTP report.*

*Further guidance on water quality risk management is given in **8.2**.*

Water quality should be measured in relation to the guideline values given in Table 1 for parameters relating to health risk, and Table 2 for parameters relating to system operation, which provide an indication of the water quality that a well-designed and maintained system is expected to achieve for the majority of operating conditions.

The results of bacteriological monitoring should be interpreted with reference to Table 3. The results of general system monitoring should be interpreted with reference to Table 4.

NOTE *Water quality will fluctuate particularly following rainfall events when there might be a short-term change.*

Table 1 **Guideline values (G) for bacteriological monitoring**

| **Parameter** | **Guideline values by use** | | **System type** |
|---|---|---|---|
| | **Pressure washers and garden sprinklers** | **Garden watering and WC flushing** | |
| *Escherichia coli* number/100 mL | 1 | 250 | Single site and communal domestic systems |
| *Intestinal enterococci* number/100 mL | 1 | 100 | Single site and communal domestic systems |
| *Legionella* number/litre | 100 | — | Where analysis is necessary as indicated by risk assessment (see Clause **8**) |
| Total coliforms number per 100 mL | 10 | 1 000 for garden watering and WC flushing | Single site and communal domestic systems |

Table 2 **Guideline values for general system monitoring**

| **Parameter** | **Guideline values** | **System type** |
|---|---|---|
| Dissolved oxygen in stored rainwater | >10% saturation or >1 mg/L $O_2$ (whichever is least) for all uses | All systems |
| Suspended solids | Visually clear and free from floating debris for all uses | All systems |
| Colour | Not objectionable for all uses | All systems |
| Turbidity | <10 NTU for all uses (<1 NTU if UV disinfection is used) | |
| pH | 5–9 for all uses | Single site and communal domestic systems |
| Residual chlorine | <0.5 mg/L for garden watering<br><2 mg/L for all other uses | All systems, where used |
| Residual bromine | <2 mg/L for all uses | All systems, where used |

[1] Market Transformation Programme (MTP), *Rainwater and Grey Water: Review of water quality standards and recommendations for the UK*, www.mtprog.com [13].

Table 3 **Interpretation of results from bacteriological monitoring**

| Sample result A) | Status | Interpretation |
|---|---|---|
| <G | Green | System under control |
| G to 10G | Amber | Re-sample to confirm result and investigate system operation |
| >10G B) | Red | Suspend use of rainwater until problem is resolved |

A) G = guideline value (see Table 1).

B) In the absence of *E.coli*, *Intestinal enterococci* and *Legionella*, where relevant, there is no need to suspend use of the system if levels of coliforms exceed 10 times the guideline value.

*NOTE It might be necessary to include some type of UV or chemical disinfection to attain the more stringent bacteriological standards suggested, in situations where higher exposure might occur or for systems within public premises (see the Health and Safety Executive (HSE) Approved Code of Practice and guidance L8 [14]).*

Table 4 **Interpretation of results from system monitoring A)**

| Sample result B) | Status | Interpretation |
|---|---|---|
| <G | Green | System under control |
| >G | Amber | Re-sample to confirm result and investigate system operation |

A) When monitoring pH, the system is considered to be under control ("green" status) when levels are within the range recommended in Table 2. If levels are outside this range, the system status becomes "amber" and re-sampling is necessary. Where colour or suspended solids are present at levels which are objectionable, it is necessary to investigate the system operation to resolve the problem.

B) G = guideline value (see Table 1).

# 7 Maintenance

Human entry into tanks should be avoided, wherever possible. Where entry is essential, it should only be undertaken by trained personnel with personal protection equipment suitable for confined spaces.

Maintenance procedures should be in accordance with manufacturer's maintenance recommendations.

In the absence of any manufacturer's recommendations, the maintenance schedule given in Table 5 should be followed. The maintenance intervals listed here are for initial guidance but the frequency should be modified in the light of operational experience.

A log should be kept of inspections and maintenance.

