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**Tree-Ring Analysis of Timbers from the Great Hospital,
Bishopgate, Norwich, Norfolk**

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Tree-Ring Analysis of Timbers from the Great Hospital, Bishopgate, Norwich, Norfolk

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Summary

Several individual buildings in the complex that makes up the Great Hospital were investigated. Some were found not to contain any, or sufficient numbers of timbers with enough rings for dating. Some areas were sampled but failed to be dated; these include the stairs to the church wards on either side of St Helen's Church, and the floor beams supporting both the Parker and Eagle Wards. The wagon roof of Eagle Ward, and timbers in the tower, were identified as potentially datable, but were not sampled in the present study because of access problems.

However, some areas were successfully dated, giving more information about the development of this site. A truss retained in the stairway up to Parker Ward, originally part of the south aisle of St Helen's Church, was made from timbers felled in the period AD 1378-99. The cloister roof was constructed from timbers most likely felled in the period AD 1447-63. The roof of Parker Ward was made of timbers most likely felled in AD 1403 or very soon thereafter. Some timbers from the Parker Ward roof matched well with those used in the truss from St Helen's Church, indicating that they may have come from the same source.

Keywords

Dendrochronology
Standing Building

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Introduction

The Great Hospital, Norwich (NGR TG 2358 0897; Figs 1 and 2), also known as the Hospital of St Giles, is a medieval hospital, founded in AD 1249, incorporating a parish church. Several buildings date from the thirteenth to the fifteenth century, and there were extensive alterations in the sixteenth century, and more recent additions have been made. The main areas of interest in this particular study were the church wards on either side of St Helen's Church, on the south side of the complex of buildings. These buildings are listed grade I, and work is being carried out on the Eagle Ward, at the east end. The Eagle Ward takes its name from the ribbed chancel wagon roof, thought to have been constructed *c* AD 1370-80, which is painted with black eagles in each of its 252 panels, thought to honour Anne of Bohemia who visited Norwich in AD 1383. Both wards have inserted floors, thought to have been inserted in the sixteenth century, that at the east end using timbers re-used from the Bishop's Palace. The cloister roof is thought to have been built in AD 1447-57 (Wilson pers comm) and the roof of the Parker Ward was thought to have been built in either AD 1370-80, or *c* AD 1430.

Dendrochronology was requested by the local English Heritage architect Trudi Hughes, in order to inform grant-aided repairs and assist in developing knowledge about the development history of the buildings. The original brief was extended to include assessment of other areas for future reference. In addition, the site could add to our database of chronologies for this part of East Anglia, an area for which tree-ring information is less well-replicated than many.

Methodology

The site was visited on three different occasions, first in late AD 2001 when an assessment of the potential of different areas was made, and subsequently in January and March AD 2002, when sampling was undertaken in different areas.

The timbers were assessed for their potential use in dendrochronological study. Oak timbers with more than 50 rings, traces of sapwood, and accessibility were the main considerations in the initial assessment. Those timbers judged to be potentially useful were cored using a 15mm auger attached to an electric drill. The cores were glued to wooden laths, labelled, and stored for subsequent analysis. Sometimes cores have less than 50 rings when extracted; those with over 40 rings are analysed as these short sequences will sometimes date when there is sufficient other material from the same phase available.

The cores were prepared for measuring by sanding using an electric belt-sander with progressively finer grit papers down to 400 grit. Any further preparation necessary, eg where bands of narrow rings occurred, was done manually. Suitable samples had their tree-ring sequences measured to an accuracy of 0.01 mm using a specially constructed system utilizing a binocular microscope with the sample mounted on a travelling stage with a linear transducer linked to a PC. The software used in measuring and subsequent analysis was written by Ian Tyers (1999a).

Ring series were plotted to allow visual comparisons to be made between sequences on a light table. This activity also acts as a measure of quality control in identifying any errors in the measurements when the samples crossmatch. Statistical comparisons were made using Student's *t*-test (Baillie and Pilcher 1973; Munro 1984). The *t*-values quoted below were

derived from the original CROS program (Baillie and Pilcher 1973). Those t -values in excess of 3.5 are taken to be indicative of acceptable matching positions provided that they are supported by satisfactory visual matches, and give consistent matching positions.

When crossmatching between samples is found, the ring-width sequences are meaned to form an internal 'working' site mean sequence. Other samples may then be incorporated after comparison with this 'working' master until a final site sequence is established, which is then compared with a number of reference chronologies (multi-site chronologies from a region) and dated individual site masters in an attempt to date it. Individual long series which are not included in the site mean(s) are also compared with the database to see if they can be dated.

The dates thus obtained represent the time of formation of the rings available on each sample. Interpretation of these dates then has to be undertaken to relate these findings to the construction date of the phase under investigation. An important aspect of this interpretation is the estimate of the number of sapwood rings missing. In this instance, the sapwood estimates are based on those proposed for this area by Miles (1997), in which 95% of samples are likely to have from 9 to 41 sapwood rings. Where bark is present on the sample the exact date of felling of the tree used may be determined. For a group of contemporaneous timbers, the sapwood estimate is added to the mean last heartwood ring date to obtain the likely felling date for the group.

The dates derived for the felling of the trees used in construction do not necessarily relate directly to the date of construction of the building. However, evidence suggests that, except in the re-use of timbers, construction in most historical periods took place within a very few years after felling (Salzman 1952; Hollstein 1965).

