Environment Agency

conserving water in buildings

A practical guide

We are the Environment Agency. It's our job to look after your environment and make it a better place – for you, and for future generations.

Your environment is the air you breathe, the water you drink and the ground you walk on. Working with business, Government and society as a whole, we are making your environment cleaner and healthier.

The Environment Agency. Out there, making your environment a better place.

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Introduction

Water is essential for life. We use it in our homes and gardens, in commerce, industry and agriculture. We need to use water wisely to make sure that we have enough to meet our needs as well as the needs of the environment, now and in the future.

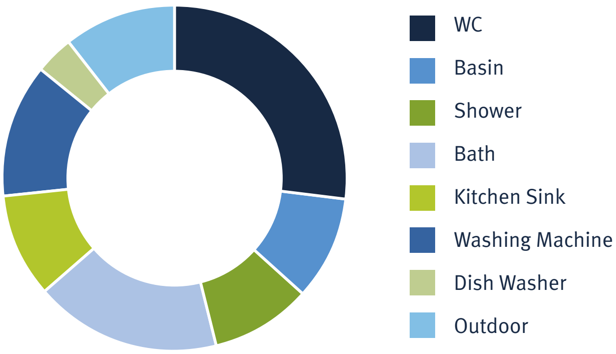
Although England and Wales are often considered to have a wet climate, high population density means that some parts of the country have less water available per person than many Mediterranean countries.

Climate change experts predict that we will experience more extreme weather patterns, with wetter winters and drier summers. This could mean less water when we need it most, unless we use water wisely and make the best use of the resources available.

Simply adopting good habits can save a considerable amount of water, for instance using your washing machine or dishwasher only when full, or fixing dripping taps promptly.

This document shows you how to save water through a variety of water efficiency measures. Each chapter is dedicated to a different type of water use and some water saving measures cost very little. For instance toilet retrofit options which convert your toilet to variable flush, or taps with spray fittings. The more costly measures may be appropriate when constructing a new building or carrying out major renovation work, for instance, installing efficient toilets or shortening pipe runs to reduce the time taken for water to run hot.

Figure 1: Daily water usage in an average household



Source: *Assessing the cost of compliance with the code for sustainable homes*. Environment Agency (2007)

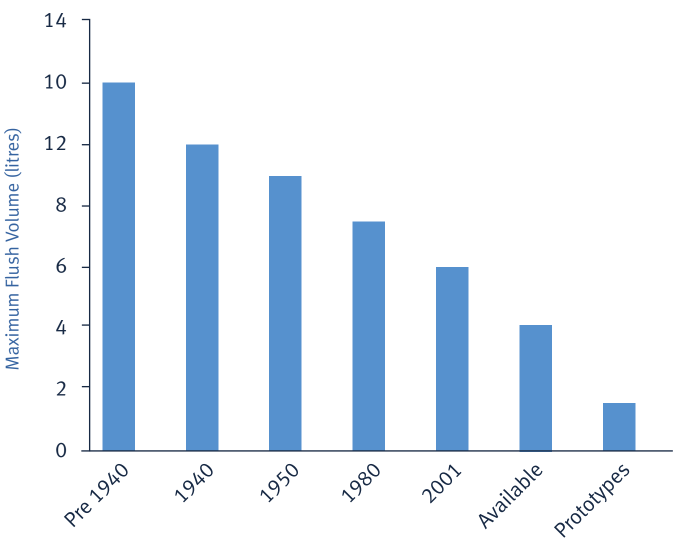
Conserving water in buildings shows you how you can reduce the amount of water you use, not only saving water and the natural environment but also saving money (if you are metered), whether at home or at work. We have selected all the measures on the basis that they perform well when fitted and used correctly.

Note: Reference to Water Regulations in this document includes reference to the Water Supply (Water Fittings) Regulations 1999 in England and Wales, the Scottish Water Byelaws 2004 and Water Regulations, Northern Ireland or whatever regulations might replace these.

1 toilets

It is essential that toilets flush effectively to maintain standards of hygiene, but designs are now available that use significantly less water than was required in the past. In older properties, flushing the toilet represents the largest proportion of water used in the home. An average household[1] with a nine litre toilet flushes around 110 litres down the pan – that's 30 per cent its total water consumption per day. This should reduce as older toilets are replaced with newer ones with lower flush volumes. Toilets in offices, schools and public conveniences account for an even greater proportion of total water use although the exact percentage will depend on factors such as whether urinals are available.

Figure 2: Toilet full flush volumes have reduced and continue to fall



Valves and siphons

Before January 2001, all domestic toilets in the UK had to use a siphon flush, which was originally developed to prevent water wastage. When we pull the handle, a piston lifts water to start a siphon, which empties the cistern into the toilet bowl. When the cistern is empty the siphon is broken and the cistern refills ready for the next flush.

Since January 2001 approved drop valves and flap valves have been permitted. These allow a button operated flush and more obvious two-button dual-flush operation. But sooner or later, unlike the siphon, they will leak. The Water Regulations require endurance testing of 200,000 flushes under laboratory conditions, but mechanisms can be incorrectly installed and debris can enter the cistern during installation, causing immediate leaks. Evidence from water companies shows that leakage from valves is already becoming a serious problem[2].

From a sample of over 500 properties that were investigated due to unusually high water bills, Bournemouth and West Hampshire Water identified 31 properties where the cause of the high water use was leaking drop valve operated toilets. On average, six month water bills for these properties were over £370 more than the bill for the six month period before the leak.

1 Average occupancy 2.4 people.

2 Data supplied by Bournemouth and West Hampshire Water for the period July 05 to Jan 07.

Table 1: Comparisons of toilet flushing mechanisms.

Flush mechanism	Advantages	Disadvantages
Siphon flush (all UK toilets prior to 2001)	• No leakage • Fail-safe • Robust • Familiar technology in UK	• Lever rather than button(s) • Dual flush operation less obvious to the user • Gives a lower flow rate than a drop valve toilet
Drop valve	• Can be button operated • Dual flush operation is more easily understood by user • Allows lower flush volumes by giving a higher flow rate	• Will eventually leak which can be hard to detect • Poor installation or DIY intervention can cause valve to stick • Seals are vulnerable in hard water areas

Detecting a leaking flush valve

Small leaks are likely to go unnoticed but should be detected by the following test:

If the toilet has been flushed recently, allow the water under the rim to drain for about a minute. Wearing rubber gloves, dry the back of the pan below the rim with toilet paper. Any leak should be obvious. If you can't see a leak, hold a sheet of toilet paper against the back of the pan for about 30 seconds and check that it stays dry. Since most cisterns with valves have an internal overflow that discharges into the pan, a leak could be due to either the inlet or the flush valve. If turning off the water to the toilet quickly stops the leak, check the inlet valve.

