Environment Agency

Greywater for domestic users: an information guide

May 2011

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Foreword

This document provides information on greywater systems in the UK.

It covers the use of greywater for non-potable domestic water uses such as WC flushing and garden watering. It considers the greywater from showers, baths and hand basins and excludes the more contaminated water from washing machines and kitchen sinks.

This publication does not give recommendations on specific greywater reuse systems.   It does provide guidance on the:

- benefits of these systems;
- savings you can achieve;
- alternatives to consider;
- cost of installations;
- suitability of greywater reuse systems;
- maintenance requirements
- water quality issues; and
- regulations and guidance you should refer to.

Also included are examples of where these systems are already in use and any associated costs, savings and experiences.

Throughout the document there is reference to a number of different sources where further details and guidance can be found on the installation of a rainwater harvesting system.

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1. Introduction

Greywater is wastewater from showers, baths, washbasins, washing machines and kitchen sinks. You can collect it from some or all of these sources and, after treatment, use around the home for purposes that do not require drinking water quality such as toilet flushing or garden watering.

This guide considers greywater as wastewater from showers, baths and hand basins only. It excludes the more contaminated water from washing machines and kitchen sinks.

As we become more environmentally aware, there has been an increased interest in using 'green' technologies and greywater recycling is no exception. This publication focuses on systems for domestic uses and is intended for homeowners, house builders, planners, architects and building managers. It discusses:

• different types of systems available;
• design, installation and maintenance requirements;
• economic and environmental issues.

1.1 Why reuse greywater?

Despite the common perception that it rains a lot in England and Wales, our water resources are under pressure. A high volume of water is taken from the environment for human use. Demand for water is rising because the population is increasing, lifestyles are changing and the impacts of a changing climate are becoming more clear. In the South East of England, where large numbers of people live and work, water is scarcer than anywhere else in England and Wales. In fact, there is less water available per person in this region than in many Mediterranean countries.

We need to plan carefully for the future to ensure reliable water supplies are available for everyone whilst protecting the natural environment.

The Environment Agency favours a "twin track" approach, that is, developing resources and managing demand. Exploring ways to reduce demand for mains water is essential to ensure a sustainable future for water resources. One of the options is to install greywater systems to substitute mains water use for purposes where drinking water quality is not required.

1.2 What are the benefits?

If used for toilet flushing, a well-designed and fully functional greywater system could potentially save a third of the mains water used in the home. You could also reuse greywater for other uses where potable water quality is not essential, such as garden watering. The greater the proportion of greywater used, the less mains water will be needed, which will ease the pressure on water resources. Section 3 describes this in more detail.

Reusing greywater not only reduces the consumption of mains water, it also reduces the volume of water discharged into the sewerage system. Consumers with water meters could therefore save money on both their water supply and wastewater bills. The economics of recycling systems are covered in more detail in section 5.

1.3 Greywater systems in the UK

Greywater systems are starting to become more common in England and Wales. However, they are not as common here as they are abroad, which may be because:

- systems are expensive to purchase, maintain and run, while the cost of water is relatively low;
- at the time of writing, only 37 per cent of domestic customers have a water meter. This means that the majority of customers don't pay for water by volume so there is no real financial incentive to install a greywater system;
- currently there are no regulations to cover the quality of reused water. Although there are some national standards relating to reused water that have been developed by the British Standard Institute;
- historically, the reliability of greywater systems has been poor and are still relatively unproven.

In the UK the Code for Sustainable Homes (CSH) provides an environmental assessment method for rating and certifying the performance of new homes, aimed at encouraging continuous improvement in sustainable home building. To achieve the highest levels of the code, the internal per person daily water use has to be less than 80 litres. To meet this target, either greywater or rainwater harvesting is often used.

View the CLG *Code for Sustainable Homes Technical Guide 2010*[1] for more information.

Part G of the updated Building Regulations[2] introduces a new requirement that, for any new dwelling, the potential wholesome water consumption should not exceed 125 litres per person per day. To help achieve this the Regulations have been amended to allow non-wholesome water to be used for toilet flushing. See *G1 Cold Water Supply* that covers the quality of water required for sanitaryware fixtures and fittings.

2. Types of greywater systems

Greywater reuse systems vary significantly in their complexity and size from small systems with very simple treatment to large systems with complex treatment processes. However, most have common features such as:

- a tank for storing the treated water;
- a pump;
- a distribution system for transporting the treated water to where it is needed; and
- some sort of treatment.

All systems that store greywater have to incorporate some level of treatment, as untreated greywater deteriorates rapidly in storage.

This rapid deterioration occurs because greywater is often warm and rich in organic matter such as skin particles, hair, soap and detergents. This warm, nutrient-rich water provides ideal conditions for bacteria to multiply, resulting in odour problems and poor water quality. Greywater may also contain harmful bacteria, which could present a health risk without adequate water treatment or with inappropriate use. The risk of inappropriate use is higher where children have access to the water.

[1] http://www.planningportal.gov.uk/uploads/code_for_sustainable_homes_techguide.pdf
[2] http://www.planningportal.gov.uk/buildingregulations/approveddocuments/partg/approved

Greywater systems can be grouped according to the type of treatment they use. Note that the commercially available systems quoted in this guide are for illustration only. The Environment Agency does not recommend any particular manufacturer or system. All company websites cited in this guide were available as of February 2011.

2.1 Direct reuse systems (no treatment)

It is possible to reuse greywater without any treatment provided that the water is not stored for long before use. For example, once bath water has cooled, it can be used directly to water the garden.

Very simple devices are available to make this practical. Among these is the 'WaterGreen' by Droughtbuster UK Ltd[3], which is essentially a hose pipe with a small hand pump to create a siphon. This allows cooled bath water to be taken directly from the bath and sent through the hose to the garden (usually via an open window).

Using greywater in this way may not suit everyone, but it does provide an inexpensive and easy way of saving water and avoids greywater storage issues. It is particularly useful for keen gardeners when water use restrictions are in place. Experts usually advise that greywater should not be used on fruit or vegetable crops. See our website (http://www.environment-agency.gov.uk/savewater) for more information on water efficient gardening.

Other equipment is designed to reuse greywater direct from a sealed main drainage system. For example, a valve can be fitted to an external waste pipe that drains water from the bath or shower. This valve can be used to direct greywater to a water butt where, once cooled, it can be used for garden irrigation. An example of this type of valve is the 'Water Two'[4] valve, which can be fitted to existing piping and switched to either divert greywater to a drain or to storage. The greywater is not treated, so must not be stored for too long because the water quality will deteriorate rapidly.

