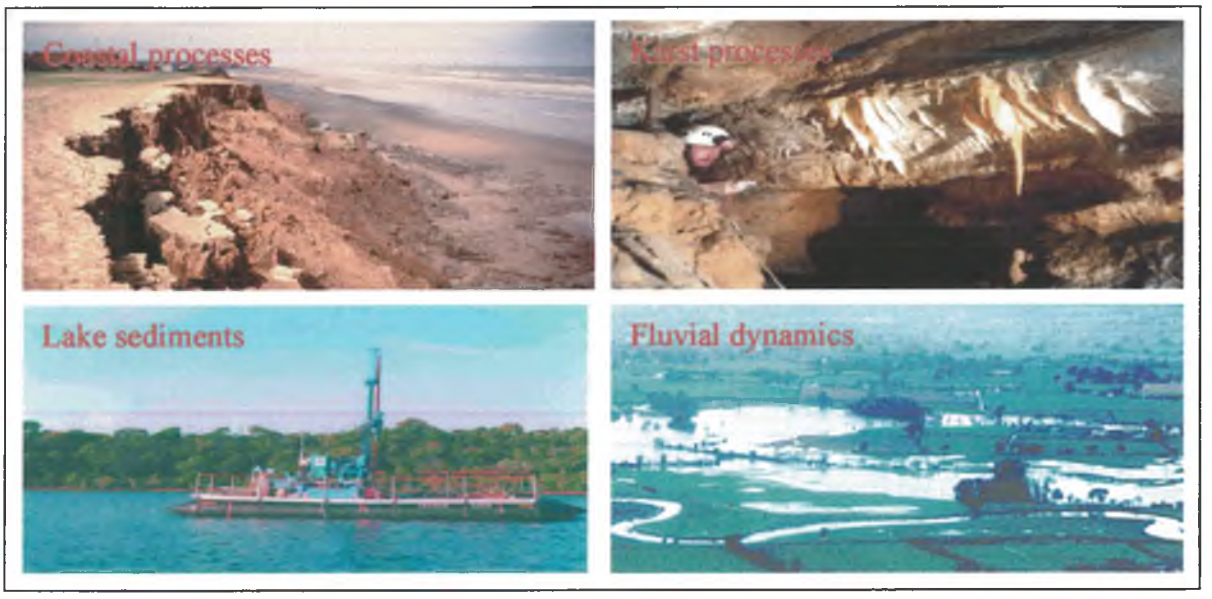
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River Crake Freeze Coring Report

(River Crake at Bouthrey Bridge)

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Study of hydrodynamics and sediment in fluvial, coastal and lacustrine environments

INTERIM PROJECT REPORT
(Detailed particle size analysis of fine sediments to follow)

RIVER CRAKE (UPSTREAM of BOUTHREY BRIDGE) FREEZE CORING

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1. Executive Summary

The percentage by weight of fine sediments for the six freeze cores was found to be lower than first expected, given the visual appearance of the reach. However the fines were found to be distributed evenly down the cores with a marked absence of an upper, coarse gravel armour layer. In addition the median grain size (D_{50}) of the six samples were generally low, falling to 6mm for core 5. The low median grain size and the absence of a coarse grained upper strata are considered detrimental to the success rate of salmonid spawning.

2. Project Background

Following an observed decline in quality of salmonid fisheries at the site an investigation was initiated to assess the extent of ingress of fine sediments into the spawning gravels. Fine sediments from one potential source, upstream riverbanks, are also compared to those isolated from the spawning gravels.

