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WELTON MANOR GOLF CENTRE, WELTON , LINCOLNSHIRE

*Gradiometer Survey*

( Survey Ref: 0860596/WEL/OTT )

MAY 1996

Produced by

**OXFORD ARCHAEOTECHNICS LIMITED**

under the direction of

**A.E. Johnson BA(Hons)**

Commissioned by

Lindsey Archaeological Services

on behalf of

C. Ottewell & Sons

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## *SUMMARY*

*A geophysical evaluation programme comprising gradiometer survey was carried out on land adjacent to Welton Manor Golf Centre, Hackthorn Road, Welton, Lincolnshire in advance of a proposed fishing lake (centred at TF 015812).*

*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 magnetometry).*

*In the present case, no underlying features of archaeological interest were detected.*

## 1. INTRODUCTION

- 1.1 Geophysical survey was commissioned by C. Ottewell & Sons on land adjacent to Welton Manor Golf Centre, Hackthorn Road, c.1 km north of the village of Welton (centred at TF 015812) in advance of a proposed fishing lake. The location is shown on Fig. 1. The fieldwork was carried out in May 1996.
- 1.2 The survey area comprises an area of arable farmland 0.5 ha in extent.
- 1.3 The underlying geology is predominantly limestone, although the proposed lake has been sited to take advantage of a local pocket of clay, situated within a shallow former stream valley, now drained by a ditch (which impinges upon the extreme northwestern edge of the survey area. The land is currently cultivated, with a young cereal crop.
- 1.4 Although no sites or finds of archaeological significance are known from the survey area, aerial photographs have revealed enclosures and structures of probable Romano-British date in the vicinity.
- 1.5 The present magnetometer (gradiometer) survey aimed to identify activity areas and characterise 'cut' features and structural remains of later prehistoric or subsequent periods. 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 The survey grids were tied in to the western paddock fence and northwest corner post of the paddock enclosure (Fig. 2).
- 2.2 Approximately 20 *in situ* topsoil magnetic susceptibility measurements were taken using a Bartington Instruments MS2 meter with an 18.5 cm loop both to determine the magnetic susceptibility of topsoils within the survey area, and also to compare and contrast topsoils overlying the local clays with those (situated some 100 m east) directly overlying the limestone. Soils here were found to average 40 SI, whereas soils above the clay pocket measured less than half this value, and locally registering as low as 7 SI.
- 2.3 The whole of the area of the proposed lake was examined by detailed gridded gradiometer survey using 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
- 2.4 Field data were stored to 3.5-inch disks, and processed using Geoscan Research Geoplot and Oxford Archaeotechnics software.
- 2.5 Magnetometer data have been presented as grey scale and raw data stacked trace plots (Figs. 3 & 4); a summary and interpretation of results is shown on Fig.3.

### 3. SURVEY RESULTS

- 3.1 The whole of the area of the proposed excavation for a new fishing lake was covered by eight 30 x 30 m gradiometer survey grids, forming a rectangular survey area of 120 x 60 m. An Anglian Water Authority water main runs close to the southern edge of the survey area, and the survey grids were positioned to avoid the gross effects of this ferrous pipeline.
- 3.2 All recorded magnetic anomalies are extremely weak, generally less than +1 nT, and consist of subtle weak lineations on two trends: almost east - west and generally northwest-southeast. These weak linears are most probably interpreted as agricultural striations or drainage features. Four of these striations are shown on Fig. 3. A scatter of ferrous objects are also recorded.
- 3.3 Extremely subtle patterns on the gradiometer plot suggest some local variations in topsoil thickness.

#### 4. CONCLUSIONS

- 4.1 Despite the relatively low magnetic susceptibility of the topsoils within the area of the gradiometer survey, some subtle regular magnetic anomalies have been generated, which are interpreted as probably agricultural in origin,
- 4.2 No underlying features were recorded which can confidently be described as having archaeological significance.

## REFERENCES

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- GALE, S.J. & HOARE, P.G. 1991. *Quaternary Sediments: petrographic methods for the study of unlithified rocks*. Belhaven Press: London (see Section 4.7, pp.201-229, "The magnetic susceptibility of regolith materials").
- SCOLLAR, I., TABBAGH, A., HESSE, A. & HERZOG, I. 1990. *Archaeological Prospecting and Remote Sensing*. Cambridge University Press.
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## ACKNOWLEDGEMENTS