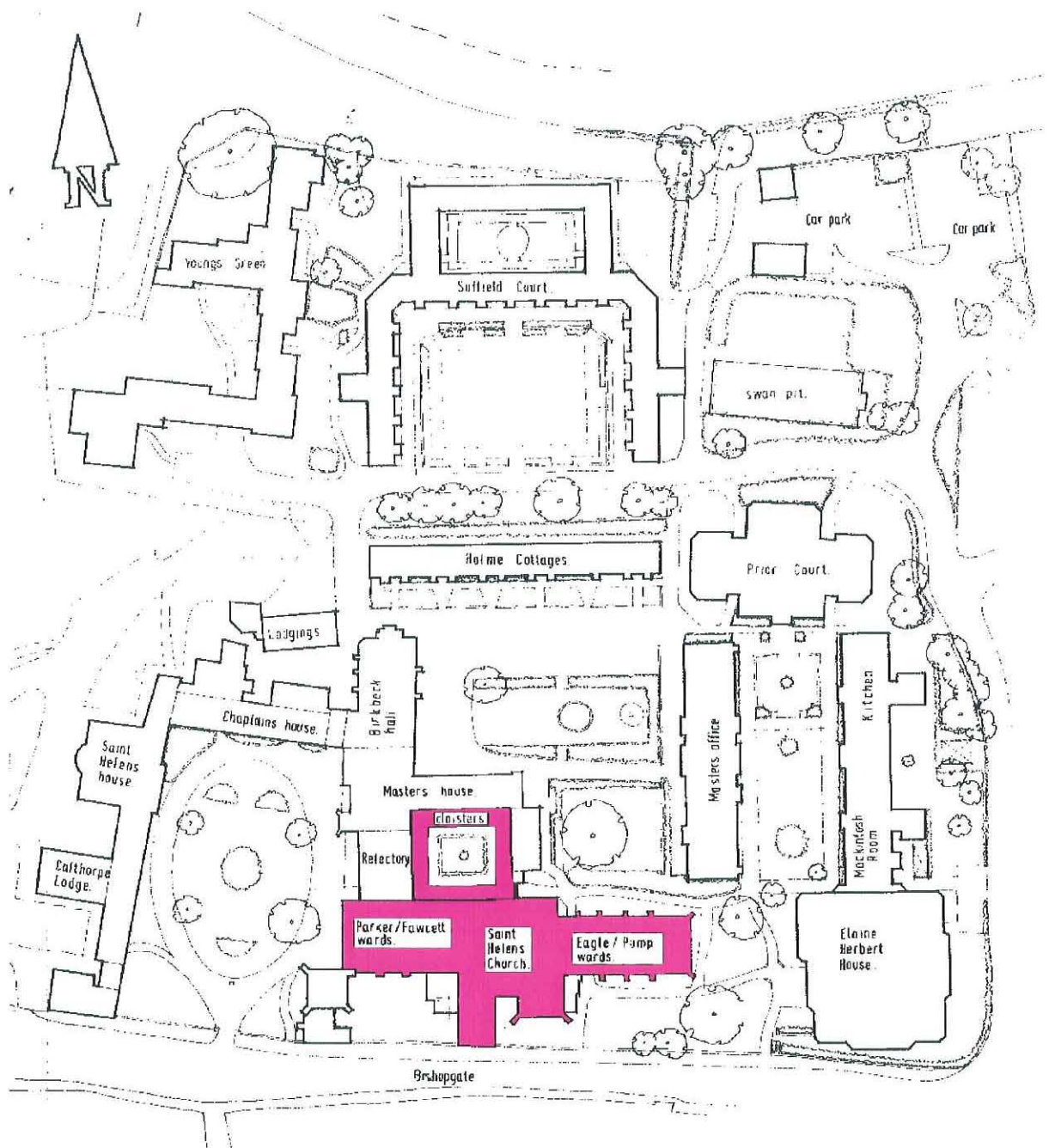


Figure 2: Plan of the Great Hospital, Norwich, highlighting areas discussed in the text (based on an original drawing by Wearing, Hastings, and Norton)

Results

All the timbers assessed and sampled were of oak (*Quercus* sp.) The results of assessing various areas of the Great Hospital buildings were that some areas were deemed unsuitable because they had too few, or no timbers with sufficient rings. These included the Refectory with its carved spandrels, and the roofs over the Master's House and adjoining sections to the west. The panelled ceiling to the Eagle Ward and roof timbers above could not be properly assessed. The *in situ* panels are painted and the grain could not be seen, and the roof timbers above were inaccessible. The decision was made that this area would be looked at again if work on the ceiling and roof was necessary during repairs to the east window to avoid any unnecessary intervention.

Further potentially useful areas identified were timbers in the tower, many of which would not be accessible without scaffolding, and the door to St Helen's Church. If repair or renovation work is done in the tower in the future, it may be possible to carry out further dendrochronological work at the same time. The door to the church is more of academic interest, there is no particular question over its age to be answered in terms of the development of the buildings.

For clarity, the different structures are discussed in different sections below. Samples were taken from the roof of the Cloisters, the roof of Parker Ward, timbers supporting the stairs up to both Parker and Eagle Wards, the beams supporting the floors to both these wards, and a truss which was originally part of the south aisle to St Helen's Church, but which is now in the stairway up to Parker Ward.

The Cloister Roof

The square cloister, on the north side of St Helen's Church (Fig 2) was erected in the mid-fifteenth century (Wilson, pers comm, based on documentary evidence). It has a nearly flat double-pitched roof and elaborately moulded wallplates. The central ridge comprises a roll flanked by hollows, and is pegged into similarly moulded principal rafters at regular intervals. The west and east cloisters have three common rafters per bay (Fig 3), the north and south have four. Each side has eight bays plus two corner bays, and there are large diagonal timbers at each corner. Some timbers look much more modern and are assumed to be repairs, only those timbers thought to be primary were sampled.