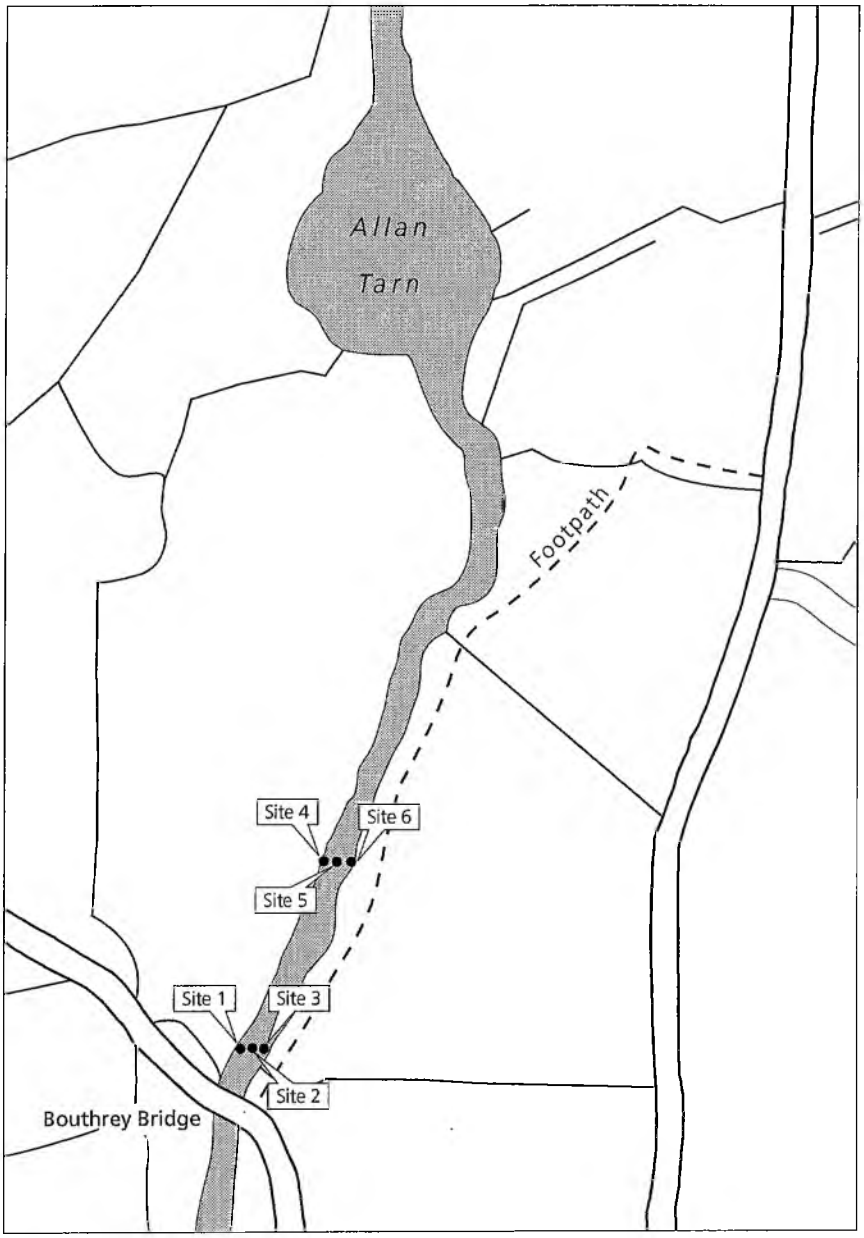
3. Site Details (NGR: SD 292 891)

A total of six freeze cores were taken from two sections across the River Crake upstream of Bouthrey Bridge, shown in Map1. These sites were chosen in consultation with Mr. B. Bayliss, Fisheries Officer with The Environment Agency (Penrith Office), during a preliminary site visit during January 1999. In addition bulk sediment samples were collected from exposed sediments in upstream riverbanks.

4. Methodology

Cores were collected using standard freeze coring methods a summary of which follows. Sediment samples were extracted by using a copper standpipe inserted into the river bed, liquid nitrogen is decanted down into the stand pipe to freeze the pipe and the surrounding interstitial water within the river bed sediments. The pipe is then extracted from the bed complete with an undisturbed bed sample using a winch. Details of freeze coring equipment are given in Carling and Crompton (1988). Intact cores were then photographed and inspected for stratigraphic divisions. In addition core lengths were measured and the whole core weight measured in order to calculate void ratios.

Samples were then dried at room temperature and then sieved mechanically using a Fritch Analysette. Sieving time was 15 minutes using an intermittent mode of amplitude sufficient to mobilise the coarsest fractions. As grain size distributions



River Crake- Freeze Core Sites

PRINCIPAL PARTICLE SIZE DIVISIONS

Particle Diameter

Units				
- 11	2048mm	V Large	Boulders	GRAVEL
- 10	1024mm	Large		
- 9	512mm	Medium		
- 8	256mm	Small		
- 7	128mm	Large	Cobbles	
- 6	64mm	Small		
- 5	32mm	V Coarse	Pebbles	
- 4	16mm	Coarse		
- 3	8mm	Medium		
- 2	4mm	Fine		
- 1	2mm	V Fine		
0	1mm	V Coarse	Sand	
+1	500μ	Coarse		
+2	250μ	Medium		
+3	125μ	Fine		
+4	62μ	V Fine		
+5	31μ	V Coarse	Silt	MUD
+6	16μ	Coarse		
+7	8μ	Medium		
+8	4μ	Fine		
+9	2μ	V Fine		
			Clay	

approach a logarithmic distribution samples were sieved at 1phi (Ø) intervals in the range <0Ø (<1mm) to –6Ø (64mm). The use of the phi scale is common practice in sedimentological investigations and the relationship to the mm and Wentworth scales is shown in Table 1.

