

**DENDROCHRONOLOGICAL ANALYSIS OF OAK TIMBERS FROM
WISSON HILL, 16 WELFORD ROAD
BIDFORD-ON-AVON, WARWICKSHIRE, ENGLAND**

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Tree-Ring Services Report: BIWH/45/19

SUMMARY

The main range of the house now comprises two long bays, oriented east-west, with the purlins extending a short distance beyond the east wall of the hall, where a later two-bay parlour crosswing has replaced the inferred third bay. A former cross-passage at the west end of the hall range also suggests the possibility of a further bay beyond it. The hall occupies one and a half bays and has an original ceiling with heavy transverse and longitudinal beams, chamfered with pyramid stops.

The roof trusses have clasped purlins and raking queen-struts, with curved windbraces, but most of the common rafters have been replaced. All the original timbers over both bays and those extending to the east are substantially smoke-blackened, despite the existence of the original hall ceiling. It seems likely that part of the westernmost section of the ceiling held a smoke-hood from which the smoke simply rose into the roof space.

Most of the structural timbers are of elm, but the main range roof trusses are of oak. Measured tree-ring series from five timbers sampled are matched together to form an 85-year site chronology, which is dated to span 1445 to 1529. Three timbers felled in the spring of 1530, together with a compatible felling-date range produced from two other timbers dated, provide good evidence that construction occurred in 1530, or perhaps soon after. Thus, the house dates from the very earliest period of modernisation, converting medieval open halls to ceiled houses with chimneys, typically in Warwickshire during the sixteenth century.

All the accessible timbers in the cross-wing are of elm, so could not be dated, but it seems likely to have been added later in the sixteenth century.

KEYWORDS

Dendrochronology, 16th Century, Standing building, Warwickshire, Bidford-on-Avon.

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Individual dendrochronology reports should perhaps be considered interim reports which make available the results of specialist investigations in advance of possible further analysis and publication. Their conclusions may sometimes have to be modified in the light of information which was not available at the time of the investigation. Readers are requested to contact the author before citing this report in any publication. Reports may be ordered from the Tree-Ring Services website (www.tree-ring.co.uk).

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INTRODUCTION

The increased interest in Britain's past is demonstrated by such television programmes as "Time Team" and "The House Detectives". More and more people wish to know precisely when ancient buildings were constructed in order to better understand the history of their occupants and land in which we live. Although it is sometimes possible to date a building on stylistic grounds, a precise date is rare except when there is a date-stone or documentary evidence.

The increasing use of dendrochronology (tree-ring dating) has changed this scenario, at least for buildings with timbers containing sufficient rings for analysis. The science is simple in concept. The width of a tree's growth rings varies from year to year, so that each series of years has a unique pattern of narrow and wide rings. We now know in detail the pattern of rings shown by oak trees in England for at least the last 2000 years, and there is some work in progress on other species, such as pine, beech and yew. Tree-ring dating typically involves small cores of wood being taken from the structural timbers of a building. Once sanded to a polished finish, these samples show the pattern of rings laid down during the lifetime of the trees from which the timbers were cut. If this pattern is then compared with "master chronologies" it is often possible to identify the felling date of the trees with astonishing accuracy. Where bark is present, it is possible to give a precise year, sometimes even the season of the year. We know that oak for building was almost always used "green", (unseasoned, not having been felled and prepared until required), so construction dates can be determined in which we can place considerable confidence.

Recording Timber-Framed Buildings

National trends in building activity inevitably conceal regional differences that can only be explained by detailed local studies. The Royal Commission on the Historical Monuments of England (RCHME) has analysed 53 medieval buildings in Kent (Pearson 1994). Hampshire County Council has analysed well over 100 buildings in the county (Roberts 2003). These projects utilize the specific dates provided by tree-ring analysis to refine the typological and stylistic dating of buildings.

Tree-Ring Services is committed to the development of date-range spans for stylistic features to help refine the dating of timber-framed buildings. Buildings are recorded using a 'Tick-Box' sheet (available at www.buildingarchaeology.co.uk) which is used to summarise the most common and distinctive 'key features'. This information is entered into a purpose-built Building Archaeology Research Database (BARD), a resource then available for further analysis (Moir *et al.* 2012). BARD has been used to analyse 177 dwellings in Surrey and establish date ranges for 52 key features (Wild and Moir 2013). Each additional building tree-ring dated by Tree-Ring Services adds to this research and should eventually allow date ranges to be extended to other counties.

