

**THE CITY & GUILDS TEXTBOOK**

**LEVEL 2 NVQ DIPLOMA IN  
PLUMBING AND  
HEATING**

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# UNDERSTAND AND APPLY DOMESTIC COLD WATER SYSTEM INSTALLATION AND MAINTENANCE TECHNIQUES

**T**he supply of fresh, wholesome cold water to people's homes is a basic human requirement. As a domestic plumber, it is your job to get the water from the main external stop valve to the taps in a clean and fit state for human consumption. To do this, you will need to understand the processes that occur before the water reaches this point, the regulations that govern the plumbing industry and the practices that enable you to work safely and correctly on domestic cold water systems at every stage.

## IN THIS CHAPTER, YOU WILL COVER:

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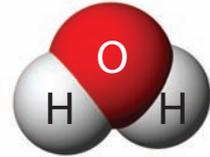
## Test your knowledge

## A COLD WATER SUPPLY AND TREATMENT

The first part of this chapter investigates how water is recycled in nature, time and again, and how it is collected and cleaned ready for use. As a plumber, you need to understand where water comes from and who is responsible for its cleanliness.

### A1 THE ORIGIN, COLLECTION AND STORAGE OF WATER

Water is a simple compound made up of two hydrogen atoms attached to a single atom of oxygen, with the chemical symbol  $H_2O$ . Water is tasteless and odourless, and in small quantities it is colourless – in large quantities it possesses a light-blue hue.

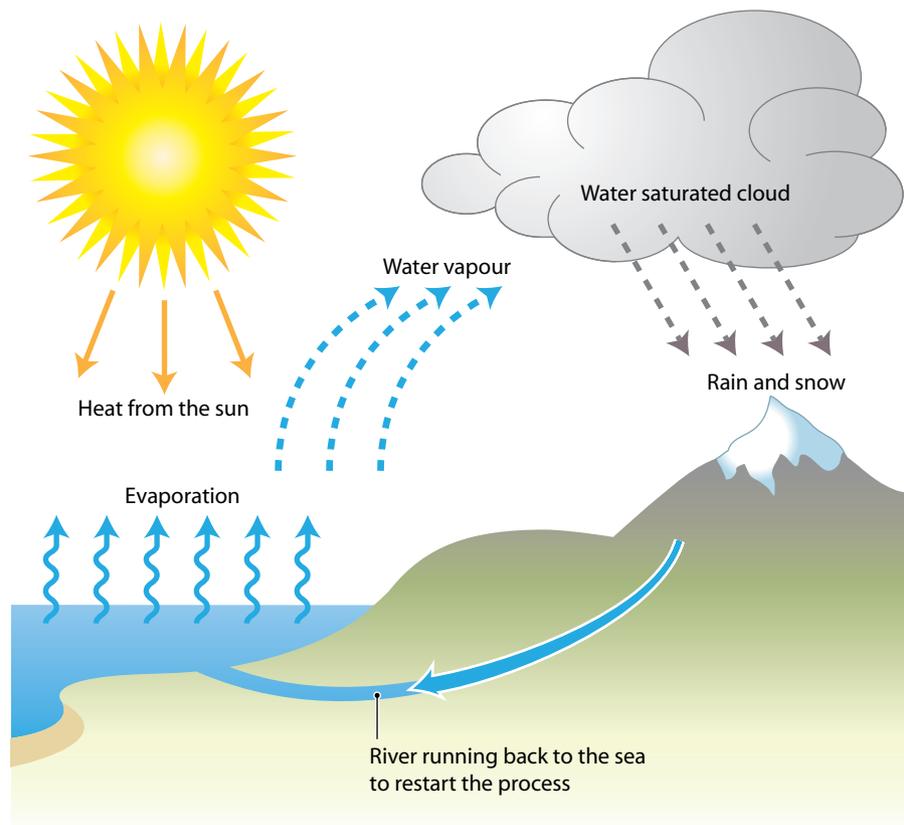


Water molecule

#### The rainwater cycle

There is no 'new' water on Earth. All water is about 4.2 billion years old, whether it is seawater (saline), river or stream water, ground water, fossilised water or water from the polar ice caps.

Water moves constantly, in what is scientifically known as the hydrological cycle. We know this by its more common name – the rainwater cycle. This is a natural process where water is continually exchanged between the atmosphere, the Earth's surface, the ground and plants.



