Warmley Brassworks, Siston, Bristol
NGR 366927 172821

SAM no. 28518

Archaeological Recording Exercise

Report

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1. Introduction

1.1. This report details the results of an emergency archaeological recording exercise undertaken on 13th October 2006 at the Warmley Brassworks, Siston, near Bristol (NGR 366927, 172821), a Scheduled Ancient Monument (SAM No. 28518). The recording action was initiated following on from reports of damage to the monument, which is under private ownership.

1.2. The area of the damage was to the north and west of a lightweight industrial building, known as the Former Lindmans Works, off Tower Lane. A large swathe of land had been machined away by a tracked excavator using a toothed bucket from the rear of the building up to the adjacent property boundary, to a depth ranging from 10 – 22m from the building. The section was 88m in length, and at its apex over 5m in height. Approximately 1000 cubic meters of soil is thought to have been removed, although not all of this would represent archaeological deposits, as the truncation had cut into the natural geological deposits.

1.3. The recording exercise was carried out by a team from Archaeological Projects, English Heritage, at the request of Phil McMahon, Inspector of Ancient Monuments, English Heritage, South-west Region, and David Haigh, Archaeology and Conservation Officer, South Gloucestershire Council. The works were carried out in accordance with an approved Project Design (English Heritage, 2006).

1.4. The purpose of the archaeological work was to record the exposed remains in order to understand and assess the level of damage to the archaeological resource as best as possible. Samples were also taken for scientific analysis. Decisions could then be made regarding the need for further archaeological fieldwork, and also to determine if the terms of the 1979 Ancient Monuments and Archaeological Areas Act and/or the 1990 Town and Country Planning Act had been breeched.

2. Archaeological Background

2.1. The Warmley brassworks complex, founded by William Champion in 1743, was one of the largest brassworks of its kind in the 18th century. The monument includes buildings, garden features and other archaeological remains representing Warmley brassworks, an area of industrial works, water supply, worker's housing, manager's house and garden located in a bend of the Siston Brook, a tributary of the River Avon, on the eastern outskirts of Bristol.

2.2. The Warmley complex was the first to integrate the production of copper, brass and zinc. It was also the first works in England to produce zinc on a commercial scale, for which Champion was granted a patent in the 1730's. It is of interest in containing the only recorded remains of a cementation furnace in the brass industry in Europe and being the first place where all the processes of the brass industry were carried out on one site. A brief discussion on the technological aspects of the brassworks can be found in the appended scientific assessment report.

2.3. The complex reached its apex in 1761, by which time the site had expanded to include, amongst other buildings, a windmill and two horse mills, 22 copper furnaces, 15 brass furnaces and 25 houses and tenements for works. Over-expansion caused Champion to declare bankruptcy in 1769, at which point the site was purchased by the Bristol Brass Company (Day, 1988, 32). Production continued into the 19th century, though on a reduced scale and possibly limited to zinc smelting, and by the mid 19th century the site had been converted to a pottery. By the late 19th century this was know as the Haskins Pottery Works. The factory, which specialised in drainage pipes, bricks and tiles, was shut for good in 1967 (http://weldgen.tripod.com/memories-of-warmley/id5.html accessed 4/12/06).

2.4. A schematic map derived from the 1740 Tithe Map of the estate (Day, 1988, fig. 6) shows that the present site, which lies to the south of Warmley House and to the immediate east of the Clocktower Building, was occupied by factory buildings. By the 1st edition Ordnance Survey Map many of the earlier buildings are shown labelled as 'Drainage Works' but again are across the present site.

3. Methodology

3.1. The site methodology as given in the Project Design was adhered to where possible; however given the condition of the site when the team arrived, some modifications to the PD were affected. This can primarily be attributed to the scale of the truncated area, which was larger than anticipated, and also with the difficulty in reaching the archaeological deposits, as they were mainly situated in the upper portions of the section and in some circumstances could only be reached by ladder. In addition, the western building exposed was completely obstructed by a large pile of deadwood and felled timbers, which hampered safe and easy access to the section.

3.2. It was decided, therefore, that in order to make a complete a record as possible in the day allocated for recording, that only the portions of the section that contained archaeological deposits would be drawn in detail, and that the remainder of the section would be only recorded

photographically, so that a photomosaic of the section could be produced. These images are included as figures 3 and 4. Only 13 contexts were recorded in detail whilst on site; the remaining context numbers were allocated during post-excavation with the context information taken from annotated section drawings.

3.3. Eleven samples were removed from six contexts for scientific analysis, as advised by Dr David Dungworth, English Heritage. It was thought that these samples would not only provide further information on the foundry activities and methods, but could also assist in assigning function to the deposits and structures from where they had been taken. No stratified dating material, however, was recovered.

4. Results

4.1. As the site was recorded only in section, and no datable material was recovered, phasing and dating the exposed buildings is difficult. Therefore, the exposed archaeological features will be described from west to east as they appeared in the section.

4.2. Natural

4.2.1. The natural geology of the site is sandstone, which slopes downwards to the east and south, following general topographic contours. The height of the sandstone sloped downwards to the east from c. 44.30m AOD, although it is likely that some truncation to the upper levels of this deposit had occurred in the past during earlier construction. In some areas of the section, the upper levels of the sandstone deposits [019] had degraded into a fine sand [037]. This was particularly evident under the central large building.

4.3. The culvert

4.3.1. The first archaeological structure encountered from the west was a small culvert, approximately 2.40m long x 1.60m high (Section 1). The culvert was constructed by excavating through the natural sandstone [018], then reusing the excavated material bonded with a cement mortar to form the walls and floor of the culvert [017]. The floor was capped with slate bedded in cement, which was also used to render the interior. The top of the culvert was capped with a single course of cast slag blocks [001], which was sampled for its composition and is discussed in the appendix.

4.3.2. Approximately 0.30m to the east of the culvert was a second cut, [014]. This measured c. 1.30m across, and was at least 3.0m deep, at which point it continued below the section cut. It was backfilled with redeposited natural sandstone [015]; it was suggested by the Kingswood Museum that

this was the cut for a second culvert or drain, as map evidence showed several in the area.

4.4. The western building

4.4.1. The second archaeological structure encountered on the site was a large building centred at approximately ST6690072832 (Sections 3 and 5). This was marked on the west by wall [022] (cut [021]) and the east by wall [027] (cut [028]) and associated features, making the structure c. 10.40m long. Recording of this structure was severely hampered by on-site conditions, as it was almost completed obscured by a large pile of felled timbers, which blocked access to the section.

4.4.2. The western wall [022] was set into cut [021], which measured 0.60m wide x 1.20m high. The wall was constructed of irregular sandstone blocks bonded with a chalky mortar and the cut backfilled with redeposited natural [023]. Remnants of a mortar floor were seen abutting the wall on the western side of the structure only ([051]). The wall on the eastern side of the building was of a similar size and construction, but was more severely damaged by machining.

4.4.3. The building, when out of use, was backfilled with an extensive clinker deposit [013] running the entire length of the building and which was, in places, up to 1.60m thick. The deposit contained lenses of a pale, ashy material, and some tip lines were evident within the deposit. The deposit also contained [012], a lens of pale purple material that measured c. 1.40m c 0.25m. A sample of this material was removed for scientific analysis, and was subsequently identified as being composed of droplets of metallic zinc, coal, charcoal and refractory material in a zinc compound matrix (fully discussed in the appendix).

4.4.4. This material almost certainly will have been related to the zinc smelting processes occurring on the site, but its composition has no known published parallels. It is known from documentary evidence that zinc smelting was occurring on the site from at least 1754, and that although the Champion Factory went into receivership later that decade, the manufacture of metallic zinc may have continued until the mid-19th century. As this deposit could not, therefore, have been created after the mid-19th century, the building which it backfills must pre-date this, and may in fact be substantially earlier.

4.4.5. The final episode of activity in this area of the site was the later introduction of a non-bonded sandstone wall [026] placed in cut [025]. The cut was a minimum of 0.80m wide and 1.20m deep, but the full width was truncated by animal burrowing alongside wall [026]. The wall itself was formed of loosely packed sandstone with no bonding material

evident, and was c. 0.45m wide x 1.0m high. This wall was later enhanced on the western side by a brick and rubble drain, which contained a cast-iron drain pipe [024]. The 1st Edition Ordnance survey map of the site shows that greenhouses associated with Warmley House were evident in this area, and this wall and drain may well be associated with greenhouse or gardening activity.

4.5. The central building

4.5.1. The primary building(s) exposed in the section can be found at c. ST669437289, and is composed of three walls, with associated make-up layers, floor surfaces, demolition material and backfill (Section 2). Given the machine damage, it was not possible to ascertain different phases within the building, and it may be that this structure has one or more periods of construction or alteration.

4.5.2. The building and dump layers to the east are all contained within a single cut, [033], which measures approximately 11.30m east-west and cuts natural deposits.

4.5.3. The western wall, [034], was c. 0.60m x 1.0m, and consisted of roughly coursed sandstone bonded with an off-white mortar with charcoal flecks. This was the same construction as wall [035], some 2.10m to the east, although wall [035] was more robust, being 1.20m wide.

