The University Of Sheffield.

Biwater, Clay Cross, Derbyshire

Archaeological Watching Brief and Mitigation

ARCUS report 1114d.2(2)

July 2009

Client: Maximus Ltd./Cavendish Estates

ARCUS

Biwater, Clay Cross

Grid Reference: NGR SK 4001 6431

Archaeological Watching Brief and Mitigation

Assessment Report No. 1114d.2(2)

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Client: Maximus Ltd (watching brief); Cavendish Estates (mitigation)

Client address: c/o Scott Wilson Ltd, West One, Wellington Street, Leeds, LS1 1BA

Location of archive: Weston Park Museum

Planning reference: NED/06/01334/OL; Planning consent received for redevelopment

Checked by:	Passed for submission to client:
Date: 27/7/09	Date:27/7/09
Neil Dransfield *Project Archaeologist*	Richard O'Neill *Project Manager*

OASIS SUMMARY FORM

PROJECT DETAILS		
OASIS identifier	Arcus2-55754	
Project title	Biwater, Clay Cross	
Short description of the project	The watching brief was required to comply with the planning condition placed upon planning approval for the site. The scope of works consisted of a prolonged sequence of demolition and remediation of the standing buildings pertaining to the Biwater Works, formerly the Clay Cross Works. The results of the watching brief identified the survival of sub-surface archaeological remains pertaining to the Clay Cross Works. This led from the generalised watching brief to a phase of mitigation areas, targeted specifically to provide a greater quantity of detailed information regarding the structures originally exposed during the watching brief. In January 2009, ARCUS were commissioned by Cavendish Estates to undertake mitigation in advance of demolition in order to effect coal extraction. The specific mitigation areas corresponded to some of the focal points for industrial activity on the site: the main foundry building or 'Big Shop' (area 1), coke ovens (area 2), the gasworks (area 3) and blast furnaces (area 4). This interim report is a brief outline of the results of the watching brief and the concomitant phase of mitigation.	
Project dates	23-10-08 to 30-01-09	
Previous/future work	Buildings appraisal	
Monument type and period	19th century Iron Works beehive ovens, gasworks.	
Significant finds (artefact type and period)	Victorian metalwork, glass.	
PROJECT LOCATION		
County/Parish	Derbyshire	
Site address	Biwater Works, Clay Cross, Derbyshire	
Site co-ordinates	NGR SK 4001 6431	
Site area	24.07 ha	
Height OD	110.53m AOD-101.01m AOD	
PROJECT CREATORS		
Organisation	ARCUS	
Project brief originator	Derbyshire County Council	
Project design originator	WSP/Scott Wilson	
Project supervisor	Richard Jackson	
Project manager	Richard O'Neill	
Sponsor or funding body	Maximus Ltd/Cavendish Estates	
PROJECT ARCHIVES		
Archive Type	**Location/Accession no.**	**Content (e.g. pottery, metalwork, etc)**
Physical	Weston Park Museum	Pottery, glass, metalwork
Paper	Weston Park Museum	report, context sheets, plans, sections,
Digital	Derbyshire HER	pdf copy of report
BIBLIOGRAPHY		
Title	Archaeological Watching Brief and Mitigation, Biwater, Clay Cross, Derbyshire.	
Report no	1114d.2(2)	
Author	Richard Jackson, N.Dransfield	
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CONTENTS

LIST OF ILLUSTRATIONS AND PLATES

Illustrations

Plates

NON-TECHNICAL SUMMARY

In October 2008, ARCUS were commissioned by Maximus Ltd to undertake an archaeological watching brief on a site at the former Biwater Works, Clay Cross, Derbyshire, (SK 400 643). The watching brief was required to comply with the planning condition placed upon planning approval for the site. The scope of works consisted of monitoring the prolonged sequence of demolition and remediation of the standing buildings pertaining to the Biwater works, formerly the Clay Cross Works.

The results of the watching brief identified the survival of sub-surface archaeological remains pertaining to the Clay Cross Works. This led to a phase of mitigation trenches, targeted specifically to provide a greater quantity of detailed information regarding the structures originally exposed during the watching brief.

In January 2009, ARCUS were commissioned by Cavendish Estates to undertake mitigation in advance of remediation in order to effect coal extraction.

The specific mitigation areas corresponded to some of the focal points for industrial activity on the site: the main foundry building, or 'Big Shop' (Area 1), coke ovens (Area 2), the gasworks (Area 3) and blast furnaces (Area 4).

This assessment report is intended to elaborate upon the results of the interim report, and should be read in conjunction with the interim.

1 INTRODUCTION

1.1 Scope of Report

This report presents the results of an archaeological watching brief and mitigation works on the site of the Biwater Works, Clay Cross, Derbyshire. This was required by Derbyshire County Council as a condition of planning consent on an application for redevelopment at the site (Planning reference: NED/06/01334/OL). The works were undertaken in line with North East Derbyshire Local Plan policy BE6 and BE7-BE10, and with the government's planning guidelines set down in PPG16 (1990). A project design was prepared for the watching brief (WSP 2008), based on a brief provided by Steve Baker (Development Control Archaeologist, Derbyshire County Council). A project design for the mitigation trenching was prepared by Scott Wilson (2008) and agreed by Steve Baker and Dave Barrett (Derbyshire County Archaeologist). ARCUS were commissioned by Maximus Ltd to undertake the watching brief and by Cavendish Estates to undertake the mitigation excavation.

1.2 Site Location

The site (centred on NGR SK 400 643), is located in North East Derbyshire, between the small villages of Clay Cross to the south and North Wingfield to the north. The site lies on the western flank of the valley formed by the River Rother (**Illustration 1**).

The underlying geology consists of coal measures across the majority of the southern half of the site and sandstone in the northern apex, between the converging railway lines.

1.3 Archaeological & Historical Background

The history of Clay Cross, as with many small villages in the industrial hinterland of Derbyshire and South Yorkshire, is closely bound to the development of adjacent industry, in this case the Clay Cross Works. The excavation of a nearby tunnel for the North Midland Railway line in 1837 by George Stevenson (1781-1848) exposed extensive deposits of coal deemed of a suitable grade for coke production. This discovery led to the purchase of surrounding land by George Stephenson and Company in 1839. By 1845, 10% of all coal supplied to London originated from the Clay Cross Collieries. Deposits of iron ore were found locally under similar circumstances, although sources of the ore were sought from locations further a field as smelting and casting activities increased in intensity. Coal and coke from the Clay Cross Works were exported all over the country providing fuel for a myriad of industrial processes, including fuel for the locomotive engines of the time. Iron working commenced on the site in 1846. The concern was then managed by Stephenson's son, Robert, following the death of George Stephenson in 1848. Robert held the largest share in the company at the time, but his directorship of the company was short-lived. He severed his connections with the company in 1851, citing a conflict of interests between the Company and Robert Stephenson's railway holdings. It may be inferred that Robert Stephenson sold his shares to Samuel Morton Peto, who acquired a ten-twelfth share in the company at the same time. It is at this point that the company name was changed to The Clay Cross Company.

Although the Stephenson name was instrumental in assembling the investors and the original board of directors, it was under Peto's longer chairmanship that the Clay Cross Company expanded and diversified, and was able to continue as a competitive supplier to a burgeoning global market for at least a century. Although it is easy to look back upon these men in the flattering light of their successes, it is important to

remember that investors such as those of the Clay Cross Company were ploughing world-changing amounts of money into an effectively untried industry; there was no substantial rail network in this country before 1830, and each new line required a separate act of parliament before the colossal problems of engineering and maintaining such systems could be addressed. Creating a national rail network was on the verge of being prohibitively expensive. One particular period of expansion, the so-called 'railway mania' of 1844-47, tied up so much capital that it significantly contributed to the national economic calamity of 1847.

2 AIMS AND METHODOLOGY

2.1 Aims and Objectives (Watching Brief)

The general aim of the watching brief was to determine, as far as reasonably possible, the location, extent, nature and significance of surviving archaeological remains within the area affected by the development.

The specific aims of the watching brief were:

- to identify, and, where possible, characterise archaeological remains associated with the Clay Cross Works;
- to assess the extent of damage to archaeological deposits caused by modern development;
- to assess the requirements for any further archaeological mitigation.

2.2 Watching Brief Methodology

All site work was carried out in accordance with the methodology outlined in the written scheme of investigation (WSP 2008). This was based on a brief issued by Steve Baker, Derbyshire DCA. The work was carried out in accordance with IfA guidelines (2008a), health and safety regulations (SCAUM 2007) and current industry best practice.

The scope of the watching brief consisted of ARCUS monitoring DSM demolition activities. All buildings, with the exception of the powerhouse, were demolished to ground level. Concrete floor slabs within the building footprint were then removed to allow the monitoring archaeologists to inspect the exposed surface for archaeological remains. In the absence of any apparent sub-surface structures, no further monitored excavation was undertaken. In areas where further sub-surface structures were present, further monitored excavation was undertaken to a maximum depth of 2m in order to remove foundations, ring beams and stanchions.

Where possible, a full written, drawn and photographic record was made of all features and deposits within the excavated areas. Observed structures were geo-referenced using GPS and Total Station instruments. The recording and finds collection was undertaken following the strategy agreed in the written scheme of investigation (WSP 2008).

2.3 Aims and Objectives (Mitigation)

The general aims of the mitigation were to determine the extent, nature and significance of surviving archaeological remains within the area affected by the development, as identified during the preliminary watching brief stage (**Illustration 2**).

The area-specific aims of the mitigation were:

Area I (Foundry Hall)

- to establish the chronological relationships of archaeological structures and deposits;
- to identify the form and character of any pipe pits observed within the confines of the foundry hall;
- to identify the industrial processes, products, by-products and residues of the foundry processes;
- to identify how the processes used fitted in with the overall operation of the works.

Area II (Beehive Kilns)

- to establish the chronological relationships of archaeological structures and deposits;
- to identify the form of the beehive kilns and the presence of associated flues;
- to identify the industrial processes, products, by-products and residues of the coking process;
- to identify how the processes used fitted in with the overall operation of the works;
- to enhance knowledge about the coking process in the East Midlands.

Area III (Gas Works)

- to establish the chronological relationships of archaeological structures and deposits;
- to identify the form and character of the gas works;
- to further assess the gas retort chamber and associated ovens/ash pits.

Area IV (Circular structures to the south of the foundry)

- to determine the presence of the structures depicted on the 1881 Ordnance Survey map;
- to assess the level of survival of any structures encountered.

2.4 Mitigation Methodology

All site work was carried out in accordance with the methodology outlined in the project design (Scott Wilson 2008). The project design was agreed by Steve Baker, Derbyshire DCA. The work was carried out in accordance with IfA guidelines (2008b), health and safety regulations (SCAUM 2007) and current industry best practice.

The scope of the works entailed four targeted areas of excavation. The location of these was informed by the results of the watching brief and subsequent consultation with the DCA. The locations of Area II and Area III were heavily influenced by the watching brief results, which had established the high potential for sealed sub-surface archaeological structures pertaining to the Clay Cross Works. Area IV was selected for mitigation to address the survival of structures which had not been exposed during the watching brief, but were considered appropriate for mitigation due to the key role of the operation of blast furnaces at the Clay Cross Works. Area I was mitigated because it was the focal area for one of the major, if not key industrial processes undertaken within the site.

The excavation areas and all features were planned by hand, with the exception of the

gasworks and structures in Area III which were geo-referenced using GPS and Total Station instruments as appropriate. The recording and finds collection was undertaken following the strategy agreed in the project design (Scott Wilson 2008).

2.5 Fieldwork Programme

The project was managed by Richard O'Neill. The watching brief was undertaken between October and December 2008, by Neil Dransfield, Chris Harrison, Richard Jackson, Susie Matthewson and Chris Swales. Mitigation excavation was undertaken between 5th January 2009 and 30th January 2009 by Matt Copley, Phil Roberts, Tim Cobbold, Adam Tinsley, Helen Holderness, Joanna Debska, Sam Fairhead, John Haworth, Lucy Dawson and James Thompson, Neil Dransfield (Project Archaeologist) and Richard Jackson (Supervisor).

3 RESULTS

3.1 Watching Brief Results

The watching brief results are discussed in accordance with the numbering scheme initialised during the buildings recording phase (ARCUS 2007). Context numbers were ascribed according to relevant buildings numbers; for example, context numbers pertaining to Building 5 ran in sequence commencing with [5000].

3.1.1 Building 5

Monitored activities in this area entailed demolition of the standing building followed by slab removal. The underlying material comprised a loose black sand deposit [5000], which was homogenous and extensive across the exposed footprint of Building 5. The only irregularity observed within [5000] comprised a clast of pale yellow sand [5001], which was interpreted as a dumping or tipping event preceding the instatement of the slab floor in Building 5. Contained within [5001] were several fragments of concrete with impressed fragments of early 20th-century ceramic fragments (**Plate 1**) of a wide variety of styles. As there is no evidence as to the original location of this strange conglomeration of ceramic, the interpretation surrounding the deposition remains problematic. The recovered material was not attached to any *in-situ* structures, so therefore may be interpreted as deliberate deposition before the instatement of the concrete slab floor.

3.1.2 Building 19

The removal of the concrete pad within the footprint of Building 19 revealed modern dipping tanks. No further work in this area was warranted.

3.1.3 Building 22

In-situ structures relating to the Gas House (Building 22) were initially identified during the watching brief (**Plate 2**) and investigated further during mitigation works (Area III). In brief, the structures characterised during the watching brief comprised a flue channel [22016] and railway [22009] which facilitated the operation of the gas retort. This was the central operating device of the original gasworks; it is within the retorts that the coal was heated to produce gas, which was then purified and transferred to larger vessels for storage. The remnants of these structures were sealed *in–situ* by approximately 2m of made ground and demolition overburden.

3.1.4 Building 23

Archaeological monitoring within the footprint of Building 23 was limited to observation of concrete slab removal. Upon removal of the slab, the underlying made

ground deposit [23002] was inspected for any further evidence of sub-surface structures, and was interpreted as archaeologically sterile.

3.1.5 Building 31

Upon removal of the concrete slab covering the footprint of Building 31, a series of archaeological structures were observed (**Illustration 3**). The preservation had been compromised by the insertion of a series of concrete stanchion bases, which were removed as part of the ground works scheme before archaeological works commenced. The archaeological structures were only recorded once the demolition works had been competed. In general, the state of preservation beneath the concrete slab in Building 31 was poor, and many of the relationships between structures had been compromised. A small surviving segment comprised a series of square structures [31029], [31028] and [31030] constructed from cast iron plates. Each plate measured 0.56m x 0.1m x 1.2m, and was bolted in place to form a box structure. The iron structures were aligned in a row orientated east-west, with a 2.2m interval between each structure.

The south edges of these structures butted a substantial concrete block [31031], which measured 5.8m (east-west) by 3.4m (north-south) by 1.2m deep. Affixed to the upper surface of [31031] were two iron structures, [31032] and [31033]. Both of these structures were aligned north-south. The iron structure [31032] comprised a horizontally-mounted housing for a superstructure, which may have fulfilled the role of some kind of linear actuator; in the absence of any associated structural information this interpretation must remain tentative. The same is true of the adjacent iron structure [31033] (**Plate 3**), which comprised a central screw-threaded rod, fixed into two large circular bolts. The proximity of this structure to the previously described [31032] suggests a complementary function, although as both structures suffered considerable truncation during demolition the final interpretation remains unclear.

The north-facing section (**Illustration 4**) exposed directly to the west of structure [31030] comprised a north-south flue [31024], associated laminate fill [31025] (**Plate 4**), north-south wall [31026] and curvilinear flue [31027] (**Plate 5**). These structures were exposed during remediation works, all continuations of these structures to the north and east had been destroyed during later ground works. Any continuations of these structures were beyond the remit of remediation works, and were therefore not exposed for inspection.

Structures [31021] and [31022] comprised flue channels, which were located approximately 3m to the north-east of the spin engine structures. The flues were constructed from yellow fire-brick, some of which were stamped with the maker's mark of "Thistle". The flue structures were of composite construction: an inner casing of header-built fire-brick was cocooned in an outer casing stretcher-built of red brick. The flues had an internal width of 0.61m, and were excavated to a depth of 0.7m. Flue [31021] comprised the east butt-end of a flue which would have been orientated east-west, although the western continuation of [31021] had been truncated. Flue [31022] was similar in construction to [31021] and was orientated north-south. Despite the similarity of construction methodology and the close proximity of the two structures, different uses of these structures can be inferred from the staining on the internal surfaces of the flue channels. The internal faces of [31021] were heavily coated with a red powdery material, whereas the internal faces of [31022] were stained with a blue-black residue. The red staining in [30121] has been interpreted as the gradual oxidation of the fire-brick caused by successive and prolonged episodes of heating. By contrast, the black residue within [31022] suggests

that metal or slag residue was present in the hot gases transmitted by [31022]. Due to the incomplete nature of the flue system in this area any further interpretation would be invalid.

These structures were collectively interpreted as the remains of a housing or base for a spin engine. The adjacent flues can be interpreted as relating to associated boilers for producing pressurised steam for motive power.

The chimney [31003], located directly east of the structures discussed in this section, was interpreted as a modern continuation of the works undertaken in the 19th century. Chimney [31003] measured 2.5m in diameter. The insertion of this chimney into the surrounding matrix had clearly caused substantial truncation to the pre-existing structures. The remains of sandstone wall [31015] were only visible in the north-facing section created by the remediation excavations (**Illustration 5**), and measured 0.3m wide by 0.6m deep. The wall was constructed from roughly-hewn sandstone blocks with no discernable bonding matrix. The chimney and associated structural remains were situated approximately 50m east of the 'spin engine' apparatus. As such, no conclusive cross-interpretations may be made.

The area surrounding these structures comprised a considerable depth of slag used as a backfill deposit. A sample of the slag was retained for specialist assessment (**Appendix 6**).

3.1.6 Building 32

The north end of this building was constructed over the mid-section of a preceding range of beehive ovens. The monitored slab removal within the footprint of Building 32 exposed a series of friable brick structures. As this building was recognised as the primary location of the beehive coke ovens, the area was recommended for archaeological mitigation (Area II).

