LAND SOUTH OF HORSESHOE ROAD, SPALDING, LINCOLNSHIRE

Topsoil Magnetic Susceptibility & Gradiometer Survey

(Survey Ref : 1750299/HSL/SAM)

FEBRUARY 1999

Produced by

OXFORD ARCHAEOTECHNICS LIMITED

under the direction of

A.E. Johnson *BA(Hons)*

Commissioned by

John Samuels Archaeological Consultants

on behalf of

Broadgate Builders (Spalding) Ltd

OXFORD ARCHAEOTECHNICS

99/03

EVENTS 41867 41868
SOURCE 41620.
23799 418349 Undated

Specialist Archaeological Field Evaluation

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SUMMARY

A geophysical evaluation programme comprising topsoil magnetic susceptibility mapping and gradiometer survey was carried out on former horticultural/nursery land south of Horseshoe Road, on the southwestern outskirts of Spalding, Lincolnshire (centred on NGR 523400 321350).

The survey area lies on the eastern extremity of an extensive area of cropmarks, and there is considered to be a moderate potential for the discovery of archaeological material beneath up to 1 m depth of post Roman marine silts.

The survey was based upon the principle that past human activity and its associated debris usually creates slight but persistent changes in the local magnetic environment which can be sensed from the surface (using magnetic susceptibility measurement and magnetometry).

The area responded favourably to magnetic survey, producing a dynamic topsoil magnetic susceptibility map which showed graphic patterns of former landuse. Selective magnetometer (gradiometer) survey revealed a number of anomalies, mostly silted linears (ditches), although one area produced anomalies with sufficient geometry to indicate the presence of a discrete area with archaeological potential containing a small rectilinear enclosure or possible structure, together with a number of further anomalies suggesting the presence of pit forms or silted hollows.

1. INTRODUCTION

1.1 Geophysical survey was commissioned by John Samuels Archaeological Consultants on behalf of Broadgate Builders (Spalding) Limited on land situated on the southwestern outskirts of Spalding, Lincolnshire, in advance of proposed development. The location is shown on Fig. 1. The fieldwork was carried out in February 1999.

1.2 The survey area (centred on NGR 523400 321350) lies within an area of former horticultural/nursery land situated between Horseshoe Road to the north and a complex of derelict glass houses and nursery buildings in an area known as Little London to the south. The land has been under intensive horticultural cultivation for at least the last fifty years (Air Photo Services 1998).

1.3 Although originally intended to cover an area of 10 ha, the northwestern part of the proposed survey area, covering some 2.5 ha, was found to be under a dense crop of brussels sprouts which was in the process of being harvested and therefore unavailable for survey. Just over half of the accessible land was under a cabbage crop in various stages of maturity, whilst the remainder had been recently harvested. Surface visibility was good in some places, but for the most part was generally poor.

1.4 The land lies at c.4 m AOD. The underlying geology is marine alluvium, of post Roman date (JSAC 1998).

1.5 A recent appraisal of air photographs (Air Photo Services 1998) has confirmed that the survey area lies on the eastern edge of an extensive area of cropmark enclosures and trackways, a number of which (elements of both large and small enclosures) are visible extending just within its western boundary. Recent excavations some 400 m to the north (south of Bourne Road) revealed evidence for prehistoric and early Romano-British occupation associated with salt production sealed beneath 1m of marine alluvium, and there is a possibility that features seen as cropmarks on the west of the survey area may extend within it, masked beneath alluvial silts.

1.6 The geophysical survey comprised a combination of topsoil magnetic susceptibility field sensing and magnetometry. An explanation of the techniques used, and the rationale behind their selection, is included in an Appendix to the present report.

2. MAGNETIC SURVEY DESIGN

2.1 Survey control was established to the National Grid by EDM Total Station.

2.2 The equipment used for the direct topsoil magnetic susceptibility survey was a Bartington Instruments MS2 meter with an 18.5 cm loop.

2.3 *In situ* magnetic susceptibility readings were taken on a 10 m grid, an interval known to give a high probability of intersecting with dispersed horizons from a wide range of archaeological sites, particularly those associated with occupation and industrial activity from the later prehistoric period onwards. Soils over former occupation and industrial sites usually register as stronger patterning, frequently showing a marked focus. Agricultural activity helps to both generate (by ploughing casting up underlying deposits), and ultimately disperses the more magnetic soils over a wider area. Patterns recorded by 10 m magnetic susceptibility mapping tend to define zones of former activity rather than locate individual elements. Nevertheless, in some contexts, a focus of markedly stronger soil magnetic susceptibility (or markedly magnetically lower soils indicative of ploughed down earthworks) is occasionally found to relate to material dispersed from specific underlying features.

2.4 Routine scanning by gradiometer was undertaken at 25 m traverse intervals to check for any major concentrations of underlying archaeological features whose presence may not have been detected by the topsoil susceptibility survey. Five areas (totalling 1.2 ha) showing significant enhanced topsoil magnetic susceptibility and/or gradiometer scanning anomalies were targeted for detailed gridded gradiometer survey with a Geoscan Research FM 36 Fluxgate Gradiometer (sampling 4 readings per metre at 1 metre traverse intervals in the 0.1 nT range). The nanotesla (nT) is the standard unit of magnetic flux (expressed as the current density), here used to indicate positive and negative deviations from the Earth's normal magnetic field.

2.5 The topsoil magnetic susceptibility colour shade plot (Fig. 3) shows contours at 20 SI intervals. Magnetometer data have been presented as grey scale and stacked trace (raw data) plots (Figs. 4 - 10); an interpretation of results is shown on Figs. 4 - 8 and an overview on Fig. 11.

3. SURVEY RESULTS

TOPSOIL MAGNETIC SUSCEPTIBILITY SURVEY (Fig. 3)

3.1 747 *in situ* magnetic susceptibility readings were recorded. Susceptibility is reported in SI:volume susceptibility units (x 10^{-5}), a dimensionless measure of the relative ease with which a sample can be magnetized in a given magnetic field.

3.2 *In situ* topsoil susceptibility measurements ranged between 12 and 260 (x 10^{-5}) SI units. The mean for the survey was 41.8 SI units and the standard deviation calculated against the mean was 26.4 SI units.