4.5.4. A sandy make-up layer, [008], comprised of redeposited natural with occasional fragments of slag, was deposited between the two walls as used as the basis for mortar flooring [032]. The slag contained within [008] was analysed, and in composition and structure is likely to be residual, and earlier than the Champion factory (see appendix).

4.5.5. The easternmost wall of this building, [005], had a different construction, and was significantly more substantial. The eastern corner of the wall is composed of sandstone blocks, cut to a roughly uniform size at base and squared off to form courses. These are bonded together with an off-white mortar with frequent charcoal flecks. The exposed section is smooth, which may represent an original face, and the stone is a pink colour different from the natural sandstone elsewhere on the site, perhaps indicating that it had been effected by heat although there was no indication of in-situ burning. Sandstone blocks are also evident on the western face of this wall, which has a brick core. The wall in total measures c. 1.55m east-west, by 1.30m high.

4.5.6. Between walls [035] and [005] a series of floors were laid; [009] was a mortar surface c. 0.10m thick, which was sealed by [010], made from crushed ceramic building material in a mortar matrix 0.04m thick, and

finally [011], a 0.13m thick deposit of sandy mortar. Samples of these surfaces were removed for analysis, and were found to be composed of lime mortar. Lime mortar would not survive the temperatures needed to smelt zinc or copper or those needed for brass cementation. Therefore, although these structures are almost certainly part of the Champion factory, smelting and other manufacturing practices did not take place within them.

4.5.7. East of wall [005] was context [004], a series of tapering deposits of coal slack, a mixture of coal fragments and coal dust. This deposit, which had a maximum depth of 0.75m, tapered for some 3.70 to the east, and clearly accumulated in stages against the wall front.

4.5.8. It was not possible to definitively date this building, or even assign phases within its construction, but there are some clues as to the date. To the east of wall [005], above dump layer [004], were two mixed rubble deposits, presumably marking the demolition of the building. [006] was as grey silty loam, c. 0.13m thick, which contained ceramic building material fragments, building debris, and a significant amount of mortar fragments. [007] was more mixed, with brick, tile, chalk, mortar and slag noted as inclusions in the sandy silt loam – this may in part be a levelling layer mixed in with demolition material. What is significant, however, is that these deposits were sealed by [003/038], which is a layer of demolition material in places up to 0.50m thick. What marks this deposit as different is that it is the first deposit in the sequence to contain ceramic drain pipes, which may have derived from the Hoskins Pottery on the site from the mid to late 19th century. That no such material is included in the stratigraphically earlier deposits suggests that they pre-date the drain pipe factory.

4.5.9. In between the two exposed buildings, to the east of wall [027] and the west of wall [034], lies layer [002], a loose deposit of slag and clinker. As fully explained in the appendix, the presence of both slag and clinker together in a deposit is typical of waste material generated in a reverberatory furnace, as was used in the Champion factory, in copper smelting. This deposit contained little or no other material, and appears to represent freshly dumped waste material from the active phase of the Champion factory, likely from 1747 – 1761. The relationship between this deposit, therefore, and the buildings is crucial in determining their dates – unfortunately at present these relationships, particularly in regards to the eastern building and wall [034], are inconclusive. Very careful cleaning of this area may clarify the relationship, and if context [002] can be demonstrated as being later than wall [034], the building must relate to the first phases of the factory complex.

4.6. The eastern section

4.6.1. East of the central building the nature of the site changes dramatically, moving from buildings and structures to a less well defined area of possible quarry pits and reworked natural deposits, some of which show evidence of burning. A sample section was drawn and recorded (Section 4), showing an ephemeral cut, [050], which measured c. 3.20m east-west, and which was filled with several layers of re-deposited natural. An extensive demolition/levelling layer, [003/038], capped these deposits.

5. Conclusions

5.1. Following on from the above recording and sampling exercise, it is clear that archaeological remains were affected by the unauthorised machining at the site.

5.2. Three discrete structures were affected by the machining: a drain or culvert at the western end of the site, and two multi-phased buildings in the centre of the recorded area.

5.3. The western of these buildings has a primary backfill of a zinc-rich material that does not have published parallels, but which will be related to the zinc smelting occurring on the site. Further scientific analysis of this substance may be able to clarify how this material was derived, which in turn may provide a terminus post quem for the building itself, which can at present only be ascribed to the mid 19th century or earlier.

5.4. The central large building on the site can be shown to pre-date the Hoskins Pottery factory, and is therefore associated with the earlier works. The function of the building is uncertain, but given the survival of lime mortar floors it was not a furnace or an area where extreme temperatures were generated. The building appears to have been constructed in two separate phases, but as seen in section the ordering of these phases cannot be determined. The relationship of wall [034], at the western end of the building, with deposit [002] should be further explored, as the deposit is likely dated to 1747 – 1761, which would provide a date for the building.

5.5. The eastern end of the site appears to be a series of reworked and redeposited layers, but cleaning of the section would better define the nature of these deposits.

5.6. A detailed map regression exercise utilising the estate maps and plans, particularly if rectified, may be able to further elucidate the date and/or nature of the buildings exposed. It is clear from the 1740's Tithe Map of the area showing the Champion Works that the area of the central

building was well developed at that time – a closer examination of these maps using the present survey data would assist in defining these buildings.

5.7. Preliminary scientific analysis of several deposits has highlighted several areas where further study is recommended, including detailed investigation of the above deposits and an unstratified fragment of a probable zinc smelting retort. This further analysis will clearly contribute a great deal to the understanding of the processes that Champion developed and to the development of the industry. It is intended that further scientific analysis will be undertaken by the Archaeological Science team at English Heritage. A joint publication between Archaeological Projects and Archaeological Science will be produced for the English Heritage Research Report Series.

6. Archiving

6.1. The site archive is presently stored at the English Heritage archaeological archive in Fort Cumberland, Portsmouth. In due course it is intended for the archive to be deposited with the Bristol City Museum and Art Gallery.

6.2. An OASIS form has been completed, and is attached as Appendix 3.

7. Acknowledgements

7.1. The site was initiated by Phil McMahon, Inspector of Ancient Monuments, English Heritage, South-west Region, and David Haigh, Archaeology and Conservation Officer, South Gloucestershire Council, who both also provided background information and on-site assistance. The field work was carried out under the direction of Kim Stabler with David Dungworth, Tom Cromwell, Duncan Stirk and Neil Hall participating in the recording. John Vallender and Tom Cromwell produced the illustrations. Thanks should also be given to Alan Bryant and the Kingswood Heritage Museum who were most helpful on the day and subsequently provided maps of the factory site.

Appendix 1
Context register

Context	Description	Notes
[001]	Culvert/drain	Cast slag block capping (ST6689172830) of western culvert
[002]	Layer	Extensive layer of slag and clinker
[003]	Layer	Contains numerous examples of late 19th century drainage pipes
[004]	Layer	Black deposit against stone pier (ST6694372829)
[005]	Pier & Wall	Stone pier (ST6694372829) and associated wall, within cut [033]
[006]	Layer	Demolition layer above [004]
[007]	Layer	Dumped layer above [005]
[008]	Layer	Make-up layer below building
[009]	Layer	Mortar floor
[010]	Layer	Mortar floor (with crushed brick)
[011]	Layer	Mortar floor
[012]	Layer/inclusion	Mauve coloured deposit rich in zinc and zinc compounds
[013]	Layer	Large deposit of clinker backfilling western building (ST6690072832)
[014]	Cut	Cut for eastern culvert
[015]	Fill	Fill of cut [014]
[016]	Fill	Uppermost fill of cut [018]
[017]	Culvert/drain	Main structure of western culvert
[018]	Cut	Cut for western culvert
[019]	Natural	Natural sandstone
[020]	Layer	Reworked topsoil
[021]	Cut	Cut for western wall of western building (ST6690072832)
[022]	Wall	Western wall of western building, within cut [021]
[023]	Fill	Construction backfill of western wall cut [021]
[024]	Culvert/drain	Brick culvert/drain with cast iron pipe cut into western building
[025]	Cut	Cut for wall [026] and drain [024]
[026]	Wall	Sandstone wall, within cut [025]
[027]	Wall	Eastern wall of western building, within cut [028]
[028]	Cut	Cut for wall [027]
[029]	Layer	Redeposited natural used as a make-up layer to west of wall [034]
[030]	Layer	Mortar floor surface west of wall [034]
[031]	Layer	Demolition layer above [030]
[032]	Layer	Mortar floor surfaces in eastern building
[033]	Cut	Cut for eastern building
[034]	Wall	Western wall of eastern building, within cut [033]
[035]	Wall	Central wall of eastern building, within cut [033]
[036]	Layer	Brick and mortar ?make-up layer in eastern building
[037]	Layer	Natural sand
[038]	Layer	Demolition layer
[039]	Cut	Cut for ceramic drainpipe [040]
[040]	Fill	Ceramic drainpipe, fill of [039]
[041]	Cut	Cut to east of eastern building
[042]	Fill	Fill of cut [041]
[043]	Layer	Redeposited natural sealing [042]
[044]	Fill	Redeposited natural in cut [050]
[045]	Fill	Fill of cut [050]
[046]	Fill	Fill of cut [050]
[047]	Fill	Primary fill of cut [050]
[048]	Layer	Burnt clay lens
[049]	Layer	Burnt clay lens
[050]	Cut	Cut containing [044, 045, 046, and 047]
[051]	Layer	Mortar floor for western building

Appendix 2
Assessment of samples taken during the recording of damage to Warmley SAM

David Dungworth
19th October 2006

Introduction

The recording of a section through the disturbed/damaged archaeological deposits at the Warmley brass works on 13th October 2006 provided the opportunity to take samples of material for laboratory examination and analysis. This document provides an assessment of the samples taken based on the laboratory work. The purpose of the laboratory work is to provide further information which assist with the interpretation of the archaeological deposits. It is intended that further scientific examination and analysis will be undertaken and a Research Department Report issued in due course.

