Northamptonshire County Council

Northamptonshire Archaeology

Archaeological excavation at

Cotes Road, Barrow upon Soar

Leicestershire

2006

Accession Number X.A. 144.2005

Danny McAree

December 2007

Report 07/148

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REGISTERED IFA ORGANISATION

SITE ADDRESS:	COTES ROAD BARROW UPON SOAR LEICESTERSHIRE
SITE CODE:	BOSP 06
ACCESSION NUMBER:	X.A 144.2005
NGR:	SK 5740 1838
ORIGINATING BODY:	NORTHAMPTONSHIRE ARCHAEOLOGY, NORTHAMPTONSHIRE COUNTY COUNCIL
CLIENTS NAME:	CgMS CONSULTING THE MANOR SOUTH STREET, NORMANTON ON TRENT NEWARK NOTTINGHAMSHIRE NG23 6RQ 01636 821727

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OASIS REPORT FORM

PROJECT DETAILS		
PROJECT TITLE	Cotes Road, Barrow upon Soar	
Short description	Archaeological excavation was carried out on 14ha of land off Cotes Road, Barrow upon Soar. At the west of the site, three ring ditches, with associated pits and field boundaries, produced evidence of middle Iron Age activity. The remainder of the site had been extensively quarried for limestone, before being reinstated as farmland. Circular and linear lime kilns of the intermittent 'clamp' type were exposed at the south-east of the site. Archaeomagnetic analysis indicates use from the mid 15th century to late 16th century with a clear overlap in the use of the differing kilns. The remainder of the site revealed remains of brick-lined 'pot' type lime kilns with steeply sloping ramps to the firing/draw hole at the base of each kiln. Archaeomagnetic analysis of these kilns indicates use between the early 18th and late 19th centuries. In the north central area of the site, a battery of five lime kilns recorded on 1888 mapping of the area were exposed. These were substantial brick-built 'pot' kilns up to 4.5m in diameter with steeply stepped ramps to the base of each kiln. Each had a brick-lined ring flue around the base with vertical flues behind the internal brick lining of each kiln. Archaeomagnetic data from the two excavated examples indicates they were last fired in the late 19th century, entirely consistent with the early mapping of the site.	
Project type	Strip, map and record, watching brief, open area excavation	
Previous work	Desk Based Assessments (JSAC), Geophysical Surveys (GSB Prospection), Evaluation Trenches (Oxford Archaeology)	
Current land use	Open farmland, plant nursery, orchard and gardens	
Future work	No	
Monument type/period	Iron Age ditches and pits, Medieval and post-medieval lime quarries/kilns	
Significant finds	15th-16th century clamp kilns, 18th-19th century brick-lined pot kilns	
PROJECT LOCATION		
County	Leicestershire	
Site address	Cotes Road, Barrow upon Soar, Leicestershire	
Study area	14ha	
Easting /Northing	SK 5740 1838	
Height OD	68m OD	
PROJECT CREATOR		
Organisation	Leicestershire County Council Planning Department	
Project Brief originator	Richard Clarke, Planning Archaeologist	
Project Design originator	John Samuels Archaeological Consultants (now CgMS)	
Director/Supervisor	Danny McAree	
Project Manager	Iain Soden	
Sponsor or funding body	Miller Homes, David Wilson Homes	
PROJECT DATE		
Start date	January 2006	
End date	June 2006	
ARCHIVES	(Accession no.)	Content
Physical	X.A. 144.2005	Pottery, brick, tile, animal bone
Paper	X.A. 144.2005	Site records, photos and slides, drawings/ report
Digital	X.A. 144.2005	PDF File on DVD
BIBLIOGRAPHY	Journal/monograph, published or forthcoming, or client report	
Title	Archaeological excavation at Cotes Road, Barrow upon Soar, Leicestershire	
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Author(s)	Danny McAree	
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ARCHAEOLOGICAL EXCAVATION AT

COTES ROAD, BARROW UPON SOAR

JULY 2006

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Abstract

Archaeological excavation was carried out in eight areas totalling 14ha of land off Cotes Road, Barrow upon Soar. Areas 1-4 were located east of Cotes Road and north of Strancliffe Lane. Area 5 was in an isolated field to the south of Strancliffe Lane and backing onto Buttermere Way. Areas 6-8 were all in the field to the east of Area 5 and extended from Strancliffe Lane in the north to the properties that back onto Nottingham Road and Willow Road to the south and east.

Area 5 produced evidence of early to middle Iron Age settlement including traces of two round houses and field boundary ditches. There was good survival of medieval ridge and furrow cultivation across the whole field.

There was some survival of ridge and furrow cultivation to the south and east of the development area with plough scars visible across part of Area 8. In this area, ten clamp kilns up to 2m in diameter were exposed. All survived only as sub-circular areas of bright orange/red burnt or vitrified lime and clay from the base of the kilns. Archaeomagnetic analysis of samples from the bases of three of these kilns suggests a date of last firing to between 1490 -1510, 1510-1540, and 1570-1600.

Two 'linear' kilns were located in Area 8 and a further twelve were exposed in Area 7 just 15m to the north. All were rectangular, up to 5m long and 0.75-1m wide. Each was located within a distinctive area of bright orange/red burnt lime and clay surface forming the base of the kiln. Analyses of samples from five of these 'linear' kilns suggest last firing dates in the ranges 1475, 1490, 1515-1535 and 1540.

Brick lined kilns were found in all the remaining areas of the site. They were circular and varied in diameter from 3-4m at the top, tapering to about 1-1.3m wide at the base and were up to 2.6m deep. All had been lined with bricks bonded with lime mortar. Prior to abandonment, the brickwork was removed down to the last few courses at the base of the kiln. An out-turned stoke hole was present in each kiln with an external working area and a sloping ramp up to the ground level. Archaeomagnetic analysis of samples from these kilns produced dates for the last firings of, 1700-1750, 1750, 1795-1840, 1825-1860 and 1825-1870.

The largest type of kiln was located at the north of the eastern field and comprised a group of five kilns identified on the 1888 Ordnance Survey map. These varied between 4-5m in diameter all tapering to about 1-1.3m in diameter at the base and up to 3m deep. They had all been brick lined with a brick ring flue around the base and three vertical flues. Each had an out-turned firing arch or stoke hole, a working area and a stepped access from ground level to the working floor of the kiln. Archaeomagnetic analysis of samples from two of the kilns produced dates of last firing in the ranges 1870-1880 and 1885-1910.

1 INTRODUCTION

David Wilson Homes Ltd (East Midlands) and Miller Homes Ltd (East Midlands) were granted planning permission by Charnwood District Council for development of land to the north of Barrow-upon-Soar in the Charnwood District of Leicestershire. The development comprises residential housing, new roads and access to main highways. Open landscaped areas have been provided for public recreation and leisure facilities (Application Reference P/04/0999/2).

The site is situated on the brow and south-eastern slope of Catsick Hill, between Cotes Road and Willow Way (NGR SK 5740 1838, Fig 1). The site is bounded by Cotes Road to the west, existing development along Nottingham Road to the south and a new development at Willow Way to the east. The north of the site is only partially defined by pre-existing field and property boundaries. An east-west aligned lane (Strancliffe Lane) divides the north-west area being developed by Miller Homes Ltd, from the south-east area being developed by David Wilson Homes Ltd.

As a condition of the planning process, and in response to desk based assessments (JSAC 2000, 2004), geophysical survey (GSB 2000, 2003) and trial trenching (Redvers-Higgins 2005), a further phase of archaeological mitigation works was required. These were set out in a specification prepared by the former John Samuels Archaeological Consultants, now CgMS (JSAC 2005) and undertaken by Northamptonshire Archaeology between January and June 2006. The works entailed monitoring and recording of soil stripping during the construction of the new spine road from Cotes Road to Willow Way and the monitoring, recording and excavation of targeted features within eight defined intervention areas prior to development. Areas 1-4 were all to the north-west of Strancliffe Lane on the Miller Homes development area. Areas 5-8 were to the south and east of Strancliffe Lane on the David Wilson development area. The watching brief was carried out in accordance with the specification prepared by John Samuels Archaeological Consultants (JSAC 2005). Excavation and recording strategies for the eight intervention areas were adapted, modified and agreed following site visits by Richard Clark, Planning Archaeologist, Leicestershire County Council, Karen Francis, Project Manager (JSAC) and Iain Soden, Senior Project Officer, Northamptonshire Archaeology. The excavations were directed by Danny McAree, Senior Project Supervisor, Northamptonshire Archaeology. Technical guidance and advice was generously provided by David Johnson, archaeologist and author specialising in the history and development of the limeburning industry of England and of Yorkshire.

2 ARCHAEOLOGICAL BACKGROUND

2.1 The limeburning process

The Chemistry

Limestone and chalk are forms of calcium carbonate ($CaCo_3$) formed on the floor of warm shallow seas from the compacted shells and skeletons of millions of small sea creatures.

Huge deposits of limestone and chalk were laid down during the Carboniferous and Jurassic eras and again in the Cretaceous. The geology of Barrow upon Soar is formed of Upper Triassic and Lower Jurassic rocks including layers of Jurassic limestone banded between layers of silt mudstones (Appendix A).

When calcium carbonate (limestone) is heated to a temperature of 900-1100 degrees centigrade, the gas carbon dioxide (CO_2) is driven off leaving calcium oxide (CaO) known as '*quicklime'*. This process is known as '*calcining*'.

Quicklime reacts fiercely with water generating heat sufficient to create steam and forming a new compound, calcium hydroxide, $Ca(OH)_2$, known as '*slaked* ' or '*hydrated*' lime. This slowly reacts further with the carbon dioxide and water in the atmosphere to revert to calcium carbonate, thus completing the cycle (Williams 2004). It is this process that allows lime plaster or mortar to 'set'.

The history of limeburning

There is evidence that lime plaster was used in Anatolia from at least 7000 BC, and elsewhere in the Middle East by about 6000 BC. The earliest positive identification of a limekiln was at Khafje, Mesopotamia and dated to only 2450 BC. At Knossos on Crete, early lime mortar has been dated to about 1500 BC (Johnson 2002, Williams 2004).

Although much early building, whether in stone or mud brick, relied upon clay for bonding and plastering, lime was a superior product and was used extensively throughout the Middle East in prehistoric times. Evidence of lime mortar and plaster has been observed within the pyramids in Egypt (Dancaster 1916).

Both the Greeks and the Romans recognised the water-resistant qualities of hydraulic lime in their buildings. Using volcanic pumice and tufa as aggregate the Romans invented a form of lightweight hydraulic cement (*pozzolana*) that allowed them to develop the scope and scale of their public buildings to an extent not emulated until modern times.

In addition to use as a building material, lime has been used extensively in agriculture. In the 2nd century BC, a Roman treatise on agricultural practice described the benefits of lime as part of 'good husbandry'. It also gave detailed instructions for the construction and operation of a limekiln (Cato 234-149, 'De Agricultura'). Pliny the Younger writing in the 1st century AD offered advice on the use of lime for both building and in agriculture.

Roman limekilns have been excavated both in Britain and across Europe. Given the plethora of building types, both public and private, the construction of massive infrastructure projects, harbours, roads and bridges as well as military and town defences, not to mention agricultural and industrial uses of lime, in tanning for example, it is perhaps more surprising that many more Roman lime kilns have not been excavated in Britain.

With the decline of Roman influence, there was a reduction in demand for materials not readily available in the immediate locality. With the emergence of the early Saxon kingdoms, there were huge stores of cut stone available for use in the abandoned towns and buildings of the Roman period. Although localised limeburning for agricultural and specific building projects may have continued, there is little evidence for widespread lime processing during the Anglo-Saxon era.

Although there are only occasional references to the use of lime mortar or lime plaster in the surviving records of the period, late Saxon and early medieval building sites have produced ample evidence of how the product was used when it reached consumer sites.

Mortar mixers in the midlands have been excavated at Northampton (7th-8th century), Eynsham Abbey (11th century) and Wallingford (11th century) (Williams 1979, 71-3,118-133; Hardy, et al 2003; Soden, forthcoming, respectively).

It was only after the Norman Conquest that there is a demonstrable resurgence of limeburning in England commensurate with their stone-building tradition. The initial conquest saw the Normans consolidating their lands and controlling the countryside with the erection of huge numbers of earth and timber (motte and bailey) castles. These sufficed to protect and support units of military personnel until time, money and military necessity brought on a second phase of castle building, this time in stone. Contemporary with this was the explosion in the building of stone churches and the founding of monasteries and nunneries where, even in the early years, the church was likely to be of stone even if the vernacular buildings were initially of wood and thatch.

Stone structures, particularly castles and substantial church buildings needed huge quantities of lime for mortar and plaster. Many building projects built their own kilns at or near the construction site and it is likely that most stone castles would have had their own kilns.

With the arrival of the Tudor period, there was a shift to building in brick rather than stone. Great palaces and houses were built and the use of brick allowed people of lower social standing to aspire to a substantial brick-built house, all of which still required vast amounts of lime for mortar and for plastering the inside walls. Even wooden or cobb buildings were whitewashed with lime which acted to both weather proof the buildings and acted as an antiseptic coating limiting infestation of insects and fungi. Lime was used extensively in the manufacture of medicines and the processing of leather and continued to be widely used in agriculture to improve the soil and increase the yield of the land. A treatise published in the 1520s indicates that limeburning for the liming of fields was already common practice and that landowners in areas of suitable geology commonly built their own kilns and produced lime for their own use and for sale to others (Johnson 2002).

From the 16th century onwards, there is evidence for the increasingly common usage of lime as an agricultural soil improver as well as its continued use in buildings. Lime was often used as only one of a number of soil improvers, the others being sea sand (containing sea shells, thus naturally calcareous) and marl, a friable mix of clay and sand, often rich in naturally calcareous shell.

Although changes in land management and husbandry were on-going, the changes were often small, localised and almost imperceptible on a national scale. While there was movement and development over the next 100 years, it was not until the late 18th century that circumstances arose to force the rate and scale of change. The establishment of the Board of Agriculture in 1793 allowed dissemination of best farming practice based on surveys of agricultural methods across the whole country. Surveys were conducted around the country between 1793 and 1795 with all of the county reports complete and published over the ensuing years.

During the Napoleonic Wars, vast numbers of limekilns were constructed and in some areas, every farmer had his own kiln. Between 1801 and 1851, the population of Britain doubled in size.

With an ever increasing urban population there was sustained and growing demand for agricultural production. This was matched by an increasing use of lime and the expansion in the number of lime kilns. In many places, instead of a small single kiln producing sufficient lime for personal or localised use, production in double or multiple kilns increased with individuals becoming full-time lime burners to meet demand.

The increase in demand from agriculture was matched by huge increases in demand for lime for use in the construction of first the canal and then the new railway infra-structure of the country.

By the turn of the 19th into the 20th century, mass production had become concentrated at the larger limestone quarries and chalkpits with the railways (and later road transport) allowing economical distribution from a smaller number of centres.

Despite an ongoing market for agricultural lime, the demand for lime mortar began to decline steadily in the latter part of the 19th century as a cheap and effective alternative, Portland cement, became more readily available. Produced by burning limestone and clay at very high temperatures and then grinding the resultant clinker to a fine powder, cement was a much stronger and more versatile product than simple lime mortar.

Industrial machinery could now produce finely ground limestone or chalk as an alternative to quicklime for liming at an economic and competitive price.

Isolated rural limekilns were no longer economic and many hundreds if not thousands were destroyed or fell into ruin. There was a late revival in 1937 when the government issued a subsidy on agricultural lime and some kilns were refurbished and re-opened, some still operating (albeit un-profitably) in 1984 (Williams 2004).

Lime is still produced on a small scale for the buildings conservation market. It is still has a role in agriculture but is generally applied as crushed limestone powder rather than burnt lime. It is more often an ingredient in other soil improvers or fertilizers.

Fuel

Limestone was quarried locally and burnt using whatever fuel was to hand. On mountain and moorland, peat, gorse and bracken were often used. Elsewhere wood was the normal fuel and has been described as ‘technically the ideal fuel for burning lime’ (Bessey 1975). Wood burns with a longer and lazier flame than many other fuels and releases steam as the moisture evaporates which helps to prevent overburning of the limestone. Heat from the flame also tends to penetrate deeper into the stone to give a more even burn right through each piece of limestone. Concerns were expressed at the rate at which woodland was being destroyed to feed lime kilns as early as the 13th century, with coal coming into use in the following century (Johnson 2002).

The use of *culm* as a fuel appears in many of the early accounts. Culm is technically a type of carbonaceous shale (shale with a high carbon content) but may also refer to fissile anthracite coal. In some parts of the country it refers to any type of anthracite coal, in others it is used to describe small or powdery coal.

Whatever its designation, huge quantities of culm and coal are recorded as being transported throughout the medieval period for the purpose of burning lime. Although the small coal would burn, its small size meant that it could filter down and block the gaps between the stones and stifle the fire; as airflow was a key factor in a successful burn, this was a critical failing. Anthracite was larger and burnt better but was much more expensive. It is likely that in the non-profit, individually operated kilns, the cheapest and nearest available fuel was used, only those producing lime for onward sale having the income to justify buying higher quality fuel.

By the late 18th century expanding industrialisation of limeburning had brought improvements to kilns and fuel types. It was found that the ideal mix was coal and coke in equal proportions. Coal could only reach maximum efficiency when all the bitumen within it had been burnt off. When coal is burnt in the kiln, it turns to coke anyway and during this process is not functioning efficiently as a fuel to burn limestone. By adding coke at the start, it not only saved on costs (coke being much lighter to transport) but also allowed coke to act directly in the calcining process.

It was calculated that the output of burnt lime could be increased three-fold in a given time by the use of the coal-coke mix (Johnson 2002).

Another variable in the volume of fuel needed to fire a given volume of stone was the carbon content of the raw stone, higher carbon stone would provide fuel of itself and reduce the amount of fuel needed to fire each load. The ratio of coal to stone could vary from as high as 1 unit of coal to 1.5 units of stone to as low as 1 unit of coal to 6 units of stone. The main problem of using coal however was not this ratio, it was the control of the fire. While wood burned with a slower lazy flame, coal produces a shorter and more aggressive burn raising the potential to cause overburning and clinkering of the limestone making it virtually un-saleable.

Despite its shortcomings, coal was the most efficient fuel. In the mid 19th century it was recorded that to burn 35 cubic feet of limestone (1 cubic metre) it required 28 cwt (1422 kg) of hardwood or 45 cwt (2286 kg) of peat but only 4.5 cwt (229 kg) of coal (Johnson 2002).

Lime kilns

An *intermittent* or *periodic kiln* is one that is loaded, fired, cooled, emptied and then re-loaded for another firing.

A *continuous, perpetual, running* or *draw kiln* is one in which the kiln is kept burning and additional supplies of raw material and fuel are fed in as the lime is drawn off.

A *flare kiln* is one in which the fuel is not in contact with the limestone or chalk to be fired, as distinct from a *mixed feed kiln* where alternate layers of fuel and stone are built up for the initial firing and then alternately replenished on a continuous basis.

Sod or clamp kilns

The most basic design of kiln was the *sod* or *clamp kiln*. The size depended on the amount of stone to be burned and could be circular or rectangular. A shallow pit was excavated and might be lined with stone, either limestone or other local stone. Within this alternate layers of fuel and limestone were laid building up to form a dome. An external banking helped to support the mound with a small opening left for raking or extracting burnt lime. The whole would be covered in turf (sods) or clay forming a 'clamp' very similar to those used for charcoal burning and used to control the burn which could take from 2-3 days to 10 days or more for a very large kiln.

The overall height of the dome or clamp rarely survives in the archaeology but evidence from Lothians indicate heights of 7-8 feet (2.15-2.46m) while others in Sussex ranged from 8-10 feet (2.46-3.08m) high. Evidence from excavations in South Wales indicate similar construction and use to those described above and corroborates evidence from a widespread survey of such kilns in the Dales (Johnson 2002).

After firing the *quicklime* (sometimes called '*lump lime'* or '*lime shells'*) could be drawn from the hole left at the base. It is axiomatic that if the kiln was intended for a single use, it did not need an entrance or a draw hole, it could merely be dismantled. It therefore seems likely that many clamp kilns were intended and indeed used for multiple firing.

Pye kilns

Pye kilns are effectively a larger type of 'clamp' kiln but with a more substantial structure. They are known from Peeblesshire in Lothians (Skinner 1979) and from Derbyshire (Leach 1995). They are rectangular structures, up to 40-50 feet (12.3-15.3m) in length and up to 20 feet (6.1m) wide. A pye kiln at Newhaven, Derbyshire was described by John Farey in 1811; it was built in a limestone pit and had a total height of 14 feet (4.3m) including the heaped top covered in turves. It had a rough stone and earth wall at the front with draw holes, partly destroyed to extract the lime. The charge was built up of alternating layers of fuel and limestone and covered in turves and clay before being fired for several days. It could produce as much as 50 tons of lime at one firing and took up to 12 days to burn and cool.

Horseshoe kiln

The *horseshoe* kilns of Dudley and Walsall were a type of a mixed feed intermittent kiln of similar principle to a pye kiln but lined with brick or stone and provided with a front wall broken down after firing (Green 1977).

Brick and stone built kilns

The earliest kilns excavated in Britain were built by the Romans and closely match the kiln described by Cato in the 2nd century BC (Dix 1995). They comprised a stone built chamber with either one or more entrances and occasionally an ash pit in the base of the kiln. The chamber may be variously described as a '*crucible', 'bowl* 'or even a '*well'* but the simplest term*, 'pot',* is commonly used (Williams 2004). This is one of the principal types encountered at Barrow in the current excavations.

