TREE-RING ANALYSIS OF TIMBERS FROM LOW HARPERLEY FARMHOUSE, WOLSINGHAM, COUNTY DURHAM

With a contribution by Martin Roberts

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SUMMARY

Analysis undertaken on 96 samples from timbers of this building resulted in the dating of site sequence LWHBSQ01 to AD 1356–1604.

Prior to the tree-ring dating it was thought that the present roof of the main building was an eighteenth-century construction containing fourteenth-century timbers. In fact all dated roof timbers are sixteenth or early-seventeenth century, with the majority dating to AD 1565. It is possible that this roof could be a mid-sixteenth or early seventeenth-century construction but equally possible it is an eighteenth-century construction, utilising reused and repositioned timbers.

A number of floor joists (AD 1564–89) and a doorframe (AD 1551–76) in the attic also have felling date ranges consistent with an AD 1565 felling.

Confirming the major sixteenth-century restructuring and repositioning of floor levels, ceiling joists in the east wing have been dated to AD 1563 and those in the west wing to AD 1524–48 and AD 1576–1601.

Timbers from the east cottage roof have been dated to *c* AD 1606, potentially suggesting construction in or soon after this date. Also dating to the very late sixteenth/early seventeenth century are timbers from the west cottage roof. This roof also contains timbers dating to AD 1562–83.

Two further site sequences are undated.

Introduction

Low Harperley, located near Crook in County Durham (NZ 119 349; Figs 1–3) is an isolated grade II* listed manor house of medieval date. It is orientated along a north-west-south-east axis, facing south-west towards the river. For the ease of description this has been simplified in the following text to a west-east axis, house facing south. The house may be described as a two storey and attic principal (or main) building, made up of a small central range and two flanking wings (east and west wings), all brought under a large single all-embracing roof form. To the east and west of the outer wings are further smaller two-storey ranges, independently roofed, below described as the east and west cottages (Fig 4).

Phase One. Medieval high-status manor house

Harperley is noted in the Boldon Book (AD 1183) and Hatfield's Survey (*c* AD 1374), when a hall, chamber, and kitchen are mentioned, as well as ruined buildings (a chapel, barn, and cow byre). From the fourteenth century onwards, throughout the medieval period, the house was held of the Bishop of Durham by the Conyers family.

The surviving building contains substantial portions of the medieval house, most appearing to date from the thirteenth century or the first half of the fourteenth century. There is evidence of fabric in the whole of the east wing to full height, including probably a ground floor internal doorway, possibly the jamb of another doorway in the south wall, and what was thought to be a rare survival of the remains of the original common rafter roof structure in the attic (Figs 5 and 6).

In the adjacent central range, the evidence of the walling around the sixteenth-century windows suggests they are insertions and this is confirmed by a fine Caernarfon-arched doorway of early fourteenth-century date in the attic, leading out of the west wall into a contemporary building that has since disappeared. The attic space has evidence of medieval walls rising to an eaves line running north-south, later raised into gables, when the eighteenth-century roof was constructed with its axis east-west (Fig 7).

The position of the vertical circulation in the medieval house is unknown. The most likely clue is the curved wall in the south wall of the central block (Fig 4) which strongly suggests a stone newel rose in this position.

The analysis of this fabric demonstrates that Low Harperley was a substantial building, no doubt of high status, probably at least three storeys high in three ranges, at least two of which had independent roofs. In none of those ranges is there evidence for a substantial medieval hall. It is possible that the house had only two floors, with high first-floor chambers open to the roof. However the position of the fourteenth-century doorway, between floors, in the attic suggests this floor level was too high to be a first-floor level and must represent a second-floor level.

It is also possible that the original medieval house was a tower house with a first-floor hall of modest size, but the evidence of the sixteenth-century chimney breast, inserted into the east wall of the east wing, suggests that it was designed as an internal feature, its rough offsets not designed for external weathering. So the medieval building was larger than its present form.

Phase Two. Sixteenth-century remodelling

During the sixteenth century the house was still held by the Conyers family, and under their direction this large, tall medieval house underwent substantial remodelling. The evidence of the surviving fabric, notably the lack of any sixteenth-century work in the west wing and the internal character of the east-wing fireplace, noted above, suggests the larger medieval house, perhaps with its missing hall and service wing, was wholly retained in this remodelling, a remodelling probably without extension.

The remodelling adjusted floor levels; inserting new floors still visible in the east wing, fine stone doorways and fireplaces with pyramidal stops to the chamfers, used on both opening and breast in the fireplaces.

The east wing underwent most change with the insertion of arch-headed mullioned windows in the north and south walls, notably to the first-floor main chamber, and a substantial arched fireplace in the room below. Suspicions that this ground-floor room was a service room, a kitchen, with the principal chamber above, were discounted by the discovery of the four-centred arched doorway in its west wall leading into the central range. The doorway is very finely carved, with ‘GC’ and ‘1564’ cut into the spandrels – a George Conyers was in possession of Harperley *c* AD 1606–17. The quality of this doorway clearly marks the ground floor rooms it links as higher-status rooms in the use of the family rather than their servants. This assumption, in turn, suggests that a service wing must have been elsewhere, perhaps beyond the east end of the missing hall?

The central range, was also refenestrated on its north face on all three floors, with two single-lights to the ground floor, one suspiciously like a fire window, and single two-light windows on the upper floors. Those ground-floor windows, set in the corners of the room, out of alignment with those above, suggest some other feature occupied the centre of the wall, where there is now a modern window opening.

The sixteenth century window changes should not be ascribed to the AD 1564 date without question, given the use of arched heads to the principal windows, which could indicate an earlier date. On balance, however, given that the period *c* AD 1550–90 witnessed an uneven shift across the region from the medieval arched form to the plainer mullioned lights, one might ascribe the use of the older form to the conservative nature of the owner, rather than postulate two sixteenth-century phases. Arched heads would also have implied a higher status than the more cheaply constructed square-headed mullions. Certainly the reordering of floors would have necessitated major changes to all wall openings, so doors and windows may be all of one period.

Phase Three. Seventeenth-century symmetry

During the early years of the seventeenth century, ownership of Low Harperley appears to have moved from the Conyers family, through other families, but ultimately into the hands of the Craddocks of Gainford. The Craddocks had built a notable new house at Gainford in AD 1603 but this Harperley line limited itself to alterations and extensions rather than complete rebuilding.

If the hypothesis is still valid, one suspects that the eastern medieval hall and service wing would have finally disappeared at this time, to be replaced on the western side of the house by a new wing of ground floor service rooms with bedchambers over. Building this new wing would have required the removal, or extensive remodelling, of yet another medieval range, the three-storey block accessed at attic level by the Caernarfon-arched doorway in the central range, and suspected of being a garderobe tower. A preliminary examination of the fabric of this west wing suggests there is little medieval masonry incorporated and certainly no obvious features, although the wall size retains impressive medieval proportions, at over a metre thick.

The new west wing, with its plain mullioned windows, echoed on plan the surviving east wing and gave something of a symmetrical appearance to the house, on approaching from the north. Whether this symmetry on plan was extended to the elevation of the new wing, rising up three floors to match the adjacent medieval ranges, can only be conjectured.

The means of vertical circulation in the seventeenth-century house is again difficult to establish. If one discounts circulation by some additional staircase building, since demolished, then within the surviving building, it can only have taken place in the central range, given the survival of substantial sixteenth and seventeenth-century first-floor structures in the flanking wings. Any staircase would most probably have been in the smaller room on the south side, site of the medieval newel stair and a space ample enough to accommodate a modest timber dogleg or well stair. The alternative site would be the larger central range room to the north but the presence of a fireplace on the first floor suggests otherwise and points to the ground-floor room in this block, now a rather bleak and damp pantry, possibly, on plan at least having served in the seventeenth century as an entrance hall. For that suggestion to be valid the room needs an external door, possibly where the modern window now is. Why else would the sixteenth-century windows here be single-light and in the corner of the room rather than central, unless to flank another opening?

Phase Four. The eighteenth-century farm

In the middle years of the eighteenth century, the then owners of Harperley decided to build a new Hall on the brow of a hill about half a mile to the southwest of the medieval house, which henceforth became known as Low Harperley. From this period, the old house became a much lower status farm, probably the home farm of the estate. The buildings may have been subdivided into more than one house.

The physical changes to the house in this period are dramatic. Whatever the precise configuration of the old medieval house, its tall three-storey, triple-roofed profile was drastically rationalised, lowering the top floor and laying an all-embracing barn-like roof over the three ranges, catsliding to the north over the projecting wings where once stood proud gables. The south elevation was extensively renewed utilising seventeenth-century window components at the same time, though whether this is of eighteenth or nineteenth-century date is hard to say.

The final eighteenth-century change was the addition at each end of the building of modest two-storey accommodation, each bearing a date stone, 1762 to the west and 1765 to the east, the east and west cottages. These small buildings were not complete houses in themselves but appear to have been added to a subdivided main house, now perhaps two or three houses, to compensate for some loss of accommodation in both the eastern and western houses. An additional staircase in the west wing eased circulation, right up to the attic, and disturbed walling outside the north-west corner of the east wing, in the angle with the central range, suggests there may have been external access to the first floor here.

The precise configuration of this subdivided house has yet to be deduced but its legacy into the nineteenth and twentieth century was a tortuous circulation route between one part of the house and the other. This plan remained even when in the late twentieth century the house was occupied as a single dwelling again. During this period the old staircase, conjectured in the south room of the central range, was replaced by a plain modern flights. In AD 1999 the house became vacant on the death of its elderly owner and was subsequently bought by Mr and Mrs Paul Allison.

The importance of Low Harperley lies in the survival of a major medieval manor house of relatively early fabric, in its adaptation during the sixteenth and seventeenth century to a more commodious country seat, its final abandonment by its gentry owners and its transformation into the centre of working farm. This development has a number of contextual parallels at both national and regional levels, and even within Weardale the demise of former gentry houses can be seen at several other sites.

The survival of any **medieval high-status house** of at least early-fourteenth century date is of considerable national importance. A building of probably three ranges and three storeys is of more significance especially in a regional context. An important part of Low Harperley's construction occurred during one of the most turbulent half-centuries in the region's history (AD 1300–1350), when Scottish incursions into Northumberland and County Durham were deep and frequent. When its plan form is finally deduced, it may well illuminate the important regional shift from an undefended to highly defensible gentry building. In an interim report, it may well be worth recording that the lack of an easily explicable plan to the original medieval house may ultimately point to an unusual development.

Of the medieval fabric, the fourteenth-century stone doorway(s?) are important features, while the evidence for the east-wing roof of the same date is

particularly important. This includes not only the remains of its common rafter roof timbers, but also the survival of red paint or stain, which is extremely rare.

The **sixteenth-century transformation** of Low Harperley has left the most substantial fabric remains in the east and central ranges. These heavily adapted ranges incorporated new timber floors, stone doorways and fire surrounds – an important collection of architectural features. The discovery of a dated doorway (AD 1564) in the east wing is particularly valuable feature.

The adaptation of medieval gentry houses during the Elizabethan period was a national trend, which is reflected locally in a number of Weardale buildings. The mighty Bradley Hall, a medieval moated site, less than a mile away to the north east, displayed a fine new Renaissance loggia on its southern front, probably built in the last third of the sixteenth century. Higher up the dale at Stanhope, the similarly moated site at Unthank Hall underwent two periods of renewal to its courtyard ranges in AD 1552 and AD 1594.

The **seventeenth-century work** at Low Harperley both added and, most probably, removed buildings. If the hypothesis suggested above is ultimately proven, the removal of the medieval hall and the redevelopment of new facilities around the core of the solar wing (the west wing of the original house, the east wing of the existing house) reflect another significant national trend. The development has parallels in the county at Crook Hall, Durham, where a linear development in the seventeenth and eighteenth centuries abandoned the old hall to a minor service use, only surviving by later adaptation to a beer factory. Much closer, at Bradley Hall, the existing house of eighteenth-century appearance developed out of the former solar wing, the sole survivor of the medieval courtyard house to remain in occupation.

The **eighteenth-century developments** at Low Harperley reflected the abandonment of the old family seat for a new Georgian house with commanding views and expansive parkland gardens. Transforming the old house into farm accommodation entailed a radical rationalisation of the buildings and particularly the roof structure. Within Weardale this process has striking similarities to changes at three Stanhope buildings – Unthank Hall, Stone House, and the Old Hall, which suggest this change at Low Harperley may be part of a significant local trend, at the very least. At Unthank Hall, as at Low Harperley, a relatively complex sixteenth-century roof formation with triple dormers was cropped in a later reconstruction, as was the attic floor of the early sixteenth-century rectory at Stone House. At the Old Hall, the similarity of the existing all-embracing roof with the roof form at Low Harperley is very strong and appears to represent the same rationalisation of an earlier complex roof form.

The mid-eighteenth-century additions of the east and west cottages exhibit the vernacular qualities more appropriate to lower status farmhouses. In particular, the creation of a hearth passage at the west end reflects a significant feature of the Weardale farmhouses of earlier centuries.

This house reflects national, regional, and local trends throughout its evolution and contains a wealth of historic fabric, some of significantly early date. Low

Harperley represents one of the most important manor houses in the county and an important component in the medieval secular architecture of the North East.

The Laboratory would like to thank Mr and Mrs Paul Allison, the owners of the property, for allowing sampling to be undertaken. Martin Roberts of English Heritage provided the above building description, gave valuable on-site advice during the initial assessment, and has written a section on the impact of the tree-ring dating on the interpretation of this building. Where not otherwise credited the drawings are by Martin Roberts and Robin Dower of Spence and Dower. Cathy Groves of University of Sheffield Dendrochronology Laboratory gave invaluable advice and comments on early drafts of this report and also provided Figures 17 and 18.

Sampling and analysis by tree-ring dating was funded by English Heritage to inform the forthcoming listing consent required prior to a major programme of repair. It was hoped that tree-ring dating would more precisely date the phases of construction prior to major repair works.

Sampling

Ninety-six core samples were taken from oak timbers in various parts of the building. Each sample was given the code LWH-B (for Lower Harperley) and numbered 01–96. A large number of samples was taken from the timbers in the eastern, western, and central parts of the roof and in the attic space of the main building. The timbers sampled here were the redundant sole pieces (LWH-B01–04), the reused common rafters (LWH-B05–13), some exposed floor joists (LWH-B14–18), reused principal rafters (LWH-B19–21), roof timbers thought to relate to the later reroofing (LWH-B22–41), and a doorframe (LWH-B94–6). Further roof timbers were sampled in the west cottage (LWH-B42–52) and the east cottage (LWH-B53–64). Ground-floor ceiling joists were sampled in the east wing (LWH-B65–76), the west wing (LWH-B77–90), and from the entrance passage to the west cottage (LWH-B91–3). The position of samples, where known, was noted at the time of sampling and has been marked on Figures 5 and 8–16. Two of the sampled sole pieces (LWH-B03 and LWH-B04) were no longer in place and so it is not known exactly where these are from. Further details relating to the samples can be found in Table 1.

During the initial assessment Martin Roberts expressed interest in the dating of some oak panelling which is due to be dismantled and moved at some point in the future. At the time of sampling, this panelling was still in place and so this will have to be undertaken at a later date.

Analysis and Results

At this stage it was noticed that seven of the samples (LWH-B18, LWH-B42, LWH-B44, LWH-B45, LWH-B53, LWH-B55, and LWH-B71) had too few rings for secure dating, and so these were rejected prior to measurement. The

remaining 89 samples were prepared by sanding and polishing and their growth-ring widths measured; the data of these measurements are given at the end of the report. These 89 samples were then compared with each other by the Litton/Zainodin grouping procedure (see appendix).

At a least value of *t*=4.5, 78 samples formed three groups. Firstly, 74 samples matched and were combined at the relevant offset positions to form LWHBSQ01, a site sequence of 249 rings (Figs 17 and 18). This site sequence was then compared with a large number of relevant reference chronologies for oak indicating a consistent match when the date of its first ring is AD 1356 and of its last measured ring is AD 1604. The evidence for this dating is given by the *t*-values in Table 2.

Two samples matched and were combined at the relevant offset positions to form LWHBSQ02, a site sequence of 90 rings (Fig 19). This site sequence was then compared with a large number of relevant reference chronologies for oak but could not be satisfactorily matched and so these two samples remain undated.

Finally, two further samples matched and were combined at the relevant offset positions to form LWHBSQ03, a site sequence of 93 rings (Fig 20). This site sequence was again compared with the reference chronologies but also could not be matched and remains undated.

The remaining 11 ungrouped samples were then compared individually against the reference material but no consistent match could be found and these samples remain undated.