3.3 The topsoil magnetic susceptibility map shows clear anthropogenic patterning relating to former landuse. An area of just over 2 ha (centred on NGR 523350 321300) shows a number of foci of magnetically enhanced soils spread to well defined former boundaries; the topsoil magnetic susceptibility levels within this zone generally exceed 60 SI, peaking at over 200 SI. Topsoil susceptibility levels drop considerably, with little local variation, to both the northeast and southwest of this distinctive block of more magnetic soils. The pattern clearly relates to differential landuse within former enclosures. The predominant alignments are orthogonal with the modern plan, first mapped on the South Holland Enclosure Plan of 1819. Within this enhanced zone there is a suggestion of further elements of regular patterning, with foci situated close to the southern boundary of the enhanced soils, and spaced at approximately 60 m intervals; three are apparent and the fourth is suggested lying within the unsurveyed angle of the survey area (the course of a substantial southwest-northeast ditch was subsequently found by gradiometer survey to run along the axes of these stronger foci, see Fig. 11). A further (less well-defined) zone of enhancement, extends northwestwards and may continue beyond the survey area.

pattern of many foci reflects modern land use.

3.4 Both the strong interfaces of topsoil patterning suggestive of former land enclosures or field systems, and several of the discrete foci were investigated by detailed gridded gradiometer survey (below).

MAGNETOMETER (GRADIOMETER) SURVEY

3.5 The survey area was scanned by gradiometer on 25 m traverses. Five areas (totalling 1.2 ha) were selected for detailed gridded gradiometer survey in areas of enhanced topsoil magnetic susceptibility and/or gradiometer scanning anomalies; their location is shown on Fig. 2. Magnetic anomalies relating to potential archaeological features locally exceeded 10 nT.

AREA 1 (Figs. 4 & 9)

3.6 Five contiguous 30 m square survey grids (0.5 ha) were sited to investigate the northwestward extension of topsoil magnetic susceptibility patterning in an area where gradiometer scanning had indicated quite strong sporadic magnetic anomalies.

3.7 The gradiometer revealed a rectilinear (almost square) feature measuring some 12 x 10 m, on an approximate southwest - northeast alignment, whose geometry suggests a possible former structure or small enclosure with what may be an entrance on its southwest side (with perhaps substantial post pits some 2m apart flanking the entrance). The possibility of internal features is suggested by two discrete anomalies along the central axis. An irregular semi-circular pattern of anomalies curving around the eastern half of the rectangle, may be a remnant of another enclosure. A number of large anomalies, possibly pits measuring up to 2 - 3 m in diameter, are evident within 20 m to the southeast of the rectilinear enclosure.

3.8 There is the slightest suggestion of what may be a further (perhaps concentric) rectilinear feature (the inner element 5 m and outer 15 m in width) within the northernmost extension of the survey grid (centred on NGR 523250 321380), although it is conceivable that this pattern is a 'conspiracy' of agricultural marks, elements of which are generally present crossing the site from southwest-northeast.

3.9 A light litter of ferrous material has been recorded, but with no concentration within the area of the principal rectilinear and curvilinear anomalies.

AREA 2 (Figs. 5 & 9)

3.10 A 60 x 30 m survey grid (0.18 ha) was sited to investigate the northwestern edge of a well-defined interface between strong and relatively weak magnetic topsoils to locate any possible associated boundary ditch.

3.11 The gradiometer revealed a subtle pattern of orthogonal linear elements which are consistent with the trends of the topsoil magnetic susceptibility patterning. No well-defined linear anomaly was identified along this interface, although a rather disjointed feature appears to broadly reflect the position of the magnetic soil boundary, with further perpendicular (northwest-southeast) anomalies reflecting the trend of topsoil magnetic susceptibility patterns present within the enhanced zone..

AREA 3 (Figs. 6 & 10)

3.12 A 60 x 30 m survey grid (0.18 ha) was sited over a more subtle area of topsoil enhancement appended to the main zone of topsoil magnetic enhancement within the eastern part of the survey area.

3.13 Some subtle magnetic patterning was recorded, together with only the slightest suggestion of what may be weak linear anomalies.

AREA 4 (Figs. 7 & 10)

3.14 A 60 x 30 m survey grid (0.18 ha) was sited to investigate a strong focus of enhanced topsoils along the western edge of the main zone of topsoil magnetic susceptibility patterning.

3.15 A number of relatively strong (3 - 6 nT) anomalies were recorded, including several possible pit forms and linears aligned on a disjointed linear anomaly which represents a former silted ditch perhaps some 1.5 m in width: this ditch can be seen to continue into Area 5 to the east, a distance of almost 100 m (Fig. 11).

AREA 5 (Figs. 8 & 10)

3.16 This 60 x 30 m survey grid (0.18 ha) was sited just beyond the topsoil magnetic susceptibility survey area in order to investigate strong magnetic anomalies recorded during gradiometer scanning, within an area bounded by strong magnetic patterning (see 3.3 above), but lying beyond the designated topsoil magnetic susceptibility survey area. .

3.17 The gradiometer revealed at least three linear features, two of which probably represent relatively substantial ditches of perhaps 2 m or more in width, running on a southwest-northeast trend. It is probable that the principal linear, a continuation of an anomaly recorded in Area 4 above, is in part responsible for the series of stronger foci visible on the topsoil magnetic susceptibility map.

4. CONCLUSIONS

4.1 The survey area responded favourably to magnetic survey. The topsoil magnetic susceptibility map shows both a very strong pattern of former landuse with clear interfaces indicative of specific enclosures, and also a series of discrete foci which are suggestive of more localised activity.

4.2 Gradiometer survey revealed a series of anomalies whose alignment suggests an association with the major zone of topsoil magnetic susceptibility patterning. A number of discrete features were also recorded, including a rectilinear structure or small enclosure with what may be associated internal features, together with pit forms.

4.3 More ephemeral linear anomalies suggestive of further features with archaeological potential were also identified, although it is possible that some may be attributable to former agricultural subdivisions and patterning. Although clearly of archaeological potential, there is no indication from the morphology of the topsoil magnetic susceptibility pattern nor the majority of the gradiometer features to suggest the date of the landscape revealed. Although a correspondence in alignment with elements of the existing landscape may argue for a relatively modern origin, the presence of well-defined interfaces of contrasting magnetic soils is not necessarily an indication of recent activity, as such boundaries can be extremely persistent. It should also be stressed that whilst the magnetic evidence is graphic, certain elements and features of archaeological potential could be locally masked by alluvial cover, and the presence of some features with fills of lower magnetic susceptibility, which would make them less visible to magnetometer (gradiometer) survey, may also be anticipated.