Table 5 **Maintenance schedule**

| System component | Operation | Notes | Frequency [A)] |
|---|---|---|---|
| Gutters/downpipes | Inspection/ Maintenance | Check that there are no leaks or blockages due to build up of debris; clean the gutters if necessary | Annually |
| Filter | Inspection/ Maintenance | Check the condition of the filter and clean, if necessary | Annually |
| Storage tank/cistern | Inspection | Check that there are no leaks, that there has been no build up of debris and that the tank is stable and the cover correctly fitted | Annually |
| | Maintenance | Drain down and clean the tank | Every 10 years |
| Pumps and pump control | Inspection/ Maintenance | Check that there are no leaks and that there has been no corrosion; carry out a test run; check the gas charge within the expansion vessel or shock arrestors | Annually |
| Back-up water supply | Inspection | Check that the back-up supply is functioning correctly, that there are no leaks and that the air gaps are maintained | Annually |
| Control unit | Inspection/ Maintenance | Check that the unit is operating appropriately, including the alarm function where applicable | Annually |
| Water level gauge | Inspection | Check that the gauge indication responds correctly to the water level in the tank | Annually |
| Wiring | Inspection | Visually check that the wiring is electrically safe | Annually |
| Pipework | Inspection | Check that there are no leaks, that the pipes are watertight and that overflows are clear | Annually |
| Markings | Inspection | Check that warning notices and pipework identification are correct and in place | Annually |
| Support and fixings | Inspection/ Maintenance | Adjust and tighten, where applicable | Annually |
| UV lamps | Inspection/ Maintenance | Clean and replace, if necessary | Every 6 months |

[A)] These frequencies are recommended if no information is given by the manufacturer.

# 8 Risk management

## 8.1 General

A risk assessment should be carried out to determine whether the system is safe and fit for purpose. This should take place when the system is being designed.

The risk assessment should follow a recognized process, such as that described in BS 31100.

*NOTE 1 Additional guidance and examples are provided in WRAS Information and Guidance Note No. 9-02-04 [15]. See also the HSE Approved Code of Practice and guidance L8 [14].*

The risk assessment should consider the design, installation, testing and commissioning, operation and maintenance of the system, including water quality (see also **8.2**), structural stability, electrical safety and access provision.

The risk assessment should consider the effects of exposure to, and the potential impacts of, the system on:

a) people, including operators, installers, maintainers, and water users, particularly those who might be more susceptible to poor water quality (e.g. children or the elderly);

b) the environment, including domestic and feral animals, birds and fish, plants, water courses and groundwater;

c) physical assets, including buildings, foundations, drains, paved areas and gardens.

The risk assessment should be used to identify additional actions, process improvements or enhanced controls that can reduce risks in a cost-effective manner.

*NOTE 2 The use of rainwater for WC flushing and general garden watering is considered to be a low-risk application due to the low level of human exposure. However, there are some factors, such as the use of pressure washers and garden sprinklers, that increase the extent of exposure through aerosols, thus making risk assessment necessary.*

## 8.2 Water quality

*NOTE The World Health Organization endorses the "water safety plan" approach to protect the safety of water supplies. This involves a system of risk assessment and risk management.*

The risk assessment should consider potential sources of contamination of water entering or already in the system.

The risk assessment should be used to identify the need for any further water quality control measures, including additional monitoring, for systems where a ground-level and/or highly trafficked collection surface is to be used.

