Floodplain sedimentation in the RACS river basins

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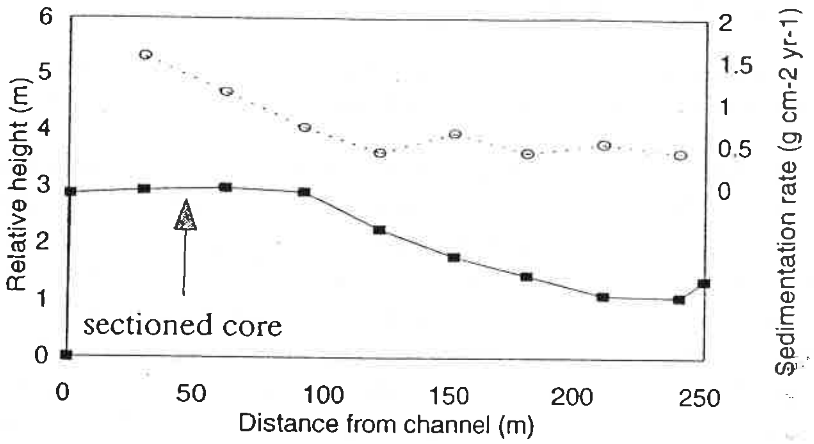
There is increasing recognition that floodplains play an important role in the delivery of sediment from the point of mobilisation to the catchment outlet. More particularly, floodplains can represent important sinks or storage sites for sediment and sediment-associated contaminants (such as heavy metals, radionuclides and hydrophobic micro-organics) during overbank flows. Furthermore, floodplains may act as a source of such contaminants if the floodplain sediments are subsequently remobilised. An appreciation of rates and patterns of overbank sedimentation is therefore an essential part of any study, such as LOIS, which is concerned with the flux of materials, both from a contemporary and historical perspective and for predictive modelling.

Fallout caesium-137 (^{137}Cs) measurements have been used to assess the magnitude and pattern of suspended sediment storage on floodplains along the main channels in the non-tidal sections of the Ouse and Tweed basins, as a result of overbank sedimentation during the last ca. 40 years (i.e. since the start of ^{137}Cs fallout in the early 1950s). ^{137}Cs measurements can be used to estimate rates of overbank sedimentation on the basis that (a) there is a correspondance between the pattern of atmospheric fallout and the vertical distribution of ^{137}Cs in the sediment profile or (b) that the ^{137}Cs inventory in excess of the atmospheric fallout flux or reference inventory for a sediment core can be ascribed to the ^{137}Cs associated with sediment deposited during periods of overbank flooding. In this study, approximately 10 sediment cores were collected along each of 26 and 10 transects perpendicular to the channel in the Ouse and Tweed basins, respectively. Most of the cores were bulked, but one sectioned core was also collected from each transect. The depth distribution of ^{137}Cs in the sectioned core was then used to estimate the rate of sedimentation at that sampling point, based on either the depth of sediment above the 1963 peak in ^{137}Cs fallout (for uncultivated sites) or the depth to which ^{137}Cs extends below the plough depth (for cultivated sites). The sedimentation rates for the other bulk cores in the transect were then determined from their total ^{137}Cs inventories using a numerical model. Figure 1 illustrates the application of this approach for a transect of the floodplain of the River Ouse at Acaster Malbis. Rates of sediment accumulation decrease with distance from the channel and this pattern is typical for most of the floodplain transects. The average sedimentation rate and length of each transect and the length of floodplain between consecutive transects were then used to calculate the total storage of floodplain sediment for each river basin.

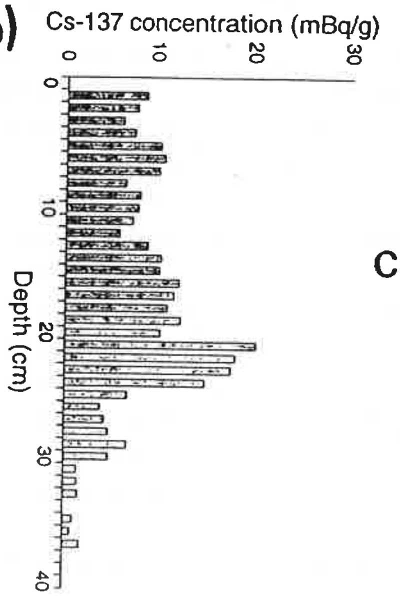
Table 1 provides preliminary estimates of floodplain sediment storage along the main channels of the Ouse and Tweed catchments. In both cases, floodplain storage plays a very significant role in the suspended sediment budget, and represents between 33 and 46% and between 17 and 25% of the fine sediment delivered to the channel system in the Ouse and Tweed basins, respectively.

Figure 1 - Rates of overbank sedimentation for a transect of the River Ouse at Acaster Malbis (a), with the ^{137}Cs depth distribution for the sectioned core (b) and the function used to calculate sedimentation rates for the bulk cores (c)

a)



b)



Inventory = 438 mBq cm^{-2}
1963 peak = 21 cm (30.9 g cm^{-2})
Sedimentation rate = 0.66 cm year^{-1} (0.95 g cm^{-2} year^{-1})

c)

$$R_i = R_{\bullet} \cdot \left(\frac{I_n}{I_{\infty}}\right)\left(\frac{\bar{S}_{\bullet}}{\bar{S}_i}\right)^{0.75}$$

R_i = sedimentation rate at site i (g cm^{-2})
$R_{\bullet}$ = sedimentation rate for sectioned core (g cm^{-2})
I_n = excess ^{137}Cs inventory at site i (mBq cm^{-2})
I_{∞} = excess ^{137}Cs inventory for sectioned core (mBq cm^{-2})
$\bar{S}_{\bullet}$ = specific surface area for sectioned core (cm^2 g^{-1})
$\bar{S}_i$ = specific surface area at site i (cm^2 g^{-1})

Table 1 - Preliminary estimates of the storage of suspended sediment on main channel floodplains in the non-tidal sections of the Ouse and Tweed river basins.

River	Storage (t year^{-1})	Annual sediment load (t year^{-1})‡	River	Storage (t year^{-1})	Annual sediment load (t year^{-1})‡
Swale	31293		Teviot	5540	
Nidd	12768		Ettrick	11976	
Ure/Ouse	45408		Tweed	26467	
Total	89469	105000 - 175000	Total	43983	131700 - 219500
Wharfe	19792	24600 - 41000			

‡ Based on the assumption that the specific sediment yields for the rivers are between 30 and 50 t km^{-2} year^{-1}

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