Centre for Archaeology Report 64/2004

Tree-Ring Analysis of Timbers from the Roof of St Catherine's Chapel (South-East Transept), Wells Cathedral, Somerset

A J Arnold, R E Howard and Dr C D Litton

ISSN 1473-9224

The Centre for Archaeology Report Series incorporates the former Ancient Monuments Laboratory Report Series. Copies of Ancient Monuments Laboratory Reports will continue to be available from the Centre for Archaeology (see back cover for details).

Centre for Archaeology Report 64/2004

Tree-Ring Analysis of Timbers from the Roof of St Catherine's Chapel (South-East Transept), Wells Cathedral, Somerset

A J Arnold, R E Howard and Dr C D Litton

Summary

Fourteen samples from the roof of the south-east transept of Wells Cathedral, which houses St Catherine's Chapel, were analysed by tree-ring dating. This analysis produced a single site chronology comprising 12 samples with a combined overall length of 157 rings. These rings are dated as spanning the years AD 1169 to AD 1325.

Interpretation of the sapwood on the dated samples would indicate that the timbers they represent were felled in AD 1325. Such a date is very much in keeping with that assigned to the south-east transept on stylistic grounds, and is in keeping with documentary evidence suggesting work on St Catherine's Chapel was nearing completion in AD 1324. Two samples remain undated.

Keywords

Dendrochronology
Standing Building

Author's address

Nottingham Tree-Ring Dating Laboratory, School of Mathematical Sciences, University of Nottingham, University Park, Nottingham, NG7 2RD.

Introduction

Exactly when the construction of Wells Cathedral (ST 552 459; Figs 1 and 2) was begun is not absolutely certain, but work was certainly in progress by AD 1186. It is one of the first truly English Gothic churches, using the pointed arch throughout rather than the earlier round-headed Romanesque type. The main body of the church was largely complete by AD 1215, with the nave and the great west front, with its 400 niches, being finished thereafter. It was consecrated to St Andrew in AD 1239. The east end of the cathedral was remodeled in the fourteenth century and twin towers were added to the west front.

Of particular relevance to this report is the south-east transept at Wells which houses St Catherine's Chapel. On stylistic grounds the Chapel is assigned to the early-fourteenth century and, on the basis of documentary evidence, there is strong reason to believe that it was largely complete by *c* AD 1324. An examination of the roof over the Chapel, undertaken by Drs Jerry Samson and Warwick Rodwell, shows that it is clearly of one unified design and of a single build.

The Laboratory would like to take this opportunity to thank the Dean and Chapter of Wells Cathedral for allowing sampling. The Laboratory would also like to thank Dr Warwick Rodwell, consulting archaeologist, for advising on, and assisting with, the sampling, and to thank Mr Jerry Samson of Caroe and Partners for providing plans and drawings. We would also like to thank Michael Hayecroft, Clerk of Works, for his invaluable cooperation and assistance during sampling. Finally, we would like to thank the roofing contractors of Lee & Son, Roofing, of Oxford, for their help in the roof during sampling.

Sampling

Sampling and analysis by tree-ring dating of the roof of St Catherine's Chapel were commissioned by English Heritage. The purpose of this was to establish a precise date for the roof construction and help understand the chronological development of this part of the cathedral complex. The results of this work would help inform grant-aided repairs to the roof of the cloister.

The roof consists of nine close-set common rafter frames with collars, the structure strengthened at frames 1 and 8 with tiebeams (though the tiebeam of frame 1 has long since been removed). Both tiebeams were also attached to the wall plates by short, slightly curved, horizontal struts or braces, but only those to frame 8 now remain. There are no purlins to this roof, and no ridge beam. An illustration of frame 1 is given in Figure 3.

After discussion with Dr Rodwell, and in conjunction with the English Heritage brief, a total of 14 core samples was obtained from the available timbers. All these samples were taken from timbers which were believed to be integral to the structure of the roof, these timbers for the most part being common rafters and collars, with the remaining tiebeam at truss 9 also being sampled. The wall plates, which might have been sampled, were thought to be too decayed to provide worthwhile cores.

Each sample was given the code WLS-C, (for Wells, site "C") and numbered 46 – 59 (samples WLS-C01 – C19 having been obtained from the east cloister roof, and samples WLS-C20 - C45 from the west cloister roof (Howard *et al* 2001, 2002)). The positions of these newly obtained samples are marked on plans made by Jerry Samson, reproduced here as Figure 4. Details of the samples are given in Table 1. In this Table, as in Figure 4, the frames are numbered from north to south with individual timbers being described on an east - west basis as appropriate.

Analysis

Each of the samples obtained was prepared by sanding and polishing and the growth-ring widths of all 14 were measured; the data of these measurements being given at the end of the report. The growth-ring widths of all 14 samples were compared with each other by the Litton/Zainodin grouping procedure (see appendix). At a minimum value of t=4.4, slightly below this Laboratory's usual minimum of t=4.5, two groups of samples could be formed. The first group comprises seven cross-matching samples which were combined to form site chronology WLSCSQ01(3). This site chronology has an overall length 156 rings. Site chronology WLSCSQ01(3) was then satisfactorily dated by comparison to a number of relevant reference chronologies for oak as spanning the years AD 1169 to AD 1324.

The second site chronology comprises two samples, having a combined overall length of 89 rings. This site chronology could not be dated.

All the ungrouped samples, plus the two grouped but undated samples, were all then compared individually with a large number of reference chronologies held at both the Nottingham Laboratory and by the Sheffield Dendrochronology Laboratory. Consistent dating results were indicated for five of these samples. These five samples were then compared with each other to a minimum value of t=3.5. This analytical process showed repeated cross-matching at consistent relative positions. Although the intra-site t-values are relatively low, they are maximum values and are above the statistically reliable minimum of t=3.5.