# Annex A (normative) Sizing for integrated stormwater control

## A.1 The simplified approach

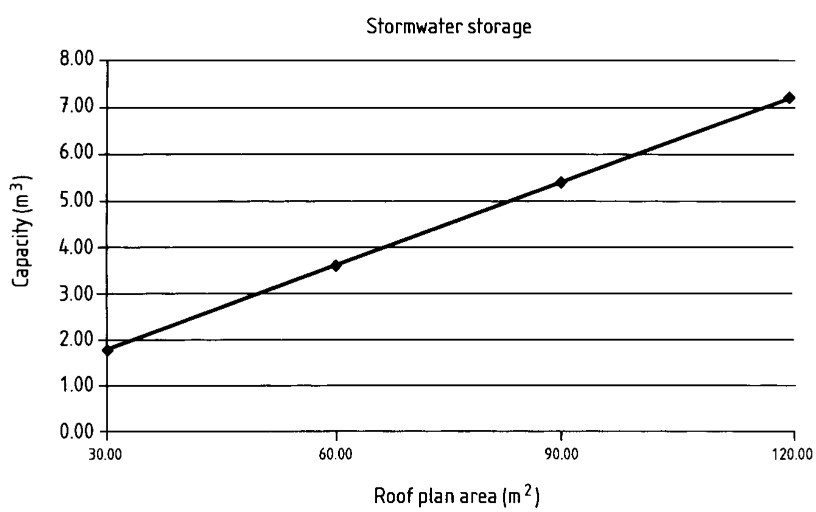
*NOTE 1 Rainwater harvesting reduces the amount of run-off from a site and therefore reduces the impact of stormwater on the receiving drainage system. However, on sites where a reduction in run-off into the drainage system is to be taken into account in its design, sizing the storage capacity for water supply alone, as detailed in* ***4.1.2.2****, does not provide sufficient spare stormwater control storage.*

Where stormwater control is to be integrated into the rainwater harvesting system, the storage capacity should be determined by adding the relevant value from Figure A.1 to that obtained from the simplified approach given in **4.1.2.2**.

This simplified approach should only be applied where the demand is more than the supply of rainwater and therefore is not recommended for systems where the storage capacity is dictated by demand rather than yield (see Figure 3).

*NOTE 2 Where storage is dictated by population, detailed analysis in accordance with* ***A.3*** *is needed to demonstrate the benefits of stormwater control. However, it is noted that for most properties the roof plan area and annual rainfall is such that stormwater control is applicable.*

Figure A.1 **Additional storage capacity for non-potable domestic use and integrated stormwater control (simplified approach)**




*NOTE Based on 100% run-off for 60 mm of rainfall, which approximately represents a 100 year, 6 hour event.*

## A.2 The intermediate approach

*NOTE Where demand for non-potable water is greater than the supply, it is likely that the tank will not be full for most of the time. What is difficult to estimate is how much storage is available at any instant. Thus an allowance for stormwater storage needs to be provided to ensure that the majority of run-off from large storm events is captured.*

Where stormwater control is to be integrated into the rainwater harvesting system, the additional storage capacity needed should be determined using the following equations, which make an allowance for some storage being available in the tank. Where the tank is to incorporate a back-up supply, analysis should take account of the reduced storage capacity in the tank.

Where $D_N > Y_R$

$$SC = R_d \times A - (D_N - Y_R) \times 0.5 \quad (3)$$

However, where $D_N < Y_R$

$$SC = 0 \quad (4)$$

where:

$D_N$ is the non-potable water demand (L);

$Y_R$ is the annual rainwater yield (L);

$SC$ is the stormwater control capacity (L);

$R_d$ is the design storm event rainfall depth (mm);

$A$ is the collecting area ($m^2$);

0.5 is the coefficient for allowance of spare storage.

*COMMENTARY ON **A.2***
*The values normally used for each of the parameters in these equations are as follows.*

*a) Stormwater control capacity*

*There is no coefficient of reduction used, which therefore means that 100% run-off is assumed. Wetting of the surface is of little relevance for big events, but filter efficiency still theoretically applies. However, as the equation selects relatively arbitrary rainfall depth values, this is seen as an unnecessary refinement.*

*b) Rainfall depth*

*A rainfall depth of 60 mm is approximately equal to a 100-year 6-hour event across the UK. For a longer duration event, the return period is more frequent. Although it is an arbitrary figure, it does tie in with other current best practice requirements for drainage design.*

*Design of drainage pipe systems downstream can assume that no run-off is contributed from the collection surfaces used for the rainwater harvesting sized on this basis. However design of downstream storage ponds and attenuation structures ought to make explicit allowance for this upstream storage in the rainwater harvesting system.*

