Chilterns Conservation Board

River Chess Fine Sediment Analysis

Joshua Moore, Bailey Stickings

COMMERCIAL IN CONFIDENCE

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Executive Summary

APEM UK Ltd was commissioned by the Chilterns Conservation Board to undertake fine sediment sampling and analysis to help develop an understanding of fine sediment storage along the River Chess. Riverbed sediment samples were collected from eight locations on the River Chess between Chesham and Rickmansworth, the sampling locations chosen to complement an existing monitoring programme.

Samples were collected using the stilling well method of Lambert and Walling (1988). Samples were then analysed to quantify sediment concentration and particle size distribution by mass for the fine (suspended) sediment and bulk sediment samples.

Bed sediment storage shows considerable variation between each site and between samples within a given site but values presented are generally comparable to those reported in published literature, with higher fine bed sediment storage at Chesham Moor. Excluding Chesham Moor), the values recorded had a much tighter range, suggesting more even distribution of sediment storage on the River Chess. These findings suggest that broadly the River Chess is as affected by aggradation of fine sediment as many rivers in the published literature, with potential for greater impact at Chesham Moor. However, some caution is required in this interpretation, as size fractions analysed in this study and the literature vary, placing reliability limitations on the comparisons.

Three macroinvertebrate monitoring locations were identified as co-located with PSA locations: Below Broadwater Bridge (34306), Above Valley Farm Ford (34310), and Above Colne (34311). Across these three monitoring locations no impact of excessive fine sediment deposition was indicated, as supported by sediment data for Broadwater Bridge and Sarrat Watercress Beds, which demonstrated substrate predominantly composed of medium gravels and coarser material. A long-term improving trend in macroinvertebrate data was also observed at Below Broadwater Bridge and Above Valley Farm Ford, which might suggest lessening pressure of excess fine sediment over time, although this trend may have been driven by reductions in other pressures.

Evidence available in literature suggests that salmonid spawning may be inhibited with the levels of fine sediment storage observed at some locations in the River Chess. Environment Agency fish data has been assessed where available, and this suggests that brown trout may be associated with locations of modest sediment accumulation, with higher levels of fine sediment associated with grayling. However, the data are insufficient to allow rigorous examination and as such, only tentative observations can be made.

Macrophyte data were also too few to allow rigorous interpretation.

1. Introduction

APEM UK Ltd was commissioned by the Chilterns Conservation Board to undertake a programme of fine sediment sampling and analysis to develop an understanding of fine sediment storage along the River Chess, contributing to the Chess Smart Water Catchments Initiative developed by Thames Water.

APEM have been tasked with calculating fine sediment storage within the bed of the River Chess, to conduct particle size analysis to understand the distribution of grain sizes of sediment that comprises the riverbed and to understand the potential impact of the composition of the bed material on target plant, fish and invertebrate species (Table 1-1).

Table 1-1 Key target species to be assessed.

Target species		
Plants	**Fish**	**Invertebrates**
• *Ranunculus* spp. • *Callitriche* sp. • Watercress (*Nasturtium officinale*) • Water mint (*Mentha aquatica*) • Water parsnip (*Berula erecta*)	• Grayling (*Thymallus thymallus*) • Bullhead (*Cottus gobio*) • Brown trout (*Salmo trutta*)	• Mayflies (including *Paraleptophlebia werneri*) • Stoneflies (including *Nemoura lacustris*) • *Heptageniidae* (including *Heptagenia sulphurea*) • Blue-winged olives (*Serratella Ignita*)

2. Methodology

2.1 Sampling strategy

A range of monitoring has been undertaken on the River Chess as part of Thames Water's Smarter Water Catchment initiative. Monitoring has included fish, macrophytes, macroinvertebrates, and water quality and has been undertaken by the Environment Agency (EA), WildFish (as part of their SmartRivers citizen science scheme), and by the Chilterns Chalk Stream Project (CCSP) and Chilterns Conservation Board (CCB). However, only limited sediment sampling has been undertaken. In this study, riverbed sediment samples were collected from eight locations on the River Chess between Chesham and Rickmansworth. The sampling locations were chosen to complement an existing monitoring programme and to allow for robust inferences to be drawn about the impact of fine sediment on ecological receptors.

Three replicate samples were taken at each sampling location to account for spatial variability across the channel bed. However, given time and budget constraints, only a single round of sampling was undertaken. As such, this analysis represents a point in time and does not capture temporal variations in channel bed characteristics, including seasonal differences and longer-term changes. Seasonal differences may, for example, arise from ploughing regimes, spate/ run-off driven sediment inputs or periods of baseflows that may not be sufficient to flush fine sediment or organic matter. Longer term changes may arise from channel evolution (itself in part a response to bed substrate changes) and physical modification.

2.2 Sample collection

Samples were collected on 16 August 2023 during dry weather. Discharge on the River Chess at Rickmansworth was 0.41 $m^3 s^{-1}$, which is approximately equal to the flow equalled or exceeded 63% of the time (Q63).

To quantify fine sediment storage mass in the bed of the River Chess, samples were collected using the stilling well method of Lambert and Walling (1988). This involved isolating a section of the bed from the flow using a barrel before removing the coarse surface armour layer (where necessary). In most cases, however, the bed was not strongly armoured so this step was not required. The upper 0.1 to 0.2 m of the bed material was then agitated manually to lift fine sediment into the water column to allow for collection of a suspended sediment sample in a 1 litre bottle.

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Figure 2-1 Sample locations on the River Chess between Chesham and Rickmansworth.

Once a fine sediment sample had been collected, the upper 0.1 to 0.2 m of the channel bed was removed in bulk so that the full particle size distribution of the bed surface material could be established. Samples were collected in 5 litre buckets and varied in mass from approximately 4 to 8 kg. Given that bed material was predominantly sand and gravel, samples of this size were deemed sufficient for the derivation of statistically robust particle size distributions.

2.3 Sample processing

Samples were processed and analysed by Kenneth Pye Associated Ltd. (KPAL) to quantify sediment concentration and particle size distribution by mass for the fine (suspended) sediment and bulk sediment samples, respectively. For the fine samples, sediment concentration was used to calculate bed storage of fine sediment, S (g m^{-2}) by application of Equation **1**.

$$\boldsymbol{S} = \frac{\boldsymbol{C_s} \times \boldsymbol{W_v}}{\boldsymbol{A}} \qquad \text{Equation 1}$$

Where sediment concentration in the water samples, Cs (g/L), is considered in relation to the volume of water in the cylinder, Wv (L), and the sampled channel bed area, A (m^2). Calculated values of S were compared with values available in published literature for UK rivers (with a focus on chalk streams and lowland settings) (e.g. Walling et al., 1998; Owens et al., 1999; Wilson et al., 2004, APEM, 2015) to establish the relative degree of fine sediment storage within the River Chess and, consequently, the likely impact on ecological receptors.

Bulk samples underwent wet separation at 63 µm before the coarser fractions (>63 µm) were sieved and the finer fractions s (<63 µm) analysed by laser diffraction. The two distributions were combined through mathematical merging. Relevant statistics from the full particle size distributions were calculated, including percentage of fine (<2 mm) and median particle size (D50). These statistics were also compared with suitability values for key life stages of target fish species available in the published literature (e.g., Armstrong et al., 2003; Greig et al., 2005; Kemp et al., 2011).

Ecological data provided by CCB were reviewed in the context of bed material composition data to assess the likely impacts of fine sediment on target fish, plant and macroinvertebrate species.

3. Results

3.1 Particle size distribution

The results of particle size analysis derived from bulk samples of the bed surface material are presented for each site as a series of graphs below and tabulated in Appendix A.

- Meades Water Garden (Figure 3-1)
- Chesham Moor (Figure 3-2)
- Broadwater Bridge (Figure 3-3)
- Restore Hope Latimer – Little Chess (Figure 3-4)
- Restore Hope Latimer – Main channel (Figure 3-5)
- Sarratt Watercress Beds (Figure 3-6)
- Loudwater Estate (Figure 3-7); and,
- Elms Lake (Figure 3-8).

With the notable exception of Elms Lake, all sites are predominantly composed of medium gravels or coarser. Only three samples consist of predominantly fine gravels or finer grains, and only one sample consists of predominantly very coarse silt of finer grains. Generally, only 10% or less (20% at two sites and ~100% at one site) of the bed material at each site is composed of fine sediment (fine sediment defined here as particles <2 mm in diameter).

