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THE BELLFRAME
ST MARY AND ALL SAINTS' CHURCH
HAWKSWORTH
NOTTINGHAMSHIRE

SURVEY, RECORDING, AND TREE-RING ANALYSIS OF TIMBERS

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NGR: SK 75283 43457
MARCH 2015

THE CHURCH OF ENGLAND
Diocese of Southwell & Nottingham

heritage lottery fund
LOTTERY FUNDED

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SUMMARY
Dendrochronological analysis undertaken on samples taken from timbers of the bellframe at this church resulted in the construction of a single site sequence.
Site sequence NBFKSQ01 contains eight samples and spans the period AD 1592–1691. Interpretation of sapwood suggests felling of all timbers in AD 1694–1719, with construction likely to have followed shortly after.

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INTRODUCTION

Parts of the Grade II* listed church of St Mary and All Saints' Church located in the Nottinghamshire village of Hawkworth (Figs 1 & 2) are thought to date back to the Norman period, as testified by the carved tympanum, re-set on the south side of the tower. It comprises a chancel, nave with a north aisle and red brick west tower; the nave was largely rebuilt in AD 1812–13, the north aisle in AD 1837, and the chancel in AD 1851 when the rest were also renewed. The west tower is seventeenth century in date (http://southwellchurches.nottingham.ac.uk/hawksworth/main/hindex.php).

Bellframe

The oak bellframe for four bells is of mixed trusses, some jack-braced and others not, Pickford Groups 6.A and 6.B, with orientation being a mirror image of plan Group 4.2 (Figs 3 & 4). It sits on a substantial timber floor, which in turn sits on four beams, orientated east to west, which enter the north and south walls; two are adjacent to the north and south walls and the other two are equally spaced between them. Beneath these beams are two substantial beams, orientated north to south, again equally spaced between the east and west walls. All timbers are pegged together through the mortise and tenon joints with two pegs.

On the top sill of the outer south truss (truss B) is incised '18 MH 15'. As the frame was thought to date from *circa* AD 1800, it was thought likely that this represented the date of the frame and the initials of either the maker or a churchwarden.

The bells

Inscribed:

1. GOD SAVE HIS CHVRCH R DVBELDAY I BAGVLAY WARDENS 1698

2. Blank.

3. J : TAYLOR & C.. FOUNDERS LOUGHBOROUGH 1873

Physical data:

	Diameter(cm)	Weight (Cwt)	Note
Treble.	70.5	c 3.5cwt	D
2.	77	c 5cwt	C
Tenor.	97.5	10.2.0	A

The tenor was added to the ring in AD 1873 and was not a recast of an older bell. The treble is the work of William Noone of Nottingham, whilst the second un-inscribed bell could be dated to the mid-eighteenth century on stylistic grounds, though it is completely different to the treble.

The AD 1764 Terrier mentions 2 bells.

PRINCIPLES OF TREE-RING DATING

Tree-ring dating relies on a few simple, but fundamental, principles. Firstly, as is commonly known, trees (particularly oak trees) grow by adding one, and only one, growth-ring to their circumference each, and every, year. Each new annual growth-ring is added to the outside of the previous year's growth just below the bark. The width of this annual growth-ring is largely, though not exclusively, determined by the weather conditions during the growth period (roughly March to September). In general, good conditions produce wider rings and poor conditions produce narrower rings. Thus, over the lifetime of a tree, the annual growth-rings display a climatically determined pattern. Furthermore, and importantly, all trees growing in the same area at the same time will be influenced by the same growing conditions and the annual growth-rings of all of them will respond in a similar, though not identical, way.

Secondly, because the weather over any number of consecutive years is unique, so too is the growth pattern of the tree. The pattern of a short period of growth, 20 or 30 consecutive years, might conceivably be repeated two or even three times in the last one thousand years. A short pattern might also be repeated at different time periods in different parts of the country because of differences in regional micro-climates. It is less likely, however, that such problems would occur with the pattern of a longer period of growth, that is, anything in excess of 60 years or so. In essence, a short period of growth, anything less than 50 rings, is not reliable, and the longer the period of time under comparison the better.

The third principal of tree-ring dating is that, until the early-to mid-nineteenth century, builders of timber-framed houses usually obtained all the wood needed for a given structure by felling the necessary trees in a single operation from one patch of woodland or from closely adjacent woods. Furthermore, and contrary to popular belief, the timber was used "green" and without seasoning, and there was very little long-term storage as in timber-yards of today. This fact has been well established from a number of studies where tree-ring dating has been undertaken in conjunction with documentary studies. Thus, establishing the felling date for a group of timbers gives a very precise indication of the date of their use in a building.

Tree-ring dating relies on obtaining the growth pattern of trees from sample timbers of unknown date by measuring the width of the annual growth-rings. This is done to a tolerance of 1/100 of a millimetre. The growth patterns of these samples of unknown date are then compared with a series of reference patterns or chronologies, the date of each ring of which is known. When a sample "cross-matches" repeatedly at the same date against a series of different relevant reference chronologies the sample can be said to be dated. The degree of cross-matching, that is the measure of similarity between sample and reference is denoted by a "*t*-value"; the higher the value the greater the similarity. The greater the similarity the greater is the probability that the patterns of the samples and references have been produced by growing under the same conditions at the same time. The statistically accepted fully reliable minimum *t*-value is 3.5.