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Topsoil magnetic susceptibility mapping and magnetometer survey by Oxford Archaeotechnics Limited under the direction of A.E. Johnson *BA(Hons)*, with: M. Tomkins *BA*, *MA* and M. Laidlaw *BSc.*

APPENDIX 1 - MAGNETIC TECHNIQUES: GENERAL PRINCIPLES

A1.1 It is possible to define areas of human activity (particularly soils spread from occupation sites and the fills of cut features such as pits or ditches) by means of *magnetic survey* (Clark 1990; Scollar et al. 1990). The results will vary, according to the local geology and soils (Thompson & Oldfield 1986; Gale & Hoare 1991), as modified by past and present agricultural practices. Under favourable conditions, areas of suspected archaeological activity can be accurately located and targeted for further investigative work (if required) without the necessity for extensive random exploratory trenching. Magnetic survey has the added advantages of enabling large areas to be assessed relatively quickly, and is non-destructive.

A1.2 Topsoil is normally more magnetic than the subsoil or bedrock from which it is derived. Human activity further locally enhances the magnetic properties of soils, and amplifies the contrast with the geological background. The main enhancement effect is the increase of *magnetic susceptibility*, by fire and, to a lesser extent, by the bacterial activity associated with rubbish decomposition; the introduction of materials such as fired clay and ceramics - and, of course, iron and many industrial residues - may also be important in some cases. Other agencies include the addition and redistribution of naturally magnetic rock such as basalt or ironstone, either locally derived or imported.

A1.3 The tendency of most human activity is to increase soil magnetic susceptibility locally. In some cases, however, features such as traces of former mounds or banks, or imported soil/subsoil or non-magnetic bedrock (such as most limestones), will show as zones of lower susceptibility in comparison with the surrounding topsoil.

A1.4 Archaeologically magnetically enhanced soils are therefore a response of the parent geological material to a series of events which make up the total domestic, agricultural and industrial history of a site, usually over a prolonged period. Climatic factors may subsequently further modify the susceptibility of soils but, in the absence of strong chemical alteration (e.g. during the process of podzolisation or extreme reduction), magnetic characteristics may persist over millions of years.

A1.5 Both the magnetic contrast between archaeological features and the subsoil into which they are dug, and the magnetic susceptibility of topsoil spreads associated with occupation horizons, can be measured in the field.

A1.6 There are several highly sensitive instruments available which can be used to measure these magnetic variations. Some are capable, under favourable conditions, of producing extraordinarily detailed plots of subsurface features. The detection of these features is usually by means of a *magnetometer* (normally a fluxgate gradiometer). These are defined as passive instruments which respond to the magnetic anomalies produced by buried features in the presence of the Earth's magnetic field. The gradiometer uses two sensors mounted vertically, often 50 cm

apart. The bottom sensor is carried some 30 cm above the ground, and registers local magnetic anomalies with respect to the top sensor. As both sensors are affected equally by gross magnetic effects these are cancelled out. In order to produce good results, the magnetic susceptibility contrast between features and their surroundings must be reasonably high, thereby creating good local anomalies; a generally raised background, even if due to human occupation within a settlement context, will sometimes preclude meaningful magnetometer results. The sensitive nature of magnetometers makes them suitable for detailed work, logging measurements at a closely spaced (less than 1 metre) sample interval, particularly in areas where an archaeological site is already suspected. Magnetometers may also be used for rapid 'prospecting' ('scanning') of larger areas (where the operator directly monitors the changing magnetic field and pinpoints specific anomalies).

A1.7 *Magnetic susceptibility measuring systems*, whilst responding to basically the same magnetic component in the soil, are 'active' instruments which subject the sample area being measured (according to the size of the sensor used) to a low intensity alternating magnetic field. Magnetically susceptible material within the influence of this field can be measured by means of changes which are induced in oscillator frequency. For general work, measuring topsoil susceptibility *in situ*, a sensor loop of around 20 cm diameter is convenient, and responds to the concentration of magnetic (especially ferrimagnetic) minerals mostly in the top 10 cm of the soil. Magnetically enhanced horizons which have been reached by the plough, and even those from which material has been transported by soil biological activity, can thus be recognised.

A1.8 Whilst only rarely encountering anomalies as graphically defined as those detected by magnetometers, magnetic susceptibility systems are ideal for detecting magnetic spreads and thin archaeological horizons not seen by magnetometers. Using a 10 m interval grid, large areas of landscape can be covered relatively quickly. The resulting plot can frequently determine the general pattern of activity and define the nuclei of any occupation or industrial areas. As the intervals between susceptibility readings generally exceed the parameters of most individual archaeological features (but not of the general spread of enhancement around features), the resulting plots should be used as a guide to areas of archaeological potential and to suggest the general form of major activity areas; further refinement is possible using a finer mesh grid or, more usually, by detailing underlying features using a gradiometer.

A1.9 Magnetic survey is not successful on all geological and pedological substrates. As a rule of thumb, in the lowland zone of Britain, the more sandy/stony a deposit, the less magnetic material is likely to be present, so that a greater magnetic contrast in soil materials will be needed to locate archaeological features; in practice, this means that only stronger magnetic anomalies (e.g. larger accumulations of burnt material) will be visible, with weaker signals (e.g. from the fillings of simple agricultural ditches) disappearing into the background. Similar problems can arise when the natural background itself is very high or very variable (e.g. in the presence of sediments partially derived from magnetic volcanic rocks).