Technological Background

The Warmley brass works was established by William Champion in the 1740s (Day 1973). In 1754 the site was visited by the Swede Angerstein who recorded 15 copper furnaces, 12 brass furnaces, 4 zinc furnaces, and various mills for the manufacture of sheet, wire and finished goods (Berg and Berg 2001, 137). A 1761 inventory lists 22 copper furnaces, 15 brass furnaces, 5 zinc furnaces and various other mills (Day 1973, 82). Champion continued to expand the business but financial problems caused it to collapse in 1767. The site was bought by a rival firm which continued some activities (possibly only zinc smelting) into the early 19th century.

The copper was smelted in reverberatory furnaces which were rectangular and approximately 2.6m by 1.2m (external dimensions). The reverberatory furnace had two chambers separated by a low wall: the fuel (coal) was burnt in the smaller chamber while the ore was placed in the other chamber. The hot gases from the burning coal melted the copper ore and allowed the extraction of the metal it contained. This process was helped by a chimney at the far end of the ore chamber and the low ceiling of the ore chamber which reflected heat down onto the ore. Most of the copper ores used were copper- or copper-iron-sulphide ores and so were charged with silica (eg sand). The silica would react with the iron to form a slag which would be tapped from the furnace as a runny liquid. At least in the 19th century, some slags were charged into the furnace with ore to recover the small amounts of copper still left in them. Slag was also cast into architectural blocks. As the fuel and ore were kept separate, the vitrified ash of the coal would not be absorbed by the smelting slag and would form a separate

residue: clinker. The initial product of the smelting process would be matte, copper sulphide, which would be further roasted and smelted to remove the sulphur and other impurities (arsenic, antimony, etc). Copper smelting in the Bristol area went into decline in the 1780s, and probably ceased by the end of the 18th century (Day 1991, 154)

The brass furnaces were used to produce brass from metallic copper and zinc ore by cementation. The extreme volatility of zinc made smelting of the metal by conventional means impossible and so most brass was manufactured by the cementation process. Zinc ore, copper and charcoal (Angerstein notes the use of small amounts of coal at the bottom of the crucible, Berg and Berg 2001, 38) were charged in crucibles. The crucibles were sealed and heated in a circular furnace similar to a glass furnace. The charcoal reduced the zinc ore to zinc (actually a vapour); because the crucible was sealed the zinc could not escape and was absorbed by the copper to form brass. The absorption of zinc by copper was limited by a number of factors, such as the purity of the copper and its surface area. The best copper was of a very high purity and granulated. The absorption of zinc was also limited by the melting temperatures of the different components: the process could not take place below the boiling point of zinc (906ºC) but a brass containing ~33wt% zinc would melt at this temperature. Once the brass melted the reduction in surface area would severely reduce the rate of diffusion of zinc into the brass. Up to the mid 18th century the maximum zinc content of brass was ~33wt%. It was William Champion who patented a method for the direct manufacture of zinc, thereby opening the way to the production of brasses with higher zinc contents. Angerstein (1754) describes brass cementation crucibles in Birmingham as being 0.36m high and 0.23 in diameter at the mouth (Berg and Berg 2001, 38). Percy describes (1861) describes crucibles in the same town as being 0.37m high and 0.26m diameter at the mouth (with walls 25mm thick at the rim and 50mm thick at the base).

Champion had patented a method for the manufacture of metallic zinc in 1738 by which the zinc vapour formed in the crucible was condensed in a second vessel. The crucibles (more correctly retorts) were 1.22m high (Day 1991, 180); Percy illustrates retorts 1.0m high with a diameter 0.9m and wall thickness from 40 to 65mm (Percy 1861, 551–3). The retorts had an opening at the base in which was fitted one end of an iron pipe, the other end of which was placed above a vessel filled with water. The retorts were filled with zinc ore and a reducing agent, and then heated for three days in a coal-fired furnace similar to a glass furnace. The zinc condensed in the iron pipes and dripped into the water-filled vessels below. Angerstein (1754) refers to the use of coal (Berg and Berg 2001, 143) and Percy (1861, 557) to the use of coke. Percy records that 20cwt of calcined zinc ore would give 6 to 8cwt of zinc (Percy 1861, 557) which suggests that approximately half of the charge would remain in the retort as ‘residuum’ which would then be scrapped out (Percy 1861, 558). The zinc produced was extremely expensive (due to the large quantities of coal consumed in the process) and was used only for the manufacture of specialist high-zinc brasses.

Description of contexts

Table 1. Contexts

Context	Description	Notes
[001]	Culvert/drain	Cast slag block capping (ST6689172830). Sample is a copper smelting or refining slag (see below).
[002]	Layer	Extensive layer of slag and clinker (see Figure 1). The slag consists of fragments of cast slag blocks. Two samples have similar compositions and microstructures to the sample from [001].
[003]	Layer	Contains numerous examples of late 19th century drainage pipes.
[004]	Layer	Black deposit against stone pier (ST6694372829) (see Figure 2). Flame test confirms this to be fine coal (slack).
[005]	Layer	Stone pier (ST6694372829) (see Figure 2).
[006]	Layer	Demolition layer above [004] (see Figure 2).
[007]	Layer	Dumped layer above [005] (see Figure 2).
[008]	Layer	Make-up layer below building. Contains some tap slag (see below).
[009]	Layer	Mortar floor (see Figure 3). Dilute HCl confirms the presence of carbonate.
[010]	Layer	Mortar floor (with crushed brick) (see Figure 4). Dilute HCl confirms the presence of carbonate.
[011]	Layer	Mortar floor (see Figure 3). Dilute HCl confirms the presence of carbonate.
[012]	Layer/inclusion	Mauve coloured deposit rich in zinc and zinc compounds (within [013])
[013]	Layer	Large deposit of clinker (ST6690072832)

Figure 1. Context [002]

Figure 2. Contexts [004], [005], [006] and [007]

Figure 3. Contexts [009], [010] and [011]

Figure 4. Contexts [012] and [013]

List of samples

Samples were taken from a selection of contexts in order to help understand how and when the contexts were formed.

Table 2. Details of samples taken for detailed examination and analysis

Lab No.	Context	Description
01	[001]	Slag brick used to cap culvert
02	[002]	Copper slag brick fragment
03	[002]	Clinker
04	[002]	Copper slag brick fragment
05	us	Refractory (zinc retort?)
06	[008]	Tap slag
07	[008]	Tap slag
08	[012]	Zinc-rich deposit (tough)
09	[012]	Zinc-rich deposit (friable)
10	[013]	Clinker
11	[013]	Clinker

Methods

All of the contexts were examined in the field and samples collected from some of these. These were examined visually, including with low-powered microscopes, and in most cases qualitatively analysed using energy dispersive x-ray spectrometry to identify the range of elements present (this technique cannot identify organic components and provides no information about speciation, eg whether zinc is present as a metal, as an ore or as a corrosion product). In addition, a simple flame test was used to confirm the coal was coal and dilute hydrochloric acid (HCl) was used to identify the presence of carbonate in the calcium-rich samples.

Some samples were mounted in epoxy resin and polished to expose cross-sections. These cross-sections were examined using a scanning electron microscope (SEM). Further chemical analyses were performed using an energy dispersive x-ray spectrometer attached to the SEM (SEM-EDS for short).

Examination of the copper slag

The three samples of copper slag (the capping from the culvert/drain [001] and two samples from [002] all shared very similar characteristics and are dealt with together. The slag is an iron-calcium-aluminium-silicate slag typical of the post-medieval period. It contains two types of inclusions which may shed light on the sorts of process that produced it, namely silica polymorphs (SiO_2) and copper/iron/zinc sulphides (Figure 5). The presence of the sulphide inclusions suggests that it was principally sulphide ores that were being smelted. This is in agreement with the documentary evidence which suggests that the Bristol copper smelting industry principally used sulphide ores from Cornwall (Day 1973; Percy 1861). Quartz, and some lime, were commonly added to Cornish copper ores during the smelting process to help produce the slag. The presence of zinc in this slag is unexpected as zinc is not usually found in Cornish copper ores (see Appendix for chemical composition). It is possible that the Warmley copper smelters blended ores from different sources; it is known that they obtained some copper ores from North America.