However, rather than attempt to date each sample individually it is usual to first compare all the samples from a single building, or phases of a building, with one another, and attempt to cross-match each one with all the others from the same phase or building. When samples from the same phase do cross-match with each other they are combined at their matching positions to form what is known as a "site chronology". As with any set of data, this has the effect of reducing the anomalies of any one individual (brought about in the case of tree-rings by some non-climatic influence) and enhances the overall climatic signal. As stated above, it is the climate that gives the growth pattern its distinctive pattern. The greater the number of samples in a site chronology the greater is the climatic signal of the group and the weaker is the non-climatic input of any one individual.

Furthermore, combining samples in this way to make a site chronology usually has the effect of increasing the time-span that is under comparison. As also mentioned above, the longer the period of growth under consideration, the greater the certainty of the cross-match. Any site chronology with less than about 55 rings is generally too short for satisfactory analysis.

SAMPLING STRATEGY

A total of ten samples were taken from various timber elements with each sample being given the code NBF-K and numbered 01–10. The location of all samples was noted at the time of sampling and has been marked on Figures 5–12. Further details can be found in Table 1.

ANALYSIS & RESULTS

At this stage two of the samples (NBF-K03 and NBF-K06) were found to have too few rings for secure dating to be a possibility and so were rejected prior to preparation. The remaining eight samples were prepared by sanding and polishing and their growth-ring widths measured. The growth-ring widths were then compared with each other resulting in all eight samples matching to form a single group.

The eight samples were combined at the relevant offset positions to form NBFKSQ01, a site sequence of 100 rings (Fig 13). This site sequence was then compared against a series of relevant reference chronologies for oak where it was found to match consistently and securely at a first-measured ring date of AD 1592 and a last-measured ring date of AD 1691. The evidence for this dating is given by the *t*-values in Table 2.

INTERPRETATION

Eight of the samples taken from this bellframe have been successfully dated. Although none of these samples have complete sapwood, seven do have the heartwood/sapwood boundary ring which in all cases can be seen to be broadly contemporary (Fig 13). The average heartwood/sapwood boundary ring date for these seven samples is AD 1679, allowing an estimated felling date to be calculated for the timbers represented to within the range AD 1694–1719. The final dated sample (NBF-K08) does not have the heartwood/sapwood boundary ring date and so an estimated felling date cannot be calculated for it. However, with a last-measured ring date of AD 1663, this would be estimated to be AD 1679 at the earliest, a *terminus post quem* felling which does not preclude this sample having also been felled in AD 1694–1719 with the rest of the timber.

Felling date ranges have been calculated using the estimate that 95% of mature oak trees in this region have between 15 and 40 sapwood rings.

DISCUSSION

Prior to the tree-ring dating being undertaken this bellframe was thought to date to *c* AD 1800 on the basis of stylistic grounds and an inscription on one of the top cills. The dendrochronology has demonstrated that the timber utilised within the construction of the bellframe was felled in AD 1694–1719, with construction likely to have followed shortly after, making the frame somewhat earlier than previously thought and probably contemporary with the treble bell dated to AD 1698.

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ACKNOWLEDGEMENTS

The Laboratory and George Dawson would like to thank Anne Dunn for facilitating access and Professor John Beckett and Dr Chris Brooke for the information on the Southwell and Nottingham Church History website. Thanks are also given to Dr Chris Brooke for his comments on early drafts of this report. The research was undertaken as part of the Southwell and Nottingham Church History Project and this element was joint funded by The Heritage Lottery Fund and Nottinghamshire County Council.

Table 1: Details of samples taken from the bellframe at St Mary and All Saints' Church, Hawksworth, Nottinghamshire

Sample number	Sample location	*Total rings	**Sapwood rings	First measured ring date (AD)	Last heartwood ring date (AD)	Last measured ring date (AD)
NBF-K01	Top cill, truss D	54	h/s	1629	1682	1682
NBF-K02	East brace, truss F	88	13	1604	1678	1691
NBF-K03	West brace, truss F	NM	--	----	----	----
NBF-K04	Top cill, truss A	81	h/s	1604	1684	1684
NBF-K05	South brace, truss A	54	07	1632	1678	1685
NBF-K06	North jack brace, truss A	NM	--	----	----	----
NBF-K07	Top cill, truss E	48	02	1631	1676	1678
NBF-K08	North brace, truss G	60	--	1604	----	1663
NBF-K09	Top cill, truss C	77	03	1605	1678	1681
NBF-K10	Middle brace, truss C	90	05	1592	1676	1681

1

*NM = not measured

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

Table 2: Results of the cross-matching of site sequence NBFKSQ01 and relevant reference chronologies when the first-ring date is AD 1592 and the last-measured ring date is AD 1691

Reference chronology	*t*-value	Span of chronology	Reference
Oakham Castle, Rutland	6.3	AD 1598–1737	Arnold and Howard 2013
Bolsover Castle (Riding House). Bolsover, Derbyshire	5.9	AD 1494–1744	Howard *et al* 2005
13 Hall gate, Diseworth, Leicestershire	5.9	AD 1538–1671	Arnold *et al* 2008
Wren Wing, Easton Neston, Northamptonshire	5.5	AD 1468–1686	Arnold *et al* 2008
5 The Green, Lyddington, Rutland	5.5	AD 1566–1678	Arnold and Howard 2010 unpubl
Rufford Mill, Nottinghamshire	5.3	AD 1571–1727	Laxton *et al* 1984
Chapter House Roof, Worcester Cathedral, Worcestershire	5.1	AD 1558–1660	Arnold *et al* 2004