Harris (1978) provides a useful introduction to the study of timber-framed buildings, while Brunskill (2000) details the study of vernacular architecture. Alcock's (1996) glossary provides illustrative drawings which are particularly useful in facilitating the naming of timbers in a building.

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Wisson Hill (SP 1081 5119)

The main range of the house now comprises two long bays (**Photos 1 & 2**), oriented east-west, with the purlins extending a short distance beyond the east wall of the hall, where a later two-bay parlour crosswing has replaced the inferred third bay. A former cross-passage at the west end of the hall range also suggests the possibility of a further bay beyond it; a narrow room between the cross-passage and the hall was perhaps a buttery/pantry. The hall occupies one and half bays and has an original ceiling with heavy transverse and longitudinal beams, chamfered with pyramid stops (**Photos 3 & 4**). The wall-framing consists of large rectangular panels with curved braces and jowled posts.



Photo 1: Wisson Hill – main range (right) & wing (left)



Photo 2: Wisson Hill – west end of main range



Photo 3: Mortice in front wall post formerly holding the end of one of the hall ceiling's transverse beams

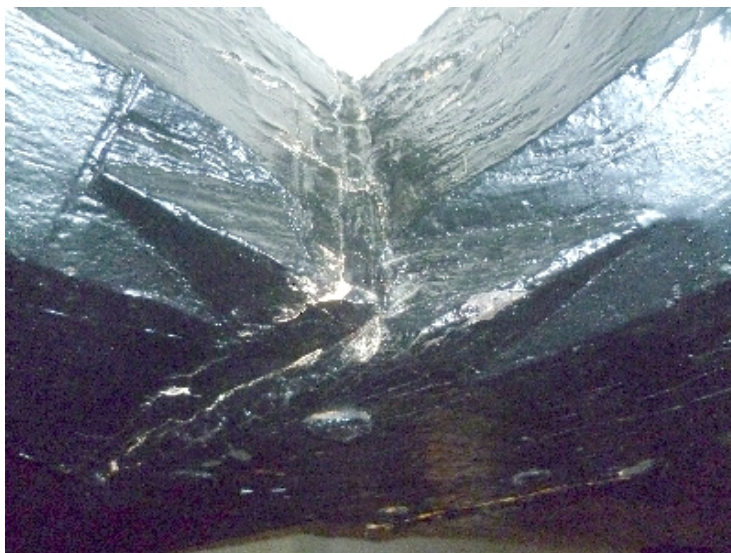


Photo 4: Pyramid stops on the floor beams



Photo 5: Smoke-blackened principal rafter and windbraces

The roof trusses have clasped purlins and raking queen-struts, with curved windbraces, but most of the common rafters have been replaced. All the original timbers over both bays and those extending to the east are substantially smoke-blackened (**Photo 5**), despite the existence of the original hall ceiling. It seems likely that part of the westernmost section of the ceiling held a smoke-hood from which the smoke simply rose into the roof space. Later, a lateral stack was inserted in the hall and the upper floor ceiled and partitioned, with a stair inserted in the position of the former smoke hood.

The cross-wing seems likely to have been added later in the sixteenth century.

Objective of the Analysis

The main objective of this analysis was to provide dendrochronological evidence to date the primary phase of construction of the building.

Dendrochronological Assessment

Wisson Hill was visited on the 12th November 2019 and the timbers assessed for their potential use in dendrochronological study. Oak timbers with more than 50 rings, traces of sapwood or bark, and accessibility were the main considerations.

The wall-frame timbers observed appeared to be oak, but the transverse and spine beams were thought to be elm. The majority of rafters appeared to be elm replacements, interspaced with a few smoke-blackened oak timbers. The timbers in the principal roof trusses were oak and smoke blackened, although the collars were thought to be elm. The oak timbers in the roof trusses appeared to contain around 60 rings, and full sapwood survived on a number of these timbers, therefore sampling concentrated mainly on these timbers.