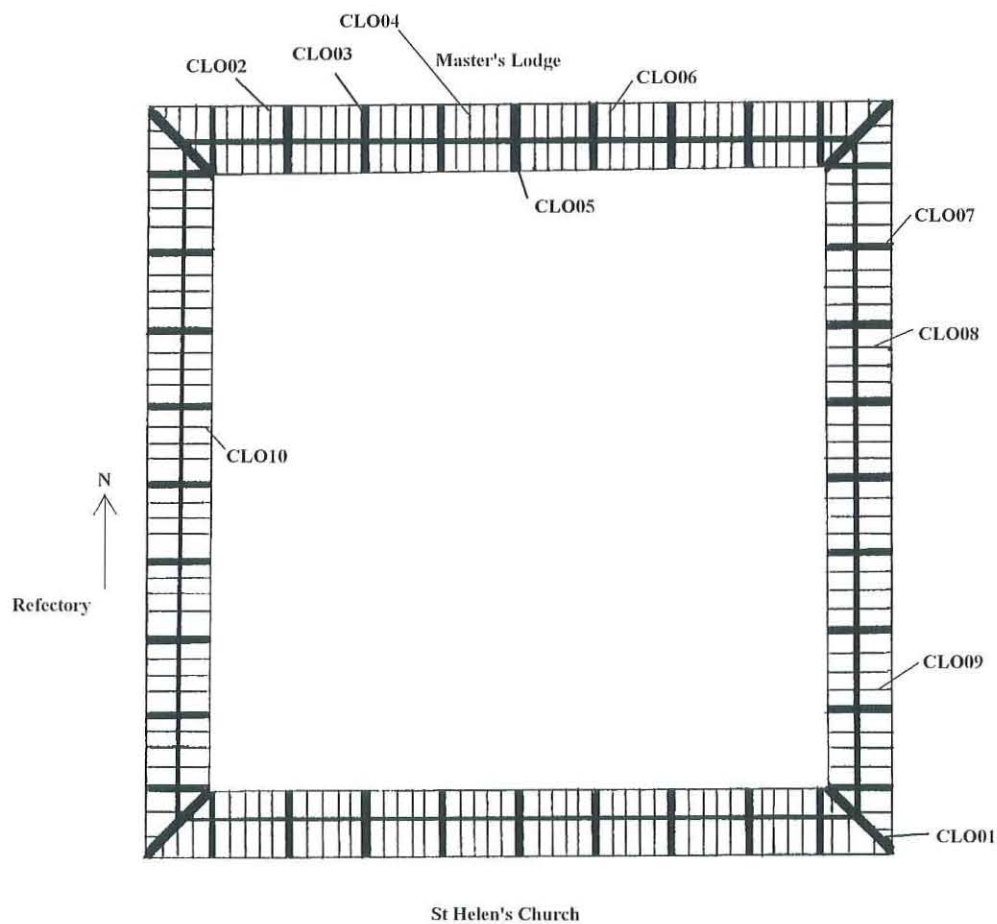


Figure 3: Sketch plan of the cloister roof (not to scale) showing the timbers sampled for dendrochronology

Table 1: Oak (*Quercus* spp.) timbers sampled from the Cloister Roof, Great Hospital, Norwich. h/s = heartwood-sapwood boundary. The bays and rafters were numbered in a clockwise direction along each side (see Fig 2)

Sample number	Origin of core	Total no of years	Average growth rate (mm yr ⁻¹)	Sapwood details	Date of sequence AD	Felling date of timber AD
CLO01	South-east diagonal tie	62	2.19	15	undated	unknown
CLO02	Rafter 4, bay 1, north side	<40	unmeasured	-	undated	unknown
CLO03	Principal rafter 2, north side	<40	unmeasured	-	undated	unknown
CLO04	Rafter 2, bay 4, north side	95	1.34	-	1319 - 1413	after 1422
CLO05	Principal rafter 4, north side	45	1.20	?h/s	undated	unknown
CLO06	Rafter 1, bay 6, north side	90	1.25	-	1316 - 1405	after 1414
CLO07	Principal rafter 2, east side	<40	unmeasured	-	undated	unknown
CLO08	Rafter 1, bay 3, east side	70	1.24	13 (+12)	1366 - 1435	1447 - 63
CLO09	Rafter 3, bay 7, east side	46	1.33	-	1318 - 63	after 1372
CLO10	Rafter 3, bay 5, west side	<40	unmeasured	-	undated	unknown

Details of the sampled timbers from the cloister roof are provided in Table 1. The locations of the samples are shown in Figure 3. Table 2 shows the crossmatching between the dated timbers from the cloister roof, and Table 3 gives the dating evidence for the chronology formed by combining the dated timbers. Sample CLO09 gives relatively weak matches individually against the other cloister roof timbers, though it gives a better match ($t = 4.0$) and is visually well matched against a working master comprising the other three timbers. The positions of overlap of the dated timbers, along with their interpreted felling dates are illustrated in Figure 4. The data for the chronology CLOISTER are given in Table 4.

Table 2: Crossmatching between the dated timbers from the cloister roof. A – indicates a t -value less than 3.0, a \ indicates too short an overlap to calculate a match

	<i>t</i> -value		
Sample no	CLO06	CLO08	CLO09
CLO04	8.6	5.6	3.4
CLO06		3.0	3.9
CLO08			\

Table 3: Dating of the oak site chronology CLOISTER, for the cloister Roof, Norwich Great Hospital.

	CLOISTER AD 1316 - 1435	
Dated multi-site or single-site master chronology	<i>t</i> -value	Overlap (yrs)
East Midlands (Laxton and Litton 1988)	5.4	120
Anglia01 (Bridge unpubl)	5.3	120
London1175 (Tyers pers comm)	4.1	120
Cressing, Essex (Tyers 1993)	5.3	116
Chicksands, Bedfordshire (Howard <i>et al</i> 1998)	5.2	120
Marriots, Norfolk (Tyers 1999b)	5.1	120
Widdington, Essex (Tyers 2001)	5.0	75
'Romans', Little Hallingbury, Essex (Bridge 2002)	4.6	71
Upminster, Essex (Tyers 1997)	4.4	99
Bentfield, Essex (Bridge 2002 forthcoming)	4.4	56
Cranfield, Bedfordshire (Bridge 1998a)	4.3	94

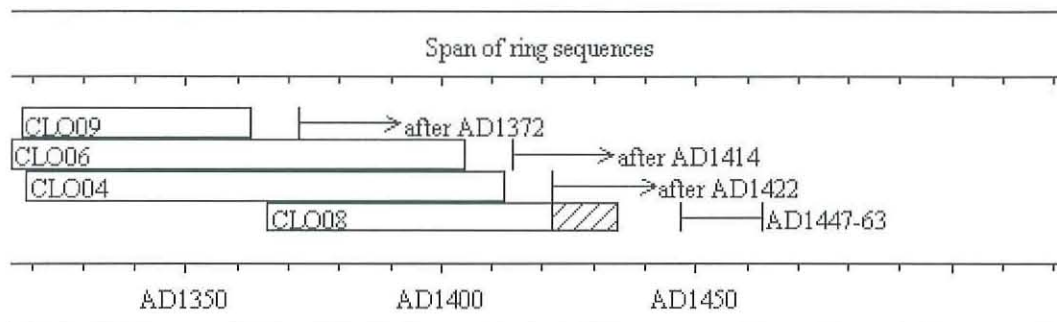


Figure 4: Bar diagram showing the relative positions of overlap and interpreted felling dates of the dated timbers forming the site chronology CLOISTER

Interpretation and Discussion

The site chronology CLOISTER dates reasonably well against material mostly from the East Anglian region, suggesting a local origin. Only one timber had sapwood, making the interpretation of the date of felling for the timbers used in this construction of limited value. The date of AD 1447-63 obtained from the single timber with sapwood does however tally well with the information from documentary sources that the cloister was built between AD 1447 and AD 1457.