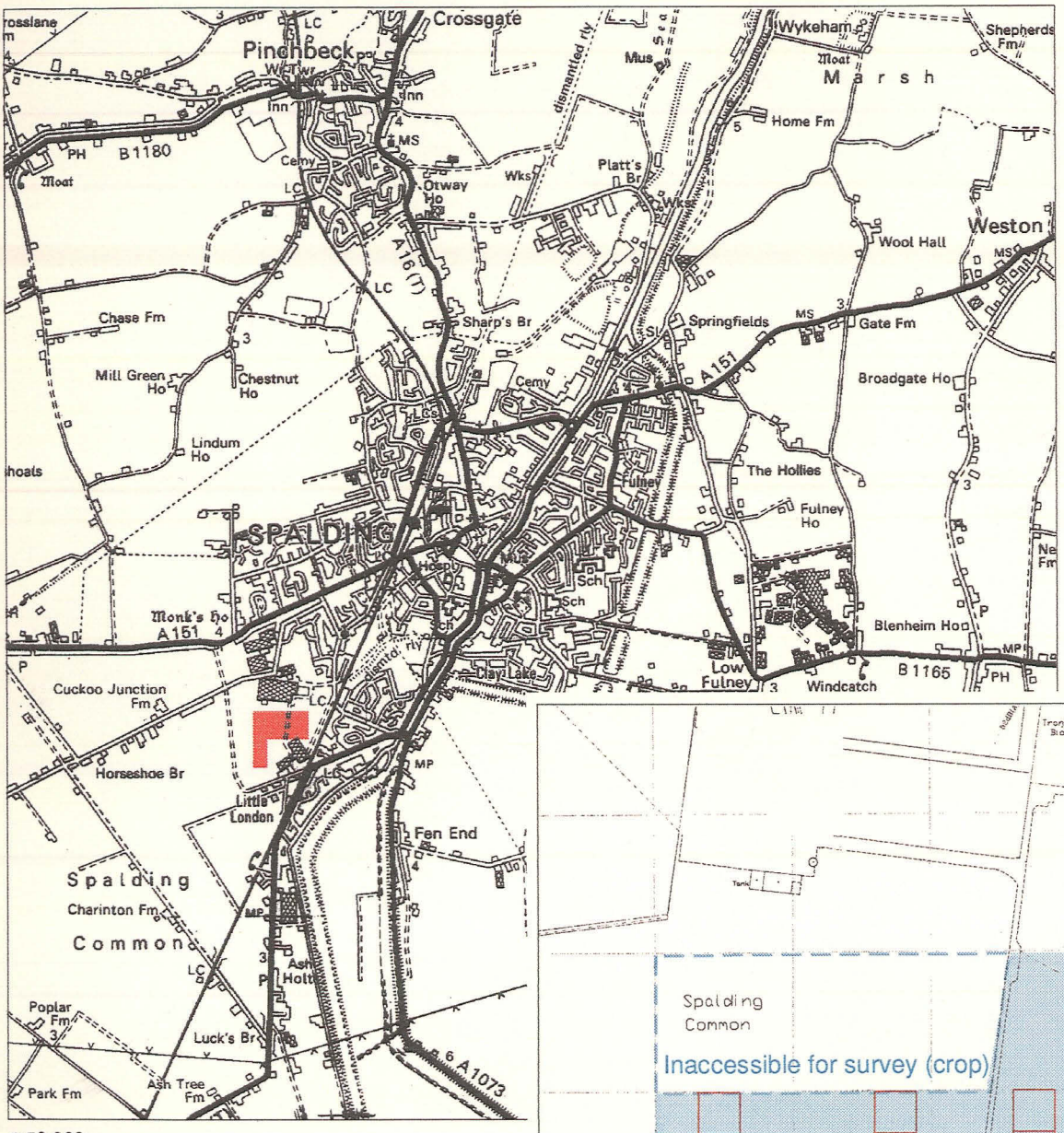
A1.10 The precise physical and chemical processes of changing soil magnetism are extremely complex and subject to innumerable variations. In general terms, however, there is no doubt that magnetic enhancement of soils by human activity provides valuable archaeological information.

A1.11 As well as locating specific sites, topsoil magnetic susceptibility survey frequently provides information relating to former landuse. Variations in the soils and subsoils, both natural and those enhanced by anthropogenic agencies, when modified by agriculture, give rise to distinctive patterns of topsoil susceptibility. The containment of these spreads by either natural or man-made features (streams, hedgerows, etc.) gives rise to a characteristic chequerboard or strip pattern of varying enhancement, often showing the location of former field systems, which persist even after the physical barriers have been removed. These patterns are often further amplified in fields containing underlying archaeological features within reach of the plough. More subtle landuse boundaries and indications of former cultivation regimes are often suggested by topsoil magnetic susceptibility plots.

A1.12 Where a general spread of magnetically enhanced soils contained within a long-established boundary becomes admixed over a long period by constant ploughing, it can be diffused to such a point that the original source is masked altogether. Magnetically enhanced material may also be moved or masked by natural agencies such as colluviation or alluviation. Generally, it appears that the longer a parcel of land has been under arable cultivation, the greater is the tendency for topsoil susceptibility to increase; at the same time there is increasing homogeneity of the magnetic signal within the soils owing to continuous agricultural mixing of the material. Some patterns of soil enhancement derived from underlying archaeological features are, however, apparently capable of resisting agricultural dispersal for thousands of years (Clark 1990).

Horseshoe Road, Spalding, Lincolnshire

Archaeological geophysical survey



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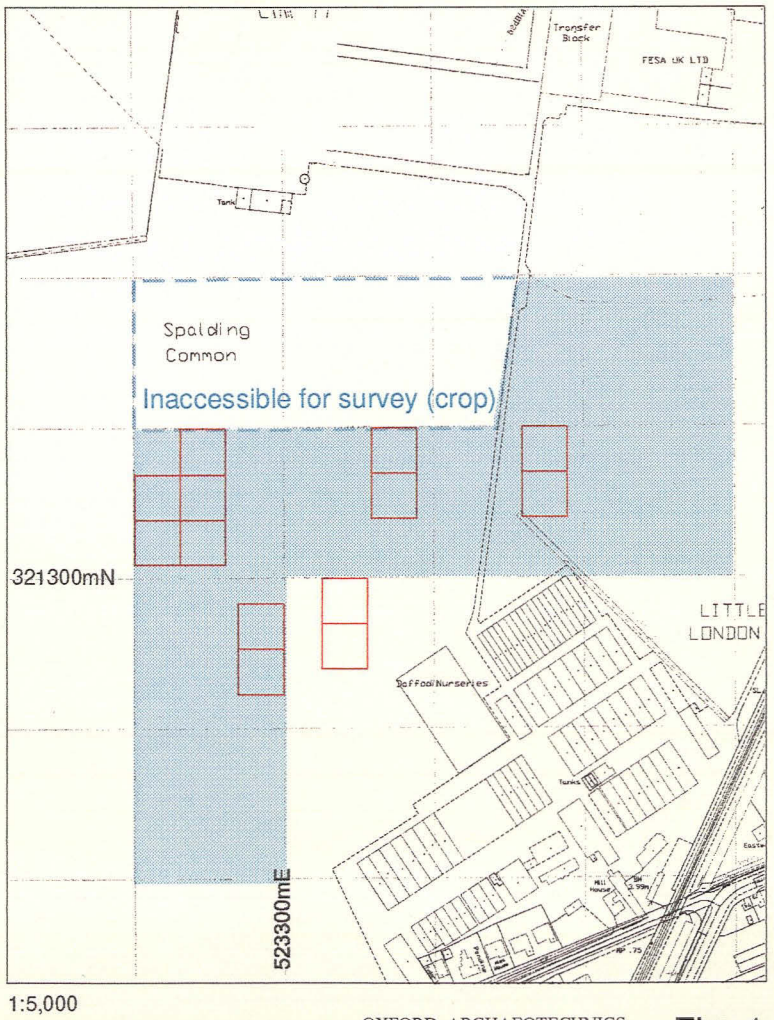

