BNWAT 19: Alternative sources of water – greywater and rainwater reuse: Innovation Briefing Note

Version 1.3

This Briefing Note and referenced information is a public consultation document and will be used to inform Government decisions. The information and analysis form part of the Evidence Base created by Defra's Market Transformation Programme.

1 Summary

The common perception is that England and Wales receive plenty of rain. However, the growing concentration of population in the southeast, coupled with the effects of climate change, means that water resources in some regions are increasingly under pressure. Building more homes in the southeast will only increase the demand for potable water in this already water-stressed region.

At present, most buildings use water from the public supply, treated to drinking water quality standards (wholesome water) for all domestic use. The use of wholesome water for toilet flushing accounts for around 30% of the water used in the average household. Alternative sources of water such as greywater, rainwater and reclaimed water can be used instead of mains water for a number of purposes where non-wholesome water is satisfactory, such as toilet flushing and garden watering. However, there are a number of issues to overcome before the technology is widely accepted.

In new and existing homes, it is generally more economic to reduce water use by fitting more water efficient appliances and educating customers in 'waterwise' behaviour before considering the use of either rainwater (except a garden water butt) or greywater. However, for new developments, using an alternative source of water for some applications that do not require drinking quality water may be a feasible option, providing it is taken into account at the planning or construction stage.

2 Sector profile

Approximately two thirds of mains drinking quality water are used by the domestic sector in England and Wales, but water is a finite resource and the need to reduce water usage is based on three primary factors:

- The increasing use of water. Water use has increased in recent years (eg we wash more frequently[1]). Also, the overall requirement for water has increased due to the changing demographic toward more single dwellers.
- The increasing number of households
- The impact of climate change, which is likely to result in more extreme rainfall patterns

The suitability and sustainability of developments will increasingly be judged, in part, on their requirements for water supply and wastewater removal.

Development in southern England (eg the Thames Gateway, for the Olympics, etc) will place additional pressure on water supply in an already water-stressed region of the country.

Sustainable water management is essential to protect the water environment and to meet current and future demand. The key to water efficiency is reducing waste, not restricting use.

3 Definitions

3.1 Greywater

Greywater – water originating from the mains wholesome water supply that has been used for bathing (showers or baths) and in hand basins is usually clean enough for flushing the WC, following basic treatment.

3.2 Rainwater

Rainwater – water collected from the external surfaces of buildings or hard-standing areas by diverting the flow to a storage tank.

3.3 Reclaimed water

Reclaimed water – water, other than water direct from the mains (eg untreated borehole water), that has been used in a process and is collected and treated for specific non-wholesome applications such as irrigation or the flushing of WCs.

4 Drivers and the water hierarchy

There are many ways to improve water efficiency and reduce waste by encouraging innovation or the wider adoption of proven technologies, for example:

- WCs that use less than 5 litres, regardless of water pressure and either don't leak or warn of leakage.

[1] Architectural Digest for the 21st Century, Oxford Brookes University

- Shower development that improves performance with minimum water use.
- Tap design that incorporates a standard outlet for sprays, aerators etc, or includes an 'eco brake'.
- Creating incentives for designers to come up with new features that save water and energy.

However, the overriding objective is to reduce consumption of water in households by encouraging the efficient use of water. This can be achieved through:-

4.1 Education

- Turning off taps when cleaning teeth.
- Filling kettles with only the amount required.
- Keeping grass longer during summer months.
- Only using the washing machine with full loads.
- Fixing dripping taps.

4.2 Identifying ways of raising awareness about water efficiency.

- Metering, monitoring and targeting to evaluate and quantify current water supply, use and disposal.
- Identifying where usage occurs – water products usage (labelling).
- Evaluating the potential for water saving.

4.3 Legislation

- Strategic Regional Plans.
- London Assembly's Water Plan.
- New Building Regulations Approved Document G.

4.4 Engineering solutions

- Water efficient appliances.
- Labelling.
- Rainwater harvesting.
- Greywater recycling.
- Reclaimed water.

