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A Horizontal-wheeled Watermill of the Anglo-Saxon Period at Corbridge, Northumberland, and its River Environment

Margaret E. Snape
with a contribution by David G. Passmore

CONTENTS

Introduction, topography and previous research	37–46
The 1995 evaluation	46–54
Horizontal-wheeled water mills	54–56
The structure at Corbridge	56–62
The Corbridge mill and implications of status	62–64
Conclusions	64–65
Appendix: River Tyne alluvial deposits	65–70
Acknowledgements	70–71
Bibliography	71–72

SUMMARY

A structure beside the north bank of the River Tyne at Corbridge has been identified as the remains of a horizontal-wheeled watermill of pre-Norman date, closely resembling the Anglo-Saxon watermill at Tamworth, Staffordshire. Mills of this period are extremely rare, and the Corbridge example was a particularly substantial and well-built example. There is strong evidence to show that the settlement of Corbridge was of religious, economic and social significance during the Anglo-Saxon period, sited at a strategic river crossing in the Tyne valley. Geochemical studies of the river terraces have shown that river patterns and the floodplain environment may have changed considerably since the period when the mill was in use. Much remains to be learnt about the site, its cultural and landscape setting and its close similarities to other pre-Norman mills in England and Ireland. Nevertheless, the fact that these questions can now be posed emphasises the important of the Corbridge mill and its setting.

INTRODUCTION

In September 1995 an evaluation consisting of survey and limited excavation was carried out by Tyne and Wear Museums Archaeology Department at two sites beside the River Tyne at Corbridge. One of these sites was the southern abutment of the Roman bridge (C on fig. 1) whilst the other is the subject of this paper: a platform of stone and timber submerged in shallow water beside the north bank of the river (A on fig. 1). The work was undertaken to assess the precise nature and importance of the archaeological remains – and to establish the extent of damage caused to them by the erosion which had been observed over the previous two decades. The project, which was directed by Paul Bidwell and the author, was funded by English Heritage and Northumberland County Council.

The importance of this platform had already been signalled by radiocarbon dating of its timbers (see below) which indicated that the structure belonged to the Anglo-Saxon or Viking period. As a result of the evaluation, the remains can now be identified as parts of the basement of a horizontal-wheeled or 'Norse' watermill. These are buildings, constructed close to a river (or tidal water, or periodical stream, filling up a pool), which consist of a basement wheelhouse, with a room at ground level for the millstones on which the grain was milled. Water was fed into the wheelhouse from a leat or mill pool, and spent water left the mill through an outfall or tail race, into the river (fig. 11). Although watermills are well documented in the pre-Norman period – there are 5624 listed in the Domesday Book (Hidgen 1939) – very few remain in the archaeological record (Wikander 1985). Examples from Old Windsor, Tamworth, Raunds and Barking Abbey (Rahtz and Meeson 1992) and Ebbsfleet (Anon. 2003) are virtually the only parallels from pre-Norman England which can be cited alongside these Corbridge remains.

In all of the discussion which follows it is important to remember that although the remains at Corbridge are now submerged, the mill when in use would have stood on dry land. Since the Anglo-Saxon period, erosion has drastically lowered the ground surface surrounding the mill, leaving only the terrace of stones and gravel on which both the floor of the basement and the timber sill beams that carried the uprights for the superstructure once rested. This is best understood by comparing the plan of the remains shown on fig. 8 with the suggested reconstruction on fig. 13b. In the elevation drawing on the lower part of this figure the surviving remains are shown shaded. The unshaded features represent the superstructure, the walls of the basement, the sides of the mill pool feeding the mill and the outfall carrying water away from it; all traces of these have been swept away. This demonstrates the changes in the course of the river over time, and its power to erode substantial structures. It should be borne in mind that the presumed line of the river in the Roman period as shown on fig. 2, is only a hypothesis; as indicated by Dr Passmore (p. 70) the Anglo-Saxons may have known a multi-channel river and flood plain environment very different from that of today. Therefore the Anglo-Saxon watermill need not have been even as close to the river bank as suggested on fig. 2; it could have been further away from the main river channel, but fed by a stream or leat.

Following the fieldwork, interim summaries were produced (Snape 1995; English Heritage 1995–6; Snape, 1995–6; Snape 1997; Bidwell and Snape 2001). This paper, which presents the full results of the evaluation of the structure, has been funded by English Heritage and the Research Committee of the Society of Antiquaries of Newcastle.

LOCATION, TOPOGRAPHY AND MODERN SETTING

The study area is located immediately to the south of the remains of Corbridge Roman town (figs 1–3), which lie in Corchester Fields (also sometimes in the past called Colchester), at the top of an escarpment. Bordering the northern edge of the Roman site is Corchester Lane, a road running to the modern village of Corbridge, about 1 kilometre to the east. Running west from Corbridge, along the river bank, is a footpath following the line of the medieval road to Carlisle; this sector of which was known as Carelgate. This path runs between the foot of the escarpment and the dense bushes and willow trees at the water's edge, to a building called Corbridge Mill (B on fig. 1). This was the site of a vertical-wheeled watermill from the medieval period; the present building, constructed *c.* 1800 (Listed Building NY 95 SE 9/119) has now been converted to a private house. The path ran past the mill, crossed the Cor Burn and then re-used part of the Roman road; this sector of road was known in the medieval period as the Stanegate.

The Cor Burn is one of three streams within the study area which all flow into the River Tyne (figs 1, 2 and 3). It flows down from the north, and the Red House Burn from the west; the low-lying ground between the Red House Burn and the Tyne is known as Red House

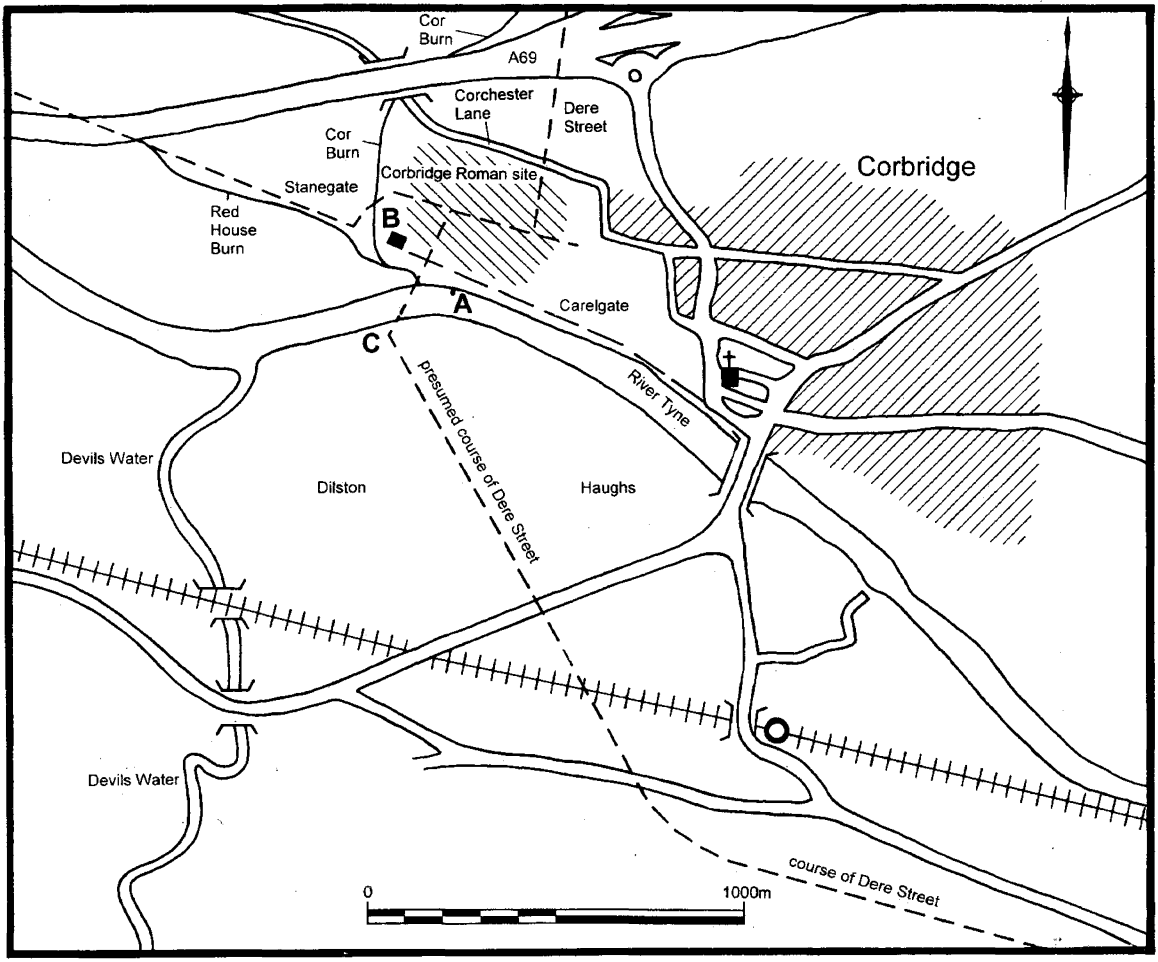


Fig. 1 Location map showing Corbridge village and Corbridge Roman site in relation to the River Tyne and its tributaries, the Cor Burn, the Red House Burn and the Devil's Water. Roman roads are shown as short dashes, the medieval road as long dashes, and modern roads in solid lines. The position of St Andrew's church in Corbridge is also shown. The Anglo-Saxon watermill is shown at A, Corbridge Mill is shown at B, and the Roman bridge abutment at C. Scale 1:20,000.

Haughs. On the south side of the river, the Devil's Water flows north across Dilston Haughs to join the Tyne a little upstream from the confluence of the Cor Burn and the Red House Burn. These streams cause instability in the river regime. When in spate they can erode banks, and material can be washed down into the river to form islands or gravel banks. Over time, the landscape of the study area will have undergone many changes, as described below.

The Roman road known as Dere Street approached from the south-east, although its precise course across the flood plain is unknown. Its course is not visible on air photographs (fig. 3). The road was carried across the river on a bridge to the Roman town, and from there it continued north. Remains of the southern abutment of the bridge (C on fig. 1) are now submerged and the position of the northern abutment is unknown, but the line of the bridge

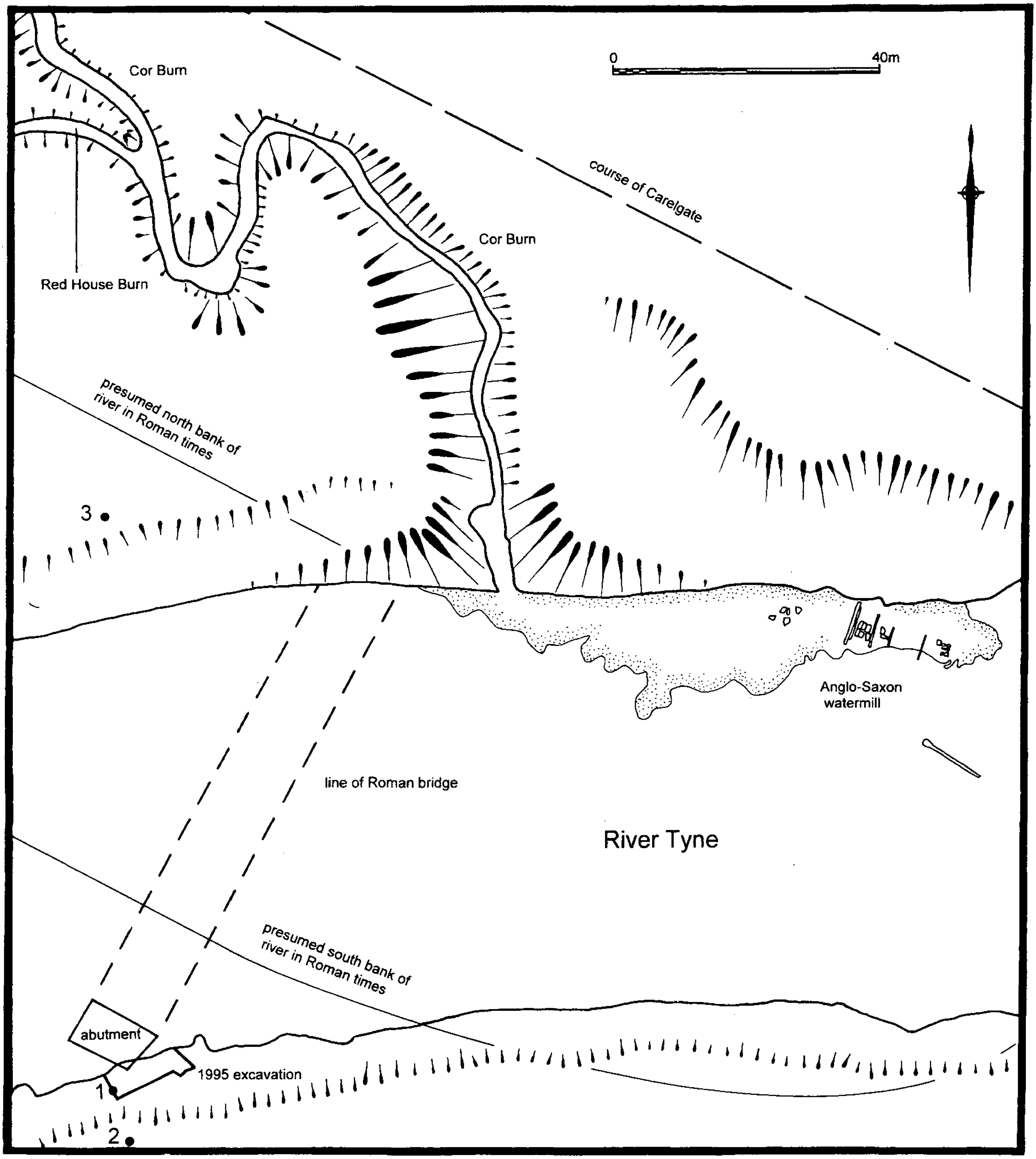


Fig. 2 The area of the 1995 survey, showing the location of the Anglo-Saxon watermill on a submerged stony shelf to the west of the junction between the Cor Burn and River Tyne. Also shown are the Roman bridge abutment, the line of the Roman bridge, the presumed course of the river in the Roman period and the line of the medieval Carelgate on the north bank. Numbers 1, 2 and 3 indicate the position of sediment samples Corb-1, Corb-2 and Corb-3, taken for analysis of trace metal geochemistry. Scale 1:1000.