Interpretation

Analysis of 89 samples taken from timbers at Low Harperley has resulted in the construction and dating of a single site sequence. Site sequence LWHBSQ01, of 249 rings, contains 74 samples from all parts of the building, and spans the period AD 1356–1604. For the purpose of clarity each group of timbers has been dealt with separately and according to area (Figs 17 and 18).

Main building: redundant sole piece
Only one of the sole pieces was successfully dated, to a last measured ring date of AD 1510. Without the heartwood/sapwood boundary ring an estimated felling date cannot be calculated except to say this timber would have been felled at the earliest in AD 1526.

Main building: reused common rafters
Nine reused common rafters were dated in this site sequence. One of these dated samples (LWH-B11) has complete sapwood and the last measured ring date of AD 1565, the felling date of the timber represented. The heartwood/sapwood boundary ring of five of the other dated samples is consistent with that of LWH-B11, making it likely that these five samples are from timbers also felled in AD 1565. One further sample (LWH-B12) has the

heartwood/sapwood boundary ring. However, this is later than the rest, AD 1573, giving an estimated felling date for the timber represented within the range AD 1588–1613. The remaining two reused common rafters do not have the heartwood/sapwood boundary ring. By adding the minimum expected number of sapwood rings (15) to their last measured ring dates of AD 1495 (LWH-B08) and AD 1507 (LWH-B14) these timbers are known to have been felled after AD 1510 and AD 1522, respectively.

Main building: reused principal rafters
Three samples taken from reused principal rafters in the main building roof were also contained within this site sequence. Two of these have a similar heartwood/sapwood boundary ring date, suggestive of a single felling. The average of these is AD 1585, giving an estimated felling date range for the two timbers represented to within the range AD 1600–25. The third reused principal rafter does not have the heartwood/sapwood boundary ring. Its last measured ring date of AD 1549 gives it a *terminus post quem* date of AD 1564.

Main building: roof
This site sequence contains 15 samples taken from the roof timbers of the main building. Of these one sample (LWH-B41) has complete sapwood and the last ring date of AD 1565, the felling date of the timber represented. Five other samples have a heartwood/sapwood boundary ring broadly contemporary with that of LWH-B41, suggesting they were also felled in AD 1565. Four other samples also have the heartwood/sapwood boundary ring but this is slightly later, which might suggest separate felling/s. Two (LWH-B33 and LWH-B34) have similar heartwood/sapwood boundary ring dates, the average of which is AD 1551, giving an estimated felling date within the range AD 1566–91 for the two timbers represented. The other two samples (LWH-B35 and LWH-B40) also have similar heartwood/sapwood boundary ring dates, the average of which is AD 1572, giving an estimated felling date for the two timbers represented within the range AD 1587–1612. Five further dated roof samples do not have the heartwood/sapwood boundary ring. However, with last measured ring dates ranging from AD 1478 (LWH-B36) to AD 1517 (LWH-B31) it is possible that these timbers were also felled in the second half of the sixteenth century.

Main building attic: floor joists
Four of the attic floor joists were dated within this site sequence. Of these three have heartwood/sapwood boundary ring dates which are broadly contemporary and suggestive of a single felling. The average heartwood/sapwood boundary is AD 1549, which calculates to an estimated felling date range of AD 1564–89 for the three timbers represented. The fourth sample (LWH-B14) does not have the heartwood/sapwood boundary ring, but its last measured ring date of AD 1507 is also not inconsistent with a felling of AD 1564–89.

Main building attic: doorframe
Two of the samples taken from the doorframe in the attic were successfully dated. Both of these samples have the heartwood/sapwood boundary ring. The average date of these is AD 1536 which calculates to an estimated felling date for the two timbers represented of AD 1551–76.

Main building east wing: ceiling joists
This site sequence contains seven samples taken from the ceiling joists of the east wing. Three of these (LWH-B65, LWH-B74, and LWH-B75) have complete sapwood and the last ring date of AD 1563, the felling date of the three timbers represented. A fourth sample, LWH-B76, has the heartwood/sapwood boundary ring date of AD 1536 which, allowing for this sample having a last measured ring date of AD 1553 with incomplete sapwood, gives an estimated felling date for the timber represented within the range AD 1554–76, consistent with an AD 1563 felling. The other three dated ceiling joists from the east wing do not have the heartwood/sapwood boundary ring and so estimated felling dates cannot be calculated, except to say that with last measured ring dates of AD 1446 (LWH-B73), AD 1536 (LWH-B67), and AD 1554 (LWH-B66) these would be after AD 1461, AD 1551, and AD 1569 respectively.

Main building west wing: ceiling joists
Fourteen of the samples taken from the ceiling joists of the west wing are contained within this site sequence. Of these only five have the heartwood/sapwood boundary ring. Sample LWH-B84 has the heartwood/sapwood boundary ring date of AD 1508, which equates to an estimated felling date range of AD 1524–48. The heartwood/sapwood boundary ring dates of the other four samples are broadly contemporary, suggestive of a single felling. The average of these is AD 1561, which gives an estimated felling date range of AD 1576–1601 for the four timbers represented. The other nine ceiling joist samples do not have the heartwood/sapwood boundary ring, which means estimated felling date ranges cannot be calculated for them, except to say that with last measured ring dates ranging from AD 1451 (LWH-B81) to AD 1528 (LWH-B78), these could all have been felled in either felling date range, or may represent totally separate felling(s).

East cottage: roof
Nine of these samples are contained within site sequence LWHBSQ01. One of these samples (LWH-B64) was taken from a timber with complete sapwood, but *c* 3mm of this was lost during the sampling process. By looking at how many rings 3mm represents on the core it is possible to estimate that *c* 2 sapwood rings have been lost, giving the timber this sample represents a felling date of *c* AD 1606. Five further samples have a similar heartwood/sapwood boundary ring date to that of LWH-B64, making it likely that these samples are also from timbers felled in *c* AD 1606. The three other dated samples from this roof do not have the heartwood/sapwood boundary ring and so estimated felling dates cannot be calculated, except to say with last measured ring dates of AD 1485 (LWH-B57), AD 1510 (LWH-B54), and AD 1544 (LWH-B59) these would be estimated to be at the earliest AD 1500, AD 1525, and AD 1559, respectively.

West cottage: roof
The site sequence contains seven samples taken from the west cottage roof timbers. Interpretation of the heartwood/sapwood boundary ring would suggest two separate fellings. Three samples, taken from two lower purlins and one collar, have similar heartwood/sapwood boundary ring dates. The average of

these is AD 1543, giving an estimated felling date range for the timbers represented of AD 1562–83 (allowing for sample LWH-B47 having a last measured ring of AD 1561 with incomplete sapwood). Three other samples, all from upper purlins, have slightly later heartwood/sapwood boundary ring dates, the average of which is AD 1580, giving an estimated felling date for the three timbers represented of AD 1595–1620.

West cottage entrance passage: ceiling joists
All three samples taken from the ceiling joists of the entrance passage to the west cottage were successfully dated. Unfortunately, none of these samples have the heartwood/sapwood boundary ring and so an estimated felling date range cannot be calculated for them. However, by adding the minimum expected sapwood rings (15) to the last measured ring dates of AD 1470 (LWH-B91), AD 1504 (LWH-B93), and AD 1516 (LWH-B92), this would provide *terminus post quem* dates of AD 1485, AD 1519, and AD 1531, respectively.

All felling dates have been calculated using the estimate that 95% of mature oak trees from this area have between 15–40 sapwood rings.

Discussion

Prior to the tree-ring analysis it was thought that the timbers under investigation represented four main phases of construction or modification. The reused and redundant timbers in the roof of the main building were believed to represent the remnants of an original roof dating to the first half of the fourteenth century, whilst the remaining roof timbers in the main building were thought to be associated with re-roofing in the third quarter of the eighteenth century. The floors in the east wing and central range were thought to be associated with major modifications undertaken in the sixteenth century, whilst those in the west wing were associated with remodelling in the seventeenth century. The east and west cottages were thought to have been added in the eighteenth century.

The results from the tree-ring analysis indicate two main periods of felling and hence building activity in the mid-sixteenth century and the late sixteenth/early seventeenth century. However each of these periods may represent several slightly different felling phases. No timbers have been identified which relate to felling phases either in the fourteenth or eighteenth centuries.

All of the dated material from the roof of the main building appears to represent two, or possibly three, felling phases. The roof structure seems to be dominated by timbers felled in the mid-sixteenth century, probably in AD 1565, but there is clearly some timber dating to the late sixteenth or early seventeenth century. It is also possible that some roof timbers may have been felled at a date lying between these two felling phases in the period AD 1566–91, and thus representing a third felling phase. The AD 1565 and late sixteenth/early seventeenth century felling phases both include reused and apparently primary oak timbers. Thus whilst there are some softwood timbers that may date to the eighteenth century, the roof structure actually consists

largely of oak timbers dating to the mid-sixteenth century and the late sixteenth/early seventeenth century. It is conceivable that either of the two main felling phases identified could relate to the initial construction of the roof but it is also possible that the extant roof structure was erected at a later date utilising mostly reused or repositioned timbers. Further investigation of roof construction details may determine which of these potential interpretations is more likely. What is clear is that there is no evidence of reused fourteenth century timbers and no evidence of oak timbers felled in the eighteenth century.

The dated timbers from the main building attic floor and doorframe appear to date to the mid-sixteenth century and could be associated with the AD 1565 felling date identified in the main building roof or the AD 1563 felling date indicated by timbers from the ground-floor ceiling in the east wing (see below). However, with so much timber in the main building roof being potentially reused, it is difficult to determine from the dendrochronological results whether these dated timbers may also be reused, or whether the construction of the attic floor and doorframe actually occurred in the mid-sixteenth century, shortly after felling.

The felling date of AD 1563 indicated for timbers from the ground-floor ceiling in the east wing certainly supports the suggested period of modification of the east wing and central range in the sixteenth century and may well be connected to the date of ‘1564’ carved into a doorway in the east wing. However the ground-floor ceiling timbers in the west wing, thought to be associated with remodelling in the seventeenth century, are the product of at least two felling phases, during AD 1524–48 and AD 1576–1601. Again, with the concern over the possible widespread use of reused timber elsewhere in the main building, it is difficult to determine from the dendrochronological analysis whether these felling dates or felling date ranges actually indicate the date of construction or modification of the floors.

The timbers from the east cottage roof appear to represent a single phase of felling dated to circa AD 1606, which suggests that construction occurred shortly after this date. However, this is within the late sixteenth/early seventeenth century felling period indicated by various other dated timbers from the site which may have been reused, so this potential early seventeenth-century construction date for the east cottage should be treated cautiously until further investigation of construction details has been undertaken.

The timbers from the west cottage roof represent at least two felling phases, during AD 1562–83 and AD 1595–1620. In the absence of any trace of sapwood on timbers from the ceiling in the entrance passage, all that can be said is that they appear likely to be broadly contemporary with the rest of the material. Consequently, some timbers in the west cottage could be associated with the felling dates identified in the AD 1560s, but some clearly represent a late sixteenth or early seventeenth-century felling phase. The presence of two felling phases combined with the potentially widespread use of reused timber elsewhere in the building again means that it is difficult to determine from the

dendrochronological analysis whether these felling phases actually indicate the date of construction of the west cottage.

Conclusion

The tree-ring analysis has identified two main periods of felling within the timbers of this building. These are in the mid-sixteenth and late sixteenth/early seventeenth century. Surprisingly, contrary to what was expected, no timbers from the fourteenth or eighteenth centuries have been found, although this does not necessarily mean timbers from these periods do not exist within the building. It may be that timbers of these dates are unsuitable for this dating process and so were not sampled, or even that some of the undated samples belong to these periods.

A large amount of obviously reused and potentially reused material has been identified throughout the various parts of this building, making interpretation on the basis of the dates gained very difficult. In light of these results it is hoped that further survey work might elucidate the development of the building.

As mentioned above, interest has been expressed in the possible dating of some oak panelling which exists within the house. Although it was not possible to investigate this panelling at the same time as the rest of the work was being carried out, this is due to be dismantled and moved to a new location within the house at some point in the future. This would allow us to gain access to the edges of the panels with the aim of measuring and potentially dating these.

LOW HARPERLEY: INTERPRETATIVE DISCUSSION BY MARTIN ROBERTS IN LIGHT OF THE TREE-RING ANALYSIS

The results of the tree-ring dating analysis of Low Harperley require some reconciliation with the conjectured architectural development of the building. Given the validity of much of the architectural evidence, and the very extensive reuse of many of the oak timbers, the dendro results do not prompt a radical reassessment of the building. Taking each architectural phase of the building in turn, the timber dating can be commented upon.

Late thirteenth/early fourteenth century.
The evidence of the east range attic points to a common rafter medieval roof of broadly thirteenth-fourteenth century date having been constructed there. The design of the roof structure, with steep pitched common rafters, braced at their feet by ashlar pieces on sole plates, all accords with contemporary local examples (Seatonholme, Easington, and Kepier Hospital, Durham). The evidence of the solitary sole plate dating, coupled with the absence of any fourteenth-century timbers, primary or reused, throughout the building, strongly suggest that the whole building was extensively repaired at various stages in the sixteenth and early-seventeenth century, when all earlier timbers appear to have been condemned. It seems quite plausible that the earlier common rafter roof may have simply been repaired on a like for like basis, rather than reconstructed to a different design.

Mid-sixteenth century remodelling.
The dendrochronological evidence here is very emphatic and accords with the doorway dated to AD 1564 in the ground floor of the east wing, and the architectural evidence suggesting a major realignment of floor levels. Clearly, from the evidence of the reused roof timbers there was extensive repair to earlier roofs as well as perhaps new roof structures, noting that the building in the 1560s was almost certainly larger than its present size, so the origins of the reused timbers of this date can include buildings now gone.

Late sixteenth-early seventeenth century phase
The architectural interpretation of the building originally conjectured a simple seventeenth-century phase of construction for the west wing. The dendrochronological analysis suggests a more complex picture, of perhaps two late sixteenth/early seventeenth century phases. The latter phase, *c* AD 1575–1600, would accord architecturally with the suggested ‘seventeenth century’ date (a similar conservative seventeenth-century dating was given to nearby Unthank Hall at Stanhope, where the timbers actually dated to 1594).

Eighteenth-century remodelling: main house
The dendrochronological analysis only sampled oak, but some softwood exists in the main roof structure. This, coupled with the extensive reuse of timbers of varying sixteenth-century dates, the form of the roof structure, and the fact that it truncates late sixteenth-century features, points to an extensive later remodelling, most probably in the eighteenth century, when softwood would have supplemented the existing supply of reused oak. Individual analysis of sampled timbers should, ideally, be carried out, to identify possible earlier

structural configurations, noting that evidence of earlier use might have been removed when larger timbers were converted into smaller roof timbers.

Eighteenth-century remodelling: east and west cottages

The architectural evidence for these two buildings being eighteenth-century additions is strong and a brief visual appraisal of the roofs in both buildings identified extensive reuse of principal and common rafters. One, at least, of the roof structures, suggested a reworking of a steeper cruck or curved principal roof truss. Again, the extent of softwood in both roofs should be identified, although even a total absence should not suggest an earlier date, given the availability of reused timbers at the time of the remodelling, from both the main house and, presumably, extensive service and farm outbuildings. Again, ideally recording of the reused principal timbers in these two roofs might enable reconstruction of the original truss design, that would at least contribute to a wider regional roof chronology if not contribute greatly to the interpretation of the standing buildings at Low Harperley.

