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Bromley Hall, Gillender Street, London Borough of Tower Hamlets

Tree-ring Analysis of Pine Timbers

Martin Bridge

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SUMMARY

Fifteen pine structural roof timbers were dated, producing a site chronology covering the period AD 1376–1686. The difficulties associated with the positive identification of sapwood in some samples made interpretation difficult, but the grouping of the outer ring dates of the majority of the samples strongly suggests that the trees used in the construction of the roof were most likely felled within a short period. The results indicate that this felling took place in the last decade of the seventeenth century or in the early eighteenth century, and that this was the most likely time of construction of the roof. Two pine floorboards from a first-floor room were also dated. Neither appeared to retain sapwood, but it is suggested that the floor was probably laid at about the same time as the re-roofing of this medieval structure. The timbers appear likely to have been imported from Scandinavia, the best matches being found with sites in southern Sweden and south-east Norway.

CONTRIBUTORS

Dr M C Bridge

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This study was commissioned by the English Heritage Scientific Dating team following earlier work by the author on the oak framing and floors, as well as from the results of the survey work undertaken by the late Andy Wittrick, who worked for English Heritage at the time. Access was facilitated by the on-site contractors, Noble and Taylor of Ongar. I would like to thank Cathy Tyers (formerly University of Sheffield, now English Heritage) who assisted with the fieldwork, lent a corer designed for working with conifers, aided the cross-dating process through the provision of access to a wider range of conifer chronologies, and made useful comments on earlier drafts of this report. The study was commissioned by Peter Marshall of English Heritage.

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INTRODUCTION

Bromley Hall is a Grade II* listed Tudor brick house with several later additions which now sits immediately adjacent to the east side of the dual carriageway which forms the main northern approach to the Blackwall Tunnel (Figs 1 and 2). Previous work at the site (Bridge 2002; 2003) had dated the primary phase oak timbers to the period AD 1482–95, earlier than had been previously thought. The building was on the Buildings at Risk register, but at the time of sampling, contractors were carrying out extensive repair and renovation work, which included stripping tiles from the roof, thus allowing easy access to the conifer timber used in its construction. The conifer timbered roof, thought to be late-seventeenth century (Wittrick pers comm), dates from a drastic remodelling of the house which had been a tower house. The tower was reduced in height to the level of the second floor, and a steeply pitched, hipped roof was built, enclosing the second floor within the roof space, which was then lit by the use of dormer windows. The central area of the roof is flat. During the current repairs a number of coniferous floorboards were also being removed from a room, designated 1F08 in the north-west corner of the first floor, providing an opportunity to study these as well.

METHODOLOGY

Fieldwork for the present study was carried out in April 2005. In the initial assessment, accessible conifer timbers with more than 50 rings and where possible, traces of sapwood were sought. Those timbers judged to be potentially useful were cored using a specialist auger, designed by Thomas Bartholin and made available by Cathy Tyers (then of the University of Sheffield), which was attached to an electric drill. In addition, thin sections were sawn from various timbers, such as sarking boards, that were being removed from the roof and floorboards being removed from room 1F08. The cores were glued to wooden laths, labelled, and stored for subsequent analysis.

The cores and sections were polished on a belt sander using 80 to 400 grit abrasive paper to allow the ring boundaries to be clearly distinguished. The samples had their tree-ring sequences measured to an accuracy of 0.01mm, using a specially constructed system utilising a binocular microscope with the sample mounted on a travelling stage with a linear transducer linked to a PC, which recorded the ring widths into a dataset. The software used in measuring and subsequent analysis was written by Ian Tyers (2004). Cross-matching was attempted by a combination of visual matching and a process of qualified statistical comparison by computer. The ring-width series were compared for statistical cross-matching, using a variant of the Belfast CROS program (Baillie and Pilcher 1973). Ring sequences were plotted on the computer monitor to allow visual comparisons to be made between sequences. This method provides a measure of quality control in identifying any potential errors in the measurements when the samples cross-match.

In comparing one sample or site master against other samples or chronologies, *t*-values over 3.5 are considered significant, although in reality with coniferous timbers it is common to find much higher values than this. In oak, where two individual samples match together with a *t*-value of 10 or above, and visually exhibit exceptionally similar ring patterns, they may have originated from the same parent tree. Same-tree matches can also be identified through the external characteristics of the timber itself, such as knots and shake patterns. Lower *t*-values however do not preclude same-tree derivation. In coniferous timbers the threshold value is higher, and *t*-values of 15 or above have been suggested as potentially suggesting same-tree samples (C Tyers pers comm).

Ascribing felling dates and date ranges

Once a tree-ring sequence has been firmly dated in time, a felling date, or date range, is ascribed where possible. With oak samples which have sapwood complete to the underside of, or including bark, this process is relatively straightforward. If the sapwood is partially missing, or if only a heartwood/sapwood transition boundary survives, then an estimated felling date range can be given for each sample. The number of sapwood rings can be estimated by using an empirically derived sapwood estimate with a given confidence limit. If no sapwood or heartwood/sapwood boundary survives then the minimum number of sapwood rings from the appropriate sapwood estimate is added to the last measured ring to give a *terminus post quem* (tpq) or felled-after date.

Guidance from Cathy Tyers resulting from the English Heritage conifer dendrochronology project has provided information gained from European colleagues indicating that the number of sapwood rings in conifers is highly variable between regions and periods and is strongly influenced by the age of the trees (eg Zetterberg and Hiekkanen 1990). For instance, for pine, the number of sapwood rings in northern Sweden tends to be over 100, but in the south (ie south of Stockholm) it is generally circa 50±30 (Eggertson pers comm). In southern Norway it ranges from as few as 20 to over 100 depending on tree age (Bartholin pers comm). For example a 100-year-old tree has in the order of 30–70 sapwood rings, whereas a 200-year-old tree has in the order of 45–110 sapwood rings. This, therefore, generally precludes the provision of a felling date range for pine timbers. However, as with oak, if bark-edge survives, then a felling date can be directly obtained from the date of the last surviving ring. In some instances it may be possible to determine the season of felling according to whether the ring immediately below the bark is complete or incomplete. However the onset of growth can vary within and between trees and this, combined with the natural variation in actual ring width, means that the determination of felling season must be treated cautiously.

