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Tree-Ring Analysis of Timbers

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Summary

Prior to tree-ring analysis being undertaken on the roofs and ground and first-floor ceilings of the South, East, and West Range of this building, these were thought to be the result of a substantial rebuilding undertaken in the early-seventeenth century.

Dendrochronological analysis of samples taken from the timbers representing this rebuilding has resulted in the construction and dating of a single site sequence, KNGHSQ01. This site sequence contains 39 samples and spans the period AD 1391–1564.

Six of these timbers were felled in AD 1563 and a seventh in AD 1564. Interpretation of the heartwood/sapwood boundary points to a further 29 of these dated samples having a felling date range also consistent with a felling of AD 1563/4.

Tree-ring analysis has shown the roofs of all three ranges to be contemporary with each other and with the flooring of the building. Additionally, it has been shown that rather than occurring in the early-seventeenth century, this work was undertaken early in the second half of the sixteenth century, making Kingsbury Hall an early example of a double-pile building in England.

Keywords

Dendrochronology
Standing Building

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Introduction

Kingsbury Hall is a Grade II* listed building and Scheduled Ancient Monument located in north-west Warwickshire, to the south of Tamworth (Fig 1; SP 214 963). The Hall itself lies in the north-western corner of a clearly once defended site, believed to have its origins in the Saxon period. In the south-eastern corner of the site are two sections of wall, the remains of a once substantial curtain wall. At the junction between these two lengths of wall is a contemporary projecting open-backed half-octagonal tower. In the south-western part of this tower is a garderobe and there are the remains of a second garderobe at the western end of the southern section of the wall. To the south-east of the Hall is the former foldyard of the farmstead, its southern and eastern sides delineated by the medieval curtain wall (Fig 2).

In the late Saxon period Kingsbury manor was owned by Lady Godiva, before passing to the Earls of Chester and then to the Crown. After the Conquest, Kingsbury was held by Turchil de Warwick, who had married Countess Godiva's granddaughter. In turn he was succeeded by his son and grandson. The grandson's daughter married John de Bracebridge, which began a long relationship between Kingsbury and the Bracebridge family that continued during the fourteenth and fifteenth centuries.

In AD 1516 Kingsbury was held by a Thomas Bracebridge. After his third marriage in AD 1557, Thomas left Kingsbury and moved to Twyford, near Derby. In AD 1559 he leased Kingsbury Hall to Sir Ambrose Cave, Chancellor of the Duchy of Lancaster, along with the park. After a dispute involving one of Thomas' sons, this arrangement was redrawn as a 21-year lease, subsequently extended to 300 years from AD 1564.

Thomas Bracebridge the elder died in AD 1569. His son tried to persuade Sir Francis Willoughby of Middleton Hall to buy the Kingsbury Manor outright. An arrangement was made in AD 1585 but Thomas reneged on the deal, which eventually led to him being arrested and losing all claim to the land. Willoughby granted the manor of Kingsbury to his daughter Bridget and her husband, Sir Percival Willoughby from Kent.

Meanwhile, Kingsbury Hall was still leased. Sir Ambrose Cave had died in AD 1568, at which point the capital messuage of Kingsbury passed to his daughter Margaret, wife of Henry Knollys, and, on her death in AD 1602, to her elder daughter, Elizabeth, wife of Sir Henry Willoughby – probably a cousin of Sir Percival. Elizabeth died in AD 1621 and Sir Henry in AD 1649, the estate passing to their third and only surviving daughter, Anne.

Anne's son from her second marriage, Willoughby Aston, inherited the estate and also obtained the Hundred itself. In the eighteenth century both eventually passed to Henry Hervey Aston, the fifth son of the Earl of Bristol, after his marriage to Catherine, the sister and heiress of Sir Thomas Aston. Early in the nineteenth century the lordship was sold to Sir Robert Peel and the Peels remained lords of the manor until the start of the twentieth century (Morriss 2005).

The description of Kingsbury Hall below summarises the relevant details from Morriss' structural survey of the building (Morriss 2005).

Description

The Hall can be divided into four main component parts, termed the South Range, the East Range, the West Range, and the North Range (Fig 2).

The South Range

The South Range is the largest of the components making up the Hall, measuring approximately 24m long (west-east) and 8m wide. Mainly built of grey sandstone, it is of two storeys with attics, but with the first floor level clearly being the most important.

Superficially, it seems to be of one phase contemporary with the adjacent West and East ranges; however, there are indications that it incorporates the remains of an earlier building.

The Roof (Fig 3)

Although there are suggestions that the masonry of this range could be of more than one phase, the gabled roof over it is evidently of a single phase – and also contemporary with the roofs of the adjacent West and East ranges. The end trusses are set immediately inside the coped gable ends and generally the rest of the trusses have no obvious relationship with the masonry carcass of the building beneath.

It is of seven irregular bays, though there is a form of logic in the bay pattern, supported by the logical sequences of mainly knife-cut carpenters' marks on the truss principals, ties, and wind-braces.

It can be divided into two sections on either side of an off-centred central 'bay'; that is at the junction of the roof structure of the East Range, which is at right-angles to this roof structure. To the east, there are three fairly evenly spaced bays in the roof structure. To the west, there are two long bays and a much shorter bay.

The roof structure is mainly hidden in this roof, as it is elsewhere in these three ranges, by primary lath-and-plaster ceilings and side walls. The trusses consist of tiebeams, principal rafters, a single collar, and a pair of fairly short queen struts to the principals.

The queen struts form part of the framing for the side walls of the attic and only the section of the principals between their tops and the ceiling (directly under the collars) is carefully worked and chamfered.

Hidden behind the plasterwork the major roof timbers are fairly crude. The trusses support two tiers of butt purlins. In the five eastern bays the lower purlins are supported by pairs of straight wind-braces, simply half-lapped into them.

In the longer westernmost bay, both tiers were stiffened by longer curving wind-braces, though only one survives *in situ.* There is only a single, short – and possibly reused – wind-brace in the other long bay to its east – at the west end of the upper purlin. The design of this bay – set between the two masonry cross-walls below – is different to that of the others.

The common rafters are trussed by collars above the ceiling and have bridled apex joints. Their feet are tenoned into substantial single wall-plates – the sections of which are joined by double-tenoned pegged scarf joints – and the roof covering was overhung from the wall faces by apparently primary timber 'sprockets' with moulded 'feet'. The roof covering is now of plain tiles supported on split-laths.

On the northern side of the roof there is evidence for a lost dormer gable in the second bay from the east; this had an introduced rafter midway in the bay to support it. The absence of

one of the wind-braces in the bay seems to have been primary and there are surviving stave grooves in the tops of the adjacent rafters that would have taken the panel infills of the dormer cheeks.

The East Range

The East Range is the smallest of the three older ranges. Structurally it is built at right-angles to both of the other ranges and effectively acts as a link between them. Its south wall is shared with the South Range and its west wall with the West Range. Consequently, only its east wall and north gable are external. As in the other two older ranges, its first floor was clearly the most important.

The Roof (Fig 4)

The plain tiled roof is of two bays at right-angles to the contemporary roof structures of the South and West ranges. This roof runs into the side of the former and the latter runs into it.

The roof structure is virtually identical to that of the other two roofs, with trusses consisting of tiebeams, principal rafters, a single collar, and a pair of fairly short queen struts to the principals.

The queen struts form part of the framing for the side walls of the attic and only the section of the principals between their tops and the ceiling (directly under the collars) is carefully worked and chamfered.

The end truss is set immediately inside the coped gable and the trusses support two tiers of purlins hidden behind the side walls or ceiling – the lower ones originally stiffened by straight wind-braces, most of which have been removed.

The West Range

The West Range is the second largest of those that make up the Hall, but probably the most complex. Because of the adjacent ranges little of this range is visible externally – apart from the west gable and a short return on the south side, and its north-eastern corner.

At the eastern end this range has an odd junction with the East Range; it seems that it utilised the existing wall of that range for most of its east wall, but as its northern wall is set further forward, a new section of east wall was required to fill the gap. Oddly, this was not built in line with the western wall of the East Range, but slightly to the east of it.

The Roof (Figs 5 and 6)

Although, as with the South Range, there are suggestions that the masonry carcass of this range could be of more than one phase, the gabled roof over it is evidently of a single phase – and also contemporary to the roofs of the adjacent East and South ranges.

The end trusses are set immediately inside the coped gable ends and generally, the rest of the trusses have no obvious relationship with the masonry carcass of the building beneath.

It is of four fairly regular bays, and runs into the cross-gabled roof of the East Range. Structurally, it is virtually identical to the roofs of the other two ranges. The roof structure is mainly hidden by primary lath-and-plaster ceilings and side walls.

The trusses consist of tiebeams, principals, a single collar, and a pair of fairly short queen struts to the principals. The queen struts form part of the framing for the side walls of the

attic and the only section of the principals between their tops and the ceiling (directly under the collars) is carefully worked and chamfered.

Hidden behind the plasterwork the major roof timbers are fairly crude. The trusses support two tiers of butt purlins, the lower ones stiffened by straight wind-bracing.

The common rafters are trussed by collars above the ceiling and have bridled apex joints and sprocketted eaves. The roof covering is now of plain tiles supported on split-laths.

There is an indication of a dormer gable in the westernmost bay of the northern roof slope – there being no wind-brace in one half of that bay and a definite trace of a primary doorway through the 'ashlar' frame to the attic floor within.

The North Wing

The North Wing is the most modern of the components that make up the Hall and, architecturally and archaeologically, the least complex. It was clearly built against the existing north wall of the West Range, but it is not clear whether or not it replaced an earlier structure on the same site.

Phasing

Phase One: The Saxon Period

There is nothing surviving above ground of the Saxon period, but elements of the surrounding earthworks may date from that period – notably the manmade ditch between the grounds of the Hall and those of the church to the south.

