Groundwater: a valuable resource

This note provides a brief technical overview of groundwater in the UK, describing the social, economic and environmental benefits it provides, some of the issues which threaten it, from pollution to over-abstraction, and measures to encourage sustainable groundwater management.

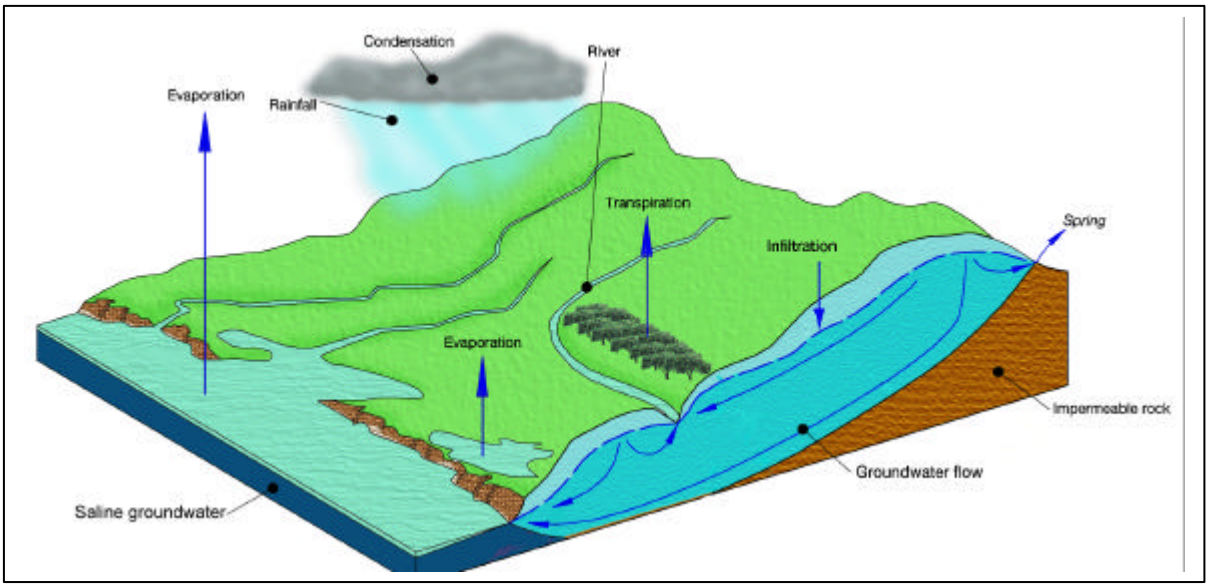
The UK possesses abundant groundwater resources, which provide vital water supplies, help to shape and maintain our countryside, and support economic progress.

Groundwater is used across the UK, from the Isle of Wight to the Orkneys, although it is found in greater abundance in some regions than others. It is a high quality, reliable and practical source of water for public supply, agriculture and industry. It also plays an essential part in sustaining the country's natural biodiversity and the functioning of the environment as a whole. However, groundwater is vulnerable to pollution and depletion, and needs to be managed carefully and sustainably to avoid serious economic and environmental costs.

What is groundwater?

Groundwater is stored in permeable rocks, known as **aquifers**. It is **recharged** by rainfall and surface water which infiltrate the soil and percolate down until they reach the **water table**, the level below which the rock is completely saturated. Groundwater is stored in, and flows through, connected pore spaces between the small grains that make up the rock, or through the many narrow cracks that intersect it. The water is filtered during its slow passage through the ground, resulting in the good quality and consistent chemical composition which is typical of groundwater in its natural state. Groundwater may be stored in aquifers for a few days or many thousands of years, but eventually it emerges at the surface.

Groundwater is a renewable but finite resource. Its availability depends on the amount and distribution of recharge and the volume of aquifer storage. If abstraction from aquifers exceeds the average long term recharge from rainfall, groundwater levels steadily decline and the aquifer yield will eventually fall.



The UK Groundwater Forum is a means for the major stakeholders in the UK groundwater sector to discuss research and information needs and help to ensure that groundwater plays its full part in meeting the needs of society and the environment. The Forum is run by a Steering Committee which includes representatives of the UK environment regulatory agencies and the water industry. It is supported by a Secretariat.

