RESEARCH DEPARTMENT REPORT SERIES no. 88-2010 ISSN 1749-8775

BROCTON WW1 ARMY CAMP, CANNOCK CHASE, STAFFORDSHIRE
AN INVESTIGATION OF THE WINDOW GLASS

TECHNOLOGY REPORT

Roger Wilkes

ARCHAEOLOGICAL SCIENCE

ENGLISH HERITAGE

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Research Department Report Series 88-2010

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NGR: SJ 9755 1865

ISSN 1749-8775

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SUMMARY
The scientific examination and chemical analysis of glass from Brocton Camp WW1 army base located at Cannock Case in Staffordshire was carried out to compliment other research into historic window glass.
The results show all the glass is soda lime silicate that is considered to be manufactured from fairly pure raw material composition. The majority of the glass was indeed window or plate glass comparable to that of late19th-century manufacture. Three samples were comparable to early 20th-century bottle glass from Hightown Castleford Yorkshire.

ACKNOWLEDGEMENTS
Stephen Deen of Staffordshire County Council for supplying the glass
Ray Smith for the front cover postcard image Fort Cumberland, Fort Cumberland Road

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DATE OF RESEARCH
2010

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INTRODUCTION

Brocton Army Camp is located south of Brocton within Cannock Chase in the county of Staffordshire. It had a relatively short life between 1914 and 1919 and was built as a transit camp, where 250,000 British and Commonwealth troops passed through on their way to the trenches of Europe. By 1950 virtually all traces of the camp had been removed.

Fifty fragments of apparently window glass were recovered by the Development Services Directorate of Staffordshire County Councils from the Great War Rubbish dump at the camp in 2010. The analysis of this glass will contribute to a larger project investigating the chemical composition of window glass produced and used in Britain during the past five centuries and specifically to fill a missing gap in dating in the early 20th-century. Samples of window glass have been selected from archaeological excavations and from historic buildings. These have been analysed to determine their composition. A comparison of the chemical composition with the available dating evidence shows that a series of changes in window glass manufacturing took place during this period. The aim of this research is to provide a technique to date the manufacture of individual panes of glass in historic buildings. This knowledge will allow architects and others to make more informed judgements about which glass to retain and which can be replaced (Clark 2001). Specifically with the Brocton Camp glass it is hoped to fill the gap with existing data, eg Welch Rd c1895 (Dungworth 2010a) typically showing minor amounts of magnesium, lesser amounts of sodium and more lime, in comparison to post 1930s sites, eg Fort Cumberland c1940 (Dungworth 2010b) which notably contain magnesium of between 2 to 4%, introduced in the 1930s to aid the drawing method of manufacture (Cable 2004).

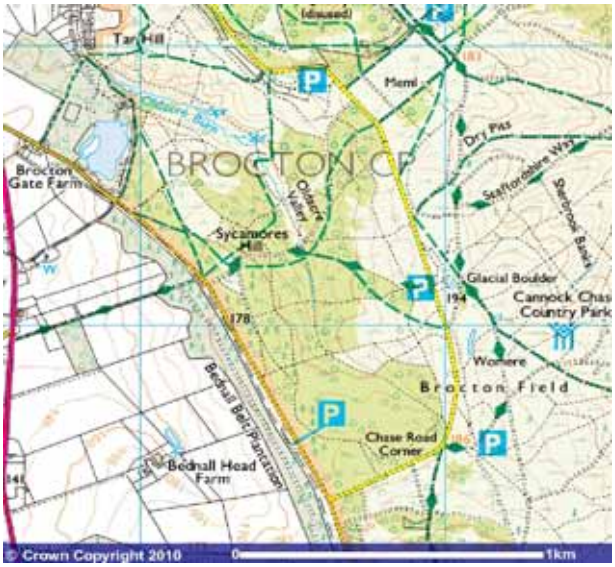

Figure 1. Shows location of Brocton Army Camp site south of Brocton within Cannock Chase Staffordshire. © Crown Copyright. All rights reserved. English Heritage 100019088. 2010

