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A dendrochronological analysis of oak timbers from the early medieval site at Dundas Wharf, Bristol

By REBECCA A. NICHOLSON and JENNIFER HILLAM

Summary

This paper presents the results of the dating by dendrochronology of waterlogged oak timbers recovered from excavations at Dundas Wharf, Bristol, in 1982–3. The resulting 432-year chronology spans the period AD 770–1202 and adds another tree-ring chronology to those already constructed for south-west England. The importance of the dendrochronological dates for site phasing is discussed, and the timber is examined with regard to its provenance and subsequent incorporation into structures.

Introduction

This report concerns the analysis by dendrochronology of 62 oak timbers from a site at Dundas Wharf, Bristol (ST 5899 7272), excavated in 1982–83 by Mr L. Good for Bristol City Museum (see Iles 1984, 57–59). Prior to dendrochronological analysis, phasing of the site had been on the basis of stratigraphical relationships, many of which were obscured by later cellaring (Good pers. comm.), and dates suggested from pottery evidence. It was hoped that the dendrochronology would help to resolve questions concerning the site's stratigraphy as well as providing absolute dates for the wooden features. This report is presented as a guide to the methodology and potential of dendrochronological analysis in the context of the archaeological study of medieval Bristol. It is published with the full co-operation of the site excavator and Bristol City Museum, as a preliminary contribution to the final publication of the work at Dundas Wharf.

Dendrochronology, in brief, is the dating of timbers by the analysis of the sequences of tree-rings exhibited by the timbers. The tree-ring widths are measured and the resulting sequence of measurements is, assuming the timber is suitable, sufficient to enable it to be dated by matching the sequence to a longer, absolutely dated sequence or tree-ring master chronology. The method relies on the fact that woody plants produce annual increments, or growth-rings, the width of which is determined by the growing conditions available to the plant during the year. In ideal situations the tree will lay down a thick growth-ring, whereas in times of stress, caused by factors such as insufficient water, light, or parasite attack, growth will be less. The factors which cause the most widespread changes in ring width are climatic, and it is this which causes trees over a large area to exhibit similar patterns of wide and narrow rings. Dendrochronology relies on the theory that the unique ring sequence exhibited by a tree will date to one point in time only, so, assuming the dendrochronological matches are sound, the date obtained is irrefutable. With complete oak timbers the date of felling can be found, and in certain cases, where the inner bark surface is present, the season of felling (Hillam 1979). If sapwood (the soft, light coloured band of living xylem cells between the heartwood and bark) is present an estimation of the date of felling can be made using an estimate of the number of sapwood rings likely to have been present, within

confidence limits. As dendrochronological dates are arrived at independently of archaeology they are not subject to revision after reconsideration by the archaeologist. Thus dendrochronological dates are of great value for testing the traditional methods of archaeological phasing and dating, such as pottery chronologies.

Most dendrochronological work in Britain and north-west Europe uses oak. This is because, firstly, oak is the timber most commonly used for building and so most easily available for constructing reference chronologies. Secondly, oak is a long-lived tree often attaining an age of 100–200 years, so yielding the long ring-sequences necessary for chronology building. Thirdly, as a ring-porous tree its rings are usually clear and easy to measure, and fourthly, it appears not to suffer from missing rings, in contrast to other species (Baillie 1982).

The site

This section outlines the archaeology of the site and is based on personal information from Mr L. Good and from Jones *et al.* (forthcoming). The interpretations given here reflect a preliminary assessment of the excavated material and will be subject to revision after post-excavation work has been completed.

The site of Dundas Wharf lies in the Redcliffe suburb of Bristol, on the east bank of the River Avon (FIG. 1). The excavation uncovered the remains of three medieval tenements, one of which extended from the frontage at Redcliffe to the quay of the floating harbour built in 1804–9. These tenements seem to have been shops and workshops with yards behind and a path or common slip