2.2 Short retention systems

These systems take wastewater from the bath or shower and apply a very basic treatment such as skimming debris off the surface and allowing particles to settle to the bottom of the tank. For example, the 'Ecoplay' unit[5] aims to avoid odour and water quality issues by treating the greywater to a basic standard and makes sure it is not stored for too long. If it is not used within a certain time, the stored treated water is released and the system is topped up with mains water. Potential water savings are dependent on usage patterns.

These systems use the simplest level of treatment so are relatively cheap to buy and run. The risk of equipment failure is reduced so expensive repairs (of more complex systems) can be avoided. According to the Ecoplay website the system is 'maintenance free' with 'no filters to clean or replace'. Another benefit of short retention systems is that they can be located in the same room as the source of greywater, reducing the need for expensive, dual-network plumbing.

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3 http://www.mygreenerhome.co.uk/water-savers-5/watergreen-syphon-pump-from-droughtbuster-80.html
4 http://www.watertwo.co.uk/index.htm
5 www.ecoplay-system.com/default.aspx?id=1

The Ecoplay systems is;

- only supplied to the domestic market (including hotels) where the balance of shower use and toilet flushing makes it relatively effective.
- suited to installing in newly built homes and renovation projects, but maybe more difficult to retrofit.

2.3 Basic physical and chemical systems

Some systems use a filter to remove debris from greywater before storing and use chemical disinfectants (e.g. chlorine or bromine) to stop bacterial growth during storage. You will need to assess the overall costs and benefits as using disinfectant has an environmental impact and cost implications.

The Environment Agency's study (NWDMC 2000) on this type of system reported:
• water savings ranged from less than 6 to over 32 per cent of total water use;
• reliability varied;
• filters required regular cleaning to avoid blockages;
• occurrence of odour problems due to either poor water quality or high levels of disinfectant;
• instances where the system had failed and switched to mains back-up with users unaware of the failure.

Other studies have also revealed similar reliability issues. For example, South Staffordshire Water installed and monitored physical/chemical greywater systems in a block of flats and found them unreliable[6]. Some residents were initially happy with the systems but, with time, residents identified problems such as odour, performance, noise and water poor quality. These problems were exacerbated by difficulties in gaining access to the systems in the flats for service and repair, and eventually led to their removal. The payback was estimated at over 65 years which, in this case, was significantly longer than the life of the systems.

This project highlighted the technical and practical issues that can occur with the installation of basic greywater systems. For example, access issues could have been avoided if a communal system had been installed instead of individual systems in each flat.

2.4 Biological systems

Biological systems vary in their complexity and form, but the concept is the same: bacteria are used to remove organic material (contamination) from wastewater. The process uses the principles employed at sewage treatment works. Oxygen is introduced to wastewater to allow the bacteria to 'digest' the organic contamination. Different systems supply oxygen in different ways; some use pumps to draw air through the water in storage tanks while others use plants to aerate the water.

In nature, reeds thrive in waterlogged conditions by transferring oxygen to their roots. Biological systems generally use reed beds to add oxygen to wastewater and allow naturally occurring bacteria to remove organic matter. Wastewater can be passed through the soil/gravel in which the reeds are growing and the bacteria fed by oxygen from the reeds and nutrients from the wastewater decompose the waste. Reed beds are an established method for treating wastewater/sewage and can also be used to treat

[6] South Staffordshire Water, 2004 *A Study on the Effectiveness of Grey Water Recycling Technology.* [Unpublished].

greywater. However, they require some expertise to create and/or maintain and availability of a suitable, relatively large outside area.

Water Works UK markets a system called GROW (Green Roof Water Recycling System[7]). This system uses a series of gravel-filled troughs which filter greywater through a reed bed containing active bacteria. The greywater is pumped to the gravel troughs where it passes through the filter for around 18 hours. This filtered water then passes through an ultraviolet (UV) filter to kill any remaining bacteria and is dyed green to distinguish it from potable water.

A second system (GROW2) is now available, which is a smaller version and is designed for individual households. The system costs approximately £800 plus installation and can be positioned in the garden if no appropriate roof area is available[8].

2.5 Bio-mechanical systems

The most advanced domestic greywater treatment systems use a combination of biological and physical treatment. An example of such a system is the 'AquaCycle® 900'[9]. This system was developed in Germany where greywater systems are more common. The 'AquaCycle® 900' is a substantial system about the size of a large fridge, which means it needs to be installed in a basement or garage. It is best installed during construction and is not suitable for retrofitting into existing buildings due to cost and other practical difficulties.

The AquaCycle® 900 is an 'all-in-one' unit which treats and stores water in three enclosed tanks. Greywater is filtered through self-cleaning filters as it flows into the storage unit. Organic matter is removed by microbial cultures formed on rubber chips. Solid material is allowed to settle to the bottom of the tank and is removed automatically. The system encourages bacterial activity by bubbling oxygen through the water. The final stage of the system is UV disinfection to remove any remaining bacteria. This process claims to produce treated water that meets EU bathing water standards.

Another commercially available all-in-one system is the 'WME-4'[10] which uses biological pre-treatment through aeration and then membrane filtration to produce high quality treated greywater.

Combining physical and biological treatment generally produces the highest quality water, but it also uses a significant amount of energy (see section 6), is expensive to purchase and operate (the AquaCycle® 900 costs around £3,000 to buy), and maintenance costs are uncertain.

This high level of water quality may not be required if the use of treated greywater is restricted in an individual property for toilet flushing. But where stored greywater is treated to a high standard, there is potential for its use in other applications such as vehicle washing. A high standard of water quality may also be required in communal systems to overcome both real and perceived risks associated with using the treated water.

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[7] http://www.wwuk.co.uk/grow.htm
[8] http://wwuk.co.uk/grow2.htm
[9] http://www.freewateruk.co.uk/greywater-III.htm
[10] http://www.aqua-lity.co.uk/index.php?id=118

2.6 Integrated greywater/rainwater systems

Integrated systems use both treated greywater and harvested rainwater. These systems can be used where one or the other of the non-potable sources are insufficient to meet the end uses. You should only consider these systems if, after calculating the individual system separately, neither is sufficient to meet the intended demand on its own.

Integrated systems need careful planning prior to installing because complications can arise. As a minimum, you should consider the following:

- The rainwater harvesting and greywater reuse system should conform to national standards. See *BS 8525-1:2010 Greywater Part 1 – a code of practice*[11] (**BS 8525**), *BS 8515:2009 Rainwater Harvesting Systems – Code of Practice*[12] (**BS 8515**) and the Environment Agency information guide on rainwater harvesting[13] for more guidance.
- Sizing of the storage capacity requires detailed calculations, and the ratio of demand from greywater and rainwater should be determined.
- Water quality still needs to meet or exceed the guidelines referenced in section 4.
- The overflow from an integrated system must be discharged into the foul sewer, from the point when greywater has been introduced, as only surface water is permitted to be discharged into water courses, surface water sewers or storm drains.