5. Results

5.1. Core Descriptions

As none of the cores showed evidence of any vertical structure within their body further analysis was undertaken on the cores as a whole. All the cores appeared to contain sediments solely from the fluvial regime of the river, that is none penetrated into the strata underlying the river. All samples contained gravels of varying sizes within a finer matrix. They ranged in length from 32cm to 41cm.

5.2. Whole Core Data

Core	1	2	3	4	5	6
Total length (cm)	35	32	36	39	41	37
Number of Sections	1	1	1	1	1	1
Total Dry Weight (g)	31545	6759	8687	15918	7795	8977
Total Wet Weight (g)	43000	10000	12000	23000	13000	14500
% Weight >0Ø (1mm)	91.6	93.7	92.1	92.5	90.1	93.4
% Weight <0Ø (1mm)	8.4	6.3	7.9	7.5	9.9	6.6

5.3. Median Grain Size (D_{50})

Core	1	2	3	4	5	6
D_{50} (mm)	32.5	16	9	20	6	49

5.4. Percentage of Fines (% Weight <0Ø (1mm)) Within the Cores

Core	1	2	3	4	5	6
% Weight <0Ø (1mm)	8.4	6.3	7.9	7.5	9.9	6.6

5.5. Core Compaction

Compaction is generally expressed as the void ratio (E) where:

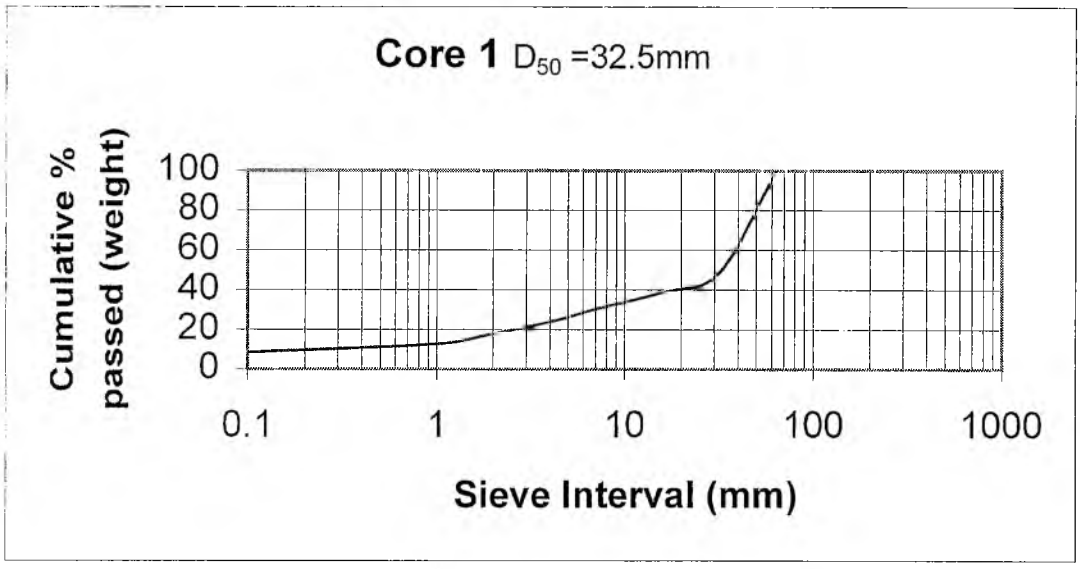
E = *Volume of water in the core /Volume of Gravel in the core*