METHODS

All fifty of the fragments of glass were visually inspected, then mounted in epoxy resin and ground then polished to a three-micron finish to expose a cross-section through the glass. The samples were inspected using an optical microscope (bright field and dark field illumination) to identify any corrosion. Three of the Brocton Camp samples exhibited subtle surface corrosion on one face, however, this area was not analysed. The samples were analysed by SEM-EDS and EDXRF to determine chemical composition. The energy dispersive X-ray spectrometer (EDS) attached to a scanning electron microscope (SEM) provided accurate analyses of the required elements while the energy dispersive X-ray fluorescence spectrometer (EDXRF) allowed an improved detection limit, due to enhanced peak to background noise for minor elements such as manganese, iron, arsenic, strontium and zirconium.

Table 2. Minimum Detection limits (MDL) and analytical errors for each oxide

	EDXRF			SEM-EDS	
	MDL	ERROR		MDL	ERROR
V_2O_5	0.02	0.03	Na_2O	0.1	0.1
Cr_2O_3	0.02	0.03	MgO	0.1	0.1
MnO	0.02	0.03	Al_2O_3	0.1	0.1
Fe_2O_3	0.02	0.03	SiO_2	0.1	0.2
CoO	0.02	0.02	P_2O_5	0.1	0.1
NiO	0.02	0.03	SO_3	0.1	0.1
CuO	0.02	0.01	Cl	0.1	0.1
ZnO	0.02	0.01	K_2O	0.1	0.1
As_2O_3	0.03	0.01	CaO	0.1	0.1
SnO_2	0.10	0.05	TiO_2	0.1	0.1
Sb_2O_5	0.15	0.07	BaO	0.2	0.1
Rb_2O	0.005	0.005			
SrO	0.005	0.005			
ZrO_2	0.005	0.005			
PbO	0.03	0.02			

The SEM used was a FEI Inspect F operated at 25kV with a beam current of approximately 1.2nA (spot size 5). The X-ray spectra generated by the electron beam were detected using an Oxford Instruments X-act SDD detector. The quantification of detected elements was achieved using Oxford Instruments INCA software. The EDS spectra were calibrated using a cobalt standard. De-convolution of the X-ray spectra and quantification of elements were improved by profile optimisation and element standardisation using pure elements and compounds (MAC standards). The chemical composition of the samples is presented in this report as stoichiometric oxides with oxide weight percent concentrations based on likely valence states (except chlorine which is expressed as element Wt %). The accuracy of the quantification of all oxides was checked by analysing a range of reference materials, ie Corning, DGG, MPI, NIST and

Newton/Pilkington. A number of elements — vanadium, chromium, cobalt, nickel, copper, zinc, antimony, tin, rubidium and barium — were sought but not detected.

THE GLASS

Visual Inspection

The majority of the samples of glass are very pale green and flat or very flat window glass. Two of these samples are slightly melted or burned (BC 03 and BC 46). One also has a yellow surface corrosion (BC46). Three samples were bottle glass, one pale green (BC 01), one a darker green (BC 48) and one clear (BC 12). The two 7mm thick samples of glass (BC 49 and BC50), considered to be plate glass are clear.

Figure 2. All 50 samples of glass

See Appendix 1 for a full description of each piece of Brocton Camp Glass.

Compositional Analysis

All fifty samples of glass from Brocton Camp are soda lime glass. The samples have been divided into several compositional groups: Group 1 (sheet glass), Group 2 (plate glass) and bottle glass. The sheet and plate glass samples are all made of good quality materials containing low concentrations of impurities (for full chemical results see Appendix 2). The sheet glass samples are very similar in composition, and all but one of them can be placed into four sub-groups: Groups 1a, 1b, 1c and 1d (see Figures 3–5). These different Groups have compositions which are subtly distinct: Group 1a has the lowest soda, Group 1b has the highest lime and Group 1c has the highest soda (Figure 3). Group 1d is subtly different in composition as it contains rather more iron, notably less potassium, but includes traces of arsenic (see Figures 4 and 5). Group 1d comprises the two samples of thick (7mm) plate glass. Sample BC02 is sheet glass but does not match the compositional groups identified; it is similar to Groups 1a, 1b and1c but has a higher iron content (see Figure 4).