On its own, the overflow from a rainwater harvesting system can be discharged into surface sewers. However, an integrated system will normally require all overflows to discharge to foul sewer as the two non-potable sources may be mixed in the same tank. This means that the water is not of sufficient quality to be discharged into water courses. It may be possible for a combined system to have an overflow into the storm drain, but only if it is guaranteed that the rainwater will not be mixed with greywater when overflowing. This may involve using a diverter valve for example.

An example of a successfully installed integrated rainwater/greywater system can be found in Germany. In Aachen, Decren Water Consultants[14] installed a combined system in a local house.

An external tank was installed to collect the greywater from the house and aerated filtration treated the greywater and reduced bacterial content. The treated greywater fed into the tank along with harvested rainwater and was used for toilet flushing and also to supply the washing machine.

3. Supply and demand

On average, every person in England and Wales uses around 150 litres of water per day (l/p/d). About a third of this is used for toilet flushing and this proportion could potentially be replaced by treated greywater. Figure 1 shows the elements (micro components) of the average demand for water in measured households.

[11] BS 8525-1:2010 Greywater Part 1 – a code of practice, www.standardsuk.com
[12] BS 8515:2009 Rainwater harvesting systems – Code of practice, www.standardsuk.com
[13] http://www.environment-agency.gov.uk/static/documents/Leisure/geho0108bnpnee_886790.pdf
[14] http://www.dwc-water.com/technologies/grey-water-recycling/index.html

Figure 1 – Current Demand[15]

Figure 1: Measured total England and Wales microcomponent use 2009-10 (%)

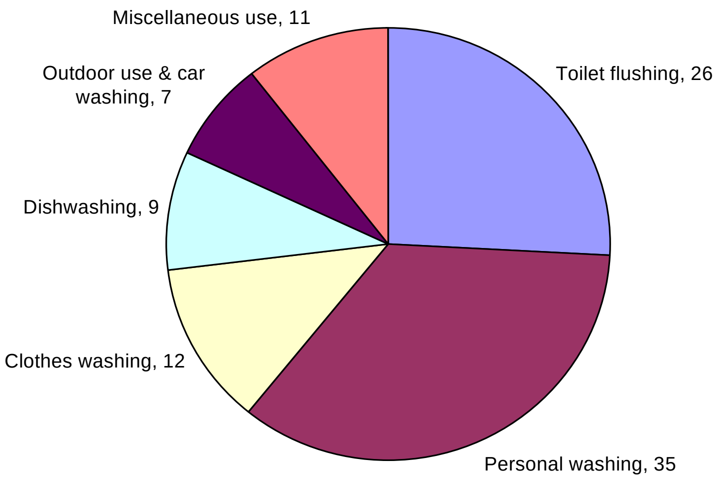


Figure 1 shows that the volume of water used to flush the toilet in a typical household is slightly smaller than the volume of water available from showers, baths and washbasins. This suggests that water demand for toilet flushing could be met by reusing greywater. This would provide significant savings as toilet flushing represents a relatively large proportion of household demand.

However, forecasts show that a decreasing proportion of water will be used for toilet flushing and an increasing proportion used for personal washing. This is due to an increase in:

- installing progressively lower flush toilets
- installing high water consumption showers
- mains pressure for hot water systems.

The trends show there is still more than enough greywater available to meet the demand for toilet flushing. However, the amount of water saved would be lower. Where ultra low flush toilets are installed, the potential savings become smaller still. Smaller water savings lead to longer payback periods so, as toilet technologies improve, the potential for water saving through greywater recycling reduces.

3.1 Demand for greywater

Your water demand should be the driver for which type of system to select. This will prevent unnecessary collection and treatment of greywater you won't use. Use the hierarchy below to consider potential non-potable uses:

1. WC flushing;
2. external use – non-spray;
3. laundry use; and
4. external use – spray.

Water use patterns vary widely between households. This is why greywater systems have to be assessed for suitability in specific households. For example, some households

[15] Environment Agency 2010

may use a large amount of water for showering and bathing in the morning and evening, and spend most of the day at work where other toilet facilities are available. This situation would produce a surplus of greywater and water savings would be minimal. Alternatively, occupants could have a low use of water for bathing and spend the majority of the day at home, therefore using a larger amount of water for flushing the toilet. This would create a higher demand for treated greywater than the quantity available and would also lead to minimal water savings.

Communal greywater systems can potentially avoid the problem of uneven supply and demand encountered by a single household system as people's different consumption patterns cancel each other out. Maintenance may also be easier – cheaper per household and of a higher standard as it can be undertaken by qualified staff.

Using greywater as a source of non-potable water can provide a more reliable and consistent supply of water than that available from rainwater harvesting. This is a distinct advantage over the use of rainwater as a supply of non-potable water. The supply of greywater will be reliable throughout the year, reducing the amount of mains back-up required at peak times when the mains water supply is already stretched.

3.2 Perceptions of greywater systems

Popularity of reused greywater systems is affected by perception. A positive attitude to the use of greywater for toilet flushing is supported by the findings of a number of studies (WROCS, 2000[16] and Ogoshi *et a*l 2001[17]). Other uses that require more direct contact, such as watering the garden are generally less accepted.

Studies into people's perceptions of communal recycling schemes have found that users prefer to reuse their own greywater rather than someone else's (Jeffrey 2002). Research suggests that where communal systems are installed, people prefer larger 'city wide' schemes where the source of the water is anonymous, and not more local schemes where they may know many of the people involved (Po et al. 2003).

The acceptability of greywater reuse is heavily influenced by what its used for. For example use in golf courses, parks and industry is relatively well accepted, but reuse in people's houses is less popular. Furthermore, acceptability is lower for water uses where contact with the reused water is greater (e.g. in washing machines) than it is for water uses where contact is minimal, for example, toilet flushing (Jeffrey 2002).

4. Regulations

4.1 Water quality

Water quality is a wide term covering physical, chemical and biological quality.

• **Physical quality** includes how clear the water is (that is, turbidity), total suspended solids in the water and its temperature.
• **Chemical quality** includes how acid or alkaline the water is (that is, pH), how much disinfectant is present (residual chlorine or bromine), the amount of dissolved oxygen in the water and biochemical oxygen demand (BOD) – a measure of the amount of organic material in the water.
• **Biological quality** mainly relates to the presence of bacteria and viruses. The groups of

[16] Water Recycling Opportunities for City Sustainability (WROCS) (2000). Final report to the industrial collaborators. Cranfield University, UK.
[17] Ogoshi, M., Suzuki, Y. and Asano, T. (2001) Water reuse in Japan. *Wat. Sci. Tech.*, **43**(10), 17–23.

bacteria chosen as indicators of biological water quality are those abundant in human and animal faeces. Their presence indicates faecal contamination.