Dual flush

Dual flush siphon and valve flush toilets both offer potential savings, particularly in the home. For commercial and public toilets, the savings are likely to be less, as users may not know how to use the system and will often have no financial incentive to save water.

Typically the effective flush volume has been calculated as the average of one full flush and three reduced flushes. Therefore a 6/4 dual flush toilet should average 4.5 litres per flush, but this figure can vary depending on who is using it.

When specifying water efficient toilets, check the Water Technology List for approved products at:

www.eca-water.gov.uk

Low-cost retrofit options

One of the most cost effective domestic water efficiency measures[3] is to convert an existing toilet to variable flush and/or to optimise the full flush volume. Retaining the original siphon avoids the problem of leaking valves.

Effective flushing volumes

An effective flush volume is the volume of water needed to clear the toilet pan and transport solids far enough to avoid blocking the drain. In reality, few toilets when fitted flush with the optimum volume of water. Too little water will lead to double flushing and increased risk of the drain blocking, whilst too much will waste water. Many devices are available to avoid wasting water. Some displace a volume of water in the cistern and so reduce each flush by an equivalent amount, typically one litre. Before and after you fit this type of device check that the flush works well, that the inlet valve does not leak and that it is adjusted so that the water is up to the level marked in the cistern. Lowering the water level will reduce the flush volume, but may also make the flush less efficient. Cistern displacement devices are often available free of charge from local water companies, or a suitable plastic bottle filled with water can be placed in the cistern.

If double flushing is needed to clear the pan, the amount of water used could actually increase. If there are problems with flushing, remove the cistern displacement device immediately.

Variable flush devices

These devices allow the user to choose how much water is used for each flush. Some allow a flush to be interrupted once the pan is clear and some allow one of several pre-determined flush volumes to be selected before flushing. Fitting variable flush retrofit devices resulted in an 8.5 per cent reduction in total domestic water use in trials by water companies and the Environment Agency[4].

[3] *The Economics of Water Efficient Products in the Household*, Environment Agency 2003

[4] *Retrofitting variable flush mechanism to existing toilets*, Environment Agency 2005.

Individual households have achieved even greater savings with no evidence of double flushing. Many older toilets are already fitted with dual flush siphons, but with the dual flush function disabled by adding a small plug. Removing this plug converts a nine litre toilet into a 9/4 dual flush and requires the flush lever to be held down to achieve a full flush.

Retrofit devices that follow the same 'pull and hold for full flush' are available. This seems logical but people will need to be told what to do. Whilst instruction stickers are supplied, these are often not fitted for aesthetic reasons.

The Thomas Dudley Duo siphon is designed so that it defaults to full flush. Whilst there is a risk that users may never discover the part flush function, visitors will be spared embarrassment and repeated flushing.

Delayed action inlet valves

As a toilet flushes, it immediately starts to refill so the actual flush can be significantly greater than expected. In a simple test, Portsmouth Water researchers found that a 5.8 litre flush increased to 6.8 litres with the inlet valve left on during the flush – a 17 per cent increase. This problem is solved by the Torbec Ecofill inlet valve which stays shut until the flush has stopped.

Do low flush toilets cause drain blockage?

Properly designed and correctly installed toilets with flush volumes as low as four litres can be connected to conventional drains without fear that the drains will become blocked[6]. When the existing nine litre toilets at St Leonard's Middle School, Hastings were replaced with four litre water efficient models, the previous problems of bad smells and blockages disappeared[7]. For flush volumes lower than four litres care may be needed with the design of the drain.

As the amount of water we use has increased considerably since most of the UK's sewers were built, sewers (mains drains) are no more likely to become blocked due to less water being used to flush the toilet or indeed due to any other water efficiency measures.

Regulations

Toilets that are to be connected to the mains water supply must meet the Government's performance specification[8]. Water Regulations Advisory Scheme (WRAS) approval is the best way to demonstrate that a product complies, but there is no legal requirement to independently test and verify products.

Table 2: Low cost retrofit devices that retain the leak-free siphon. The cheapest of these devices can be obtained free of charge and the most expensive will cost up to £20 to buy plus installation costs.

Device	Saving per flush[5]	Advantages	Disadvantages	Cost
Cistern displacement devices	0.5 to 2.5 litres	• Low cost or DIY labour only	• Only beneficial if the existing full flush is excessive	£
Interruptible flush – user releases lever or pushes a button when the pan is clear	30%	• Low flush default forces regular user to learn the operation • Accurate control of flush volume possible	• First time users may assume the flush is ineffective unless instructions are provided • Potential for double flushing	££
Variable flush – knob rotated for high, medium and low flush	30%	• Obvious operation without instructions	• Might not appeal visually to all users • Requires two operations, adjust and flush • Potential for double flushing	££
Dual flush retrofit or replacement siphon – default to part flush	30%	• Low flush default forces regular user to learn the operation	• First time users may assume the flush is ineffective unless instructions are provided • Potential for double flushing	£££
Dual flush retrofit or replacement siphon – default to full flush	30%	• Pan should always be cleared	• Without instructions, users might never discover the part flush function	£££

[5] This will vary depending on the toilet performance, existing flush volume and user awareness.

[6] Lillywhite, MST, Webster, CJD and Griggs, JC. 1987. Low-water-use washdown WCs. BRE.

[7] Keating and Styles. 2004. Performance Assessment of Low Volume Flush Toilets; St Leonards Middle School, Hastings. Southern Water.

[8] Water Supply (water fittings) Regulations 1999: WC Suite Performance Specifications.

WRAS approved toilets will have been tested for flush performance including a trailing-volume test, which is an indicator of drain line carry.

The future

Some technologies exist or are being developed to achieve even lower flush volumes, but the currently available four-litre (full flush) and two-three litre reduced flush approaches the lower limit for conventional drains. Using smaller diameter drains or boosters that collect a number of flushes before discharging them all at once, could allow flush volumes to be reduced further for new developments in the future.

A prototype currently undergoing independent trials is claimed to work effectively with only 1.5 litres of water per flush. This frugal performance is achieved by using air pressure to help clear the pan.

Alternative technology

Vacuum and compressed air toilets

Vacuum drainage is used in trains, boats and aircraft where it is necessary to use the minimum amount of water. It is not currently cost-effective or practical for houses or flats.

Macerating toilets

Marine toilets using compressed air and low-flush macerating toilets are a lower-cost option, and have been used in houses, particularly where cesspool-emptying charges make them very cost-effective. Compressed air can be used to increase the force of the flush, allowing less water to be used. Macerators can be used to break down solids to make them easier to flush away and reduce the volume of water required. You would need to make sure that the installation complies with the Water Regulations if the toilet has a direct mains water connection, as some designs have to be modified to comply. Macerating toilets are an especially useful technology in properties with long drains or in basement flats.