In addition, relatively low but again consistent, maximum, t-values were obtained between a number of the individuals of the two groups of timbers. Because of this analysis the seven samples in site chronology WLSCSQ01(3), plus the five additional samples cross-matched and dated in further analysis, were combined with each other to form site chronology WLSCSQ02(3). This has a combined overall length of 157 rings, the relative positions of the 12 cross-matching samples being shown in the bar diagram Figure 5.

Site chronology WLSCSQ02(3) was compared with a series of relevant reference chronologies for oak, indicating a series of satisfactory cross-matches when the date of its first ring is AD 1169, and a last measured ring is AD 1325. Evidence for this dating is given in the t-values of Table 2.

Interpretation

Analysis by dendrochronology has produced a single site chronology of 12 samples with a combined overall length of 157 rings, these being dated as spanning the years AD 1169 to AD 1325. Three of these samples, WLS-C50, C53, and C56, retain complete sapwood. This means that they have the last ring produced by the trees they represent before they were felled. In each case the date of the last measured ring is the same, AD 1325. This is thus the felling date of the timbers represented. The amount of sapwood, and the relative positions of the heartwood/sapwood boundaries, on the other dated samples is highly indicative of timbers with a single felling date, and it is almost certain that all the other dated timbers were felled in AD 1325 as well.

Conclusion

The analysis reported upon here thus shows that a number of the sampled timbers in the roof of St Catherine's Chapel date to the early-fourteenth century, a group of 12 timbers being felled in AD 1325. Such a date would coincide closely with that generally assigned to the south-east transept on stylistic grounds. This date would also agree with that intimated from the documents suggesting that work on the Chapel was nearing completion in AD 1324.

It is perhaps worth noting that, judging by the *t*-values of the cross-matches between some of the samples, some timbers appear to be from a small group of trees all growing fairly close to each other. Indeed some beams may be derived from the same tree, with samples WLS-C46 and C48 cross-matching with each other with a value of t=9.2. Similarly, samples WLS-C51 and C54 cross-match with each other with a value of t=9.9. It is thus possible that the dated material in site chronology WLSCSQ04(3) represents only four or five trees.

Other material, particularly the timbers represented by samples WLS-C49, C50, C51, C52, and C56, is probably from a different source or sources. The timbers represented by these samples tend to have wider, and thus fewer, rings.

Two samples, WLS-C47 and C59, remain undated. Both samples have sufficient rings for satisfactory analysis, and neither of them shows any abnormalities to their growth patterns which might make cross-matching and dating difficult. It is possible that the timbers represented are from different sources again making them, in effect singletons. Individual, single, samples are often more difficult to date.

Bibliography

Arnold, A J, Howard, R E, and Litton, C D, forthcoming *Tree-ring analysis of timbers from New Inn House, 7 Wotton Road, Kingswood, Gloucestershire,* Centre for Archaeol Rep

Bridge, M, 1988 The Dendrochronological Dating of Buildings in Southern England, *Medieval Archaeol*, **32**, 166-74

Groves, C, Hillam, J, and Pelling-Fulford, F, 1997 Dendrochronology in Excavations on Reading Waterfront sites 1979-1988 (eds J W Hawkes and P J Fasham), Wessex Archaeol Rep, **5**, 64 – 70

Howard, R E, Laxton, R R, Litton, C D, and Simpson, W G, 1988 List 27 no 4 - Nottingham University Tree-Ring Dating Laboratory results, *Vernacular Architect,* **19,** 46-7

Howard, R E, Laxton, R R, Litton, C D, and Simpson, W G, 1992 List 44 no 19a/b - Nottingham University Tree-Ring Dating Laboratory results, *Vernacular Architect,* **23**, 51 – 6

Howard, R E, Laxton, R R, and Litton, C D, 2001 *Tree-ring analysis of timbers from the East Range of the Cloister, Wells Cathedral, Somerset, Centre for Archaeol Rep* ***49/2001***

Howard, R E, Laxton, R R, and Litton, C D, 2002 *Tree-ring analysis of timbers from the roof of the West Range of the Cloister, Wells Cathedral, Somerset, Centre for Archaeol Rep* ***51/2002***

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 & Archaeol Studies, Monograph Series, **III**

Tyers, I, and Groves, C, 1999 unpubl England London, unpubl computer file *LON1175*, Sheffield Univ

Table 1: Details of samples from the roof of St Catherine's Chapel, Wells Cathedral

Sample no.	Sample location	Total rings	*Sapwood rings	First measured ring date	Last heartwood ring date	Last measured ring date
WLS-C46	Collar, frame 2	131	h/s	AD 1169	AD 1299	AD 1299
WLS-C47	West rafter, frame 3	73	13C	------	------	------
WLS-C48	Collar, frame 3	97	17	AD 1224	AD 1303	AD 1320
WLS-C49	East rafter, frame 4	63	15	AD 1259	AD 1306	AD 1321
WLS-C50	West rafter, frame 4	73	18C	AD 1253	AD 1307	AD 1325
WLS-C51	Collar, frame 4	111	h/s	AD 1194	AD 1304	AD 1304
WLS-C52	East rafter, frame 5	79	h/s	AD 1241	AD 1304	AD 1319
WLS-C53	West rafter, frame 5	83	32C	AD 1243	AD 1293	AD 1325
WLS-C54	Collar, frame 5	129	h/s	AD 1172	AD 1300	AD 1300
WLS-C55	East rafter, frame 7	109	19	AD 1204	AD 1293	AD 1312
WLS-C56	West rafter, frame 6	62	24C	AD 1264	AD 1301	AD 1325
WLS-C57	West rafter, frame 7	99	no h/s	AD 1192	------	AD 1290
WLS-C58	West rafter, frame 8	72	18c	AD 1253	AD 1306	AD 1324
WLS-C59	Tiebeam, frame 8	50	14	------	------	------