Phase Two: The Medieval Period

The most obvious survival of the medieval period is the south-eastern section of the curtain wall, the half-octagonal turret, and the remains of two associated garderobes. The balance of evidence suggests that these are of one single period and probably date to the fourteenth century.

Traces of medieval fabric within the fabric of the Hall itself are less easy to identify. There are no obvious indications of medieval openings in the external walls that predate those of the post-medieval period. The only one with a hint of medieval form is the blocked first-floor doorway in the south wall of the South Range's 'Great Hall'.

There is a suggestion of blocked openings in the spine wall between the South and West Ranges that predate the fireplaces in the latter range.

The Hall in its present form is essentially a double-pile structure – with two parallel main ranges separated by a spine wall. Such a layout is not medieval in character and, indeed, the earliest surviving double-pile mansion in England was probably not built until the second half of the sixteenth century.

Phase Three: The Kingsbury Hall of c *AD 1600*

Whatever the surviving medieval portions of the Hall, the present house is largely the result of a very radical rebuilding that resulted in the creation of a fairly large and high status dwelling of rather unusual layout.

The rebuilt Hall included the three surviving older ranges of the present building – the South, East, and West. Ignoring possible and probable construction breaks and phasing in their

masonry walls, these ranges were clearly all floored and roofed at the same time and in the same manner.

The Mid-Seventeenth Century

The main features are all variations of timber-framed partitions, all of a very similar character of basic carpentry but differing in some details.

The Mid-Eighteenth to Early-Nineteenth Century

By the mid-eighteenth century, Kingsbury Hall was evidently no longer a high status dwelling. It the house had been considerably larger in the early-seventeenth century, it may have been at this time that all but the surviving portion was demolished because it was simply too large. The house seems to have become a farmhouse, and much of it was converted to agricultural or storage use.

The external changes included the addition of the present North Wing. This wing seems to have been the core of a new but smaller house set within the carcass of the larger Hall.

Morriss' structural survey concluded on various grounds that a date early in the seventeenth century would be likely for this major phase of work at Kingsbury Hall during the time Sir Henry and Elizabeth Willoughby were tenants.

Acknowledgements

The Laboratory would like to thank Richard Morriss from whose Architectural and Archaeological Assessment of the building the above description and interpretation was taken (edited). Figures 7–9 have been produced by Acanthus Clews Architects.

Sampling and analysis by tree-ring dating was commissioned and funded by English Heritage. Tree-ring dating was requested to inform a programme of restoration. It was hoped that dating of the accessible structural timbers and ceiling frames would establish the significance of the house within the context of its redevelopment. Dating the roofs would confirm whether all three were indeed contemporary with each other and with the apparently primary floor timbers. Kingsbury Hall is registered as a Building at Risk and is currently undergoing stabilisation and survey work.

Sampling

In accordance with the specifications set out in the Class Consent Order, drill core samples were taken from 43 timbers. Each sample was given the code KNG-H (for Kingsbury Hall) and numbered 01–43. Samples were taken from the roof structure (KNG-H01–20), the first-floor ceiling joists (KNG-H21–33), and the ground-floor ceiling joists (KNG-H34–43). The position of samples was noted at the time of sampling and has been marked on Figures 7–9. Further details relating to the samples can be found in Table 1. Unless otherwise stated, trusses and bays were numbered from north to south or east to west.

The dendrochronological potential of several partition walls, window sills, door lintels in the South, East, and West ranges, and two plank doors have also been assessed and their timbers were found to be in many cases suitable for analysis. It is hoped that in the future these might also be sampled, thereby further improving our understanding of this building.

Analysis and Results

At this stage it was noticed that one of the samples from the first-floor ceiling frame (KNG-H29) had too few rings to make secure dating a possibility and this sample was rejected prior to measurement. The remaining 42 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. All 42 samples were compared with each other by the Litton/Zainodin grouping procedure (see appendix).

At a least value of *t*=4.5, 39 samples matched and were combined at the relevant offset positions to form KNGHSQ01, a site sequence of 174 rings (Fig 10). 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 1391 and of its last measured ring is AD 1564. The evidence for this dating is given by the *t*-values in Table 2.

Attempts to date the remaining three ungrouped samples were unsuccessful and these remain undated.

Interpretation

Analysis of 42 samples taken from the roofs and ceiling joists of this building has resulted in the construction and dating of a single site sequence, KNGHSQ01. This site sequence has been dated to the period AD 1391–1564 and contains 39 samples. These samples are from a mixture of roof and ceiling frame timbers of the South, East, and West ranges.

Roof

All 20 roof samples have been successfully dated. Three of these (KNG-H04, KNG-H09, KNG-H20) have complete sapwood and the last-ring date of AD 1563, the felling date of the three timbers represented. Sixteen other roof samples, from all ranges, have the heartwood/sapwood boundary ring. The average date of this ring is AD 1541, which allows an estimated felling date to be calculated for the timbers represented to within the range AD 1563–81 (allowing for samples KNG-H03, KNG-H10, and KNG-H17 having AD 1562 as their last measured ring date with incomplete sapwood), also consistent with a felling date of AD 1563. The final roof sample (KNG-H15) does not have the heartwood/sapwood boundary ring and so an estimated felling date cannot be calculated for it, except to say that with a last measured ring date of AD 1488 this would be AD 1504 at the earliest, a date which would not preclude a felling date of AD 1563.

Ground-floor ceiling joists

Nine of the samples taken from these timbers have been dated. One of the South Range samples, KNG-H34, has complete sapwood and the last-measured ring date of AD 1563, the felling date of the timber represented. Five of the other dated samples (two from the South Range, one from the East Range, and two from the West Range) have the heartwood/sapwood boundary ring. The average date of these rings is AD 1541, giving an estimated felling date for the five timbers represented to within the range AD 1556–81, also consistent with a felling date of AD 1563. The other three dated samples do not have the heartwood/sapwood boundary and so an estimated felling date range cannot be calculated. However, with last measured ring dates of AD 1529 (KNG-H38), AD 1531 (KNG-H39), and AD 1535 (KNG-H42), these would be estimated to be at the earliest AD 1545, AD 1547, and AD 1551, respectively.

First-floor ceiling joists

Ten of these samples were successfully dated. Three of these have complete sapwood and, therefore, their last-measured ring dates are the felling dates of the timbers represented. Two of these (KNG-H21 from the South Range and KNG-H33 from the West Range) were felled in AD 1563, and one in AD 1564 (KNG-H25 from the South Range). Seven of the other dated samples (three from the West Range, three from the South Range, and one from the East Range) have the heartwood/sapwood boundary ring, the average date of which is AD 1542, giving an estimated felling date for the timbers represented within the range AD 1563–82, allowing for sample KNG-H31 having a last-measured ring date of AD 1562 with incomplete sapwood. This felling date range is also consistent with a felling of AD 1563/4.

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

Discussion

Prior to the tree-ring analysis being undertaken, the roof and floor frames of the South, East, and West ranges were thought to be contemporary, representing a single phase of construction in the early-seventeenth century.

The dendrochronological analysis has confirmed that all three roofs and the two floor frames are indeed contemporary. However, rather than belonging to the early-seventeenth century, this work was undertaken some 40 years earlier, soon after the timbers used in its redevelopment were felled in AD 1563/4. At this time the manor was owned by Thomas Bracebridge with the Hall and park being leased to Sir Ambrose Cave. The AD 1563/4 felling coincides with the 300-year extension of the original 21-year lease drawn up between the two.

The date gained at Kingsbury Hall is not only important for the building itself but also for the chronology of this type of building. Previously, it had been suggested that the earliest surviving example of a double-pile structure was Whitehall, Shrewsbury, built from AD 1579 onwards (Mercer 2003), but the dendrochronological results show that Kingsbury Hall was substantially redeveloped more than a decade earlier.

Given the interesting results gained for the roofs and floor frames of Kingsbury Hall, it is perhaps even more important that further work is undertaken on the other suitable timbers identified during the assessment, such as those forming the partition walls. This might provide greater insight into the development of this building.

Bibliography

Arnold, A J, Howard, R E, and Litton, C D, 2003 *Tree-ring analysis of timbers from Hulme Hall, Allostock, Near Northwich,* Anc Mon Lab Rep, **84/2003**

Baillie, M G L, and Pilcher, J R, 1982 unpubl A master tree-ring chronology for England, unpubl computer file *MGB-EOI,* Queens Univ, Belfast

Howard, R E, Laxton, R R, Litton, C D, and Simpson, W G, 1995 Nottingham University Tree-ring Dating Laboratory Results: general list, *Vernacular Architect*, **26**, 47–53

Howard, R E, Laxton, R R, and Litton, 1998 *Tree-ring analysis of timbers from Naas House, Lydney, Gloucestershire,* Anc Mon Lab Rep, **36/1998**

Howard, R E, Laxton, R R, and Litton, C D, 2003 *Tree-ring analysis of timbers from Combermere Abbey, Whitchurch, Cheshire,* Anc Mon Lab Rep, **83/2003**

Laxton, R R, and Litton, C D, 1988 *An East Midlands master tree-ring chronology and its use for dating vernacular buildings*, University of Nottingham, Dept of Classical and Archaeol Studies, Monograph Series, **III**

Mercer, E, 2003 *English Architecture to 1900: The Shropshire Experience*, Little Logaston, Herefordshire: Logaston Press

Morriss, R K, 2005 *Kingsbury Hall, Kingsbury, Warwickshire An Archaeological and Architectural Analysis and Recommendations for Restoration*, Mercian Heritage Series No **243**

Siebenlist-Kerner, V, 1978 *Chronology, 1341–1636, for hillside oaks from Western England and Wales*, in Dendrochronology in Europe (ed J M Fletcher), BAR Int Ser, **51**, 295–301