This Briefing Note considers the 'engineering' solution of this water efficiency hierarchy by considering alternative sources, such as rainwater harvesting and greywater, for certain uses where non-wholesome water is satisfactory thus reducing the demand on mains drinking quality water.

While it is possible to introduce both these alternative water sources into existing buildings, consideration at the planning stage can improve their effectiveness, make installation more straightforward and reduce cost.

In addition to the strain on water resources, there are also concerns about rainwater drainage from urban areas. Planning authorities are required to consider the effects of surface water drainage and the potential impact on flood risk, (in England, Planning Policy Guidance Note 25 (PPG25)). This means that the accepted approach to rainwater drainage will have to change, resulting in increasingly strict

controls on run-off from sites. Rainwater harvesting can contribute to an overall approach to sustainable urban drainage systems (SUDS).

Reclaimed water systems can play a part in water conservation by reducing the amount of mains supplied water used in the home and non-domestic buildings. However, it is vital to ensure that the design, installation and maintenance of such systems do not compromise public health by contamination of the wholesome mains water supply through inadvertent cross-connection or backflow. Installations must, therefore, comply with the Water Supply (Water Fittings) Regulations 1999 in England and Wales[2] and Approved Document H of the Building Regulations[3].

5 Goals

At present, rainwater (and greywater) systems are not common in England and Wales for four main reasons:

- The relatively high cost of the systems.
- Concerns that the quality of the water (particularly greywater) may pose a risk to health.
- In order to benefit financially from an alternative water source, the normal wholesome supply needs to be metered. At present the national average of domestic customers that have meters is 26%[4] so, although they may have meters fitted free of charge, at present the majority of home owners would have no immediate financial incentive for an alternative water use.
- The relatively low cost of water in England and Wales

In existing homes, it is generally more economic to make use of water saving appliances than to use either rainwater (except a garden water butt) or greywater. However, with new developments, alternative sources of water can be a more feasible opportunity.

The situation is different for non-domestic premises as these are generally all metered and the savings achieved, by rainwater harvesting systems in particular, will be greater in larger buildings (such as industrial units and schools) due to their larger roof areas and potentially greater demand.

Using rainwater for garden watering, toilet flushing and washing machines could save up to around 50% of household water use[5]. Correctly collected and stored, rainwater can meet all these requirements without further treatment. However, in practice, most domestic roof areas are too small to satisfy all this potential demand (regardless of practical storage tank capacity) so it is important to evaluate the potential savings before investing in an expensive installation.

In non-domestic premises, however, rainwater may be used in many other areas of application as a substitute for mains water (eg cleaning, process water, irrigation and humidification, fire–fighting, toilet flushing etc) In addition, reclaimed water might be

[2] Water Supply (Water Fittings) Regulations 1999 in England and Wales
[3] ODPM, Building Regulations Approved Document H – Drainage and waste disposal. 2002 Edition.
[4] OFWAT, Security of supply, leakage and the efficient use of water, report 2004-05
[5] Environment Agency Fact Card.

reused along with rainwater in industrial applications (eg for cooling water, filter backwash water and some process water).

Using greywater or reclaimed water could save around 18,000 litres of water a year for each person. This typically represents around a third of the household water that is used for flushing WCs. However, as greywater is usually collected waste water from baths, showers and washbasins, personal bathing habits will influence the potential for actual saving because collection needs to roughly balance usage to achieve the greatest benefit. Greywater from baths, showers and washbasins is usually clean enough for flushing WCs after only basic biological treatment, but problems with water quality can arise when warm, nutrient-rich greywater is untreated, as bacteria levels can build up in tanks, WC cisterns and pipes etc. It is, therefore, undesirable to have too large a storage tank.

Other components in a greywater system may include a filter to remove coarse matter, a disinfection process, a pump and a header tank plus piped connection to the WC(s). The header tank should also incorporate a mains water connection for when supply does not meet demand and this must include backflow protection, in order to comply with the Water Supply (Water Fittings) Regulations 1999 and prevent contamination of the mains supply.