3.1.7 Building 33

This building, orientated east-west, was constructed to directly overlap the western half of the original range of beehive ovens. The sequence of structured demolition in this area allowed a small fragment of the south-facing elevation of the beehive oven range to be temporarily exposed and recorded (**Plate 6, Illustration 6**). The main feature of note was a composite arch constructed from both red brick and fire brick [33000], which measured 2.5m in width. The arch was heavily vitrified as a result of successive episodes of heating to high temperatures. This structure was interpreted as the south-facing 'drawing-out' doorway into the domed chamber of a beehive oven. The south-facing elevation also showed evidence of later rebuilding directly on top of the beehive structure, in this case wall [33004], which comprised a red-brick wall bonded with black ash mortar and orientated east-west. The structure exhibited evidence of subsequent demolition and rebuilding activities, in the form of levelling cut [33002] and subsequent made ground deposit [33003].

The fire-brick structure [33009] was interpreted as evidence of stockpiling of re-construction materials for blocking doorways. This activity would have been undertaken before the oven had been loaded or 'charged' with a fresh load of coal. The blocking would then be removed after each firing to allow the coke to be raked out of the doorway and into the rail carts waiting below.

Structure [33008] comprised a north-south red-brick wall, which merits mention as it was the only linear structure of this particular orientation in this area. The length of the structure was indeterminate, due to the location of [33008] in a south-facing section. As the structure was constructed from machine-made red bricks and was

bonded with cement, [33008] was interpreted as a later insertion, constructed in the late 19th or early 20th century.

3.2 Summary of Artefactual Data

A summary list of recovered artefacts is presented in Appendix 1.

3.3 Reliability of Results

All work on the watching brief was undertaken with a high level of confidence in relating identified structures to historical map evidence. The results of the watching brief detail the remains mitigated and recorded by ARCUS in accordance with site Health and Safety procedures and demolition schedule.

3.4 Mitigation Results

3.4.1 Area I (The Foundry Building)

The layout of investigated structures in Area I closely matched the final phase of the building footprint as shown on historical map data. Excavation commenced immediately after the floor slab was removed and associated concrete stanchion bases were demolished.

The deposit immediately beneath the slab floor comprised casting sands which had been re-deposited and levelled to accommodate the overlying floor surface. The deposit was excavated to a depth of no greater than 0.4m across the general extent of Area I to achieve resolution of the underlying structures (**Plate 7**). The exposed archaeological features comprised a physical record of the use and re-use of the structure from original construction to final demolition (**Illustration 7**).

Phase I (1865)

Most of the primary phase of archaeology within Area I comprised a series of substantial sandstone walls. These were typically constructed from faced irregular blocks of sandstone bonded with different varieties of white lime mortar. The best evidence available from excavation suggests that these walls were at their greatest vertical extent towards the north side of the building, whereas the sandstone walls constructed towards the south side had shallower foundations. This was most likely a response to the prevailing topography at the time of original construction.

The primary phase of the foundry building was delineated to the west by structure [1051], to the east by structure [1037] and to the south by sandstone structure [1008]. Any structures within the boundaries of [1051] and [1037] were interpreted as belonging to the primary phase of construction, such as casting pits [1044] and [1003]. Although the excavated extent of casting pits [1044] and [1003] were generally similar to the pits in the later extensions, these can be interpreted as subsequent re-builds of earlier structures. Neither is the contemporary use of sandstone and brick inconsistent with this scheme of phasing; rather, it represents the best use of materials for specific purposes. The foundry building was simply a means to protect the casting pits and their workers from the elements, so the building methodology follows the local vernacular style. The pits themselves, however, represented the very beginnings of a new stage in the life of the Clay Cross works and the application of a technology completely new to the site. As such, it seems appropriate that bricks produced on site were used.

As casting pit [1003] was recognised as the most complete pit in plan, mechanical excavation of the fill [1006] was undertaken to assess any sub-surface features of pit [1003]. Deposit [1006] comprised dark brown friable sand, with occasional inclusions of slag, brick fragments and mortar. The fill was homogenous and otherwise

unremarkable. Continued excavation of the pit exposed a substantial cast iron spigot [1084], affixed vertically in the centre of the casting pit base (**Plate 8**). The spigot could not be directly measured, as ARCUS staff members were not permitted to enter the feature. The feature was therefore recorded with a reflectorless EDM survey. The central spigot measured 2m in height and 1m in diameter. The iron used in construction of [1084] measured 0.14m in thickness. The spigot was interpreted as the point of attachment for the main vertical beam of the treadle crane which would have been located in the centre of the casting pit during the later stages of use. The excavated pit measured 3.7m in depth and 6.43m in diameter.

Structures [1051], [1037] and [1008] comprised substantial sandstone walls. The structure [1051] measured 1.14m in width, which was similar to the width of [1008]. Structure [1037] only measured 0.5m in width. Although this is considerably less than the other two walls of the same phase, it was still of sufficient width to be interpreted as a main structural wall.

The area surrounding these early casting pits was densely populated with a collection of smaller, ancillary structures. Although the majority of these structures were constructed from local red brick, one of the central structures [1039] was built from very roughly shaped sandstone blocks of irregular sizes. The constituents were bonded with a white lime mortar, which had been applied unevenly and often in generous amounts. The structure appeared in plan as the corner of a larger square structure, which had subsequently been truncated by flue [1034] to the north. Sample excavation of [1039] confirmed the lack of sophistication in the construction methodology; the structure comprised an irregular-bond wall which increased in profile width with depth. This widening profile was interpreted as an attempt to spread the load of the structure into the surrounding loose casting material. The definitive use of this structure could not be determined by excavation. The structure has therefore been interpreted as the foundation or sub-structure of a larger and more complex superstructure, such as a crane base. From its position towards the southeast corner of the foundry, the crane would have been well-placed to facilitate the movement of heavy goods in and out of the foundry pit without causing an obstruction.

Structure [1035] was one of the less substantial features related to phase I, although the consistent use and alteration of the structure throughout the operating life of the building suggests a function key to the operation of the works. The structure comprised a single-brick-thickness wall orientated north-south with the south end curving sharply to the west before being truncated by concrete [1028], and measured approximately 4m in length. The structure was heavily degraded and friable, which was interpreted as evidence of *in-situ* heating over a prolonged period. Once this had been established, it became clear that a similar heat signature was visible on the remains of the west face of [1037], which led to the interpretation that the flue formed by [1035] and [1037] was effectively built into the side of the main east wall of the original foundry building (**Plate 9**). As the westward curve at the south end of [1035] was located directly in the southeast corner of the phase I building, it is reasonable to suggest that the original flue may have continued along the south edge of the foundry building in the same fashion. This methodology, probably chosen to save floor space inside the building, may have had potentially disastrous consequences for the long-term structural integrity of the foundry. If the heat damage was consistent, it may have instigated the later re-build of all the external foundry walls.

Phase II (1866)

The second phase of the building comprised an extension to the west. Unfortunately, due to consistent re-use and re-construction, no original features from this phase of construction are preserved *in-situ.*

The most obvious feature associated with phase II was casting pit [1047], located at the west end of the phase II building. This casting pit was built into the original west wall [1051] to maximise the use of space in the centre of the building. This implies that the original west wall [1051] was retained within the extended phase II building to act as an internal sub-division.

The date for this phase is ascribed based on documentary evidence pertaining to the site, which states that the foundry was constructed in 1865 and extended the following year. Interestingly, the source also records the relative cost of the first two phases of construction. The first phase in 1865 cost £544, but the extension the following year is documented as having cost £744 (Williams 2005, 47). It seems unusual that the cost of enlarging a building should be considerably more than the cost of constructing the original building from scratch. One interpretation for this high cost would be that the fabric of the original building required extensive renovation and possibly even reconstruction in order to be extended. Alternatively, the cost may be due to extensive renovations to the existing casting pits and associated technology. Regardless of the methodology, the sums of money involved show a high degree of confidence in a comparatively new process. It is reasonable to assume that the owners of Clay Cross would not have countenanced authorising additional funds to extend an unprofitable part of their enterprise. It follows, therefore, that within a year the operators of the foundry were able to demonstrate a capacity for iron production which, if not even immediately profitable, showed that substantial profits could be made following extensions to the foundry. The pig iron produced immediately to the south of the foundry building would have provided no shortage of raw material for casting, so the only limiting factor upon the establishment of the methodology would have been the size and suitability of the building itself.

Phase III (*circa* 1870s)

The third phase of alterations comprised an extension to the east, terminating in north-south sandstone wall [1009]. The construction methodology and bonding materials were similar, but not identical, to those employed in the construction of the primary phase walls [1051] and [1037]; both these walls and the new east wall were constructed from virtually identical stonework, and density and distributions of lime inclusions within the lime mortar used were also comparable. Only one segment of the south main wall [1113] from the third phase was exposed during excavation, and the relationships to earlier and later phases of the main south wall had been truncated by demolition. The surviving fragment of sandstone wall [1113] was butted to the north by a circular red-brick structure [1015], which comprised hand-made red brick bonded with grey lime mortar (**Plate 10**). The structure measured 1.62m in diameter, and subsequent excavation established the foundation depth to be 0.95m below ground level. This was equivalent to the foundation depth of the adjacent section of [1113]. This circular structure is set apart from the rest of the circular structures on this site by virtue of the fact that [1015] was directly bonded to the north face of [1113], whereas all the other circular structures within the foundry building were free-standing. This suggests the interpretation that [1015] was a small internal chimney stack, possibly serving a hand forge or cupola hearth which would have been necessary to melt the incoming pig-iron for casting.

This phase of expansion included the construction of casting pit [1086]. The casting pit was constructed from hand-made red brick and had a diameter of 9m. The construction methodology of [1086] differed slightly from the other excavated casting pits. Instead of using the same mortar consistently throughout, as was observed in [1004] etc., the internal courses of [1086] were bonded with a friable cream-coloured mortar, whereas the outer courses were bonded with a friable grey-coloured mortar. This suggests that casting pit [1086] was extensively repaired or re-built during its use. This casting pit was the only excavated pit to exhibit such evidence.

As the radius of [1086] overlapped the line of [1037] to a greater degree than the overlap of [1047] over [1051] at the opposite end of the building, it is reasonable to suggest that the construction of [1086] would have necessitated the demolition of [1037] and the concomitant phase I flue [1035]. Despite the loss of [1035] to this phase of construction, there was clearly still a need for a flue channel to serve both the area to the south of pit [1003] as well as the new pit [1086] to the east. This is demonstrated by the bifurcation of the replacement flue [1034]. This flue is best understood as a deliberate attempt to improve on one of the technological aspects of the foundry building. The surviving remains of [1034] comprised the foundation and one standing course of brickwork (**Plate 11**). The structure was built in a typical fashion; a floor of bricks formed the base of the flue, flanked by the eastern and western side walls. Although the methodology was standard, the choice of materials was not; the walls were constructed from frogged red brick, as opposed to the yellow fire-clay bricks typically used in 19th-century flue construction. The coursing and orientation of this structure was not as regularised as is usually the case in industrial archaeological contexts. The structure appeared to decline slightly to the south, which can be interpreted as the result of post-construction subsidence.

The multi-phase flue system [1034]/[1035] running to the east of casting pit seemed to exhibit a structural relationship with a small, circular, brick structure [1109]. The fill of this structure, context [1110], was the only excavated context in Area I to provide any ceramic. The single sherd of ceramic was dated to the 19th century (**Appendix 2**). This system of structures was interpreted as a means for conveying waste emissions from melting furnaces out of the foundry building to nearby chimneys. It is quite possible that the first phase of the chimney was incorporated into the main wall [1037], which was subsequently truncated by the later expansion of the foundry building. Unusually, the internal structure of the secondary phase of flue [1034] was coated with a thick layer of gas tar. This does not necessitate a direct link with the gasworks, although it may represent an opportunistic use of surplus materials. It is possible that the preserved length of [1034] may represent an air intake, rather than a hot exhaust flue. This interpretation rests on the plastic qualities of gas tar; application of tar would have helped seal the flue and, conversely, it is likely that hot exhaust gases would have caused the gas tar lining to melt away completely.

Concomitant to the third phase of construction in the main foundry building were the structures to the south of east-west wall [1008], such as sandstone structures [1018] and [1080]. These structures comprise the remains of the first stage of construction of the drying chambers to the south of the main foundry, representing an increase in the sophistication of the operating methodology within the foundry. Structures such as [1080], [1018] and [1020] were all of approximately equal length (generally between 3.5 and 4.5m) and orientated north-south. All of these walls butted up against the north face of [1019], an east-west wall constructed from machine-made red brick. The main wall measured 0.6m in width, and the total excavated length measured 21.7m. With the construction of several extensions off the original south wall of the foundry, [1019] became established as the main south wall of the extended phase III building. As

such, it became the focal point for structural additions or adjustments. The obvious structures that fall into this category are the hearth-places [1079] and [1078]. These structures had been demolished to foundation level prior to the instatement of the slab floor across the entire building.

Hearth [1078] was constructed from unfrogged red brick and bonded with white lime mortar (**Plate 12**). The whole structure was keyed into the north face of [1019], suggesting contemporary construction. The waste output of this hearth was transmitted through south wall [1019] by virtue of an inserted iron pipe, which fed into a secondary flue system running along the outside of external wall [1019]. This secondary flue was ascribed context number [1022], and was observed to be intermittently preserved along the south face of [1019]. Although the structure had been truncated at several points, the total observed length of the structure measured 15.5m. As mentioned previously, the waste heat and smoke from the hearths situated along the north face of [1019] was transmitted to the flue by a series of iron conduits.

This layout of structures within the alcoves along the south edge of the building is the archaeological record of the diversification of practices within the foundry building; a need was recognised for a specific area where sand moulds could be dried before molten iron was poured into them. As a result, the preparation of moulds could be undertaken indoors and set to dry immediately. The completed moulds could then be moved a short distance into the main foundry building with a minimum of effort. This spatial distribution of specific tasks or stages of the manufacturing process is a classic example of industrial expansion, and a demonstration of how such expansion will in turn encourage diversification of manufactured products.

The structures [1074] and [1075], located immediately south of the line of main external wall [1008]/[1014], are also to be considered under the category of ancillary technological development. The archaeological remains of these structures constitute a base of some description, comprised of a circular red brick platform delineated by an iron band around the perimeter (**Plate 13**). The platforms measured 2.25m in diameter. Structure [1075], to the east, was the slightly better preserved structure out of the two. In addition to the brick base, [1075] comprised a circular iron plate laid on top of the red brick platform. Aside from their physical characteristics, the only other factor facilitating their interpretation was their spatial distribution in relation to the foundry building as a whole. As [1074] and [1075] were next to each other, it is unlikely that they could be effectively utilised as crane bases; these are typically more widely distributed to allow the effective distribution of heavy goods around the building. The structures are currently interpreted as foundations for steam boilers, due to the heat-affected nature of the surviving bases. Vertical boilers were used in instances where floor-space was at a premium, and a popular design was patented in 1878 by Edward Crompton and J. T. Cochran (Jones 2006).

Phase IIIa (*circa* 1880s)

Sandstone walls [1010] and [1011] belong as an additional sub-phase of construction between phases III and IV, as they appeared to comprise a small structural extension off the east wall [1009]. Chimney base [1012] was interpreted as contemporary to this sub-phase of construction. Subsequent excavation around these structures also exposed red-brick platform [1112] which was interpreted as a phase IV structure due to its close proximity to casting pit [1002]. The relationship between these two structures will be discussed in the next section.

The precise function of the phase IIIa extension is unclear, as any internal detail was obliterated by the subsequent phase IV rebuild. The space created by this extension would have been comparatively small, approximately 5m by 7m. There was no direct

evidence of an interconnecting doorway between the extension and the main building, and any potential evidence of a doorway through to the north or south of the extension was obliterated by subsequent reconstruction in phase IV. The proximity of chimney base [1012] to the extension suggests the possibility that the lean-to structure represented by [1011] was built to house a boiler or furnace for melting pig-iron. The hot exhaust gases would have been vented into the adjacent chimney. If this was the case, it is another example of the concurrent use of both sandstone and red brick in construction; once again sandstone was used for simple linear structures whereas the red brick was reserved for more intricate work.

Phase IV (*circa* 1896)

The final phase of re-construction at the Foundry Shop is best represented by the north wall [1050], which was exclusively constructed from machine-made red brick. This substantial structure, possibly reflecting an increase in the height of the building to accommodate larger castings and more complex operations, completely removed any traces of earlier foundations. This reflects construction methodologies of the period; new structures for experimental or untried procedures were generally constructed gradually over time from a variety of materials, but once the working pattern of the building is established the outer casing is often rebuilt in a more planned and uniform fashion, usually reflecting the growing productivity, and therefore wealth, of the works. In this case, the entire external wall was replaced, leaving only foundation traces of earlier walls, such as [1008] under the new south wall [1014]. This final phase of extension and renovation resulted in a substantial brick-built foundry building which was approximately three times the length of the original building. Several metal objects were found adjacent to wall [1050], and were recovered for subsequent specialist analysis (**Appendix 6**).

The sub-excavation intended to expose and define the full extent of the phase IIIa wall [1011] also exposed a simple platform [1112] constructed from standard machine-made bricks. This platform possessed no underlying foundation, and had been simply laid onto the casting sand at a seemingly arbitrary height. Close inspection of the adjacent casting pit [1002] revealed an interesting aspect of the construction; the mortar visible on the external face of [1002] had been neatly grouted to a depth of approximately 0.9m below the current ground surface, but the mortar below this depth had not been grouted at all. Accordingly, the adjacent brick platform was interpreted as a temporary area of hard-standing created to facilitate the construction of casting pit [1002]. It is likely that the general surface level surrounding [1002] was reduced slightly to aid the construction of the pit. Below the level of the brick platform, the construction of the casting pit would have effectively entailed building a circular wall to line the excavated hole. Once the height of the brick platform was reached, the outside of the structure would have been exposed to allow neater grouting of the nine uppermost courses of mortar.