There is no discernible downstream trend between the sites to suggest any clear trend in bed substratum along the sampled reach. Particle size analysis between the sites reveals a variable downstream trend that does not match the established literature (e.g., Walling *et al*., 1998), i.e., that particle size reduces in the downstream direction, though this may be a consequence of differences in scale of study.

As can be seen the analysis of triplicate samples has resulted in generally comparable results at four of the eight sites; Chesham Moor, Broadwater Bridge and the two sites at Restore Hope Latimer. Of the other sites, samples 2 and 3 taken at Meads Water Garden were similar, but sample 1 shows considerable deviation at the 63-125 µm grain size, and samples 1 and 2 taken at Sarrat Watercress beds are similar, but sample 3 shows deviation around 125-250 µm grain size. The remaining 2 sites (Loudwater Estate and Elms Lake) show considerable deviation between each of the three samples. Most notable of these deviations is Sample 2 at Elms Lake showing a considerable deviation, being mostly composed of very fine silty material with little gravel content. This deviation is likely explained by proximity to the lakes where flow velocities are likely to be low, enabling the deposition of finer material across the bed, smothering any coarser material present in the subsurface.

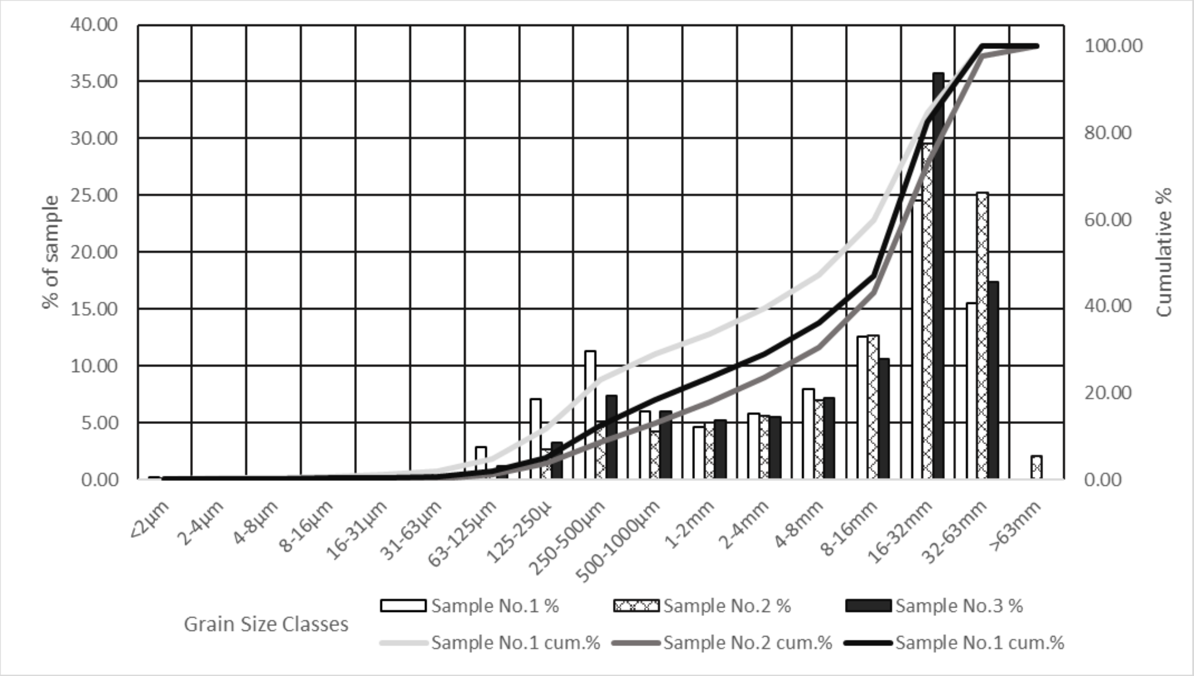

Figure 3-1. Meades Water Garden particle size analysis results

	D10 (µm)	D50 (mm)	D90 (mm)
Sample No.1	218.7	9.53	36.1
Sample No.2	621.7	20.96	53.83
Sample No.3	398.1	17.69	38.99

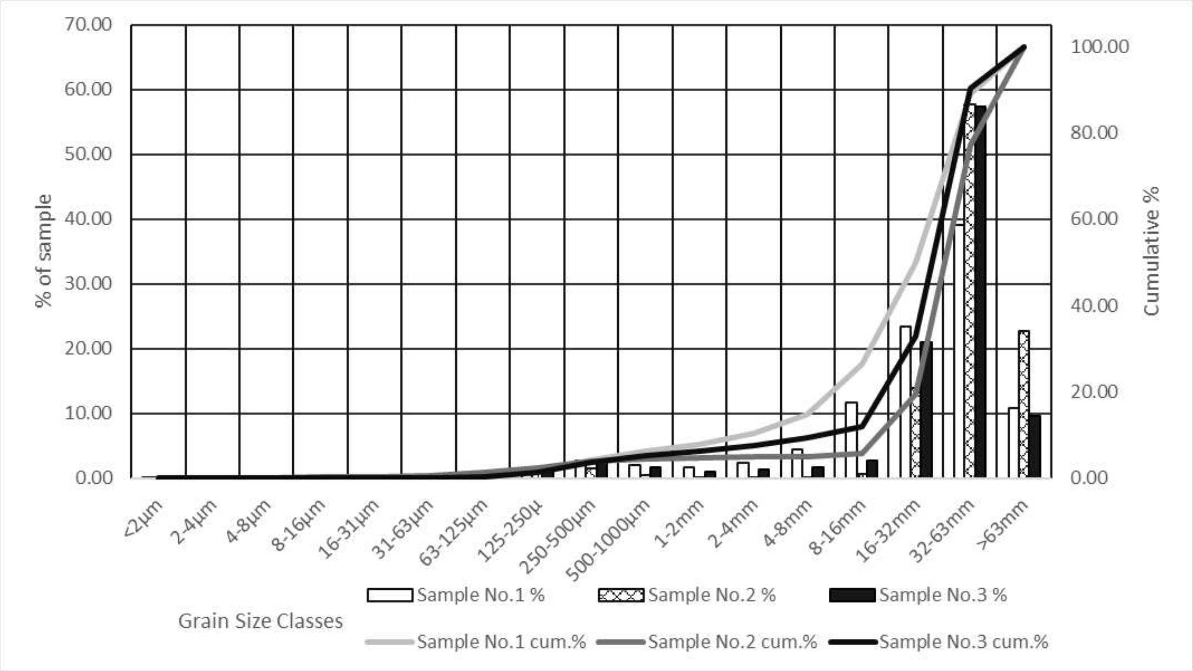

Figure 3-2. Chesham Moor particle size analysis results

	D10 (mm)	D50 (mm)	D90 (mm)
Sample No.1	3.66	32.01	64.88
Sample No.2	23.34	49.53	76.94
Sample No.3	98.95	38.92	62.75