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

## APPENDIX - 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.

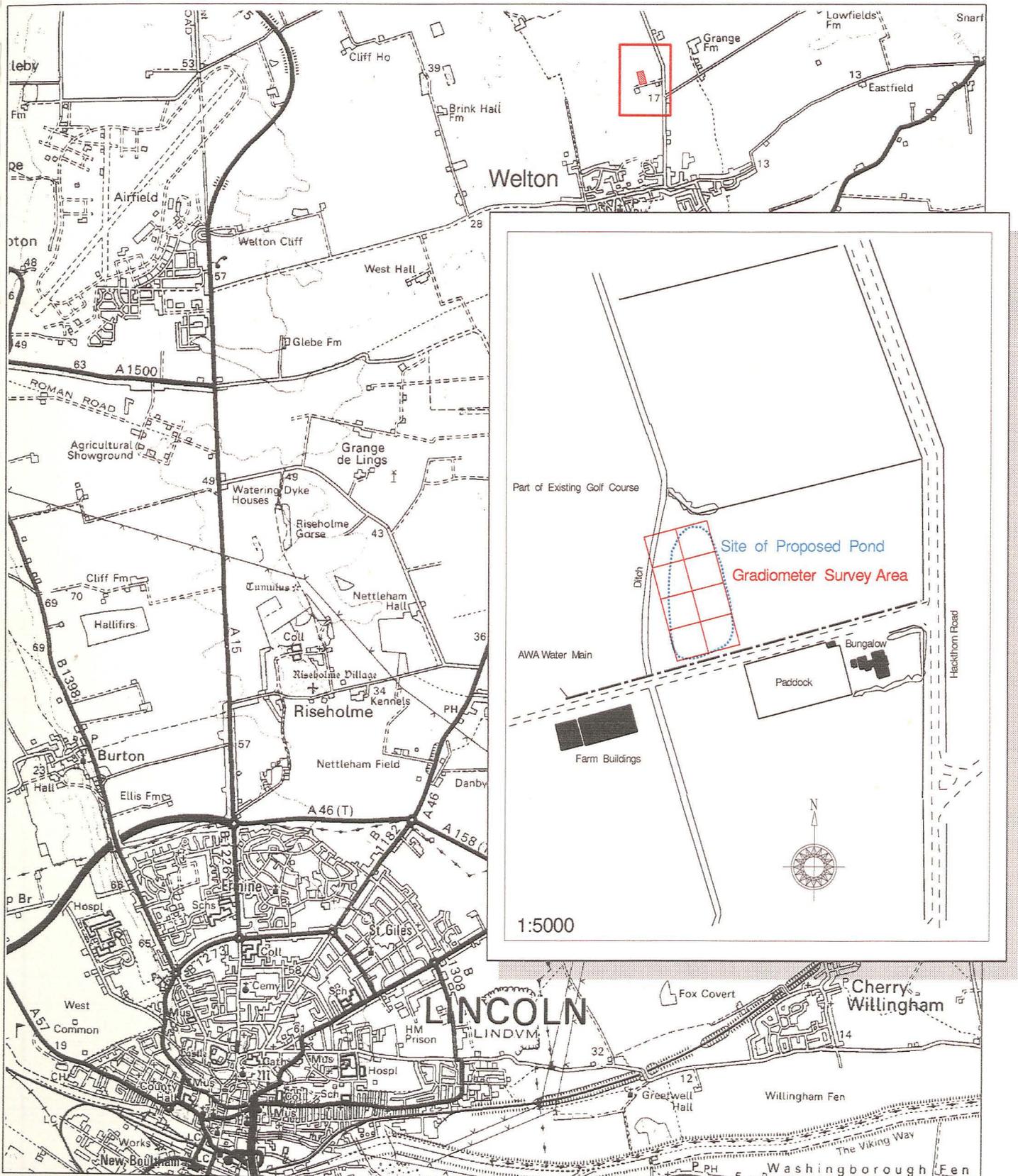
A1.12 Where a general spread of magnetically enhanced soils contained within a long-established boundary becomes admixed over a long period by constant ploughing, it can be diffused to such a point that the original source is masked altogether. Magnetically enhanced material may also be moved or masked 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).

## FIGURE CAPTIONS

- Figure 1. Location maps. Scale 1:50,000 and 1:5000. Based upon OS 1:50,000 Map 121, and 1:2500 scale Ryland Design base map supplied by C. Ottewell & Sons.
- Figure 2. Location of gradiometer survey, Scale 1:2500, and gradiometer grey shade plot (Geoscan Research Geoplot Licence No. GPB 885-6). Scale 1:1000.
- Figure 3. Gradiometer survey. Grey shade plot and interpretation. (Geoscan Research Geoplot Licence No. GPB 885-6). Scale 1:1000.
- Figure 4. Gradiometer survey. Stacked trace plot: raw data (Geoscan Research Geoplot Licence No. GPB 885-6). Scale 1:1000.