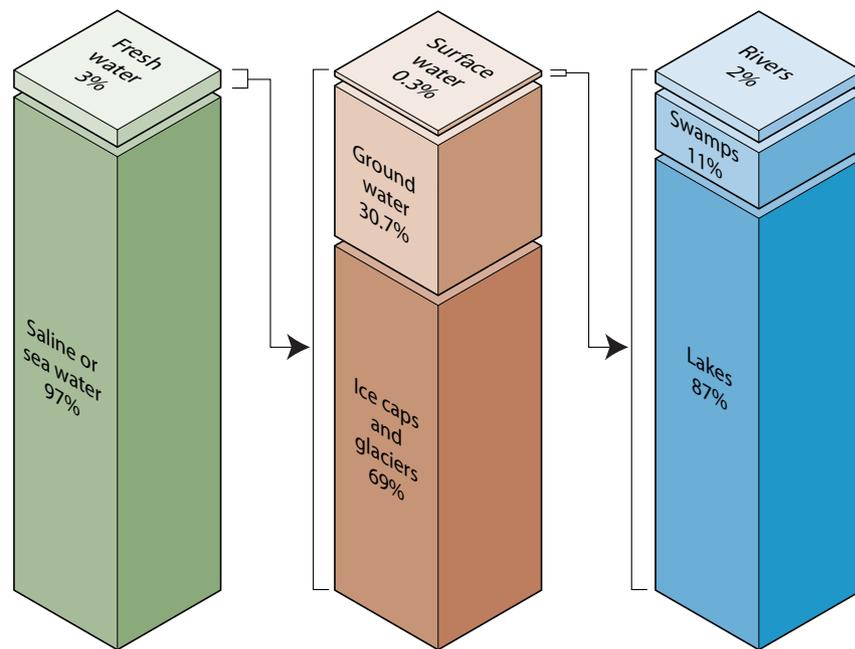
The rainwater cycle

As the sun warms the Earth, surface water evaporates and plants lose water through transpiration. This vapour rises through the air and is carried by the prevailing winds. If the vapour passes over land, some of it condenses to form clouds. As more water vapour is attracted to the cloud or the ground beneath it rises (in hills or mountains), it becomes saturated to the point where it can no longer hold all the moisture. The vapour is then released from the cloud in the form of rain, sleet, snow or hail.

On reaching the ground, the water may re-evaporate back into the atmosphere; it may be absorbed by the ground, where it will travel towards the water table or aquifer; or it may remain on the surface where it will eventually find its way into rivers, streams, lakes or the oceans. Here, the process begins again.

### Sources of water

If we look at all the water on Earth, 97 per cent is saline (seawater) and only 3 per cent is fresh water. Of fresh water, nearly 69 per cent (or 2.07 per cent of the Earth's total water resources) is trapped in the polar ice caps and glaciers and 30.1 per cent (0.9 per cent of the total water resources) is ground water. It is this ground water that the Earth's population relies on for its drinking water supply.



Distribution of earth's water

The total supply of fresh water for the world is in the region of 1350 trillion litres, the majority of which is stored on the ground, where it is available in reservoirs, streams, rivers, lakes, etc. A further 13,650 trillion litres is also available in the form of water vapour, which will eventually fall as rain. Conversely, about 1100 trillion litres of water evaporates into the atmosphere worldwide every day.