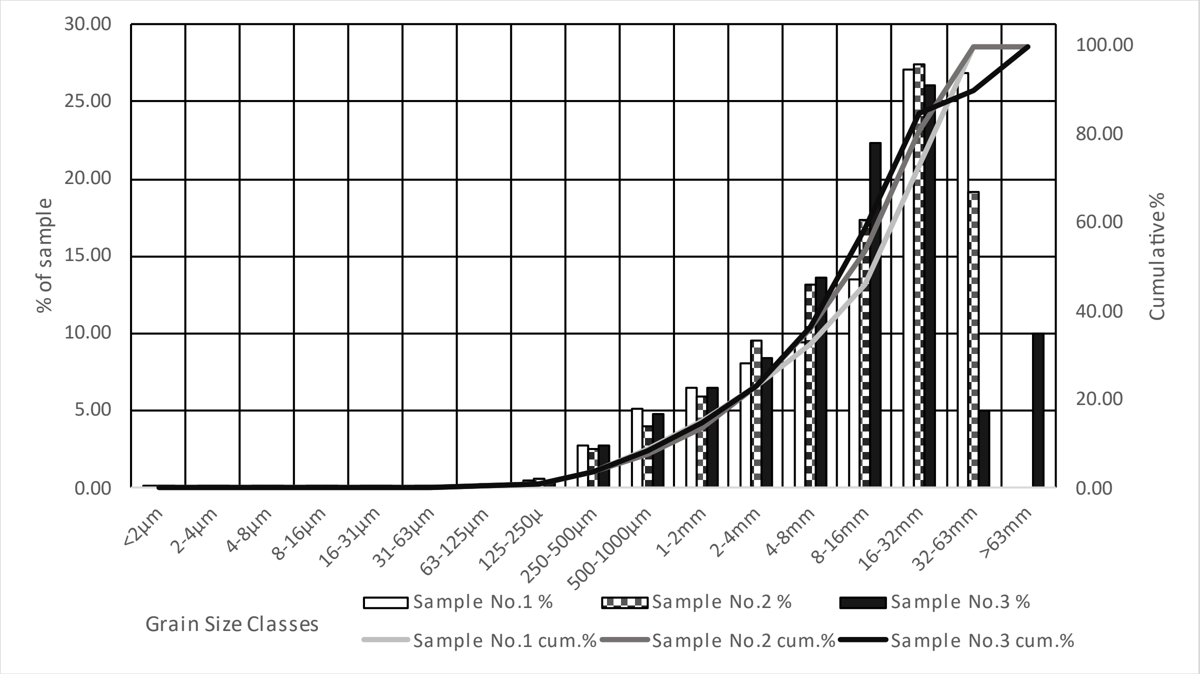

Figure 3-3. Broadwater Bridge

	D10 (mm)	D50 (mm)	D90 (mm)
Sample No.1	1.17	17.78	41.56
Sample No.2	1.42	14.07	38.73
Sample No.3	1.23	12.13	62.82

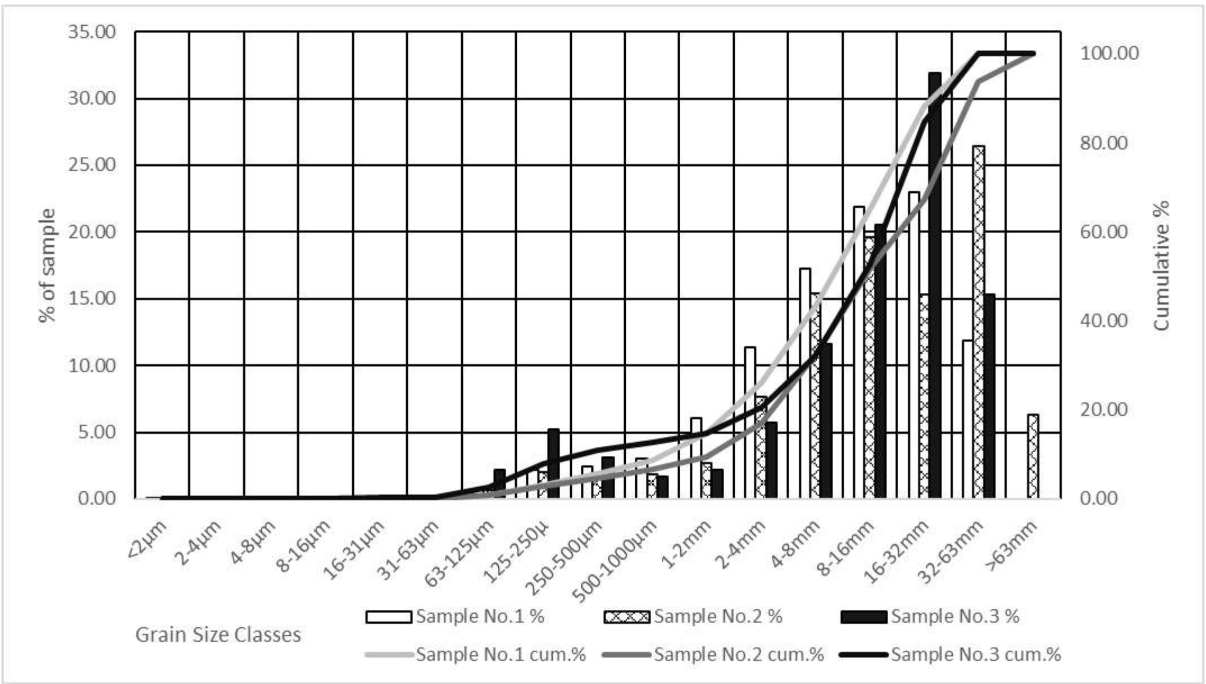

Figure 3-4. Restore Hope Latimer (Little Chess)

	D10 (mm)	D50 (mm)	D90 (mm)
Sample No.1	12.22	9.829	35.30
Sample No.2	21.70	14.85	58.19
Sample No.3	0.37	14.50	37.83

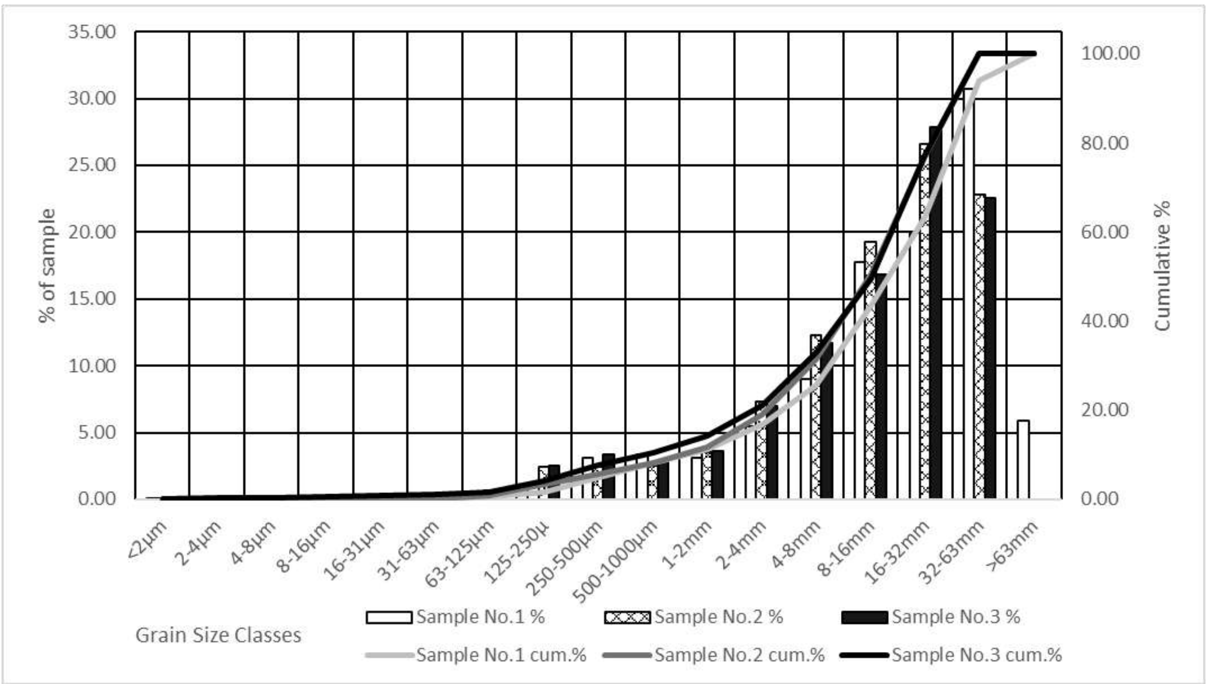

Figure 3-5. Restore Hope Latimer (main stem)

	D10 (µm)	D50 (mm)	D90 (mm)
Sample No.1	1.52	19.69	57.43
Sample No.2	1.46	15.65	49.85
Sample No.3	0.88	16.14	41.70