It must be emphasised that dendrochronology can only date when a tree has been felled, not when the timber was used to construct the structure or object under study. In the case of imported timbers there is as yet not much information about the periods involved between felling the trees, and their use in construction in buildings in this country, but the indications are that this period was actually relatively short (eg Tyers *et al* forthcoming).

RESULTS

Details of the samples and their locations are given in Tables 1a and 1b, and those from the roof are illustrated in Figure 3. The samples were all pine and, bearing in mind the source identified, probably Scots pine (*Pinus sylvestris* L.). Two samples from the structural roof timbers (bhr04 and bhr29) were found to contain too few rings, and were discarded from further analysis, as were all the sections from the sarking boards (bhr18-bhr25).

The roof timbers were treated as a single group, and cross-matching between them proceeded in a stepwise manner, the best matching sequences being combined into working site master sequences, and further comparisons between these sequences and the remaining sequences allowing others to be added into to make further site sequences (Table 2). Whilst it is possible that some of the better matching sequences may have come from the same parent tree (eg samples bhr01 and bhr10), only one pair (bhr12 and bhr14) met the arbitrary *t*-value of 15. Fifteen of the twenty measured sequences were eventually combined into a 311-year site master series, BRMHLLR1 (Fig 4), which was subsequently dated to the period AD 1376–1686 by comparison with dated reference material, the best results being shown in Table 3.

The floorboard sequences were also initially treated as a separate group, with cross-matches being found between 1F08B *v* 1F08C ($t = 6.7$ with 42 years overlap) and 1F08E *v* 1F08F ($t = 10.1$ with 74 years overlap) (Figs 4 and 5). Both pairs of sequences were combined into new sequences (1F08BC and 1F08EF respectively) for further analysis. These and the remaining individual series were compared with the dated roof sequence (BRMHLLR1). Series IF08EF gave a $t = 6.0$ with 95 years overlap, a match that was confirmed when it was compared to the dated reference material, with the result that this series was dated to the period AD 1531–1625 (Table 3). This floorboard sequence was then added into the existing roof chronology to produce a new mean site sequence BRMHLLR2, which contains the combined sequence from bhr12 and bhr14 and all other dated individual sequences. Not unexpectedly, this did not have much influence on the overall dating of the sequence (Table 3).

INTERPRETATION AND DISCUSSION

Interpretation of the results with respect to when the timbers were felled is not straightforward because of the difficulty in recognising sapwood on some samples. This is a relatively common problem with pine assemblages found in this country, where apparently coeval groups of timbers most likely felled at the same time contain a mix of timbers, some with obvious sapwood present, whilst others show no obvious sapwood rings (C Tyers pers comm). However the distribution of end dates in Figure 4 strongly suggests that the timbers were probably felled around the same time, in spite of some of the samples not having readily recognisable sapwood even though it was thought at the time of sampling that some of these did have sapwood. The roof was thought to have

been built as a single phase, which further supports this finding. The variable level of matching between the individual samples from the roof suggests that they may have come from different sources, and the clustering of the final dates of many of the samples, along with the evidence of unmeasured sapwood rings, suggests felling in the late-seventeenth, or possibly early eighteenth, century. It would seem that the roof was most likely constructed during this same period therefore. Although only two floorboards dated, neither had sapwood, but it seems likely that they probably represent a similar phase, and may well have been laid in the same phase of work as the re-roofing of this building.

The best matches were found against other imported conifer series from within Britain and native sequences from Norway and Sweden, suggesting a Scandinavian source for the timbers utilised in the roof and floor of room IF08.

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FIGURES

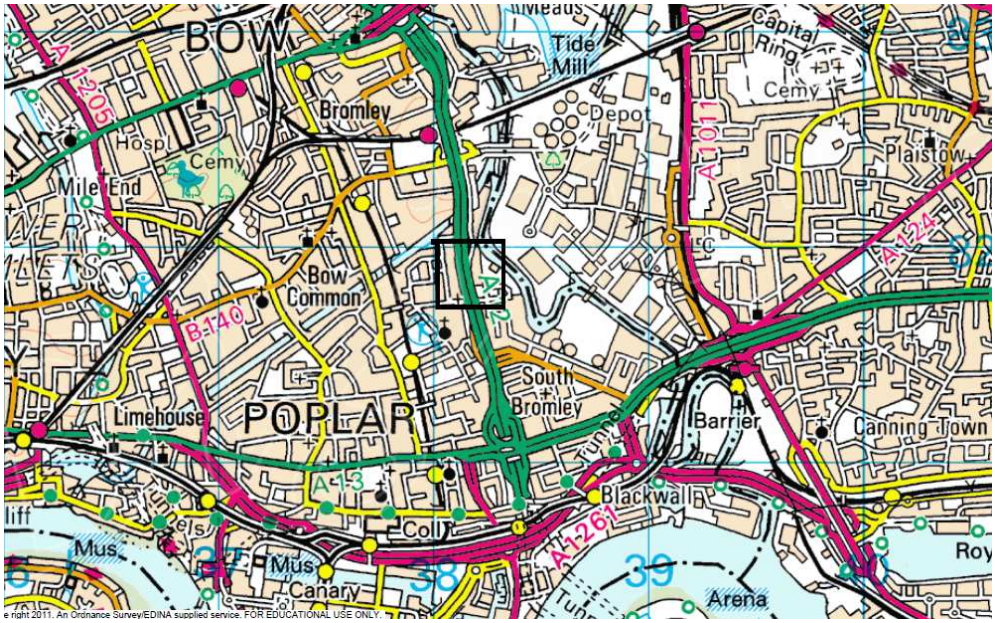

Figure 1: Map showing the site of Bromley Hall. © Crown Copyright and database right 2015. All rights reserved. Ordnance Survey Licence number 100024900