Table 4: Ring width data for the site chronology CLOISTER AD 1316 - 1435

ring widths (0.01mm)										no of trees									
420	261	155	174	144	138	131	109	103	109	1	1	2	3	3	3	3	3	3	3
102	112	100	76	86	60	78	65	126	130	3	3	3	3	3	3	3	3	3	3
105	113	100	119	80	50	90	107	119	200	3	3	3	3	3	3	3	3	3	3
122	128	145	113	125	176	143	115	82	68	3	3	3	3	3	3	3	3	3	3
152	187	108	115	166	120	186	184	152	205	3	3	3	3	3	3	3	3	2	2
164	124	127	186	75	89	120	106	155	117	3	3	3	3	3	3	3	3	3	3
115	147	153	118	145	182	167	125	95	156	3	3	3	3	3	3	3	3	3	3
153	223	214	177	195	171	96	124	144	124	3	3	3	3	3	3	3	3	3	3
149	133	113	149	180	101	89	104	207	190	3	3	3	3	3	3	3	3	3	3
178	123	121	112	102	95	133	124	56	60	2	2	2	2	2	2	2	2	1	1
93	81	85	73	108	87	80	122	94	62	1	1	1	1	1	1	1	1	1	1
50	62	63	87	70	93	105	86	85	92	1	1	1	1	1	1	1	1	1	1

Western truss of St Helen's Church (now within the stairway to Parker Ward)

This truss is now located in the stairway up to Parker Ward (Fig 5) and is on the far east wall, immediately next to the south aisle of St Helen's Church, of which it is likely to be a relict. The few timbers available were recognised by Richard Bond as of great interest historically, and though little wood was available to sample, two timbers had in excess of 100 rings, and it was felt important to try and date this relict truss (Fig 6).

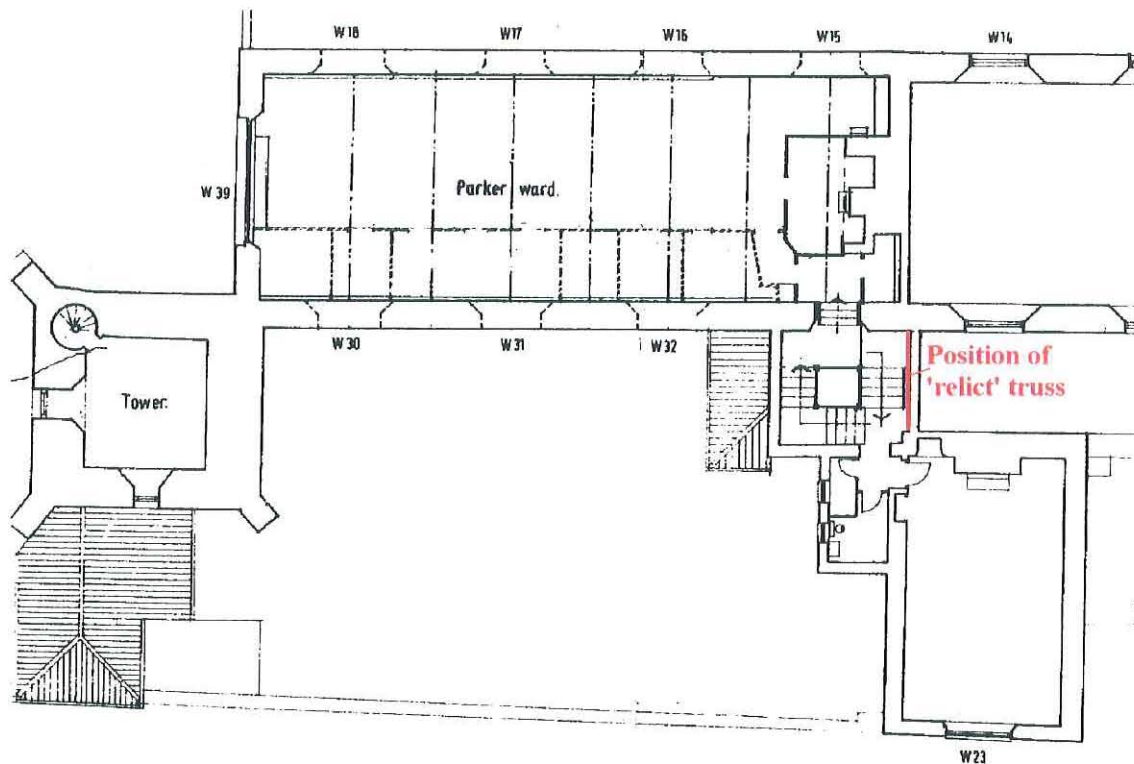


Figure 5: Plan of the first floor of part of the Great Hospital complex, showing the position of the truss sampled (adapted from original drawings by Wearing, Hastings and Norton, Norwich)

Details of the five samples taken are given in Table 5 and their locations are shown in Figure 6. One sample was rejected from further analysis as it had too few rings. Two samples (NGH-STH01 and NGH-STH03) crossmatched with each other ($t = 8.3$, 118 years of overlap) and were combined into a site master, TRUSS, which was dated by comparison with a range of reference chronologies, the best results being shown in Table 6, with the data for TRUSS being given in Table 7.

Table 5: Oak (*Quercus* spp.) timbers sampled from the 'relict' truss. h/s = heartwood-sapwood boundary

Sample number	Origin of core	Total no of years	Average growth rate (mm yr⁻¹)	Sapwood details	Date of sequence AD	Felling date of timber AD
NGH-STH01	North post	109	1.72	h/s	1250 - 1358	1367 - 99
NGH-STH02	North brace	66	1.97	-	undated	unknown
NGH-STH03	Tie beam	119	1.19	h/s	1251 - 1369	1378 - 1410
NGH-STH04	South brace	43	2.58	-	undated	unknown
NGH-STH05	South post	<40	unmeasured	-	undated	unknown