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Table 1: Details of tree-ring samples from Low Harperley farmhouse, Wolsingham, County Durham

Sample number	Sample location	Total rings*	Sapwood rings**	First measured ring date (AD)	Last heartwood ring date (AD)	Last measured ring date (AD)
Main building: roof; redundant sole pieces						
LWH-B01	Sole piece (first from north	82	--	1429	----	1510
LWH-B02	Sole piece (fifth from north)	60	--	----	----	----
LWH-B03	Sole piece – unknown	56	--	----	----	----
LWH-B04	Sole piece – unknown	93	--	----	----	----
Main building: roof; reused common rafters						
LWH-B05	South common rafter 2, bay 2	102	h/s	1443	1544	1544
LWH-B06	South common rafter 2, bay 3	144	37	1416	1522	1559
LWH-B07	South common rafter 3, bay 3	67	h/s	1481	1547	1547
LWH-B08	South common rafter 3, bay 6	54	--	1442	----	1495
LWH-B09	North common rafter 1, bay 3	77	03	1466	1539	1542
LWH-B10	South common rafter 4, bay 4	69	h/s	1471	1539	1539
LWH-B11	South common rafter 6, bay 5	107	28C	1459	1537	1565
LWH-B12	North common rafter 4, bay 6	129	h/s	1445	1573	1573
LWH-B13	North common rafter 1, bay 8	74	--	1446	----	1519
Main building: attic; floor joists						
LWH-B14	Joist 5 (north of central beam)	152	--	1356	----	1507
LWH-B15	Joist 6 (north of central beam)	97	09	1464	1551	1560
LWH-B16	Joist 12 (north of central beam)	119	05	1432	1545	1550
LWH-B17	Joist 14 (north of central beam)	119	07	1441	1552	1559
LWH-B18	Joist/bridging beam (south side)	NM	--	----	----	----
Main building: roof; reused principal rafters						
LWH-B19	North principal rafter, truss 1	72	--	1478	----	1549
LWH-B20	South principal rafter, truss 4	93	h/s	1495	1587	1587
LWH-B21	North principal rafter, truss 4	72	h/s	1511	1582	1582

Main building: roof						
LWH-B22	South queen post, truss 1	85	--	----	----	----
LWH-B23	South principal rafter, truss 2	97	15C	----	----	----
LWH-B24	South queen post, truss 2	89	--	1423	----	1511
LWH-B25	Tiebeam, truss 2	74	--	1417	----	1490
LWH-B26	North principal rafter, truss 2	69	03	----	----	----
LWH-B27	North queen post, truss 2	132	h/s	1411	1542	1542
LWH-B28	North lower purlin, bay 4	126	22	1435	1538	1560
LWH-B29	North middle purlin, bay 5	125	h/s	1414	1538	1538
LWH-B30	Tiebeam, truss 3	63	h/s	----	----	----
LWH-B31	South queen post, truss 3	84	--	1434	----	1517
LWH-B32	South lower-middle purlin, bay 5	128	h/s	1413	1540	1540
LWH-B33	South principal rafter, truss 5	74	04	1479	1548	1552
LWH-B34	South queen post, truss 5	129	h/s	1426	1554	1554
LWH-B35	Upper collar, truss 5	153	h/s	1423	1575	1575
LWH-B36	South queen strut, truss 5	75	--	1404	----	1478
LWH-B37	North queen strut, truss 4	109	h/s	1432	1540	1540
LWH-B38	North queen post, truss 4	71	13	----	----	----
LWH-B39	North queen post, truss 5	107	--	1409	----	1515
LWH-B40	North principal rafter, truss 5	150	h/s	1419	1568	1568
LWH-B41	South lower purlin, bay 8	122	29C	1444	1536	1565
West cottage: roof						
LWH-B42	South principal rafter, truss 1	NM	--	----	----	----
LWH-B43	North principal rafter, truss 1	56	10	----	----	----
LWH-B44	South principal rafter, truss 2	NM	--	----	----	----
LWH-B45	North principal rafter, truss 2	NM	--	----	----	----
LWH-B46	South upper purlin, bays 1-2	164	h/s	1419	1582	1582
LWH-B47	South lower purlin, bays 1-2	115	16	1437	1535	1551
LWH-B48	North lower purlin	90	h/s	1454	1543	1543
LWH-B49	Collar, truss 1	132	h/s	1409	1540	1540

LWH-B50	South upper purlin, bay 3	96	h/s	1478	1573	1573
LWH-B51	North upper purlin, bay 2	113	h/s	1472	1584	1584
LWH-B52	Collar, truss 2	54	--	1399	----	1452
East cottage: roof						
LWH-B53	South principal rafter, truss 1	NM	--	----	----	----
LWH-B54	Collar, truss 1	95	--	1416	----	1510
LWH-B55	South lower purlin, bay 2	NM	--	----	----	----
LWH-B56	North lower purlin, bay 3	98	h/s	1489	1586	1586
LWH-B57	North upper purlin, bay 3	80	--	1406	----	1485
LWH-B58	Ridgebeam	82	h/s	1501	1582	1582
LWH-B59	North lower purlin, bay 1	78	--	1467	----	1544
LWH-B60	North common rafter 3, bay 1	125	17	1477	1584	1601
LWH-B61	South common rafter 4, bay 1	90	09	----	----	----
LWH-B62	North common rafter 2, bay 3	116	h/s	1470	1585	1585
LWH-B63	North common rafter 4, bay 3	119	17	1476	1577	1594
LWH-B64	North common rafter 5, bay 3	68	20(+c2)	1537	1584	1604
Main building: east wing; ground-floor ceiling joists						
LWH-B65	South middle main joist	111	22C	1453	1541	1563
LWH-B66	South common joist 3 (from east)	85	--	1470	----	1554
LWH-B67	South common joist 4	76	--	1461	----	1536
LWH-B68	South common joist 5	111	11	----	----	----
LWH-B69	South common joist 6	89	h/s	----	----	----
LWH-B70	Central common joist 5	102	24C	----	----	----
LWH-B71	Central common joist 6	NM	--	----	----	----
LWH-B72	Central common joist 8	52	h/s	----	----	----
LWH-B73	Central common joist 9	69	--	1378	----	1446
LWH-B74	Central common joist 14	163	10C	1401	1553	1563
LWH-B75	North common joist 8	130	21C	1434	1542	1563
LWH-B76	North common joist 13	101	17	1453	1536	1553

Main building: west wing; ground-floor ceiling joists						
LWH-B77	Main N-S bridging beam (north room)	63	--	1413	----	1475
LWH-B78	East joist 2 (north room)	88	--	1441	----	1528
LWH-B79	East joist 3 (north room)	91	h/s	1462	1552	1552
LWH-B80	East joist 4 (north room)	79	--	1422	----	1500
LWH-B81	West joist 2 (north room)	64	--	1388	----	1451
LWH-B82	West joist 4 (north room)	64	--	1390	----	1453
LWH-B83	Main N-S bridging beam (south room)	101	--	1402	----	1502
LWH-B84	East joist 3 (south room)	83	15	1441	1508	1523
LWH-B85	East joist 4 (south room)	86	--	1405	----	1490
LWH-B86	East joist 5 (south room)	113	07	1448	1553	1560
LWH-B87	West joist 6 (south room)	60	--	1425	----	1484
LWH-B88	West joist 7 (south room)	66	--	1409	----	1474
LWH-B89	East joist 8 (south room)	117	02	1456	1570	1572
LWH-B90	East joist 9 (south room)	119	h/s	1451	1569	1569
West cottage: entrance passage; ceiling joists						
LWH-B91	Joist 1 (from east)	67	--	1404	----	1470
LWH-B92	Joist 2 (from east)	114	--	1403	----	1516
LWH-B93	Joist 3 (from east)	115	--	1390	----	1504
Main building: attic; doorframe						
LWH-B94	North jamb	111	h/s	1427	1537	1537
LWH-B95	South jamb	116	h/s	1420	1535	1535
LWH-B96	Top	67	h/s	----	----	----

*NM = not measured
**h/s = the heartwood/sapwood ring is the last ring on the sample
c = complete sapwood on timber, all or part lost in sampling (estimated number of sapwood rings lost)
C = complete sapwood retained on sample, last measured ring is the felling date

Table 2: Results of the cross-matching of site sequence LWHBSQ01 and relevant reference chronologies when the first-ring date is AD 1356 and the last-ring date is AD 1604

Reference chronology	*t*-value	Span of chronology	Reference
East Midlands	7.2	AD 882–1981	Laxton and Litton 1988
England	7.2	AD 401–1981	Baillie and Pilcher 1982 unpubl
1-2 The College, Cathedral Precinct, Durham	11.0	AD 1364–1531	Howard *et al* 1992
Aydon Castle Latrine Block	9.7	AD 1406–1545	Arnold *et al* 2002a
Bull Hole Byre, Bearpark, Durham	8.7	AD 1452–1620	Arnold *et al* 2002b
Witton Hall Frm, Witton Gilbert, Co Durham	8.6	AD 1395–1475	Howard *et al* 1996
Dilston Castle, Corbridge, Northumberland	8.5	AD 1402–1611	Arnold *et al* 2003

Figure 1: Maps to show the location of Low Harperley

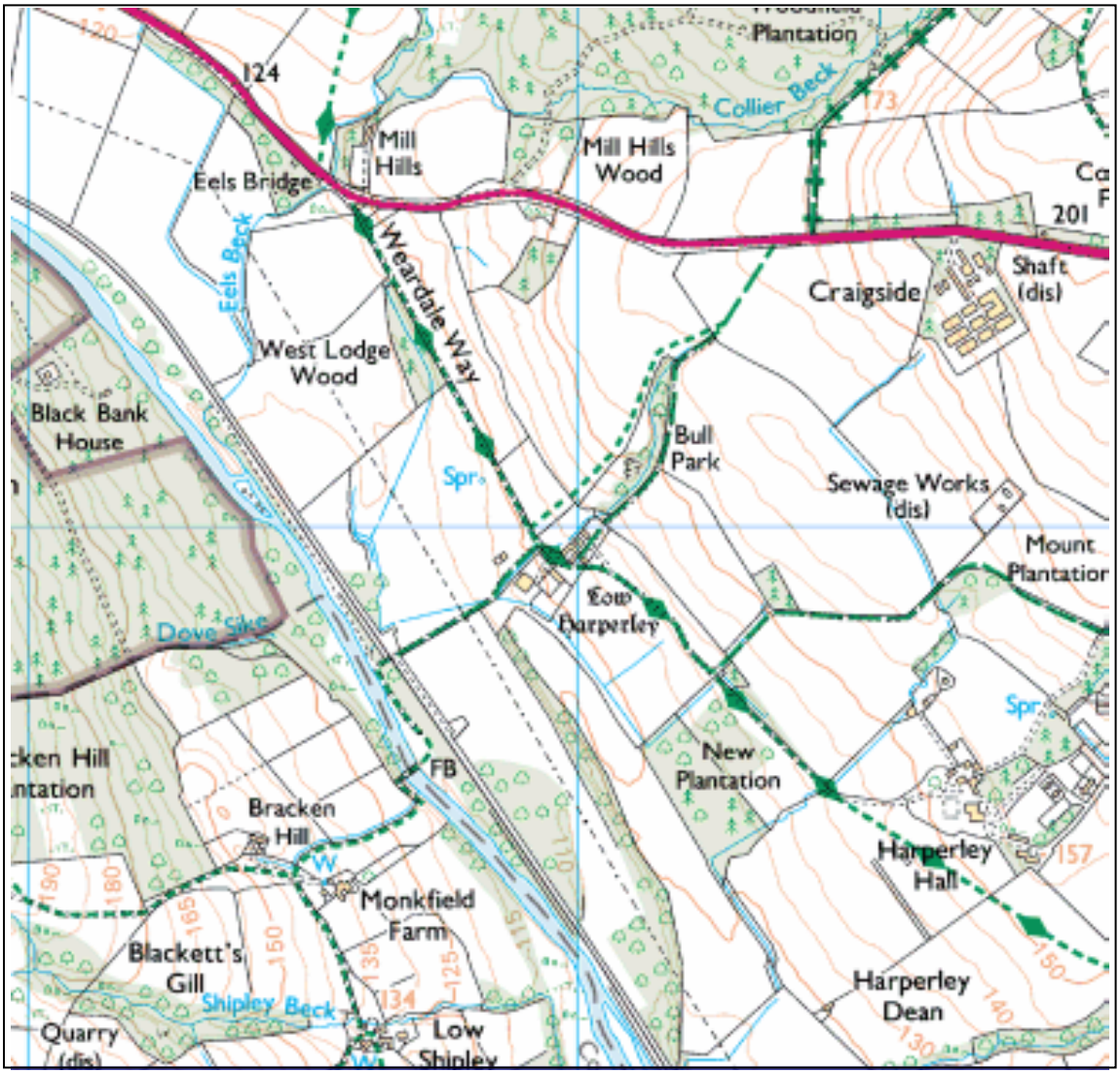


Figure 2: Low Harperley farmhouse, viewed from the north

Figure 3: Low Harperley farmhouse; viewed from the south

Figure 4: Low Harperley farmhouse; ground-floor plan illustrating its components (not to scale)

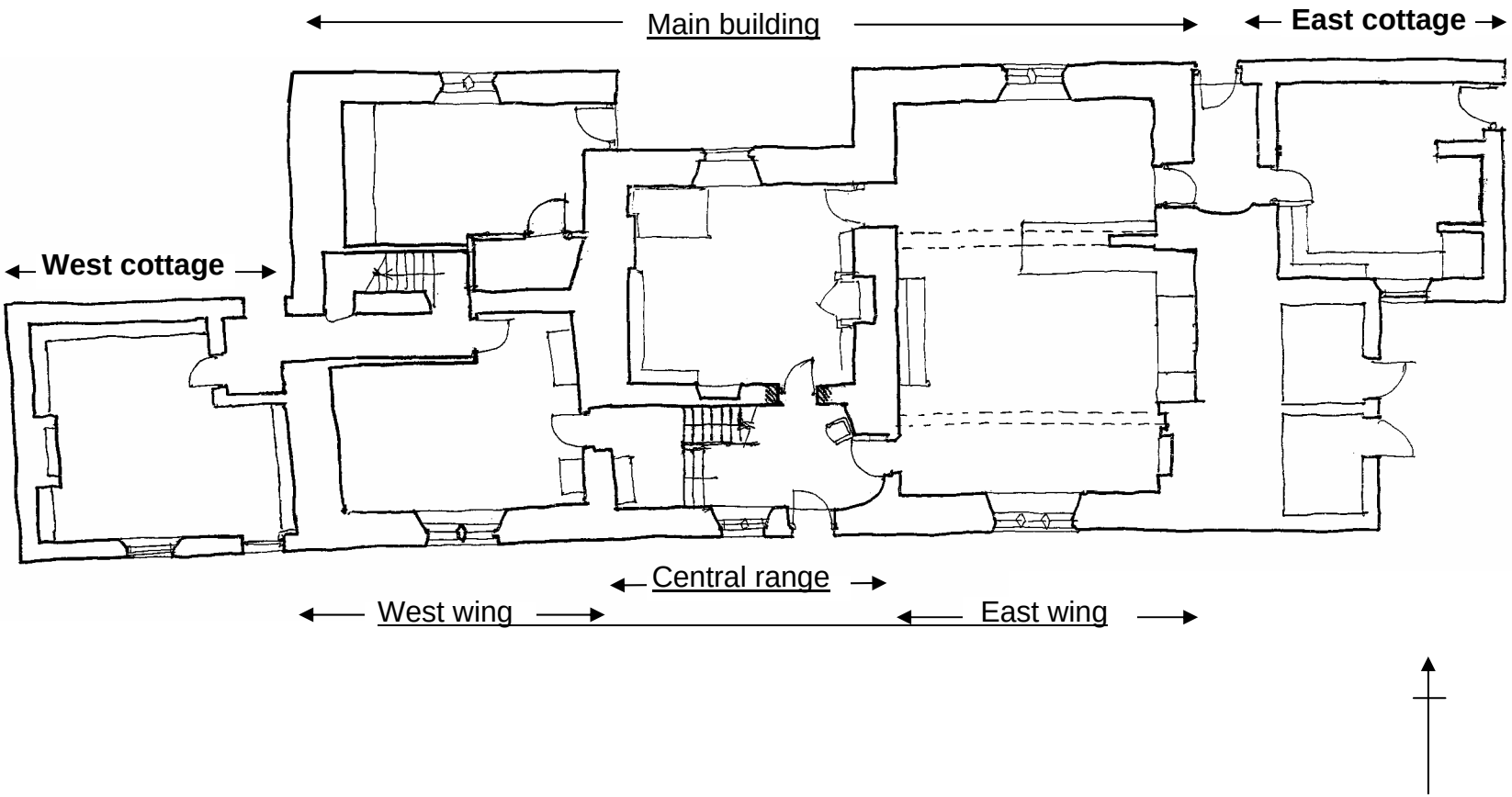


Figure 5: Low Harperley farmhouse; main building, east wing; east wall, showing the remains of the earlier common rafter roof and the location of samples LWH-B01 and LWH-B02 (Peter Ryder)

