Suspended and Bedload Sediment Transport Dynamics in Two Lowland UK Streams – Storm Integrated Monitoring

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INTRODUCTION

There is little information on the role of channel storage and remobilisation in determining sediment transport dynamics in lowland streams (Walling, 1996). In particular the response to macrophyte cutting and storm events has not been well quantified.

A one-year monitoring programme was conducted at two contrasting tributaries of the River Kennet, in Southeast England to address these issues. The River Lambourn sub-catchment lies on chalk and groundwater is the dominant source of baseflow. A shallow, rapid flowing channel with low seasonal variation in discharge (2-year range 0.725 – 2.77 m^3s^{-1}) and extensive macrophyte beds results from these conditions. The River Enborne sub-catchment is overlain by low permeability sands, silts and clays. The river has sluggish flow within a deeper channel. During high intensity rainfall events, generation of overland flow pathways led to peaky, variable flow (2-year range 0.116 to 25.3 m^3s^{-1}). Submerged macrophytes are usually sparse due to water depth, turbidity and instability in the bed sediment.

METHODS

Suspended sediment concentrations were determined using two automatic watersamplers on each river reach (upstream and downstream stations) set on a 24-hour collection cycle. At the onset of storm events, an additional sampler was triggered to collect samples every 60-minutes by a float switch. Bedload material transported along the streambed of the river was sampled using two 25x25cm pit type sediment traps on each river reach (upstream and downstream stations). The boxes were emptied weekly.

SUSPENDED SEDIMENT TRANSPORT

Suspended sediment concentrations in the Enborne were high (means 29-39 mg l^{-1}) and very variable (Figure 1a). Suspension of bed sediment and bank erosion were postulated as the main sources of sediment. Concentrations increased during high flow periods in the winter. This was probably due to the activation of overland flow and drainage ditches pathways that delivered considerable quantities of sediment to the channel during storm events. Strong, linear relationships between suspended sediment and flow were observed at the two sampling stations (r^2 0.63 and 0.78). Varied response times to increases in flow, displaying multiple peaks in concentration, indicated the variety of sediment sources to the channel. The period between December 1998 and January 1999 exemplified the effect of sediment exhaustion in the River Enborne channel (Figure 1b). A clockwise, cyclical loop in suspended sediment response to storm events indicated that concentrations were higher on the rising than on the falling stage of the hydrograph.

In the Lambourn, suspended sediment concentrations (means 8-9 mg l^{-1}) were lower, and year round variations were less marked (Figure 1c). Suspension of bed sediment and bank erosion were probably the only sources of sediment to the channel. Although increasing suspended sediment concentrations were generally associated with high flows, the relationship between the two parameters was much weaker than on the Enborne. Notably high suspended sediment concentrations also occurred on the Lambourn during low flows (see Figure 1d). Periodic flushing of fine material during macrophyte clearance or livestock disturbance of bed sediment at the time of sampling might have caused this.

BEDLOAD SEDIMENT TRANSPORT

Bedload transport weights were far lower in the Lambourn (weekly means 12.7 and 19.7g) than the Enborne (weekly means 87.2 and 102g) (Figure 2). This was thought to be a function of hydrologic behaviour, sediment supply and in the Lambourn macrophyte sediment trapping and bed armouring. River Enborne bedload had a stronger relationship to flow (e.g. r^2 0.84 for 5.00 – 0.250mm size fraction) than in the Lambourn.

ENTRAINMENT THRESHOLDS

The competence of flows throughout the sampling period to mobilise bed sediment of different calibres was investigated. In the Enborne, bedload was dominated by fine sand-sized particles (0.250 – 0.063mm). Preferential transport of finer material (<0.038mm) occurred during storm events. In the Lambourn however, a more even distribution of particle sizes were transported with fine material transported in baseflow conditions. These contrasts were thought to be a function of different critical shear velocities for the two rivers.

Table 1 Estimating shear velocity (μ_*) in the Rivers Lambourn and Enborne (Julien 1995)

Flow conditions	**Lambourn μ_* (ms^{-1})**	**Enborne μ_* (ms^{-1})**
Low	0.0596	0.0027
High	0.0646	0.0065

Fine sand, silts and clays were transported irrespective of flow conditions in the Lambourn. However, movement of granules and coarse sand was restricted at low flows indicating the higher entrainment threshold required. A decrease in silt and clay-size material in the bedload during high flows suggested that these particles were resuspended into the water column.

