

Archaeological Field Unit

**Middle Saxon Iron Smelting Furnaces and Other Sites Along the
Wing to Peterborough Pipeline:
Archaeological Evaluation and Excavation**

William Wall

1999

Cambridgeshire County Council

Report No. 158

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Wing to Peterborough Pipeline : Archaeological Evaluation and Excavation**

William Wall BA

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Editor Tim Malim BA

Illustrators Jon Cane BA, Caroline Gait MPhil (Cantab)

With Contributions by David Hall, Twigs Way PhD, Rowena Gale, Steven Critchley BSc MSc

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©Archaeological Field Unit
Cambridgeshire County Council
Fulbourn Community Centre
Haggis Gap, Fulbourn
Cambridgeshire CB1 5HD
Tel (01223) 881614
Fax (01223) 880946

Arch.Field.Unit@libraries.camcnty.gov.uk
<http://www.camcnty.gov.uk/library/afu/index.htm>

Summary

Between April and September of 1997 a field evaluation was conducted by Cambridgeshire County Council Archaeological Field Unit (AFU) in advance of construction of a replacement water trunk main between Duddington in Northamptonshire (SK 989 004) and Chesterton, to the West of Peterborough, Cambridgeshire (TL 127 945). The total length of the route was 20.7km and the width of the easement was in general 30m. The work was commissioned by Anglian Water Services Ltd. and was carried out in accordance with a design brief provided by the Cambridgeshire County Archaeology Office - Development Control (Kaner 1997) and by Northamptonshire Heritage (Kidd 1997).

Following an archaeological desktop assessment, also carried out by the AFU in March and April, 1997, nine areas were selected as having high archaeological potential. For each of these areas a series of non-intrusive evaluation techniques were proposed for deployment in advance of test-pitting or trial trenching. In addition, the entire easement was to be fieldwalked.

Near Bonemills Farm, Wittering (TF 0475 0153), remains of two iron-smelting furnaces and of a third feature which was probably a smithing hearth were discovered. These were fully excavated in advance of their destruction by the pipeline.

The two furnaces were of a similar type, consisting of sub-oval pits about 2.2m long 0.6m wide and 0.15m deep. There was evidence of slag-tapping, with thick flows of tap slag remaining in situ from the last firing. The probable smithing hearth was different, consisting of a circular pit about 0.60m in diameter and 0.33m deep. The site had been heavily ploughed and nothing appears to have remained of the furnace or hearth superstructure. Other features nearby contained burnt iron ore and charcoal and were probably ore-roasting pits. Metalworking residues from the smithing hearth suggested it had been used for primary smithing of the bloom and there was no evidence of artefact manufacture on the site.

Charcoal from one of the slag-tapping furnaces gave a radiocarbon date of 1350 +/- 80 BP, cal AD575 to 875 (2 sigma, 95% probability). That from the probable smithing hearth gave a date of 1230 +/- 50 BP, cal AD680 to 905 and cal AD920 to 950 (2 sigma, 95% probability).

No other new sites were located outside the areas of high potential already identified. Even within these areas, results were mostly disappointing, with few archaeological features being found. Problems with access to the route delayed fieldwalking until crop growth was well advanced, and this also affected geophysical and metal detector surveys. The conditions under which subsequent archaeological work took place may also have affected the results. Construction work associated with an earlier pipeline along the same route had also destroyed archaeological remains in many places.

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**Middle Saxon Iron Smelting Furnaces and Other Sites along the Wing to
Peterborough Pipeline: Archaeological Evaluation and Excavation
SK 989 004 to TL 127 945**

1 INTRODUCTION

Between April and September of 1997 a field evaluation was conducted by Cambridgeshire County Council Archaeological Field Unit (AFU) in advance of construction of a replacement water trunk main between Duddington in Northamptonshire and Chesterton, to the West of Peterborough, Cambridgeshire (fig. 1). The work was commissioned by Anglian Water Services Ltd. and was carried out in accordance with a design brief provided by the Cambridgeshire County Archaeology Office - Development Control (Kaner 1997) and by Northamptonshire Heritage (Kidd 1997). The pipeline route was 20.7 kilometres long and the easement was in general 30m wide. All evaluation and excavation undertaken was confined within this working width, and no work took place outside the fenced pipeline easement.

Following an archaeological desktop assessment, also carried out by the AFU in March and April, 1997, nine areas along the route were selected as having high archaeological potential. Of these selected areas, seven lay in Cambridgeshire and two in Northamptonshire. A phased scheme of works was set out in the design brief in which phase one considered the whole route with a view to locating any previously-unrecorded archaeological remains; phase two incorporated field evaluation of the areas of high potential already noted, plus any new areas located by phase one; and phase three covered the mitigation of the impact of the development by archaeological excavation of remains where appropriate.

Near Bonemills Farm, Wittering, evaluation uncovered two iron-smelting furnaces and other metalworking features, including a probable smithing hearth. These were subsequently fully excavated in advance of their destruction by the pipeline. Charcoal from one of the furnaces and from the smithing hearth gave closely contemporary radiocarbon dates in the Middle Saxon period. This proved to be the only area along the route where further work beyond the evaluation stage was undertaken. In all of the other evaluation areas, few archaeological remains were found within the pipeline easement. The iron working site at Bonemills Farm was also the only new site, in the form of unexpected archaeological remains encountered along the route.

The paucity of new discoveries may reflect the way in which the pipeline route avoided known archaeological sites as far as possible. The success of the project, however, cannot be measured simply by the number of new sites located. The finding, recording and above all the secure dating of the furnaces at Bonemills Farm is of great regional, possibly even national importance. This reminds us that important archaeological remains can still be found unexpectedly on such a project and demonstrates the worth of an archaeological presence at all stages of the pipeline construction, in addition to archaeological

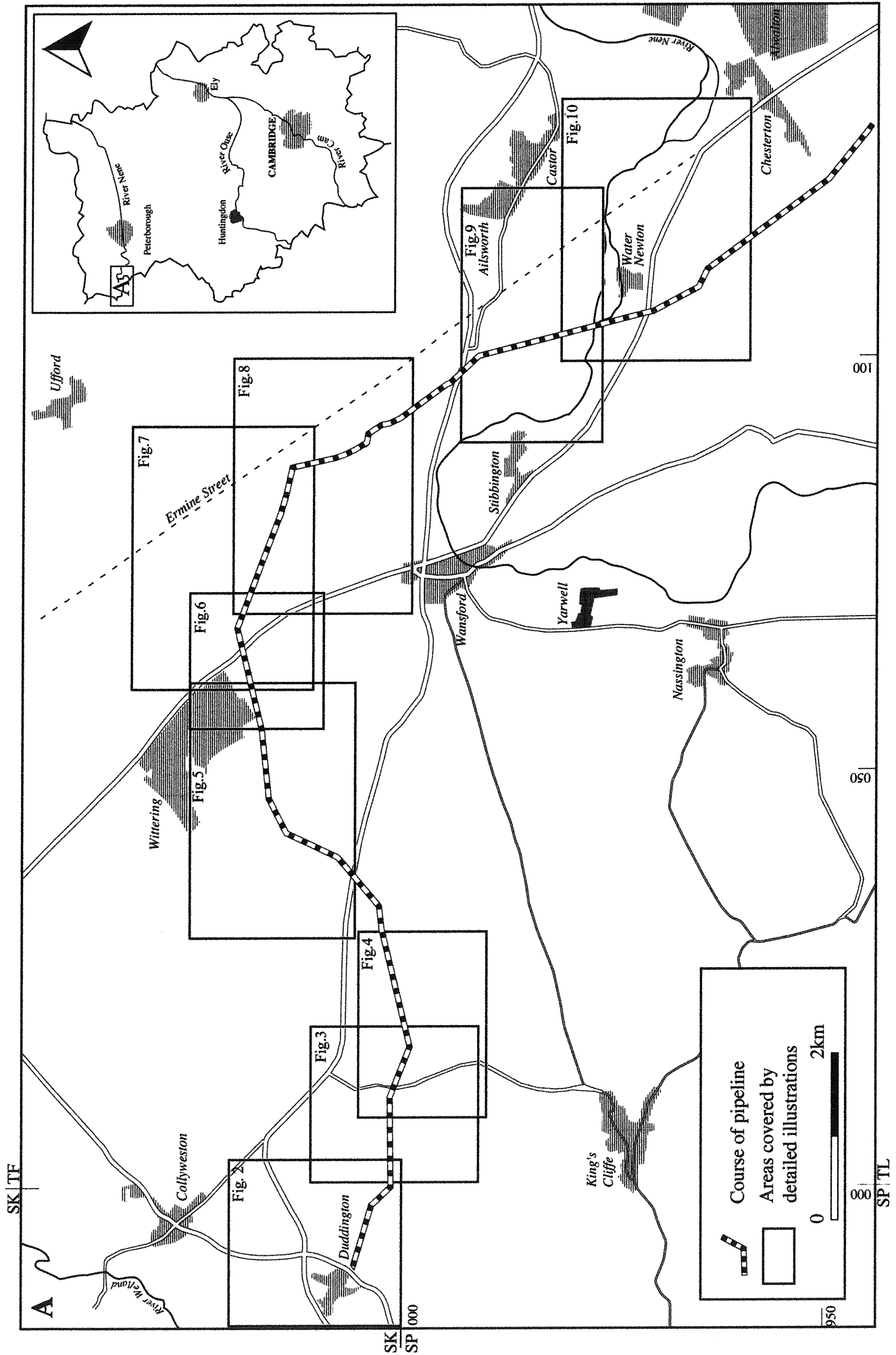


Figure 1 Pipeline route

input at the planning stage. Likewise, whilst the results are subject to many limitations, the scope of the project nevertheless represents a large-scale transect across the archaeological landscapes of eastern Northamptonshire and north-west Cambridgeshire. In this context, the absence of finds, although to be interpreted with caution, is nonetheless a significant addition to our knowledge of these areas.

Some of the limitations and problems of the project are endemic to pipeline archaeology, such as the narrowness of the pipeline easement and the inability to undertake any work beyond its confines. Others, however, were specific to this project. Some, such as soils and weather conditions, were beyond anyone's control; some were not so fortuitous. The timing of the archaeological work, the provision of access for it sufficiently in advance of construction and the conditions imposed on it by methods of construction and reinstatement adopted could all, perhaps, have been arranged differently. The lessons learned about methodologies and working conditions are discussed at length below (under *Methodology*). The purpose of this discussion is to allow an accurate assessment of the results of the work and to assist all those who, whether as curatorial archaeologists, archaeological contractors or pipeline engineers, undertake similar work in the future.

Organisation of the Report

The original designations of selected areas in the design brief have been changed in this report which treats each area in turn, starting at Duddington in Northamptonshire and running eastwards into Cambridgeshire. Thus areas are numbered and considered in the order in which the pipeline route encountered them, from west to east. The furnace excavations at Bonemills Farm are treated separately at the end of the sections dealing with the evaluation areas.

2 TOPOGRAPHY AND GEOLOGY

The pipeline was 20.7 kilometres long, beginning at Duddington on the River Welland, and running east and south, crossing the River Nene near Water Newton (fig. 1). The route traversed a wide range of geologies and historic landscapes, from the limestone uplands of east Northamptonshire to the terrace gravels of the valley of the River Nene. The topographic and geological background to the route has already been described in the desktop assessment (Denham 1997) and the reader is referred to that work for further information. The specific geological and topographic background to each of the selected areas, however, is dealt with below in the relevant account of the results of the evaluation. Present-day landuse along the route included some areas of pasture and some woodland, but the overwhelming majority of the fields traversed by the pipeline were arable.

3 ARCHAEOLOGICAL AND HISTORICAL BACKGROUND

As noted above, the pipeline route crossed a wide range of landscapes, encompassing a similarly wide range of archaeological sites of different types and periods. The archaeological background has already been set out in the desktop assessment (Denham 1997) and will therefore not be repeated here. Known archaeological information and SMR data is shown on the detailed location maps for each evaluation area. Some extra information, derived from his own fieldwork and not all noted in the SMR, was provided by David Hall. The historic landscape and landuse along the route has also been studied for this project by David Hall, and a separate report by him appears in appendix 1. Summary information about historic landuse, derived from this report, is given below for each evaluation area.

4 METHODOLOGY

For each of the areas of high potential identified in the design brief a series of non-intrusive evaluation techniques were proposed for deployment in the first phase of works. These techniques varied according to the expected character of the archaeological remains, but included fieldwalking, geophysical survey and the use of metal detectors. In addition, the entire easement was to be fieldwalked in advance of topsoil stripping, both as a means of evaluating known or expected sites, and to locate any unexpected sites along the route. Based on the results of these non-intrusive surveys, areas of high potential already selected, and any new areas discovered, were to be sampled by trial trenching or test pitting, as appropriate.

There were numerous problems with the implementation of this proposed scheme, however:

- Starting the project in April meant that crop growth was already sufficiently advanced to prevent effective fieldwalking in many places. Since much of the route was sown with oil seed rape, already well-grown by April, surveys by metal detector or magnetometer were hampered, or indeed, completely prevented.
- Problems over access in many areas of the route allowed crop growth to advance even further ahead of field survey as time went on.
- In many other areas, access even for non-intrusive survey was not available until the easement was fenced; and in all cases, no excavation could take place until the fences were erected. This was at the insistence of Anglian Water, in accordance with the wishes of landowners and their agents. Owing to the urgency of the construction programme, topsoil stripping followed rapidly on from fencing. The result of this, and of crop conditions was that most of the route could only be examined archaeologically after the topsoil had been removed.

- The presence over almost the entire route of an existing pipeline with an electrical corrosion protection system also greatly interfered with geophysical surveying, and limited the areas available for trial trenching and test-pitting, which, for safety reasons, had to be located as far as possible from the existing pipe.
- Previous construction work associated with this earlier pipeline had in any case destroyed archaeological remains in many places, leaving little to be evaluated by the present project.

In spite of these difficulties, some areas of the pipeline route, principally at the western end, west of the A1, were fieldwalked and surveyed by metal detector in advance of topsoil stripping. In addition the whole of the pipeline route, including those areas examined before topsoil stripping, was walked after the topsoil had been taken off and both the spoil heaps and stripped easement were searched by eye and with a metal detector. Although under these less-than-ideal conditions ceramic sites or ephemeral remains might well have escaped detection, it seems unlikely that any substantial Roman or medieval settlements lying within the pipeline easement would have been missed.

All construction work, and hence the archaeological response, was confined within the pipeline easement, which was generally 30m wide; no access was available outside this working width. In addition, there was a requirement to maintain strict segregation of topsoil from subsoil in order to facilitate reinstatement of arable land. In most places, as noted above, this meant that no excavation work could take place until after the easement had been stripped of most of its topsoil. Trial trenching then consisted of excavating through the last few centimetres of topsoil to the interface with the subsoil and any archaeological remains. Locations of trial trenches and test pits were further constrained, not only by the presence of the existing pipeline mentioned above, but also by the need to allow continued access for traffic along the easement, which was in effect also the contractors' construction road.

In terms of records and archives, each of the areas selected for evaluation along the route was treated as a "site" and was assigned a site code on the AFU's normal parish-based system. Fieldwalked material and metal detector finds from the pipeline route away from sites was recorded by the parish in which it was found plus the code "PL" for pipeline. All finds and archives are held at the AFU's office in Fulbourn, Cambridge.

Geophysical Survey

Geophysical survey by Fluxgate Gradiometer was undertaken in appropriate areas of the pipeline route by Rob Wardill of the Essex County Council Field Archaeology Group. The detailed methodology and results of this work are covered in separate report (Wardill 1997). Results were in general disappointing. Some of the problems with the work have been referred to already, the principal difficulty being the presence of an existing pipeline adjacent to the easement along most of its length. Severe interference from this, probably

caused by the electrical corrosion protection system (cathodic protection), reduced the effectiveness of the survey. In one location (area 5) where the evaluation area lay some distance from the existing pipeline, good results were apparently obtained. Upon excavation, however, several anomalies proved to be natural, sand-filled fissures in the underlying limestone.

The results of geophysical surveying are discussed below under the headings for each separate evaluation area where they were deployed. Owing to the poor nature of the results, the geophysical report is not included in full in this report. Copies of the full geophysical report are held with the project archive.

5 RESULTS

General

The main result of this project is the important discovery of the Middle Saxon furnaces at Bonemills Farm. This is a find of regional, possibly even national importance. Accordingly, the description and discussion of this site is dealt with separately below (pp 30-48)

In all the other evaluation areas, the results revealed a generally low density of archaeological remains. The many constraints that affected the work have already been referred to above (see *Methodology*). The limited fieldwalking that was possible along the route produced only a very thin scatter of abraded Roman and medieval sherds, probably the results of dispersed, off-site activities such as manuring. Metal detector surveying, where possible, also failed to locate concentrations of artefacts. A general scatter of Roman coins and metalwork along the route probably also reflects dispersed activities of some kind.

The detailed results of work in each of the areas evaluated are discussed below. The order in which sites appear reflects the way in which the pipeline route encountered them; thus the discussion begins with Area 1 at Duddington, the westernmost of the evaluation areas, and runs through to Area 9 at Water Newton. The letters in brackets after the area numbers, e.g. Area 1 (Site H), refer to the order in which the selected evaluation areas appeared in the design brief.

Area 1 (Site H) Three Subareas East of Duddington (fig. 2)

Topography and Geology

Between the A43 trunk road just south of the village of Duddington (Northants) (SK 989 004) and the woodland called “The Assarts” (SK 996 000), the pipeline ran west to east up a west-facing slope above the River Welland. Beyond the river valley, the route ran on westwards across the boulder clay plateau. The first two fields crossed by the route were arable; the third, adjacent

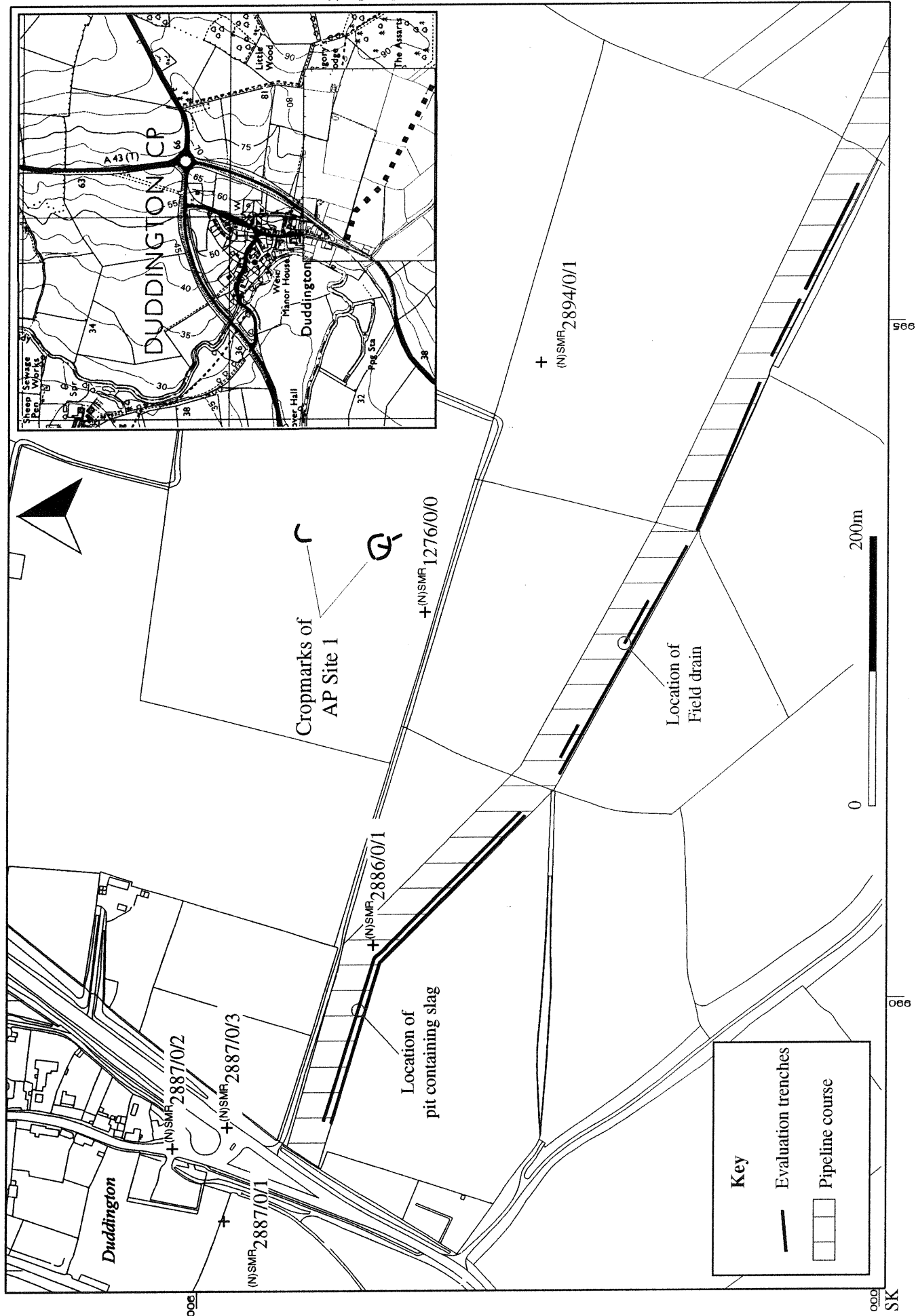


Figure 2 Evaluation Area 1 (Site H) - three sub-areas east of Duddington

to the woodland, was pasture. The pipeline as finally constructed followed a slightly different route a little way south of that shown in the desktop assessment. The route as constructed is shown in figure 2.