*h/s = the heartwood/sapwood boundary is the last ring on the sample
C = complete sapwood retained on sample. The last measured ring date is the felling date of the timber
c = complete sapwood retained on timber, all or part lost from core in sampling

Table 2: Results of the cross-matching of site chronology WLSCSQ02(3) and relevant reference chronologies when first ring date is AD 1169 and last ring date is AD 1325

Reference chronology	Span of chronology	*t*-value	
Southern England	AD 1083 – 1589	9.7	(Bridge 1988)
Reading waterfronts, Berks	AD 1160 – 1407	8.9	(Groves *et al* 1997)
New Inn House, Kingswood, Glos	AD 1191 – 1519	8.2	(Arnold *et al* forthcoming)
Chichester Cathedral, West Sussex	AD 1173 – 1295	8.1	(Howard *et al* 1992)
East Midlands	AD 882 – 1981	8.0	(Laxton and Litton 1988)
England, London	AD 413 – 1728	7.9	(Tyers and Groves 1999 unpubl)
Cross Keys Inn, Leicester	AD 1104 – 1309	7.3	(Howard *et al* 1988)

Figure 1: Map to show general location of Wells Cathedral

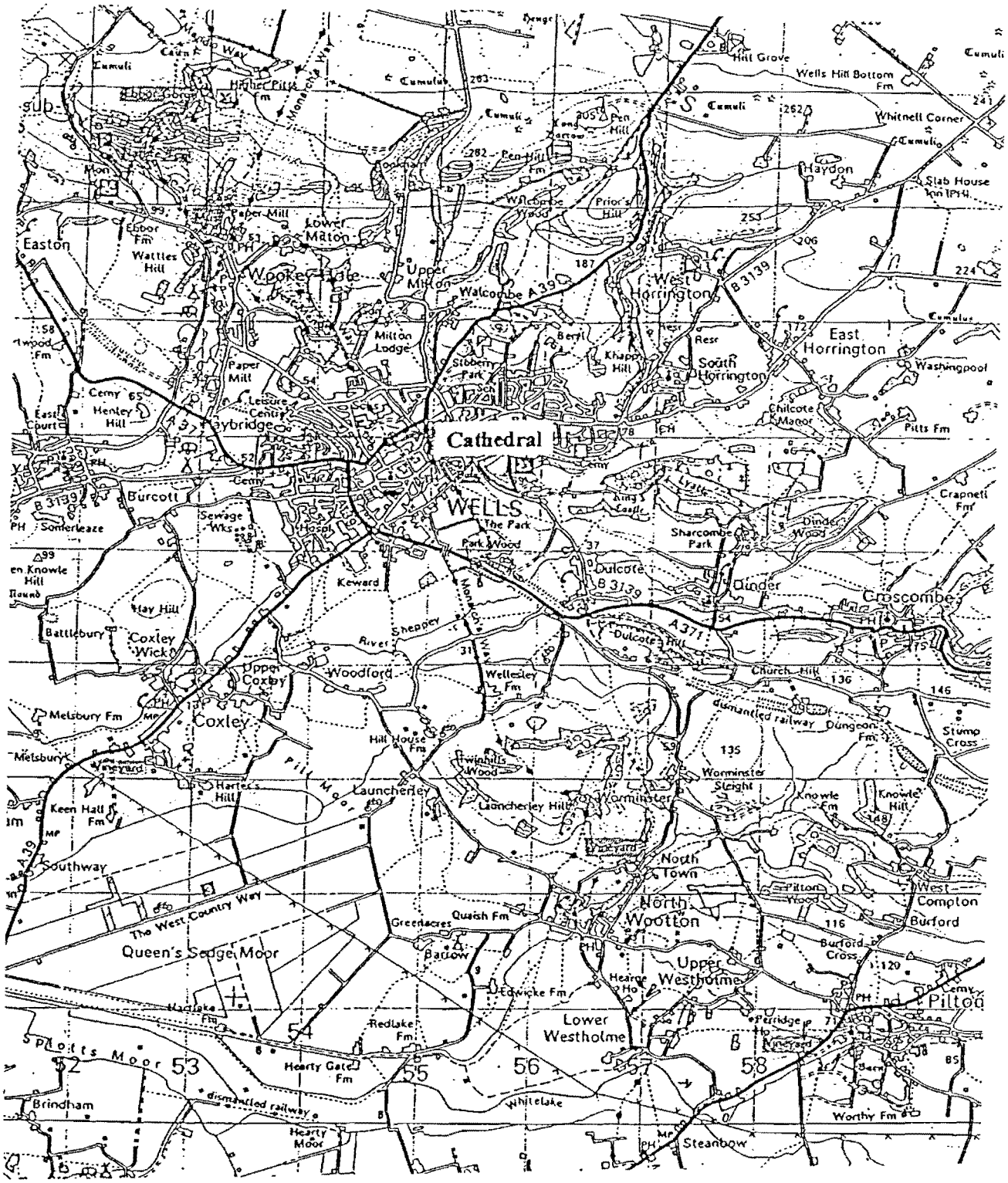


Figure 2: Map to show location of St Catherine's Chapel

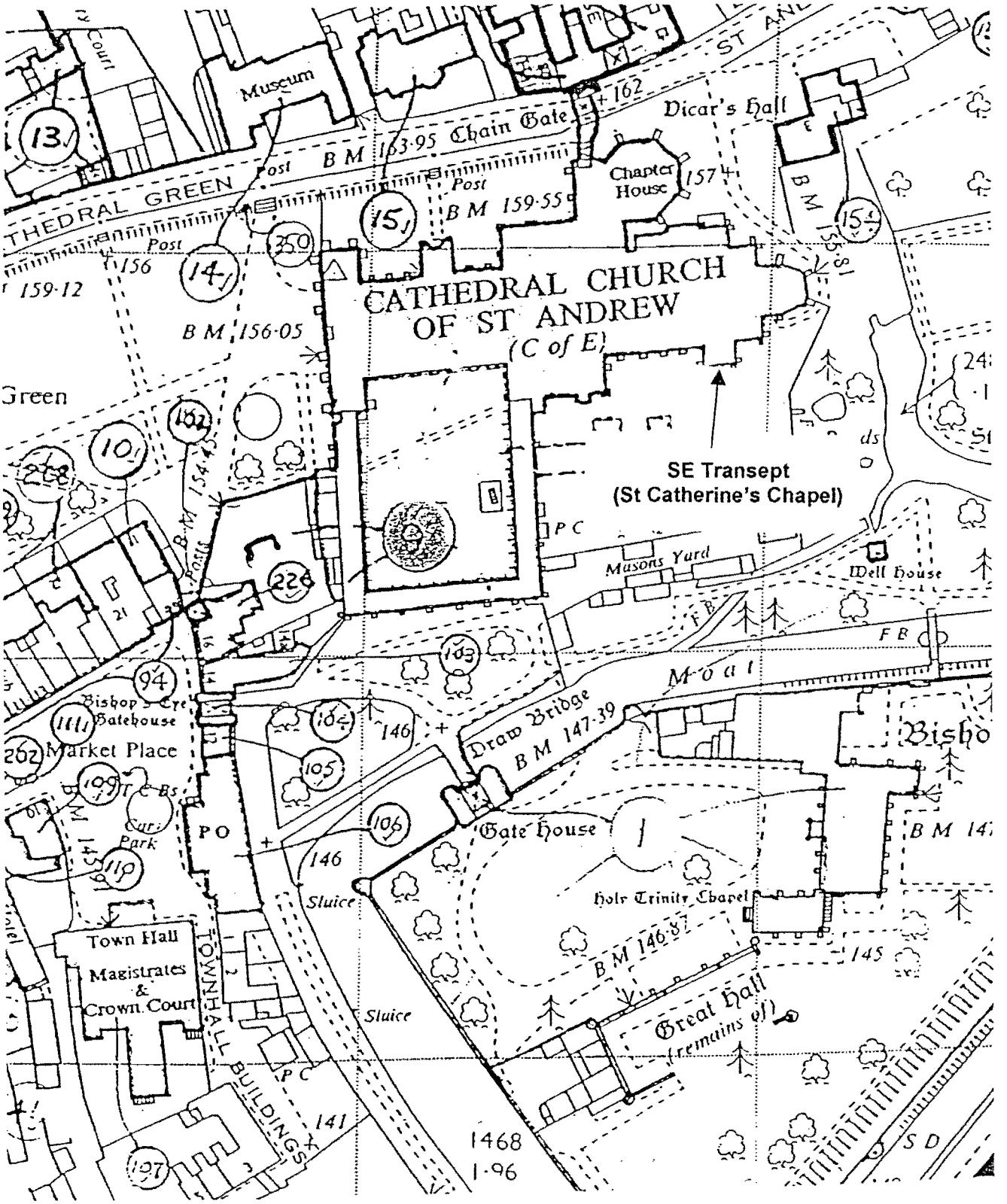


Figure 3: Illustration of frame 1
(viewed from the south looking north)