For a larger scale system, greywater may be treated in the same way as sewerage using traditional biological methods combined with modern filtration methods. Such a system may be combined with a sustainable drainage system as a concept at a building's design stage rather than post construction retrofit. The economy in both the reduction of water and sewerage charges may tip the financial balance in favour of such a system.

6 Demand and economics

An alternative water supply removes some of the demand from the wholesome mains water supply while, at the same time, reducing the volume of water discharged into drainage system. However, there are a number of significant obstacles to be overcome before such systems can be used outside a niche market.

On average, each person in England and Wales uses just over 150 litres of mains, drinking quality water every day[6], so a family of four uses around 220,000 litres per year. In theory, of this average mains water use, approximately 50% is used for non-potable applications and could be met from rainwater or around one third could be met from greywater. So for a four-person household there is a potential saving of around 300 litres per day from the use of rainwater or around 180 litres per day from greywater (WC flushing only).

Unfortunately, alternative water systems are unlikely to achieve these savings due to limited catchment area, rainfall and storage capacity for rainwater harvesting or the mismatch in use and reuse for greywater.

[6] OFWAT Security of supply, leakage and the efficient use of water. 2003-2004 report.

In addition to the component cost for an alternative water source, there is also the cost of installation and maintenance to consider. A rainwater harvesting system will require labour and excavation equipment to install the storage tank and all the systems will require a trained plumber to install the ancillary components and distribution pipework.

At present, any financial gain from a small-scale alternative water source is minimised by the relatively low cost of mains water in England and Wales. In addition, on average, only 26% of household have metered water bills. However, new dwellings are metered and it costs less to design and install an alternative water source into a new dwelling.

It may also be possible to incorporate communal systems into large-scale housing developments thus bringing economies of scale to the installation, performance and maintenance of the systems.

Conversely, water companies share a concern that they will be called upon to support rainwater collection systems in drought conditions, which has an impact on water resource planning.

7 Design considerations and maintenance

7.1 Regulations

- Water Supply (Water Fittings) Regulations 1999 in England and Wales.
- Building Regulations Parts G and H.
- Water Supply (Water Quality) Regulations 2000 (May be too strict for harvested rainwater. Not applicable unless water is used for domestic purposes, which excludes toilet flushing and garden watering).

7.2 Space for tanks – rainwater or greywater

- Underground storage tank for rainwater.
- Collection/holding tank for grey/recycled water positioned in a relatively cool but frost-free environment to minimise bacterial growth.

7.3 Rainwater collection area/rainfall/storage

- Rainwater may be harvested from roofs and hard-standing, such as driveways.
- The total catchment area should take account of both roof area in m^2 and, if used, the water run-off from a hard standing into a sustainable drainage system.
- A drainage coefficient (run-off factor) is used to adjust the efficiency of collection and, therefore, the required size of tank.
- Filter efficiency will also have an effect on the harvested quantity.
- Local rainfall data may be available from the Environment Agency or the Meteorological Office.
- For domestic application, rainwater storage tanks are commonly sized at 5% of the rainwater supply or of annual demand, using the smallest of the figures.
- Rainwater tanks are usually sized according to the following formula: Tank size (l) = catchment area (m^2) x drainage coefficient x filter efficiency x annual rainfall x 5%.

- The design of non-domestic systems may be more thoroughly considered, particularly where specific needs are to be catered for.

7.4 Storage tanks and pipework

- Greywater holding tanks need to be sized to hold a useful reserve while maintaining a reasonable throughput. Too big, and water will remain unused for too long, too small, and the full benefit will not be realised.
- Rainwater is usually pumped from the underground storage tank to a header tank located at high level. A similar arrangement is commonly used for greywater.
    - In the event that the alternative water supply cannot meet demand though lack of rain or pump failure, mains water may be used to top up the tank via a required type AA air gap.
    - Some appliances can be adapted for a connection to both wholesome and a non-wholesome water supply (eg a WC cistern may be adapted for dual feed, provided that a type AA air gap is provided to prevent mains water contamination).
    - All pipework carrying non-wholesome water must be clearly marked.
- All installations must comply with the Water Regulations.