Three samples of the Brocton glass made available for analysis proved to be fragments of bottles (probably square-sectioned bottles). Two samples are pale green and have compositions which are broadly similar to the sheet glass, except for the relatively high iron content of the bottle glass (see Appendix). Sample BC 48 also contains some copper, zinc, and antimony (0.048%, 0.035% and 0.41% respectively). The remain sample colourless and is characterised by high soda and low lime content (as well as low iron).

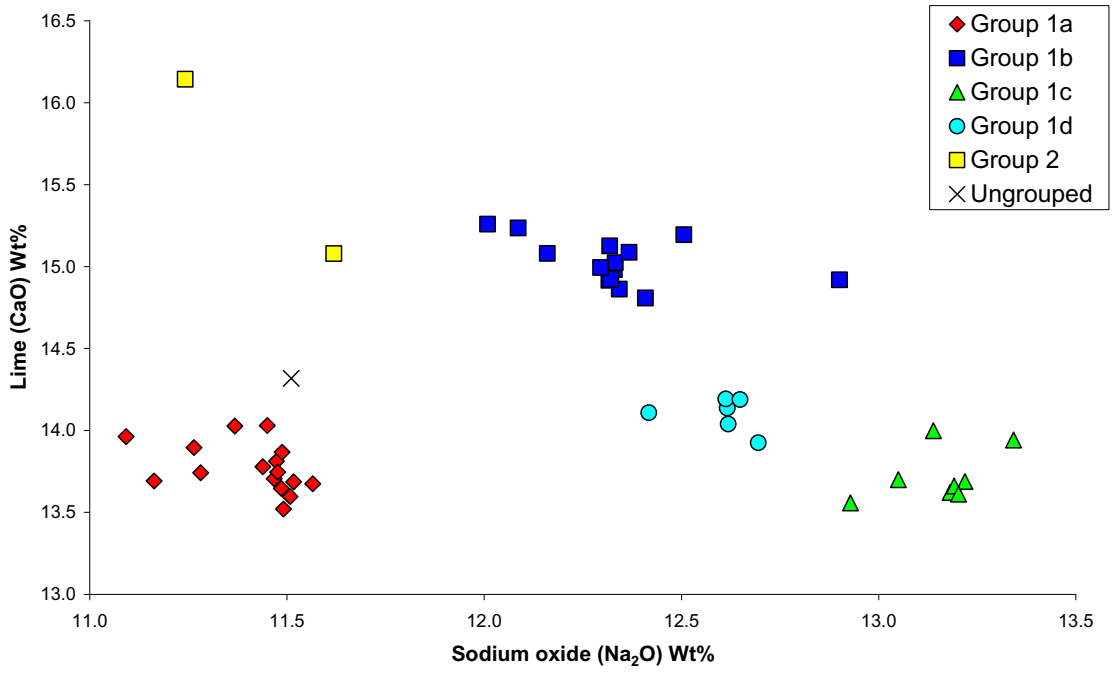

Figure 3: Soda (Na_2O) and lime (CaO) comparison of the Brocton Camp window glass (three samples of bottle glass are omitted)

