Chapter 6 Fluvial geomorphology of central and southern England

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Fluvial landforms and processes in central and southern England

Introduction

The boundary between the 'Highland Zone', of the north and west of Britain, and the 'Lowland Zone', of the south and east, is usually taken as a line running approximately from the mouth of the River Exe to the mouth of the River Tees. The area defined here as central and southern England includes some portions of the Highland Zone. These are principally found in south-west England, where three upland plateau areas of western Cornwall rise above a landscape that is dominated by coastal low plateaux cut across resistant Palaeozoic rocks. Also representing the upland scenery and resistant rock theme of the Highland Zone are the Mendips and the Quantocks, although the limestone features of such areas as the Mendips are included in another volume in this series. The central and southern Pennines also have the relief, scenery and resistant rock outcrops characteristic of the Highland Zone. Such areas have features similar to those already described for Wales and for north-west and north-east England.

Much of the remainder of the area is made up of two types of landscape which are scarplands or lowlands. A cuesta is an asymmetrical feature made up of a steeper scarp slope and a comparatively gentle dip slope that leads into a vale which is usually underlain by clay. This scarpland pattern of alternating scarp, dip slope and vale is a recurrent theme across much of central and southern England and makes up the scarpland landscape of much of southern Britain. The scale of cuestas varies very considerably from one area to another. Overlooking the lower Severn valley, the scarpland of Jurassic rocks at Birdlip Hill is up to 250 m above the Vale of Gloucester. The Cretaceous Chalk outcrops of southern, southeastern and eastern England are also characterized by cuesta landscapes, and there are major scarp slopes bordering the Chalk outcrops in Lincolnshire and in southeast England, where there are scarps bordering the North and South Downs. Although these are the major scarp and dip slopes making up cuesta landscapes, there are many smaller cuestas picking out variations in lithology that make up the diverse geological map of southern and central England.

A second type of area is made up of lowlands, which include the areas of the Fens, the London Basin, the Hampshire Basin, the lower Severn valley and the Trent and Ouse lowlands of eastern England, and also the Vale of Pickering, between the Jurassic rocks of the Yorkshire Moors and the Cretaceous rocks of the Yorkshire Wolds. In these lowland areas the surface rocks and deposits are usually comparatively young and often include sequences of recent Quaternary sediments.

Prevailing themes

Although the contrast between the Highland and Lowland zones, and also the basic character of the cuesta landscape and of the lowlands, owes much to the underlying rock type and the superficial deposits, there are several other distinctive themes that have influenced the pattern and character of river development in central and southern England.

Firstly, there are still traces of the original east-flowing rivers which were thought to have provided the ancestors of the present river system in Britain. Thus the Trent has east-flowing sections that were complemented by a north-flowing section when rock types allowed the development of subsequent streams. The Thames is also dominantly eastward-flowing, and originally there was an east-flowing major river along the line of the present Solent. Many characteristics of rivers in central and southern England reflect the fact that the headwaters of many rivers originate in the Highland Zone. The fluvial characteristics of some rivers of central and southern England need to be seen as depositional counterparts of fluvial systems of the Highland Zone. Thus headwaters of the Severn and Wye in Wales are associated downstream with the characteristics of the middle and lower Severn, draining into the Bristol Channel. Similarly, the Trent, Ouse and Humber receive characteristic Upland rivers from the Pennines and from the North York Moors.

A second major characteristic of central and southern England is that the recent evolution of the landscape is still firmly imprinted on the scenery. This is particularly significant because the most recent glaciation did not extend over much of this area, and the most southerly maximum limit of Quaternary glaciation was north of the present River Thames. This means that, according to the influence of glaciation, three major areas can be distinguished in central and southern England: one north of the Devensian limit, influenced particularly by deposits in the most recent glaciation; a second, to the south, where there are areas influenced by earlier glaciations; and a third, over the southernmost areas and in south-west England, where there are areas which were periglacial and beyond the maximum limits of Quaternary ice sheets. Whereas, in this southern area, the periglacial influence of permanently frozen ground (or 'permafrost') and a much more seasonal climatic regime produced river systems in the past which were different in character, regime and extent from those of today, in formerly glaciated areas there are some thick deposits of till, fluvioglacial sands and gravels, and diversions of drainage such as that of the Severn, which have all influenced characteristics of the present fluvial system. Along rivers such as the Severn, the Trent and the Thames, terrace sequences clearly indicate the stages of river and valley development.