Compost toilets

Composting and other dry toilets do not need water at all, but are not currently suitable for general use in the UK. However, for sites without a reliable water supply or drainage, they can be an excellent solution.

Further information

Water Conservation: a guide for installation and maintenance of low-flush WCs, BRE 1997, Published by CRC.

Lifting the Lid, Harper and Halestrap, Centre for Alternative Technology 1999

Waterwise: **www.waterwise.org.uk**

2 urinals

Uncontrolled urinal flushing can easily account for most of the water used in public and commercial buildings. Fitting flush controllers or waterless urinals overcomes this problem. Waterless urinals that use no water, other than for daily cleaning, are now widely available and the best designs effectively eliminate odour and trap blockage problems. Either option can be a cost effective solution for reducing the amount of water used.

Urinal controls

Many urinal installations do not have controls and so flush continuously, and often at a higher rate than specified by the regulations. For an office with a 40-hour working week this means that 76 per cent of the flushing occurs when the building is unoccupied.

Under the Water Regulations, urinals should use no more than 7.5 litres per bowl per hour (10 litres for a single bowl) and should have a device fitted to prevent flushing when the building is not being used. In practice, flow rates are rarely measured and will drift with time, or are deliberately increased in a usually vain attempt to solve odour problems.

Many designs of flush controller are available. These either use a timer to match the hours of use or detect the presence of people. This is typically achieved by means of infrared movement detectors or door switches. Mechanical designs use water flow or variations in pressure caused by taps being used, to open a valve to the urinal cistern.

Some controls allow the urinal cistern to fill slowly unless no activity has been detected for a preset period.

Chesswood Middle School saved nearly 900m^3 per year (a 68 per cent reduction in the total amount of water used by the school) by fitting urinal flush controllers[9].

Urinal flush controllers proved to be the most cost effective of a range of water efficiency measures installed throughout the school. Similar savings have been seen in many other case studies.

Water use due to urinals	1314 m^3 per year
After fitting controllers	419m^3
Water saved	895m^3
Money saved	£1414 per year
Cost of installation	£960
Payback	Around eight months

Other designs allow the cistern to fill quickly, causing it to flush when people are detected. An electronic delay prevents further flushing for a preset period. Each method has its advantages. Where a large number of urinals are installed with a quick-fill system, separate controllers may be needed to prevent all the bowls flushing when one person enters the room.

Whatever system is installed, it must be correctly set up, tested and maintained. Monitoring at Worthing High School found the urinals were responsible for over 40 per cent of the schools total water use. This rose to 80 per cent as the trial progressed. The problem was traced to faulty urinal controllers, and the situation might have continued undetected had the school not been carrying out a detailed water audit.

The same circuitry can control lights and shut off the water supply when the washroom is unoccupied, therefore saving energy as well as water.

[9] Water Efficient Schools: Chesswood Middle School Project, Magada Styles and Terry Keating, Southern Water 2000

Flush-per-use systems

The Water Regulations allow the use of single urinal bowls with pressure-flushing valves and a flush volume no greater than 1.5 litres. Each office urinal might serve between one and 30 male workers[10]. The graph shows how flush per use systems can be more economical when each urinal serves less than about 15 users, assuming the automatically flushed urinals are correctly controlled and adjusted.

Waterless urinals

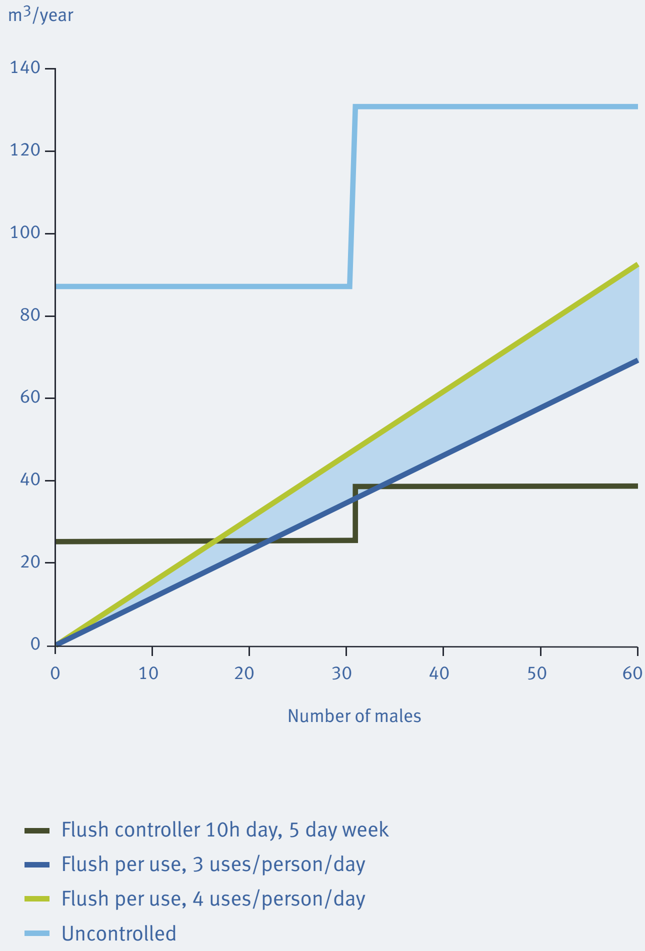
As the name suggests, waterless urinals work without using any water other than for routine cleaning. Some systems are supplied as a complete unit, while others can be retrofitted to standard bowls and troughs.

As well as offering significant water savings, waterless urinals also claim to address some of the problems associated with conventional urinals, namely scale, odour, blockage, and subsequent flooding. Hard water from flushing can form an absorbent layer of lime scale on the bowl, which is thought to contribute to odour. Waterborne lime scale also makes traps and drains block more quickly and the resulting solids are very difficult to remove. Simply turning off the water does not cause odour and may reduce blockages in hard water areas[11] provided the traps are sluiced at least once per week.

Unlike toilet flushing, even normal urinal flushing is not fast enough to clear out the trap and prevent blockages. Waterless designs deal with blockages in a number of ways. Some use a removable disposable trap that retains the urine salts, while others replace the trap with a one-way valve so that urine is not retained and crystals do not have time to form. Some systems retain the conventional tubular trap but prescribe daily or weekly sluicing with water and detergent to flush away solids.

As odour is perceived to be a problem with waterless urinals, most manufacturers offer a countermeasure, usually in the form of a scented block, stick or pad. In reality, odours are usually caused by trap leaks or general hygiene problems around the urinals rather than the lack of water[12].

Figure 3:
Theoretical water consumption for correctly installed urinals.



Flush per use and with automatic cisterns. One urinal serves up to 30 male staff.