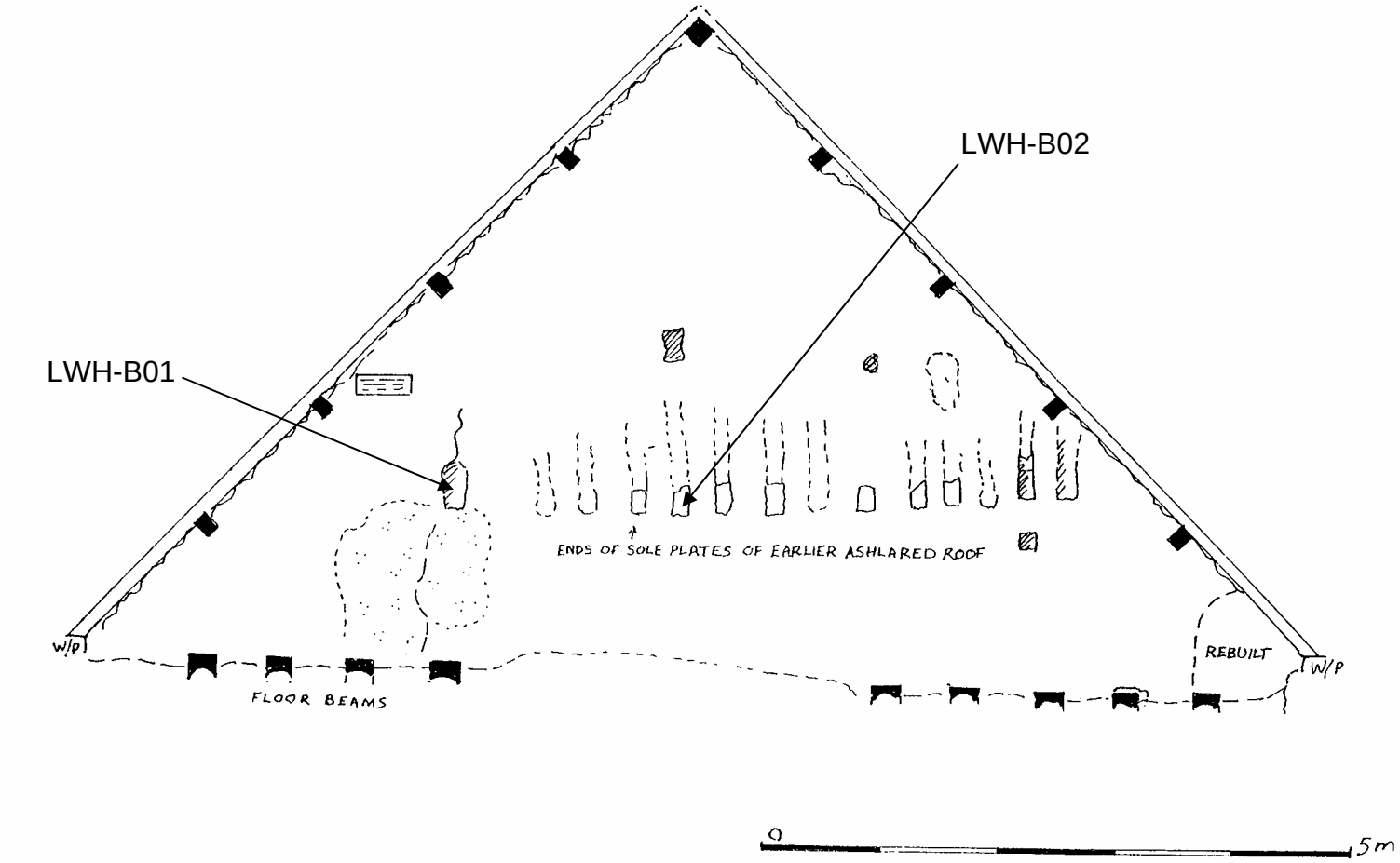


Figure 6: Low Harperley farmhouse; main building, east wing, west wall, showing the remains of the earlier common rafter roof (Peter Ryder)

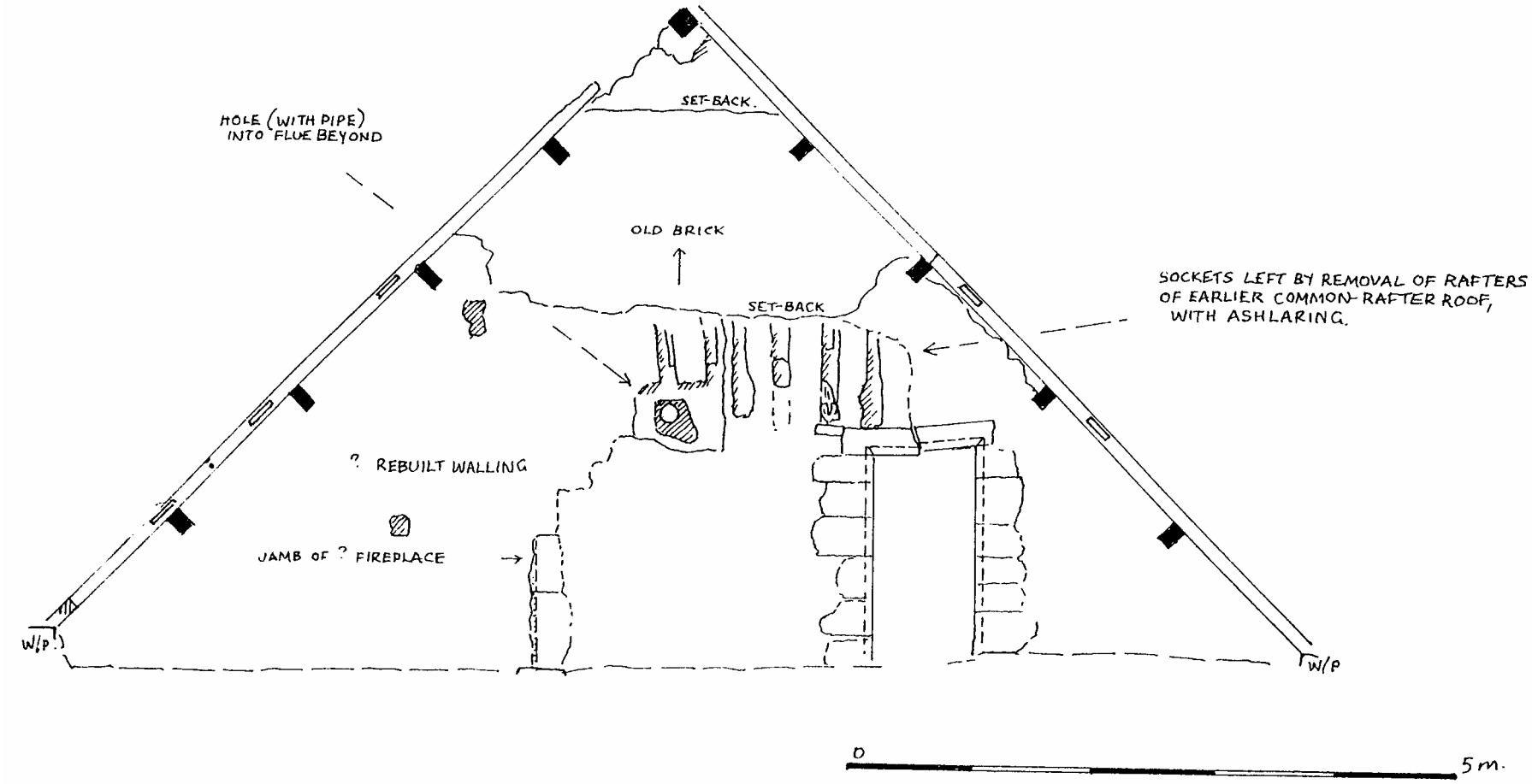


Figure 7: Low Harperley farmhouse; main building, attic of east wing; section looking north (Peter Ryder)

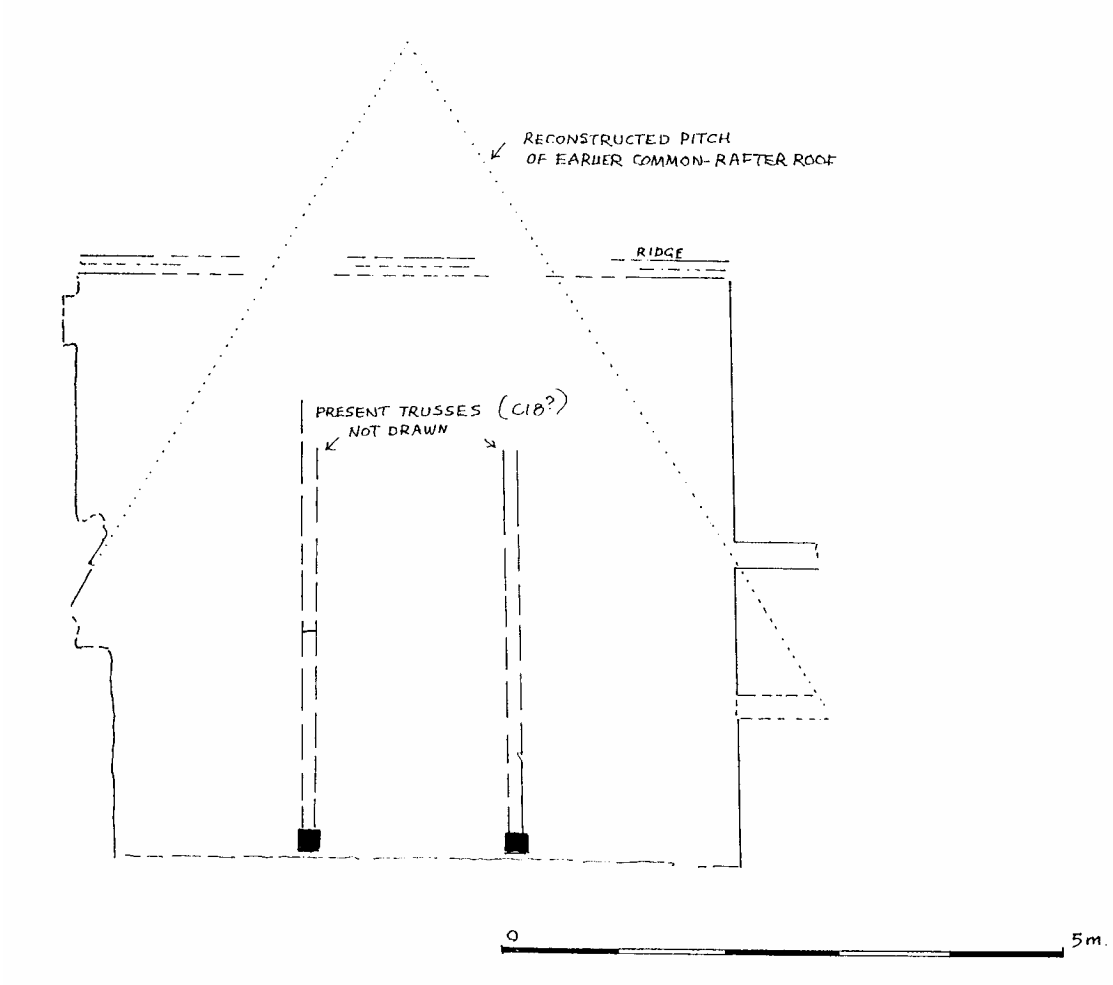


Figure 8: Low Harperley farmhouse, main building; attic plan, showing truss and bay numbering, and the location of samples LWH-B05–18 and LWH-B29

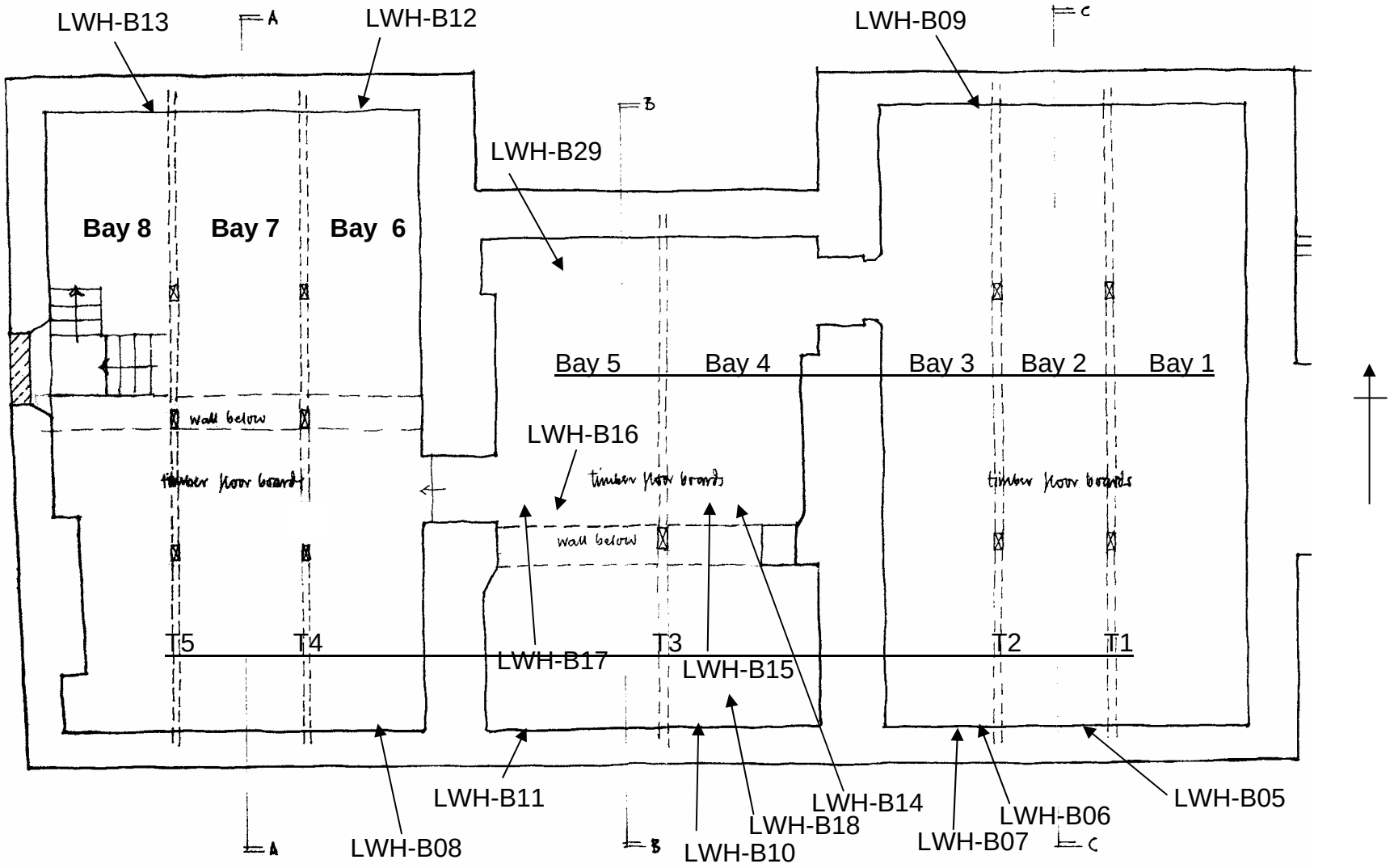


Figure 9: Low Harperley farmhouse; main building, attic; west wing (A-A), showing the location of samples LWH-B20–1, LWH-B37–8, and LWH-B94–6, facing east

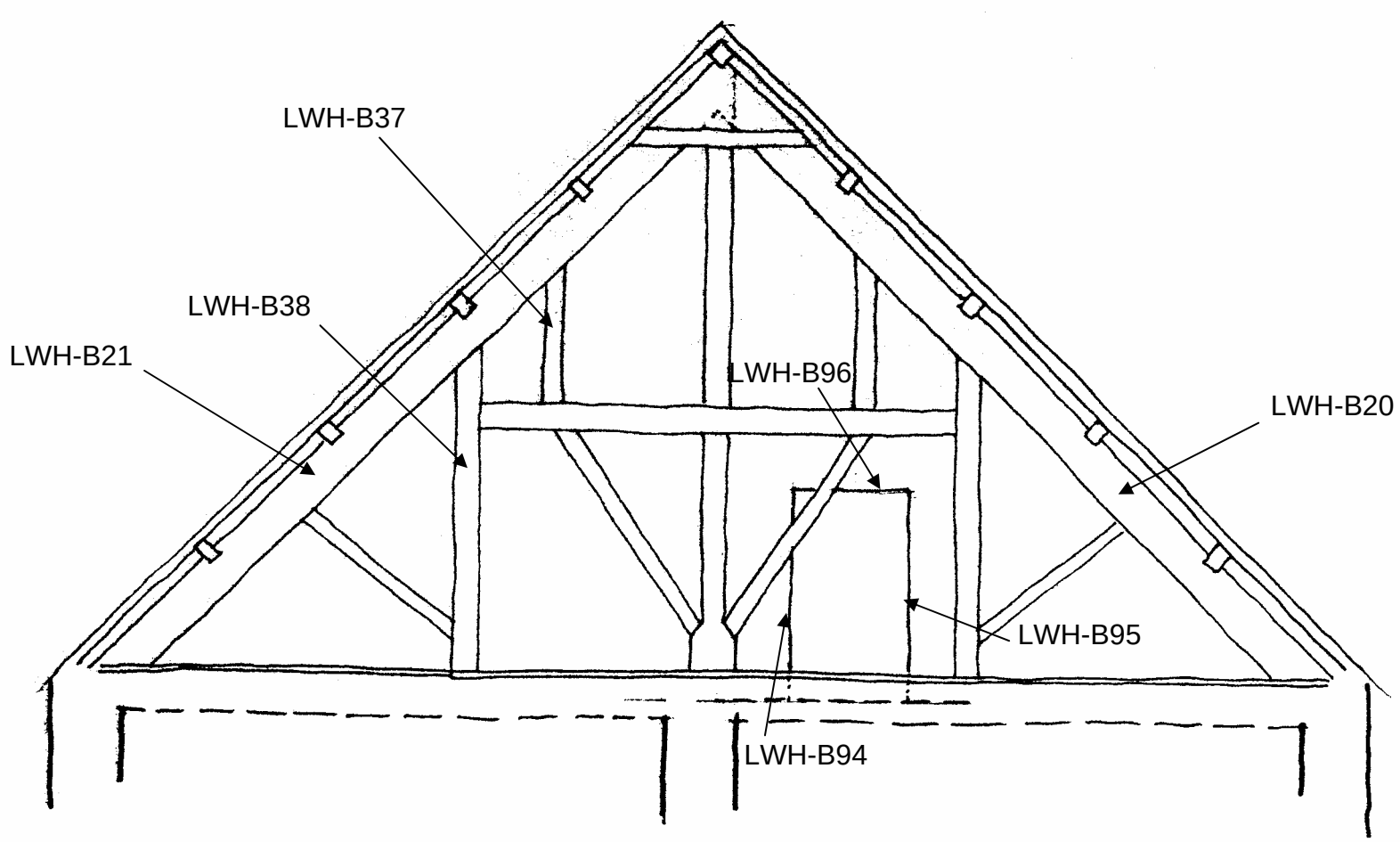


Figure 10: Low Harperley farmhouse; main building, attic, central space (B-B), showing the location of samples LWH-B28 and LWH-B30–1, facing east