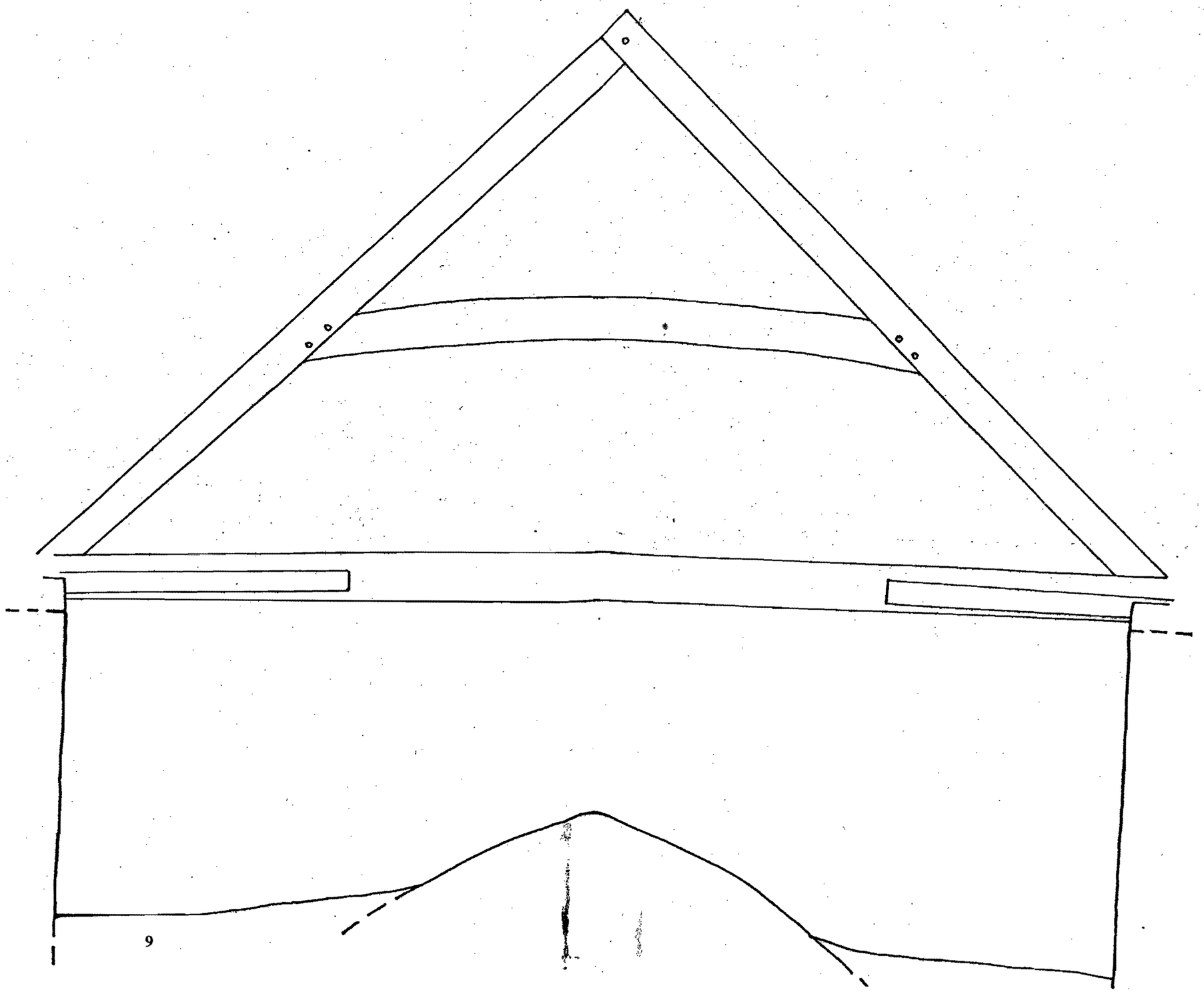


Figure 4: Roof plan to show location of timbers sampled

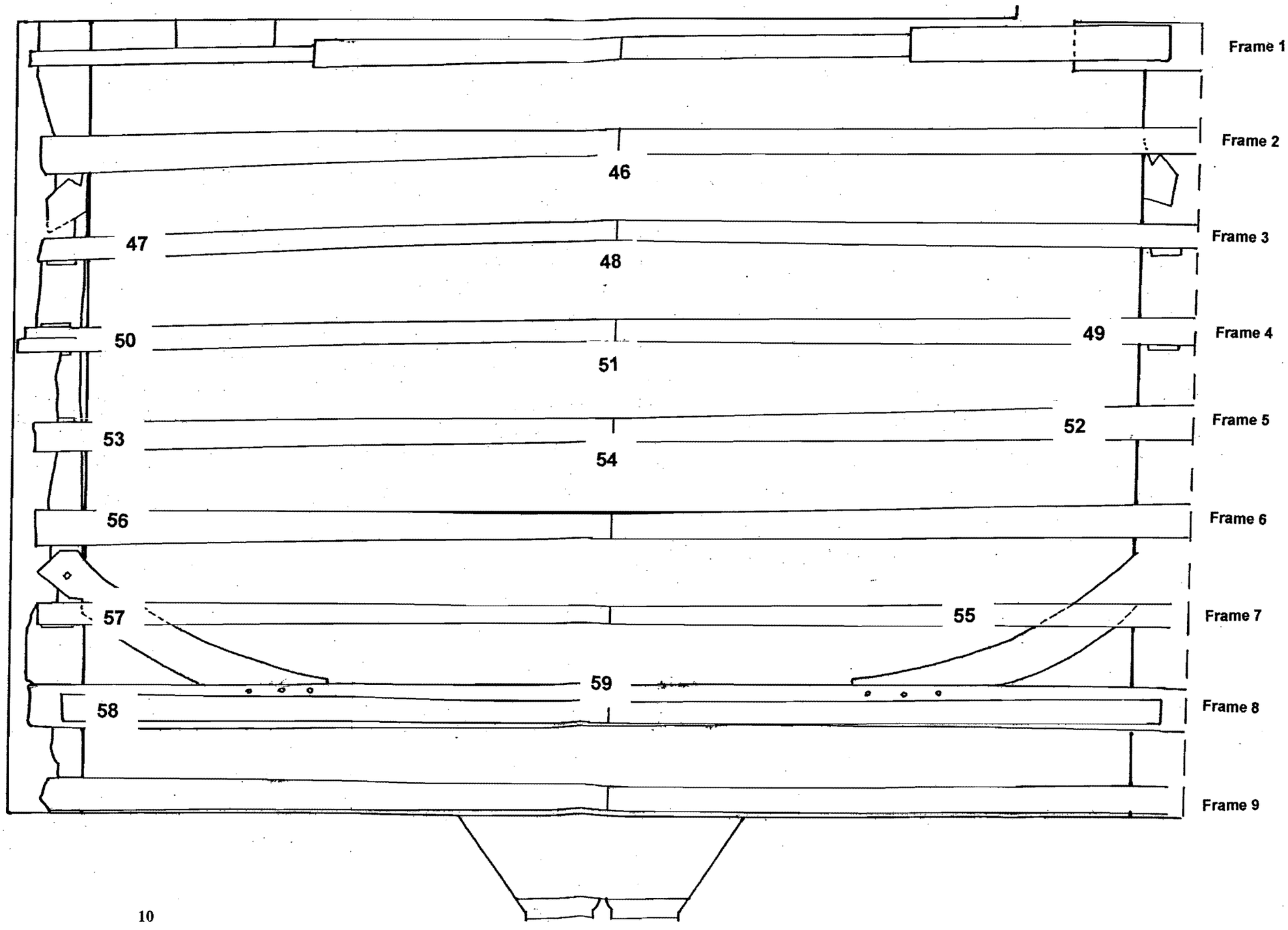
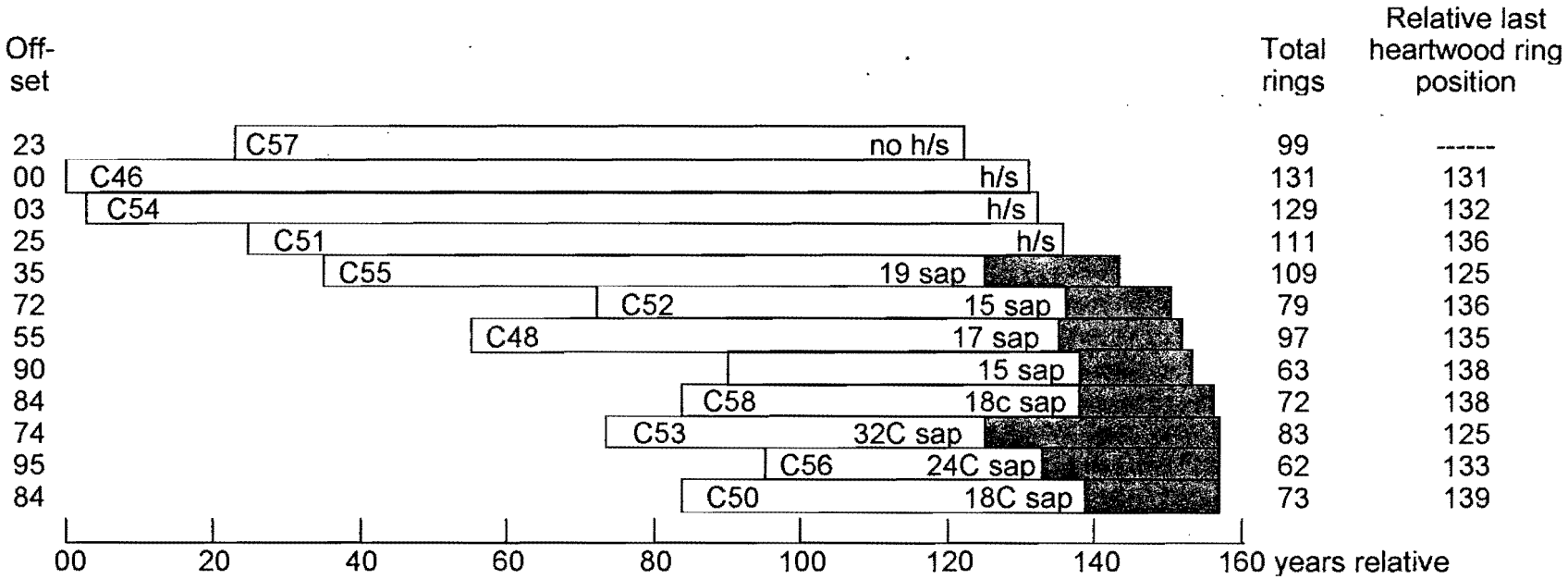


Figure 5: Bar diagram of samples in site chronology WLSCSQ02(3)



White bars = heartwood rings, shaded area = sapwood rings
h/s = heartwood/sapwood boundary is last ring on sample
C = complete sapwood is retained on the sample, the last measured ring date is the felling date of the timber