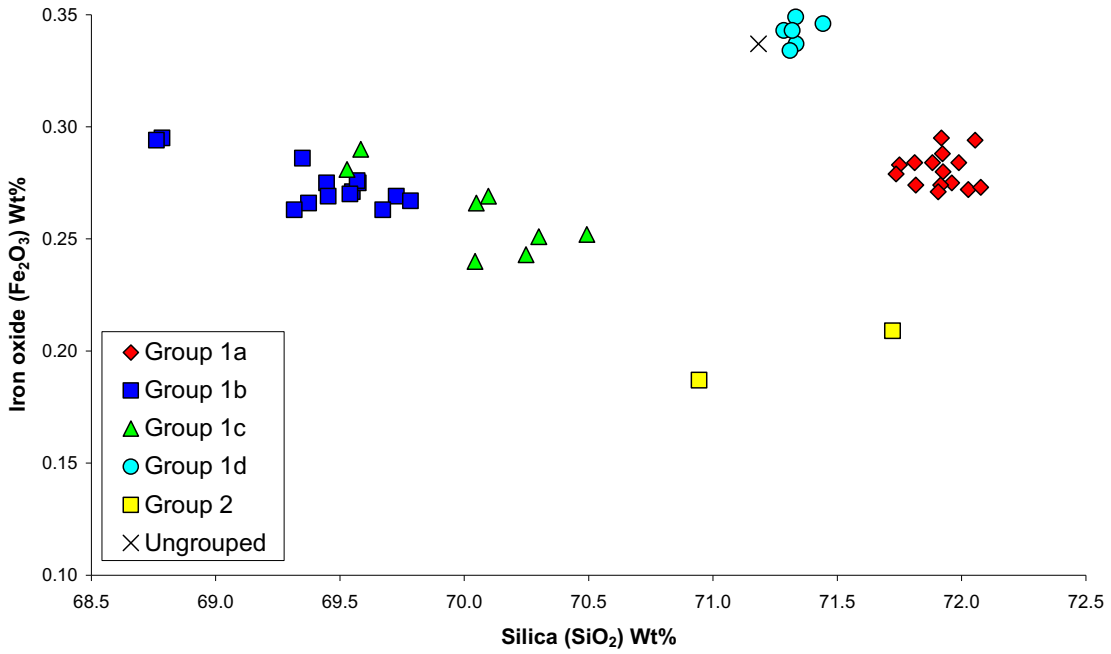

Figure 4: Silica (SiO_2) and iron oxide (Fe_2O_3) comparison of the Brocton Camp window glass