These were intermittent flare kilns using wood or peat as fuel. Inside the pot, an arch or dome of large lumps of limestone was built up, often on a ledge designed for this purpose, this creating a hollow in which the fire could be built. It was not a particularly economical method of production but produced excellent lime.

In the medieval period, stone built kilns with thick stone walls tapering to a narrower base are found, particularly on castle or religious sites. They have one or more entrances or draw holes and were often fired with coal. It seems likely that they operated on an intermittent basis to provide sufficient lime for each phase of building (*ibid*).

From the 16th century onwards, small intermittent kilns or '*field*' kilns become more common. The most common type of kiln was built of local stone or brick with a circular, open topped bowl or pot, usually tapering in at the base and with one or more draw holes or '*eyes*' at the base. Through these, the fire was lit, ashes were raked and the calcined lime eventually removed. The load was initially supported on a network of timbers or occasionally on metal firebars forming an arch (sometimes known as an '*iron horse*').

The initial firing was contained in order to set or fuse the load of limestone above the fire. More extreme heat was then built up until calcining was complete within 24-36 hours. There would have been a lengthy cooling down period and the full process probably took up to a week to complete. Kilns of this type have been recognised from all parts of the country with well documented examples from Sussex, Surrey, Warwickshire, Staffordshire, Derbyshire and Yorkshire as well as Scotland and Ireland.

They were often built into hill slopes or into roadside banks to allow for easy filling from the upper bank where fuel and fresh lime could be tipped into the bowl ready for firing.

Multiple 'draw holes' or 'eyes' were incorporated for the ease of clearing ash and calcined lime from the kilns. 'Rodding eyes' were incorporated at higher levels in the kiln so that 'hang-up' or the accretion of masses of clinker and slag in the heart of the kiln could be broken up using long iron poles. This allowed the freer circulation of air, heat and gasses and improved the efficiency of the burning and calcining process.

Some of these earlier flare kilns were strictly 'intermittent' being fired and allowed to cool. It is clear however that many were being used for extended periods as 'continuous' kilns with additional fuel and limestone being added during the course of the burn. This allowed greater quantities of lime to be produced before the build up of clinker and ash forced the cooling and clearance of the kiln before the process of loading and firing began again.

By the 19th century, as a result of the industrial revolution, technological advances in the design and operation of iron and steel furnaces began to filter down into the design and build of other kiln industries, particularly brickmaking, pottery and inevitably, the other ore burning industries. Lime kilns became larger and were built in groups (batteries) so that there was a continuous production even if an individual kiln had to be taken out of service to allow for essential repairs or re-lining.

Improvements in design resulted in large above ground structures built in brick or stone and lined with fire resistant materials, normally fire bricks. Flues built into the walls of the structure allowed air and hot gasses to circulate more effectively giving a more efficient burn with greater heat and calcining from the same or smaller amounts of fuel.

These later kilns were designed to operate at three levels. The initial fuel load of kindling and coal was laid on fire bars and covered with limestone. The remainder of the kiln was then filled with alternating layers of fuel and limestone until full. The lower part of the kiln was the coolest, the space below the fire bars allowed the ash, clinker and calcined lime to drop through the bars and be raked out through the draw hole or eye of the kiln.

The fire, once lit, created the greatest heat in the central part of the kiln. The heat, smoke and gases rising from the central fire pre-heated the upper part of the charge, driving off some of the water and allowing for the partial 'coking' of the coal. This created a more efficient fuel which allowed greater loads to be calcined with less fuel. These kilns were capable of producing limestone on the industrial scale required to meet the demand for building, agriculture and industry generated by the accelerating industrial development of the country into the late 19th and into the 20th century.

2.2 Barrow upon Soar

The village of Barrow-upon-Soar has medieval origins and the historic core is located to the south of the current site. (Sites and Monuments Records and Historic Environment Records in the immediate area are shown on Figure 2).

Early evidence for human activity at Catsick Hill, is represented by a double-ditched, circular enclosure identified in the northern half of the site in 2003 (GSB 2003, SMR MLE15820).

Possible Bronze Age ring ditches (SMR MLE825, MLE462) have been identified from aerial photography either side of Cotes Road, *c*200-300m to the west and south

west of the development area. Two rectilinear enclosures in the same area may indicate Iron Age enclosures (SMR MLE 463).

Metal detecting at this site between 1991 and 1998 has produced a collection of two Iron Age coins, thirty seven Roman coins, thirteen brooches and two early Anglo Saxon brooches. A medieval seal was also found in the same area (SMR MLE 9860-64). Additional metal detecting finds reported in 2006 include two early Anglo Saxon brooches from the west of the development site immediately adjacent to the rear boundaries of properties facing Cotes Road. Subsequent archaeological watching brief as part of the current works found no evidence of occupation or other cut features.

To the south of the river at Pillings Lock, archaeological evaluation and excavation revealed Iron Age enclosures and structures (SMR MLE 9541).

At a greater distance, a Roman road, the 'Salt Way' lies 1.5km to the south of the development site (SMR 51NE/BN). There may be a Roman small town located along this road or adjacent to the crossing point on the River Soar in the adjoining Quorndon parish (SMR 51NE.CM).

The earliest reference to the place name Barrow is in the Domesday Survey of 1086 when it was recorded as *Barhou*. Barrow might derive from Old English (OE) *beorg* meaning 'hill' but is more likely to derive from *Bearhu* meaning 'grove, wood' linked with the (OE) name for the local river: thus 'Grove on the (river) Soar' (English Place Name Society).

At the time of the Domesday Survey, Barrow lay in the 'Wapentake' of Guthlaxton, the Danelaw equivalent of the Saxon 'Hundred'.

The lands of Hugh, Earl of Chester, in Guthlaxton Wapentake:

Earl Hugh holds Barrow upon Soar (Barhou) of the King. There are 15 caracutes of land. In demesne he has $4^{1}/_{2}$ ploughs and 2 slaves with 1 female slave. and 40 villans with 13 bordars have 11 ploughs. There are 3 mills rendering 30s. [and] woodland 1 league long and 4 furlongs broad which renders 5s.

Earl Harold had held this manor with a number of appendages.

A rough rule of thumb is that a caracute (or hide) was the equivalent of 120-150 acres of arable land, depending on the yield of the soil.

The Earl of Chester's holding at Barrow upon Soar would thus equate to between 1800-2250 acres (728-910 ha) of mixed arable land. The woodland attached to the earl's holdings would have amounted to about 47 acres (19.2 ha).

In 1222 there is evidence that the sixth Earl of Chester was managing this woodland for hunting (Hardy 1833, 531). Following his death in 1232, it passed to the earl-apparent of Arundel, Hugh d'Albini, although Henry III administered it for a period, Hugh being a minor until 1235.

Aerial photography has identified earthwork remains of former ridge and furrow cultivation across the two fields at the east of the site, indicating that it was under arable cultivation by the later medieval period. An earlier geophysical survey carried out on the southern half of the site in 2000 recorded numerous anomalies indicative of industrial activity (GSB 2000, MLE16045).

Barrow has probably been linked with lime quarrying and lime burning since Roman times. A limekiln producing lime for the construction of the Roman city wall at Leicester is believed to have used limestone quarried and transported from Barrow (Cooper 2004). The earliest certain evidence of limestone working is a reference to the extraction of limestone at Barrow in the reign of Henry II, 1154-1189 (Ball 1976).

It seems highly likely that Barrow lime was used in the construction of nearby Mountsorrel castle, destroyed in 1217.

Medieval production of lime is attested from at least 1396 in a dispute between John Howson and Richard Freeman regarding '*lymputes*' in the field of Barrow (Farnham 1930). An account of 1474 records 55 lime pits at Barrow and 85 pits in 1481 (Farnham 1912). Lime from Barrow was used extensively in the construction of Kirby Muxloe Castle, Leicestershire in 1481-1484 (Hamilton Thompson 1913-14, Appendix A).

The association with lime continued through the medieval period with additional references to quarrying and the burning of lime at Barrow between the 1500s to the 1750s although with little specific reference to the exact location of either the quarries or the kilns. In 1564 and again in 1615 references are made to '*lyme pitt holes'* and '*the common lyme pitts'* of Barrow (Farnham 1930). The lime pits are recorded increasingly into the modern era and in 1673 it is recorded that Barrow lime was well known for its binding qualities (Nichols 1800).

The early 1" to 1 mile map of Leicester produced by J Prior in 1779 indicates at least three lime works in the vicinity of the development site with quarries and other limeworks in the north west and south east of Barrow upon Soar. In 1790, the 2" to 1 mile map of the Navigation Canal indicates additional limeworks to the south east of Barrow.

The opening of the Leicester Navigation Canal from Leicester through to Loughborough in 1794 and the later Midlands Counties Railway line opened up new markets for Barrow lime. Initially, both enterprises were users of Barrow lime in the construction of the canals and railways, and later, provided for the cheap transport of fuel to Barrow and the delivery of lime from Barrow to a wider market. The industry remained vigorous throughout the 19th century and survives to the present day but in a much-reduced form.

The early geological maps of the area surveyed in 1831 and 1835 respectively indicate the existence of many limeworks and quarries in the Barrow area although definitive locations of these are not made clear.

The 1831 census records indicate the number of workers employed in the quarries at Barrow was 92 (1831 Census Records, Barrow upon Soar).

Nichols includes a description of the limestone working at Barrow upon Soar in his 'History and Antiquities of the County of Leicestershire' (Vol III circa 1800). Limestone could be found between 2 feet (0.6m) and up to 10-12 feet (3-3.6m) below ground level. It was found in a series of distinct 'floors' separated by layers of shale and mudstone. The upper layer of stone where present was called 'Bank Hurs', the next layer 'Rummel' was considered 'generally only fit for building walls'. Subsequent layers were 'First Floor', 'Second Floor', 'Hurs', 'First Hog', 'Second Hog', 'Bottom Floor', 'Good-for-nought' and 'Four-foot'. This deepest lime floor was to be found at depths of about 30 feet (9m) but diggings up to 40 feet (12m) were common where the overburden was deeper.

The lime was extracted in the main from open quarries, the strip of land to be quarried was referred to as a 'delph' perhaps from 'delving' into the soil. It was generally dug in piece work or gang work sections 4 yards wide, 4 yards deep and 9 yards long and called a 'hade'. The lime workers contracted a set price for each yard of lime or each hade excavated. Nicholls records it cost 3d per cubic yard (0.76cu.m) for digging it and bringing it out in hand barrows.

The lime was rich in fossils, each layer being identifiable from the fossils found within it. In 1851, the first recorded Plesiosaurus skeleton was found in the lower

Barrow lime beds and has since become the symbol of the town. Plesiosaur and Icthyosaur remains are found in two of the three lower lime beds at Barrow.

Ansted writing in 1866 refers to the fame of the town for producing fossil specimens and comments upon the work of a local collector, Mr William Lee who both collected, displayed and sold specimens obtained from the Barrow 'cement-stone pits'. It was reputed that the town generated as great a source of income from the sale of the fossils as they did from the sale of the limestone or lime itself.

In 1877, the main quarries were all in the hands of Messrs John Ellis and Sons of Barrow upon Soar. Their pits extended along both side of the railway and focused in the south and east of the town. Most of the records of their development of the lime industry were lost when the company was taken over by Redland Aggregates in the 1960s. No archive of company material from the earlier Ellis works has been retained. It is not now possible to trace the early development of the Ellis holdings but they are recorded as lime burners in Kellys' Directory of 1855 and are mentioned as quarry owners by Ansted in 1866. Ellis leases held at Leicestershire Records Office relate to the working of lime quarries at Tithe Farm immediately to the north east of the development site.

The Ellis's had experience of underground mining from other business ventures and had introduced this expertise into their workings at Barrow. Underground workings were commenced from a drift in the area of the present Redlands works and the old Ellis quarry in the south east of Barrow. The cost of recovering the lime rose with the depth of overburden to be removed. Ellis were contracted to supply thousands of tons of lime for the construction of the underground railways in London in the last decades of the 19th century. The move to underground extraction was an economic response to the need to produce vast quantities of lime to meet the expanding demand. It was later collapse of these workings that caused the partial destruction of a block of flats in Grays Court, Barrow in 1978 and major subsidence along the Sileby Road in 1987 (Freer 1979, Wardell Armstrong 1987).

The 1888 First Edition Ordnance Survey map of the area records a complex of kilns just to the south Strancliff Lane (SMR MLE 9914, Fig 3). An associated roadway and track linked this site to lime pits, at Tithe Farm, to the north (SMR MLE 9915). Additional lime pits are shown to the east of the development area (SMR MLE 16294). A clay pit is shown at the south-east of the site adjacent to Willow Way (SMR MLE 9916). The map data confirms the results of the desk-based assessment and evaluation trenching which show that extensive quarrying and limeburning had taken place across much of the development site (JSAC 2000 and 2003, Fig 2, MLE15821, MLE15822, MLE16045, Fig 3).

2.3 Topography and geology

The site is located on the brow and south-eastern slope of Catsick Hill on the northern outskirts of Barrow-upon-Soar, between Cotes Road and Willow Way, and is centred on NGR SK 5740 1838 (Fig 1). It covers a total area of approximately 14 ha.

The surface geology consists of Jurassic and Cretaceous clay and drift; the underlying bedrock is Permo-Triassic grey mudstone and reddish till. The excavation area is underlain by flat-bedded grey mudstones, inter-leaved with limestones which stratigraphically form part of the Upper Triassic and Lower Jurassic horizons. Termed the Barnstone Member, these rocks, varying in thickness, from 8 to 12 m, were formerly known as the Hydraulic Limestone beds because of their past importance for lime production. They contain abundant limestone beds, generally 0.1 to 0.3 m thick.

The area to the north and west had originally been open pasture fields with several houses and gardens along the line of Cotes Road to the west. A 20th century garden centre had extended east across the centre of the field parallel to Strancliffe Lane.

The area to the south and west of Strancliffe Lane was formed from two separate fields. Area 5 lay in a field to the west of the development site. It was under pasture and retained distinctive earthworks denoting former ridge and furrow cultivation. The larger field to the east also retained traces of ridge and furrow earthworks. The remainder of the site was open pasture. Two possible quarry pits were noted, with one surviving as a large dished hollow in the north-east of the field. The southern boundary of the site is formed by existing residential development and by the grounds of the Humphrey Perkins School. The eastern boundary aligns with Willow Way and the northern boundary is defined by existing field boundaries and newly erected stock fencing.

At the north of the site, Strancliffe Lane is located at the junction of the two development areas and is located at 68.6m AOD. The land slopes gently to Cotes Road in the west at 61m AOD and to the south-east to Willow Way at 57.3m AOD.

3 OBJECTIVES AND METHODOLOGY

3.1 Objectives

The main objective of the archaeological excavation was to excavate and record the archaeological remains in order to understand the nature, function and character of the site in its cultural and environmental setting. The specific aims of the project were to:

- Determine the character of the prehistoric development and occupation of the site as suggested by the archaeological remains recorded during evaluation
- Understand the medieval industrial activity on the site as evidenced by the lime burning kilns and extraction pits recorded during evaluation
- Understand the post-medieval activity on the site
- Develop a chronological sequence for the human and industrial activity on the development site and place it within the context of the development of Barrow upon Soar and within their local, regional and national context

The national framework for research is set out by English Heritage (1997); the regional framework is set out in 'The archaeology of the East Midlands: An archaeological resource assessment and research agenda (Courtney; Campion, in Cooper 2006). The research aims set out in these documents are addressed by the project.

A report on the project will be published, possibly in the proceedings of the Leicestershire Archaeological Society (LAS) and placed the regional annual report of the Council for British Archaeology (CBA).

3.2 Method statement

Mitigation Strategy

It was proposed to mitigate the impact of the development on the archaeological deposits through preservation by record.

Strancliffe Lane divides the north-west area from the south-east area. A new spine road extending from Cotes Road at the north-west cut across the site to Willow Way at the south-east of the site. The boundary between the two different development areas, each owned by a different developer, was located at the junction of the spine road with Strancliffe Lane (Fig 4).

A strip, map and recording action was initially undertaken during construction of the spine road and the installation of mains services. This was followed by the stripping and mapping of eight discrete areas identified from the site assessments, geophysical analysis and trial trenching. Areas 1-4 were located in the Miller Homes area, Areas 5-8 were in the David Wilson Homes area (Fig 4). Areas 1 and 4 were subject to a watching brief only.

Fieldwork and Recording

All works were conducted in accordance with the *IFA Standards and Guidance for Archaeological Excavations (*1994, revised 1999*)* and the *Code of Conduct* of the Institute of Field Archaeologists (1985, revised 2000).

Monitoring of the programme of fieldwork was carried out by Leicestershire Heritage Services on behalf of Charnwood District Council.

The excavation and recording methodologies adopted were in accordance with a brief and written specification agreed by all parties (JSAC, Northamptonshire Archaeology and Leicestershire Heritage Services). Variations to meet changing needs and circumstances as encountered were discussed and agreed at site meetings.

4 THE EXCAVATED EVIDENCE

4.1 Summary of chronology

The following phases of activity were identified:-

Table 1: Site chronology and phasing

ACTIVITY	PERIOD	PHASE
Ring ditches, ditches and pits	middle Iron Age	Phase 1
Lime quarrying and simple clamp kilns	15th-16th century	Phase 2
Lime quarrying and 'linear' kilns	15th-16th century	Phase 3
Lime quarrying and brick built kilns	18th-19th century	Phase 4
Lime quarrying, roads, brick built kilns with internal flues	19th-20th century	Phase 5
Reversion to pasture	20th century	Phase 6

Details of all contexts are retained in archive.

The archaeological evidence is presented chronologically to record changes in land use and activity across the site. The use of area labels in the text is purely to assist in understanding the spatial distribution and location of the various features across the development area.

The exposed natural subsoil was orange/brown sandy clay, very compact, stiff and sticky. It contained ribbons and patches of grey mudstone, grey or yellow silt clays and bands of orange/red coarse sands and gravel.

4.2 Ring ditches, ditches and pits, middle Iron Age (Phase 1)

Extensive limestone quarrying had destroyed much of any early archaeology on the site, only in Area 2 and Area 5 was there any survival of pre-medieval features.

Area 2

A single ditch aligned roughly north-south survived adjacent to the modern hedge line and property boundary at the north of the excavation area (Figs 4 and 8). The ditch, previously located in evaluation, was up to 1.7m wide and 0.25m deep and extended about 5m to the south beyond the limit of the mitigation area. Pottery from the ditch fill is dated to the middle Iron Age. Its continuation was destroyed in a later quarry.

About 10m to the west, a shallow irregular pit 0.6m long and 0.4m wide was cut into the natural and terminated on a layer of laminate limestone bedrock. It contained two pieces of cut-marked antler (SF 2, Fig 8).

Area 5

In Area 5 the furrows of former ridge and furrow cultivation had truncated much of the underlying archaeology. Evidence for early occupation was concentrated in the southern part of the area where three ring ditches [5004, 5044 and 5085], linear ditches [5006, 5036, 5039, 5049, 5054, 5078, 5082 and 5090] and a scattering of pits [5010, 5012, 5026, 5031 and 5074] had survived the cultivation regime (Fig 4-5, Plates 1-4).

Two of the ring ditches were circular, about 9m in diameter, the third was roughly oval in shape, 13m long and 10m wide (Fig 5, Plates 1-3). In common with other features of this type, both regionally and nationally, they each had an entrance causeway in the south-east quadrant.

The south-west ring ditch contained postholes in each terminal [5062 and 5079] adjacent to the entrance causeway and the ephemeral traces of four possible postholes that may have supported an internal roof support (Fig 5). A truncated pit at the centre of the feature contained large pieces of burnt stone and may indicate the location of a hearth.

The second ring ditch survived only as fragmentary arcs with no internal features (Fig 5). The oval ring ditch had a posthole in each of the terminals adjacent to the entrance causeway. Pottery from these postholes and ring ditch is dated to the middle Iron Age.

The surrounding area contained several truncated pits and had been demarcated at some point by four ditches aligned roughly north-west to south-east and two aligned roughly east to west (Fig 5). Where these ditches could be related to the ring ditches,

they pre-dated the occupation evidence. All of the pottery recovered from this area was dated to the middle Iron Age.

The ditches extended beyond the stripped area and it is not possible to state what area had originally been enclosed or whether other occupation features might have once been present. Elsewhere there was minimal survival of Iron Age features and this concentration of prehistoric material may be seen as an anomalous survival in a landscape largely denuded of early features as a result of intensive quarrying for limestone.

4.3 Lime quarrying and 'Sod' or 'Clamp' kilns, 15th-16th century (Phase 2)

At the south of the site, in Area 8, the natural subsoil was marked with linear bands of dark grey mudstone forming fairly symmetrical rectangular outlines (up to 10m long and 5m wide) forming a grid like pattern across the whole area.

These were examined and found to be peri-glacial features caused by differential freezing and thawing during and after glaciation (Appendix A, Plate 5). These no doubt account for the linear patterns identified in the geophysical survey of the area (GSB 2000, 2003, SMR MLE9917).

Field boundaries and cultivation

Aligned roughly north south across Area 8 were two field boundaries. To the east a ditch extended across the whole width of the stripped area, up to 1m wide with steep sides and a rounded base 0.6m deep (Fig 4 and 6, Plate 5). It matches a property boundary shown on the 1889 First Edition Ordnance Survey map of the site.

Further to the west, a boundary ditch 1.5m wide and 0.6m deep with 45° sides sloping to a 'V' shaped base was aligned north to south and clearly divided the activities between the east and west portions of Area 8.