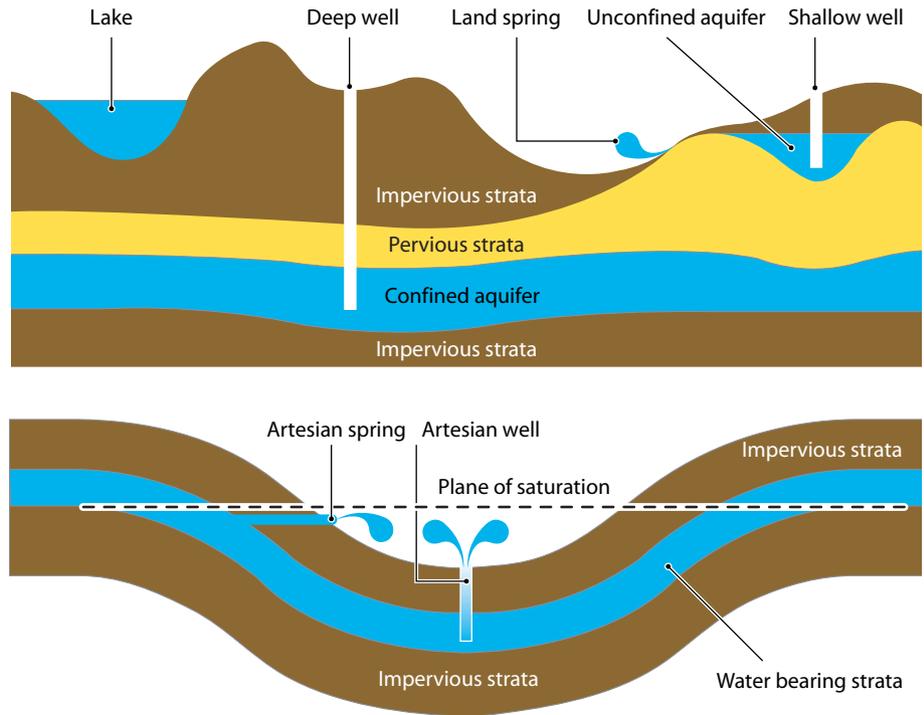
## Sources of water in the United Kingdom

Of the rain that falls on the United Kingdom annually, only 5 per cent is collected and stored in reservoirs for drinking water supply. The rest flows in rivers to the sea or is filtered down to the natural water table or aquifers that exist below the ground surface. The main sources of water in the UK are shown in the table below:

Source of water	Description	Properties of water from this source
<b>Deep well</b>	A machine-dug well that draws its water from below the shallow, impervious strata.	Usually good quality, as it is extracted from below the Earth's surface.
<b>Shallow well</b>	A well dug by hand or excavator that only penetrates the first water-bearing strata, or aquifer, in the Earth's surface	Must be considered dangerous because it may be contaminated with water from cesspits or broken drains, etc.
<b>Upland surface</b>	Water that has collected in upland lakes and rivers without passing through the Earth's strata.	Naturally soft and acidic, this water is not contaminated with salts or minerals. It is the main water source for the northwest of England.
<b>Spring</b>	A naturally occurring flow of water from the Earth's surface.	The purity of spring water is highly dependent on the distance it has travelled from the source.
<b>River</b>	A large, natural flow of water usually starting as a small stream on high ground, which enlarges with distance travelled. Rivers usually terminate at the sea and may be tidal, for example the river Avon.	Usually poor quality due to industrial pollution. The cost of treatment is high.
<b>Canal</b>	Most canals are a product of the Industrial Revolution and for many years fell into dereliction and disrepair. Many have now been cleaned and re-opened and are now sites of natural beauty.	Very poor quality, generally only used for industrial purposes and irrigation.
<b>Aquifer</b>	Naturally occurring water-bearing strata, often deep beneath the Earth's surface. Mostly consists of permeable rock, such as sandstone, gravel silt or clay, which soaks up water like a sponge.	Very good quality, but prone to contamination by nitrates from farming.
<b>Artesian well and spring</b>	Water that rises from underground water-bearing rock layers under its own pressure, but only if the well head is below the level of the water table.	Usually very good quality, as the water is filtered naturally through layers of rock.
<b>Borehole</b>	Man-made well drilled directly to a below-ground water source; the water is extracted for use when connection to a water main is extremely difficult.	Very high-quality water that, in most cases, is cleaner than the water undertaker's water main. Filtering and chlorination are not necessary although the quality should be monitored.

**KEY POINT**

Visit [www.groundwateruk.org](http://www.groundwateruk.org) for more information on the use and distribution of aquifers in the UK.



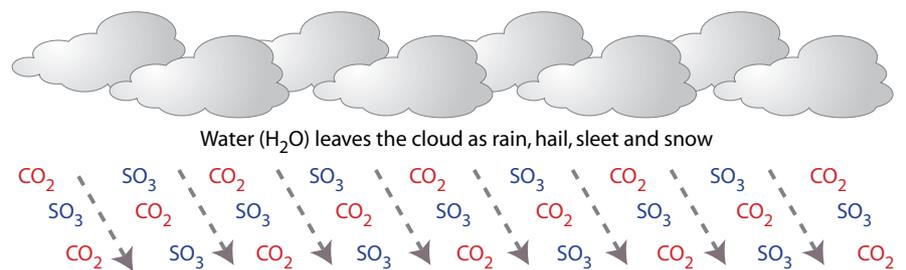
Sources of water

**KEY POINT**

The Environment Agency is the overseeing authority of all water courses in the UK. They sample about 7000 river and canal sites twelve times per year to test their chemistry and nutrients, and to see whether there are any pollutants present and if they need to target areas for improvement.