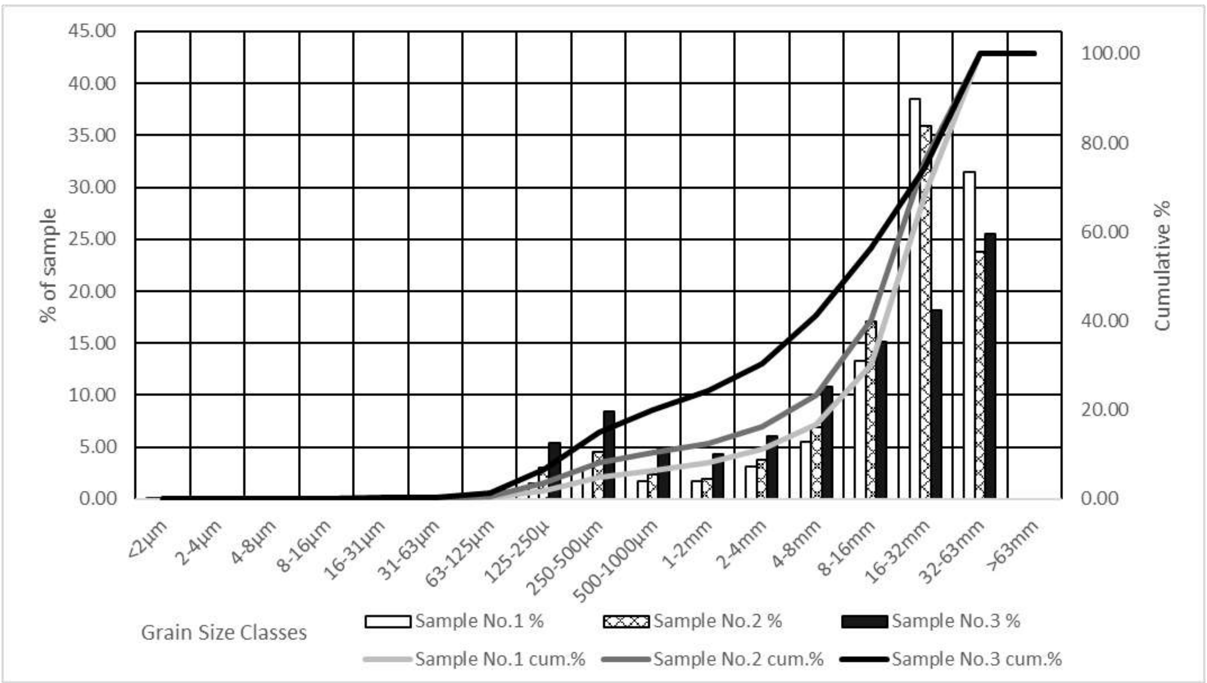

Figure 3-6. Sarrat Watercress Beds

	D10 (µm)	D50 (mm)	D90 (mm)
Sample No.1	3.12	24.36	44.16
Sample No.2	0.84	20.06	41.72
Sample No.3	3.16	11.85	52.40

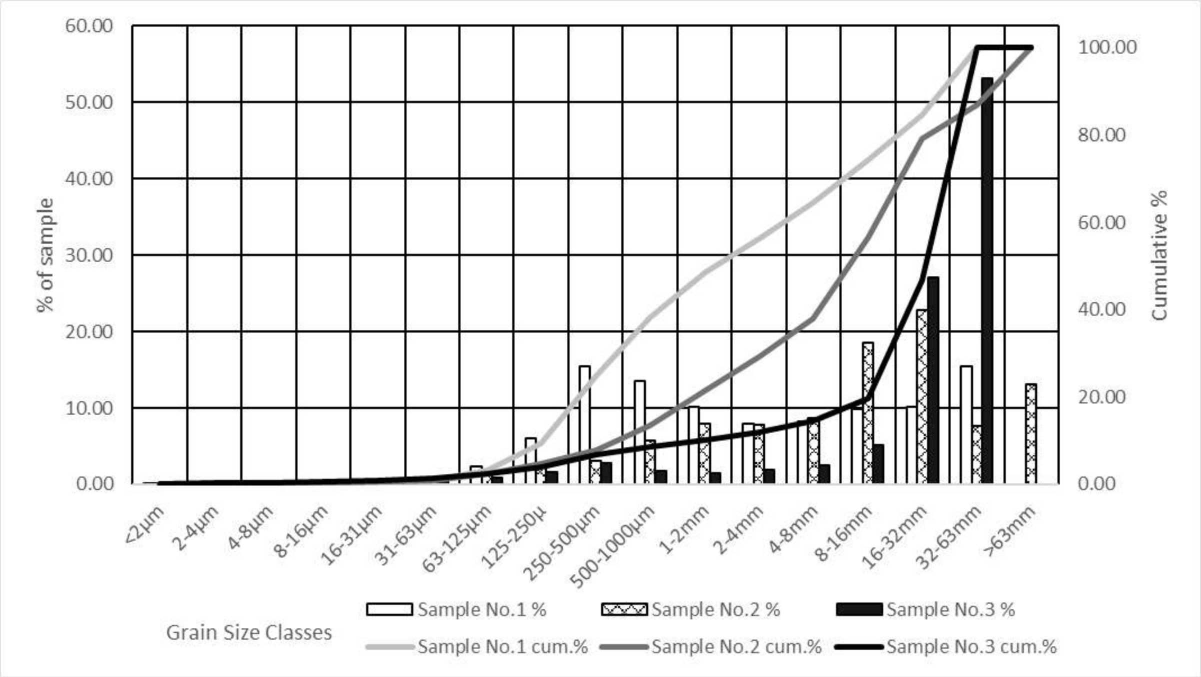

Figure 3-7. Loudwater Estate

	D10 (µm)	D50 (mm)	D90 (mm)
Sample No.1	0.26	2.31	45.51
Sample No.2	0.69	13.29	68.48
Sample No.3	1.94	33.24	54.99

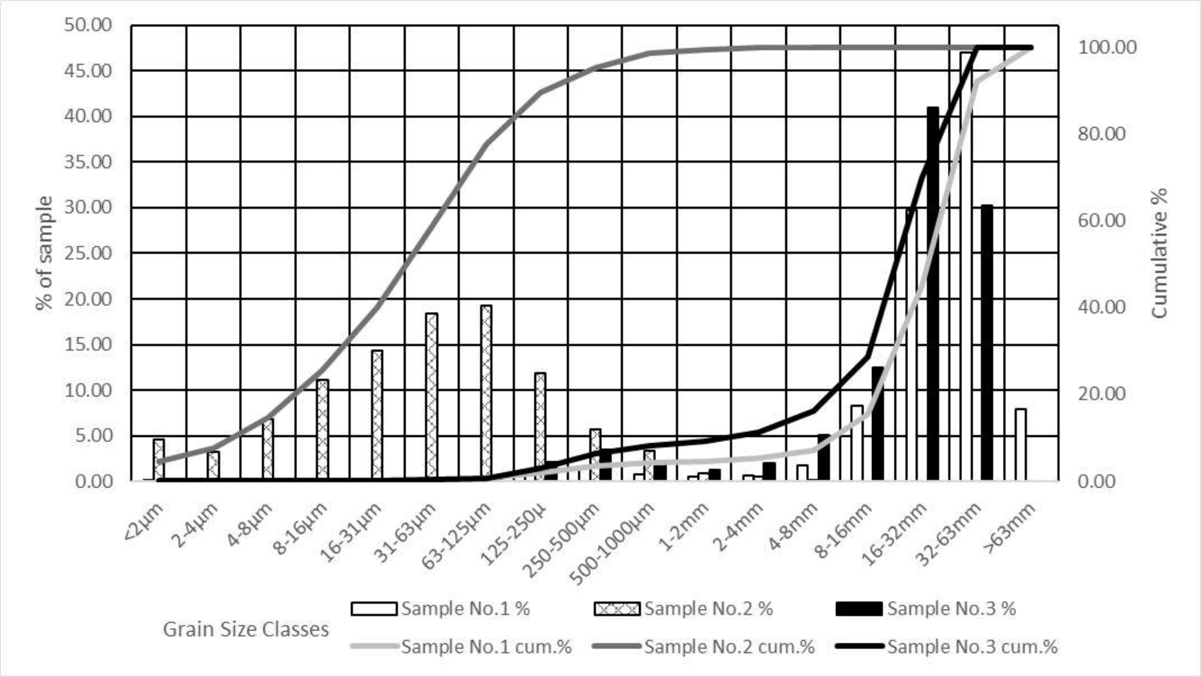

Figure 3-8. Elms Lake

	D10 (µm)	D50 (mm)	D90 (mm)
Sample No.1	11.35	33.95	60.64
Sample No.2	0.01	0.05	0.27
Sample No.3	2.72	24.13	42.27

3.2 Fine bed sediment storage

Fine (>2 mm) bed sediment storage was calculated for each sample at each site. Results of these have been presented in Table 3-1 and Table 3-2. Bed sediment storage shows considerable variation between each site and between samples within a given site. Results show no discernible downstream trend in average sediment storage between each site.

Unlike particle size analyses, triplicate samples show little to no correspondence between samples at most sites with variations between samples between factors of 1.11 and 37.2. This suggests that sediment storage in the riverbed is generally variable. Pairs of samples at Meades Water Gardens, Broadwater Bridge, Sarrat Watercress Beds, and to a lesser extent on the Main Chess at Restore Hope Latimer, delivered comparable results suggesting sediment grain sizes were more comparable across the riverbed, but there is still a considerable range in the size of material forming the bed. Chesham Moor and Elms Lake are considerable outliers to this. At Chesham Moor this may be due to local geomorphological differences. Elms Lake samples were taken in proximity to lake features, which is likely to encourage depositional processes resulting in a sample that is not representative of the typical characteristics of the watercourse.