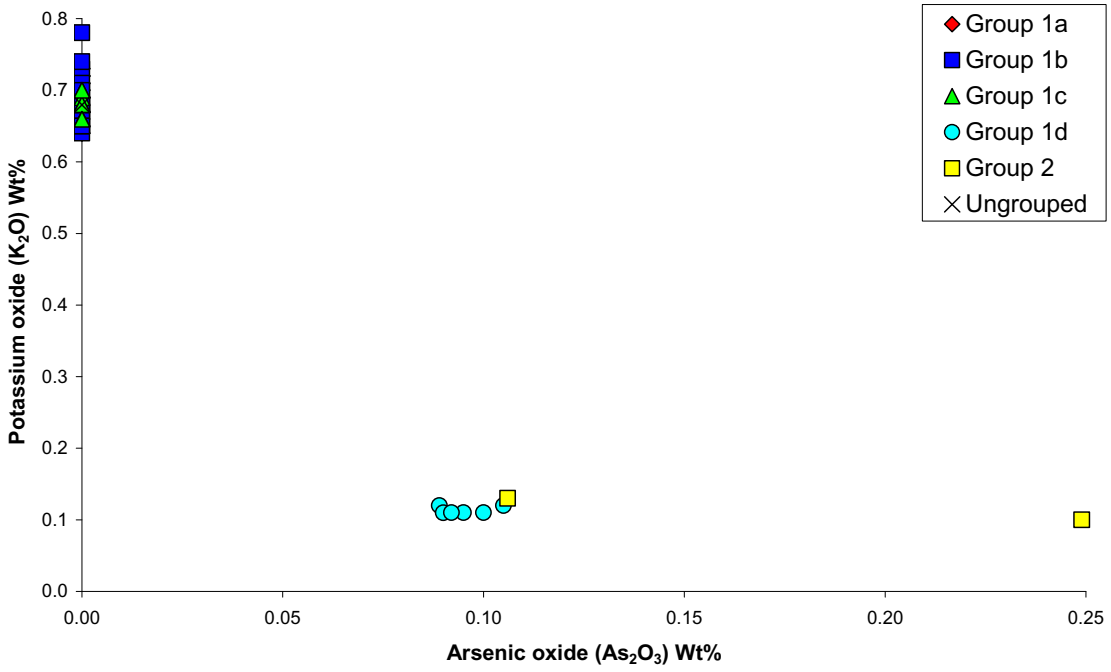

Figure 5: Arsenic oxide (As_2O_3) and potassium oxide (K_2O) comparison of the Brocton Camp window glass. Note Groups 1a–1c contain less than 0.03wt% As_2O_3

DISCUSSION

Window Glass

Groups 1a to 1c are made of high-quality materials with low impurities and show no traces of magnesia thus fitting most satisfactorily to the composition expected of early 20th-century window glass. Group 1d however is subtly different with a higher iron and less potassium with traces of arsenic. Significant arsenic has so far generally been missing from analysis of all post mid 19th-century window glass (See Table3).

Table 3 Chemical composition of some 19th- and 20th-century window glass (nr = not reported). (Sources: 1 = Dungworth 2009; 2 = Wilkes and Dungworth 2010; 3 = Dungworth and Wilkes 2010c; 4 = Hatton 2004; 5 = Dungworth and Wilkes 2010a; 6= Dungworth 2010a; 7 = Dungworth and Wilkes 2010b; 8 = This Report; 9 = Dungworth 2010b; 10 = Smrcek 2005)

	Source	Date	Na_2O	Mg O	Al $_2O_3$	Si O_2	SO $_3$	K_2O	Ca O	Fe_2O_3	As $_2O_3$
Chatsworth 1		1837–40	13.6	0.1	0.7	70.0	0.5	0.1	14.5	0.20	0.41
Tower of London	2	1845	11.8	0.3	0.5	71.6	0.4	0.1	14.6	0.14	0.05
Flint Lodge	3	1851	11.6	0.1	0.5	71.5	0.6	<0.1	14.9	0.16	0.02
Nailsea 4		1830–70	13.1	0.2	0.8	68.9	0.6	0.1	13.6	0.33	0.22
Wentworth 5		1877	11.9	0.4	0.7	71.5	0.2	0.3	14.3	0.28	<0.02
Welch Road	6	1894–95	11.6	0.1	1.5	72.5	0.3	0.6	13.4	0.25	<0.02
Highland House	7	1880	12.1	<0.1	1.5	71.7	0.3	0.6	13.2	0.22	<0.02
Brocton Camp 1a	8	1915–19	11.4	<0.1	1.5	71.9	0.4	0.7	13.8	0.28	<0.03
Brocton Camp 1b	8	1915–19	12.3	<0.1	1.5	69.4	0.7	0.7	15.0	0.27	<0.03
Brocton Camp 1c	8	1915–19	13.2	<0.1	1.5	70.0	0.7	0.7	13.7	0.26	<0.03
Brocton Camp 1d	8	1915–19	12.6	<0.1	0.9	71.3	0.5	0.1	14.1	0.34	0.10
Fort Cumberland GH	9	1940	14.5	2.9	0.2	72.7	0.2	<0.1	9.3	0.13	<0.02
Drawn 10		1930–60	13.8	2.7	1.1	72.1	0.5	0.1	9.8	0.12	nr
Float 10		1960–99	13.8	4.1	1.1	71.9	0.2	0.6	8.1	0.19	nr

Bottle Glass

The bottle glass samples are soda lime glasses with compositions which resemble contemporary bottles manufactured in England (Gardner 2009; Lucas 2010; Turner 1926).

CONCLUSION

The window glass used at Brocton Camp WW1 site is a soda-lime glass of the same broad type manufactured in the late 19th century (Dungworth 2010a; Dungworth and Wilkes 2010a; 2010b). The Brocton Camp glass does not have the magnesia which was added to aid more fully automated window glass manufacture from the end of the 1920s (Cable 2004).