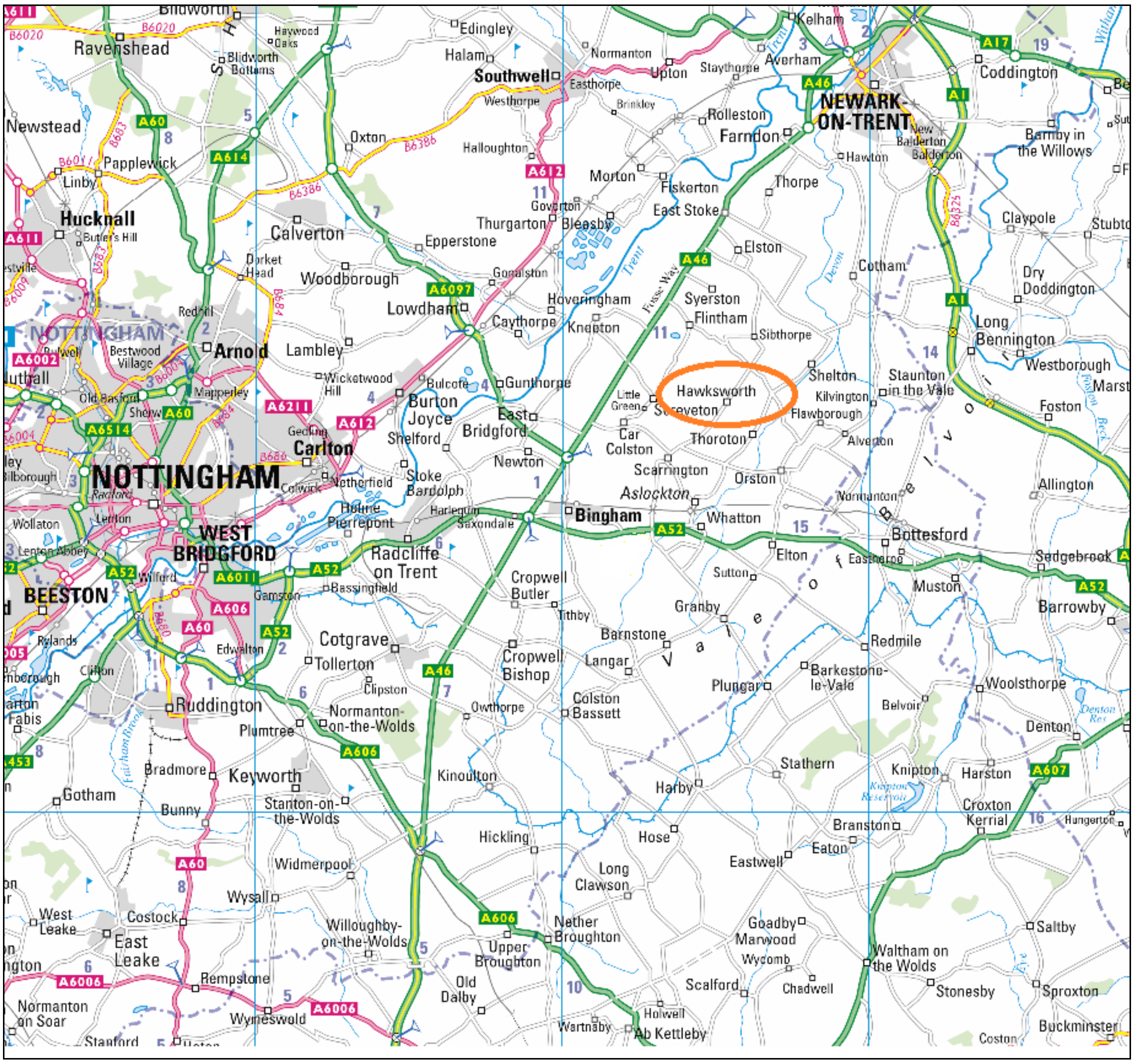

Figure 1: Map to show the general location of Hawksworth, circled (based on the Ordnance Survey map with permission of the Controller of Her Majesty's Stationery Office, ©Crown Copyright)