Table 3-1 Bed sediment storage for each sample.

	Meades Water Garden			Chesham Moor			Broadwater Bridge			Restore Hope Latimer - Little Chess		
	1	2	3	1	2	3	1	2	3	1	2	3
Sed Conc. (g l)	42.17	22.88	26.65	11.61	135.25	4.00	3.14	7.44	3.95	6.91	9.36	12.87
Cylinder Vol (L)	12.57	12.57	10.00	38.00	38.00	38.00	44.00	31.00	31.42	18.85	31.42	33.93
Sample Area (m^2)	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13
Sediment Storage (g m^2)	4217.00	2288.00	2120.74	3510.80	40898.84	1209.58	1099.44	1835.37	987.50	1036.50	2340.00	3474.90
Sediment Storage (g cm^2)	4.22	2.29	2.12	3.51	40.90	1.21	1.10	1.84	0.99	1.04	2.34	3.47

Table 3-2 Bed sediment storage for each sample (cont.)

	Restore Hope Latimer - Main Chess			Sarrat Watercress beds			Loudwater Estate			Elms Lake		
	1	2	3	1	2	3	1	2	3	1	2	3
Sed Conc. (g l)	3.77	4.63	4.89	4.76	4.63	5.57	4.58	6.01	10.86	6.44	72.34	6.84
Cylinder Vol (L)	26.39	25.13	33.93	45.24	47.75	51.52	22.62	25.13	20.11	57.81	56.55	56.55
Sample Area (m^2)	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13
Sediment Storage (g m^{-2})	791.70	926.00	1320.30	1713.60	1759.40	2283.70	824.40	1202.00	1737.60	2962.40	32553.00	3078.00
Sediment Storage (g cm^{-2})	0.79	0.93	1.32	1.71	1.76	2.28	0.82	1.20	1.74	2.96	32.55	3.08

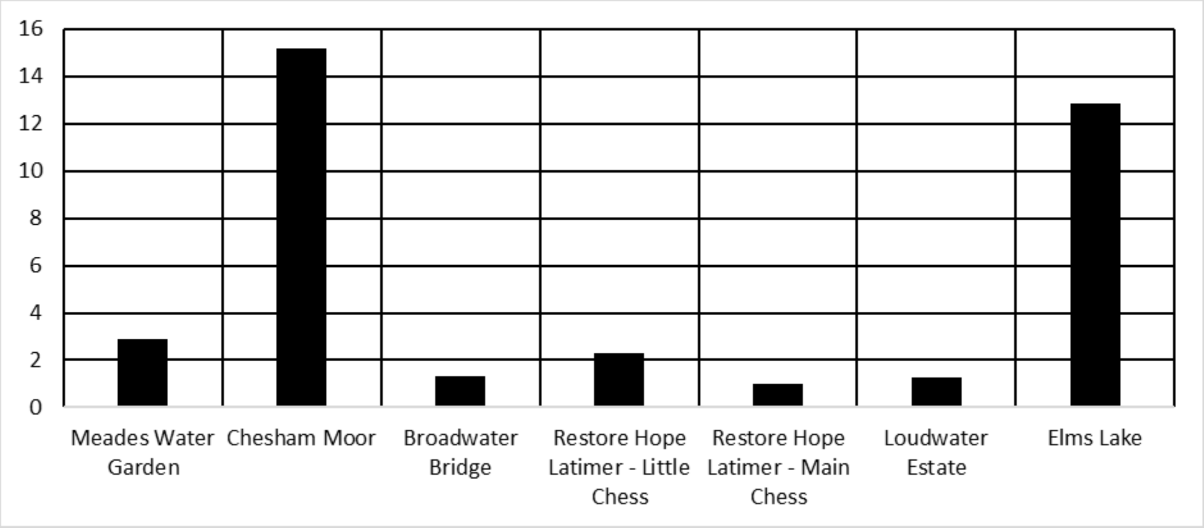

Figure 3-9. Sediment storage (Kg m^{-2}) for each of the sampled locations.

Table 3-3 Bed sediment storage statistics

Site	Mean fine sediment storage (Kg m^{-2})	Standard deviation
Meades Water Garden	2.88	0.95
Chesham Moor	15.21	18.19
Broadwater Bridge	1.31	0.38
Restore Hope Latimer Little Chess	2.28	1
Restore Hope Latimer Main Chess	1.01	0.22
Sarrat Watercress beds	1.92	0.26
Loudwater Estate	1.26	0.37
Elms Lake	12.86	13.92

4. Comparisons with figures in reported literature

Literature relating to riverbed sediment storage reveals that volumes of fine sediment bed storage along the River Chess are generally not in excess of those in neighbouring chalk streams with the exception of Chesham Moor, which is greatly in excess of reported values, and Elms Lake (though this is likely due to the presence of the effect of the lakes and as such, is not directly comparable).

At the Upper River Tern, River Pang and River Lambourne, regionally proximal rivers of comparable characteristics, fine sediment bed storage values are reported for grain sizes <63 µm. Mass-area values for these watercourses are broadly comparable, despite the much finer grain size, with values for these rivers ranging from 0.86 kg m^{-2} to 5.5 kg m^{-2}, 0.470 kg m^{-2} to 2.29 kg m^{-2} and 0.77 kg m^{-2} to 1.76 kg m^{-2} respectfully (Collins and Walling, 2007). Given the comparable bed storage values for <63µm size sediment at the reported watercourses with <2mm size sediment in the River Chess, it would be expected that inclusive of grains between 63µm and 2mm the mass of fine sediment per area in the reported watercourses would be greater than the River Chess. This would suggest that comparatively, the River Chess suffers with a lesser degree of sedimentation.

Fine sediment (<150 µm) bed storage in the channels of the River Ouse, River Swale, River Nid and River Wharfe, rivers with substantial contributions from limestone catchments in Yorkshire were calculated to have a mean range between 0.17 kg cm^{-2} and 9.24 g cm^{-2} (Walling *et al*., 1997). Here, whilst the values reported are considerably less than the values calculated for the River Chess, the grain size used was also significantly less. Similar to the above study inclusion of sediment between 150µm and 2mm would increase the reported amount of fine sediment bed storage such that, it may be at least comparable to the River Chess, though it is difficult to compare without the raw data available for the study.

Comparison to rivers of different type elsewhere within the UK (Table 4-1) yields similar findings to the comparison with regionally proximal chalk streams. Values reported for the River Leadon, River Tone, River Wylye and River Torridge in Southwest England, range from 0.07 kg m^{-2} to 1.28 kg m^{-2} for bed storage of grains <63µm (Wilson *et al*., 2004), and values for the River Tweed in Scotland, range from 0.12 kg m^{-2} to 0.96 kg m^{-2} for bed storage of grain <150µm (Owens *et al*., 1999).

Values presented in this study are therefore broadly comparable to those reported in published literature, with this study finding slightly higher values of fine bed sediment storage at particular locations. However, given that values recorded in literature focused on a defined particle size, that being either less than 63µm or less than 150µm. As the particle size of the suspended sediment has not explicitly known it is possible that samples taken for this study may include grain sizes that are in excess of the grain sizes assessed in literature. This introduces reliability limitations for comparability of the results of this study with reported literature.

The values recorded (excluding Chesham Moor) had a much tighter range than those quoted in the literature, suggesting more even distribution of sediment storage on the River Chess. These findings suggest that the River Chess is generally similarly affected by aggradation of fine sediment as the rivers in the published literature, with greater impact at particular locations (Chesham Moor) along the River Chess than along the rivers investigated by published literature.