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Topsoil magnetic susceptibility survey

Magnetometer (gradiometer) survey

(30m grids)

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Fig. 1

Horseshoe Road, Spalding, Lincolnshire

Archaeological geophysical survey

Location of magnetometer (gradiometer) survey grids

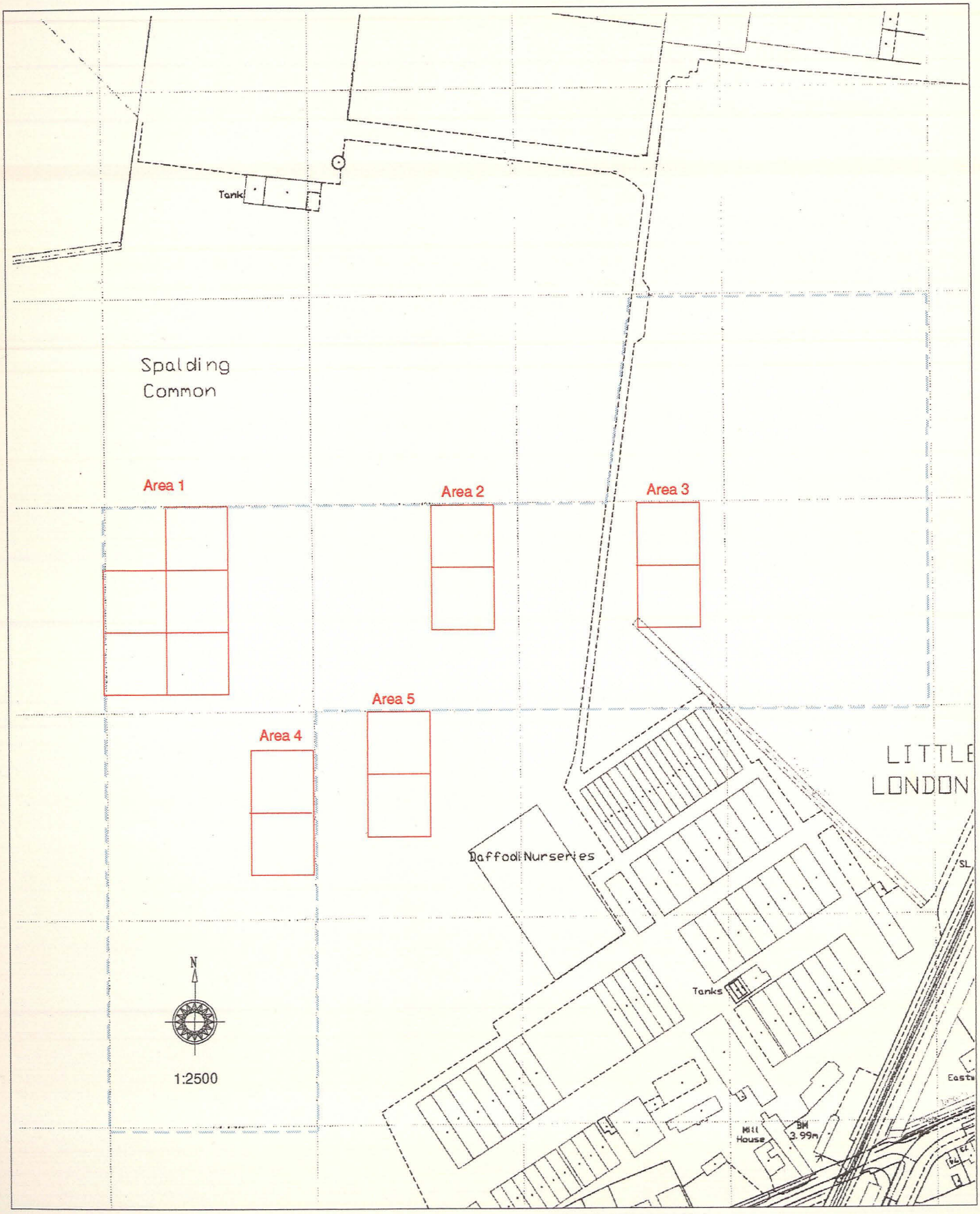

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Fig. 2

Horseshoe Road, Spalding, Lincolnshire

Archaeological geophysical survey

Topsoil magnetic susceptibility

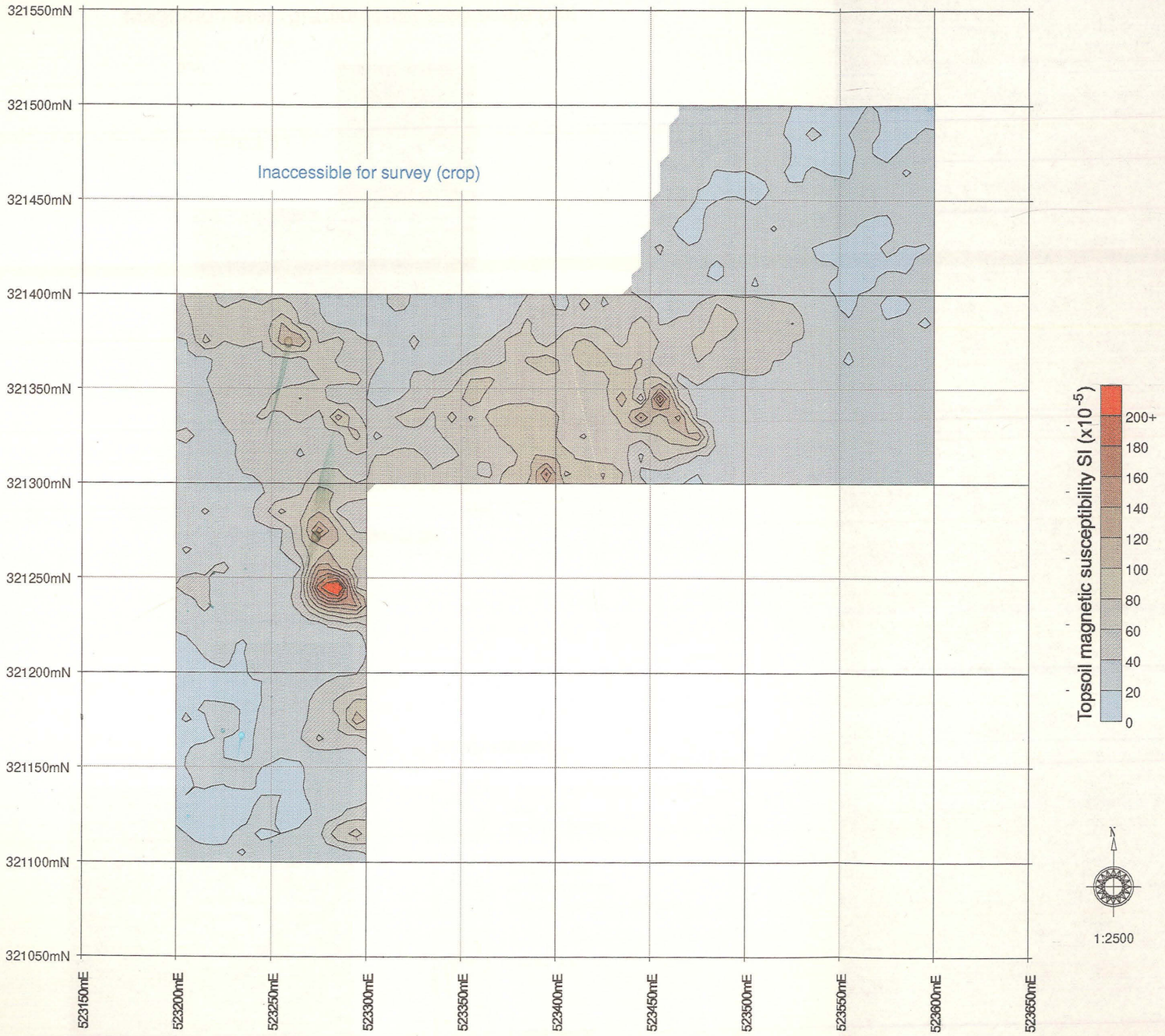

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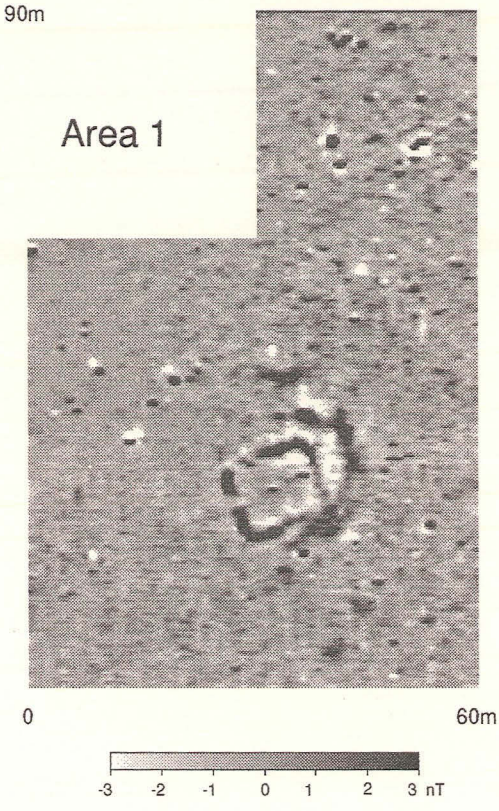
Fig. 3

Horseshoe Road, Spalding, Lincolnshire

Archaeological geophysical survey

Magnetometer (gradiometer) grey scale plot