Fig. 3 Aerial photograph of Corbridge and the River Tyne taken in 1984. The western extent of the modern village is at top right, the Roman site at top left. The Anglo-Saxon watermill is at A, Corbridge Mill at B and the Roman bridge abutment at C (compare with fig. 1). The Cor Burn is marked as CB, Red House Burn as RHB, the mouth of the Cor Burn as M, and the Devil's Water as DW. Many paleochannels can be seen on Dilston Haughs to the south of the river, but the course of Dere Street is not visible across this area. Parch marks in the fields north of the river show the course of Roman roads. Dere Street can be seen at 1, running north from the Roman bridgehead. The Stanegate, east of its crossing with the Cor Burn can be seen at 2, and the junction of Dere Street and the Stanegate at 3. The course of Dere Street running north out of the Roman site can be seen at 4. (Photo no. Rc8–HB 230, Cambridge University Collection of Aerial Photographs: copyright reserved; annotations by Tyne and Wear Museums). The area shown is slightly larger than 1km².

is known because the remains of six stone piers on the river bed have been recorded (Bourne 1967). This alignment is shown on fig. 2.

Downstream from the point where the line of the Roman bridge meets the present northern bank is a relatively level shelf or terrace consisting of boulders and gravel, now lying under water (figs 2 and 3). The terrace extends out from the bank for 12–20m before dropping steeply into the main river channel. It ends *c.* 90m east of the line of the bridge before dropping into another deep pool. When the river level is high during autumn and winter, and after storms, it is submerged under several feet of fast-flowing water. For a few months in the summer, however, the river is sufficiently low for the features, here identified as the remains of the watermill, to be clearly visible in shallow water (figs 7 and 9). The remains occupy an area 18m by 7m at the eastern end of the terrace and consist of a platform of dressed stones derived from the Roman bridge, together with large timbers. The stones were large rectangular blocks, of average size 1.10m by 0.60m, which had been part of *opus quadratum* construction; they were cut by lewis holes, clamp slots and dowel holes.

The terrace to the west of the remains is covered by a concentration of large, irregularly-shaped boulders, with occasional worked blocks dislodged from the Roman bridge. There were also many large displaced stones overlying the eastern part of the mill remains, but most of these were worked blocks, more than half them derived from the Roman bridge. The number of features visible on the structure itself varies from season to season, as some parts may be obscured by the deposition of silt, gravel or boulders deposited by the river, while other areas are freshly exposed by the action of the current.

THE SITE IN ITS ANCIENT LANDSCAPE SETTING

It is likely that the Roman bridge was originally constructed to cross the river at right angles (the probable lines of the north and south banks of the river in the Roman period are shown on fig. 2). Its angle to the present south bank therefore shows the considerable change of course of the river since Roman times, as noted in a survey of 1907 (Forster 1908, fig. facing 216).

The bridge appears to have been in a state of decay by the late seventh century, as stones from it were almost certainly used in the construction of the crypt of the church dedicated to St Andrew in Hexham, which was founded by St Wilfrid in AD 674 (Bidwell and Holbrook 1989, 105; Eaton 2000, 115–6). The collapse of the bridge is no doubt the reason for the settlement shift to the present site of Corbridge village, where the river was fordable (fig. 4). Corbridge church, also dedicated to St Andrew, may have been founded as early as the seventh century (Taylor and Taylor 1965, 172–6).

The remains of the watermill are not parallel with the present waterline, but angled north-west/south-east, *i.e.* at right angles to the line of the Roman bridge. This suggests that in the Anglo-Saxon period the river still flowed on the same alignment as that suggested for Roman times. The edge of the submerged terrace of gravel and boulders therefore probably represents the Anglo-Saxon waterline. If the remains are correctly identified as the floor of a basement (see below), then river erosion must have lowered the ground surface in the vicinity of the mill by at least two metres since Anglo-Saxon times.

Evidence for the subsequent (post-Conquest) history of the medieval landscape is more readily available. The ford across the river at Corbridge was replaced by a bridge in 1236 (Craster 1914, 64, pl. II); this was close to the position of the seventeenth-century bridge shown on fig. 4. The area of the former Roman settlement was cultivated in the medieval period, if not before, to judge by a plan of Corchester Fields in 1776 (fig. 5) which shows a medieval field system surviving in common meadows and narrow strip cultivation. This would explain why the medieval road only followed the Roman Stanegate to the west of the Red House Burn, and not along its line straight through the ruins of the Roman town; instead

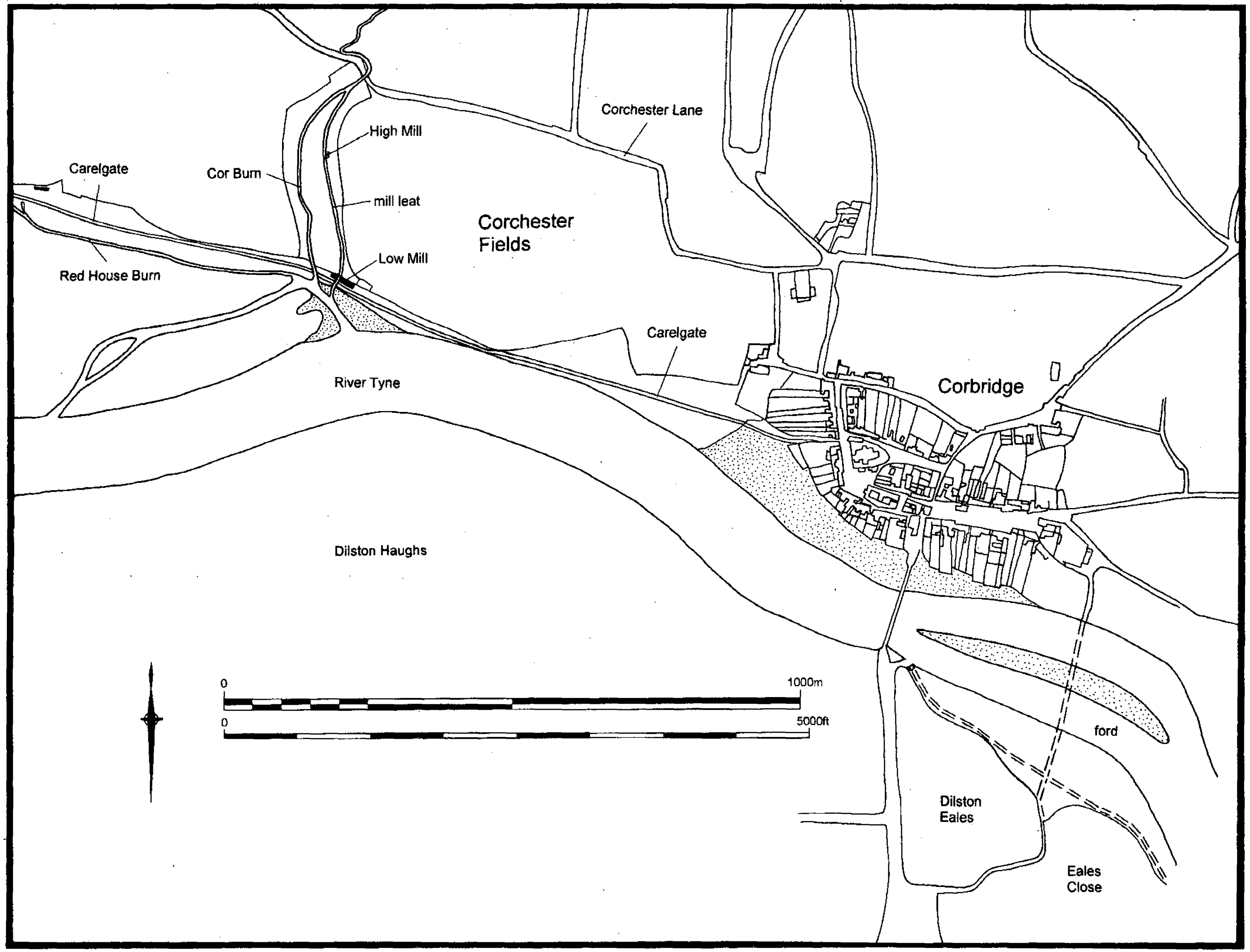


Fig. 4 Corbridge and environs in 1778, redrawing with additional labels of a map by John Fryer (original in Northumberland Record Office, NRO ZCL/C/1).

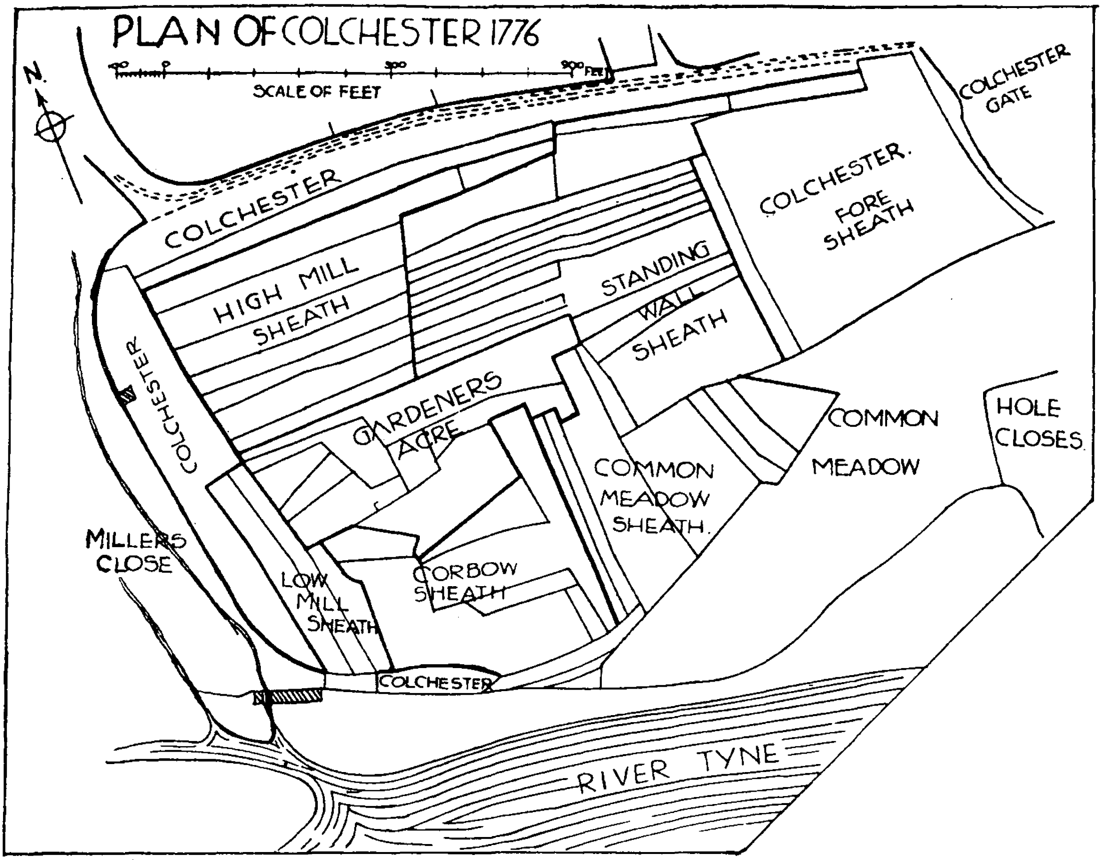


Fig. 5 Plan showing a medieval field system surviving in Corchester Fields in 1776 (from Craster 1914, following p. 136).

it swung along the Carelgate section along the river bank to avoid the field system.

A mill is recorded at Corbridge in 1175, when money was spent on its repair after it had been burnt during an invasion by the Scots (Craster 1914, 50). There is no evidence however for its location. By 1500 there were two corn-mills at Corbridge (Craster 1914, 117–8), and it is tempting to equate them with the two mills on the plan of 1776 (fig. 5). This shows an area called 'Millers Close', and two small buildings, the nearby field names indicating that these were the Low Mill and the High Mill.

The broad flood plain of Dilston Haughs was probably a marsh from early times until the medieval period. The changing courses of many palaeochannels can be seen on air photographs (fig. 3), and the local historian Robert Forster cited the frequent use of the name 'Eales' in this area to indicate the former presence of islands (Forster 1881, 4 fn). Two fields with the name 'Eales' are shown on Fryer's map of 1778 (fig. 4), their irregular boundaries appear to represent streams left when the surrounding areas of marsh had dried up, allowing the former islands to be enclosed as fields. A map in the *Northumberland County History* (Craster 1914, facing p. 136) is annotated to show that Eales Close was enclosed in 1304; presumably before that date it was an island in the marsh.

There is evidence for great changes in river regime in the post-medieval period. Five maps dating from 1749 to 1820 all show islands in the river, beside both the river crossing at Corbridge village and the confluence with the Cor Burn and Red House Burn. One of the maps is reproduced as fig. 4; the others are listed elsewhere (Snape 1997, 47). In the late eighteenth and early nineteenth centuries there were several floods along the Tyne. One in 1771 caused extensive damage, and there was a further significant flood in 1782 (Rennison 2001); these were followed by a series of floods in 1815, 1824 and 1829, of which the highest was in 1815 (Forster 1881, 45–7). In 1881 the existing bridge in Corbridge village was widened because of flood damage (Forster 1881, 52–3). The tributaries of the Tyne were also active during this time. The course of the Cor Burn for example altered in the period between the 1820s–30s and *c.*1879, and the slope of the bank changed; the changes in course revealed many human burials to the west of the burn, presumably from a Roman cemetery (Forster 1881, 8 fn). Similarly in 1825 repairs were carried out on the south bank of the river to prevent land being washed away near the junction of the Devil's Water and the river (Forster 1881, 14 fn).