It is important that the water we use is fit for purpose. Treated greywater will not be of the same water quality as mains water so you should be aware of;

- the type of contamination;
- what the risks could be; and
- how clean the water needs to be.

4.1.1 Type of contamination

Greywater from showers, baths and washbasins will often be contaminated with human intestinal bacteria and viruses as well as organic debris such as skin particles and hair. Greywater will also contain residues of soaps, detergents and other cosmetic products that often contain nutrients that help bacteria develop. This combination of bacteria, organic material and nutrients provides ideal conditions for bacterial growth. This is exacerbated by the relatively high temperature of greywater, which can further encourage the growth of bacteria further. This is why untreated greywater should never be stored for more than a few hours.

4.1.2 Potential risks?

The most significant risk from greywater is exposure to pathogenic micro-organisms derived from faecal contamination. However, the physical and chemical characteristics of greywater are also important as these can encourage the growth of bacteria, interfere with treatment or disrupt the operation of fittings that use water. For these reasons, the physical, chemical and biological water quality of greywater must be suitable for its intended use.

4.1.3 How clean does the water need to be?

While stringent standards guard drinking water quality in the UK, there are no regulatory standards for the quality of non-potable water. Many groups have called for appropriate standards for non-potable water to overcome concerns about potential health hazards and to bolster public confidence in using non-potable water. However, the enforcement of such standards would be difficult as most systems are independently owned and maintained.

4.2 Water monitoring

Whilst there are no regulations covering the quality of reused water, the British Standards Institute (BSI) has produced some guidelines for both greywater and rainwater reuse. For the first time, guidance introduces embedded water quality parameters for water reuse applications. Compliance with these parameters is designed to ensure public health is not compromised.

The guidelines in **BS 8525** have taken the standards included in the Bathing Water Directive[18] and developed values based on detailed research into specific applications where greywater is to be used.

Guidelines and monitoring arrangements are displayed in the tables below[19]. The guidance recommends that whilst frequent water sampling is not necessary, it is good practice to observe water quality during maintenance checks.

[18] http://ec.europa.eu/environment/water/water-bathing/index_en.html

The four microbiological water quality indicators that are looked at are:

- Escherichia coli
- Enterococci
- Legionella
- Total coliforms

Table 1 gives guidelines for monitoring the bacteriological health risk of greywater systems. Use with the traffic light system shown in table 2.

Table 1 – Guideline values (G) for bacteriological monitoring

Parameter	**Spray application**	**Non-spray application**			**System type**
	Pressure washing, garden sprinkler use and car washing	**WC flushing**	**Garden watering**	**Washing machine use**	
Escherichia coli (number/100mL)	Not detected	250	250	Not detected	Single site and communal domestic systems
Intestinal (enterococci number/100mL)	Not detected	100	100	Not detected	Single site and communal domestic systems
*Legionella pneumophila (*number/100mL)	10	N/A	N/A	N/A	Where analysis is necessary
Total coliforms (number/100mL)	10	1000	1000	10	Single site and communal domestic systems

Table 2 – 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 greywater 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.

Table 3 looks at the parameters relating to system operation, and provides an indication of the water quality that a well designed and maintained system is expected to achieve for the majority of operating conditions. Interpret this information with reference to table 4.

[19] Permission to reproduce extracts from BS 8525 is granted by BSI. British Standards can be obtained in PDF or hard copy formats from the BSI online shop: www.bsigroup.com/Shop or by contacting BSI Customer Services for hardcopies only: Tel: +44 (0)20 8996 9001, Email: cservices@bsigroup.com.

Table 3 – Guideline values (G) for general system monitoring

Parameter[)]	Spray application	Non-spray application			System type
	Pressure washing, garden sprinkler use and car washing	WC flushing	Garden watering	Washing machine use	
Turbidity NTU	<10	<10	N/A	<10	All systems
pH (pH units)	5 - 9.5	5 - 9.5	5 - 9.5	5 - 9.5	Single site and communal domestic systems
Residual chlorine (mg/L)	<2.0	<2.0	<0.5	<2.0	All systems where used
Residual bromine (mg/L)	0.0	N/A	0.0	N/A	All systems where used

[A)] In addition to these parameters, all systems should be checked for suspended solids and colour. The treated greywater should be visually clear, free from floating debris and not objectionable in colour for all uses. Colour is particularly relevant for washing machine use.

Table 4 - Interpretation of results from system monitoring

Sample result [A)]	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 3. 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 questionable, it is necessary to investigate the system operation to resolve the problem.
[B)] G = guideline value (see Table 3).

The tables provide an indication of the water quality that a well designed and maintained system is expected to achieve for the majority of operating conditions.

4.3 Water fittings

The Water Supply (Water Fittings) Regulations 1999[20] govern the efficient use and protection of drinking water in England and Wales. They apply to all plumbing systems, water fittings and equipment supplied from the public water supply.

These Regulations require that the correct level of backflow prevention is provided to prevent contamination of the public mains water supply. For greywater systems this is usually in the form of an air gap, which will prevent non-potable water entering the mains water supply.

You should discuss backflow prevention for specific appliances with the manufacturer to ensure that a suitable fluid category 5 (air gap) backflow prevention has been incorporated into the appliance.

[20] Statutory Instrument 1999 No. 1148 (http://www.hmso.gov.uk/si/si1999/19991148.htm) and Statutory Instrument 1999 No. 1506 (http://www.opsi.gov.uk/si/si1999/19991506.htm)

4.4 Water Regulations Advisory Scheme (WRAS)[21]

To manage the risk of accidental cross-connections between potable and non-potable supplies, it is important to follow the good practice described in *Guidance on Marking and Identification of Pipework for Reclaimed (Greywater) Systems* produced by the Water Regulations Advisory Scheme (WRAS) (WRAS 1999).

WRAS offer independent guidance and advice on the regulations and publish a number of useful free to access guides.

WRAS Information and Guidance note 9-02-05[22] states that:

- It is important that all pipework supplying reused water is readily identifiable to those who come across it for the first time.
- Pipework should be both recognisable and distinguishable from that supplying mains water.
- Pipes must be marked and labelled.

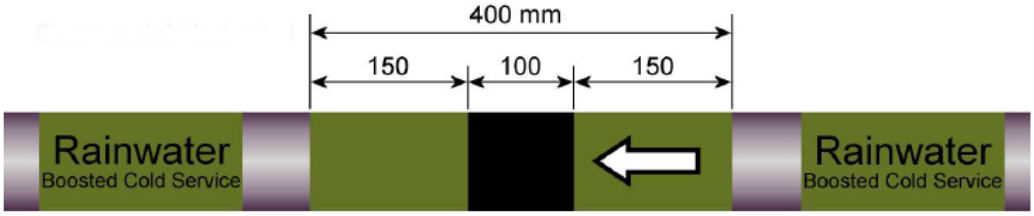
In accordance with BS 1710:1984 '*Identification of pipelines and services'* pipes that distribute reused water should be colour coded with a green-black-green banding:

- The basic identification colour, green, identifies the contents as water and the banding should be approximately 150mm wide.
- The code indicator colour, black, identifies the contents as unwholesome reused water and should be approximately 100mm in width.

