Hydrogeology and water supply, geology and man, Northern England

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Contents

Introduction

Distribution of surface water from the Lake District reservoirs. P916109.

Water supply across north-east England is largely drawn from surface reservoirs. Of these, the Kielder Water reservoir in the uppermost reaches of the River North Tyne has the largest capacity (200 000 Ml) of any UK reservoir and is the largest artificial reservoir in western Europe. It was opened in 1982 to supply Tyneside, Wearside and Teesside. Water is released from Kielder Reservoir into the River Tyne and can be transferred thence into the Rivers Wear and Tees. Abstracted river water is then used to supplement the traditional supply from groundwater and smaller reservoirs, notably those at Derwent and Cow Green.

In north-west England, the radial lakes of the Lake District are important sources of supply (P916109). Haweswater and Thirlmere have been developed to supply water southwards to Barrow

and the Manchester conurbation; supplementary supplies are drawn from Ullswater and Windermere. The west Cumbrian towns are largely supplied from Crummock Water and Ennerdale Water, whilst Wast Water is used as a source of supply for the Sellafield nuclear site. In the Isle of Man there are no productive aquifers and the public supply is currently derived exclusively from surface sources such as the Sulby Reservoir to the west of Snaefell.

Lower Palaeozoic rocks

The impermeable Lower Palaeozoic rocks forming the central Lake District (and most of the Isle of Man) create an important gathering ground for surface water. Low bulk permeability is provided mostly by fissures, which also allow some groundwater infiltration. Variations in fissure width, extent and interconnection produce a range of groundwater conditions and hydraulic yields are unpredictable. Mineral springs rise from the Skiddaw Group near Derwent Water and Keswick, and from Dent Group limestone at Shap; their chemistry suggests the slow circulation of peaty water along calcite-bearing mineral veins.

Carboniferous rocks

The Border Group's Fell Sandstone Formation contains important aquifers that for over a century, and despite some saline intrusion, have supplied Berwick-upon-Tweed. The Fell Sandstone is hydrogeologically complex and multilayered, with up to seven discrete sandstone aquifers separated by thick, laterally persistent layers of impermeable mudstone. The majority of water flow is via fractures or thin, coarse-grained horizons. Large springs are associated with cross-cutting dykes intruded into fault zones: near Rothbury, Cartington Spring (NU 042 044) and Tosson Spring (NU 030 002) jointly yield in excess of 9000 m3/d.

Limestone, sandstone and conglomerate of the Ravenstonedale and Great Scar Limestone groups act as aquifers throughout their northern England outcrop, confined by intervening argillaceous rock layers. Bulk permeability is due almost entirely to fissures except in some of the calcareous sandstones where a secondary intergranular permeability has developed after leaching of the cement. Intergranular and bulk porosities are always low so that storage capacity is limited, whilst rapid drainage from fissures makes borehole yields unpredictable.

Groundwater in Carboniferous limestone is of a calcium bicarbonate type. Its storage and transmission depends entirely on fissure size, extent and interconnection. Earlier periods of karstic weathering have left passages and enlarged fissures that may now be open, flooded or plugged by sediment. If flow is dispersed through the rock mass there is a water table, relatively slow drainage and limited storage; if restricted to well-defined passages there is no water table, rapid drainage and negligible storage. Abstraction of water may alter hydraulic conditions by unplugging fissures or plugging them with sediment. Limestone aquifers are highly vulnerable to pollution since fissures give ready access to the surface.

Sandstone aquifers in the Yoredale and Pennine Coal Measures groups give good yields. Intergranular permeability occurs in some coarse sandstone but fissures are the main influence on water-bearing properties. Major fissures occur along fault planes, and minor fissures are present along joints and bedding planes. Most close with depth so that permeability decreases downwards within a single aquifer and lower aquifers are generally less permeable than higher ones. Below depths of 250 m, the majority of fissures are closed; at still greater depths, any remaining fissures can give initially high discharges when intercepted, but yields decrease rapidly to zero showing that any recharge at depth takes place very slowly. Only faults are likely to yield persistent discharges at depths below 300 m.

Mine pumping in the Cumbrian Coalfield has abstracted up to about 20% of the reliable yield, dominating the flow pattern, and drawing in sea water to pollute the aquifers. Chemical analyses of mine drainage water reflect the infiltrated sea water, but suggest that normal groundwater is probably a sodium sulphate type with subordinate amounts of chloride. Mine workings in the Northumberland and Durham Coalfield were extensively interconnected and pumping maintained a water table at about 150 m below the ground surface. With the end of mining activity, groundwater levels are rising.