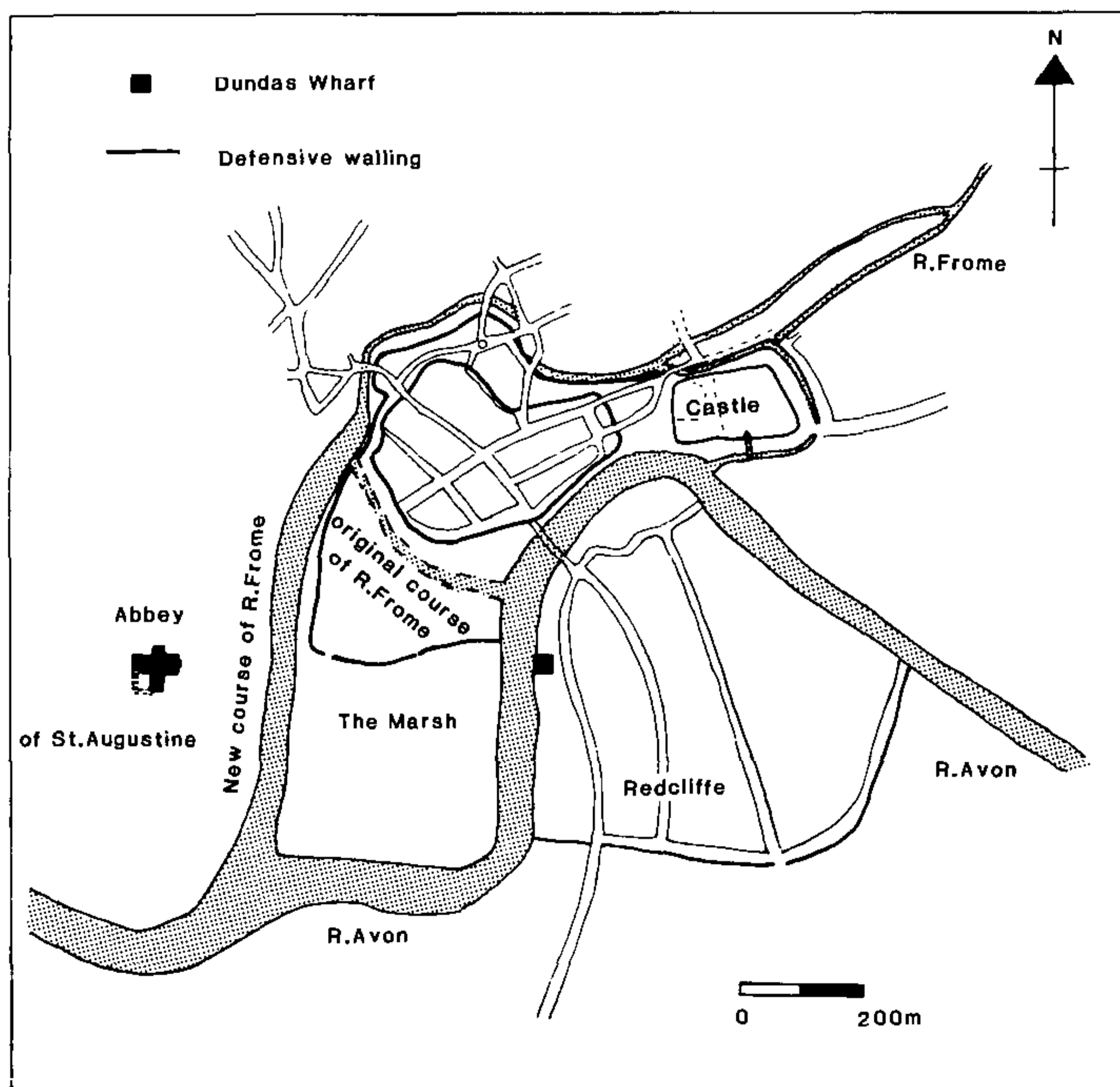


FIG. 1. Location of Dundas Wharf in relation to medieval Bristol and Redcliffe (after Jones *et al.* forthcoming).