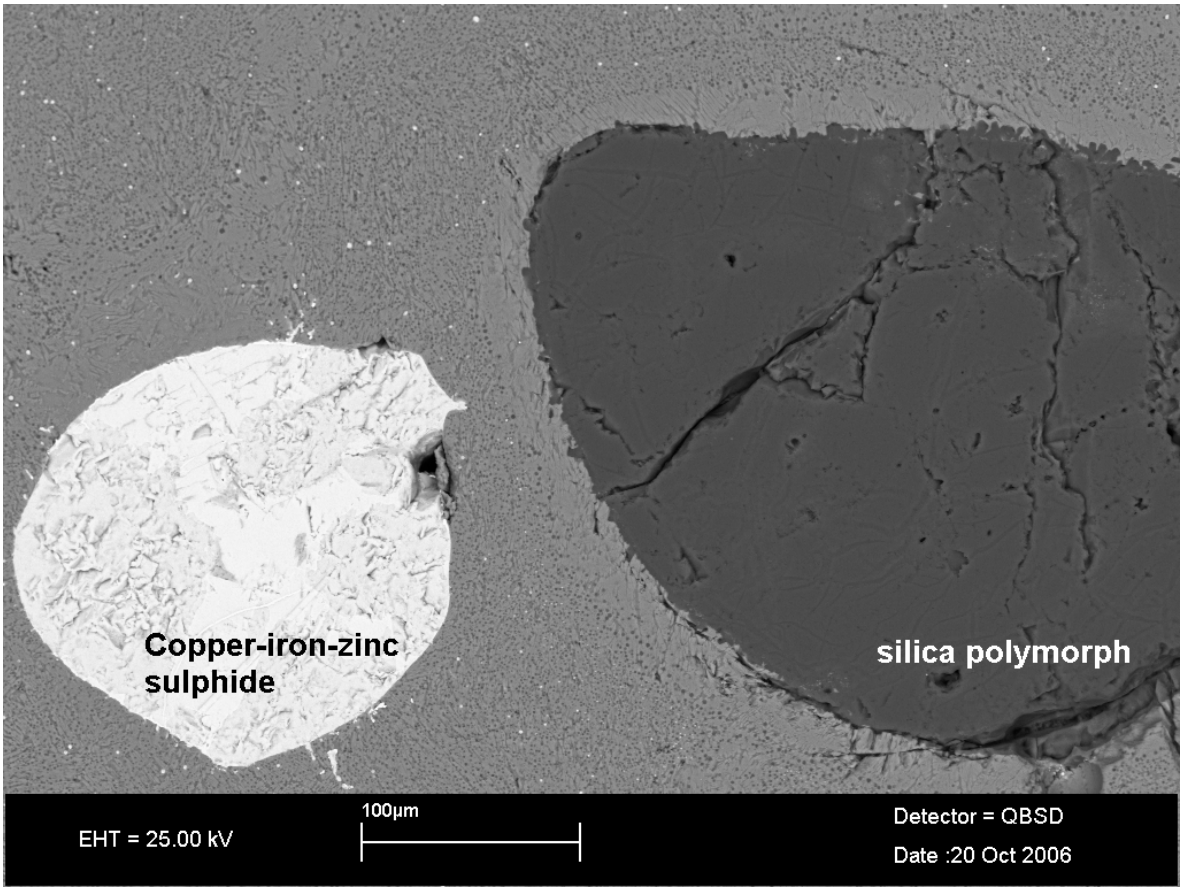


Figure 5. SEM photograph of sample 01 (copper slag block from culvert [001]).

Examination of the tap slag

The two samples of tap slag from the make-up layer below the large building have compositions and microstructures (see Figure 6) which correspond to bloomery iron slags (Morton and Wingrove 1969; 1972). The closest parallels are the bloomery slags from the Forest of Dean Carboniferous and Bristol–Mendip area (Paynter 2006): these slags were clearly produced in the region. The bloomery iron smelting process originates in the Iron Age and continued to be employed in England until the 18th century, however, it started to decline from the early 15th century with the introduction of the blast furnace. It is likely that this bloomery slag was produced long before Champion moved to Warmley and is probably residual in this context.

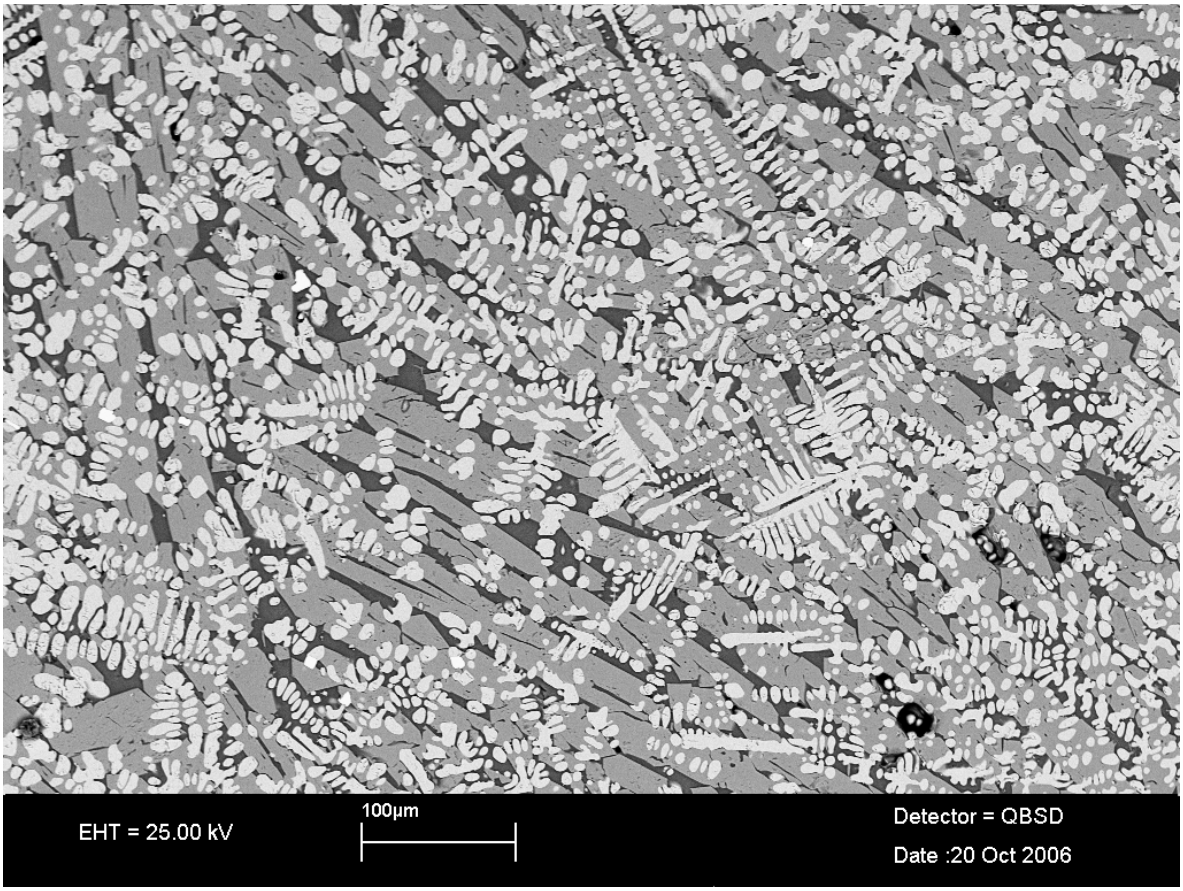


Figure 6. SEM photograph of sample 07 (tap slag from [008]).

Examination of the zinc-rich deposit in [013]

This is a complex deposit, containing droplets of metallic zinc (0.01–2mm in diameter), fragments of coal, fragments of charcoal and fragments of refractory material, in a zinc compound matrix. The nature of the zinc compound forming the matrix is uncertain, however, no sulphur was detected and so it is not zinc sulphide ore. The metallic zinc droplets are in many cases very small and finely dispersed throughout the material. It is possible that this material is the 'residuum' left inside a zinc-smelting retort mentioned by Percy (1861, 558).

Figure 7. SEM photograph of sample 09 (zinc-rich material from [012]).

Flame and HCl tests

Context [004] (see Figure 2) appeared in the field to be composed almost entirely of small fragments of coal and coal dust. This was confirmed by exposing samples to a flame: the coal burnt.

Contexts [009], [010] and [011] appeared in the field to be mortar floor surfaces (see Figure 3). Qualitative analysis showed a high calcium content in each case. Samples from each context were tested by adding small amounts of dilute hydrochloric acid. In each case the samples bubbled vigorously indicating the presence of calcium carbonate. Therefore these floor surfaces can be described as lime mortar floor surfaces.

Examination of unstratified refractory

An unstratified fragment of refractory material was identified as deriving from either a brass cementation crucible or a zinc retort (figure 8). This is approximately 48mm thick (not including the vitrified layers on both surfaces),

which would be more in keeping with a zinc-smelting retort than a brass cementation crucible. The vitrification of the outer surface resembles that seen on the exterior surface of crucibles used in the coal-fired glass industry (eg Dungworth 2003), and is probably due to the action of coal fumes and ash (with some zinc vapour). The vitrification on the exterior surface is heterogeneous and vesicular. The chemical composition (see appendix) and microstructure, eg presence of zinc-aluminium spinels, of the ceramic core are similar to those reported by Freestone (1988). The absence of copper (see appendix) indicates that this is a fragment of a zinc smelting retort rather than a brass cementation crucible. The vitrification on the interior surface contains a variety of phases and may be the 'residuum' left after zinc smelting (Percy 1861, 558).