Data of measured samples – measurements in 0.01 mm units

WLS-C46A 131
233 219 311 347 395 302 180 247 122 176 191 134 187 296 177 141 181 165 190 96
104 194 146 213 181 121 167 182 123 125 133 227 218 160 148 108 95 71 58 56
60 95 69 50 39 47 47 70 43 34 52 73 78 65 60 81 121 159 96 138
160 115 93 87 130 106 136 76 109 151 121 101 119 73 100 171 183 148 169 119
185 127 115 82 200 127 150 123 125 103 112 118 174 209 139 180 186 186 151 176
131 134 225 180 191 160 101 97 126 138 119 133 135 166 127 184 121 121 96 71
94 119 84 104 127 118 75 80 74 79 98
WLS-C46B 131
226 230 359 300 409 294 189 232 133 165 209 133 207 293 166 141 171 162 187 89
124 197 147 200 187 114 166 199 118 112 125 227 219 164 144 126 89 67 61 51
51 88 76 46 36 51 50 61 36 41 55 73 94 52 68 75 116 139 93 135
168 120 95 87 129 106 143 81 115 140 127 94 118 76 100 163 171 144 179 116
186 129 138 79 204 122 138 131 130 95 106 124 172 215 137 191 196 175 136 203
139 120 210 176 192 167 98 94 132 131 117 133 137 165 134 165 113 133 95 67
97 118 92 109 131 117 73 89 82 84 88
WLS-C47A 73
122 117 184 266 152 309 296 178 131 180 226 126 133 228 209 147 160 94 92 154
203 400 211 179 154 192 150 202 179 211 359 154 111 113 164 156 159 217 127 78
90 100 169 173 156 134 127 114 172 209 170 132 140 148 258 258 210 176 138 165
212 256 273 216 214 198 148 178 196 218 272 172 213
WLS-C47B 73
148 120 185 259 191 406 274 193 140 196 209 126 131 231 203 147 156 88 100 150
237 405 219 184 155 174 160 208 186 207 353 153 109 118 156 160 156 235 125 85
96 95 164 172 165 133 114 117 166 205 191 122 145 145 256 247 225 171 136 167
205 262 267 204 221 180 174 173 203 245 249 170 194
WLS-C48A 97
155 158 183 141 161 210 94 70 61 116 86 159 104 112 125 104 84 146 93 149
171 182 157 151 111 206 178 201 122 192 154 219 223 202 176 140 174 195 232 181
197 185 177 139 184 108 179 171 157 219 153 113 91 95 91 97 102 84 95 59
55 75 82 75 40 82 103 51 83 114 101 74 99 112 166 114 110 128 113 129
93 100 133 85 99 91 75 63 67 69 69 106 91 119 75 104 106
WLS-C48B 97
170 154 190 132 167 207 174 94 106 134 111 143 94 120 132 120 88 169 93 158
180 188 152 160 135 193 219 168 134 181 158 214 230 207 179 145 163 215 231 182
191 179 181 154 159 124 165 183 159 225 161 99 84 93 98 99 103 91 97 58
64 66 87 56 42 98 96 50 81 117 101 69 95 132 136 115 125 128 111 133
85 94 127 91 95 90 76 61 65 64 75 99 96 116 80 95 104
WLS-C49A 63
146 228 178 181 196 251 182 153 111 193 124 118 149 135 191 186 133 143 154 147
153 172 134 133 158 113 106 101 62 53 60 77 60 83 78 95 92 71 70 94
74 89 77 100 57 92 119 138 232 184 177 136 166 215 157 135 115 133 114 110
104 124 129
WLS-C49B 63
171 225 195 180 177 138 222 207 123 191 119 123 171 152 192 198 138 146 150 154
160 168 144 133 156 112 105 100 62 55 62 77 75 89 80 92 97 67 80 90
80 81 80 87 60 89 106 149 238 174 168 153 168 210 154 139 123 128 110 106
104 130 134
WLS-C50A 73
282 270 429 335 347 316 187 159 226 245 227 369 382 412 234 413 356 264 154 185
210 279 180 228 238 209 246 269 210 253 225 117 129 121 77 72 95 154 122 156

82 116 88 148 126 113 69 64 119 211 132 192 189 200 212 102 99 113 149 142
124 140 178 194 270 192 144 322 296 296 219 189 192
WLS-C50B 73
240 280 419 321 324 335 202 173 206 258 243 368 412 409 225 415 352 267 149 189
211 280 148 219 234 223 233 260 210 254 229 115 131 114 74 68 100 147 132 164
73 122 101 106 151 102 78 71 99 201 138 191 204 194 219 120 83 121 147 136
134 127 169 192 291 155 147 301 315 330 193 185 194
WLS-C51A 111
301 298 262 245 170 196 171 228 126 145 67 83 64 59 112 167 159 174 189 151
202 258 176 151 171 200 200 125 118 84 89 147 162 102 164 188 83 79 119 157
133 106 118 169 174 158 133 110 153 166 130 112 151 151 111 130 150 120 125 89
128 150 142 118 130 126 94 124 135 96 84 148 164 122 194 115 99 116 135 164
127 154 125 130 129 139 132 129 185 148 154 167 135 112 89 134 184 160 134 155
122 144 125 144 104 126 118 88 117 86 122
WLS-C51B 111
248 275 295 165 172 189 164 219 178 128 76 85 58 58 105 139 106 168 180 136
195 233 184 141 183 203 192 141 111 78 97 133 162 123 161 169 85 78 116 124
123 139 101 171 186 182 128 120 156 154 130 113 123 155 116 99 153 143 107 108
123 178 134 151 112 115 105 128 110 99 89 133 156 128 193 118 98 127 141 167
120 160 132 122 130 140 138 128 172 151 140 184 131 119 110 124 184 149 153 147
117 147 123 153 107 116 129 94 113 91 123
WLS-C52A 79
160 170 82 121 145 288 309 126 186 163 208 159 197 170 171 165 170 161 157 284
237 170 164 206 291 306 183 245 129 181 249 240 456 344 310 299 280 229 250 269
257 193 122 122 104 162 119 103 175 270 268 305 183 228 151 121 139 117 118 134
128 220 173 175 120 265 205 177 143 88 114 125 173 189 190 176 124 90 147
WLS-C52B 79
122 166 96 109 146 296 328 132 185 166 193 145 204 159 176 139 164 144 154 275
255 159 169 208 289 305 181 248 131 174 288 244 444 333 325 302 285 235 250 258
253 193 141 105 106 176 120 114 177 264 270 293 187 230 144 139 129 109 127 117
120 224 166 167 130 274 220 167 137 89 136 114 167 190 204 176 125 118 165
WLS-C53A 83
380 319 154 232 152 133 227 375 442 270 259 164 178 201 313 363 335 212 264 215
246 231 247 326 263 298 238 251 276 289 351 270 145 132 122 226 207 235 197 244
208 141 157 195 162 83 101 120 92 136 105 106 113 71 61 94 83 67 81 106
71 68 70 132 133 109 89 91 62 67 73 78 106 95 98 55 59 46 37 54
43 59 76
WLS-C53B 83
445 314 142 244 178 145 229 376 429 256 274 145 180 213 305 370 287 173 272 219
253 214 271 334 288 340 235 226 293 246 384 266 147 136 112 225 229 210 209 260
197 155 148 191 161 95 97 105 97 141 104 114 101 63 72 86 81 76 79 103
94 52 77 119 134 111 94 90 65 66 71 70 119 89 99 54 59 47 35 59
58 49 65
WLS-C54A 129
331 361 334 317 269 188 198 184 164 246 125 73 78 116 119 135 98 128 175 260
285 235 169 198 162 141 136 157 147 157 179 111 87 60 47 51 106 103 132 132
131 107 125 145 159 107 135 159 186 166 119 94 145 145 130 86 154 157 74 82
92 96 115 115 108 153 211 150 137 152 175 178 196 143 180 155 106 91 150 99
99 98 126 153 154 134 112 129 120 112 113 95 77 98 105 110 122 98 73 105
97 114 89 140 118 107 99 120 110 118 130 104 90 124 85 82 71 74 92 130
130 163 128 130 101 160 95 92 110
WLS-C54B 129
335 354 328 244 270 203 178 193 143 243 142 73 62 105 120 163 90 107 157 217
276 221 187 203 156 143 150 153 151 138 168 103 93 51 48 61 94 104 129 109
145 100 136 145 168 101 137 152 187 164 121 88 138 140 135 74 159 139 74 80