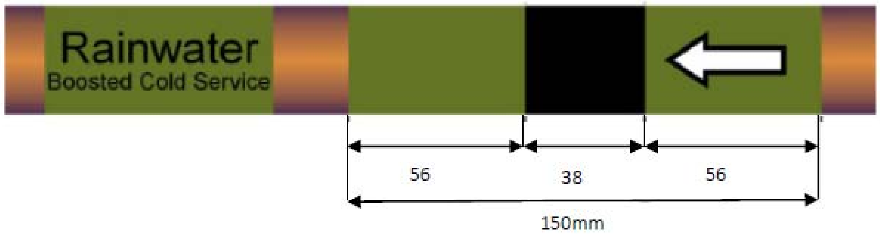
In domestic properties the pipework is likely to be smaller, but the same principles apply.

Figure 2: suggested labelling of internal pipes containing reclaimed water for both non-domestic and domestic properties.

Commercial/Industrial



Domestic



The WRAS guidelines also recommend reclaimed water pipeline apparatus are identified by signage which clearly identifies that an unwholesome reused water system is in use. An example is shown in Figure 3.

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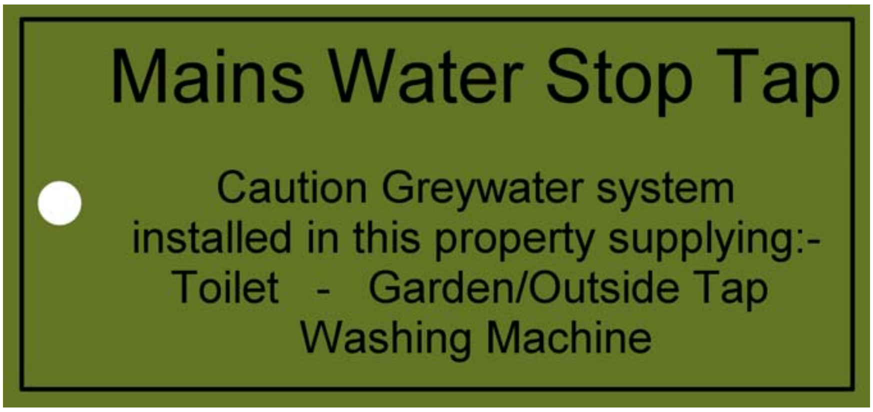
[21] www.wras.co.uk
[22] http://www.wras.co.uk/PDF_Files/IGN%209.02.05.%20version%202%20April%202011.pdf

Figure 3: typical reclaimed water marker plate as shown in the WRAS guidelines

It is also recommended that a label is attached to the incoming stop valve or other key points so that users are aware that a reused water system has been installed (see figure 4).

Figure 4: Example label for use at stop valve and other key connection points



Further guidance is made by The National Joint Utilities Group (NJUG) *Guidelines on the Positioning and Colour Coding of Underground Utilities' Apparatus*[23]*.* NJUG focus on promoting best practice and safety.

This includes recommendations for the colours of pipework to identity different uses. For greywater, they recommend that pipework is black with green stripes. This is only an industry practice guide, and it should not be assumed that all services will conform to the recommendations for colour coding. However it must be recognised that blue coloured pipe is universally accepted for drinking water use and therefore should not be used for any non-wholesome uses.

[23] www.njug.org.uk

4.5 Non-compliance with regulations

As reused greywater will not be of drinking water quality, it is important to manage the risk of cross-contamination with the drinking water supply appropriately. This risk is higher in systems designed to serve more than one property because the reused water network is more complex.

A drinking water quality incident at Upton[24] eco-housing development in Northampton has highlighted the risks associated with not complying with regulations. Whilst the example applies to an incident with installing a rainwater harvesting system, many of these issues apply to greywater systems, and the lessons learnt are equally relevant.

What started with Anglian Water receiving some complaints of 'sewage' odours in tap water from a house on the development, resulted in the identification of a small number of cases of E.Coli contamination.

A detailed report from the Drinking Water Inspectorate (DWI)[25] concluded that an incorrect use of a cross-connection between a RWH system and potable water supply, which by-passed the harvesting unit, was in breach of the Regulations. The following issues were highlighted as contributing to the contamination:

- Labelling – There were a number of visits by water company staff to the site of the first complaint before the cause of the odour was established. It was not until the fourth visit that it was discovered that a RWH system was present at the property. Only once this was discovered was a full water fittings inspection arranged.

  There was further delay as the pipework for the RWH system was hidden behind fitted kitchen units. During the inspections of other properties, Anglian Water found there were labelling infringements in most of the properties inspected.

- Non-compliance with regulations – there was a breach of regulations which resulted in the incorrect use of a cross-connection. There was no backflow detection device, and some of the valves were left in the open position, allowing rainwater to enter the drinking system .

In this case, the products supplied were all correct and the rainwater equipment did have an appropriate air-gap on the back-up supply correctly supplied by the manufacturer. It was the cross-connection by the installer that allowed rainwater to enter the drinking water system as there was no backflow prevention device. Valves were in place but some of these were left in the open position. This was exacerbated by poor labelling which meant is was not obvious a rainwater system was installed.

Sampling highlighted a contamination of greater than 100/100ml *E.coli* and an open cross connection between the RWH system and the drinking water supply. As a result, all houses with the same RWH system installed were investigated. In total three open cross connections were identified at the Upton eco-housing development. Cross connections were found at 87 properties, but fortunately the isolation valve was in the closed position, preventing contamination of the mains water.

This incident is a lesson to the water and construction industries on the dangers of incorrectly installed water-saving systems. The DWI has recommended that water companies:

- send guidance to their approved plumbers to ensure wider knowledge of the risks; and

[24] http://www.homesandcommunities.co.uk/upton-northampton.htm
[25] http://www.dwi.gov.uk/upton-eal.pdf

- include the risks of cross contamination from water-saving systems in their water supply risk assessments, designed to protect against quality failures.

Anglian Water has now given specific instruction to check for both RWH and greywater reuse systems during all future investigations at customer properties. The company has also briefed its staff about this event and plans to familiarise staff with ***BS 8515*** and ***BS 8525*** codes of practice.

Anglian Water has written to the UK Rainwater Harvesting Association to ensure its members are aware of the incident. As a result UKRHA has produced a communication that highlights this as an installation issue relating to a breach of regulations and confirming that all products supplied by the manufacturer were correct. All members have also been reminded that they have to comply with BS8515.