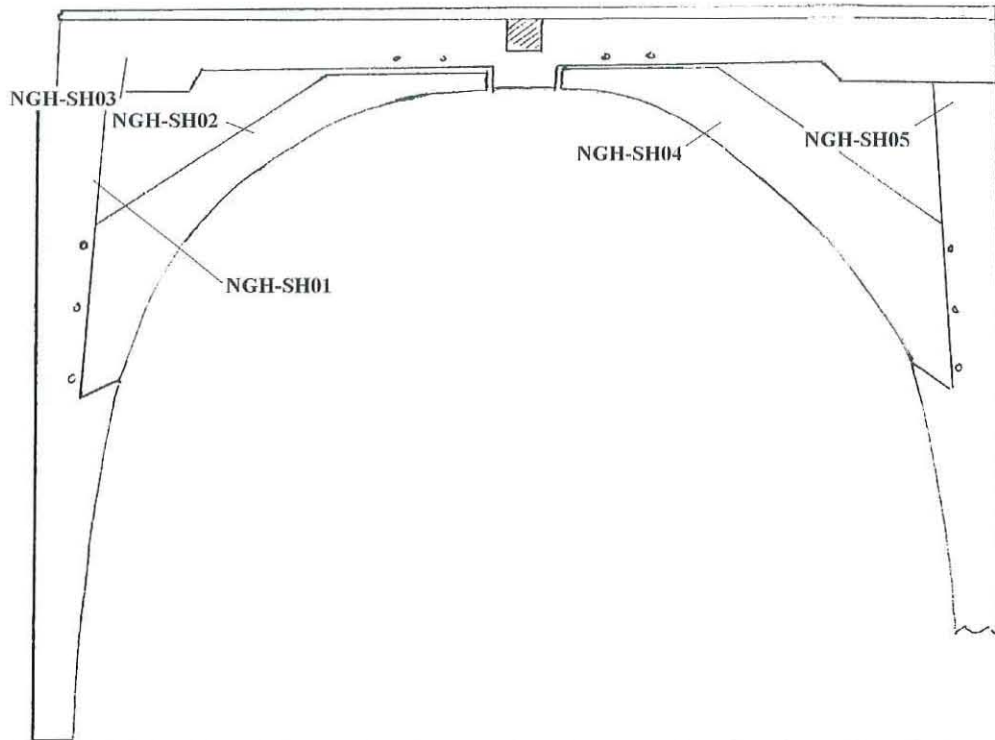


Figure 6: Sketch of the relict truss, looking east, showing the timbers sampled for dendrochronology

Table 6: Dating of the oak site chronology TRUSS

Dated multi-site or single-site master chronology	TRUSS	
	AD 1250 - 1369	
	<i>t</i> -value	Overlap (yrs)
Southern England (Bridge 1988)	4.7	120
East Midlands (Laxton and Litton 1988)	4.4	120
Oxon93 (Miles pers comm)	4.1	120
Beverley94, Yorkshire (Groves pers comm)	6.2	75
Castle Acre, Norfolk (Tyers 2000)	6.0	115
Steyning, West Sussex (Miles 1994)	5.3	120
Winterbourne, Gloucestershire (Miles 2001)	4.4	92
Toddington, Bedfordshire (Bridge 2001a)	4.3	120

Interpretation and Discussion

Although only two timbers dated, the derived felling date of AD 1378-99 for these two timbers does provide useful information about this truss in relation to the development of the building. When considered in relation to the roof of the Parker Ward, to which the stairway in which this truss has become preserved leads, it would seem that work on this section of the building is likely to have taken place before the construction of Parker Ward roof, but possibly only by a few years (see below). There were no preconceived ideas as to the date of this truss, although it is presumed to be part of the building of St Helen's Church. This information suggests that the church may have been completed a little before the building of the adjoining wards.

Table 7: Ring width data for the site chronology TRUSS AD 1250 - 1369

ring widths (0.01mm)										no of trees									
252	254	241	262	269	363	248	303	155	221	1	2	2	2	2	2	2	2	2	2
304	256	276	166	108	157	147	203	332	271	2	2	2	2	2	2	2	2	2	2
207	172	129	162	151	153	175	218	191	173	2	2	2	2	2	2	2	2	2	2
152	186	161	144	142	142	114	128	138	193	2	2	2	2	2	2	2	2	2	2
207	160	159	176	185	156	103	134	126	175	2	2	2	2	2	2	2	2	2	2
171	169	104	129	113	126	136	177	150	110	2	2	2	2	2	2	2	2	2	2
117	128	142	153	149	147	165	180	113	86	2	2	2	2	2	2	2	2	2	2
102	121	108	94	54	71	78	115	128	87	2	2	2	2	2	2	2	2	2	2
68	82	101	95	107	111	69	81	94	112	2	2	2	2	2	2	2	2	2	2
129	86	72	84	81	158	107	85	140	111	2	2	2	2	2	2	2	2	2	2
103	128	127	90	123	88	69	92	78	59	2	2	2	2	2	2	2	2	1	1
60	63	57	69	87	50	51	54	63	75	1	1	1	1	1	1	1	1	1	1

Parker Ward Roof

The roof of Parker Ward (Fig 7) was thought from documentary references to have been constructed either around AD 1380, or AD 1430, and thus getting an independent date for it would help in the understanding of the development of the site. Access to the roof was by scaffold tower, and for practical reasons of limiting the movement of this tower, only timbers on the south side were sampled.

Details of the locations of the samples and other relevant information are given in Table 8 and shown in Figure 7. Three timbers were rejected from further analysis as they contained too few rings. Four timbers crossmatched each other (Table 9) and were combined into a working site chronology which was subsequently dated to the years AD 1255 – 1403. Samples NGH-PKR06 and 09 did not give significant matches with the other four timbers from the Parker Ward Roof, but they did match TRUSS, with *t*-values of 6.5 and 6.4 respectively. Both were independently dated as well, and when their dates were confirmed, they were added to the working master to produce a new site master, PARKER, which was subsequently dated to AD 1249-1403, the evidence for the strongest matches being presented in Table 10. The positions of overlap and interpretation of felling dates is shown in Figure 8, and the data for the chronology are given in Table 11.

Table 8: Oak (*Quercus* spp.) timbers sampled from the roof of Parker Ward. h/s = heartwood-sapwood boundary, C = complete sapwood

Sample number	Origin of core	Total no of years	Average growth rate (mm yr ⁻¹)	Sapwood details	Date of sequence AD	Felling date of timber AD
NGH-PKR01	Bay 2, rafter 2	105	1.46	5	1286 - 1390	1394 – 1426
NGH-PKR02	Bay 2, rafter 1	121	1.23	12	1275 - 1395	1395 – 1424
NGH-PKR03	Bay 2, rafter 8	122	1.34	20C	1302 - 1403	1403
NGH-PKR04	Bay 2, ashlar piece 8	<40	unmeasured	-	undated	unknown
NGH-PKR05	Bay 2, rafter 7	94	1.17	-	1255 - 1348	after 1357
NGH-PKR06	Bay 2, south wallplate	148	1.29	23	1249 - 1396	1396 - 1414
NGH-PKR07	Bay 3, rafter 4	<40	unmeasured	-	undated	unknown
NGH-PKR08	Bay 3, ashlar piece 2	<40	unmeasured	-	undated	unknown
NGH-PKR09	Bay 3, rafter 2	52	1.95	-	1321-72	after 1381