**Types of water**

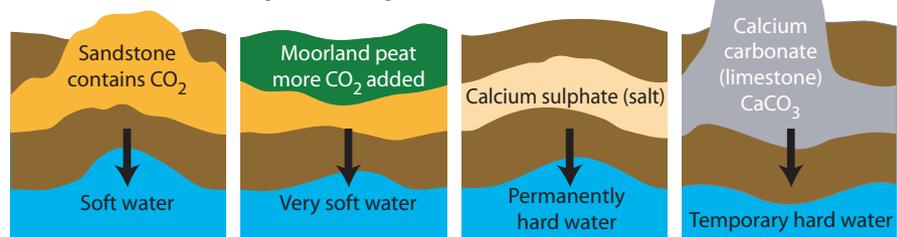
When water leaves the cloud as rain, hail or snow, it is almost pure, and contains very few impurities. As it falls to the ground it absorbs some of the carbon dioxide ( $\text{CO}_2$ ) present in the atmosphere to become a weak solution of carbonic acid ( $\text{H}_2\text{CO}_3$ ), and if there is sulphur trioxide ( $\text{SO}_3$ ) also present, it can become very weak sulphuric acid ( $\text{H}_2\text{SO}_4$ ). When this acidic solution reaches the ground, it dissolves some of the salts it comes into contact with, which will affect its pH value. A pH value below 7 leads to soft, plumbo-solvent water that attacks lead in plumbing systems (see Chapter 004, page 166). A pH value above 7 may indicate temporarily hard water, which can be softened by boiling and leaves



As the rain, hail, sleet and snow falls from the cloud, it absorbs contaminants such as carbon dioxide and sulphur trioxide becoming mildly acid water dissolving more salts, minerals and gases on the ground

**KEY POINT**

Rainwater that contains sulphur trioxide has the chemical symbol  $\text{H}_2\text{SO}_4$ . It is better known as very weak sulphuric acid, and is responsible for the 'acid rain' that destroyed the Scandinavian pine forests.



Types of water

limescale in kettles and pipework, or permanently hard water, which cannot be softened by boiling.

## Removing water hardness

Temporarily hard water can cause many problems within plumbing systems. If hard water is heated above 65°C, it loses its calcium. If you look at a kettle in a hard-water area, you'll see that a layer of limescale has built up on the inside of the kettle. When limescale builds up in plumbing and heating systems, the following problems can occur:

- The limescale insulates the water from the heat source, resulting in bad heat transfer, which wastes fuel and means a longer heating-up time.
- The limescale may block heat exchangers and pumps, causing localised boiling as the water cannot move away from the heat exchanger fast enough and the water boils momentarily. This is known as 'kettling'.

For this reason, hard water is often treated using a water softener, which reduces hardness by the use of the 'base exchange' process. This technique removes the ions that cause the water to be hard – in most cases, calcium and magnesium ions. A water softener collects hardness minerals within its conditioning tank and from time to time flushes them away to drain, replacing them with sodium and potassium salts through the exchanger reservoir.

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## A2 THE TREATMENT OF WATER

This part of the chapter looks at the way the water we use every day for drinking, washing and cooking is filtered, cleaned and sterilised to ensure that it is fit for human consumption. Fresh, clean water is described as 'wholesome' or **potable**.

### The UK water undertakers

The supply of wholesome water to consumers is the responsibility of the UK water authorities, often referred to as the 'water undertakers'. They are responsible for the collection of water, carrying out any treatments necessary to make the water fit for human consumption, and maintaining the supply of water to dwellings and other consumers.

All water undertakers are Public Limited Companies (PLCs) owned by shareholders. There are 21 companies supplying water in England and Wales. Water rates differ across the UK, and you cannot switch your water supplier. There are water-only companies and combined water and sewerage companies. You may pay the company a standing charge for water or have a meter fitted. Scotland has only one water undertaker; Northern Ireland also has only one and domestic customers there do not have to pay water rates.