Presumably these floods caused such scouring that the islands and gravel bars were swept away, as no islands appear on the first edition of the Ordnance Survey map of 1865.

The flood plain of Dilston Haughs is thus likely to have silted up in comparatively recent times, obscuring the line of Dere Street. The work of Dr Passmore (see p. 70) has shown that the deep silt layers on both the north and south banks of the river in the vicinity of the watermill were deposited in the last two centuries.

HISTORY OF PREVIOUS RESEARCH AND SURVEY

The remains of the watermill have long been known. The first study took place in the early years of the twentieth century, during a large-scale survey of the Roman remains at Corbridge (Woolley 1907, 180; Forster 1908, 216). The remains were then described as consisting of a stone platform 37 feet (11.28m) in length, with four horizontal massive timbers, one at either end and two more running parallel to them at approximately equal intervals through the centre. These can presumably be identified with Timbers 1–2, 3, 4 and 5 on fig. 8, the first two timbers having been misidentified as a single beam. There was a cross tie between the first and second timbers at the west (see Timber 6 on fig. 8). The total width of the stonework was given as 10 feet (3.05m). The platform was interpreted as a medieval quay or a jetty for a medieval ford.

The structure was later surveyed and a sketch plan produced by J. P. Gillam in 1949 (redrawn here as fig. 6). The overall dimensions were recorded as identical to those noted by Forster, but the western end was seen to comprise not one, but two closely abutting timbers. Part of the northern end of Timber 2 is left unrecorded on the sketch plan; it is likely to have been obscured by the cobbles, and silt which are constantly moved by the current, causing different parts of the structure to be covered or uncovered at different times. The cross tie (Timber 6) seen in 1908 is shown on fig. 6, where it appears to sit in a slot in Timber 2. This same cross tie was still in position when the western end of the remains were photographed in 1969 by J. E. Jackson (fig. 7). The position of Timbers 3 and 4 on the Gillam plan does not quite correspond with the positions found in 1984 and 1995. It is probable that in drawing up the plan of 1949, the positions of the outermost timbers were surveyed in, but Timbers 3 and 4 were sketched in by interpreting literally Forster's observation that these timbers ran 'at approximately equal intervals through the centre'. The intervals are not in fact equal, as has already been noted (Bidwell and Holbrook 1989, 106).

The structure appeared to have suffered considerable damage by the time it was surveyed again in 1984 (Bidwell and Holbrook 1984,106–7). The cross tie was missing, together with some of the stone blocks to the east, and the most easterly of the five large timbers (number 5). Further damage occurred

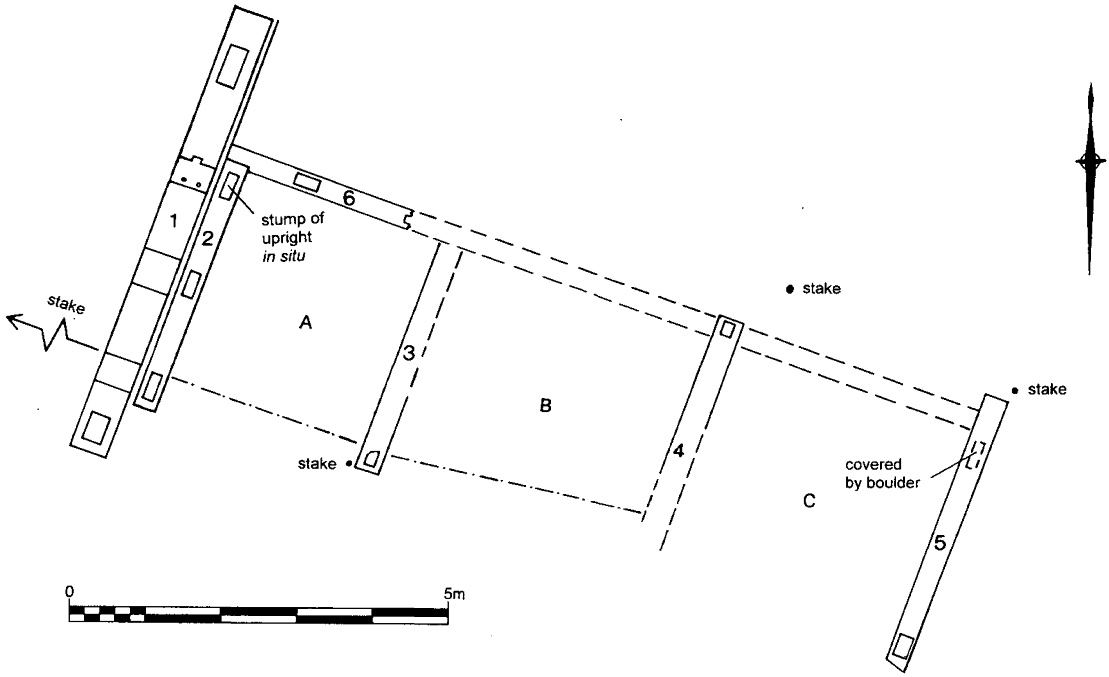


Fig. 6 Plan showing the results of a survey of the watermill remains in 1949 by J. P. Gillam. Redrawn at scale 1:100.

later in that year, when another timber (4 on fig. 8) was dislodged during a storm. Mr R. Selkirk recovered this timber (recorded in an annotation on a sketch plan in the archive at Corbridge Museum), and part of it was later given to the Department of Archaeology of the University of Newcastle upon Tyne, who kindly made it available to Tyne and Wear Museums, where it is now stored.

In May 1991 samples cut from the two most westerly timbers were submitted for radiocarbon dating (Anderson 1992, 40–1). The results were as follows (Table 1)

Unfortunately there is no record of which sample came from which timber. Nevertheless this analysis provided the crucial important information that the structure, whatever its function, was of pre-Norman date.

Further research was carried out in 1995 by P. T. Bidwell, who suggested that the structure could be the remains of the basement of an Anglo-Saxon watermill, similar to an example found at Tamworth, Staffordshire (Rahtz and Meeson 1992). Following a site visit made by the author in May 1995, a project design for further study was drawn up (Bidwell and Snape 1995) and an evaluation was carried out in September of that year, taking advantage of the exceptional drought conditions which meant that the water level remained unusually low into the early autumn.

THE 1995 EVALUATION

Methods

The north and south banks of the river were surveyed for a distance of 250m, and a field plan drawn at a scale of 1:500. Features at the northern extent of the survey included the footpath with follows the course of the medieval Carelgate, the course of the Cor Burn and its

Fig. 7 Photograph by J. E. Jackson showing the remains of the watermill in 1969. Viewed from the south.

Table 1 Radiocarbon dates for two timbers from the Corbridge structure.

Laboratory number	Sample number	*Material*	Radiocarbon age (BP)	Calibrated date range (68% confidence)	Calibrated date range (95% confidence)
Beta-37206	1	Wood	1190 ± 70	cal AD 720–960	cal AD 660–1000
Beta-44425	2	Wood	1040 ± 60	cal AD 900–1030	cal AD 880–1160

[**Note:** Peter Marshall of English Heritage provided the following information. The results are conventional ages (Stuiver and Polach 1977), and are quoted in accordance with the international standard known as the Trondheim convention (Stuiver and Kra 1986). The calibrated date ranges for the samples have been calculated using the maximum intercept method of Stuiver and Reimer (1986), and are quoted in the form recommended by Mook (1986) with end points rounded outwards to 10 years. The results have been calibrated with data from Stuiver *et al.* (1998) using Oxcal (v3.5) (Bronk Ramsey 1995; 1998)].

junction with the Red House Burn, and the edges of the submerged spread of stones on which the remains of the pre-Conquest structure rest (fig. 2). On the south bank the position of the southern abutment of the Roman bridge was plotted, together with the 1995 excavation trench. The line of the Roman bridge was established by plotting some positions on the remains of piers on the river bed. Contours were not surveyed, apart from recording the

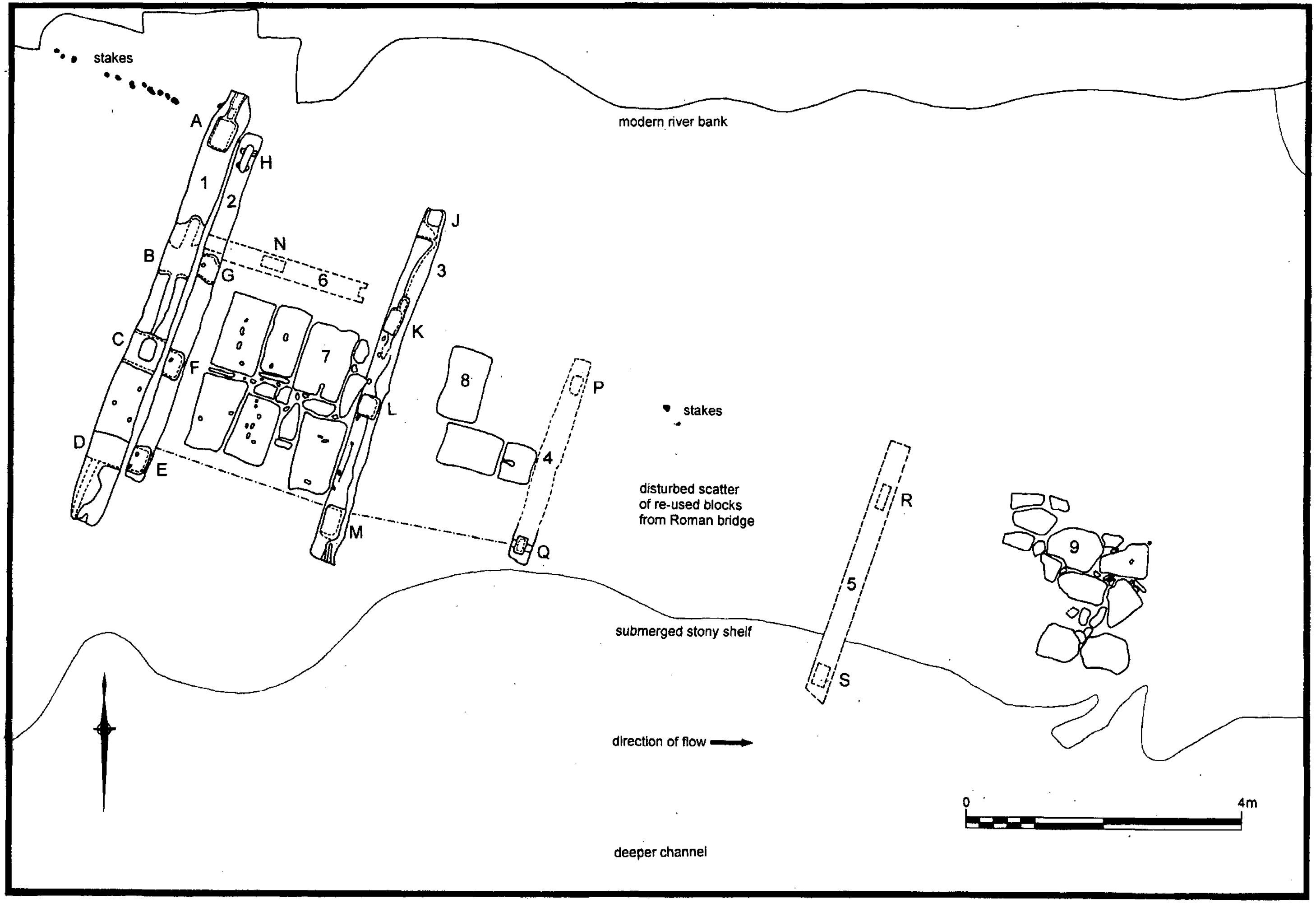


Fig. 8 Plan showing the results of excavation and survey by Tyne and Wear Museums in 1995. Timbers in dashed outline now no longer in situ, their position is established by reference to Gillam's plan (fig. 6). The three surviving areas of paving are marked 7, 8 and 9. During excavation of the line of stakes, the river bank was cut back to the 'stepped' edge seen upper left. A test pit was dug to the west of G on Timber 2 for a distance of 1m between the stone floor and the position originally occupied by Timber 6. Scale 1:100.

manner in which the ground was sharply 'stepped' down to the water's edge.

Before detailed investigation, a catalogue was made of all displaced worked blocks, and their positions were planned; the remains of the timber and stone platform were cleared of surface debris of branches and boulders. Silt and gravel was brushed off the areas of flagging and the timbers, which were then recorded (fig. 8). At this stage in the survey the archaeological features were covered by only a few centimetres of water and details of the mortice holes, peg holes and slots in the timbers were clearly visible when freed of the silt which had clogged them. Many previously unrecorded features were planned.

Excavation was limited to small investigations at the north-west corner of the main structure. An area close to the river bank was surrounded by a temporary dam of sandbags and the bank was cut back in an area 4.8m in length and 1.4m deep, to record a line of stakes running to the north-west (fig. 8). In addition a small test pit was dug to establish the nature of the foundations of the structure and to assess its stability (see caption on fig. 8).

Dr David Passmore of the Department of Geography, University of Newcastle upon Tyne, took samples of alluvium from both banks of the river for the purpose of dating by metal geochemistry to establish the period of its deposition (see below, pp. 65–70). A sample cut from the remains of the timber removed from the river in 1984 (Timber 4 on fig. 8) was sent in 1995 to Dr Jennifer Hillam and Cathy Groves of the Dendrochronology Laboratory of the Archaeological Research School of Sheffield University (see below). During the survey site visits were made by Drs Susan Stallibrass and Jacqueline Huntley of the University of Durham to both the southern abutment of the Roman bridge and the remains of the watermill to assess the potential of the sites for palaeozoological and palaeobotantical analysis (see below).

Work on the survey ended abruptly in October 1995, when heavy rains caused a rapid rise in river levels against which the temporary dam was ineffective. When the water receded, the site was re-instated. Because of concern for erosion, sandbags were used in backfilling the small excavation trench in the river bank and cuttings of willow were planted at the water's edge.

