River Culm at Rewe, Devon

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Highlights

The River Culm, at Rewe, Devon is an active depositional environment in which overbank river flows deposit large amounts of fine sediment on the floodplain. Evidence indicates that this is an important mechanism in floodplain development, with sediment deposition rates varying spatially and temporally.

Introduction

The floodplains of lowland rivers are regions of considerable geomorphological, environmental and economic importance (Nicholas and Walling, 1995). Well-developed floodplains may be an important sink for suspended sediment and this can be investigated through an understanding of contemporary rates of floodplain deposition (Walling and Bradley, 1989). New techniques have been developed to assess contemporary overbank sedimentation rates and patterns which, together with the use of hydraulic and sediment transport models, have allowed the gap between form and process studies to be narrowed. The River Culm is an important site for contemporary floodplain deposition, with its spatial variations in sedimentation rates.

The River Culm, which joins the Exe about 3 km north of Exeter, has a catchment area of 276 m^2. Between Cullompton and Stoke Canon, the river meanders across a floodplain (Figure 6.43) averaging 450 m in width (Lambert and Walling, 1987). The channel has a gravel bed and is approximately 12 m wide, while the banks are up to 1 m high and composed of fine alluvial material (Walling and Bradley, 1989). Overbank flooding is relatively frequent during winter months, significant inundation occurring generally seven times a year.

The depth of flooding varies from 40 cm during mean annual flood to 70 cm during a 50-year flood (Walling and Bradley, 1989).

The site at Rewe is part of a 13 km reach which is instrumented by two gauging stations, at Woodmill and Rewe (Lambert and Walling, 1987), providing continuous monitoring of river stage (for discharge) and suspended sediment concentrations. A number of techniques have been used to assess rates of temporal and spatial overbank sedimentation, including the analysis of sediment load data (Lambert and Walling, 1987), the use of sediment traps (Lambert and Walling, 1987; Walling and Bradley, 1989) and the use of caesium-137 concentrations as an indicator of fluvial activity (Lambert and Walling, 1987).

Description

Analysis of the gauging station records shows that an average conveyance loss of 28% occurs between Woodmill and Rewe (Lambert and Walling, 1987). In (Figure 6.44) is illustrated a typical flood event whereby floodplain inundation between the gauging stations has attenuated the flood peak and resulted in a net loss of suspended sediment, on this occasion estimated as at least 374 tonnes. By assessing sediment load data, bank erosion within the reach and tributary input from the River Weaver, estimates of conveyance loss can be made. Hooke (1977) described the Culm as a relatively stable stream with slow but steady bank erosion with rates up to 0.2 m yr^{-1}. On Hooke's (1977) study reach about 18% had changed its course over a 100 year period of which 40% had changed in characteristics, sediment composition was considered a major factor affecting the spatial distribution of erosion. Sediment supply from this source has been estimated at 150 t yr^{-1} and inputs from the River Weaver at 600 t yr^{-1}, which for the period November 1982 to May 1994 gives an average annual sediment conveyance of 2500 t yr^{-1} (Lambert and Walling, 1987). Assuming an average area of inundation of 5 km^2 this approximates to 0.5 mm yr^{-1} deposition (Walling and Bradley, 1989).

Deposition rates can also be measured directly using sediment traps both for individual storms (Lambert and Walling, 1987) and for longer periods (Walling and Bradley, 1989). Both experimental design strategies have demonstrated temporal and spatial variation at individual sites. For example, for the period December 1986 to February 1988, total sedimentation rates vary by an order of magnitude between different sites (Park Farm 17 278 gm^{-2}) and within sites (sites at Rewe had a range of 286–1319 gm^{-2}) (Lambert and Walling, 1989). Micro-scale variations in sedimentation rates relate (Figure 6.44) Conveyance loss and flood attenuation, River Culm. (After Lambert and Walling, 1987.)

to surface topography, and to the incidence of depressions.

Distributions of caesium-137 fallout from atmospheric testing in the late 1950s and early 1960s can be used to assess rates of deposition. By comparing floodplain samples with control samples, taken from above the flood limit, the level of Cs-137 'excess' can be used as a measure for both deposition and erosion. From 120 site samples throughout the reach, Walling and Bradley (1989) measured an increasing depth and rate of sediment deposition downstream in response to the increased width and decreased slope of the flood-plain. For example, near Rewe and Stoke Canon rates up to 13 mm yr^{-1} were recorded. Micro-variation in deposition at Rewe, derived from 74 cores, is illustrated in (Figure 6.45). Two small depressions close to the channel have the highest rates of sedimentation as they experience a backwater effect, while further from the channel a decline in the levels of caesium-137 'excess' represents reduced inundation and hence lower rates of deposition.