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APPENDIX 1

Visual description of glass Brocton Camp Glass

#	Colour	Th (mm)	Finish	Comment
1	Darker green	1.2–2.0	curved	Bottle glass
2	Pale green	1.3	flat	
3	Pale green	1.6	flat	Slightly melted
4	Pale green	1.6	flat	Possibly match to 5
5	Pale green	1.6	flat	possibly match to 4
6	Pale green	1.9	flat	
7	Pale green	1.9	flat	
8	Pale green	1.9	flat	
9	Pale green	1.9	flat	
10	Pale green	1.9	flat	
11	Pale green	1.9	flat	
12	Colourless	1.9–3.1	curved	Bottle glass
13	Pale green	2.0	very flat	
14	Pale green	2.0	very flat	
15	Pale green	2.0	very flat	
16	Pale green	2.0	very flat	
17	Pale green	2.0	very flat	
18	Pale green	2.0	very flat	
19	Pale green	2.0	very flat	
20	Pale green	2.1	very flat	
21	Pale green	2.1	flat	
22	Pale green	2.1	flat	
23	Pale green	2.1	flat	
24	Pale green	2.1	flat	
25	Pale green	2.1	very flat	
26	Pale green	2.2	very flat	
27	Pale green	2.2	very flat	
28	Pale green	2.2	very flat	
29	Pale green	2.2	very flat	
30	Pale green	2.2	very flat	
31	Pale green	2.3	very flat	One face slightly corroded
32	Pale green	2.3	very flat	
33	Pale green	2.3	very flat	
34	Pale green	2.3	very flat	
35	Pale green	2.3	very flat	
36	Pale green	2.3	very flat	
37	Pale green	2.4	very flat	
38	Pale green	2.4	very flat	
39	Pale green	2.4	very flat	
40	Pale green	2.6	very flat	
41	Pale green	2.7	flat	One face slightly corroded
42	Pale green	2.7	very flat	
43	Pale green	2.7	very flat	
44	Pale green	2.9	flat	Both faces slightly corroded
45	Pale green	2.9	flat	
46	Pale green / Yellow	2.9–3.1	distorted	Burnt, melted, surface corroded
47	Pale green	3.0	very flat	
48	Darker green	3.0–3.6	curved	Bottle glass
49	Colourless	7.0	very flat	Polished radius on one edge, internal cracks
50	Colourless	7.4	very flat	One face slightly corroded, polished radius on one edge