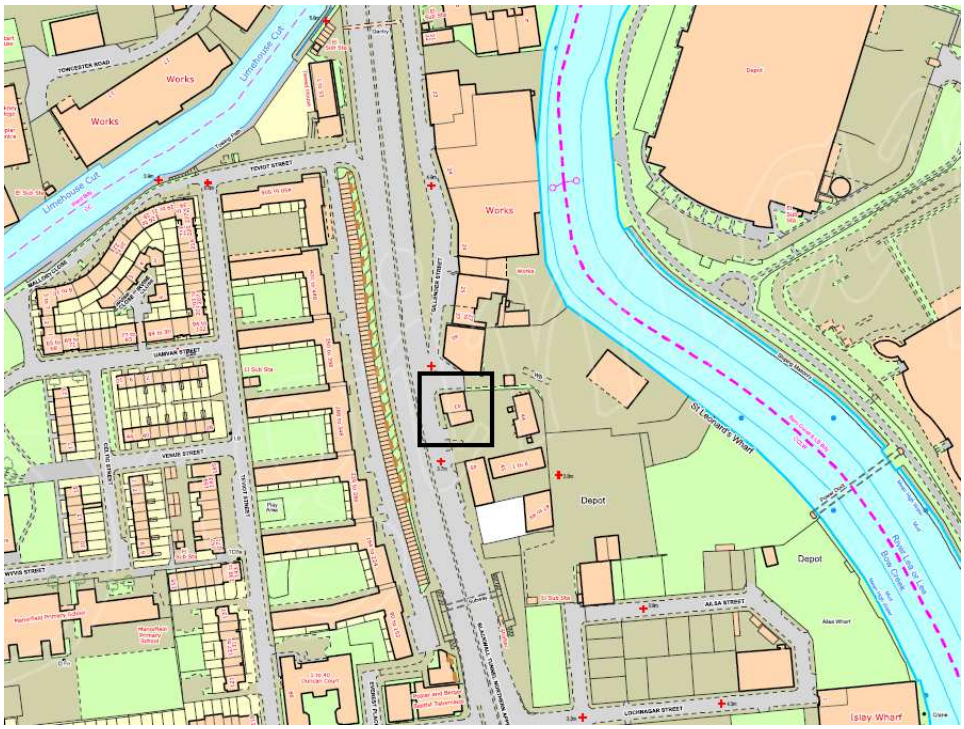

Figure 2: Detailed map of the immediate environs of Bromley Hall showing its position on the east side of the A12. © Crown Copyright and database right 2015. All rights reserved. Ordnance Survey Licence number 100024900

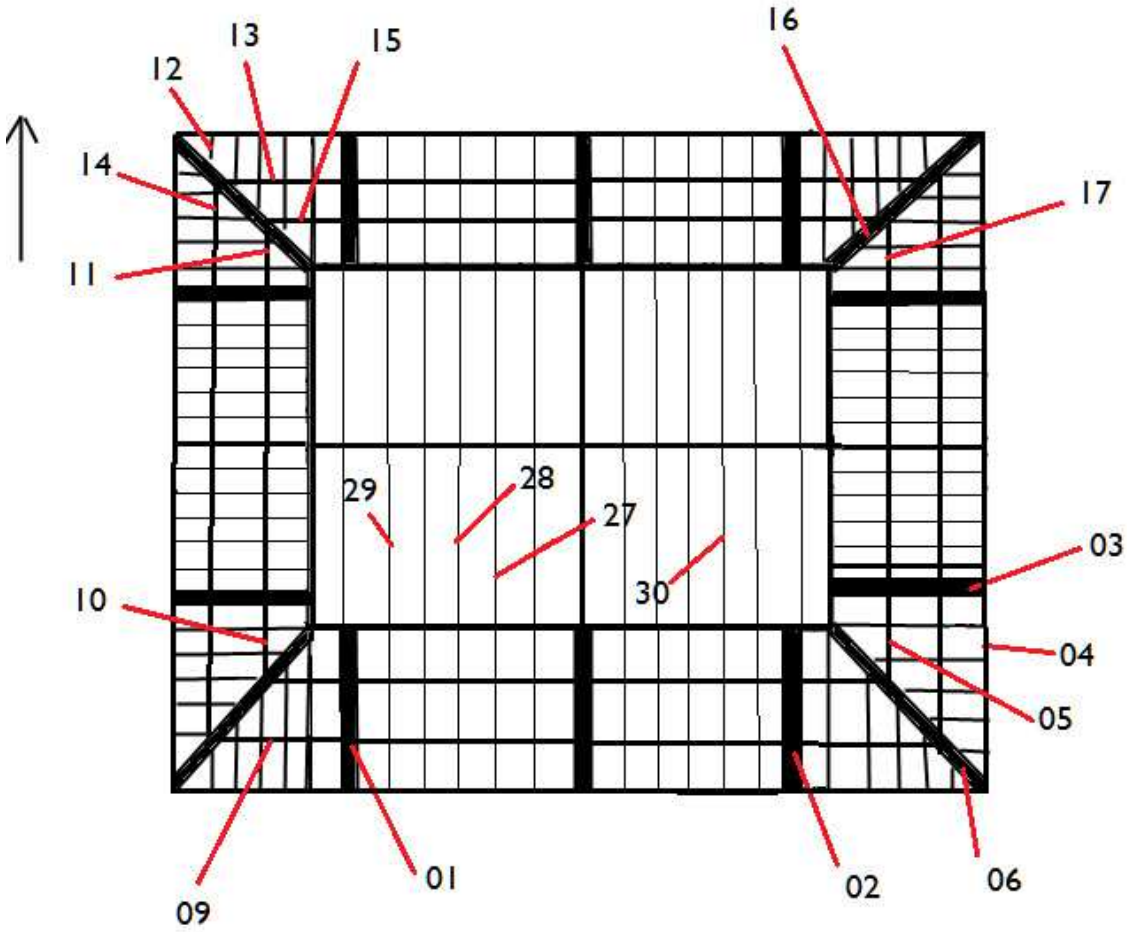

Figure 3. Sketch plan of the roof showing most of the timbers sampled for dendrochronological analysis