Excavation in the south-west area of the building exposed a piece of *in-situ* cast iron (**Plate 14**). The material measured approximately 3m in length, and had been simply cast into a depression in the general casting sand deposit [1089]. The cast iron was ascribed context number [1090] and sampled accordingly. This sample was the only piece of *in-situ* casting material to be recovered from site. This material has been interpreted as waste or run-off material which was not considered for reclamation by the foundry operators. This is in itself unusual, as any run-off material could have been re-melted. Further metallurgical analysis of the sample in the final report will determine if there area any inherent flaws in the metal which would have precluded it from re-introduction into the melt. The presence of cast material at this precise location raises another issue relating to the interpretation of the technological

development of the works. It is reasonable to assume that the original molten iron issued forth from some kind of container; this suggests the interpretation that the red brick pad [1065] immediately south of cast material [1090] was in fact a small foundation for a re-melting furnace. Given the close physical proximity of [1090] to [1065], it is possible that the two features were contemporary and that [1065] was the actual base for the melting furnace which produced [1090].

The only other metallurgical artefacts recovered from the site comprised small fragments of structural material, which may have related to the cranes associated with the casting pits. The specialist assessment of these artefacts is currently in progress.

Several structures were excavated on the southern side of the area which were not directly related to the casting process, but nonetheless fulfilled a vital secondary role in the operation of the foundry. The southern side of the main foundry building contained a number of small, circular, red brick structures, such as [1064], [1056], [1040] and [1041]. All these structures were of similar size and construction. The majority had been constructed from handmade red brick; only [1056] and [1041] differed in their use of machine-made brick and modern brick respectively. Due to the lack of supporting physical evidence associated with these structures, their definitive function is currently undetermined, although they may be reasonably interpreted as bases of rotary mechanisms for the effective transfer of iron into the foundry, as depicted in an 1865 text by William Fairbairn (1789-1874), a contemporary of Stephenson. The described mechanism comprised a large cast iron ladle supported on a horizontal arm, which pivoted on a vertical column set into the floor (**Plate 15**). The movement of the mechanism would have allowed molten iron to be transferred quickly and comparatively safely from the melting furnace to the casting pit. If these features do represent the remains of ladle foundations, then they must be interpreted as a continuing technological development from the early stages of construction; by the time of the final stages of construction an overhead travelling crane had superseded the use of individual ladles. Despite the uncertainty over their ultimate function, the structures as a set were archeologically interesting because they represented a continuity of use over time; even though more modern materials were in use by the construction of [1041], the actual form of the structure had not appreciably changed.

The network of railways surrounding the foundry was also partially excavated to the south of the building. Despite the limited physical extent of the excavations beyond the building line, two distinct arrangements of track were exposed, both exhibiting different gauges: [1068] had a gauge of 1.57m (or 5.15 feet), whereas [1071] had a gauge of 1.2m (4 feet). Track [1068], to the south-west of the building, was interpreted as external track for mass movement of raw materials and product into and out of the works. Track [1071] was aligned on the same east-west orientation but located less than two metres to the south of [1068]. This is likely to have been for the use of hand- or push-carts.

The casting sand of the foundry floor as excavated appears late in the site's stratigraphy. Excavation of a large sondage across the east end of the building established that the sand floor of the foundry building was continually being re-deposited; the section (**Illustration 8**) clearly demonstrates that the casting sands exposed in plan [1103]/[1106] had all been deposited on top of the material [1099] disturbed by the reconstruction of the main north wall [1050]. The deposits of casting sand within the foundry building, therefore, relate only to the final phase of activity prior to the instatement of the concrete slab floor. The uppermost casting sand was

ascribed the general number [1089], and was found to contain occasional inclusions of small brick fragments. The only artefacts recovered from this context comprised 7 fragments of aqua-green and green glass dating to the late 19th or early 20th century (**Appendix 5**). A solitary square feature [1025], situated close to the north face of main foundry wall [1008], was half-sectioned and shown to be a simple square-cut negative feature measuring 1.1m in width and 0.4m in depth. The feature had been deliberately backfilled, and was interpreted as a temporary locating of a casting mould. The metal objects exposed during excavation were recovered for subsequent specialist assessment (**Appendix 6**).

The date 1896 is ascribed to this phase due to mention made in documentary sources of an improvement at this time to the foundry apparatus (Williams 2005, p. 34) Although reference is made to the installation of a new pit, it is unclear as to whether such an undertaking would have required a separate phase of building in which to accommodate it. The pit was constructed specifically to manufacture economiser tubes, a development of boiler technology patented in 1845.

One of the project aims was to identify how the processes used fitted in with the overall operation of the works. With the decreasing dependence on coke as a fuel and the refinement of the coke production process, production of cast iron engineering products became the focus of operations at the Clay Cross works. Once the reputation and profitability of a production centre such as this becomes established the proximity of the raw materials and markets for products, which would have been the main factors governing the original location of the works, becomes irrelevant. A successful works can purchase the materials needed from a global market to ensure quality products that can reliably be sold for profit. The demand for these products will bring them to market. From this perspective it can be said that the iron foundry which was originally established merely to make use of the iron ore cast up during coal extraction became a connection between the town of Clay Cross and the global manufacturing market. It was this very connection which enabled the works to continue existing into the 20th century, as a production centre for economisers and most recently the ubiquitous cast and spun pipes under the new name of Biwater. This is a considerable return on the initial cost of £544 for the first foundry building in 1865.

There is also mention of specific workers being brought to Clay Cross to run the foundry. This foundry contributed to the general transhumance occurring during the Industrial Revolution. These men, although lower in social status than their employers, were actively sought out and re-located to undertake work vital to the growth and profitability of the larger works. In turn, by inextricably linking these families to the works in this manner the players involved were establishing a system which could ensure mutual success for their respective descendants as long as the *status quo* was maintained.

3.4.2 Area II (The Beehive Ovens)

The dimensions of Area II were determined by the results of the watching brief, and on the known dimensions of the original building which contained the individual structures. Given the known extent of preservation of the beehive oven briefly exposed during the watching brief, the decision was made to locate the centre of the east-west trenching area on the oven characterised during the watching brief (Building 32). It was expected that the remaining ovens would probably be of reduced extent and frequency, due to the impact of subsequent phases of re-building and demolition.

In total, the remains of 22 beehive ovens were excavated in Area II (**Illustration 9a**

and 9b). The ovens were distributed evenly along both sides of a central flue (**Plate 16, Illustration 10**), with the exhaust gas and heat being vented from each individual oven into the central flue [2159] via a short ancillary flue [2009 etc.]. All flue structures were constructed from standard-sized fire-brick, although the ancillary flues were capped with specially-made trapezoidal slabs. This detail was only evident at the east end of the trench where preservation was the most extensive (**Plate 17**). The central flue had become backfilled with context [2016], which comprised a black gritty deposit mainly composed of soot residue with frequent inclusions of fire brick, sandstone and red brick fragments. This context may have been originally generated by the operating processes of the beehive ovens, but was undoubtedly compromised during demolition. Excavation of [2016] recovered three fragments of 19th century clay pipe (**Appendix 4**), as well as one fragment of glass bottle neck, which was identified as late 19th or early 20th century in date (**Appendix 5**).

Each oven was virtually identical in terms of construction methodology to its neighbour. The only differentiating factors between ovens comprised small-scale repairs to the fabric of the structures. This practice was evident on the south side of oven 3; the outer red-brick casing [2032] became weakened at the point of abutment with the archway into the ancillary flue [2152]. The degraded red bricks were replaced with patches of yellow fire-brick [2151] and [2153].

Similar repairs were undertaken on the fabric of oven 17. A grey lime mortar was used to bond machine-made red bricks into the north side of the inner wall [2096] of the oven. As the repair was discrete, it was ascribed context [2170]. The repair was small, measuring 0.38m by 0.38m. It was noted during recording that the same mortar used to bond [2170] to [2096] had also been used sporadically to repair smaller gaps in [2096].

Despite these minor alterations, there was no evidence to suggest any of the structures had been completely rebuilt during the operational lifetime of the range, as is the case with other types of reusable heating structures such as crucible or cementation furnaces. Of course, if total rebuild of any individual structure were undertaken, it is unlikely the change in materials would be visible, due to the consistent background heating and the homogenising effect this had on the colour of building materials *in-situ*. This thermal effect was also evident within the bulk backfill material [2185], a sand context which had been consistently oxidised to a pink-red colour across the entire range of structures. Any disturbance to this material to effect repairs to the underlying brick structures would be quickly obscured by the virtually continuous heat generated by the coking process. Excavation of [2185] provided the only other clay pipe bowl recovered from Area II (**Appendix 4**).

The floor surfaces within the beehive ovens had been subject to intermittent replacement during the use of the ovens. In one particular oven (8), the west half of the floor had been replaced with newer machine-made bricks [2117], while the older brick flooring in the east half [2116] had remained *in-situ* (**Plate 18**). Close examination of the structures suggested that this procedure could have been undertaken without dismantling any of the superstructure, as the floor was inset within the beehive oven and structurally independent. It is probable that this reflects a deliberate design on behalf of the oven manufacturers to facilitate straightforward repairs to the part of the oven likely to suffer most attrition during use. This suggests the possibility that continuous heating of these structures was not the main factor governing their rate of attrition; rather, a combination of heating *and* wear as a result of continued friction caused by raking out of the coke produced by the oven.

The sequential truncation of the beehive ovens was more extensive in the central

section of Area II, as opposed to the east end which was almost completely intact. Some of these partially-demolished structures were surveyed with a reflectorless EDM in order to re-create a digital model of one of the beehive ovens (**Illustration 11**).

3.4.3 Area III (The Gasworks)

Characterised during the watching brief on Building 22, the sub-surface archaeological structures pertaining to the 1881 gas works (**Illustration 12**) were situated within an area heavily contaminated by hydrocarbons and arsenical compounds. Due to these mitigating factors, a strip-and-record methodology was employed in this area; all excavation was undertaken with the mechanical excavator, and no ARCUS personnel entered the area at any time. Respirators were worn by the monitoring archaeologist and the plant operator at all times.

Mitigation of Area III entailed removing the substantial deposits of overburden down to the level established as the relevant archaeological horizon during the watching brief stage. Subsequent excavation and machine cleaning exposed the gas retort [3011], comprising a horizontal open-ended cylinder orientated north-south and constructed from riveted iron plates. The cylinder bore evidence of circular apertures, which were interpreted as the points of attachment for the vertical ascension pipes, which were used to draw the gas produced out of the retort and on to further processing and storage. This structure was insulated from the ground by a horizontal iron plate surface [3010] and by red-brick structure [3021] to the east. This system of structures comprised the area of the gasworks where the raw coal or coke was introduced and heated in order to produce town gas, which could then be transferred to purifiers and thence above-ground storage tanks.

The heat to catalyse this process was provided by a bank of ovens to the east, represented here by structures [3016]-[3018]. Structure [3016] comprised an exterior oven wall, which incorporated six supporting pillars and was constructed from unfrogged fire-brick bonded with white lime mortar. This structure formed the supporting foundation for the overlying ceramic structure [3017], which was semi-circular in profile. The remains of supporting structure [3016] suggested that this segment of the retort apparatus held at least two more structures similar to [3017]. These structures were orientated approximately east-west, with the west end of the structure butting up against a large horizontal cylindrical structure [3011], which was constructed from shorter segments of iron tubing which had been riveted together. Although [3011] had been slightly truncated during the watching brief, the presence of two circular apertures in the top of [3011] support the interpretation that this structure was the retort chamber, into which coal would be fed to be heated by the adjacent ovens in order to evolve gas from the coal. The gas produced would then be fed off via the apertures in the top of the retort to be processed and subsequently stored for use.

As a structural unit, the gas retort and ovens (**Plate 19**) represent a specific stage in the development of gas-producing technology, before the invention of vertical retorts, when the gas was still produced by a batch process, rather than the continual process facilitated by vertical retorts.

This works was constructed by 1853, at the optimum time for the gas industry- the better grade of coal was still freely available and ancillary technology had developed sufficiently to construct a gasworks from scratch based on existing, proven technology, rather than the inherent financial risk of achieving the same result through years of expensive experimentation.

3.4.4 Area IV (Circular Structures to the South of the Foundry Building)

This mitigation area was located in order to assess the potential for surviving sub-surface structures relating to the use of furnaces (**Illustration 7**). The excavation area was located on the original location of the range of blast furnaces, as depicted on the 1881 OS map of the area. However, excavation of the area established that subsequent re-builds of the furnace structures on the same foundation had obliterated any primary evidence relating to these structures (**Plate 20**). The original location was retained upon rebuilding because the new furnaces could then be constructed in an area already well-supported by the logistical mechanisms on site. Excavation showed that newer foundations had been set in substantial amounts of concrete. This, and identified contamination, effectively negated the opportunity of recovering any meaningful information from further excavation of the foundation structures.

The general state of preservation demonstrated by the surviving structures excavated within Area IV was poor. Much of the area had been deliberately truncated and subsequently reconstructed with massive concrete slabs. A circular structure [4016] constructed from refractory bricks, was interpreted as the base for the most recent iteration of the blast furnace apparatus. The bricks were sampled for assessment (**Appendix 3**).

3.5 Summary of Artefactual Data

A summary list of recovered artefacts is presented in Appendix 1, followed by the specialist assessment reports.

4 CONCLUSION

4.1 Summary and Discussion

The combined results of the Watching Brief and Mitigation phases of archaeological fieldwork represent a considerable wealth of unique information pertaining to the development of the works as a whole, in addition to precise details of the nature, extent and significance of some of the best preserved industrial archaeology on the site.

The palimpsest of features uncovered within the Foundry building offer not only an opportunity to examine in detail the utilization of space within a busy casting operation but also to examine those changes and developments within an historical framework to developments within the iron industry during the 19th- century. General trends within the industry can be correlated with developments taking place at the foundry to assess whether these changes reflect wider changes within the industry as a whole. This work will be undertaken in the further reporting proposed in this assessment.

The foundry also provided us with an excellent opportunity to examine the technological developments at the works. From the original construction of the foundry in 1865 and subsequent developments a year later and in the 1870's and 1890s it is clear that technological developments at the site rarely stood still for long. At a period when hydraulic systems for the massive public sewage and hydro projects were being undertaken along with demand for larger more powerful and energy efficient steam engines the demand for iron pipe-work must have been great. It is likely that the technological developments at the site were driven by the need to keep pace with demand. The excavation results allow the reconstruction of the method of construction for the vertical casting pits along with adaptations to the internal flue

systems, minor and major repair episodes as well as an examination of ancillary structures such as the re-heat furnaces and casting ladles. The results also demonstrate that the use of the foundry's space was also determined by the practical realities of increasing production more efficiently. The extensions to the original foundry, the construction of drying rooms for sand moulds, the integration of the internal rail network to the south of the building and installation of re-heat furnaces, steam boilers indicate that the foundry was re-designed as a focal point for the efficient mass production of cast iron pipe. This level of detail within a foundry complex is relatively rare. A careful appraisal of the results can examine the process flow throughout the building during specific phases and can correlate those developments with potential fluctuations in productivity and will form part of the further reporting that is recommended as part of this assessment.

It is unclear whether the bee-hive coke ovens were those constructed by George Stephenson. From their position relating to later 19th-century and early 20th- century maps of the site it is more likely that the bee-hive ovens uncovered in Area II probably relate to the last of the bee-hive ovens evident on site between the 1880s and the 1920s. Nevertheless, the archaeological remains of the coke ovens provide a complete composite record of the differing architectural elements of the bee-hive kilns themselves and also the flue system that may have transported the waste gases to the gas works, uncovered in Area III, to be purified. It is interesting to note that the bee-hive design is still favoured at the site in favour of specialist coke ovens, such as the Coppee or Carves ovens, that were introduced in the early 19th- century (Jones 2006).

The significance of the site and its connection to George Stephenson can not be overlooked. The tunnel completed by Stephenson in 1839 uncovered both coal and iron at Clay Cross. Stephenson decided then to locate a coke plant and colliery at the site and by 1840 the population of Clay Cross had almost trebled. The social impact of this localised population explosion and influx of specialist labour on this small village community will be considered as part of the further reporting recommended by this assessment.

4.2 Further Work

Given the site's connection to George Stephenson and the impact that the formation and working of the site had on the village of Clay Cross it is proposed that a full final client report be made available for possible publication. The level of detail and change within the foundry building is worthy of inclusion in further reporting as well as the structural components of the bee-hive kilns. The specialist assessment of the *in-situ* slag may well prove important to the analysis of run-off metals and their re-use within the cast iron process. It is proposed that the results of the watching brief and subsequent mitigation are to be described in more detail in a forthcoming final report, including the specialist assessment and analysis of *in-situ* metallurgical samples.

5 ARCHIVE

The project archive will be deposited with Weston Park Museum under an accession number to be determined. The archive will be prepared by ARCUS staff in accordance with the requirements specified in Management of Research Projects in the Historic Environment (English Heritage 2006) and with UKIC guidelines (1990). In addition, copies of this report will be deposited with the Derbyshire County Council HER, circulated to the client, and retained in the offices of ARCUS.

