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Hydro-ecological functioning of the Pang and Lambourn catchments, UK: An introduction to the special issue

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The research context

The water environment faces increasing pressures, for example changes in land use associated with urbanisation and agricultural intensification, with associated point and diffuse pollution loads, increased demand for water supply, and uncertainties over climate change. There is also increasing recognition of the need to protect vulnerable ecosystems. These pressures create challenges for catchment management that have been recognised in Europe by the EU Water Framework Directive (CEC, 2000); clearly integrated catchment management is needed, and management solutions that take account not only of the quantity and quality of water, but also the associated biological systems. However, the focus on integrated management and, in particular, on ecological quality, raises major scientific and technical questions. Improved understanding of catchment systems and hydro-ecological interactions is required and the development of appropriate decision support tools. However, the necessary science base can only be obtained from integrated, multi-disciplinary experimental research and the associated development of truly inter-disciplinary scientific collaboration.

In the UK, as elsewhere, the focus of experimental hydrology has been in the uplands, and at small catchment scale (<10 km^2). However, arguably the major management pressures lie in the lowlands, and for catchment management units that are significantly larger, perhaps of the order of 300–400 km^2. Hence, an urgent need for research facilities was identified, to develop the scientific understanding of lowland catchments to underpin integrated catchment management at these larger scales. This lead to the development in the UK of a national programme of Lowland CAtchment Research (LOCAR) (Wheater and Peach, 2004). The focus of LOCAR was to be on lowland catchments underlain by permeable geology, since these catchments are important for water supply, subject to intense management pressures, support a large number of protected habitats, and are poorly understood.

This Special Issue focuses on one of the selected pairs of LOCAR catchments, the rivers Pang and Lambourn, and presents some of the first results from the research.

Lowland permeable catchments — the LOCAR programme

The main water supply aquifers in the United Kingdom, namely the Cretaceous Chalk and Permo-Triassic Sherwood

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Sandstone, are situated, for the most part, in lowland England, particularly in the Midlands, South and South East. These aquifers have a major, often dominant influence on the river systems that they underlie. For example, a typical Chalk stream has a predominantly seasonal hydrograph, reflecting the water table dynamics of the aquifer which it drains (winter recharge and a progressive water table decline through summer and autumn); the stormflow component of streamflow response may represent as little as 2% of the incident rainfall, appearing as noise superimposed on the seasonal hydrograph. The streamflow source migrates seasonally, moving up the catchment in winter and retreating during summer; under drought conditions (or due to over-abstraction), flow may cease over significant lengths of channel. Where the geology of a catchment includes poorly permeable rocks, this groundwater dominated response will be modified by a streamflow regime more characteristic of conventional hydrology, i.e. one in which stormflow response to individual events is a dominant hydrograph component. These permeable lowland catchments are subject to a complex set of management pressures. They are intensely utilised for public and private water supply, are subject to a range of more or less intensive agricultural activities, and commonly support valuable riparian and aquatic ecosystems. The LOCAR research programme was therefore formulated with the following aims:

- To develop an improved understanding of hydrological, hydrogeological, geomorphological and ecological interactions within permeable catchment systems, and their associated and temporal scales and for different land uses;
- To develop improved modelling tools to inform and support the integrated management of lowland permeable catchment system.

This was to be achieved through the study of:

- The surface and near-surface environment — surface and near-surface runoff generation, the unsaturated zone, recharge and material transport;
- Groundwater flow and transport processes on lowland permeable catchments, including preferential flows and heterogeneity in flow and transport processes, groundwater/surface water interactions, water/rock interactions;
- Physical, chemical, and biological processes within the valley floor corridor;
- In-stream, riparian, hyporheic and wetland habitats, both structure and function, and their dependence of flow and flux regimes;
- The impacts of society on the functioning of lowland permeable catchments, especially changing land-use.

To develop the research, funding of £7.75 million was provided by the UK Natural Environment Research Council, supplemented by £2 million from a UK government initiative to support research infrastructure (the Joint Infrastructure Fund). Three locations were selected (see Wheater and Peach, 2004), the Tern catchment, a tributary of the River Severn in Shropshire (the UK Midlands) located on the Triassic Sandstone, the Frome and Piddle catchments, located on the Chalk in Dorset (South Coast), and the Pang and Lambourn catchments, tributaries of the Thames, located on the Chalk west of London. Each location had existing infrastructure (and historical data), which was augmented to provide a primary set of research infrastructure and supported by a full-time technical support team. Research applications were requested and selected following national and international peer review. A set of 12 projects was funded (see Wheater et al., in press, for more detail), of which the majority were located or had an element of work in, the Pang and Lambourn catchments. This Special Issue is the first collated set of research outputs from these and related projects.

The Pang and Lambourn catchments

The rivers Pang and Lambourn are adjacent catchments, located near Reading (and near Wallingford), some 60 km west of London in the Berkshire Downs. The Pang is a minor tributary of the River Thames; the Lambourn is a tributary of the River Kennet, which in turn drains to the Thames. The location, topography and surface water catchments are shown in Fig. 1.

Average annual rainfall varies from a maximum of 743 mm in the North and West, where there are the highest elevations, to a minimum of 655 mm, in the South and East. The mean annual rainfall (1968—1997) for the Pang is 692 mm and for the Lambourn is 731 mm (Peach et al., 2004). One output from LOCAR research has been improved estimation of actual evaporation. Preliminary estimates for 2003 range from 300 to 480 mm (Harding, pers. comm.).

The solid geology is shown in Fig. 2. Both catchments are predominantly underlain by the Chalk, the main aquifer of the region, and the north-facing Chalk scarp slope of the Berkshire Downs defines their northern boundaries. The rivers drain in a generally south easterly direction down the dip slope of the Chalk Downs towards the rivers Kennet and Thames, and in the South of the area, the Chalk is overlain by Palaeogene deposits, consisting of silty clay and sands. More detail of the geology can be found in Wheater et al. (in press) and Peach et al. (2006). Both rivers are fed by the Chalk aquifer and exhibit many of the characteristics of Chalk groundwater-dominated river systems outlined above. The dominant influences on regional groundwater flow are the River Thames and, to a lesser extent, the River Kennet. However, locally, groundwater flow may be influenced by structures in the Chalk, and by sub-karstic development and near surface weathering of the aquifer.

Despite the importance of the Chalk as a major UK aquifer, knowledge of the subsurface movement of water and solutes is poor. Groundwater flows are complex; catchments vary seasonally and are ill-defined and karst features are locally important. As noted above (see Fig. 2), the Lambourn is predominantly a Chalk system; the Pang by contrast, has extensive areas of Palaeogene deposits in the lower reaches. The stream hydrographs (Fig. 3) clearly reflect this. The Lambourn flows are dominated by a seasonal response, reflecting groundwater recharge during the late autumn and winter and the subsequent drainage of groundwater to the streams. Response to individual storm