Other advantages

Urinals that do not need water eliminate frost-and-vandal-prone plumbing and avoid flooding when bowls block due to scale or sabotage. Washroom control systems save energy and can help prevent damage by automatically turning off the water supply to unoccupied washrooms.

10 British Standard, 6465 Part 1, 2006. BSI.

11 Unpublished BRE research, John Griggs 1979 and experiments by the Author.

12 Ibid.

3 showers and baths

In new houses, showers and baths now account for around 45 per cent of the water used. Modern plumbing, en-suite bathrooms and changes in lifestyle are all contributing to the trend towards using significantly more water for bathing and showering.

Showers can be a water-saving alternative to baths but people tend to take them more frequently. Recent trends with 'power showers' and mains pressure systems, however, have increased flow rates to the point where a long shower can use more water than a bath.

The fact remains that a shower can use about a third of the water of an ordinary bath. Also, as bathing water is heated there is an associated energy and carbon cost. In an efficient home, hot water typically uses more energy than space heating.

Retrofit options

For older houses with electric showers or simple gravity-fed mixer showers, there is little scope to save water. Homes with pumped or mains pressure showers can be fitted with simple flow regulators or 'water saver shower heads' to limit the maximum flow rate to below nine litres per minute.

Before spending money on a new showerhead it is worth measuring the flow of your existing one. The simplest way to do this is with a watch and a small bucket or large jug. Set the shower to the highest flow rate and direct it into the bucket for 10 seconds. Measure this volume with a measuring jug or kitchen scales (1 litre = 1kg) and multiply by six for litres per minute. Table 3 shows typical flow rates of different types of showers.

You can use the same test to check that an instantaneous water heater, for example a combi or multipoint boiler will work at low flows. For example, if you are considering buying a six litre per minute shower head, set the flow rate of the existing shower to six litres per minute and check that the temperature is stable at this flow rate. Some combi boilers are unable to operate at low flows and may not cut in or the temperature might be erratic.

Obviously even high flow rate showers can be turned down but the shower may not perform as well as a purpose-designed low flow showerhead. Also, some people might not be as conscious of saving water, which is why limiting the maximum flow rate can bring about savings, rather than just relying on people to adjust their behaviour.

Showers

In the UK there is no agreed definition of a water-efficient showerhead. Also, the amount of water a shower uses depends very much on the person using it, for example what flow setting they are using and how long they shower[13]. A quick three minute shower with the flow adjusted to a comfortable five litres per minute uses only 15 litres of water, whilst 10 minutes at 15 litres per minute will use ten times as much water and energy without making us any cleaner.

[13] A little more than the flow from a high power electric shower.

How much flow do we like?

Many showerheads have no flow regulation and so the maximum flow rate is only limited by the available water pressure. Trials by the Building Research Establishment (BRE) suggest that most people find flow rates of less than three litres per minute in a shower unacceptable. Currently there are no upper limits on flows in the UK, while in the US the maximum flow rate is 9.5 litres per minute.

Bathers are interested in comfort and only a handful of people have any idea how much water their shower uses. However, it is commonly assumed that flow equals comfort and so most manufacturers are hesitant to make water efficiency claims for their products and indeed boast of high flow rates.

'Water-saver' showerheads usually work by creating finer drops or by incorporating air into the flow. Typically, these showerheads require a pressure of at least one bar, which is available from mains pressure and pumped systems but rarely from gravity-feed hot water systems. These water-saver showers typically work at a flow rate of between four and nine litres per minute, and the effect is usually perceived as a 'power shower' but with perhaps half the flow rate.

The perceived performance of a showerhead is influenced by the quality as well as the flow rate. For more information on typical flow rates from different shower designs, see Table 3. Another important consideration for many buyers will be how a showerhead looks. Happily, water efficient shower heads are now available in a range of styles and need not look any different to a standard shower head. Showerheads can provide a gentle rain effect, an aerated champagne flow with almost no splashing, or a more invigorating massage effect with high skin pressure. Showerheads that create fine droplets can lead to cold feet since smaller water droplets cool quickly. Other showerheads can be quite noisy adding to the illusion of 'power' and flow. All this makes performance testing and recommendations difficult since user perceptions of what makes a good shower vary so widely.

In trials by Liverpool John Moores University[14], fitting an aerated showerhead was effective in reducing flow-rate by 28 per cent (3.2 litres per minute) on average, whilst improving or only marginally reducing customer satisfaction with the shower performance. Despite the reduced flow rate, eight of the nine households where an aerated showerhead was fitted asked to keep it.

It can be dangerous to use water-saver showerheads and restrictors with electric showers. Check with the equipment manufacturer.

Water use in showers depends on a number of factors:

Heating mechanism:

- Combination-boiler warm-up.
- Pipe dead-leg (time for water to run hot).

Fixed / adjustable controls:

- Separate flow and temperature controls.
- Stability of combination-boiler temperature control.
- Stability of plumbing system pressures.

Flow rate:

- Pressure and spray pattern influence perception of flow.
- Small flow reductions may not be noticed.
- Position of header tank/mains pressure/ pumped pressure.

Water efficient showers are important for saving water, energy and carbon. They also allow a comfortable shower without using up all the hot water when storage capacity is limited.

Mixer valves

The choice of mixer valve will also influence comfort and volume of water wasted during showering. Simple hot and cold tap controls mean both taps have to be adjusted with an infinite number of possible combinations in order to achieve the desired flow and temperature. As this must be done by feel, the valves will have to be adjusted as the hot water starts to reach the mixer. This presents an increased risk of scalding.

Thermostatic mixers usually have a calibrated dial, so the temperature can be set from experience. The flow is adjusted with a separate control so that reducing or interrupting the flow, for example to apply shampoo, is simple.

[14] Water and Energy Efficient Showers: Project Report Richard Critchley, United Utilities and Dr David Phipps, Liverpool John Moores University 2007.

Table 3: Shower flow rates.

	4 litre/minute	7.2kW electric	9.8 kW electric	6 l/minute water saver	9.5 l/minute water saver	'Power Shower'
Flow litre/minute	4 l/minute	3.5 l/minute 30°C temp rise	4.7 l/minute 30°C temp rise	6 l/minute regulated flow	9.5 l/minute regulated flow	Typically 12+ l/minute
Notes	Can be effective but probably the lower limit for most people especially if the bathroom is cold.	May be perceived as poor performance particularly in winter.	Perceived by by many as adequate.	A 'good shower' by traditional UK standards.	Maximum flow rate permitted in the USA.	Might not be used at full flow
Plumbing system compatibility	Combi boiler and some thermostatic mixer valves unlikely to work at such a low flow rate.	Fed from mains pressure cold water.	Fed from mains pressure cold water.	Mains pressure or pumped hot water. Some combi boilers might not work at this flow rate.	Mains pressure hot water or pumped.	
Water use for 5 minute shower	20	17.5	23.5	30	47.5	60+
As a % of 70 litre bath	29	25	39	43	68	86+
Kg CO_2 Gas boiler	0.07-0.27	0.34 direct electric	0.45 direct electric	0.27-0.4	0.42-0.63	0.53-0.8+

Baths

The main variables which determine how much water is used to fill a bath are the volume and shape. Tapered or peanut-shaped baths may provide more space for bathing with less water.