Tyers, I, 1997 *Tree-ring Analysis of Timbers from Sinai Park, Staffordshire*, Anc Mon Lab Rep, **80/97**

Salzman, L F, 1947 *The Victoria history of the county of Warwick, volume four: Hemlingford Hundred,* London: Oxford University Press

Table 1: Details of tree-ring samples from Kingsbury Hall, Kingsbury, Warwickshire

Sample number	Sample location	Total rings*	Sapwood rings**	First measured ring date (AD)	Last heartwood ring date (AD)	Last measured ring date (AD)
Roof						
South Range						
KNG-H01	South principal rafter, truss 6	123	h/s	1429	1551	1551
KNG-H02	South principal rafter, truss 5	113	h/s	1421	1533	1533
KNG-H03	South lower purlin, trusses 5-6	100	14	1463	1548	1562
KNG-H04	Tiebeam, truss 4	87	26C	1477	1537	1563
KNG-H05	North lower purlin, trusses 5-6	96	h/s	1451	1546	1546
KNG-H06	North common rafter 2, bay 5	118	22	1443	1538	1560
KNG-H07	North principal rafter, truss 5	96	h/s	1432	1527	1527
KNG-H08	North lower purlin, trusses 3-4	135	14	1427	1547	1561
KNG-H09	North common rafter 2, bay 2	107	22C	1457	1541	1563
East Range						
KNG-H10	East principal rafter, truss 2	131	31	1432	1531	1562
KNG-H11	East lower purlin, trusses 1-2	102	01	1442	1542	1543
KNG-H12	West common rafter 4, bay 1	62	16	1499	1544	1560
KNG-H13	East principal rafter, truss 1	113	h/s	1424	1536	1536
KNG-H14	West principal rafter, truss 3	120	02	1432	1549	1551
West Range						
KNG-H15	North common rafter 1, bay 1	57	--	1432	----	1488
KNG-H16	North lower purlin, trusses 1-2	106	h/s	1441	1546	1546
KNG-H17	Tiebeam, truss 3	154	30	1409	1532	1562
KNG-H18	Tiebeam, truss 4	48	h/s	1501	1548	1548
KNG-H19	South lower purlin, trusses 4-5	92	02	1454	1543	1545
KNG-H20	South common rafter 1, bay 3	93	25C	1471	1538	1563
First-floor ceiling frame						
South Range						
KNG-H21	Common joist 2 (from south) F1	121	18C	1443	1545	1563
KNG-H22	Common joist 1 (from south), F1	65	05	1497	1556	1561
KNG-H23	Common joist 3 (from south), F2	94	13	1460	1540	1553
KNG-H24	Common joist 2 – 1 missing (from north), F1	84	01	----	----	----
KNG-H25	Common joist 6 (from east), F4	174	26C	1391	1538	1564

KNG-H26	Common joist 9 (from east) F4	145	09	1403	1538	1547
East Range						
KNG-H27	Common joist 1 (from east), F13	63	h/s	1478	1540	1540
KNG-H28	Common joist 3 (from east), F13	82	--	----	----	----
KNG-H29	Common joist 6 (from east), F13	NM	--	----	----	----
West Range						
KNG-H30	Common joist 2 (from north), F6	138	26	1425	1536	1562
KNG-H31	Common joist 3 (from north), F6	127	21	1436	1541	1562
KNG-H32	Common joist 3 (from north), F5	66	h/s	1480	1545	1545
KNG-H33	Common joist 1 (from north), F6	103	27C	1461	1536	1563
Ground-floor ceiling frame						
South Range						
KNG-H34	Main joist G1-G2	146	21C	1418	1542	1563
KNG-H35	Main joist G3	122	08	1417	1530	1538
KNG-H36	North joist 3 (from east), G4	67	h/s	----	----	----
KNG-H37	South joist 4 (from east), G4	60	05	1493	1547	1552
KNG-H38	North joist, G5	92	--	1438	----	1529
KNG-H39	South joist, G5	110	--	1422	----	1531
East Range						
KNG-H40	West common joist 10, G6	115	08	1435	1541	1549
West Range						
KNG-H41	Main joist G7	114	h/s	1434	1547	1547
KNG-H42	Main joist G8/7	128	--	1408	----	1535
KNG-H43	Common joist, west 6, G8	129	h/s	1413	1541	1541

*NM = not measured
**h/s = the heartwood/sapwood ring is the last ring on the sample
C = complete sapwood retained on sample, last measured ring is the felling date

Table 2: Results of the cross-matching of site sequence KNGHSQ01 and relevant reference chronologies when the first-ring date is AD 1391 and the last-ring date is AD 1564

Reference chronology	*t*-value	Span of chronology	Reference
East Midlands	10.3	AD 882–1981	Laxton and Litton 1988
England	9.8	AD 401–1981	Baillie and Pilcher 1982 unpubl
Wales and West Midlands	9.5	AD 1341–1636	Siebenlist-Kerner 1978
Sinai Park, Burton on Trent, Staffs	12.9	AD 1227–1750	Tyers 1997
Naas House, Lydney, Glos	9.9	AD 1373–1568	Howard *et al* 1998
Hulme Hall, Allostock	9.7	AD 1574–1689	Arnold *et al* 2003
Lodge Park, Aldsworth, Glos	9.7	AD 1324–1587	Howard *et al* 1995
Combermere Abbey, Whitchurch, Cheshire	9.0	AD 1363–1564	Howard *et al* 2003

Figure 1: Map to show the location of Kingsbury Hall, Warwickshire

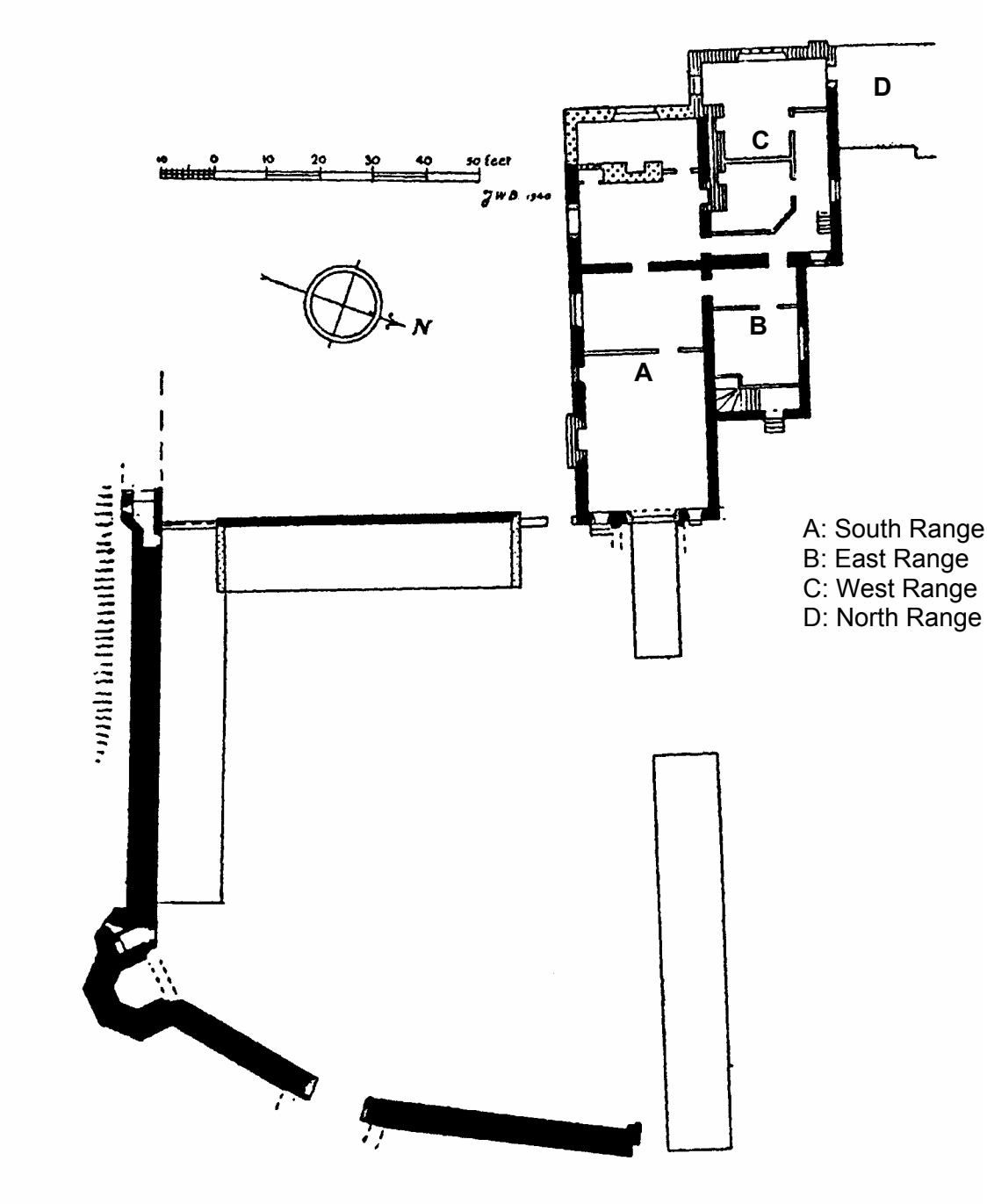

Figure 2: Kingsbury Hall, Warwickshire; site plan showing the medieval remains. Black thought to signify medieval; hatching, late-sixteenth century; dotted, eighteenth century; and blank, 'modern' (Salzman 1947)

Figure 3: Kingsbury Hall, Warwickshire; South Range roof (looking north-east)

Figure 4: Kingsbury Hall, Warwickshire; East Range roof (looking north)