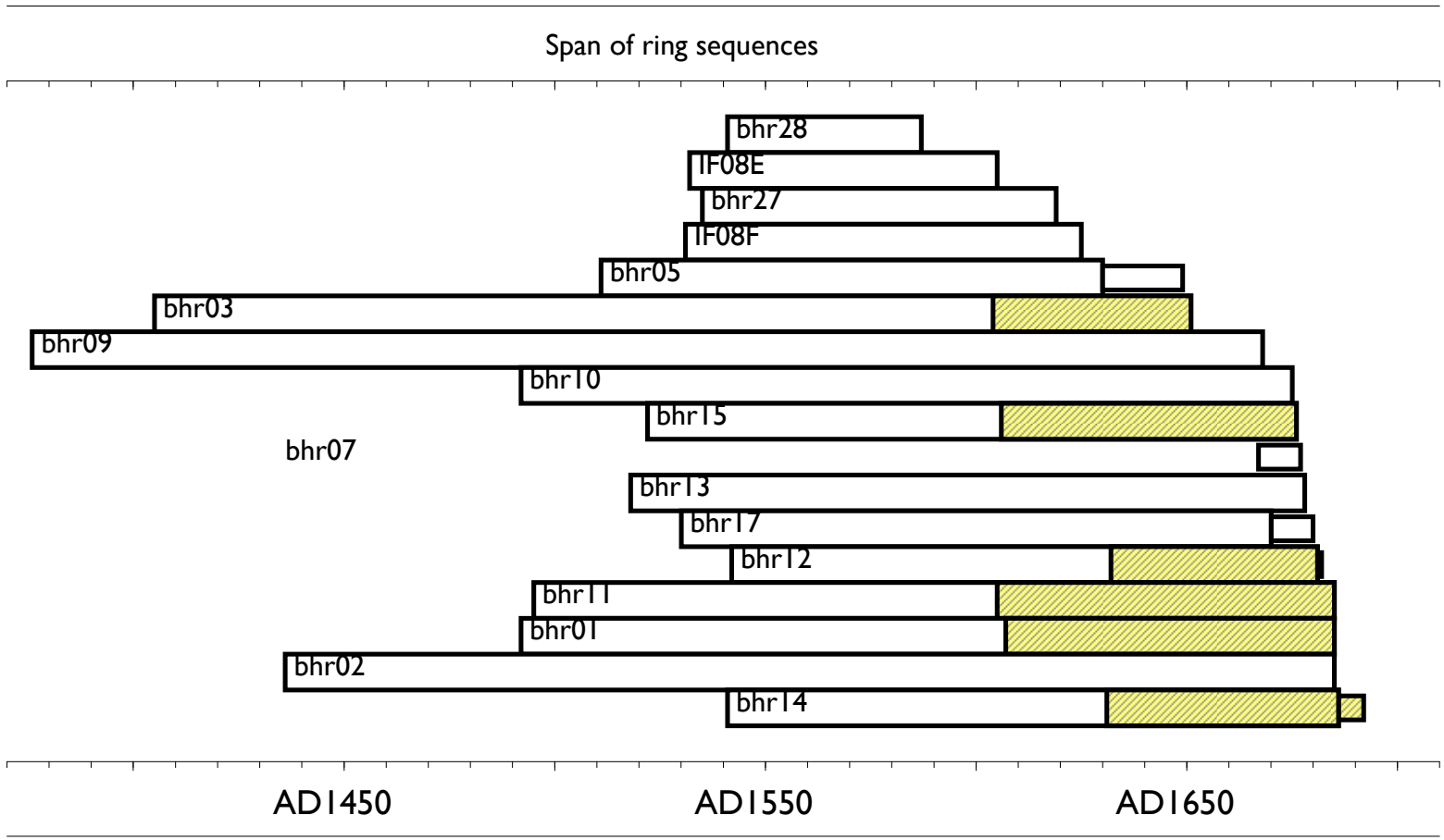

Figure 4: Bar diagram showing the relative positions of overlap of the dated pine sequences. White bars represent heartwood rings; yellow hatched portions of the bars represent sapwood rings; narrow sections represent additional unmeasured rings

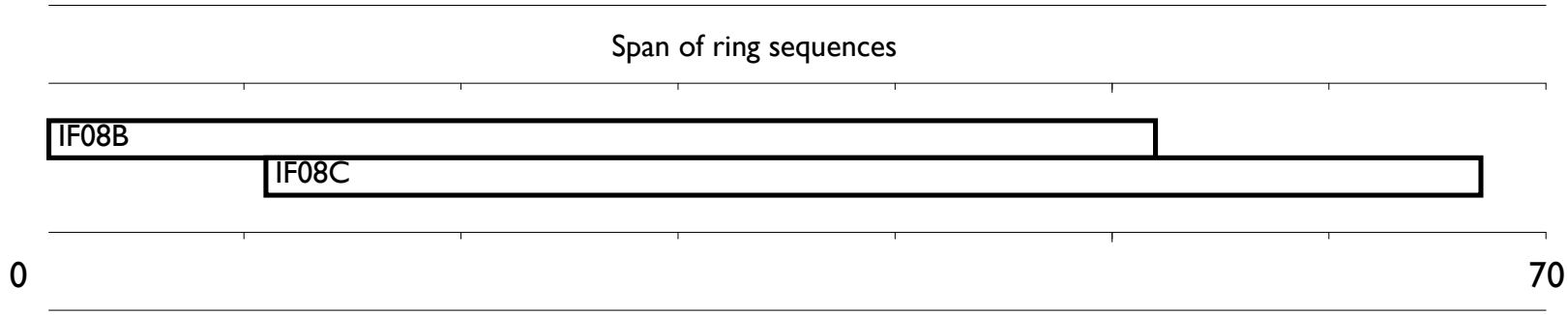

Figure 5: Bar diagram showing the relative positions of overlap of the matched but undated pair of samples. White bars represent heartwood rings.

TABLES

Table: 1a. Details of pine samples taken from the roof of Bromley Hall

Sample	Timber and position	No of rings	Date of sequence AD	Mean ring width (mm)	Mean sens (mm)	Sapwood
bhr01	Principal rafter, south side, 3rd from east	194	1492–1685	0.96	0.19	79
bhr02	Principal rafter, south side, east-most	250	1436–1685	0.64	0.18	-
bhr03	Principal rafter, east side, south-most	247	1405–1651	0.82	0.19	47?C
bhr04	Wallplate, east side	<45	-	NM	-	-
bhr05	Middle purlin, east side	120 +19NM	1511–1630	1.51	0.17	-
bhr06	Corner rafter, south-east	157	-	1.03	0.19	-
bhr07	Floor beam at middle purlin height	234 +10NM	1434–1667	0.78	0.17	-
bhr08	Tiebeam in south-east corner	156	-	1.33	0.17	-
bhr09	Lower purlin, south side, west end	293	1376–1668	0.58	0.19	-
bhr10	Middle purlin, west side, south end	184	1492–1675	1.01	0.19	-
bhr11	Middle purlin, west side, north end	191	1495–1685	1.01	0.18	80
bhr12	Rafter, north side	140	1542–1681	1.31	0.18	49 + 1NM
bhr13	Lower purlin, north side, west end	161	1518–1678	1.03	0.21	-
bhr14	Lower purlin, west side, north end	146	1541–1686	1.35	0.17	55 +6NM?C
bhr15	Middle purlin, north side, west end	155	1522–1676	1.03	0.21	70
bhr16	Corner rafter, north-east	140	-	1.13	0.16	46
bhr17	Middle purlin, east side, north end	141 +10NM	1530–1670	1.16	0.17	-
bhr18 - 25	Sarking boards	<45	-	NM	-	-
bhr26	Diagonal brace to upper purlin, north side	71	-	1.18	0.14	-
bhr27	Joist, south west quarter, 2nd from centre	85	1535–1619	0.82	0.16	-
bhr28	Joist, south west quarter, 3rd from centre	47	1541–87	0.86	0.17	-
bhr29	Joist, south west quarter, 5th from centre	<45	-	NM	-	-
bhr30	Joist, south east quarter, 4th from centre	198	-	0.59	0.22	76