A third theme arises from interaction with the sea. Estuarine influences in the areas adjacent to the Humber, the Bristol Channel, the Severn estuary, the Thames and the Wash arise because river activity and sediment transport and accretion interact with estuarine circulation and sedimentation. The finer sediments that reach estuarine environments may be influenced by different chemical processes involving, for example, flocculation of clays in saline waters. The largest area of alluvium in Britain surrounds the Wash, and sedimentation in this area, and also in the Vale of York, the Thames estuary and the Somerset Levels, has resulted not only from offshore sources from marine sedimentation, but also from peat and salt marsh development (Lewin, 1981).

Human activity is a fourth theme, because it has had a greater effect on the fluvial system of central and southern England than in other parts of Britain. Because the average population density is greater in this part of Britain, there is the potential for the fluvial system, rivers and river channels to be modified much more extensively than in other areas. The impact of human activity has been registered substantially in the past and continues to be significant at the present time. Deforestation is now known to have had a significant influence upon lowland rivers, and considerable amounts of alluvium have accumulated along rivers, including the Severn and the Thames, as a consequence of deforestation over the past 4000 years, which released suspended sediment transported by rivers and accumulated along floodplains. Although human disturbance of woodland may have influenced valley alluviation, Macklin and Lewin (1994) have suggested that climatic controls, including storms and floods, were important. More recent drainage modification, particularly along river valleys in the Chalk areas of central and southeastern England, include water meadows developed for irrigation purposes, which still complicate the pattern of river channels. In some cases the precise impact of human activity has not been so easy to reconstruct and, whereas an early view (Jennings, 1952) regarded the Norfolk Broads as 'natural', it was subsequently realized that they are relics of medieval peat digging (Lambert *et al.,* 1970). At the present time along the Norfolk Broads, the implications of human activity continue, since bank erosion arises from the scour induced by boats, including pleasure cruisers, and this has necessitated protection measures in Norfolk.

In recent years, therefore, many river channels in central and southern England have been modified (Brookes *et al.,* 1988) and the extent of channelization between 1930 and 1980 is demonstrated in (Figure 1.6). The density of channelization in England and Wales is, on average, 20 times greater than that in the USA, and in this area of central and southern England, the average density of channelization reaches is greater than 0.06 km^2.

Channelization is a direct modification of river channels, but the indirect consequences of other human activities have also been reconstructed in recent years (Gregory, 1987). The effects of these human activities on river channels and on the processes operating in the drainage basin can lead to the downstream changes. An excellent example is provided by the effects of urban areas, which provide greater impervious surfaces, encourage more runoff to flow directly and more rapidly into streams and rivers, and so potentially can increase the amount of discharge downstream of the urban area. This can lead to increased flooding, which has been a reason for the widespread introduction of flood prevention schemes in many parts of central and southern England. The increased discharges can also cause channel erosion. Because the size, shape and character of the river channel reflect the amount of discharge and the sediment conveyed to a particular cross-section, if the water and sediment delivery change as a result of urbanization, then so the river channel may similarly also change. There are many cases throughout Britain where stream channels have changed in

the past century as a consequence of the increase in flows following urbanization. A change in river channel dimensions, often involving a decrease, can occur downstream of dams and reservoirs. The impoundment of reservoirs can reduce the frequency of downstream flooding, and this reduction of the high discharges delivered to a particular river channel means that, over a period of years, the river channels can adjust their morphology and ecological characteristics as a consequence of the changed flows (Petts, 1988b). Adjustments of river channels in central and southern England range from point changes, such as those due to the input of water from stormwater drainage systems from urban areas, to the construction of bridges, the construction of dams across the channel, and the extraction of sediments from the channel. There are also spatial changes that affect the whole or part of the drainage basin, including changes of land use from forest to farmland. It is therefore essential that, in the interpretation and appreciation of rivers and river channels in central and southern England, one recognizes the extent to which human activity has had a continuing role in producing the channels that we see today.

A fifth dominant influence is that the rivers of central and southern England are essentially low-power channels, and in this sense contrast dramatically with those of Wales, northern England and Scotland. Thus Ferguson (1981) showed that the stream power for rivers in this part of England was often less than 0.1 kWm^{-1}, which is much lower than the values characteristic of Wales and of Scotland. Low stream power values in this part of the UK can be thought of in relation to three major characteristics: firstly, because of the low relief in much of central and southern England, which is associated with low river velocities; secondly, because precipitation totals are lower than in other parts of Britain and much of southern England receives less than 1000 mm per year, except those parts of the region that are in the Highland area; and thirdly because the extent of the permeable rocks is very considerable in this area. These permeable rocks can act as aquifers and, as the proportion of groundwater flow is quite considerable, the regimes of the rivers are characterized by high base flows fed by groundwater sources and comparatively low peak flows fed by storm runoff. This means, in turn, that stream power values tend to be relatively low and that channel dimensions also tend to be comparatively small compared with those in the Highland Zone.