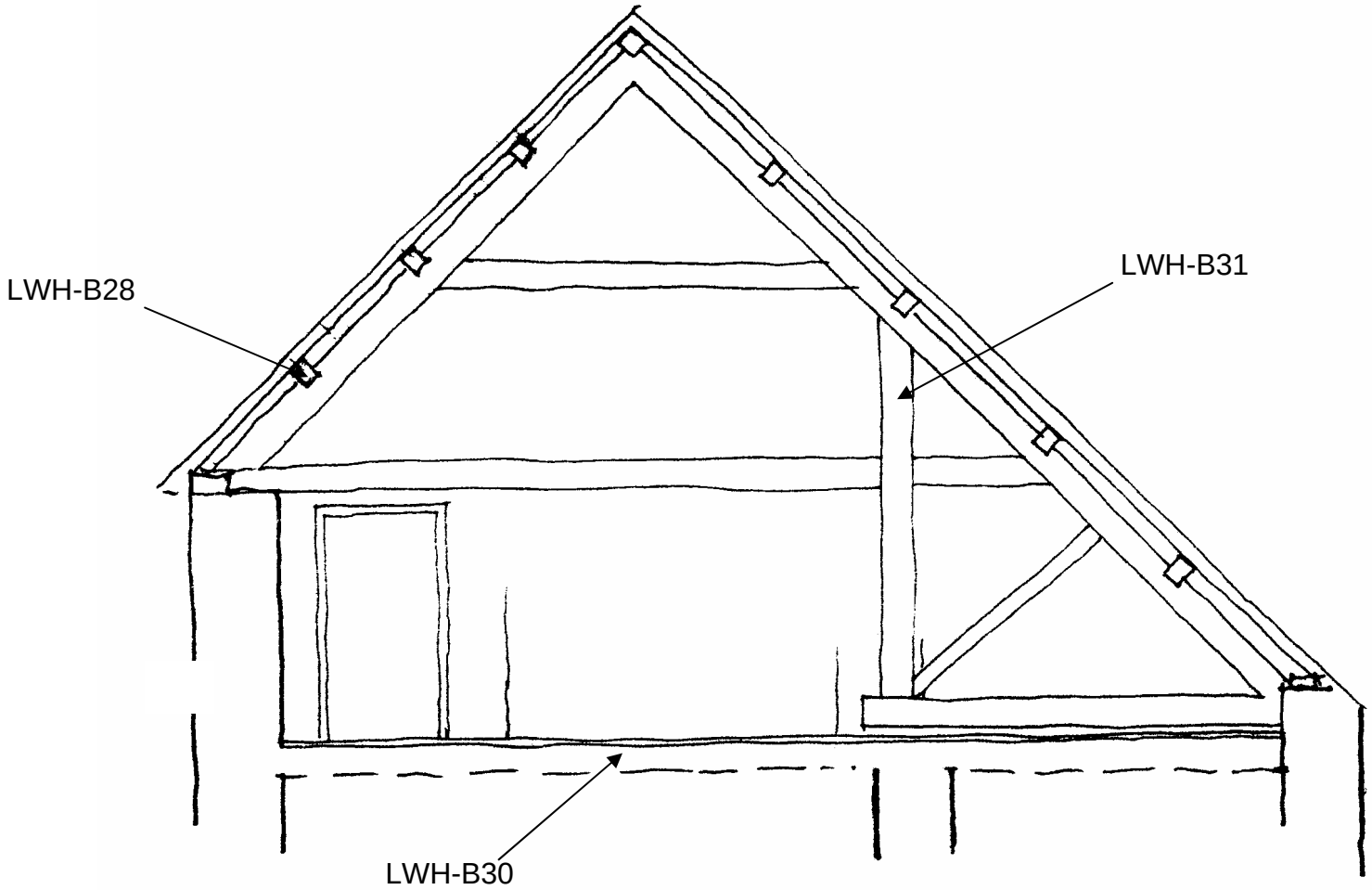


Figure 11: Low Harperley farmhouse; main building, attic; east wing (C-C), showing the location of samples LWH-B19 and LWH-B22, facing east

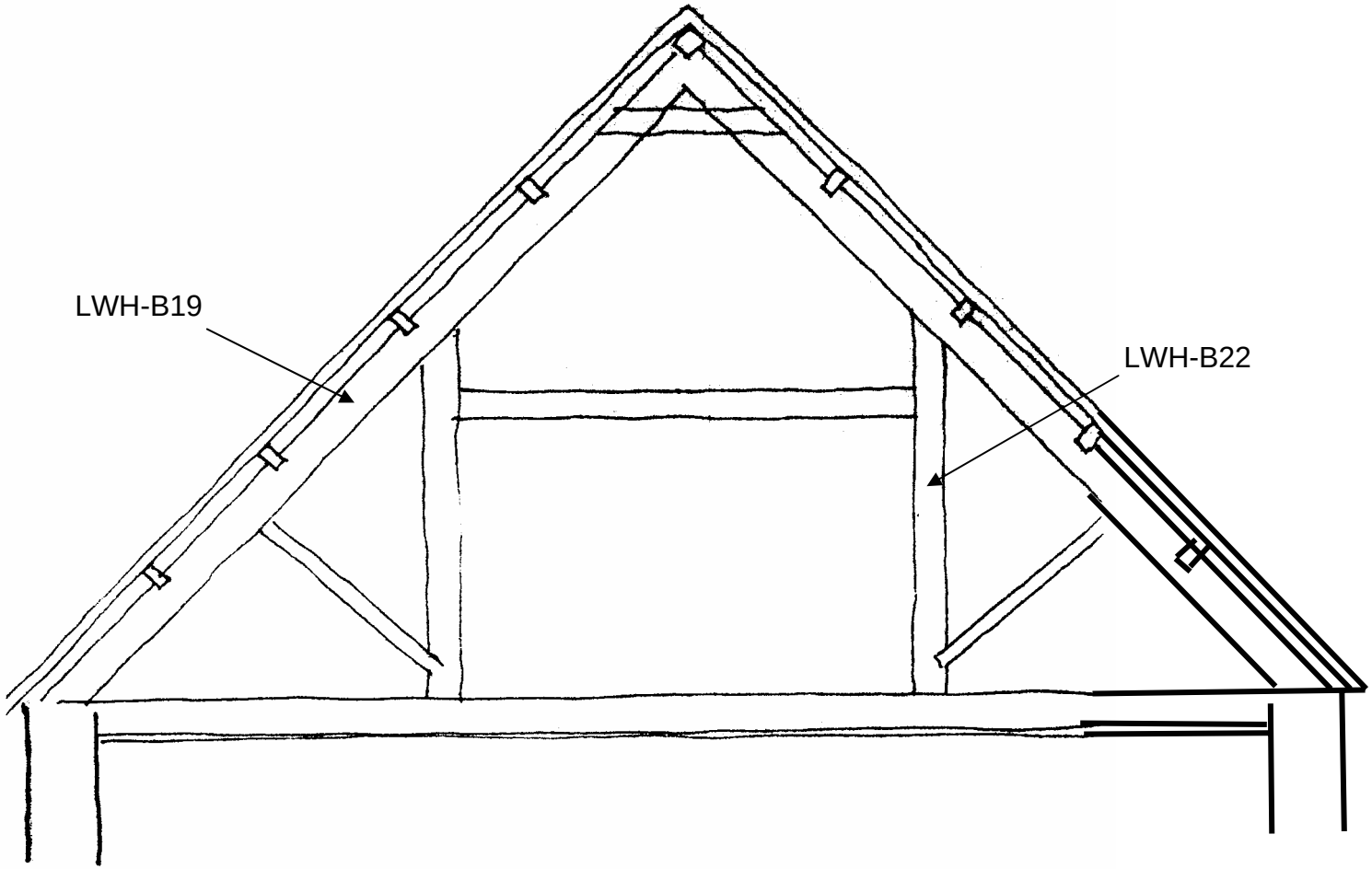


Figure 12: Low Harperley farmhouse; main building, east wing, truss 2, showing the location of samples LWH-B23–7, facing east

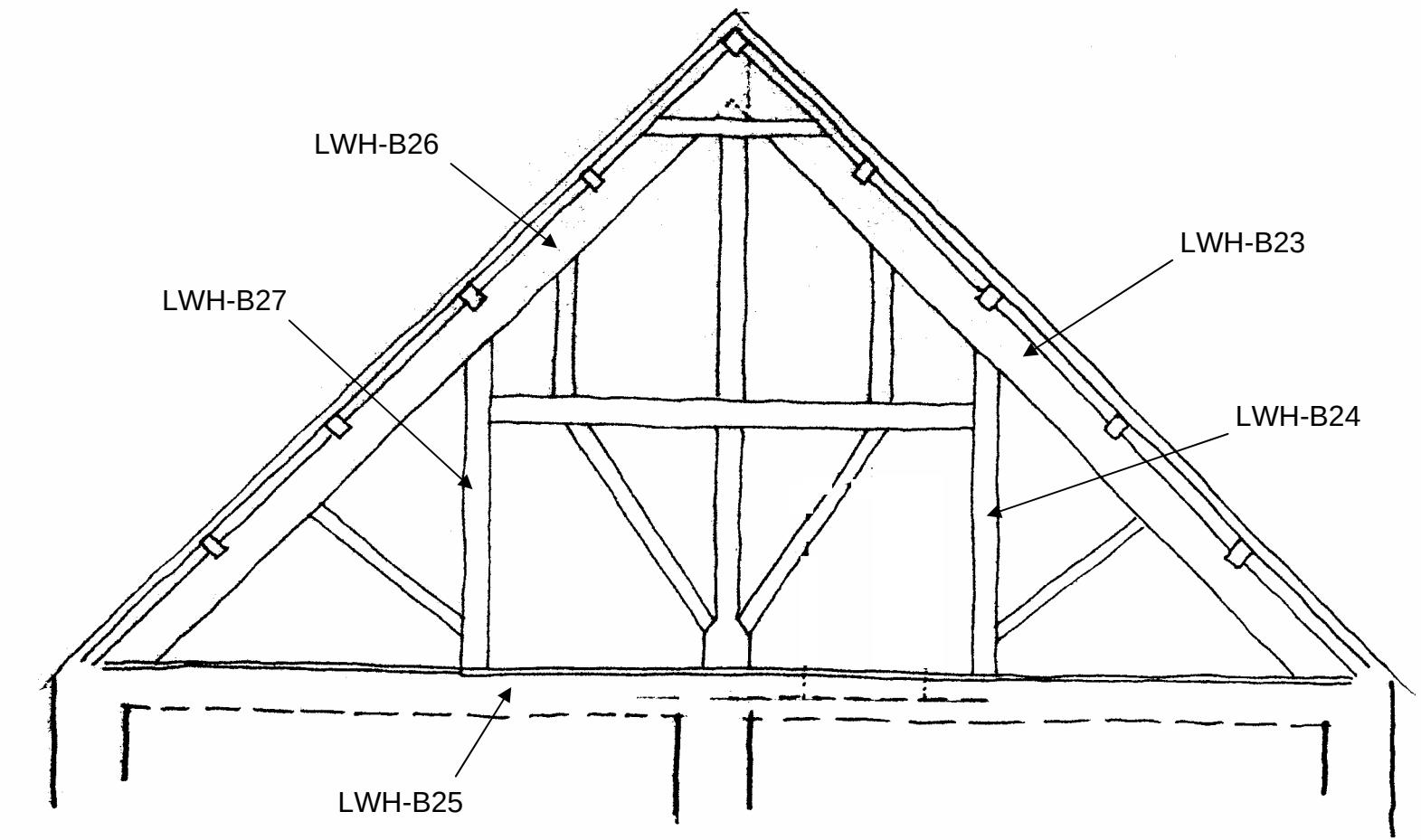


Figure 13: Low Harperley farmhouse; main building, west wing, truss 5, showing the location of samples LWH-B32–6 and LWH-B39–41, facing east

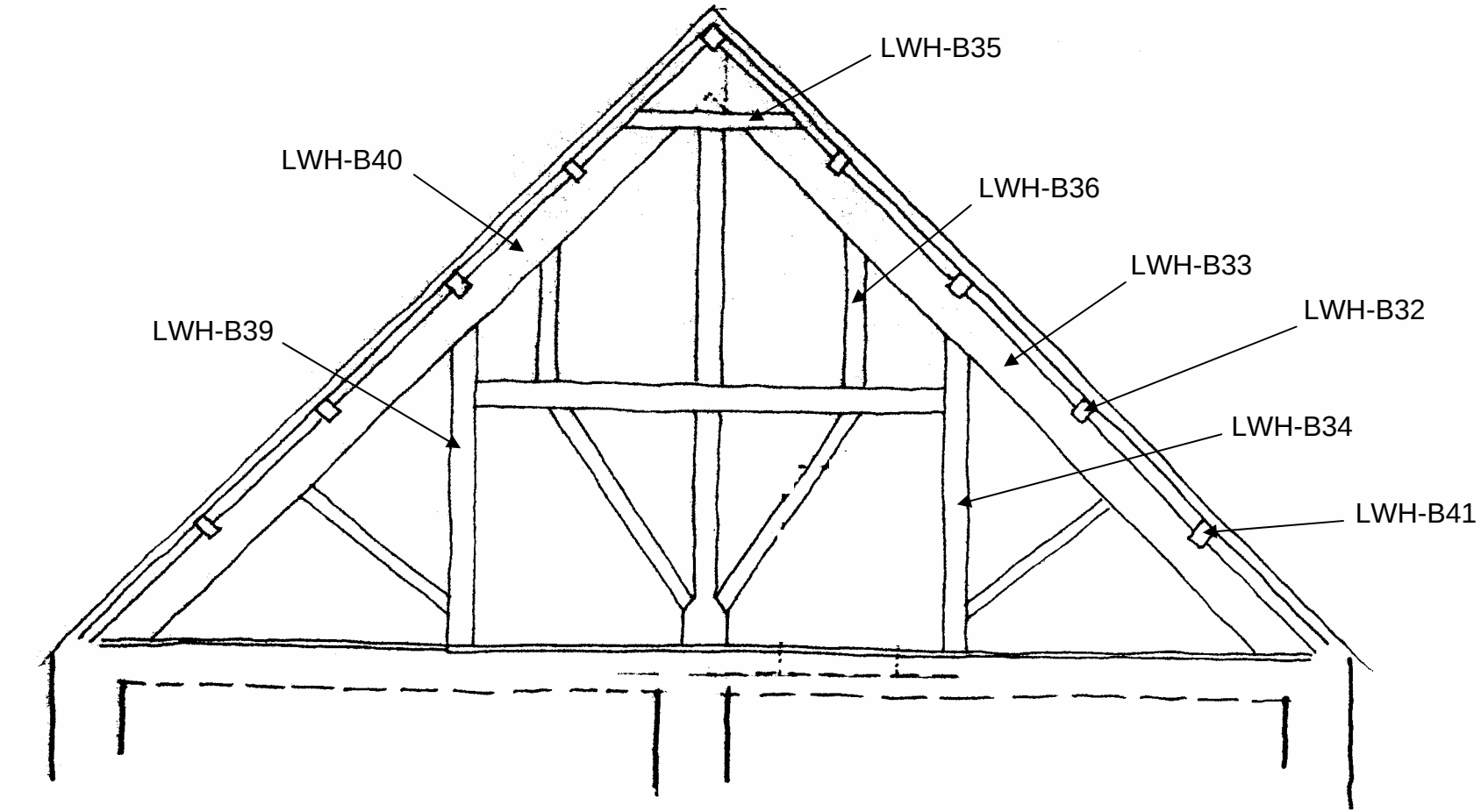


Figure 14: Low Harperley farmhouse; east cottage: roof – looking east, showing the location of samples LWH-B53–64