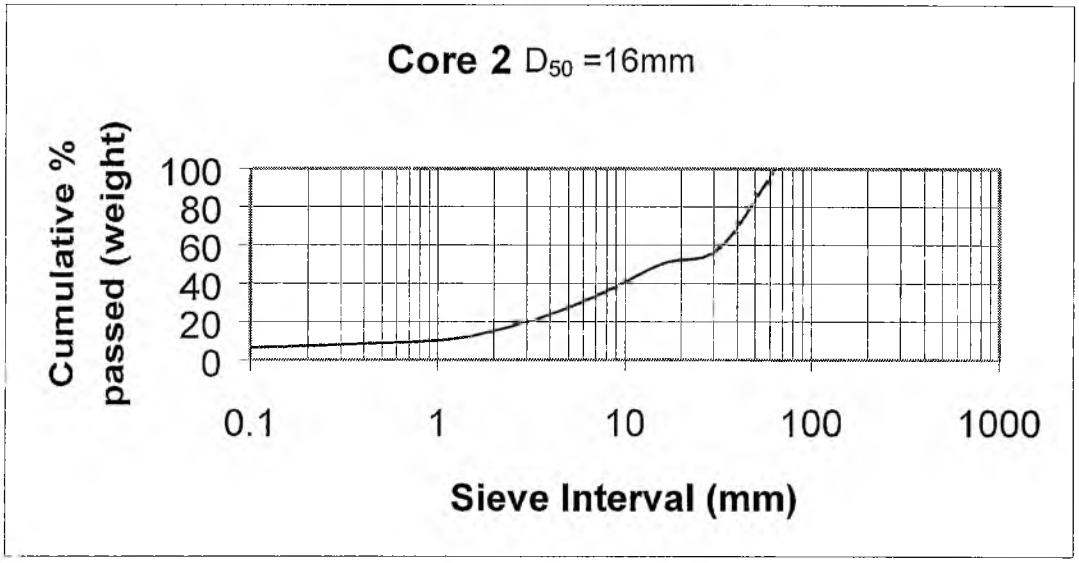
Or as porosity (p) where:

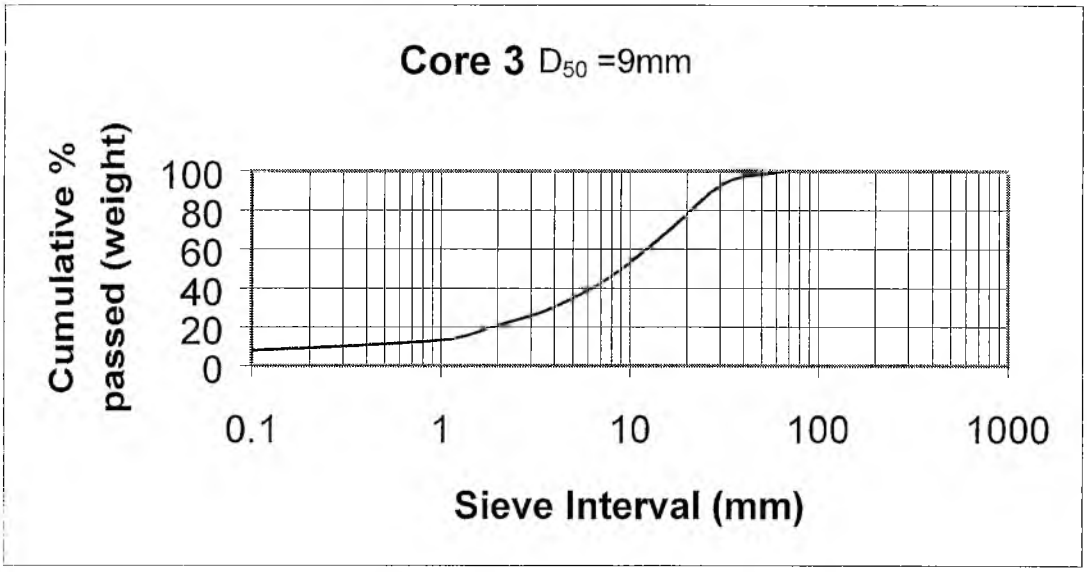
$P = E / (1+E)$

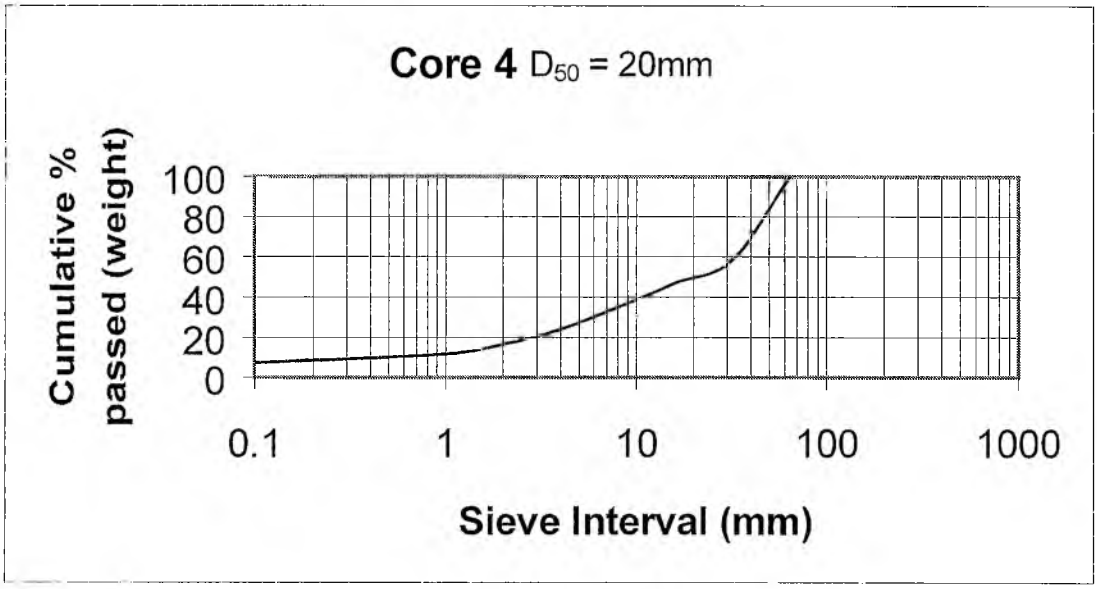
Reported values of E for upland stream gravels are in the order of 0.14 – 0.5, Carling and Reader (1982). The void ratios determined in this study were found to lie between 0.9 and 1.5, clearly an untenable result. These discrepancies are likely to result from an expansion of pore space between the gravels caused during the taking of the core and none interstitial water being frozen to the outside of the core.