Bath volumes are usually given in promotional literature and are specified to the centre of the overflow but other manufacturers consider Archimedes' principle and subtract the volume of an adult (about 70 litres), so make sure that you compare like with like. Very few modern baths hold less than 130 litres, which is about 60 litres of water with a submerged adult. Some larger baths hold more than 300 litres, equivalent to the average volume of water two people use each day.

Under the Water Regulations you have to let your water supply company know if you plan to install a bath with a volume of more than 230 litres.

Further information

Water and Energy Efficient Showers: Project Report, Richard Critchley, United Utilities and Dr David Phipps. Liverpool John Moores University 2007.

4 domestic appliances

Dishwashers and washing machines account for around 16% of the total volume of water used in a typical household.

New washing machines use about half the water and energy of the average 10-year-old machine. Most new washing machines now use less than 50 litres of water per 6kg wash and the most efficient machines claim less than 40 litres for the same 6kg load. However, some washer-dryers use mains water to condense moisture which means they don't need an external vent. This can increase water consumption to between 100 and 170 litres per wash even though most machines cannot dry the whole load because of the smaller drum.

Dishwashers are also becoming more water and energy-efficient, with the most efficient machines using as little as 12 litres to wash 12 place settings.

Whilst there is still potential for technical improvement from manufacturers, the greatest savings are now to be achieved by using the appliances carefully, for example only washing full loads and not rinsing dishes before putting them in the machine.

Although it is common for washing machines and dishwashers to have half-load programmes, full loads are still far more water efficient. However, a survey by Which? revealed that a typical household clothes wash weighs around 2kg[15], although most machines are now designed to be able to take 6kg[16].

The price of efficiency

Being efficient with water and energy no longer carries a price premium. Whilst quality and features do vary with price, budget washing machines are available that claim less than 50 litres per wash and some of the cheapest dishwashers claim a respectable 14 litres to wash 12 place settings[17].

Machine or hand wash?

Whilst few people would argue for hand washing clothes, opinions and preference vary when it comes to dishwashers. Dishwashers now use between 12 and 18 litres to wash 12 place settings and Which? estimates that washing the same crockery by hand would use 40 litres of hot water.

So if you dislike washing up then a dishwasher is easily justified, but avoid rinsing items before putting them in the machine and make sure it is full before switching it on. However, if you want to save cash and kitchen space, then careful washing up by hand using water heated by gas or solar and modest amounts of washing up liquid is probably the greenest option.

15 Which? Online product testing report, August 2000

16 www.waterwise.org

17 *The Economics of Water Efficient Products in the Household*, Environment Agency 2003.

Should I replace my machine?

The typical lifespan of both washing machines and dishwashers is about eight years. It is not normally sensible to replace a reliable machine with a new model unless you use it very often. However, since about 90 per cent of the life cycle impact of white goods is due to operation and only around 10 per cent is due to manufacture and disposal, it might be more economical and even environmentally responsible, to replace an older machine with a more efficient one rather than paying to have it repaired.

Choosing a machine

All new washing machines and dishwashers must display an energy label. The energy label allows buyers to compare the energy efficiency and water consumption of each machine. "A" rated machines are the most, and "G" rated machines the least, energy efficient. Water consumption is listed separately. These labels are a useful tool but testing by Which? has produced different results to those shown on the labels. You can keep up to date by referring to Which? magazine, which tests a new range of appliances about once a year. Which? is not able to test all machines, but you can use their results together with the energy label to help you make an informed choice.

Whilst 6kg is the standard load size, machines are now available with up to a 10kg capacity. Bigger machines generally use less water per kilogram washed but only if fully loaded.

Further information

Department of the Environment, Food and Rural Affairs (Defra): www.defra.gov.uk/environment/consumerprod/energylabels/index.htm

Which? Online: **www.which.co.uk**

5 taps

Around 20 per cent of domestic water flows through sink and basin taps. A good deal of this (usually hot) water goes down the plug hole without performing any useful purpose. With long, un-insulated pipe runs a lot of tepid water can be wasted whilst waiting for the tap to run hot (or cold).

Spray taps can save about 80 per cent of the water and energy used for hand washing but they can restrict the flow too much to fill the basin quickly. A clever invention that aims to address this problem is the Tapmagic insert, which can be fitted to most taps with a round outlet hole or standard metric thread. At low flows, the device delivers a spray pattern suitable for washing hands or rinsing toothbrushes. As the flow is increased, the device opens up to allow full flow to fill the basin.

Another innovation is a water-saving cartridge for single-lever mixer taps. As the lever is lifted, resistance is felt. If a higher flow is needed, the lever can be pushed past this step. Some designs make sure that only cold water comes out when the lever is in the middle position.

Where water is supplied at mains pressure, an aerator or laminar flow device can eliminate splashing. These devices can incorporate flow regulators and provide the illusion of more water than is actually flowing. Available flow rates for basin taps include eight, six and five litres per minute. All provide plenty of flow for using directly or filling a small basin.

Other considerations

- In hard-water areas, sprays may need de-scaling regularly to make sure that they do not become blocked.
- To avoid long delays while water runs hot, pipes to spray taps should be close to the source of hot water or pumped loop.
- Because of the low flow rate, smaller bore pipes can be used, further reducing the dead-leg.

Commercial washrooms

About a third of the water used in every office comes through the tap. Installing taps with high quality flow regulated sprays can reduce this amount by up to 80 per cent. Taps with a standard M22 or M24 outlet thread can easily be fitted with sprays, and round outlets can be adapted. When installing new taps, specify models with metric outlets, as this allows the flexibility to add a range of outlet devices such as sprays and aerators.

Sensor taps and timed turn-off push taps prevent wastage and flooding where taps may be left running. They also offer improved hygiene, as the tap does not have to be touched after hands have been washed. To make sure savings are achieved and the user is satisfied, the fitting must suit the water pressure and allow for correct adjustment.

Legionella

Concern has been raised that spray fittings and aerators might introduce a risk of Legionella by creating aerosols that could be inhaled. In practice, well-designed and regulated spray fittings provide a very gentle flow with little or no splashing. Laminar flow fittings are an alternative to aerators for high-risk applications such as care homes.

The temperature of the water is an important factor in the occurrence of Legionella outbreaks. Sufficiently hot water will kill off the Legionella. Also, regular de-scaling and regulating the flow of water to taps will reduce the amount of aerosol droplets produced, which is how Legionella usually enters the body.

