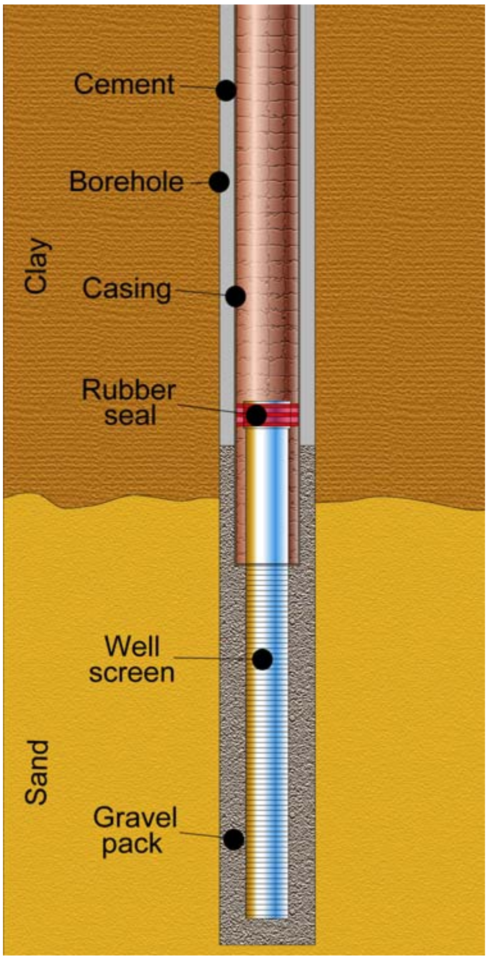
Groundwater development

Springs and wells have been used for water supply from time immemorial. Many villages and towns were sited on spring lines or where shallow aquifers in river valleys could be readily tapped by hand-dug wells. With the advent of the steam age and the development of pumps capable of lifting water from much greater depths, as well as mechanical drilling equipment, deep wells and boreholes were increasingly constructed during the nineteenth and twentieth centuries. Towns and cities such as Brighton, Portsmouth, Peterborough, Liverpool and Grimsby owe at least part of their expansion and prosperity to a good local supply of groundwater.



Section of a borehole showing a well screen and a gravel pack (or filter) in unconsolidated sands. The annulus around at least the upper 15 metres of the borehole is sealed with cement to prevent, possibly contaminated, surface water seeping in.

Nowadays groundwater is abstracted for public supply and industrial use from boreholes 450 to 900 millimetres in diameter and generally up to 100 metres deep. If the aquifer consists of sands that could collapse into the borehole, the borehole is lined with a slotted steel or plastic pipe (a well screen) that may be surrounded by a gravel filter (or gravel pack). The water is pumped to the surface with electrically driven pumps referred to as electric-submersibles because both the pump and the motor are installed in the borehole below the water table. Such boreholes yield as much as 100 litres / second.

Many farms, households and communities in rural areas still obtain their water supply from shallow wells or small-diameter boreholes. In these situations groundwater is the only practical means of supply. Because such sources are relatively shallow and often near habitation, they are vulnerable to contamination. Care is necessary to ensure that the annulus between a well or borehole and the rock strata is well cemented to a depth of about 15 metres to prevent the ingress of surface drainage or possibly farm effluents.

In the past, tunnels or adits were driven horizontally from large-diameter wells to tap a larger volume of an aquifer. This practice has been discontinued partly because of the cost but mainly because the required yield could be obtained more efficiently from drilling more boreholes. However, in the Chalk of south-east England there are many kilometres of water adits still in use, in the Lee and Darent valleys, east of London, there are 18 kilometres and on the Isle of Thanet, in Kent, 14 kilometres.

If groundwater is abstracted from an aquifer at rates that exceed the average long-term replenishment from rainfall, water levels steadily decline and the yield of water will eventually decrease. The long-term decline of levels is undesirable but must not be confused with short-term falls during periods of drought. The management of groundwater resources is concerned with the optimum use of the water stored in aquifers, storage that has very little value unless it is put to good use. An aquifer is a reservoir and to use the storage capacity effectively it must be accepted that water levels will fall as short-term demands for water are met. Water levels recover quickly when rainfall patterns are re-established.