APPENDIX 2

Chemical composition of the Brocton Camp Glass

#	Group	Na_2O	MgO	Al_2O_3	SiO_2	SO_3	K_2O	CaO	MnO_2	Fe_2O_3	As_2O_3	PbO	SrO	ZrO_2
03	1a	11.28	<0.1	1.45	72.03	0.43	0.70	13.74	<0.02	0.272	<0.03	<0.03	0.008	0.010
04	1a	11.51	<0.1	1.50	71.93	0.43	0.69	13.60	<0.02	0.280	<0.03	<0.03	0.010	0.006
05	1a	11.47	<0.1	1.55	71.96	0.32	0.71	13.70	<0.02	0.275	<0.03	<0.03	0.009	0.006
09	1a	11.45	<0.1	1.48	71.75	0.31	0.64	14.03	<0.02	0.283	<0.03	<0.03	0.008	0.009
14	1a	11.47	<0.1	1.47	71.74	0.39	0.72	13.81	<0.02	0.279	<0.03	<0.03	0.008	0.010
15	1a	11.44	<0.1	1.51	71.88	0.32	0.72	13.78	<0.02	0.284	<0.03	<0.03	0.013	0.007
19	1a	11.48	<0.1	1.54	71.92	0.32	0.69	13.75	<0.02	0.295	<0.03	<0.03	0.009	0.010
22	1a	11.52	<0.1	1.45	71.92	0.42	0.67	13.69	<0.02	0.288	<0.03	<0.03	0.014	0.011
25	1a	11.49	<0.1	1.44	71.92	0.32	0.64	13.87	<0.02	0.274	<0.03	<0.03	0.013	0.005
26	1a	11.57	<0.1	1.47	71.81	0.34	0.72	13.67	<0.02	0.284	<0.03	<0.03	0.009	0.011
27	1a	11.26	<0.1	1.51	71.99	0.36	0.73	13.90	<0.02	0.284	<0.03	<0.03	0.008	0.006
29	1a	11.09	<0.1	1.47	72.05	0.34	0.73	13.96	<0.02	0.294	<0.03	<0.03	0.009	0.007
35	1a	11.49	<0.1	1.46	72.08	0.43	0.71	13.52	<0.02	0.273	<0.03	<0.03	0.010	0.008
42	1a	11.49	<0.1	1.45	71.91	0.41	0.70	13.65	<0.02	0.271	<0.03	<0.03	0.012	0.006
45	1a	11.37	<0.1	1.45	71.82	0.40	0.65	14.03	<0.02	0.274	<0.03	<0.03	0.006	0.009
47	1a	11.16	<0.1	1.48	72.31	0.30	0.71	13.69	<0.02	0.289	<0.03	<0.03	0.009	0.008
06	1b	12.32	<0.1	1.47	69.45	0.63	0.69	15.13	<0.02	0.275	<0.03	<0.03	0.013	0.009
07	1b	12.33	<0.1	1.45	69.55	0.66	0.67	14.98	<0.02	0.271	<0.03	<0.03	0.010	0.005
10	1b	12.51	<0.1	1.62	68.78	0.70	0.78	15.19	<0.02	0.295	<0.03	<0.03	0.010	0.011
11	1b	12.90	<0.1	1.68	68.76	0.68	0.73	14.92	<0.02	0.294	<0.03	<0.03	0.120	0.009
13	1b	12.32	<0.1	1.57	69.35	0.62	0.74	14.92	<0.02	0.286	<0.03	<0.03	0.007	0.012
21	1b	12.33	<0.1	1.48	69.37	0.69	0.66	15.02	<0.02	0.266	<0.03	<0.03	0.010	0.011
28	1b	12.34	<0.1	1.46	69.57	0.69	0.64	14.86	<0.02	0.275	<0.03	<0.03	0.009	0.010
30	1b	12.01	<0.1	1.52	69.45	0.68	0.71	15.26	<0.02	0.269	<0.03	<0.03	0.005	0.007
31	1b	12.09	<0.1	1.44	69.57	0.69	0.70	15.24	<0.02	0.276	<0.03	<0.03	0.012	0.006
32	1b	12.16	<0.1	1.48	69.54	0.67	0.67	15.08	<0.02	0.270	<0.03	<0.03	0.008	0.008
36	1b	12.32	<0.1	1.42	69.73	0.65	0.65	14.92	<0.02	0.269	<0.03	<0.03	0.006	0.008
38	1b	12.37	<0.1	1.51	69.32	0.70	0.68	15.09	<0.02	0.263	<0.03	<0.03	0.009	0.010
40	1b	12.30	<0.1	1.43	69.67	0.64	0.68	14.99	<0.02	0.263	<0.03	<0.03	0.008	0.008
43	1b	12.41	<0.1	1.41	69.78	0.65	0.65	14.81	<0.02	0.267	<0.03	<0.03	<0.005	0.007
16	1c	13.18	<0.1	1.36	70.25	0.61	0.68	13.62	<0.02	0.243	<0.03	<0.03	0.011	0.009
18	1c	13.22	<0.1	1.42	70.04	0.60	0.66	13.69	<0.02	0.240	<0.03	<0.03	0.009	0.009
23	1c	13.14	<0.1	1.51	69.58	0.75	0.70	14.00	<0.02	0.290	<0.03	<0.03	0.009	0.009
33	1c	13.34	<0.1	1.45	69.53	0.72	0.69	13.94	<0.02	0.281	<0.03	<0.03	0.012	0.006
34	1c	12.93	<0.1	1.38	70.49	0.61	0.68	13.56	<0.02	0.252	<0.03	<0.03	0.006	0.006
39	1c	13.19	<0.1	1.40	70.10	0.70	0.68	13.66	<0.02	0.269	<0.03	<0.03	0.010	0.009
44	1c	13.20	<0.1	1.40	70.05	0.75	0.66	13.61	<0.02	0.266	<0.03	<0.03	0.010	0.006
46	1c	13.05	<0.1	1.37	70.30	0.58	0.70	13.70	<0.02	0.251	<0.03	<0.03	0.009	0.006
08	1d	12.62	<0.1	0.83	71.29	0.47	0.12	14.14	0.105	0.343	0.089	<0.03	0.015	0.008
17	1d	12.42	<0.1	0.86	71.44	0.52	0.12	14.11	0.103	0.346	0.105	<0.03	0.013	0.014
20	1d	12.61	<0.1	0.82	71.33	0.46	0.11	14.19	0.106	0.337	0.095	<0.03	0.011	0.009
24	1d	12.65	<0.1	0.89	71.33	0.42	0.11	14.19	0.110	0.349	0.090	<0.03	0.012	0.011
37	1d	12.70	<0.1	0.86	71.32	0.41	0.11	13.93	0.103	0.343	0.100	<0.03	0.015	0.008
41	1d	12.62	<0.1	0.86	71.31	0.44	0.11	14.04	0.106	0.334	0.092	<0.03	0.014	0.013
02	–	11.51	<0.1	1.59	71.18	0.39	0.68	14.32	<0.02	0.337	<0.03	<0.03	0.010	0.009
49	2	11.62	<0.1	0.45	71.72	0.62	0.13	15.08	<0.02	0.209	0.106	<0.03	0.006	0.005
50	2	11.24	<0.1	0.35	70.94	0.59	0.10	16.14	<0.02	0.187	0.249	<0.03	0.019	0.005
12	Bottle	15.93	0.15	0.32	74.16	0.17	0.79	7.12	0.274	0.189	0.159	1.04	0.015	0.005
01	Bottle	11.35	0.76	1.38	71.20	0.40	0.44	13.85	0.094	0.453	0.074	0.18	0.016	0.009
48	Bottle	11.78	0.69	1.22	71.28	0.32	0.57	12.59	0.092	0.543	0.073	0.82	0.013	0.006