METHODOLOGY

Methods employed by Tree-Ring Services in general are those described in English Heritage guidelines (Hillam 1998). Part 2 of the Guidelines is designed for large projects in conjunction with other specialist disciplines and is not applicable to the type of privately commissioned dendrochronological analysis generally conducted by Tree-Ring Services and is therefore not used. Details of the methods employed for the analysis of this building are described below.

Sampling and Preparation



Photo 6: Extraction of a core in progress

Whenever possible, timbers with more than 50 annual growth rings are selected for sampling. This is necessary to provide a pattern of rings of sufficient length to be unique to the period of time when the parent tree was growing. Timbers are sampled using purpose-made 12mm and 15mm diameter corers attached to an electric drill. Sampling is located as discreetly as possible in what appear to be original timbers and is orientated in the most suitable direction to maximize the numbers of rings for subsequent analysis. Extracted core samples are immediately taped and glued onto wooden laths on site and then labelled, ready for subsequent analysis.

Tree-ring series are revealed through sanding with progressively finer grits to a 600 abrasive grit finish to produce results suitable for measuring, see **Photo 7**. When required, for example where bands of narrow rings occur, further preparation is performed manually. Where requested, extraction holes are "made good", employing pine dowelling, wood-glue, sawdust and wood stains to restore the timbers to their original appearance.



Photo 7: An example of the tree-ring series revealed through the sanding of cores

Tree-ring series are measured under a $\times 20$ stereo microscope to an accuracy of 0.01mm using a microcomputer-based travelling stage. All samples are measured from the centremost ring to the outermost. Samples considered unsuitable for dating purposes are then rejected. These include samples with disturbed ring series which cannot be measured due to knots or bands of extremely narrow rings, and samples with too few rings.

Samples of fewer than 50 rings are sometimes rejected from dendrochronological analysis because their ring patterns may not be unique (Hillam *et al.* 1987). Although this is certainly true of all ring series of fewer than 30 rings, which should not be used in dating (Mills 1988), samples with 30 to 50 rings may be dated in some circumstances (Hillam 1998). It has been felt wise to maximize the recorded amount of data, and therefore series of 35–50 rings are included in analysis and considered for dating, usually when they match well with a number of other series. Samples are measured twice and the two sets of measurements cross-matched and plotted visually as a check. Where series match satisfactorily they are averaged and the resulting series are used in subsequent analysis.

Series containing fewer than 50 rings are suffixed ‘-S’, and series from managed trees ‘-M’ to help indicate that additional caution must be exercised in dating.

Cross-correlation algorithms are then employed to search for the positions where tree-ring series correlate and therefore possibly match. All statistical correlations are reported as *t*-values derived from the original CROS73 algorithm (Baillie and Pilcher 1973). A value of 3.5 or over is usually indicative of a good match as it represents the value of *t* which should occur by chance only once in every 1000 mismatches (Baillie 1982), and the higher the *t*-value the closer to congruency in the cross-matching. However, due to the remaining small risk of high *t*-values being produced by chance, all indicated correlations are further checked to ensure that corroborative high results are obtained at the same relative position against a range of independent tree-ring series. Visual comparisons of series are also employed to support or reject possible cross-matches and serve as a means of identifying measuring errors.

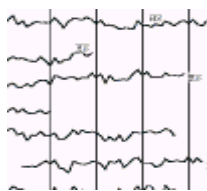
Timber Groups



A further element of the tree-ring analysis of buildings and archaeological assemblages is the grouping of timbers within the sampled material. Inspection of *in situ* timbers may indicate that samples derive from a common timber, while common arrangements of anatomical features (knots & branching) may also indicate that samples are derived from a single tree.

Tree-ring analysis is used to support suggestions of same-tree groups between samples based on a combination of information. Timbers derived from the same tree are generally expected to have *t*-values over 10, although lower *t*-values may be produced when different radii measured from the same tree are compared. Tree-ring series producing *t*-values of 10 or above are examined to identify same-tree groups. Good comparisons of visual matching, growth rates, short and longer-term growth patterns, are combined with pith information, sapwood boundaries, bark and anatomical anomalies, to help decide whether timbers are likely to come from the same tree. Where timbers are assessed as deriving from the same tree, to avoid bias the series are averaged to produce a single tree-ring series before inclusion in the final site chronology, but inevitably some same-tree samples go undetected by dendrochronology.