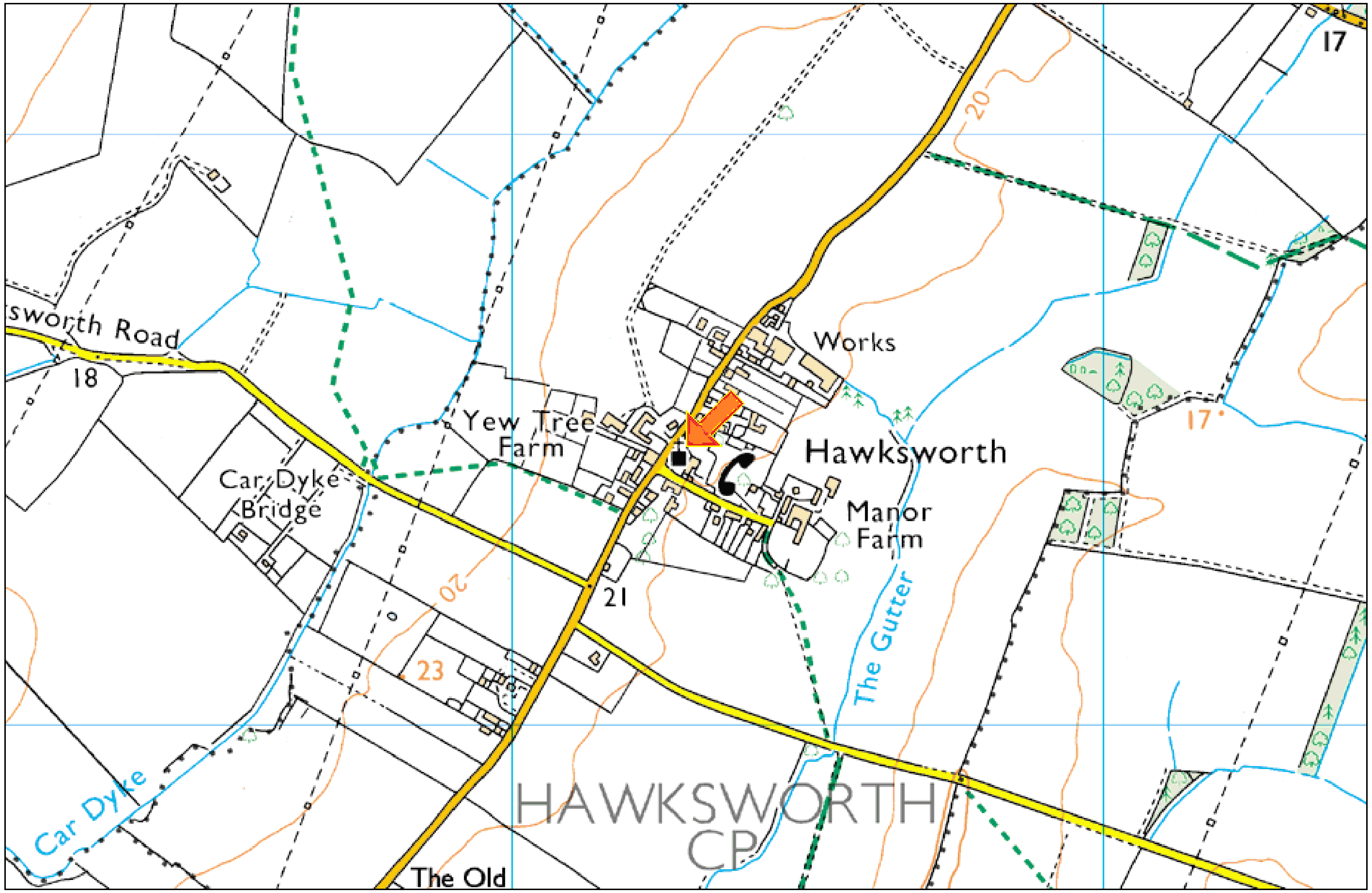

Figure 2: Map to show the location of St Mary and All Saints' Church, arrowed (based on the Ordnance Survey map with permission of the Controller of Her Majesty's Stationery Office, ©Crown Copyright)

Figure 3: The bellframe, photograph taken from the west

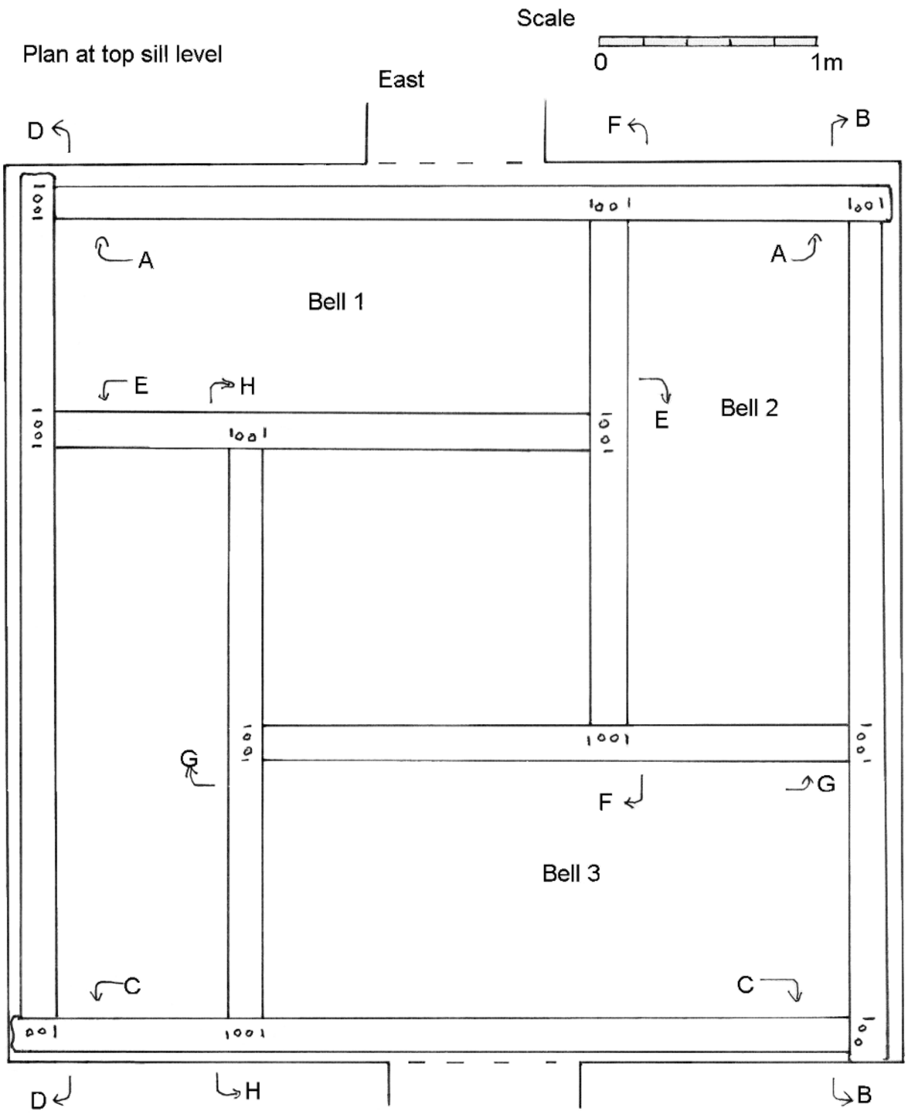

Figure 4: Plan, showing truss labelling (George Dawson)