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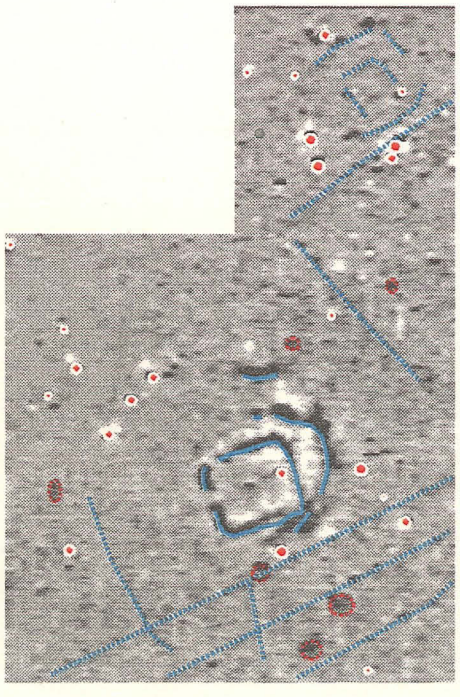

Interpretation

Linear and curvilinear features

Weak linear and curvilinear features, including agricultural striations

Possible pits

Ferrous material

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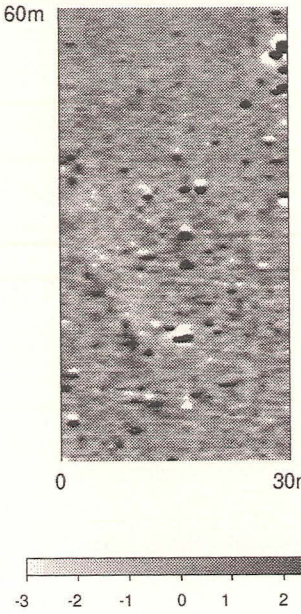
Fig. 4

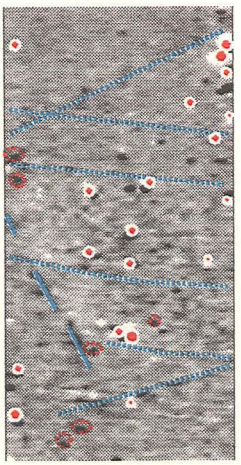
Horseshoe Road, Spalding, Lincolnshire

Archaeological geophysical survey

Magnetometer (gradiometer) grey scale plot

Area 2





Interpretation

Linear and curvilinear features

Weak linear and curvilinear features, including agricultural striations

Possible pits

Ferrous material

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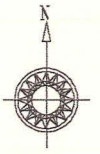
Fig. 5