Background

This area was selected for evaluation because of known sites lying on or near the pipeline route. These were a possible smelting furnace uncovered during construction of the existing pipeline (Northants SMR 2886/0/1), and a cropmark in a field to the north of the route (Northants SMR 1276/0/0). A third site, also uncovered during the previous pipeline work, was avoided by the re-alignment of the route noted above.

Historic Landscape and Landuse

David Hall's maps (figs 14-19) show the western part of this section of the route as having been part of the open fields of Duddington in 1650. The woodland known as "The Assarts" is the result of Forestry Commission planting since the 1920's. The name "The Assarts" refers to arable land created by grubbing up woodland. This process had happened and "The Assarts" had been brought into hedged fields before the 18th century. Ridge and furrow earthworks from the former open fields survive in some of the recent forestry plantations in Duddington, but none were observed along the pipeline route.

Methodology

Evaluation techniques proposed here were fieldwalking and metal detector and geophysical survey, followed by trial trenching. The state of the crop in the arable fields permitted fieldwalking which was carried out using four transects equally spaced across the easement, with collection lengths of 30m. Further fieldwalking, with total collection within a 30mx30m grid was also carried out over the route in the first field east of the A43. An intensive metal detector survey using the same grid was also undertaken. No significant finds were located by either survey. The third field along the route was pasture and so was not fieldwalked. The tall growth of grass here also prevented effective metal detector survey.

Geophysical survey was attempted in the first field east of the A43 with the aim of locating the remains of metalworking that were already known there. However the presence of an existing pipeline with an electrical corrosion protection system plus the detritus left behind after the construction of this earlier pipeline caused too much disturbance, and the survey was abandoned.

Once the easement had been fenced, trial trenches were dug along the whole length between the A43 and the woodland called "the Assarts". This trenching took place between 6th and 12th May 1997. Two trenches 2m wide were dug by machine down to the base of the ploughsoil. Both were parallel to the southern fence of the easement, the first 1m north of it, the second 8m north of it. The placing of these trenches took into account, amongst other considerations noted elsewhere, the need to sample the area furthest from the existing pipeline which

was therefore the least disturbed by previous construction work. The total length of trenches dug was 1067m.

Finds and records are held at the AFU office in Fulbourn under the site code DUDPL 97.

Results

Only a single archaeological feature was noted. This lay at SK 9899 0038, about 50m west of the site of the possible furnace recorded in the Northants SMR (see fig. 2). In form it was a shallow sub-oval feature about 2.1m long and 0.60m wide, with a circular pit 0.70m in diameter and 0.37m deep at the east end. The pit contained a single fill which was a dark olive brown firm sandy silty clay. The fill also contained frequent large lumps of slag. The total amount of slag recovered from the feature was 7kg, and the largest single lump weighed 2071g. There were also several irregular fragments of fired clay with a total weight of 269g, the largest being a rough slab c80x60mm and c25mm thick. Another fragment also appeared to have been vitrified or slagged on one surface. There was no other indication, such as of discolouration of the sides or base of the pit, to suggest that high-temperature processes had taken place within the pit itself. The feature appeared to have been badly damaged by ploughing. A traverse across the feature and its immediate surroundings with a magnet failed to locate any further metalworking residues. Apart from metalworking residues, the only find from the pit was a single tooth of sheep/goat.

A stone-lined field drain was noted running across the trial trenches in the second field east of the A43, but was not excavated.

Metalworking Residues

All excavated metalworking residues were weighed and quantified, then sorted and classified on morphological criteria, using the categories set out by MacDonnell (1992).

The single largest lump of slag, mentioned above, is a plano-convex hearth bottom (PCB). Its maximum diameter is 160mm and it is 60mm deep. It now weighs 2071g, but has recent fresh-looking fractured edges, so was probably even heavier originally. The depressed top of the PCB is heavily convoluted, and the base is also very irregular with many large (>20mm) charcoal impressions in it. The fractured surfaces appear blue-black in colour and glossy, and very coarsely vesicular. The fractured areas show further charcoal impressions within the mass, and in one place, a lump of entrapped charcoal survives.

This is at the extreme end of the size and weight range for PCBs, which are usually regarded as smithing residues. A more detailed discussion of PCB size and weight ranges, and the processes that produce them is given below under the discussion of the metalworking residues from the Middle Saxon metalworking site at Bonemills Farm (below, p39-41). By analogy with the Bonemills Farm residues, this PCB is thought to be the result of primary smithing, i.e. initial forging and consolidation of a freshly-smelted bloom.

The rest of the slag is very similar to the PCB, and probably results from the same process, but has been broken up into smaller pieces, probably after being discarded as waste.

Discussion

The form of this feature, and especially of the deeper circular pit at one end, is reminiscent of the possible smithing hearth found near Bonemills Farm (see below, pp 40-48). This, plus the presence of metalworking residues (slag) and the proximity to a known ironworking site suggests that the feature may have been connected with metalworking. Nevertheless, it is clear from the distribution of the slag, which was found dispersed within the fill, and from the absence of any evidence of high-temperature processes, that the metalworking residues here are not *in situ*. Rather, the find has the character of a dump of slag, incorporated into the backfill of the pit following its disuse. Likewise, the irregular fired clay fragments in the fill may have derived from some kind of furnace structure, but are clearly not *in situ*. The absence of any micro-residues, (e.g. hammerscale, spheroidal slag), which can be abundantly produced during bloom smithing (Crew 1991) also suggests that metalworking did not take place within the immediate vicinity of this feature, although deposits containing residues may have been ploughed away. The function of the pit therefore is unclear, although the presence of such a quantity of slag suggests it may have been on the periphery of an area where iron smelting did take place. The character of the metalworking residues (bloom smithing waste) also suggests that they result from nearby smelting.

Area 2 (Site J): Area of Historic Woodlands of Rockingham Forest (figure 3)

Topography and Geology

East of the woodland called “The Assarts”, from TF 004 000 to a point just south of the woodland called Easton Hornstocks where the pipeline crossed the Cambridgeshire border at TL 018 998, the route ran through an area of cleared historic woodland. The route of the pipeline as finally constructed here ran on a slightly more southerly alignment from that described in the desktop assessment. Figure 3 shows the route as constructed.

Background

This area was selected for evaluation as there was a possibility that it could contain evidence relating to former woodland-based activities, such as charcoal burning. There was also potential for earthworks or ploughed-out earthworks such as woodland boundaries to exist here.

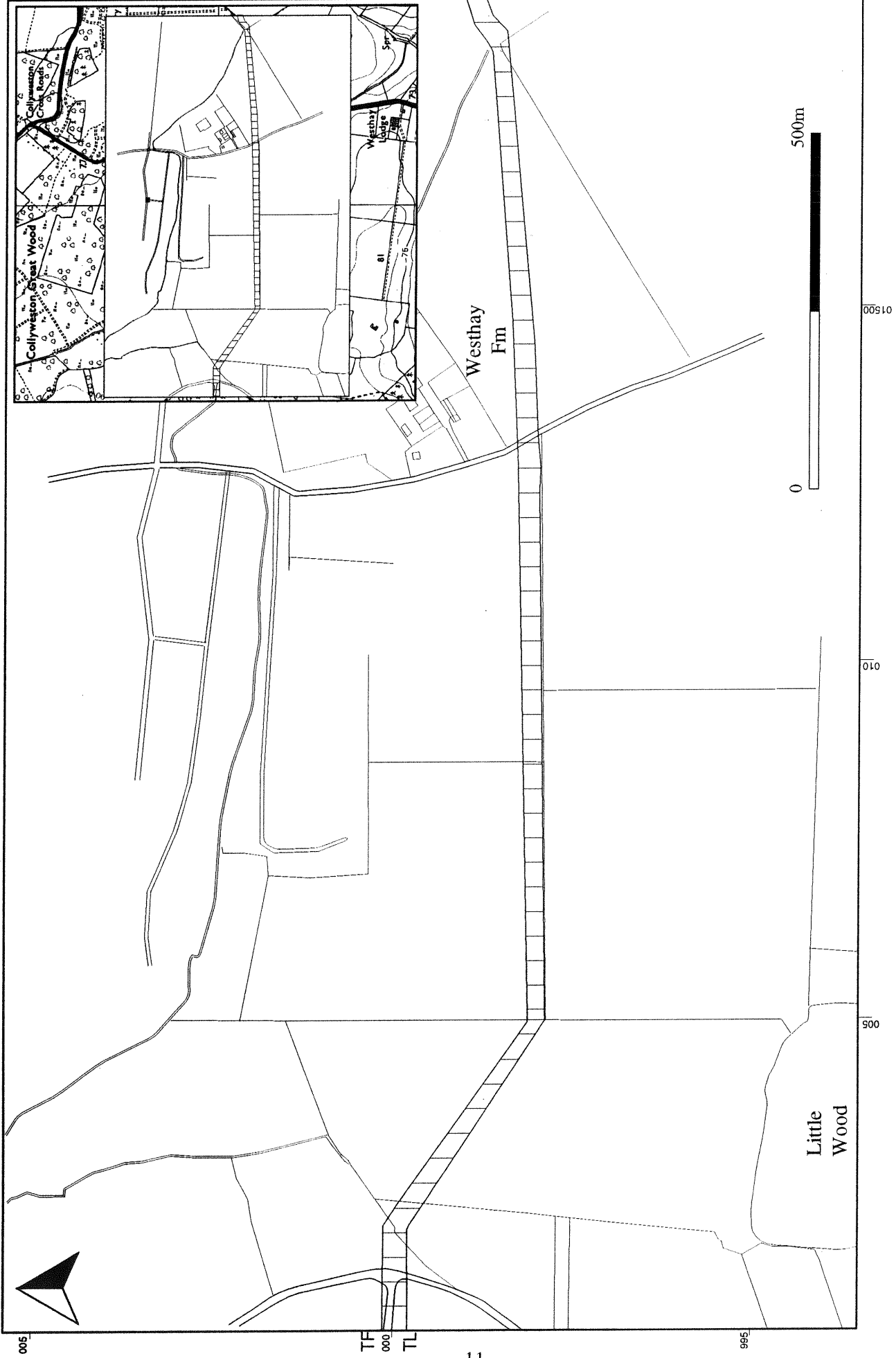


Figure 3 Evaluation Area 2 - south of Westhay Farm

Historic Landscape and Landuse

David Hall's maps (figs 14-19) show all the land east of "The Assarts" as far as the Cambridgeshire border as having been woodland in 1650. There was a royal deer park in this northern part of the present parish of King's Cliffe, with a keeper's lodge, wooded coppices, which were often surrounded by earth banks or ramparts, and open spaces and rides called "plains". The deer park was completely disparked and converted to closes before 1711.

Methodology

The whole of this area was in arable cultivation at the start of the project. Evaluation techniques proposed were fieldwalking and metal detector survey. The state of the crops, however, precluded any effective work with either of these techniques before topsoil stripping. A walkover survey was nevertheless conducted during April 1997 in order to locate any remaining earthworks. Once the easement was fenced and stripped, a metal detector survey was carried out; the surface of the easement was also examined, and the topsoil spoil heaps searched for artefact concentrations. This work was carried out in May and June 1997.

Results

No significant finds were made. No traces were found of any surviving earthworks within the pipeline easement. The crop cover noted during the walkover survey may, however, have obscured the slightest of ploughed-out earthworks. Searches of the soil heaps and stripped easement produced only a couple of very abraded pot fragments. Metal detection revealed no significant artefacts.

Area 3 (Site A): **To the south of Wittering Coppice and north-west of Cross Leys Farm (figure 4)**

Topography and Geology

Between TL 018 998 and TF 028 001 in the west of Thornhaugh parish, the pipeline route ran across two large arable fields to the south of Wittering Coppice and north-west of Cross Leys Farm. This area lies on Boulder Clay overlying Blisworth Limestone.

Background

The site was selected as having a high archaeological potential because of two known sites nearby; one (Cambs. SMR 00001) was a Roman metalworking site and the other (Cambs SMR 00002) a possible Roman settlement. Air photographs also showed a cropmark of two parallel linear features running into the pipeline easement at TF 027 001.

Historic Landscape and Landuse

David Hall's maps (figs 14-19) show the whole of the area traversed by this section of the pipeline route as having been woodland in 1650.

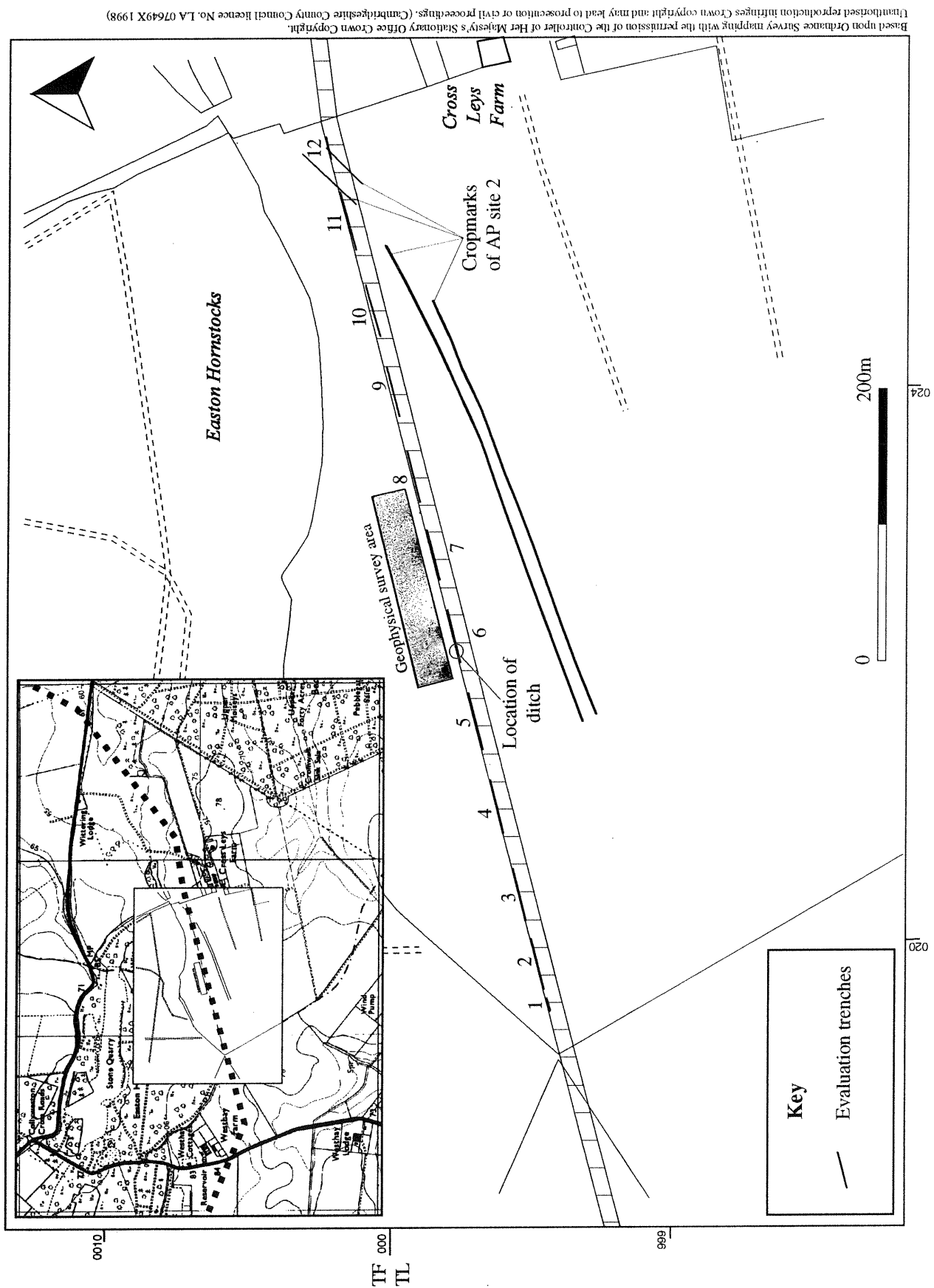


Figure 4 Evaluation Area 3 (Site 4) - South of Wittering Coppice and north-east of Cross Leys Farm

Methodology

Non-intrusive techniques proposed for this site were fieldwalking, metal detecting and geophysical survey. These choices reflected the expected archaeological remains, which might have included surface scatters of pottery, metal artefacts and subsoil features associated with Roman settlement, and furnaces or hearths associated with ironworking.

Finds and archive are held at the AFU office in Fulbourn under the site code THUCLF 97.

Results

Field evaluation took place here between 7th April and 12th June 1997. Access to the site for non-intrusive survey was first obtained on 7th April. Part of the area was by then under a well-grown oilseed rape crop and the other part unploughed stubble and fieldwalking or metal detecting were impossible. Geophysical survey was carried out, in spite of the rape crop, but considerable interference was experienced from the existing buried pipeline and its electrical corrosion protection system. The area surveyed was relocated just to the north of the proposed pipeline route to avoid the interference. No significant anomalies were located near to the route, but a roughly circular anomaly in the north-eastern corner of the area surveyed may correspond with the metalworking site noted in the SMR.

Trial trenching was only possible after topsoil stripping and took place from 5th - 12th June 1997. A total length of 539m of trenches were dug with a JCB with a 1.5m wide toothless ditching bucket. A single linear feature in trench 7 was the only archaeology encountered. This was 1.5m wide and 0.35m deep, and ran from north-east to south-west across the trench at TL 0237 9998, about 420m west of the point where the pipeline easement crossed the field boundary at Cross Leys Farm. A single small sherd of pottery, probably Roman, was the only find from this feature.

Area 4 (Site B):

South-east of Bonemills Farm

Topography and Geology

Between TF 045 015 and TF 052 016 south-east of Bonemills Farm in Wittering Parish, the pipeline route ran west - east across the top of a south-facing slope above a small stream. The area lies on Northampton Sand Ironstone overlying Upper Lias Clay.