Results of the survey

The timbers of the structure

The three timbers surviving *in situ* were found at the western end of the remains (see 1, 2 and 3 on fig. 8), embedded in the natural gravel and cobbles of the submerged terrace. Timber 1 was the largest, while Timbers 2 and 3 were equal in size; all were rectangular in section. The northern end of Timber 1 had been more roughly dressed than the others for about a third of its length. Figs 4 and 6 show this portion protruding from the water; the maximum depth of this part of Timber 1 was 0.35m. Fig. 9 shows how the central portion of the timber had been cut down; the southern end was also higher, but had been more severely eroded by the river than other parts. Timber 3 had also been eroded, as shown by the irregular grooves drawn on fig. 8.

All the timbers had been cut by slots, dowel holes. and mortice holes for upright timbers, part of one upright still *in situ* in 1949 (see below). A noticeable feature of Timbers 1, 2 and 3 is that all the mortices at the same level were regularly arranged in lines of three (fig. 8, B–G–K, C–F–L and D–E–M) and a pair (H–J), the mortice A being at a higher level. The depths of the mortice holes are shown in Table 2. Details of other features are as follows:

Timber 1: The slot running out of mortice hole A was 0.12m deep. Extending from C to a point north of B was a shallow slot, 90mm deep. To the south of C there were three dowel holes; the most northerly was 30mm deep, the other two still had fragments of wooden pegs *in situ.* At the southern end was a very eroded slot, the surviving depth of which was 20mm. The Gillam plan (fig. 6) shows a square mortice hole here, of which the irregularly-shaped eroded edge recorded on fig. 8 may be the remnant.

Table 2 Depth of timbers and mortice holes

Feature		Depth (m)	Feature	Depth (m)	Feature	Depth (m)	Feature	Depth (m)
Timber 1 *north end*		0.35	Timber 2	0.28	Timber 3	0.29	Timber 4	0.17
A		0.15						
			H	0.10	J	0.10		
B		0.07	G	0.11	L	0.11		
C	max	0.14			F	0.10	K	0.16
	min	0.09						
D		0.22	E	0.12	M	0.17	Q	0.17
Possible mortice at end of timber		0.17						

Timber 2: At the sides of mortice H were shallow slots, presumably for pegs originally fastening an upright timber in position. An annotation on the Gillam plan, drawn in 1949 records the stump of an upright still in position in mortice G (fig. 6); all that remained in 1995 was a dowel hole containing part of a wooden peg. A dowel hole with part of a peg was also found in mortice F, and there were two further examples in E.

Timber 3: Between mortice holes K and L there were three dowel holes, and there were four more between L and M. There were no pegs *in situ*, and the depth of the holes was 40–50mm.

Timber 4: Annotations on the Gillam plan state that this, and Timber 3 were 'much eroded'. The southern end of this beam was only 0.17m deep, and mortice Q was cut through the full depth. At either side were slots, 10–20mm in depth.

Timber 5: The only information is that shown on the Gillam plan (fig. 6).

Timber 6: This is shown on the photograph taken by J. E. Jackson in 1969 (fig. 7), when the beam appeared to have suffered damage since it had been recorded in 1949 (fig. 6). On the photograph part of this timber stands higher than the flagged surface beside it. There is no clear indication of how it was joined to other timbers, but the way it is drawn on the Gillam plan suggests that a slot cut in its base enabled it to lap over Timber 2.

Timber from Corbridge Museum: In the museum collection there is the end of a timber beam (acc. no 75.4648) labelled 'from the structure on the north bank of the Tyne, near the Roman bridge'. The end of the beam is cut into a tenon, through which are two peg holes (fig. 10b). Although the upper end of the beam is very eroded, it is clear the original cross section was 0.25m by 0.19m. The tenon measures 0.25m by 0.08m, and the two oval peg holes are each 30mm by 40mm. The cut for the tenon had been made diagonally across the beam, so that one side of the tenon was 0.12m deep, the other side 0.16m. The beam therefore must have formed a diagonal support of a structure when in use.

The stone surfaces

Between Timbers 2 and 3 was a surface formed by six large dressed rectangular sandstone blocks (see 7 on fig. 8). A small test pit cut between Timber 2 and the north-western block showed that the block was 0.27m in depth, and was simply lying on the natural river cobbles and gravel. It is evident that the blocks are derived from the Roman bridge, because of their dimensions and the presence of lewis holes, crowbar slots and a clamp hole (Bidwell and Holbrook 1989, 106). The spaces between the blocks were filled with small boulders and cobbles. The resulting surface was level and had been worn smooth.

Fig. 9 The watermill during survey by Tyne and Wear Museums in 1995. Viewed from the west. At centre left, both ends of Timber 1 protrude from the water. In the centre the wheelhouse floor is overlain by a large boulder. The displaced blocks from the outfall are at centre right.

One of the smaller stones at the south-eastern side overlay part of Timber 3, while the south-western side conforms with the edge seen by Gillam. The photograph taken in 1969 (fig. 7) shows that the space between the surviving blocks and Timber 2 had originally been filled by two blocks of the same length as those still *in situ*, but half the width.

Between Timbers 3 and 4 were the remains of a similar surface (8 on fig. 8), consisting of three more re-used blocks from the Roman bridge. The outer edge of the most northerly block coincides with a line drawn between the mortice holes K and P in Timbers 3 and 4. In 1949 this stone surface extended further to the south-east; the edge seen by Gillam formed a line between mortice holes M and Q on Timbers 3 and 4.

The Tyne and Wear Museums' survey identified another stone surface not recorded in previous accounts, lying near the south-eastern end of the submerged terrace (9 on fig. 8). It consisted of irregularly-shaped flagstones set into the river cobbles and included one fragment of re-used Roman stone which had a crowbar slot or eroded lewis hole. This surface was more smoothed by erosion than surfaces 7 and 8. On the Gillam plan (fig. 6) nothing is drawn on this area, but there is the following annotation: 'This area covered by small boulders, but these finish sharply in a curved line that appears to be a part of a masonry structure'. No evidence of this 'curved line' survived in 1995.

All three stone surfaces were remarkably level. Surface 7 was at an average height of 23.39m OD, while surfaces 8 and 9 were both

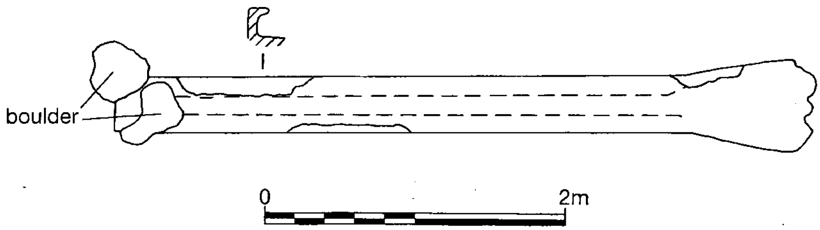


Fig. 10a Sketch of the worked timber seen on the river bed in 1995. Scale 1:50.

at 23.37m OD. The upper edges of the timbers were slightly uneven, but roughly on the same level as the stones (figs 7 and 9), apart from the higher ends already noted on Timber 1.

Timber stakes

In 1949 the Gillam survey located the remains of timber stakes set into the river bed. Four of these were recorded on plan, close to Timbers 3, 4 and 5 (fig. 6); a fifth was indicated by an arrow running north-west (upstream) from near the southern end of Timber 1, with the annotation 'some feet in this direction is another stake, but the distance was not measured'.

A careful search was made for the other stakes recorded by Gillam, but these were no longer *in situ*. It is apparent that river erosion has caused these features to be washed away, but other features have been uncovered, as other stakes were found which were not visible in 1949.

Two new stakes were found between the positions of Timbers 4 and 5 (fig. 8). In addition, a line of stakes just visible at the north-west corner of the site were clearly important because of their relationship with the large timbers. One stake lay in between Timbers 1 and 2, and the stump of another lay partially under the end of Timber 1, suggesting this beam was added in a later phase. The small excavation to cut back the river bank revealed a line of eleven more stakes beyond Timber 1, running north-west (fig. 8). The tops had been eroded, and the average surviving length was 0.1m. They were not set vertically, but pitched at differing angles, suggesting they were the uprights around which wattles had been woven.

Displaced dressed blocks

A total of 39 displaced blocks of worked sandstone were recorded. They extended from the outer edges of surface 7 to a point just east of surface 9, with the greatest concentration lying between the positions of Timbers 4 and 5. A plan of their position and a catalogue listing their dimensions and details such as tool marks and lewis holes is deposited in the site archive. Twenty two of these can be identified as coming from the Roman bridge, of which twenty one had been split in half lengthways to form slabs of thickness varying between 0.10m and 0.18m. One stone (No. S39 in the archive) was 0.24m thick and had long grooves gouged down its sides, suggesting an attempt to split it.

A possible leat

A search was made of the north-western part of the submerged terrace for any traces of the type of leat that would have been used to channel water into a mill. On the terrace, at a distance of 7.5–12m from the main structure, was a group of five large irregularly-shaped sandstone blocks (fig. 2). These were notable amongst the general concentration of boulders and cobbles, because they were much larger (an average size of 0.90m by 0.80m by 0.35m), and also because the sides of some of them appeared to have been roughly worked. Whilst it is possible that these were simply randomly deposited by the river, the possibility should be borne in mind that these particularly large blocks could originally have formed the sides of a leat, which would have collapsed when the ground level was drastically reduced by river erosion. Figs 13a and 13b show how these blocks might have

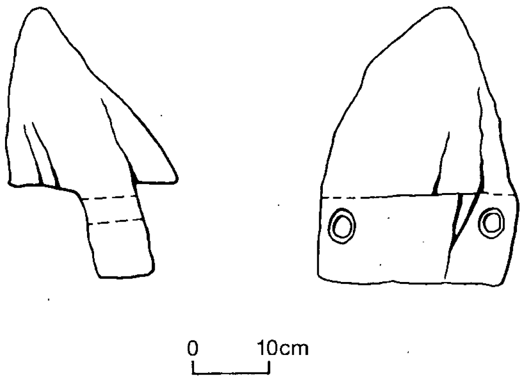


Fig. 10b Timber found near the watermill, now in Corbridge Museum (Acc. no. 75. 4648), part of a diagonal strut. Scale 1:10.

formed the sides of a channel or leat *c.* 1m in width.

Worked timber (or timbers) submerged in the river

During this 1995 survey, a worked timber was observed lying on the river bed *c.*15m to the south-east of the remains of the main structure (fig. 2). It resembled a form of water chute or 'penstock' known from mills of early medieval date in Ireland (see below). One end of it was splayed and appeared to be flattened; the remainder was straight-sided and had been hollowed out to form a trough (fig. 10a). Although damaged, parts of the side walls of the trough survived; these had been undercut to form an incurving rim. The timber lay with the splayed end on the edge of the terrace of boulders, submerged in *c.* 1m of water, the narrow end went down into very deep water. Without diving equipment, it was only possible to sketch the timber and to take a few measurements. The splayed end was 0.60m wide, narrowing to 0.38m. The open central groove was 0.27m at the splayed end, narrowing to 0.15m. It was impossible to measure the depth of the timber. The end which lay in deeper water was embedded in the river cobbles and large boulders lay on top of it. The total measurable length was 4.60m.

In 1996 the author made another site visit with two divers, John Buglass, North-East Training Co-ordinator of the Nautical Archaeology Society and Peter Pritchard, of Pritchard Diving Services, who were able to dive in the area where the timber had been seen in 1995. They located a timber of the same general description, and by diving into deeper water downstream were able to measure that the total length was 10.30m (this is the length which is shown on fig. 2). It may be that this was the same timber recorded the previous year, and that the action of the river had moved many of the stones covering it, enabling a greater length to be seen. Alternatively, it is possible that there are two different worked timbers, one 4.6m in length, the other 10.30m. The divers also observed large blocks of dressed stone lying nearby.

The interpretation of this timber, or timbers, is not straightforward, as discussed below.

Environmental analysis

(a) Analysis of alluvium

See report by Dr David Passmore below, pp. 65–70.

(b) Dendrochronology

Although it was possible to measure 155 rings on the sample of Timber 4 which was sent for analysis to Sheffield University, the ring pattern unfortunately showed no similarity to any known reference curves (J. Hillam, record in site archive). Because more dendrochronological work had been carried out in the northern region since 1995, the data was re-analysed by C. Groves early in 2002 (details in site archive). Timber 4 has now been compared to all currently available chronologies (published and unpublished) for the last two millenia from Britain and elsewhere in Europe, but no consistent results have been obtained. It therefore remains undated, but the data will remain in the database and will be periodically reanalysed.

(c) Assessments of palaeobotanical and palaeozoological potential

Because a sudden rise in river level caused flooding of the banks, it was not possible to take samples. However, attention was drawn to the potential significance of the sealed mill pools and leats for the preservation of charred or waterlogged plant remains throwing light on crops and local vegetation (Huntley 1996, report deposited in site archive) and the potential for well-preserved animal bone in rubbish deposited in these features (Stallibrass 1996, report deposited in site archive).

HORIZONTAL-WHEELED WATER MILLS

Description

This type of watermill has a wide distribution throughout the world. In Europe there are two main groups, one in the Mediterranean and the other in Scandinavia, Ireland and the north and west of Britain. They are also found in Asia, South Africa and the Americas, and are still in use in many parts of the world today, although vertical-wheeled mills have been the most commonly-used type in recent times. Many early examples of horizontal-wheeled mills are known from Ireland, dating from the second half of the sixth century AD to the tenth (Rynne 1992). In England the best-preserved example of a horizontal-wheeled mill of comparable date to the Corbridge remains is the Anglo-Saxon watermill at Tamworth in Staffordshire, dated to the middle of the ninth century (Rahtz and Meeson 1992). The history and technology of the horizontal-wheeled mill is described in the two reports mentioned above, and in other publications (Rahtz 1981, Hutt 2001, and see references given in these two publications), so only a brief description is given here.