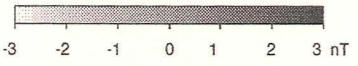
Horseshoe Road, Spalding, Lincolnshire

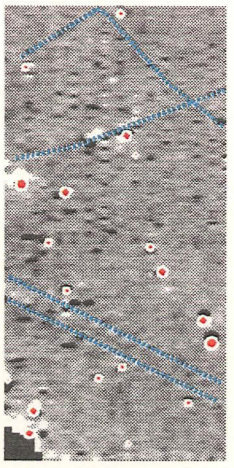
Archaeological geophysical survey

Magnetometer (gradiometer) grey scale plot

Area 3







Interpretation

Linear and curvilinear features

Weak linear and curvilinear features, including agricultural striations

Ferrous material

Possible pits

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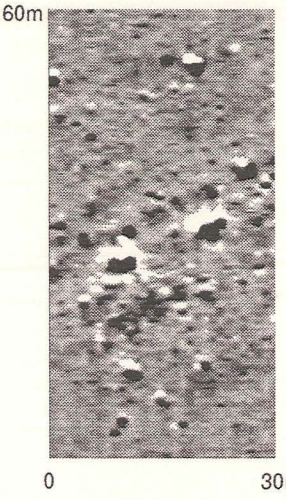
Fig. 6

Horseshoe Road, Spalding, Lincolnshire

Archaeological geophysical survey

Magnetometer (gradiometer) grey scale plot

Area 4



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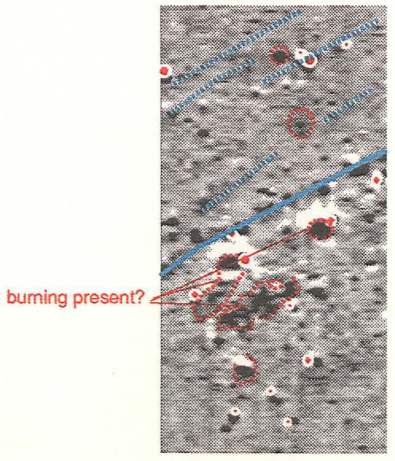
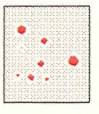


Interpretation

Linear and curvilinear features

Weak linear and curvilinear features, including agricultural striations

Possible pits



Ferrous material

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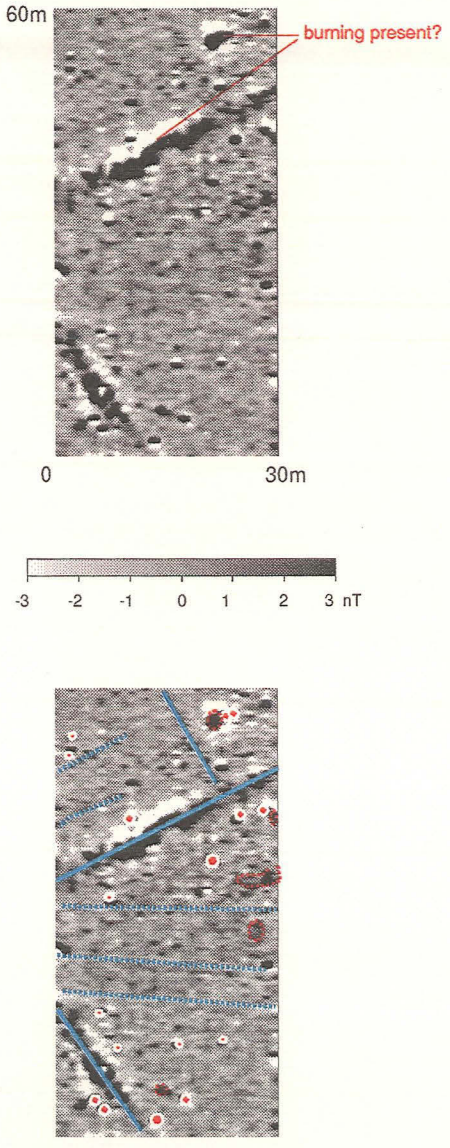
Fig. 7

Horseshoe Road, Spalding, Lincolnshire

Archaeological geophysical survey

Magnetometer (gradiometer) grey scale plot

Area 5



Interpretation

Linear and curvilinear features

Weak linear and curvilinear features, including agricultural striations

Possible pits

Ferrous material

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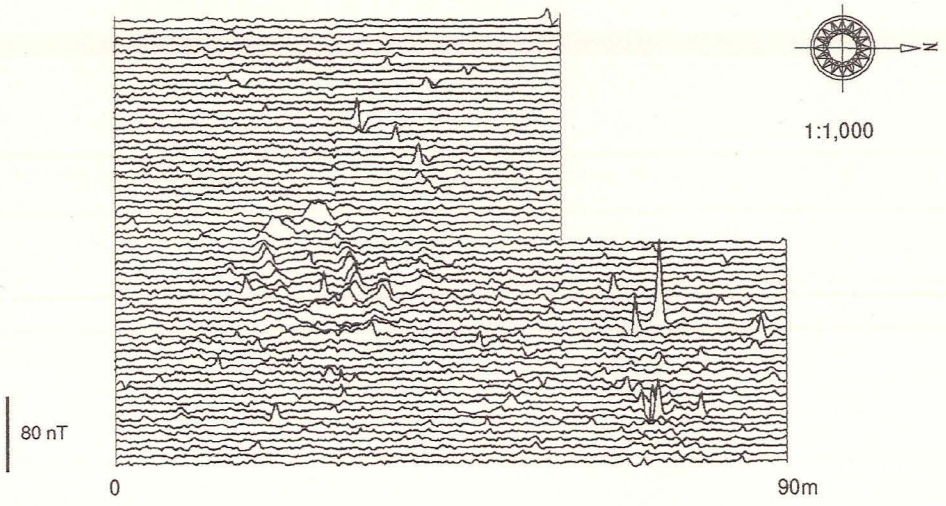
Fig. 8

Horseshoe Road, Spalding, Lincolnshire

Archaeological geophysical survey

Magnetometer stacked trace plots (raw data)

Area 1



Area 2

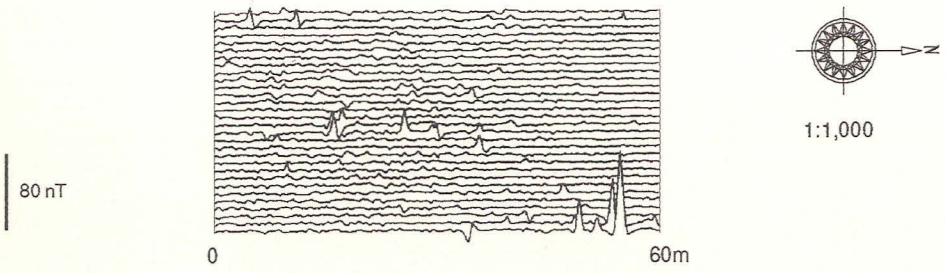


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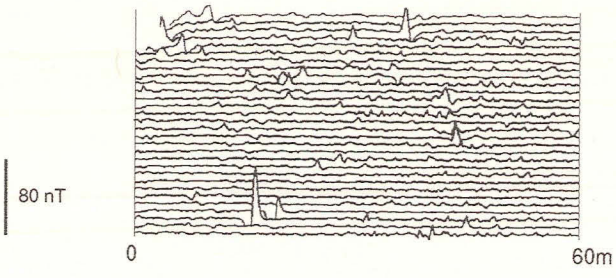
Fig. 9