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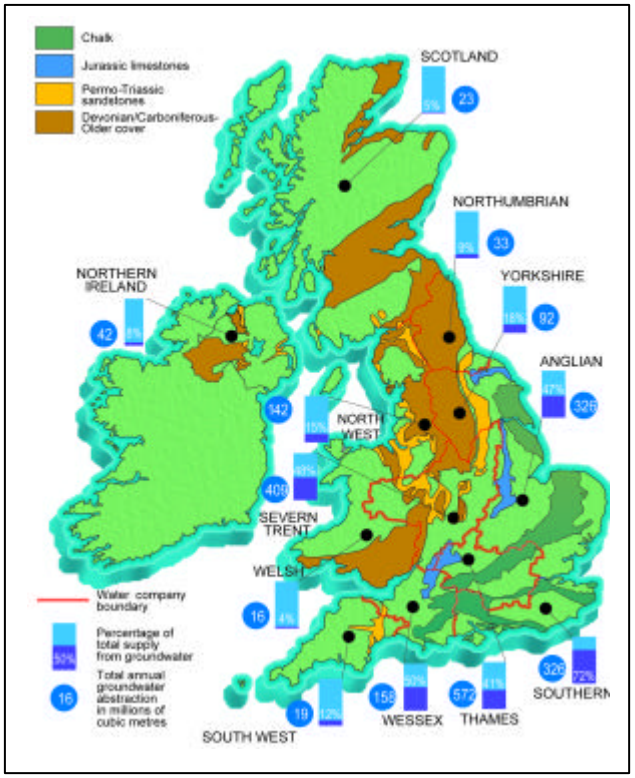
A pure and abundant water source

Groundwater is usually of high **quality**, because of the protective filtering action of the rocks through which it flows. It normally needs little treatment except disinfection. Unlike rivers and surface reservoirs, aquifer yields are not much affected by normal dry summers, and even during abnormal droughts aquifers don't dry up, although they can stop overflowing from springs. The major aquifers in the UK are the Chalk, providing 60% of all groundwater abstracted, and Permo-Triassic sandstones, providing 25%. The volume of groundwater abstracted every year for all purposes in the UK is 2,400 million Ml (megalitres) – almost equal to the total storage in all surface water reservoirs in the UK.

The value of groundwater

Groundwater is an important source for **public water supply**, playing a vital role in maintaining supplies during dry summers and prolonged droughts. Groundwater provides 5% of public water supply in Scotland, 8% in Northern Ireland, and 33% overall in England and Wales, rising to over 70% in the south-east of England. Groundwater is used more in the south of the UK because the most productive aquifers are there, and because generally low summer rainfall in this region leads to falling surface water stores during the summer – just as demand for water reaches its highest!



Groundwater is also important for rural water supplies in more remote parts of the UK. In many such areas, groundwater from wells or shallow boreholes is the only practical means of supply for farms and communities.

Groundwater is an essential part of many of the **natural environments** we take for granted. Rivers which drain areas of permeable rocks, such as in the Chalk downlands of southern England, obtain virtually all their water from groundwater. Flows are at a maximum in early spring, when groundwater levels are high, and decline naturally from late spring to autumn as water tables fall. Wetlands are formed in valley floors by groundwater discharging at the ground surface. Many wetlands are designated as sites of special scientific and often international interest, because of the diversity of plant and animal ecosystems they support.

The groundwater abstracted annually in the UK has an **economic value**, too, representing over £2 billion in asset to the nation. Groundwater supports economic activity through its use in agriculture and industry. Activities as diverse as freshwater fish farming, beer and whisky production, mineral water abstraction and food processing may be dependent on groundwater. Fish farming alone uses over 100,000 Ml of groundwater every year. All these industries need high quality, reliable sources of water, for which groundwater is ideal. The total capital cost of developing a groundwater supply to serve over 150,000 people (27 Ml per day) is of the order of £25,000,000 – low compared to developing a new surface water resource. This includes hydrogeological surveys and borehole siting, drilling, testing and pump installation. Operational costs are also favourable, because groundwater needs little treatment and because boreholes can be developed close to where they are needed, so long pipelines and expensive transport systems aren't needed.