7.5 System pumps may be either submersible or suction.

- A submersible pump would be located in the main storage tank, a suction pump would need to be sited in a frost-free location close to the main storage tank.
- Automatic sensors are usually used to activate the pumps to replenish the header tank or directly refill a WC cistern.
- Sensors to protect pumps from dry running should also be considered.
- Filters are the first line of treatment, initially preventing solid debris from entering the holding tank. Finer downstream filters may be required depending on the uses to which the alternative water supply is to be put.
- For greywater (and where rainwater may be used for applications other than flushing the WC), disinfection or additional water treatment will be required to subdue bacterial growth and improve water quality.
- For any alternative water supply, frost protection must be taken into account in the system design and installation.

7.6 Maintenance

An alternative water supply is not a ‘fit and forget’ technology, maintenance schedules must be adhered to in order to keep a system running correctly and avoid bacterial growth and contamination. Maintenance should, therefore, include[7] :

- General cleaning and maintenance of rainwater collection areas.
- Removal of debris that could block a system.
- Annual visual inspection of the system components.
- Cleaning/replacement of filters in accordance with the manufacturer’s recommendations.
- Regular checks on greywater disinfection in accordance with the manufacturer’s recommendations.

[7] This is not an exhaustive maintenance list. In general, specific guidance supplied by a system installer or OEM should be followed and adhered to.

- Checks that the mains water top-up is functioning.

7.7 Planning

Water metering and new buildings in the Thames Gateway and water-stressed southeast of England may increase the requirement for architects and planners to design and install alternative sources of water in new buildings.

8 Costs

At present, water is relatively inexpensive in England and Wales, typically around 89p/m^3 for supply + 46p/m^3 for wastewater services[8]. The installation of an alternative domestic water supply is quite costly, with an initial outlay of around £1,500 for a basic system and plumbing and fitting costs which can exceed £1,000. How much money is saved depends on the supply and demand for water, maintenance needs and the lifetime of parts before they need replacing. Suppliers of rainwater harvesting systems currently claim savings of over 14% of water used by the average household, but this still gives payback periods well in excess of 10 years.

In the short term, water conservation devices and water efficient products offer greater financial and water saving benefits. However, in the longer term, the financial and environmental benefits for the water-stressed areas of England and Wales may well shift the balance in favour of alternative water supplies.

8.1 Benefits

- Reduction in water bills.
- Reduction in wastewater treatment charges.
- Reduced discharge into the storm water/sewerage systems.

8.2 Disadvantages

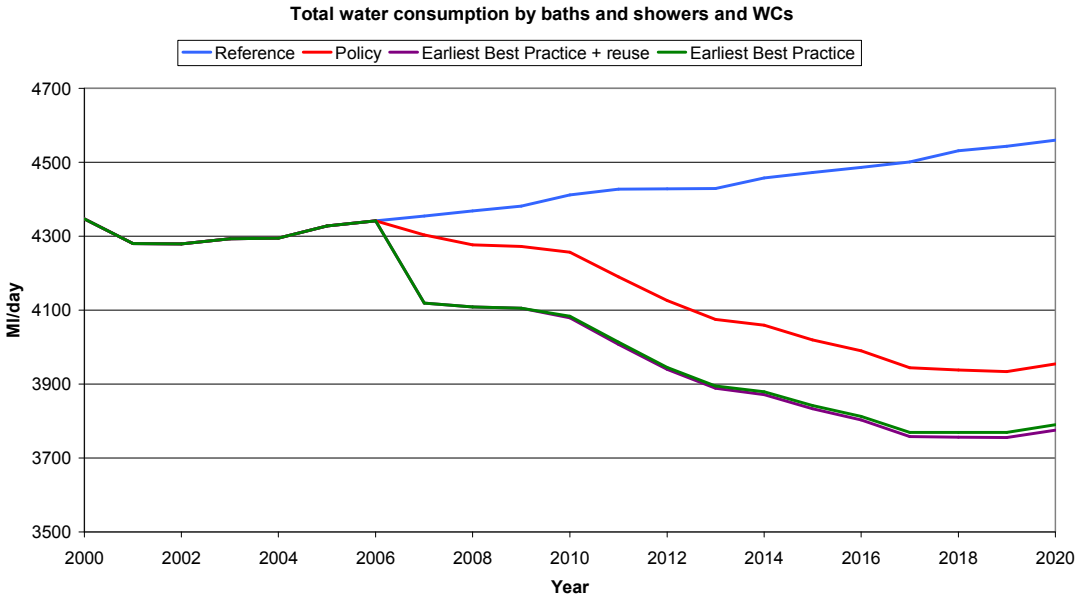
- Capital costs.
- Installation issues.
- Maintenance costs.
- Impact on water resource planning.

