

The UK is heavily dependent on groundwater, especially in the densely populated south-east. **Christopher Jackson** and **Michael Cheetham** investigate the consequences of changing climate on this important resource.

# The future of groundwater

Despite the importance of groundwater in the UK and an increasing recognition that the climate is changing, the potential impacts of climate change on our groundwater resources have not yet been fully assessed. In particular, we need to understand the potential effects of more frequent extreme events.

The link between climate change and increased greenhouse gas emissions is now well established. In 1996, when the Intergovernmental Panel on Climate Change published their Second Assessment Report, the effects of human activity were not clearly distinguishable

from natural climate variability. However, subsequent research has indicated that it is very unlikely that the warming over the past 100 years has been due to natural climate variability alone and there is strong evidence that most of the warming observed over the

past 50 years is attributable to human activities.

In line with the warming of the global climate over the past 100 years, the climate of the UK has changed and average temperatures have risen. The instrumental record of temperature for central England provides evidence for this and shows that 12 of the 22 warmest years between 1659 and 2005 have occurred after 1989. UK temperatures are predicted to increase by between about 2°C and 3.9°C by the 2080s with respect to the 1961–90 average and winters will probably become wetter and summers drier. It is likely that there will be greater variability in climatic conditions, with extremes — flooding and drought — becoming more common.

Such predictions place a responsibility on water professionals to assess the impacts of climate change on water resources. In much of the UK this involves forecasting the effects on groundwater because in the south-east of England groundwater sources provide up to 70% of the water used for public supply. Overall, groundwater resources are likely to be relatively robust in the face of climate change compared with surface water, due to the buffering effect of groundwater storage. Consequently, if managed appropriately, groundwater may have an important role to play in ameliorating the worst effects of climate change on the water environment.



*Dry bed of a Chalk stream near Salisbury, Wiltshire in October 2003.*

Management options might include schemes that use aquifers for short-term storage of water where no suitable sites exist for surface-water reservoirs.

In recent years a significant amount of research has been undertaken to examine the possible impacts of climate change on surface water; however, research examining the effects on groundwater is limited. Our Groundwater Management programme is addressing this need and undertaking research into the impacts of climate change, as well as extreme events such as groundwater-induced flooding and droughts.



*Groundwater flooding at Compton, Berkshire in February 2001.*

Because a central theme of this groundwater research is predicting the impacts of climate change, much of the work relies on the application of models to hydrogeological systems. This can involve the transfer of output from a global climate model (GCM) to a catchment- or site-scale hydrological or groundwater model. Alternatively it could be based on a simpler approach of scaling historical time-series of hydrological data to examine future effects. Models have been used to examine possible future changes in the patterns of groundwater recharge (that is, the amount of rainfall reaching the water table), groundwater storage, and river flows. They have also been applied to investigate the intrusion of saline water into coastal aquifers as sea levels rise, as well as the fate and movement of contaminants under different groundwater conditions and land-use regimes.

The modelling generally shows that for the early part of the twenty-first century summer and autumn recharge is likely to decrease, due to a reduction in rainfall and an increase in evaporation. Warmer summers would extend the seasonal deficits in the soil moisture content into the autumn and therefore lead to a shorter season of groundwater recharge during the winter. This could be compensated, at least to some extent, by

an increase in winter rainfall. However, aquifers are recharged more effectively by prolonged steady rain which continues into the spring, rather than short periods of intense rainfall. Looking further into the future, groundwater availability may increase during the second half of the twenty-first century if the wetter summers predicted by some GCM scenarios become a reality. However, there is some uncertainty associated with these findings.

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The uncertainty in the modelled results arises from a number of sources, the most significant of which is associated with the prediction of future emissions of greenhouse gases. Another significant source of uncertainty is related to the differences between the current suite of GCMs. Tasks such as downscaling

output from GCMs to the catchment scale, constructing hydrological models using historical data and then applying them to predict outside the range of past events, introduce additional uncertainty.

We are committed to undertaking research relevant to climate change and groundwater. Stakeholders in groundwater management have identified the need to provide tools to assess the impact of climate change on groundwater levels and the yields of pumping wells used for public supply. We must also address the effects of changes in climate variability rather than just average changes. Our science programme is focusing on these needs and improving our understanding in this rapidly changing area of research. More research is needed to improve the prediction of climate extremes. However, it is clear that, even so, the country may have to adjust its aspirations for environmental sustainability in the future.

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