#### KEY POINT

The water industry in the UK is governed by OFWAT. Its job is to ensure that the water companies provide a high-quality service and maintain a good standard of drinking water throughout the UK. Find out more through their website, [www.ofwat.gov.uk](http://www.ofwat.gov.uk).

#### Potable

(pronounced poe-table)  
Water that is fit to drink.

#### SUGGESTED ACTIVITY...

Find out which water undertaker is responsible for the delivery of water in your area. On what occasions might you need to contact them during your work as a plumber?

## Sedimentation, filtration and sterilisation of water

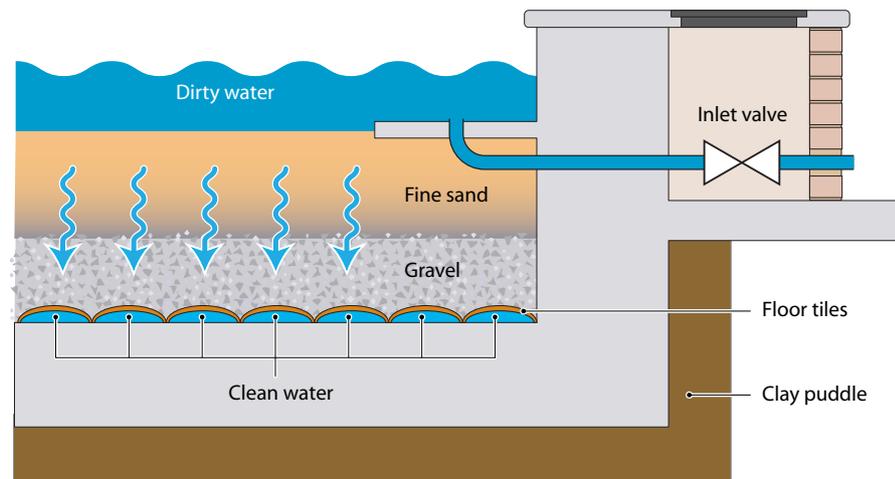
Before it is considered wholesome, the water undergoes several stages of treatment to ensure its cleanliness and quality: sedimentation, filtration and sterilisation. These stages are the responsibility of the water undertaker.

### Sedimentation

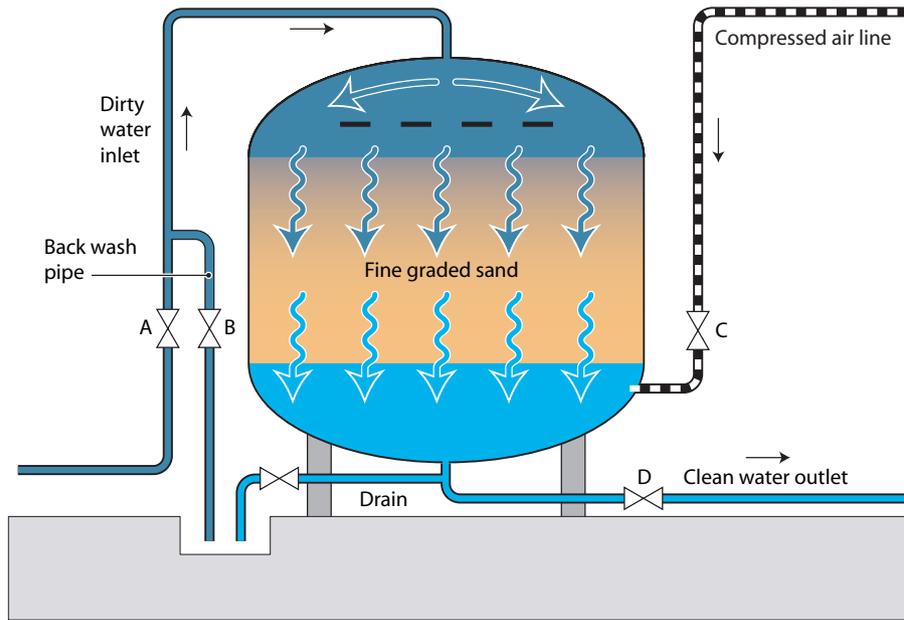
The rainfall is initially collected and stored in lakes and reservoirs, where it is allowed to remain undisturbed. Here, the solid impurities such as grit, mud and decaying vegetation sink to the bottom. This is known as 'primary sedimentation'. Storage also has the effect of reducing the bacteriological content of the water. From here the water is pumped from the storage reservoir through coarse strainers and is held in sedimentation tanks where further sedimentation takes place before being filtered.