Key: HW = heartwood; Mean sens = mean sensitivity; h/s = heartwood/sapwood boundary; NM = not measured; ?C = possible bark surface

Table: 1b. Details of pine samples taken from the floorboards from first floor room 1F08 of Bromley Hall

Sample	No of rings	Date of sequence AD	Mean ring width (mm)	Mean sens (mm)	Sapwood
1F08A	81	-	1.76	0.15	-
1F08B	52	-	0.68	0.18	-
1F08C	57	-	0.69	0.19	-
1F08D	58	-	1.02	0.19	-
1F08E	74	1532–1605	1.04	0.22	-
1F08F	95	1531–1625	0.94	0.13	-
1F08G	77	-	0.81	0.15	-
1F08H	53	-	0.79	0.14	-
1F08I	58	-	1.51	0.18	-

Table: 2: Cross-matching between dated sequences from Bromley Hall roof. Blue shaded cells indicate t-values of 3.5 or over which are statistically significant

	t-values													
Sample	bhr02	bhr03	bhr05	bhr07	bhr09	bhr10	bhr11	bhr12	bhr13	bhr14	bhr15	bhr17	bhr27	bhr28
bhr01	2.3	2.1	0.7	1.0	2.6	13.0	8.5	3.9	1.4	3.6	2.2	2.5	3.3	2.5
bhr02		10.4	1.1	4.9	3.9	2.7	2.1	2.8	1.6	4.7	1.4	3.8	8.5	6.5
bhr03			2.1	3.8	4.6	2.5	2.6	3.4	3.3	3.1	2.9	4.3	7.0	5.6
bhr05				2.4	0.9	1.0	0.0	2.8	11.4	1.8	6.3	4.1	0.9	1.1
bhr07					3.3	2.8	2.6	4.0	2.8	3.9	3.8	3.3	8.2	4.7
bhr09						2.9	1.7	3.0	1.9	3.6	2.2	3.3	2.7	2.4
bhr10							9.3	4.3	2.6	4.1	3.2	2.5	3.2	2.1
bhr11								3.1	1.1	3.3	1.5	4.0	2.7	1.3
bhr12									2.9	16.6	2.8	4.6	4.3	3.1
bhr13										3.4	9.1	6.4	1.9	2.4
bhr14											2.7	6.1	5.5	4.9
bhr15												5.1	3.5	3.5
bhr17													3.4	3.5
bhr27														10.2

Table 3: Dating evidence for site chronologies BRMHLLR1, and BRMHLLR2 (AD 1376–1686) and IF08EF (AD 1531–1625)

Chronology name:	Short publication reference:	File name:	Spanning: (yrs AD)	Overlap (yrs)	BRMHLLR1 *t*-value	BRMHLLR2 *t*-value	Overlap (yrs)	IF08EF *t*-value
99200010	(Thun pers comm 2004)	99200010	871–1986	311	11.2	11.0	95	4.1
Jermyn Street, Westminster	(Groves and Locatelli 2005)	JEMGRP3	1367–1710	311	8.8	8.8	95	5.4
Helsingland, Sweden	(Bartholin pers comm 1994)	SWED_HLI	1001–1861	311	8.1	8.1	95	3.6
Dalarna, Sweden	(Bartholin pers comm 1994)	SWED_DAL	1001–1852	311	7.9	8.0	95	4.9
The Granary, Berwick upon Tweed	(Arnold *et al* forthcoming)	bwkd-t7	1486–1762	201	7.6	7.6	95	5.2
Ranger's House, Greenwich Park	(Tyers forthcoming)	RANGR-PI	1246–1632	247	7.4	7.5	95	3.0
2 Love Lane, Berwick upon Tweed	(Arnold *et al* forthcoming)	bwkbsq01	1525–1756	163	6.8	7.0	95	7.0
St George's Church, Bloomsbury	(Miles *et al* 2007)	gbl01	1504–1719	183	6.0	6.2	95	-
Middridge Grange, Co Durham	(Arnold *et al* 2006)	MRGASQ05	1528–1681	159	5.7	5.7	95	-
Danson House, Bexley	(Groves 2002)	DANSON1	1220–1489	123	5.0	5.0	-	-
Jaemtland, Sweden	(Bartholin pers comm 1994)	SWED_JM2	1305–1827	311	6.0	5.8	95	-
Uppland, Sweden	(Bartholin pers comm 1994)	SWED_UP	1031–1638	253	5.7	5.6	95	-

- = no significant overlap

APPENDIX

Ring width values (0.01mm) for the sequences measured

bhr01

208	221	222	175	136	133	148	191	144	173
244	184	155	119	196	207	207	241	181	234
181	216	226	195	212	203	253	221	218	160
152	161	111	166	204	194	146	151	145	217
129	119	121	167	111	126	117	76	84	97
88	71	78	74	105	114	124	132	90	62
92	82	80	77	88	34	45	51	67	60
100	98	139	133	136	133	126	91	103	132
91	70	65	69	89	78	84	95	87	112
80	103	151	133	64	96	89	66	82	54
69	59	73	101	78	74	98	90	89	63
104	79	90	73	52	67	89	85	70	84
57	76	61	60	43	51	47	57	58	52
37	46	23	27	38	33	51	43	39	32
42	29	36	57	54	52	39	50	61	62
58	59	57	55	59	85	61	84	98	85
78	63	70	47	38	34	39	38	51	53
70	69	82	62	50	46	53	48	47	33
32	31	30	40	45	52	56	68	52	58
65	50	39	36						