Chronology Building and Cross-dating



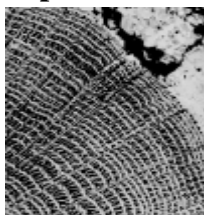
The process of cross-matching compares all tree-ring series against one another and those found to cross-match satisfactorily together are combined to create an average series. The site mean(s) and individual ring series which remain unmatched with the site mean are then tested against a range of established reference series (reference chronologies). Significant *t*-values replicated against a range of series at the same position with satisfactory visual matching are similarly used to establish cross-matches with reference chronologies. Where cross-matching is established against dated reference chronologies, calendar dates can be assigned to the site series. The dates of the first and last rings of dated series are produced as date spans. These dates should not be confused with felling dates.

Felling Dates



Series dated by the cross-dating process provide calendar year dates for the final tree-ring present in the measured timber sample. The interpretation of these dates then relies upon the nature of the final rings in the series. Where bark survives intact on a sample a felling date is given as the date of the last ring measured on the tree-ring series. Based on the completeness of the final ring it is sometimes even possible to distinguish between spring, summer or winter fellings, corresponding to approximately March to May, June to September and October to February, respectively. Where timbers were felled in either spring or summer and the final ring is incomplete and therefore not measured, allowance has to be made for the one-year discrepancy between the end of a measured series and the actual year of felling.

Sapwood Estimates



Where bark is missing from oak samples, as long as either sapwood or the heartwood/sapwood boundary have been identified, an estimated felling-date range can be calculated using the maximum and minimum number of sapwood rings that were likely to have been present. Sapwood estimates have varied over time with different data sets, geographical location and researchers. A general trend identified is that the number of sapwood rings in oak decreases from north to south and from west to east across Europe.

However, simply not enough is yet understood about sapwood variations and the mechanisms responsible for them. A generally accepted sapwood estimate of between 10 and 55 rings for British and Irish oaks (at 95% confidence) was given in 1987 (Hillam *et al.* 1987). Analysis of the increased data set available ten years later indicates a range of 10 to 46 rings to be more appropriate for England (Tyers 1998). Currently, as research in areas improves, sapwood estimates are refined and new estimates applied. Therefore, when dendrochronological dates are produced, the reference to the sapwood estimate used in its calculation should always follow.

This report applies a sapwood estimate of a minimum of 9 and maximum of 41 annual rings, which means that 19 out of every 20 trees examined is expected have between 9 and 41 sapwood rings. This sapwood estimate is currently applied to most of the south-east region and has been arrived at by Oxford Dendrochronology Laboratory (Haddon-Reece *et al.* 1990; Miles 1997). Felling-date ranges have been calculated by adding the sapwood estimate of minimum and maximum missing rings to the date of the heartwood/sapwood boundary. Felling-date ranges have been refined by the presence of surviving sapwood where appropriate, see **Table 3**. Where samples ending in heartwood were dated, "felled after dates" have been calculated by adding the minimum expected number of missing sapwood rings to the samples' final ring dates. These dates represent the earliest probable felling dates. However, the actual felling date of a tree may be decades later due to an unknown number of missing heartwood rings.

Felling Groups



It is common to find that timbers used in the construction or repair of smaller buildings, or identifiable parts of larger buildings, date into groups whose felling dates occur within a narrow range of years. These groups are called associated fellings. Where they are identified the average heartwood/sapwood boundary of the component timbers is used

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to calculate an overall estimated period of felling. Close location association and a short (21 years at most) range of heartwood-sapwood boundary dates are normally used to define these groups. The estimates do not assume that trees within a group were felled at the same time. However, evidence published by the Nottingham University Tree-Ring Dating Laboratory indicates that the range estimate encompasses the possible different individual felling dates (English Heritage 2001). Where bark is present within a group of timbers and other evidence does not dispute the date, it is assumed that all the trees within a felling group were felled in the same year.

Date of Construction



It is vitally important to understand that dendrochronological analysis provides dates for when trees were felled and not necessarily when their timbers were used. Green or freshly felled wood is, however, far easier to work and it is standard practice to assume that medieval timbers were felled as required and used green (Rackham 1990; Miles 1997).