Background

The site was selected for evaluation because the pipeline route crossed the known location of a scatter of Mesolithic flints (Cambs SMR 00013).

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Historic Landscape and Landuse

David Hall's maps (figs 14-19) show this area to have been part of the open fields of Wittering in 1650. The land alongside the stream at the bottom of the valley south of the route is shown as meadow.

Methodology

Evaluation techniques proposed for this site were fieldwalking of the area of the easement around the known flint scatter, to be followed by test pitting to determine the extent of the distribution of artefacts within the ploughsoil, and to prospect for cut features.

Finds and archives are held at the AFU office in Fulbourn under the site code WTTBF 97

Results

Field evaluation was conducted from 14th - 25th April 1997. Fieldwalking was carried out in two stages; firstly, an extensive survey, with four transects being walked along the fenced pipeline easement, using 30m collection lengths. The results of this work were used to select an area for intensive fieldwalking on a 10m grid. A total of 104 pieces of worked flint were recovered, incorporating 60 waste chips and flakes, 20 bladelets, 6 cores or core fragments and 12 classifiable tools. All could be dated to the Mesolithic. The distribution of flints had clearly been altered by ploughing and no grid square contained more than 6 artefacts. A widespread area of slightly higher density at TF 048 015 may indicate an originally more discrete area within the overall scatter. The full report on the flints by Dr Twigs Way appears below in appendix 2.

All of this work was carried out before the easement was stripped of topsoil, but unfortunately, for reasons detailed above (see *Methodology*), no excavation work was possible until after topsoil stripping. With the topsoil removed, the same 10m grid was used to lay out fifteen 5m x 5m test-pits along the easement. These were excavated by machine down to the base of the ploughsoil. Forty-litre samples of the test-pit spoil were dry-sieved through a 6mm mesh. In spite of the results of fieldwalking, only a single snapped bladelet was found in the spoil from test pit 8 and a waste chip from test pit 5. A single feature was located in one of test-pits, a shallow gully about 3m long, 0.3m wide and 0.1m deep. This did not produce any finds, and is probably the product of recent deep ploughing. Intensive metal detector survey following topsoil stripping failed to locate any significant metal artefacts

Iron Smelting Furnaces

After topsoil stripping in this area, two further features were located at TF 0475 0153 which proved to be iron smelting furnaces. There was also another feature which may also have been connected with metalworking, and some further features which are interpreted as being connected with smelting operations. These were subsequently fully excavated before pipeline construction operations reached them. A separate account of these excavations is given below (p00).

Area 5 (Site C): South of the village of Wittering (figure 6)

Topography and Geology

Between TF 057 017 and TF 065 019, the pipeline route ran from south-west to north-east across two large fields which lay immediately west of the A1 trunk road and about 300m south of Wittering village. A woodland called Diamond Jubilee Plantation lay immediately to the south. The land here is largely flat, with only a very gentle slope to the south and south-east towards Lound wood and Abbott's Wood and Thornhaugh village. The underlying geology is Upper Lincolnshire Limestone to the West of Diamond Jubilee Plantation, and Lower Lincolnshire Limestone to the East.

Background

This site was selected for evaluation on the basis of known sites near to the pipeline route. These included two Roman inhumations and a tile kiln, possibly associated with a large villa site known in West Wood some 500m to the south-west. One of the inhumations (SMR 10700) was of a female with a child. The other (SMR 10699) was of another female who had been decapitated, her head placed between her feet. The tile kiln is not shown on figure 6, but was located several metres to the west of SMR 10699; three additional burials were found during excavations there (Ron McKenna pers. comm.) Additional information was provided by David Hall about a scatter of Iron Age pottery found very near to the pipeline route west of Diamond Jubilee Plantation (Hall pers. comm.)

Historic Landscape and Landuse

David Hall's maps (figs 14-19) show the whole of this area to have been part of the open fields of Wittering in 1650.

Methodology

Non-intrusive techniques proposed here were fieldwalking, geophysical survey and metal detecting. This choice of techniques reflected the expected archaeology, which included the possibility of further burials and settlement remains of domestic and industrial character.

Field evaluation was conducted here from 2nd - 18th April 1997. Most of the easement was pasture and the arable areas were under a tall rape crop, so no fieldwalking was possible. Metal detection failed to locate any significant finds. This was one of the few areas of the pipeline route where existing pipelines were sufficiently far away from the proposed pipeline easement to avoid interference with geophysical survey. This was duly carried out over the pasture areas and appeared to indicate several linear anomalies, possibly part of a field system.

It was not possible to carry out trial trenching here in advance of topsoil stripping. However, once most of the topsoil had been stripped by bulldozer, four trenches 1.5m wide and approx. 5m apart were excavated with a JCB down to the base of the ploughsoil. These trenches ran continuously along the

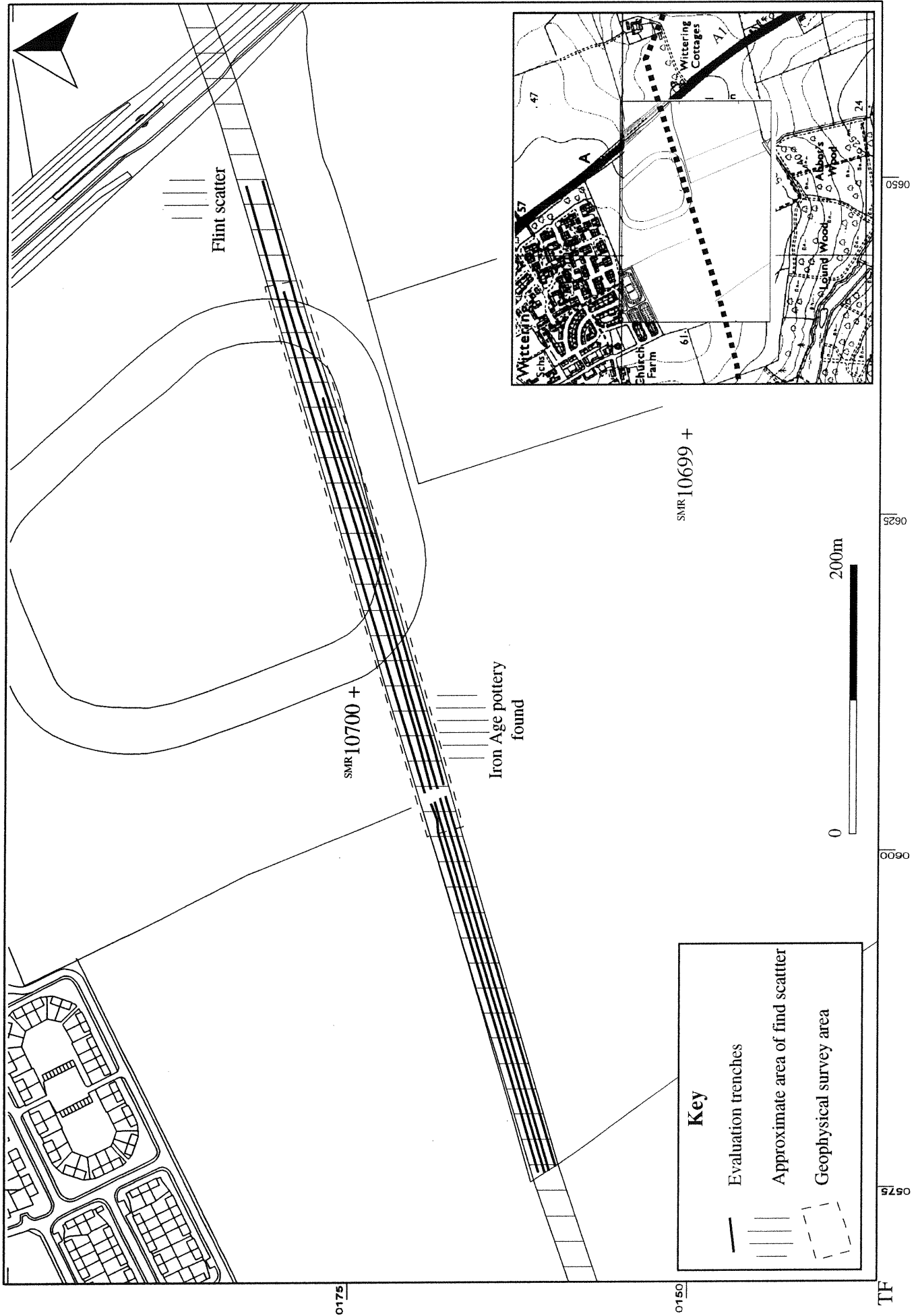


Figure 6 Evaluation Area 5 (Site C) - south of the village of Wittering

entire length of the pipeline easement within the area to be evaluated, a length of c800m. The total length of trenches dug was therefore c3200m.

Finds and records are held at the AFU office in Fulbourn, under the site code WTTDJP 97.

Results

Little was found in these trenches. Three linear features were found in the field nearest to the A1 adjacent to Diamond Jubilee Plantation. These were shallow and did not produce any finds. Their locations appeared to correspond with anomalies located by the geophysical survey. Several very clearly marked linear anomalies located by geophysical survey at the eastern end of the area, however, proved to be of geological origin. A single shallow ditch was observed crossing the easement in the field west of Diamond Jubilee Plantation. This again produced no finds. Intensive metal detecting over the stripped easement and the trench spoil failed to produce any significant finds, although casual detecting over the topsoil heap did produce a single copper alloy pin, which is probably of late Anglo-Saxon date.

Discussion

The results of evaluation here were disappointing. Since this was the best area along the whole route for the deployment of geophysical techniques, because of its location away from the existing pipeline, it is unfortunate that several of the clearest anomalies proved to be of geological origin. Limestone is one of the most responsive geologies for magnetometry (Dr Mark Noel pers. comm.) and this may explain the deceptive clarity of these anomalies. Their regular arrangement, whilst suggestive of a field system, must in fact be fortuitous. It seems unlikely, however, given the responsiveness of the area, that there could be any remaining features within the area surveyed that did *not* show as geophysical anomalies. In addition, the particular circumstances of the trenching scheme here have uncovered a large sample of the total area of the easement. The absence of features is therefore likely to be representative.

The results of the work would suggest that in this area the easement crossed the periphery of an area of settlement, cutting through some of its outlying field boundaries. It is tempting to associate these with the area of Roman settlement known to the south-west of the pipeline route, but the absence of dating evidence makes a definitive statement impossible..

Area 6 (Site D): South of Southorpe Bottom (figure 7)

Topography and Geology

Between TF 065 019 and TF 079 014 south-east of Elms Farm and south of Southorpe Bottom, the pipeline route ran south-east across three arable fields on a long, east-facing slope running down to a small stream. The boundary between Wittering and Thornhaugh Parishes ran along the southern edge of the

Figure 7 Evaluation Area 6 (Site D) - south of Southorpe Bottom

first field south-east of Elms Farm. The underlying geology here is Lower Lincolnshire Limestone.

Background

The site was selected for evaluation because the pipeline crossed a known flint scatter from which numerous flint artefacts of Neolithic/Bronze Age date had been recovered (Cambs SMR 01981). Information from David Hall revealed that a scatter of Romano-British pottery lay to the south of the pipeline route near Elms Farm (Hall pers. comm.).

Historic Landscape and Landuse

As noted above, the pipeline route here runs out of Wittering parish and into Thornhaugh. David Hall's maps (figs 14-19) show the relevant areas of both parishes to have been open fields in 1650.

Methodology

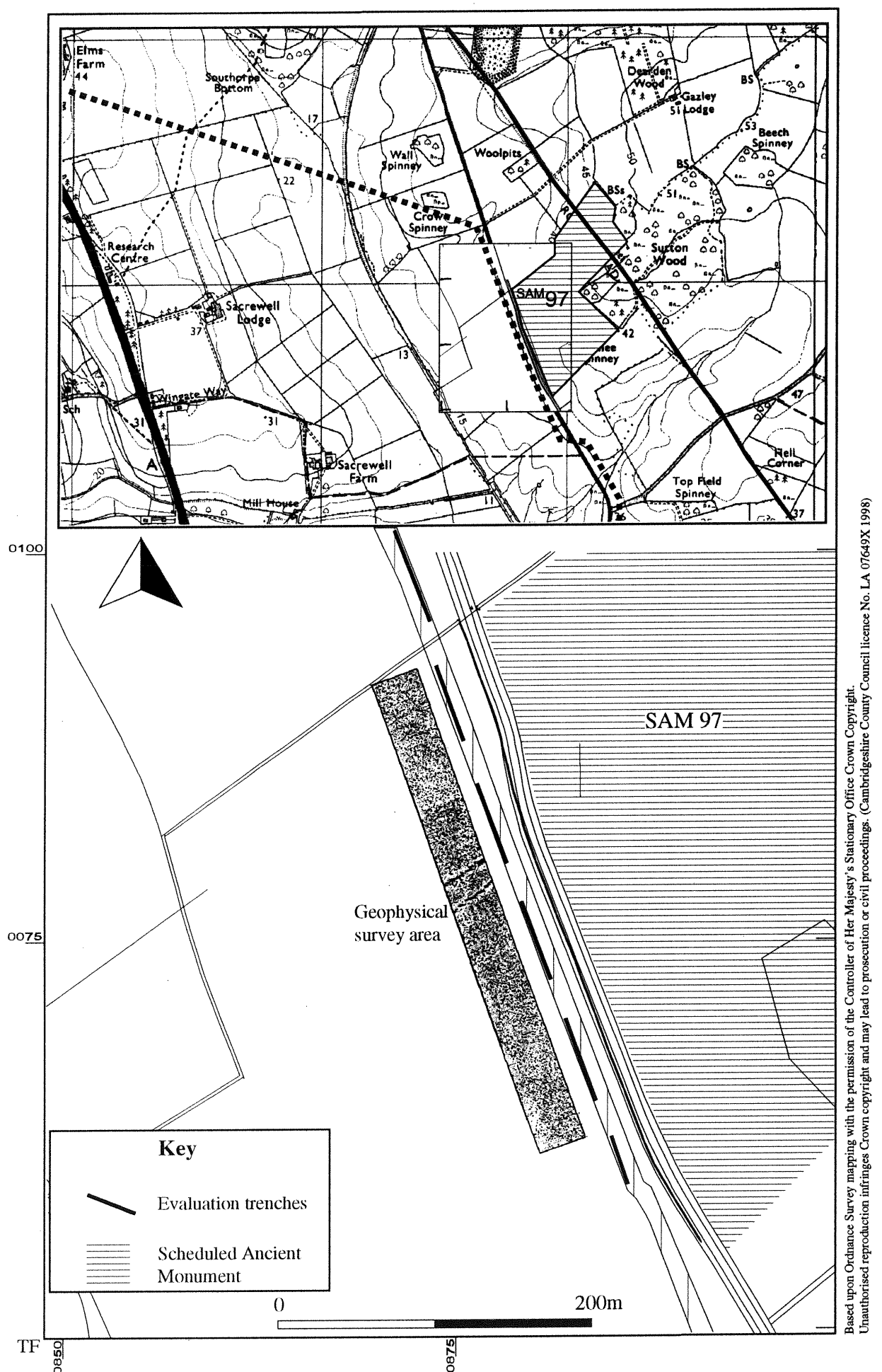
Evaluation techniques proposed here were fieldwalking of the pipeline easement followed by test pitting in order to determine the character and extent of the distribution of artefacts within the ploughsoil, and to prospect for any cut features.

Field evaluation was conducted from 22nd to 24th April 1997. Fieldwalking proved impossible owing to the advanced state of the crop growth by the time access was permitted. Before topsoil stripping took place, however, thirty-four 5m x 5m test-pits were dug by machine to the base of the ploughsoil. Test-pits were spaced at 25m intervals along the pipeline easement, starting from the track near Elms Farm and running into the field immediately south of Southorpe Bottom. Spoil from the test-pits was scanned by trowel and in addition, 40ltr. samples were dry-sieved through a 6mm mesh on site. Test-pit spoil was also scanned with a metal detector.

Finds and records are held at the AFU office in Fulbourn under the site code WTTEF 97. At the south-eastern end of the site, the easement ran into Thornhaugh parish at Southorpe Bottom; records for this part of the pipeline were given the site code THUSB 97

Results

No archaeological features were seen in any of the test pits. The only artefacts recovered were a few abraded sherds of Roman pottery from test pits 2, 3 and 5 at the western end of the easement near Elms Farm. No worked flints were recovered from any of the test pits. Topsoil stripping by bulldozer followed closely behind the archaeological work. Examination of the stripped area of the easement failed to locate any worked flints, although a number of sherds of Romano-British pottery were found. Their location corresponds well with the scatter of Romano-British sherds noted by David Hall. The abraded pottery from the test pits is probably derived from the same source.



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Figure 8 Evaluation Area 7 (Site E) - north and west of Sutton Heath Romano-British settlement

Area 7 (Site E): North and West of Sutton Heath Romano-British Settlement (figure 8)

Topography and Geology

Between TF 087 010 and TF 089 004 the pipeline route crossed two arable fields lying immediately west of Southorpe Road. The pipeline route ran north-west to south-east parallel to the road. The land slopes away gently to the south-west, towards a small stream running north-west to south-east along the valley bottom. This stream joins the Nene about a kilometre further to the south-east. The underlying geology here is Lower Lincolnshire Limestone.

Background

The eastern side of the road marks the western boundary of a Scheduled Ancient Monument at Sutton Heath (SAM 97). The site was selected for evaluation on the basis that features occurring in the Scheduled Area might run across the road into the pipeline easement.

Historic Landscape and Landuse

David Hall's maps (figs 14-19) show most of the land traversed by this section of the pipeline as heath in 1650.

Methodology

The techniques proposed for this site included fieldwalking and geophysical survey to be followed by trial trenching.