bhr02

63	64	78	63	58	44	55	63	65	72
91	82	55	80	109	108	54	64	56	44
57	47	54	51	57	43	34	48	50	57
60	66	63	71	64	64	87	87	83	87
92	53	61	86	94	70	49	57	58	59
84	53	43	43	46	58	54	40	49	59
60	72	72	60	95	103	77	110	82	136
112	135	135	151	146	118	107	108	81	99
119	143	148	117	111	103	90	87	99	108
131	113	119	104	99	106	106	114	125	129
117	118	105	113	112	118	98	72	60	56
58	86	126	91	53	54	76	39	48	61
40	46	60	91	87	82	103	101	83	78
67	74	89	103	88	67	57	44	48	64
71	52	70	57	45	78	68	50	78	103
66	52	57	52	55	57	54	69	86	84
69	66	62	55	64	50	38	47	57	42
59	66	69	55	59	62	44	48	45	39
57	59	69	56	45	52	44	58	57	44
45	42	51	65	55	39	41	37	27	48
27	32	22	29	45	32	31	36	28	24
30	23	33	31	36	45	31	20	27	22
22	21	14	19	23	28	24	28	23	18
21	21	22	27	25	30	35	36	27	34
39	24	40	39	35	33	29	35	31	25

bhr03

73	66	48	52	65	53	77	54	81	67
46	52	62	63	77	76	102	84	70	92
60	88	140	135	142	122	115	76	83	80
63	76	72	60	51	62	50	74	69	76
79	90	93	64	67	66	88	51	62	69
50	60	57	70	73	74	75	72	88	65
51	56	66	60	110	115	94	112	86	91
107	125	75	80	126	162	125	108	108	106
116	105	95	105	111	119	135	128	116	87
117	88	106	107	91	121	150	121	115	82
122	112	141	103	151	223	230	209	203	196
202	126	161	168	138	125	139	164	125	156
224	144	150	125	114	143	125	101	125	173
158	139	153	134	122	118	121	101	75	51
55	56	57	101	79	52	36	54	30	38
49	38	37	69	80	72	79	98	120	103
85	77	91	95	79	78	83	58	40	52
65	55	50	75	74	62	78	57	46	44
68	57	48	53	43	44	50	39	68	105
86	86	71	91	77	61	60	55	67	79
51	46	55	44	34	41	49	55	52	39
34	47	38	45	34	44	44	34	47	45
33	40	41	41	45	44	34	34	49	46
55	36	39	38	29	37	28	30	32	33
22	27	31	31	23	35	35			

bhr05

516	449	470	398	442	365	321	282	284	245
272	235	241	262	371	309	245	300	269	253
162	233	273	286	244	296	315	282	292	243
178	175	173	131	210	170	213	167	99	118
131	143	129	101	118	139	130	112	104	139
129	107	85	136	142	137	177	137	93	153
152	120	107	99	79	68	75	116	109	82
138	108	107	125	150	87	66	58	64	68
55	46	38	55	61	70	86	115	96	78
78	89	91	71	63	62	57	62	67	78
106	115	94	71	77	71	71	48	65	66
57	63	88	72	51	53	49	48	47	40

bhr06

246	295	284	185	192	246	284	248	245	289
241	238	236	264	265	255	273	222	210	234
269	180	129	112	109	129	145	186	181	148
137	181	194	126	147	114	115	113	103	92
115	113	78	107	98	118	112	106	143	109
117	135	153	111	141	151	135	139	121	154
123	133	119	124	126	131	169	123	109	102
76	75	65	76	60	103	70	18	72	86
72	83	77	80	54	67	57	49	50	59
69	63	88	65	41	52	58	66	70	58
59	51	61	66	81	61	74	77	70	62
76	85	63	60	43	44	79	71	68	75
49	64	77	54	70	51	52	47	56	40
49	47	29	39	42	42	53	39	25	31
21	30	35	29	34	32	25	27	30	21
17	21	20	11	14	11	25			

bhr07

320	250	214	224	223	242	234	216	206	242
205	227	215	250	221	210	234	228	119	127
134	112	125	105	121	155	151	164	138	134
79	122	120	142	107	85	70	70	103	81
103	94	92	76	96	115	82	77	71	96
70	51	58	56	60	69	83	114	88	57
43	74	88	89	87	99	79	99	89	84
94	109	75	104	83	76	86	79	80	79
58	82	77	77	41	21	46	53	53	46
49	60	61	49	58	55	52	54	46	61
60	56	37	50	63	63	60	59	53	51
47	31	39	49	48	40	45	50	57	52
42	52	36	40	52	62	59	54	60	42
60	47	51	67	63	60	53	60	45	53
45	64	69	59	82	63	57	67	54	56
71	81	54	58	68	42	58	56	54	48
43	46	53	60	61	60	62	59	76	79
62	44	52	67	63	45	48	54	52	52
57	38	53	53	52	53	56	57	48	53
60	50	39	37	44	46	60	43	64	46
66	51	44	58	57	71	54	49	41	53
48	55	61	57	43	40	41	44	53	74
54	60	57	45	46	33	38	43	39	46
47	33	32	32						

bhr08

413	273	237	184	275	251	208	264	300	248
247	270	248	292	318	290	296	324	304	317
357	368	320	145	137	143	96	129	274	291
281	297	323	282	229	160	120	146	137	145
171	171	131	98	132	196	228	153	129	107
109	110	90	78	94	107	83	78	71	68
46	52	66	91	108	96	96	58	70	66
63	63	84	94	99	84	84	107	137	125
157	127	125	140	131	113	116	134	114	108
109	127	123	104	105	114	13	106	92	94
96	88	89	93	100	77	69	92	72	80
72	75	66	89	101	102	74	92	71	73
81	72	90	78	68	67	69	72	83	65
83	77	95	87	106	96	97	82	83	86
94	64	61	76	76	62	67	55	86	83
67	58	69	74	66	65				