To the east the subsoil showed evidence of former ridge and furrow each side of the eastern ditch, the former property boundary. To the west, the land had been quarried and then re-instated with the re-deposited mudstone and clay upcast from the quarrying activity (Fig 6, Plate 9).

About 15m to the north of Area 8 was another stripped area, Area 7. Neither of the two field boundaries exposed in Area 8 extended into Area 7. It must be assumed that an east to west boundary provided a junction with the two ditches within the unexcavated strip between the two excavation areas.

Aligned roughly north-west to south-east across Areas 6, 7 and 8 were the remnants of former ridge and furrow cultivation earthworks including a pattern of plough scars aligned with the surface remains (Plates 5-7).

'Sod' or 'Clamp' kilns

Visible on the exposed soil surface in the eastern portion of Area 8 were ten sub-circular patches of bright orange/red scorched and baked clay and mudstone (Fig 6, Plates 5-8). The scorched areas varied between 3-4.5m long and 2.5-3.5m wide. Three of them had surfaces of burnt and vitrified clay and lime, possibly the remnants of the firing floors of the kiln structures.

The heat reddened area extended about 0.3m around all sides of the features and up to 0.2m below the kiln floors and into the underlying geology or quarry fill.

Two had spreads of coal adjacent but no evidence survived for working surfaces or stoke holes (Fig 6, Plates 6-7). No finds were present in any of these features.

Archaeomagnetic analysis from two of these kiln bases produced dates for the last firing in the periods 1490-1510 and 1510-1540 (Appendix D).

4.4 Lime quarrying and linear kilns, 15th-16th century (Phase 3)

Area 8

To the west of the large boundary ditch in Area 8, on the exposed surface of the earlier quarry fill were two long, narrow rectangular areas of bright orange/red scorched and baked clay and mudstone (Fig 4 and 6, Plate 9). These were similar to the clamp kilns seen further east on Area 8 but were very much longer and narrower.

To differentiate the structural difference between the two types of remains, they have been referred to as 'linear' kilns.

The northern kiln [8004] was aligned roughly north south with steep, near vertical sides 0.1-0.15m deep, 5m long and tapering from 0.85m wide at the north to 0.5m wide at the south (Fig 6, Plate 9). There was no evidence of a lining to the sides or floor of the kiln. The original construction trench had cut through the re-deposited quarry fill of grey, laminated mudstone that had then been heated and scorched to a hard biscuit-like consistency forming distinct lips to the base of the kiln. The base was flat with a thin layer of lime mortar and ash up to 5mm thick forming a hard surface along the length of the structure.

The clay and laminate mudstone in which it was located had been heated and scorched bright orange or red up to 0.2m wide along the length of both sides of the kiln and extending to 0.3m around the northern end of the kiln.

The heat affected area was narrowest at the south of the kiln where there was evidence of an opening with the lime/ash layer extending over the 'lip' of the kiln and forming a small hard surface up to 0.35m around the southern end.

Extending in a rough oval south from the kiln was a probable working area up to 2.5m long and 1.5m wide. It had very shallow sloping sides to a broad dished base 0.15m deep and was filled with re-deposited clay and mudstone mixed with scorched clay, baked mudstone, burnt limestone, coal, charcoal and ash.

The southern kiln [8007] was on a similar alignment, 4.5m long and tapering from 0.8m wide in the north to 0.5m at the south of the kiln (Fig 6). The sides were steep, near vertical 0.15m deep with a flat base sealed below a layer of burnt/vitrified lime and ash up to 5mm thick. This was very fragmentary and had been damaged by ploughing.

The clay and laminate mudstone fill into which it was cut had been heated and burnt bright red/orange up to 0.2m wide along both sides and up to 0.3m around the north end of the kiln. The burnt area tapered to about 0.1m at the south of the kiln where the kiln opened out with the lime/ash layer extending up to 0.3m south of the kiln. Extending south of the kiln in a rough oval up to 2.5m long and 1.8m wide was a working area containing burnt clay and mudstone, coal fragments, burnt lime and ash. It had shallow sloping sides with a broad dished base 0.2m deep.

Analysis of archaeomagnetic samples from the base of this kiln dates the last firing to the period 1570-1600 (Appendix D).

Area 7

Scattered across the whole of the exposed area were twelve linear kilns between 5-6m long and varying in width from 0.9m-1.5m to 0.5m-0.65m at the narrower, open end of the kiln (Fig 4 and 7, Plates 10-12). Each was surrounded by a halo of scorched clay and mudstone, narrowest adjacent to the entrance and widening in an arc around the closed end of the kiln. Every kiln had a working area extending beyond the open end of the kiln up to 4m long and 3m wide forming a rough oval shape (Plates 10-12). These all had shallow sides sloping to a broad, undulating dished base.

All of the kilns had been cut into the sub soil with steep near vertical sides and flat undulating bases. There was little evidence for any structural lining of the features, the natural clay/mudstone had been heated /burnt to a hard brittle consistency around and below each kiln. In two of the excavated kilns, there did appear to be a lining of mudstone or limestone along the sides of the kiln forming a hard edge (although it is possible this was the coincidental cutting of natural layers in these locations).

In every case, the floor of the kiln had been natural clay/mudstone over which a layer of burnt lime and ash had collected to form a hard layer up to 17mm thick. There was no evidence that this had been deliberately applied, in each case it seems to have occurred naturally as part of the firing and lime extraction process. There was no evidence of the superstructure of the kilns.

The fill within the kiln bases was mainly burnt/desiccated clay and mudstone with occasional fragments of burnt limestone, together with a scattering of burnt coal, charcoal and ash.

It was notable that the kilns did not follow a consistent alignment, six were aligned roughly north to south, four were aligned close to east-west with the other two set at varying angles (Fig 7).

All of the excavated working areas revealed fragments of coal and ash in their fill.

Archaeomagnetic samples were taken from four of the kilns in this area. The analysis of the samples from the four kilns gives dates of last firing as *c*1475, *c* 1490, 1515-1535 and *c* 1540 (Fig 7 and Appendix D).

4.5 Lime quarrying and brick built pot kilns, 18th-19th century (Phase 4)

Area 2

Almost the whole of Area 2 had been quarried for limestone and then reinstated. The edge of the quarry was parallel with the field ditch and hedgerow that formed the northern boundary of this area. The quarry had removed the sub soil across the remainder of this strip area. The land had been reinstated by re-depositing mixed clay, mudstone and limestone waste from the quarry excavation mixed with ash and burnt-stone kiln-waste. Aligned east to west across the quarry fill were occasional plough scars from later cultivation (Plates 13-14).

Cutting the surface of the reinstated land were four circular kilns, each with an oval working area extending up to 5m long and 3.5m wide. One kiln was fully excavated, two were half-sectioned and the fourth was excavated sufficiently to establish its size and profile (Fig 8, Plates 13-16).

The three excavated kilns were all circular and between 3m-4m in diameter, 1.8m-2m deep, tapering to a base diameter of 1-1.3m diameter. On each kiln, about two thirds of the circumference of the kiln walls survived. The portion above the kiln entrance had been removed prior to abandonment and backfill.

The original construction cut was steeply sloping and the surrounding clay and mudstone quarry fill had been scorched bright red/orange by the heat of the kiln process. This area of scorched clay and stone extended up to 0.2m wide all round the surviving edges of the kilns (Plates 13-16).

Occasional patches of hard, white lime mortar adhered to the sides of the kiln walls in places and carried the imprint of brickwork lining. At the base of each kiln, up to eight courses of bricks survived *in-situ* showing that the whole internal surface of the kiln had originally been faced in this way. The bricks were bonded with hard white lime mortar and bedded on a floor of bricks laid on bed.

The upper brickwork had all been stripped out before abandonment and backfill of each of the kilns. The compacted demolition debris, lime mortar and ash from the robbing of the internal kiln lining had buried the brickwork at the lowest level preserving it *in situ* (Plates 14-16).

The surviving brickwork had been exposed to extremely high temperatures, the bricks being re-fired deep blue and purple and in places the brick surface had vitrified and distorted showing bubbles and ribbons of glassy glaze.

Each kiln had a narrow entrance (up to 0.6m wide) on one side (one facing south, a second south-west, one facing east and one facing west). This was built of brick incorporating occasional blocks of roughly shaped limestone. None of the kiln entrances survived more than 0.6m high (Plate 16).

Where exposed, the entrances were abutted on each side by a low dry-stone wall built of large slabs of broken limestone up to 1m high and extending up to 3m from the kiln enclosing a roughly oval working space (Fig 8, Plates 16). This was relatively flat immediately outside the kiln access but then sloped steeply upwards tapering and narrowing from the kiln entrance to ground level. The floor of the working area was covered in a hard, uneven layer of lime mortar and ash up to 25mm thick sealing the clay and mudstone quarry fill below. The interior of each of the kilns was filled with layers of broken brick, lime mortar and burnt clay and mudstone demolition debris. This was mixed with re-deposited clay and mudstone quarry fill. Mixed in with this material were fragments of both burnt and natural limestone up to 0.4m long and 0.2m thick.

Analysis of archaeomagnetic samples taken from the burnt brick lining of two of these kilns [2030, 2009] give the dates of last firing in the range 1795-1840 and 1825-1860 respectively (Appendix D).

Area 3

Area 3 was located to the north west of the spine road at the very eastern edge of the Miller Homes development area (Fig 4 and 9, Plates17-21). The natural geology in this area had also been quarried in the past and had been reinstated with re-deposited quarry waste, mixed clay and mudstone. In places the quarry fill carried traces of subsequent plough scarring aligned roughly north to south.

Cut into the earlier quarry fill were four circular kilns between 3-4m in diameter tapering to about 1.3m at the base and up to 2.2m deep. One kiln was partially exposed at the edge of the strip area and was recorded only on plan.

Of the remaining kilns, one was aligned roughly north-west to south-east, the other two were roughly almost south-east to north-west. One was half sectioned, the remaining two were fully excavated (Fig 9). The section of the kiln wall above the entrance was missing on all of the kilns and the outline of the surviving walls was marked by a band of bright orange/red scorched clay and mudstone up to 0.4m wide.

The internal brick lining of the kilns survived only at the lowest level, the remainder of the brickwork having been removed for re-use prior to abandonment. Each kiln had a floor of bricks laid flat onto a bed of lime mortar laid directly onto the quarry fill. The walls were built of roughly coursed bricks bonded with hard white lime mortar.

Each kiln had a narrow entrance up to 0.6m high and 0.65m wide and abutted on each side by drystone walls up to 1.4m high, built of large blocks of limestone forming curving walls enclosing an oval working space sloping from the kiln entrance to ground level (Fig 9, Plates 17-21).

The kiln entrances were floored with either a threshold of bricks laid flat or a layer of limestone slabs forming a flat surface. The remainder of each working area was covered in a hard layer of lime mortar and ash up to 60mm thick and sloping quite steeply to ground level.

Along the base of the walls were small drifts of lime mortar, ash and burnt stone that had become concreted to the floor and walls of the working area (Plates 18-19).

Each of the four kilns in this area had an associated mortar working surface at ground level (Fig 9, Plates 17-21). The partially exposed kiln at the extreme north of the site had several slabs of limestone set in hard white lime mortar forming a flat working surface (3035) immediately to the west of the kiln access ramp. Associated with this were two ephemeral parallel linear features, 1.3m apart but only 0.06m wide and 0.05m deep. These faded out about 5m to the south of the working surface and may represent cart tracks cut into the soft surface of the site.

The kiln immediately to the south [3005] had a roughly rectangular area of hard white lime mortar forming a working surface immediately west of the access ramp (Fig 9. 3071). The working surface contained two long curved depressions terminating in round basin shaped holes at the southwest. There was also a centrally placed basin shaped depression between the two linear features (Fig 9, Plate 17 and 20). It was unclear whether the depressions had been excavated and lined with mortar, or if working practices had eroded the holes in the floor. A section through the mortar surface showed it was made up of thin layers of mortar forming a solid pad up to 85mm thick.

To the south, kiln [3054] had two associated mortar surfaces, one either side of the access ramp (Fig 9, Plate 17). The area to the south of the kiln ramp [3050] was roughly rectangular, 3m long and 1.6m wide. It was badly damaged by ploughing and survived only as an undulating mortar surface 0.07m thick.

The surface to the north [3059] was 1.8m long and about 1m wide. It appeared to be worn into a sight hollow nearest the ramp access to the kiln. Each side of this worn section and set within the mortar surface was a 0.05m square hole containing the decayed remnant of a wooden post. Two further postholes were observed along the northern edge of the mortar surface. Both were roughly 0.1m square and up to 0.2m deep.

The kiln at the west of the area [3021] had a roughly rectangular spread of mortar [3065] 2.5m long and 1.7m wide on the north west of the kiln access ramp. Along the edge nearest the kiln were two roughly circular depressions up to 0.8m diameter and 0.2m deep. The northern most of these two features was badly damaged by ploughing and the machining of the site (Fig 9, Plates 17 and 21). A further spread of mortar to the north [3064] may indicate another kiln beyond the mitigation area.

Samples for archaeomagnetic analysis were taken from all three excavated kilns in this area. One sample disintegrated during processing [kiln 3005], the remaining samples [for kilns 3021 and 3054] gave dates of last firing in the period 1700-1750 AD and 1825-1870 AD respectively (Appendix D).

Area 4

Area 4 was subject only to a watching brief during the cutting of construction trenches for roadways, services and the erection of houses on this part of the site (Fig 4). Thus it has no separate area plan in this report. During the watching brief, remains of five pot kilns were observed. Due to the depth of the excavations in an area made of primarily re-deposited quarry fill, it was impossible to fully record these features except by locating them on plan. One kiln exposed in the cutting of a service trench was fully recorded (Plate 22) and a second in the cut for a house foundation was recorded in section (Plate 23).

Area 6

A single large pot kiln [6005] was exposed on Area 6 immediately east of the group of five larger kilns recorded on the 1888 Ordnance Survey First edition mapping of the area (Fig 3 and 10, Plate 24). It was of almost identical construction to those in Areas 2 and 3.

The lower part of the kiln was filled with a concreted deposit of grey/white lime mortar containing ash, vitrified silica, slag and burnt limestone. It was sealed below a layer of demolition debris from the dismantling of the kiln superstructure. The remainder of the area and access ramp was filled with bands of re-deposited quarry waste (Fig 10, Plate 24). Archaeomagnetic analysis of samples obtained from the surviving brickwork [6007] at the base of this kiln indicates at date of last firing in the period *c* 1750 (Appendix D).

4.6 Lime quarrying, roads and brick built kilns with flues, 19th-20th century (Phase 5)

The 1888 First Edition Ordnance Survey map of the area clearly shows a group of five kilns located to the west of this part of the site (Fig 3). The kilns were apparently surrounded by a rectangular enclosure and a track extended from the east of the site towards a limestone quarry to the north.

Evaluation trenching in 2005 indicated the survival of walls and possible working areas at this location. Topsoil stripping exposed a substantial stone roadway aligned north south and parallel to the field boundary along the west side of the site (Fig 10, Plate 25). The roadway extended about 160m and was 3m wide and surfaced with large blocks of limestone set in hard white lime mortar.

At the south of the mitigation area, the roadway forked with a 2.2m wide extension to the south east. Exposed in the cutting for a new estate road to the south of the mitigation area were surface traces of two large kilns with brick lined flues (Plates 37-38). One was located within the wedge of land between the roadway and the south-east fork, the other lay to the east of the extension road.

At the north of the site, a need to preserve public access to an existing right-of-way prevented the full exposure of the mapped kilns. To the north of the path, the plan of four kilns was exposed (Fig 10, Plate 26). A fifth kiln was exposed immediately to the south of the path.

Trenches excavated to the north and east of the kilns established some survival of the rectangular enclosure/structure shown on the 1888 mapping. While no evidence survived to the north, a mortared path sloped up from within the quarry fill and along

the postulated line of the east side of the enclosure/structure potentially once giving access to the open tops of the kiln structures (Fig 10, Plate 33).

Along the west side of the kilns and extending east to the group of four kilns were the backfilled access ramps to the kilns. One [6164] was partially excavated to show its profile (Plate 27). One kiln [6043] was half sectioned and recorded, then fully excavated (Fig 10, Plates 28-31), a process repeated for kiln [6022] to the south of the public footpath (Fig 10, Plates 34-36)

The upper section of the kilns was 3.9-4.2m in diameter, 2.8m-3.3 deep tapering to 0.9m at the base. Occasional patches of hard white lime mortar adhered to the kiln walls and carried the imprint of brickwork that must have originally lined the kiln.

Symmetrically located around each kiln were three vertical flues. These were cut into the quarry fill and were lined with bricks forming three sides of a hollow box, the robbed out brick lining of the wall would have completed the flue (Fig 10, Plates 28-31, 34-36). In both excavated examples, all three flues were deliberately blocked about 2.5m above the floor level by placing two courses of bricks across the hollow core of the flue. Above this the flue opened out and continued up as before.

At the base of the kiln, a circular brick-built ring-flue was concealed behind the surviving brickwork which was pierced in five places by vents allowing circulation of air, heat and gasses around the ring flue and up the three vertical flues (Fig 10, Plates 28-30, 34-36). The flue appears to have been open to the air each side of the flue entrance. The floors were formed of bricks laid flat with straight-line joints. They were bedded and bonded with hard white lime mortar.

The floor and walls of the kilns showed evidence of exposure to heat but no evidence for the burning and vitrification of the bricks observed in the smaller pot kilns. A halo of red/orange scorched clay and mudstone quarry waste up to 0.3m wide surrounded the kilns.

In the base of the kiln to the north of the public footpath, a curved metal grill (SF 1, Plate 29) was recovered from this demolition layer. The upper part of the kilns and the access to the kilns were filled with layers of clay and mudstone, the re-deposited upcast from limestone quarrying in the vicinity. The remains of these kilns all lie in the rear gardens of the new houses along this stretch of the spine road and will be preserved *in situ*.

Archaeomagnetic analysis of samples taken from the two excavated kilns indicates the date of last firing to lie in the period 1870-1880 AD and 1885-1910 AD (Appendix D).

4.7 Reversion to agriculture, 20th century (Phase 6)

It seems probable that as each area of the site was systematically quarried and backfilled in each phase, that area reverted to agriculture with either ploughing or pasture taking place on the reinstated topsoil ground surface. The map regression evidence clearly shows that following the demolition of the large group of kilns on Area 6, the entire site reverted back to agriculture once more. This marked the virtual end of the limeburning industry in this part of Barrow upon Soar.

The presence of plough scarring on the upper surfaces of the reinstated quarries across the site is mute evidence that ploughing and agriculture did continue when the industrial activity had ceased at each previous phase, testament to the considerable efforts of early industry to mitigate their impact upon the landscape. The land continued as agricultural land until the present day.

5 CONCLUSION

It is evident from the Sites and Monuments Records data, documentary and map research and the excavated remains, that there was wide spread early settlement in and around Barrow upon Soar and across the development area. There are indicators of both Bronze Age and Iron Age features identified to the west and south west of the development site. It is also clear that, extensive lime quarrying has taken place across the same landscape, much of the area subject of this report had been quarried for limestone and the land re-instated and re-used for agriculture prior to the present phase of development.

It is perhaps fortuitous that some early remains from the Iron Age were recovered at the west of the site. The excavated evidence clearly shows occupation with at least three structures possibly forming a small settlement or farm within a cluster of ditches marking probable contemporary field boundaries. Although material evidence for occupation was sparse, contemporary finds are indicators of occupation of the site in the middle Iron Age. The isolated section of ditch and the pit exposed in Area 2 at the north of the site also date to this general period. Given the extent of the quarrying across the site, the survival of even this small amount of evidence must be seen as anomalous and perhaps peripheral to the investigation of the development of the limeburning industry in later periods.

It is believed that lime from Barrow upon Soar was used in the construction of the Roman town wall defences of Leicester in the 3rd century AD (Cooper 2004). It is probable that limestone continued to be exploited during the Anglo-Saxon period as building stone.

It is highly likely that there was at least some limeburning going on locally as calcined lime was essential for the tanning of leather and in the dying industry; some may even have been used for mortar and plaster in the churches of the surrounding area.

From the 11th century onwards it is inconceivable that the limestone at Barrow was not exploited in the expansion of building that followed the Norman invasion and occupation of the country. Castles, churches and religious houses, as well as roads and bridges all required huge amounts of lime.

It highly likely that Barrow lime was used in the construction of nearby Mountsorrel castle, probably built during the 12th century but destroyed in 1217. Medieval production of lime at Barrow is attested from at least 1396 and an account of the 15th century records 55 lime pits at Barrow. Some of the large sub-rectangular and linear clamp kilns uncovered at Barrow upon Soar can be dated to the latter part of the 15th century period (dates of last firing are recorded in the range 1475, 1490 and 1490-1510) and it is possible that lime from these kilns was produced for the construction of nearby Kirby Muxloe Castle in the 1480s.

The 1480-84 building accounts from Kirby Muxloe record payments to no more than nine or ten named producers of lime at Barrow (Appendix E). It is impossible to state from the evidence whether they were the only producers, or if other people were producing lime on their behalf to fulfil the huge quantities required for the castle construction. The accounts also include details of payment for the carriage of lime from Barrow to Kirby. The inference must be that the normal price paid for Barrow lime was paid for delivery at the kiln where prices varied between 7d to 13d per quarter (112lbs or 50.8kg). Each cart load seems to have equated to four quarters (there were 5 quarters in the imperial ton). The lime was transported from Barrow at a cost of 14d per load. The accounts also record payments for the making of barrels and the purchase of used barrels for holding mortar.

