# SECTION 3

## SOURCE SELECTION, PROTECTION AND MONITORING

Section Contents


3.1 Introduction
3.2 The hydrological cycle
3.3 Source selection
3.3.1 Streams and rivers
3.3.2 Springs
3.3.3 Wells and boreholes
3.4 Source protection
3.4.1 Streams and rivers
3.4.2 Springs
3.4.3 Wells and boreholes
3.5 Monitoring


Private Water Supplies

### 3.3 Source selection

Sources of private supplies are mainly springs, wells and boreholes. Whatever the source, it must consistently yield enough water for the user.

**Streams and rivers** – offer more reliable yields but may be susceptible to pollution and may exhibit variable quality, and so are normally used only where a groundwater source is unavailable. Treatment systems should be designed for the worst expected raw water quality. A small reservoir or tank installed at the source can help, but this will require regular inspection and cleaning.

**Springs** – the quantity of water available from a spring depends on its source, with those from deep-seated aquifers being the most reliable. Treatment is usually simpler than for surface waters because spring water is likely to contain less suspended matter.

Some ‘spring’ sources are in fact artificial land drains and should be regarded as effectively surface waters, with their associated variable quality.

**Wells and boreholes** – normally a properly designed and constructed borehole will be able to supply water sufficient for at least a single household.

Groundwaters are usually of good quality and treatment may consist of disinfection only. However, some contain high concentrations of iron, manganese, nitrate, pesticides and/or chlorinated solvents.

## 3.4 Source protection

**Streams and rivers** – water may be pumped directly from the stream or river or it may be collected from the ground in the immediate vicinity.

Intakes should not be situated on bends in the stream or river or at places where sudden changes in level occur. Most commonly, they are situated in the stream or river, protected by a strainer. The inlet pipe feeds a settlement tank built of a material that will not impair water quality but will keep out vermin and debris. The tank outlet is fitted with a strainer and is situated above the floor of the tank to prevent contamination by sediment.

**Springs** – A small chamber built over the spring will protect it from pollution, provide storage and serve as a tank. The tank should have a lockable watertight access cover, an overflow and an outlet pipe with a strainer. It should be built of a material that will not impair water quality but will keep out vermin and debris. It should also be fenced off, with a small ditch upslope for run-off.

**Wells and boreholes** – even shallow wells and boreholes may provide good quality water if built and sited correctly.

The upper section of the well shaft must be lined and sealed against the surrounding material, and the lining must not affect water quality.

Where boreholes are drilled through a perched aquifer, this area should be sealed to maintain water quality. A gravel packing may be necessary if the borehole penetrates unconsolidated sand or sand and gravel.

At ground level, the well or borehole should be covered by a lockable, watertight chamber, and have a sloped concrete apron to drain surface water. All wells and boreholes should be sited up-hill of and well away from potential sources of pollution.

### 3.5 Monitoring

Sampling frequency increases with the size of the supply in accordance with the requirements of the new Private Water Supplies Regulations.

Larger supplies should be sampled for all parameters specified in the drinking water Directive. Smaller supplies could be sampled for a reduced list, but those used for food production should be sampled more frequently than purely domestic ones.

*E. coli* and coliforms are still the most commonly used indicator organisms, while testing for enterococci (faecal streptococci) might be useful in identifying faecal pollution as being of human or animal origin. Also, the presence of *Clostridium perfringens* in the absence of *E. coli* and enterococci can be taken to indicate a historic pollution event.

Appropriate monitoring is generally impractical for small water supplies, however, and therefore a risk assessment of the catchment should be carried out, and protection measures taken. If there is a high risk of faecal contamination, alternative sources of supply will need to be considered. If there is no alternative supply, treatment barriers must be strengthened and assessed against microbial predictions, and contingency plans should be in place for a boil water regime if necessary.