However, the use of previously felled timbers in vernacular construction was not uncommon, with short-term stockpiling of usually not more than 1 to 2 years (Miles 1997), and the use of leftovers or re-used timbers may certainly give rise to differences between felling dates and the date of construction where samples are analysed in isolation. A number of samples having a close range of felling dates are required from different elements of a building either to strongly indicate a single date of construction or to identify separate phases of construction.

Tree-Ring Services - Methods and Criteria



Tree-ring analysis and graphics are achieved via a dendrochronological programme suite developed by Ian Tyers of Sheffield University (Tyers 1999). Alcock's (1996) timber-framed building nomenclature has been adopted throughout to facilitate regional comparisons. Summary features of most buildings dated, are made available on the Building Archaeology Research Database (Moir *et al.* 2012). Tree-Ring Services reports are published with tree-ring data to enable independent verification and

allow their use in dating. Report may be ordered through the website at www.tree-ring.co.uk.

For the analysis of a building an initial assessment is conducted with the owner and recommendations in line with English Heritage guidelines on sampling strategies made, (i.e., that a minimum of 8 to 10 samples are obtained per building or per phase). However, the final decision concerning the number of samples taken for analysis rests with the individuals who commission the analysis. It is generally beyond the scope of an analysis to describe a building in detail or to undertake the production of detailed drawings. Without the benefit of other specialist disciplines there is always the danger that re-used timbers may be inadvertently selected, and the conclusions presented in a report may be modified in the light of subsequent work.

RESULTS

Nine core samples and one section were taken from the main range of Wisson Hill on the 12th November 2019. The main trusses of the main range were numbered from 1 in the east to 3 in the west (with a partition between truss 1 and 2 labelled X). The wing was

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labelled from truss 4 in the north to truss 6 in the south. Sampling locations are indicated on a sketch plan of the building (see **Appendix I**), and the exact locations of the samples taken are shown in the photographs below.



Photo 8: Core BIWH01



Photo 9: Section BIWH02 (left) & core BIWH03 (right)



Photo 10: Cores BIWH04 (right) & BIWH05 (left)



Photo 11: Cores BIWH06 (left) & BIWH07 (right)



Photo 12: Cores BIWH08 (left) & BIWH09 (right)



Photo 13: Core BIWH10

All ten samples were confirmed as oak (*Quercus* spp). Series BIWH01, BIWH06 and BIWH07 contained less than 50 rings and were identified by the suffix '-S'. Sample BIWH08 contained sudden and sustained periods of ring-width reduction characteristic of

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direct management and was identified by the suffix ‘-M’. Three samples were recovered with complete sapwood and one with probably complete sapwood.

Five series were found to match together (see **Table 1**) and combined to form an 85-year site chronology named BIDFD-WH.

Table 1: Cross-matching between the five series which form the site chronology BIDFD-WH

File names	Start dates	End dates	BIWH02	BIWH03	BIWH04	BIWH05
BIWH01-S	AD1468	AD1511	4.86	-	-	-
BIWH02	AD1468	AD1529		-	5.34	4.94
BIWH03	AD1445	AD1500			3.54	4.15
BIWH04	AD1474	AD1529				8.45
BIWH05	AD1467	AD1529				

KEY: - = *t*-values less than 3.50. \ = overlap < 30 years.

This site chronology was found to produce consistently high *t*-values against reference chronologies (**Table 2**), with the first ring of the series at AD 1445 and the final ring of the series at AD 1529.

Table 2: Dating evidence for the site chronology BIDFD-WH against reference chronologies