5. Cost-effectiveness

The cost-effectiveness of greywater systems varies and the amount of money you save will depend on:
• volume of water saved;
• price of the mains water replaced;
• costs of installing, running and maintaining the greywater system.

Before investing in a greywater system, it's worth calculating what sort of savings you are likely to see on your water bill.

5.1 Reusing greywater for toilet flushing

You can estimate how much you could save by using the standard usage figures for toilets (see Table 5). You can adapt the calculation to reflect your individual situation by adjusting occupancy, toilet flush volume and the cost of water and sewerage in your area . If you add outdoor use, make sure that the supply of greywater is sufficient to meet your projected demand. Table 5 shows:

• how much money could be saved if the demand for toilet flushing in a typical 2.4 person household was met entirely by treated greywater;
• the effect of moving to best practice low flush toilets also supplied entirely by treated greywater;
• example charges of two water and sewerage companies representing the higher and lower ends of the range of water charges in England and Wales.

Payback periods are calculated by comparing the savings to an estimated initial investment. The cost of greywater systems varies, but the estimation of approximately £3000, including £2,500 for purchase and £500 for installation is used. This cost is a conservative figure but is useful to illustrate the calculation for an individual domestic system. As water charges tend to increase year on year so payback periods will shorten.

Table 5: Example cost savings from greywater systems in areas with different water charges

Appliance	Low water/wastewater charges*		High water/wastewater charges**	
	Standard toilet	Low flush toilet	Standard toilet	Low flush toilet
Litres per flush	6.0	4.5	6.0	4.5
Flushes/person/day	4.8	4.8	4.8	4.8
Number of occupants	2.4	2.4	2.4	2.4
Total flushes/day	11.5	11.5	11.5	11.5
Daily use (litres)	69.1	51.8	69.1	51.8
Annual water use (m^3)	25.2	18.9	25.2	18.9
Unit cost of water supply and wastewater treatment (£/m^3)***	**1.64**	**1.64**	**4.33**	**4.33**
Estimated savings from greywater (£/year)	**41.33**	**31.10**	**109**	**81.74**
Cost of greywater system (£)	**3000**	**3000**	**3000**	**3000**
Payback (years)	**73**	**96**	**27**	**37**

* Thames Water (2010-11 measured charges)
http://www.thameswater.co.uk/cps/rde/xbcr/corp/201011-metered-charges-leaflet.pdf

** South West Water (2010-11 measured charges)
http://www.southwestwater.co.uk/media/pdf/e/5/FinalCS10111_webV0.1.pdf

*** For Thames Water, the sewerage contributions are based on 90% of the water you use giving you a 10% allowance for water you use but which is not returned to our sewers. This figure is 95% for South West Water.

These calculations ignore maintenance costs, which will inevitably increase payback periods. These costs are excluded as they depend on the type of system and this data is not well known. Any significant maintenance or repair costs will have a major impact on saving money.

Running costs need to be built in too. For example, chemicals and energy use for treating and pumping. In fact, payback periods may be longer than the operational life of the system.

The cost of communal systems vary more. However, they do spread the cost of installation, operation and maintenance (service contracts) so allow for a more intensive (expensive) treatment process. Supply and demand (by avoiding specific usage variations) is also evened out. Energy use could also be reduced by installing bigger, more efficient pumps and treatment processes. For all these reasons, communal systems probably make more financial sense than individual systems. Unfortunately the lack of detailed case studies on communal greywater systems means we are unable to provide evidence.

A guide published by the Construction Industry Research & Information Association (CIRIA) provides basic advice on the use and development of model operation and maintenance agreements for rainwater and greywater systems, together with simple guidance on their incorporation into developments (CIRIA 2004). This guide can be purchased from the CIRIA website[26].

Installation during construction makes systems more cost-effective; the costs of retrofitting can be very high and the process disruptive. Many existing properties in England and Wales may also be unsuitable for greywater systems that require a large area to house them (e.g. AquaCycle® 900).

[26] http://www.ciria.org

5.2 Reusing greywater in the garden

If you use a large volume of water to irrigate your garden and you purchase a simple system to divert cooled bath water, you could make substantial savings with very little capital investment.

Where the requirement for outdoor water use is significant, savings could be greater than those indicated in Table 5, assuming the supply of greywater is sufficient to meet demand. At a flow rate of 9 litres per minute, a hosepipe can use 540 litres of water per hour. Where there is significant demand for garden irrigation, which was previously met by mains water, savings could be significantly higher and payback periods shorter. For more information on how to reduce water use in the garden, see chapter 6 of our publication, *Conserving Water in Buildings*[27].

6. Energy

The section explores the energy requirements and resulting greenhouse gas emissions from greywater reuse systems. There are many different types of greywater systems available. Their energy requirements and carbon emissions will vary depending on system type, installation arrangements and level of the demand.

6.1 Carbon emissions

You would assume that treating water to drinking water quality and then flushing it down the toilet is a huge waste of energy and unnecessarily adds to carbon emissions. However, a report published by the Environment Agency estimates that potentially up to 100%[28] more carbon is emitted when using a greywater recycling system instead of mains water.

The exception to this is a short retention system. This is because:

- there is less pumping;
- collected water is stored close to both source and point of use;
- minimal treatment is required.

The carbon emissions of a greywater system can be divided into those resulting from manufacture, transportation and installation of system components (embodied emissions) and those resulting from use of the system itself (operational emissions).

6.1.1 Embodied carbon emissions

Embodied carbon is the 'cradle to site' carbon footprint and includes the materials and manufacture of the item plus distribution to the site.

Storage and treatment tanks have the highest proportion of embodied carbon. However as they tend to have a long life (if it remains undamaged a tank should last significantly longer than the typical 15 year manufacturer's warranty), so the embodied carbon emissions from the tank decreases over time. This is in contrast to pumps, which are usually the second largest contributor to embodied carbon. They will need replacing during the life of the system so their proportional contribution to embodied carbon increases over time.

[27] http://publications.environment-agency.gov.uk/pdf/GEHO1107BNJR-E-E.pdf
[28] Environment Agency 2010

6.1.2 Operational carbon emissions

Most greywater reuse systems require energy to operate; generation of this energy emits greenhouse gases. Pumping water is the greatest contributor. Estimates of operational emissions will depend on assumptions made about electricity use.

6.1.3 Carbon implications

It generally takes more energy to treat and supply a litre of greywater than a litre of mains water, so greywater is more carbon intensive than mains water. The scale of carbon emissions will depend on design of the system and components used.

Over a 30 year lifetime the net emissions split by operational and embodied energy varies considerably. Research shows that for an average 90m^2 semi-detached house with 3 occupants the split is 69% operational to 31% embodied emissions, excluding emissions from excavation and transport.