Fig. 11 shows a schematic representation of a horizontal-wheeled mill, based on the Tamworth mill and other examples; and illustrations of the Tamworth mill are reproduced as figs 12a and 12b. Water from a leat or millpool was directed towards a horizontally-set wheel with wooden paddles. To supply sufficient power, it was necessary to provide a 'head' of water between the source and the wheel. This was done by housing the wheel in a basement. The water was carried in a 'driving chute', or 'penstock'. Unfortunately the penstock did not survive at Tamworth, but examples from other sites show these to be wooden troughs, boxes or pipes, the interior tapering to a small hole at the end to produce a concentrated jet of water at high velocity (Rynne 1992).

The 'wheel-assembly' consisted of wheel paddles, fixed to a hub, and a shaft which was connected to the upper of two millstones, located in the ground-floor wheelhouse. No gearing mechanism was used in these mills: the jet of water from the driving chute caused the rotation of the whole wheel-assembly, including the shaft. This in turn rotated the upper millstone, while the lower remained stationary. Grain was fed from a hopper into the central hole in the upper stone.

The friction between the millstones could be controlled by varying the gap between them. This was done by raising or lowering the whole wheel-assembly, the shaft and the upper millstone. The mechanism is illustrated in fig. 11. A flexible plank, the 'sole-tree' was attached to the side of the wheelhouse; in the plank was set a bearing supporting the wheel-assembly. The sole-tree was raised or lowered by means of the 'lightening-tree', which was itself controlled by a wedge or lever, the 'sword', located in the millhouse above.

There was also a controlling mechanism which could halt the working of the mill by lowering the level of the water in the millpool. This was done by means of a second chute. Opening a sluice allowed water to flow through this 'by-pass chute', into the mill at one side of the wheel. Eventually the millpool was emptied to a level where water no longer flowed through the driving chute to turn the wheel. At Tamworth a support beam at the edge of the millpool in which were cut emplacements to carry the rear of the driving chute and the by-pass chute (figs 12a and 12b, and see Rahtz and Meeson 1992, pls III–IV). This is termed the 'rear support beam' by Rynne (1992, 57, 63),

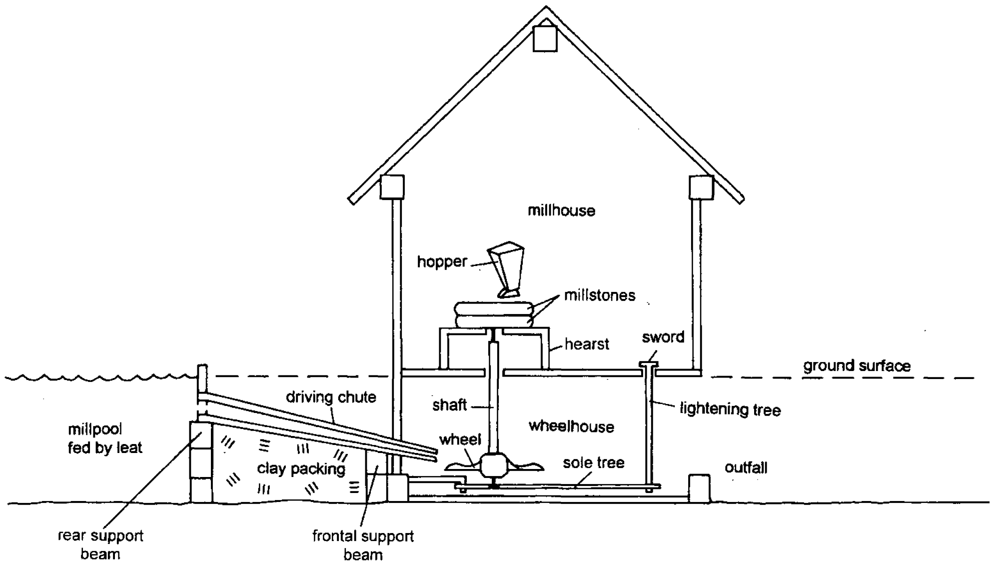


Fig. 11 Schematic representation of a horizontal-wheeled mill (after Rahtz and Meeson 1992, fig. 94).

who cites an example from Cloontycarthy, Co. Cork, dated to the ninth century. Also at Tamworth there was a similar support beam for the front of both chutes at the point where they entered the wheelhouse (figs 12a and 12b). 'Frontal support beams' are known from several Irish sites dating to the ninth century (*ibid.*, 63).

The spent water which had driven the wheel, and the water introduced through the by-pass chute, left though an opening in the wheelhouse wall into an outfall or tailrace. This was an extension of the construction cut in which the wheelhouse was built. At Tamworth the outfall was lined with planks and carried the water back into the river from which it had originally been derived.

Comparison between horizontal-wheeled mills and undershot vertical-wheeled mills

The undershot vertical-wheeled mill has already been extensively studied and described (Rynne 1989); all that is necessary here is a brief description of some important features. The vertical wheel was positioned above an open wooden trough, the water flowing through a head-race channel to strike the paddles of the vertical wheel at the lowest part of its circumference, and flowing out beneath the wheel to an outfall channel. The entry and exit of the water was *at floor level*, in contrast to the operation of the horizontal-wheeled mill, in which a concentrated jet of water was directed *from above* onto a wheel situated in a basement. This operational difference leaves clear differences in the archaeological record.

The obvious difference observed in the structural remains of the two types is the presence of a basement floor in the horizontal-wheeled mill. Another diagnostic feature is the penstock. This term has been used to describe the trough beneath the vertical undershot wheel (Rynne 1989, 24–6), as well as the driving chute delivering water to the horizontal wheel. However, as described above, the two differ in function and design. The former was an open trough with open ends of equal width, whereas the diagnostic feature of the penstock of Irish horizontal-wheeled mills is a square fore end with a small bored hole (Dr Colin Rynne, pers.

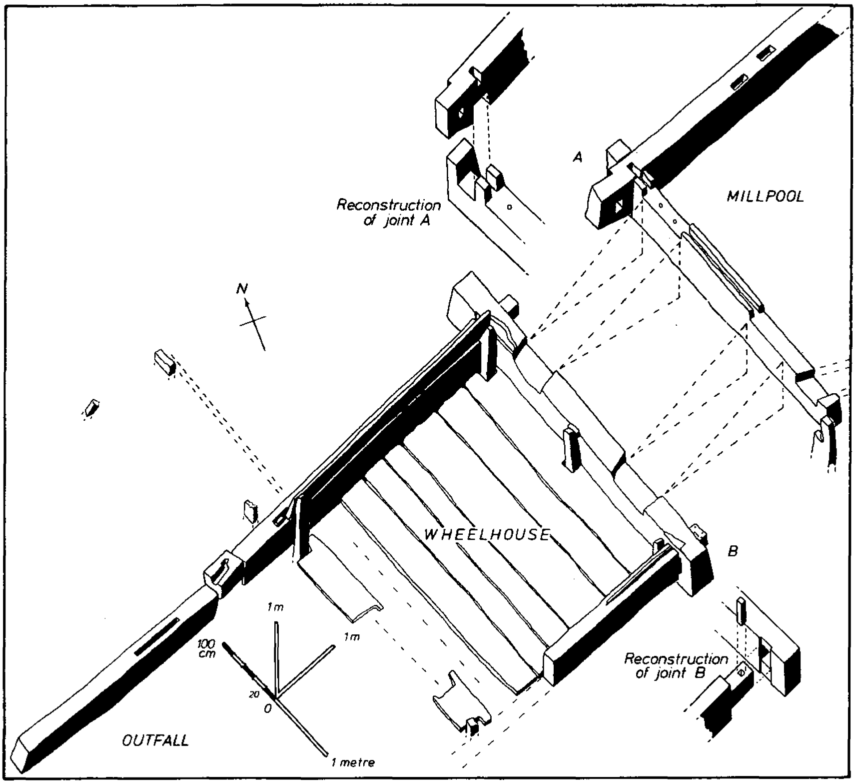


Fig. 12a Axonometric restoration drawing of the horizontal-wheeled mill at Tamworth. From Rahtz and Meeson 1992, fig. 82, reduced to scale 1:100 (with annotations by Tyne and Wear Museums).

comm.). Examples are known from Mashanaglass, Cloontycarthy, Dawstown and Kilphilibeen in Co. Cork (Rynne 1992, figs 1 and 2), and from other sites in Co. Cork, Co. Limerick, Co. Fermanagh and Kilkenny (*ibid.*, 57–63). The photograph of the recently discovered horizontal-wheeled mill at Ebbsfleet, Kent (Anon. 2003) shows two closed troughs with squared ends.

IDENTIFICATION OF THE STRUCTURE AT CORBRIDGE AS A HORIZONTAL-WHEELED MILL

Structural evidence

The interpretation of the remains at Corbridge as a mill of this type rests on two pieces of evidence. The depth of the remains – at the present river level and presumably well below Anglo-Saxon ground surface – identifies them as a basement. Secondly, the main part of the structure at Corbridge closely resembles the remains of the wheelhouse of the Anglo-Saxon mill at Tamworth, Staffordshire. This is seen by comparing the stone floor (7) and its surrounding timbers on fig. 8 with the plank floor and Timbers T, U, V and W on fig. 12b.

Clearly there are some differences between the two structures; there is no surviving millpool at Corbridge, but there are other timbers and paved surfaces not present at Tamworth. Some clarification comes from considering the direction of flow of water. The Tamworth mill was fed from the by water coming from the north-east, but Professor Philip

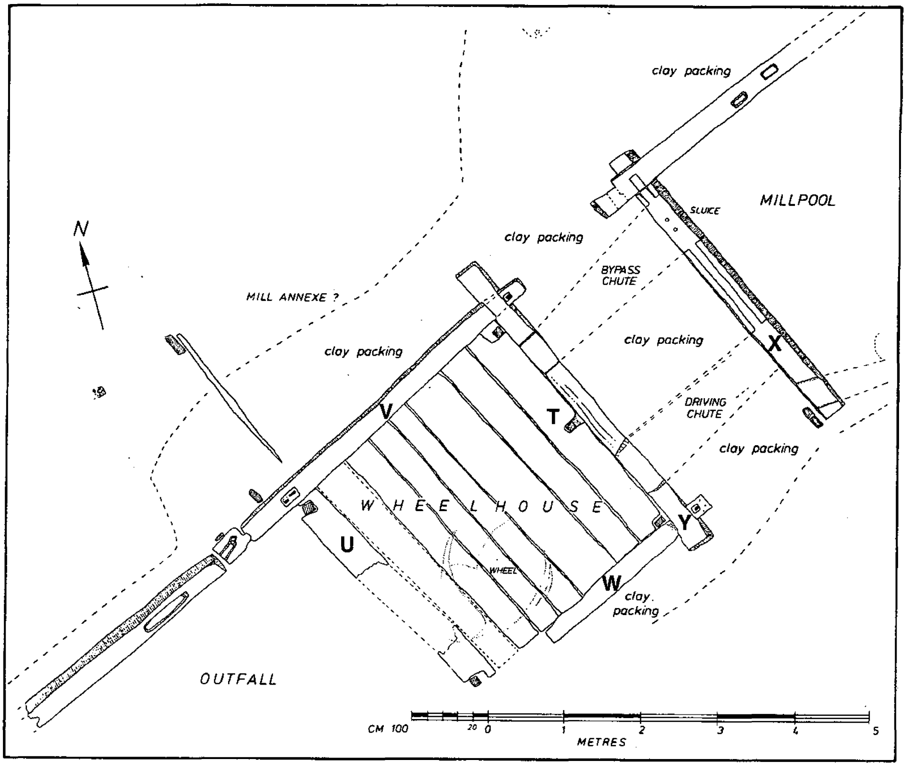


Fig. 12b Plan of the horizontal-wheeled mill at Tamworth. From Rahtz and Meeson 1992, fig. 79, reduced to scale 1:100.

Rahtz has suggested (*in litt*) that the Corbridge structure is consistent with a mill fed from the west or north-west by the Cor Burn itself, or a leat from it. The outfall would then be to the south-east, Timbers 4 and 5 carrying the supports for a timber tailrace. Comparison of figs 8 and 12b then shows the Corbridge structure as a 'mirror image' of the Tamworth mill.

Once allowing for this difference in orientation, it is possible to make a more detailed comparison. The part of Timber 2 at Corbridge which has the three mortice holes at E, F and G then corresponds to Tamworth Timber T with its three uprights. Corbridge Timber 3 with mortices K, L and M corresponds to Tamworth Timber U (although the latter's central upright does not survive). Similarly Timber 6 and a missing timber originally between E and M correspond to Timbers W and V at Tamworth.

It is argued below that Timber 1 at Corbridge is a re-used beam, not in its original position, and that no equivalent of Tamworth Timber Y survives at Corbridge. The surviving timber at the northern edge of the outfall at Tamworth occupies a position equivalent to the line between M and Q on fig. 8, and the interpretation of this part of the Corbridge site as a mill outfall is also discussed below.

The worked timber or timbers on the river bed at Corbridge could have provided crucial evidence in support of the presence of a mill, if it had been possible to make a detailed record. The timber sketched in fig. 10a bears a good general resemblance to the penstocks from horizontal-wheeled mills of the eighth, ninth or early tenth centuries in Co. Cork (Rynne 1992, 57–8, fig. 2) and Knocknagranshy, Co. Limerick (Rahtz and Meeson 1992, fig. 102; Lucas

1969, figs 2, 3). The visible extent of the Corbridge timber, at 4.6m, is only a little greater than the Irish examples, which were 3–4m in length. Unfortunately since the end of the Corbridge timber was obscured by boulders, there is no means of confirming the presence or absence of the square end and small bored hole diagnostic of horizontal-wheeled mills. It could therefore have been a simple open trough like the penstock of an undershot vertical-wheeled mill at Morett, Co. Laois (Rynne 1989, fig. 2A), a site dated by dendrochronology to AD 770 (Baillie 1982, 182). It is possible that it represents part of an as yet undiscovered vertical-wheeled mill somewhere in the vicinity of the proposed horizontal-wheeled structure. It will be seen from the discussion below (pp. 63–65) that there are parallels for both types of mill being found at the same site.