In north-east England, the Yoredale Group's Stainmore Formation constitutes a multilayered aquifer in which thick sandstone and limestone beds act as individual aquifers confined by impermeable mudstone. In many places springs issue from the base of water-bearing horizons and have provided small-scale village supplies. Groundwater storage and movement is predominantly through joints and fractures with only minor contributions via the rock matrix. Borehole yields are dependent on the number and size of fractures encountered in a productive horizon and many boreholes penetrate more than one productive horizon.

Across the Northern Pennine Orefield, mine workings have modified the original hydrogeological character by interconnecting previously separate aquifers, and by creating preferential flow paths now discharging at mine entrances. Some substantial flows have been recorded from drainage adits (soughs). Langthwaite Level (locally known as Goose Nest) is a good example that, during the late 1960s and early 1970s, supplied the villages of Langthwaite (NZ 005 025) and Arkle Town (NZ 008 019).

Permian and Triassic rocks

Within the Permian to Triassic succession of north-west England, there are several productive aquifers in the Penrith Sandstone Formation (Appleby Group) and the Sherwood Sandstone Group. These aquifers have high groundwater potential and could be exploited either by direct abstraction to supply, or as sources of water for regulating river flow.

The rocks of the Penrith Sandstone Formation have intergranular and fissure permeability with the highest porosity and permeability in the weakly cemented sandstones south of Cliburn (NY 359 527). Elsewhere, silica cementation produces sharp reductions in intergranular porosity and permeability, whilst similar reductions are associated with the development of calcite and gypsum cements near the contacts with the Brockram and the overlying Eden Shales Formation. The reductions may be offset locally by fissure flow or re-solution of cement. The groundwater is typically of calcium bicarbonate type with moderate to low total dissolved solids and low hardness. Water confined close to the Eden Shales has higher total dissolved solids and sulphate concentrations, whilst harder water close to the Brockram arises from the solution of carbonate cement.

The Sherwood Sandstone Group forms a very large, continuous aquifer. Intergranular porosity and permeability are generally lower than in the Penrith Sandstone Formation due mainly to compaction and cementation, but fissures are well developed and allow water transmission. The groundwater is typically hard, sodium bicarbonate water with a moderate concentration of total dissolved solids. Saline intrusion occurs in areas of heavy pumping near Barrow and probably occurs to some extent all along the Cumbrian coast. Water confined below the Mercia Mudstone Group is harder than elsewhere, has more total dissolved solids and a higher sulphate concentration.

In north-east England, both the Rotliegendes and Zechstein groups contain productive aquifers. In the Sunderland district, the Yellow Sands Formation of the Rotliegendes Group forms an important aquifer with high granular porosity, and has been tapped by many wells and boreholes. The groundwater quality is generally good. The large volume of water held in the Yellow Sands

Formation posed a particular problem for drainage of mine workings in the immediately subjacent Coal Measures.

The Zechstein Group contains good aquifers with hydraulic continuity despite the presence of impermeable interbeds. Permeability depends largely on fracturing, with some intergranular storage in reef limestone and where dolostone predominates. Yields are extremely variable, but highest where the fracture density is greatest, commonly in the vicinity of faults. Yields may also be enhanced by collapse and brecciation of the aquifers caused by dissolution of underlying gypsum beds. The groundwater quality is generally good, though the waters are very hard and there is a high vulnerability to surface pollution with high nitrate concentrations reported in places. Sulphate and chloride concentrations increase markedly down-dip due to the presence of gypsum and halite in the confining strata.

Quaternary and Holocene deposits

Superficial deposits are highly variable. Aquifers occur within sand and gravel units and may be confined by interbedded silts, clays or glacial till. All supplies are likely to fluctuate rapidly in response to variations in precipitation. The water is generally hard, due to bicarbonate or sulphate concentration, and may be ferruginous. Brackish water occurs in the marine deposits along the coast. The aquifers are liable to pollution from agricultural and industrial discharges. The main significance of Quaternary and Holocene deposits in the context of regional hydrogeology is that they form the confining bed over the main aquifers and control recharge and influence water chemistry.

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