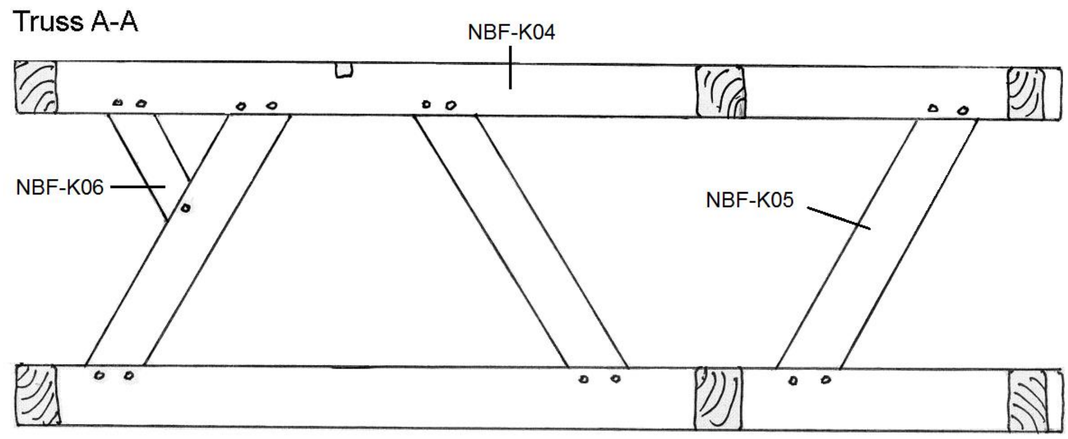

Figure 5: Truss A, showing the location of samples NBF-K04–06 (George Dawson)

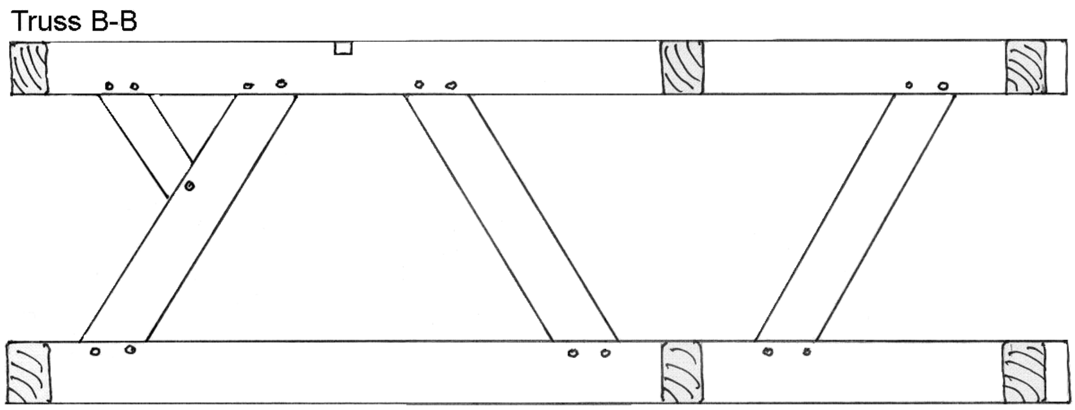

Figure 6: Truss B (George Dawson)

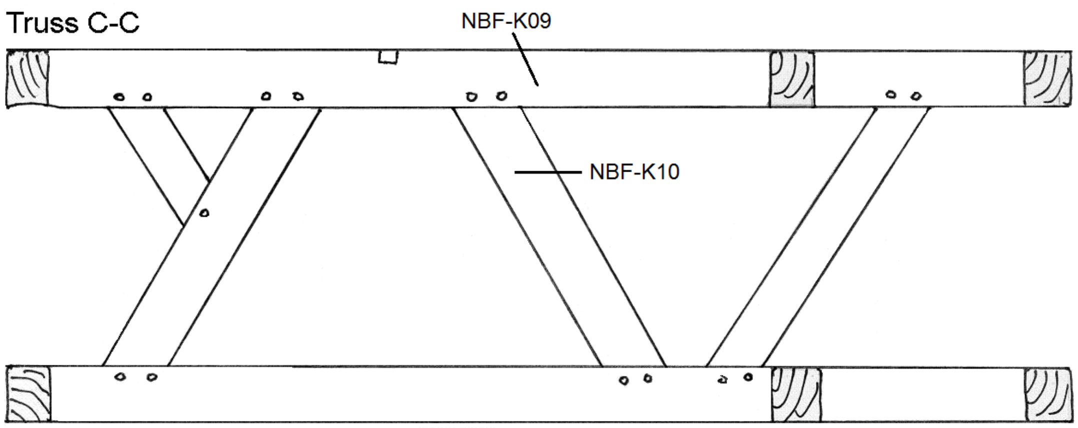

Figure 7: Truss C, showing the location of samples NBF-K09 and NBF-K10 (George Dawson)