Water sitting in warm pipes for long periods is another concern that could be made worse by reduced flows. However, good water and energy efficient design aims to reduce dead legs and these issues should be considered on a case-by-case basis.

The Building Services Research and Information Association (BSRIA) has produced guidelines for temperature with respect to outbreaks of Legionella (see futher information, below). For low-usage applications, sprays are not recommended and would offer minimal savings.

Further information

Guide to Legionellosis – Temperature Measurements for Hot and Cold Water Services,BSRIA Application Guide 4/94

Health & Safety Executive, Legionnaires' disease **www.hse.gov.uk/legionnaires**

6 gardening

In the UK it is possible to have a beautiful and productive garden without using mains water.

The average amount of water used outdoors in the UK, which includes watering gardens and washing cars, accounts for only about six per cent of the amount of domestic water used each year. However, on hot summer days, when supplies are tightest, over 70 per cent of the water supply may be used for watering gardens. Much of this water is probably not doing plants that much good.

Water-efficient gardening

There is much that gardeners can do to reduce the need for watering. Adding organic matter, home compost, composted bark or rotted manure at about a bucketful per square metre will boost the amount of water that soil can retain. Water efficient gardens also save labour, as there is less need to water them and mulches suppress the growth of weeds.

Choosing plants suited to the soil and site will mean that they grow good roots which can search out moisture. Mulching with organic matter such as bark chips or with other materials such as gravel or ornamental crushed glass will help to promote good root growth and reduce moisture losses from the soil.

Newly planted areas and newly laid lawns won't survive without watering if you plant them in the summer. Set out plants and lawns as early in spring as possible so that they develop good roots early. If drought strikes, these should have top priority for whatever water is available.

Lawns can survive drought very well and even if brown recover when rain returns. Gravel and other mulches, or prostrate evergreen plants such as Juniperus squamata, can be used as an alternative to lawns.

Hotter, dry areas are ideal for the grey leaved, aromatic, summer-flowering shrubs, such as lavender, phlomis and artemesia. These sun lovers come from climates where the summer is intensely hot and the winters wet and often cold. Use these with plants that grow when the soil is moist between October and May. Choose crocuses, cyclamen and colchicums for autumn flowers, and daffodils and tulips for colour in the spring.

Plants for no-watering garden

For small areas, thymes (Thymus), oreganos (Origanum), lamb's ears (Stachys), santolinas and dwarf bulbs such as crocus and tulips are colourful and need little watering or other care.

Grasses such as fountain grass (Pennisetum alopecuroides) and giant feather grass (Stipa gigantea) make bold statements and are drought tolerant. Colour can be added with drought-resistant perennials such as hardy geraniums (Geranium x oxonianum) and oriental poppy (Papaver orientale).

Rainwater is better for plants than mains water and for people on water meters it can save money. Rainwater kits fitted to downpipes allow water to be collected in water butts without overfills and floods. Water butts come in all shapes and sizes, they can be joined up and there are slim ones to fit tight spots. Trellis and climbers such as clematis provide an easy way to make water butts look attractive. Pump kits to apply water from butts can be used where it is not feasible to water by hand.

Cooled wastewater from the kitchen, baths and showers can sustain plants, but should not be used for edible varieties. Stored greywater can build up harmful bacteria so this water is best used once cooled and within a few hours.

Watering – equipment and techniques

Good watering aims to apply enough water to replenish the soil moisture at a steady, gentle rate, without inundating the soil. You should apply water only at the stem bases beneath the foliage canopy leaving the surrounding soil dry. This reduces weed problems and makes sure all water goes to where it is needed.

Seep or drip hoses

Water seeps slowly from these and sinks into the soil to wet the root zone (top 30cm). Unless timing is controlled, these potentially water saving devices can waste large volumes of water. Current legislation treats this equipment as hoses if connected to mains water and they are forbidden during hosepipe bans.

To know when to water, examine the soil at a depth of 30cm. If the soil feels damp there is unlikely to be any need to water, but if it is dry then watering is probably needed for some plants. Gardeners should be aware that clay feels damp even when all available water has been used and sand can feel dry even if some water is available. Only experience in matching the state of the soil to the growth rate of the plants can help gardeners fine-tune their watering.

Excess water will run to waste below the root depth, so before watering check the weather forecast and wait to see whether watering is really necessary.

Water Supply (Water Fittings) Regulations 1999:

Hose taps in non-domestic premises must incorporate a suitable air gap.

In any premises, irrigation systems with fixed outlets not less than 150mm above the watered surface may be connected directly to the supply pipe via a backflow protection device that provides fluid category three backflow protection.

In domestic gardens, mini-irrigation systems, which do not use fertilisers or insecticides (for example a porous or seep hose), can be directly connected to the supply pipe using a type DB device (that is, a pipe interrupter with an atmospheric vent and moving element).

Garden ponds filled or supplied with mains water need to be watertight and should not have a permanent connection to the mains. Rainwater is preferred for refilling ponds.

Do

- 'Pond': using earth banks to retain water allows water to soak in;
- If you have to use a hose pipe, use a lance or trigger device. These control the flow, directing the water gently to where it is needed;
- Regularly weed and hoe your garden, to make sure that watering helps plants and not weeds;
- Water early in the morning or in the evening to reduce losses through evaporation.

Don't

- Use hosepipes directly on the soil: Large droplets and jets of water damage the soil surface;
- Frequently water lightly as it encourages shallow roots rather than deep moisture-seeking ones;
- Leave hoses trickling beside plants as the water goes straight down to below the root zone, where it is out of reach of plants.

Further information:

RHS Drought-Resistant Gardening – Ideas:
www.rhs.org.uk/advice/waterconference/index.asp

RHS Water – Advice:
www.rhs.org.uk/advice/watering.asp

RHS Drought-Resistant Gardening – Advice:
www.rhs.org.uk/advice/profiles1105/drought.asp

RHS Water in the Garden:
www.rhs.org.uk/learning/research/gardeningmatters/index.asp

The Dry Garden, Beth Chatto, Orion 1998.

Drought Resistant Gardening, The Royal Horticultural Society 1999.

Gardening Without Water, Charlotte Green, Search Press 1999 (HDRA).

Low Water Gardening, John Lucas, CPRE 1993.

Plants for Dry Gardens – beating the drought, Jane Taylors-Frances, Lincoln 1993.

Create an Oasis with Greywater, Art Ludwig 1994.

7 reusing greywater and harvesting rainwater

The apparent madness of using fresh drinking water to flush the toilet or water the garden partly explains the appeal of reusing bath and shower water or rain from the roof for these purposes.