### Filtration

Slow sand filters provide the most common method of filtration. The water flows over a graded sand bed. The top of the bed is provided with large colonies of minute vegetable algae growth, which form naturally. The algae assist the purification of the water by living off any contaminants. As the algae builds up, so the filtering process slows down and the water becomes clean. Rapid sand filters speed up the process by operating under pressure; they require frequent maintenance and backwashing, although this is automated by mechanical plant.



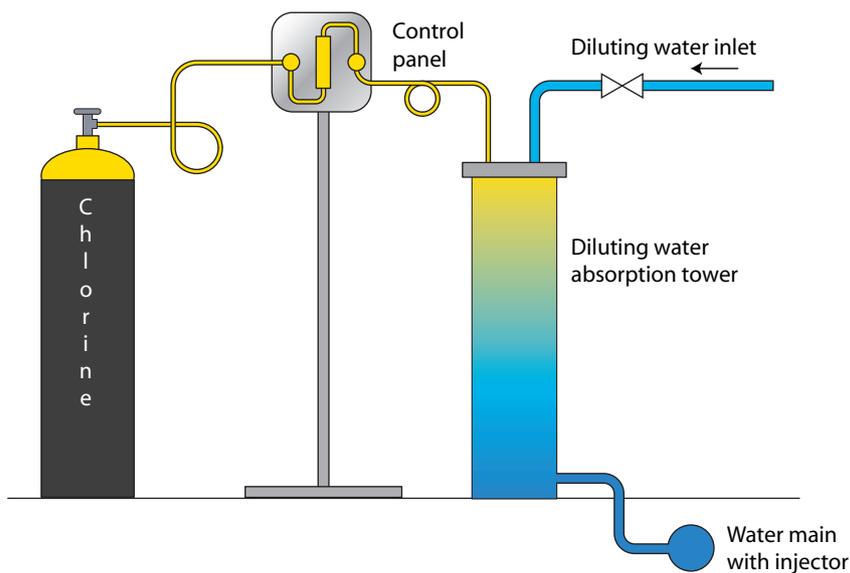
Slow sand filtration



Rapid sand pressure filtration

### Sterilisation

Finally, water is treated with chlorine and ammonia before it enters the water supply. This will kill off any bacteria missed by the water filters. Fluoride is still added in some parts of the UK but only in minute quantities.



Sterilisation by injection of chlorine

## Alternative private sources of wholesome water supply

A private water supply is a wholesome water source that is not provided by a licensed water undertaker. This is typically from a local well, borehole, spring, lake, river or stream. The water quality is the responsibility of the owners of the property from where the water source is extracted and/or used, and should be closely monitored.

The majority of the UK population is supplied with water from a water undertaker, but about 1 per cent of the population is supplied from a private supply: there are around 140,000 private suppliers. Water from a single private water supply may be used for one or more premises, including dwellings, businesses, holiday homes, caravan parks or hotels.

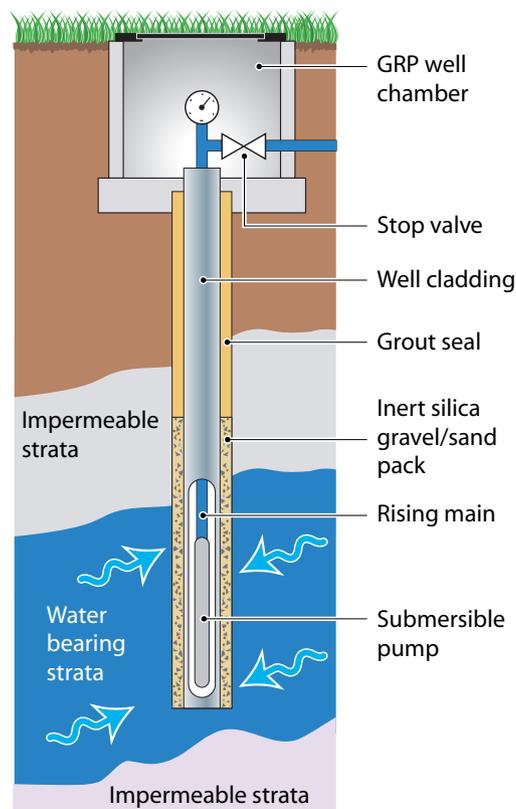
The revised Private Water Supply Regulations 2009 came into force in January 2010 – do not confuse these with the Water Supply (Water Fittings) Regulations 1999, which are covered in detail later in this chapter. They identify the powers and responsibilities of the Local Authority to enforce compliance of the regulatory requirements by the owner or person responsible for the water supply.