Interpretation

Nicholas and Walling (1995) have now coupled a hydraulic model with a sediment transport component to model the dispersion of suspended sediment away from the channels during inunda tion. For their study reach at Rewe, a reasonable degree of correspondence was obtained between measured and predicted rates, with a maximum value of 1.0–1.5 mm yr^{-1} estimated for abandoned channel fill sites.

Significant spatial differences in sediment deposition occur at both the macro- and micro-scale. These can be related to variations in floodplain morphology and the frequency and level of inundation, while at the micro-scale small variations in surface topography control the velocity, duration and depth of inundation. Greatest deposition rates occur in closed depressions and small backwater embayments, while scour is also evident from caesium-137 measurements in secondary channels which convey flow on the floodplain during inundation. Analysis of the floodplain and suspended sediments showed that sand and coarse and medium silt fractions are preferentially deposited, although a significant proportion (>50%) of clay was also deposited, possibly reflecting the importance of aggregates in the natural transport process (Walling and Bradley, 1989).

Research along the River Cu1m illustrates the nature of contemporary overbank sedimentation and the magnitude of conveyance losses along a lowland floodplain river system. Fine alluvial deposits are widespread among the floodplains of many lowland rivers in the UK, and have been interpreted as evidence of long-term overbank deposition due to man-induced accelerated erosion in the Late Holocene (Brown, 1983; Burrin, 1985). Contemporary rates of deposition have been shown to exert considerable spatial variation with rates of up to 17 mm yr^{-1} reported (upstream of Rewe) against average rates of 1.5 mm yr^{-1} (Walling and Bradley, 1989). Through the use of hydraulic and sediment transport models, measured rates of deposition can now be predicted which will lead to a greater understanding of the processes of overbank sedimentation.

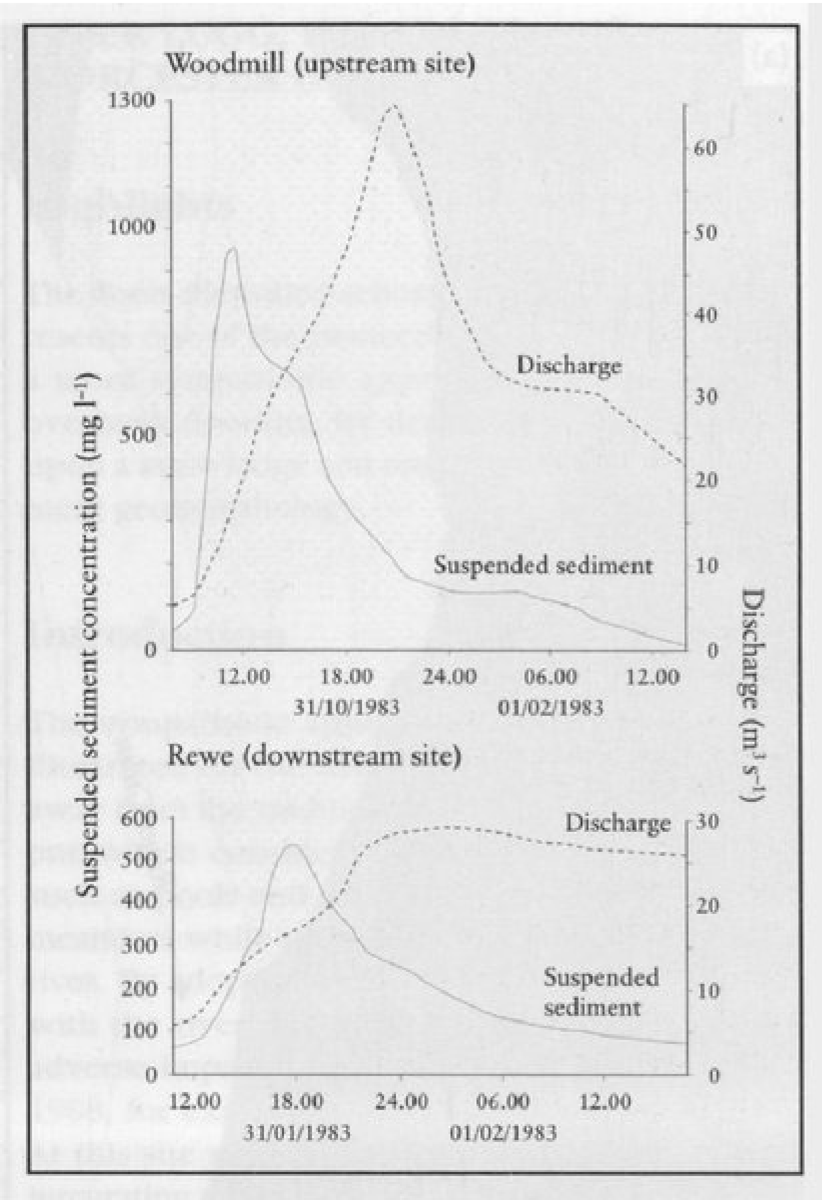
Overbank sedimentation is an important process on lowland streams. This is one of the few sites in Britain, and indeed internationally, where the processes have been studied in detail. New techniques have been used which have allowed measurements of contemporary rates and distribution of sedimentation. It is also a site at which longer-term studies of forms and processes provide a context for the interpretation.