The observation of a timber 10.30m in length with a splayed end (above p. 53) adds a further complication. Whether one or two timbers are represented, and derived from what type of mill, are questions which can only be resolved by further investigation. For the present, the suggested reconstruction presented below follows the hypothesis that there were two timbers on the river bed, representing penstocks belonging to a horizontal-wheeled mill.

Phases of use

The original structure was considerable modified or repaired; this is shown by Timber 1, and there are two pieces of evidence. It has been noted above that Timber 1 was probably not primary, because, unlike Timber 2, it overlies the stump of one of the stakes. Secondly, it can be identified as a beam originally in use as part of the millpool.

As re-used material, Timber 1 would be likely to show the complex carpentry of more than one phase. It is notable that it differs from the other beams in having been cut away down the central sector (fig. 9). If this central cut, and the three mortice holes (B, C and D on fig. 8) in it, belong to a secondary phase, then the remaining slots and dowel holes bear a remarkable resemblance to the features in the poolside support beam still *in situ* at Tamworth (Timber X on fig. 12b). The centre of this beam had a slot, 0.10m deep to take a plank wall. A square cut at one side of the slot was interpreted as an emplacement for the driving chute; two dowel holes in the base of the emplacement may have belonged to a sluice gate (Rahtz and Meeson 1992, 146). At the other side of the slot was the cut for the by-pass chute emplacement. Each end of the beam had joints to form the junctions with timbers forming other sides of the millpool.

Timber 1 at Corbridge is wider and longer, but otherwise of exactly the same form as the Tamworth beam, but the central portion has been levelled down and recut with other features. The shallow groove, 90mm deep, running between B and C on fig. 8, can therefore be interpreted as the surviving base of a slot originally deep enough to carry a plank wall. The three dowel holes at the end of the slot presumably indicate the position of the emplacement for the driving chute, as at Tamworth.

The removal of Timber 1 from the millpool at Corbridge, and its re-use as part of the wheelhouse therefore indicates the scale of rebuilding or repair carried out.

The Primary Mill

The wheelhouse

The similarity between the main part of the Corbridge structure and the wheelhouse at Tamworth has already been pointed out. The difference between the materials used for the floor – wooden planks at Tamworth, but massive stone blocks at Corbridge – may simply reflect the availability of local materials. A more significant difference is the way in which Timbers 2 and 3 at Corbridge extend back away from the wheelhouse floor, towards mortice holes H and J. This extension, not found at Tamworth, is discussed below.

The line of stakes running north-west from the end of Timber 2 is in much the same position as the edge of the construction cut for the Tamworth mill (shown as a dashed line on fig. 12b). Presumably at Corbridge the sides of the construction pit were lined with wattle. An annotation on the Gillam plan (fig. 6) suggests a parallel line of stakes also running north-west from the other end of the timber.

The supply of water

As described above, the group of large stones to the north-west of the wheelhouse is the only evidence for a possible leat. There are no surviving traces of a millpool in the 7.5m between these stones and the wheelhouse. However, Timber 1 provides an important piece of evidence to see a millpool in the primary phase, as it is potentially originally a poolside support beam.

Fig. 13a shows a suggested reconstruction of the primary mill, with Timber 1 restored as the chute support beam at the edge of a millpool. Although there is no surviving evidence for its original position, placing it with the north-eastern end beside the known limit of the line of stakes allows sufficient space for a millpool between it and the large stones of the postulated leat, and for a driving chute 4.60m in length, like the timber on the river bed observed in 1995.

On this reconstruction there is a gap of 3.30m between the millpool and Timber 2, the sill beam carrying the uprights for the millhouse wall. Clay packing originally filling this area would have been washed away by the river. Also shown on fig. 13a is the suggested position of a frontal support beam against the wheelhouse; there was a beam in this position at Tamworth (Timber T on fig. 12b). It would have needed to be higher than the top of Timber 2, so that the jet of water from the driving chute could be directed at the wheel.

A reconstruction with Timber 1 and its driving chute in this position gives the probable location of the wheel within the wheelhouse. It is less easy to decide whether there was a by-pass chute and where it might have been. The north-eastern end of Timber 1 is roughly flattened (fig. 9), but there is no clear indication of a cut for the chute emplacement. Possibly this was smoothed out when the beam was re-used, or erosion by the river may have been heavy. Possibly a chute could simply have been held between a central plank wall and the upright set in mortice hole A (fig. 8). If there was indeed a by-pass chute in this position, it could not have fed into the main part of the wheelhouse. Perhaps that is the reason for the extension of the basement beyond the floor of the wheelhouse. Fig. 13a shows a separate compartment between Timber 6 and a presumed external wall between mortice holes H and J. Perhaps the mortice holes in Timber 6 indicate some mechanism for controlling the flow of the by-pass water into the main compartment of the wheelhouse. If so, this is a more complex arrangement than that at Tamworth.

Since none of the remains at Corbridge has survived above the level of the basement floor, there is no evidence about the position of the sole-tree or lightening-tree to raise and lower the wheel-assembly. There is however, much clearer evidence about the outfall from the mill, between the uprights at K, L and M (figs 8 and 13a). Wooden walls could have run between Timber 3 and the uprights set in mortice holes P and Q of Timber 4. The space so enclosed coincides with the extent of the stone surface observed by Gillam, of which three large blocks are still *in situ.* The remainder of the area, where there are no longer any stones *in situ*, measures 4.11 sq. m. However, there are seven large displaced blocks between these two timbers, and three further blocks overlying Timber 4. Their total surface area was calculated to be 3.95 sq. m. Allowing for the fact that spaces between large blocks may have been filled with small cobbles, this is sufficient stone to cover the whole of the base of this part of the outfall. The stones would have prevented scouring by the water leaving the wheelhouse.

It is significant that Gillam also noted that Timbers 3 and 4 were the most heavily eroded of all the beams; presumably this was caused by the flow of spent water through the outfall. It is difficult to explain the line of dowel holes between the uprights at K–L–M on Timber 3. They may simply indicate that a worked timber was re-used.

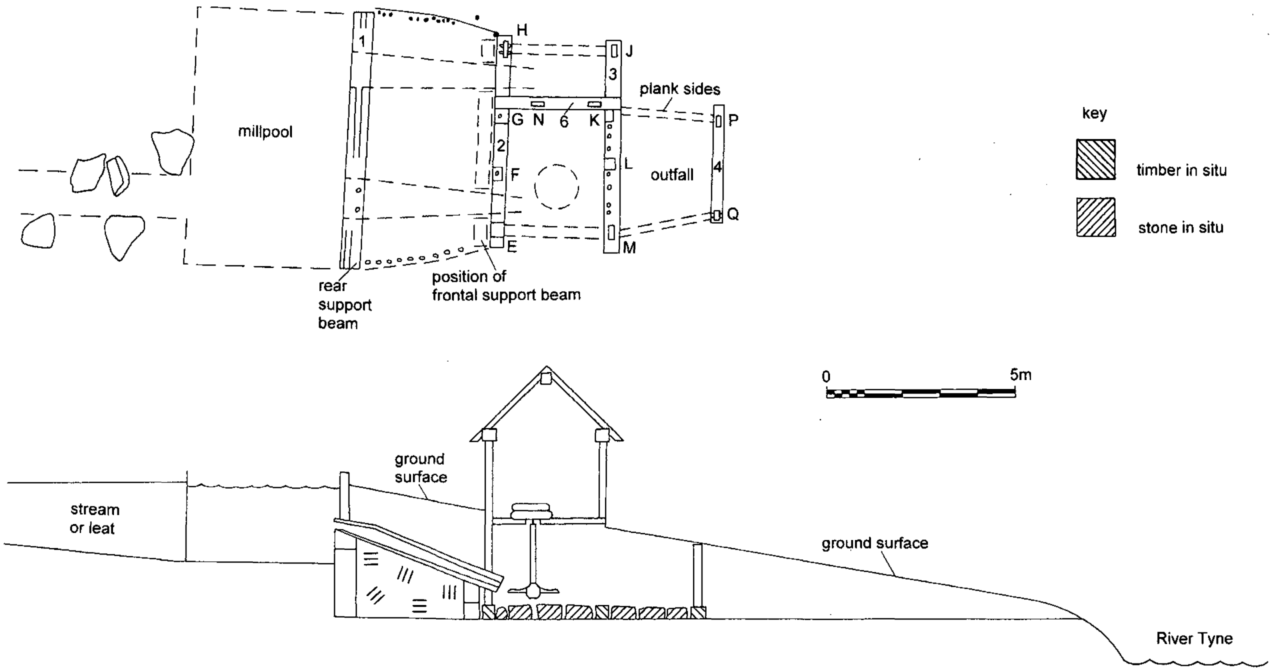


Fig. 13a Suggested reconstruction of the primary watermill at Corbridge. There is insufficient evidence for the position of the sole-tree or the lightening-tree. Scale 1:200.

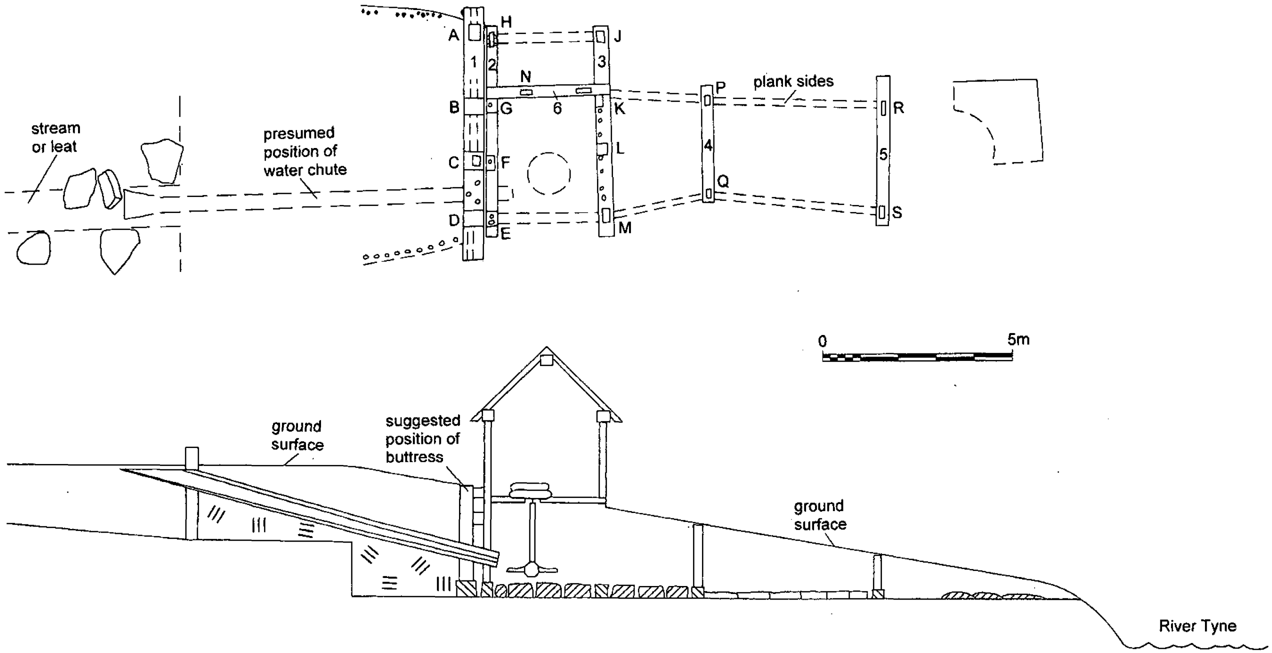


Fig. 13b Suggested reconstruction of the modified watermill at Corbridge. Scale 1:200.

Modifications to the Mill

Fig. 13b is a reconstruction of the probable modifications made to the mill. It is suggested that Timber 1 was moved from the edge of the millpool and moved to its present position abutting Timber 2. The central portion was levelled, removing all but a trace of the plank slot, and three new mortice holes were cut in it (B, C and D). Large uprights set in these mortices would buttress the existing uprights at E, F and G in the wheelhouse wall. This repair could have been made necessary because millpool was damaged or leaking, or because the wheelhouse was in need of support, or both.

There is no evidence to say whether the millpool was replaced. It need not have been; water could have been brought in a trough or pipe from the end of a leat. It may be significant that the distance from the surviving large stones of the supposed leat to the wheelhouse is a little over 10m. Possibly the worked timber 10.30m in length, observed by the divers in 1996, may have been used in this position.

The location of Timber 5 appears to indicate an extension to the outfall. It may be significant that Gillam did not record this beam as being heavily eroded like Timbers 3 and 4, suggesting that it might have been a later addition. Side walls between uprights at P–R and Q–S would channel the spent water slightly more to the south than in the primary arrangement. Evidence that this part of the outfall had a stone floor comes from the displaced worked blocks which were found throughout the area of the mill remains, the greatest concentration being in the area between Timbers 4 and 5. As the dimensions of the blocks had been catalogued, it was possible to calculate the surface area they represented (details in the site archive). This proved to be almost equal to the area of the outfall between Timbers 4 and 5. Though the blocks are no longer *in situ* in the sense of being embedded in the river cobbles, they have not been washed far downstream. Indeed that might seem unlikely, given their size. The river has eddied around the back of the mill, scouring out cobbles and gravel of the river bed to loosen the blocks and leave most of them tilted at an angle.

This suggested reconstruction, with the areas between Timbers 3–4 and 4–5 completely paved with stone blocks would accord with the description given in 1908 (see above) of a masonry platform 11.28m in length with four massive timbers and a cross tie, the only real discrepancy being the need now to recognise that Timbers 1 and 2 were not a single beam.

It is not possible to say whether the patch of paving (9) to the east belonged to the primary mill or the later modifications. It seems likely to have been inserted there to counteract erosion by water from the outfall, and had certainly been worn very smooth. It was here that the survey of 1949 recorded that small boulders 'finish here sharply in a curved line that appears to be part of a masonry structure'. This could have been a wall to channel the outflow water back into the river or a revetment to prevent the river scouring away the ground on which the mill stood. No trace of this line of boulders was seen in the survey of 1995.