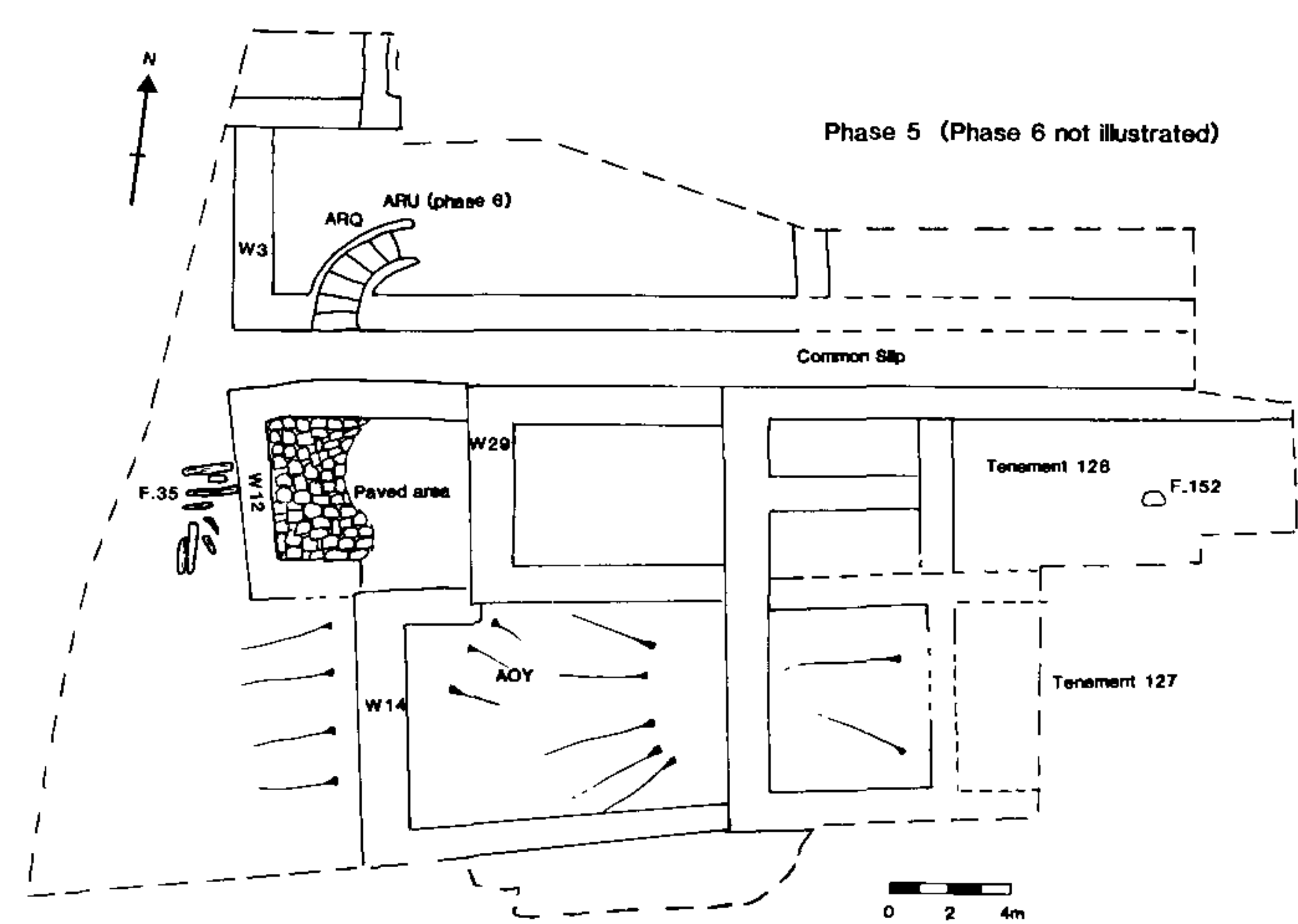
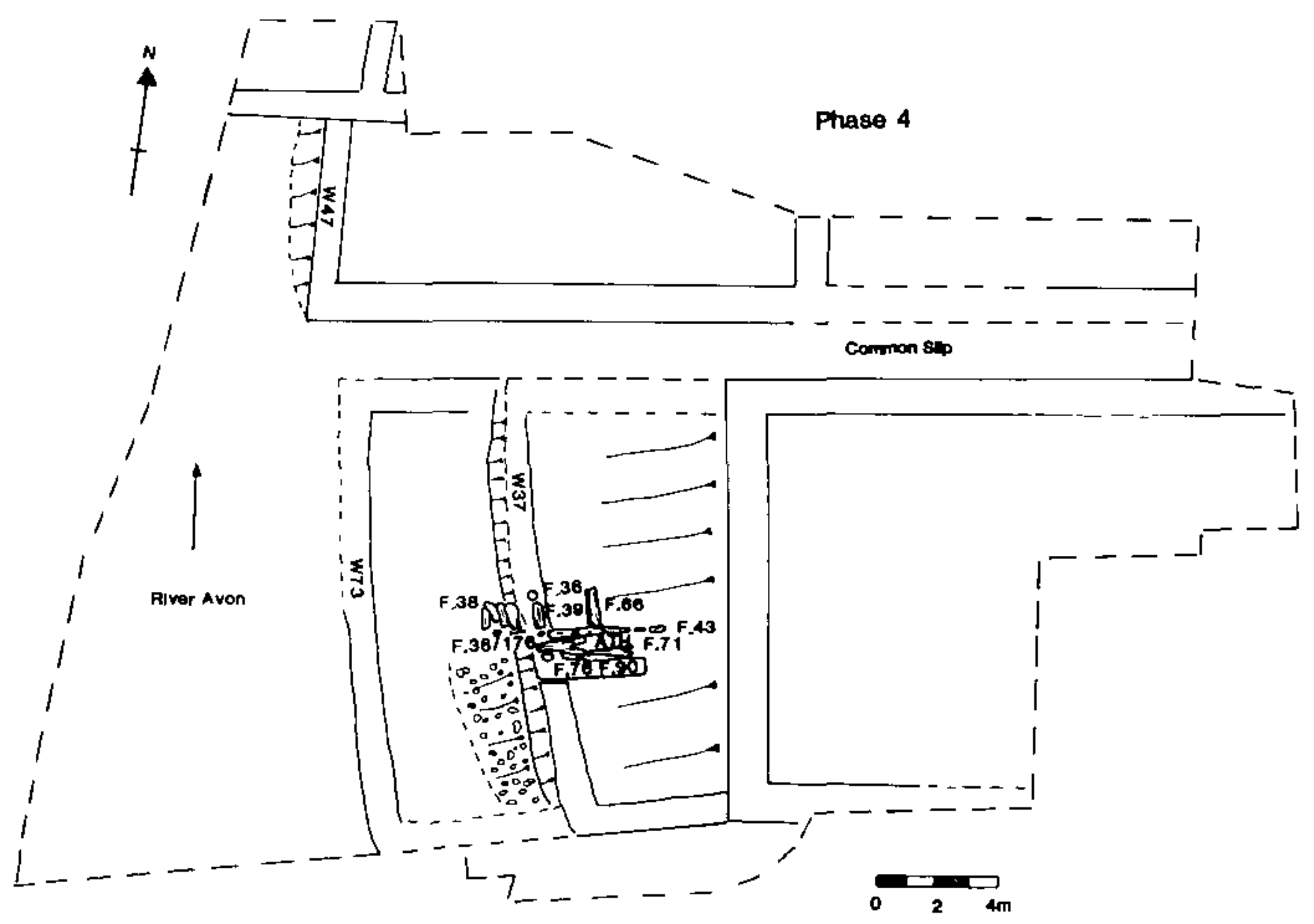
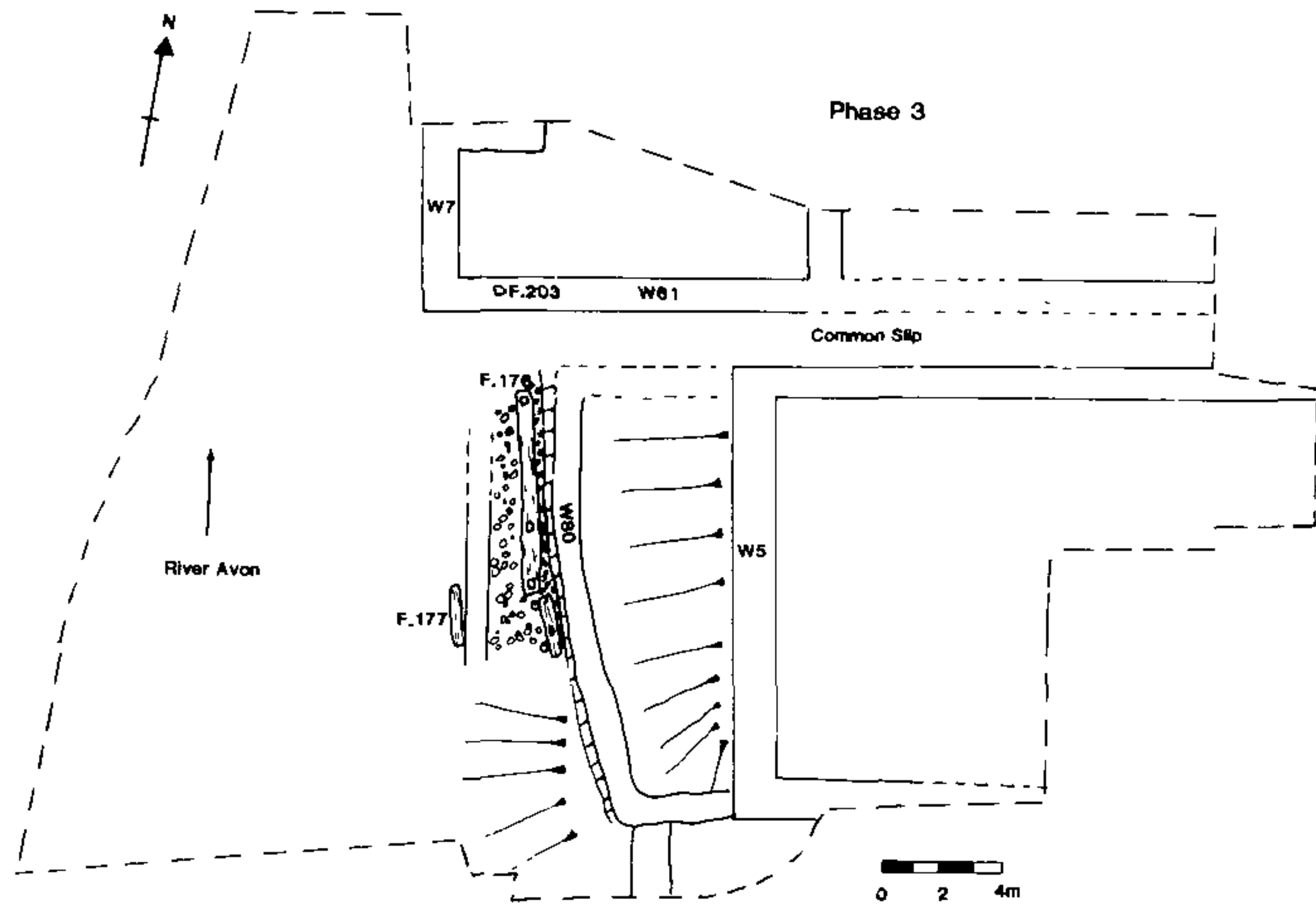
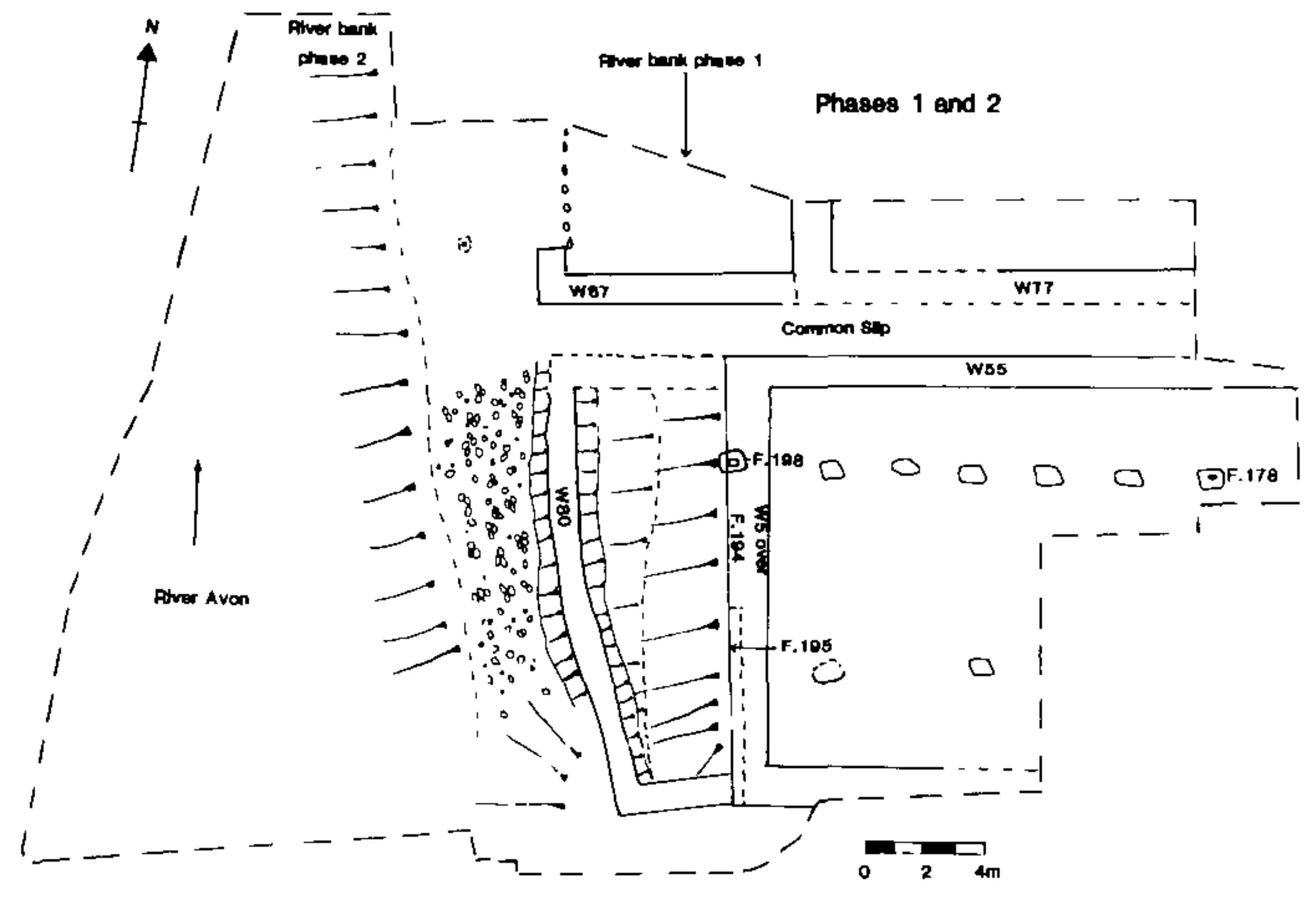