Figure 5: Kingsbury Hall, Warwickshire; West Range (looking west)

Figure 6: Kingsbury Hall, Warwickshire; West Range, with East Range in background (looking east)

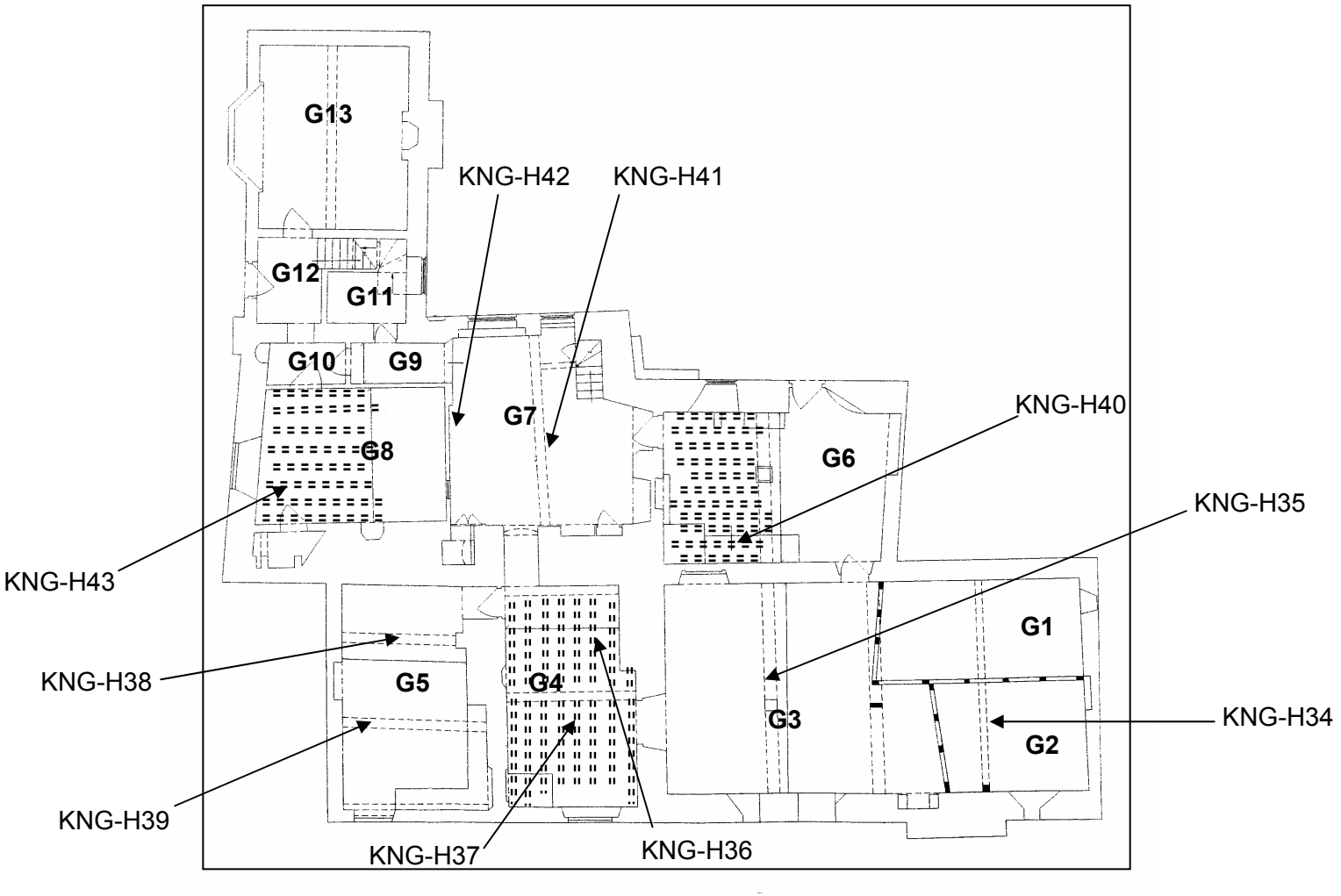

Figure 7: Kingsbury Hall, Warwickshire. Ground-floor plan, showing the location of samples KNG-H34–43 (Acanthus Clews Architects)

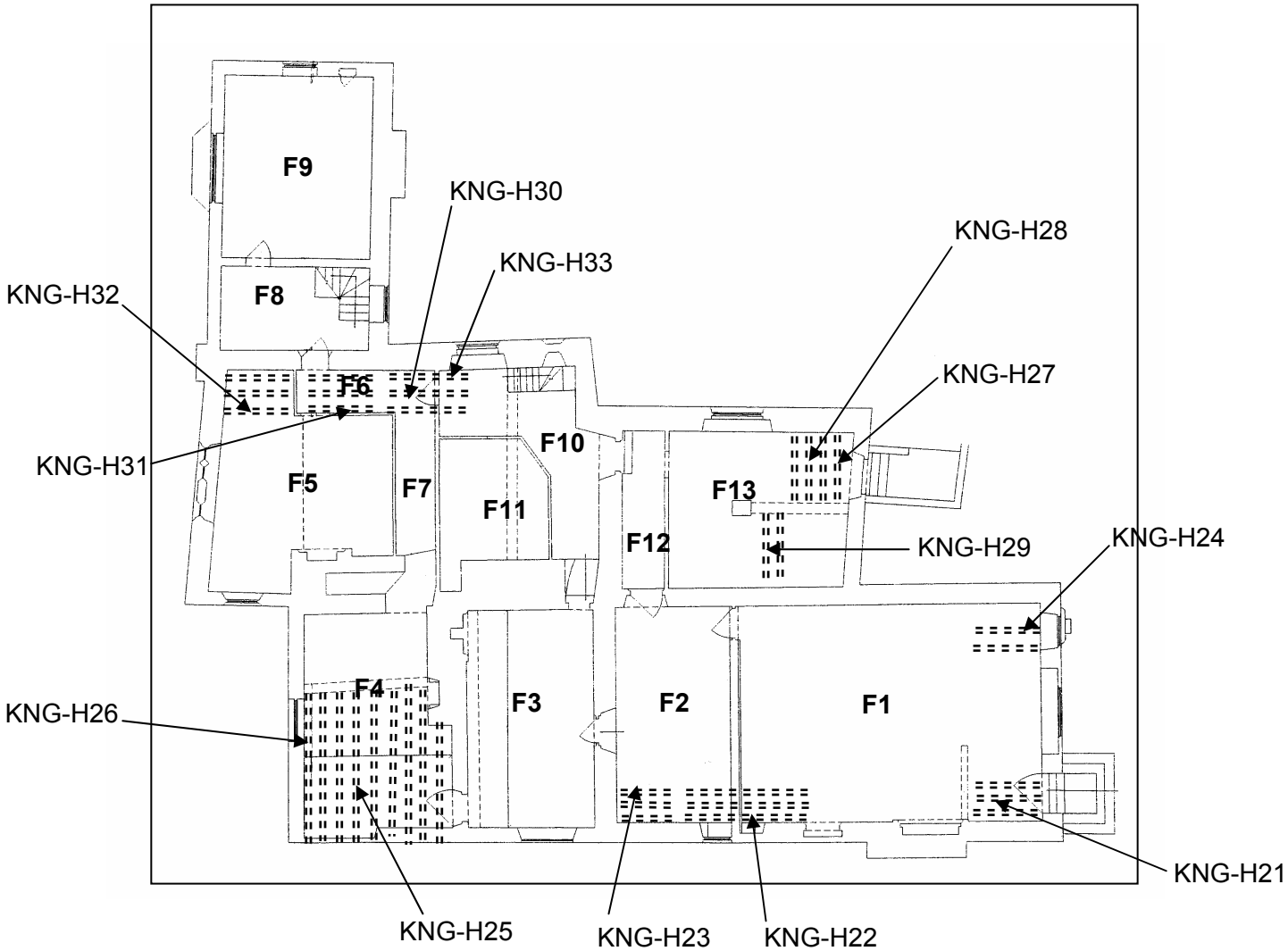

Figure 8: Kingsbury Hall, Warwickshire. First-floor plan, showing the location of samples KNG-H21–33 (Acanthus Clews Architects)