9 Effect on MTP scenarios

The effect on MTP scenarios assumes a phased uptake in alternative water supplies over the next fifteen to twenty years, particularly for new build applications.

[8] Thames Water.

Figure 1 The effect of the use of alternative sources of water on MTP scenarios for domestic water consumption.



In Figure 1 above:

- The reference line assumes a continuation of the current rising trend in per-capita water consumption.
- The P1 line illustrates the predicted reduction in consumption if the water sector P1 policies and action plans for water conservation are fully realised.
- The EBP line illustrates the additional reduction in water consumption predicted if the uptake of the Environmental Best Practice strategy and action plan is fully realised.
- Finally, the EBP + reuse line illustrates the predicted effect on per-capita consumption if a proportion of daily use is met from an alternative water supply for WC flushing.

Assumptions are that a rainwater system could provide[9]:

- 25% WC flush water;
- 25% clothes washing;
- 20% garden watering;
- 25% car wash water.

A greywater system could provide:

- 30% WC flush water.

Predicted system uptake would be:

[9] Note, the modelling in Figure 1 currently only covers baths, showers and WCs and therefore the impacts of rainwater on clothes, garden and car washing usage are not considered within the Figure.

- By 2010 – 0.5% of homes have some rainwater harvesting and another 0.5% reuse some greywater.
- By 2015 – 1.0% of homes have some rainwater harvesting and another 1.0% reuse some greywater.
- By 2020 – 2.0% of homes have some rainwater harvesting and another 2.0% reuse some greywater.

10 Critical issues

Water supply and storm water management are becoming of increasing concern in many parts of England and Wales. Technology such as rainwater harvesting and greywater recycling, together with sustainable drainage systems, needs to be considered from the outset on all new developments.

Rainwater that can lead to flooding is considered a problem for planners. The perception that rainwater needs to be drained and disposed of as quickly as possible needs addressing to encourage its retention as an asset for non-wholesome use.

Rainwater is free of charge and can be used in many commercial applications. Since rainwater harvesting equipment has been added to the Enhanced Capital Allowance Scheme[10], businesses can now offset 100% of the cost and installation of the equipment listed on the Water Technology List against their taxable profits in the year the equipment was purchased.

Other potential reasons for installing rainwater harvesting equipment include:-

- Financial reasons, such as reduced water supply and disposal charges.
- Promotional reasons, such as presenting a distinct environmental image, assisting with a planning proposal or contributing towards a better BREEAM[11] or EcoHomes[12] rating.
- Technical reasons, such as a need for naturally soft water in a hard water area.
- Ecological reasons, such as reduced consumption of wholesome water combined with the possibility that rainwater harvesting may be able to contribute to an overall approach to SUDS.

Greywater and recycled water systems do not attract the ECA benefit of rainwater systems; however, their installation and use can still reduce both the demand for wholesome water and drainage discharge. At present, their installation as a retrofit together with their frequent maintenance requirements suggest that any financial saving will be small, leading to a long payback period. Although greywater systems have the potential to save up to 30% of water, a number of issues need to be resolved, including a return to sewer charges, before greywater systems are widely accepted.