*c) Allowance for spare storage*

*Where demand is more than supply, there is likely to be spare storage in the tank. As this capacity can be quite significant, an allowance has been made to this effect. An arbitrary use of 50% of this spare storage has been assumed to ensure a precautionary approach.*

*Where there is uncertainty over whether demand is significantly greater than supply, it might be appropriate to not allow for this capacity component.*

d) *Systems where supply is greater than demand*

*In situations where stormwater control is desirable but demand is less than supply, such as in many commercial or industrial buildings, it is still possible to obtain some stormwater control benefits. Options include:*

1) *green roofs or flat roofs, which result in much lower yields from the rainfall, e.g. a green roof would result in a yield coefficient of 40% or less;*
2) *a tank which attenuates flows with an outlet throttle to discharge excess flows (throttles can be as low as 0.05 L/s);*
3) *a large tank which is sized for stormwater storage and automatically pumped out or otherwise drained after the event;*
4) *a standard-sized tank which is connected to an infiltration system for excess flows.*

*As extreme rainfall events, which cause major drainage system problems, generally have a short duration and occur in the summer, spare storage is likely to exist anyway.*

*However it is advised that the design of stormwater control for all these situations uses the detailed approach given in* ***A.3****.*

## A.3 The detailed approach

### A.3.1 General

Where stormwater control is to be integrated into the rainwater harvesting system, the additional storage capacity needed should be determined in accordance with one of the following methods:

a) analysis of 20+ extreme events (see **A.3.3**);

b) 100+ year extreme stochastic series (see **A.3.4**); or

c) probability analysis with a five-year time series (see **A.3.5**).

Each of these methods should only be applied by experts in hydrology and drainage modelling.

*NOTE The fundamental underlying principle is that analysis is needed using time series rainfall, which has embedded within it the seasonal and inter-event characteristics of the rainfall for any region.*

### A.3.2 Rainfall yield

Although uncertainty in the yield from a collection surface is fairly low for standard pitched roofs, even these surfaces have significant losses for small events and run-off; models should therefore take account of antecedent conditions by using a depression storage or a soil moisture function, as well as a run-off factor (see Table A.1).

Loss models for permeable pavements and green roofs are fairly uncertain; however, for the purpose of a time series rainfall approach, the run-off parameters given in Table A.1 are recommended.

*NOTE In particular cases where rain-shadow is thought to exist (e.g. from vegetation, other buildings, orientation, strong prevailing winds), a reduction in the coefficients might be appropriate.*

Filter efficiencies should be explicitly applied. The manufacturer's information with regard to the usable rainwater volume flow should be taken into consideration for hydraulic-action filter systems that are used in the storage tank supply line.

Table A.1 **Yield coefficients**

| Type | Run-off | Depression storage |
|---|---|---|
| Pitched roof with profiled metal sheeting | 0.9 | 0.1 |
| Pitched roof with tiles | 0.8 | 0.3 |
| Flat roof without gravel | 0.8 | 1.0 |
| Flat roof with gravel | 0.8 | 2.0 |
| Green roof, intensive [A)] | 0.5 | 5.0 |
| Green roof, extensive [A)] | 0.7 | 4.0 |
| Permeable pavement [A)] – Granular media | 0.7 | 4.0 |
| Permeable pavement [A)] – Plastic crates | 0.8 | 2.0 |

A) The run-off yield is uncertain for these surfaces and design needs to take account of the possibility of yields that are up to 20% higher or lower. In particular, the hydraulic run-off behaviour of green roofs depends on their design.

### A.3.3 Method 1 – analysis of 20+ extreme events

Daily rainfall events that exceed 40 mm to 50 mm should be selected. More than one gauge event may be used as long as they are independent of each other (best achieved by not selecting storms from the same day). This data should be hourly information, which enables the modelling to demonstrate the impact downstream if the storage system becomes full. Each event should have at least three months of antecedent rainfall and should be modelled with the initial storage depth, preferably based on the average depth found from running the 5-year series.

An analysis of the 20+ observed rainfall events should be carried out to establish the return period of each of the events in the context of the site location.