6 ACKNOWLEDGEMENTS

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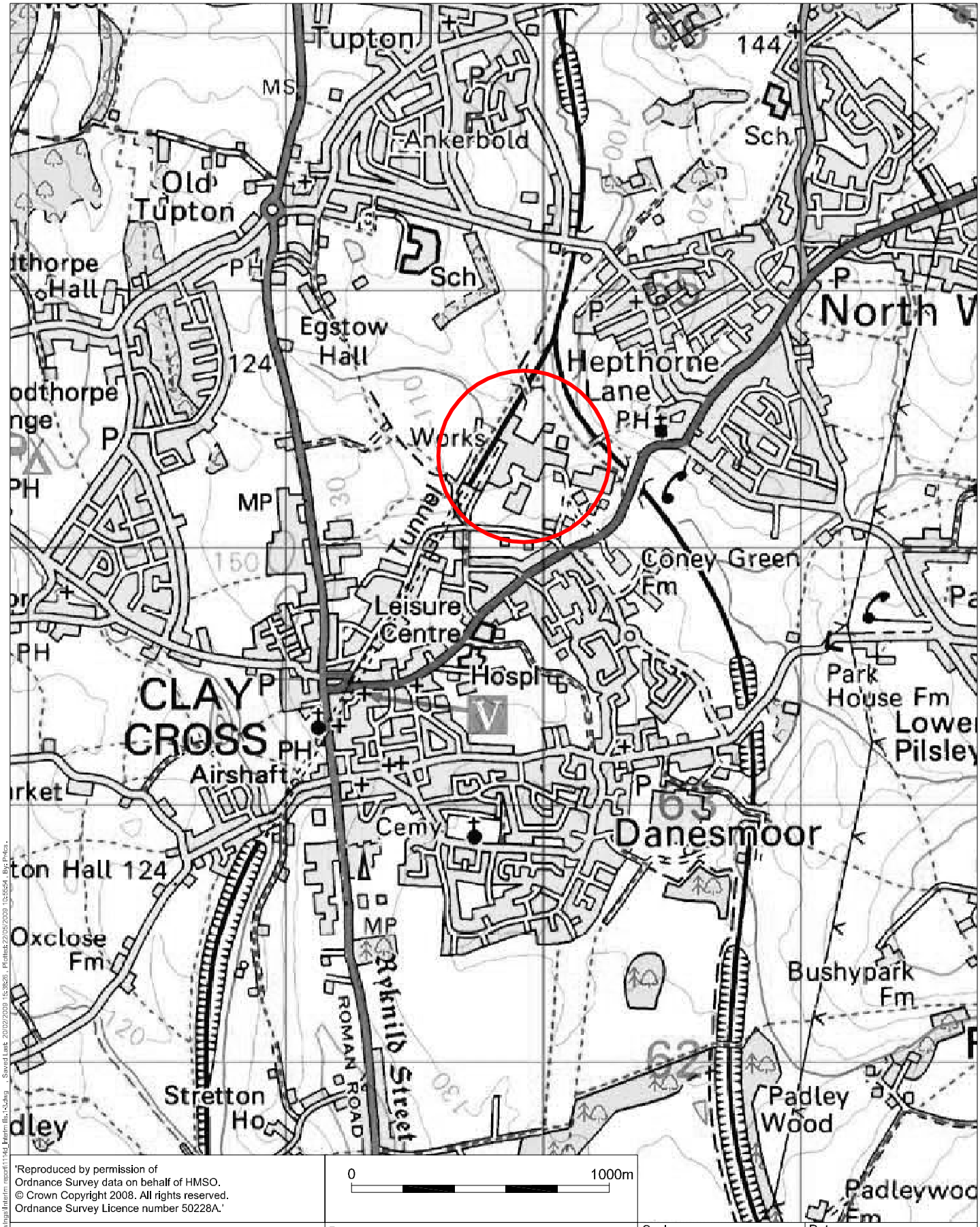
8 ILLUSTRATIONS AND PLATES



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Project: **Biwater, Clay Cross Works**	Scale 1:20000
	Date May 2009
Title **Site location**	NGR SK 3991 6435 (centred on Area 1)
	Drawn CS
	Project No. **1114d.2(1)**
	Illustration No. **1**

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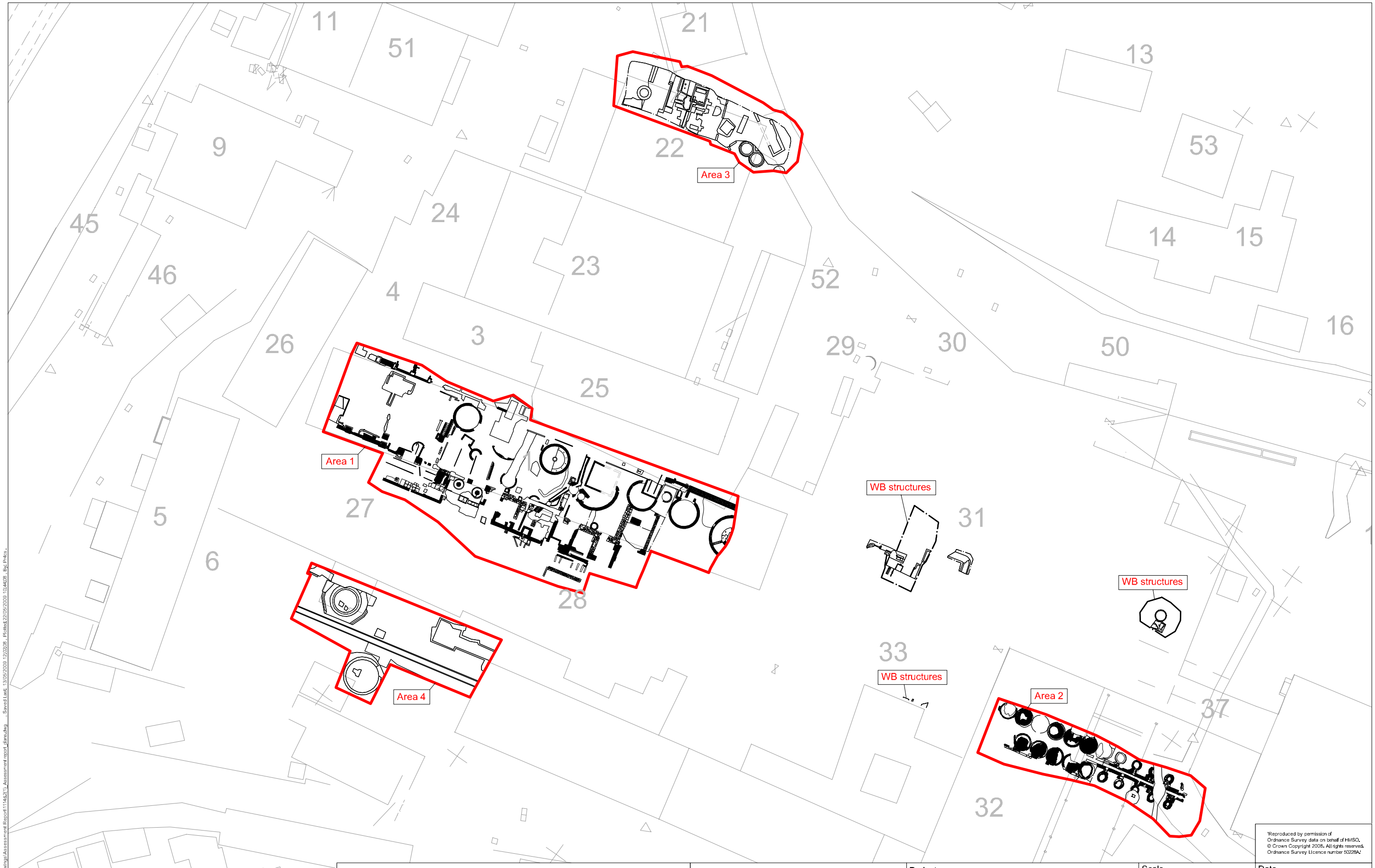

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Project: **Biwater, Clay Cross Works**

Title: **Site plan showing trench locations**

Scale	Date
1:750	May 2009
NGR: SK 400 643	Drawn: CS
Project No.: 1114d.2(1)	Illustration No.: 2

Illustration 3a

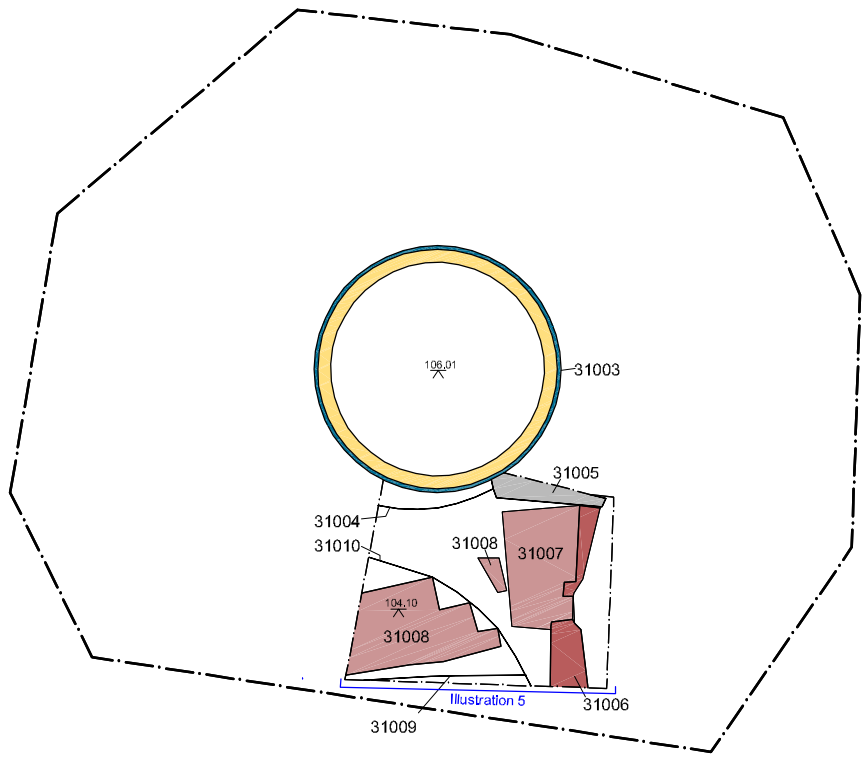
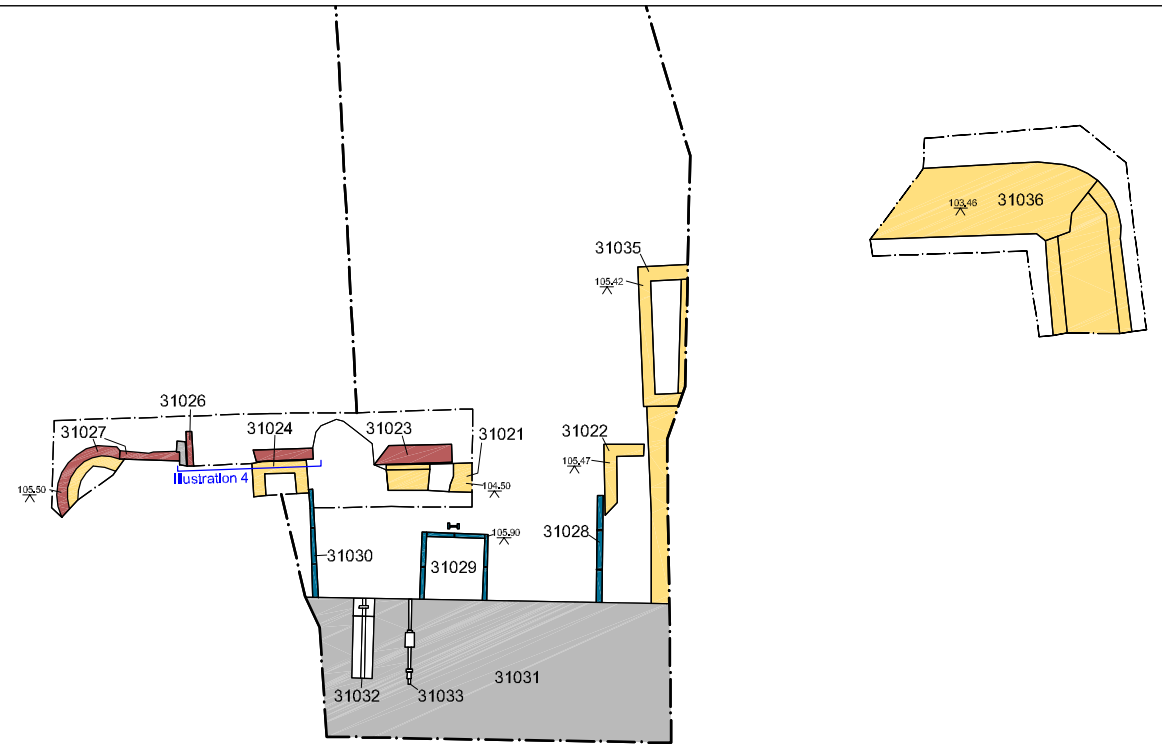
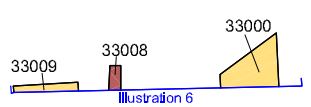


Illustration 3b





Key: Materials

- Red Brick structure
- Red Brick other
- Fire Brick structure
- Stone structure
- Concrete structure
- Metal
- Mortar
- Coke Tar
- Wood

0 Illustration 3a scalebar 5m

0 Illustration 3b scalebar 10m

N

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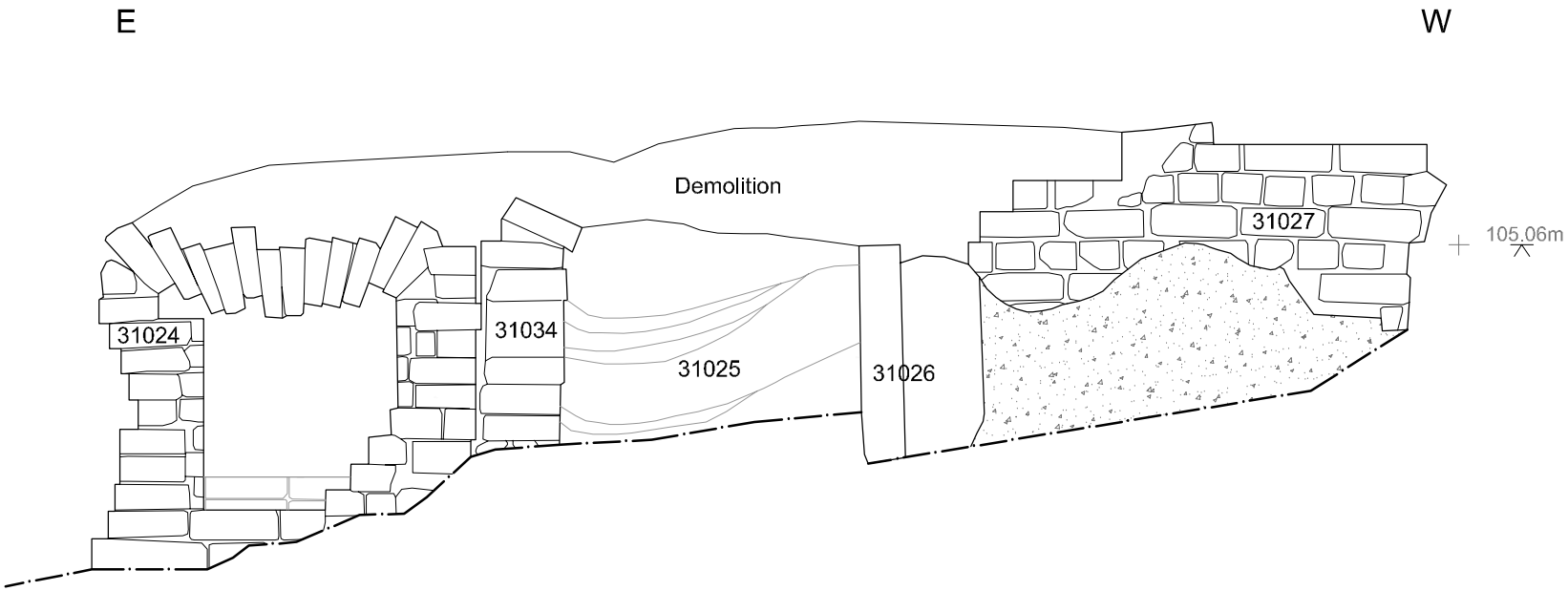
Project: **Biwater, Clay Cross Works**

Title: **Plan showing structures recorded during watching brief on buildings 31 & 33**

Scale	Date
Ill.3a @ 1:75 Ill.3b @ 1:150	May 2009
NGR	**Drawn**
SK 400 643	CS
Project No.	**Illustration No.**
1114d.2(1)	**3**



0 1m

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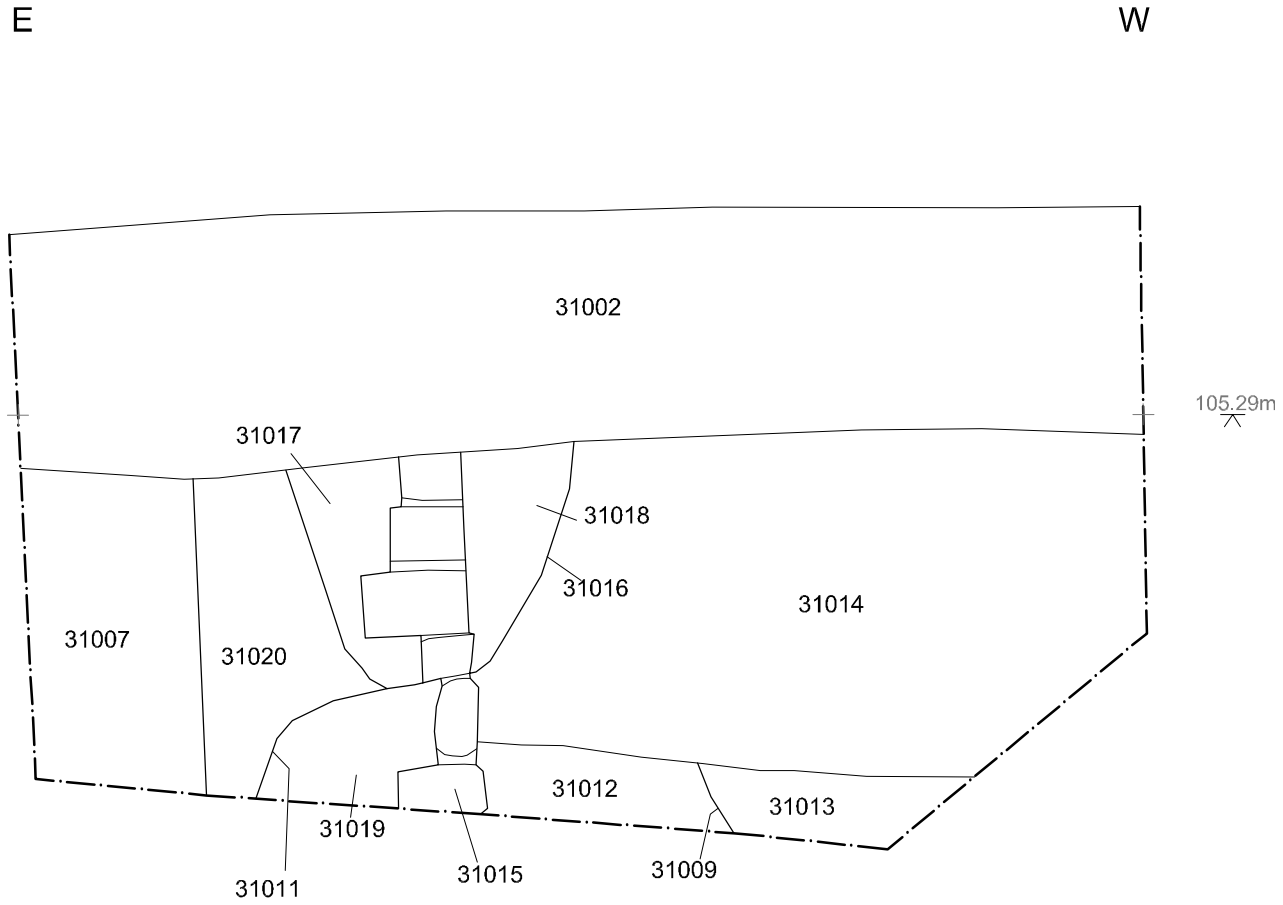
Project:
Biwater, Clay Cross Works