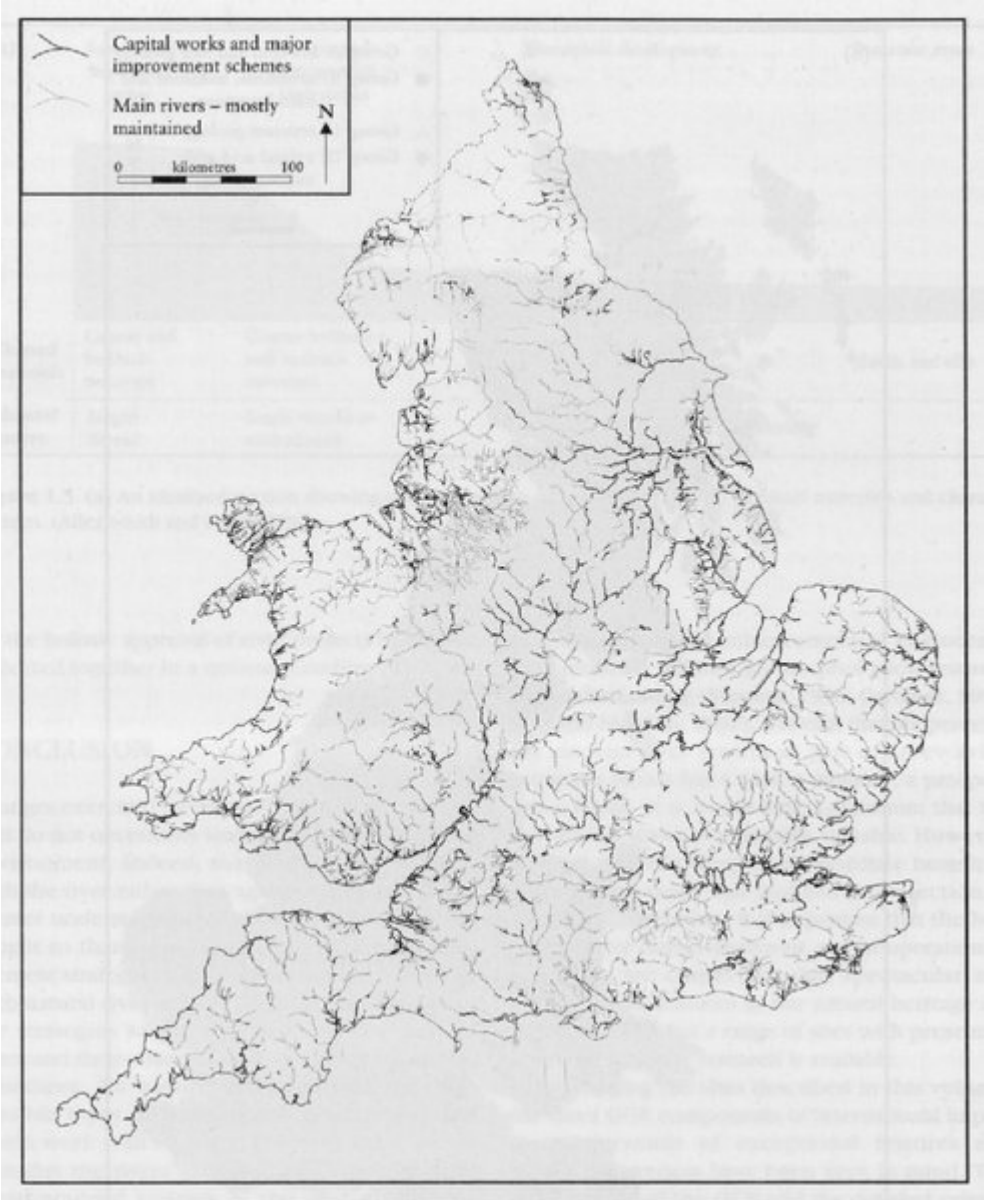
GCR site selection

Against this background, the selection of GCR sites in central and southern England was quite difficult.