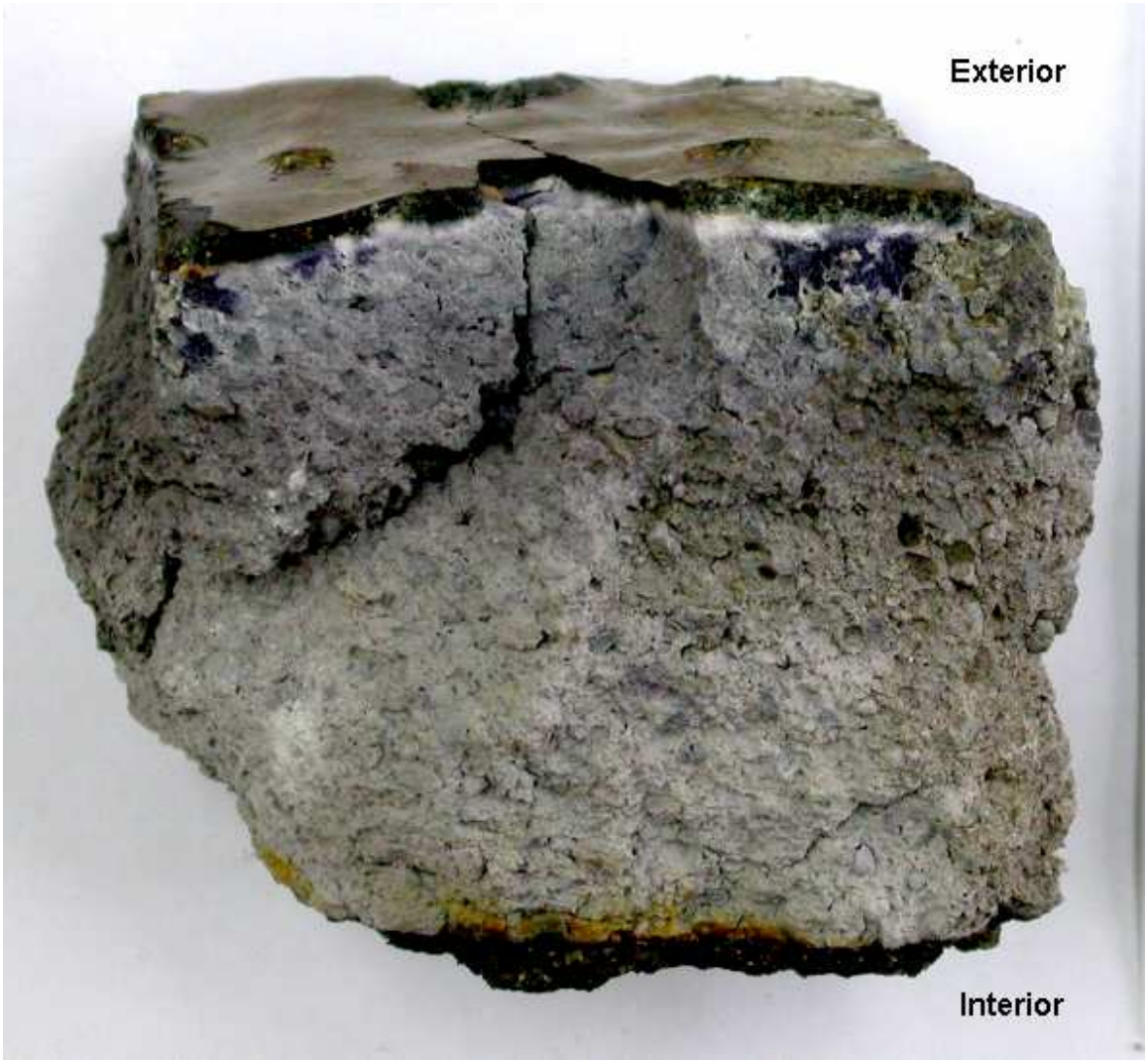


Figure 8. Unstratified refractory material (sample 05)

Discussion/Conclusions

The scientific examination of material recovered from Warmley brass works can be used to help understand the features and contexts recorded in the field.

The fragment of a probable zinc smelting retort provides tangible evidence for Champion's process. Physical evidence for this process is virtually unknown. It is unfortunate that this fragment was not archaeologically recovered. The physical evidence for the early zinc smelting process merits further investigation.

The series of floor surfaces within the building or structures exposed at approximately ST6694372829 were made using lime mortar which would not survive being exposed to temperatures in excess of 870ºC. Brass cementation required temperatures slightly in excess of 900ºC (and the other processes higher temperatures), therefore the structures were unlikely to have been used for copper smelting, zinc smelting or brass cementation.

The extensive layer of slag and clinker [002] appears to represent dumping of waste material from the mid to late 18th-century copper smelting. The presence of slag and clinker in the same context is entirely to be expected from smelting in a reverberatory furnace. The microstructure of the slag is largely that to be expected from smelting Cornish copper ores. The chemical composition is close to that expected but the presence of zinc is unexpected and merits further investigation. The fact that this context contains slag and clinker with little or no other material or sediment suggests that it is not a re-worked deposit and that it represent 18th-century activity (probably c.1747 to 1761).

The zinc-rich material recovered from [012] has no known published parallels. It is certainly related to zinc smelting but the exact processes which generated this material are unclear and should be further investigated.

References

Berg, T & Berg, P (eds) 2001 *R R Angerstein's Illustrated Travel Diary, 1753–1755*. London: Science Museum

Day, J 1973 *Bristol Brass. The history of the industry*. Newton Abbot: David and Charles

Day, J 1988 'The Bristol brass industry: furnace structures and their associated remains'. *Historical Metallurgy* **22**, 24–41

Day, J 1991 'Copper, zinc and brass production', *in* J Day and R F Tylecote (eds) *The Industrial Revolution in Metals*. London: Institute of Metals, 131–199

Freestone, I 1988 'Appendix 1. Report on the examination of blue material from industrial remains at Warmley', *in* Day 1988, 37–38

Morton, G R and Wingrove, J 1969 'Constitution of bloomery slags, part 1: Roman'. *Journal of the Iron and Steel Institute* **207**, 1556–64

Morton, G R and Wingrove, J 1972 ‘Constitution of bloomery slags, part 2: medieval’. *Journal of the Iron and Steel Institute* **210**, 478–88
Percy, J 1861 *Metallurgy. Fuel; Fire-clays; Copper; Zinc; Brass; Etc*. London: John Murray

Appendix: SEM-EDS analyses

For information about the sample numbers see Table 2 above

	01	02	04	05 inner	05 ceramic	05 outer	06	07
Na_2O	<0.5	<0.5	0.8	0.8	1.2	2.5	<0.5	<0.5
MgO	0.6	0.6	0.4	0.5	0.3	0.6	0.5	0.7
Al_2O_3	7.3	6.9	5.0	19.2	15.9	18.5	5.6	4.2
SiO_2	47.3	45.6	45.5	65.9	69.6	58.9	27.6	21.6
P_2O_5	<0.2	<0.2	<0.2	<0.2	<0.2	0.6	<0.2	0.4
SO_3	2.0	2.3	<0.2	0.2	<0.2	<0.2	<0.2	<0.2
K_2O	0.9	0.5	0.3	3.5	0.5	5.0	1.7	1.3
CaO	8.9	10.6	15.7	1.7	0.2	1.3	2.6	1.4
TiO_2	0.2	0.2	0.3	1.1	1.1	0.9	0.2	0.2
MnO	0.2	<0.1	0.2	0.2	<0.1	<0.1	<0.1	0.1
FeO	24.8	27.9	26.4	4.8	1.2	5.8	61.8	70.1
CuO	0.3	0.7	0.4	<0.1	<0.1	<0.1	<0.1	<0.1
ZnO	6.0	4.7	5.0	2.1	10.0	5.9	<0.1	<0.1
As_2O_3	1.1	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
SnO_2	0.4	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5

Appendix 3
OASIS Form

OASIS DATA COLLECTION FORM: England

List of Projects | Search Projects | New project | Change your details | HER coverage | Change country | Log out

Printable version

OASIS ID: centrefo1-21588

Project details	
Project name	Warmley Brassworks Scheduled Ancient Monument, Siston, Bristol
Short description of the project	Unauthorised machining had created a large section (c. 88m east-west) through an area of the Champion Brasswork factory (SAM 28518), and recording of the section was requested by the county archaeologist and English Heritage. This was undertaken in a single day by members of English Heritage's Archaeological Projects team. Two post-medieval buildings and a culvert were exposed that are very likely associated with the factory. Scientific analysis of several samples removed from the site is ongoing, and is expected to inform further on the processes utilised in the factory.
Project dates	Start: 13-10-2006 End: 13-10-2006
Previous/future work	No / Not known
Any associated project reference codes	28518 - SM No.