The evidence shows that collecting, storing and pumping greywater to flush toilets is not an energy saving technology. Whilst substituting mains water with treated greywater for toilet flushing will inevitably reduce mains water use, it will not reduce total water use and will have trade-offs which should be considered on an individual basis. One of these trade offs is greenhouse gas emissions.

However, it's important to put these emissions in context. The amount of energy used by even the most complex greywater systems is small compared with the energy used to heat water in the home. Heating water for domestic uses, such as showering and bathing currently contributes about 5 per cent[29] of the UK's annual greenhouse gas emissions.

Reducing use of hot water is the easiest way to reduce the energy associated with your water use. Many water efficiency measures such as aerated shower heads (which use less water but give the illusion of 'high flow') are simple and cheap to install and use. However you don't even need to change your shower head to reduce energy and water use: just spending one less minute in the shower will also save a significant amount of water and energy over a year.

See further reading for more information:

- *Energy and Carbon Implications of Rainwater Harvesting & Greywater Recycling – Final Report* **(AECOM Report)**[30]; and
- *The Water-Energy Nexus: Investigation into the energy implications of household rainwater systems, [prepared for CSIRO], Institute for Sustainable Futures, University of Technology, Sydney*[31].

6.2 Energy used in greywater system components

In general, the higher the standard of water quality required the more energy intensive the treatment process. Using cooled bath water to irrigate the garden in place of mains water will not use any energy. But using a bio-mechanical system to treat greywater will generally use more energy than if mains water was used instead.

The pump is generally the component that will require the most energy. Its energy use will be determined by how much work the pump has to do and how efficient it is. This will vary depending on the number of end uses and the location of the storage unit (underground or

[29] http://www.energysavingtrust.org.uk/Water/Water-and-energy
[30] http://publications.environment-agency.gov.uk/pdf/SCHO0610BSMQ-E-E.pdf
[31] http://www.isf.uts.edu.au/publications/retamaletal2009wenlitreview.pdf

above ground). To reduce energy use you can use a more efficient pump or design the system to use the pump less. A broad range of pumps are available and it's important to select a pump designed to suit the individual system.

6.2.1 Ultra violet treatment

UV lamps may sometimes be installed where water quality is seen as a particular priority. This involves the passing of treated water through a UV filter to kill any remaining bacteria. The use of UV lamps as part of a treatment process will also increase the energy consumption of a system.

7. Other/alternative water efficiency measures

A greywater reuse system should not be viewed as a substitute for water efficiency. Simple water saving measures can provide significant benefits at a much lower cost. We recommend that you should always reduce water use before looking to reuse or recycle water. We recommend that a **reduce, reuse, recycle** hierarchy is followed:

Reduce – for example, install a low flush (6 litre/4litre) toilet, fit low flow taps or an aerated shower; adopt efficient behaviour like turning the tap off when you brush your teeth;
Reuse – use water from a water butt to water the garden;
Recycle – install a greywater reuse system.

More information on how to save water through a variety of different water efficiency measures is available in *Conserving Water in Buildings*. For water efficient fittings please refer to www.water-efficiencylabel.org.uk.

8. Case Studies

Greywater recycling systems are not as common in the UK as they are in some other countries. Until recently, the only use of greywater in the UK was to supplement irrigation during long periods of drought.

This section sets out some examples of projects where greywater systems were installed.

8.1 Oxley Gate – Milton Keynes

Oxley Gate[32] is an environmentally friendly housing development in Milton Keynes comprising of 150 dwellings. To help the housing association meet carbon reduction targets and higher levels of Code for Sustainable Homes (CSH), the homes have been equipped with Ecoplay greywater management systems, that reuse bath and shower water for toilet flushing.

The Ecoplay system can hold up to 100 litres of water, which can provide approximately 15 toilet flushes.

[32] www.buildingtalk.com/news/pok/pok113.html

8.2 Heybridge

In 1997 Essex & Suffolk Water worked with the Building Research Establishment (BRE)[33] involving a small development of new Housing Association Homes in Heybridge, Essex[34]. Three houses had greywater systems installed. The Water Dynamics Well Butt System takes water from the bath and bathroom hand basin and filters and disinfects it (by passing it through aqua bromide tablets). This water is then used to flush toilets.

The systems were installed at a cost of £1286. Each property had a different number of people living in them and this produced varying results:

Table 6 – Household consumption

Property type	Total occupancy	Property composition	% of time the system worked	Potable water saved (%)
3 bedroom end of terrace	**3**	**1 adult, 2 teenagers**	**63%**	**53%**
3 bedroom terrace	**3**	**1 adult, 2 teenagers**	**83%**	**65%**
4 bedroom end terrace	**7**	**2 adults, 3 teenagers and 1 under 5**	**39%**	**24%**

Essex and Suffolk Water identified a number of factors that determined how much water was saved by properties as a result of installing a greywater system:

- unexpected failure of the system components during the trial reduced water saved;
- lifestyle patterns influenced the amount of water saved. The family of seven usually all bathed on a Saturday night, generating enough greywater for WC flushing up to the end of the following Tuesday. This routine of bathing at weekends only, combined with how much water the tanks hold, did not supply enough greywater for WC flushing for a full week.

As well as looking at the savings, the study also analysed the greywater quality. Samples were taken from three locations and the following observations were made:

- collection tank – low faecal indicator organisms suggested the absence of pathogens. No legionella was detected;
- WC cistern – showed the treatment process was effective as only a low number of coliforms were present, indicating the absence of any pathogens; and
- header cistern – similar observations to the WC cistern.

It was noted that the turbidity of the water increased over time in some of the collection tanks, suggesting that there is a need for regular cleaning and disinfecting.

8.3 Maidenhead Study

In ***Rainwater and Greywater in Buildings; Project and case studies*** (see further reading), Brewer et al report on a study at a new build development of executive homes in Maidenhead. In 1999 a short retention greywater system was installed that collected greywater from 2 baths, 2 showers and 3 hand basins. The collected greywater was filtered through a mesh screen before being stored underground in a garden tank that can

[33] http://www.bre.co.uk/
[34] http://www.eswater.co.uk/Waterefficientnewhomes.aspx

hold 140 litres. The water was then pumped to a cistern in the loft to serve the 5 toilets in the house.

A key feature of the system is that the cistern in the loft has an auto-drain capillary tube that allows water to slowly drain so it is not stored for too long. During the study there were issues with the pump tripping the circuit breaker meaning the greywater system was not always in operation. However, based on a month's continuous system use the following analysis was made:

Table 7 Cost of installation and payback

Item	Cost
Water use and costs	
Total annual WC water consumption	246 m^3
Total annual cost of water consumption (mains)*	£169.74
Water Savings	
Total annual greywater contribution to WC consumption	31 m^3
Annual financial savings*	£21
Annual reduction of sewage charge**	£13
Annual financial savings on water bill	**£34**

*Mains water costs assumed to be £0.69 m^3 and excluding standing charge
** Sewage disposable cost assumed to be £0.42 m^3

The data in this table was estimated to give an indication of the financial implications of installing a greywater system and should only be used as a guide due to the lack of consistent system operation during the study. Additionally, the capital cost, cost of maintenance, filters, distribution and collection pipework all need to be considered.