As the tank provides a high level of protection against flooding for short intense storms, but much less for very long storms, subsequent analysis of the downstream drainage system, particularly storage units such as ponds, should cater for this aspect and take into account the level of service provided by the tank.

*NOTE The observed events can be modelled for both the sizing of the tank itself and the assessment of the performance of the tank and the rest of the downstream system.*

### A.3.4 Method 2 – 100+ year extreme stochastic series

*NOTE This method is effectively the same as Method 1, except that by having at least a 100+ year series, an analysis of the events is not needed. Theoretically the performance of the proposed tank can be measured against all significant events of a 100+ year series.*

The stochastic series should be up to four times longer than the return period being investigated to allow an accurate assessment of the storage needed to meet a specific return-period criterion.

The series should be evaluated before use as it might only provide an approximate representation of rainfall through the year (numbers of events, dry periods, intensities etc.).

### A.3.5 Method 3 – Probability analysis with a 5-year time series

*NOTE 1 This method has the advantage of using real rainfall from a series which is long enough to provide enough information on the range of depths for various return frequencies. Assuming that extreme events are independent of ordinary rainfall, this information can be used by simply allowing an additional depth allowance, based on a return-period analysis for various durations. Thus the chance of an extreme event occurring when the water level in the tank is above the 80 percentile level (80% of the time it is less full) can be computed. This analysis can take into account seasons as well as different categories of storms.*

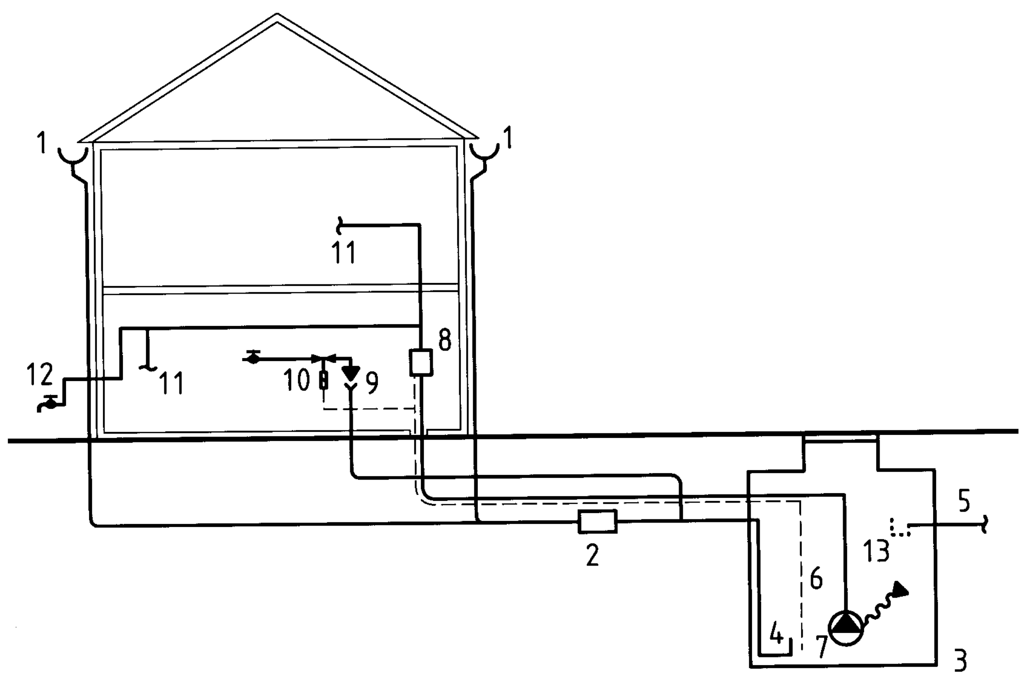
A relevant 5-year time series for the area should be run through a simulation model and the maximum volume of water stored for 20% of the time should be assessed.

*NOTE 2 This may be broken down into seasonal volumes if there are significant differences through the year.*

# Annex B (informative) Examples of typical rainwater harvesting systems with different back-up supply arrangements

Examples of typical systems with different back-up supply arrangements are given in Figures B.1 to B.3.