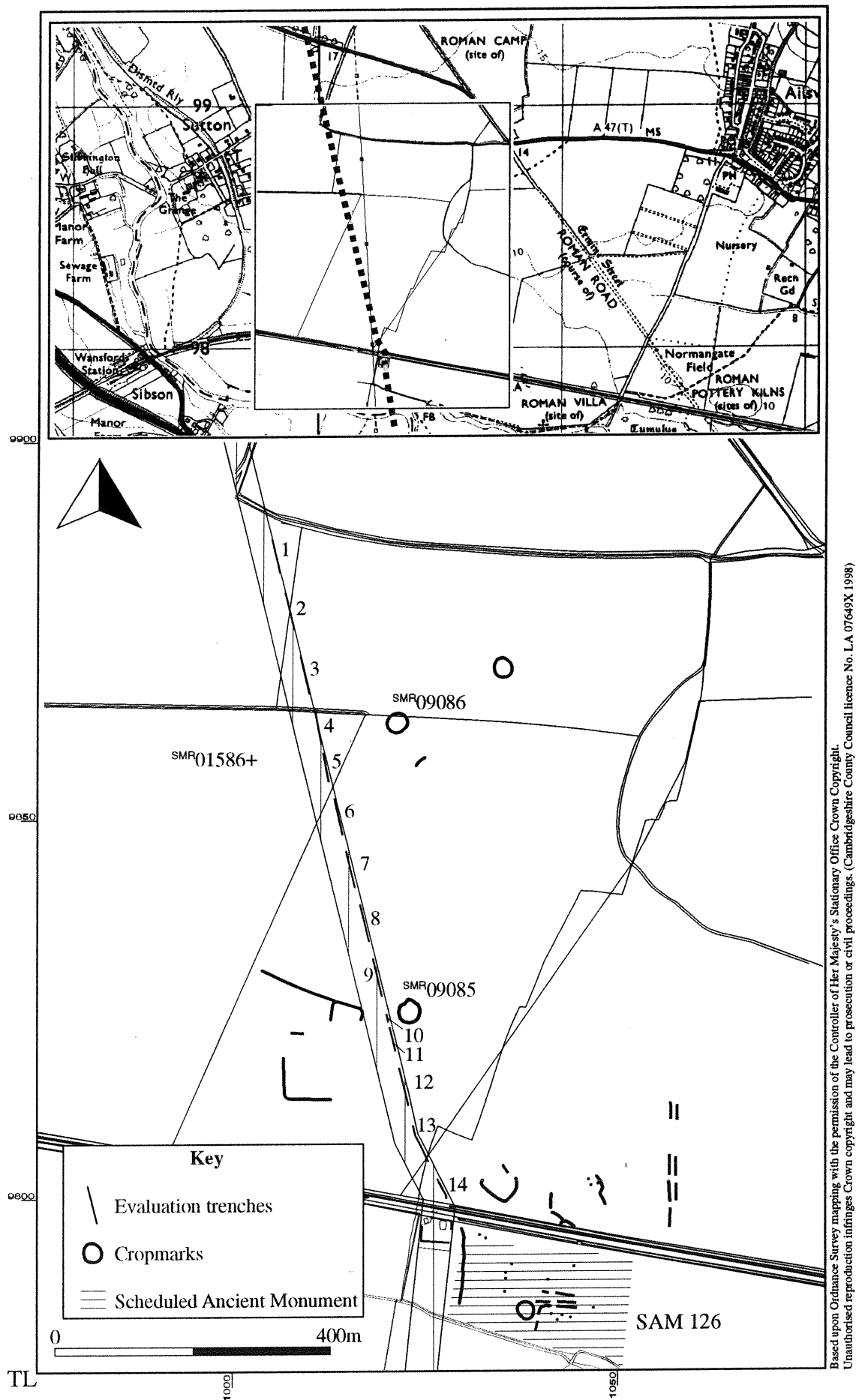
Field evaluation was undertaken from 15th to 19th May 1997. Fieldwalking was not possible owing to the state of the crop. Geophysical survey was carried out, though again the results were affected by the presence of an existing pipeline with an electrical corrosion protection system. Nevertheless, two linear anomalies were located towards the south end of the field opposite the Scheduled Monument.

Trial trenches were dug in advance of topsoil stripping with a JCB with a 1.5m wide toothless ditching bucket. A total of six trenches of about 50m length were dug, spaced at 25m intervals along the easement and arranged so as to investigate the geophysical anomalies. All the trenches were located on the western edge of the easement, as far as possible from the existing pipeline.

Records are held at the AFU office in Fulbourn under the site code SUNSH 97

Results

No archaeological finds or features were encountered in any of the trenches. There was no trace of any features that could have given rise to the geophysical anomalies.



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Figure 9 Evaluation Area 8 (Site F) - east of the village of Sutton

Area 8 (Site F): East of the Village of Sutton (fig. 9)

Topography and Geology

Between TL 101 989, just to the east of Manor Farm, Sutton and TL 102 979 just south of the Nene Valley Railway line, the pipeline route ran almost due south across three arable fields on the first and second terrace gravels of the River Nene.

Background

The site was selected for evaluation because of several known sites near the route. Most of these sites were found as cropmarks showing on air photographs. The techniques proposed for this site were fieldwalking and metal detecting, followed by trial trenching.

Historic Landscape and Landuse

David Hall's maps (figs 14-19) show the whole of this area to have been part of the open fields of Sutton in 1650. The land immediately south of the River Nene, between the river and the modern A1 trunk road (actually in Water Newton Parish) is shown as meadow. The new pipeline route, however, did not cross this area; between the Nene Valley Railway and the A1 the existing pipeline was used.

Methodology

Field evaluation took place here from 28th May to 13th June 1997. Access in advance of fencing and topsoil stripping was not possible. Trial trenching consisted of scraping off the last of the topsoil and, where this revealed no archaeological remains, continuing to excavate through the subsoil to the natural gravel. A total of fourteen 50m trenches were dug at 25m intervals along the eastern edge of the easement. Trench location was as usual constrained by the need to avoid the existing pipeline and to allow continued access along the easement.

Records are held at the AFU office in Fulbourn under the site code SUNMF 97 for the area between Manor Farm, Sutton and the Nene Valley Railway, and AILNVR 97 for the area south of the Railway in Ailsworth Parish.

Results

Fieldwalking of the stripped easement and examination of the topsoil spoil heap did not produce any artefacts. Metal detecting was similarly unproductive, although it did produce a single silver coin, a "Tealby" type penny of Henry II (1154 - 1189), which was found adjacent to the northern boundary of the Nene Valley Railway line.

Archaeological remains were found in trench six only. These consisted of a ditch, about 2.5m wide and 0.20m deep cut into the subsoil, and an isolated posthole about 0.25m in diameter and 0.13m deep. The ditch ran northeast - southwest across the trench about 3m from its north end and appeared to have been heavily truncated, probably by ploughing. No finds were recovered from either feature.

A portion of the pipeline easement in an arable field south of the Nene Valley Railway was not fenced or topsoil-stripped until September 1997 and was dealt with separately once available. This area lay across the boundary in Ailsworth Parish, adjacent to the western edge of a complex of cropmarks which were a Scheduled Ancient Monument (SAM 126). Only a small area of about 900 square metres south of the NVR was fenced and stripped, as the pipeline was designed to utilise the existing trunk main in its crossing of the River Nene. It was possible, however, that features from the scheduled cropmark complex could have extended westwards into this area.

No access was possible until after the easement had been fenced and stripped of topsoil. Archaeological work then took place on 10th September 1997. The stripped surface of the easement was examined by eye and with a metal detector. No finds were recovered. Three evaluation trenches (all 1.5 m wide) were excavated through the last few centimetres of topsoil, down to the interface with the subsoil. A total length of 63m of trenches were dug. No archaeological features of any kind were discovered in any of the trenches. Almost the whole of the area had been badly disturbed during construction of the previous pipeline.

A test-pit 4m long, 1.5m wide and 0.90m deep was excavated in the south eastern corner of the area, and this encountered natural gravel at a depth of 0.50m. Overlying this was a silty clayey sand subsoil. No archaeological finds or features were encountered.

Area 9 (Site G): South of the A1 at Water Newton (fig. 10)

Topography and Geology

Between TL 104 971 and TL 107 968, the pipeline route ran south-east from the southern side of the A1 trunk road at Water Newton to cross Elton Road at a point about 250m south of its junction with the A1.

Background

This site was selected for evaluation because a scheduled Ancient Monument (SAM 130) lay on the eastern side of Elton Road, alongside the A1. Features from this cropmark complex were thought likely to extend into the area of the pipeline easement, which was masked by ridge and furrow until recently (1975 or later). There was also a possibility that this was the site of a Roman cemetery referred to by Stukeley (Denham 1997).

Historic Landscape and Landuse

David Hall's maps (figs 14 -19) show the whole of the area crossed by this section of the pipeline to have been open fields in 1650.

Methodology

Evaluation techniques proposed for this site were fieldwalking and metal detection followed by trial trenching. Field evaluation took place here from 16th to 20th June 1997. By the time access was available the state of the crop completely prevented fieldwalking and metal detecting. Before topsoil stripping took place, nine trenches 1.5m wide, were dug at about 10m intervals along the eastern edge of the pipeline easement. These were numbered from 1 south of the A1 to 9 at Elton Road.

Records are held at the AFU office in Fulbourn under the site code WNTER 97.

Results

Archaeological remains were found in trenches 2 and 3 only. A series of possible intercutting postholes in trench 2 were very badly damaged by recent ploughing, which was also evident in all the other trenches. A shallow linear feature about 0.65m wide and 0.10m deep in trench 3 had probably been similarly damaged. A series of similar shallow, truncated linear features were also observed in trench 3 running parallel to the first linear. No dating material was recovered from any of these features. A search of the trenches and trench spoil with a metal detector was similarly unproductive.

6 DISCUSSION - THE EVALUATIONS

Overall, the results of these evaluations were disappointing. The many problems that hampered the work have already been set out in detail, and will not be repeated here. Once trial trenches or test pits were excavated, few archaeological features were uncovered, and none of the sites selected as having a high archaeological potential contained anything like the expected density of remains. In spite of the many problems experienced at all stages of the work, both before, during and after topsoil stripping and trial trenching, this absence of archaeological features is nevertheless considered to be a true reflection of the archaeology of the pipeline easement.

In part, this is the result of confining the evaluation within a narrow working width. Archaeological remains might well have lain just outside the easement, but no work could take place beyond the fences. In part, this is the result of the pipeline route deliberately avoiding known sites of importance (Scheduled sites along the route, for example, were all avoided). Yet another factor was that the pipeline followed the route of an existing trunk main, which had already destroyed archaeological remains in some places.

Nevertheless, the pipeline route does represent a large-scale transect across the landscapes of eastern Northamptonshire and north-west Cambridgeshire. As such, even though the results should be treated with caution, the absence of finds along the route is nonetheless a significant addition to our knowledge of these areas.

Only one site along the route was considered worthy of further work beyond the evaluation stage. This was the area around Bonemills Farm, Wittering, where a series of iron-smelting furnaces of Middle Saxon date were discovered. These were the subject of an excavation to preserve them by record in advance of pipeline construction, which is reported on in detail below.

7 THE MIDDLE SAXON IRON SMELTING FURNACES

7.1 Introduction

During examination of the surface of the pipeline easement after topsoil stripping at area 4 (site B), a series of features was observed at TF 0475 0153 (see fig. 5) at least two of which were thought to be iron smelting furnaces. This find was unexpected, as fieldwalking of this area before topsoil stripping did not produce large quantities of slag.

Further excavation work, undertaken between 19th and 27th May 1997, showed that there were a total of two identifiable furnaces and one other feature which may have been a smithing hearth, or possibly a third furnace using a different type of technology. A radiocarbon date obtained from charcoal from furnace 1 and a second one from charcoal from this third feature were contemporary, giving dates within the Middle Saxon period. There were also several other features, containing charcoal and burnt ironstone, which are interpreted as ore-roasting pits. A further feature may have been a beamslot or possible structural feature, but was short (1.8m long) and apparently isolated, so its interpretation remains difficult. It may in fact have been connected with ore preparation or charcoal production.

7.2 Topography and Geology

The site lies roughly 15km west of Peterborough, about 1km south-west of Wittering village, and about 300m south-east of Bonemills farm. Here, between TF 045 015 and TF 052 016, the pipeline route ran west - east across the top of a south-facing slope above a small stream which flows south-eastward to become a tributary of the River Nene. To the west, the stream runs through a deep, narrow ravine, whilst at the site's location, the land rises more gently from the valley bottom at about 40m OD up to the valley sides at 50m OD where the furnaces were found. Geologically, the site lies at the interface between the Northampton Sand Ironstone and the underlying Upper Lias Clay. A separate note (by Steven Critchley) on the geology with reference to local iron ore appears in appendix 4. Within the pipeline easement, which was 30m wide, the land around the site sloped gently down to the south and to the west.

7.3 Research Design

Following discovery and provisional identification of the furnaces, a research design was formulated in order to guide their excavation. This posed the following research questions:

A At what date was smelting taking place on this site?

B Are there any ancillary ironworking features present, such as ore-roasting pits?

- C What processes in the ore-to-artefact cycle were conducted on this site?
(For example, did bloom smithing, artefact production or artefact recycling take place here, in addition to smelting?)

7.4 Excavation Methodology

Following topsoil stripping and identification of the site, the area around the furnaces was hand-cleaned and all features identified were hand-excavated. All archaeological work was confined, as everywhere else along the pipeline route, to the area within the 30m wide easement. Since the site was only discovered after topsoil stripping had taken place, however, the northern part of the easement area was taken up with the topsoil spoil heap, and the southern part had to be left as an access road for the pipeline contractors, further limiting the area available for excavation. The total area cleaned and investigated was therefore about 18m long and 8m wide, amounting to c148 square metres. In fact, the furnaces and associated features clustered on the northern side of the easement, adjacent to the topsoil heap. Further features may have been located under the spoil heap but it was not possible to undertake any further spoil movement to confirm this. Examination of the stripped easement, however, suggested that features did not extend beyond the cleaned area to the south, east or west.

Excavation and recording followed the AFU's standard context-based system, and was supplemented by hand-drawn plans and section drawings, and photographic recording in both monochrome and colour. The site grid was tied in to the OS National Grid using a Zeiss RecElta total station theodolite.

7.5 Results (fig. 11)

As no artefacts were recovered from any of the features (the single flint blade from furnace 1 excepted), and there were no significant stratigraphic relationships, the phasing of features has been difficult. Absolute dating has been provided by radiocarbon determinations using charcoal from two of the metalworking features, but relative dating and chronological grouping of most features has been impossible. Features are grouped below, therefore, according to their similarity of morphology or assumed function.

Metalworking Features

Furnace 1 (fig. 12)

Furnace 1 (1002) was the most westerly of the furnaces. On the stripped surface of the pipeline easement it appeared as a fairly irregular sub-oval feature 2.3m long and 0.70m wide. At the northern end were two semi-circular bands of discolouration, a reddish band lying outside and around a bluish band. At first sight these bands appeared to be remnants of a clay furnace lining or structure; further excavation, however, suggested that they were in fact formed from the underlying clay into which the furnace was dug, discoloured by intense heat.

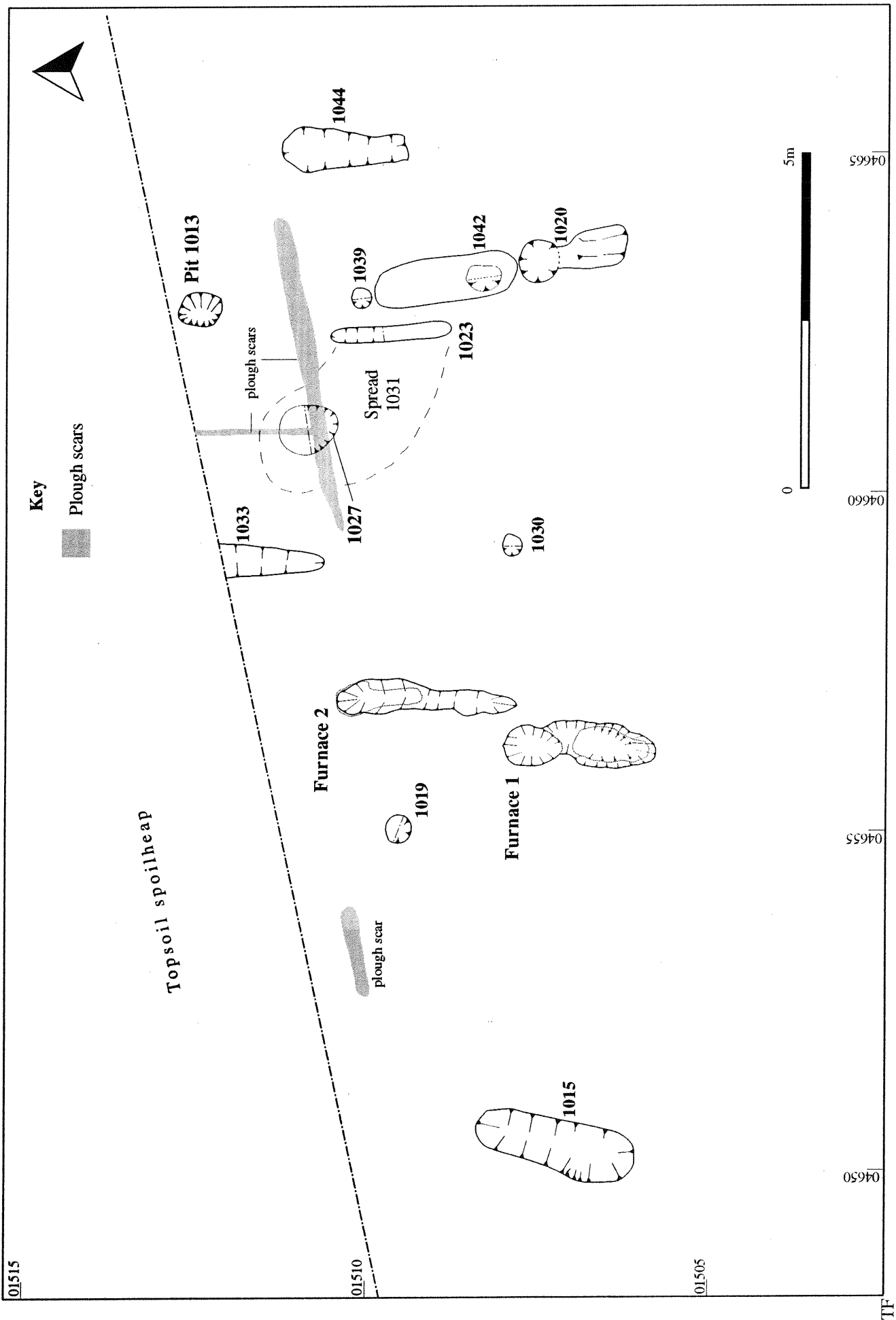


Figure 11 Plan of furnace excavation

Running out from these bands of discolouration was a flow of tap slag, visible even before excavation, which covered most of the northern half of the feature. The southern half appeared to be filled with a different, charcoal-rich material.

Upon excavation, the feature proved to be a shallow pit about 0.15m deep, filled with a dark brown sandy silt (1003), which contained a wide range of coarse components, including charcoal and possible fired clay furnace structure fragments, as well as gravel and limestone fragments. Within this was a single solid flow of tap slag weighing over 12.2kg. This was clearly *in situ*: it was found in one solid lump, but broke into several pieces when lifted. It was much too brittle to have been lifted and redeposited in antiquity without breaking into several pieces. There were also several other fragments of tap slag within 1003, amounting to a total of 5.5kg.

In the centre of the feature was a deposit of yellowish-brown clay (1006) which appeared to have been placed on the base of the pit and formed a barrier across it. South of this clay barrier, the feature was slightly deeper (0.17m) and the fill was different. This fill (1005) was a very dark greyish-brown slightly silty sand, containing charcoal, limestone fragments and gravel. Only a little tap slag (201g) was recovered from it. The clay barrier may have been placed across the pit in order to contain the flows of tap slag within the northern half.

Once the feature was excavated, it became clear that the discoloured area, which extended along the base of the pit for 1.25m from the north end, was not a remnant of the furnace structure, but rather showed the area of the base of the feature where the underlying clay substrate had been scorched and baked by intense heat. No traces were in fact found of any furnace structure, and these remains are interpreted as the truncated base of the furnace foundations only.

Charcoal from the fill of the northern half of the furnace pit (1003) gave a radiocarbon date in the Middle Saxon period (see below, page 00)

Furnace 2 (fig. 12)

Furnace 2 (1008) lay about 2m north and east of furnace 1. Superficially, it appeared as an irregular sub-oval pit similar to furnace 1, but was a little smaller at 1.9m long and 0.4m wide. As with furnace 1, the outline of the northern end of the furnace pit was rounded or semi-circular. Around this rounded end lay bands of red and blue discolouration, similar to furnace 1. Slag was also visible on the surface of this feature, but to a lesser extent than with furnace 1.