Title
North-facing section of structures [31024] and [31027]

Scale	Date
1:20	May 2009
NGR	Drawn
SK 400 643	CS
Project No.	Illustration No.
1114d.2(1)	**4**



0 1m

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Project:
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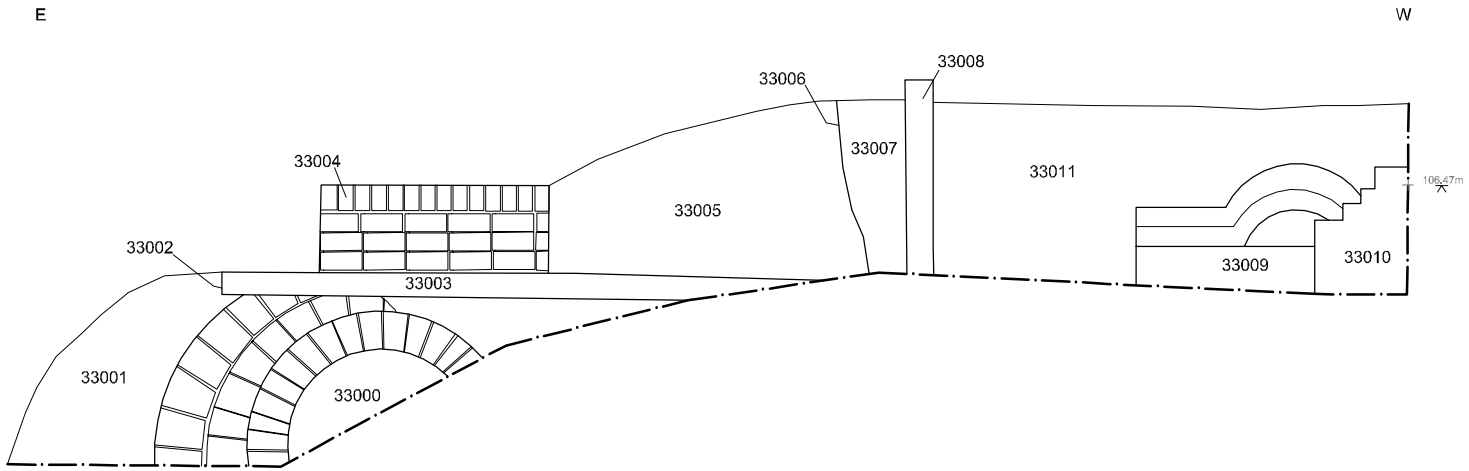
Title
Section showing features assiciated with chimney [31003]

Scale	Date
1:20	May 2009
NGR	Drawn
SK 400 643	CS
Project No.	Illustration No.
1114d.2(1)	**5**



0 2.5m

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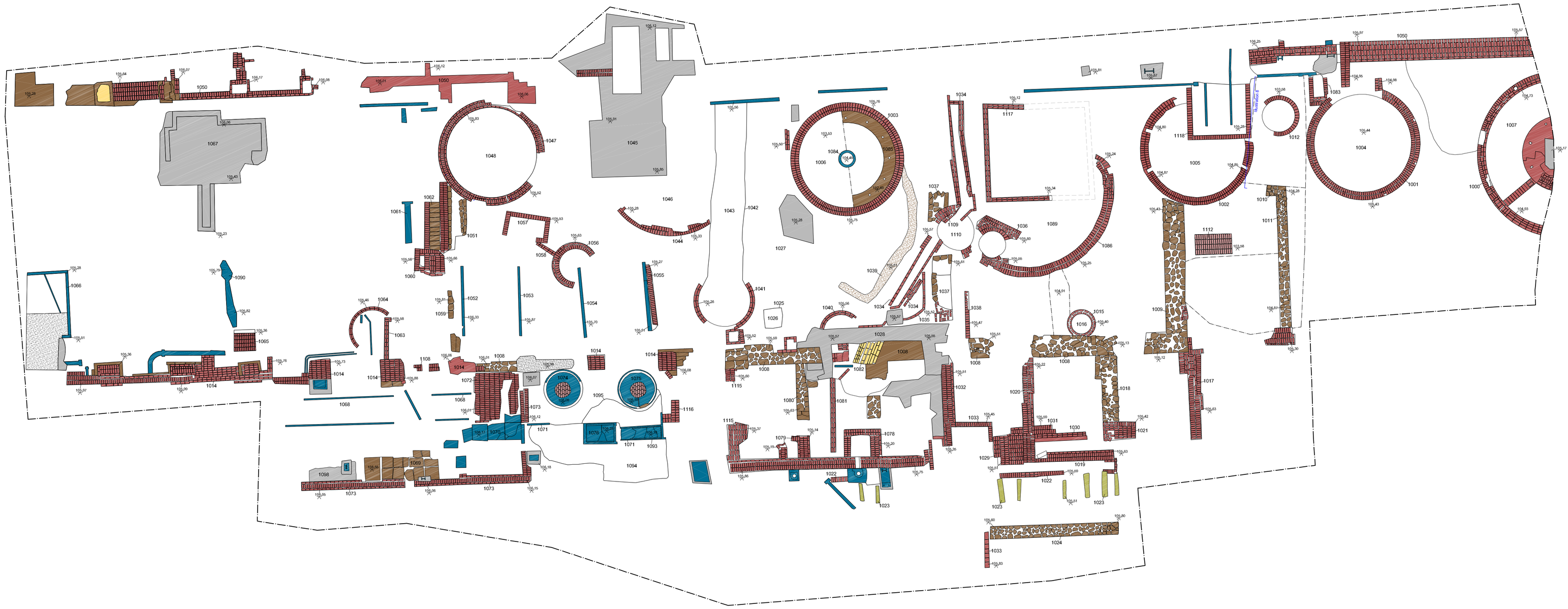
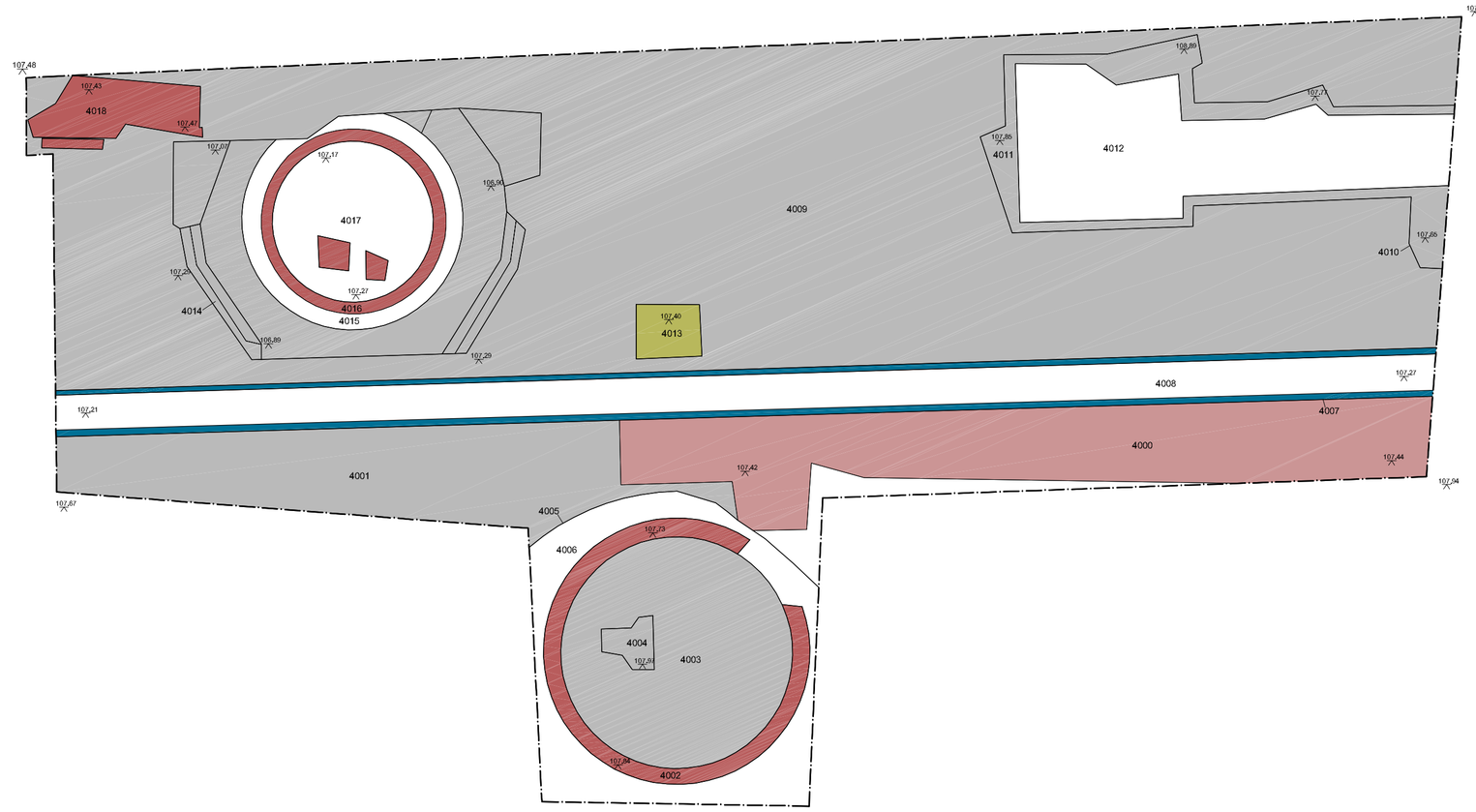
Project:
Biwater, Clay Cross Works

Title
North-facing section of beehive entrance, Building 33

Scale	Date
1:40	May 2009
NGR	Drawn
SK 400 643	CS
Project No.	Illustration No.
1114d.2(1)	**6**





0 5m

Key: Materials

- Red Brick structure
- Red Brick other
- Fire Brick structure
- Stone structure
- Concrete structure
- Metal
- Mortar
- Coke Tar
- Wood

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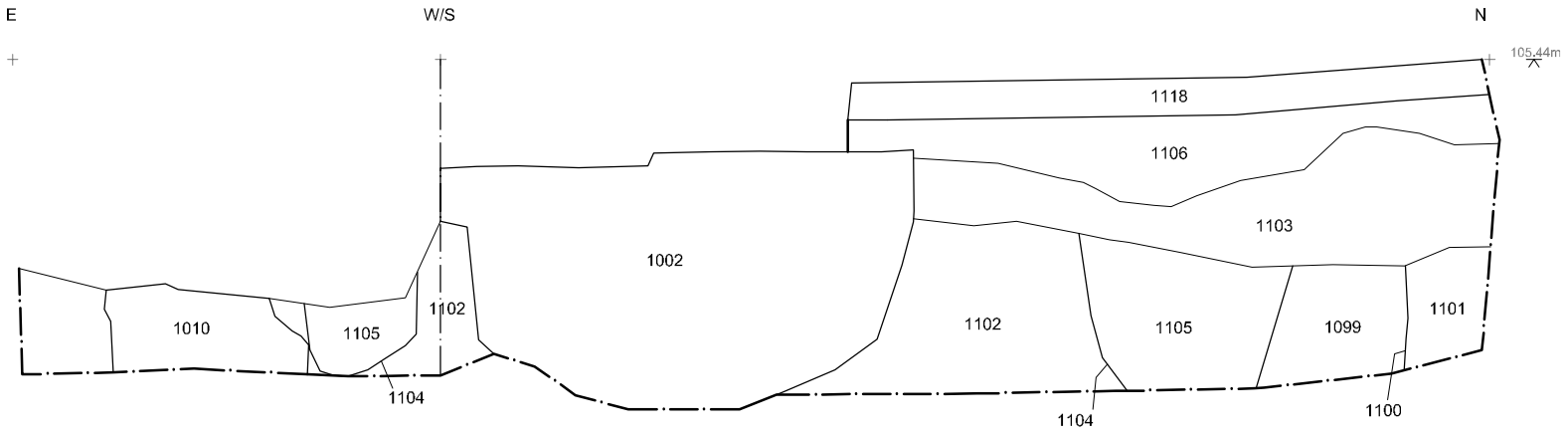
Project:
Biwater, Clay Cross Works

Title
Plan of Area 1 and Area 4

Scale	Date
1:125	May 2009
NGR: **Area 1: SK 39914 64356 Area 4: SK 39891 64322**	Drawn: CS
Project No. **1114d.2(1)**	Ill. No. **7**



0 2.5m

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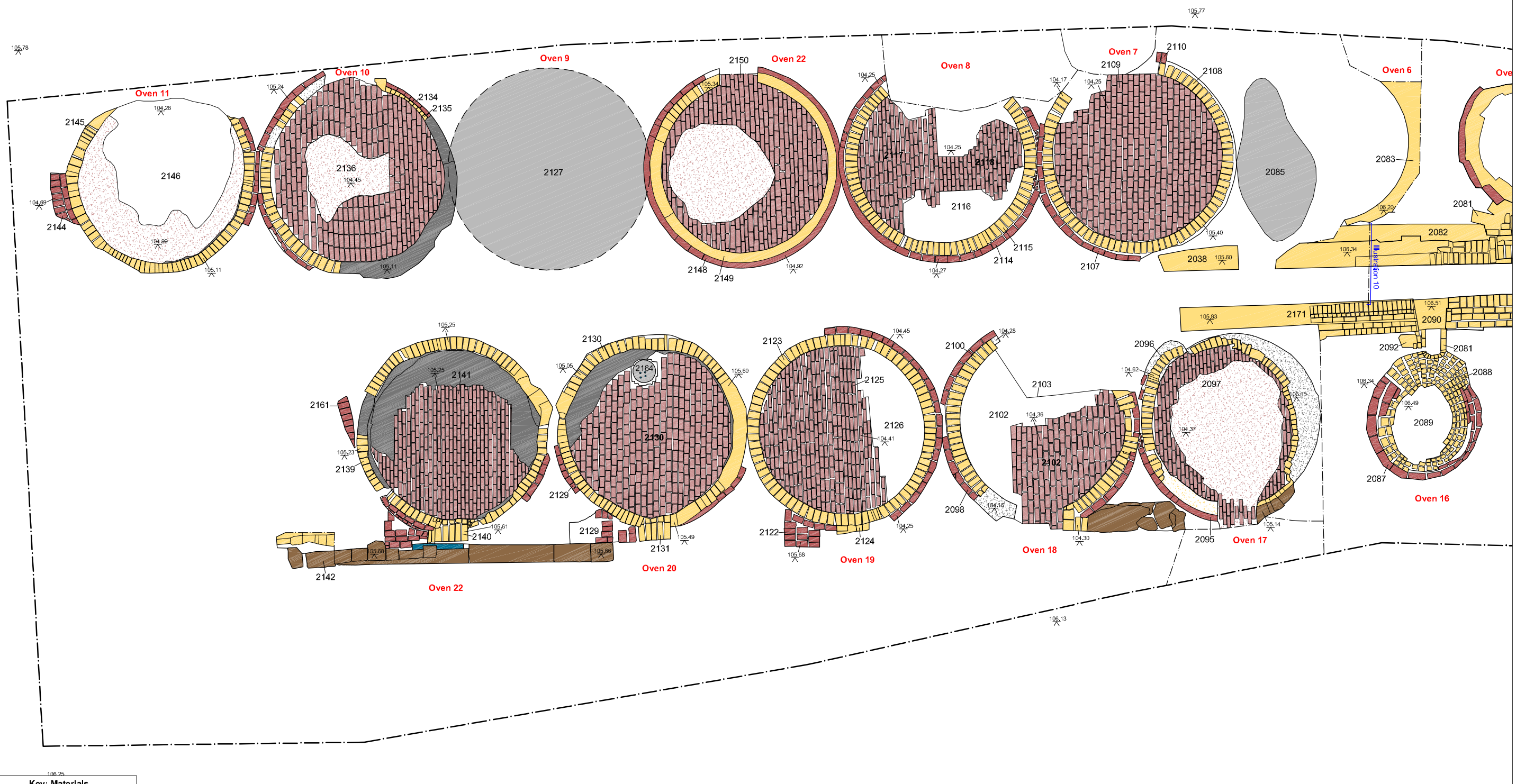
Project:
Biwater, Clay Cross Works

Title
East facing section in Area 1

Scale	Date
1:40	May 2009
NGR	Drawn
Area 1: SK 39914 64356	CS
Project No.	Illustration No.
1114d.2(1)	**8**



Key: Materials

- Red Brick structure
- Red Brick other
- Fire Brick structure
- Stone structure
- Concrete structure
- Metal
- Mortar
- Coke Tar
- Wood

0 5m

N

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Project: **Biwater, Clay Cross Works**	Scale 1:75	Date May 2009
Title **Plan of Area 2: Western half**	NGR Area 2: SK 40037 64295	Drawn CS
	Project No. **1114d.2(1)**	Illustration No. **9a**

Oven 7
Oven 6
Oven 5
Oven 4
Oven 3
Oven 2
Oven 1
Oven 16
Oven 15
Oven 14
Oven 13
Oven 12
Oven 17
Section 10

Key: Materials

- Red Brick structure
- Red Brick other
- Fire Brick structure
- Stone structure
- Concrete structure
- Metal
- Mortar
- Coke Tar
- Wood