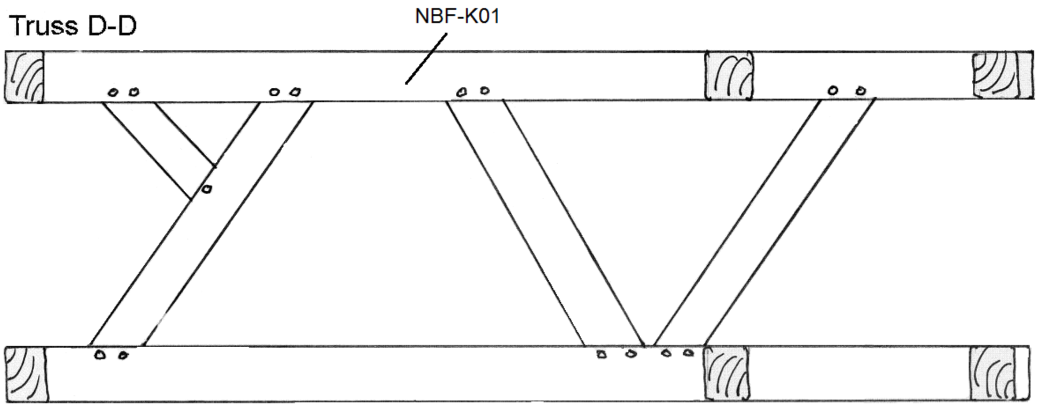

Figure 8: Truss D, showing the location of sample NBF-K01 (George Dawson)

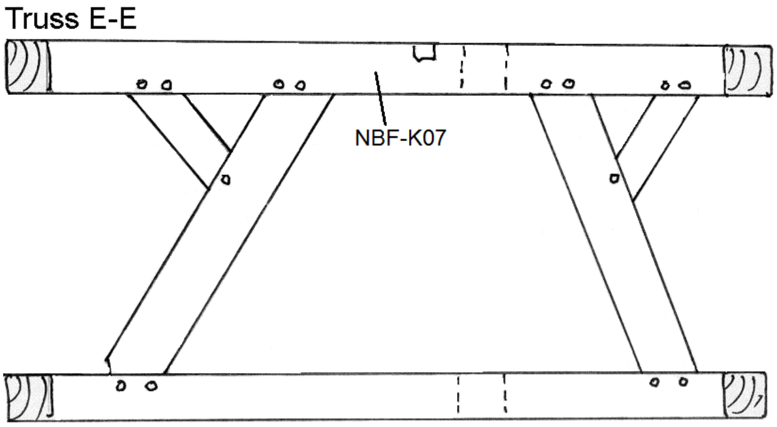

Figure 9: Truss E, showing the location of sample NBF-K07 (George Dawson)

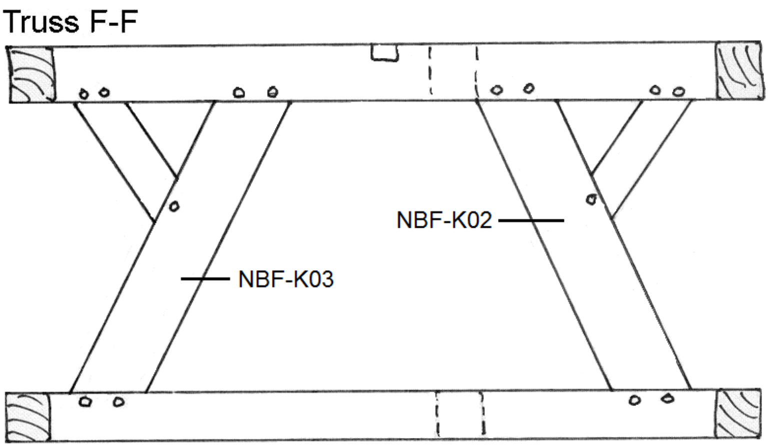

Figure 10: Truss F, showing the location of samples NBF-K02 and NBF-K03 (George Dawson)

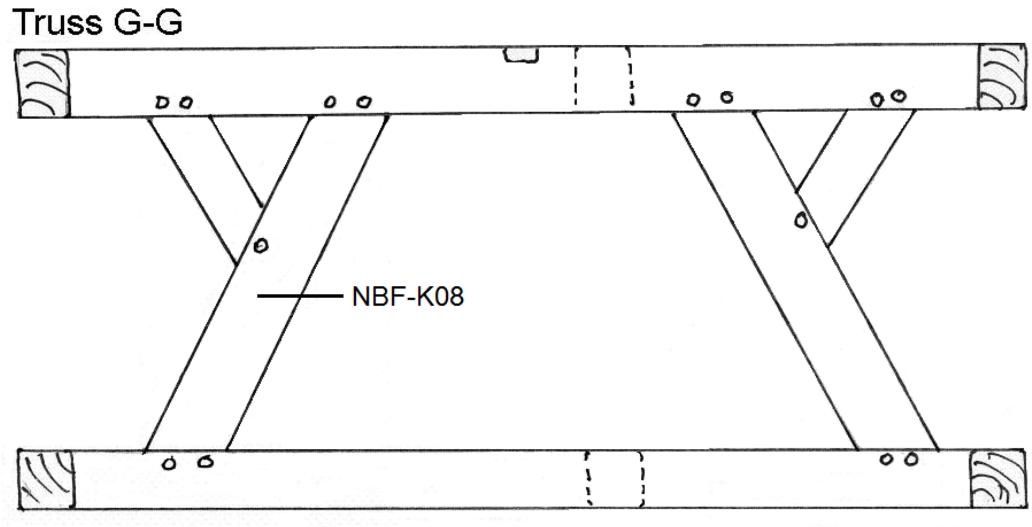

Figure 11: Truss G, showing the location of sample NBF-K08 (George Dawson)