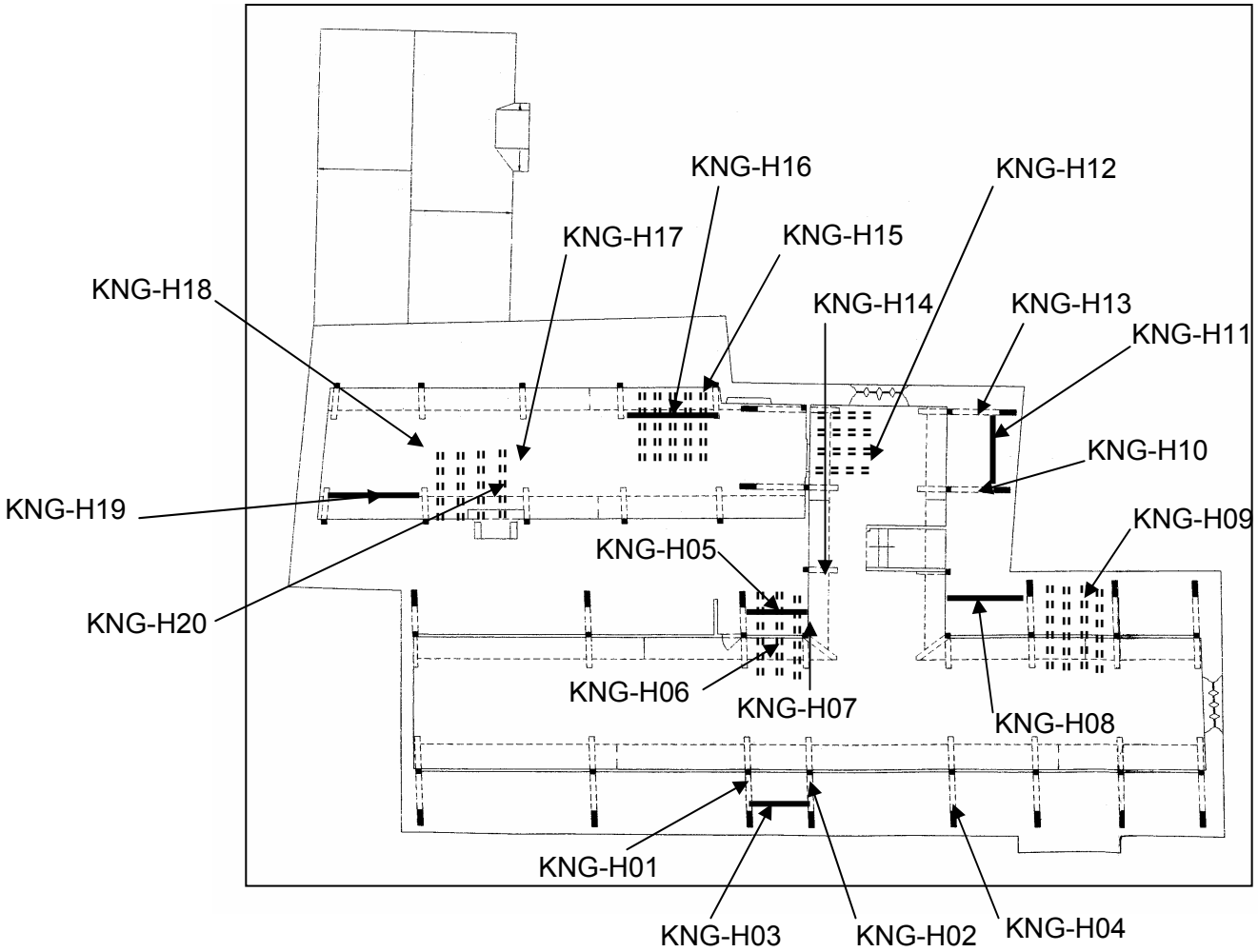

Figure 9: Kingsbury Hall, Warwickshire. Second-floor plan, showing the location of samples KNG-H01–20 (Acanthus Clews Architect)

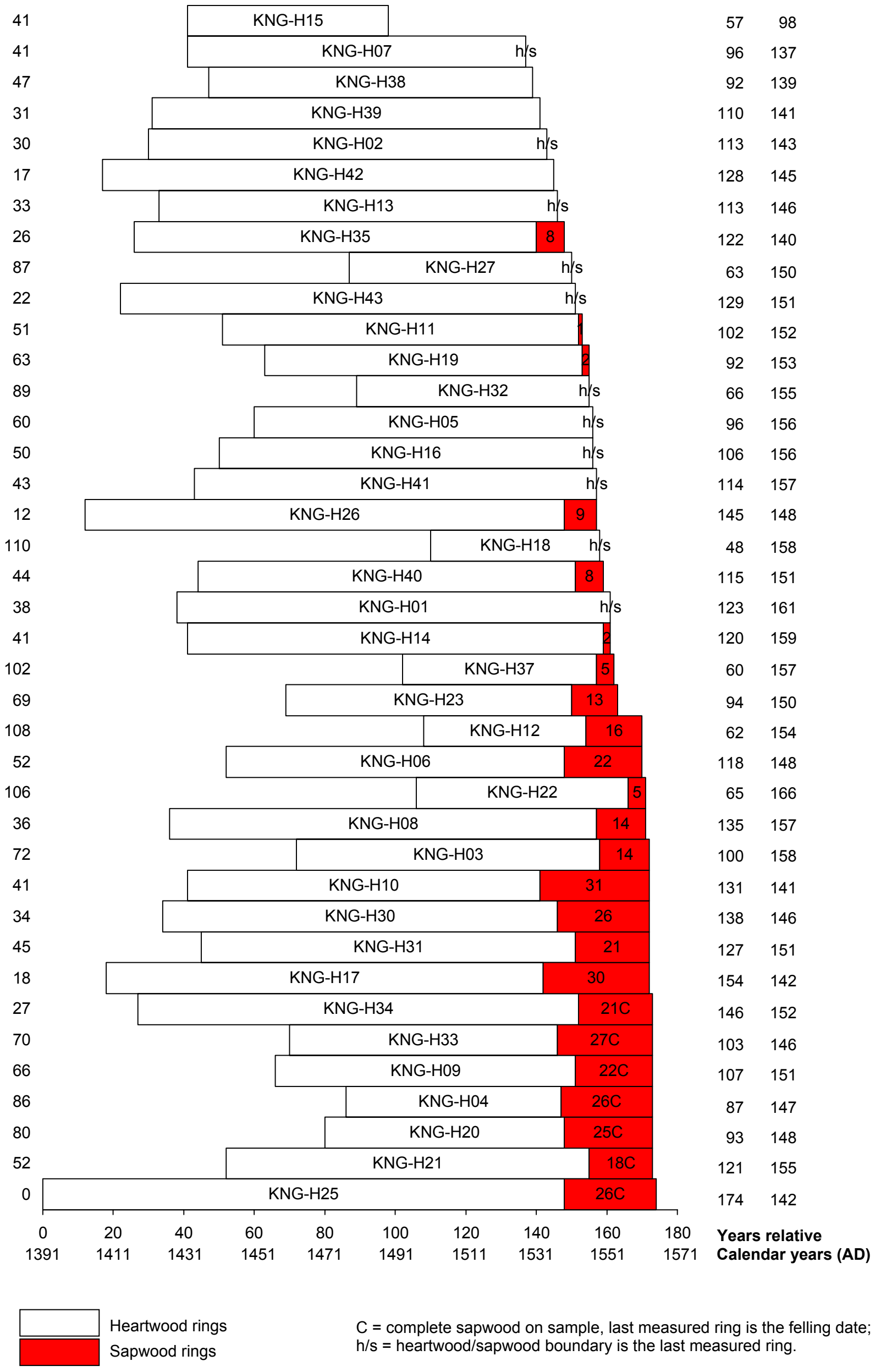

Figure 10: Bar diagram of samples in site sequence KNGHSQ01

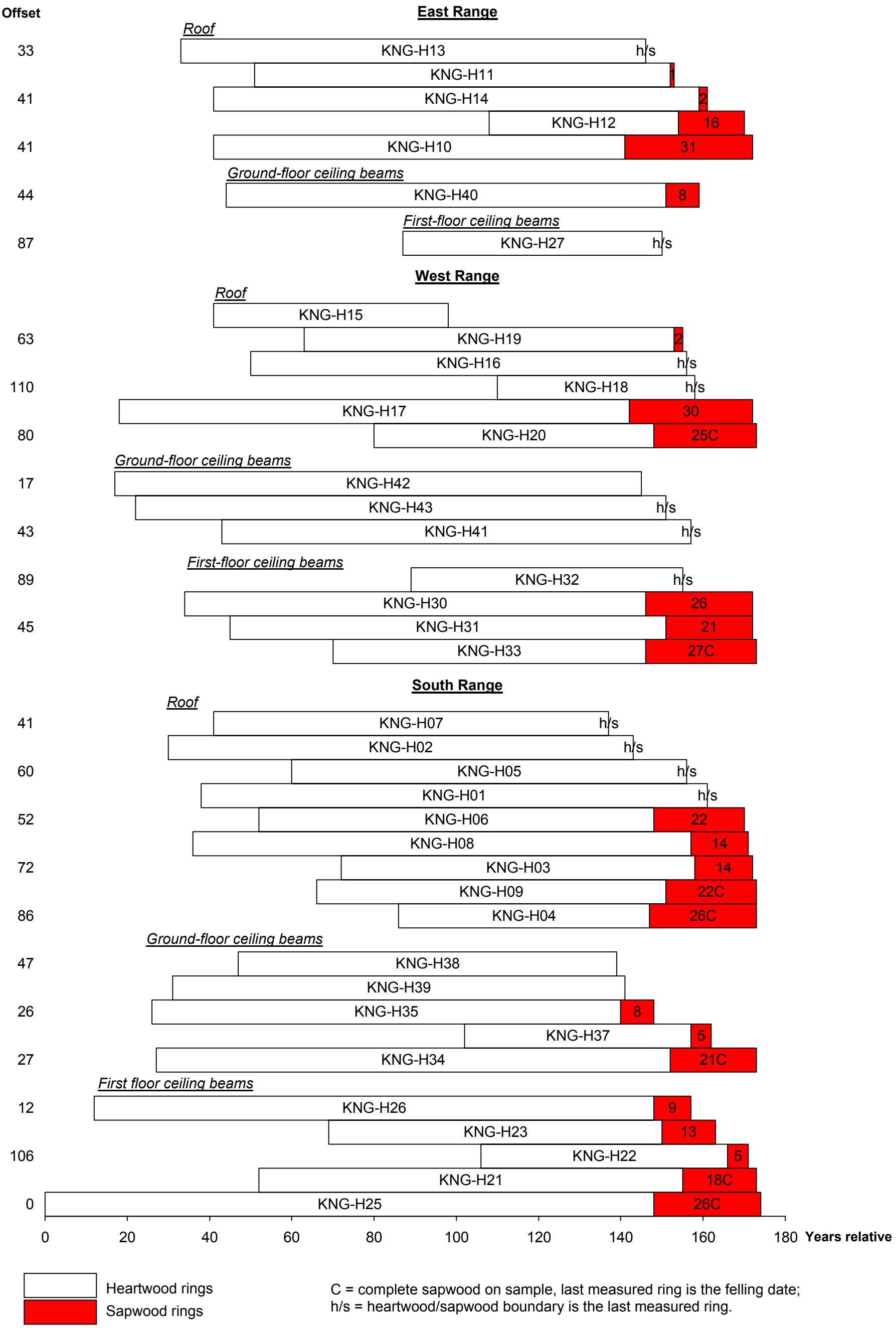

Figure 11: Bar diagram of samples in site sequence KNGHSQ01, sorted by range and location