Table 9: Crossmatching between the individual dated components in chronology PARKER

Sample no	NGH-PKR02	NGH-PKR03	NGH-PKR05	NGH-PKR06	NGH-PKR09
NGH-PKR01	8.4	5.8	5.8	-	-
NGH-PKR02		4.8	5.6	4.3	3.2
NGH-PKR03			5.9	-	3.2
NGH-PKR05				3.7	3.2
NGH-PKR06				-	-

Table 10: Dating evidence for chronology PARKER

Dated multi-site or single-site master chronology	PARKER AD 1249 - 1403	
	<i>t</i> -value	Overlap (yrs)
Hants97 (Miles pers comm)	5.9	155
Southern England (Bridge 1988)	5.8	155
London1175 (Tyers pers comm)	5.7	155
Castle Acre, Norfolk (Tyers 2000)	8.5	108
Gentleman's Row, London (Bridge 1997)	7.5	113
Little Wymondley, Hertfordshire (Bridge 2001b)	6.9	88
Cann Hall, Essex (Tyers 1998)	6.6	103
Toddington, Bedfordshire (Bridge 2001a)	6.2	144
Fyfield, Essex (Bridge 1998b)	6.2	86
Thetford, Norfolk (Groves 2002)	6.1	155
Odiham, Hampshire (Miles and Haddon-Reece 1996)	6.0	155

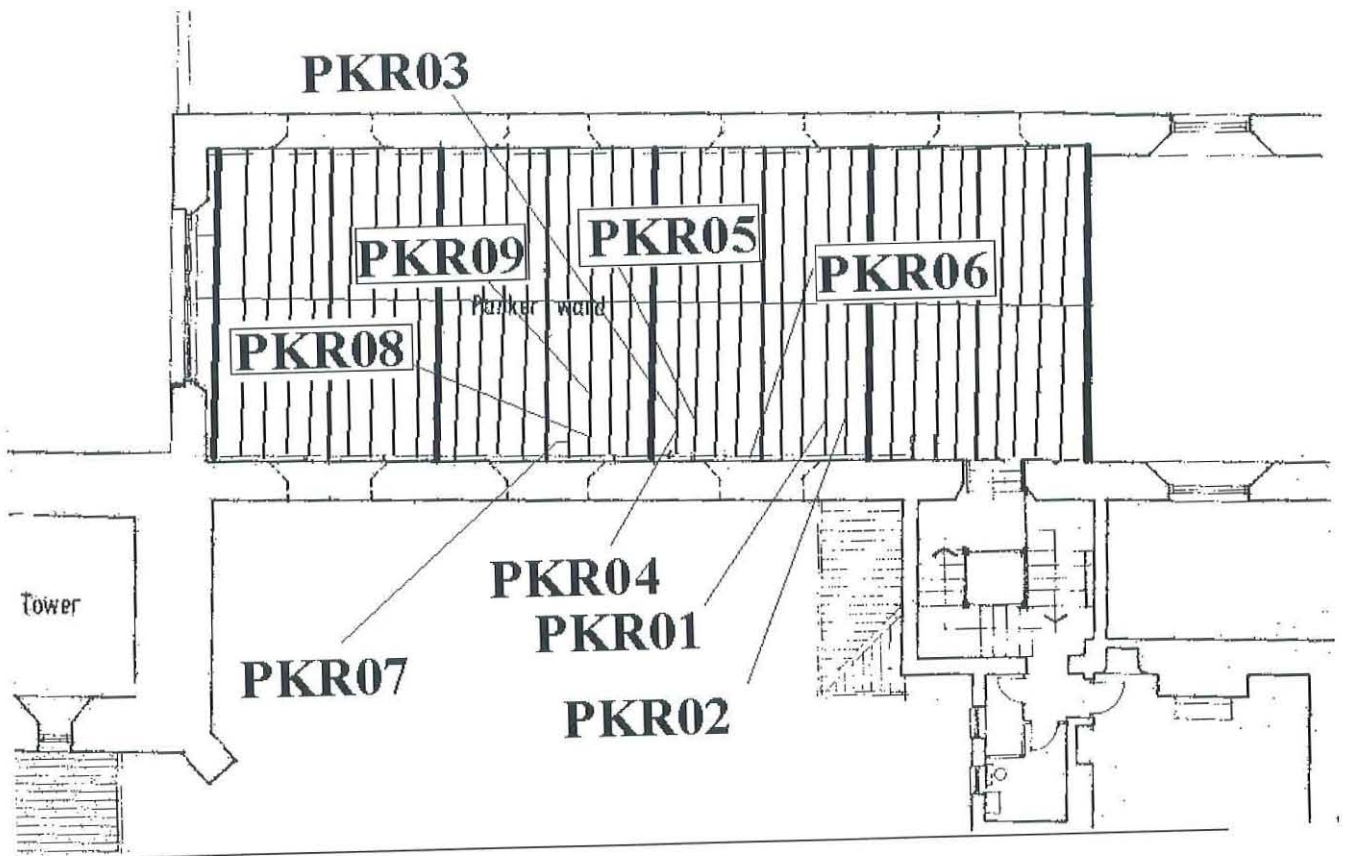


Figure 7: First-floor plan of Parker Ward and some neighbouring buildings showing the approximate locations of samples taken for dendrochronology

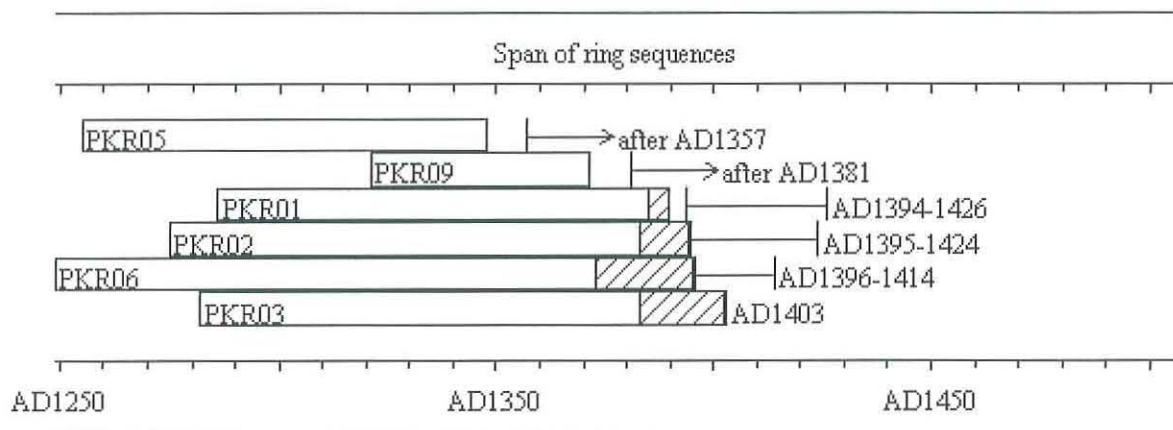


Figure 8: Bar chart showing the relative positions of overlap of the dated timbers from the roof of Parker Ward. Hatched portions of the bar represent sapwood, and the interpreted felling dates have been added