0 5m

N

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Project: **Biwater, Clay Cross Works**

Title: **Plan of Area 2: Eastern half**

Scale: 1:75

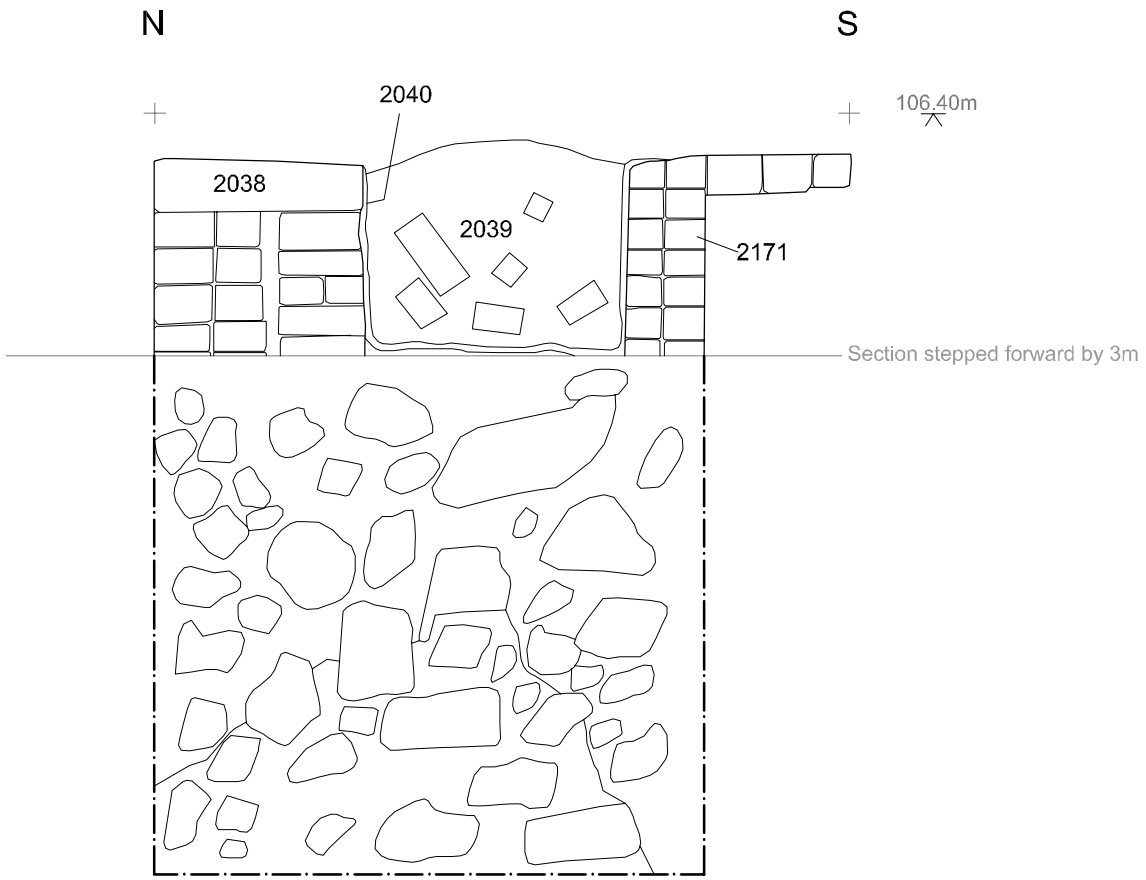
Date: May 2009

NGR: Area 2: SK 40037 64295

Drawn: CS

Project No.: **1114d.2(1)**

Illustration No.: **9b**



0 1m

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Project:
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Title
West facing section of flue in Area 2

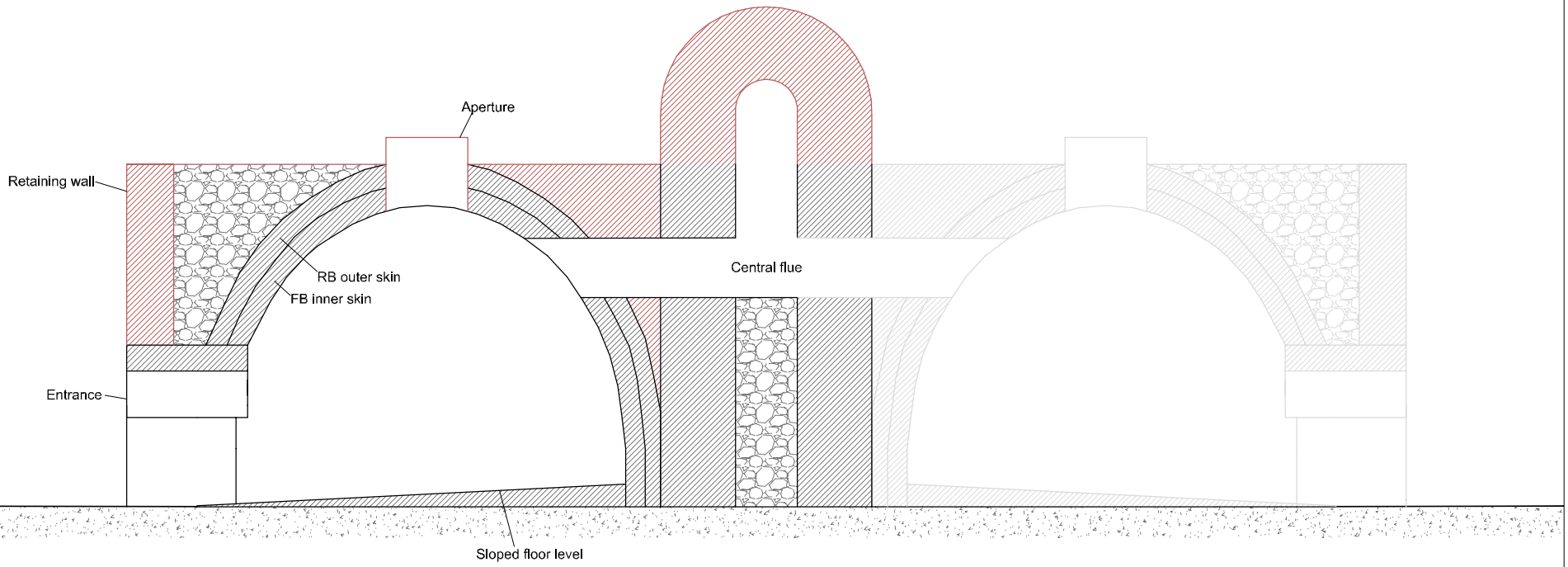
Scale	Date
1:20	May 2009
NGR: Area 2: SK 40037 64295	Drawn: CS
Project No.: **1114d.2(1)**	Illustration No.: **10**

SW

NE

Oven 17

Oven 7
(Stepped back)



0 2.5m

Key

- Surviving structure
- Reconstructed
- Structure cut by section
- Ground surface
- Rubble backfill

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Project:
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Title
Re-creation of Beehive ovens and flue

Scale	Date
1:50	May 2009
NGR	Drawn
SK 400 643	CS
Project No.	Illustration No.
1114d.2(1)	**11**

Key: Materials

- Red Brick structure
- Red Brick other
- Fire Brick structure
- Stone structure
- Concrete structure
- Metal
- Mortar
- Coke Tar
- Wood

0 — 10m

N

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Project: **Biwater, Clay Cross Works**	Scale 1:125	Date May 2009
	NGR Area 3: SK 39955 64432	Drawn CS
Title **Plan of Area 3**	Project No. **1114d.2(1)**	Illustration No. **12**

Plate 1: Fragment of concrete with impressed ceramic from Building 5.

Plate 2: Gasworks retort during watching brief, viewed facing northwest.

Plate 3: Possible remains of spin engine; [31033] (top) and [31032] (bottom), Building 31, viewed facing west.

Plate 4: North-south flue [31024] and associated laminate fill [31025], viewed facing south.

Plate 5: Curvilinear flue [31027], viewed facing southeast.

Plate 6: Building 33, front arch of Beehive Oven, viewed facing north.

Plate 7 – A view south-east across the east end of Area I.

Plate 8: Casting pit [1003] containing spigot [1084], viewed facing east.

Plate 9: Flue [1035], viewed facing north. Wall [1037] at right of photograph.

Plate 10: Wall [1113] butted to the north by structure [1015], viewed facing south.

Plate 11: Surviving remains of [1034], viewed facing northeast.

Plate 12: Hearth [1078], viewed facing south.

Plate 13: Boiler base [1075], viewed facing north.

Plate 14: *In situ* cast iron [1090], viewed facing west.

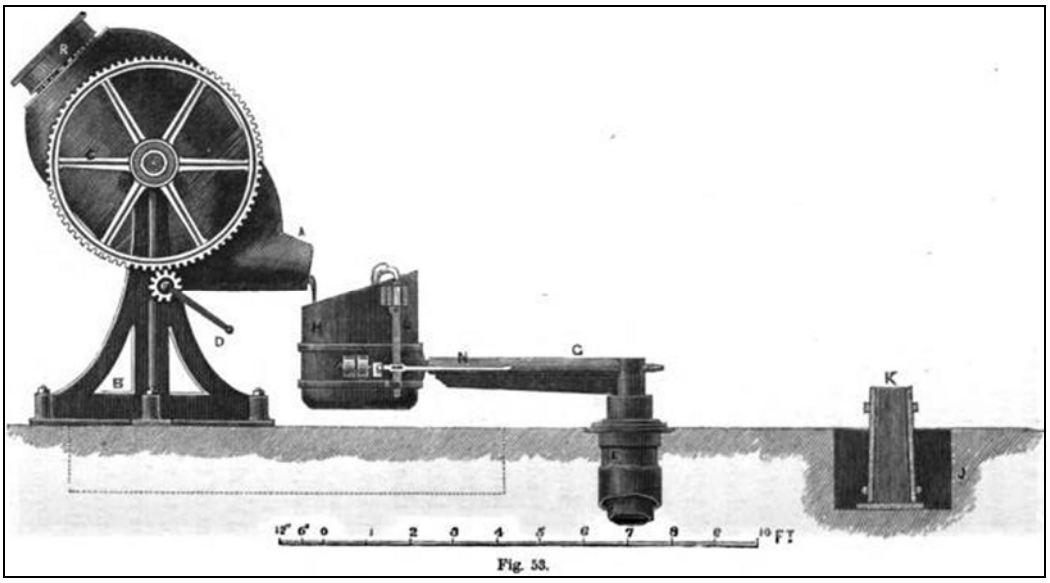

Fig. 53.

Plate 15: Fairbairn's diagram of casting ladle, from "Iron: Its History, Properties and Processes of Manufacture." (W. Fairbairn 1865, 2nd edition).

Plate 16: General shot of Area II, viewed facing west.

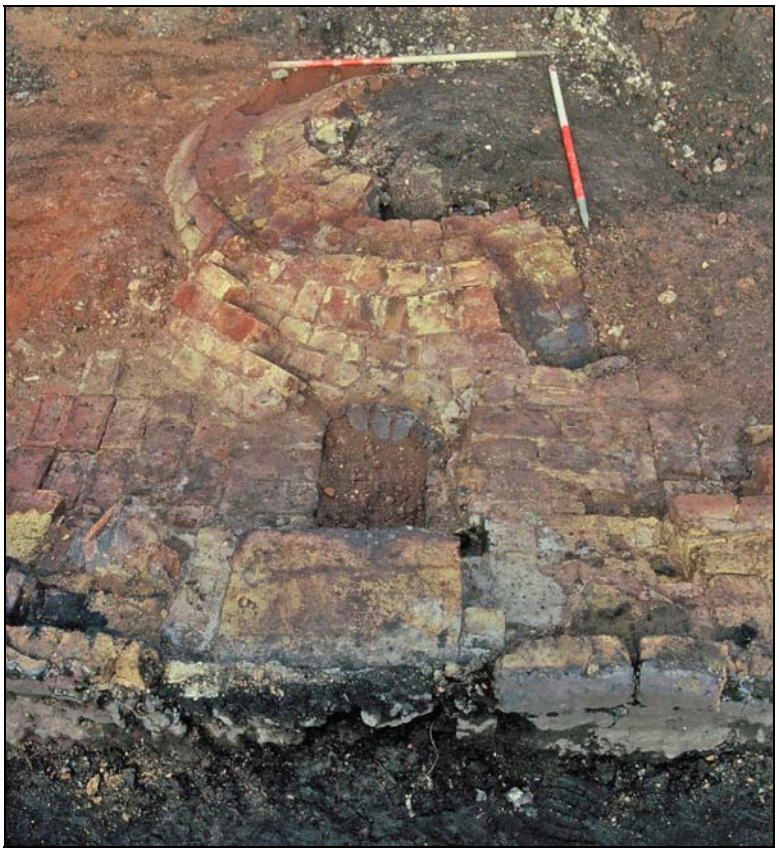

Plate 17: Ancillary flue and capping stone, oven 3, viewed facing north.

Plate 18: Repair [2117] to oven floor [2116] in oven 8, bottom right of photograph. Viewed facing south.

Plate 19: Retort bench in Area III viewed facing northwest.

Plate 20: Furnace base in Area IV, viewed facing northwest.

9 APPENDICES

Appendix 1	Archive Contents
Appendix 2	Ceramic assessment
Appendix 3	Ceramic Building Material assessment
Appendix 4	Clay Pipe assessment
Appendix 5	Glass assessment
Appendix 6	Archaeometallurgical assessment
Appendix 7	List of Contexts

APPENDIX 1: ARCHIVE CONTENTS

The artefacts and paper archive will be deposited with Weston Park Museum.

Summary:

Ceramics	Animal Bone	Metal objects	Glass	Clay Pipe	Industrial process residue	Slag	Leather	Shell	Wood	Building material	Misc	Environ-mental Samples
1	0	36	8	4	0	0	0	0	0	2	69	0

Table 1: Finds Archive

Description	Number of sheets
Field drawings	41
Drawing register	4
Photographic register	26
Context sheets	461
Context register	18
Finds sheets	0
Finds register	0
Soil sample register	1
Soil sample sheets	5
Brick recording sheets	115
Grindstone recording sheets	0
Levels register	0
Trench record sheets	0
Copy report	

Table 2: Paper Archive

Description	Number of pictures
Black & White contact sheets	11
Black & White negatives	11
Colour slides	11
Digital photographs (1 CD)	350

Table 3: Photographic Archive

APPENDIX 2: CERAMIC ASSESSMENT

by Linzi Harvey and Chris Cumberpatch

A single fragment of pottery was recovered from Biwater (ARCUS 1114d). The fragment has been individually examined and details recorded here. This single fragment weighed 4 grams and represented a maximum of one vessel.

This sherd was recovered from 1110, the fill of circular brick structure 1109. It was a body sherd from a bowl or dish with exterior blue banded decoration. The decoration was painted rather than printed. This fragment can be broadly dated to the 19th century (Chris Cumberpatch, *pers comm*.)

Although no further work is recommended, the ceramic sherd should be retained for the site archive.

APPENDIX 3: CERAMIC BUILDING MATERIAL ASSESSMENT

by Linzi Harvey

Two ceramic building material items were recovered from Biwater (ARCUS 1114d). These two fragments were retrieved from a single context, and have been individually examined with their details and measurements recorded in **Table 4,** below.

The assemblage consists of one complete and one part brick of the same dimensions and fabric type. These bricks were recovered from blast furnace structure 4016. The homogeneous fabric, large size and dense nature of these bricks is in keeping with it being a refectory blast furnace brick. The form of these bricks is in keeping with the 20th century rebuild episodes which took place at the site of the blast furnace.

Although no further work is recommended, the bricks should be retained for the site archive.

Context	Context information	Quantity	Date range	Description and measurements
4016	Blast furnace	2	20 C	1 complete large brick; dense, homogenous black slightly mica rich fabric, unfrogged with no markings. Probably machine made, narrows slightly at one end. Measures 300mm in length, 150mm wide and 75mm deep. 1 part brick of same type as above.
Totals		**2**		

* indicates item to retain

Table 4: Ceramic Building Material

APPENDIX 4: CLAY PIPE ASSESSMENT

by Linzi Harvey

Four fragments of clay pipe were recovered from Biwater (ARCUS 1114d). The clay pipe fragments have been individually examined and details recorded here. Published schemes including Oswald (1975), Russell (1996) and Ayto (2002) were used to identify bowl form or decoration where applicable.

Three small fragments recovered from context 2016 (the upper fill of the central flue system, Area II) fitted together to form an incomplete bowl. This was a fairly large thin-section bowl with milling around the rim, likely to date to the mid-19th century. Another incomplete bowl was recovered from levelling deposit 2185. This was lightly decorated with a possible floral design and a small knob towards the base on both left and right sides, and a short forward projecting spur. This is similar to bowl examples illustrated in Russel (1996: 39) which date to the second half of the 19th century.

Although no further work is recommended, the clay pipe should be retained for the site archive.

APPENDIX 5: GLASS ASSESSMENT

by Linzi Harvey

A total of eight fragments of glass were recovered from Biwater (ARCUS 1114d). These items were from two stratified contexts and are described below in **Table 5.**

All glass fragments were individually examined. The glass was counted, weighed and sorted into container (bottles, jars etc) or non-container glass (including window, decorative and 'miscellaneous' fragments). The Society for Historical Archaeology website (SHA, 2008) was used to identify and sort the nineteenth and twentieth century material. A minimum vessel count (MNI) was determined using the SHA guidelines and Jones (1986) typology for bottle finishes. This allowed a minimum vessel count to be identified, based on the number of neck finishes or near complete bottles present.

A total of eight glass fragments were recovered. All of these were from containers such as bottles or jars. The assemblage weighed approximately 562 grams in total. Glass was recovered primarily from disturbed casting sand deposit 1089 in Area I, whilst a single fragment was retrieved from 2016, the upper fill of the central flue system in Area II.

A minimum of one vessel was identified on the basis of finish type. This was an internal thread finish (SHA type 29) from context 2016. The applied nature of this finish places the production of this bottle to the latter part of the 19th or early 20th century.