### KEY POINT

Because boreholes are classed as private water sources, they are not subject to the Water Supply (Water Fittings) Regulations 1999. It is an offence to cross-connect water from a borehole with water from a water undertaker's main.

### Boreholes

Water boreholes are the modern equivalent of the well, but are smaller, less intrusive and easier to maintain. As water passes through the ground and into the water table it flows through layers of rock and chalk, which act as natural filters. This produces water that is usually far cleaner and purer than the water provided by most water companies.



A typical modern borehole

A single borehole has over forty times the water capacity that an average home would need. Twenty thousand litres of water per day can be extracted from a borehole without the need for any permissions or licenses. An average four-bedroom house uses approximately 50,000 litres of water over a three-month period; this amount can legally be extracted from a borehole in two and a half days.

## Sources of recycled, unwholesome water supply in domestic dwellings

Over the past twenty years, demand for water has increased dramatically in the UK. The average person in the UK uses 150 litres of water a day for washing, flushing the WC, drinking, cooking, gardening and other household tasks. Government targets set out in the Code for Sustainable Homes aim to reduce this to 80 litres per day. There are many ways in which water usage can be reduced in a dwelling, from simple rainwater collection in water butts for garden use, to more complex systems such as rainwater harvesting and grey water recycling for clothes washing and flushing the WC. Remember that this type of water is not fit for human consumption; the pipework must be marked in a way that makes identification easy. For example, BS 1710 suggests colour coding the pipework, using green adhesive tape with a black stripe to denote reclaimed water. Any installation of this type in a dwelling must not cross-connect with the mains cold water supply.

There are two types of water recycling:

- 1 Grey water** – this is water from wash basins, showers, washing machines and baths that is reused, after being filtered and cleaned, to flush WC cisterns only. It is stored in separate storage cisterns away from wholesome water supply cisterns.
- 2 Rainwater harvesting** – rainwater is collected, filtered and cleaned before being used to flush WC cisterns and in some clothes-cleaning operations.

These systems are described in detail in Chapter 003, page 248–50.

### KEY POINT

For more information about private water sources, see the United Kingdom Water Treatment Association website at [www.ukwta.org/privatewatersupplies.php#what](http://www.ukwta.org/privatewatersupplies.php#what).

## Black water

This is water and effluent from WCs and kitchen sinks that can only be treated by a water undertaker at a sewage works. In some domestic systems that are a distance away from the main sewer, black water will flow into a septic tank or cess pit where it is collected, usually at three-month intervals, by a specialist waste water collection company.



A tap re-seating tool

### F3 SIMPLE MAINTENANCE TASKS

Here, some of the basic maintenance tasks you may have to perform on cold water system components, such as taps and FOVs, are covered.

#### Re-washing and re-seating a BS 1010 rising spindle tap

BS 1010 taps are probably the easiest of all taps to maintain. During the maintenance operation, taps should be re-seated as well as re-washed. This involves using a special tool (a tap re-seating tool), which grinds the seat of the tap to remove any pits that have occurred due to water passing between the seat and the tap, ensuring that the washer sits evenly on the tap seat.

Start by ensuring that the water supply is isolated and then opening the tap to relieve the pressure. Put the plug into the sink. This will ensure that any dropped small screws and nuts do not disappear down the sink waste and into the waste pipe trap.



**STEP 1** - Locate the screw that holds the tap head on to the spindle and carefully remove with a small screwdriver.



**STEP 2** - Carefully remove the tap head. Many BS 1010 taps are cross-top heads, which can prove difficult to remove. Take care to prevent damage to the appliance that the tap is fixed to.



**STEP 3** - With the head removed, break the joint between the tap head workings and the tap body using an adjustable spanner. This may involve using a pair of water pump pliers to counteract the force of the adjustable spanner on the head workings. Ensure that a cloth is used to protect the tap body from the effects of the jaws of the water pump pliers on the tap body.