Upon excavation, the furnace feature was found to be a shallow pit, 0.16m deep at the northern end, but becoming progressively shallower as it ran southwards. It contained two fills, separated by a layer of tap slag. The total weight of this tap slag was 5221g. The lower fill (1010), below the tap slag layer, was a dark brown sandy silt, containing occasional small rounded stones. The upper fill (1007), above the tap slag layer was a brown sandy silt, containing frequent large lumps of tap slag with a total weight of 7kg, and moderate amounts of fired clay fragments, perhaps derived from the furnace

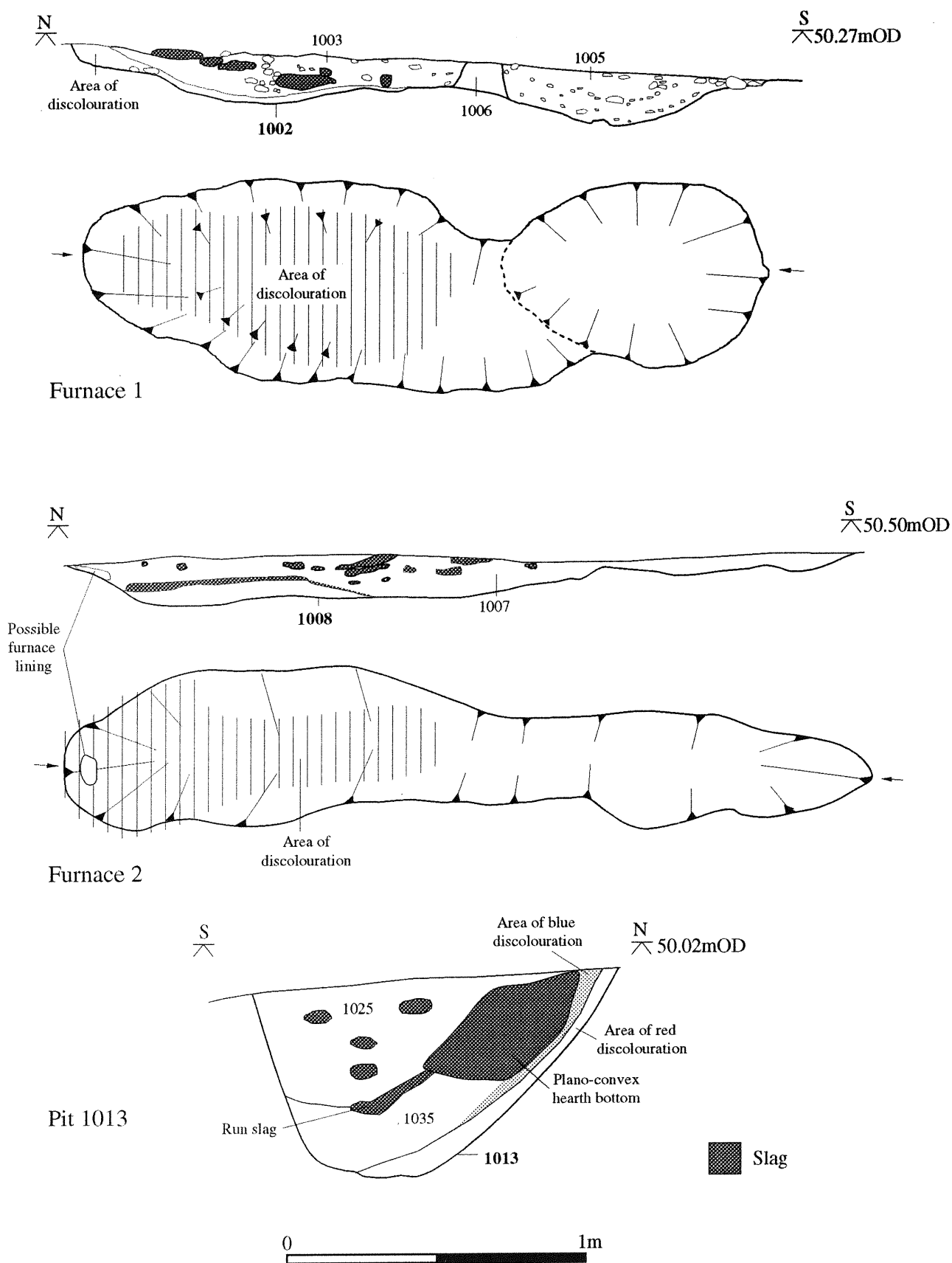


Figure 12 Plans and sections of furnaces and pit 1013

superstructure, as well as occasional chalky flecks and charcoal fragments. At the north end of the feature, within 1007, was a fragment of fired clay 90mm x 140mm and c30mm thick which may have been part of the furnace lining. Once the feature was excavated, a discoloured area was observed extending along the base of the pit for 1.24m from the north end, similar to that seen in furnace 1. This presumably showed, as with furnace 1, the area of the base of the feature where the underlying clay had been baked by intense heat. As with furnace 1, no trace survived of the furnace superstructure, apart from the fired clay fragments mentioned above.

A Possible Smithing Hearth or Furnace (fig. 12)

About 6m north-east of furnace 2 was a third feature, 1013, consisting of a roughly-circular pit about 0.60m in diameter and 0.33m deep, with steeply-sloping sides and a flat base. The natural silty clay into which the feature was cut appeared to be heavily discoloured by heat in places. This discolouration extended around the northern half of the pit, and penetrated to a maximum depth of 40mm into the natural clay. There were two distinct layers in the discoloured area, an outer, more extensive layer coloured red, and an inner layer, covering a smaller area of the pit, coloured a dark bluish-black. There was a distinct difference in texture between the two different-coloured layers: the reddish layer was soft whilst the dark bluish-black layer was brittle. Above this area of discolouration, the basal fill of the pit (1035) was a very dark brown firm silty clay, containing frequent charcoal fragments. Above this lay a large mass of ironworking residues of at least two distinct types (a plano-convex hearth bottom and some run slag), which are described below. Above this complex of residues was the top fill of the pit (1025), which was identical in all respects to the basal fill 1035, except that it also contained occasional lumps of slag (mostly run slag) amounting to a total of 566g.

Charcoal from the top fill of the pit (1025) gave a radiocarbon date in the Middle Saxon period (see below, page 00)

Possible Associated Features (fig. 11)

About 1.5m south-west of pit 1013 lay a spread of dark yellowish brown sandy silt, 1031. This deposit appeared in plan as an irregular oval, about 3m long and 2m wide, extending north-westwards from just west of feature 1023. It was thin, with a maximum depth of 0.02m, and contained occasional charcoal flecks and occasional limestone fragments. The deposit's relationship with feature 1023 could not be established, and its horizontal limits were difficult to define clearly. Plough scars cutting into the top of this deposit demonstrated that it had been truncated.

In the centre of its north-west end, 1031 was cut by a sub-oval feature, 1027. This was 0.98m long, 0.78m wide and 0.11m deep. Its base was flat and level, although the deposit through which it was cut and the underlying natural sloped away to the south and west. This feature had a single fill, 1026, which was a dark yellowish brown silty sand containing moderate amounts of charcoal, mostly concentrated towards the top of the fill, occasional fragments of

ironstone and occasional small (10 - 30mm max. dimension) fragments of slag. Plough scars also cut into the top of this fill.

Fill 1026 was sampled (for floatation and environmental study originally) and the heavy residue was examined with a magnet. This produced a large amount of magnetised fragments of ironstone, and 4 slag spheres, but no hammerscale.

Possible Ore-Roasting Pits (fig. 11)

Several pits adjacent to the furnaces were found to contain charcoal and burnt ironstone, with evidence of burning at the pit base. Pit 1015 lay at the extreme western end of the cleaned area, about 5m west of furnace 1. Upon excavation it was found to be an irregular oblong 2.55m long, 0.8m wide and 0.16m deep with an irregular base. It had two fills: the basal fill, 1021, was a dark red firm silty clay, containing occasional charcoal flecks. Apart from the colour and the charcoal flecks, this was superficially similar to the substrate into which the feature was dug, which was a dark yellowish brown silty clay. Above this was a second fill 1014, which was a dark greyish brown silty clay, containing frequent charcoal lumps and a large quantity (2000g) of burnt ironstone. No other artefacts were found in this pit.

Pit 1033 lay at the northern edge of the excavated area, about midway between furnace 2 and pit 1013. It ran into the northern edge of the excavation area and under the topsoil spoil heap. Upon excavation it proved to be an irregular oblong depression, its long axis running north - south. It was at least 1.40m long and 0.46m wide, but only 0.04m deep. The single fill, 1032, was a dark greyish brown silty clay, containing a moderate amount of charcoal flecks and lumps and occasional burnt stone fragments. Although no finds were recovered from this fill, cleaning over the surface of the feature produced 1716g of slag.

Pit 1044 lay at the extreme eastern edge of the excavated area, about 2.5m south-east of pit 1013. In form it was an irregular oblong, 1.4m long, 0.5m wide and 0.05m deep. The single fill, 1043, was a dark greyish brown silty clay containing frequent charcoal fragments and occasional fragments of burnt stone. A small quantity of slag (93g) was the only artefactual material from the fill.

Possible Structural Features (fig. 11)

Feature 1023 lay c1.5m south of pit 1013 and c5m east of furnace 2. It was a parallel-sided linear feature, 1.79m long, 0.27m wide and 0.06m deep. It had vertical sides and a flat base and ran almost exactly north - south. The fill, 1022, was a dark yellowish brown sandy silt containing very frequent flecks and larger fragments of charcoal, as well as occasional fragments of slag and ironstone. The charcoal content of the fill was such that, when first uncovered, it appeared completely black.

Post hole 1019 lay c2m north-west of furnace 1. It was roughly circular, about 0.55m in diameter and about 0.22m deep. It had vertical sides and a flat base. The single fill, 1018, was a brown sandy silt containing frequent ironstone fragments and occasional charcoal flecks.

Post hole 1030 lay c2m east of furnace 2. It was oval, 0.38m long, 0.31m wide and 0.18m deep. The single fill, 1029, was a brown silty clay containing occasional charcoal fragments, burnt stone fragments and pebbles. No artefacts were found within the fill.

Post hole 1039 lay just to the east of feature 1023. It was circular, about 0.25m in diameter and 0.13m deep. It had vertical sides and a flat base. The single fill, 1038, was a dark brown silty sand, containing occasional charcoal flecks, occasional angular limestone fragments and occasional small pieces (10 - 30mm) of slag. Apart from the slag, there were no other artefacts from the fill.

Remaining Features (fig. 11)

Feature 1042 lay c2.5m south of pit 1013. It consisted of an irregular oblong area of natural, about 2.40m long and 0.60m wide and aligned roughly north-south. The naturally-occurring silty clay, limestone and ironstone within this area had been discoloured to a dusky red by intense heating. In the centre of this reddened area lay a shallow, roughly oval depression about 0.60m long, 0.45m wide and 0.04m deep. This was filled with a dark brown sandy silt, containing frequent charcoal lumps, occasional burnt ironstone fragments and fragments of burnt and unburnt limestone.

Feature 1020 lay immediately to the south of feature 1042 and had the same alignment. It was an irregular oblong 1.43m long, 0.60m wide and had a maximum depth of 0.16m. It had a single fill, 1024, which was a dark yellowish brown firm sandy silty clay, containing moderate amounts of angular limestone fragments, fragments of burnt ironstone and fragments of charcoal. Once excavated, the base of this feature showed evidence of burning in the form of reddening of the underlying natural.

7.6 The Finds

No metal artefacts of any kind were recovered during the excavations, in spite of an intensive metal-detector survey. There was likewise no pottery from any of the features and the only artefact recovered from a feature (as opposed to surface finds) was a single flint blade of Mesolithic date recovered from the fill of furnace 1.

Lithic Artefacts

A total of 23 lithic artefacts (including the flint blade from the furnace) were recovered during this second-stage excavation, mainly as surface finds. This assemblage fitted well within the overall assemblage recovered during fieldwalking and could be classified as Mesolithic. These flints presumably derive from the same source as those found by fieldwalking. A separate report (by Dr Twigs Way) on the lithic artefacts recovered during the furnace excavations appears in appendix 2 below.

7.7 Phasing and Dating

The almost complete lack of artefacts from the site lead to a search for alternative methods of dating the furnaces. Two possible scientific dating methods were contemplated, archaeomagnetic dating of the fired clay at the bases of the furnaces, and radiocarbon dating of charcoal from the fills of the furnaces and pit 1013.

Archaeomagnetic Dating

Dating by archaeomagnetic methods was attempted with the lining of one of the furnaces (furnace 1). A separate report on the methodology and detailed results of the archaeomagnetic dating by Dr Mark Noel is included in the project archive. The archaeomagnetic date given for the last firing event in furnace 1 was 1540 - 1700 AD (Noel 1997).

Such a post-medieval date for this furnace, however, is very unlikely to be correct. No records of post-medieval iron smelting in this area are known, and by this date, the land here was part of the open fields of Wittering (Hall appendix 1 below and see fig. 18). By this time, the predominant method of iron production was by the blast furnace (Tylecote 1992). Although bloomeries continued in use in Britain at least until the 17th century, such small scale furnaces as the Bonemills Farm examples are unlikely to date from the post-medieval period. The date may well therefore be aberrant, perhaps affected by the presence of a large mass of iron in this or a neighbouring furnace (Noel pers comm).

Radiocarbon Dating

Charcoal from the fill (1003) of furnace 1, and from the fill (1025) of pit 1013 were submitted for radiocarbon dating to Beta Analytic, inc, of Miami, Florida, USA. Before submission, the charcoal samples were submitted to a wood anatomist for identification to genus. A separate report (by Rowena Gale) on the charcoal identifications appears in appendix 3. the radiocarbon determinations were as follows:

Furnace 1

Oak (*Quercus* sp) sapwood from (1003)

Lab. no. Beta-111221 1350 +/-80 BP

cal AD 575 to 875 (2 sigma, 95% probability)

Pit 1013

Elder (*Sambucus* sp) charcoal from (1025)

Lab. no. Beta-111222 1230 +/-50 BP

cal AD 680 to 905 and cal AD 920 to 950 (2 sigma, 95% probability)

These two dates are not statistically significantly different at 95% confidence (Ward and Wilson 1978). This means that they could in fact be exactly contemporary.

7.8 Metalworking Residues

All excavated metalworking residues were weighed and quantified, then sorted and classified on morphological criteria, using the categories set out by MacDonnell (1992). During the excavation a magnet was used to detect the presence of micro-residues such as spheroidal slag and hammer scale. Following processing (floatation) of the environmental samples, the heavy residues from these were also tested with a magnet and the magnetic material extracted and examined by eye.

By far the most abundant metalworking residue recovered from the site was tap slag. This was readily identifiable by its "ropey" flowed upper surface, which is the result of the semi-liquid slag cooling rapidly as it was tapped and allowed flow out of the furnace. Tap slag also has a characteristic blue/black lustre (MacDonnell 1992). Furnace 1 produced a total of 17.90kg of tap slag, and furnace 2 produced 12.22kg. All the slag deriving from these two furnaces could be identified as tap slag.

The quantity of slag from each of these furnaces was relatively small. In fact the total amount of slag from the site as a whole was well under 50kg. This can be compared with the amounts of slag found on nearby sites of Roman date (e.g. Laxton, Northants.), where deposits can be measured in cubic metres, with a total weight of several thousand tonnes (Crew 1998). Those deposits represent repeated use of the furnaces at Laxton over a number of years, whilst the slag from the Bonemills Farm furnaces could represent simply the residues resulting from a single operation of each furnace. At Laxton, as at many other sites, there was evidence of repeated relinings of the furnaces, as they were refurbished over a number of smelting campaigns. Similar evidence of relining appears to be absent from the Bonemills Farm furnaces, although the site had been heavily ploughed and it is clear that only the very base of each furnace survived.

The metalworking residues from pit 1013 were quite different. The lowest element in this complex was a large, thin (30mm max. thickness) flow of run slag, weighing 1804g. Run slag is slag that has been subjected to higher than usual temperatures, causing it to flow (MacDonnell 1992). The term is used here to denote slag with a characteristic "ropey" flowed surface and glossy blue-black colour, but which is clearly not tap slag.

Above this run slag was a single large lump of metalworking residue. Morphologically, this was a classic so-called plano-convex hearth bottom (PCB) (see fig. 13). A hearth bottom is slag that formed as a plano-convex "dish", with a rounded lower surface and a flat or dished top surface, in front of and below the tuyere (air inlet) in a smith's hearth. It is usually seen as the characteristic form of smithing slag. It is presumed to result from reactions between the iron oxide on the surface of the metal being worked and the flux, possibly silica sand, which was applied to the iron to prevent excessive oxidation of the metal, which blacksmiths call "burning". A thin layer of slag formed on the surface of the metal and excess slag then dripped off to form the hearth bottom in the base of the smithing hearth. The hearth bottom could build

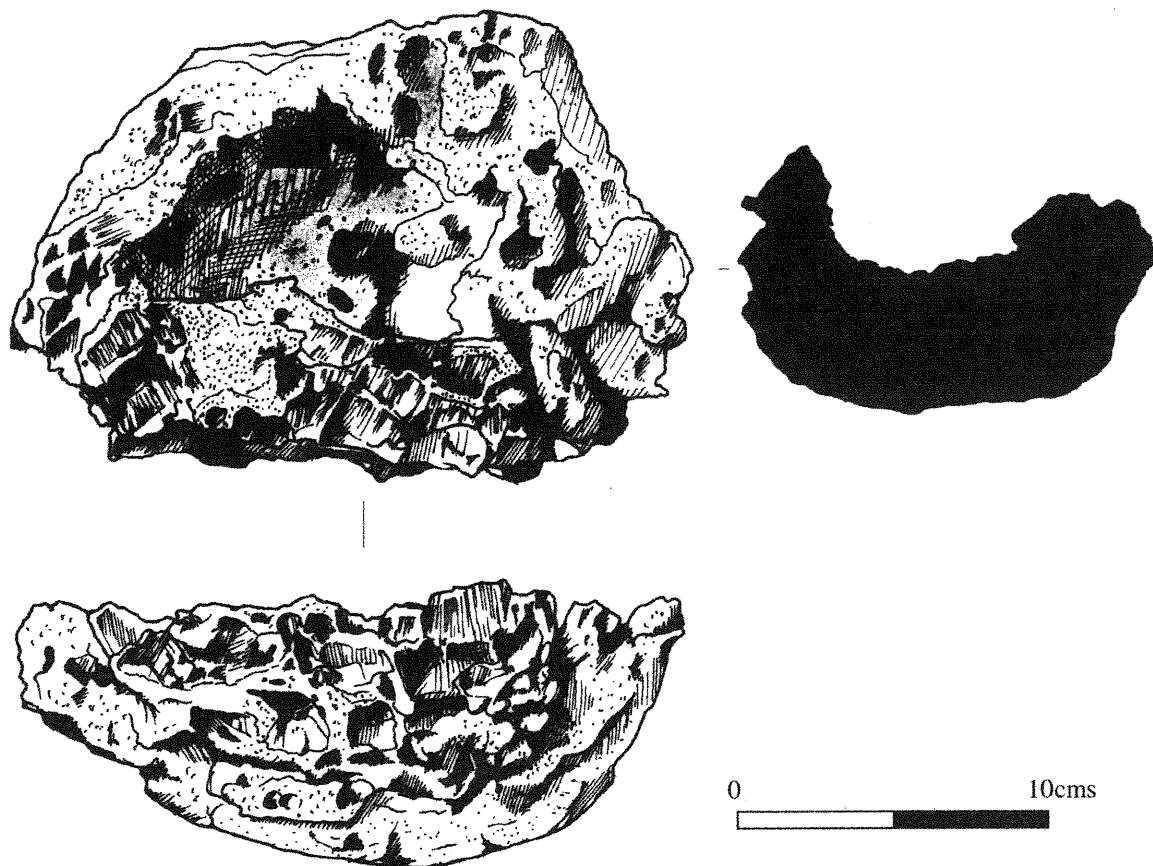


Figure 13 *Plano-convex hearth bottom from pit 1013*

up until it reached a size where it blocked the air blast from the tuyere, and had to be removed (McDonnell 1992).