THE CORBRIDGE MILL AND IMPLICATIONS OF STATUS

Introduction

It is crucially important to note that dating evidence indicates the mills at Corbridge and Tamworth were broadly contemporary. The radiocarbon dates for two of the timbers from Corbridge mill are cal AD 660–1000 (Beta-37206; 1190 ± 70 BP) and cal AD 880–1160 (Beta-44425; 1040 ± 60 BP). Given that the wood was not identified prior to radiocarbon analysis the possibility exists that it is considerably older than the date of construction of the mill. For example, if the dated material was oak heartwood, then it may be 100 years or more older than the actual construction date of the mill (Peter Marshall, pers. comm.). Thus the dates only provide *a terminus post quem* for construction.

Evidence that the primary mill at Corbridge was extensively repaired or rebuilt, suggests that the two dates obtained could possibly indicate a building constructed in or after the mid-ninth century and modified in or after the end of the tenth century. Tamworth mill was also in use in the mid-ninth century; a timber was dated by dendrochronology to AD 855 ± 9 (Rahtz and Meeson 1992, 158).

Because examples of these structures are so rare at this period, questions have arisen about their status and the status of the sites they served. Tamworth began in the late seventh century as either a palace or a monastery and from the eighth century onwards it became the favoured residence of the Mercian rulers (*ibid.*, 1–5). Rahtz and Meeson highlighted the need for comparative evidence from other mills in order to judge whether the Tamworth mill was a high-status structure belonging to the royal site, or whether it served the town (*ibid.*, 158).

There is a considerable body of evidence which points to the high status of the Corbridge settlement during this period, and therefore the study of Corbridge mill can add significantly to our knowledge.

Watermills in the pre-Norman period

It is notable that there are very few references to mills in pre-Norman charters (Rahtz and Bullough 1977, 18–9). Of this small number, the majority refer to mills on royal residences and estates, or royal grants to churches or laymen, and there is also a marked increase in the number of references to mills in the tenth century (*ibid.*, 26–7). Rahtz and Bullough point out that once the technology of the mill was understood, it was likely to be adopted on royal estates more rapidly than others, because of the need for unrestricted access to watercourses, and because of the materials and labouring skills required. More recently the possible connection between the horizontal-wheeled mill and religious or monastic sites has been discussed (Fowler 2002, 174–8).

Excavations at Old Windsor in Berkshire revealed an important mill complex. In the earliest phase (for which dendrochronolgy has provided *a terminus post quem* in the late seventh century (Fletcher 1981, 151)) there was a large and sophisticated mill with three vertical water-wheels. This was post-dated by a narrow channel which fed a small horizontal-wheeled mill; the channel went out of use in the early eleventh century. Old Windsor features in Domesday Book as an important *vill*, eventually abandoned under Henry I (Anon. 1958).

Excavations at West Cotton, Raunds, Northamptonshire, revealed three phases of watermill serving a late Saxon and Norman manor (Windell *et al.* 1990, 29–32). The late Saxon mill was probably an undershot, vertical-wheeled-mill. The remains of the second mill, belonging to a Saxo-Norman courtyard building, were badly disturbed, but are assumed to have been of the horizontal-wheeled type. In the twelfth-century a stone manor was constructed. Its mill was clearly of the horizontal-wheeled type, but smaller in size than Tamworth mill and simpler.

There may be no great significance in the fact that both horizontal- and vertical-wheeled mills were found Old Windsor and West Cotton; both types were in use in Ireland in the pre-Norman period (Rynne 1989; Baillie 1982, 182). We cannot know the reasons for the use of both types at the same site, nor use it to draw conclusions about the relative status of horizontal-wheeled mills in relation to vertical-wheeled mills.

In general then, the status of mills and the sites they served is far from uniform or certain. Against this background, evidence on the status of Corbridge is particularly significant.

The status of Corbridge at this period

The growth of Anglo-Saxon Corbridge between the fifth and the early eighth centuries has been described (Cramp 1983; Knowles and Forster 1909, 405–8; Forster and Knowles 1910, 272). The strategic position beside Dere Street, guarding the major road crossing of the Tyne, are factors determining the importance of the site by the eighth century (Cramp 1997, 63). Corbridge may have been an administrative centre with its own court of justice and a reeve or sheriff (Craster 1914, 36–40), and also an ecclesiastical centre (*ibid.*, 40–1). It is known there was a monastery there in 786, and a royal presence in Corbridge is shown by the murder of a king there in 796 (*ibid.*, 15–6).

An event showing the importance of Corbridge as a trading centre is the annual fair held at midsummer. Until the early twentieth century this took place at Stagshaw Bank beside Dere Street, a mile to the north of Corbridge and close to the gateway known as Portgate, which carried the road through Hadrian's Wall in the Roman period. Thirteenth-century documents show that the fair was then of considerable importance (Craster 1914, 33). However, it may have originated much earlier. The Anglo-Saxon word *port*, meaning a market, strongly suggests that the name Portgate means either the road to a market town, or the market place itself (*ibid.*, 35).

There is some evidence to suggest that Corbridge may have prospered even during the time of Viking raids on northern England. Ó Cróinín (1995, 250) cites a work by an Irish poet of the mid-ninth century, telling of the colourful adventures of an Irishman named Murchad, captured by Viking raiders and taken to Corbridge, where he was sold as a slave to a nunnery. Even if the character and events are fictitious, apparently a mid-ninth century author outside Northumbria had not only heard of Corbridge, but considered it a likely place in which to set the scene of a trading centre where slaves might be bought and sold.

It is known that Corbridge was the scene of a battle or battles between Vikings from Dublin and a combined army of Scots and Northumbrians in 914 or 918 (Smyth 1975, 93–103; South 2002, 105–7). This fighting may be an indication of the size and wealth of Corbridge. It is significant that the Norse of Ireland frequently attacked important sites on great festival days when large numbers of people could be captured as slaves (Smyth 1979, 130–1). If the great midsummer fair at Corbridge, noted above, was in existence as early as the beginning of the tenth century, Ragnall of Dublin and his followers would have been aware of large numbers of potential victims for the slave trade.

There are finds from Corbridge dating to the Viking Age; two sculptured stones were found on the Roman site (Richardson 1994). The carved figure on one of them closely parallels examples from Lindisfarne, and is therefore dated to the late ninth or early tenth century, although a date in the later tenth century cannot be ruled out.

Finally, the location of the Corbridge watermill at some distance from the settlement need not imply that it belonged to a farmstead or minor site rather than the possible royal *vill* itself. The siting of mills on estate boundaries frequently occurs because the watercourses suitable for turning mills also formed 'natural' boundaries (Rahtz and Bullough 1977, 28–9). The mill at Tamworth lies outside the known circuit of the *burh* fortifications of 918, and the earlier 'royal precinct' (Rahtz and Meeson 1992, 158).

CONCLUSIONS

This survey has succeeded in identifying the remains of a substantial and well-built horizontal-wheeled watermill at Corbridge. Although it was not possible to determine precise dating through dendrochronology, radiocarbon dating of two of the timbers suggests usage from the mid-ninth century until at least the late tenth or early eleventh century, placing the watermill firmly in the Anglo-Saxon period. It is not clear when the mill went out of use. It cannot be identified with the mill which was burnt and repaired in 1175 (Craster 1914, 50); the surviving remains show no sign of burning, and there was no dating evidence to suggest a late twelfth-century rebuild. Possibly therefore, the mill recorded in 1175 was a replacement for the mill described in this report.

The rarity of excavated examples of Anglo-Saxon watermills, the substantial nature of the Corbridge mill and the information known about the Corbridge settlement at this date are of great significance in answering the need for evidence from other mills against which the Tamworth mill can be compared (Rahtz and Meeson 1992, 158). The two mills closely resemble each other in form and dimensions.

The considerable investment of material and labour that went into the construction of the Corbridge mill can be seen from the large blocks of Roman stone which had been split lengthways, as well as the use of massive timbers, showing it to be a structure of high status. It was part of the focus of Christianity in the Tyne Valley in the eighth century, and the evidence suggests it was an economically important site in the ninth and tenth centuries. It not only survived the Viking raids of this period, but the raids themselves may be testimony to its economic prosperity. Throughout this period Dere Street and the river crossing would have ensured Corbridge remained strategically important.

This study has provided a suggested reconstruction of the operation of the mill and modifications to it. However, it should be emphasised that this reconstruction can only represent the best attempt at interpreting a site where much is still undiscovered. In particular, we know nothing of the structures such as pools and leats, remains of which may survive beneath the present alluvial terraces or on the river bed; nor do we know whether or how the mill was connected to a road system. Equally the question of whether the partially visible timber or timbers on the river bed indicate a penstock from the horizontal-wheeled mill, or whether there could also have been an undershot vertical-wheeled mill in the vicinity remains a problem. The discussion of the analogous sites has shown that both types of mill could be found on the same site, either operating contemporaneously, or one type replacing another.

The study has also looked at the ancient landscape setting of the mill. The results of the analysis described in the Appendix, below, suggest it was set in a landscape very different from the present one, of a wider, multi-channel river with bars and islands, and a different floodplain environment. While it is true that some evidence can be extrapolated from a study of antiquarian maps and records, a great deal more remains unknown about the river and its valley in ancient times, which can only be determined through further geochemical and geomorphological analysis. As conditions prevented the recovery of botanical or faunal remains, nothing is known about the land use surrounding the mill or whether there was human occupation in the immediate vicinity. Furthermore, the rarity of this type of monument, which gives the remains at Corbridge their importance, also means that there are few parallels on which to draw.

Many questions remain to be answered about Corbridge and its mill, and explanations sought for the parallels with the site at Tamworth and the sites in Ireland and elsewhere. However, set against a background where nothing is known of the secular aspects of settlement sites in the north-east before the eleventh century, with the exception of Yeavering and other princely sites, the watermill at Corbridge must be seen as an important source of information on this region and for parallels further afield.

APPENDIX: STRATIGRAPHY AND TRACE METAL GEOCHEMISTRY OF HOLOCENE ALLUVIAL DEPOSITS OF THE RIVER TYNE IN THE STUDY AREA

David G. Passmore

Note: this report uses the standard chemical abbreviations Pb (Lead) and Zn (Zinc).

Introduction

Alongside the survey and excavation of the site, geochemical and preliminary geomorphological analyses of fine-grained alluvium in the area were carried out. The report which follows has been condensed from an assessment report (Passmore 1996), which was part of the Corbridge evaluation carried out by the Tyne and Wear Museums Archaeology Department, and which had the following objectives:

1. to determine the age of fine-grained alluvium forming river terraces that (i) overlie the remains of the Roman Bridge abutment on the south bank of the river, and (ii) lie

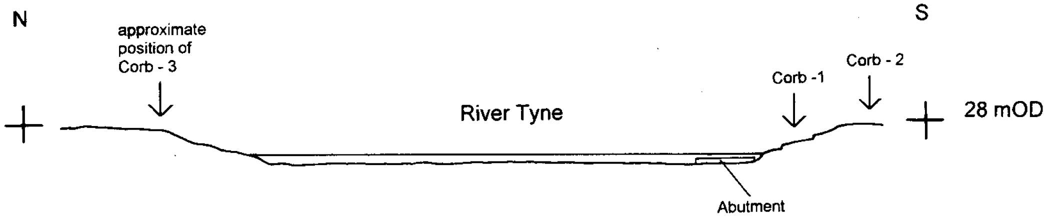


Fig. 14 Cross-profile of the River Tyne at the study site, showing locations of cores Corb-1, Corb-2 and Section Corb-3. Scale 1:1000.

adjacent to the confluence with Cor Burn, in the vicinity of the northern bridge abutment and an Anglo-Saxon watermill on the north bank of the river;

2. on the basis of this investigation, and in the light of previous work in the Tyne basin by the author and co-workers, assess the geomorphic development of the Tyne in this reach during (i) recent historic times, and (ii) during the Roman and Anglo-Saxon period with particular regard to the river environment contemporary with construction of waterfront structures, and
3. to assess the potential for further geoarchaeological evaluation of valley floor archaeology in the locality (this is set out in the site archive). The age of the river terrace is particularly important in attempting to define the contemporary landscape in which the mill was located.

Methodology

Investigations of the dispersal of nineteenth-century and early twentieth-century metal mining waste in the region's rivers have demonstrated the utility of sediment geochemical analysis as a means of dating recent historic alluvial deposits (Macklin and Lewin 1989; Passmore *et al.* 1992; Macklin *et al.* 1992; Passmore and Macklin 1994). These studies have established a methodology that has been followed by this project.

(i) Study sites and field sampling

A total of four alluvial units were investigated:
a) Two adjacent alluvial terraces lying respectively 1.5m (Corb-1) and 3m (Corb-2) above present river bed level on the south bank of the river (figs 2 and 14). Both terraces were investigated using a sand auger which allowed continuous recovery of fine sediment above impenetrable gravels (or masonry). Unit Corb-1 was observed during excavation to directly overlie the southern bridge abutment and comprises finely laminated sands and silts to a depth of 1.2m. Unit Corb-2 comprises similarly bedded fine alluvium to a depth of 3.2m. Both units were sub-sampled at 10cm intervals for laboratory analysis.
b) An alluvial terrace (Corb-3) lying adjacent to the confluence of Cor Burn with the Tyne and at an elevation of *c.* 3.5m above present river level (figs 2 and 14). Fine, poorly-bedded sandy silt comprising the uppermost 0.5m of this terrace was sampled at a section exposed by localised slumping; the section was cleaned and sub-sampled at 10cm intervals for laboratory analysis.
c) An alluvial terrace (DW-1) exposed by bank retreat on the Devil's Water immediately upstream of its confluence with the Tyne (DW-1 not shown on plan, but see fig. 1 for course of Devil's Water), at an elevation *c.* 3.8m above the present tributary channel bed and believed initially to be equivalent to unit Corb-2. This section revealed 3.1m of finely laminated sands and silts overlying gravels; fine sediments were sub-sampled at 10cm intervals for laboratory analysis.