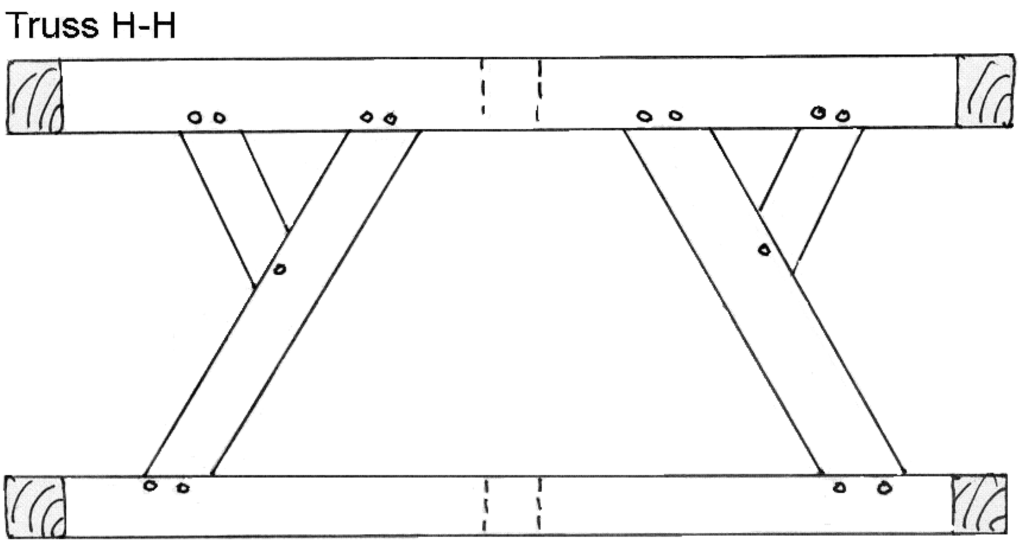

Figure 12: Truss H (George Dawson)