Conclusion

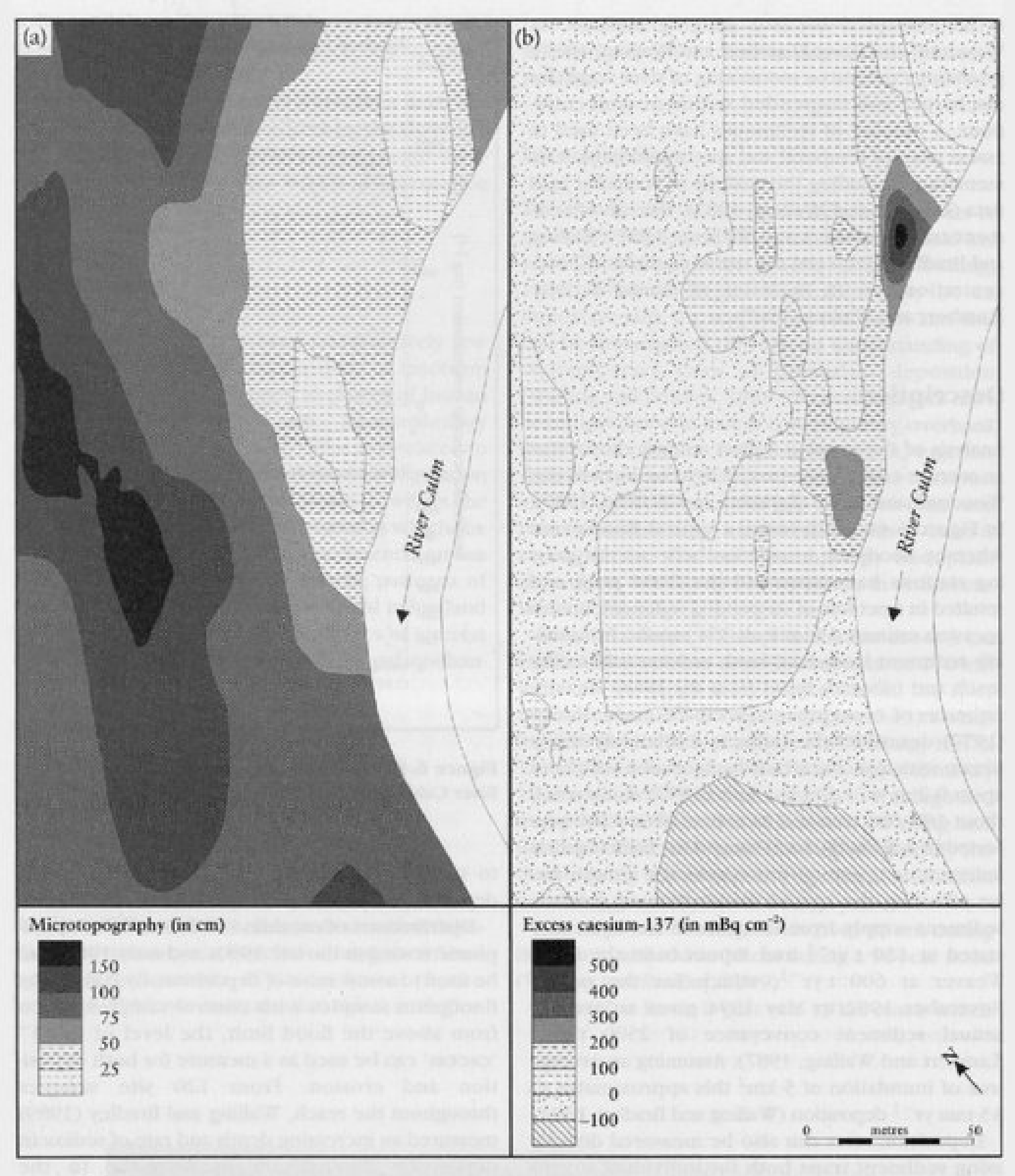
This is a site that is becoming internationally important for innovative measurements of over-bank depositions. Significant spatial variations in deposition are revealed and can be related to the floodplain topography and frequency of flooding.

References

(Figure 6.43) Culm River and floodplain. (Photo: H. Rowlands.)



(Figure 6.44) Conveyance loss and flood attenuation, River Culm. (After Lambert and Walling, 1987.)



(Figure 6.45) Microtopography and excess caesium-137, River CuIm floodplain at Rewe. The contours on (a) refer to heights in centimetres above an arbitrary datum representing the lowest point on the floodplain surface within the sampled area. (b) The pattern of excess caesium-137. (After Walling and Bradley, 1989.)