The PCB from pit 1013 was very large and heavy, weighing 3000g. Its major diameter was 230mm and its minor diameter 140mm, with a maximum depth of 80mm (fig. 13). By contrast, the largest lump of slag mentioned in the report on the Middle Saxon site at Maxey, Cambs. (formerly Northants.) weighed 2lb (909g). This was probably a smithing residue, although the report is unclear (Biek 1964). In a comprehensive study of ironworking residues from 9th to 11th century levels at Coppergate in York, the range of weights for PCBs is given as 45 - 2100g, with the commonest size being 200-299g (McDonnell 1992 p474-5). The PCB from pit 1013 was clearly *in situ*, firmly attached to the fired natural clay forming the side of the pit; when it was removed, fired clay from the pit side remained adhering to its base.

Metalworking micro-residues, such as hammer scale and spheroidal slag, were also sought, both during the excavation and in the examination of environmental samples, as noted above. These are both diagnostic residues from smithing.

Hammer scale is formed on the surface of the iron during heating and broken off either by thermal shock or by hammering. Spheroidal slag is produced when liquid slag is expelled from a welded joint made by hammering together two pieces of very hot iron (McDonnell 1992). Testing of the cleaned surface of the excavation area with a magnet failed to produce any convincing metalworking residues. Heavy residues from the environmental samples were also tested with a magnet, and magnetic material separated for examination by eye. Almost all of the magnetic material recovered from the samples proved to be fragments of ironstone magnetized by heating (probably ore fines). One or two slag spheres and a similar number of flakes of hammer scale were recovered from 1005, one of the fills of furnace 1. From 1025, upper fill of pit 1013, came a single slag sphere, a few flakes of hammer scale and several prills of run slag.

7.9 Discussion - The Excavation

The interpretation of the two furnaces is reasonably straightforward. They are both small slag-tapping furnaces with an internal diameter of about 0.35m. Only the furnace bases were preserved, but it seems likely that a clay superstructure existed forming a shaft. The height of this is of course, unknown, but shaft furnaces are likely to have a height-to-width ratio greater than 2, giving a minimum height of 0.70m (Tylecote 1986). The fact that slag could be made sufficiently liquid to be tapped from the furnaces suggests that (depending on the composition of the ore used) a high operating temperature was reached, which in turn reinforces the idea of a shaft (Clough 1984). There is little evidence of continued or repeated use of the furnaces, in that there is no evidence of relining, although any such evidence may simply have been ploughed away. The relatively small overall quantity of slag (well under 50kg) from the site as a whole (and indeed from the fieldwalking that preceded the excavation) also reinforces the impression of occasional or limited production.

Interpretation of pit 1013, however, is more difficult. The plano-convex hearth bottom from 1013, at 3000g, is very large and heavy. As stated above, hearth bottoms are generally regarded as diagnostic smithing residues. Smithing in the bloomery process, however, takes place in two forms: primary smithing, which is consolidation and refining of the freshly-smelted bloom, and secondary smithing, which is forging iron artefacts out of bar-iron, previously prepared by primary smithing. A recent experimental study of prehistoric iron production has set out and replicated these processes in some detail (Crew 1991). The smaller PCBs are relatively easy to explain as products of secondary smithing. Larger hearth bottoms have been found before and are sometimes referred to as "furnace bottoms", but it is often difficult to say whether they are products of smithing or smelting (Tylecote 1986 p136).

In order to address the questions in the research design (para. 6.3 above), and especially question C, "What processes in the ore-to-artefact cycle were conducted on this site?", it is necessary to determine whether the very large PCB from pit 1013 represents smelting or smithing. Certainly, the shape of the slag from 1013 is absolutely characteristic of a smithing residue, even having the

dished top surface where the blast from the bellows blew the liquid slag to either side. Such a large slag may be thought unlikely to result from secondary smithing, since it is so much larger and heavier than those normally found and attributed to secondary smithing. Primary smithing (that is, initial refining of the bloom) does tend to produce larger amounts of slag (Crew 1991 and pers. comm.). It seems possible, therefore that the large PCB from 1013 may represent a slag from primary smithing, where a bloom was heated and hammered to consolidate it and remove excess slag.

Under these circumstances, one might expect to find large amounts of micro-residues, such as hammerscale and other fragments of slag (what are referred to as "anvil slags" in Crew 1991 p30) which are produced in abundance during the bloom smithing process. These would especially be found around the site of the anvil on which the bloom was forged. The small amount of these residues actually recovered, therefore, is hard to explain. Deposits containing smithing micro-residues from the area around pit 1013 may well have been disturbed and dispersed into the topsoil by ploughing over many years. Micro-residues might also be expected to occur in the smithing hearth. Examination of samples from the upper fill (1025) of pit 1013 yielded only a single slag sphere and a few possible flakes of hammerscale along with some small prills of run slag. These residues could all be products of bloomsmithing, but they are not abundant. the top fill of the pit, however, probably post-dates its use for metalworking, so perhaps this explains the lack of residues. Unfortunately the lower fill, 1035, was not sampled.

The possibility remains that the large PCB from 1013 could be a smelting residue. Pit 1013 would then be a furnace, but of a quite different type from furnaces 1 and 2, with no possibility of tapping the slag off during smelting. In this case it might be classified as a slag-pit furnace. In this type of furnace, the slag is not tapped off, but drips down into a pit dug below the working zone of the furnace, where it collects as a large "cake" of slag.

The radiocarbon dates from pit 1013 and furnace 1 are very closely contemporary. It might be considered unlikely that two such different smelting techniques could be in use at the same time within a few metres of each other. In fact, it is not uncommon to find two or more different types of furnace on smelting sites. This occurred at Wakerley, where there were three types of furnaces (Jackson et al. 1978), including both slag-pit and slag-tapping types. At Ramsbury, Wiltshire, four furnaces were found and dated by radiocarbon to the late 8th to early 9th centuries. Of these, only the latest had slag-tapping facilities (Haslam et al. 1980). The author saw this as evidence of a developing and improving technology, and this idea of technological progress often appears in the literature, although the absence of close dating for many excavated furnaces causes problems.

In fact, there is growing tendency to reject the idea of a rigid classification or typology of furnaces, which in the past has been used for culture-historical reconstruction and has been strongly influenced by the 19th-century idea of "progress". Rather, furnace dimensions and characteristics, such as slag-tapping

or non slag-tapping, are seen as related to functional considerations such as ore composition and the desired final product (Clough 1984 p27).

If the difference in technology between furnaces 1 and 2 and pit **1013** is no objection to the latter's identification as a furnace, nevertheless, the residues found in it are not those normally associated with slag-pit furnaces. Such residues are known from Mucking, Essex and Aylsham, Norfolk. The Mucking example is probably Saxon, but neither of these finds are well stratified (Tylecote 1986). The Mucking find weighs 24kg and that from Aylsham about 50kg; the published photograph of the Aylsham slag-pit furnace bottom (*ibid.* fig 81 p135) looks completely unlike the residues from pit **1013**.

The final possibility is that the material in pit **1013** results from a failed smelt (Crew pers. comm.). If **1013** were a furnace blown with a single tuyere, the slag might form sticking to the furnace wall like a PCB. This would normally be where the bloom formed and slag and bloom together would be extracted from the furnace for further refining (Crew 1991 p26, fig. 1) It is possible that the bloom did not form and only slag was produced, but this does not seem a particularly likely explanation.

In concluding this discussion of the very unusual metalworking features found at Bonemills Farm, it should be stated that explanation has been hampered by the apparent lack of comparable finds to those made in pit **1013**. The author's casual search of selected literature cannot be described as exhaustive, but nevertheless, has not located any similar feature. In the author's opinion, the most likely explanation for pit **1013** is that it represents a smithing hearth where primary smithing took place: that is, where blooms, smelted in the adjacent and contemporary furnaces, were heated and hammered in order to refine and consolidate them, remove excess slag and prepare them for further manufacture elsewhere into finished iron objects.

Discussion - Possible Associated Features (fig. 11)

The proximity of feature **1027** to pit **1013** makes it tempting to associate it with some aspect of the ironworking process. Nevertheless, there is in fact no other evidence to link these features together. There is not even any evidence that they are contemporary, since **1027** remains undated. The presence of slag fragments within the fill of **1027** proves little. One possible ironworking installation, however, which might conceivably create such a feature would be a large tree stump or block of wood, which could have acted as a base for an anvil. If **1027** were to represent the location of an anvil used for smithing, one might expect to find hammer scale and spheroidal slag around it (McDonnell 1992 p475). The absence of hammer scale, then, and small quantity of spheroidal slag actually found is difficult to explain. It is possible that significant deposits containing diagnostic residues have been removed by ploughing, but in the end there is no conclusive evidence to link **1027** with pit **1013** or with any of the metalworking processes that occurred on the site.

Discussion - Possible Ore-Roasting Pits (fig. 11)

The factor which links all of the possible ore-roasting pits together is the evidence they all contain for *in situ* burning. Not only do they all exhibit reddening of the underlying natural of their bases, but they also all contain charcoal and reddened, burnt ironstone within their fills. Ore roasting, which is the heating of the broken-up ore in a wood fire in order to dry it out and break it down even further, is a normal preliminary step in the iron-making process (McDonnell 1995). Similar features have been excavated on a site at Wakerley, Northants., about 10km west of Bonemills Farm (Jackson et al. 1978). These are described as "channel hearths" and it is suggested they were either for ore-roasting prior to smelting or for forging the bloom after its removal from the furnace (ibid. p165). The presence of what is apparently roasted ore in the Bonemills farm features strongly suggests the former explanation.

Discussion - Possible Structural Features (fig. 11)

It is difficult to make sense of any of these possible structural features. Their proximity to the furnaces and other metal working features might suggest that they were contemporary with them, and could be associated with them in some way. Nevertheless, they do not readily form themselves into any coherent structural arrangement. The most convincing of them is **1023**, which resembles a beam slot, but this is so short (1.79m) that it is unlikely to represent part of a building. Its proximity to **1013** makes it tempting to suggest that it functioned with this feature in some way, perhaps as a foundation for a windbreak, a useful structural adjunct to any high temperature process. The beam slot's north-south alignment, however, and its position relative to both **1013** and the furnaces may reduce the likelihood of this explanation; it lies due south of pit **1013** and east of the furnaces, and could have provided little shelter from a (presumably) west or south-westerly prevailing wind.

The charcoal-rich fill of **1023** presumably derives from and is contemporary with smelting or forging operations, since that is when a large amount of charcoal is likely to have been present on the site. Recent experimental work has confirmed the very large quantities of charcoal that are required during the smelting process (Crew 1991, p21). If this fill is in turn associated with the disuse and backfilling of **1023**, then it is possible to see this feature as belonging to a structure that was already demolished by the time smelting was taking place on the site. The short length of the slot may suggest that it represents only part of the evidence for a structure, the remainder of which has either been destroyed by ploughing, or lies beyond the northern edge of the excavation, under the spoil heap.

Alternatively, the short length of **1023** may suggest that it is not structural, but had some other function. Although it is shorter and narrower than the supposed ore-roasting pits, it is narrow relative to its length like they are. In shape, **1023** strongly resembles the "channel hearths" from Wakerley (Jackson 1978 p154), which were interpreted as ore-roasting pits or smithing hearths (though the latter explanation now seems unlikely). It is possible therefore that **1023** had a similar kind of function associated with ironworking. The charcoal-rich fill might perhaps suggest that it was connected with charcoal production in some way.

It is tempting to associate all of the possible structural features together and suggest that they all belong to phase of occupation that pre-dates the metal working features and has only been partially uncovered by the present work. The complete absence of dating evidence for them, and the lack of any stratigraphic relationships between them, however, makes a definitive interpretation difficult.

Discussion - Remaining Features (fig. 11)

The similarity of the alignment and width of 1020 to that of 1042 suggests that the former may simply be the southward extension of the latter. 1042 appeared to be an area of burnt natural rather than a cut feature, whilst 1020 was clearly a cut with a single fill. Both features, however had evidence of *in situ* burning; both had clearly been affected by ploughing, and what remained of 1020 was fairly shallow in depth at 0.16m. It is possible that these two features together represent the truncated remains of a single, shallow oblong pit, reminiscent of those interpreted as ore roasting pits elsewhere on the site (cf. 1015, 1033, etc.).

8 CONCLUSION

Pipeline Archaeology

The environmental benefits of pipelines are unquestioned: there can be few better ways of transporting bulky, possibly dangerous materials across country than through underground pipes. In the case of a water pipeline, one has only to turn on the tap to appreciate the benefit.

Cross-country pipeline construction, however, is complex and construction schedules rapid. Archaeological considerations are only one of the many apparently peripheral issues that pipeline engineers must take into account. From an archaeological perspective, though, the timing of the work is absolutely vital. The time between the discovery of a new site and its obliteration is, in this environment, potentially very short. Having an archaeological presence continuously available during construction means that important archaeological remains have the best chance of being properly recorded. The present project has graphically demonstrated this.

The discovery, recording and above all the secure dating of the Middle Saxon furnaces at Bonemills Farm is of considerable importance, not only regionally within Cambridgeshire, but also nationally. In conclusion, an attempt will be made to put these finds into their local, regional, national and period context.

The Middle Saxon Furnaces in Context

Iron smelting has been going on throughout Leicestershire, Rutland and Northamptonshire since Roman times. a recent survey of Roman iron production (Condon 1997) has suggested that specialist smelting activities had grown up here by the 1st century AD and that the East Midlands may have served as source of iron for a wider area. This Roman exploitation of local iron resources certainly extended into western Cambridgeshire and the Peterborough region.

geological resources do not respect political boundaries, and the outcrops of iron ores at or within 3m of the surface that were exploited by the Romans follow the Jurassic and Liassic ridge which runs from Oxfordshire to Lincolnshire and extend as far east as Water Newton, Cambridgeshire. The site at Bonemills Farm lies on Northampton Sand Ironstone, within which a readily-available ore source existed (see appendix 4).

It is interesting to note that the site also appears to be situated at the edge of the local Northampton Sand Ironstone deposit, right at the point where the underlying Oxford Clay outcrops in the valley side. This location may be fortuitous, or may reflect a deliberate selection of a site with local sources of the natural materials needed for furnace building and smelting - iron ore and clay. The other natural resource required was extensive woodland for making charcoal. Recent experimental work has shown that vast quantities were required in the smelting process, perhaps as much as 100kg of charcoal for every 1kg of finished iron produced (Crew 1991). It is interesting to speculate, in the light of the apparently short-lived nature of the ironworking at Bonemills Farm, whether the exhaustion of local woodland resources, either by over-exploitation for charcoal, or through clearance for other purposes such as agriculture, forced the smelters to move on.

Unfortunately, our knowledge of Middle Saxon environment and settlement patterns in this region are very sparse. Evidence of any kind of activity of Anglo-Saxon date within the area traversed by the pipeline is also very sparse. Within Wittering parish, there have been finds of early Saxon material in the form of cremation urn sherds (found south of the pipeline route in the field west of Diamond Jubilee Plantation, about 1km east of the site of the furnaces), and Wittering church contains some late Saxon fabric, but this is all. This lack of Anglo-Saxon finds was highlighted by the desk-based assessment (Denham 1997), but it was noted that this probably reflects a lack of archaeological investigations rather than a real lack of Saxon occupation in the area.

The earliest traditions of the foundation of Peterborough assert that Peada, son of king Penda of Mercia founded a monastery at *Medeshamstede*, as Peterborough was then called, in the mid-7th century. Why Peterborough should be chosen is hard to know, but many early monasteries south of the Humber were founded at or very close to a royal palace (Mackreth n.d.). Why there should be a Mercian royal palace here is again, hard to know, but the natural advantages of *Medeshamstede* were many, according to the 12th century author Hugh Candidus. Perhaps in addition to its fen-edge location and easy access to the sea, one of the area's other attractions in Middle Saxon times might have been its iron resources.

Dated evidence of smelting here in the Saxon period is virtually absent, however, and the present finds appear to be the first securely-dated evidence for Middle Saxon iron smelting found in the Peterborough region. Nevertheless, Evidence for iron smelting and smithing dating to the Saxon period has of course been found elsewhere in England. In general, though, this is evidence of smithing, rather than smelting, and often it is in the form of residues from either process

which are not found *in situ*. In *Hamwic*, for example, a Saxon smithy has been excavated at Six Dials. This consisted of a single shallow pit containing slag and charcoal, although there is no suggestion that the slag was *in situ* in the way it was at Bonemills Farm. There were also associated spreads of slag and charcoal, clay floors and evidence of timber buildings (Youngs et al. 1987). In Ipswich, evidence of smithing has been found in the form of slag, again not *in situ*, but in considerable quantities, with 217kg of slag and industrial waste coming from later 9th century contexts (Nenk et al. 1991). From London, there is evidence from a site at 2-26 Shorts Gardens and 19-41 Earlham Street of smithing, and possibly smelting too, (although the preliminary report is a little ambiguous) which has been dated by archaeomagnetic methods to the 8th century. Large amounts of slag and micro-residues and many iron objects were recovered, along with a broken stone anvil, and it seems clear that iron artefact production, at least, was going on here in a fairly intensive fashion in Middle Saxon London (Connor 1990).

Direct evidence of smelting (i.e. *in situ* furnaces and slags) is less widespread in Saxon contexts, but there is evidence of Saxo-Norman (11th century) furnaces at Stamford, Lincolnshire (Mahany et al. 1982). In Northampton, the site at St Peter's Street produced evidence of smelting from the 10th century. Two furnaces were excavated here, one a slag-tapping furnace, the other non slag-tapping, but contemporary with the first. There was also some elusive evidence of Middle Saxon smelting in the form of tap slag and furnace bottom amounting to a rather small total of 1.5kg. (Cleere 1979).

The best evidence for Middle Saxon smelting known to the author is from Ramsbury, Wiltshire (Haslam et al. 1980) and has already been alluded to above. Here, there was a total of four smelting furnaces, the latest having slag-tapping arrangements. There was evidence of continuous use of the site for metalworking over a number of decades, generating large quantities of slag. There was also evidence of the importation of ore to the site, possibly from up to 30km away. There was evidence of smithing and artefact manufacture, but the excavated smithing hearths bear no resemblance to pit 1013 at Bonemills Farm. Smithing hearth 117, for example was a shallow, elongated hollow in the natural, 1.6m x 0.8m and 0.15m deep. There was evidence of *in situ* burning in the form of reddened patches in the sides, and it was filled with fine charcoal and smithing waste (presumably smithing slag), but nothing like the *in situ* PCB from Bonemills Farm appears to have been found. the site was dated by radiocarbon to the late 8th to early 9th centuries.

The common factor in all of the above parallels is the urban nature of the sites mentioned. In part this is a function of the elusive nature of Saxon rural settlement sites, especially in the Middle Saxon period, and in part it is a function of the nature of Saxon urbanism: craft specialisation in things like blacksmithing, production in static workshops and importation of raw materials are part of the urban adaptation. Even Ramsbury, which was not a Middle Saxon town, was nevertheless, it is argued by Haslam, an important place, probably a royal estate, which with its intensity of ironworking and importation of raw materials, could perhaps be regarded as proto-urban (Haslam et al. 1980).

What then was happening in the countryside? If we look at excavated early Saxon sites, West Stow, for example, there was evidence of smithing here in the 5th to 7th centuries. This took the form of smithing hearth bottoms and other smithing slag. Although no quantification is given, the sense is of small-scale secondary smithing only. There was no evidence to suggest smelting on the site (Macalister 1985). At the Middle Saxon settlement site at Maxey, although the report suggests that both smelting and smithing were demonstrated by the slags, the total weight of slag recovered was only 12lb (5.5kg). There was also no evidence for *in situ* slags or furnaces (Biek 1964).

At Wharram Percy, North Yorkshire, two Middle Saxon smithing hearths were excavated in toft 10, site 59. these were shallow, bowl like pits, apparently quite unlike pit **1013** from Bonemills Farm. One of the hearths gave a radiocarbon date of ad 730 \pm 80. There was evidence for protracted use and around the hearths were scattered large amounts of smithing slag. There was no evidence, however, of smelting on the site (Youngs et al. 1983).