FIG. 2 Interim phase plans of the excavations at Dundas Wharf (after Jones *et al.* forthcoming and Good pers. comm.). Phase 6 is not shown separately as only one timber (ARU) was present and the position of this is included on the Phase 5 plan.

between two of the tenements leading to the waterfront. Samples for dendrochronology were taken from a series of waterlogged organic and riverine clay deposits associated with quay structures, between the tenements and the river. The deposits indicated periods of refuse dumping interspersed with periods of flooding. Several walls parallel with the riverfront were revealed, for which the preliminary interpretation was a series of double quays. The maximum tidal range in the Bristol Avon is 13 m with the minimum being around 4 m. The medieval mean high-water spring and neap tide levels have been estimated from the height at which fluvial clays remain and are thought to be within 0.5 m of the present-day values, with the difference between MHWS and MHWN being about 3.3 m, as at present (Jones *et al.* forthcoming). Thus it would seem that any one quay would only have been usable at one state of the tide, so if the waterfront was to be used efficiently a double quay would have been necessary.





















The preliminary archaeological interpretation of the site, in brief, divided the site into six phases (FIG. 2), the earliest of which was represented by a row of post-pits in which two timbers survived (samples 34 and 35). This phase was followed by the development of a number of walls, interpreted as sets of double quays, the earliest being wall 5, built on a row of stakes (F. 194, samples 36–43) with a refacement (F.195, samples 44–46) built along the crest of the original riverbank to stand above MHWS. This was soon followed by wall 80, which provided a low-water quay. Wall 89 replaced wall 80. Sample 23 was a large timber set into the base of wall 89 and samples 1–5 were two large timber base-plates, and associated pegs, set behind wall 89 and in front of wall 80. These possibly represented the base-plate for stairs to a low-water hard, as at Trig Lane, London (Milne and Milne 1982). Wall 37 later replaced wall 5 as the high-water wall, with wall 73 as the low-water quay wall. A timber feature, F.36, behind wall 37, was apparently constructed at this time and was initially interpreted as a fish trap (Ponsford 1985) but is now thought more likely to have been a latrine (Good pers. comm.). The last two phases saw the construction and development of the tenements. The provisional dating ranged from the late 12th/early 13th century (phase 1) to the late 14th/15th century (phase 6).






















Methods

Samples were taken from most of the oak timbers on the site which were considered suitable for dendrochronological analysis (i.e. excluding timbers obviously with very few rings). Where a feature contained many similar timbers (e.g. stakes under a wall) a selection was sampled. All the timbers were waterlogged, and preparation methods followed Hillam (1985). The wood was deep frozen for at least 48 hours before planing with a file to expose the rings clearly. If the timber was very fragile or fibrous a 10 mm strip was pared with a knife along a radius of the timber. The wood was left to thaw before measuring, as the rings are seen more clearly in the defrosted state. Ring-widths were measured with the aid of an incremental measuring unit, in effect a travelling stage, which was linked to a microcomputer. The rings are viewed down the microscope, the cross-hairs being aligned to the start of the innermost ring, parallel to the rays. When a ring is traversed the press of a button sends the measurements, in units of 0.02 mm, to the computer's memory, and complete sets of measurements may be printed out. The timber is measured along the maximum clear radius, avoiding knots by carefully traversing a ray when necessary.






