Base and body fragments from context 1089 were embossed with the initials 'RJL' and the place name 'Mansfield'. Mansfield is around 12 miles to the east of the Biwater, Clay Cross site. This indicates that this bottle, possibly a beer or soda bottle, was made fairly locally.

Due to the small size of the assemblage it is impossible to interpret the kinds of glass recovered and activity on site. Although no further work is recommended, material marked as of interest in the tables below should be retained and deposited in the appropriate museum.

The glass assemblage is in a stable condition and requires no further conservation.

			Containers						Complete bottle dimensions							
Context	Weight (g)	# Fragments	# complete/nr complete	# base fragments	# body fragments	# neck	Finish	Etching, embossing, labels	Height (mm)	Width/circumference of base (mm)	Date	Colour	Shape	Function (e.g. wine, beer or medicinal)	Notes	MNI
1089	68	4			4						19-20	Various		Beverage	3 AG, 1 green.	*
1089	438	3		1	2			"R..../ TRADE RJL MARK / MANSFIELD" on side, "RJL" on base.		75	19-20	AG	Round	Beverage	Press moulded, AG bottle base. Three pieces fit together.	*
2016	56	1				1	Internal thread				19-20	AG		Beverage	Applied finish, internal thread.	1*
TOTALS	**562**	**8**	**0**	**1**	**6**	**1**										**1**

* indicates item to retain

Table 5 – Container glass

APPENDIX 6: ARCHAEOMETALLURGICAL ASSESSMENT

by Roger Doonan

Introduction

The assemblage reported here comes from excavations undertaken at Biwater, Clay Cross (ARCUS 1114d). The site was thought to be associated with a range of production processes including ferrous casting and iron production. Archaeological investigation revealed the presence of a series of beehive coking kilns, a furnace base and the presence of casting pits. This report evaluates the further potential of an assemblage of archaeometallurgical finds recovered from excavation.

The assemblage

The assemblage comprises two classes of material, namely ferrous objects and slag.

Ferrous objects

A total of 12.5kg of ferrous objects were assessed (see **Table 6**). The majority of the assemblage comprised a variety of bolts and other fragments of architectural ironwork. In addition there was also a corroded ferrous plate which appeared to be derived from some form of shovel head (**Figure 1**). The presence of an open socket with evidence for rivets confirm such identification.

Slag

A total of seven slag or slag/iron concretion fragments were assessed (see **Table 7**). The range of slags examined are clearly related to a variety of processes. The large sample from near Building 31 appears to be associated with iron founding, evidenced by the large inclusions of cast iron embedded in the slag but this needs to be confirmed with subsequent analysis. This most likely relates to the founding associated with the large fragment of cast iron shown in **Figure 3**.

Recommendations

The iron work assessed is most likely derived from site infrastructure and includes fragments of tools and architectural elements. No further work is recommended for this aspect of the assemblage.

The slag assemblage is varied and most likely derived from a broad range of processes. It is recommended that a range of work is carried out to better characterise this material. In line with current EH guidelines it is suggested that compositional analysis supported by microstructural analysis is undertaken for all slag samples, in addition to the two samples of *in situ* cast iron taken from the iron run pictured in **Figure 3**.

Context	Material	Weight	No.	Description
1026	Metal (ferrous)	1020g	3	Concreted ferrous objects—likely bolts
1050	Metal (ferrous)	4651g	14	4 bolts, 4 rods/spikes, 1 rod with a loop in the end, 1 'U' shaped object, 1 rod/nail slightly bent, 1 'S' shaped bracket, 1 large pin, 1 bracket. Selection of architectural ironwork.
1089	Metal (ferrous)	2350g	1	Shovel head with riveted socket
1089	Metal (ferrous)	4570g	1	Ferrous fragments

Table 6: Catalogue of ferrous material.

Site	Context	Material	Weight	No.	Description
1114c	^1 Near building 31	Slag	>15kg	1	Large conglomerate>15Kg. Black glassy slag with large ferrous inclusions. Foundry melting slag.
1114c	^2 Near Bldg 31	Slag	2460g	2	Black glassy vesicular slag. Fragment. Inclusions of coke.
1114d	^3 4017	Slag	1270g	2	Light grey dense slag. Feldspar inclusions.
1114d	^4 4017	Slag / iron concretion	1325g	2	Ferrous concretion.

Table 7: Catalogue of slag.

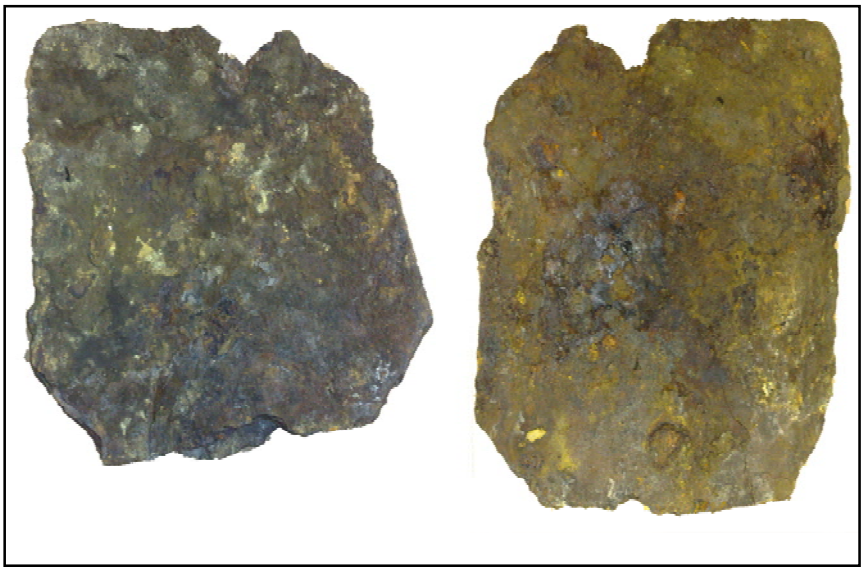

Figure One: Shovel head from 1089. Note rivets and socket.

Figure Two: Selection of ironwork from 1050

Figure 3: Large cast Iron run found *in situ* and channelled towards area of casting pits.

APPENDIX 7: LIST OF CONTEXTS

Table 4: Watching brief contexts (ARCUS site code 1114c)

Site sub-division	Context No	Context type	Description
Building 5	5000	Deposit	Redeposited casting sand
Building 5	5001	Deposit	Later dump within [5000], contains concrete and ceramic mosaic
Building 19	19001	Structure	Concrete pad
Building 19	19002	Structure	Dipping tank 1
Building 19	19003	Structure	Dipping tank 2
Building 22	22001	Structure	Concrete pad underlying building 22
Building 22	22002	Structure	Concrete stanchion beneath pad
Building 22	22003	Structure	Concrete stanchion beneath pad
Building 22	22004	Structure	Concrete stanchion beneath pad
Building 22	22005	Structure	Concrete stanchion beneath pad
Building 22	22006	Structure	Concrete stanchion beneath pad
Building 22	22007	Structure	Concrete wall associated with B.22
Building 22	22008	Structure	Large rectangular concrete sump
Building 22	22009	Structure	N-S Fe rail track
Building 22	22010	Structure	Brick access points/man holes
Building 22	22011	Cut	Construction cut for sump [22008]
Building 22	22012	Structure	Wooden sleeper for rail track [22009]
Building 22	22013	Deposit	Group of made ground deposits within but predating building 22
Building 22	22014	Deposit	Backfill of [22008]
Building 22	22015	Structure	R/B structure at bottom of sondage 2
Building 22	22016	Structure	E-W aligned flue associated with 1880 gas house
Building 22	22017	Cut	Truncating flue [22016]
Building 22	22018	Structure	Fe tank/boiler
Building 22	22019	Deposit	Backfill of cut [22017]
Building 22	22020	Cut	Cut for flue [22016]
Building 22	22021	Deposit	Backfill for construction cut [22020] for flue [22016]
Building 22	22022	Deposit	Vitrified material surrounding flue [22016]
Building 22	22023	Deposit	Made ground dump
Building 22	22024	Cut	Unknown cut
Building 22	22025	Deposit	Slump of vitrified material
Building 22	22026	Deposit	Silting in cut [22024]
Building 22	22027	Cut	Possible robber cut
Building 22	22028	Deposit	Dump of industrial material in [22027]
Building 22	22029	Deposit	Silting into top of cut [22027]
Building 22	22030	Deposit	Dump of made ground
Building 22	22031	Cut	Construction cut for wall [22032]
Building 22	22032	Structure	E-W firebrick wall
Building 22	22033	Deposit	Backfill of construction cut [22031]
Building 22	22034	Deposit	Dump of made ground under B.22
Building 22	22035	Structure	R/B footing beneath B.22
Building 22	22036	Cut	Construction cut for [22036]
Building 22	22037	Deposit	Backfill of [22036]
Building 22	22038	Structure	Group of R/B walls at NW of site. Associated with 1880's gas house
Building 22	22039	Structure	R/B structure at eastern edge of site
Building 22	22040	Structure	Red Brick structure
Building 22	22041	Cut	Construction cut for R/B structure [22039]
Building 22	22042	Deposit	Backfill of construction cut [22041]
Building 22	22043	Deposit	Made ground layer, cut by all surrounding features

Site sub-division	Context No	Context type	Description
Building 22	22044	Cut	Drain for B.22
Building 22	22045	Deposit	Backfill of cut [22044]
Building 22	22046	Cut	SE-NW drainage cut
Building 22	22047	Deposit	Backfill of cut [22046]
Building 23	23001	Structure	Concrete raft
Building 23	23001	Deposit	Made ground below [23001]
Building 31	31001	Structure	Modern concrete pad of B.31
Building 31	31002	Deposit	Made ground beneath concrete pad [31001]
Building 31	31003	Structure	Modern steel chimney
Building 31	31004	Cut	Cut for steel chimney
Building 31	31005	Structure	Concrete wall
Building 31	31006	Structure	S/S flooring or base before chimney
Building 31	31007	Structure	N-S brick wall
Building 31	31008	Structure	R/B surface/wall
Building 31	31009	Cut	Cut for [31008]
Building 31	31010	Cut	SE-NW orientated cut
Building 31	31011	Deposit	Possible demolition material
Building 31	31012	Deposit	Dump of made ground
Building 31	31013	Deposit	Backfill of construction cut [31009] for [31008]
Building 31	31014	Deposit	Dump of made ground prior to construction of walls [31007],[31015]
Building 31	31015	Structure	Fragment of sandstone wall
Building 31	31016	Cut	Construction cut for wall [31015]
Building 31	31017	Deposit	Backfill of cut [31016]
Building 31	31018	Deposit	Backfill of construction cut [31016] for wall [31015]
Building 31	31019	Cut	Construction cut for wall [31007]
Building 31	31020	Deposit	Backfill of construction cut [31019]
Building 31	31021	Structure	Flue end, possible chimney base
Building 31	31022	Structure	A structure contemporary to [31021], but with a different function
Building 31	31023	Structure	N-S R/B wall
Building 31	31024	Structure	Flue
Building 31	31025	Deposit	Laminated fill between chamber 31024 & wall 31026
Building 31	31026	Structur	N-S aligned wall adjacent to 31024
Building 31	31027	Structur	Curvilinear flue
Building 31	31028	Structure	Fe plates, part of possible spin engine
Building 31	31029	Structure	Unknown structure, possible part of spin engine in building 31
Building 31	31030	Structure	Fe plates forming edge of possible spin engine
Building 31	31031	Structure	Engine mounting and flooring of possible spin engine
Building 31	31032	Structure	Machine fixing, possible part of spin engine
Building 31	31033	Structure	Fixing bolt
Building 32	32001	Structure	Possible kiln/furnace, E corner
Building 32	32002	Structure	Possible kiln/furnace, W corner
Building 32	32003	Structure	Possible kiln/furnace, SW corner
Building 32	32004	Structure	Possible kiln/furnace, SE corner
Building 32	32005	Structure	Possible kiln/furnace, E corner
Building 33	33000	Structure	Brick flue (into beehive area?)
Building 33	33001	Deposit	Made ground surrounding flue [33000]
Building 33	33002	Cut	Levelling construction cut
Building 33	33003	Deposit	Levelling deposit
Building 33	33004	Structure	Unknown red brick structure
Building 33	33005	Deposit	Deposit of possible casting sand as backfill
Building 33	33006	Cut	Construction cut for wall [33008]
Building 33	33007	Deposit	Fill of wall [33008]

Site sub-division	Context No	Context type	Description
Building 33	33008	Structure	N-S alligned red brick wall
Building 33	33009	Structure	Unknown fire brick domed structure
Building 33	33010	Structure	Red brick wall corner, NE return
Building 33	33011	Deposit	Backfill of possible casting sand
Building 52	52001	Structure	Tarmac surface around B.52
Building 52	52002	Deposit	Made ground beneath [52001]
Building 52	52003	Structure	Concrete surface beneath [52002]

Table 5: Mitigation Contexts (ARCUS site code 1114d)

Site sub-division	Context No	Context type	Description
Area 1	1000	Structure	East circular brick structure
Area 1	1001	Structure	Circular RB structure, casting pit
Area 1	1002	Structure	Circular RB structure, casting pit
Area 1	1003	Structure	Circular RB structure, casting pit
Area 1	1004	Deposit	Casting sand? Within circular structure [1001]
Area 1	1005	Deposit	Fill of casting pit [1002]
Area 1	1006	Deposit	Fill of casting pit [1003]
Area 1	1007	Deposit	May have been a casting sand
Area 1	1008	Structure	Sandstone structure, part of original foundry wall
Area 1	1009	Structure	Original exterior wall of foundry, possibly foundation
Area 1	1010	Structure	E-W wall, part of original foundry complex
Area 1	1011	Structure	N-S sandstone wall, part of original foundry complex
Area 1	1012	Structure	RB part of a chimney or small casting pit?
Area 1	1013	Structure	RB pad, SE corner of trench
Area 1	1014	Structure	RB S wall, same allignment as [1008]
Area 1	1015	Structure	RB circular structure, N side of [1008]
Area 1	1016	Deposit	Backfill, probably part of secondary phase of construction
Area 1	1017	Structure	RB N-S wall
Area 1	1018	Structure	N-S sandstone wall
Area 1	1019	Structure	RB south wall of foundry
Area 1	1020	Structure	Probably wall of 'drying rooms' in S of foundry
Area 1	1021	Structure	Square red brick hearth
Area 1	1022	Structure	Flue serving hearths in 'drying rooms'
Area 1	1023	Structure	Sleepers for rail track
Area 1	1024	Structure	SS block E-W S wall of foundry
Area 1	1025	Cut	Square pit
Area 1	1026	Deposit	Backfill of [1025]
Area 1	1027	Deposit	Possible narrow band of casting pit
Area 1	1028	Structure	Concrete path
Area 1	1029	Structure	RB pad, W end of [1019]
Area 1	1030	Structure	E-W RB structure
Area 1	1031	Structure	Buttress/hearth support
Area 1	1032	Structure	Partition wall for alcoves in S wall
Area 1	1033	Structure	20thC alteration to alcove off main casting shop
Area 1	1034	Structure	Latest flue arrangement
Area 1	1035	Structure	Early phase flue, superseded by [1034]
Area 1	1036	Structure	Truncated circular RB structure E of [1034]
Area 1	1037	Structure	Early SS foundry wall
Area 1	1038	Structure	N-S RB linear, butts [1008]
Area 1	1039	Structure	Sandstone wall
Area 1	1040	Structure	Semi circular RB structure

Site sub-division	Context No	Context type	Description
Area 1	1041	Structure	Modern circular RB structure
Area 1	1042	Cut	Modern cut for pipe
Area 1	1043	Deposit	Backfill of pipe cut [1042], modern
Area 1	1044	Structure	RB circular casting pit
Area 1	1045	Structure	Modern concrete tank
Area 1	1046	Deposit	Fill of [1044], truncated by [1045]
Area 1	1047	Structure	RB circular casting pit
Area 1	1048	Deposit	Casting sand backfill of [1047]
Area 1	1049	Structure	Brick tank/hearth?
Area 1	1050	Structure	Main N wall of foundry
Area 1	1051	Structure	N-S SS wall truncated by [1047]
Area 1	1052	Structure	N-S Cast iron divider for sand hoppers
Area 1	1053	Structure	N-S Cast iron divider for sand hoppers
Area 1	1054	Structure	N-S Cast iron divider for sand hoppers
Area 1	1055	Structure	N-S Cast iron divider for sand hoppers
Area 1	1056	Structure	RB circular casting pit?
Area 1	1057	Structure	RB rectangular structure
Area 1	1058	Structure	RB channel/flue
Area 1	1059	Structure	SS exterior wall of foundry
Area 1	1060	Structure	RB machine/crane base
Area 1	1061	Structure	Large cast iron pipe
Area 1	1062	Structure	RB and SS pad or trackway
Area 1	1063	Structure	Wall foundation for internal foundry wall
Area 1	1064	Structure	Possible RB casting pit
Area 1	1065	Structure	RB pad, S side of W end area 1
Area 1	1066	Structure	Rectangular tank, W end
Area 1	1067	Structure	Modern concrete tank, NW end
Area 1	1068	Structure	Rail track, E-W
Area 1	1069	Structure	Metal plate flooring
Area 1	1070	Structure	Metal plate track, same alignment as [1071]
Area 1	1071	Structure	Rail track, same alignment as [1070]
Area 1	1072	Structure	RB surface N of [1070], W of [1073]
Area 1	1073	Structure	RB wall N-S, either side of [1071]
Area 1	1074	Structure	Fe ring, possible crane base
Area 1	1075	Structure	Possible crane bases
Area 1	1076	Structure	Fe trough lying to S of [1074],[1075]
Area 1	1077	Structure	Sand divided by Fe plates
Area 1	1078	Structure	RB hearth and flue
Area 1	1079	Structure	RB hearth and flue
Area 1	1080	Structure	SS N-S 1st phase foundry wall
Area 1	1081	Structure	Red brick wall. 2nd phase
Area 1	1082	Structure	Upper element of a flue system
Area 1	1083	Structure	RB rectangular hearth
Area 1	1084	Structure	Fe spigot of central crane apparatus
Area 1	1085	Structure	Fe fixing plate for spacing of cast items
Area 1	1086	Structure	RB circular casting pit
Area 1	1087	Structure	Demolition backfill of [1039]
Area 1	1088	Deposit	Loose sand, foundry floor
Area 1	1089	Deposit	Disturbed/used casting sand
Area 1	1090	Deposit	Fe runoff in situ running NE-SW
Area 1	1091	Deposit	Fe runoff, unstratified
Area 1	1092	Structure	RB floor surface/foundation for [1070]