The environmental role of groundwater also has an economic value, although it is not usually expressed. Many ecologically important and naturally beautiful environments which are dependent on groundwater are important to tourism. Groundwater-maintained river flows can also be vital for the proper dilution of discharged wastewater.

Limitations and threats

The quality and quantity of groundwater and dependent surface water environments are vulnerable to the effects of man's activities and to the potential impacts of climate change. Groundwater is a finite resource, and there needs to be a balance between abstraction for human use and the environmental requirements. Over-abstraction and pollution can harm the natural environment and increase the costs of providing water supplies, for example if expensive water treatment is needed to remove pollutants. Some of the key threats to groundwater are summarised here.

Industrial pollution and contaminated land

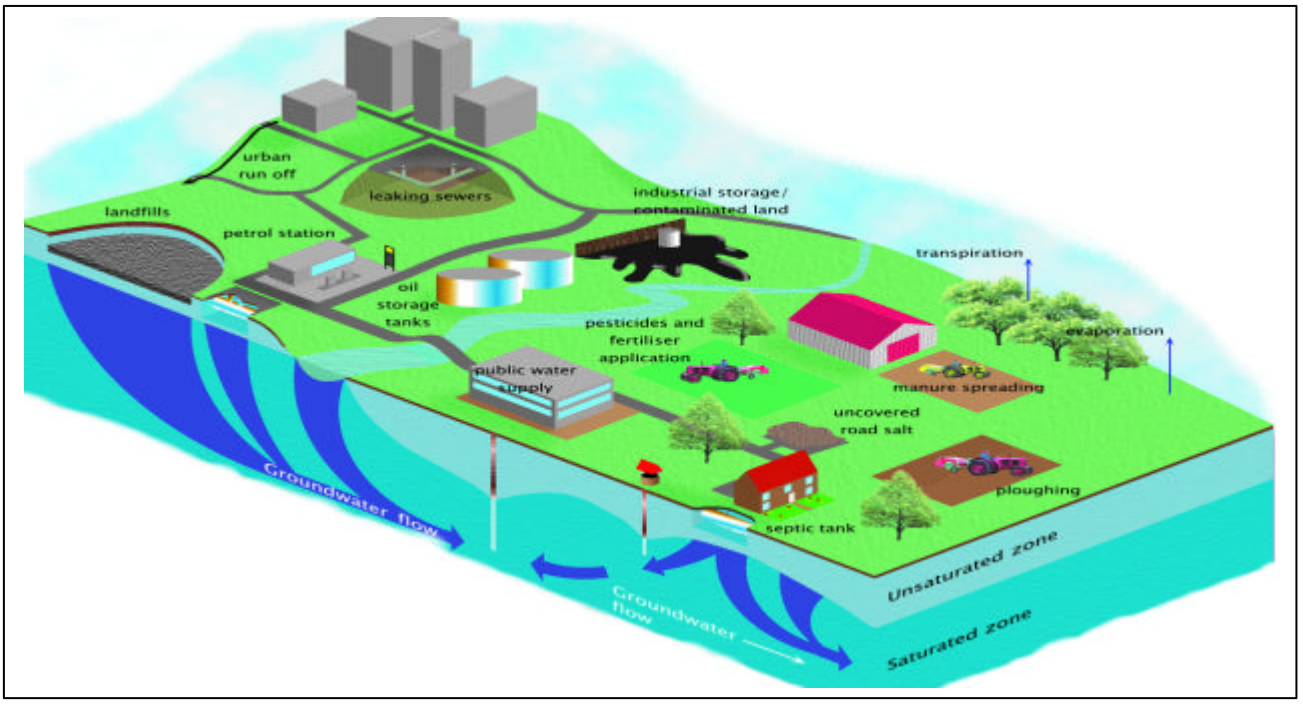
Industrial activity can contaminate soils with potentially toxic substances, including heavy metals, petroleum products and chlorinated hydrocarbons. There are at least 50,000 contaminated sites in the UK, covering more than 500 km^2. Contaminated sites overlying aquifers can cause groundwater pollution, especially when sites are disturbed during redevelopment, unless they are properly assessed and regulated.

Direct spills or leaks of industrial chemicals from tanks and pipelines also threaten groundwater quality. If these often long-lasting chemicals reach the water table, they can dissolve and contaminate large volumes of groundwater. The maximum level of synthetic organic compounds allowed in drinking water in the UK is only 10 parts per billion.