An advantage of groundwater as a source of water is that it is not affected by abnormal seasonal weather as much as surface water sources. Groundwater supplies in major aquifers are little affected by one or even two dry winters. During droughts groundwater levels are often

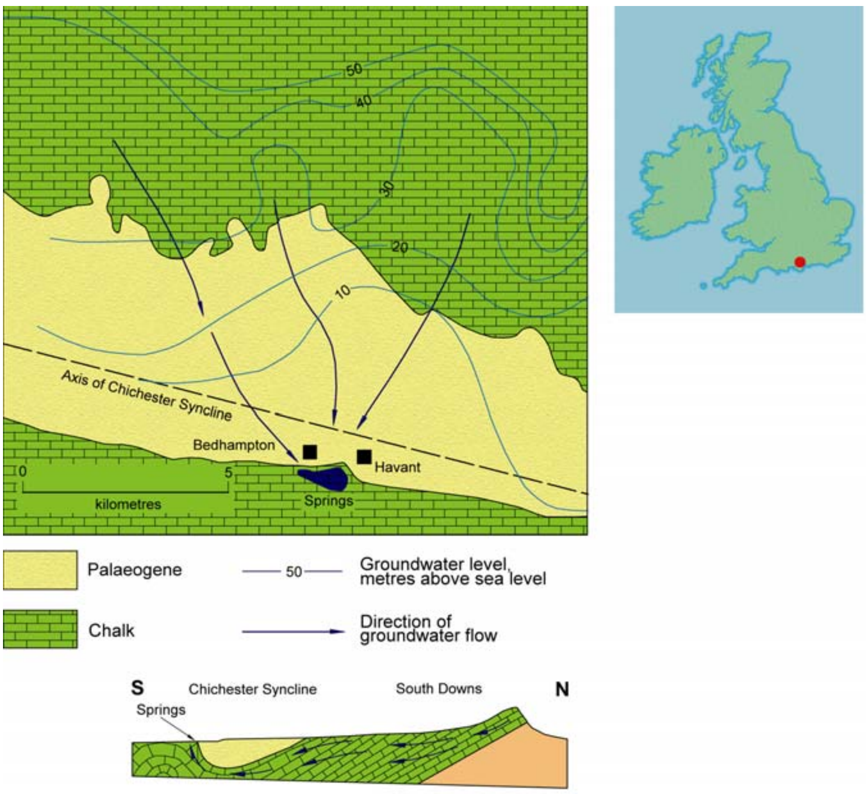
Groundwater flowing from a fracture in the Chalk into a tunnel (or adit) driven from a well in the Lee Valley.

said to be ‘very low’, the mental link being with very low levels in surface reservoirs. But ‘very low groundwater levels’ in the Permo-Triassic sandstones are generally no more than a metre below the mean, while the thickness of the aquifer is some 200 metres or more. In a fractured aquifer, such as the Chalk, the difference between drought water levels and the mean level is greater, ranging up to possibly 7 or 8 metres below areas of high ground, although less below low ground, in an aquifer at least 50 metres thick. Yields from boreholes do decline in the summer and autumn following dry winters, but aquifers, unlike surface reservoirs, do not dry up, although they do stop overflowing from springs. Aquifers can also be developed gradually, in stages as required, and often where the water is needed; long pipelines are not necessary.

Development of groundwater must ensure a sustainable balance between the proportion of the natural recharge abstracted for supply and the amount left to flow naturally from an aquifer to protect the aquatic environment, particularly river flows. At times of low river flows, problems of water quality increase, putting aquatic life at risk. Thus, the sustainable yield of an aquifer must allow for both the consumptive and environmental uses of groundwater.

Chalk springs supply Portsmouth

Portsmouth obtains its water supply from a closely defined group of 28 springs which issue from the Chalk between Bedhampton and Havant, some 10 kilometres to the north-west of



The origin of the Bedhampton and Havant Springs. Groundwater flow in the Chalk aquifer is focused on a fractured zone in the Chalk which allows the water to pass below the Chichester syncline.

the city. About 60 Ml are abstracted each day. It is the largest public water supply from a spring source in the UK. The flow of the springs actually varies between about 65 and 165 Ml/d with an average flow of about 100 Ml/d.