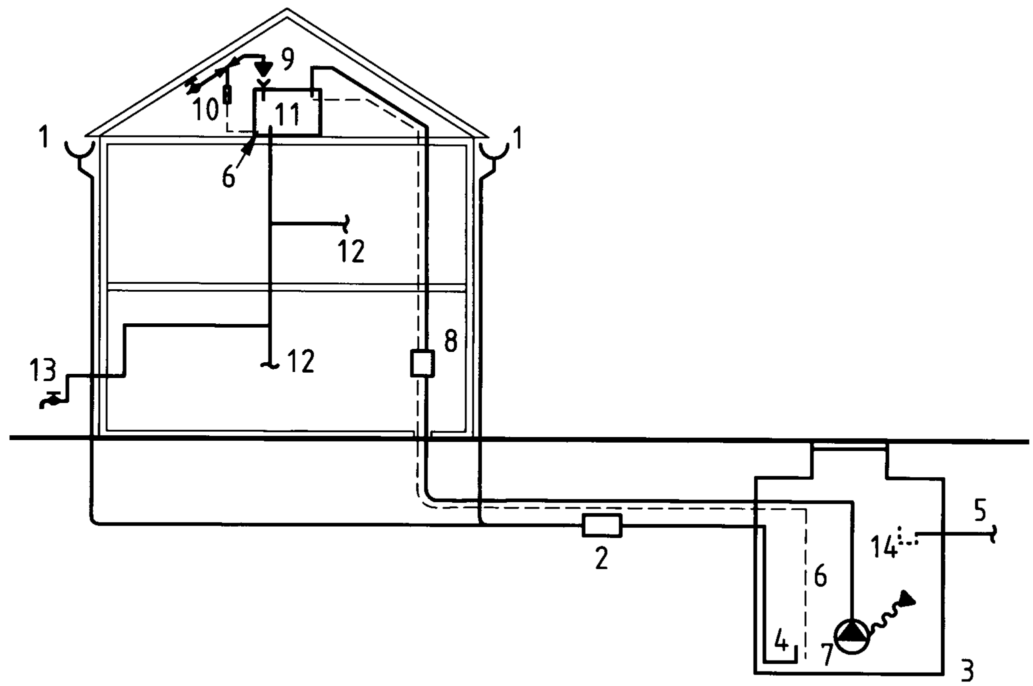
Figure B.1 **Typical system with direct primary supply and Type AA air gap**




**Key**

1 Gutter/downpipe
2 Filter
3 Storage tank
4 Calmed inlet
5 Overflow pipe
6 Sensor/float switch
7 Submersible pump with floating extraction
8 Pump control with dry-running protection
9 Type AA air gap in accordance with BS EN 1717 and BS EN 13076
10 Solenoid valve for back-up water supply
11 Non-potable applications e.g. WC, washing machine
12 Garden tap
13 Optional outlet trap