BIDFD-WH dated AD 1445 TO AD 1529					
File	Start Date	End Date	<i>t</i> -value	Overlap (yr.)	Reference chronology
RHLS07	AD1469	AD1559	6.30	61	Little Santon Farm - Reigate Heath - Surrey (Moir 2012)
BAYASQ02	AD1469	AD1550	6.07	61	The Dower House - Little Bayham - E Sussex (Arnold and Howard 2006)
CRANL-WM	AD1451	AD1540	5.85	85	Whitemeads - Cranleigh - Surrey (Moir 2008b)
GODAL-CS	AD1440	AD1556	5.85	85	3 Church St - Godalming - Surrey (Moir 2005a)
BOYES	AD1470	AD1553	5.82	60	Boyes Croft - Maltings - Dunmow - Essex (Bridge 1999)
8CORONA	AD1466	AD1540	5.78	64	8 Coronation Square - Lydd - Kent (Moir 2001)
CRANL-9	AD1309	AD1577	5.47	85	Cranleigh Area - Surrey (Moir 2008a)
EFFIN-H3	AD1472	AD1550	5.41	58	Front wing - Home Farmhouse - Effingham - Surrey (Moir 2010)
CHIDD-SL	AD1397	AD1531	5.34	85	Skinnners Land Farm - Chiddingfold - Surrey (Moir 2007)
WITLY-2	AD1353	AD1567	5.15	85	Parish of Witley - Surrey (Moir 2005b)
WITLY-TC	AD1367	AD1567	5.12	85	Turnpike Cottage - Milford - Surrey (Moir 2005c)
NWDGT-O2	AD1445	AD1540	5.11	85	Old beam Brook - Newdigate - Surrey (Moir 2003)

KEY: **Bold** = indicates a composite reference chronology consisting of multiple site chronologies.

INTERPRETATION

Felling Dates

The sapwood allowance used to calculate the felling dates now discussed is presented in **Table 3**, and the bar diagram (see **Figure 1**) helps to demonstrate the findings visually.

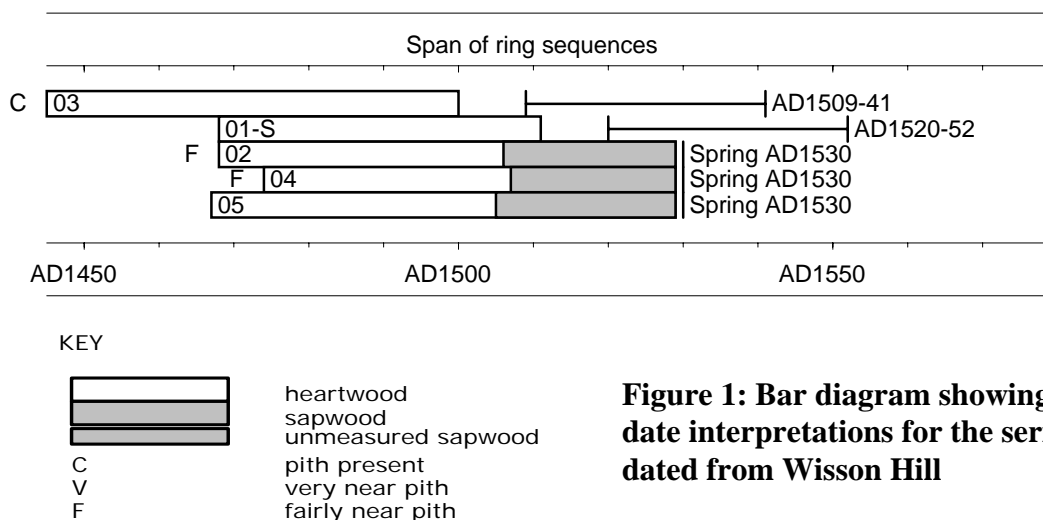


Figure 1: Bar diagram showing the date interpretations for the series dated from Wisson Hill

Wisson Hill produced three precise felling dates. Under the microscope, three samples were all felled in the spring of 1530. Together with the compatible felling-date range for two other samples dated, this provides good evidence that construction occurred in 1530, or soon after.

The average age of the trees dated is 73 years.

CONCLUSIONS

Most of the structural timbers are of elm, but the main range roof trusses (with the exception of the collars) are of oak. Measured tree-ring series from five timbers sampled are matched together to form an 85-year site chronology, which is dated to span 1445 to 1529. Three timbers felled in the spring of 1530, together with a compatible felling-date range produced from two other timbers dated, provide good evidence that construction occurred in 1530, or perhaps soon after. Thus, the house dates from the very earliest period of modernisation, converting medieval open halls to ceiled houses with chimneys, typically in Warwickshire during the sixteenth century.