It is possible that the newly fired quicklime was transported in similar barrels from kiln to site, reducing the risk of spontaneous combustion should the load get wet en route.

Although the early kilns exposed during excavation have very different shapes, they belong to the 'clamp kiln' tradition. All of the linear kilns lie on areas that had already been subjected to quarrying and re-instatement. The larger sub-rectangular clamp kilns were located on undisturbed natural sub soil. It is probable that land tenure may be reflected in the difference in kiln types on the two areas, particularly as there is some overlap in the dating of their use.

The contemporary use of the differing styles of kiln and their proximity to each other, is likely to be an indication of intensive industrial activity.

If substantial quantities of lime were required, a clamp kiln requiring 10-12 days from construction, loading, firing, cooling, clearing, packing and transporting the lime would have been far too inefficient if worked on a single kiln basis. It is probable that manufacture of lime for a major project like Kirby Muxloe would have been on a multiple kiln basis with several kilns in operation, each at a different phase of the loading, firing, cooling and clearing operation. In this way, the relatively few individuals recorded in the building accounts could have produced the large quantities of lime as evidenced in the recorded deliveries of numerous cart loads of Barrow lime at Kirby Muxloe (Appendix E).

This is particularly true as limeburning was a largely seasonal occupation taking place from spring through until autumn. This coincided with the building season as the wet and cold of winter prevented lime mortar from curing or setting properly. In addition, the inherent dangers in producing hot 'quicklime' in wet or damp conditions which could have triggered spontaneous combustion in the carts or containers used to transport it would have made it a fine weather occupation. It is also unlikely there would have been adequate dry storage to keep lime over winter on site at the kiln or at the construction site if lime production had continued unabated throughout the year.

What is certain is that huge areas of the land around Barrow upon Soar have been quarried for limestone. Every area excavated during the present development showed some evidence of quarrying and re-instatement. There were survivals of undisturbed natural sub-soil; in the south-east of the site, this was separated from the quarried area by a field boundary ditch no doubt backed by an earth bank and hedgerow when quarrying was taking place.

From the excavated kilns in the development site, it is evident that the earlier kilns are all at the base of the hill and closest to the core of Barrow upon Soar. The later pot kilns and the larger pot kilns with flues are all higher up the hill slope and further from the village.

It seems probable that limestone was quarried and burned as a cottage industry and moved further out around the village as closer supplies were used up. It is possible that any gaps in the exploitation of the landscape are the results of different land ownership in any given period. It is however impossible to produce clear evidence for this as land ownership records are far from complete.

Both types of clamp kiln would have had little substantial superstructure and would have been largely rebuilt after each firing, requiring only a covering of turves and clay to contain the burning. The heat generated by these kilns is evidenced by the scorching of the underlying earth coloured bright orange/red up to 200mm deep under the larger kilns.

If this is equated with the effects of contemporary charcoal clamps, where the earth scorching rarely exceeds 40-50mm, it seems likely these kilns were repeatedly used with temperatures around 1000º maintained over several days to produce the evidence of extreme heat in the sub soil remains exposed on site.

Both the sub-rectangular and linear clamp kilns are found only in the south-east of the site. For the larger clamp kilns, only the survival of a localised area of intense scorching marked where each kiln had operated. Several of the kilns retained layers of desiccated and scorched mudstone and clay mixed with lime and ash, which may be the remains of the firing floor of the kiln. They were built with a shallow base dug into the topsoil and the fuel and limestone would have been stacked in alternating layers before being covered in turves and earth. When firing was complete, the turves were removed allowing the calcined lime to be removed.

The shell of the kiln could be re-used several times before the effort to re-instate was greater than that to start again.

In respect of the linear kilns, these had been dug up to 300mm into the sub-soil but no substantial remains of any above ground structure survived. From the evidence of the kiln bases, at the closed end of each linear kiln the halo of scorched earth was wider and deeper than along the sides of the kin indicating greater heat. At the opposite end, there appears to have been an opening to act as a firing or draw hole for the kiln. It is likely that this type of kiln operated on a draw principle with an open flue or chimney at the closed end, creating a draught to draw air through the kiln and perhaps creating a quicker and more intense burn. While this could produce lime quicker, it is likely to have been less efficient in the ratio of fuel consumed to the volume of lime produced.

Although scatters of coal were found in proximity to the larger clamp kilns, only the linear kilns had evidence for an attached working area, one of them producing a centrally placed posthole perhaps indicating a lightweight shelter over the working area.

Given the volatile nature of quicklime, even a rudimentary shelter would be necessary to protect the lime from inclement weather during unloading of the kiln and putting the lime in containers for transportation. As the limestone was fired in a clamp, the draw hole would have been used to increase or decrease the draught to ensure an efficient and complete burning of the lime. The working area would then have served to process the quicklime, probably by breaking it into smaller pieces for packing and transportation.

In the absence of any substantial kiln structure, archaeomagnetic samples could only be recovered from those kilns with surviving putative floor surfaces. Some of these results have tended to stray from the Master Curve for dating although all the samples from these early clamp kilns cluster within a 100 year period. This consistency of dating together with the similarity of structure and close proximity give additional confidence to the arcaheomagnetic results obtained. The evidence all indicates that both types of kiln were operating in the late 15th century and that limeburning using the linear kilns continued through until the end of the 16th century.

The third type of kiln found on site was a circular brick-built ‘pot’ kiln, examples of which were spread over most areas of the site. Although they did not appear in the excavated areas 7 and 8, examples were seen in the roadways and house foundations being excavated across all of the north and the south east part of the site by the developers. These seem to be a classic pot kiln of the ‘intermittent’ type but probably used on a ‘continuous’ basis as need arose. These took the form of an inverted cone, up to 3-3.5m in diameter and dug up to 2.2m deep into the ground. The sides tapered to a base about 1-1.3m in diameter. The upper walls were all stripped of the brickwork and the wall above and around the draw arch removed in every case.

The kiln would have been open to the sky and would not have projected more that 300-500mm above ground level.

In all the excavated brick pot kilns, the lower layers of brickwork have been subjected to intense heat with evidence of bloating, cracking and vitrification of the sands and clay within the bricks. The obvious conclusion must be that the walls at the base of the kiln were subjected to repeated and prolonged exposure to intense heat.

It is probable that the kilns were loaded with a charge of limestone, either supported on a timber or metal frame or being carefully built to form a dome over the kindling and the initial charge of fuel laid in the base of the kiln.

Additional fuel and layers of stone would then be loaded from the open top of the kiln. While the kilns could be operated on an intermittent basis, it is highly likely that when demand was high, the kilns were operated on a continuous basis with additional fuel and stone being added from the top of the kiln as the charge burnt and settled. Ash and clinker would be raked from the base of the kiln through the draw hole.

This could also be opened or closed by placing large blocks of stone and earth against it to control the draught through the kiln.

It is almost certain based on comparative evidence elsewhere that the upper part of the kiln wall above the draw hole would have had additional rodding holes where the load in the kiln could be poked with long iron tools to prevent clinker and ash clogging the air flow and killing the fire.

No evidence of fire bars or an internal ledge in the surviving brickwork has survived and it is probable that large slabs of limestone were used to form a ‘horse’ or dome which supported the upper load within the kiln and allowed the initial firing from the base of the kiln as well as providing a flue for the draught necessary to fire the upper part of the charge and a space to rake out ash and clinker. When the firing was complete, the kiln was allowed to cool and then the entire charge of calcined lime could be removed.

Each kiln had a working area immediately outside the draw arch, revetted with slabs of stone and floored with slabs of stone and/or a lime mortar floor. Each was approached down a steeply sloped ramp with a lime mortar base. Associated with at least five of the kilns there were additional working surfaces at ground level, some with what appear to be working hollows. At least one of these surfaces produced evidence of postholes that would have supported a roof over the working area. As with the earlier kilns, these were almost certainly lightweight shelters where the quicklime from the kiln was broken down and packed ready for transportation away from the site.

Eighteen of these kilns were seen during excavation or uncovered during building works outside the designated mitigation areas. Three were fully excavated, five were half sectioned and the remainder recorded in plan. Samples for archaeomagnetic analysis were obtained from six of these kilns but only four produced positive results, one sample disintegrated during processing and could not be analysed and one result was off the Master Curve but can be estimated with some degree of confidence. All of these kilns date from the 18th and 19th century. This is entirely consistent with the development of this type of kiln elsewhere and the recorded increase in demand in that period from the increase in agricultural production to feed the burgeoning population and the demands of the growth of industrialisation and the development of canals and railways.

The final kiln type excavated on site appears to be a logical progression from the smaller brick lined pot kiln to a much larger and sophisticated brick-lined pot kiln with vertical flues.

These kilns appear on the 1888 Ordnance Survey First Edition map of Barrow upon Soar and comprise a battery of five kilns shown within a surrounding enclosure.

Two kilns were fully excavated. They are substantially larger than the earlier pot kilns being in excess of 4.5m diameter and dug up to 3.6m into the ground. They had a working area outside the draw arch with stone slab wall revetting and a steep access, in both cases fitted with stone steps. The major refinement over the smaller pot kilns was the introduction of three vertical wall flues in each kiln. There must have been an optimum size beyond which the size and weight of the loading would have compressed the fire at the base killing it and stopping the calcining process. It is probable this was overcome by the introduction of a ring-flue around the base of the kiln allowing a draft to be introduced below the fire bars to feed the fire.

The vertical shafts allowed air to be drawn further up the kiln to assist with pre-heating and burning as the kiln got into full flow. Each of the vertical flues was deliberately blocked at about 2.5-3m above the base, but was then open again above that height.

From comparative studies elsewhere and examination of contemporary and later lime, tile, brick and pottery kilns, it is plausible to assert that this was to allow air in the lower part of the kiln to circulate and create the intense heat, the upper part of the flue carried smoke, hot air and gases further up the kiln, drying the stone and pre-heating it so that heating was quicker and more efficient, without a requirement for additional fuel.

In these kilns, the brickwork that survives in the base of the kilns shows no evidence for the intense heat evidenced in the smaller pot kilns. Part of an iron grid forming one half of an arched fire grate was recovered from the base of one of the kilns (Plate 29). The grate or ‘horse’ would be in two parts, either hinged or bolted together so that it could be removed through the narrow draw arch. The initial charge of fuel was laid on the fire grate with alternating layers of stone and fuel added from the open top of the kiln. Only the light timber and brushwood kindling would be fired in the base of the kiln, the main heat being generated in the centre and upper part of the kiln. With the flues, this was clearly a more efficient way to heat large quantities of limestone rather than the simpler stone horse construction within the earlier types of pot kiln.

Samples from the brickwork in the base of the two excavated flue kilns indicate they were last fired in the late 19th or early 20th century. As the kilns had been stripped and back-filled by the time the Ordnance Survey Second Edition mapping was produced in 1904, this dating is fully supportive of the map regression evidence.

The 1888 mapping of the area indicates a track from the kilns to the lime quarry at Tithe Farm to the north east. This quarry was operated by John Ellis and Sons and it is highly probable that they were also operating these large kilns producing high quality lime for the construction of the London Underground.

On all parts of the site and in all the kilns sampled, right back to the 15th century kilns, the fuel was coal. Samples of the residual ash and fuel in the bases of all excavated kilns indicates only coal residue with occasional fragments of small wood charcoal. There is no evidence of large heartwood charcoal on site and it is likely that light timber and brushwood was used as kindling in the kilns with coal as the main fuel.

The evidence of pottery and bone recovered from the excavations is indicative of manuring scatters and land reinstatement rather than activity at or around the kilns. The pottery fragments are strictly utilitarian domestic wares with no evidence of industrial activity.

Bone recovered on the site is generally discard of domestic food waste but is such small numbers it cannot indicate anything more than a random scatter.

Analysis of the bricks used in the construction of both the smaller pot kilns and the flue kilns has proved fairly inconclusive. All the bricks appear to have been of local manufacture, probably purely for use within the kilns.

There are no well-dated examples for comparison in the area. Many of the surviving bricks were heavily burnt and vitrified, often on opposing faces indicating that they were re-used, either within the same kiln as part of ongoing maintenance and repair, or more likely, they were stripped from each kiln as it was abandoned and backfilled and re-used to line a new kiln elsewhere on the vicinity.

There was little surviving evidence for the enclosure surrounding the latest kilns as shown on the First Edition Ordnance Survey mapping of the site. Trenches cut at the north, south and east of these kilns found no evidence for any above ground structures. Aligned along the side of the roadway to the west of the kilns were the foundations of a brick wall forming an intermittent barrier between the roadway and the open kilns. It was pierced by each of the kiln access ramps and it is likely that it originally extended all the way around this group of kilns forming a boundary or barrier to prevent access to the kiln site.

At the rear of the kilns, there is evidence for a ramp from the surrounding quarry to ground level by which limestone (and/or fuel) could be taken to the kilns to load them and provide a continuous process of burning, replenishing the kiln charge as the lower layers of fuel were spent and the calcined lime raked out.

All the evidence is that the whole area had been intensively quarried and most of the excavated kilns were actually built onto or cut into the backfill of large quarry pits. This means that the exploitation of the lime must pre-date the earliest kilns uncovered. It is entirely possible that many earlier kilns were actually located within the quarries and only later were they built into the reinstated quarry fill of earlier workings. Excavations for deep drains and sewage pipes on the development site went down in places over 6m without bottoming the quarries. Engineering reports following the collapse of a block of flats in 1978 and major subsidence along the Sileby Road in 1987 (Freer 1979, Wardell Armstrong 1987) indicate that quarrying and mining of limestone from shafts and tunnels may have gone at least as deep as 16m and possibly much deeper.

The excavations at Cotes Road have demonstrated the wealth of surviving archaeological evidence for the extensive limestone industry at Barrow upon Soar. The physical remains of kilns contemporary with the recorded delivery of lime from Barrow to nearby Kirby Muxloe castle is clear evidence of a substantial industry already in place in the 15th century and other records indicate exploitation of this resource earlier in the medieval period. Lime remained a major factor in the local economy through until the present. While later exploitation of lime is increasingly well-recorded nationally, the survival of so many kilns spread across the whole of the development site must be a strong indicator of the potential for further work in the vicinity.

Of particular note is the evidence for earthwork remains of ridge and furrow cultivation across much of the site, often taken to indicate undisturbed agrarian land use. At Cotes Road, these have been proved to overlie both limestone quarries and lime kilns dating to the 15th century or earlier. The potential for further extensive finds relating to the limeburning industry at Barrow upon Soar can reasonably be expected in all areas where there is, or has been, underlying limestone geology.

6 ARCHIVE

The road corridor for the construction of the spine road from Cotes Road to Willow Way was subject to a strip, map and recording brief. Details were recorded on daily record sheets and substantive features planned, drawn and photographed.

Area 4 was subject only to a watching brief during the excavation of two sets of foundations located immediately west of Strancliffe Lane at the north-east of the Millar Homes development area. Due to the constraints of both width and depth of the foundations through quarry backfill, no access could be gained to the trenches. Features were recorded by photograph and sketch plans only and noted on the daily site record sheets.

The archive of materials comprises the following:

Site records

Plans	37 sheets (A2) drawn at either 1:20 or 1:100
Sections	22 sheets (A2) drawn at 1:20 or 1:50
Contexts	558 (A4) *pro-forma* record sheets
Site daily record sheets	77 (A4) pages
Supporting records	25 (A4) pages of *pro-forma* record sheets
Colour slides	342 colour slides
B & W photography	11 film negatives and contact sheets

Finds

Miscellaneous finds	1 box (includes pottery, bone, antler, glass etc)
Brick	7 boxes
Metal finds	1 poly-box
Metal grill (fragmentary)	1
Lime samples from kilns	2 boxes

Environmental samples

Flots and fine residues	6 boxes

All records and materials will be compiled in a structured archive in accordance with the guidelines of Appendix 3 in the English Heritage procedural document, *Management of Archaeological Projects* (1991).

The archive and finds together with a copy of the excavation report will be deposited in accord with the brief. Deposition of the archive will conform to the guidelines of the receiving museum.

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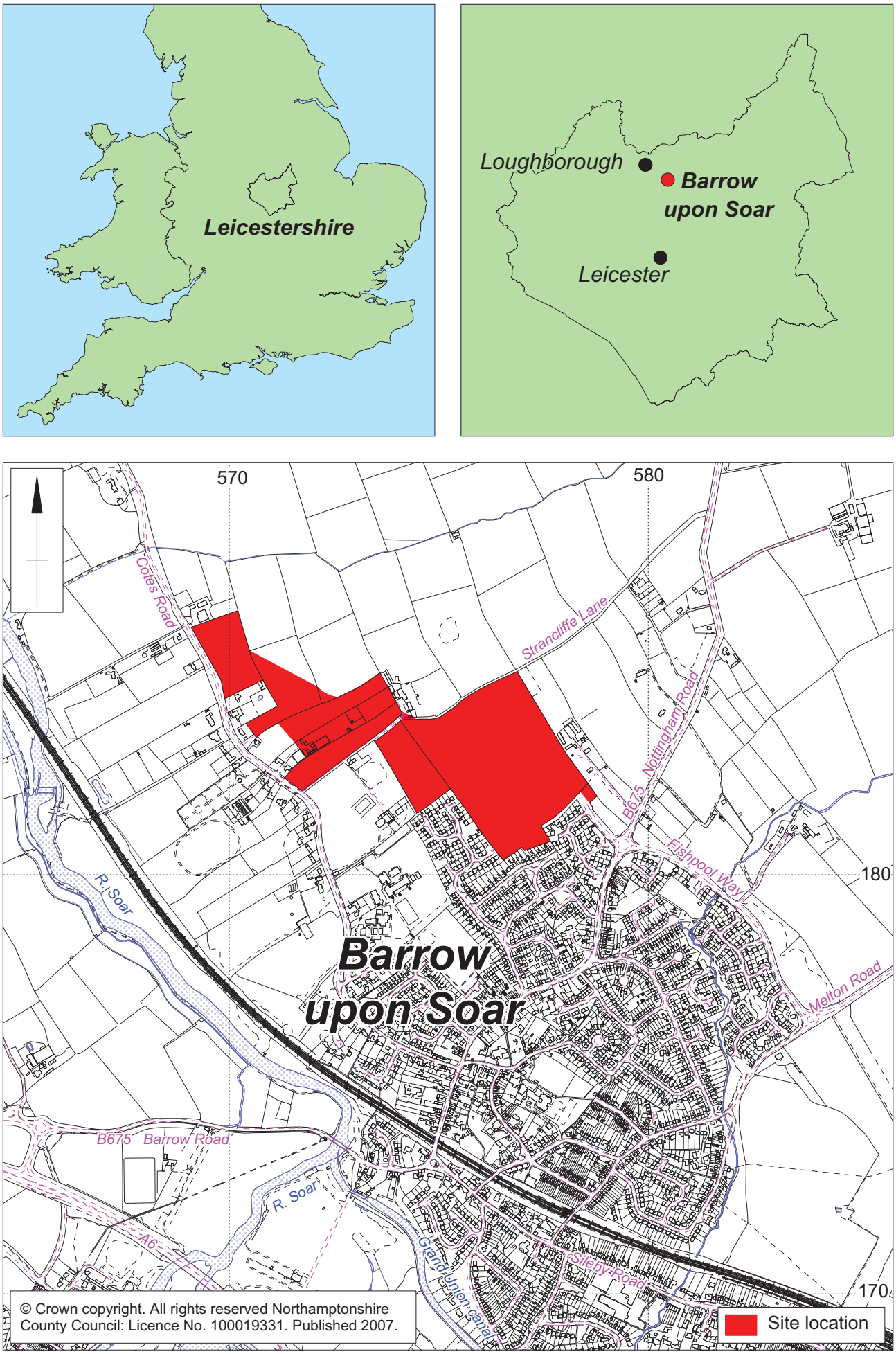
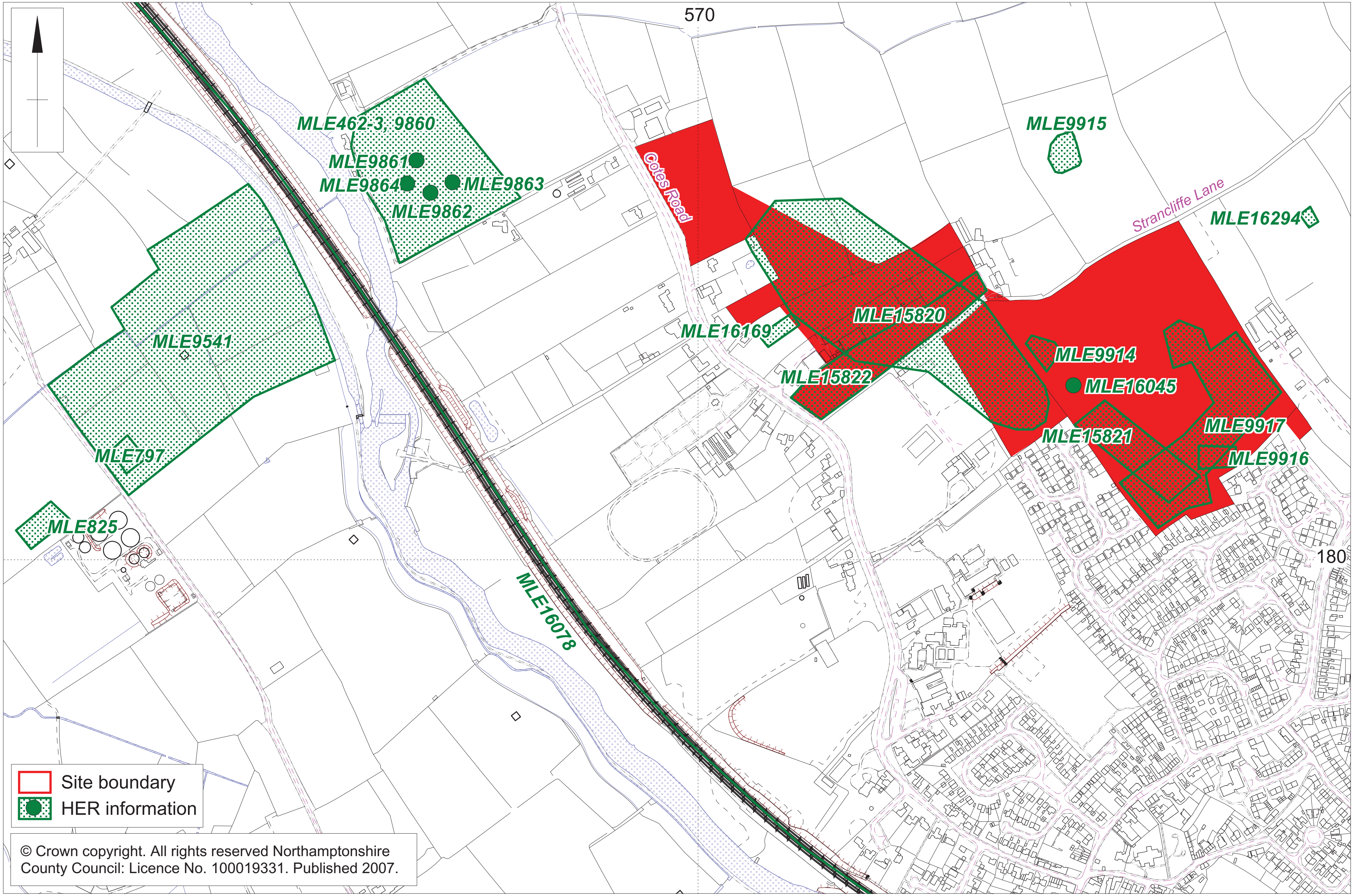