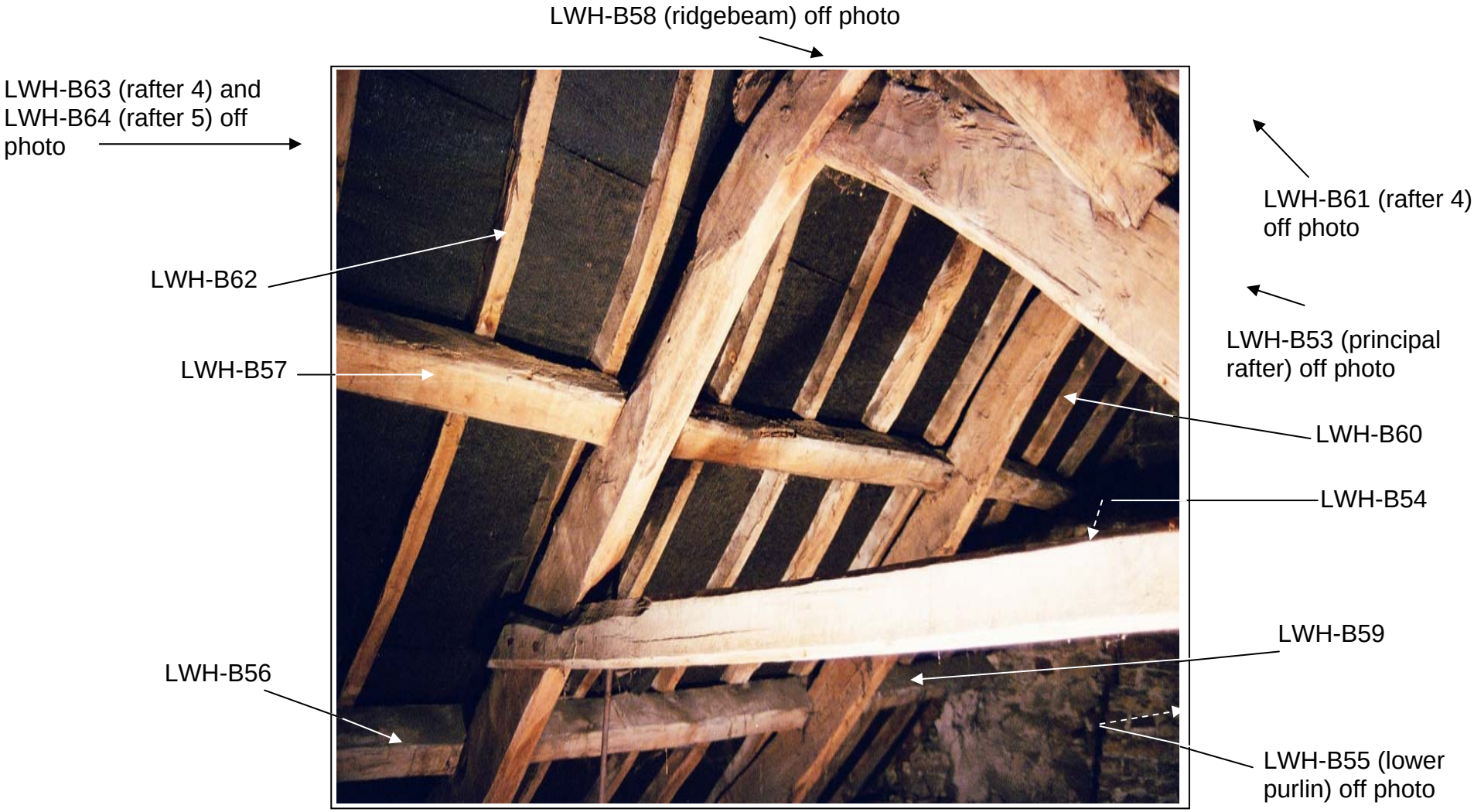


Figure 15: Low Harperley farmhouse; west cottage: roof, looking west, showing the location of samples LWH-B42–52

Figure 16: Low Harperley farmhouse; main building and west cottage: ground-floor plan, showing the location of samples LWH-B65–93 (Green 2003 unpubl)

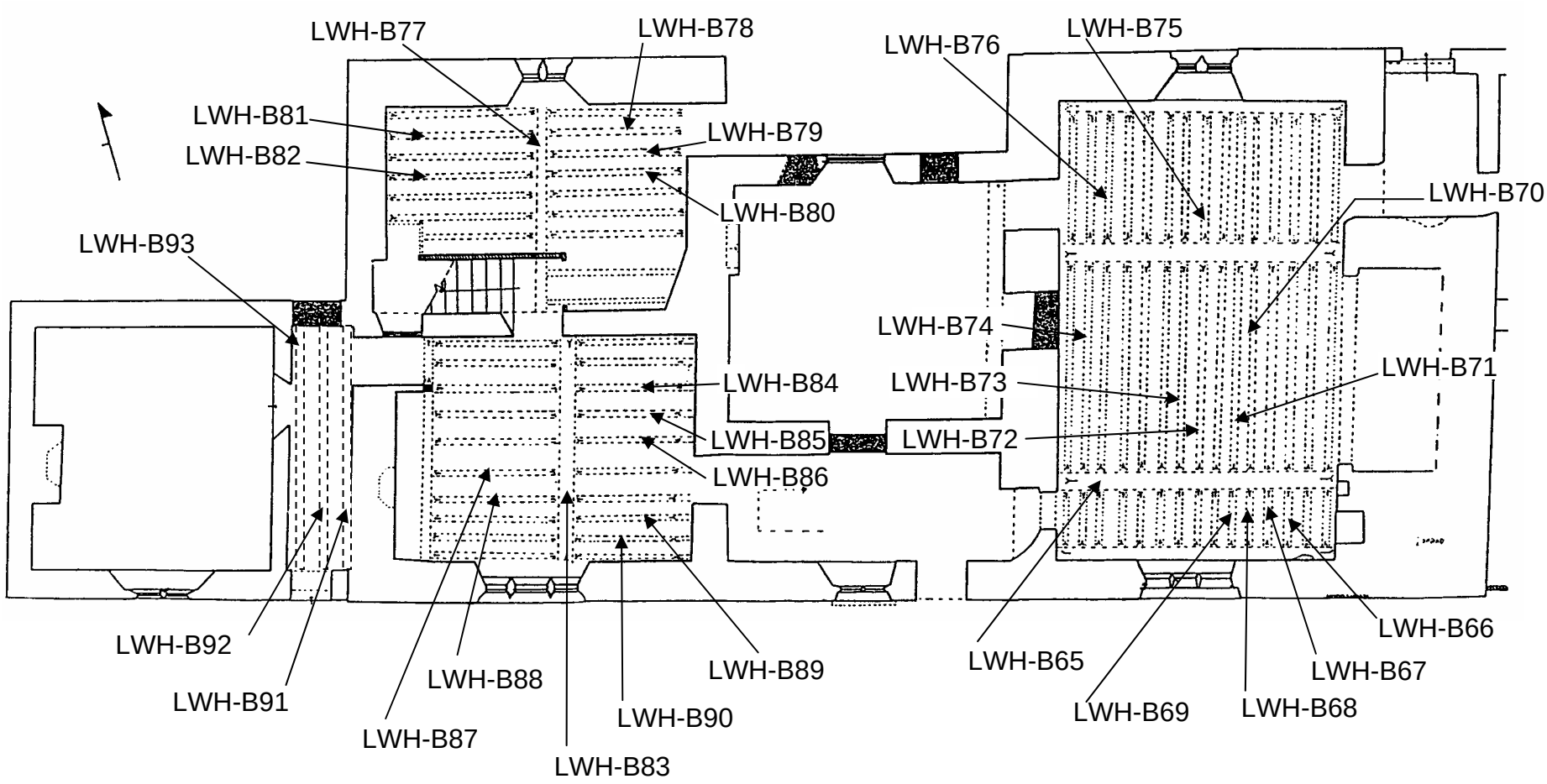


Figure 17: LWHBSQ01 components sorted by group, showing individual felling dates/ranges and group fellings

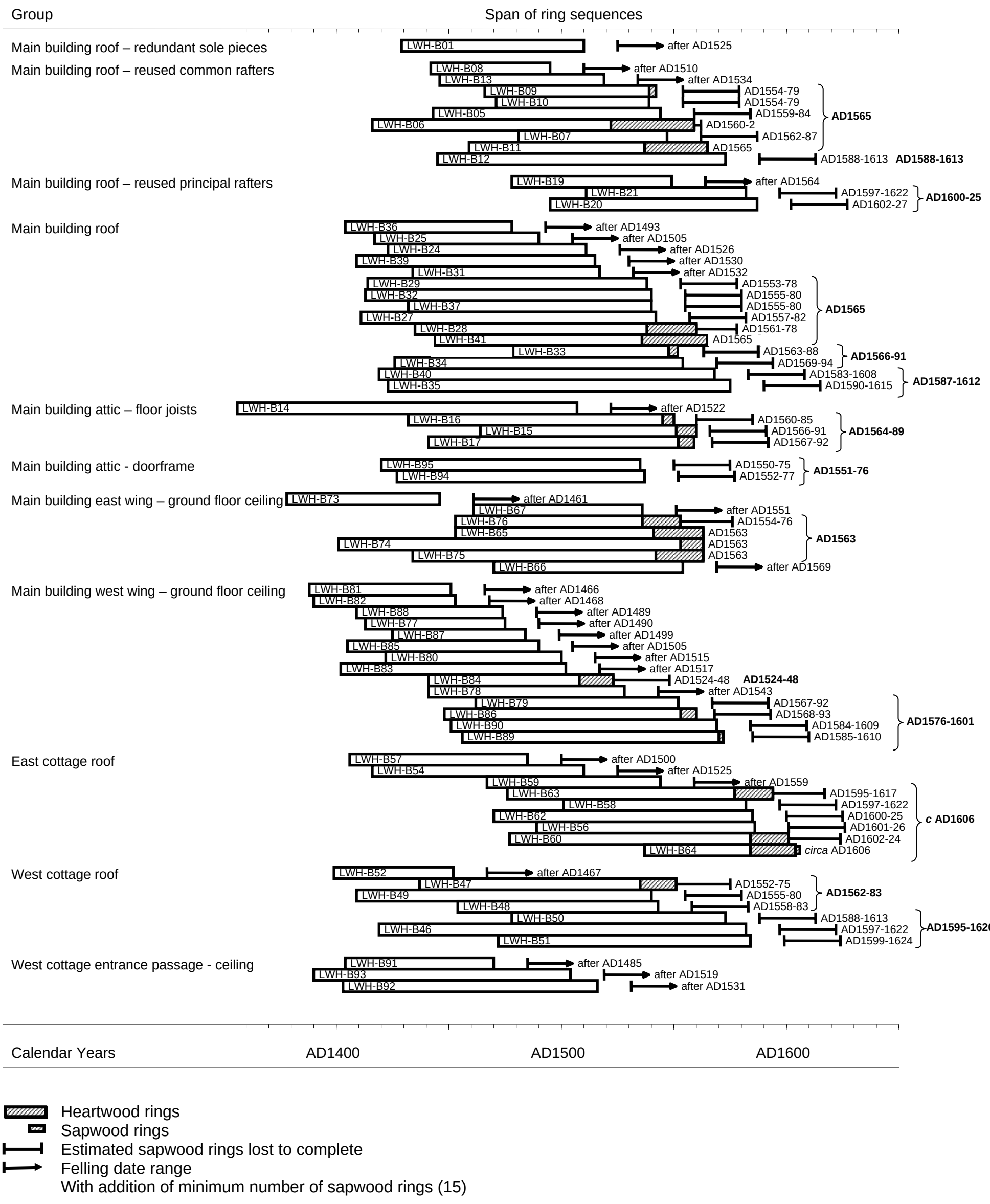


Figure 18: LWHBSQ01 components sorted by interpretation

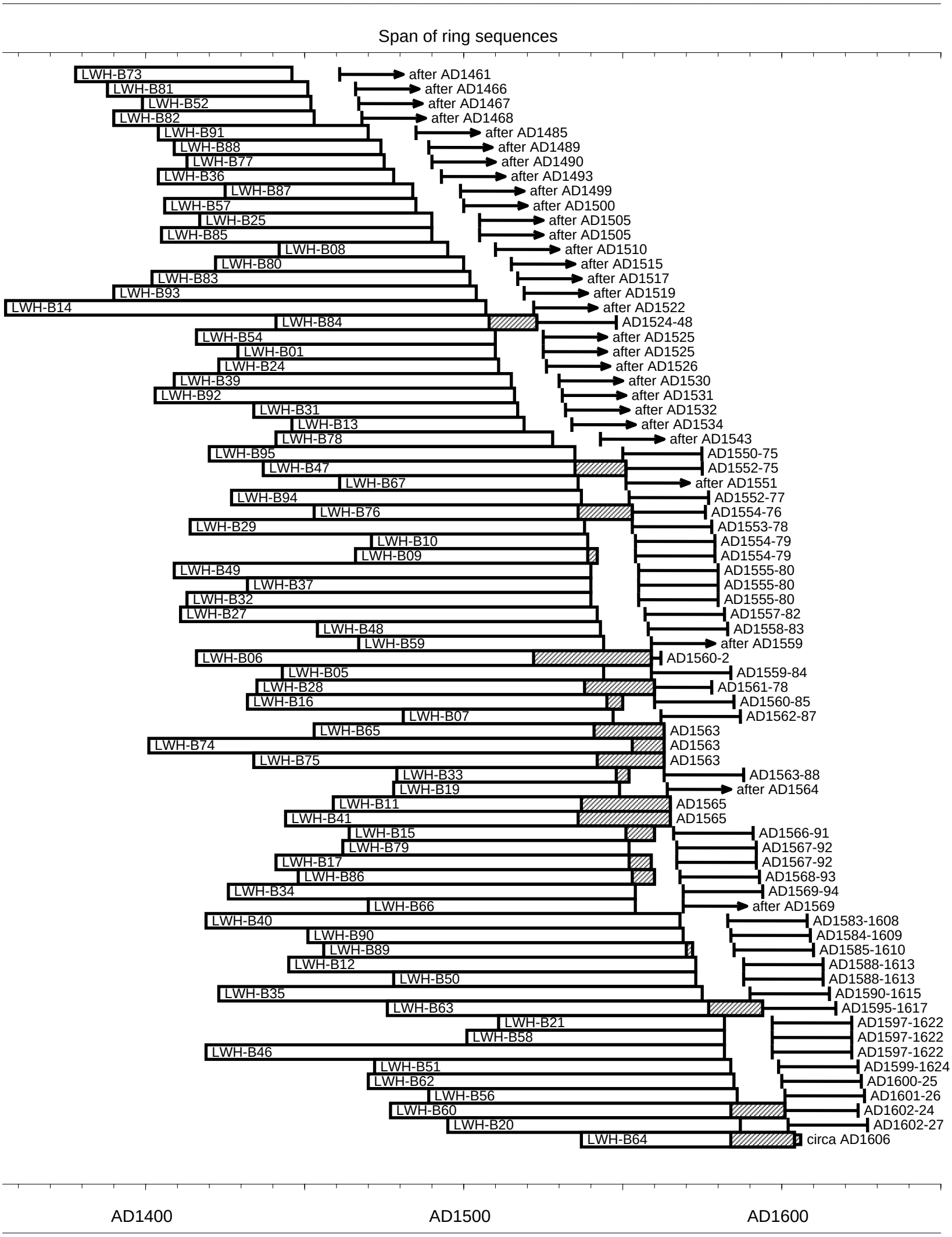
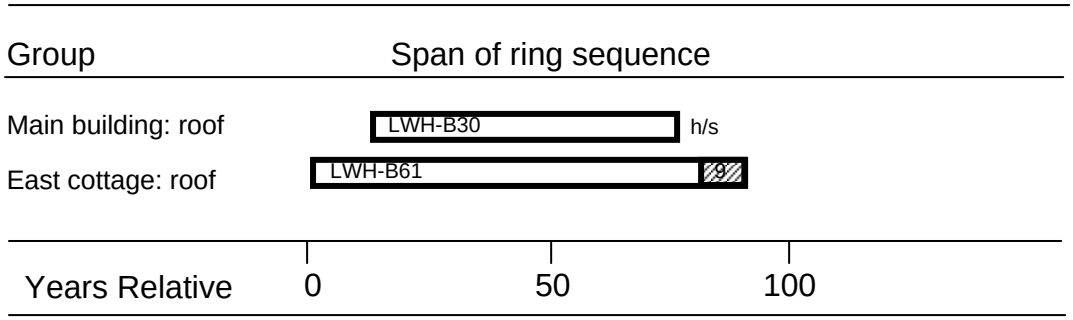