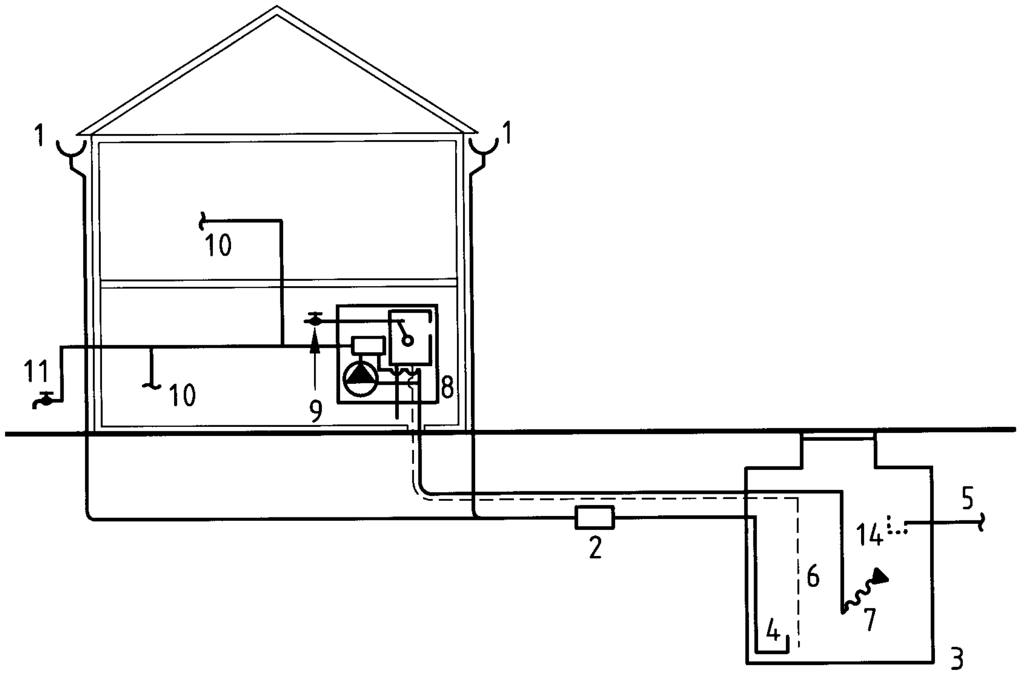
Figure B.2 **Typical system with indirect primary supply and Type AA air gap**




**Key**

1 Gutter/downpipe
2 Filter
3 Storage tank
4 Calmed inlet
5 Overflow pipe
6 Sensor/float switch
7 Submersible pump with floating extraction
8 Pump control with dry-running protection
9 Type AA air gap in accordance with BS EN 1717 and BS EN 13076
10 Solenoid valve for back-up water supply
11 Cistern in loft
12 Non-potable applications e.g. WC, washing machine
13 Garden tap
14 Optional outlet trap

Figure B.3 **Typical system with module and Type AB air gap**




**Key**

1 Gutter/downpipe
2 Filter
3 Storage tank
4 Calmed inlet
5 Overflow pipe
6 Sensor/float switch
7 Floating extraction
8 Module including pump, pump control with dry-running protection and back-up water supply with Type AB air gap in accordance with BS EN 1717 and BS EN 13077
9 Back-up water supply
10 Non-potable applications e.g. WC, washing machine
11 Garden tap
12 Optional outlet trap

# Annex C (normative) Marking and labelling

*NOTE 1 Attention is drawn to the Water Fittings Regulations [6] which require that any water fitting conveying rainwater to be clearly identified so as to be easily distinguished from any supply pipe or distributing pipe supplying wholesome water. This is to prevent inadvertent cross-connection between waters of different qualities, particularly drinking water.*

*NOTE 2 See also **4.11.2** for recommendations concerning the colour of pipework.*

## C.1 Pipework

### C.1.1 General

All distribution pipework should be identified as supplying rainwater. For most systems, more than one form of identification should be used to ensure that identification is possible throughout the life of the installation. The following methods are recommended:

a) permanent marking made at the time of manufacture; and/or

b) labels attached during installation.

Insulated pipes should be labelled on the outer surface of the insulation, regardless of whether the pipe has been identified prior to insulation. Buried pipes should be clearly identifiable during any subsequent excavations.

Marking and labels should be located along the length of the pipework, at intervals of no more than 0.5 m and at key connection points.

Marking and labels used for the identification of rainwater distribution pipes should differentiate between non-potable supplies of different pressures, qualities and designated uses.

### C.1.2 Labelling

The labels used for the identification of rainwater distribution pipes should:

1) be either self-adhesive or mechanically secured to the pipe;

2) be no less than 100 mm in length;

3) be coloured green in accordance with BS 4800:1989, colour 12 D 45;

4) have "RAINWATER" in black lettering, no less than 5 mm in height.