Scale 1:12,500

Site location Fig 1



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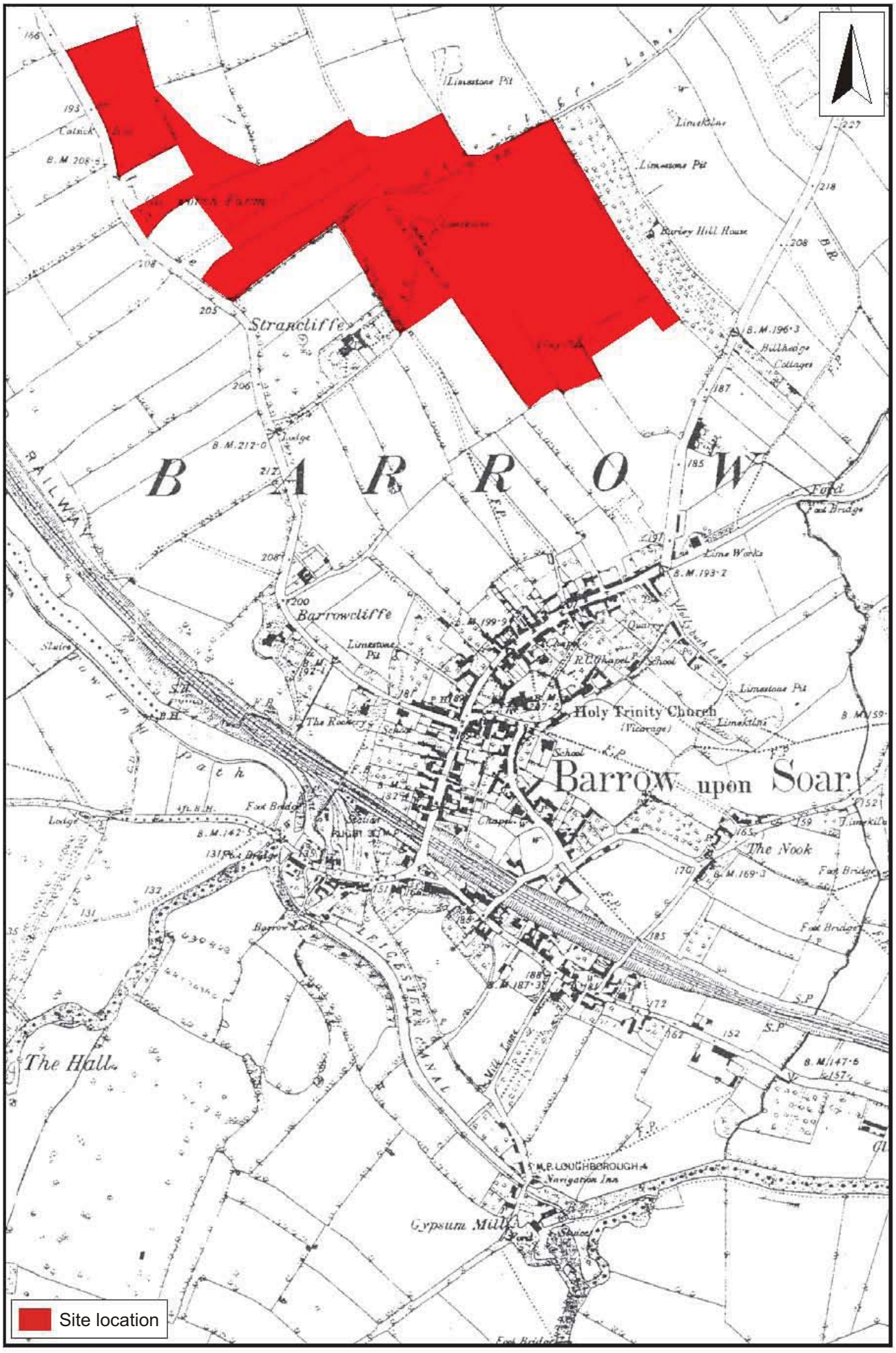
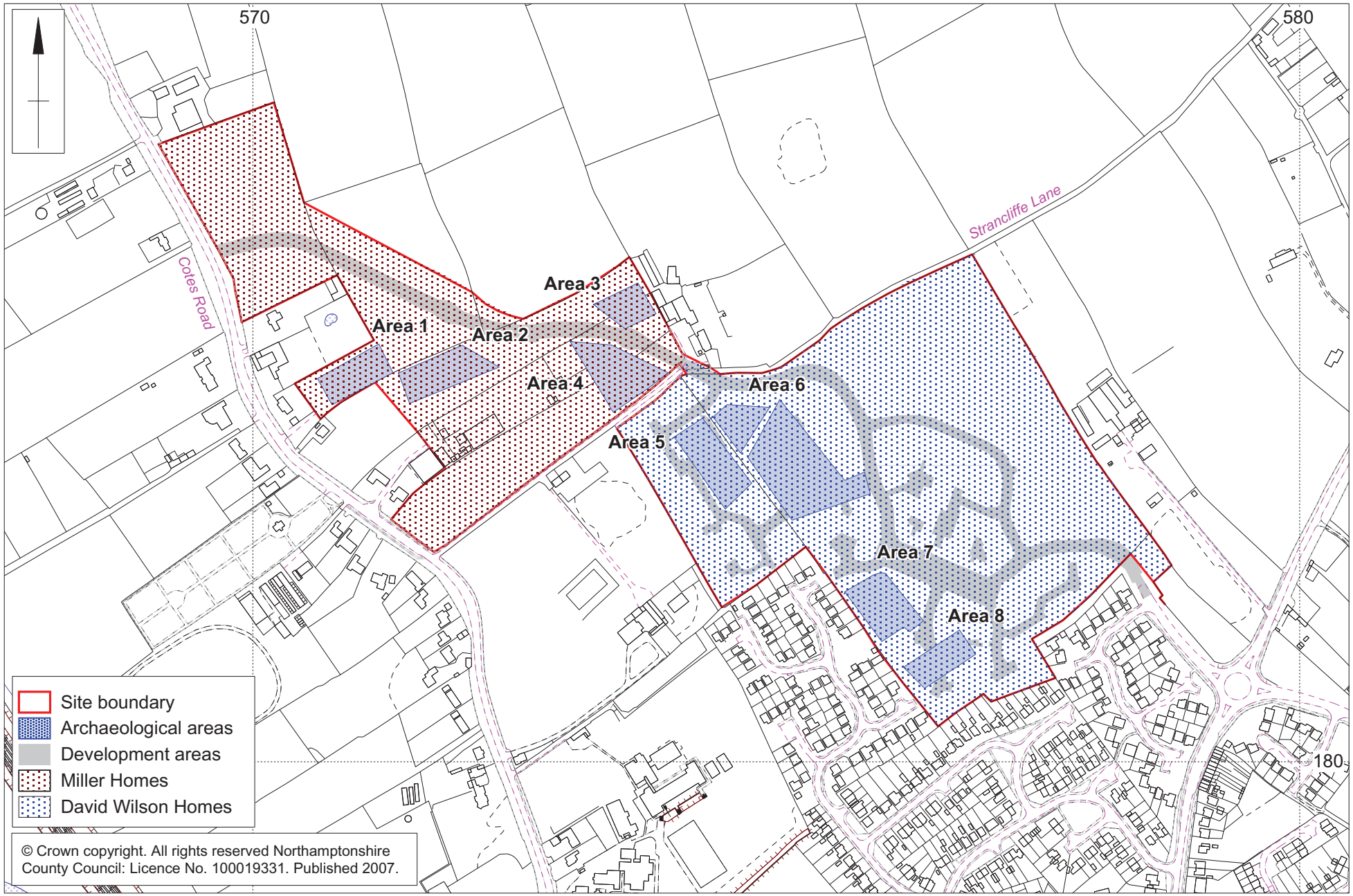
Historic Environment Record (HER) information