ENGLISH HERITAGE RESEARCH DEPARTMENT

English Heritage undertakes and commissions research into the historic environment, and the issues that affect its condition and survival, in order to provide the understanding necessary for informed policy and decision making, for sustainable management, and to promote the widest access, appreciation and enjoyment of our heritage.

The Research Department provides English Heritage with this capacity in the fields of buildings history, archaeology, and landscape history. It brings together seven teams with complementary investigative and analytical skills to provide integrated research expertise across the range of the historic environment. These are:

* *Aerial Survey and Investigation*
* *Archaeological Projects (excavation)*
* *Archaeological Science*
* *Archaeological Survey and Investigation (landscape analysis)*
* *Architectural Investigation*
* *Imaging, Graphics and Survey (including measured and metric survey, and photography)*
* *Survey of London*

The Research Department undertakes a wide range of investigative and analytical projects, and provides quality assurance and management support for externally-commissioned research. We aim for innovative work of the highest quality which will set agendas and standards for the historic environment sector. In support of this, and to build capacity and promote best practice in the sector, we also publish guidance and provide advice and training. We support outreach and education activities and build these in to our projects and programmes wherever possible.

We make the results of our work available through the Research Department Report Series, and through journal publications and monographs. Our publication Research News, which appears three times a year, aims to keep our partners within and outside English Heritage up-to-date with our projects and activities. A full list of Research Department Reports, with abstracts and information on how to obtain copies, may be found on www.english-heritage.org.uk/researchreports

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