In the Enborne, lower shear velocities explained the absence of coarse material in traps during baseflow conditions. However, larger rates of change in shear velocities and bedload transport to increasing flows implied that particles were more responsive to changes in flow than in the Lambourn. Reasons for this were threefold:

- Absence of macrophytes/bed armouring which protect fine bed material from transport by retarding flow and sheltering in the Enborne
- Supply of additional particles into the channel via overland flow pathways in the Enborne
- Steeper and larger magnitude rising limbs on hydrograph in the Enborne

CONCLUSIONS

Principal research findings were that suspended and bedload transport varied on both a temporal and spatial scale. Factors affecting sediment dynamics included sub-catchment geology, flow delivery pathways, flow magnitude, physical retention devices (macrophyte growth, bed armouring) and readily available sediment within the catchment/river channel.

REFERENCES

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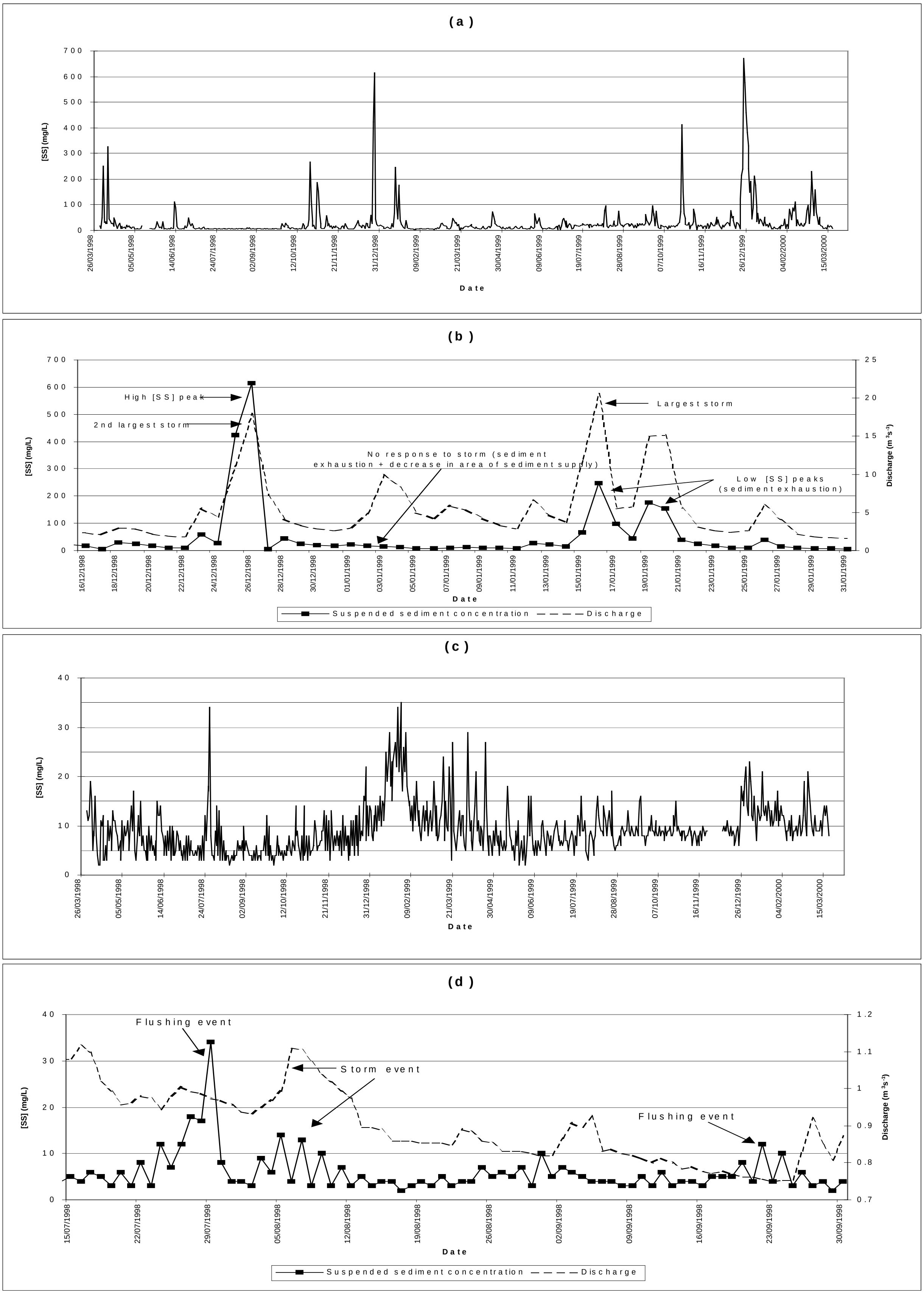