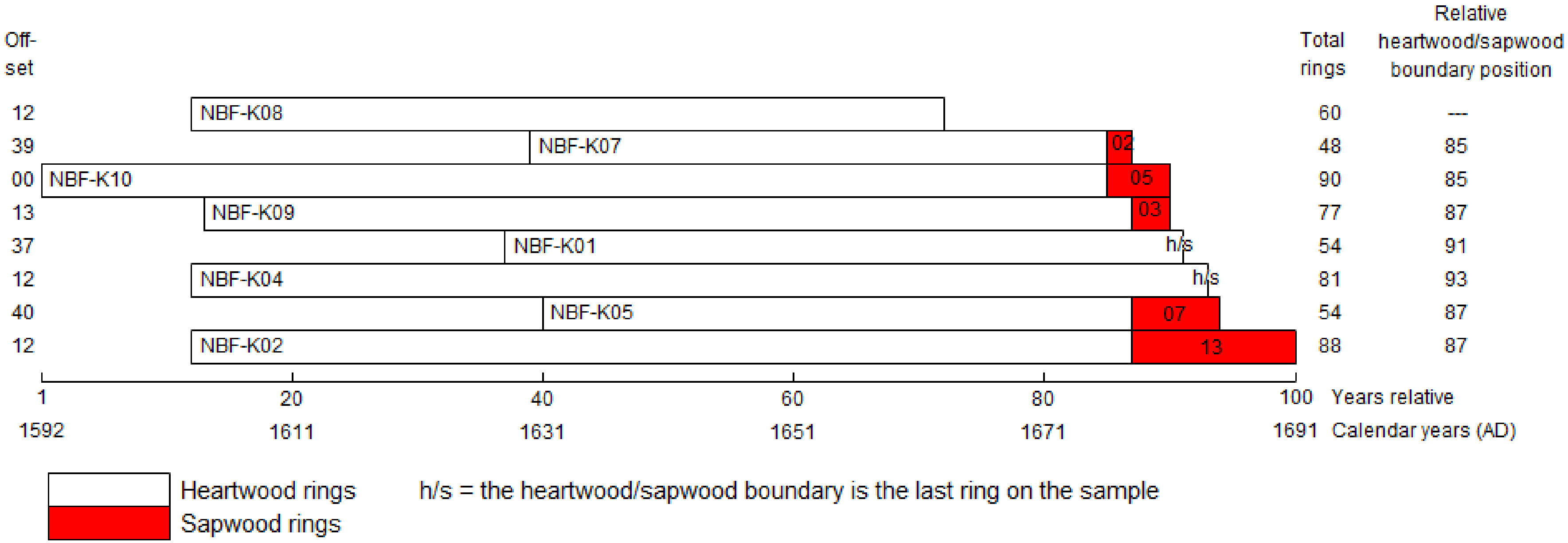

Figure 13: Bar diagram to show the position of samples in site sequence NBFKSQ01

DATA OF MEASURED SAMPLES

Measurements in 0.01mm units

NBF-K01A 54
56 36 46 103 162 122 71 63 78 118 131 149 175 156 234 141 116 152 137 125
109 130 123 91 129 161 212 159 123 156 94 131 154 142 169 148 230 170 193 202
168 243 245 202 230 281 197 163 205 225 401 307 285 431
NBF-K01B 54
63 38 39 111 159 121 92 62 103 116 118 151 185 144 223 152 126 165 133 109
117 128 117 96 119 159 222 157 116 159 98 129 152 121 174 156 236 157 173 189
175 243 228 184 236 278 198 166 200 257 365 303 288 425
NBF-K02A 88
299 199 173 223 178 254 224 245 130 94 72 88 95 88 97 83 94 83 99 90
85 67 86 237 554 425 174 159 319 352 225 146 100 166 169 253 310 424 245 297
247 302 182 186 417 200 288 232 217 230 346 506 258 302 268 291 361 310 291 227
244 316 212 291 253 212 381 345 251 340 371 270 211 202 204 325 229 231 317 377
221 285 335 289 282 178 172 232
NBF-K02B 88
307 197 176 227 177 256 227 210 130 98 68 89 83 94 104 85 92 85 99 96
83 74 81 243 558 487 181 151 327 347 241 134 97 180 178 251 305 439 258 302
259 294 218 188 410 201 299 210 220 242 352 505 273 312 294 301 352 300 294 230
231 319 212 282 257 216 374 334 245 331 373 268 214 204 210 331 229 228 325 389
238 282 332 228 296 181 170 230
NBF-K04A 81
371 274 326 331 265 223 377 273 317 201 177 159 145 231 225 188 215 171 232 233
190 176 122 373 337 253 170 164 229 275 192 172 123 141 158 116 133 81 96 85
84 98 140 169 160 133 114 102 71 102 114 200 182 183 188 131 126 157 177 175
187 177 129 120 112 145 178 252 152 170 224 140 112 199 246 308 208 214 219 191
125
NBF-K04B 81
385 292 356 350 273 230 379 290 316 194 177 164 158 233 231 193 223 181 236 263
186 162 128 363 342 253 184 171 226 283 193 168 125 141 160 113 135 78 96 80
81 95 149 163 156 135 119 95 73 97 125 205 186 176 182 125 129 158 176 175
192 173 129 121 113 148 181 249 152 174 224 132 129 203 257 309 227 187 235 177
127
NBF-K05A 54
219 298 215 196 212 294 226 295 443 397 330 325 206 215 260 283 393 331 262 171
143 159 199 331 251 203 195 190 211 217 229 265 230 231 170 208 251 290 313 250
267 255 278 171 156 204 285 314 253 224 273 218 211 183
NBF-K05B 54
259 299 215 189 208 275 218 290 440 403 329 333 204 216 256 281 390 328 252 170
144 164 199 333 256 206 205 168 220 218 230 257 236 227 174 204 245 293 317 254
262 253 278 170 160 204 293 298 264 210 279 209 218 198
NBF-K07A 48
244 312 376 160 135 193 170 152 174 317 396 252 291 180 237 227 208 389 241 351

203 216 160 291 515 293 249 225 208 245 334 287 211 175 170 162 211 257 213 412
309 209 220 225 194 180 239 247
NBF-K07B 48
252 319 368 159 134 180 172 156 177 316 401 246 303 180 245 231 189 388 242 338
209 227 182 287 514 294 225 228 203 245 333 297 214 175 173 161 203 250 231 412
308 211 219 229 197 184 229 258
NBF-K08A 60
203 217 195 279 259 202 151 141 149 186 141 90 82 57 53 65 42 40 35 42
38 40 46 521 654 497 238 158 322 347 262 194 293 287 195 354 544 600 422 500
368 419 561 472 667 458 333 227 160 201 381 640 606 455 370 312 403 407 340 346
NBF-K08B 60
211 247 192 270 271 205 138 153 159 191 134 95 100 54 62 51 41 41 34 43
36 30 34 558 669 508 248 177 325 338 263 200 316 312 194 366 554 607 433 475
386 423 551 457 664 446 323 222 163 196 391 626 590 456 385 301 374 391 322 345
NBF-K09A 77
169 226 189 202 176 140 156 133 128 138 134 88 92 78 92 82 83 72 63 52
41 38 56 92 56 47 57 80 80 61 123 103 120 191 118 185 209 178 183 218
172 244 211 230 199 182 187 142 159 211 277 241 202 261 184 173 205 195 236 207
225 168 157 193 201 211 222 156 227 247 220 189 238 276 226 258 177
NBF-K09B 77
182 237 210 200 184 147 162 144 138 135 142 99 85 83 91 90 77 79 61 52
41 38 58 108 47 44 63 81 84 69 115 104 131 194 124 194 214 176 194 238
175 256 204 236 196 181 186 150 147 227 281 238 200 270 175 190 204 198 237 210
227 170 161 189 204 210 224 159 226 247 222 198 234 277 285 210 166
NBF-K10A 90
164 139 217 182 165 189 211 275 277 235 285 329 334 242 327 300 238 258 264 197
129 114 140 151 102 101 161 153 147 121 125 237 123 105 115 510 949 614 176 239
248 330 207 192 126 164 202 265 272 265 149 180 149 207 204 182 346 208 281 217
173 148 256 363 249 256 238 170 162 279 270 167 187 214 166 176 267 246 328 226
202 230 192 191 174 226 187 185 255 161
NBF-K10B 90
167 172 181 114 125 167 207 271 265 251 263 352 339 245 318 303 248 267 283 189
132 115 128 161 114 98 159 153 155 120 124 238 124 103 117 514 947 624 176 234
251 345 227 198 133 172 190 262 275 264 145 178 155 207 214 184 338 202 280 217
178 150 257 375 249 237 256 170 161 263 281 176 184 222 159 178 266 243 332 241
206 222 206 189 178 241 188 207 236 165