bhr09

471	333	385	417	382	305	278	245	219	157
187	200	171	139	176	133	114	89	98	134
159	128	139	149	124	105	79	102	94	108
106	91	76	73	89	72	73	88	67	47
47	43	49	63	37	60	55	49	53	30
46	73	93	82	84	72	90	92	83	95
86	63	50	45	51	38	39	34	32	37
48	53	49	60	66	80	71	66	76	60
58	45	53	56	50	48	44	42	41	51
52	52	49	65	70	74	66	66	84	70
73	66	64	45	45	34	29	54	34	39
51	36	35	30	43	50	48	41	37	52
48	48	47	46	38	33	35	42	44	47
42	33	33	31	43	46	37	39	34	20
28	29	32	34	42	10	27	22	31	30
34	29	35	23	38	42	38	48	54	33
27	31	36	34	38	42	31	18	23	24
26	17	32	31	29	28	37	25	22	27
23	20	28	25	26	18	9	13	19	22
19	25	25	21	26	22	42	36	28	59
47	27	38	39	32	39	26	34	58	85
68	80	61	62	69	46	43	42	53	58
56	50	54	68	82	59	77	63	50	54
51	44	47	51	59	72	50	54	43	35
37	51	32	34	52	49	43	37	46	33
20	14	26	42	44	31	26	26	31	30
19	21	19	27	29	20	18	25	22	15
14	21	15	15	21	17	19	17	15	16
18	18	19	17	27	27	23	17	24	22
20	24	21							

bhr10

115	203	255	217	275	239	245	243	211	235
246	206	190	131	239	253	266	254	238	247
211	230	221	184	208	240	269	220	223	186
187	177	149	194	250	194	128	136	129	165
126	100	137	147	104	106	123	104	120	146
125	84	99	61	74	86	111	115	68	70
79	98	75	69	64	33	34	39	52	56
81	77	100	88	95	121	75	67	64	74
65	51	52	67	86	73	86	95	80	91
66	85	94	102	59	67	67	54	80	59
83	75	92	95	67	59	78	84	69	56
78	69	63	49	53	64	62	66	67	96
67	67	78	76	60	62	48	63	64	57
51	53	30	30	30	45	49	39	57	38
46	35	51	65	35	47	30	49	56	57
59	58	67	73	106	112	94	113	98	91
60	77	70	61	48	40	50	45	62	69
62	68	77	70	60	50	46	36	45	24
33	34	28	28						

bhr11

193	235	206	202	189	174	193	224	208	188
122	242	265	244	255	246	294	248	234	252
183	240	248	255	173	183	197	170	217	163
214	210	237	162	170	149	182	123	116	168
185	103	119	150	147	150	193	162	121	94
87	60	120	137	143	126	94	119	131	121
112	100	46	55	57	77	70	88	96	162
124	144	48	111	115	114	123	90	64	70
73	82	85	70	79	76	68	69	94	130
124	75	75	84	63	92	76	79	87	97
82	65	61	74	66	75	64	106	96	74
58	48	53	61	67	60	75	58	64	61
54	51	69	55	56	71	46	50	63	35
29	50	62	55	59	54	43	47	48	70
76	56	62	40	55	56	53	50	51	46
54	64	66	63	57	58	47	51	52	37
32	41	34	40	33	49	49	46	48	74
64	68	54	48	38	53	45	42	48	40
36	62	53	50	61	53	51	57	62	60
54									

bhr12

291	283	309	288	286	282	188	208	211	256
270	274	198	199	138	89	118	180	164	161
192	148	182	157	160	168	163	169	209	199
136	120	147	188	182	168	143	155	134	188
159	136	165	200	169	180	138	126	132	115
126	138	179	167	207	244	216	169	145	92
110	129	154	165	146	123	142	137	152	192
173	151	114	91	155	174	133	143	170	140
91	126	86	88	80	72	66	67	68	65
48	41	64	61	54	68	65	74	86	60
44	56	54	58	63	69	48	58	69	45
44	50	71	89	71	47	55	56	75	86
99	103	128	120	120	76	79	110	120	66
70	113	86	72	100	79	90	130	80	129

bhr13

242	289	247	285	260	221	273	404	306	246
266	310	304	164	241	310	287	258	286	271
246	273	258	234	178	162	127	183	178	209
213	120	125	166	172	146	121	156	138	125
125	118	144	152	126	143	196	146	161	187
121	76	96	119	128	95	113	74	55	87
120	71	88	113	73	80	92	118	79	51
64	85	81	37	43	35	42	60	50	63
99	113	92	68	95	89	69	74	61	60
63	62	55	82	76	82	62	61	58	54
36	45	54	45	57	64	84	49	49	56
53	62	44	27	37	45	63	54	44	47
46	54	54	53	66	45	52	41	45	43
42	40	49	40	37	32	33	50	39	23
24	20	21	12	12	18	24	15	15	16
16	15	22	12	10	16	9	14	15	21
21									

bhr14

274	297	256	270	282	269	295	222	202	194
236	252	261	225	233	145	130	142	199	185
160	217	181	207	179	189	235	209	218	217
178	143	125	139	174	177	160	153	163	151
177	147	145	190	230	181	196	147	171	142
121	136	160	192	166	237	220	181	153	158
90	130	153	164	163	131	137	149	134	161
208	162	172	132	87	133	186	154	163	211
174	105	148	109	105	101	84	78	86	68
76	52	48	70	79	73	91	67	102	116
96	74	75	82	86	80	78	72	74	82
58	44	60	71	95	76	58	47	50	77
68	59	67	64	60	58	56	57	68	84
53	63	85	63	66	90	71	83	112	85
97	68	70	76	61	85				

bhr15

165	345	392	485	424	300	302	323	339	229
280	354	327	318	285	315	279	300	245	272
216	258	206	224	209	231	224	136	134	193
183	137	149	165	118	121	116	131	146	153
153	188	230	161	128	111	78	53	98	136
123	55	37	26	20	35	56	63	66	92
79	73	84	119	67	75	83	67	63	34
32	23	36	43	43	56	81	79	85	57
108	84	59	56	46	64	54	70	66	68
53	56	67	43	63	69	59	64	69	64
52	59	52	41	20	18	19	12	14	11
13	16	17	19	20	22	27	35	42	57
63	45	53	54	74	62	57	44	47	36
37	38	36	34	33	25	18	27	14	17
24	22	30	27	26	29	18	16	28	11
12	16	15	17	25					