Figure 1 Suspended sediment concentrations (a) River Enborne 2-year record (b) River Enborne during storm event (c) River Lambourn 2-year record (d) River Lambourn during storm and flushing events

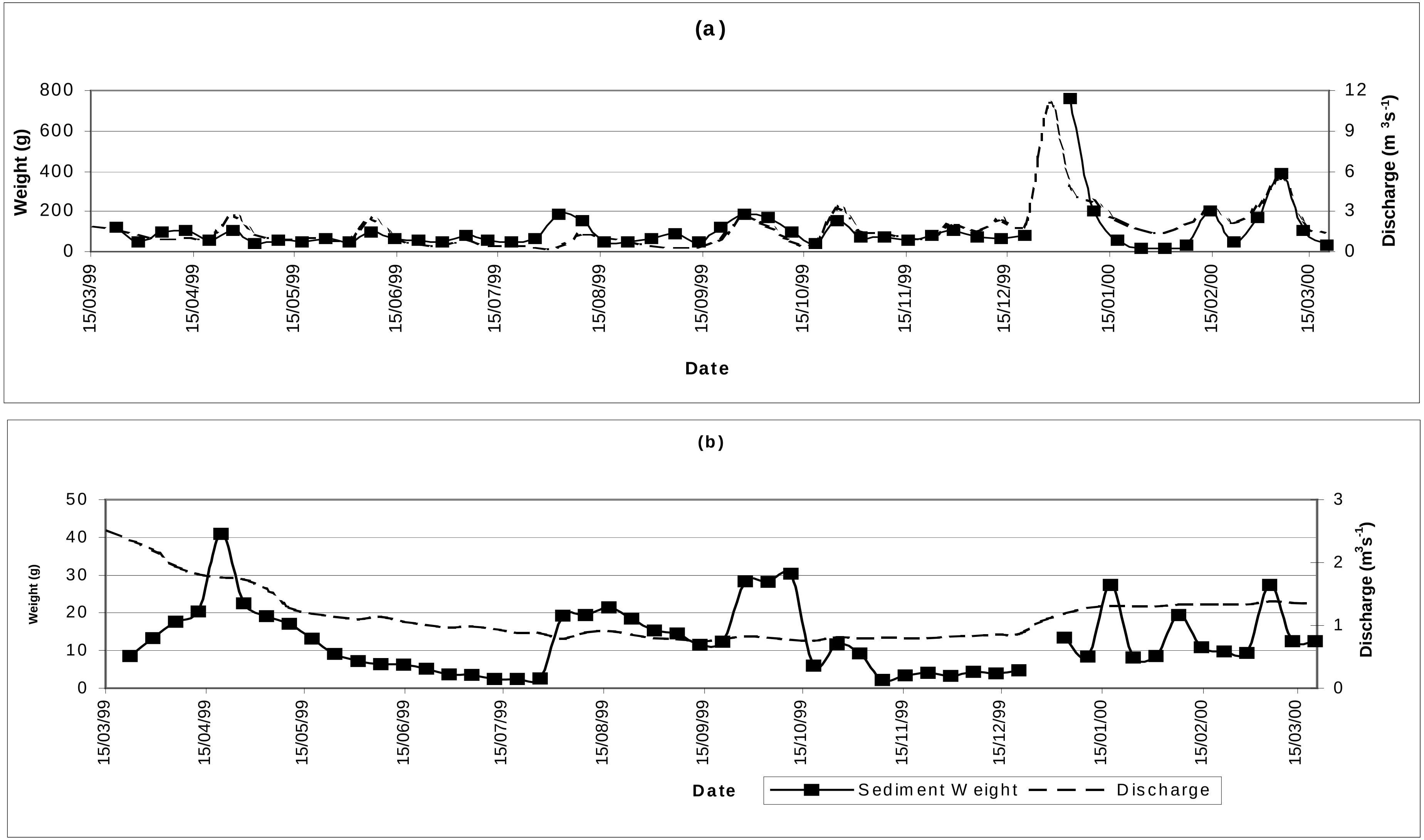

Figure 2 Bedload weights transported in (a) River Enborne upstream station (b) River Lambourn upstream station