The model one might postulate, therefore, for ironworking in the Middle Saxon period, at least away from towns and proto-urban centres, royal estates or other special places, is of smelting taking place near to where the raw materials required (iron ore, clay, wood for charcoal) could be found. From here, finished iron, perhaps in bar form, would be taken to the settlements, where it was finally smithed into artefacts.

In conclusion, we can now answer the questions posed in the research design for the Middle Saxon furnace excavation (see para. 7.3 above). It is clear that at Bonemills Farm ore, probably from local deposits, was first roasted in pits on the site before being smelted in at least two shaft furnaces, where slag was tapped off as part of the process. Following smelting, primary smithing or bloom smithing took place nearby in at least one adjacent hearth of so far unparalleled design. Blooms were smithed into billets of semi-finished iron, but there is no evidence of the manufacture on site of finished iron artefacts. All of these activities took place, over what was probably a fairly limited time span, at some time during the Middle Saxon period.

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APPENDIX 1.

HISTORIC LANDSCAPE AND LANDUSE ALONG THE PIPELINE ROUTE

David Hall

The pipeline route begins at Duddington on the River Welland, crosses the River Nene, and continues farther south to Chesterton. Although not very lengthy, it traverses several types of historic landscape, some of them no longer obvious with effects of enclosure, 19th century woodland removal and modern agriculture. The varied geology of riverine gravels, interleaved beds of ironstone, limestone and clays, with drift deposits of Till (boulder clay) as well as sand from decalcified limestone, was particularly attractive to peoples from the earliest times, and hence the abundant archaeology.

The historical setting of the area is that it lies in the two counties of Huntingdon and Northampton, part of the East Midlands that was once dominated by intensive open field agriculture. Remnants of the intermixed strip holdings are visible as ridge and furrow, preserved, for instance in Peter's Nook, Duddington, SP 9845 9915. However, much of Northamptonshire crossed by the pipeline was not dominated by strip fields but formed part of the royal Rockingham Forest, being the eastern section known as Cliffe Bailiwick, and administered from King's Cliffe where there was an enclosed park used for hunting deer.

The royal parks were disparked and the wood removed during the Commonwealth in the 1650s, and by the late 18th century much woodland had been sold or otherwise removed from the crown's jurisdiction. The complicated woodland rights of various parties were resolved by a series of enclosure acts made 1796-1834. This led to further removal of woodland north of King's Cliffe, mainly in the 1860s, giving rise to a landscape that today is more open than formerly.

As can be seen from Figure 00, the extent of the woodland and the associated Cliffe Park was once very great. As well as being used primarily for deer hunting and as a source of timber, the woods had other functions: neighbouring villages were allowed to graze their animals and underwood was cut for fuel and charcoal production. Charcoal was needed on the industrial scale as fuel for pottery kilns and iron smelting.

Historical references for the management of timber and underwood are abundant, as described in an account of the history of Northamptonshire forests in the 17th century (Pettit 1968). Woods were divided into compartments of c.20-80 ha, surrounded by ramparts, called coppices. They were felled every 20 years or so, leaving timber trees (about 11 to the acre) to mature and taking the underwood for fuel and other uses. Deer and village animals were excluded

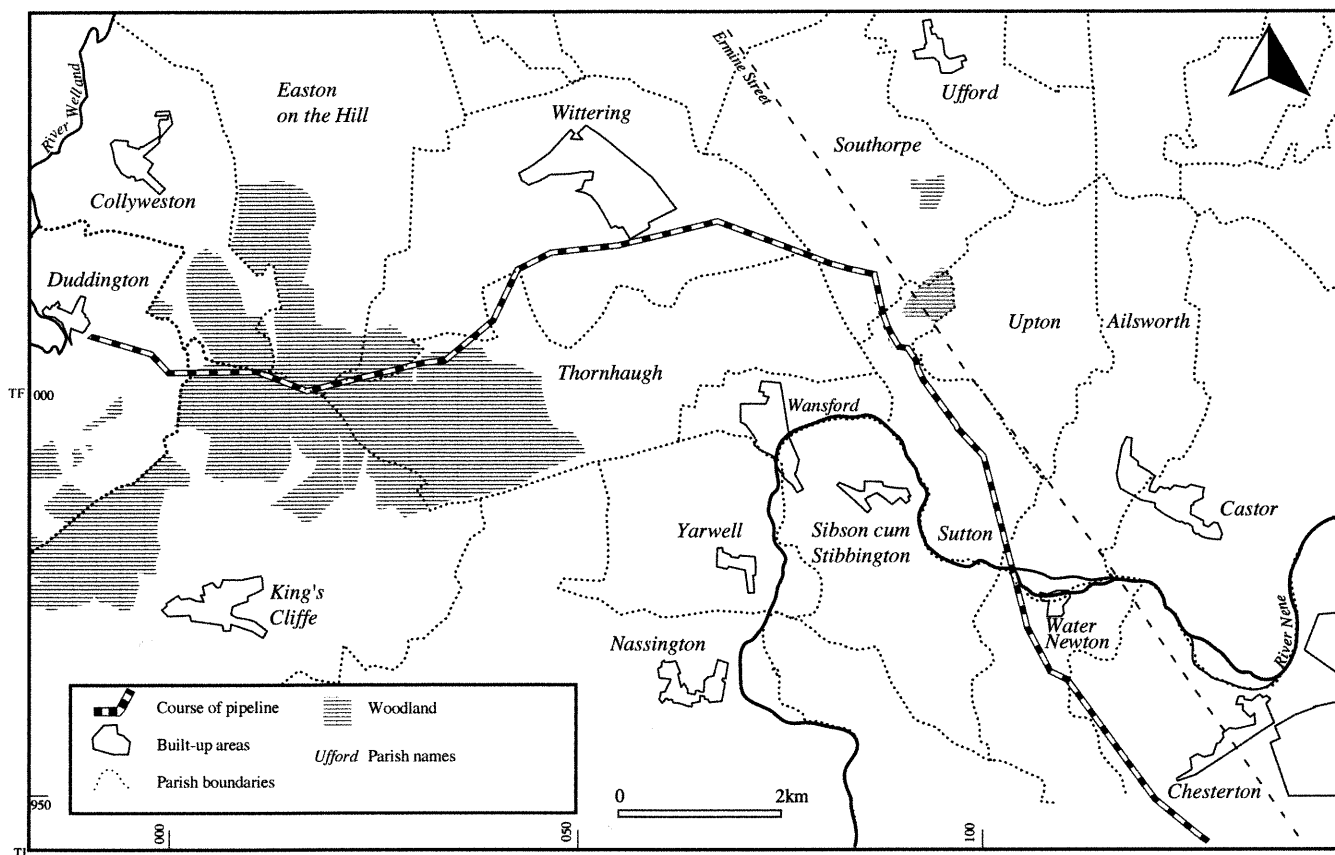


Figure 14 Historic landuse along the pipeline route - woodland

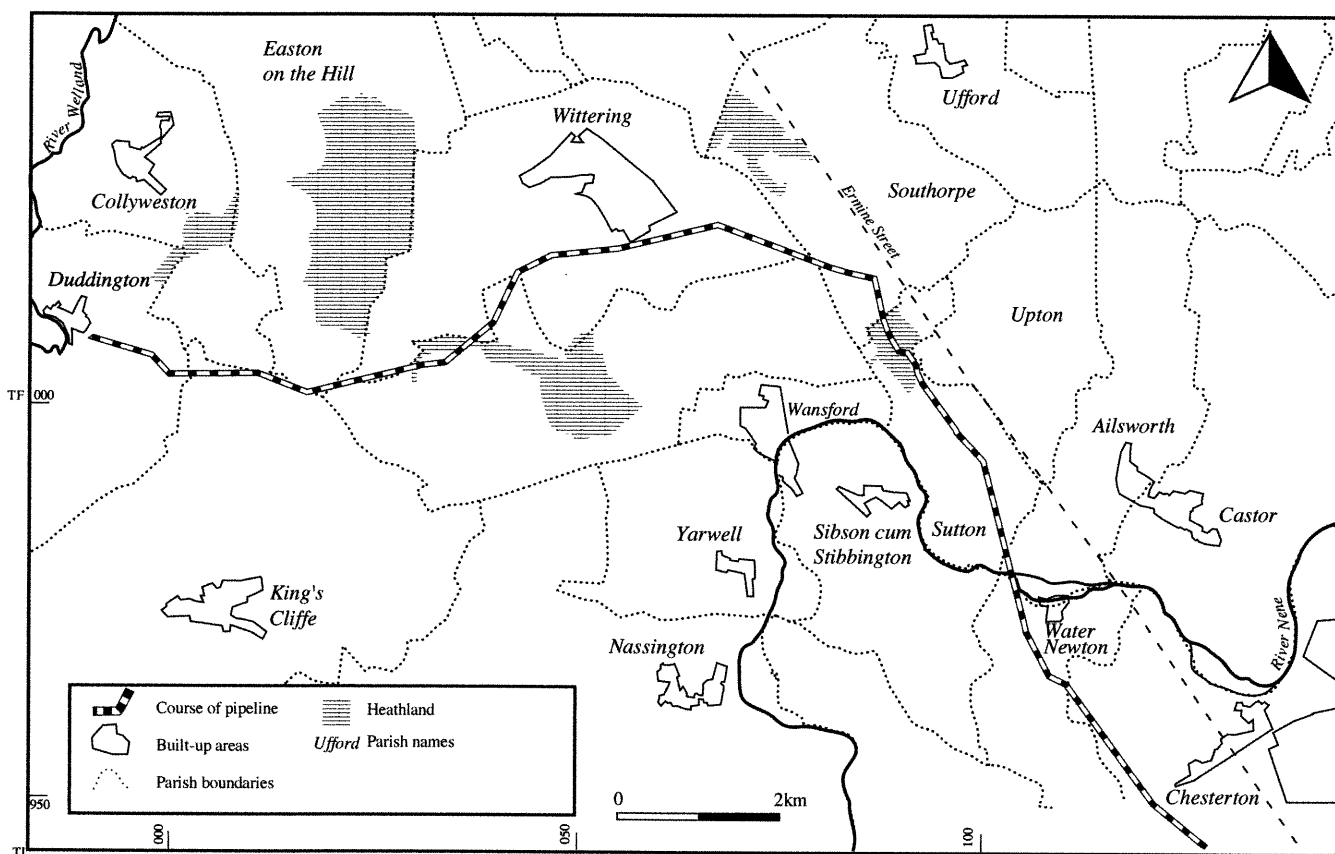


Figure 15 Historic landuse along the pipeline route - heathland

from the coppices for 7 years by heightening the ramparts with temporary fences, which allowed stumps to sprout and regenerate naturally into underwood. Likewise, the management of deer parks can be deduced by studying surveys, commissions for the appointment of officers, lodge building accounts, and court records of trespass and poaching.

Details of each village and its open-field farming are plentiful in the forms of land grants, open-field court regulations and detailed descriptions of each strip called *terriers* (Hall 1982, 1995). Some places have maps of the strip system (Sibson cum Stibbington, 1770, Sutton 1843). The open-field system of agriculture dates from about the 9th century and there were changes over time. After c.1450 some land was put down to permanent pasture (*leys*), small amounts were taken into enclosures (*hedged fields*), usually next to the settlement. The extents of old enclosure and the unploughed meadows can be determined from open-field maps or enclosure maps, thus identifying landuse areas. If a parish was enclosed before the 18th century, less detail is known. Most of them have tithe maps made c.1838-1850 from which field names indicate areas of former meadow or heath, but the extent of ancient enclosure around the village cannot be known without detailed studies.

In contrast, the information about the charcoal, pottery and iron industries is scant. They seem to have been performed partly as cottage industries that left no regular record. There may well be references in the large collection of Public Record Office forest records (E32) but these have not been thoroughly searched. Pottery is not of concern in the present report, being confined to the west of the region near Stanion and the deserted village of Lyveden. Charcoal production has so far only been noted for 1730 in the records of Bedford Purlieu (quoted by Rix 1975, 26), but the extensive spreads of iron slag prove that it was produced in large quantities in earlier times.

Iron slag spreads and discrete patches or heaps are abundant throughout the region, some occurring in the woods or where there have been woods. The material is characteristically black and very dense, which arises because much of the iron is locked up as silicate that cannot be released without addition of limestone flux. The slag is not datable except by radiocarbon analysis of associated charcoal. Some slag is of Roman date (Jackson & Tylecote 1988), but much of it is likely to be Saxon and medieval. Iron working is recorded in the Domesday Survey of 1086 at Corby (Thorn and Thorn 1979, 1-12 from DB 219c). A grant to Fineshade Abbey made c.1209 refers to iron working (Bridges 1791, ii 307), and 'huge heaps' of slag were noted at Fineshade in 1712 by the antiquarian Morton (1712, 550). Morton refers to slag lying in all the area of the present report, as proved and mapped by fieldwork.

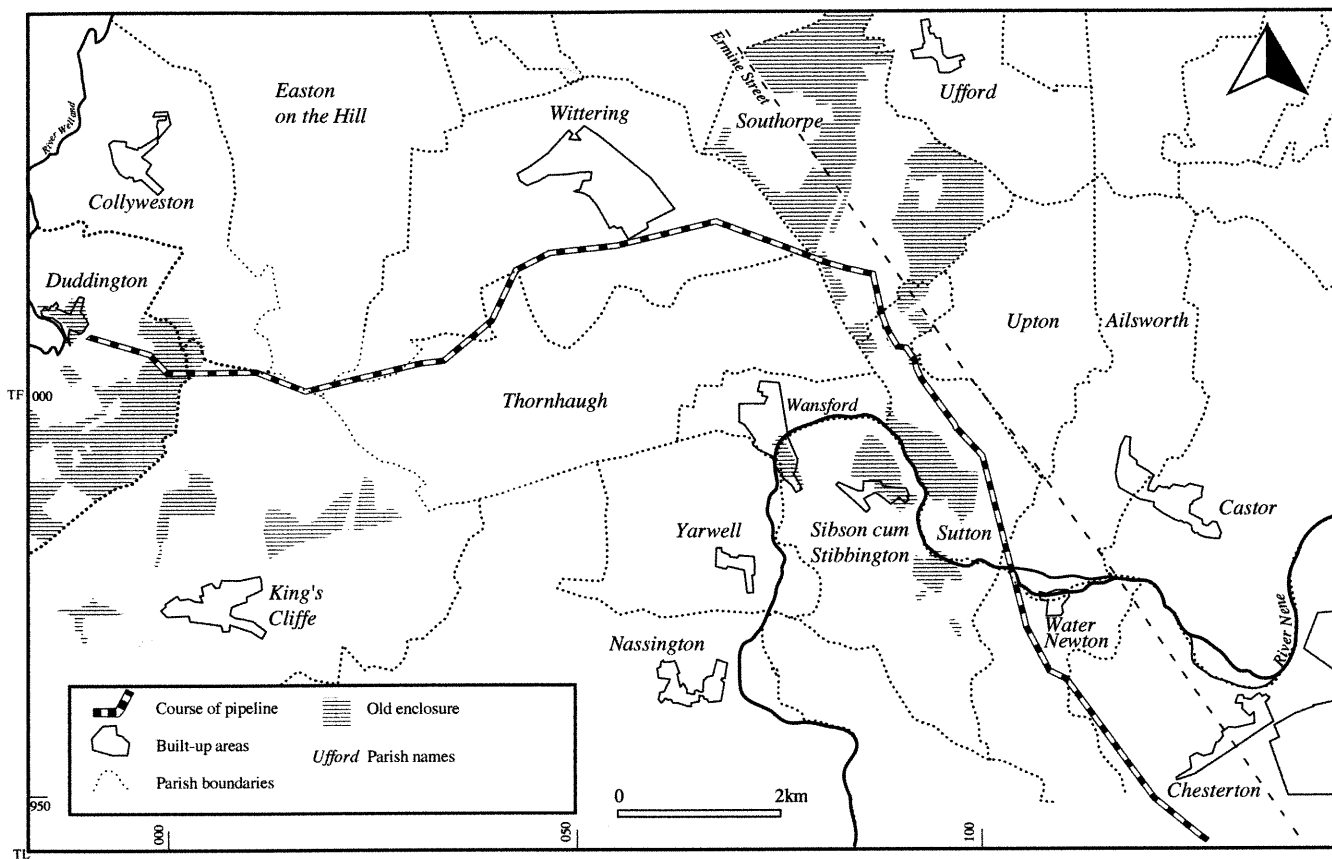


Figure 16 Historic landuse along the pipeline route - enclosure

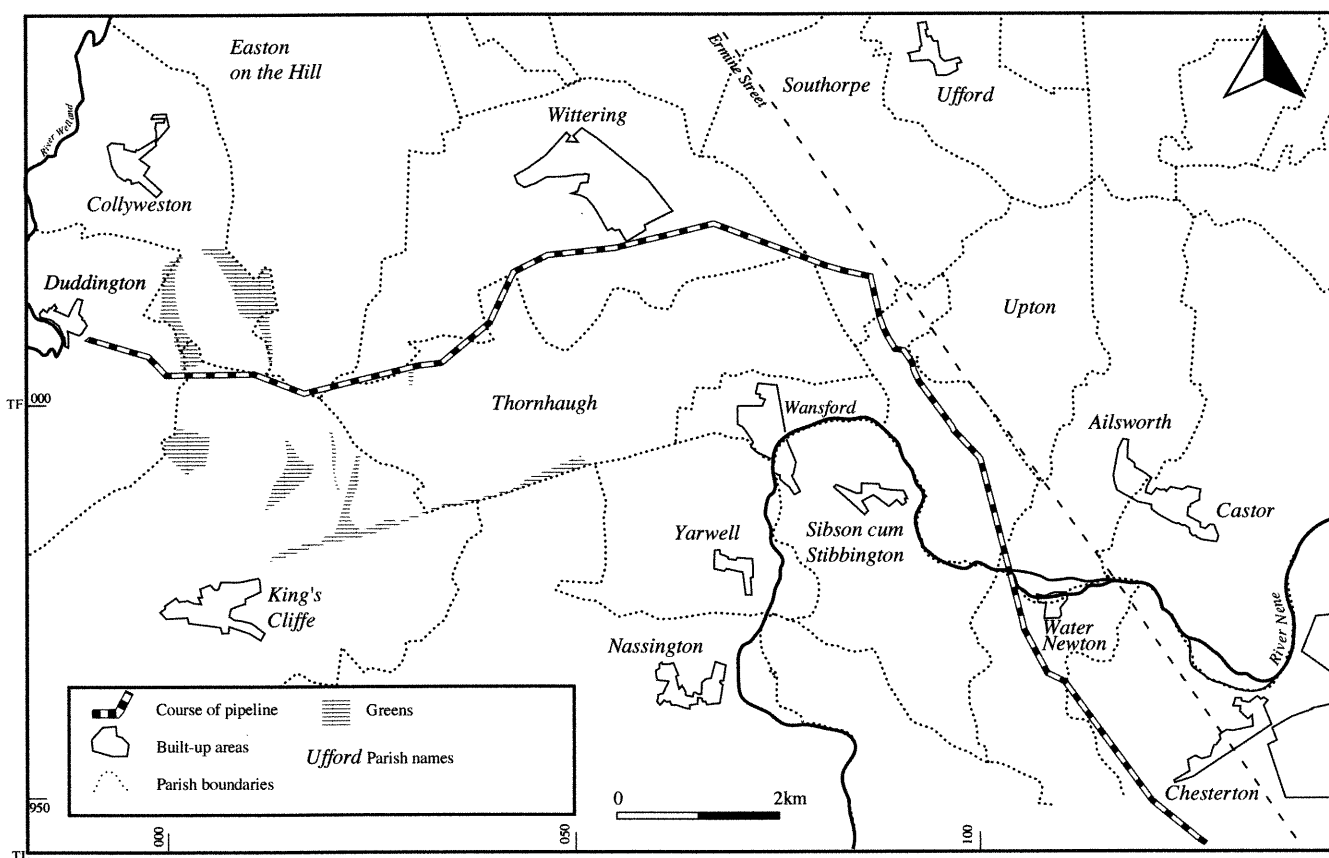


Figure 17 Historic landuse along the pipeline route - greens

To establish the landuse of the region, all known large-scale estate and enclosure maps before 1850 were consulted. Information was transferred to Ordnance Survey 1:25,000 maps and digitised. The following types of landuse were recorded:

Heath

Old enclosure (usually ridge and furrow brought into hedged fields)

Open fields (strips, former ridge and furrow)

Open spaces in woodland (greens and plains)

Meadow (visible on the ground as alluvium)

Wood

The data was amplified by use of unpublished archaeological fieldwork (ex D. Hall) that provided records of medieval fields and older sites. Ploughed out ridge and furrow blocks (called furlongs) can be mapped because they leave linear banks of soil at their boundaries. These data amplify such places as Thornhaugh that has no open field or enclosure map, and quantifies the extent of open-field.