Table 4-1 Comparison of River Chess results with results in reported literature

	River	Sediment Storage Range kg m^{-2}		Average Sediment Storage kg m^{-2}
RIVER CHESS	Meades Water Garden	2.12	4.2	2.88
	Chesham Moor	1.21	40.90*	15.21
	Broadwater Bridge	0.99	1.84	1.31
	RHL Little Chess	1.04	3.47	2.28
	RHL Main Chess	0.79	1.32	1.01
	Sarratt Watercress Beds	1.71	2.28	1.92
	Loudwater Estate	0.82	1.74	1.26
Collins and Walling 2007	Upper Tern	0.86	5.5	2.39
	Pang	0.47	2.29	1.07
	Lambourne	0.77	1.76	1.26
Walling et al., 1997	Ouse	0.18	9.2	2.00
	Swale	0.17	3.7	1.55
	Nid	0.5	2.4	1.33
	Wharfe	0.51	2.6	1.24
Owens et al., 1999	Tweed	0.12	0.96	0.56
Wilson et al., 2004	Leadon	0.42	3	1.48
	Tone	0.26	1.28	0.74
	Torridge	0.1	2.04	0.87
	Wylye	0.07	2.05	0.82

5. Effects of fine sediment storage on target species

Fine sediment has been widely attributed to adverse effects on geomorphology of the riverbed with consequent effects upon biota. As summarised by Wood and Armitage (1997), this has included killing aquatic flora, reduced macrophyte species diversity, reducing invertebrate diversity, density and abundance, change in invertebrate community structure, reduced abundance of fish species, decline in salmonid habitat and survival of salmonid eggs.

Excluding at Elms Lake and Chesham Moor, the generally coarse nature of the riverbed surface as determined by particle size analysis means that effects from fine sediment on invertebrate, macrophyte and fish species are unlikely to be widespread. At five of the eight sites, the fine proportion of the bed substrate equates to less than 10% of the overall bed composition, with two of the remaining three having less than 20% of the bed substratum comprised of fine sediment.

5.1 Macrophytes

Jones *et al*. (2011) highlights the effects of fine sediment in suspension on macrophytes, noting that studies have reported the effect of fine sediment on light availability and therefore the productivity of submerged macrophyte species. To a lesser degree, the effects are the same for emergent and floating leaved macrophytes such as ranunculus. The effect is greatest during the early growing season.

Deposition of fine sediment on leaves also directly impacts photosynthesis by covering the photosynthetic parts of the plant and restricts the diffusion of gasses into and out of the plant. Where fine sedimentation is considerable, plants can also be buried, resulting in loss of macrophytes, including ranunculus species (Brookes, 1986), or change in community to the benefit of plants with adventitious roots that can cope with being smothered. Smothering of the bed by fine sedimentation also effects propagation where propagules are buried by sediment and light and oxygen availability is restricted, impacting all but the largest and most resilient propagules. Jones *et al*. (2012) further report that the altered composition of the bed can increase the erodibility of root material (Dawson, 1981), reducing the root network. Increasing erodibility relative to root networks established in coarse grain substrate have been reported by Boeger (1992), and Clarke and Wharton (2001) report increased tendency for habitat communities to tend towards those with adventitious root systems.

Macrophyte data provided by the Environment Agency identified data at two sites which could be co- located with particle size analysis results; Sarrat Watercress Beds and Macrophyte Site 165827 and Chesham Moor and Macrophyte Site 34310). Only one year of macrophyte data is available at Chesham Moor compared to three at Sarrat Watercress Beds.

Macrophyte data revealed no Watercress was recorded but all other target species had been identified. Water Parsnip, Water Mint Ranunculus (penicillatus)and Callitriche (obtusangula) were identified at Sarrat Watercress Beds in minimal cover.

Water Mint Ranunculus (batrachian, repens (one year only in addition to batrachian) and penicillatus (the later in one year only in place of batrachian and which may represent mis-identification) and Callitriche (obtusangula) were identified at Chesham Moor.

Other than the identification of Water Parsnip at Sarrat Watercress Beds, where fine sediment concentrations are lower, there are limited differences between data sets at both sites, and insufficient data to identify potential trends between macrophyte species and sediment data collected as part of this study.

5.2 Invertebrates

The relationship between fine sediment and macroinvertebrates is still poorly defined with various responses occurring when observed at differing scales of study (Jones *et al*., 2011). Responses identified include increased drift, reduced density and diversity of sensitive species. As well as direct effects, fine sediment loading also results in the reduction in habitat availability, food availability and quality of food available. A more complex response for invertebrate communities depends on the response of the fish population to fine sediment, where visibility of invertebrate prey and reduction in abundance of fish results in changes to invertebrate populations typically favouring smaller invertebrate species which are more difficult to visually identify (Jones *et al*., 2011).

Specifically, as highlighted by Extence *et al*. (2011) sensitive mayfly and stonefly species are likely to suffer in habitats rich in fine sediment due to their having exposed gills which can be impaired by fine sediments (Corbin and Goonan 2010). The effect of fine sediment on invertebrate communities is demonstrated by Extence *et al*. (2011) on the River Chess where in a reach heavily impacted by fine sediment, the Proportion of Sediment Sensitive Invertebrates (PSI) rapidly improved following restoration in 1999, which reduced the fine sediment bed load in the reach from an impounded silt dominated reach to a free-flowing channel with heterogeneous substrate with only marginal silt.

Similarly, Larsen and Ormerod (2010) demonstrated the effect of fine sediment on invertebrates in the Usk catchment in Wales, after applying low levels of sand sized sediment (4-5 kg m^{-2}) which resulted in an increase in drift density by 45%, suggesting avoidance of habitats where sediment had been applied, and a decline in invertebrate density of 30% - 60% in affected sections. Whilst sand is of greater grain size than the fine sediments of focus in this investigation, the impacts are likely comparable.

The EA has ten macroinvertebrate sampling locations within the River Chess water body (GB106039029870) with environmental data readily available online. These data allow for calculation of Observed/ Expected ratios for a number of macroinvertebrate metrics. Details of monitoring locations are presented in

Table 5-1.

Expected values for a given metric are those which would be expected under natural conditions for the site location and in the absence of anthropogenic influence. The O/E ratios are presented along with indicative status classifications for WHPT metrics (NTAXA and ASPT), and threshold values for indicating the biological impacts of low flows and excessive fine sediment LIFE (O/E = 0.94) and PSI (O/E = 0.7), respectively. The higher the value of these indices, the higher the environmental quality indicated.

Table 5-1 EA macroinvertebrate monitoring locations within River Chess (GB106039029870) water body

EA Site ID	Name	NGR	Start Date	End Date	No. Samples	PSA Co-Located Site
33841	Water Lane Chesham	SP9584001322	08/06/1992	12/09/2023	40	n/a
33842	Waterside Road, Chesham	SP9701700382	08/03/1983	05/12/2018	22	n/a
34306	Below Broadwater Bridge	SU9774299995	09/09/1982	10/10/2023	63	Broadwater Bridge
34307	Above Chesham	SU9803799623	24/08/1982	22/11/2022	36	n/a
34045	At Bois Mill	SU9840099400	02/04/1990	25/10/2006	22	n/a
34054	At Latimer Park Farm	SU9990098500	06/03/1990	23/10/2006	19	n/a
34309	Below Latimer Bridge	TQ0050098600	06/09/1982	23/11/2005	35	n/a
34165	Above Chenies	TQ0170098750	08/03/1983	05/11/2021	27	n/a
34310	Above Valley Farm Ford	TQ0264898966	06/09/1982	12/09/2023	76	Sarrat Watercress beds
34311	Above Colne	TQ0662594665	24/08/1982	23/11/2005	35	Elms Lake

Figure 5-1 and Figure 5-2 show data for the ten locations for the following standard biotic indices:

- Whalley Hawkes Paisley Trigg Average Score Per Taxon (WHPT ASPT) (UKTAG 2014)[1]Whalley Hawkes Paisley Trigg number of scoring taxa (WHPT NTAXA);
- Lotic Invertebrate Flow Evaluation (LIFE[2]) species and family scores, including number of LIFE-scoring species and families (Extence et al., 1999); and
- The Proportion of Sediment-sensitive Invertebrates (PSI) [3]species and family scores (Extence et al., 2011).

Three macroinvertebrate monitoring locations were identified as co-located with sediment sampling locations: Below Broadwater Bridge (34306), Above Valley Farm Ford (34310), and Above Colne (34311).Across these three monitoring locations, no impact of excessive fine sediment deposition was indicated by PSI O/E ratios. This was supported by the sediment data for Broadwater Bridge and Sarrat Watercress Beds, which demonstrated substrate predominantly composed of medium gravels and coarser material. Data for Above Colne were more limited, ending in 2005; current status of macroinvertebrates for this monitoring location was unknown and comparison of macroinvertebrate data with concurrent sediment data is more tenuous.

A long-term increasing trend in PSI O/E ratios was also observed at Below Broadwater Bridge and Above Valley Farm Ford, which might suggest lessening pressure of excess fine sediment over time. However, similar long-term trends were observed for both ASPT and LIFE O/E ratios and therefore improvement over time may have related to factors other than sediment status.