However, for UK homes, it is more cost effective to save water than to reuse rainwater or greywater. Also, efficiency measures save energy and CO_2 emissions, whereas greywater and rainwater systems often increase the total amount of energy used and CO_2 emissions[18]. Even from a purely environmental point of view, cost effective measures should be prioritised as they allow greater benefits for a given outlay. For large communal domestic or commercial developments the economics may be better.

Where gardens need a lot of watering, simple, low cost greywater diversion systems can save considerable quantities of water at a time of peak demand. Similarly, the humble water butt is able to capture rain from summer showers, allowing gardeners to apply the water where it is needed most.

Reusing greywater

Greywater refers to all household wastewater other than wastewater from the toilet (blackwater). Greywater from baths, showers and washbasins is less contaminated than that from the kitchen.

Typically, domestic reuse systems collect greywater and store it before reusing it to flush the toilet. More advanced systems treat greywater to a standard that, it is claimed, can be used in washing machines and the garden. The most basic systems simply divert cooled and untreated bath water to irrigate the garden.

Systems for flushing the toilet can save around a third of daily household water demand. A trial by the Environment Agency showed a range of water savings from about five per cent to 36 per cent[19]. As newer properties tend to have lower toilet consumption, the maximum savings in a new build might be closer to 20 per cent.

What treatment is necessary?

Problems can arise when warm, nutrient-rich greywater is stored, as it incubates bacteria. There are currently three approaches for dealing with this problem.

The first is to limit the time that the greywater is stored. These systems might incorporate an electronically controlled dump valve to empty the storage tank after a period of inactivity before refilling with mains water.

The second approach is to use chemical disinfectants such as chlorine or bromine compounds that inhibit biological activity and extend possible storage time.

The third approach is to treat the greywater in a small sewage treatment plant, either by using traditional biological methods or newer membrane filtration technology. The treated water is clear and free of unpleasant odours and contains little organic matter, allowing it to be stored and reused. However, this uses a significant amount of energy and is very expensive.

Untreated greywater can be used for watering the garden if it is used immediately after it is produced, but it should not be used on edible crops. The wastewater from kitchen sinks and dishwashers is not usually collected as it is too heavily contaminated.

[18] Crettaz, P.Jolliet, O.Cuanillon, J-M and Orlando, S, 1999. Life Cycle of assessment of drinking water and rain water for toilet flushing. *Aqua* 48(3), pp.73-83.

[19] A study of Domestic Greywater Recycling, Environment Agency 2000.

Harvesting rainwater

If it is correctly collected and stored, rainwater can be used for toilets, washing machines and watering gardens without further treatment. In practice, most domestic roof areas are too small to satisfy all this potential demand regardless of the size of the storage cistern, so it is important to evaluate the potential savings before investing in an expensive installation.

The garden water butt is the simplest way of collecting rainwater. It does not need any treatment or mains backup, and it does not have to supply water when temperatures are below freezing. Household rainwater systems are, however, much more sophisticated and their installation is quite complex.

Table 4 gives an idea of the amount of water systems can yield with different roof areas and rainfall volumes. It is assumed that 60 per cent of the rain falling on the roof is collected and used. This is because there may be times when the tank is overflowing and unable to collect additional rainwater or there may be insufficient demand to use all of the water collected.

Table 4: Approximate annual yield of rainwater in cubic metres per year for a range of roof sizes with varying rainfall.

	Plan roof area m²	50	75	100	125	150
mm rain/year	500	15	22.5	30	37.5	45
	1000	30	45	60	75	90
	1500	45	67.5	90	112.5	135
	2000	60	90	120	150	180

Table 5 gives a summary of different drainage factors for different roof types. A factor of 1 indicates all the water that falls on the roof will reach the gutter, a factor of 0.5 indicates that half the rain falling on the roof will reach the gutter.

Table 5: Drainage factors for different roof types.

Roof type	Drainage factor
Pitched roof tiles	0.75 – 0.9
Flat roof smooth tiles	0.5
Flat roof with gravel layer	0.4 – 0.5

Tank sizing

Rainfall can be sporadic and so storage is needed, but the optimum tank size is usually much smaller than you might think. As a guideline, size the tank to hold 18 days worth of demand, or five per cent of annual yield, whichever is lower. To calculate the optimum tank size, first calculate the potential yield. Once you know the potential yield, simply find five per cent of this.

Calculating the tank size

The formula below can be used to calculate the optimum tank size for a rainwater harvesting system

Roof area (m²) x drainage factor x filter efficiency x annual rainfall (mm) x 0.05

Example: Consider a property with a roof area of 100 m². This is a tiled, pitched roof, so has a drainage factor of 0.9 is used (see table 5). The filter efficiency is assumed to be 90 per cent, so a filter efficiency factor of 0.9 is used. Annual rainfall is assumed as 905 mm per year, the 1961 to 1990 long run average from Met Office data for England and Wales (in a real example local rainfall must be used, as rainfall varies significantly across England and Wales[20]).

Summary of parameters for yield calculation

Effective collection area (m²)	100
Drainage factor	0.9
Filter efficiency factor	0.9
Average rainfall (mm/yr)	905
Five per cent of annual yield	0.05

Tank size =100 x 0.9 x 0.9 x 905 x 0.05 = 3665 litres or 3665/1000 = 3.7 cubic metres (m3)

Using these parameters the optimum tank size is 3665 litres or 3.7 cubic metres.

[20] www.metoffice.gov.uk/climate/uk/averages/19611990/areal/england_&_wales.html

Water Supply (Water Fittings) Regulations 1999:

There are currently no UK regulations relating to the quality of water needed for toilets and washing machines. Extensive studies in Germany have concluded that, if rainwater is collected properly, it can be used in toilets and washing machines without being disinfected. Mains water backup must be in accordance with the Water Regulations, which means using a type AA or AB airgap, and pipes should be clearly identified.

Some commercial systems have included UV disinfection to address perceived health risks, but this uses a large amount of energy which can offset some of the benefit of saving water. As well as the environmental impact of UV treatment, it is also expensive to run and maintain.

Further information:

Environment Agency Greywater information:
www.environment-agency.gov.uk/savewater

Create an Oasis with Greywater, Art Ludwig 1994.

Harvesting rainwater for domestic uses: an information Guide, Environment Agency 2003.

Reclaimed Water Systems; Information About Installing, Modifying or Maintaining Reclaimed Water Systems, WRAS Information and Guidance note, August 1999 No. 9-02-04. **www.wras.co.uk**

UK Rainwater Harvesting Association:
www.ukrha.org

8 detecting leaks and metering

Regular maintenance is crucial if savings are not to be lost through leakage or malfunction. Even slow leaks can lead to significant amounts of water being lost if they are not fixed promptly. Suspected leaks are best detected by checking the water meter overnight or when a building is unoccupied.