Private Water Supplies

This page is intentionally blank

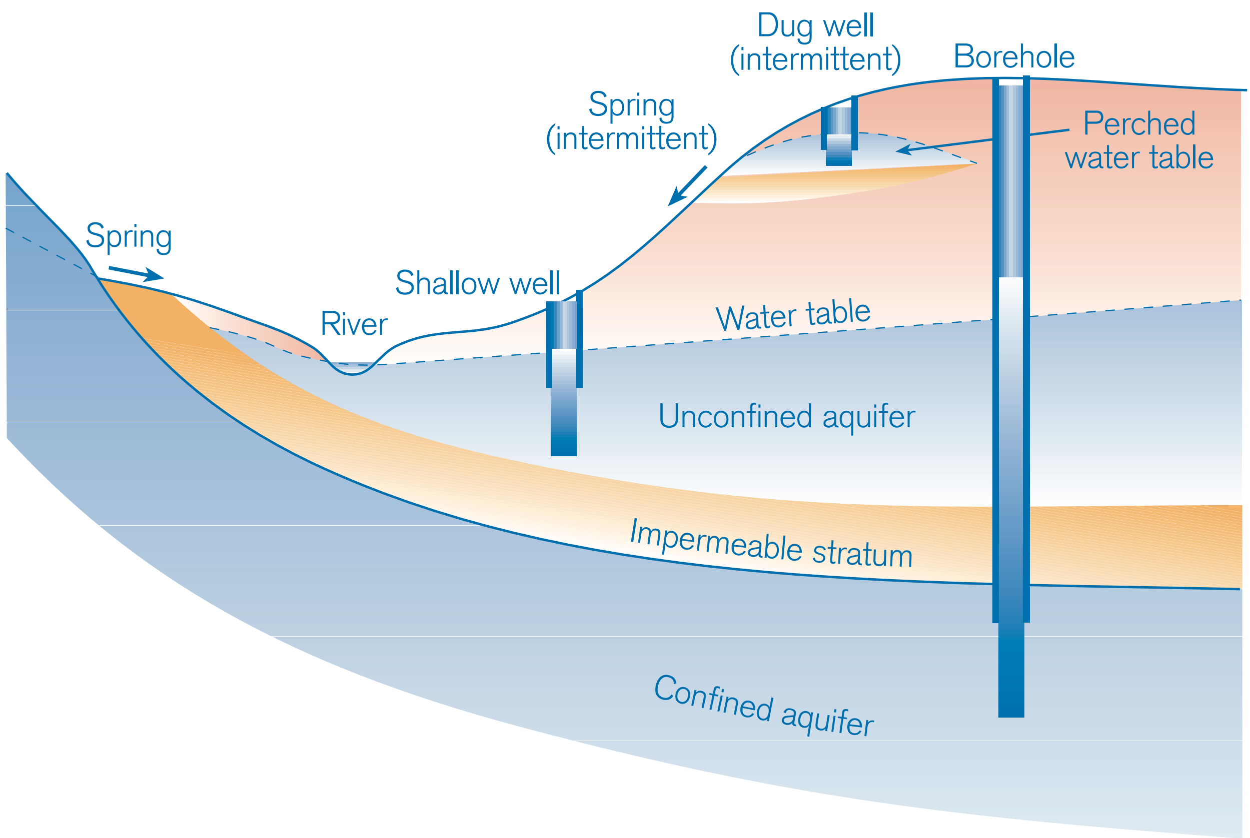
# 3 SOURCE SELECTION, PROTECTION AND MONITORING

## 3.1 Introduction

Water in oceans, lakes or lochs, rivers and the ground, as well as snow and ice, constitutes the hydrosphere. Water in the hydrosphere is involved in the hydrological cycle, which covers movement of water between the hydrosphere and the atmosphere. Precipitation and evaporation are the principal agents of this movement.

Water which flows in streams and rivers or which is contained in lakes or lochs is called surface water whilst water which percolates into the ground and reaches the water table is called groundwater. The general features of geological formations associated with surface water and groundwater sources are shown in Figure 3.1.