(ii) Laboratory analysis

Sediment samples were dried and analysed for organic content by weight-loss following ignition at 450°C for 8 hours. Total concentrations

Table 3 Chronology and maximum/minimum values of Pb and Zn (expressed as parts per million) for sampled alluvium at Corbridge (this study), Farnley Haughs and Low Prudhoe (see text for details of other sites).

Site / Section	Age	Pb (max)	Pb (min)	Zn (max)	Zn (min)
Farnley Haughs (i)	*c.*4940 — 550 BC	130	40	110	40
Farnley Haughs (ii)	*c.*550–135 BC	100	15	80	30
Farnley Haughs (iii)	*c.*1600 — 1850 AD	620	170	400	100
Farnley Haughs (iv)	*c.*1850 — 1900 AD	1200	300	950	300
Low Prudhoe	*c.*1890 — 1947 AD	2200	300	5000	300
Corbridge (Corb-1)	post 1915 AD	1400	500	1300	800
Corbridge (Corb-2)	*c.*1850 — 1915 AD	5700	550	5250	900
Corbridge (Corb-3)	post 1600 AD	520	250	510	250
Corbridge (DW-1)	post 1600 AD	1700	50	750	150

of Pb and Zn in the <2mm fraction of all samples were evaluated by atomic absorption spectrophotometry (air/acetylene flame) following digestion in nitric acid.

Results

Organic content of sampled alluvium was found to be low (typically <5%) and unlikely to significantly affect trace metal concentrations. Values of Pb and Zn are graphed on figs 15 and 16 and are summarised in Table 3. Also included in Table 3 are the ages and concentrations of Pb and Zn in similarly fine-grained Holocene sediments investigated at Farnley Haughs (Passmore and Macklin 1994) and Low Prudhoe (Macklin *et al.* 1992), located *c.* 3 km and 14 km downstream of Corbridge respectively. These well-dated alluvial sequences allow the chronology of alluvial sediments at Corbridge to be reliably estimated.

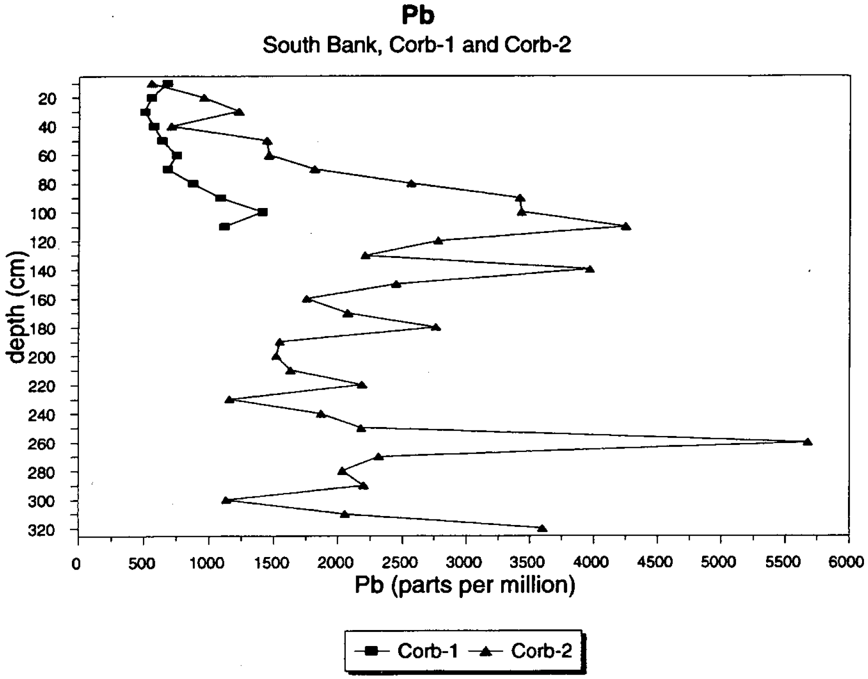
(i) South bank

All sediments sampled throughout Corb-1 and Corb-2 feature values of Pb and Zn that are significantly higher than concentrations typical of Tyne valley alluvium deposited before large-scale metal mining activity in the catchment (Table 3, figs 15 and 16). Indeed, peak values of Pb (5700 ppm) and Zn (5250 ppm) in Corb-2 are the highest recorded in the Tyne valley below the confluence with Devil's Water. Alluviation of fine-grained sediment in the vicinity of the southern bridge abutment has therefore occurred after the mid-seventeenth century, and most probably during the period between the mid-nineteenth century peak of metal production and the present day. Reduced concentrations of Pb and particularly Zn in sediments of the later Corb-1 terrace are consistent with alluviation after the closure of many mines at the end of World War 1.

Trace metal concentrations in Devil's Water alluvium (DW-1) are also higher than those characteristic of pre-mining deposits, although these sediments (particularly with respect to Zn) are less contaminated than Corb-1 and Corb-2 (figs 15 and 16). At present it is unclear whether this reflects deposition prior to peak mining activity or the distinctive signature of alluvium derived from the tributary catchment; in either case, however, the results indicate that major alluviation of fine sediments immediately upstream of the Roman bridge site occurred sometime during or after the seventeenth century AD

(ii) North bank

Alluvium from the upper part of the north bank terrace (Corb-3) is characterised by values of Pb and Zn that are similar to those of DW-1 (Table 3, figs 15 and 16), and hence these sediments were also deposited sometime during or after the seventeenth century AD Defining a more precise date for this phase of alluviation



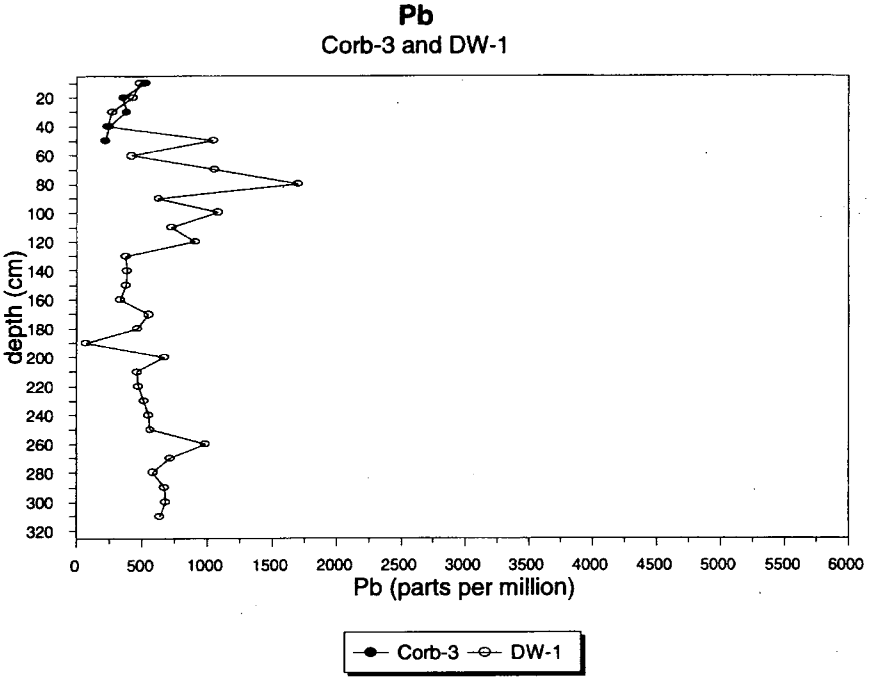
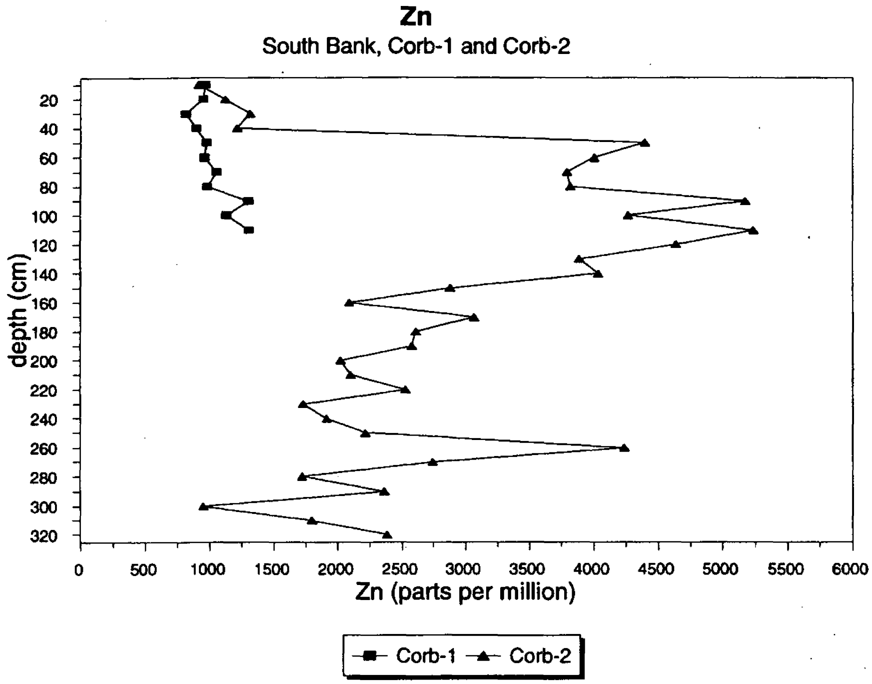


Fig. 15 Downprofile concentrations of Pb for investigated alluvial units at Corbridge.



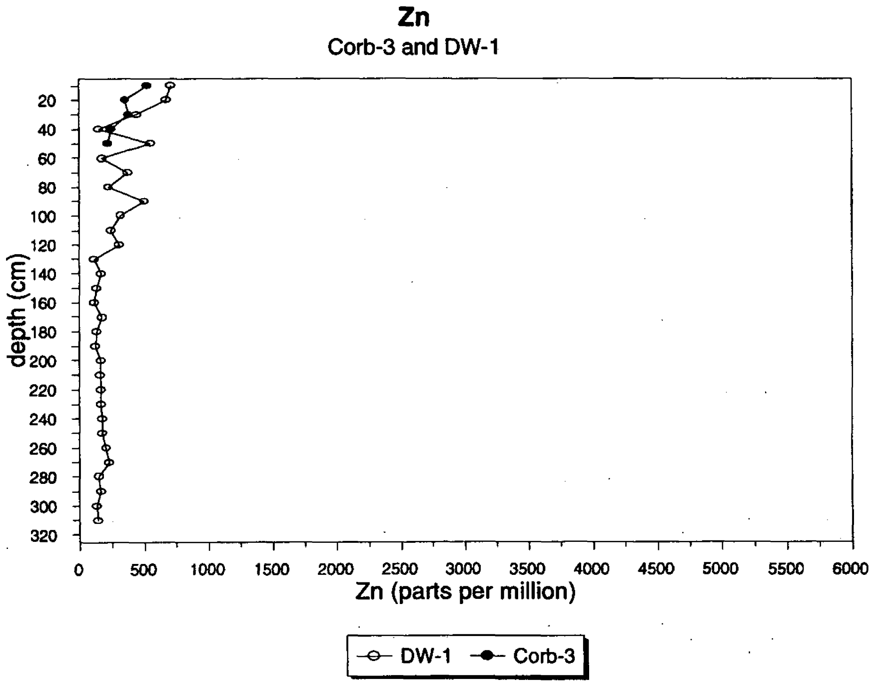


Fig. 16 Downprofile concentrations of Zn for investigated alluvial units at Corbridge.

is difficult due to the probability of contaminant dilution by 'clean' alluvium derived from the unmineralised catchment of Cor Burn. It is unclear at present, however, whether this terrace was formed entirely during or after the mining period, or whether the contaminated material represents mining-age alluvium deposited as a veneer over an older, pre-mining surface.

Summary of results

Data collected during this project clearly demonstrate the propensity of the Tyne to undergo marked changes in channel and floodplain environments over recent historic timescales. this has been associated with burial of archaeological material beneath thick deposits of alluvium. Generalisations regarding the environmental context of the Roman bridge and Anglo-Saxon mill based on modern channel and floodplain characteristics may therefore be highly misleading. Accordingly, further investigation seems warranted on this issue, and also of potentially well-preserved archaeological and palaeoenvironmental materials beneath alluvium elsewhere on the valley floor.

Discussion and Conclusions

The results of this study indicate that fine-grained alluvium comprising the terraces between Roman Bridge abutment and the flood embankment on the southern side of the Tyne, and the uppermost 0.5m of alluvium capping the terrace forming the northern bank of the river, were deposited sometime *after* the seventeenth-century onset of metal mining in the Tyne catchment. This process, as demonstrated elsewhere in the Tyne valley over this period (Rumsby 1991; Macklin *et al.* 1992; Passmore *et al.* 1993; Passmore 1994), was most probably associated with (i) vertical accretion of floodplain benches within the channel zone (especially on the southern side of the river), and (ii) narrowing, and possibly incision, of the active river bed. Thus, while large areas of the surviving Roman bridge abutment and approach structures will have been buried beneath recent historic alluvium at the study site, it is possible that the pier bases in mid-channel have been subject to erosion over the same period. Current data does not allow lateral movements of the northern river margin over the post-medieval to be fully evaluated. In recent years, however, localised erosion and slumping of the southern river bank has exposed parts of the southern bridge abutment to renewed fluvial erosion.

The recent historic age of alluvial terraces established by this study clearly precludes a reliable assessment of valley floor development, and specifically river channel morphology and(or) planform change, between Roman times and the post-medieval period. While the alignment of the bridge and mill structures are suggestive of a contemporary channel orientated on a more north-west/south-east course than present, it should be noted that the structures lie at, and immediately downstream of, minor and major tributary confluences. Here, as elsewhere in the Tyne catchment, the river is likely to have been prone to channel division and formation of braid bars and/or vegetated islands. Thus, in contrast to the present situation, Roman and Anglo-Saxon engineers may have been confronted with a wider, multi-channel river and floodplain environment.

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