# Welton Manor Golf Centre, Welton Lincolnshire

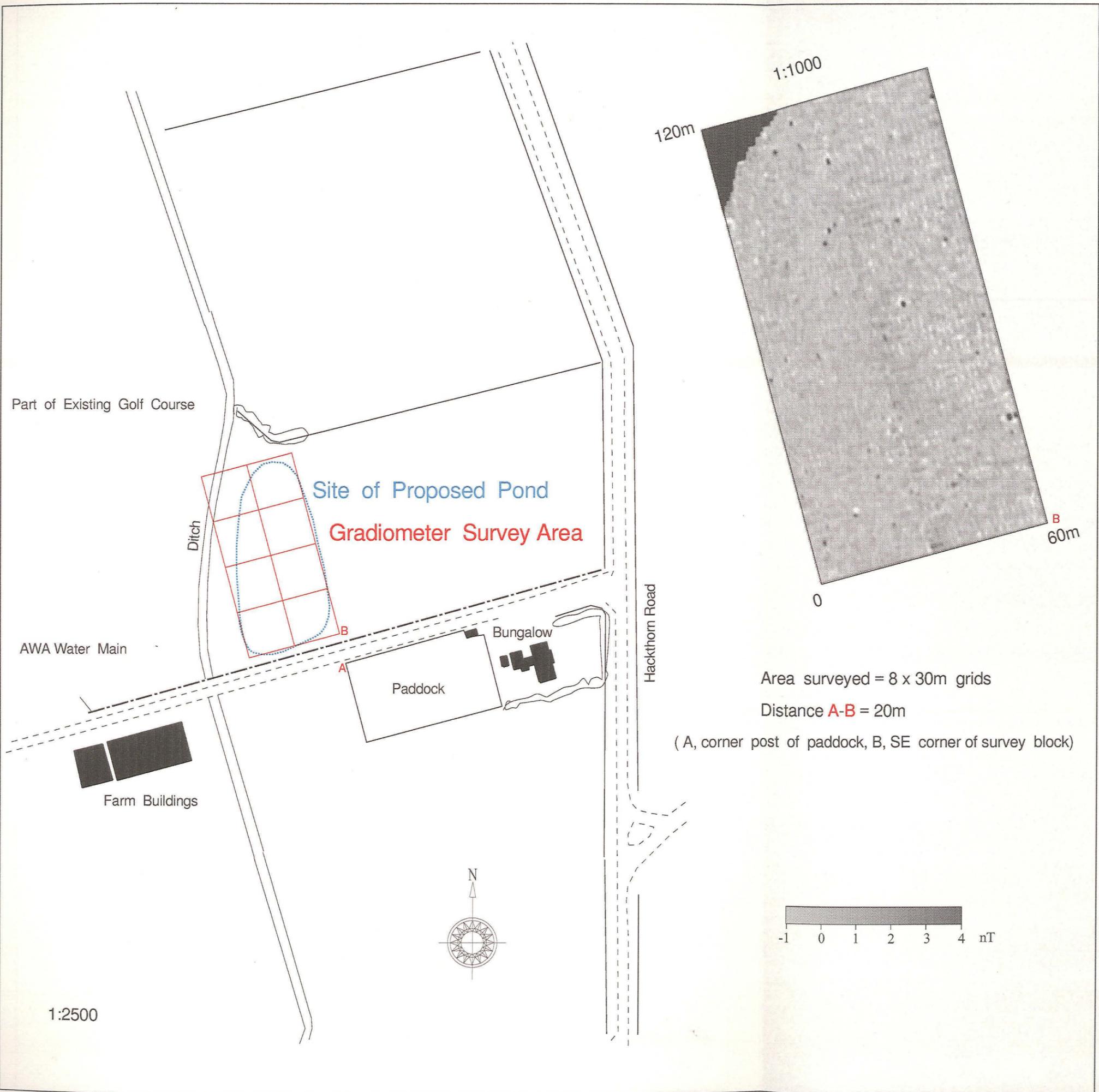
Location



1:50000

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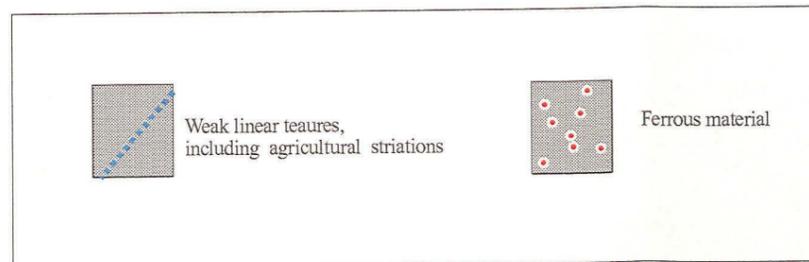
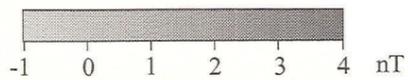
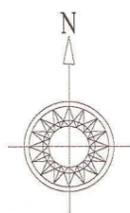