Data of measured samples – measurements in 0.01mm units

KNG-H01A 123
353 444 501 482 343 379 257 131 114 121 130 227 311 242 258 234 123 68 69 91
118 110 122 107 102 87 94 118 102 68 51 78 102 117 141 148 80 71 124 188
193 125 75 79 99 111 207 157 128 160 97 240 210 136 110 117 99 113 107 86
111 170 96 120 111 139 175 233 124 82 99 83 59 42 56 87 88 108 128 174
135 129 156 202 178 205 207 145 136 245 281 218 189 208 225 183 104 153 198 179
145 116 184 120 99 85 204 240 178 220 170 112 162 128 201 192 212 140 62 164
240 251 161
KNG-H01B 123
358 442 501 499 343 362 257 130 126 110 150 229 295 232 260 248 116 65 65 87
113 111 125 109 94 93 87 107 113 61 61 80 101 111 140 160 84 88 125 195
181 130 79 74 102 109 195 169 97 185 101 214 206 139 108 116 97 108 105 81
113 155 93 123 101 146 182 247 113 89 100 83 56 45 56 84 95 98 132 165
147 117 149 221 166 213 200 150 148 224 279 227 187 220 232 173 119 129 214 167
126 114 186 129 101 88 184 242 200 220 184 95 162 127 199 176 229 135 69 184
205 248 166
KNG-H02A 113
333 292 678 418 547 311 502 418 257 307 386 445 199 296 181 219 238 149 221 269
373 166 258 335 206 167 146 227 230 235 312 170 142 215 154 240 170 125 113 165
166 154 181 162 141 135 168 176 224 185 146 100 149 159 285 215 161 119 250 238
288 178 152 158 136 163 207 206 206 245 179 144 174 181 181 197 144 95 120 124
88 93 122 174 158 174 166 93 129 139 105 177 140 154 132 120 80 127 181 125
166 193 173 105 66 154 109 132 98 83 153 84 118
KNG-H02B 113
327 298 660 425 539 309 488 423 258 318 394 450 218 286 181 204 231 149 239 259
376 164 269 322 213 161 161 231 230 242 323 165 152 207 161 227 164 140 97 174
167 147 170 164 147 135 171 174 214 185 161 96 149 161 293 206 164 126 251 241
291 163 154 156 140 161 207 190 211 240 183 132 173 173 175 194 139 88 122 117
107 78 128 163 158 178 144 118 130 133 119 166 145 156 147 115 92 120 181 135
136 193 168 108 99 151 106 123 83 78 181 86 125
KNG-H03A 100
125 141 110 83 87 163 150 111 86 87 148 137 153 142 143 161 164 223 242 109
125 111 91 144 126 152 156 240 153 167 198 194 210 281 138 111 205 133 78 89
84 142 169 180 151 131 219 166 163 175 148 159 209 175 153 218 297 257 272 388
243 261 176 203 189 198 198 158 255 164 165 131 261 221 207 237 229 147 137 89
152 143 193 187 72 123 195 211 246 178 168 143 203 176 165 233 338 341 255 268
KNG-H03B 100
130 135 110 91 85 136 151 108 82 87 152 140 152 154 140 137 163 238 224 130
117 115 95 139 148 150 155 242 165 166 202 190 225 251 150 112 200 136 75 52
111 143 179 177 162 121 207 179 156 175 140 183 163 180 149 216 295 265 312 351
238 259 174 213 181 197 189 178 238 161 166 147 250 217 220 233 234 140 140 114
142 144 198 181 68 138 186 213 254 164 178 145 209 178 152 223 345 343 254 255
KNG-H04A 87
224 265 395 362 341 310 299 296 232 272 291 283 291 310 223 175 198 297 329 403
394 338 300 285 260 325 349 403 291 258 195 236 340 337 294 347 363 333 299 278
275 364 368 349 265 317 251 252 154 201 264 317 374 249 405 218 225 192 250 241
214 217 196 163 166 136 155 145 212 185 97 179 209 196 154 124 115 146 169 82
70 113 126 186 166 205 139

KNG-H04B 87
218 267 383 353 312 311 284 285 241 266 298 275 294 316 216 176 194 288 332 373
379 318 294 287 260 317 342 401 272 266 205 219 339 329 298 313 374 337 299 287
277 363 365 348 254 311 237 259 161 196 245 312 376 234 399 203 220 212 261 224
214 225 193 165 171 107 150 148 214 188 100 177 200 204 132 139 118 155 156 84
82 119 121 182 169 204 142
KNG-H05A 96
284 245 261 296 279 384 317 388 314 370 233 205 214 99 120 102 191 204 269 214
123 83 104 159 195 133 132 115 155 198 200 176 150 123 114 94 89 102 156 208
124 138 151 153 144 222 201 152 147 185 134 116 140 169 196 208 168 130 189 215
252 205 416 291 291 237 172 225 322 210 271 339 172 180 134 181 159 184 118 110
162 122 80 100 182 151 154 144 160 121 166 124 99 179 197 127
KNG-H05B 96
252 234 236 293 252 375 326 393 303 375 236 249 197 108 115 101 187 200 258 212
139 80 124 157 206 126 127 111 159 181 200 182 152 127 116 91 89 97 162 202
132 140 148 154 143 223 204 147 148 186 130 121 139 172 209 223 170 143 188 208
243 209 414 283 292 230 170 233 328 209 272 339 167 187 128 178 159 185 116 128
176 95 98 82 178 171 157 142 155 119 150 130 121 172 193 125
KNG-H06A 118
80 112 103 87 93 78 102 73 112 78 80 72 65 93 69 72 71 77 78 62
76 55 53 51 54 57 59 59 64 53 63 54 62 70 56 50 62 59 57 55
50 48 42 55 52 55 54 56 44 59 57 81 96 101 78 69 69 64 66 46
67 94 92 88 72 75 88 77 79 90 77 73 62 70 62 78 78 65 76 105
72 67 75 105 83 83 71 69 82 64 89 71 79 74 81 81 98 72 88 95
71 74 61 74 48 90 93 74 93 59 70 71 60 86 128 138 164 101
KNG-H06B 118
74 107 95 93 94 86 108 55 124 76 89 49 70 85 82 69 72 70 78 71
69 56 52 50 46 62 64 49 60 53 59 52 75 63 51 62 53 54 61 50
54 56 46 39 50 66 49 50 48 63 53 74 94 94 67 63 77 67 55 51
64 95 95 97 79 77 92 80 80 88 72 77 72 69 77 76 80 61 85 87
79 71 69 107 79 84 69 69 78 67 82 75 77 67 81 91 99 72 102 84
70 87 55 68 51 85 89 85 82 70 64 61 75 74 132 143 167 89
KNG-H07A 96
262 380 385 270 169 171 157 217 302 368 258 353 265 211 168 164 175 193 227 257
212 187 198 163 259 189 203 147 214 209 177 188 148 182 182 218 242 213 151 126
121 89 132 180 153 133 123 156 207 175 134 151 137 152 169 170 175 163 223 139
139 153 180 185 192 153 113 121 116 99 82 111 152 149 148 101 128 144 158 142
177 175 146 131 150 105 185 191 142 124 222 160 126 101 129 157
KNG-H07B 96
268 387 371 281 177 161 164 218 295 367 258 344 256 208 166 170 173 191 241 244
190 188 191 189 230 143 201 144 215 217 205 193 155 160 161 195 179 197 142 129
104 120 121 172 151 128 128 157 203 175 134 151 137 152 172 165 174 169 216 132
149 143 193 183 195 140 124 125 106 96 95 116 143 146 145 116 117 132 152 151
182 168 157 138 134 111 176 187 144 135 236 133 147 124 96 139
KNG-H08A 135
492 403 396 407 296 220 168 146 83 202 85 135 124 171 193 154 214 132 135 94
138 95 127 166 178 244 175 117 256 206 162 128 79 103 98 124 137 107 86 46
79 87 119 86 101 91 82 78 101 99 76 102 153 119 117 86 63 62 37 60
103 127 121 138 65 100 88 89 98 127 105 74 126 115 61 81 92 65 49 81
92 76 88 109 88 133 84 84 65 115 93 180 182 180 205 166 127 113 84 104
151 130 137 117 196 99 124 158 252 221 193 272 166 258 109 101 113 90 129 133
123 184 167 149 145 137 127 164 149 105 108 147 169 190 151