Fig 2



Ordnance Survey 1888 map Fig 3

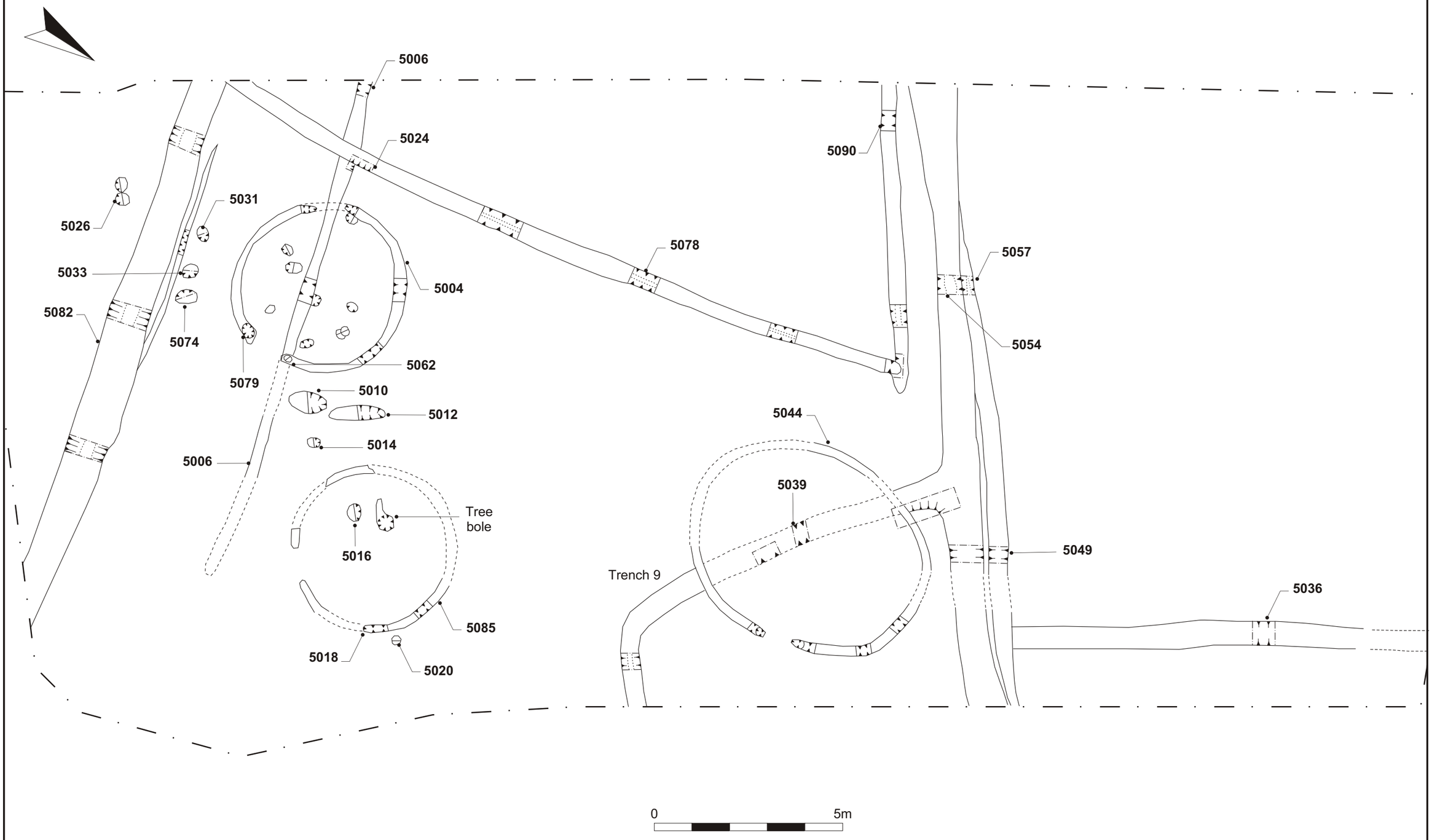


Scale 1:5000

General plan showing mitigation and development areas

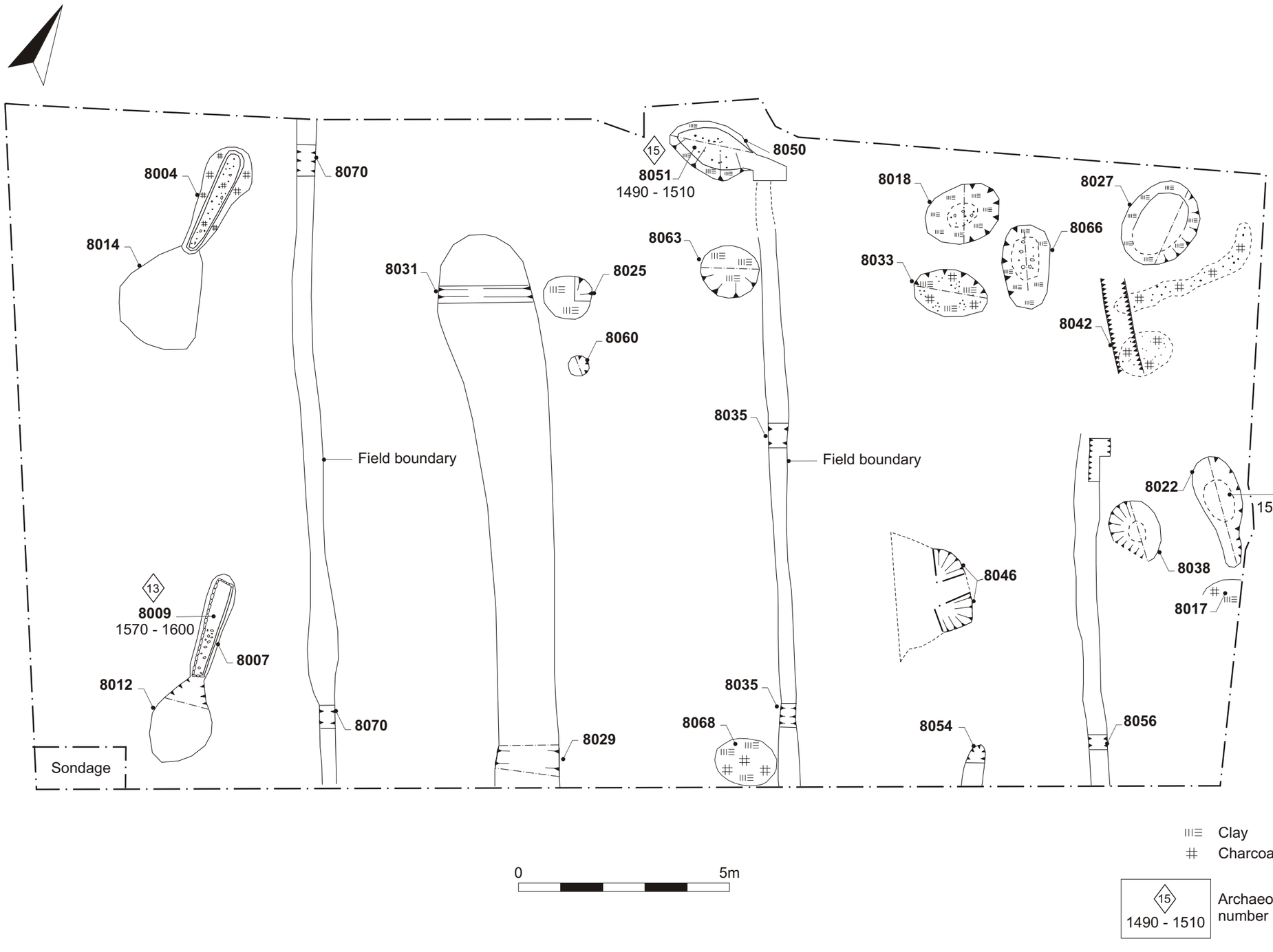
Fig 4

Area 5



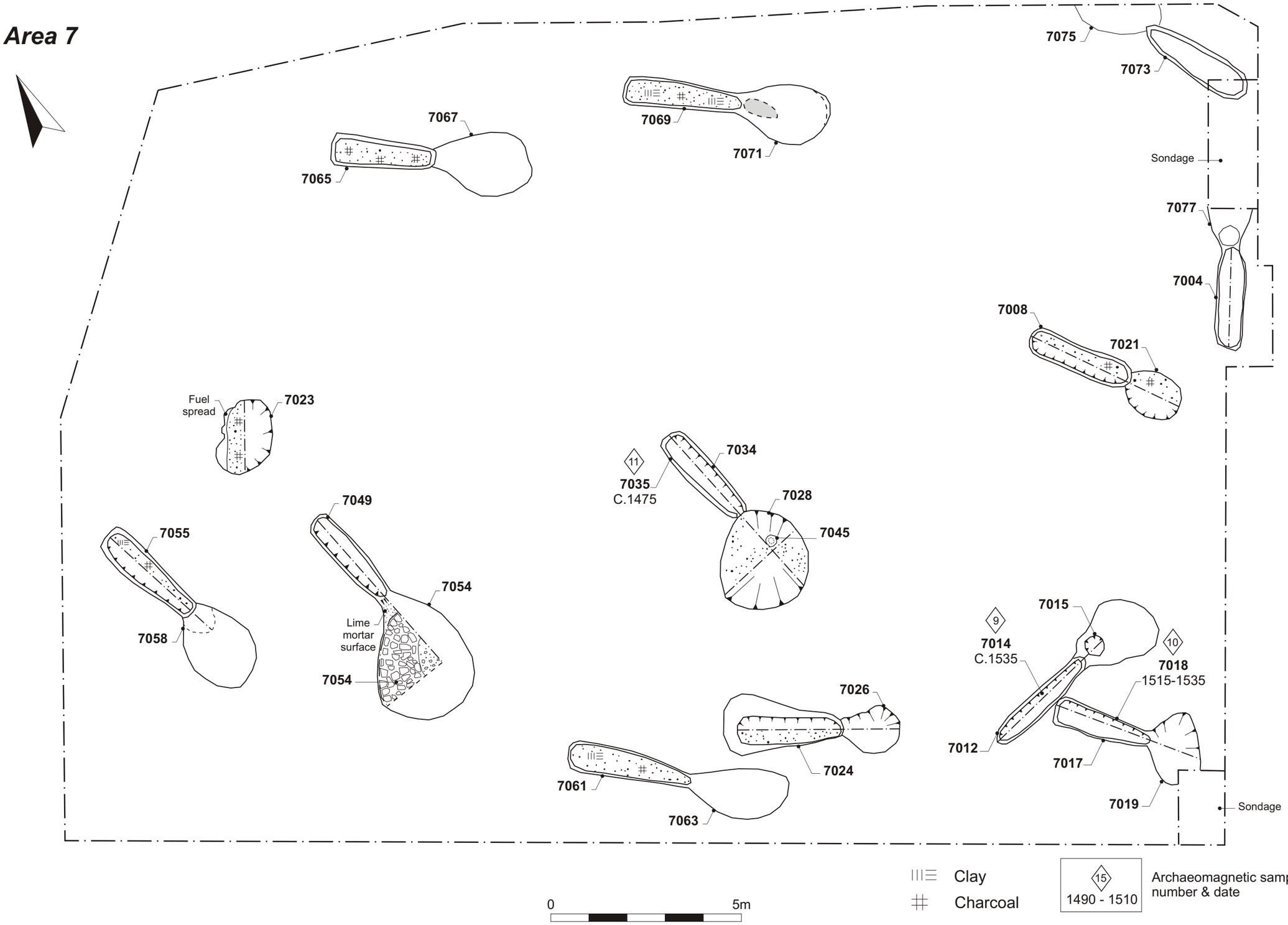
Plan of Area 5 Fig 5

Area 8



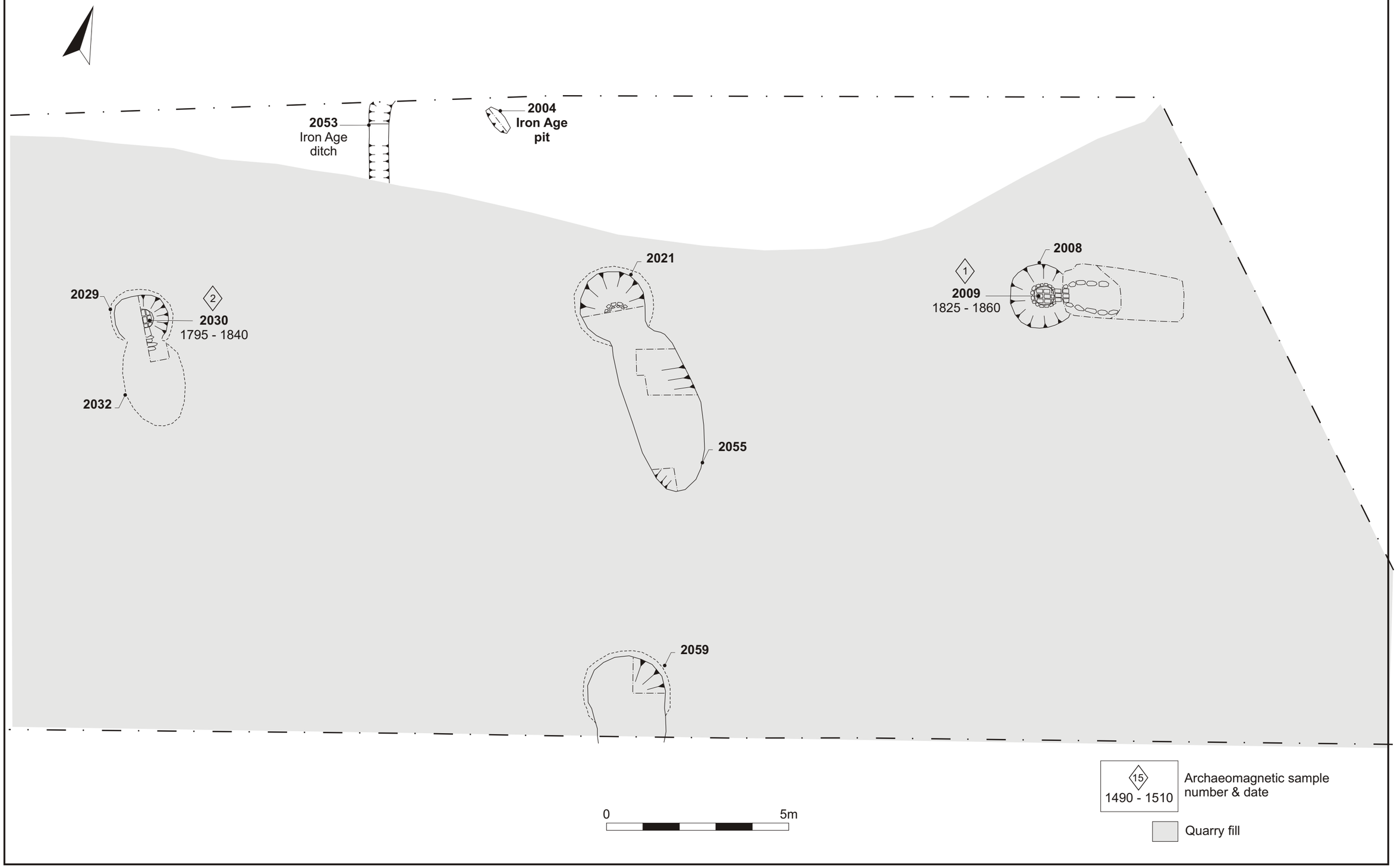
Plan of Area 8 Fig 6

Area 7

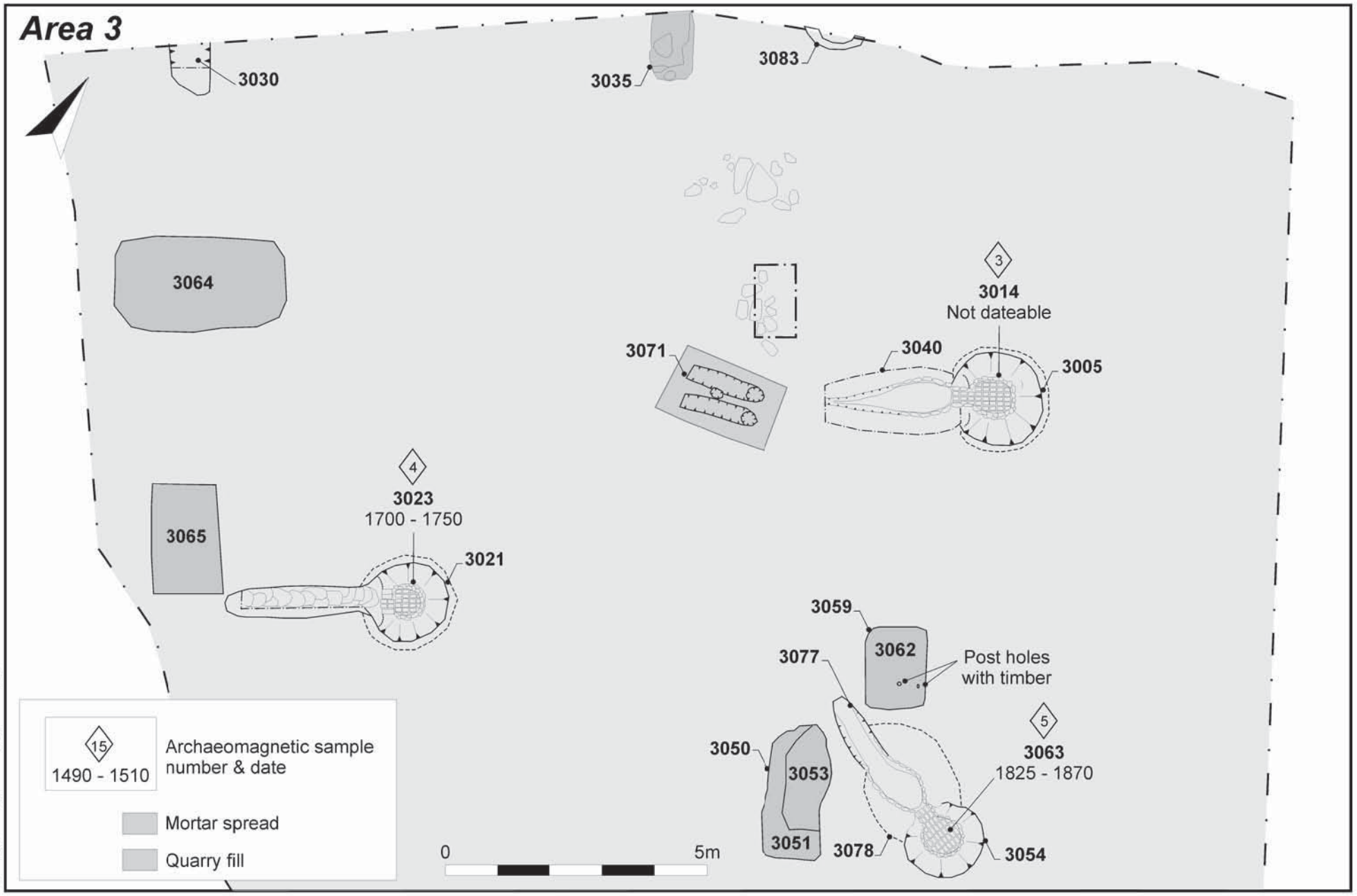


Plan of Area 7 Fig7

Area 2



Plan of Area 2 Fig 8



Plan of Area 3 Fig 9

Area 6

15
1490 - 1510
Archaeomagnetic sample number & date

Quarry fill

7
6007
c.1750

6080

6005

8
6062
1885 - 1910

6162

6166

6043

6170

6134
Wall

6164

6168

6123

6172

6022

6
6030
1870 - 1880

6145

6118 Road surface

6118 Road surface

0 5m

Plan of Area 6 Fig 10

Plate 1: Area 5 - ring ditch and pits

Plate 2: Area 5 – machine stripping ring ditch

Plate 3: Area 5 – ditch and ring ditch under excavation

Plate 4: Area 5 - excavating Iron Age pit

Plate 5: Area 8 - peri-glacial banding, plough scars and field boundary

Plate 6: Area 8 - kiln base and fuel spread

Plate 7: Area 8 - kiln bases, plough and furrow scars

Plate 8: Area 8 - section through kiln base

Plate 9: Area 8 - linear kiln cut into quarry fill

Plate 10: Area 7 - linear kin with working area

Plate 11: Area 7 - intersecting linear kilns (note working area in foreground)

Plate 12: Area 7 - linear kiln and excavated working area with posthole

Plate 13: Area 2 - surface indication of buried pot kiln

Plate 14: Area 2 – partial section through pot kiln and working area

Plate 15: Area 2 – half section through pot kiln

Plate 16: Area 2 - excavated pot kiln and working area

Plate 17: Area 3 - pot kilns and mortar surfaced working areas

Plate 18: Area 3 - pot kiln with access ramp, working area and retaining walls

Plate 19: Area 3 - pot kiln, stone walls defining working area and access ramp

Plate 20: Area 3 – pot kiln with mortar surface and parallel grooved working areas

Plate 21: Area 3 – pot kiln with mortar surface and depressed circular working area

Plate 22: Area 4 - pot kiln exposed in builder’s trench

Plate 23: Area 4 – pot kiln partially exposed in house foundation trench

Plate 24: Area 6 – half section through pot kiln

Plate 25: Area 6 - kiln access roads

Plate 26: Area 6 - surface remains of 19th century flue kilns

Plate 27: Area 6 - cut for access to 19th century flue kiln

Plate 28: Area 6 - half section through kiln, note blocking of flue

Plate 29: Area 6 – half section through kiln showing metal grate

Plate 30: Area 6 - pot kiln with flues, access steps and working area

Plate 31: Area 6 - pot kiln showing access steps and working area

Plate 32: Area 6 - base of brick boundary wall to west of flue kilns

Plate 33: Area 6 - quarry fill with lime mortar ramp to rear of flue kiln

Plate 34: Area 6 - section through flue kiln, note flues, vents and blocking

Plate 35: Area 6 - pot kiln with ring flue and vertical wall flues

Plate 36: Area 6 - kiln floor, wall and ring flue detail

Plate 37: Area 6 - access road and kiln exposed to south of Area 6

Plate 38: Area 6 - access road and kiln exposed to south of Area 6

Plate 39: classes of brick recovered from kilns

Plate 40: vitrified brick

APPENDIX A

A 1 THE GEOLOGY by Steve Critchley

The excavation area is underlain by flat-bedded grey mudstones and interbedded thin limestones, which stratigraphically form part of the Upper Triassic and Lower Jurassic Periods. Termed the Barnstone Member these rocks, varying in thickness, from 8 to 12 m, were formerly known as the Hydraulic Limestone beds because of their past importance for cement making. They contain abundant limestone beds, generally 0.1 to 0.3 m thick particularly above the Planorbis zone.

The Barnstone Member marks the base of the Jurassic Period, which is defined as the point within the strata where ammonites of the genus Psiloceras planorbis first appear. This point actually occurs a few meters above the base of the Barnstone Member and so the basal sediments form the upper most beds of the preceding Triassic Period. The stratigraphy can be summarised as follows: -

Period	**Stage**	**Group**	**Formation**	**Member**
(Jurassic)				
Lower Jurassic	Hettangian	Lias	Scunthorpe Mudstones	Barnstone
Planorbis zone				
(Triassic)				
Upper Triassic	Rheatian	Penarth	Lilstock/Westbury	Barnstone

Within Area 5 of the excavation an outcrop of Quaternary Period Anglian Stage glacial tills were observed. These are mapped overlying the Barnstone Member on the topographically higher areas and are generally considered to be the basal till deposits formed during the Anglian Glaciation in this area. Termed the Thrussington Till it is seen in fresh exposures to be a brown to blue grey sandy clay diamicton with abundant Triassic and Carboniferous rock fragments. Elsewhere evidence has been found to indicate that the ice sheets, which deposited this till, advanced from the north and northwest.

Although most of the exposures of the Barnstone Member have been greatly disturbed by multiperiod quarrying and subsequent infilling, small areas of relatively undisturbed sediments were observed in Area 8. Exposures were noted as flat-bedded mottled grey brown mudstones, calcareous mudstones and thin limestones with stratification observed in sections. These were seen to be cut in plan by a series of dark grey to light grey brown mudstone and calcareous mudstone filled features running roughly parallel to the slope and in turn were cut by archaeological features such as a boundary linear and kiln structures. A colour change in the infill was noted towards the eastern end of the excavation area possibly reflecting a greater calcareous content of the underlying strata.

The interval between the features was approximately 5m and each zone of disturbed fills was around 250mm to 350mm across. In section these features could be seen dipping at an angle of circa 35º to the northwest with the contact zone between each slice of sediment marked by a mottled dark grey material composed of sheared mudstone and calcareous mudstone.

A number of periglacial or slope failure origins for these features can be postulated although further excavation to observe the relationships at depth between adjacent segments would have been helpful to determine more precisely their mode of formation.

It is likely that these features represent the known patterns of slope failures common in the Lias clays on glacially over-steepened valley sides following the relaxation of periglacial conditions at the end of the Devensian Stage of the Quaternary.

Slope failures or shears generally occurred in the upper permafrost layers on melting with gravity sliding aided by suitable permeability boundaries within the deeper partially frozen layers or in this case at the junction with a more competent limestone bed.

The initiation of the roughly parallel shear zones may possibly reflect previous incipient thermal contraction cracking of frozen ground, weaknesses exploited on melting of the upper layers of permafrost as a response to unstable slope morphology.

Downslope movement would account for the steep angle noted at depth in the sections with the boundary sediments representing the remains of sheared/water lubricated material present between each zone of failure.

The present plan of these features could be considered as an eroded plane through a formerly complex series of slope failures that took place some 10 to 15,000 years BP.

APPENDIX B

B 1 THE IRON AGE POTTERY by Andy Chapman

A total of 91sherds, weighing 592g, of Iron Age pottery was recovered. This came from nine contexts but the majority of these contained only a handful of sherds, with only two contexts producing more than 100g.

The vessels are all hand-built and several sherds show oblique breaks where they have fractured along a coil join. At least three fabrics are present: a sandy fabric, containing fine quartz grains and occasional larger mineral inclusions, including rounded and angular pebbles up to 6mm long; a sandy fabric without larger mineral inclusions; and a sandy fabric with both larger mineral inclusions and also frequent small pellets of grog. The vessels typically have a dark grey core and inner surface, and patchy external surfaces that range from dark grey to orange-red.

The largest single group comprises 37 sherds weighing 256g from the fill, 5042 of boundary ditch [5039]. This group includes sherds from two scored ware jars, and sherds from a high-necked vessel with an everted rim.

The oval ring ditch, which was later than boundary ditch [5039], produced the second largest group overall, with eight sherds, weighing 115g, from the northern terminal [5044] and four sherds, weighing 43g, from the opposite terminal, [5092], and a few further sherds from other sections. Apart from sherds from a bowl with a flat-topped rim and a single sherd of scored ware, the material from the oval ring ditch comprises undiagnostic plain body sherds.

No pottery was recovered from the two smaller ring ditches. From an elongated pit [5012] lying between them, there are 21 small fragmented body sherds, weighing 44g, largely from a single vessel.

This small group of material contains few diagnostic features, but with the presence of scored ware it can be broadly attributed to the middle Iron Age, perhaps the 3rd to 2nd centuries BC. There are no specific characteristics to suggest a continuation into the 1st century BC, although scored ware can occur in later Iron Age assemblages.

APPENDIX B

B 2 THE POST-MEDIEVAL POTTERY by Iain Soden

The entire excavations at Catsick Hill, Barrow-upon-Soar produced only 49 sherds of post-medieval pottery in eight fabrics or types, weighing a total of 923 grammes. The sherds were counted and weighed by context and related as far as possible to the most recent published type series for Leicestershire, that by Davies and Sawday (1999).

This is a small and very fragmented assemblage and for the most part the very small sherd size (average 13g - excepting one very substantial Midland Black base) indicates that the pottery has been dispersed a number of times before eventual deposition. Much of it may derive from manuring of the fields, since none of the excavated areas lie close to contemporary domestic occupation.

While much of the pottery recovered actually came from within the backfills of a variety of lime kilns, the fragmentary nature of almost all of it indicates that very little probably originated in the daily use of and attendance at the process of lime-burning. None are sufficiently closely-datable to refine the dating for each kiln's demise over and above that which has been gleaned from samples taken for archaeomagnetic calibration. They do however, tend to confirm the scientific dating thus obtained. Only one small group of sherds is sufficiently reconstructible (including joining sherds) to suggest that a vessel may have been deposited by someone actually present during the life of the kiln or at its demise. This comprises seven sherds from an 18th century Nottingham Stoneware vessel in Area 3, Contexts 3011, 3053 and u/s. Again, it is not more closely datable than the results of archaeomagnetic dating.

The pottery present was as follows:

Table 1: Post-medieval pottery types from barrow upon Soar by fabric type

Area	Context	Origin	No	Weight (g)	Type	Common name	Production range
2	2041	Kiln 2029	2	16	MY	Midland Yellow	1500-1725
2	2041	Kiln 2029	1	4	EA3/4	Mottled ware	1680-1740
2	2041	Kiln 2029	1	2	EA11	Tin glazed Earthenware	C18th
3	u/s	-	2	13	SW3/5/6/7	Notts Stoneware	1700-1800
3	3011	Kiln 3004	3	21	SW3/5/6/7	Notts Stoneware	1700-1800
3	3011	Kiln 3004	1	15	?	Burnt, unidentifiable	?
3	3034	Kiln 3021	1	4	EA9	Pearlware	C19th
3	3051	Surface 3054	1	17	EA3/4	Mottled ware	1680-1740
3	3053	Surface 3054	2	19	SW3/5/6/7	Notts Stoneware	1700-1800
3	3073	Quarry fill	1	11	EA3/4	Mottled ware	1680-1740
5	5002	Subsoil	1	13	MB	Midland Black	1650-1750
5	5002	Subsoil	1	91	EA	Pancheon	1800-1900
5	5002	Subsoil	1	279	MB	Midland Black	1650-1750
5	5035	Furrow	1	37	EA	Earthenware	1600-1700
5	5035	Furrow	2	70	EA	Pancheon	1800-1900
5	5035	Furrow	1	53	MB	Midland Black	1650-1750
6	u/s	-	1	100	EA	Pancheon	1800-1900
6	u/s	-	3	33	EA	Mocha ware	1830-50
6	6033	Kiln 6022	1	5	EA	Mocha ware	1830-50
6	6037	Kiln 6022	1	1	EA9	Pearlware	C19th

Area	Context	Origin	No	Weight (g)	Type	Common name	Production range
6	6038	Kiln 6022	1	7	EA9	Pearlware (early)	Late C18th
6	6042	Kiln 6022	2	8	EA10	Staffs earthenware	C19th
6	6082	Kiln 6055	1	1	EA9	Pearlware	C19th
6	6084	Kiln 6055	2	2	EA10	Staffs earthenware	C19th
6	6096	Kiln 6055	1	4	EA10	Staffs earthenware	C19th
6	6133	Revetment wall	1	3	MY	Midland Yellow	1500-1725
6	6133	Revetment wall	4	4	EA10	Staffs earthenware	C19th
6	6135	Revetment wall	1	14	EA10	Staffs earthenware	C19th
8	8036	Fill of ditch 8035	2	16	EA10	Staffs earthenware	C19th
8	8038	Fill of ditch 8029	2	38	EA	Earthenware	C19th
8	8041	Fill of ditch 8040	1	5	MB	Midland Black	1650-1750
8	8041	Fill of ditch 8040	1	4	EA9	Pearlware (early)	Late C18th
8	8059	Plough scar 8058	1	13	EA	Pancheon	1800-1900

Reference:

Davies, S, and Sawday, D, 1999 ‘The post-Roman pottery and tile’, in A. Connor and R. Buckley, *Roman and Medieval occupation in Causeway Lane, Leicester*, Leicester Archaeology Monograph, **5**, 165-223

APPENDIX B

B 3 THE BRICKS by Pat Chapman

This assemblage comprises 39 samples of individual bricks or brick fragments taken from the brick-lined limekilns. There are from 11 contexts, not including the watching brief. Many of these have been used in more than one limeburning as shown by the distorted and vitrified nature on more than one face of many of the bricks.

The bricks came from cone-shaped brick-lined draw kilns up to 3m deep below modern ground surface. This type of kiln came into use about 1750 (Williams 2004, 15-19). The bricks had to be capable of withstanding continuous firing over a long period. Those that have survived without being vitrified have a slightly friable fabric, pale red to orange brown in colour with inclusions of small gravel in varying degrees of density (Plate 39). The friable fabric could be the result of being heated but not directly exposed to the limeburning. The resemblance of these bricks to 'sammels', so-called since the early 17th century due the colouring being similar to 'salmon pink', is unlikely as 'sammels' were underfired bricks only used for the inside filling of walls (Harley 1974).

There are no distinguishing features such as frogs or makers' marks, suggesting that these are bricks made specifically, and probably locally, for the kilns. At least one stretcher surface, and a few headers, of most of this sample of bricks were subjected to intensive and prolonged heating until the exposed face became blackened and bloated, expanding beyond its original dimensions, often to the point of being vitrified (Plate 40). In some cases this is of a glassy green nature. Many of the bricks had been reused where both stretcher surfaces are vitrified. Many of the bricks have streaks or lumps of lime mortar on their top and bottom surfaces.