All the accessible timbers in the cross-wing are of elm, so could not be dated, but it seems likely to have been added later in the sixteenth century.

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Table 3: Summary of dendrochronological analysis

Sample	Timber and Position	Timber Conversion	Timber Dimensions (mm)	Rings	Sapwood	Average Growth Rate (mm/yr)	Sequence Date Range	Felling Date Range	Rings to Pith	Age Estimate
BIWH01-S	South purlin - bay 2	A2	180 x 200	44	+HS	2.1	AD1468-AD1511	AD1520-52	> 15	77
BIWH02	North purlin - bay 3	A2	180 x 200	62	23+¼B	1.68	AD1468-AD1529	Spring AD1530	10	72
BIWH03	North queen post - truss 2	B2	220 x 70	56	+HS	1.98	AD1445-AD1500	AD1509-41	0	74
BIWH04	North queen post - truss 2	B2	270 x 100	56	22+¼B	1.7	AD1474-AD1529	Spring AD1530	10	66
BIWH05	South queen post - truss 2	B2	250 x 80	63	24+¼B	1.48	AD1467-AD1529	Spring AD1530	> 15	78
BIWH06-S	South wallplate - bay 2	A2	200 x 180	38	3(+2)	1.66			> 15	53
BIWH07-S	Tiebeam - truss 2	B2	280 x 200	48	+HS	2.59			> 15	63
BIWH08-M	Centre post - truss 3	B2	300 x 120	97	5(+16+?B)	1.87			10	107
BIWH09	North post - truss 3	B2	320 x 190	<35						
BIWH10	Transverse beam - truss x	A2	200 x 160	62	5(+23)	1.71			5	67

KEY	
+	= additional information not measured on the core
(+)	= unmeasured heartwood rings at the beginning or end of the core
HS	= heartwood/sapwood boundary
?B	= probable bark
¼B	= spring bark
½B	= summer bark
Bw	= winter bark
A2	= boxed heartwood & trimmed
B2	= halved & trimmed
C2	= quartered & trimmed
E2	= tangential & trimmed

Note: Timber dimensions were generally taken at the core sample location and are not necessarily the maximum dimensions of the timber

ACKNOWLEDGEMENTS

I would like to thank the owner, Amanda Billingsley, for commissioning this analysis. All the samples have been returned to be archived with the building. I am grateful to Nat Alcock of the University of Warwick for the recording and interpretation of the building.

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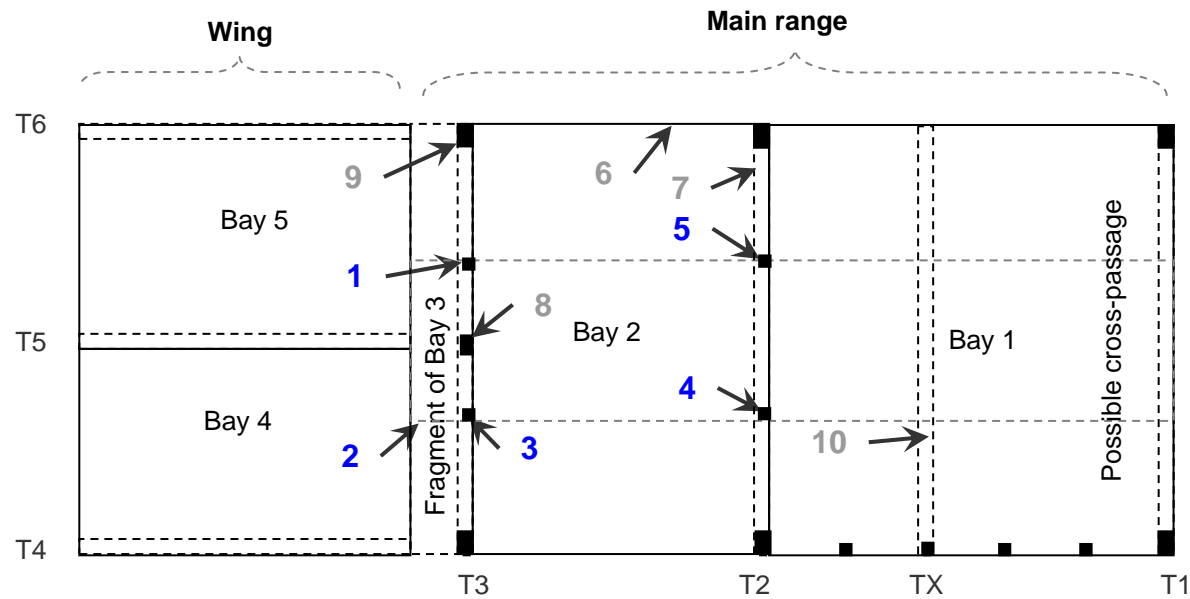
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APPENDIX I: Plan of Wisson Hill