KNG-H08B 135
490 407 413 436 313 211 153 168 96 206 96 152 111 167 216 161 214 119 138 99
146 100 128 161 199 232 176 117 235 223 153 137 81 98 100 109 152 122 88 45
74 93 130 79 93 94 92 72 95 104 77 112 148 128 111 89 57 54 34 74
99 156 137 129 69 111 64 91 113 129 106 66 104 126 47 93 82 81 57 75
88 70 88 113 102 152 91 80 50 107 102 184 161 171 204 170 128 106 87 104
135 135 135 116 208 111 123 178 220 217 178 285 209 252 125 111 101 104 114 127
146 192 176 152 154 140 140 152 152 112 97 151 160 193 169
KNG-H09A 107
193 183 151 168 181 156 193 115 137 111 143 167 161 165 150 142 162 154 160 148
181 132 179 190 203 162 149 116 133 135 160 159 143 158 132 105 138 136 111 141
106 91 108 106 94 98 106 130 118 139 117 94 114 149 103 128 111 103 103 69
81 116 117 76 97 124 132 78 86 123 136 122 98 81 142 88 110 93 139 120
114 131 124 84 168 145 149 112 86 110 60 122 139 108 127 91 88 97 97 98
85 140 98 141 68 115 115
KNG-H09B 107
187 197 158 175 155 169 169 110 148 107 155 169 165 172 148 146 161 169 145 152
179 137 177 198 208 155 144 123 129 136 153 164 151 147 130 108 148 140 102 141
105 84 106 107 96 103 107 128 117 119 124 101 111 135 136 116 108 97 101 77
90 111 106 81 88 124 122 89 88 133 134 103 104 86 124 81 121 88 142 123
108 145 117 77 171 148 147 119 88 110 45 134 126 112 124 91 89 84 96 90
86 110 92 143 65 131 111
KNG-H10A 131
340 451 547 404 319 230 147 201 292 328 262 286 338 265 243 289 331 389 309 342
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126 147 155 196 152 139 120 145 129 156 116 121 130 115 93 160 160 121 150 86
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81 79 56 91 87 113 107 104 84 121 58 98 108 123 76 52 86 106 77 93
82 80 65 83 89 54 82 92 133 141 139
KNG-H10B 131
360 464 575 402 308 233 150 199 286 338 269 283 323 320 261 286 317 370 310 352
329 288 229 243 322 342 326 326 322 286 275 273 202 215 206 223 156 228 206 182
144 137 160 202 143 136 118 145 126 155 132 155 110 98 110 168 153 109 149 114
110 121 121 131 185 116 111 105 97 94 83 74 112 123 143 115 89 129 105 138
108 104 80 72 73 48 103 125 112 109 149 88 78 72 75 96 127 108 85 128
65 88 53 94 83 116 103 108 85 128 52 105 119 106 107 44 96 86 108 101
92 73 81 69 86 65 67 100 134 100 131
KNG-H11A 102
266 362 317 287 261 287 331 324 225 329 279 270 308 314 294 273 252 291 302 359
238 266 183 183 211 220 193 234 188 175 137 165 199 249 152 181 115 184 195 178
166 92 85 53 58 76 68 83 81 80 61 98 120 89 101 77 122 136 106 123
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308 281 273 154 145 235 275 162 153 185 153 212 133 192 144 151 156 139 117 192
122 109
KNG-H11B 102
260 365 322 279 247 305 313 306 229 320 269 272 309 311 307 306 232 269 306 347
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139 127 152 181 165 145 116 153 175 190 220 272 212 249 172 228 372 357 289 237
335 278 262 139 175 230 276 164 145 187 151 212 138 198 155 160 148 133 136 179
127 120

KNG-H12A 62
201 192 145 197 154 182 133 218 177 266 282 222 227 220 236 236 171 129 105 145
170 106 124 150 115 95 88 165 238 255 166 160 240 156 127 113 188 166 177 219
166 151 169 72 115 129 107 115 63 104 164 156 157 110 105 107 110 99 97 87
104 126
KNG-H12B 62
188 187 154 190 161 186 140 207 188 263 268 232 201 213 207 226 179 129 105 144
182 107 134 151 140 100 105 178 209 286 166 146 256 153 143 116 167 177 179 184
184 164 158 73 125 117 115 103 82 113 149 171 163 102 107 110 115 100 90 68
119 127
KNG-H13A 113
381 499 351 357 418 289 275 345 426 264 333 304 270 275 255 247 205 191 156 218
310 201 161 115 154 149 146 240 156 128 130 188 162 163 156 124 236 186 158 133
91 118 69 97 112 120 88 82 76 82 92 184 148 100 103 122 161 148 181 161
100 93 107 74 119 107 90 67 96 78 77 108 100 93 43 70 69 67 61 66
109 108 83 71 79 89 80 142 143 141 67 108 130 225 272 204 81 140 110 74
86 89 89 136 147 89 103 85 163 104 125 132 106
KNG-H13B 113
431 503 369 370 377 316 264 352 414 268 339 304 272 280 262 222 222 218 136 229
312 183 172 89 143 149 150 235 167 134 128 196 176 159 153 122 239 180 162 129
93 102 87 99 101 130 84 96 75 84 87 189 147 102 93 142 167 164 174 175
100 95 110 74 127 109 106 66 83 100 74 75 113 83 58 70 70 45 80 54
98 99 84 67 99 83 83 148 123 105 93 124 117 239 270 166 116 133 81 84
94 92 100 86 63 132 91 105 84 141 115 120 158
KNG-H14A 120
377 305 440 317 198 125 105 118 168 179 140 225 228 192 112 117 158 178 148 187
173 166 102 114 206 137 107 139 164 165 150 167 150 80 97 105 179 174 136 106
85 107 107 216 119 133 163 175 180 206 177 134 148 81 105 101 98 131 159 77
115 94 137 179 179 141 87 96 75 56 38 58 92 81 140 133 168 155 175 134
171 172 175 167 158 125 191 219 207 143 236 215 164 113 148 203 164 130 95 172
105 66 72 112 119 108 83 107 59 99 55 94 117 167 108 69 159 195 156 128
KNG-H14B 120
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177 178 99 137 174 135 97 132 179 176 144 154 150 94 84 130 179 176 144 98
82 88 115 194 135 147 163 173 189 199 164 158 115 93 90 116 97 115 151 85
120 105 131 176 190 126 89 91 78 53 42 66 87 79 138 140 163 166 166 138
174 166 190 164 152 117 187 223 189 157 237 211 171 121 163 193 199 123 87 176
111 59 68 106 133 110 76 110 61 88 65 91 128 151 134 64 159 180 183 142
KNG-H15A 57
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116 122 157 240 258 149 129 165 171 205 148 137 117 139 117 89 107
KNG-H15B 57
134 140 242 172 164 109 127 114 215 260 193 181 227 167 121 106 155 194 140 197
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102 129 157 246 244 151 136 158 169 209 147 142 109 103 127 91 102
KNG-H16A 106
254 189 178 152 144 166 145 140 115 124 108 100 102 141 152 172 188 218 134 175
167 189 177 145 128 129 102 123 167 173 143 103 122 127 123 109 140 121 181 175
182 123 125 106 102 124 145 132 128 182 137 142 162 188 184 224 178 150 141 119
108 136 146 159 166 138 99 107 167 133 148 199 241 222 182 189 157 224 239 235
292 314 221 202 150 208 183 176 156 146 223 166 180 183 252 237 206 289 166 148
287 202 213 208 195 185
KNG-H16B 106
251 192 178 151 148 155 144 142 124 110 114 104 101 137 150 179 174 199 127 190
186 150 183 151 108 120 120 124 177 183 147 110 122 120 139 107 124 134 175 167

185 130 121 100 113 124 151 143 153 163 140 136 156 172 177 228 169 155 127 119
116 134 145 157 175 125 108 105 150 139 140 193 240 224 187 169 196 228 232 226
268 319 215 193 162 213 176 182 150 141 215 164 173 191 256 214 215 281 166 190
248 203 203 210 172 202
KNG-H17A 154
251 297 303 223 130 225 126 185 119 78 134 164 168 226 207 169 203 223 161 184
132 178 213 147 173 186 185 114 127 73 170 113 123 157 229 191 124 139 149 70
138 109 160 113 152 79 157 235 198 207 161 233 212 128 146 93 95 75 107 110
94 89 103 122 151 207 212 166 95 42 56 53 67 49 52 58 56 56 71 72
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154 146 105 170 148 126 116 151 94 226 190 127 149 138 128 120 86 154 165 187
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140 127 90 72 84 90 78 70 67 77 87 94 83 95
KNG-H17B 154
222 312 319 239 133 209 133 161 113 94 127 173 148 205 191 165 197 216 165 193
127 179 217 150 166 193 190 107 136 69 155 127 107 159 233 195 117 131 149 67
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139 142 115 158 127 121 118 147 100 241 206 102 152 131 142 118 69 162 180 172
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141 129 90 78 79 93 73 68 69 75 82 126 65 94
KNG-H18A 48
524 549 527 500 311 403 316 450 406 267 463 448 566 471 387 340 275 468 490 433
309 353 386 258 208 318 384 408 303 185 588 322 226 273 443 416 323 403 386 199
396 177 300 335 341 273 126 173
KNG-H18B 48
559 560 551 538 329 427 287 442 445 265 457 437 549 454 373 359 268 438 492 426
304 342 378 235 177 313 365 390 307 170 616 302 240 273 451 445 328 419 383 217
373 191 297 335 332 279 127 184
KNG-H19A 92
149 117 129 131 167 160 253 187 181 217 172 173 153 212 199 225 177 178 153 196
207 229 302 248 153 176 196 131 130 112 101 77 103 95 98 124 159 123 106 135
153 135 155 106 106 114 85 82 76 93 99 130 105 102 97 123 132 140 156 134
140 130 163 121 171 218 142 195 269 249 289 192 249 226 179 218 153 297 247 193
176 303 268 230 246 244 183 181 140 130 120 156
KNG-H19B 92
130 123 126 131 176 160 237 204 173 222 173 170 152 223 194 224 175 180 168 189
208 235 303 248 173 195 161 156 109 113 98 71 110 100 105 102 155 123 103 123
148 126 146 116 98 107 74 77 68 89 122 122 115 100 81 113 133 161 158 132
133 147 157 114 183 218 150 183 261 249 296 187 271 218 189 224 171 261 253 182
187 292 258 241 249 237 189 181 127 155 126 158
KNG-H20A 93
100 90 116 169 122 184 169 203 217 154 147 113 131 77 90 87 108 107 96 135
108 80 121 124 115 151 140 83 118 118 59 76 107 132 176 163 153 123 165 156
144 143 145 129 145 116 103 186 171 114 176 131 139 123 128 164 151 164 127 125
166 134 126 115 208 175 139 220 185 139 165 114 100 94 91 123 74 100 174 147
118 120 107 120 138 107 96 118 111 208 115 157 95