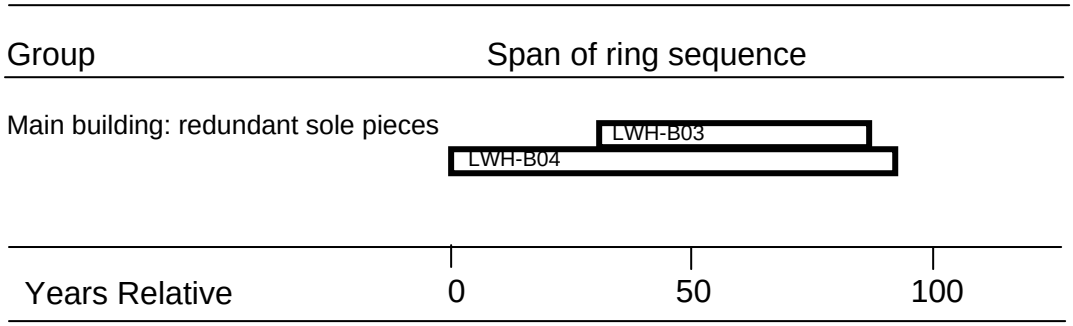
Figure 19: Bar diagram of samples in undated site sequence LWHBSQ02



Heartwood rings
Sapwood rings

h/s = the heartwood/sapwood boundary is the last ring on the sample

Figure 20: Bar diagram of samples in undated site sequence LWHBSQ03



Heartwood rings

Data of measured samples – measurements in 0.01mm units

LWH-B01A 82
134 75 80 50 70 88 82 82 97 75 65 99 151 170 199 242 212 198 302 363
413 306 246 298 294 320 311 365 386 272 258 320 306 292 200 233 171 236 263 294
221 228 189 146 166 202 233 211 195 186 220 207 196 148 188 186 268 216 248 221
271 244 211 162 118 73 117 108 138 107 111 171 129 109 114 125 139 132 164 155
163 127
LWH-B01B 82
114 92 75 47 69 67 92 101 89 72 83 145 144 190 175 218 189 150 289 366
401 317 267 306 268 326 307 362 366 303 291 302 312 293 212 226 181 236 268 282
247 211 197 131 163 202 263 239 230 200 228 195 191 148 171 204 203 232 242 228
246 252 192 139 117 73 119 133 130 106 117 155 159 106 99 115 124 151 155 155
155 118
LWH-B02A 60
325 264 263 223 260 222 225 226 235 251 171 226 231 213 187 235 217 138 126 203
189 127 79 116 182 113 117 110 119 145 169 188 183 123 140 149 143 165 135 134
139 132 116 151 130 112 112 118 147 117 185 170 168 115 122 155 170 211 271 234
LWH-B02B 60
372 215 275 250 225 228 217 230 229 247 183 226 229 196 217 246 180 162 110 187
183 115 90 117 197 113 96 113 125 129 178 171 179 138 120 153 131 168 128 147
134 153 108 137 133 120 116 117 143 110 197 152 151 114 118 170 181 198 274 220
LWH-B03A 56
110 105 138 113 107 122 145 177 189 140 96 94 82 83 115 179 129 149 134 145
94 100 93 112 129 189 203 225 157 142 137 106 160 120 176 217 159 179 118 144
129 101 87 94 109 118 117 146 156 181 177 157 178 215 175 212
LWH-B03B 56
95 95 147 111 115 105 144 181 205 133 109 102 74 102 115 170 144 149 130 147
84 110 83 109 133 186 212 205 176 141 140 111 157 148 164 180 202 169 110 144
119 103 91 89 98 116 129 150 155 190 176 155 178 204 202 204
LWH-B04A 93
217 130 197 220 160 148 157 218 195 222 195 189 345 207 251 421 233 217 235 229
247 162 85 98 145 187 157 137 144 135 141 90 85 90 133 108 118 139 175 219
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51 63 83 45 49 57 80 117 94 115 76 73 123 43 171 126 146 98 144 79
110 65 82 82 77 110 76 160 129 148 101 84 60 83 81 166 192 165 189 177
167 116 77 44 56 54
LWH-B40A 150
188 445 215 251 132 142 145 164 136 153 183 121 123 113 75 85 123 87 124 71
64 52 75 66 89 81 63 62 59 87 107 134 68 104 146 90 80 101 123 127
134 141 129 141 152 125 73 118 112 123 89 118 111 59 105 143 223 252 140 95
44 69 93 66 82 93 91 85 187 85 82 57 42 31 36 58 80 103 78 103
84 65 105 94 154 125 115 118 119 134 125 109 137 106 89 88 90 107 132 123
68 111 107 117 68 80 79 75 72 99 118 75 64 68 87 73 75 111 112 82
114 145 108 129 94 114 97 90 85 94 67 75 99 108 111 96 108 72 72 68
90 71 101 103 113 85 65 90 103 78
LWH-B40B 150
185 435 216 244 132 131 150 163 133 151 194 119 126 108 75 85 114 96 111 66
61 58 75 63 84 85 57 62 56 82 116 139 64 106 143 85 77 95 115 130
116 141 110 140 149 114 86 121 114 126 82 130 109 58 105 133 230 255 144 105
35 64 100 61 82 93 93 84 186 97 86 58 32 43 30 50 89 90 78 102
81 70 99 95 107 133 114 115 117 141 125 108 134 96 93 88 90 104 127 124
83 90 116 117 62 89 84 63 78 95 111 74 73 66 76 86 84 109 104 87
111 130 116 118 105 102 99 100 84 95 64 77 99 115 123 98 110 79 51 75
82 84 91 114 115 86 52 87 98 78
LWH-B41A 122
158 164 135 156 150 156 149 152 189 171 160 122 155 181 160 158 153 172 152 123
130 167 202 216 251 264 164 126 69 85 85 129 114 157 125 116 119 119 106 136
118 115 121 182 150 115 101 112 126 125 128 111 132 128 131 147 154 120 90 91
123 116 122 118 141 119 125 108 120 97 94 98 97 86 94 73 89 93 69 68
96 147 118 102 111 108 139 113 163 128 155 125 133 129 125 174 178 126 103 82
95 84 89 90 137 107 109 133 104 100 44 31 28 41 29 33 38 33 49 43
23 29
LWH-B41B 122
154 156 140 158 156 156 145 156 187 173 166 138 166 190 162 159 157 166 161 123
128 161 164 227 261 268 165 137 64 99 81 123 119 170 118 111 128 132 89 135
121 113 130 185 153 117 106 117 128 126 116 125 125 137 131 155 153 126 101 98
122 126 131 118 134 125 135 95 122 98 89 97 99 89 94 77 85 94 71 69
97 146 121 99 119 113 126 110 164 137 157 121 142 130 124 175 176 125 109 83
94 89 90 94 131 110 107 135 108 98 46 29 27 39 35 33 34 30 54 50
50 36

LWH-B43A 56

72 138 135 172 115 199 248 183 146 216 236 247 214 254 262 285 292 225 261 260
320 380 301 363 249 337 326 267 331 325 233 260 292 310 188 229 177 237 241 292
260 156 151 187 191 221 214 226 354 267 249 233 229 330 276 242

LWH-B43B 56

63 133 135 173 107 208 250 189 143 219 303 266 255 222 272 311 282 208 283 257
276 384 307 355 259 337 311 264 330 357 230 245 270 263 191 210 200 229 249 303
261 186 139 172 188 235 237 231 361 267 246 243 212 309 333 240

LWH-B46A 164

63 120 121 134 153 132 104 112 137 152 155 99 103 102 78 81 81 72 79 60
51 40 41 53 60 59 51 49 50 52 97 52 56 63 63 66 90 86 64 55
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85 90 94 77 84 72 76 71 64 52 52 61 72 68 60 87 124 108 96 80
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44 42 41 49 35 33 40 51 42 46 56 44 43 36 51 42 51 35 44 48
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58 42 43 49 50 34 36 30 35 31 38 40 36 46 41 37 47 43 29 31
37 32 37 34

LWH-B46B 164

119 130 125 135 152 146 97 110 141 150 155 101 103 103 78 78 86 71 84 54
50 42 46 50 51 54 47 55 42 59 55 52 60 63 60 70 81 93 57 57
71 70 63 70 73 53 54 84 71 84 69 74 73 77 78 76 87 79 77 73
81 96 93 83 78 74 81 71 65 54 48 59 67 68 62 84 125 110 96 77
77 84 66 49 58 64 67 84 75 73 83 69 59 53 45 44 41 47 35 46
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36 33 32 37

LWH-B47A 115

199 184 128 222 202 216 289 283 198 164 211 183 209 275 203 244 214 194 197 245
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204 161 165 171 207 181 208 201 157 203 245 214 191 192 184 234 166 206 180 288
248 197 214 196 143 137 128 234 191 90 73 88 146 118 96 87 77 92 123 129
142 180 127 132 127 161 126 138 205 216 138 193 222 193 145 147 125 81 79 90
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LWH-B47B 115

222 170 134 210 203 217 277 277 209 161 206 187 205 278 202 256 204 200 198 250
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203 160 161 171 207 178 211 179 178 203 252 206 191 192 180 241 162 203 179 283
252 191 211 184 139 129 116 235 181 108 67 88 134 126 99 92 85 86 110 122
136 180 130 123 127 162 116 149 207 216 142 187 234 192 145 137 132 89 85 89
106 61 110 139 69 106 68 100 133 151 162 155 108 121 120

LWH-B48A 90

170 140 132 178 122 103 105 50 41 54 77 65 62 83 87 84 151 132 90 108
93 110 152 144 144 131 95 119 105 133 134 151 171 214 138 116 139 116 132 138
151 201 240 201 140 159 92 104 95 102 144 134 70 49 74 102 96 82 86 103
113 137 148 169 163 99 68 88 99 63 63 106 84 95 80 132 119 109 90 110
68 69 82 83 113 178 186 117 58 80

LWH-B48B 90
156 136 137 162 132 106 98 61 46 61 68 80 58 73 87 93 161 110 102 92
97 119 161 139 146 130 90 126 90 139 145 134 180 214 134 121 126 129 125 158
147 209 246 197 136 170 113 102 81 89 162 133 59 53 73 106 95 76 88 108
110 143 134 178 161 97 67 92 96 76 52 103 96 82 82 138 120 115 97 113
71 72 72 93 119 183 181 111 66 70
LWH-B49A 132
251 337 267 257 230 191 198 165 144 214 142 161 197 212 325 271 143 92 61 94
57 75 148 176 95 117 136 129 123 109 101 77 93 89 130 118 111 96 93 68
109 104 136 130 98 73 99 99 88 86 57 91 95 67 69 69 76 99 109 98
67 119 161 76 79 87 134 160 127 130 72 77 115 77 74 78 74 60 105 92
81 72 61 57 60 62 76 93 69 76 87 81 68 44 47 71 85 65 59 64
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LWH-B49B 132
290 349 244 237 231 200 202 166 142 218 140 163 196 210 330 265 143 92 64 87
60 73 154 173 99 135 146 140 129 101 101 75 91 95 128 120 108 106 89 70
111 109 132 140 97 63 107 97 84 85 59 92 92 70 66 70 77 103 111 97
66 107 148 67 87 86 133 150 142 130 67 73 117 69 71 82 69 55 110 98
75 69 60 60 57 68 64 96 72 66 90 76 62 48 47 64 76 61 63 56
69 81 70 74 73 66 62 76 79 52 60 67 61 56 58 60 47 66 38 50
34 41 38 40 45 61 69 69 54 68 42 49
LWH-B50A 96
120 186 176 256 215 237 304 207 229 276 192 144 207 147 128 152 182 182 215 149
124 126 58 41 58 51 98 92 118 162 162 166 156 132 144 123 138 89 130 116
160 166 142 185 169 135 186 144 175 114 113 144 109 94 74 97 103 118 98 105
80 86 110 110 73 81 102 113 114 118 107 71 105 145 111 119 119 166 129 103
65 84 109 141 135 122 140 87 64 48 69 82 101 87 104 122
LWH-B50B 96
150 191 165 266 208 226 277 201 225 285 199 145 214 145 127 153 170 173 212 148
118 121 61 50 52 50 93 98 119 165 157 159 151 134 130 129 128 103 121 127
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81 87 100 120 65 88 96 118 104 114 112 69 105 146 111 116 125 171 120 106
63 88 110 143 131 124 138 90 60 46 70 83 110 83 98 116
LWH-B51A 113
125 126 108 112 131 132 132 138 145 167 151 165 212 178 188 194 125 119 155 148
131 130 141 202 170 138 115 128 161 114 71 63 109 125 191 163 182 229 160 163
127 67 67 70 84 48 70 55 68 89 86 56 65 65 77 70 84 95 109 120
79 84 82 93 81 88 98 100 138 93 64 74 82 81 94 80 81 85 72 101
68 81 77 79 75 69 83 102 88 84 75 87 67 59 56 41 40 64 63 79
49 77 63 71 73 64 53 68 63 65 51 58 61
LWH-B51B 113
116 120 97 112 123 135 125 167 126 136 136 184 220 182 184 192 121 108 160 151
142 132 139 201 167 144 118 136 136 103 74 72 100 123 194 168 190 229 167 162
114 76 69 70 86 42 69 54 72 90 80 65 59 62 82 68 85 96 110 118
86 73 85 93 82 82 104 101 139 98 64 73 81 89 76 91 79 85 71 104
78 79 75 86 70 68 83 107 81 92 73 89 63 60 54 38 43 64 62 76
50 72 68 77 56 65 58 67 55 73 51 56 69

LWH-B52A 54
352 331 216 218 414 378 320 367 258 316 335 239 277 322 306 227 271 180 159 230
148 151 150 165 254 254 174 104 75 99 81 89 107 168 95 94 112 90 110 81
84 74 71 86 67 63 80 58 58 54 55 60 66 45
LWH-B52B 54
369 329 220 209 420 374 321 378 278 315 337 246 276 315 303 249 266 181 152 233
147 148 156 154 255 256 175 100 75 90 81 82 111 166 99 94 111 93 98 83
86 70 69 79 65 68 69 66 60 54 61 59 59 45
LWH-B54A 80
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111 86 96 63 75 86 103 83 98 87 66 125 104 90 93 108 83 62 52 55
72 104 155 112 109 128 63 92 100 80 81 107 81 94 101 81 73 86 73 93
LWH-B54B 95
181 255 252 160 201 269 260 229 175 178 98 147 171 210 171 165 171 125 187 174
161 116 114 82 133 120 116 133 127 125 94 130 114 109 98 113 113 130 138 83
112 83 97 71 75 81 103 89 87 86 51 121 117 83 90 108 84 60 50 52
70 116 159 99 116 136 61 76 95 86 82 108 78 88 109 79 75 77 75 92
74 106 70 101 74 72 52 59 73 92 118 145 187 180 167
LWH-B56A 98
248 217 166 108 122 229 160 97 91 109 135 142 105 102 118 163 299 255 232 259
284 85 59 48 33 42 51 91 78 94 122 111 124 142 94 152 152 173 151 164
188 164 156 113 172 274 292 267 188 88 134 100 89 84 123 138 120 81 55 78
42 104 196 128 133 151 297 175 82 72 177 176 143 149 168 169 91 84 63 67
88 147 162 120 198 182 137 89 177 167 170 242 124 130 120 111 115 215
LWH-B56B 98
256 223 170 104 131 221 142 91 102 112 136 125 103 102 111 174 322 241 239 247
302 80 69 43 35 45 53 87 81 96 117 122 114 142 96 153 162 162 152 175
195 143 164 109 159 260 278 264 169 75 141 100 90 83 114 143 125 71 55 79
49 111 193 134 123 162 338 183 97 71 185 170 128 170 140 172 79 97 55 67
93 146 162 112 192 181 131 87 189 157 172 247 119 131 121 113 111 193
LWH-B57A 80
156 143 129 230 141 128 140 129 128 150 111 173 128 76 173 133 168 174 177 164
150 82 156 218 153 185 218 189 270 242 175 212 202 167 210 226 168 200 206 101
67 125 89 105 132 143 117 110 139 111 124 150 108 111 117 126 152 128 139 126
213 238 198 174 256 217 131 130 108 174 209 211 202 213 157 153 127 105 137 165
LWH-B57B 80
155 143 142 212 151 128 134 143 107 135 109 183 129 77 172 130 172 168 185 175
153 82 158 220 154 188 226 183 277 241 180 200 208 159 211 231 167 205 204 99
74 119 90 111 126 146 113 118 116 108 131 158 100 112 113 125 154 134 139 134
206 243 199 175 238 234 130 131 90 196 205 211 197 220 153 147 136 100 138 149
LWH-B58A 82
108 104 84 158 158 154 193 191 60 53 50 41 36 69 101 261 250 234 212 235
251 235 200 226 296 262 98 65 111 95 115 128 179 183 179 230 270 223 283 334
203 339 321 325 133 122 156 151 85 119 163 174 215 142 146 203 131 110 153 103
103 141 149 113 46 62 44 60 68 130 86 89 143 101 95 95 110 127 126 132
75 62