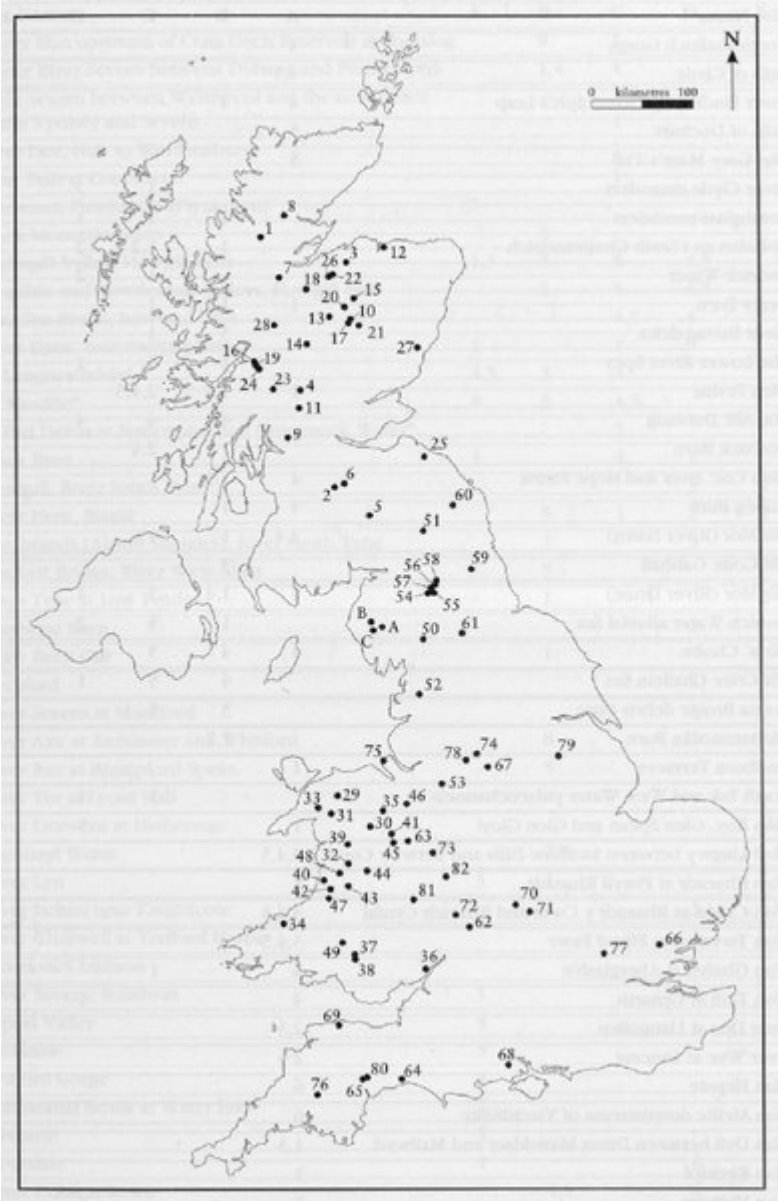
Some potential sites were excluded if their features indicated that they were more closely related to other GCR Blocks, for example, river terraces associated with Quaternary development (see, for example, Bridgland, 1994, Allen *et al.,* in prep., Campbell *et* at, in press) or sites typical of limestone areas (Waltham *et al.,* 1996). Other sites were excluded if they were heavily modified by human activity or at present maintained by human activity. The approach taken initially was to identify all locations which have been cited in the literature and for which there is some published information which could be a useful basis for site selection. These criteria allowed the initial identification of 214 possible sites, which were then classified into 15 classes according to the type of features that they contained. The distribution of the 15 classes throughout central and southern England was analysed, and then the extent to which sites were 'unique', a classic example, or a type example of a particular feature was considered. It was eventually possible to select the representative suite of GCR sites at the locations shown in (Figure 1.7), and these can be thought of in five major groups. Firstly, there are those which reflect the significant contribution made by Quaternary development to the fluvial system. This category includes the sediments at Beckford, and at Ashmoor Common, the striking Ironbridge Gorge associated with the Buildwas site, and also examples of channels that are now underfit (Cherwell, Itchen), but which originally carried much higher discharges in the past, as indicated in Dury (1977). A second group represents aspects of contemporary river-channel activity, and this involves not only examples from the Highland Zone at Alport in the southern Pennines and waterfalls and gorges in the Yorkshire Pennines at Aysgarth and the Lynford Gorge on Dartmoor, but also channel planform features on the Axe and Exe, and a channel in Essex to indicate the effect of a catchment overlain by till. Also significant is the influence of organic accumulations in channels, and this is exemplified at the site in the New Forest, which must have been typical of many other sites in central and southern England in the past. A third category includes those landforms produced by changes in channel dimensions and this is exemplified by changes downstream of reservoirs along the Derbyshire Derwent (Petts, 1977). A fourth type results from a particular flood event, the Lynmouth flood in 1974, which had dramatic effects on the catchment area of the River Lyn (Anderson and Calver, 1977). The final category includes an example of a managed channel along the River Lugg.

The selection has resulted in a skewed regional distribution, with more of the sites being in the western part of the area and fringing or within the uplands. This reflects the criteria set out and also the weight of research.

References



(Figure 1.6) A map of England and Wales showing rivers channelized, 1930–80. (After Brookes, et al., 1983.)



(Figure 1.7) A map of Great Britain showing the classification of GCR fluvial geomorphology sites. See also (Table 1.1).