**Figure 3.1 Groundwater and surface water sources**



## 3.2 The hydrological cycle

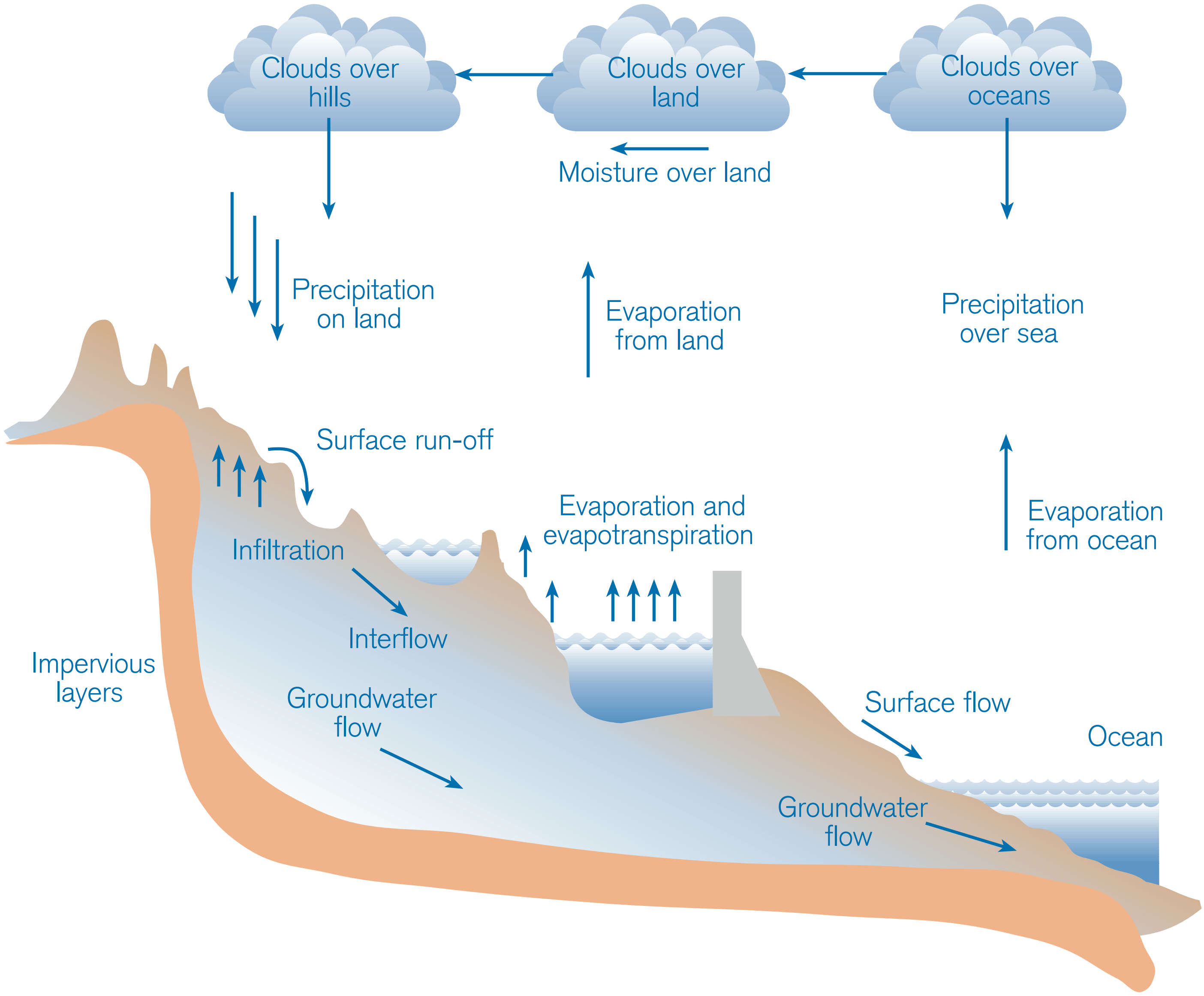
Evaporation from the oceans produces water vapour, which rises and condenses to form clouds; these clouds move with atmospheric circulation until they lose thermal energy and the condensed water vapour is released as precipitation. The precipitation introduces water into the terrestrial environment where it may percolate into the ground, run-off as rivers and streams, or be returned to the atmosphere through evapotranspiration. Eventually such moisture returns to the oceans or the clouds and the cycle begins again (Figure 3.2).