**STEP 4** - Remove the jumper plate and washer from the spindle. A little force may be needed from the flat blade of a screwdriver if the jumper plate is fixed. Some rubber tap washers are held onto the jumper plate by a small brass nut.



**STEP 5** - Carefully remove the nut and replace the existing rubber washer with a new rubber washer of the correct size, then replace the washer nut. Do not over-tighten the washer nut as it may break.



**STEP 6** - Remove the packing gland nut and the spindle by fully winding in a clockwise direction and pushing the spindle through the packing gland.



**STEP 7** - Check the spindle for any signs of wear and remove any scale that may have gathered on the spindle shaft. A non-metallic fittings cleaning pad is ideal for this. Re-grease the spindle using silicone grease.



**STEP 8** - Push the spindle back through the packing gland and wind until the tap spindle is in the fully open position.



**STEP 9** - Check the packing in the packing gland and replace with a PTFE grommet where necessary. Squeeze a small amount of silicone grease into the packing gland before replacing the packing gland nut. Do not tighten the nut at this stage.



**STEP 10** - Reinsert the jumper plate into the spindle.



**STEP 11** - Check the seat of the tap by shining a torch into the tap body. If the tap requires re-seating, use the tap re-seating tool with the correct size of grinding head and re-seat as necessary.



**STEP 12** - Check the fibre sealing washer on the head workings. These tend to break when the tap head is removed. If the fibre sealing washer needs replacing, this can be done using PTFE tape.



**STEP 13** - Replace the head workings into the tap body (ensuring the head workings are fully open) and re-tighten into the tap.

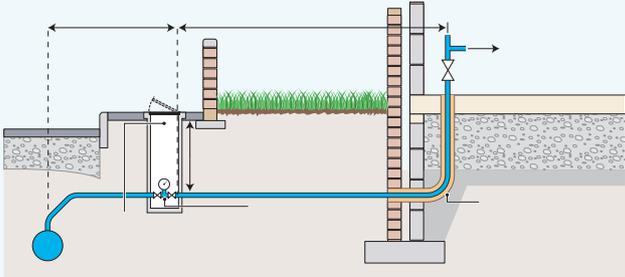


**STEP 14** - Tighten the packing gland nut, taking care not to over-tighten or the tap will be difficult to open.

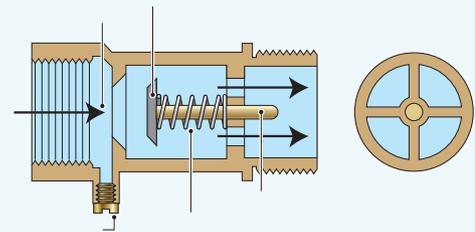


**STEP 15** - Replace the tap head but do not secure with the screw at this point. Turn on the water with the tap open. This will ensure that any debris from re-seating will be washed out of the tap. Turn off the tap and check for any drips. Finally, replace the tap head securing screw.

## 006 TEST YOUR KNOWLEDGE

1. Briefly describe the key stages of the rain water cycle.
- Name three sources of water.
- What is meant by the term **wholesome water**?
- Which chemical is used to sterilise the water before it enters the mains cold water supply?
- What are trunk mains and who is responsible for them?
- Label the following drawing:  

- What should be placed immediately above the internal stop valve as the water supply enters the dwelling?
- Briefly describe a direct system of cold water supply.
- Which system is being described: **'A system of cold water supply where only the kitchen sink is fed directly from the water main. All other appliances are fed from a protected storage cistern in the roof space'**?
- In an indirect system of cold water supply, what is the distribution pipe and where would it be fitted?
- Water for cooking and food preparation should be fed from where?

- 12 What is the minimum recommended capacity for a storage cistern serving an indirect system of cold water supply?
- 13 Describe the function of an overflow/warning pipe.
- 14 What is backflow?
- 15 Which backflow prevention device is shown below?



- 16 A BS 1212 part 1 float-operated valve can only be used on new installations if it is accompanied by a backflow prevention device. Which type of device is recommended?
- 17 What identifies the difference between BS 1212 Part 2 float-operated valves and Part 3 float-operated valves?
- 18 Which plumbing component would contain a ceramic disc?
- 19 A maintenance task in a domestic dwelling requires that the cold water supply to the property be isolated for most of the day. What should we advise the customer to do?
- 20 Name two common faults that can occur on domestic cold water supplies.