Complete sets of ring-widths are plotted on to transparent semi-logarithmic graphpaper. This condenses the wide rings and draws out the narrow rings, the latter being formed as a response to one or more limiting factors, frequently climatic. Pairs of 'curves' are then superimposed and moved along until a position where the two appear similar is found. This position is recorded as a possible position of matching and may be checked using the cross-dating option of the tree-ring software used at Sheffield University (written by Dr. J.R. Pilcher, Belfast Tree-Ring Centre). The program utilizes a parametric test to calculate the product moment correlation coefficient 'r' at each position of overlap. Student's 't' test is then used, which is a statistical measure of the probability of each observed 'r' value being the product of chance (Baillie and Pilcher 1973). A 't' value of over 3.5 is generally regarded as indicating a match but must be visually checked before being accepted. The position of cross-matching may be checked by using replication, the basic principle being that a timber must match with at least two others in the same relative position, thus A must match with B and C, B with A and C and so on. This method is extremely important, especially if timbers with short ring sequences (e.g. 50–100 rings) are to be dated (Baillie 1982).

Table 1 Details of the timbers from Dundas Wharf (sketches are not to scale)

Dendro. No.	Feature	Total No. of Rings	No. of Sapwood Rings	Mean Ring Width (mm.)	Date of Last Ring A.D.	Felling Date A.D.	Sketch	Maximum Dimensions (mm.)
1	F.99	106	38	1.06	1142	1142-1159		105 X 90
2	F.176	185	30(+ bark)	0.87	1147	1147		165 X 70
3	F.176	120	22(+ waxy edge)	0.98	1147	1147		150 X 70
4	F.176	231	32(+ bark)	0.94	1147	1147		245 X 115
5	F.176	81*	1	2.3	1132	1141-1186		320 X 200 190 radius
6	F.35	86	-	0.80	1164	after 1174		165 X 105
7	F.35	105	-	1.13	1202	after 1212		120 X 110
8	F.35	75	-	1.39	1124	after 1134		125 X 100 120 radius
9	F.35	70	-	1.37	-	-		102 X 95
10	F.35	82	26	1.25	-	-		95 radius X 105
11	F.36	129	2	1.31	1124	1134-1179		180 X 290 160 radius
12	F.36	78	16	1.86	1143	1143-1182		275 X 165 180 radius
13	F.36	126	-	1.10	1091	after 1101		230 X 120 150 radius
14	F.39	171*	-	1.21	1119	after 1129		205 X 145 180 radius
15	F.39	39	-	2.54	1131	after 1141		105 X 100
16	F.39	91*	-	0.97	1050	after 1060		170 X 90 radius
17	F.44	58	10	2.17	1141	1141-1186		135 X 120
18	F.71	104	-	1.46	1084	after 1094		280 X 150 radius
19	F.90	65	H/S boundary	1.69	1112	1122-1167		220 X 170 radius
20	F.76	58	-	3.47	1106	after 1116		280 X 170 200 radius

Dendro. No.	Feature	Total No. of Rings	No. of Sapwood Rings	Mean Ring Width (mm.)	Date of Last Ring A.D.	Felling Date A.D.	Sketch	Maximum Dimensions (mm.)
21	F.43	77	22(+waney edge)	1.12	1148	1148-1181		110 X 35
22	F.43	56	-	2.05	-	-		120 X 20
23	F.177	83	6	2.03	1136	1140-1185		310 X 190 170 radius
24	F.36/ 176	69	4	1.82	1125	1131-1176		310 X 145 130 radius
25	ATH	? Band of very narrow rings near start, leaving only 49 measurable rings, which were not dated. No continuous sapwood, but bark present.						155 radius
26	AZD	140*	?	1.88	-	-		270 X 55
		vessels very diffuse, may be 1 or many rings.						
27	ARQ	76	-	1.75	1074	after 1084		200 X 80
28	ARQ	93*	-	1.75	1066	after 1066		250 X 130
29	ARU	c.100	31(+bark)	1.20	-	-	very knotty 	115 X 100
30	ARQ	41*	-	2.83	-	-		135 X 75 radius
31	F.203	38	-	3.50	-	-		150 X 50
32	F.152	125	-	1.52	-	-		230 X 50
33	F.162	60	27(+bark)	2.15	1162	1162		110 X 130 radius
34	F.198	293	45	0.93	1123	1123-1133		280 X 200
35	F.178	70	-	3.10	-	-		390 X 175 210 radius
36	F.195	93	29(+waney edge)	1.91	1182	1182		165 X 180 radius
37	F.195	46	25(+waney edge)	3.34	1182	1182		135 X 175 radius
38	F.195	41	13(+waney edge)	2.81	1182	1182		165 X 160 radius
39	F.195	74	3	1.65	-	-		125 X 100
40	F.194	81	18	1.75	1181	1181-1218		100 X 145 radius
41	F.194	59	15	2.33	1171	1171-1209		100 X 160 radius

DENDROCHRONOLOGY AT DUNDAS WHARF

Dendro. No.	Feature	Total No. of Rings	No. of Sapwood Rings	Mean Ring Width (mm.)	Date of Last Ring A.D.	Felling Date A.D.	Sketch	Maximum Dimensions (mm.)
42	F.194	48	12(+ waney edge)	2.53	1182	1182		85 X 130 radius
43	F.194	69	16(+ waney edge)	1.89	1182	1182		75 X 140 radius
44	F.195	143	-	0.83	1113	after 1123		125 X 95
45	F.195	145	-	0.85	1107	after 1117		130 X 90
46	F.195	102	-	1.21	1102	after 1112		120 X 130
47	BTZ	30	10	3.76	-	-		300 X 180
48	BTZ	78	16	1.34	-	-		175 radius
49	F.38	100*	c.20	1.86	-	-		220 X 15
50	F.38	125	-	1.34	991	after 1001		185 X 22
51	F.38	c.151	-	0.95	918	after 928		180 X 150
52	F.38	225	-	0.88	1083	after 1093		255 X 20
53	F.38	182	-	1.37	-	-		340 X 23
54	F.38	180	-	0.76	1068	after 1078		165 X 20
55	F.39	288*	-	0.88	1103	after 1113		270 X 10
56	F.66	116*	-	3.08	-	-		195 X 10
57	F.66	337	-	0.70	1106	after 1116		260 X 10
58	F.66	92	25	3.06	1147	1147-1177		300 X 15
59	F.66	62	-	3.42	-	-		225 X 15
60	CCK	86	-	2.41	-	-		230 X 10
61	AYK	45	-	3.57	-	-		180 X 15
62	AQL	101*	-	1.73	1138	after 1148		185 X 20

* = not all rings measured, but all counted. The date given takes the unmeasured rings into account.