9 Use of greywater systems in other countries

In countries with limited water resources, greywater reuse has been practiced for a long time and on a much larger scale than in the UK. In Australia for example, areas like Melbourne see greywater reuse in gardens as a significant method to reducing domestic water demand. According to a Melbourne Water Resources Review, using greywater systems could potentially result in savings of approximately 42000 megalitres per year[35].

Internationally, legislation and incentives encourage the installation of greywater systems and may explain why they are more prevalent outside of the UK.

9.1 Legislation

The inclusion of greywater reuse in legislation results in widespread use of the technology. For example, prior to 1992, greywater recycling was not legal in California. It was considered wastewater and was required to be discharged via an approved sewerage or septic system. Driven by a combination of sustained periods of drought and the need to regulate the use of greywater for garden irrigation, the California Department of Water

[35] www.melbournewater.com.au

Resourses (CDWR[36]) produced standards for the installation and use of greywater recycling systems.

Legislation has allowed the use of greywater for garden watering, reducing the amount of mains water used and reducing water bills[37](see further reading).

9.2 Incentives

In 2006, funding from the New South Wales State Government's Water Savings Fund (now Climate Change Fund[38]), allowed Waterwise Systems[39] to investigate the benefits of greywater recycling in reducing domestic outdoor water use.

The Greywater Gardens project targeted high water uses in the Sydney Water area and installed greywater systems in participants' houses. As an incentive, 70 participants received a government rebate and a gift bag with a range of garden friendly cleaning products. The objectives were to:

- save up to 19 million litres of water per year; and
- reduce outdoor water consumption in participating households by 80-100%.

This initiative was the only state government greywater rebate available with customers eligible for a $1000 rebate on the purchase of a Greywater Gardener 230[40]. The system diverts greywater direct into the garden using a gravity powered, sub-surface drip-feed that waters the garden plants. No treatment is required as the greywater is used straight away.

The results show an average saving of 2850 litres per week and most participants confirming that greywater supply was sufficient to not require mains back up supply.

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36 www.water.ca.gov
37 Art Ludwig – *Branched Drain Greywater Systems*
38 www.environment.nsw.gov.au/grants/ccfund.htm
39 http://www.environment.nsw.gov.au/grants/recyclingprojects.htm#w
40 http://www.waterwisesystems.com/images/stories/pdf/Greywater_Gardener_230.pdf

10 Conclusions

This guide provides information on what you should consider if you are thinking of installing a greywater reuse system. There are many elements to think about; sufficient supply of greywater to meet demand, design specifics and costs to name a few. In summary, this guidance concludes that:

- There are cheaper and more simple water conservation devices, such as water butts and low flush toilets that can offer short payback periods and should be considered before a greywater system. Greywater systems should only be considered in the later stages of the reduce, reuse and recycle hierarchy.
- Greywater systems may become more common in the UK because of:

  – government building policy such as CSH;

  – the increasing cost of water;

  – an increasing awareness of the importance of conserving water.
- A greywater system provides an alternative source of water and therefore has the potential to reduce demand for mains water supply, but it does not reduce overall water consumption.
- Greywater systems vary in complexity from simple systems with minimal treatment and storage to more complex systems that can treat greywater to a standard sufficient to allow extended storage. While some simple systems have technical limitations, more complex systems have other trade-offs such as energy use (for high-tech options) and space (for intensive biological options).
- Reusing greywater at a domestic scale is generally more energy and carbon intensive than using mains water, especially when intensive treatment is used. To save energy, it is better to focus on water efficiency and specifically on reducing the volume of hot water used. Using treated greywater in place of mains water for garden irrigation saves energy and water, but the water must not be stored for long.
- Even the most intensive greywater treatment will not generally produce water suitable for drinking. It is therefore important that:
  – the water fittings regulations are followed to avoid contamination of the mains water supply; and
  – WRAS guidance on pipe labelling is followed to avoid cross connections.
- Greywater reuse systems should comply with **BS8525** to ensure maximum benefit and compliance with legislation.
- Whilst there are currently no water quality standards, **BS8525** has introduced embedded water quality parameters for water reuse applications.
- Greywater systems have lengthy payback periods. These vary depending on demand for non-potable water and local water charges. Payback periods may be shorter in future as systems become cheaper and water charges increase.
- It is cheaper and easier to install greywater systems during construction or major refurbishment than retrofitting into an existing building.
- Communal systems avoid many of the issues associated with individual installations. They can offer improved supply/demand balance, superior water

quality, greater system reliability (through better maintenance) and more reliable cost savings. However, public acceptability and an increased risk of cross connections need to be taken into account.

- The reliability of greywater systems remains largely unproven and maintenance costs are uncertain.

- Greywater can provide a more reliable and consistent supply of non-potable water than rainwater harvesting.

Suggestions for further reading

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• Water Regulations Advisory Scheme (WRAS), 1999 *Marking and Identification of Pipework for Reclaimed (Greywater) Systems*. WRAS Information and Guidance Note No 9-02-05. Gwent: WRAS. Available from: http://www.wras.co.uk/PDF_Files/IGN%209-02-05%20Marking.pdf.

Glossary of terms

Air gap	A physical break between the lowest level of the water and the maximum fault level of an appliance, installation, feed pipe, or an inlet
Backflow	Fluid that moves from downstream to upstream within an installation
Back-up supply	Supply of potable water that can supplement the non-potable supply when required
Cistern	A fixed container for holding water to be used as part of a plumbing system
Coliform	Bacteria found in the intestines, faeces, nutrient-rich waters, soil and decaying plant matter
Cross-contamination	Contamination resulting from the connection of pipes carrying mains water to pipes carrying non-potable water
Greywater	Domestic wastewater excluding faecal matter and urine
Greywater reuse	Utilising greywater for purposes that do not require potable water quality
Legionella	A bacterium named *Legionalle pneumophila* that can cause legionnaire's disease (lung infection)
Non-potable water	Any water other than potable water
Non-return valve	A pipe fitting that limits flow to one direction only
Potable water	Water suitable for human consumption that meets the requirements of Section 67 of the Water Industry Act 1991 [7]
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 in England and Wales, the Water (Scotland) Act 1980 [8] in Scotland, or the Water and Sewerage Services (Northern Ireland) Order 2006 [9] in Northern Ireland.

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