The landuse is recorded on Figure 00. It is necessarily composite, deriving from many maps of various dates. As an approximation it may be taken to show the state of the countryside in 1650, with various caveats as noted under each parish in the map list.

Maps consulted

Duddington 1775

The southern part of Duddington parish was once all open-field ridge and furrow, and some is preserved in the present woodland. It is referred to as 'assart land' (i.e. arable created by grubbing up woodland) on the Fineshade 1588 map and in 1610 (NRO J(D) 541). A Fineshade survey of 1730 refers to several closes (Daleswood, Wrights and Markham); the full extent of old enclosure is mapped on the 1775 Parliamentary enclosure map of Duddington (NRO Map 2857) and shown on Figure 00. Some of it had reverted to wood.

Chesterton 1808 & 1837

Chesterton was old enclosure and only the meadow can be identified from an estate map of 1808 (HRO PM 3/13) and the tithe map of 1837 (HRO 2196/8). Old enclosure cannot be distinguished from that made later.

Fineshade 1588

A Tudor map of Fineshade (PRO MR 398) is undated but probably relates to a dispute of 1588 (PRO E 178/1685). The parish was all enclosed at that date and had a little woodland. It remained in the same condition until relatively recently as shown by surveys of 1730 (NRO M(F) 208) and the Ordnance Survey map of 1885. The present woodland cover is largely the result of Forestry Commission planting since the 1920s.

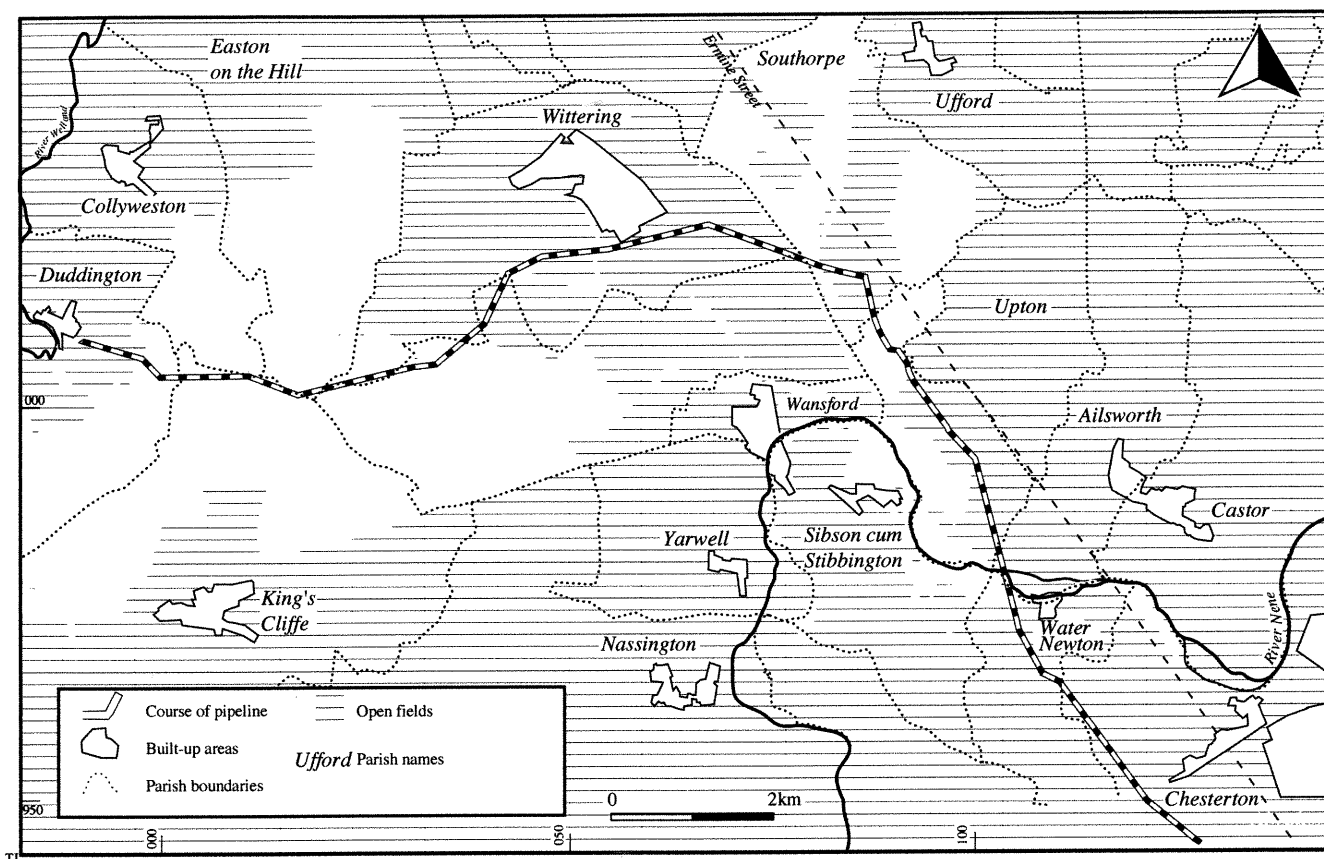


Figure 18 Historic landuse along the pipeline route - open fields

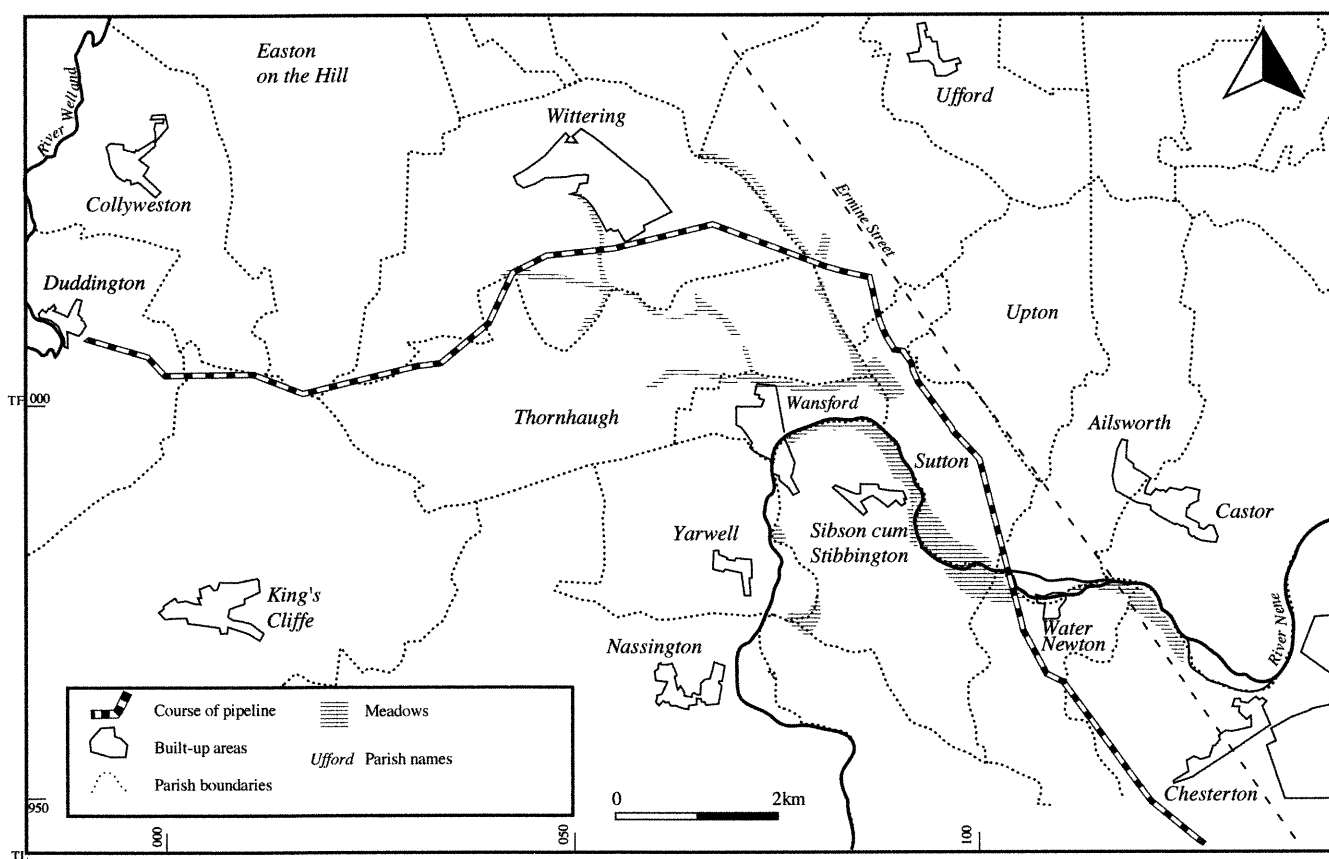


Figure 19 Historic landuse along the pipeline route - meadows

King's Cliffe 1592 and 1813

Land at the north of the present civil parish of King's Cliffe was extra-parochial until the 19th century. Part of it lay in the Forest and was mapped as coppices in the 17th century (PRO MPE 459). These were grubbed up before 1813. Also at the north was Cliffe Park, a royal deer-hunting park that contained a keepers lodge, wooded coppices and open spaces and rides called 'plains'. These were mapped in 1592 (Till 1997). It was completely disparked and converted to closes before 1711 (mapped in 1806, see Till 1997, 327). The medieval open-field parish of King's Cliffe was enclosed in 1809 (NRO Map 2860, dated 1813). There was some ancient enclosure at that time (shown on Figure 00 next to Westhay Wood).

Sibson and Stibbington c.1770

These two townships are mapped in detail on a fine map of 1769 showing full detail of the open fields (HRO PM 4/13). Meadow and old enclosure are distinguished; part of Wansford was in the parish.

Southorpe 1843

Southorpe is marked on an undated 18th-century open field map of Barnack parish (NRO Map 4040). It is more clearly mapped, in terms of landuse, on the enclosure map of 1843 (NRO Map 4431) which distinguishes heath, open-field and old enclosure. There was only a limited amount of open-field left by 1843. The meadows lay in the old enclosures and have been mapped from fieldwork data.

Sutton 1845

Sutton is mapped on the 1845 tithe map (NRO T18) when it was still open-field. The meadows, old enclosure, heath and the medieval Sutton Wood are marked and named in the schedule.

Thornhaugh 1592-1871

Thornhaugh consisted of the extra-parochial wood, Bedford Purlieus, and the medieval open-field parish. There were also the deserted village of Sibberton (TL 0685 9980) and part of Wansford. Maps dated, 1592, 1635, 1757, 1818, 1838 and 1871 show the Purlieus and land nearby (preserved at Bedfordshire Record Office and the data quoted by Rix (1975)). Some of the area marked as heath on the two earliest maps had been open-field according to the recorded furlong boundaries. It is common for marginal medieval arable to revert to permanent pasture, and the heathland marked on Figure 00 would be greater than shown at the nominal date of 1650.

Thornhaugh open-fields were enclosed after 1632 and before 1720 (NRO glebe terriers) and no maps survive before the tithe map of 1838 (NRO T198). This shows the enclosed parish and gives field-names locating heath and meadow. It is not possible to map the old enclosure. Meadow has been mapped partly from these names and partly from the extent of alluvium. During the fieldwork some peat survived in these meadows agreeable with the name 'carrs' recorded on the tithe map.

Water Newton 1674 & 1837

Water Newton was enclosed before 1674 (HRO MD2 acc.5). The tithe map of 1837 (HRO 2196/45) identifies the river meadow but the village envelope enclosures cannot be distinguished from the others.

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Abbreviations

HRO Huntingdon Record Office
NRO Northamptonshire Record Office
PRO Public Record Office

APPENDIX 2

Lithic Analysis

Dr Twigs Way

Introduction

This report gives the results of analysis of flints collected during fieldwalking of the pipeline easement around Bonemills Farm, Wittering. Fieldwalking took place in two phases, a non-intensive phase, followed by intensive rewalking of areas of high artefact concentrations. The fields in Wittering Parish through which the pipeline passed were given numbers according to the order in which the route encountered them, running from west to east. Thus field 03 is the third field that the pipeline passed through in Wittering Parish, field 04 is the fourth, and so on. In the non-intensive phase four evenly-spaced transects were walked along the 30m wide pipeline easement, finds being bagged separately for each 30m section. Within each field, 30m lengths of the easement were numbered consecutively from west to east along the route, thus 0310 refers to the tenth 30m length of the route in the third field in Wittering parish, running from west to east.

In the second phase, a smaller area of the easement was selected for intensive fieldwalking. The original 30m squares were rewalked, having been further subdivided into 10m squares. Each 10m square was given a code letter from A to I. Flints recovered during the excavation of the Middle Saxon Furnaces are also considered below.

Non Intensive Fieldwalking, Fields 03 and 04

The total number of flint artefacts curated was 28; no burnt pieces were discovered.

Raw Material

Raw material appears to have been of small flint pebbles. There is no evidence for the import onto the site of higher quality raw materials. Core and core fragments suggest a maximum size of 37mm, along a single larger 'utilised piece' with a maximum dimension of 53mm was recovered.

Typology

The collection was almost equally divided between small chips (6), flakes (6), bladelets (6) cores and core fragments (7), whilst there were three classifiable tools. The high percentage of cores may be explained by the method of collection, with microlithic material being more difficult to identify whilst fieldwalking. It should be noted that the next stage of intensive fieldwalking produced a much higher percentage of waste chips and flakes (50% of the collection), with only 6% cores.

Classifiable tools were two obliquely blunted microliths and a single horseshoe scraper on a hard hammer flake. This last piece was notable for not being heavily patinated, unlike the majority of the collection.

Of the seven cores and core fragments, three were single platform micro cores, a further example was multi platform, whilst three others were more 'adventitious' use of chunks and fragments for removal of small numbers of flakes/bladelets. Most were heavily patinated.

A Mesolithic date can be given for the assemblage.

Distribution

Most of the 30m squares walked contained 1-3 artefacts; 0316 contained 5 artefacts including 2 core/fragments.

A table giving a full breakdown of this analysis is deposited with the project archive.

Intensive Fieldwalking, Field 03

The total number of flint artefacts curated was 104, including a single burnt piece and two burnt pieces of probably unworked flint.

Raw Material

Raw material appears to have been small flint cobbles and pebbles. There is no evidence for the import onto the site of higher quality raw material. Cores and core fragments suggest a maximum size of material of 40mm, and bladelets and waste flakes agree with this size range.

Typology

The majority of pieces were classifiable as waste chips and flakes (60 pieces), with 20 bladelets, 6 cores and core fragments, 12 classifiable tools and, one 'utilised' piece.

Classifiable tools included a small thumbnail scraper, a side/end scraper, two microburins, fragment of a microlith, three broken backed bladelets, a borer, a further two possible scrapers and two retouched flakes. All of these can be dated to the Mesolithic.

The cores and core fragments are predominantly single platform and have dimensions between 25mm and 40mm (concentrating around 35mm).

Distribution

The majority of grid squares walked contained between 0 and 2 artefacts. Grid square 0309A contained 5 artefacts including tools and bladelets; a concentration around 0310A and B contained predominantly chips and flakes, as did another slightly larger concentration around 0311H and I - 0312 A and D.

Given the probability of disturbance of lithic scatters by plough damage this widespread area of slightly higher density may indicate an originally more discrete scatter within this area.

A table giving a full breakdown of this analysis is deposited with the project archive.

Excavation

Summary

23 lithic artefacts were recovered during excavation, the majority (18) from context 1000 (surface cleaning) in the area of the furnaces.

The assemblage is on a small pebble raw material, with the possible exception of one piece which is a burin on blade with a total length of 62mm. The remainder of the assemblage has a maximum dimension of 35mm and is accordance with the assemblages found during fieldwalking.

The assemblage is dominated by waste chips and flakes and snapped bladelets (6), with two small core fragments and a single burin on blade.

The assemblage fits well within the overall assemblage from the fieldwalking exercise and could be classified as Mesolithic. It was noted that much of the assemblage was heavily patinated in the same way as the fieldwalking assemblage.

A table giving a full breakdown of this analysis is deposited with the project archive.

TW 26.11.97

APPENDIX 3

Charcoal Analysis

Rowena Gale

(Folly Cottage, Chute Cadley, Andover, Hants SP11 9EB)

Samples of charcoal were identified to genus to isolate suitable short-lived taxa for radiocarbon dating.

Materials and methods

The charcoal was prepared for examination using standard methods. The fragments from each sample were fractured to expose fresh transverse surfaces and sorted into groups based on the anatomical features observed using a X20 hand lens. Representative fragments from each group were selected for further examination under high magnification. Freshly fractured surfaces were prepared in the transverse, tangential and radial planes. The fragments were supported in sand and examined using a Nikon Labophot incident-light microscope at magnifications of up to X400. The anatomical structure was matched to reference material.

Results

The anatomical structure of the charcoal was consistent with the taxa (or groups of taxa) given below. It is not usually possible to identify to species level. The anatomical similarity of some related species and/ or genera makes it difficult to distinguish between them with any certainty, e.g. members of the Salicaceae (poplar and willow).

Sample 4,	context 1003	<i>Quercus</i> sp., oak, about 50% sapwood/ 50% heartwood (sorted into separate bags). The sapwood would be suitable for C14 dating.
Sample 1,	context 1005	<i>Quercus</i> sp., oak, mostly heartwood, some sapwood. Since it was evident that insufficient material for dating was present, work on this sample was abandoned.
Sample 14,	context 1025	<i>Sambucus</i> sp., elder, >75% of sample; <i>Quercus</i> sp., oak, heartwood; <i>Salix</i> sp., willow/ <i>Populus</i> sp., poplar. Willow and poplar are anatomically similar. Either the elder or the willow/ poplar would provide suitable material for dating.

APPENDIX 4

A Geological Note on the Iron Deposits at Bonemills Farm, Wittering

Steven Critchley

The strata outcropping near the site of the iron smelting furnaces excavated near Bonemills Farm, Wittering are of the Northampton Sand Ironstone Formation. These are the lowest beds of the Inferior Oolite Series which are part of the Aalenian - Bajocian stages of the Middle Jurassic. They consist of several metres of siderite chamosite oolites and siderite mudstones. Post glacial weathering and the resultant supergene or secondary enrichment has dissolved and removed much of the calcium carbonate and oxidised the iron carbonate, siderite, to limonite. This process preferentially increases the iron content making the weathered horizons attractive as an iron ore resource. The iron content of such ore is very variable, but generally in the region of 26 - 32% Fe.