When several timbers had been cross-matched and dated relative to each other a 'mean master' was created, using the 'Mean Master' option of the Belfast tree-ring program, which produces an averaged 'curve' for the ring measurements obtained from the timbers. In this way the site master chronology was built up. Some of the timbers with long ring sequences were matched directly with the site master or with dated reference chronologies. Once the site master chronology was constructed it was dated absolutely by matching with dated reference chronologies, of which many now exist for areas of the British Isles. The dates of individual timbers could be worked out from their position within an absolutely dated master chronology. Timbers which were not dated successfully were matched with some reference chronologies from Germany (Eckstein pers. comm.; Delorme 1972; Hollstein 1980) in case the timbers were imported from the Baltic, as is suggested on historical grounds (Sherborne 1971), but in no case was a conclusive match found.

Unless sapwood is present the date of felling of the tree cannot even be estimated, as it is not possible to discover how many rings may be missing from the outer edge of the timber. When sapwood or the outermost edge of the heartwood is present an estimate can be made as to the number of missing rings. The estimate used in this study is that proposed by Hillam *et al.* (1987) of between 10 and 55 sapwood rings in oak, which represents a 95 per cent confidence limit.

Results

Out of the 62 samples submitted, 43 were dated (for details see Table 1). Twenty-seven timbers had sapwood and of these twelve had the waney or bark edge present, so enabling the date of felling to be discovered. Where timbers were not dated this tended to be due to one or a

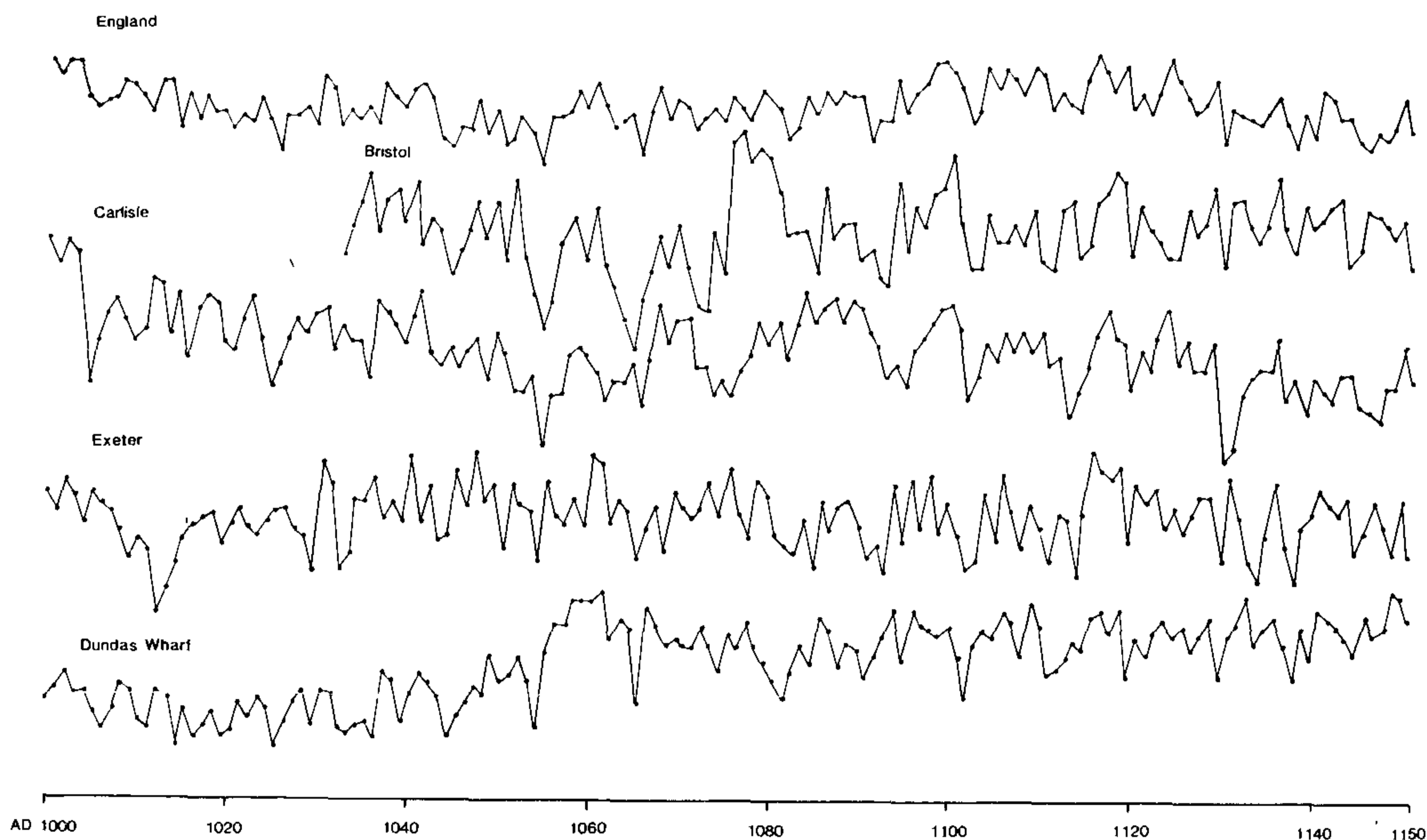


FIG. 3 Cross-matching the Dundas Wharf master chronology with dated British chronologies for the period AD 1000–1150. (The Carlisle chronology has been compiled from unpublished data from Baillie and Pilcher of the Belfast dendrochronology laboratory.)

combination of factors including short ring sequences, wide complacent rings, knotty wood, and the lack of other timbers from the same structure with which to cross-match the ring sequences. Where a number of timbers were available from the same structure even short ring sequences could be dated by using replication. When samples had very long ring sequences (e.g. samples 34, 52, 55, and 57) they could be individually matched against dated reference chronologies as well as cross-matched with other ring sequences from Dundas Wharf. The ring-width data were compared with several other dated reference chronologies including Bristol (Hillam 1984),

Table 2 T-values of the Dundas Wharf master chronology with dated reference chronologies

<i>England</i>	<i>Ref. 6</i>	<i>Exeter</i>	<i>Dublin</i>	<i>Bristol</i>	<i>Carlisle</i>
(Baillie and Pilcher pers. comm.)	(Fletcher 1977)	(Hillam 1980)	(Baillie 1977)	(Hillam 1984)	(Baillie and Pilcher pers. comm.)
T = 10.5	T = 8.1	T = 8.2	T = 7.8	T = 7.4	T = 8.1

Exeter (Hillam 1980), Dublin (Baillie 1977), Carlisle (Baillie and Pilcher pers. comm.), Ref. 6 (Fletcher 1977), and the general England chronology (Baillie and Pilcher pers. comm.). The site master chronology, Dundas Wharf (Table 3), matched significantly with all these reference chronologies (Table 2 and FIG. 3) with 't' values of between 7.4 (Bristol) and 10.5 (England).