Interpretation and Discussion

One sample (PKR06) had some distortion to the rings in the first half of the sample, and a break in the final third of the core which made the sequence difficult to match. Nevertheless, after matching against TRUSS, it was included in the site sequence PARKER and enhanced the overall matching quality of that sequence.

Sequence PKR09 did not appear to match well with the other dated sequences, but matched well against TRUSS. It has a similar felling date range to the other trees, and later than the trees in sequence TRUSS, so perhaps indicates more than one source of timber for the construction of the this roof.

One of the other dated sequences, (PKR03) had complete sapwood, and its last year of growth was AD 1403. The felling dates for the other sequences with sapwood or heartwood-sapwood boundaries included this date, and it is therefore concluded that the most likely felling date, assuming all these timbers to represent a single batch, is AD 1403, or within a few years after this date. This date is later than the possible *c* AD 1380 date for construction, which it would appear, can now be disregarded, and somewhat earlier than the alternative suggestion of *c* AD 1430. This has therefore given useful information concerning the development of this part of the site. The date is a few years after the date range for the relict truss in the stairway to this ward discussed above.

Table 11: Ring width data for the site chronology PARKER AD 1249 - 1403

ring widths (0.01 mm)										no of trees									
315	370	442	368	337	309	348	259	255	190	1	1	1	1	1	1	2	2	2	2
159	187	210	255	184	104	104	132	158	170	2	2	2	2	2	2	2	2	2	2
134	123	147	144	152	111	99	106	155	118	2	2	2	2	2	2	3	3	3	3
117	123	138	250	205	248	220	193	150	196	3	3	3	4	4	4	4	5	5	5
288	306	269	273	232	197	208	179	164	130	5	5	5	5	5	5	5	5	5	5
114	91	114	105	85	109	109	105	107	147	5	5	5	5	5	5	5	5	5	5
159	142	108	108	88	106	119	117	121	124	5	5	5	5	5	5	5	5	5	5
95	93	140	122	125	91	87	69	111	148	5	5	6	6	6	6	6	6	6	6
148	106	95	111	118	154	179	142	106	108	6	6	6	6	6	6	6	6	6	6
155	168	112	109	87	113	162	129	111	119	6	6	6	6	6	6	6	6	6	6
146	126	174	143	125	135	112	100	127	83	5	5	5	5	5	5	5	5	5	5
103	113	123	115	171	173	128	121	108	103	5	5	5	5	5	5	5	5	5	5
111	122	102	113	115	99	109	98	85	87	5	5	5	5	4	4	4	4	4	4
86	87	116	104	97	101	90	100	110	136	4	4	4	4	4	4	4	4	4	4
130	121	106	73	91	91	94	88	71	93	4	4	3	3	3	3	3	2	1	1
72	79	69	48	65						1	1	1	1	1					

Floor beams between Fawcett and Parker Wards

Five large 'inserted' beams support the floor between the lower Fawcett Ward and the upper Parker Ward (Figure 9). These had thick layers of paint over them, but are so large that it was felt that they would probably contain enough rings for further study and so they were sampled.

Some of these have traces of painted writing on, and they are thought to have been inserted in the late-sixteenth century. They appeared to have no traces of sapwood, and in most cases their painted exteriors made it difficult to determine how many rings they might contain. Numbering them from the west end, beam 2 was judged to have too few rings to be datable, despite its large size. Beam 3 had more writing than the others and was not cored. Cores were taken from beams 1, 4, and 5 (Table 12). None of these three samples, which reached to the centre of the tree, had more than 43 rings, and no further analysis was undertaken.

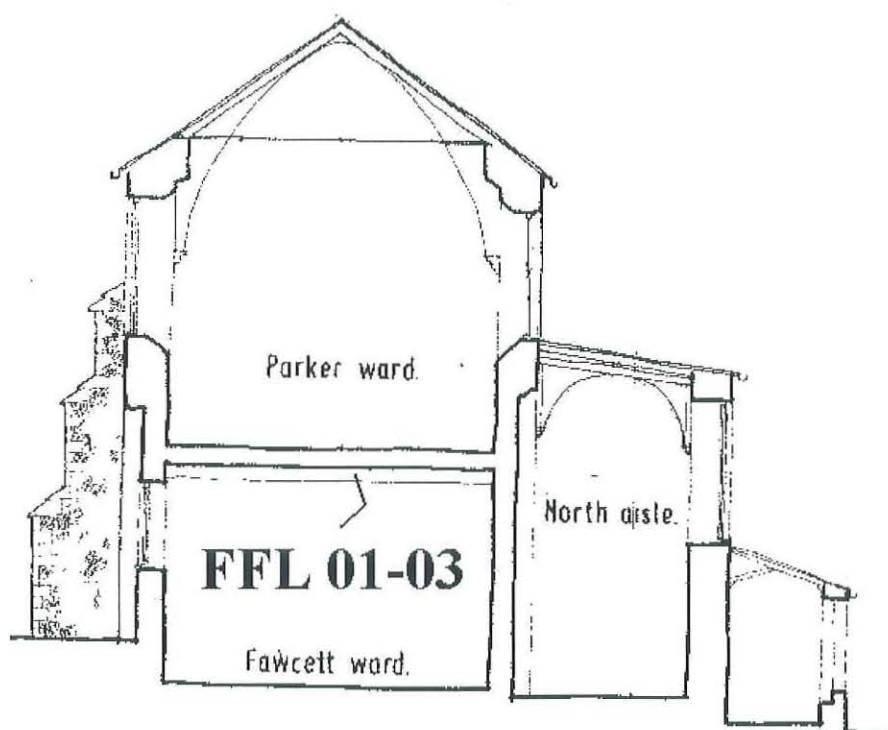


Figure 9: Cross section of Fawcett and Parker Wards showing the position of the beams sampled (adapted from an original by Wearing, Hastings and Norton, Norwich)