[10] Details of the Enhanced Capital Allowance Scheme can be found at www.eca-water.gov.uk
[11] BRE's Environmental Assessment Method (BREEAM)
[12] EcoHomes 2005 – The environmental rating for homes

However, perhaps the two biggest barriers to the widespread uptake of greywater recycling are public concern about the risk to health and system maintenance requirements. The health concerns are twofold: firstly, the health risk from contact with greywater in the normal operation of the system and, secondly, the health risk posed by the failure or ineffective operation of the treatment system. Greywater recycling systems are designed for minimal user contact with the greywater. Aerosols from toilet flushing are the only potential contact most users will have with the water and this is unlikely to have health implications providing the manufacturer's maintenance procedures are followed and the water has been properly treated.

More research is required into the energy consumption of rainwater and greywater systems, and the carbon impact of using these rather than central supplies. If the carbon footprint of using a greywater system far outweighs that of using a central supply, then the priority of water saving vs. carbon saving needs to be considered. Coupled with this, if the energy costs of running a greywater or rainwater system are too high, the costs to the customer will exceed the saving on water bills.

11 Actions

Much more work remains to be done to understand the behaviour of water users, and it is feasible that consumers will continue to 'waste' water within the home despite having rainwater/grey water harvesting equipment installed.

- It is important to continue to educate and engage customers in 'waterwise' behaviour and to encourage them to overcome the barriers to reducing waste - breaking habitual behaviour is one of the hardest things to do.
- Before embarking on complicated engineering solutions, improve water efficiency and reduce waste by encouraging the wider adoption of proven water saving technologies.
- MTP should support and encourage the water companies who are actively involved in educational activities to promote alternative sources of water, such as rainwater butts for home use and the cost saving potential of greywater and rainwater systems.
- Encouraging developers to have the confidence to offer systems (or even water butts) to private customers could seed the market, leading to a fall in cost together with more confidence in reliability of the technology.
- Progress the review of water quality standards for recycled and rainwater use in the home. At present, there are no specific standards.
  MTP is currently undertaking a review of water quality standards and recommendations for the UK for rainwater and greywater. The objective of the study is to publish a consensus-based action plan that lays out policy and stakeholder actions over a period of 10 to 20 years to ensure deployment of rainwater and/or greywater recycling technologies as mainstream in the construction sector.
- Approximately 40 litres of the average household water consumption is consumed each day for flushing the WC. If only 0.5% of homes had rainwater harvesting installed and another 0.5% could reuse greywater there is a potential to save around 17Ml/day which would equate to about 6,200 megalitres per year.

More research is also required to better understand the carbon impact of rainwater and greywater systems.

There are a number of significant obstacles to be overcome before greywater or rainwater technology can advance beyond a niche market. However, various incentives could be considered to increase appropriate uptake, as listed below.

11.1 Financial incentives.

- Subsidising the installation (rebate).
- Purchase tax incentive (lower VAT).
- Council tax incentive (lower rateable value).
- Lower water charges.
- Higher stamp duty threshold for homes with an alternative water supply.

11.2 Regulator incentives.

- New Building Regulations Approved Document G.
- Strategic Regional Plans.
- London Assembly's Water Plan.
- Code for Sustainable Homes.

Finally, while the term rainwater harvesting presents a positive environmentally friendly technology, the term greywater is rather off-putting. Within the water industry, greywater has a fairly specific identity, however, the public are somewhat uneasy about the perception of greywater. A more positive nomenclature, for example 'silver' water, together with a corresponding publicity campaign may help to improve its image and the corresponding uptake.

Related MTP information

Changes from version 1.2

Figure 1 has been updated in line with MTP modelling.

Consultation and further information

Stakeholders are encouraged to review this document and provide suggestions that may improve the quality of information provided, email **info@mtprog.com** quoting the document reference, or call the MTP enquiry line on +44 (0) 845 600 8951.

For further information on related issues visit **www.mtprog.com**