Site sub-division	Context No	Context type	Description
Area 1	1093	Structure	Iron plate frame situated south of [1074]/[1075]
Area 1	1094	Deposit	Hard metallic floor surface associated with [1093]
Area 1	1095	Cut	Circular cut for cranes
Area 1	1096	Deposit	Fill of cut [1095]
Area 1	1097	Structure	L shaped RB wall E of [1074]
Area 1	1098	Structure	Concrete floor surface abutting [1073]
Area 1	1099	Deposit	Layered sand around [1012]
Area 1	1100	Cut	Cut for 4th phase foundry extension
Area 1	1101	Deposit	Backfill of 4th phase foundry cut [1100]
Area 1	1102	Deposit	Backfill around structure [1002]?
Area 1	1103	Deposit	Layer above [1102]
Area 1	1104	Cut	Drain cut
Area 1	1105	Deposit	Drain fill
Area 1	1106	Deposit	Sand layer below rail building after demolition of [1002]
Area 1	1107	Cut	Cut for casting pit [1002]
Area 1	1108	Structure	Small brick structure N of [1068] E of [1063]
Area 1	1109	Structure	Circular brick structure SE of [1003], within flue [1034]
Area 1	1110	Deposit	Fill of [1109]
Area 1	1111	Structure	Rectangular brick structure N of [1109]
Area 1	1112	Structure	Rectangular red brick pad south of [1002]
Area 1	1113	Structure	Phase III south wall of foundry, butted by [1015]
Area 1	1114	Structure	Not used.
Area 1	1115	Structure	N-S RB wall, S of [1008]
Area 1	1116	Structure	N-S RB wall, S of [1008], W of [1115].
Area 1	1117	Structure	Brick 'square' overlying [1086]
Area 1	1118	Structure	Brick 'square' overlying [1002]
Area 2	2000	Group	Remains of Beehive oven 1
Area 2	2001	Structure	RB outer lining of Beehive oven 1
Area 2	2002	Structure	Firebrick inner lining of beehive oven 1
Area 2	2003	Structure	Single SS block over [2002]
Area 2	2004	Structure	2 SS chunks, part of floor surface
Area 2	2005	Structure	RB E-W wall. Part of flue system
Area 2	2006	Structure	Firebrick inner wall of main flue
Area 2	2007	Structure	Internal firebrick wall of flue system
Area 2	2008	Structure	External firebrick structure on N side of flue system
Area 2	2009	Structure	Fire brick structure SE of oven [2012]
Area 2	2010	Structure	2 fire clay slabs, part of flue
Area 2	2011	Structure	Firebrick structure, part of ancillary flue
Area 2	2012	Group	Beehive oven, W of [2000]
Area 2	2013	Structure	External RB skin of beehive coke oven
Area 2	2014	Structure	Internal heat proof skin of coke oven [2012]
Area 2	2015	Deposit	Demolition backfill of oven [2012]
Area 2	2016	Deposit	Upper fill of central flue system
Area 2	2017	Not used	Not used
Area 2	2018	Not used	Not used
Area 2	2019	Structure	Southern wall of main flue channel
Area 2	2020	Structure	Fire brick wall of main flue in area of oven 12
Area 2	2021	Structure	RB E wall of outer section of oven 12 flue
Area 2	2022	Structure	Fire brick wall of inner section of oven 12 flue
Area 2	2023	Structure	Fire brick W wall of inner section of oven 12 flue
Area 2	2024	Group	Beehive oven 12
Area 2	2025	Structure	The RB lined outer casing of oven 12

Site sub-division	Context No	Context type	Description
Area 2	2026	Structure	Fire brick inner casing for oven 12
Area 2	2027	Deposit	Backfill deposit of beehive oven 12
Area 2	2028	Structure	Fire brick cover of oven 12 flue
Area 2	2029	Cut	NW-SE cut for modern 20thC pipe
Area 2	2030	Deposit	Backfill of cut [2029]
Area 2	2031	Group	Beehive oven no 3
Area 2	2032	Structure	RB outer skin of oven 3
Area 2	2033	Structure	Inner coat of bricks for oven 3
Area 2	2034	Structure	Part of W flue housing to oven 3
Area 2	2035	Structure	Fire brick E wall to oven 3
Area 2	2036	Structure	Fire brick structure E of oven 3 flue
Area 2	2037	Not used	Not used
Area 2	2038	Structure	Fire brick inner N wall of main flue W of [2029]
Area 2	2039	Deposit	Backfill of flue?
Area 2	2040	Deposit	Slag build up during use. Overlain by [2039]
Area 2	2041	Not used	Not used
Area 2	2042	Structure	W flue housing for beehive kiln
Area 2	2043	Structure	Capping stone from oven to exhaust flue, On [2034],[2035]
Area 2	2044	Not used	Not used
Area 2	2045	Deposit	Backfill deposit of beehive oven 3
Area 2	2046	Group	Number for beehive oven 4
Area 2	2047	Structure	RB outer casing for oven 4
Area 2	2048	Structure	Firebrick inner lining of beehive oven 4
Area 2	2049	Deposit	Backfill of oven 4
Area 2	2050	Structure	E wall of oven 4 ancillary flue
Area 2	2051	Structure	W wall of oven 4 ancillary flue
Area 2	2052	Deposit	Backfill of oven 4 ancillary flue
Area 2	2053	Structure	Cover slab for oven 4 ancillary flue
Area 2	2054	Structure	RB floor W of oven 4 ancillary flue
Area 2	2055	Structure	RB floor surface
Area 2	2056	Structure	Fire brick section of S outer wall of main flue NW of oven 13
Area 2	2057	Structure	Firebrick capping of flue from oven 13
Area 2	2058	Group	Oven 13
Area 2	2059	Structure	Outer RB capping of oven 13
Area 2	2060	Structure	Inner fire brick wall and dome of oven 13
Area 2	2061	Structure	Fire brick E wall of ancillary flue for oven 14
Area 2	2062	Structure	W wall of ancillary flue for oven 14
Area 2	2063	Group	Oven 14
Area 2	2064	Structure	RB outer capping of oven 14
Area 2	2065	Structure	Inner wall of oven 14
Area 2	2066	Structure	Backfill
Area 2	2067	Structure	Fire brick S outer wall of main flue, continuation of [2056]
Area 2	2068	Structure	RB wall running S from [2067]
Area 2	2069	Structure	E end of fire brick slab on top of wall [2067]
Area 2	2070	Structure	RB structure W of oven 15 flue
Area 2	2071	Group	Beehive oven
Area 2	2072	Structure	RB outer casing of oven 15
Area 2	2073	Structure	Fire brick inner lining of oven 15
Area 2	2074	Deposit	Mixed backfill deposit of beehive oven 15
Area 2	2075	Group	Group number for oven 5
Area 2	2076	Structure	RB outer casing of beehive oven 5
Area 2	2077	Structure	Firebrick inner lining of beehive oven 5

Site sub-division	Context No	Context type	Description
Area 2	2078	Deposit	Demolition/ground raising related backfill of oven 5
Area 2	2079	Structure	N fire clay slab cover of oven 5 ancillary flue
Area 2	2080	Structure	S fire clay slab forming cover for oven 5 ancillary flue
Area 2	2081	Structure	Firebrick structure, possible surface W of oven 5 ancillary flue
Area 2	2082	Structure	FB wall, N wall of main flue in area of oven 3
Area 2	2083	Structure	Part of beehive oven 6
Area 2	2084	Cut	Modern cut filled by concrete
Area 2	2085	Deposit	20thC concrete
Area 2	2086	Group	Beehive oven 16
Area 2	2087	Structure	RB oute casing of oven 16
Area 2	2088	Structure	Fire brick lining of beehive oven 16
Area 2	2089	Deposit	Backfill of beehive oven 16
Area 2	2090	Structure	Fire brick slab cover of beehive oven 16 flue
Area 2	2091	Structure	Fire brick E wall section of oven 16 flue
Area 2	2092	Structure	Fire brick W wall section of oven 16 flue
Area 2	2093	Not used	Not used
Area 2	2094	Group	Oven 17
Area 2	2095	Structure	RB outer casing for oven 17
Area 2	2096	Structure	RB inner casing for oven 17
Area 2	2097	Structure	RB floor of oven 17
Area 2	2098	Group	Beehive oven 18
Area 2	2099	Structure	SS outer casing of beehive oven 18
Area 2	2100	Structure	Inner FB lining of oven 18
Area 2	2101	Structure	RB floor of beehive oven 18
Area 2	2102	Deposit	Sand bedding layer for [2101]
Area 2	2103	Cut	Cut for [2014] concrete stanction
Area 2	2104	Deposit	Sandy clay packing for stanction
Area 2	2105	Not used	Not used
Area 2	2106	Group	Oven 7
Area 2	2107	Structure	RB outer casing of beehive oven 7
Area 2	2108	Structure	Fire brick inner lining of beehive oven 7
Area 2	2109	Structure	RB floor of beehive oven 7
Area 2	2110	Structure	Fire clay blocks, part of entrance to beehive oven 7
Area 2	2111	Not used	Not used
Area 2	2112	Not used	Not used
Area 2	2113	Group	Beehive oven 8
Area 2	2114	Structure	RB outer casing of beehive oven 8
Area 2	2115	Structure	Fire brick inner lining of beehive oven 8
Area 2	2116	Structure	RB floor area in oven 8
Area 2	2117	Structure	Repaired RB floor area in oven 8
Area 2	2118	Deposit	Sand levelling later for base/floor of oven 8
Area 2	2119	Cut	20thC cut partially truncating floor [2117],[2118]
Area 2	2120	Deposit	Backfill of 20thC cut [2119]
Area 2	2121	Group	Beehive oven 19
Area 2	2122	Structure	Outer RB casing of oven 19
Area 2	2123	Structure	The inner fire brick lining of oven 19
Area 2	2124	Structure	Fire brick archway for raking out coke
Area 2	2125	Structure	RB floor of beehive oven [2121]
Area 2	2126	Deposit	Sand bedding layer for RB floor [2125]
Area 2	2127	Deposit	Concrete poured into and filling oven 9
Area 2	2128	Group	Beehive oven 20
Area 2	2129	Structure	RB outer casing of beehive oven 20

Site sub-division	Context No	Context type	Description
Area 2	2130	Structure	Fire brick lining of beehive oven 20
Area 2	2131	Structure	Fire brick arched entrance for raking out of coke
Area 2	2132	Structure	Sloping RB floor base of oven 20
Area 2	2133	Group	Oven 10
Area 2	2134	Structure	RB outer casing of oven 10
Area 2	2135	Structure	Fire brick inner casing of oven 10
Area 2	2136	Structure	Floor of oven 10
Area 2	2137	Group	Beehive oven 21
Area 2	2138	Structure	RB lined outer casing of oven 21
Area 2	2139	Structure	Fire brick inner lining of oven 21
Area 2	2140	Structure	Fire brick archway for raking quenched coal
Area 2	2141	Structure	RB sloping floor used to hold coke
Area 2	2142	Structure	E-W SS wall defining S limit of oven complex
Area 2	2143	Group	Beehive oven 11
Area 2	2144	Structure	RB outer casing for beehive oven 11
Area 2	2145	Structure	Fire brick inner lining of oven 11
Area 2	2146	Deposit	Bedding layer for floor within oven 11
Area 2	2147	Group	Oven 22
Area 2	2148	Structure	RB outer casing for beehive oven 22
Area 2	2149	Structure	Fire brick lining of beehive oven 22
Area 2	2150	Structure	RB floor/base of beehive oven 22
Area 2	2151	Structure	Repair to S side of oven 3
Area 2	2152	Structure	Brick arch, associated with oven 3
Area 2	2153	Structure	Repair to outer casing of oven 3
Area 2	2154	Structure	RB outer wall of flue system
Area 2	2155	Not used	Not used
Area 2	2156	Structure	S inner wall of main flue
Area 2	2157	Structure	Capping for ancillary flue of oven 14
Area 2	2158	Structure	Modern concrete and Fe roof support
Area 2	2159	Structure	Fire brick S wall of main flue
Area 2	2160	Structure	RB degraded floor of oven 21
Area 2	2161	Structure	Segment of fire brick oven wall W of oven 21
Area 2	2162	Structure	Part of RB wall at N end of oven 21?
Area 2	2163	Deposit	Pitch deposit in base of oven 20
Area 2	2164	Cut	Cut for stanchion in oven 20
Area 2	2165	Structure	Stanchion in cut [2164] in oven 20
Area 2	2166	Structure	Possible RB wall, N end of oven 20
Area 2	2167	Structure	Concrete and Fe stanchion N of [2165]
Area 2	2168	Structure	Entrance arch of oven 17
Area 2	2169	Structure	Fire brick remains of archway in oven 18
Area 2	2170	Structure	Fire brick patch/repairs in wall of [2096]
Area 2	2171	Structure	Fire brick S wall of main flue
Area 2	2172	Deposit	Deposit in flue system for oven 6
Area 2	2173	Deposit	Deposit in flue system of oven 15
Area 2	2174	Structure	E element of entrance archway oven 22
Area 2	2175	Structure	W element of entrance archway for oven 22
Area 2	2176	Cut	Cut for stanchions [2177]-[2179] W of oven 21
Area 2	2177	Structure	Circular concrete stanchion
Area 2	2178	Structure	Stanchion located to N of [2177]
Area 2	2179	Structure	Stanchion W of [2177]+[2178]
Area 2	2180	Deposit	Rubble fill of [2176]
Area 2	2181	Structure	Fire brick and fire brick slab cover for flue of oven 15

Site sub-division	Context No	Context type	Description
Area 2	2182	Structure	Remains of entrance arch for oven 10
Area 2	2183	Deposit	Rubble deposit in channel running from main flue to oven 3
Area 2	2184	Structure	Red mortar floor lining remains
Area 2	2185	Deposit	General levelling deposit across upper part of area 2
Area 2	2186	Deposit	Fe runoff sample #1
Area 2	2187	Deposit	Fe runoff sample #2
Area 3	3000	Deposit	Grey yellow natural clay
Area 3	3001	Cut	Construction cut for well [3002]
Area 3	3002	Structure	RB circular well
Area 3	3003	Structure	RB surface, SW corner
Area 3	3004	Structure	RB wall, possible internal division within gas works
Area 3	3005	Deposit	Made ground/backfill, same as [3023],[3012]
Area 3	3006	Structure	RB internal division wall of gas works
Area 3	3007	Structure	SS block abutting N end of [3006]
Area 3	3008	Structure	RB wall, support for machinery/pipework
Area 3	3009	Structure	Wooden floor, abutts E side of [3006]
Area 3	3010	Structure	Fe plate floor
Area 3	3011	Structure	Fe gas/coal heating retort
Area 3	3012	Deposit	Made ground/demolition same as [3005],[3023]
Area 3	3013	Structure	Concrete floor surface
Area 3	3014	Structure	RB support of unknown function
Area 3	3015	Structure	Vitrified fire brick wall
Area 3	3016	Structure	Fire brick structure supporting clay/ceramic ovens
Area 3	3017	Structure	Ceramic oven within [3016]
Area 3	3018	Structure	Ceramic oven within [3016]
Area 3	3019	Deposit	Demolition rubble
Area 3	3020	Structure	RB floor surface, internal part of gas works
Area 3	3021	Structure	RB wall/pillar base
Area 3	3022	Deposit	Fill of pit cut into [3020]
Area 3	3023	Deposit	Made ground/demolition layer, same as [3005],[3012]
Area 3	3024	Structure	RB wall, possible E wall of gas works
Area 3	3025	Structure	Concrete block/base
Area 3	3026	Structure	Concrete block/base used as a foundation for [3027]
Area 3	3027	Structure	RB wall/pillar
Area 3	3028	Structure	Concrete block/foundation base
Area 3	3029	Structure	RB trough
Area 3	3030	Structure	NE-SW RB wall
Area 3	3031	Structure	RB possible chimney base
Area 3	3032	Deposit	Backfill of [3031]
Area 3	3033	Structure	RB chimney associated with [3031]
Area 3	3034	Deposit	Backfill of [3033]
Area 3	3035	Deposit	Made ground/levelling layer
Area 3	3036	Structure	Fe tank in SE corner of excavation
Area 3	3037	Deposit	Sandy fill of Fe structure [3036]
Area 3	3038	Deposit	Layer of white lime mortar, foundation for wall [3024]
Area 3	3039	Cut	Construction cut for late [3031]
Area 3	3040	Deposit	Clay lining of [3039]
Area 3	3041	Cut	Construction cut for [3033]
Area 3	3042	Deposit	Clay lining of chimney [3033]
Area 4	4000	Structure	Brick surface S of rail track
Area 4	4001	Structure	Concrete surface S of rail track
Area 4	4002	Structure	Circular brick line structure, possible mine shaft

Site sub-division	Context No	Context type	Description
Area 4	4003	Structure	Circular concrete capping in [4002]
Area 4	4004	Structure	Pile/stanchion base/engine mounting
Area 4	4005	Cut	Cut for mine shaft? [4002]
Area 4	4006	Deposit	Backfill of construction cut [4005]
Area 4	4007	Structure	5' gauge Fe rail track
Area 4	4008	Deposit	Backfill between rails & demolition rubble
Area 4	4009	Structure	Flat concrete surface to N of rail track
Area 4	4010	Cut	Construction cut for [4011]
Area 4	4011	Structure	Modern concrete tank and channel
Area 4	4012	Deposit	Demolition backfill of [4011]
Area 4	4013	Structure	Probable vent or void cover
Area 4	4014	Structure	Circular recess within [4009]
Area 4	4015	Deposit	Backfill of void between [4014], [4016]
Area 4	4016	Structure	Blast furnace
Area 4	4017	Deposit	Slag/ore fill of blast furnace
Area 4	4018	Structure	RB E-W wall

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