Checking for leaks

Take a meter reading last thing at night when everyone has gone home and first thing in the morning before everyone arrives (when checking for leaks at home, take the readings before and after a period when you don't expect any water to be used). If the reading has changed, indicating water has been used, this is likely to be a leak. Any water normally used at night will have to be shut off or accounted for.

Reading the water meter regularly and calculating the amount of water used per person will allow you to check efficiency measures against benchmarks and previous performance, and can help to identify leaks or other problems.

Overflows

Although external overflows are no longer needed on toilets, the Water Regulations do require overflow-warning pipes on water tanks to indicate float-operated-valve leakage. Where pressure or temperature relief valves are used, these must discharge in a safe and clear way.

When valve flush mechanisms and internal overflows for toilets are introduced, leaks are harder to spot than with traditional overflow warning pipes.

Detecting leaks automatically

There are products on the market that are designed to detect leaking and burst pipes, and either sound an alarm or shut off the water supply to reduce damage and the amount of water wasted. Most provide a simple switch to turn off the water when the building is unoccupied for any length of time. Since the devices are usually fitted indoors, they do not detect leaks in the pipe between the water meter and the building.

The main reason for installing these types of devices is to protect the property rather than to conserve water, but the most sophisticated devices can actually help to save water as they can detect very low but continuous flows, for example a leaking ball valve or toilet flush valve. The Ecoflo Waterfuse is claimed to detect flows as low as two litres per hour.

9 plumbing and heating system design

Water efficiency can be built into domestic and commercial properties by thoughtfully designing the plumbing system as a whole. The scope is greater for new buildings, but refurbishment or retrofit may also offer opportunities for improvement.

Hot water pressure

The type of hot-water system will influence the choice of taps and showers and will have a direct influence on water and energy consumption. For a house, the three main choices are:

- a traditional gravity-fed system delivering low-pressure hot water;
- a combination ('combi') or multipoint boiler that directly heats the incoming mains water;
- a mains-pressure hot-water cylinder.

Implications for water efficiency

People living in a house with mains-pressure hot water tend to use more water than a household with a gravity system. This is due to the higher flow rates from hot taps and, in particular, showers.

However, with good design it is possible to achieve efficiency savings and improved comfort in a building with mains pressure hot water by incorporating the measures in Table 6.

Pipe sizing and layout

Minimising the length of hot-water pipes reduces the volume of water that has to be drawn off each time a tap or shower is used (the dead-leg). The ideal arrangement would be to have all water fittings grouped closely around the hot-water source. When arranging the layout, aim to minimise the distance to the most frequently used fittings, typically the kitchen sink. Baths are less

Table 6: Measures for use with mains pressure plumbing systems to improve efficiency and performance.

Measure	Water saving	Other advantages
Small-bore pipes	Reduced dead-leg, that is the cold water that is run to waste	Taps run hot (or cold) quickly
Regulated tap aerators	Give illusion of high flow while saving water	Eliminate splashing
Low water-use shower	Significant savings compared to baths	Can feel like a power shower due to pressure
Other flow regulation	Reduces waste when outlets left running	Flow to each outlet is balanced, shower temperature stabilised

of a concern, as some cold water is likely to be needed. For larger buildings, localised water heaters will usually provide energy and water savings.

Hot-water pipes should be placed above cold-water pipes to reduce heat transfer. Longer hot and cold pipes should be insulated to prevent heat gain and loss. Pipes in unheated areas must be protected from freezing.

Table 7: Dead leg volumes.

Pipe diametre	10mm plastic	15mm plastic	15mm copper	22mm plastic	22mm copper
Litres per 10m pipe run	0.6	1.1	1.5	2.4	3.1
Max length for 1.5 litre dead leg (m)[21]	25	13	10	6	5
Length for 30 second wait with 1.7 litres per minute spray fitting (m)	14	8	6	3.5	3

Large buildings with centralised hot water storage such as blocks of flats, hospitals and hotels will typically have a pumped secondary hot water circuit with short pipe runs from this to outlets. Whilst this arrangement solves the water run-off problem, the energy cost in lower usage applications can be very high.

Combination boilers

Combination or 'combi' boilers directly heat mains water on the way to the taps and shower. The main water-efficiency concern is that standard combi boilers increase the effective dead-leg to hot taps, which can waste between five and 10 litres of water every time hot water is required. This is because when a hot tap is turned on the boiler has to perform a start up cycle and then has to warm up the previously cold heat exchanger before hot water can be delivered. The warm-up issue has been addressed in a number of ways. Some boilers run the burner occasionally to keep the heat exchanger warm, while others incorporate a small insulated thermal store. Check with manufacturers that water savings are not achieved at the expense of significantly increased energy use.

Flow and pressure regulation

Pressure regulators are designed to maintain a constant pressure independent of flow, whereas flow regulators are designed to maintain a constant flow independent of supply pressure. Pressure regulators are typically used to limit pressures in mains-fed hot water systems, or where mains pressure is particularly high and may lead to problems such as burst hoses or leaking float-operated valves. Pressure regulators are normally adjustable and fitted to a whole building or hot-water system. Flow regulators and restrictors are low-cost devices that are typically fitted at each terminal fitting such as a tap or shower to regulate the flow rate.

In-pipe flow regulators can be used with taps and showers. However, flow can sometimes be regulated better by fitting a special showerhead or tap outlet with a built in regulator; see chapters 3 and 5.

Other advantages

Limiting the flow for any tap or appliance, even a toilet, to a minimum rate helps balance the available pressure throughout the system. If someone is in the shower and the kitchen tap is turned on full, the temperature and flow are likely to remain more stable if the kitchen tap is only able to draw as much water as it needs.

Regulating the flow can also reduce noise, splashing taps (where aerators cannot be fitted) and water hammer (sharp concussion when water flow in a pipe is suddenly stopped). Regulating flows allows simplified design and minimised pipe sizing, as peak flow rates can be accurately specified.

Further information – general

Water Regulations Guide
Water Regulations Advisory Scheme (WRAS) 2000.
ISBN 0-9539708-0-9.

Conservation of Water: An Information and Guidance Note for Architects, Designers and Installers (WRAS).

Envirowise Water Management leaflets:
www.envirowise.gov.uk/water

For information on saving water in the public sector including benchmarking information:
www.ogcbuyingsolutions.gov.uk/energy/watermark/

Waterwise, information on using water wisely:
www.waterwise.org.uk

Enhanced Capital Allowance scheme (ECA) and Water technology list:
www.eca-water.gov.uk

Energy Saving Trust:
www.energysavingtrust.org.uk

Environment Agency, information on how to savewater:
www.environment-agency.gov.uk/savewater

21 Maximum recomended dead leg volume for Energy Saving Trust Advanced Standard is 1.5 litres.

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