Type of project	Field evaluation
Site status	Scheduled Monument (SM)
Current Land use	Industry and Commerce 1 - Industrial
Monument type	BRASSWORKS Post Medieval
Methods & techniques	'Annotated Sketch','Photographic Survey','Survey/Recording Of Fabric/Structure','Visual Inspection'
Development type	reported damage to monument
Prompt	Parts 1 and 3 of AMAA Act 1979
Position in the planning process	Not known / Not recorded

Project location

Country	England
Site location	SOUTH GLOUCESTERSHIRE SOUTH GLOUCESTERSHIRE SISTON Warmley Brassworks, Siston
Study area	1000.00 Square metres
Site coordinates	ST 366927 172821 50.9509435972 -2.901348191440 50 57 03 N 002 54 04 W Point

Project creators

Name of Organisation	Central Archaeology Service
Project brief originator	English Heritage/Department of Environment

Project design originator	English Heritage Archaeological Projects
Project director/manager	Stabler, Kim
Project supervisor	Stabler, Kim
Type of sponsor/funding body	English Heritage

Project archives	
Physical Archive Exists?	No
Paper Archive recipient	Bristol City Museum and Art Gallery
Paper Media available	'Context sheet','Drawing','Matrices','Photograph','Report','Section'

Entered by	Kim Stabler (kim.stabler@english-heritage.org.uk)
Entered on	19 December 2006

OASIS:

Please e-mail English Heritage for OASIS help and advice

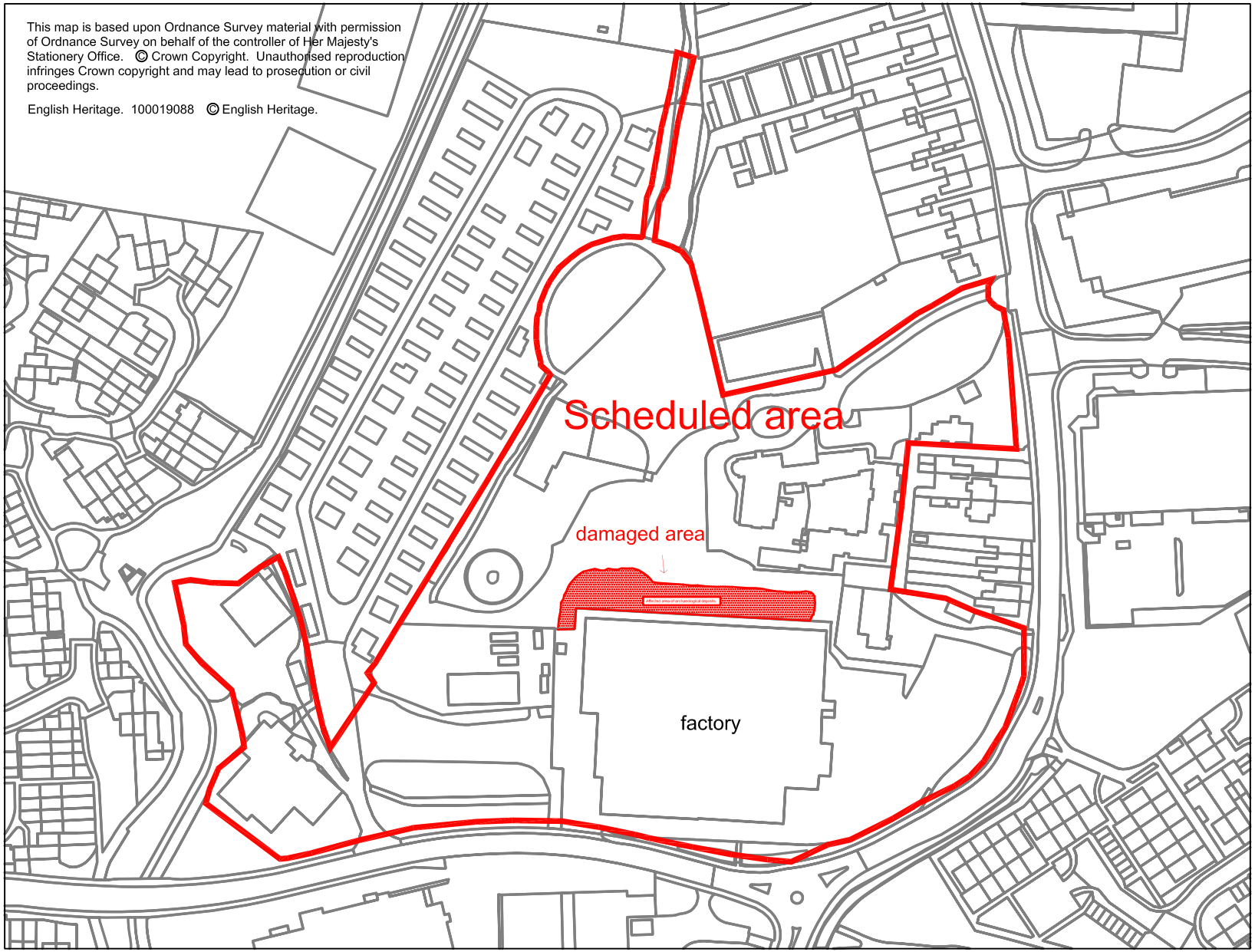


Fig 1: SAM and site location showing affected area.

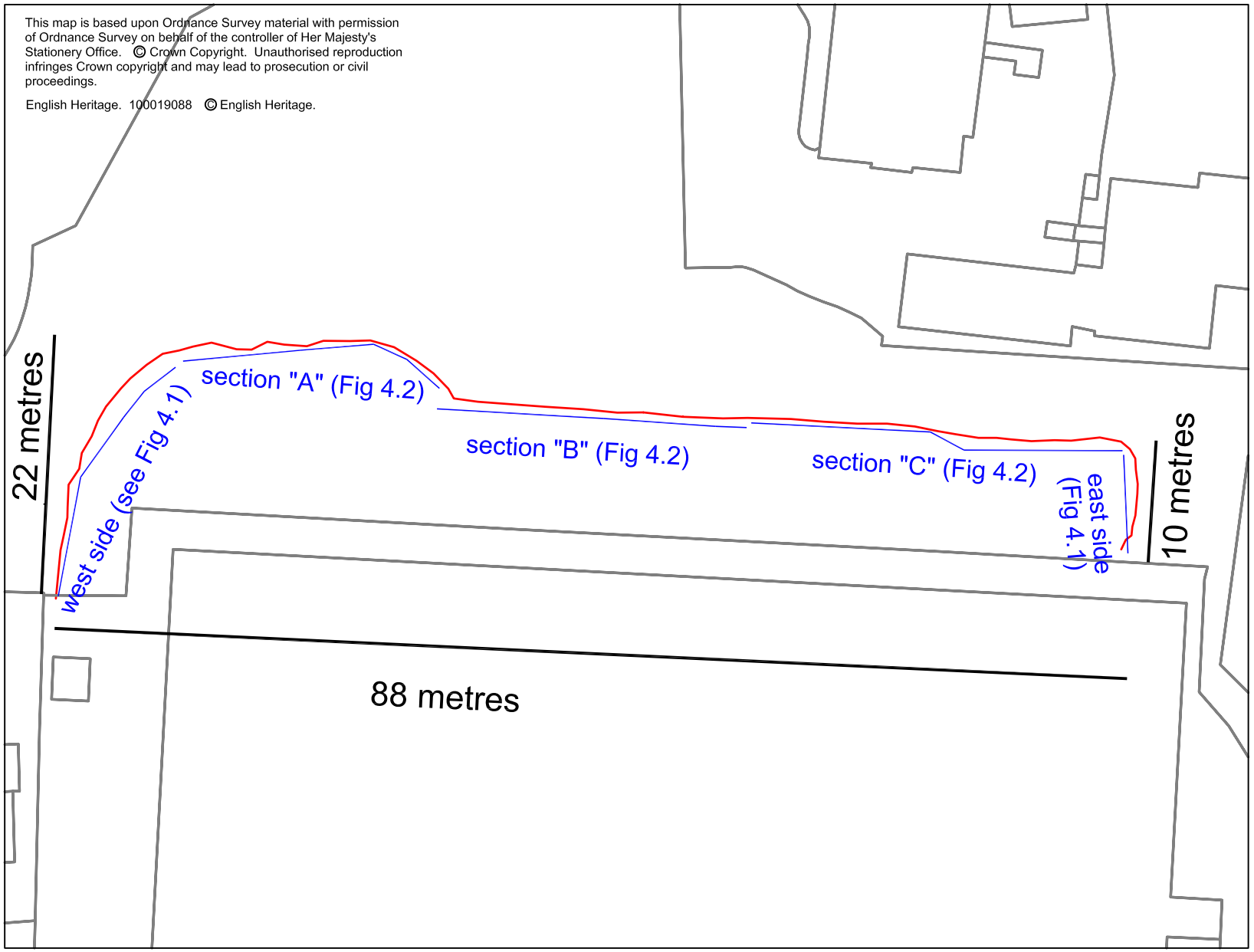


Fig 3: Locations of photomosaics in Figs 4.1 and 4.2.