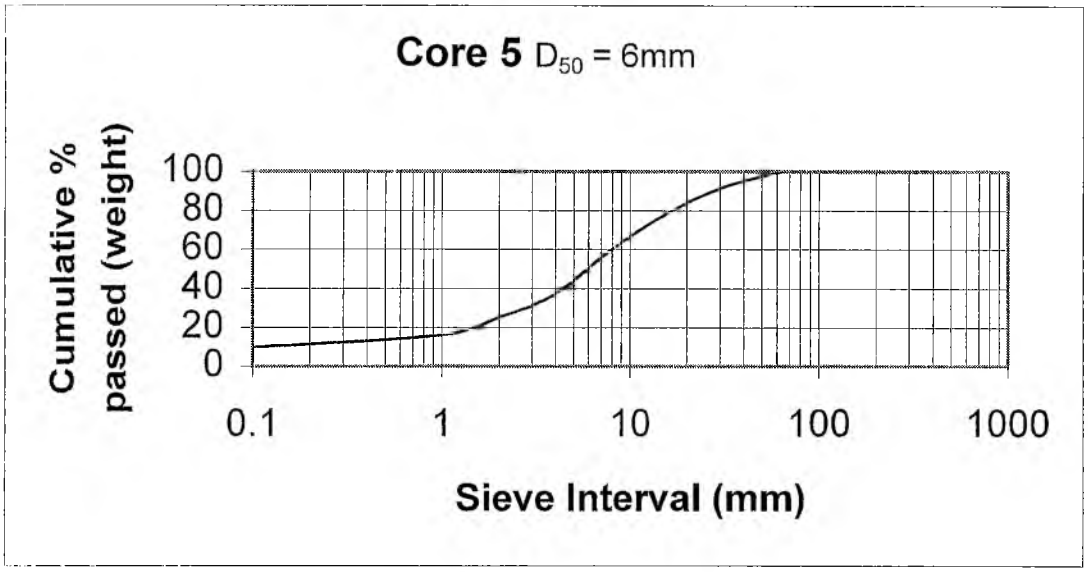
5.6. Cumulative Frequency Curves

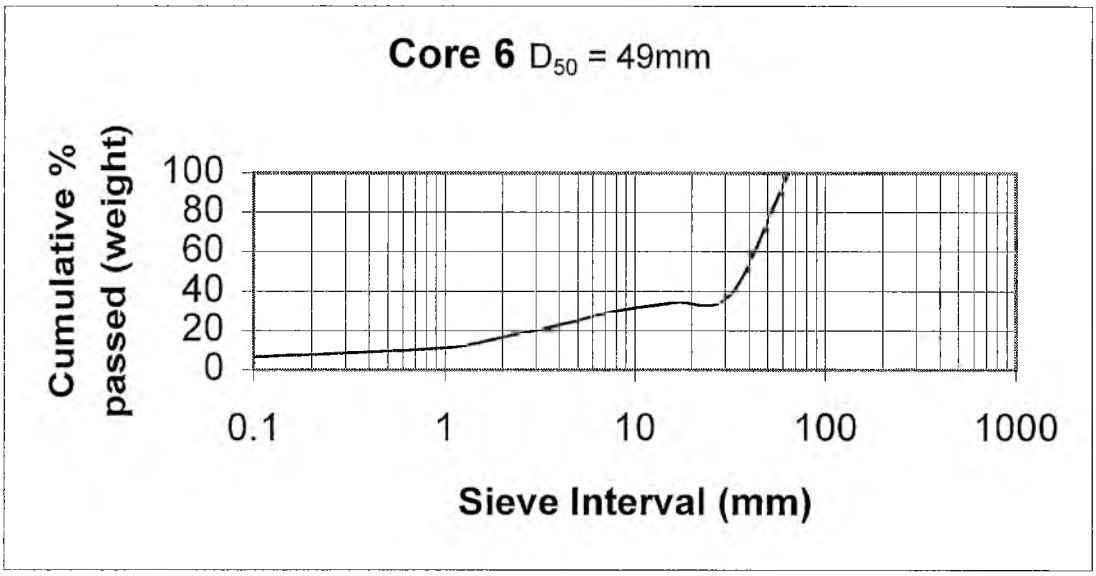



Core 2 D_{50} =16mm
Cumulative % passed (weight)
100
80
60
40
20
0
0.1
1
10
100
1000
Sieve Interval (mm)


Core 3 D_{50} =9mm
Cumulative % passed (weight)
100
80
60
40
20
0
0.1
1
10
100
1000
Sieve Interval (mm)


Core 4 D_{50} = 20mm
Cumulative % passed (weight)
100
80
60
40
20
0
0.1
1
10
100
1000
Sieve Interval (mm)





6. Interpretation

It was noted that none of the samples from the River Crake contained any evidence of vertical structures. This is in contrast to the expected norm where an upper surface layer of coarse gravel with few fines is expected with a more compacted layer below. Fines are found in apparent equal density throughout the length of the core. In some cases this resulted in difficulty in inserting the freeze core standpipe. However none of the cores were found to contain excessive percentages of fine material (<1mm) within the samples. This is in contrast to the D_{50} values taken from the cumulative frequency curves. Only two cores 1 and 6 have relatively high values, 32.5mm and

49mm respectively. The remaining four cores have values: 16mm, core 2; 9mm, core 3; 20mm, core 4; and 6mm, core 5. Crisp and Carling (1989) noted that for UK salmonids gravels between 18mm and 62mm are utilised for spawning with the 20mm-30mm range being preferred. A more detailed overview of the relationship between gravel D_{50} values and salmonid spawning and in particular the length of fish utilising the gravel is provided by Kondolf (1992).

7. Conclusions

The relatively low D_{50} values observed coupled with the lack of vertical structure within the river gravels could account for the disappointing success rate of salmonid spawning at the River Crake site. One potential source for contemporary fine sediments, upstream riverbanks, was investigated (report to follow). Other potential sources should however be considered. The second likely source being fine sediments transported from Coniston Water and or Allen Tarn. The lack of any significant tributaries upstream of Bouthrey Bridge would suggest that sediment mobilised within the catchment is unlikely to be transported directly into the Crake but overland flow, during significant rainfall events, should at least not be neglected. It was noted that the small tributary immediately upstream of the Bouthrey Bridge appeared to carry a high fine sediment load. The possibility of an ongoing series of freeze core sampling at the site should also be considered, given the highly dynamic nature of gravel bed rivers. Such a monitoring programme would provide a much clearer and detailed overview of changing conditions at the site.

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