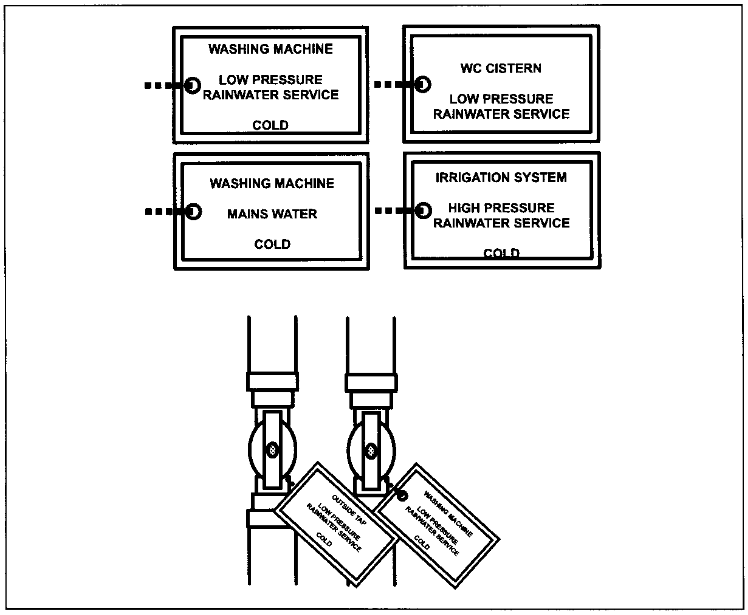
In addition, it is recommended that tags identifying each appliance and its water supply are secured to the pipework at key connection points using flexible fasteners. The lettering on these tags should be black or green, on a white background, and no less than 5 mm in height.

*NOTE 1 Tags may be green or edged in green.*

The wording on identification tags should be concise and unambiguous, and should enable the various supplies to be uniquely identified (see Figure C.1).

*NOTE 2 Identification codes alone are not sufficient.*

Figure C.1 **Examples of identification tags and their positioning**



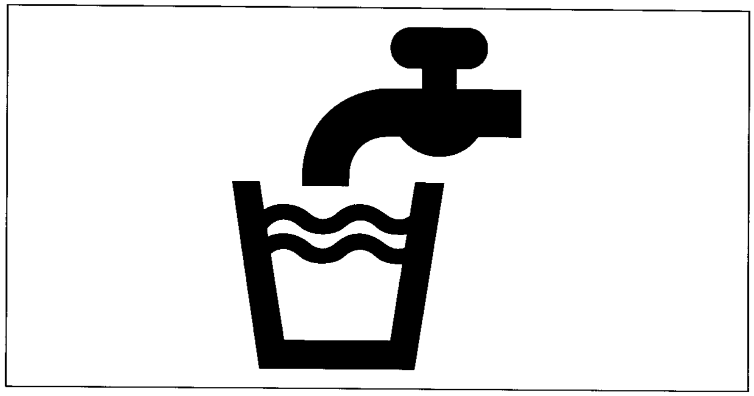

## C.2 Points of use

Points of use for the rainwater harvesting system, including all appliances, should be clearly identified with the words "Non-potable water" or a prohibition sign (see Figure C.2) so that users and maintenance personnel are aware of the non-potable water supply. Where other non-potable systems are available, e.g. greywater, the words "Non-potable water: RAINWATER" should be used.

*NOTE If the majority of points of use on industrial premises are for non-potable water, the points of use for potable water may be identified by the words "Potable water" or by the "Potable water" sign shown in Figure C.3, provided that notices are posted to draw attention to this deviation from normal practice.*

Figure C.2 **Signage for points of use supplied by non-potable water**

Figure C.3 **Signage for points of use supplied by potable water**



## Annex D (normative) Water sampling

In order to test water quality, a dip sample should be taken from the tank or cistern in accordance with BS 7592. Where more than one tank or cistern is used in the system, samples should be taken from:

a) the most upstream storage tank, to test the quality of the collected rainwater;

b) any subsequent tanks/cisterns if the stored rainwater is likely to be either affected by temperature variations (e.g. in a loft) or mixed with water from the back-up supply.

Samples should only be taken from points of use, i.e. terminal fittings fed with water from the rainwater harvesting system, if routine sampling or observations indicate a problem.

*NOTE Further guidance on water sampling is given in BS EN ISO 19458, BS EN ISO 5667-1 and BS EN ISO 5667-3.*

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