When considering the species lists for each of these co-located monitoring locations three of the four target species (Table 1-1) were found to be abundant within each dataset. Mayflies (including *Paraleptophlebia werneri*), Heptageniidae (including *Heptagenia sulphurea*), and blue-winged olives (*Serratella ignita*) were abundant at all three co-located monitoring locations and present throughout the duration of each dataset. Stoneflies were much less commonly recorded and *Nemoura lacustris* was absent from the species lists

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[1] Whalley Hawkes Paisley Trigg (WHPT) indices (UKTAG, 2014). The WHPT method is an index of overall biological quality using macroinvertebrates. WHPT average score per taxa (ASPT) is used to indicate impacts of organic pollution and WHPT number of taxa (NTAXA) can indicate habitat quality as well as impacts of pollution. These two metrics are used to determine WFD status classifications for macroinvertebrates and are useful for enabling comparison of different locations.

[2] Lotic Invertebrate Index for Flow Evaluation (LIFE) (Extence et al., 1999). LIFE is the average of abundance-weighted flow groups that indicate the preferences of each taxon for higher water velocities and clean gravel/ cobble substrata or slow/ still water velocities and finer substrata. LIFE is used to index the effect of flow variations on macroinvertebrate communities and is calculated at family (LIFE_F) level.

[3] Proportion of Sediment-sensitive Invertebrates (PSI) (Extence et al., 2011). PSI assesses potential impacts associated with excessive deposition of fine sediment and is considered useful in describing the baseline condition of the river.

across these three monitoring locations. *Nemurella picteti* was commonly recorded at location 34306 but was not recorded at the other two locations with PSA samples collected.

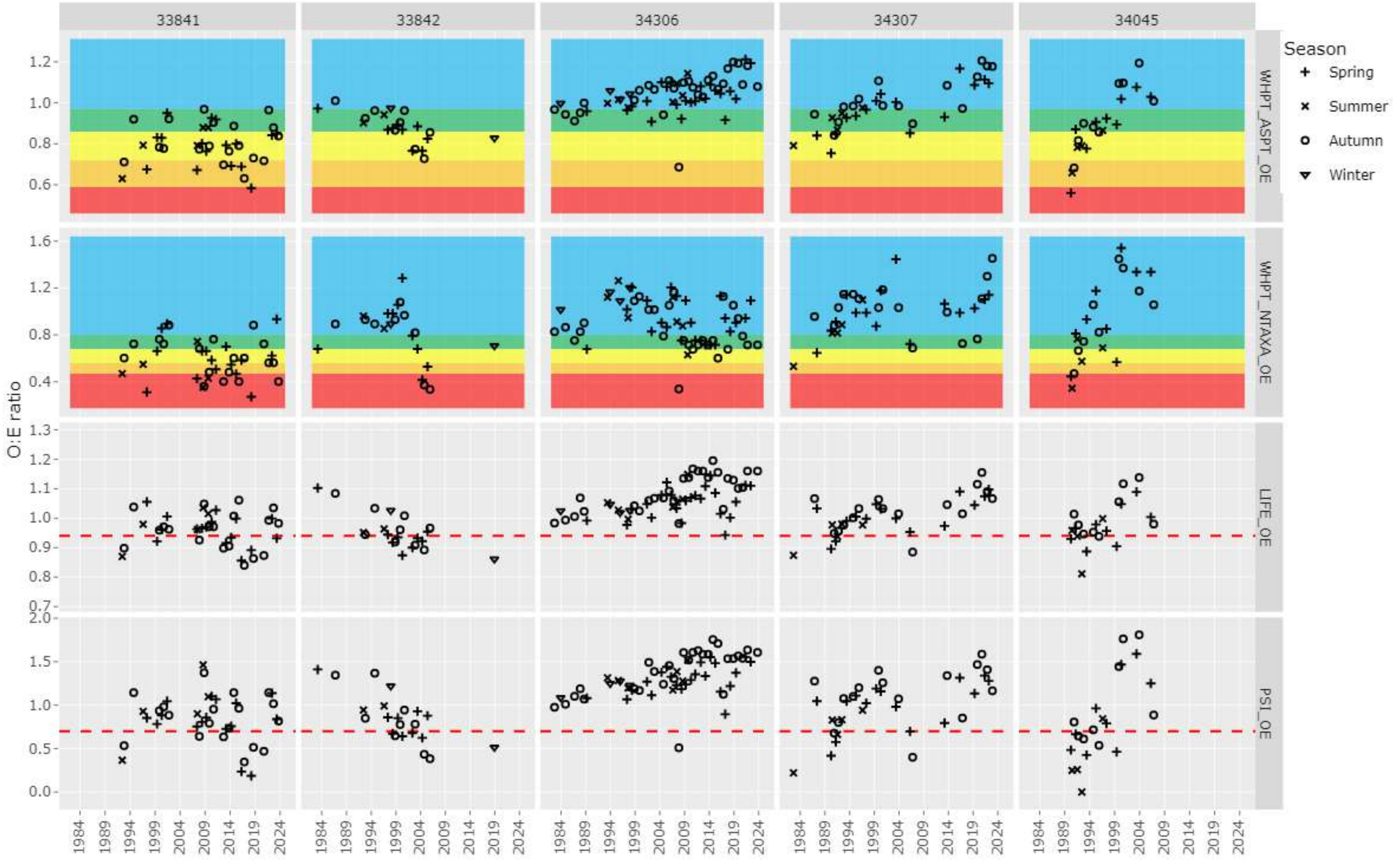

Figure 5-1 EA macroinvertebrate monitoring locations within the River Chess water body: upstream five locations.
Compliance against WFD standards is indicated by the block colour areas where appropriate, noting that this assessment does not comprise a full assessment of WFD status.

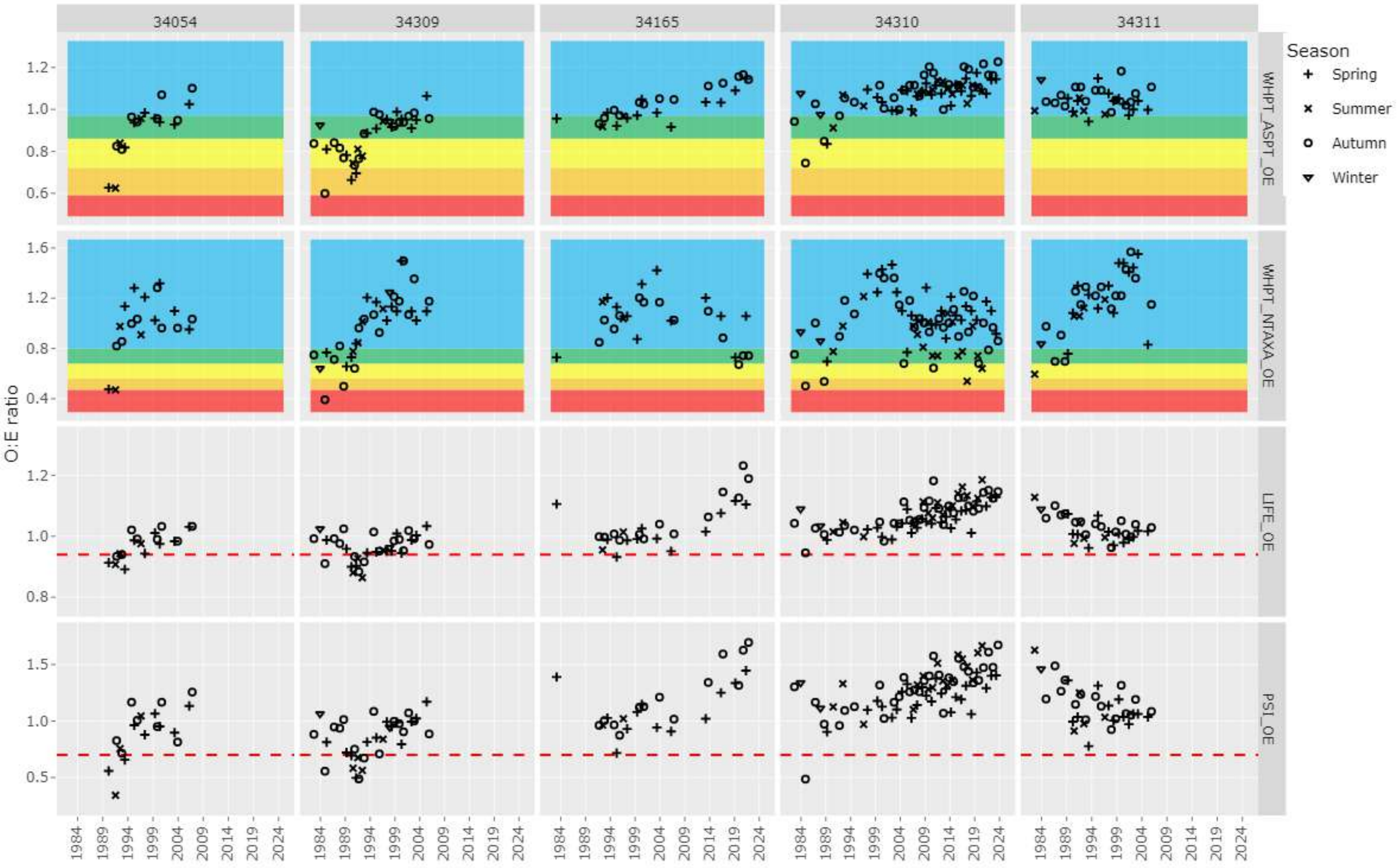

Figure 5-2 EA macroinvertebrate monitoring locations within the River Chess water body: downstream five locations