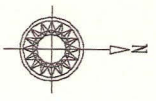
Horseshoe Road, Spalding, Lincolnshire

Archaeological geophysical survey

Magnetometer stacked trace plots (raw data)

Area 3





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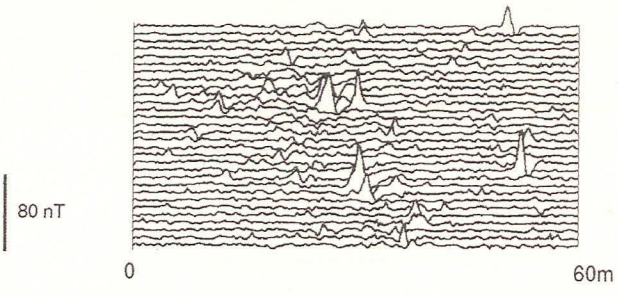
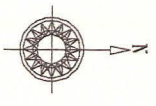
Area 4





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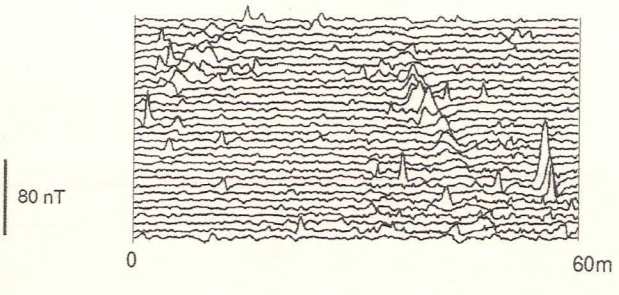
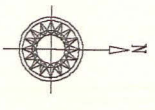
Area 5



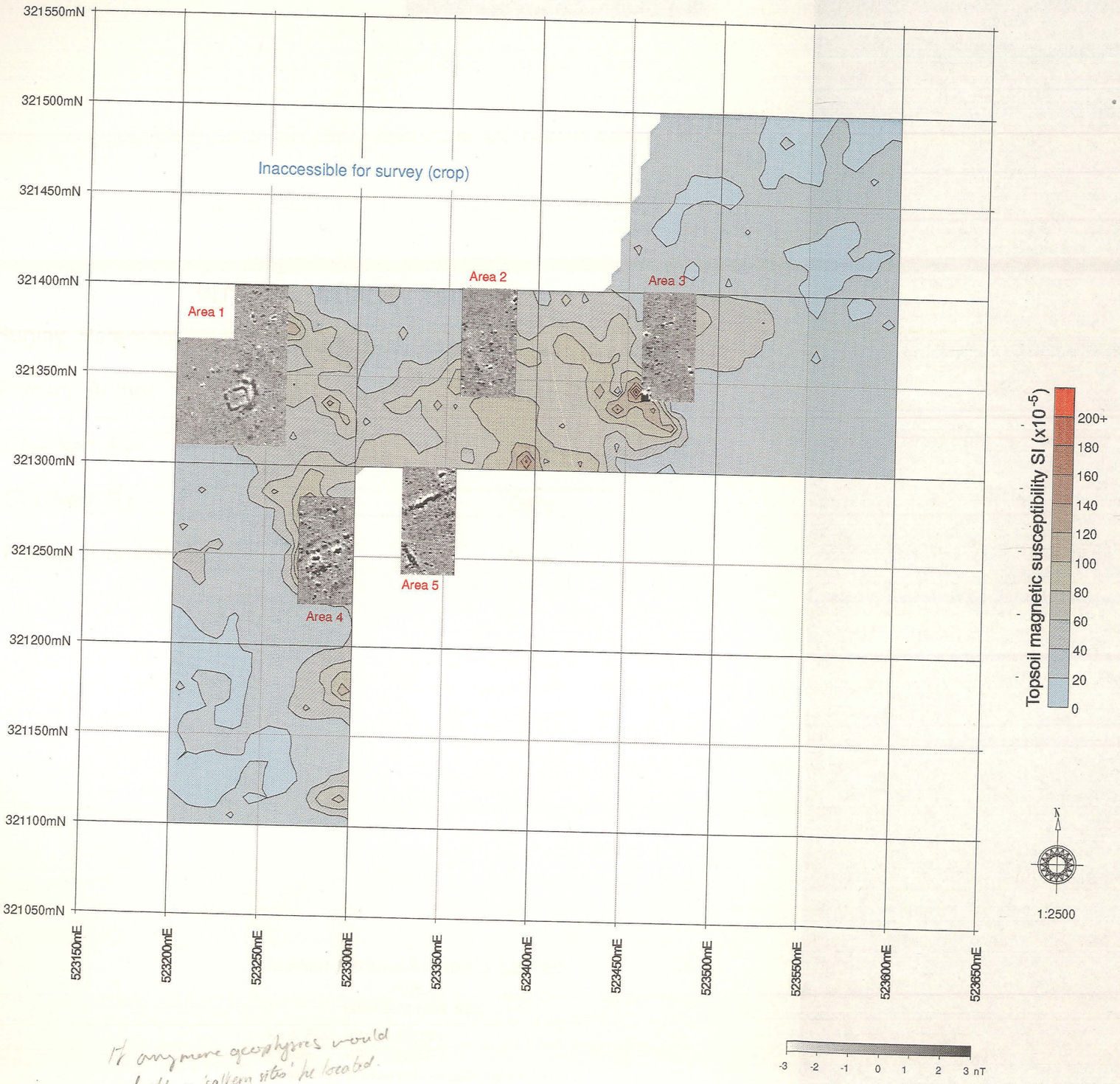


1:1,000

Horseshoe Road, Spalding, Lincolnshire

Archaeological geophysical survey

Overview



If any more geophysics would further 'saltern sites' be located.

OXFORD ARCHAEOTECHNICS

Fig. 11

INTERNAL QUALITY CHECK

Survey Reference	1750299 |HSL |SAM	
Primary Author		Date 12/2/99
Checked By	APJ	Date 12.02.99
Checked By		Date
Further Corrections		Date

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