109 80 117 120 97 165 218 147 140 139 181 167 207 126 177 151 123 98 131 114
97 78 150 151 141 132 120 135 103 121 128 89 82 85 120 101 120 101 71 109
90 119 88 129 129 105 104 125 100 130 126 101 91 139 73 95 55 75 89 133
141 149 127 125 112 151 103 70 110
WLS-C55A 109
100 119 152 162 220 161 262 230 169 205 156 173 178 132 137 194 238 319 189 140
156 124 196 164 186 255 165 68 78 82 98 122 89 154 116 121 118 58 89 121
102 100 95 96 86 117 87 95 63 127 92 126 125 130 121 79 103 142 114 88
68 75 89 59 101 81 88 110 88 99 56 84 89 102 80 73 82 75 88 80
59 83 97 61 36 75 78 60 91 133 102 78 78 65 76 81 134 91 101 96
80 119 83 105 70 81 53 81 100
WLS-C55B 109
125 110 169 159 218 151 266 233 184 204 152 177 163 122 154 180 229 310 169 161
138 158 197 169 189 267 152 70 84 81 95 120 99 152 107 118 122 64 89 115
115 96 86 93 86 116 89 103 63 134 108 132 137 126 124 88 94 125 123 81
91 62 94 54 103 75 97 102 102 89 72 67 99 98 85 58 83 76 80 84
55 88 73 57 52 58 82 63 95 121 119 73 72 71 85 65 134 92 109 74
86 121 87 68 76 62 93 67 97
WLS-C56A 62
490 419 378 276 461 336 302 320 264 346 315 217 162 146 277 392 328 251 291 200
177 211 190 135 100 195 283 292 224 160 153 92 131 182 200 250 216 263 303 154
93 118 192 148 148 117 143 126 131 180 83 134 170 194 189 250 288 362 368 405
267 231
WLS-C56B 62
386 425 390 220 438 343 294 328 248 380 302 202 150 175 301 389 324 248 306 186
179 226 181 122 107 190 279 266 208 184 135 91 133 186 203 239 206 247 299 121
106 105 197 149 140 130 138 129 130 195 82 139 181 196 180 217 311 358 370 399
273 332
WLS-C57A 99
189 257 195 196 176 197 177 154 177 236 199 150 135 166 193 179 336 162 265 182
115 128 127 112 136 158 104 120 112 152 187 199 211 175 211 157 222 159 168 118
114 140 122 138 92 118 109 129 134 107 111 132 181 176 120 133 148 148 133 144
99 149 118 142 161 103 89 88 102 137 101 80 80 86 88 78 121 114 108 131
88 106 96 93 97 123 113 88 96 107 143 125 101 107 165 117 113 132 116
WLS-C57B 99
189 253 199 197 202 200 176 158 188 239 199 146 122 162 201 204 340 156 247 165
130 138 123 120 139 148 120 107 118 149 184 185 205 196 207 150 170 161 155 121
100 142 119 143 86 120 111 122 133 122 90 143 189 158 130 137 139 131 138 150
88 143 130 151 125 105 106 78 102 127 100 82 89 80 87 86 112 113 107 135
87 94 119 72 106 119 106 122 106 102 123 116 115 74 164 123 119 121 121
WLS-C58A 72
214 352 367 368 474 373 266 222 241 192 174 300 299 306 158 255 177 197 318 251
311 253 166 236 232 245 181 181 196 200 159 124 121 142 116 90 137 144 118 168
163 166 143 123 176 153 117 105 79 108 88 59 79 104 122 116 92 89 49 34
62 66 75 73 93 81 59 73 77 58 92 49
WLS-C58B 72
221 357 380 384 480 402 231 207 289 190 157 325 294 296 185 251 197 176 299 253
297 241 167 227 237 243 175 200 198 216 168 98 125 143 115 99 136 148 110 154
173 167 142 128 174 136 138 99 80 107 74 70 81 107 98 109 128 65 53 32
61 97 63 63 94 76 50 68 70 61 66 52
WLS-C59A 50
349 283 533 389 347 240 296 335 299 369 330 329 281 338 288 326 247 173 220 221
266 392 397 299 146 143 133 107 46 96 63 75 67 69 79 122 184 190 184 204
134 146 172 152 268 139 175 71 163 175
WLS-C59B 50

373 297 529 356 264 240 282 341 291 374 321 396 270 344 287 332 248 172 222 229
255 400 407 296 115 157 143 97 64 84 69 51 69 73 73 132 164 197 185 204
110 165 167 154 261 177 164 67 155 176