KEY:
Numbers identify location of the cores taken.
Blue = Dated to AD 1530
Grey = Undated



Scale: 0 1 2 3m

APPENDIX II: Raw ring-width data

Ring widths (0.01mm), starting with innermost measured ring

BIWH01-S

108	105	67	99	62	78	107	129	90	64
52	91	96	110	107	144	108	88	71	86
95	112	149	95	118	133	185	193	251	315
197	307	366	437	493	398	375	561	539	498
383	419	361	416						

BIWH02

104	91	40	45	49	56	72	144	108	94
127	175	169	176	186	239	244	217	170	189
158	206	260	207	196	175	208	203	261	232
193	172	159	206	162	154	118	196	206	136
136	193	166	175	181	120	140	147	106	115
203	189	153	123	186	141	227	151	200	268
329	249								

BIWH03

388	217	206	157	274	259	224	196	266	181
167	128	106	117	72	91	93	182	445	355
298	236	235	194	177	157	121	190	148	179
187	184	158	181	240	300	238	269	244	329
299	192	196	174	217	256	152	163	160	150
149	178	114	88	128	109				

BIWH04

286	400	300	269	206	297	262	238	215	241
236	224	206	192	175	191	226	169	171	164
191	187	214	192	147	120	84	147	107	115
140	167	106	88	99	124	109	123	135	120
117	119	91	121	135	158	125	112	134	108
132	97	164	146	193	183				

BIWH05

222	192	229	151	156	239	152	183	250	213
225	157	238	237	209	210	190	195	145	130
135	131	170	172	154	158	142	165	154	183
141	122	100	121	142	130	138	143	156	92
91	99	141	110	116	122	104	116	105	85
99	106	118	108	94	102	80	97	91	131
144	130	159							

BIWH06-S

200	220	211	263	268	248	230	223	214	208
189	185	214	163	132	159	166	142	170	162
125	134	115	128	145	125	136	158	117	136
146	149	151	119	137	115	104	93		

BIWH07-S

376	255	362	289	269	362	668	605	277	384
397	463	532	183	496	352	262	187	125	110
158	163	149	215	191	251	196	183	173	394
281	164	80	67	82	106	119	158	209	156
207	319	250	330	291	202	201	202		

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BIWH08-M

449	403	494	420	459	548	340	650	216	62
112	113	170	233	421	279	447	147	122	510
336	311	345	440	281	309	147	410	464	150
93	176	190	144	138	150	253	116	76	89
147	231	174	208	172	205	98	64	57	81
126	107	163	181	79	59	60	93	48	70
81	102	119	148	138	267	284	226	269	259
359	170	55	81	101	87	131	110	129	104
74	41	49	66	66	102	133	45	35	40
55	72	78	103	98	84	98			

APPENDIX III: Mean ring-width data

Title : Wisson Hill - Bidford-on-Avon - Warwickshire [BIDFD-WH]

Ring-width QUSP data of 85 years length

Dated AD1445 to AD1529

Unit of Measurement 0.01mm

5 timbers raw data mean

Average ring width 181.15 Sensitivity 0.19

AD1445						388	217	206	157	274	259
AD1451	224	196	266	181	167	128	106	117	72	91	
	93	182	445	355	298	236	228	149	150	103	
	105	135	108	165	222	179	162	144	208	212	
	194	197	211	222	194	153	159	146	179	212	
	155	161	154	179	177	217	198	149	165	167	
AD1501	233	223	201	194	270	235	203	179	219	186	
	207	146	114	124	123	94	111	148	155	128	
	109	140	109	152	113	165	186	217	197		