If a fine-grained aquifer such as the Chalk is contaminated it is virtually impossible to clean it up to drinking water standards, and replacement water supplies may have to be found. Even if it is possible, the costs of treatment are high.

Nitrate

Nitrate pollution of groundwater occurs in many parts of the UK, associated with both arable and livestock farming. Nitrate is an essential plant nutrient and present in most fertilisers, as well as in animal waste. Nitrate concentrations in drinking water are limited to a maximum of 50 mg/l for health and environmental reasons. If groundwater serving a public water supply exceeds the nitrate limit, the affected borehole may have to be deepened or closed, or another water source found to replace it or to provide water for blending. If no other option is possible, nitrate must be removed by specialized and expensive water treatment. A more prudent approach is to prevent nitrate contamination of groundwater. Where surface or groundwaters exceed or are at risk of exceeding the nitrate concentration limit, their catchment area is designated as a **nitrate vulnerable zone** (NVZ), within which measures must be taken to control the amount of nitrate leached from the soil. By the end of 2000, 68 NVZs had been designated in England and Wales, 11 in Scotland and 3 in Northern Ireland.



Pesticides
Synthetic organic pesticides are widely used in agriculture and by public authorities. Even if used according to the Codes of Practice, with careful storage and disposal, there is a danger that residual pesticide may find its way into groundwater. The maximum admissible concentration of any individual pesticide in drinking water is low, at 0.1 parts per billion. Although groundwater is well protected compared with surface water, pesticides have already been detected (although generally at levels below the limit) in some aquifers. The water industry has introduced costly treatment processes to remove pesticides, but steps are also being taken to encourage the restriction of pesticide use in areas where groundwater is vulnerable to contamination.

Low river flows and wetlands
Falling groundwater levels caused by abstraction from aquifers can lead to low river flows and the drying up of wetlands. This can be harmful to aquatic ecosystems, and can reduce how effective rivers are at diluting wastewater, such as sewage treatment effluent. Appropriate groundwater management policies must ensure that there is a balance between essential groundwater abstraction and environmental protection.

Climate change
The potential impacts of climate change on water resources are complex, because of the many interactions between climate, demand and resources. Potential changes in rainfall and evapotranspiration patterns are still not fully understood, and so it is not clear how recharge to aquifers and the volume of available groundwater will be affected. Current scenarios anticipate warmer summers, with increased water demand, and wetter winters, with higher groundwater recharge. As was seen in 2000, one result of exceptionally high winter groundwater levels is serious flooding.

Groundwater and the law

Water is one of the most carefully regulated areas of European environmental law, with a range of legislative measures to protect both water supplies and the environment. In the UK, legislation requires the water suppliers to provide consumers with wholesome water, and the environment agencies to prevent water pollution and (in England and Wales) to licence water abstractions in order to prevent over-exploitation. The EC Water Framework Directive, which came into force in December 2000, should help to ensure that these requirements are met.

The Water Framework Directive aims to ensure the integrated management and protection of all inland and coastal water resources, within the framework of river basins. This will ensure that the right amount of water is available where and when it is needed. The environmental objective of the Directive is to achieve **good status** for all waters by 2015. For groundwater, this will mean effective monitoring of groundwater quality, levels and abstraction, and a programme to ensure that pollutant emission limits are met and that water quality and quantity standards are achieved.

Groundwater and the future

We need to make sure that the UK's groundwater continues to be available to provide public water supplies, maintain our natural environments and support agriculture and industry in the future. This means valuing groundwater appropriately, improving our understanding by continued research, and meeting legislative targets for quality and quantity. Together, these measures will lead to more effective and sustainable groundwater management, protected water supplies and a healthier environment.

Further Information

Groundwater – our hidden asset. British Geological Survey/UK Groundwater Forum. © NERC 1998. For more information on this layman's guide to groundwater in the UK see http://www.nwl.ac.uk/gwf/gwfbook1.htm

Environment Agency: introduction to groundwater http://www.environment-agency.gov.uk/subjects/waterres/groundwater/?version=1

EU Focus on Clean Water: facts about water and legislation in Europe http://europa.eu.int/comm/environment/eufocus/clean_water.pdf