The dimensions of the bricks vary, but within the kilns rather than through time. Dating of the limekilns has been done by archaeomagnetic dating. The dimensions of bricks can also be used as dating and Table 1 below gives a comparison of the available brick dimensions together with the relevant results of the archaeomagnetic dating. In the typology of bricks as laid out by Harley (1974), brick lengths more than 230mm (9 inches) tended to be no later than the late 18th century, apart from particular exceptions such as the Staffordshire 'Blue brick'. It can be seen that the kiln bricks appeared to be longer in the late 19th century, but this is too small a sample for a meaningful analysis.

Table1: Comparison of brick dimensions

Context	Date of last firing	Dimensions mm	Dimensions inches
6030	1750	220 x 110 x 67	8¾ x 4⅜, x 2⅝
2009	1825-60	215 x 115 x 60	8½ x 4½ x 2⅜
6007	1870-1880	230 x 100 x 73	9 x 4 x 2⅞
6062	1885-1910	220–263 x 108 x 70	8¾ - 10¼ x 4¼ x 2¾
2025	Undated	233 x 115 x 65	9⅛ x 4½ x 2½
4005	Undated	230 x 110 x 55	9 x 4⅜ x 2⅛
6066	Undated	225 x 110 x 75	8¾ x 4¼ x 3

These bricks are, unfortunately, not a useful dating tool, but more of an indication of the processes within the kilns. The damage implies that the bricks were laid as stretchers for the lining, as only a few were header damaged. The fact that both stretchers have been vitrified on many of these bricks raises the question of how they were reused. It may have been possible to reverse bricks within the kiln lining when one surface had become vitrified, unless there were structures within the kilns that were one brick thick that could be rebuilt. Perhaps bricks from an earlier kiln were reused in a later limekiln if they were not too damaged. A detailed description of the bricks is in Table 4 below.

There were two bricks from the watching brief, context (117). Both were complete and in a hard fabric with occasional small gravel inclusions, and reddish brown in colour. They both had the same marks on one stretcher surface, comprising a vertical groove on one end and a diagonal groove on the other.

Table 2: Quantification of kiln bricks

Context	Weight (g)	Dimensions (mm/inches) Length/width/thick	Description
2009	2241	215 x 115 x 60 8½ x 4½ x 2⅜	Complete length, 1 corner missing, 1 broken. Pale red, some small stones & grog, 1 stretcher vitrified
2009	1485	115 x 60 4½ x 2½	One end. Pale orange red, occasional gravel One stretcher vitrified
2025	3105	233 x 115-120 x 65 9⅛ x 4½-4¾ x 2½	Complete. Whole brick overfired, both stretchers vitrified
2025	2474	*c* 200 x 120 x 70 *c* 8 x 4¾ x 2¾	End missing. Pale red. Both stretchers vitrified
2025	2887	233 x 115 x 65 9⅛ x 4½ x 2½	Complete, corner missing. Pale red to grey. 1 stretcher vitrified
3012	598	115 x 65 4½ x 2½	Middle fragment. Pale red orange brown. 1 stretcher vitrified
3012	679	Distorted	Two sides vitrified
3012	1085	*c* 80 x 55 3¼ x 2¼	One end. Both stretchers vitrified
3012	632	*c* 100 x 65 *c* 4 x 2¼	Middle fragment. Pale red brown, occasional large stones, some small stones and grog. 1 stretcher vitrified
3012	1017	*c* 120 x 55 *c* 4¾ x 2¼	One end. occasional large stone, some small stone and grog. Vitrified to glassy green
3026	899	65 / 2½	End fragment. Both stretchers vitrified
3026	1038	*c* 100 x 60 *c* 4 x 2⅜	One end. Both stretchers vitrified
3026	1527	110 x 65 4¼ x 2½	One end. Both stretchers vitrified

Context	Weight (g)	Dimensions (mm/inches) Length/width/thick	Description
3026	835	60 / 2⅜	Orange red to purple, occasional large stones, some small. Both stretchers vitrified
3026	1669	175 x *c* 100 x 60 thick 7 x *c* 2⅜ x 2⅜	Vitrified all through, one stretcher much vitrified, the other broken off
3051	794	115 x 60 4½ x 2⅜	One end. Orange, some fine calcined flint, 1 stretcher vitrified
4005	2663	230 x 110 x 55 9 x 4⅜ x 2⅛	Complete with damage. Dark red with black flecks. Not vitrified
4005	1450	115 x 55 4½ x 2⅛	One end. Dark red black flecks. 1 stretcher vitrified
4006	1900	115 x 55 4½ x 2⅛	Brown core to very pale brown or black. Vitrified on top. Laid on side? Mortar lumps
4006	1114	60 / 2⅜ thick	One end. Both stretchers and top vitrified
6007	2878	230 x 100 x 73 9 x 4 x 2⅞	One end partly missing. Pale red, occasional small stone. 1 stretcher vitrified
6007	1992	*c* 100 x 70 4 x 2¾	One end. 1 stretcher damaged end vitrified
6007	1499	75 / 3 thick	Vitrified on three sides to glassy
6007	1573	110 x 75 4⅜ x 3	One end. 1 stretcher vitrified and the broken end. Orange
6030	3149	220 x 110 x 67 8¾ x 4⅜ x 2⅝	Complete. Reddish, corner damage. Not vitrified
6030	1719	110 x 67 4⅜ x 2⅝	One end. Reddish lots small gravel. Not vitrified
6030	1766	113 x 67 4½ x 2⅝	One end. Reddish lots small gravel. Not vitrified
6030	3416	225 x 110 x 60 8⅞ x 4⅜ x 2⅜	Complete. Reddish, lots small gravel
6030	3560	220 x *c* 100 x 80 8¾ x *c* 4 x 3¼	Complete. Both stretchers vitrified. Layer mortar 20mm thick
6030	1991	*c* 100 x 75 *c* 4 x 3	Reddish, small gravel. Vitrified both stretchers
6062	3274	263 x 108 x 73 10¼ x 4¼ x 2⅞	Complete, one end damaged. Pale orange/brown
6062	2806	220 x 108 x 70 8¾ x 4¼ x 2¾	Complete. Pale with grog and stone
6062	3680	230 x 113 x 67 9 x 4½ x 2⅝	Complete, corners damaged. Reddish, going black. 1 header vitrified
6062	3570	230 x 108 x 70 9 x 4¼ x 2¾	Complete. Reddish to black. Overfired not vitrified
6066	3427	225 x 110 x 75 8¾ x 4¼ x 3	Complete. Dark brown red, calcined flint, stone. Mortar layer 10mm thick on top

Context	Weight (g)	Dimensions (mm/inches) Length/width/thick	Description
6066	3740	225 x 114 x 70 8¾ x 4½ x 2¾	Complete, corner damaged. Purple. 1 header vitrified
6066	3565	235 x 110 x 78 9¾ x 4⅜ x 3⅛	Complete, slight damage. Orange brown
6066	2591	218 x 105 x 70 8½ x 4⅛ x 2¾	Complete, corners gone. Red brown, few buff streaks
6083	574	*c* 120 x 72 *c* 4¾ x 2¾	One end. Vitrified to green on header
w/b 17	3701	245 x 120 x 65 9¾ x 4¾ x 2½	Complete. Orange brown with small gravel. 1 stretcher vertical groove 70mm from edge, same side opposite edge diagonal from corner 68mm along. 8-13mm mortar on top
w/b 117	2296	235 x 110 x 50 9¼ x 4⅜ x 2	Complete. Reddish brown, occasional small gravel. 1 stretcher vertical groove 25mm from edge, same side opposite edge diagonal from corner 95mm along. Smooth top surface
w/b 117	955	58 / 2¼ thick	2 fragments, very orange

References:

Harley, L S, 1974 A typology of brick: with numerical coding of brick characteristics, *Journal of the British Archaeol Assoc,* 37, 63-86

Williams, R, 2004 *Limekilns and limeburning,* Shire Publications

APPENDIX B

B 4 THE FLOOR TILE by Pat Chapman

There are two fragments of floor tile from a field boundary ditch (Context 8037), one is a two-colour stamped tile, the other is plain and broken in half.

The decorated tile is a worn and damaged corner 60mm square and 23mm thick with chamfered edges. The design is possibly the corner of a shield placed diagonally and divided into diamonds. Shields of this style, of the arms of Ferrers, are known from Leicestershire, Croxton Abbey, Ulverscroft Priory, Bradgate House and Leicester All Saints (Whitcomb 1956, 43-45, nos 40-45). It is made from a slightly silty fabric with inclusions of small gravel up to 3mm long and occasional calcareous inclusions up to 5mm. As the tile is stamped rather than inlaid it is most likely to be of 15th century date.

The plain tile is 18mm thick, the top surface is very smooth, unlike the bottom surface which is rough and uneven, the surviving edge is smooth. It is made from a slightly coarse sandy, red brown fabric with some fine quartz and grog inclusions.

Reference:

Whitcomb, N, 1956 *The medieval floor tiles of Leicestershire*, Leics Archaeol and Hist Soc, The Guidhall, Leicester

APPENDIX B

B 5 THE OTHER FINDS by Tora Hylton

The assemblage includes finds of prehistoric and post-medieval date.

Finds of prehistoric date are represented by 2 pieces of red deer antler recovered from a small pit [2004] in Area 2. Both pieces join to form part of a naturally shed antler (ruptures evident, no sign of skull fragments) and includes the burr, a section of beam measuring c250mm in length, together with part of the brow tine and a protruding scar where the 'bez' tine would have been. Butchery marks in the form of short axe/knife cut incisions, measuring *c*.20mm in length are visible on both sides of the beam.

With the exception of one clay tobacco-pipe stem from Area 5, all the post-medieval finds were recovered from Areas 6 and 8. The assemblage includes fragments of clay tobacco-pipe and vessel glass. The former is represented by 9 clay tobacco-pipe stem fragments and 1 bowl fragment (upper section missing) which displays similarities to Oswald Types 5, 6 or 9 and provides a date range of c.1640-1710. Fragments of 19th/20th glass are represented by small undiagnostic sherds of clear bottle glass and a neck from a green bottle.

Finds Catalogue

Antler

Context 2004 Antler burr, red deer. Naturally shed burr (ruptures evident, no sign of skull fragments). Beam broken at 'bez' tine, terminal of brow tine missing. Numerous axe/knife cut incisions, measuring c. 20mm in length on anterior and posterior surfaces.

Antler beam, red deer. Beam with vestige of 'bez' tine. Joins with antler burr above. Numerous knife cut incisions on anterior and posterior surface, especially at point where the beam has broken.

Glass

Context 6066 Clear vessel glass – undiagnostic. Three sherds. 20th century.

Context 6137 Laminating vessel glass- undiagnostic. One sherd. 19th century.

Context 8036 Neck from green glass bottle. 20th century

Clay tobacco-pipe

Context 5035 One stem fragment (very abraded, larger stem with larger hole)

Context 6004 Two stem fragments (fine stems with very small hole).

Context 6035 One stem fragment (very abraded, larger stem with larger hole)

Context 6040 One stem fragment (fine stems with very small hole).

Context 6062 One stem fragment (fine stems with very small hole).

Context 6092 Two stem fragments (fine stems with very small hole).

Context 6098	One stem fragment (fine stems with very small hole).
Context 8052	Joining stem and bowl fragment. Bowl incomplete (upper section missing), has a small foot, burnished body and appears to display similarities to Oswald types 5, 6 or 9. The date range stretches from 1640-1710.

APPENDIX C

C 1 THE ANIMAL BONE by Karen Deighton

Method

Animal bone was recovered by hand from a range of contexts. A total of 0.7 kgs of bone was analysed using standard zooarchaeological methods

Results

Preservation

Material from contexts 5011 and 8036 was badly abraded. Material from contexts 5013 and 5051 was very fragmentary. Elsewhere the level of fragmentation and abrasion was moderate.

Two instances of butchery were noted (knife marks). Only one instance of canid gnawing was noted. No evidence of burning was observed.

Table1: Taxa present by context

Context	Horse Equus	Cow Bos	Sheep/goat Ovicaprid	Pig Sus	Large Ungulate	Small Ungulate	Total
2052			1				**1**
3019						1	**1**
3034					1		**1**
3053					1		**1**
5011	1						**1**
5013		1					**1**
5025				1			**1**
5038					1		**1**
5040		1					**1**
5042		1					**1**
5045		1					**1**
5051		4					**4**
8036		1					**1**
6135						3	**3**
Total	**1**	**9**	**1**	**1**	**3**	**4**	**19**

Ageing

Where fusion can be detected (from 4 contexts only) it suggests adult animals. No evidence of neonates was observed.

Pathology

A roughened lump on a Small ungulate rib was noted in context 3019.

Conclusion

Little can be said in terms of the animal economy of the site due to the paucity of material. However a small range of common domesticates appears to have been exploited at the site.

APPENDIX C

C 2 SOIL ANALYSIS by Karen Deighton

Method

Soil samples were collected from a range of fifty (50) features during the course of excavation. Following consultation with the excavator, only those samples with the potential to produce environmental evidence were selected for processing. These samples were processed using a siraf tank fitted with a 500micron mesh and flot sieve. The resulting flots were dried and examined with a microscope (10X magnification). Flots and residues from kilns were sorted for coal and charcoal.

Results

Preservation

Preservation observed was purely by charring. The ecofacts present are shown in the tables below.

Table 1: Samples from area 5(Prehistoric)

Sample	Context	Volume	Feature	Charcoal*	Cereal	Wild/weed	Molluscs*
32	5005	20	Ring ditch	1		1	
35	5053	10	Ditch	10			
38	5071	10	Ditch	2	1		
39	5045	10	Post hole	1			
40	5093	10	Post hole	2			

Table 2: Samples from areas 1, 2 and 7 (Kilns and associated features)

Sample	Context	Volume	Feature	Charcoal*	Cereal	Wild/weed	Molluscs*
3	1014	10	Kiln	7			
5	2024	10	Kiln3				
6	2034	10	Kiln 1	5			
7	2035	10	Kiln 1	1			
8	2052	10	Stoke hole	4	1		1
9	2056	10	Spread			6	
13	7020	10	Stoke hole	5		1	3
18	7022	10	Stoke hole	2		1	3
19	7046	10	Posthole	4		1	1
20	7031	10	Kiln	1			1
28	7036	20	Kiln floor	6		7	

Key: +=present, 1=2-10, 2=10-20, 3=20-30 ,4=30-50, 5=50-100 ,6=100-200, 7=200-300, 8=300-500, 9=500-1,000, 10=1,000+

Discussion

There was little presence of cereal grain and weed seeds in the prehistoric features (Table 1). Such low volumes can only indicate low level of activity involving cultivated grains in the near vicinity.

The few grains recovered from the ditch (5071) are hulled barley and may indicate localised cultivation. Among the weeds present the most prolific is fat hen which is present on most sites of all periods.

The charcoal fragments although fairly numerous were too comminuted to permit further identification.

The presence of seeds in later features suggests incorporation of dried plant material in kiln fires, as kindling or accidental burning (Hulled barley was found in the ashy deposit of a kiln floor (2520)). The weed seeds were generally fat hen (*Chenopodium album*) and cleavers (*Galium aparine*), both are common weeds of disturbed ground.

Snails present included *Ceciloides assicula* which were present in all samples from areas 6, 7, 8, however as this is a burrowing snail species and a late introduction to Britain its presence here is considered intrusive and it is not included in any quantification.

Two other taxa were present in smaller numbers; these were *Pupilla muscorum* and a small discoidal species. It is unwise to attempt any environmental reconstruction with only two species.

The presence of charcoal in the kiln sites along with coal suggests its possible use as kindling.

Conclusion

The environmental analysis has added little to the understanding of the prehistoric environment of the site. The weed species indicate disturbed ground, common on both pasture cut up by foraging animals, and on ploughed land. The presence of hulled barley would indicate the use of cultivated cereal, however the low count of grains present does not indicate intensive processing of cereal in the immediate vicinity.

In the samples obtained from the lime kilns across the site, the absence of large heartwood samples of charcoal is strong negative evidence that charcoal was not a primary fuel. The surviving evidence indicates mainly small branches and brush wood, indicative of kindling rather than a primary fuel.

APPENDIX D

D 1 ARCHAEOMAGNETIC ANALYSIS by Mark Noel

SUMMARY

Samples of brick lining, fired clay and fusion crust were removed from 15 contexts for the purpose of archaeomagnetic analysis and dating. Specimens were oriented in situ using the button method, combined with spirit levels and a north-seeking gyro compass. Routine demagnetisation was undertaken to remove secondary components of remanence. The archaeomagnetism in the majority of these contexts was very well defined, providing a good basis for the dating method. (It was not possible to attempt a dating for Context 3014 since too few intact samples remained after the cutting process). Archaeomagnetic vectors were compared with the UK Master Curve to suggest that the earliest kiln in the study was last fired in the interval 1490 - 1510 A.D. (Context 8053). The most recent firing in the kilns examined appears to have taken place in Context 6062 during 1885 - 1910 A.D.

We acknowledge the expert assistance given by staff from the Geomatics Section of MoLAS, who undertook the sampling.

SITE/CONTEXT DESCRIPTION

Open area excavation by Northamptonshire Archaeology at Cotes Road, Barrow-on-Soar has explored the site of a long-lived lime burning industry. Kilns of four different kinds have been found and, where lined with bricks, they appear to use brick types dating from the 16th century onwards. The latest kilns found so far are depicted on the 1st Edition of the Ordnance Survey at the end of the 19th century. Unfortunately, for dating purposes, the bricks have an unknown capacity for re-use and of the 30 kilns discovered up until April 2006, only one has pottery in association. Hence the aim of the project was to use archaeomagnetic techniques to date the likely production span of each type, and thus note the spread of the industry and its technological adjustments across the hillside. The types do seem to cluster in one area, before moving on. (Information provided by Iain Soden, Northamptonshire Archaeology).

ANALYTICAL METHODS

Sampling via button method with orientation by north-seeking gyro compass. Archaeomagnetic remanence measured using a Molspin fluxgate spinner magnetometer. Secondary components of magnetisation removed by routine partial demagnetisation in an alternating field of 2.5mT. Mean of selected vectors computed (with unit weights) and corrected to Meriden. Comparison then made to the UK Master Curve to obtain a last-firing date. Further details of technical methods are contained in this Appendix.

RESULTS

In each of the tables shown below, the contents of each column are designated as follows:

D=declination, I=inclination, J=intensity in units of mAm-1x10-3. A.F.=peak alternating demagnetising field in milliTesla. K=precision parameter, c.s.e.=circular standard error, alpha95=semi-angle of the 95% cone of confidence. Samples whose numbers are absent from the table were too small for analysis.