LWH-B58B 82

85 102 81 158 153 142 197 200 69 49 43 40 46 63 109 259 240 273 207 236
253 233 201 223 306 267 87 65 101 83 125 114 181 192 184 232 266 229 276 330
199 338 298 298 130 132 150 178 95 104 167 183 218 151 147 197 139 114 154 104
106 140 151 122 51 47 51 59 71 131 92 89 145 101 102 89 125 110 123 140
77 55

LWH-B59A 78

338 358 375 452 336 293 201 192 312 375 313 335 346 253 266 115 112 175 338 289
380 283 302 269 187 91 85 122 68 26 41 45 79 101 64 64 92 117 207 200
227 244 212 74 62 53 41 42 51 90 84 130 121 116 125 178 128 242 237 226
182 199 210 159 162 74 107 164 208 238 98 79 113 133 128 138 160 186

LWH-B59B 78

331 352 355 468 340 312 202 195 312 377 311 329 348 258 262 133 115 189 320 271
358 275 297 266 178 92 86 125 60 36 43 54 72 99 64 65 89 117 197 204
226 241 218 69 74 48 39 38 53 86 90 125 110 112 126 183 124 236 236 217
193 190 207 167 148 89 101 171 206 237 94 73 131 128 130 117 181 165

LWH-B60A 125

220 193 221 205 230 113 80 93 128 147 150 122 114 106 86 68 56 65 65 73
63 72 70 31 35 28 27 35 32 38 40 45 32 42 38 18 49 31 29 41
57 62 72 69 63 58 79 71 80 85 53 52 56 92 80 64 73 69 98 84
76 62 103 107 73 56 67 69 53 47 57 70 43 53 73 53 53 48 67 62
57 55 63 61 57 52 40 49 40 40 36 40 46 53 53 35 61 53 38 35
40 29 45 39 27 34 46 50 46 39 41 33 42 41 46 47 63 74 66 77
68 71 71 73 85

LWH-B60B 125

214 204 200 207 226 110 79 97 120 150 153 120 120 108 96 63 47 72 52 68
63 57 69 41 29 29 22 32 43 41 29 47 31 46 37 21 37 37 36 38
52 67 73 63 67 55 75 74 79 90 49 44 70 85 88 55 71 75 88 91
71 64 96 107 71 61 64 74 48 48 55 76 41 51 70 53 59 51 61 58
61 54 60 64 57 52 42 46 38 40 35 46 41 55 53 46 57 51 45 35
33 38 40 44 28 48 32 50 41 41 40 37 41 37 40 53 60 62 76 71
74 64 70 80 82

LWH-B61A 90

121 105 113 134 63 87 71 90 76 92 61 64 92 62 72 105 127 130 129 113
89 71 56 46 51 77 70 66 74 75 101 86 72 87 93 101 56 59 56 63
50 55 61 67 78 95 69 93 84 94 77 86 112 114 76 98 88 89 72 103
122 97 110 111 99 98 84 101 88 91 108 92 78 115 97 59 76 104 96 144
106 93 93 104 102 112 93 102 98 96

LWH-B61B 90

119 102 114 134 60 81 79 77 86 81 79 50 90 73 78 110 133 121 126 123
80 73 43 43 59 71 75 64 66 76 93 88 67 94 95 93 55 70 56 65
49 63 54 65 75 95 71 93 84 87 83 85 112 110 81 97 86 88 72 108
131 84 114 109 103 105 88 103 89 96 103 90 83 114 91 61 79 112 99 131
115 81 108 96 101 110 88 101 96 81

LWH-B62A 116

229 314 264 235 189 225 287 298 265 234 322 222 169 73 67 85 142 172 177 108
111 99 95 53 39 53 52 63 56 53 55 26 33 26 34 32 38 38 35 36
40 26 27 27 22 25 45 52 69 65 75 75 70 69 83 81 87 58 48 73
83 89 57 65 77 108 104 94 89 111 136 101 99 88 78 69 74 72 81 46
58 93 68 67 55 107 75 71 55 69 69 68 79 67 65 38 64 40 45 61
77 57 49 71 72 39 36 38 31 43 60 44 36 59 61 63

LWH-B62B 116

236 324 274 221 195 234 268 301 264 228 312 209 175 60 44 97 150 158 184 108
106 121 84 69 37 53 48 70 55 52 60 40 27 23 18 18 29 46 45 39
35 31 37 40 30 39 45 50 62 69 79 75 70 66 82 86 84 57 51 69
85 84 56 63 83 108 104 93 83 116 132 106 94 91 79 71 69 75 81 45
57 95 64 61 55 104 75 67 57 66 71 70 79 63 66 43 58 42 45 61
76 55 61 74 69 39 35 40 25 52 63 36 40 58 61 55

LWH-B63A 119

190 184 211 185 151 200 89 115 142 138 146 134 93 88 119 90 68 59 90 103
92 134 97 106 84 48 42 54 67 96 74 72 86 77 81 75 58 72 68 41
55 50 58 59 41 44 58 55 76 77 97 71 66 87 63 80 52 49 61 71
64 66 71 72 95 78 56 55 64 50 70 54 66 40 63 68 53 46 59 52
40 41 49 43 46 41 49 45 60 62 49 48 36 48 50 44 44 55 40 38
33 34 46 47 38 36 34 29 42 38 38 37 32 32 37 30 39 42 57

LWH-B63B 119

173 192 210 175 153 196 87 111 146 139 146 133 96 78 122 82 58 63 103 94
112 120 104 107 73 45 50 49 70 91 82 78 97 90 87 72 62 78 64 47
53 41 66 57 44 46 55 66 74 79 97 70 65 86 66 78 48 55 63 70
54 73 65 76 96 82 50 50 51 57 80 61 68 42 67 74 49 49 64 54
47 46 38 49 38 46 48 56 60 45 52 45 39 52 49 36 53 48 45 34
39 36 36 46 35 40 29 34 39 38 49 28 43 21 35 30 34 47 59

LWH-B64A 68

166 163 187 214 149 176 179 204 188 172 210 221 138 308 325 205 149 103 61 77
90 100 150 143 115 130 121 74 69 58 51 52 73 114 102 116 148 128 85 62
72 94 139 136 93 109 121 110 82 91 83 70 115 84 101 118 65 62 56 39
39 43 53 60 90 98 90 70

LWH-B64B 68

180 172 185 206 151 176 183 198 195 174 213 227 140 311 329 204 150 102 63 74
94 98 147 144 114 132 106 82 68 52 53 53 72 119 122 116 126 134 91 57
69 98 141 142 97 116 136 123 91 104 80 70 101 81 97 116 68 65 51 43
42 40 51 64 87 93 107 88

LWH-B65A 111

240 259 153 290 305 329 355 247 238 250 269 225 199 352 416 343 255 269 195 135
126 121 238 274 234 156 191 131 145 141 192 181 169 214 301 190 97 191 113 166
98 111 149 213 197 151 205 140 76 80 113 129 193 201 234 208 169 167 156 136
97 97 127 151 133 130 153 136 123 167 152 212 281 255 147 127 150 94 134 142
143 204 182 207 129 71 118 123 164 116 162 147 172 140 192 173 106 100 222 177
163 166 198 176 112 63 104 82 116 140 107

LWH-B65B 111
167 279 168 331 324 334 339 251 253 266 271 219 192 344 415 340 259 270 197 124
128 111 246 265 223 160 185 136 141 145 201 184 172 221 303 177 102 172 123 154
92 107 151 196 196 165 218 147 82 88 97 135 185 200 240 205 168 169 160 135
93 103 129 159 144 123 155 132 128 169 150 213 282 251 167 116 142 96 111 148
139 206 183 203 130 90 104 127 155 114 147 150 177 139 188 177 115 94 215 190
156 170 199 175 103 63 111 82 115 150 100
LWH-B66A 85
314 276 268 339 264 241 209 184 197 169 144 201 169 132 116 118 171 226 202 200
204 188 235 221 161 129 183 187 219 225 217 154 129 149 162 215 165 159 150 146
144 205 178 97 130 207 175 188 139 133 153 158 131 126 100 132 207 155 140 163
174 115 107 128 173 148 148 162 168 140 184 155 111 105 113 106 108 96 99 82
82 83 106 70 93
LWH-B66B 85
330 266 271 324 255 246 206 204 185 179 142 199 172 136 115 110 180 236 184 218
210 197 241 199 163 123 185 202 201 257 219 158 130 146 154 218 161 163 143 135
142 205 172 100 116 208 195 193 143 133 146 155 141 120 93 133 204 165 129 160
177 114 111 120 152 145 145 166 173 139 185 147 118 105 107 114 103 88 106 77
79 77 92 80 101
LWH-B67A 76
266 314 289 218 202 231 292 225 214 202 192 151 191 191 283 248 303 269 170 144
222 171 125 128 159 171 238 196 223 214 183 183 167 203 145 198 202 172 189 154
94 81 114 141 214 204 277 256 262 235 237 238 147 156 238 172 199 202 148 140
172 154 143 137 212 180 212 219 244 227 200 237 156 189 159 186
LWH-B67B 76
273 307 283 223 199 229 296 228 220 197 196 151 189 199 277 256 305 252 175 152
216 176 128 145 158 185 263 190 219 203 179 180 166 195 135 212 203 172 189 155
90 90 107 143 221 213 271 253 264 237 247 227 157 148 237 172 202 198 145 134
179 157 138 134 219 196 226 207 258 219 203 223 169 185 157 189
LWH-B68A 111
180 149 140 122 122 171 241 181 268 277 175 152 165 158 140 162 156 106 138 82
72 104 115 83 128 121 129 168 154 133 73 160 188 265 233 263 270 216 281 216
252 187 261 239 272 435 249 268 193 109 91 104 129 100 221 192 194 223 156 121
93 84 90 159 290 277 308 216 175 142 94 92 71 76 103 96 106 86 107 81
116 139 204 139 162 167 154 164 243 144 128 129 132 123 161 173 160 213 242 232
177 160 130 116 111 82 93 79 100 138 159
LWH-B68B 111
161 147 140 119 120 165 250 172 264 271 173 154 172 153 137 160 151 135 119 87
72 91 123 92 129 130 134 175 143 141 80 161 180 260 254 246 233 212 243 222
262 190 263 226 274 434 255 273 194 116 108 101 130 113 213 212 240 242 167 120
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116 139 210 134 163 172 168 161 206 141 135 131 127 121 164 180 138 226 242 231
170 181 125 123 104 95 106 67 97 138 111
LWH-B69A 89
392 549 485 364 484 541 350 293 289 236 280 275 269 202 270 434 308 208 197 175
158 195 207 267 199 174 164 173 165 190 201 115 213 246 220 248 321 308 297 234
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84 85 101 86 80 101 123 155 154

LWH-B69B 89
352 546 490 363 496 486 349 291 290 225 282 275 273 203 284 421 319 208 196 173
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174 140 167 129 193 199 156 180 155 84 79 131 294 361 153 114 113 187 290 252
181 217 157 227 219 213 236 133 156 163 163 136 133 95 78 99 88 102 99 97
82 79 107 84 76 89 126 170 169
LWH-B70A 102
91 133 156 139 86 85 89 115 115 78 94 150 165 88 121 105 187 278 159 141
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103 72 88 114 104 102 91 80 74 69 106 99 58 52 108 73 159 92 93 117
77 81
LWH-B70B 102
82 140 155 140 103 70 91 121 121 76 89 152 163 86 120 96 182 270 162 113
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44 44 36 52 39 51 62 122 165 212 178 151 119 49 66 63 44 58 61 70
103 83 88 114 100 107 89 73 69 76 110 96 52 73 92 78 155 98 95 115
78 73
LWH-B72A 52
176 356 344 406 480 417 251 271 315 359 267 275 211 301 391 354 262 239 194 213
554 392 387 335 340 409 311 321 260 237 214 237 127 143 178 187 100 103 98 225
229 129 184 182 146 56 103 83 263 280 209 220
LWH-B72B 52
170 338 358 422 472 395 228 287 314 358 265 275 217 297 390 359 257 240 194 213
552 390 375 341 341 420 281 285 240 232 221 248 110 139 185 180 91 98 107 205
236 148 176 183 149 58 98 90 267 281 203 226
LWH-B73A 69
171 277 206 209 219 228 265 189 267 180 203 184 177 198 196 196 219 186 222 175
291 370 464 372 353 434 364 393 366 421 433 392 341 368 367 330 267 327 220 248
292 184 226 237 209 347 288 272 211 205 193 214 193 231 281 184 265 208 192 167
144 144 191 230 277 241 280 243 218
LWH-B73B 69
179 280 199 212 219 223 263 178 263 176 192 189 169 199 198 206 212 188 226 179
288 361 458 375 348 437 368 402 375 400 430 394 344 365 365 340 252 337 216 247
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144 147 178 229 263 250 273 254 229
LWH-B74A 163
165 237 256 208 219 277 180 178 198 223 210 231 192 172 178 159 167 179 143 188
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27 34 26

LWH-B74B 163
154 222 261 190 215 263 186 174 202 218 215 241 191 164 182 166 162 173 144 183
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83 83 57 69 72 85 89 98 72 86 91 62 50 75 96 124 78 99 70 98
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69 58 65 60 61 63 51 58 51 74 77 67 65 48 35 32 26 34 32 29
30 36 23
LWH-B75A 124
195 182 134 143 128 121 162 160 165 207 216 191 160 130 90 100 122 143 164 146
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79 102 108 96
LWH-B75B 116
88 109 122 134 131 122 99 92 140 110 93 91 86 96 120 82 114 111 130 151
140 118 149 135 81 62 94 118 110 88 92 82 76 83 51 82 77 85 84 114
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80 80 73 63 56 56 49 64 44 52 51 49 58 55 54 62 66 65 80 85
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95 69 80 87 74 92 73 113 122 80 114 113 91 118 140 115
LWH-B76A 101
278 289 218 345 237 144 84 197 161 224 197 145 101 160 274 235 263 276 314 125
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141
LWH-B76B 101
282 277 235 332 237 134 93 205 176 222 211 128 104 161 278 246 253 291 309 114
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139
LWH-B77A 63
162 174 210 279 359 291 126 289 195 244 324 221 165 149 250 259 348 307 309 361
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147 168 206 172 216 98 112 81 176 143 146 126 119 161 165 261 141 184 145 97
72 101 153
LWH-B77B 63
162 177 209 274 353 221 126 288 204 248 339 228 166 146 244 261 339 275 307 358
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166 162 199 173 203 117 117 91 177 133 134 135 124 164 158 258 152 206 157 94
75 100 177

LWH-B78A 88
191 218 167 234 163 114 130 103 135 158 153 165 148 214 146 170 140 62 90 104
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LWH-B78B 88
188 213 176 227 160 122 132 92 138 169 142 161 137 209 143 173 137 61 93 96
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148 113 91 139 157 149 135 132
LWH-B79A 91
118 133 93 85 126 165 186 133 116 122 55 71 40 104 159 164 174 94 128 116
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LWH-B79B 91
117 139 79 93 123 165 175 142 120 119 61 63 41 109 156 153 182 96 125 119
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93 86 155 254 273 324 250 179 148 141 132 140 110 118 152 163 167 104 131 155
164 104 144 151 182 166 166 196 158 64 59 132 205 105 119 101 74 72 55 46
75 72 58 104 76 90 81 61 117 143 147
LWH-B80A 79
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