bhr16

193	193	200	225	197	173	126	100	145	171
155	139	157	164	175	156	177	180	191	203
176	183	178	216	128	96	65	69	75	95
153	162	150	152	187	192	156	189	126	120
101	99	107	165	145	102	148	141	166	155
124	137	136	140	163	168	140	154	149	140
125	143	195	176	134	141	136	141	127	155
130	123	110	87	115	90	107	86	122	101
85	98	86	80	91	75	74	99	104	101
72	74	76	78	93	103	81	57	63	67
58	102	52	59	52	68	74	79	62	74
87	86	81	71	69	54	61	49	58	71
58	48	51	70	45	42	41	47	47	64
73	54	99	64	54	57	74	76	92	65

bhr17

196	260	334	370	364	294	260	247	268	238
219	196	227	197	188	229	184	214	198	129
155	200	198	163	173	199	158	117	109	165
181	153	177	243	215	147	132	141	178	128
168	206	178	119	131	119	97	133	121	144
157	171	149	129	151	177	148	143	100	91
93	60	52	51	68	89	122	117	164	140
156	94	103	131	99	103	103	101	105	95
109	101	98	135	87	64	67	69	53	47
63	54	67	99	92	74	91	83	75	78
56	40	44	48	55	59	46	56	48	61
67	50	63	71	58	63	71	68	58	49
51	50	41	51	44	39	34	24	17	16
23	20	16	20	27	27	26	31	23	21
22									

bhr26

163	216	196	167	197	222	227	203	216	253
228	243	237	187	164	109	99	125	117	130
146	123	116	128	106	118	128	91	110	89
65	66	72	77	86	79	98	114	114	92
92	76	68	77	103	103	111	127	148	170
150	104	80	79	65	68	86	85	67	56
72	74	76	91	62	60	59	62	49	54
73									

bhr27

134	137	134	124	131	112	117	95	75	78
70	96	118	135	109	91	94	94	52	56
77	41	51	101	128	114	108	115	102	101
82	89	113	109	129	94	102	72	64	77
72	85	71	72	71	62	93	67	66	81
101	68	70	83	58	79	85	73	76	104
90	88	77	76	74	68	49	74	68	69
47	49	59	60	54	54	62	47	53	50
33	45	51	52	52					

bhr28

115	101	65	65	53	62	63	100	89	91
102	103	75	72	96	54	64	97	138	125
97	119	110	102	92	82	96	102	99	101
99	81	72	77	59	65	62	78	76	70
90	66	72	98	123	74	61			

bhr30

228	236	221	198	141	145	144	179	203	139
182	185	141	131	121	115	141	127	153	136
115	125	113	127	127	161	170	124	151	134
167	122	114	97	101	82	79	91	86	83
61	81	65	69	63	52	19	14	16	24
35	33	31	23	20	25	36	52	59	77
84	90	76	84	79	64	72	77	52	64
67	61	67	63	55	55	68	68	44	48
43	59	42	54	45	36	25	35	46	53
55	51	101	39	39	48	60	83	74	71
42	53	52	32	28	16	32	33	48	27
35	36	31	43	55	48	44	34	43	33
43	48	33	21	26	35	37	37	28	31
39	28	23	24	34	33	39	50	34	23
25	27	31	29	35	35	27	41	28	21
28	23	25	30	25	20	22	30	25	29
20	24	43	43	17	21	26	39	52	23
26	21	19	10	12	13	12	11	9	16
24	21	14	13	6	12	11	13	16	12
19	20	12	9	20	22	24	25		

1F08A

337	287	255	283	301	267	267	243	246	235
240	250	257	242	269	271	293	267	275	261
236	212	293	244	196	210	241	227	149	216
222	183	181	175	187	162	227	213	225	200
189	158	118	148	134	112	168	201	173	143
198	262	171	179	128	151	117	98	84	84
103	80	74	56	58	63	89	87	80	62
91	78	82	59	88	106	86	93	75	86
72									

1F08B

71	78	65	57	53	51	49	43	59	40
77	58	51	44	33	74	69	36	38	38
43	52	60	81	74	68	68	84	109	88
86	68	69	70	63	79	94	97	112	96
85	82	110	101	108	129	73	55	39	34
31	42								

1F08C

70	54	44	34	31	50	54	38	34	37
45	65	65	110	94	86	86	113	112	110
53	42	44	51	52	70	83	110	106	101
78	67	104	95	107	109	87	63	46	28
43	38	74	70	82	72	65	68	50	52
73	65	71	67	74	86	71			

1F08D

19	21	17	27	31	31	41	45	52	45
65	55	107	69	59	99	87	82	65	65
60	54	69	59	52	34	41	56	64	84
65	108	125	162	163	145	183	232	203	228
281	229	228	161	195	151	174	125	137	136
105	121	107	111	93	108	96	78		

1F08E

261	267	294	250	122	161	145	202	188	203
231	164	110	135	161	170	125	119	95	132
144	151	167	177	156	121	128	134	119	134
109	104	112	89	75	93	63	73	65	69
66	59	57	65	80	68	60	52	55	70
45	28	46	61	45	41	33	30	54	22
17	12	21	28	20	18	28	43	73	100
134	109	93	116						

1F08F

203	215	214	218	178	143	159	150	172	175
168	190	145	116	132	137	140	150	129	131
164	144	115	116	135	118	92	96	94	96
116	104	105	121	97	103	133	96	90	94
103	82	91	73	94	90	78	65	58	56
68	45	41	66	80	66	65	47	70	61
45	35	36	45	45	34	30	34	41	59
58	76	74	75	78	84	88	81	83	84
81	72	65	59	61	70	73	56	50	56
52	47	50	38	44					

1F08G

86	68	45	37	36	34	28	26	28	27
30	41	62	66	56	65	57	71	75	65
80	67	52	48	35	37	42	29	65	88
105	90	116	95	110	78	75	90	102	95
90	75	68	65	87	105	90	115	111	101
106	133	147	148	130	108	114	120	114	89
92	92	102	105	81	96	77	74	73	82
113	95	109	105	99	113	113			

1F08H

111	126	85	143	146	134	121	115	110	112
95	80	86	95	96	94	98	101	106	85
82	73	74	81	99	84	84	38	36	61
45	56	57	64	46	49	46	45	50	48
65	49	59	64	69	58	76	80	70	65
68	68	46							

1F08I

235	233	196	200	237	288	318	282	239	186
177	141	132	181	211	210	208	158	112	155
134	121	139	142	128	157	174	173	185	155
95	110	67	76	94	102	111	133	130	99
119	85	82	123	139	132	124	187	164	110
157	98	81	100	92	139	117	101		

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