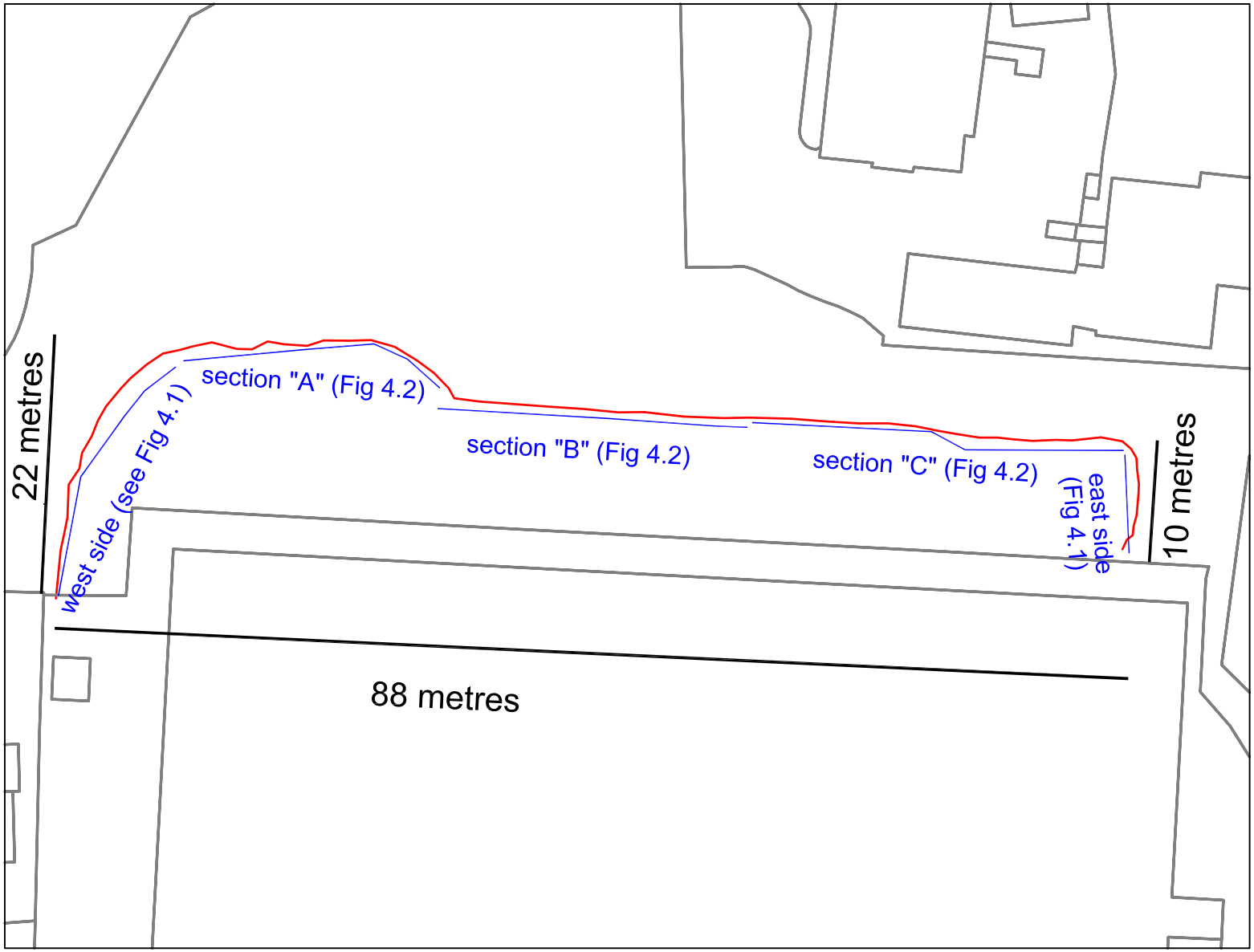
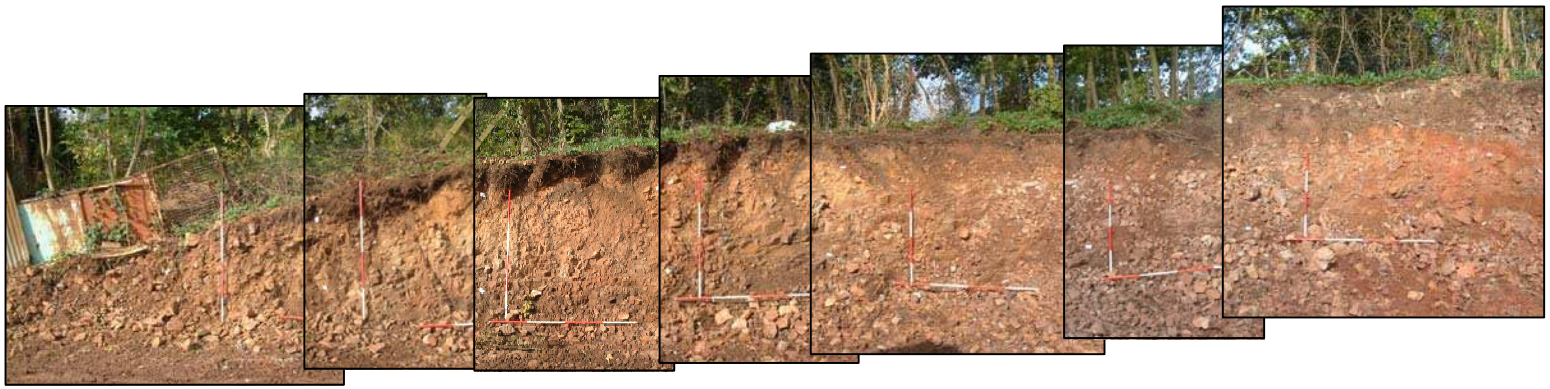


Fig 3: Locations of photomosaics in Figs 4.1 and 4.2.

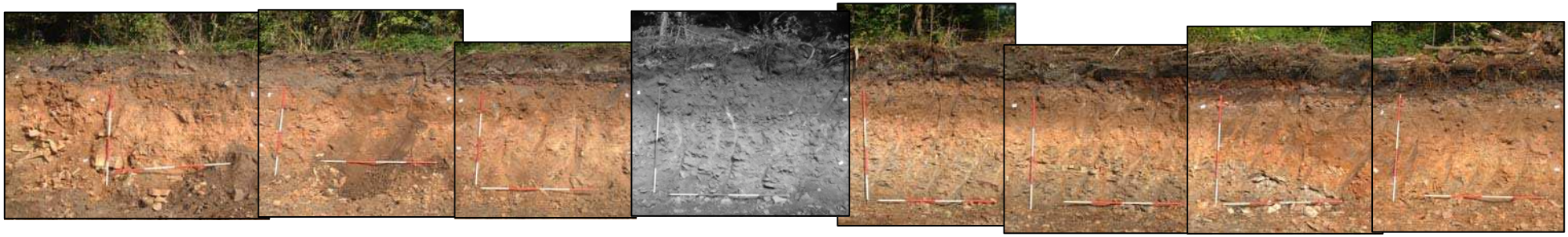


West side of site

East side of site

Fig 4.1: Photomosaics of east and west elevations of site.

Section "A" on plan (Fig 3)



Section "B" on plan (Fig 3)

Section "C" on plan (Fig 3)

Fig 4.2: Photomosaic of north side of site in elevation.

Figure 5: Detail of culvert

Figure 6: Western building, showing damage and timber debris

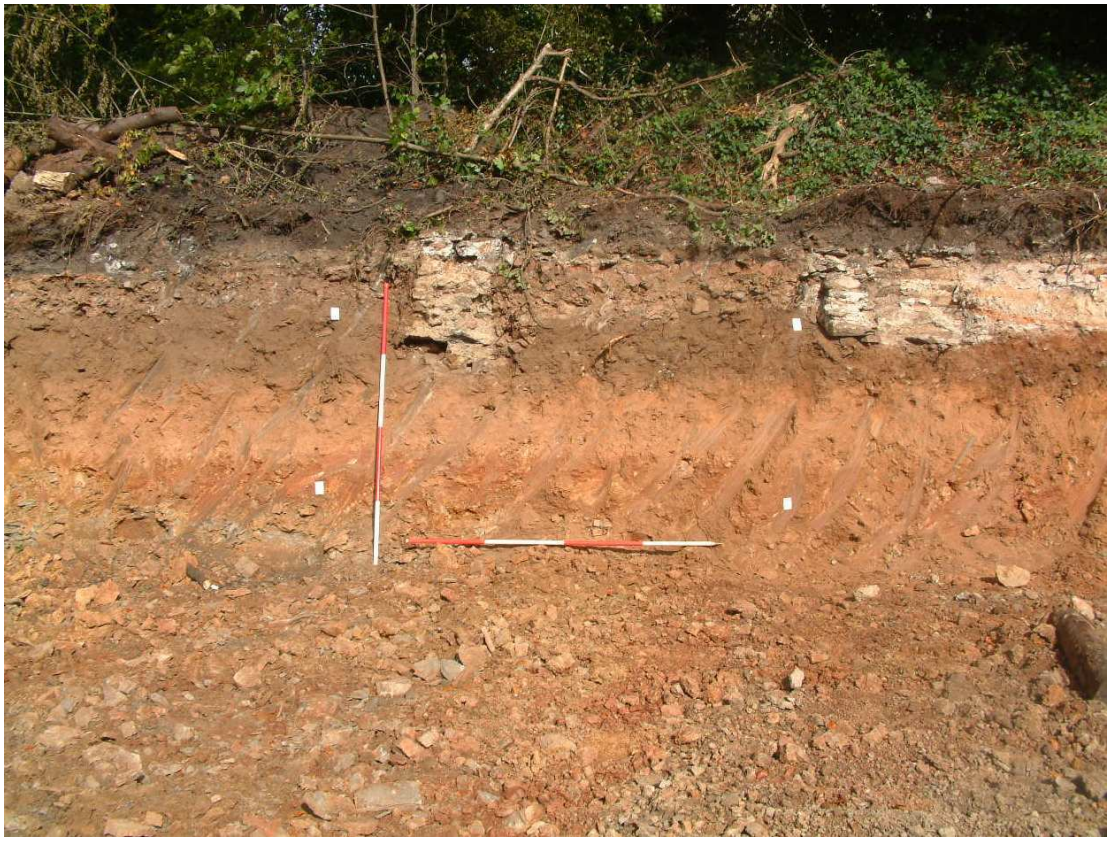
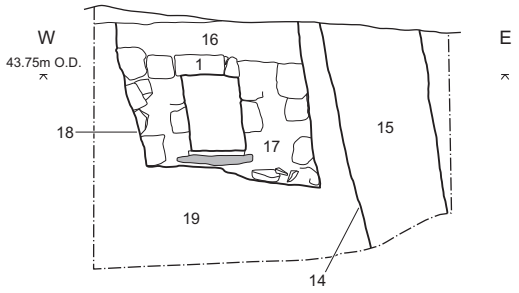