Compliance against WFD standards is indicated by the block colour areas where appropriate, noting that this assessment does not comprise a full assessment of WFD status.

The non-co-located monitoring locations provided an overall understanding of the status of macroinvertebrate communities for the water body in its entirety and no impact of excessive fine sediment deposition was indicated, based on PSI O/E ratios, when the most recent data was considered. An exception was identified at the most upstream monitoring location (Water Lane Chesham (33841)) where intermittent possible excessive fine sediment deposition was identified; however, possible confounding and/ or compounding effects of poor water quality were also indicated by WHPT NTAXA O/E ratios at this location.

5.3 Fish

Kemp *et al*. (2011) summarised the effects of fine sediment upon fish populations with effects upon fish behaviours, traits and physiology ultimately resulting in loss of fish species or communities from heavily sedimented reaches. However, fine sediment may also be preferred by some species/ lifestages – for example lamprey ammocoetes display a preference for silty marginal river habitats.

Deleterious effects of fine sedimentation occur because of direct damage to gills and abrasion of tissue, or indirect effects such as oxygen depletion, turbidity (visibility) and toxicity. Specifically, fine sediment has a well reported relationship with the availability of salmonid and lamprey spawning gravels, where it may form an impermeable layer smothering eggs and fry and preventing oxygenation and removal of waste (Soulsby *et al*., 2001, Sear *et al*., 2008).

Heywood and Walling (2007) reported 100% mortality of Atlantic Salmon (Salmo salar) at 10% fine sediment proportion of bed weight. Greig Sear and Walling reported 91.3% mortality at 10% proportion. Of the 21 samples taken, only 7 reported proportions of fine sediment below this threshold, with three of those (also the samples with the lowest % of <2mm) being the three Chesham Moor samples. This suggests that Atlantic salmon, and, similarly, brown trout, may be unlikely to be successful spawning at the locations sampled.

Fish data have been provided by the EA. Brown trout (*Salmo Trutta*) and Grayling (*Thymallus thymallus*) have been identified at each site. There are no data for Bullhead. Overall, there are insufficient data to identify potential trends between fish species and sediment data collected as part of this study. Data for Mountwood & Sarrat Watercress Beds, Little Chess and Little Chess, Large chess and Main Chess) suggest a degree of association between graylings and increased silt concentrations in the bed substrate and between brown trout and more moderate degrees of sedimentation. However, given the sample size and numerous other habitat conditions that are not quantified, this cannot be taken as firm evidence.

References

Boeger, R.T. (1992) Influence of substratum and water velocity on growth of Ranunculus aquatilis L. (Ranunculaceae). Aquatic Botany, 42, 351-360.

Brookes, A. (1986) Response of aquatic vegetation to sedimentation downstream from river channelization works in England and Wales. Biological Conservation, 38, 351-367.

Clarke, S.J. and Wharton, G. (2001) Sediment nutrient characteristics and aquatic macrophytes in lowland English rivers. Science of the Total Environment, 266, 103-112.

Collins. A. L. and Walling. D. E. 2007. The storage and provenance of fine sediment on the channel bed of two contrasting lowland permeable catchments, UK. River Research and Applications Volume 23 Issue 4. 429 – 450. https://doi.org/10.1002/rra.992

Corbin TA, Goonan PM. 2010. Habitat and water quality preferences of mayflies and stoneflies from South Australian streams. Transactions of the Royal Society of South Australia 134: 5–18.

Dawson, F.H. (1981) The downstream transport of fine material and the organic-matter balance for a section of a small chalk stream in Southern England. Journal of Ecology, 69, 367-380.

Extence, C.A., Balbi, D.M. and Chadd, R.P. (1999) River flow indexing using British benthic macroinvertebrates: a framework for setting hydro-ecological objectives. Regulated Rivers: Research and Management, 15:543–574.

Extence C. A., Chadd R. P., England J., Dunbar M. J., Wood P. J. and Taylor E. D. 2011 The assessment of fine sediment accumulation in rivers using Macro-invertebrate community response. River Research and Applications. DOI: 10.1002/rra.1569.

Greig, S. M., Sear, D. A., & Carling, P. A. (2005). The impact of fine sediment accumulation on the survival of incubating salmon progeny: Implications for sediment management. Science of the Total Environment, 344(1), 241–258. https://doi.org/10.1016/j.scitotenv.2005.02.010

Heywood, M. J. T., & Walling, D. E. (2007). The sedimentation of salmonid spawning gravels in the Hampshire Avon catchment, UK: Implications for the dissolved oxygen content of intragravel water and embryo survival. Hydrological Processes, 21(6), 770–788. Https://doi.org/10.1002/hyp.6266

Jones J. I., Murphy J. F., Collins A. L., Sear D. A., Naden P. S. and Armitage P. D. 2011 The impact of fine sediment on macro-invertebrates. River Research and Applications. DOI: 10.1002/rra.1516

Kemp. P, Sear. D. A, Collins. A, Nade. P, Jones. I 2011 The impacts of fine sediment on riverine fish. Hydrological Processes. 25, 1800 – 1821. DOI: 10.1002/hyp.7940

Owens. P. N., Walling. D. E. and Leeks. G. J. L., 1999. Deposition and storage of fine-grained sediment within the main channel system of the River Tweed, Scotland. Earths Surface Processes and Landforms. Volume 24 Issue 23. 1061 – 1076. https://doi.org/10.1002/(SICI)1096-9837(199911)24:12<1061:AID-ESP35>3.0.CO;2-Y

Larsen S. and Ormerod S. J. 2010 Low-level effects of inert sediments on temperate stream invertebrates. Freshwater Biology. 55, 476 – 486. DOI: 10.1111/j.1365-2427.2009.02282.x

Sear DA, Frostick LB, Rollinson G, Lisle TE. 2008. The significance and mechanics of fine sediment infiltration and accumulation in gravel spawning beds. In Salmonid Spawning Habitat in Rivers; Physical Controls, Biological Responses and Approaches to Remediation, Sear DA, DeVries PD (eds). AFS: Bethesda, MD; 149–174.

Soulsby. C., Youngson. A. F., Moir. H. J., Malcom. I. A., 2001 Fine sediment influence on salmonid spawning habitat in a lowland agricultural stream: a preliminary assessment. The science of the total environment 265, 295 – 307.

UKTAG (2014) UKTAG River Assessment Method Benthic Invertebrate Fauna. Invertebrates (General Degradation): Whalley, Hawkes, Paisley & Trigg (WHPT) metric in River Invertebrate Classification Tool (RICT). Stirling, UK.

Walling. D. E., Owens. P. N. and Leeks. G. J. L. 1997 The role of channel and floodplain storage in the suspended sediment budget of the River Ouse, Yorkshire, UK. Geomorphology, Volume 22, Issue 2-4 225 -242. https://doi.org/10.1016/S0169-555X(97)00086-X

Wilson. A. J., Walling. D. E. and Leeks. G. J. L., 2004. In-channel storage off fine sediment in rivers of southwest England. Sediment Transfer through the fluvial system (proceedings of the Moscow Symposium, August 2004). IAHS Publ. 288.

Wood, P.J. & Armitage, P.D. 1997 Biological effects of fine sediment in the lotic environment. Environ. Manage., 21, 203-217.