Table 12: Oak samples from the beams between Fawcett and Parker Wards

Sample number	Origin of core	Total no of years	Average growth rate (mm yr ⁻¹)	Sapwood details
NGH-FFL01	Beam 4	43	unmeasured	-
NGH-FFL02	Beam 1	43	unmeasured	-
NGH-FFL03	Beam 5	<40	unmeasured	-

Floor beams inserted between Pump and Eagle Wards

The two major beams supporting the floor between these two wards are moulded with a complex profile, with stops at one end only. They are thought to have been re-used from the nearby Bishop's Palace, being inserted here in the late-sixteenth century. Only the eastmost beam was sampled (Table 13), the other being difficult to access. This beam yielded a sequence of 92 rings (Table 14) and is rather sensitive (ie has high year-to-year variation). The series was compared with a range of chronologies, including the site series from elsewhere in the Great Hospital, but no single matching position was accepted as being well replicated enough to consider the series dated.

Table 13: Sample from the beam between Pump and Eagle Wards

Sample number	Origin of core	Total no of years	Average growth rate (mm yr ⁻¹)	Sapwood details
NGH-EFL01	Eastern beam	92	2.89	-

Table 14: Ring width data for the undated series NGH-EFL01, from the eastern re-used floor beam

ring widths (0.01mm)									
340	265	364	273	108	127	272	240	172	173
165	119	132	131	209	230	197	223	164	172
208	199	228	265	204	191	275	310	330	301
342	327	306	313	288	304	334	184	226	148
357	397	507	386	292	314	307	480	430	333
252	403	484	350	400	307	353	327	550	488
544	232	420	453	434	339	253	255	362	302
350	199	199	281	270	450	325	170	277	263
386	230	162	105	101	255	374	428	250	241
272	357								

Stairs to Eagle Ward and Parker Ward

The sets of stairs to both these wards are identical in style, and thought to be contemporaneous. No drawings are available of the timbers which support the stairs, but a few timbers of each of these supporting structures were sampled (Table 15) and their approximate locations are shown in Figure 10. The timbers from the stairs to Eagle Ward (EST) had complete sapwood on the timbers, but this disintegrated on coring.

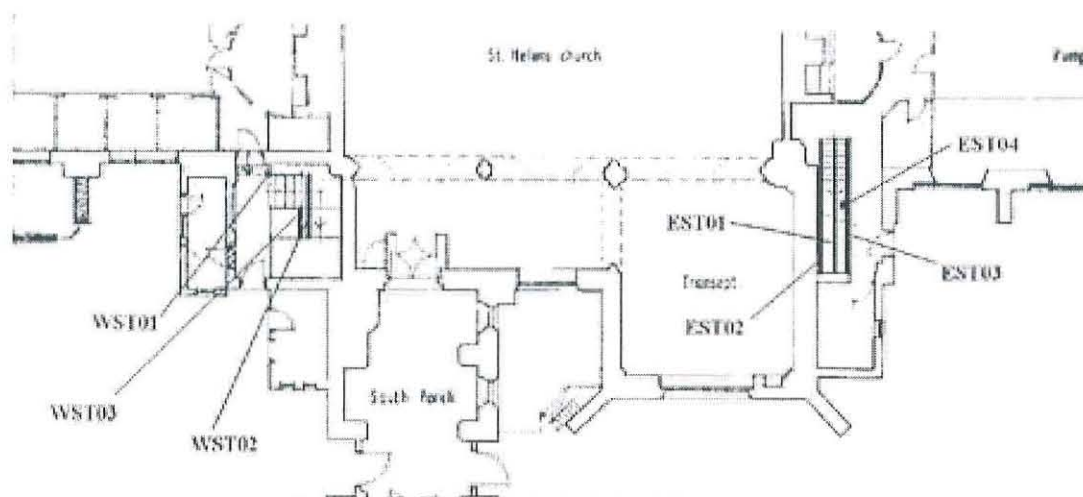


Figure 10: Drawing showing the approximate locations of the timbers supporting the stairs sampled for dendrochronology

Table 15: Oak (*Quercus* spp.) timbers sampled from the stairs to Eagle and Parker Wards. h/s = heartwood-sapwood boundary

Sample number	Origin of core	Total no of years	Average growth rate (mm yr ⁻¹)	Sapwood details
WST01	Newel post	<40	unmeasured	-
WST02	Support under treads	<40	unmeasured	-
WST03	Sole plate	<40	unmeasured	-
EST01	Central longitudinal support	51	2.88	h/s
EST02	West support	<40	unmeasured	h/s
EST03	East support	48	2.55	h/s
EST04	Stud in east wall	<40	unmeasured	h/s

Samples EST01 and EST03 crossmatched ($t = 7.5$, 47 years overlap) and were combined to form a 52-ring sequence, STAIRS (Table 16), which was compared with a range of reference material. No consistent matches were found for this short sequence, and it remains undated.

Table 16: Ring width data for the undated site chronology STAIRS

ring widths (0.01mm)										no of trees									
407	317	282	222	221	243	352	371	174	271	1	2	2	2	2	2	2	2	2	2
271	298	312	351	339	284	190	326	293	348	2	2	2	2	2	2	2	2	2	2
471	319	427	330	371	356	341	371	343	361	2	2	2	2	2	2	2	2	2	2
306	408	160	174	152	201	197	211	192	197	2	2	2	2	2	2	2	2	2	2
149	148	125	187	189	155	253	231	249	235	2	2	2	2	2	2	2	2	1	1
150	246									1	1								

Conclusions

The timbers throughout the Great Hospital showed a range of characteristics, many being fast-grown, whilst yet others, such as those used in the relict St Helen's Church truss were slow grown. This suggests that a variety of sources of timber have been used throughout its history. The work has given added dating evidence to assist in the interpretation of the development of the site, confirming the date of the cloister roof, highlighting the date of the relict truss of St Helen's Church, and its similarities to some timbers from the roof of Parker Ward. The dating of the Parker Ward roof has been valuable in dismissing a potential earlier date.

Some of the largest timbers encountered anywhere, eg the re-used timbers supporting the floor to Eagle Ward were found to contain very few rings. Areas in the tower, and the boards of the ceiling of the Eagle Ward could not be properly assessed because of problems of access, but these should be investigated if they become available at some stage in the future.

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