Interpretation

The dates obtained by dendrochronology (Table 1 and FIG. 4) differ substantially from the pottery-based date ranges initially assigned to the site. While the archaeological dates span the late 12th or early 13th century to the 15th century, the dendrochronological dates cluster in the 12th century, and only one feature, F.35, appears to be of 13th-century date (remembering that there were no dendrochronological samples from the latest phases). Perhaps more importantly, the dates obtained imply a different sequence of building from that interpreted archaeologically. While the dendrochronological dates in no case disagree with the direct stratigraphical relationships, several aspects of the phasing differ. In particular, F.194 and 195 (samples 36–46) date clearly to AD 1182. There is, therefore, no reason to see F.195 as a refacing, later than F.194. This date brings wall 5 (over F.194 and 195) to the penultimate phase on the site (excluding the phases of tenement development not dated by dendrochronology), which has obvious repercussions for the interpretation of double quays. Wall 5, in fact, may not be a quay wall at all.

In view of the discrepancies between the proposed archaeological phasing and the dendrochronological dates obtained, a short discussion outlining the development of the site as suggested by the dendrochronological dates is given below.

The first phase on the site seems to be represented by the post-pit structure from which samples 34 and 35 were taken. The constructional date for this phase is AD 1123–1133 assuming no stock-piling, repair, or re-use of timber. The possible river stairs represented by timbers in F.176 (samples 1–5) date to AD 1147–8, and as wall 89 appears on stratigraphical grounds to be contemporary, this probably represents the second phase on the site. The next phase seems to be represented by the anomalous structure F.36, but as few of the samples from it had sapwood the dating of this structure is difficult. Those samples with sapwood suggest a date contemporary with, or only slightly later than, the construction of F.176, and none of the samples without sapwood contest this date. As several samples had evidence of re-use, and sample 12 was certainly re-used from structure F.176, it is possible that the entire structure comprised re-used timbers from earlier structures including F.176. Wall 5, overlying stakes F.194 and 195, dates to 1182 and so is representative of the fourth phase dated by dendrochronology. The last phase which could be dated dendrochronologically is represented by F.35, the archaeological interpretation of which is again uncertain though it may have been a small unloading platform (Good pers. comm.). No sample from F.35 for which a date was obtained possessed sapwood, so all that can be established is that structure F.35 post-dates AD 1212, as must the associated riverside wall.

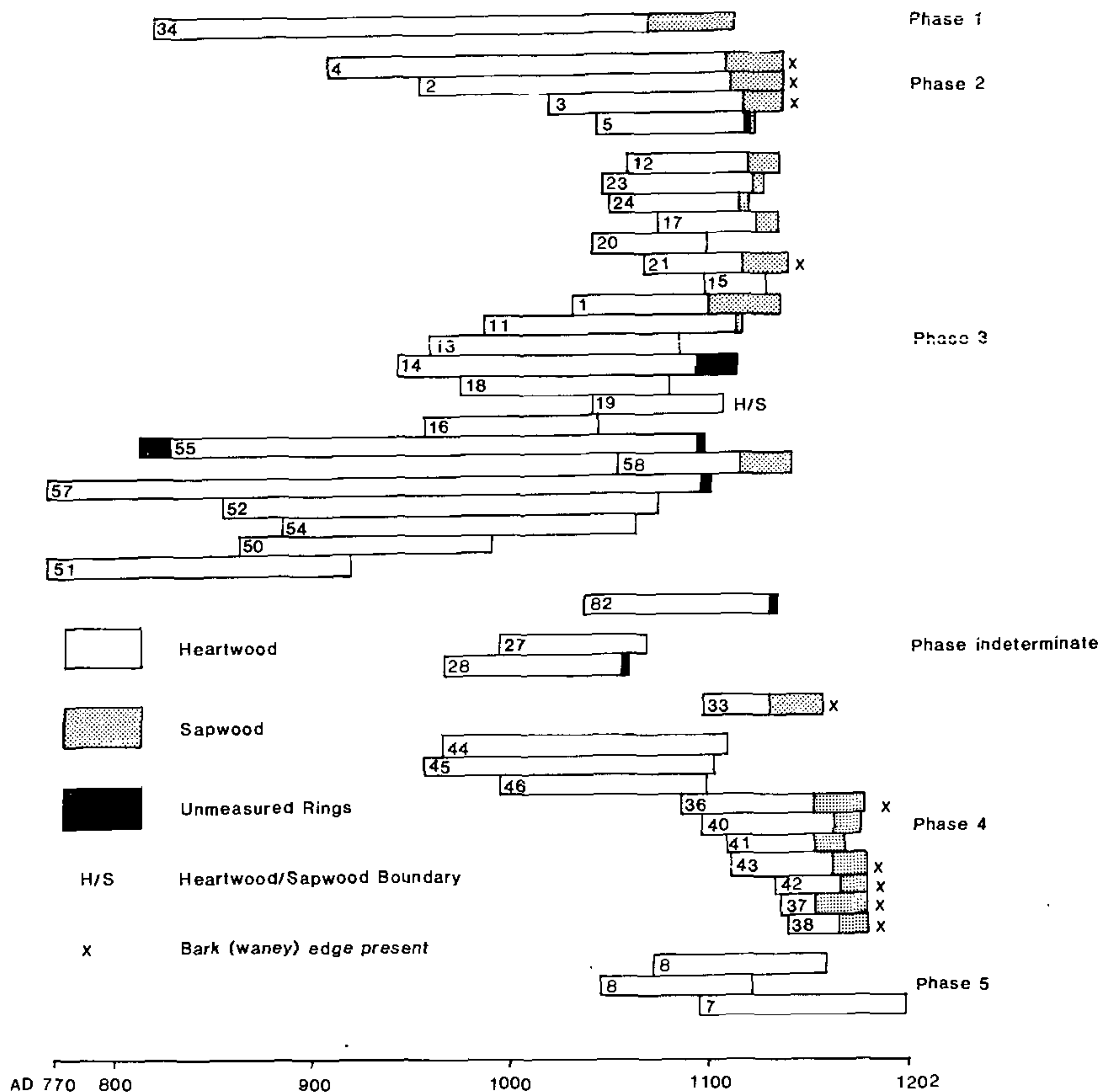


FIG. 4 Bar diagram showing the years spanned by the individual dated timbers, grouped within phases postulated on the basis of the dendrochronological evidence. The number at the left of each bar refers to the sample number as in Table 1.