Within this cycle raw water may be obtained from rivers or streams, from lakes and reservoirs, or from groundwater. Of these sources, groundwater is the most abundant. World-wide groundwater constitutes around 95% of the available freshwater reserves. Precipitation falling on to a soil will wet the soil surface and then infiltrate below ground level where it adheres to the soil particles by a combination of surface tension and molecular attraction to form pellicular water. Such pellicular water escapes the forces of gravity as the attractive forces of surface tension and molecular attraction are such that only evapotranspiration can remove this bound water. Thus precipitation will only penetrate deeper once the soil reaches its field capacity when the force of gravity exceeds the attractive forces binding water to soil particles and allows the water to drain downwards. In this region of the soil the voids present in the soil or rock are not completely filled with water and so this region of the subsurface is known as the unsaturated zone. As gravity pulls the water down to greater depths the voids become completely filled with liquid and this is termed the saturated zone. Water in this saturated zone is termed groundwater and the boundary between the unsaturated and saturated zone is termed the water table. This separation is not clear-cut and the transition phase between the unsaturated and saturated zone is called the capillary zone or capillary fringe.

If these zones are viewed in terms of pressure then it is found that the unsaturated and saturated zones have different characteristics. The pressure gradient in the unsaturated zone is less than atmospheric pressure, i.e. atmospheric minus capillary pressure, whereas in the saturated zone the voids are completely filled with water at a pressure above atmospheric pressure. Thus the water table may be defined in terms of pressure as the level in the subsurface where atmospheric pressure occurs. These pressure differentials mean that if a well or borehole is excavated into the saturated zone, water will flow from the ground into the well. Water will then rise to a level in the well where the pressures equilibrate. Groundwater can be broadly defined as that water located below the water table, i.e. in the geomatrix (soil, rock or other geological material) where the void area, the space between the constituents of the geomatrix, is approximately 100% occupied by water. These voids or pores can be used to classify groundwater-bearing rocks into two broadly exclusive groups:

- reservoirs - geomatrix containing voids that allows liquid to penetrate into the main body of the material;
- non-reservoirs - geomatrix lacking any void space and therefore unable to harbour any liquid.

## Figure 3.2 Hydrological cycle



## 3.2 The hydrological cycle (continued)

Reservoirs vary in the degree to which stored water will be released as some may not easily release their stored water, e.g. clays are reservoirs but do not release their stored water. This feature of reservoirs requires a further division into permeable and impermeable reservoirs.

Another feature is that groundwater is dynamic, being constantly in motion through the geomatrix. The ease with which water can pass through particular rock strata depends on a combination of the size of the pores and the degree to which they are interconnected resulting from the degree to which the rock is permeable. An aquifer is any rock which contains interconnected pores or fissures which can hold and transfer water (Figure 3.3) and may be defined as a water-bearing rock formation that contains water in sufficient amount to be exploited and brought to the surface by wells.

Geomatrix materials that can serve as aquifers include gravel, sand and sandstone, alluvium, cavernous limestone, vesicular basalt and jointed slate. The different components that combine to produce an aquifer system are shown in Figure 3.3. It is apparent that there are two distinct types of aquifers: confined or unconfined. In an unconfined aquifer the water table is unrestricted and can thus move up or down through the geomatrix. By contrast a confined aquifer is restrained by an upper layer of impermeable rock, termed an aquiclude, which prevents water moving upwards. As discussed above, the pressure in a confined aquifer will be above atmospheric pressure and this pressure difference will cause water to rise in a well shaft that penetrates the aquiclude. Such wells are termed artesian wells. An imaginary line joining the water surface in many wells in a confined aquifer is called the potentiometric surface (Figure 3.3).

To complete the hydrological cycle within the groundwater area, all freshwater found underground must have a source of recharge such as rainfall or leakage from surface drainage such as rivers, lakes or canals. It should be borne in mind that groundwater systems are dynamic with water continuously moving from areas of recharge to areas of discharge with transit times of many years.

## Figure 3.3 Confined and unconfined aquifers