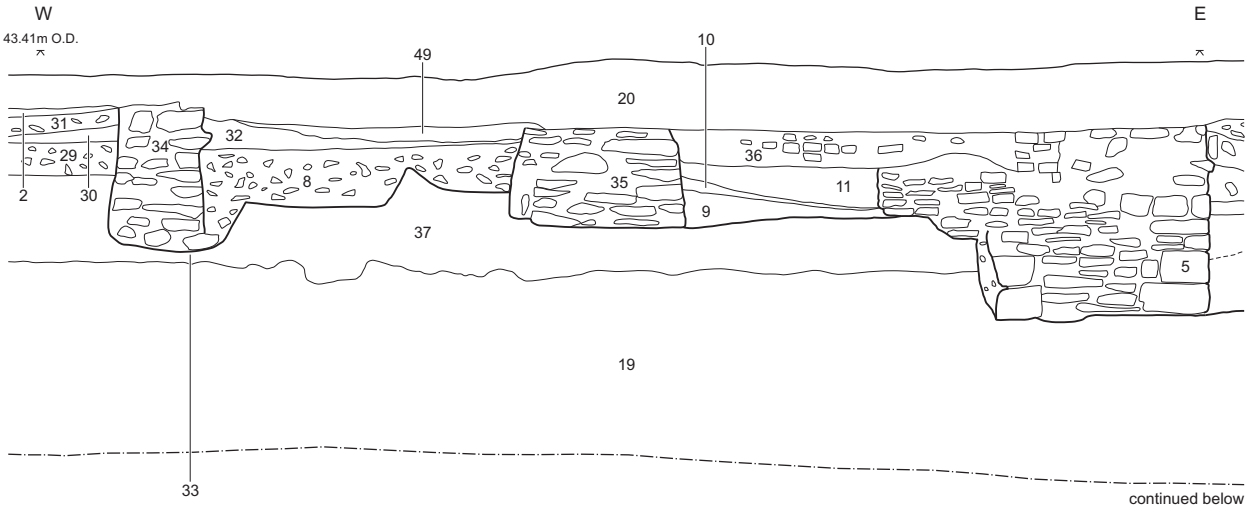
Figure 7: Eastern building (western range)

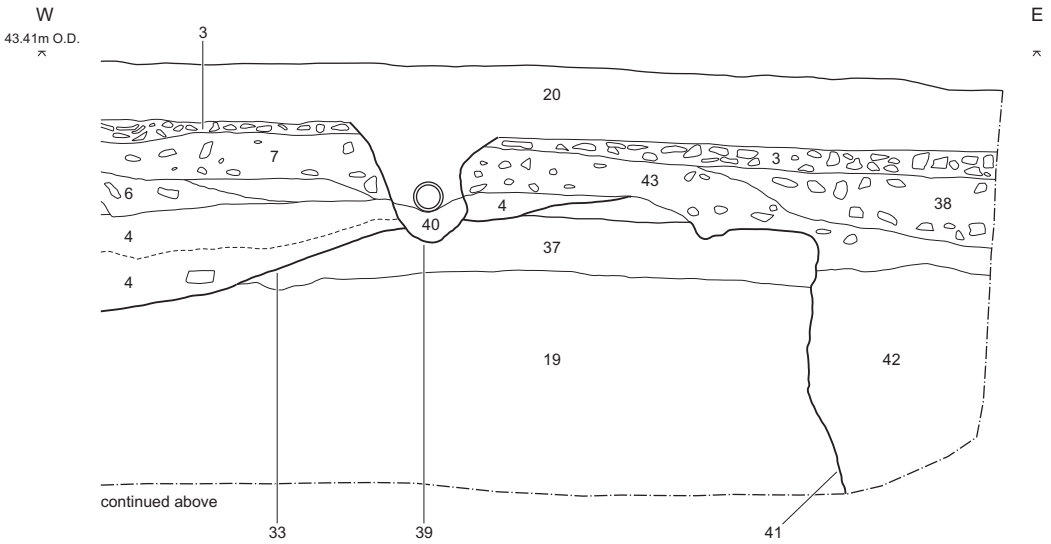
Figure 8: Eastern building (eastern range)

Section 1

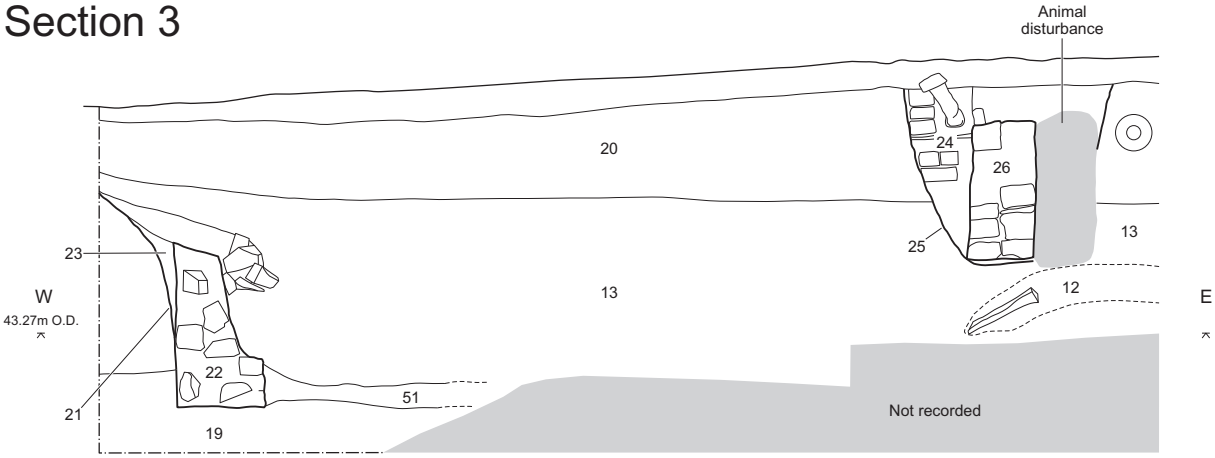


Section 2

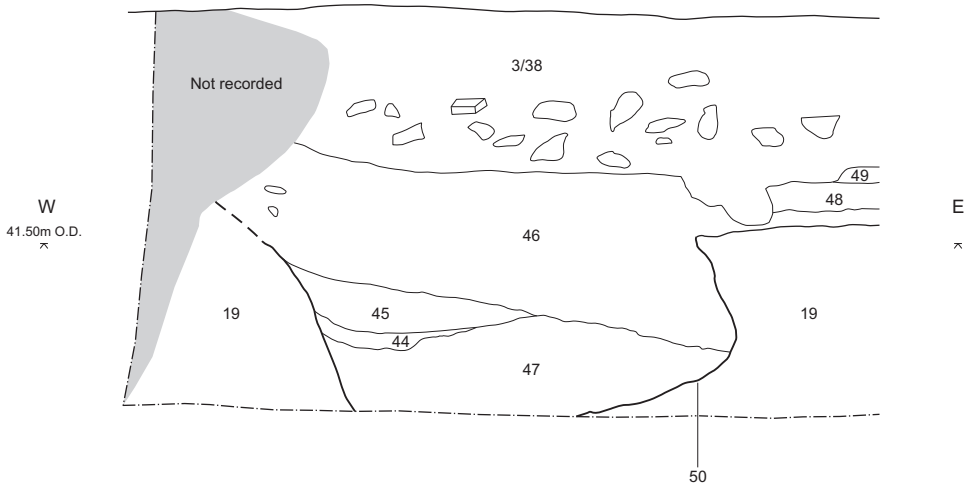




Section 3



Section 4



Section 5