Discussion

The timber from Dundas Wharf was converted from the original trees in a variety of ways (Table 1). As the felling dates of the timbers indicate a constructional period of only about half a century, little can be said about the development of carpentry techniques.

As can be seen from Table 1 the timber from Dundas Wharf is extremely varied, both in tree-age and ring-width. Tree-age varied from less than 50 years (stakes from F.194) to over 337 years (sample 57). Neither the innermost nor the outermost rings were present on sample 57 indicating a tree of well over 337 years old. Several samples were from slow grown oaks of over 200 years old, which is unusual in British medieval archaeology (Hillam and Morgan 1981; Wrobel 1983). In general in the medieval period trees seem to have been felled at under 100 years old, often at about 70 (Rackham 1976, 79). Ancient oaks were generally obtained from royal forests or parks, but would usually be granted for important building works or as gifts to religious houses rather than for general use (Rackham 1976 and 1980). Despite their age, however, none of the timbers at Dundas Wharf were huge. Sample 34, for example, had a radius of 260 mm with most of the radius present. The diameter of the tree would thus have been little over 560 mm.

Even so, the use of such long-lived trees in apparently fairly mundane structures would suggest that, at least locally, timber was not in short supply. Alternatively, the wood may have been re-used from a more prestigious structure, but although some timbers have obviously been re-used (e.g. sample 44 which had a non-functional nail and chisel hole) and other timbers may have been re-used, those pieces with sapwood, including sample 34, were probably in their original position. The match between ring-sequences from samples 44 and 45 ($t=9.7$) indicates that they probably came from the same tree. One timber (sample 25) appears to be very unusual in apparently having no continuous band of sapwood, although the bark is present. This sample is currently under investigation by David Haddon-Reece at the Ancient Monuments Laboratory, London.

The wood from Dundas Wharf was probably used green as was common practice in the medieval period. There would have been no reason to season wood used in waterfront structures, though Sherborne (1971) cites instances of wood being piled on 'the Quay' and 'the Back' (both quays used in the 13th century) but it is not clear for how long. Assuming that, by and large, timber was cut only shortly prior to its use, absolute construction dates may be obtained when the felling date is found by dendrochronology, assuming no re-use of the wood.

The variation in ring-widths from the samples from Dundas Wharf indicates that probably more than one woodland source was involved. Generally trees with very narrow rings are from forests where competition was severe, whereas trees with wide, complacent rings usually originate from open contexts where little competition was experienced (Bartholin 1978, 128–9; Hillam and Morgan 1981). Both sources of timber seem to have been exploited at Dundas Wharf.

Conclusions

Although this waterfront site did not include large timber structures such as the wooden revetments at many London sites and in the early phases of the Dublin waterfront at Wood Quay (Wallace 1981), dendrochronological analysis has proved very useful, not only for dating the site and helping to sort out the phasing, but also because the dates give the first solid evidence that developments took place at Dundas Wharf within a fairly short period, the mid-late 12th century, during a period of rapid economic growth in Bristol and Redcliffe (Carus-Wilson 1975; Sherborne 1971). In addition this work has also provided a 432-year chronology for Bristol, which should help to date other material in the future (Table 3).

Acknowledgements

This report is based on research undertaken in the dendrochronology laboratory of the University of Sheffield for an MA thesis submitted by one of us (Nicholson 1985), for which she acknowledges much helpful advice and information provided by the excavator, Mr L. Good, and from Vanessa Straker, Julie Jones, and Dr David Gilbertson. The dendrochronology laboratory is funded by the Historic Buildings and Monuments Commission for England and the MA thesis formed part of a course funded by the Science and Engineering Research Council.

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Table 3 Dundas Wharf timbers: master chronology, AD 770–1202 (nine ring-sequences are included, in which 42 individual ring-sequences are incorporated)

Year	Ring widths (0.02mm)									
	0	1	2	3	4	5	6	7	8	9
770	55	36	29	38	37	30	28	26	34	36
780	51	29	29	31	29	41	48	37	29	33
790	63	35	39	19	16	19	15	19	21	23
800	22	19	17	27	27	34	30	33	30	27
810	42	47	33	39	34	46	48	41	50	43
820	52	41	39	38	24	20	47	50	54	49
830	52	53	63	58	40	35	50	62	38	51
840	57	48	38	35	38	48	42	38	31	45
850	42	49	67	79	57	54	47	46	47	52
860	48	41	76	65	60	52	60	67	64	52
870	58	52	54	48	45	52	46	51	38	41
880	57	52	49	51	41	41	44	50	44	37
890	48	49	49	49	49	47	46	42	42	39
900	49	42	54	51	48	40	46	46	47	38
910	45	48	58	46	42	54	43	58	46	40
920	42	43	51	57	61	56	47	51	48	51
930	55	56	63	46	54	48	55	66	56	48
940	59	56	53	51	52	46	50	64	59	51
950	58	46	51	51	68	51	38	44	42	38
960	53	51	52	54	46	44	72	52	55	49
970	50	44	45	43	37	39	35	43	39	56
980	48	42	55	50	36	59	56	56	49	54
990	49	51	43	42	42	42	45	54	48	58
1000	49	53	58	51	51	45	41	46	53	50
1010	42	41	52	49	37	45	39	41	45	41
1020	41	49	46	49	47	37	43	49	51	43
1030	54	53	42	41	42	43	40	60	57	45
1040	52	59	56	51	40	44	48	53	53	66
1050	58	59	65	58	43	73	81	83	95	95
1060	94	100	77	84	79	53	93	83	77	76
1070	75	73	81	75	64	80	76	84	72	62
1080	57	53	63	75	66	90	82	67	73	71
1090	62	74	83	96	70	94	83	82	80	83
1100	73	55	76	83	81	94	90	70	99	86
1110	64	66	68	74	74	90	92	84	95	63
1120	78	73	81	89	84	85	76	90	91	64
1130	85	88	109	81	85	91	78	63	86	72
1140	93	91	89	83	75	94	86	87	121	115
1150	91	88	86	121	97	95	95	105	102	126
1160	124	66	90	111	125	119	121	97	109	131
1170	112	134	111	95	66	52	89	84	101	142
1180	83	91	125	61	32	35	44	34	32	69
1190	47	45	61	82	74	60	66	76	72	81
1200	58	73	72							

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