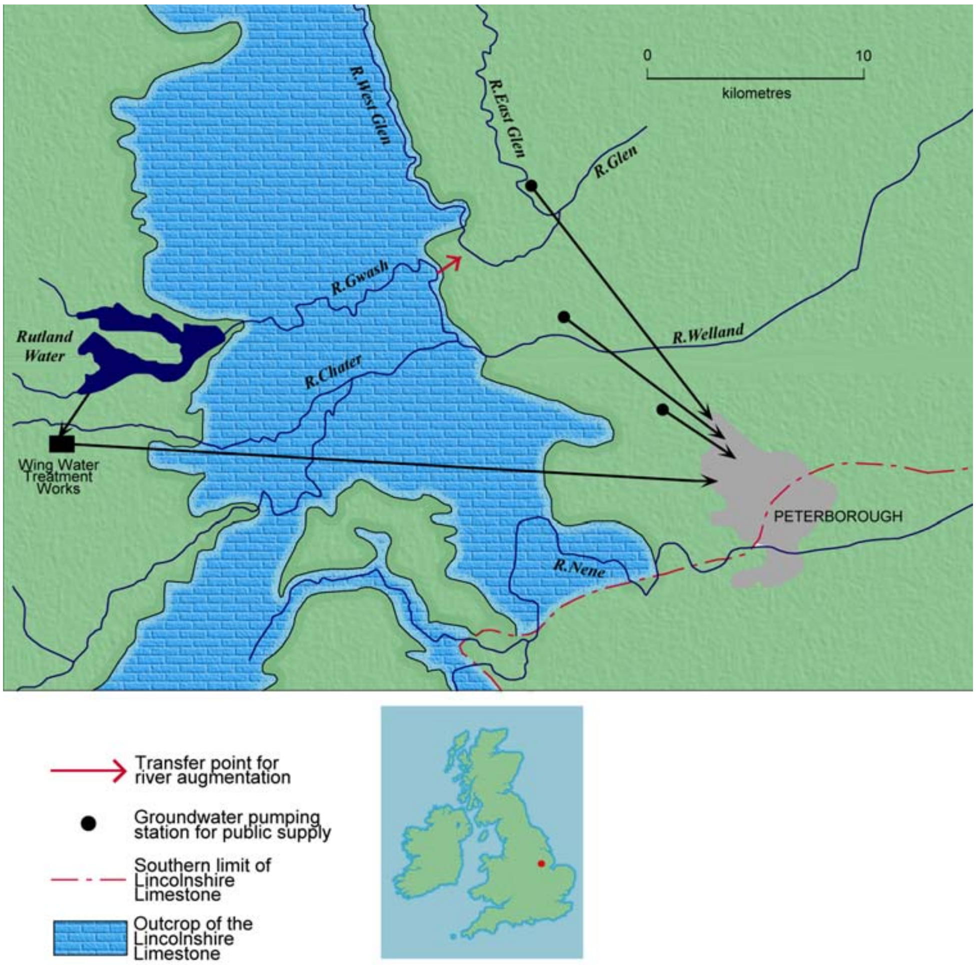
The springs are draining rainfall that infiltrates into almost 100 square kilometres of the Chalk's outcrop at the western end of the South Downs. Such a large flow of groundwater emerging from so small an area is a direct consequence of the geology. Just to the north of Bedhampton and Havant, the Chalk is overlain by Palaeogene deposits. Both formations have been folded into a syncline that takes the top of the Chalk to a depth of over 60 metres below sea level, and which acts as a barrier to the southward flow of groundwater. However, near the springs the syncline is not so deep and the Chalk is also very fractured. The groundwater is focused on this fractured zone which provides channels through the chalk allowing the water to pass under the syncline and re-emerge at the springs on the south side.

Two sources of water supply for Peterborough

Peterborough takes a major part of its water supply from the Lincolnshire Limestone. Up to 40 Ml/d are pumped to the city from this prolific aquifer with individual boreholes yielding more than 15 Ml/d.

Over much of the Fenland north of Peterborough the water pressure in the aquifer is still high enough for water to overflow at the surface. However, during periods of drought the yield declines and the rivers that depend on springs issuing from the aquifer can also dry up. When this occurs the supply to the city is augmented with surface water from Rutland Water. Water released from the reservoir into the River Gwash is also pumped into the River West Glen to maintain the flow in this river, which normally depends upon limestone springs for its supply.

In this manner a balance is struck between public water supply and the needs of the aquatic environment.



The two sources of water for Peterborough. The city obtains its water supply from the Lincolnshire Limestone aquifer. At times of drought this source is augmented from Rutland Water.

Rising groundwater levels under cities

In the nineteenth and early part of the twentieth centuries, large volumes of groundwater were pumped from aquifers below cities, including London, Birmingham and Liverpool. Considerable falls in groundwater levels resulted. In London, many industries, businesses and offices, for example the Bank of England and the Savoy Hotel, had boreholes or wells into the Chalk. The groundwater level below central London had fallen to almost 90 m below ground level by the mid-1960s.

More recently, patterns of groundwater use in cities have changed. Industrial activity has declined and many private boreholes have become disused as preference switched to public water supplies. A further factor was a decline in the quality of groundwater below cities because of surface contamination and in some cases saline intrusion from the sea or tidal rivers. Consequently water levels have begun to rise towards levels prevailing at the beginning of the nineteenth century. This has led to fears about the flooding of basements and tunnels, and damage to the foundations of buildings. In Liverpool pumping has had to be increased to provide adequate drainage for a railway tunnel and basements have been flooded in Birmingham. Below London, the water level in the Chalk is rising at a rate of up to 1.5 metres / year. The rising water levels are giving cause for concern. The foundations of the new British Library were modified because of the worry that higher water levels in the future may affect the stability of the building. The tunnels of the London Underground and deep telecommunication cable ducts are also particularly at risk.

In London a strategy has been developed to address the problem by a consortium including Thames Water, London Underground, the Environment Agency and other stakeholders.

The strategy involves increased abstraction of groundwater from boreholes to control the rise of the levels, with the majority of the water being utilised for public supply.