SAMPLE 1

FEATURE TYPE: Lime kiln

CONTEXT: 2009. Fired brick & fusion crust

SAMPLE	J	D	I	A.F	D	I	COMMENT
1	1774.7	334.2	74.0	2.5	336.6	74.8	
2	1317.5	336.5	71.9	2.5	335.2	72.2	
4	3427.8	333.5	69.6	2.5	332.7	70.3	
5	1158.5	331.3	72.1	2.5	329.6	72.5	
6	1765.6	335.3	70.9	2.5	338.2	70.9	
7	2805.1	328.5	69.2	2.5	331.5	69.5	
8	2979.3	329.9	71.7	2.5	330.7	70.7	
9	2280.3	348.4	72.9	2.5	346.9	73.0	
10	1987.9	350.2	71.7	2.5	350.4	71.0	
11	221.5	336.0	66.7	2.5	334.2	66.5	
12	688.9	333.0	68.5	2.5	334.5	69.2	
13	193.0	334.7	71.4	2.5	332.9	71.3	
14	149.2	333.2	69.2	2.5	337.2	69.4	
15	120.8	333.2	69.2	2.5	333.1	68.1	
MEAN	**K=806.9 Alpha95=1.4 c.s.e.=0.8**				**335.8**	**70.8**	
MERIDEN					**336.0**	**70.7**	

Estimated date range for last firing: **1825 – 1860 A.D.**

SAMPLE 2

FEATURE TYPE: Lime kiln

CONTEXT: 2030. Fired brick & fusion crust

SAMPLE	J	D	I	A.F	D	I	COMMENT
2	313.7	330.6	72.5	2.5	331.6	72.2	
3	174.0	339.4	69.3	2.5	336.2	69.3	
4	61.2	339.8	69.4	2.5	336.9	69.9	
5	2927.6	347.9	71.8	2.5	346.2	71.6	
7	1638.4	337.7	73.1	2.5	335.3	73.5	
8	603.2	333.6	71.2	2.5	335.7	71.9	
12	1560.7	331.4	7.5	2.5	329.5	73.2	
13	583.2	324.2	71.8	2.5	327.2	73.4	
MEAN	**K=1164.0 Alpha95=1.6 c.s.e.=0.8**				**335.0**	**71.9**	
MERIDEN					**335.2**	**71.8**	

Estimated date range for last firing: **1795 – 1840 A.D.**

SAMPLE 3

FEATURE TYPE: Lime kiln

CONTEXT: 3014. Fired brick & fusion crust

SAMPLE	J	D	I	A.F	D	I	COMMENT
1	146.6	325.0	76.7	2.5	322.0	76.8	
13	183.7	348.0	64.9	2.5	347.0	65.0	
MEAN	**K=66.0 Alpha95=31.2 c.s.e.=7.0**				**338.3**	**71.3**	
MERIDEN					**338.5**	**71.2**	

Estimated date range for last firing**:** **NOT DATEABLE**

SAMPLE 4

FEATURE TYPE: Lime kiln

CONTEXT: 3023. Fired brick & fusion crust

SAMPLE	J	D	I	A.F	D	I	COMMENT
4	140.0	346.7	71.0	2.5	343.6	69.6	
6	1074.6	355.0	70.6	2.5	356.5	70.2	
12	124.8	336.0	70.1	2.5	339.4	72.2	
13	108.3	342.0	79.4	2.5	344.9	78.5	
14	71.4	340.4	81.0	2.5	341.8	81.8	
MEAN	**K=199.3 Alpha95=5.4 c.s.e.=2.6**				**345.9**	**74.6**	
MERIDEN					**346.2**	**74.4**	

Estimated date range for last firing: **1700 – 1750 A.D.**

SAMPLE 5

FEATURE TYPE: Lime kiln

CONTEXT: 3063. Fired brick & fusion crust

SAMPLE	J	D	I	A.F	D	I	COMMENT
1	169.4	323.2	70.8	2.5	327.0	71.3	
5	741.6	334.7	68.1	2.5	334.3	67.8	
6	191.3	341.9	64.3	2.5	339.7	64.7	
7	413.9	339.0	74.8	2.5	341.5	74.6	
9	455.7	339.1	68.1	2.5	339.9	67.3	
11	630.8	335.4	70.0	2.5	335.0	70.8	
15	485.1	339.0	73.6	2.5	335.9	74.0	
MEAN	**K=412.1 Alpha95=3.0 c.s.e.=1.5**				**336.3**	**70.1**	
MERIDEN					**336.5**	**70.0**	

Estimated date range for last firing: **1825 – 1870 A.D.**

SAMPLE 6

FEATURE TYPE: Lime kiln

CONTEXT: 6030. Fired brick & fusion crust

SAMPLE	J	D	I	A.F	D	I	COMMENT
1	657.4	340.2	72.2	2.5	340.2	71.6	
2	75.9	343.3	70.0	2.5	340.0	68.1	
3	195.0	339.6	70.4	2.5	340.9	70.2	
4	223.9	341.1	69.8	2.5	339.9	69.5	
5	300.6	338.0	68.4	2.5	338.2	68.8	
6	243.4	341.3	71.0	2.5	340.5	70.4	
7	193.7	340.4	69.7	2.5	339.5	69.2	
8	341.2	338.4	69.6	2.5	338.1	69.6	
9	189.9	339.8	68.3	2.5	341.7	69.5	
10	210.8	347.1	68.2	2.5	341.9	68.6	
11	446.3	335.4	70.6	2.5	334.0	68.9	
12	100.7	337.1	71.2	2.5	337.4	70.5	
13	80.8	339.0	67.0	2.5	335.3	68.3	
14	147.0	336.2	68.5	2.5	337.3	67.6	
MEAN	**K=3550.3 Alpha95=0.7 c.s.e.=0.4**				**338.9**	**69.4**	
MERIDEN					**339.0**	**69.3**	

Estimated date range for last firing: **1870 – 1880 A.D.**

SAMPLE 7

FEATURE TYPE: Lime kiln

CONTEXT: 6007. Fired brick & fusion crust

SAMPLE	J	D	I	A.F	D	I	COMMENT
5	791.1	334.9	75.1	2.5	334.2	74.7	
6	512.1	345.4	73.3	2.5	342.7	73.0	
9	26.9	358.2	69.5	2.5	355.6	73.2	
10	25.4	342.0	60.6	2.5	341.7	60.5	
11	7.9	333.5	57.4	2.5	340.8	60.2	
12	3769.8	338.8	72.6	2.5	339.3	71.8	
13	2239.7	334.5	70.1	2.5	335.7	70.8	
14	1967.6	346.8	69.8	2.5	344.4	70.2	
MEAN	**K=835.2 Alpha95=2.1 c.s.e.=1.1**				**343.3**	**72.4**	
MERIDEN					**343.5**	**72.3**	

Estimated date range for last firing: **circa 1750 A.D.**

(Estimate based on closest approach to Master curve)

SAMPLE 8

FEATURE TYPE: Lime kiln

CONTEXT: 6062. Fired brick & fusion crust

SAMPLE	J	D	I	A.F	D	I	COMMENT
2	1616.1	352.0	76.5	2.5	356.0	76.5	
3	617.1	13.6	66.7	2.5	13.9	66.7	
6	639.0	354.3	65.2	2.5	355.0	65.1	
7	1052.2	341.4	69.9	2.5	344.5	70.7	
8	940.5	344.5	70.1	2.5	344.9	70.7	
9	2011.7	343.4	68.8	2.5	344.2	69.5	
10	351.1	345.4	67.2	2.5	345.4	67.9	
11	559.8	346.2	70.7	2.5	346.6	70.1	
12	1140.4	334.5	66.9	2.5	335.9	67.4	
13	1251.0	339.8	67.6	2.5	340.1	68.4	
14	1101.9	335.1	64.7	2.5	331.7	64.7	
15	1126.8	340.6	67.7	2.5	340.1	66.1	
MEAN	**K=589.2 c.s.e.=1.1**	**Alpha95=2.0**			**342.7**	**68.2**	
MERIDEN					**342.8**	**68.0**	

Estimated date range for last firing: **1885 – 1910 A.D.**

SAMPLE 9

FEATURE TYPE: Lime kiln

CONTEXT: 7014. Base of kiln

SAMPLE	J	D	I	A.F	D	I	COMMENT
2	1616.1	352.0	76.5	2.5	356.0	76.5	
3	617.1	13.6	66.7	2.5	13.9	66.7	
6	639.0	354.3	65.2	2.5	355.0	65.1	
7	1052.2	341.4	69.9	2.5	344.5	70.7	
8	940.5	344.5	70.1	2.5	344.9	70.7	
9	2011.7	343.4	68.8	2.5	344.2	69.5	
10	351.1	345.4	67.2	2.5	345.4	67.9	
11	559.8	346.2	70.7	2.5	346.6	70.1	
12	1140.4	334.5	66.9	2.5	335.9	67.4	
13	1251.0	339.8	67.6	2.5	340.1	68.4	
14	1101.9	335.1	64.7	2.5	331.7	64.7	
15	1126.8	340.6	67.7	2.5	340.1	66.1	
MEAN	**K=545.1 c.s.e.=1.**	**Alpha95=1.9**			**2.1**	**66.9**	
MERIDEN					**2.0**	**66.7**	

Estimated date range for last firing: **circa 1490 A.D.**

(Estimate based on closest approach to Master curve)

SAMPLE 10

FEATURE TYPE: Lime kiln

CONTEXT: 7018. Base of kiln

SAMPLE	J	D	I	A.F	D	I	COMMENT
1	4297.4	11.0	70.9	2.5	10.5	70.5	
3	2558.2	26.9	43.8	2.5	24.9	44.0	
5	10817.5	20.5	65.6	2.5	21.5	67.1	
6	4546.7	7.2	65.6	2.5	8.8	65.6	
8	4829.4	12.3	70.1	2.5	10.8	68.6	
9	4188.3	2.6	71.1	2.5	357.4	71.1	
10	1840.4	7.5	69.1	2.5	8.7	69.2	
11	2773.6	10.6	66.0	2.5	13.8	66.1	
12	2614.8	3.9	70.9	2.5	5.5	70.0	
13	1251.0	339.8	67.6	2.5	340.1	68.4	
14	1101.9	335.1	64.7	2.5	331.7	64.7	
15	1126.8	340.6	67.7	2.5	340.1	66.1	
MEAN	**K=635.9 Alpha95=2.2 c.s.e.=1.1**				**10.0**	**68.6**	
MERIDEN					**9.9**	**68.3**	

Estimated date range for last firing: **1515 – 1535 A.D.**

SAMPLE 11

FEATURE TYPE: Lime kiln

CONTEXT: 7035. Base of kiln

SAMPLE	J	D	I	A.F	D	I	COMMENT
1	6673.5	313.2	76.4	2.5	310.9	75.4	
2	9219.3	358.0	57,2	2.5	356.3	57.9	
3	7475.6	359.0	66.9	2.5	358.4	65.6	
4	3207.6	15.4	67.4	2.5	14.1	67.2	
5	1679.0	1.2	71.8	2.5	6.3	71.4	
6	3606.7	0.0	68.0	2.5	356.8	68.5	
7	5317.4	1.6	68.2	2.5	358.9	67.8	
8	3210.5	359.9	65.4	2.5	358.8	65.4	
10	2290.7	356.3	62.8	2.5	359.5	62.3	
MEAN	**K=286.2 Alpha95=3.3 c.s.e.=1.7**				**0.8**	**65.9**	
MERIDEN					**0.7**	**65.6**	

Estimated date range for last firing: **circa 1475 A.D.**

(Estimate based on closest approach to Master curve)

SAMPLE 12

FEATURE TYPE: Lime kiln

CONTEXT: 7052. Base of kiln

SAMPLE	J	D	I	A.F	D	I	COMMENT
1	772.9	4.1	74.1	2.5	0.8	74.1	
2	254.5	8.0	66.5	2.5	7.6	66.8	
3	1369.2	357.0	71.0	2.5	354.9	70.1	
6	6697.3	0.1	65.5	2.5	359.2	65.6	
7	6076.3	23.9	68.8	2.5	27.5	69.3	
8	2447.2	8.1	71.2	2.5	10.3	71.3	
9	2017.4	358.4	68.3	2.5	359.2	68.2	
10	2219.6	6.7	72.8	2.5	7.5	71.5	
11	4246.5	359.2	69.5	2.5	0.6	69.4	
10	2290.7	356.3	62.8	2.5	359.5	62.3	
MEAN	**K=364.6 c.s.e.=1.**	**Alpha95=2.7**			**5.2**	**69.8**	
MERIDEN					**5.2**	**69.6**	

Estimated date range for last firing: **Circa 1540 A.D.**

(Estimate based on closest approach to Master curve)

SAMPLE 13

FEATURE TYPE: Lime kiln

CONTEXT: 8009. Stone base of kiln

SAMPLE	J	D	I	A.F	D	I	COMMENT
1	1789.7	13.2	66.7	2.5	12.7	67.1	
3	789.7	3.9	72.2	2.5	9.0	71.3	
4	2872.3	20.5	66.7	2.5	17.5	67.7	
5	649.3	24.8	70.8	2.5	26.5	72.1	
8	383.7	28.9	76.0	2.5	29.3	75.1	
9	733.6	27.4	71.3	2.5	28.7	70.8	
10	852.9	20.1	73.4	2.5	20.7	73.5	
11	504.1	355.8	69.9	2.5	356.0	70.0	
12	2119.3	9.7	72.6	2.5	7.9	72.8	
13	1477.8	357.8	76.9	2.5	358.7	76.9	
14	366.7	357.6	74.4	2.5	2.8	74.9	
15	601.6	359.2	75.1	2.5	358.4	75.0	
MEAN	**K=297.8 c.s.e.=1.4**	**Alpha95=2.5**			**12.7**	**72.6**	
MERIDEN					**12.7**	**72.4**	

Estimated date range for last firing: **1570 – 1600 A.D.**

SAMPLE 14

FEATURE TYPE: Lime kiln

CONTEXT: 8023. Burnt natural kiln base

SAMPLE	J	D	I	A.F	D	I	COMMENT
1	16.4	5.6	67.5	2.5	7.6	67.0	
2	38.3	7.1	70.3	2.5	7.4	70.1	
3	12.0	353.4	70.2	2.5	352.2	70.3	
5	5.8	15.3	70.4	2.5	5.6	71.5	
6	2.0	17.7	70.9	2.5	354.2	68.6	
7	82.6	7.2	69.9	2.5	6.9	69.8	
8	32.0	8.5	68.4	2.5	11.5	68.9	
10	175.5	26.2	63.9	2.5	27.1	64.6	
13	48.2	22.2	66.1	2.5	24.3	67.0	
14	99.5	11.0	65.2	2.5	15.3	65.4	
15	39.7	9.9	67.5	2.5	11.9	66.0	
15	601.6	359.2	75.1	2.5	358.4	75.0	
MEAN	**K=313.9 Alpha95=2.6 c.s.e.=1.4**				**10.1**	**68.4**	
MERIDEN					**10.0**	**68.1**	

Estimated date range for last firing: **1510 - 1540**

SAMPLE 15

FEATURE TYPE: Lime kiln

CONTEXT: 8051. Hard concretion on base of kiln

SAMPLE	J	D	I	A.F	D	I	COMMENT
1	3647.3	20.4	67.1	2.5	21.7	67.2	
2	1758.5	10.8	65.3	2.5	9.2	66.5	
3	3918.5	17.7	64.9	2.5	3.6	64.1	
4	2209.1	4.9	67.6	2.5	7.2	67.8	
6	4195.4	12.1	63.8	2.5	12.2	62.7	
7	1134.4	14.1	63.6	2.5	13.8	64.0	
9	1016.5	10.8	67.9	2.5	11.2	67.5	
10	2993.9	7.8	66.4	2.5	8.3	67.4	
11	1247.9	8.4	67.7	2.5	10.7	67.6	
12	2775.5	9.7	64.2	2.5	9.3	63.5	
13	1491.7	11.8	65.7	2.5	13.3	66.7	
14	1946.3	8.2	69.7	2.5	10.3	70.2	
MEAN	**K=820.7 Alpha95=1.5 c.s.e.=0.8**				**10.9**	**66.3**	
MERIDEN					**10.8**	**66.0**	

Estimated date range for last firing: **1490 – 1510 A.D.**

Principles of Magnetic Dating

Magnetic dating is based on comparing the remanent magnetisation in an archaeological structure with a calibrated reference curve for the geomagnetic secular variation. Two distinct methods have evolved. The intensity technique relies on obtaining estimates of the past strength of the Earth's magnetic field while directional magnetic dating uses archaeomagnetic measurements to derive the orientation of the geomagnetic vector in antiquity. Intensity dating can only be applied to fired materials which have acquired a thermoremanent magnetisation upon cooling from high temperatures (>600°C) while the directional method enables the age of a broader range of archaeological materials to be determined. For example, sediments and soils may have acquired a dateable 'detrital remanence' if magnetic grains had been aligned by the ambient field during deposition. The growth of magnetic minerals during diagenesis or as a result of manufacturing processes can also give rise to a magnetisation which may enable materials such as iron-rich mortars, for example, to be dated. However hearths, kilns and other fired structures are the most common features selected for magnetic dating primarily because their thermoremanence is generally strong, stable and sufficiently homogeneous that the ancient field can be determined with sufficient precision from a small set of specimens. An analysis of dated archaeomagnetic directions, largely from fired structures, together with lake sediment and observatory records has enabled a master curve for the UK region to be synthesised for the period 2000 B.C. to the present (Clark, Tarling & Noel, 1988).

For directional magnetic dating it is essential to obtain specimens of undisturbed archaeological material whose orientation with respect to a geographic coordinate frame is known. A number of sampling strategies have evolved, enabling specimens to be recovered from a range of archaeological materials with orientations being recorded relative to topographic features, the direction of the sun, magnetic or geographic north. For this feature the miniaturised 'button method', was employed (Clark et al, 1988). Modern archaeomagnetic magnetometers are sufficiently sensitive that only small volumes of material (~1ml) are required for an accurate remanence measurement (Molyneux, 1971). This has the advantage of reducing the impact of sampling on archaeological features; of particular significance if they are scheduled for conservation and display. For dating, all archaeomagnetic vectors are transposed to Meriden, the reference location for the UK Master Curve (Noel & Batt, 1990).

References:

Clark, A.J., Tarling, D.H. & Noel, M., 1988. Developments in archaeomagnetic dating in Britain, *Archaeometry*, **15**, 645-667.

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APPENDIX E

E 1 EXTRACTS FROM THE BUILDING ACCOUNTS OF KIRBY MUXLOE CASTLE 1480 – 1484

[From *Transactions of Leicestershire Archaeological Society* **XI**, 193-345]

Week commencing 18th December 1480 (218)

Folio 4d

John Purce of Barough for 2 cart loads of lime bought from him at Barough, at 21d	3s 6d
For carriage of the said 2 loads of lime	2s 0d

Week commencing 16th April 1481 (231-2)

Folio 17d

Purchase of lime – John Purce and John Lanne, 29 cartloads of lime at 3s 4d; each cartload [carried] 4 quarters	£4 16s 8d
Purce and John Browne, 17 loads	56s 8d
Lane and Purce, 25 loads	£4 3s 4d
Lane and Purce, 17 loads	56s 8d
Purce and Brown, 15 loads	50s 0d
Purse and Lane, 30 loads	100s 0d
John Sawce and Thomas Alen, 17 loads	56s 8d
Purce and Lanne, 24 loads	£4 0s 0d
Purce and Lanne, 18 loads from Barough at 13d a quarter	60s 0d
Lanne and Brown, 3 loads	10s 0d
Purce and Brown, 30 loads from Barough	100s 0d
Lane and John Clyff, 24 loads at 13d a quarter	£4 0s 0d

Folio 18

Purchase of lime – Purce, 12 quarters at 7d	7s 0d
Purce and Lane, 10 loads at 3s 4d	33s 0d
8 quarters of lime bought at Barough at 7d, carried with the wains	4s 8d
3 loads of hay bought at Desford	6s 8d
8 quarters of lime bought of Purce at 7d	4s 8d
Purce, Lane and William Clyff, 29 loads at 3s 4d with carriage	£4 16s 8d
Purce and Lane 24 loads	73s 4d
Purce and Lane, 30 loads on the feast of the Nativity of St John the Baptist	100s 0d
Purce and Lane, 36 loads	£6 0s 0d

Lane and Purce, 16 loads	53s 0d
Purce and Lane, 26 loads	£4 6s 0d
Purce and Lane, 32 loads	106s 8d
Purce and Lane, 24 loads, paid Saturday next before St Lawrence	£4 0s 0d
Purce and Lane, 31 loads	103s 4d
Purce and Lane. 17 loads	56s 8d

Week commencing 1st April 1482 (266)

Necessary expenses – William Milner for hopying and cottyng 6 barrell for water and mortar to be put therin, in gross 20d

Purchases – John Lokyer for 4 herryng barrels for putting water and mortar in at 6d each 2s 0d

Week commencing 15th April 1482 (267)

Necessary expenses – Haslam, for his costs at Barough, and for carrying of four barrelles from Leycester to Kerby 4d

Folio 53d

Purchases of lime – John Purce and John Lanene, John Browne, 13 loads, each of 4 quarters at 10d the quarter, 3s 4d the load	43s 4d
Purce, Lane, 26 loads	£4 6s 8d
Purce, Lanne, 38 loads	£6 6s 8d
Purce, Lanne, 21 loads	70s 0d
John Lanne, John Clyffe, 22 loads	73s 4d
Purce, Lanne, 28 loads	£4 13s 4d
Purce, Lane, John Brown, 29 loads	£4 16s 8d
Purce, John (?), 30 loads	£5 0s 0d
Purce, Lanne, William Brown, 29 loads	£7 13s 4d
Purce, Lanne, 17 loads on 17 June	56s 8d
Purce, Lane, 29 loads, 6 July	£4 16s 8d
Purce, Lanne, 30 loads, 20 July	100s 0d
Purce, Lane, 22 loads	73s 4d
Purce, Lanne, 10 loads, 3 August	33s 4d
Clyffe, Purce, 14 loads, 10 August	46s 8d
Purce, Lanne, 26 loads	£4 6s 8d

Folio 54

Purce, Lanne, 17 loads	56s 8d
Lane, Purce, William Brown, 29 loads, 9 Sept	£4 16s 8d
Purce, Lane, Clyff, 22 loads	73s 4d
Purce, Lane, 24 loads from Barough	£6 0s 0d
Purce, Thomas brown, 36 loads, 30 Sept	£6 0s 0d
Lanne, Purce, Thomas Clyff, 31 loads	103s 4d
Purce, Lanne, John Clyff, 30 loads, 30 October	100s 0d
Lane, Purce, 20 loads, 26 October	66s 8d
Sum this year [1482]	£103 13s 4d

Week commencing 10 March 1483 (304)

Folio 96

Payments for burning lime – John Love of Barrough, 1 March. At Leycester.

anno 22 Edw.IV.	60s 0d
Paid by the hand of John Grage, 20 April	60s 0d
John Love, at Kerby, 4 May	40s 0d
John Love, by the hand of John Brown, 24 May, at Kerby	60s 0d
Sum	£11 0s 0d

Folio 96d

Carriage of lime – John Somerveyll, James Samon, John Baker, John Grage,

William Doxe, William Bradshawe, 16 loads at 14d	18s 8d
Richard Coolles,John Claybroke, 5 loads each of 4 quarters	5s 10d
John Baker of Groby, 11 loads from Barough	12s 10d
John Somerffelde, 7 loads	8s 2d
John Grage, William Doxee, William Bradshawe, Richard Sare, 17 loads from Barough	19s 10d
John Clerk, Samon, Somerfeld, Baker, John Clerk, 26 loads from Barough	30s 4d
Sare, Grage, John Tawell, 15 loads	17s 6d
John Browne, Thomas Brown, 14 loads from Barough	16s 4d
Grage, 3 loads from Barough	3s 6d
John Claybroke, 15 loads from Barough	17s 6d
Sum	£7 10s 6d

Week commencing 2 June 1483 (315)

For a sieve for lime 'riddelyng' for Corbell 1d

Week commencing 30 August 1483 (338)

For carriage of lime – Bolot 3 loads from Barough at 14d 3s 6d
{Roger Bowlett was the clerk of Works in the castle construction)

Week commencing 27 September 1483 (340)

Carriage of lime – Bolott, 4 loads from Barough at 14d 4s 8d