KNG-H20B 93
87 106 106 163 141 177 167 193 225 163 152 105 127 77 91 88 105 117 94 130
98 84 126 116 126 147 144 77 127 106 75 71 98 133 183 160 142 129 149 161
129 148 147 136 142 120 92 210 144 122 171 147 139 132 125 164 160 170 129 118
168 137 121 120 212 149 152 217 176 178 128 118 111 85 91 96 88 113 152 158
115 129 120 163 103 103 84 111 131 175 145 174 109
KNG-H21A 121
125 163 205 214 185 134 173 193 123 141 144 126 73 78 101 92 88 117 113 133
122 83 113 92 94 85 98 100 109 80 74 93 69 113 76 74 90 85 111 63
63 69 58 59 79 72 51 76 81 86 80 75 88 104 52 49 59 57 53 45
63 92 98 117 76 88 106 91 97 118 133 96 122 114 92 173 145 124 110 118
90 129 73 121 104 112 74 57 106 68 80 94 166 177 129 114 116 76 140 95
128 101 129 128 117 54 103 131 110 115 74 111 64 81 80 76 75 93 96 95
60
KNG-H21B 121
124 163 214 209 182 123 181 187 131 127 146 135 73 103 85 85 79 116 100 138
113 80 116 95 88 94 95 101 109 82 79 90 71 120 72 73 98 84 98 72
57 76 51 66 73 70 58 82 76 83 77 76 87 111 48 50 61 51 58 46
86 92 97 115 78 85 115 84 99 119 124 107 108 120 92 175 135 135 119 128
87 133 68 128 105 103 81 55 98 71 86 93 162 177 137 107 98 101 129 96
126 120 111 135 111 51 106 123 122 98 81 91 79 86 75 84 68 98 88 104
63
KNG-H22A 65
168 113 101 101 129 133 97 142 242 172 165 101 141 145 128 162 144 141 155 137
154 203 226 156 201 220 134 138 102 150 127 154 136 89 121 123 127 124 210 237
188 208 181 185 262 220 207 217 267 169 86 135 169 241 214 196 198 253 277 162
150 149 154 245 144
KNG-H22B 65
131 89 98 110 129 137 102 142 246 178 174 105 131 154 131 160 136 139 131 138
154 201 222 162 188 207 135 143 108 140 141 141 134 86 133 114 133 121 212 245
196 212 175 198 248 225 210 207 275 186 80 158 175 229 212 196 201 228 292 176
157 145 168 237 139
KNG-H23A 94
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126 220 137 101 96 66 79 59 91 109 129 99 105 123 144 221 226 151 123 143
160 59 60 86 116 165 123 99 92 130 127 151 171 138 186 168 147 152 229 276
156 189 278 219 164 137 178 220 211 151 85 226 154 131 125 314 208 221 206 178
133 181 87 119 125 126 100 56 100 124 134 146 104 99
KNG-H23B 94
167 122 146 186 117 114 108 92 112 165 123 104 85 122 183 171 152 138 111 198
181 202 125 91 97 71 77 67 107 112 125 105 111 117 178 180 227 146 139 136
152 65 57 101 90 162 128 102 92 135 131 151 178 158 190 172 165 143 212 280
167 196 262 217 168 132 170 212 216 151 123 213 157 116 131 261 211 203 196 169
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KNG-H24A 84
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44 42 42 49 47 36 51 65 54 69 58 70 67 77 75 72 82 102 67 98
55 108 96 70

KNG-H24B 84
103 82 106 77 84 97 122 88 107 56 93 98 77 87 105 74 90 81 86 51
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45 51 33 41 50 46 49 61 57 60 58 65 63 81 75 82 76 103 62 99
53 110 100 70
KNG-H25A 174
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166 195 240 232 256 252 185 202 144 230 207 206 270 241 269 229 196 187 235 261
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113 82 98 80 108 121 98 102 86 98 100 87 99 81 97 92 136 165 119 98
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137 128 114 104 102 79 105 95 138 142 150 115 131 146
KNG-H25B 174
160 154 174 154 201 255 221 252 226 234 264 194 251 232 229 188 193 229 229 177
174 181 227 238 241 271 194 203 131 226 216 192 282 234 263 228 192 184 242 246
199 170 140 120 151 120 118 78 107 120 108 97 133 124 112 105 97 114 97 98
106 94 88 87 101 118 109 92 102 100 88 103 88 92 95 95 121 164 121 99
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56 40 41 29 35 36 34 33 48 36 36 24 31 31 48 36 30 39 43 40
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58 41 44 74 48 57 83 71 85 91 97 63 83 79 52 92 77 110 87 111
137 118 124 109 92 91 97 97 136 140 154 119 131 159
KNG-H26A 145
230 223 235 204 207 219 204 159 121 156 158 158 200 200 139 167 126 197 186 162
216 206 191 188 143 134 172 185 193 238 195 182 190 156 180 171 127 164 172 138
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176 179 198 201 207 229 250 205 111 136 151 128 159 168 161 121 126 98 137 113
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48 48 37 34 38 47 68 65 90 80 79 59 32 53 76 55 75 49 52 76
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102 87 101 120 85
KNG-H26B 145
175 217 224 212 206 221 207 160 122 161 150 161 201 197 141 163 124 210 190 154
216 213 187 184 150 149 165 188 196 205 179 196 181 150 166 158 142 167 177 142
172 162 131 130 137 180 151 151 156 156 151 103 128 162 143 134 128 118 118 157
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39 48 40 46 36 45 62 68 84 83 84 54 37 47 72 63 68 48 60 68
59 47 48 62 68 51 75 46 79 55 53 82 87 94 92 98 91 97 138 92
109 94 90 110 81
KNG-H27A 63
143 167 132 151 119 86 102 87 129 192 166 218 159 81 120 139 162 197 269 115
72 91 102 41 87 120 149 76 125 124 99 125 136 148 211 110 73 54 68 92
147 131 103 141 115 101 115 72 83 77 118 121 91 129 81 97 154 197 237 198
249 176 139

KNG-H27B 63
144 160 137 147 117 89 87 80 141 196 178 190 168 83 109 145 164 180 270 124
72 86 109 41 90 125 145 65 130 115 103 130 127 156 172 111 74 56 73 92
146 129 113 139 119 101 115 64 86 78 117 115 103 121 91 92 146 201 234 194
252 175 137
KNG-H28A 82
163 461 466 332 420 227 365 307 344 404 347 289 213 209 83 132 103 151 210 228
280 212 246 113 119 96 126 75 129 156 146 144 131 148 148 141 103 123 152 124
123 161 225 173 97 111 128 125 226 76 134 120 175 173 224 205 83 133 79 66
51 36 30 31 37 61 97 100 125 145 90 124 121 232 161 142 87 66 78 146
87 127
KNG-H28B 82
214 476 478 341 421 248 370 309 351 405 333 249 213 198 95 160 103 149 231 241
275 197 229 114 133 105 119 72 134 167 128 155 149 145 146 147 107 132 126 122
133 159 230 175 114 110 126 128 199 92 126 114 165 202 230 211 89 132 95 84
48 33 33 38 43 42 109 98 139 145 98 132 128 219 167 156 93 57 83 140
77 136
KNG-H30A 138
271 187 184 200 178 151 215 180 157 131 150 137 155 117 102 113 113 100 112 92
60 57 48 80 62 103 100 91 79 118 118 117 111 95 92 93 70 65 86 67
90 59 61 95 105 100 79 75 69 84 72 72 69 64 92 90 98 58 69 38
50 52 36 39 36 49 48 42 44 44 45 40 37 46 59 42 45 49 47 42
48 59 46 45 48 44 49 43 59 51 64 59 69 93 80 54 74 107 87 83
83 102 124 111 60 78 104 90 92 86 111 108 93 115 130 101 116 105 102 101
111 90 62 127 150 126 107 93 59 112 101 100 115 116 110 164 84 80
KNG-H30B 138
263 186 169 197 171 152 196 189 149 137 152 132 159 123 101 118 106 94 112 97
61 50 68 79 78 102 100 86 82 110 133 125 116 89 97 96 71 64 103 66
83 68 59 87 116 96 86 64 72 75 67 80 75 65 88 96 92 87 60 43
51 45 40 39 39 45 47 39 45 36 48 46 41 41 35 61 48 36 48 69
53 58 40 55 40 48 36 61 54 51 77 47 66 93 85 61 70 116 81 92
72 116 111 106 77 86 119 71 109 77 116 100 96 129 110 110 114 99 105 119
81 89 58 129 148 116 114 82 76 113 99 103 107 125 101 138 97 79
KNG-H31A 127
185 266 189 165 190 191 147 171 185 113 89 117 161 128 163 215 161 164 169 208
141 157 135 131 144 103 107 131 67 108 77 78 111 121 119 114 91 83 88 92
88 90 85 108 87 116 78 79 42 32 30 42 42 43 24 42 34 32 37 51
36 36 39 54 51 49 41 57 52 50 65 56 41 43 45 45 42 39 41 52
41 46 56 72 54 53 73 86 65 75 104 105 101 83 70 104 70 87 67 103
98 108 109 128 104 135 118 136 130 85 109 71 157 170 141 132 107 105 106 92
79 114 152 135 193 121 86
KNG-H31B 127
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KNG-H32B 66
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KNG-H33A 103
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KNG-H33B 103
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KNG-H34A 146
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KNG-H34B 146
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KNG-H35A 122
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KNG-H36A 67
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KNG-H37A 60
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