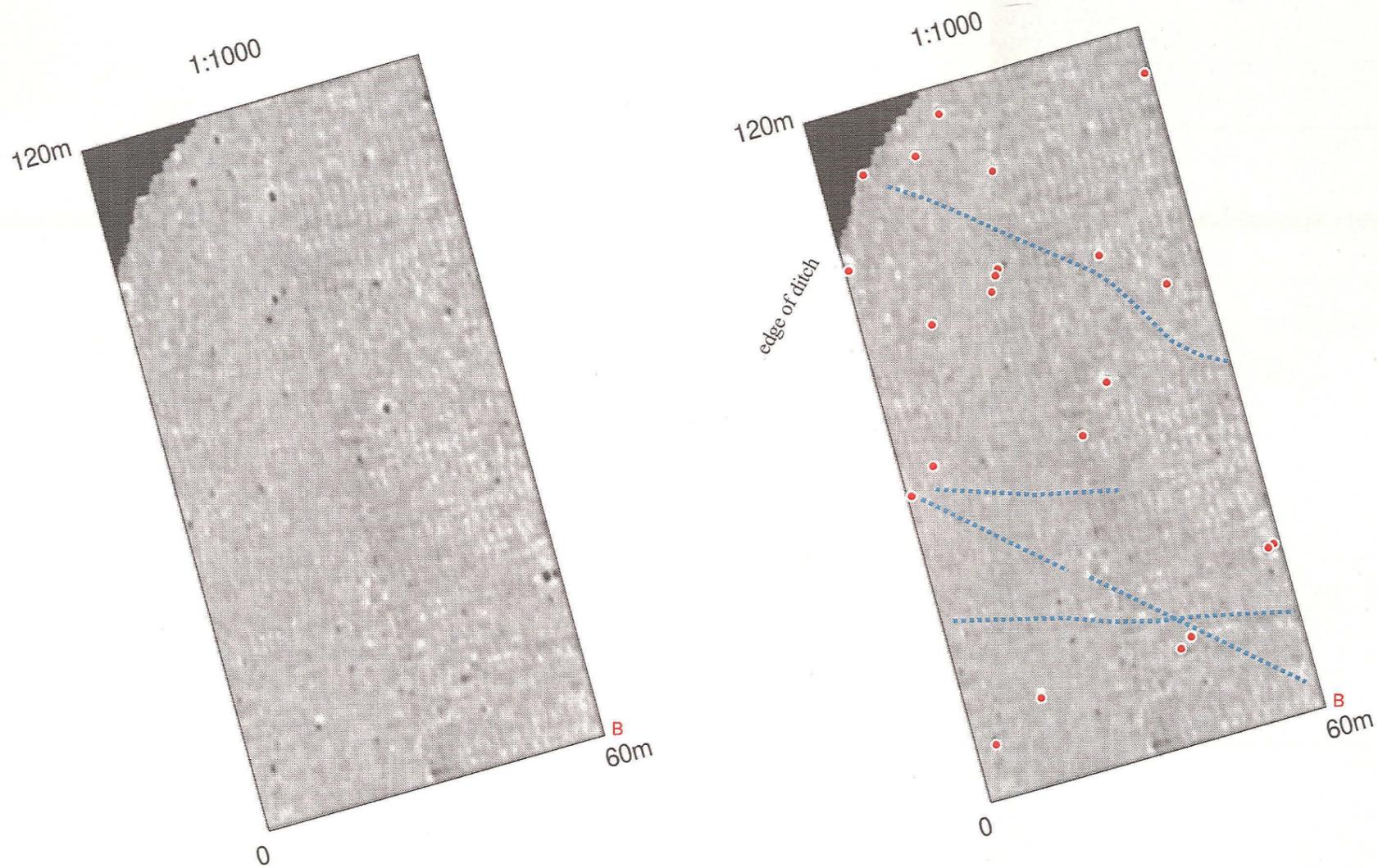
Fig 1



Welton Manor Golf Centre  
 Welton Lincolnshire  
 Gradiometer grey shade plot

Location, 1:2500  
 Gradiometer plot 1:1000

Welton Manor

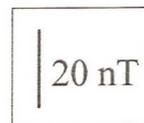
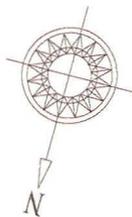
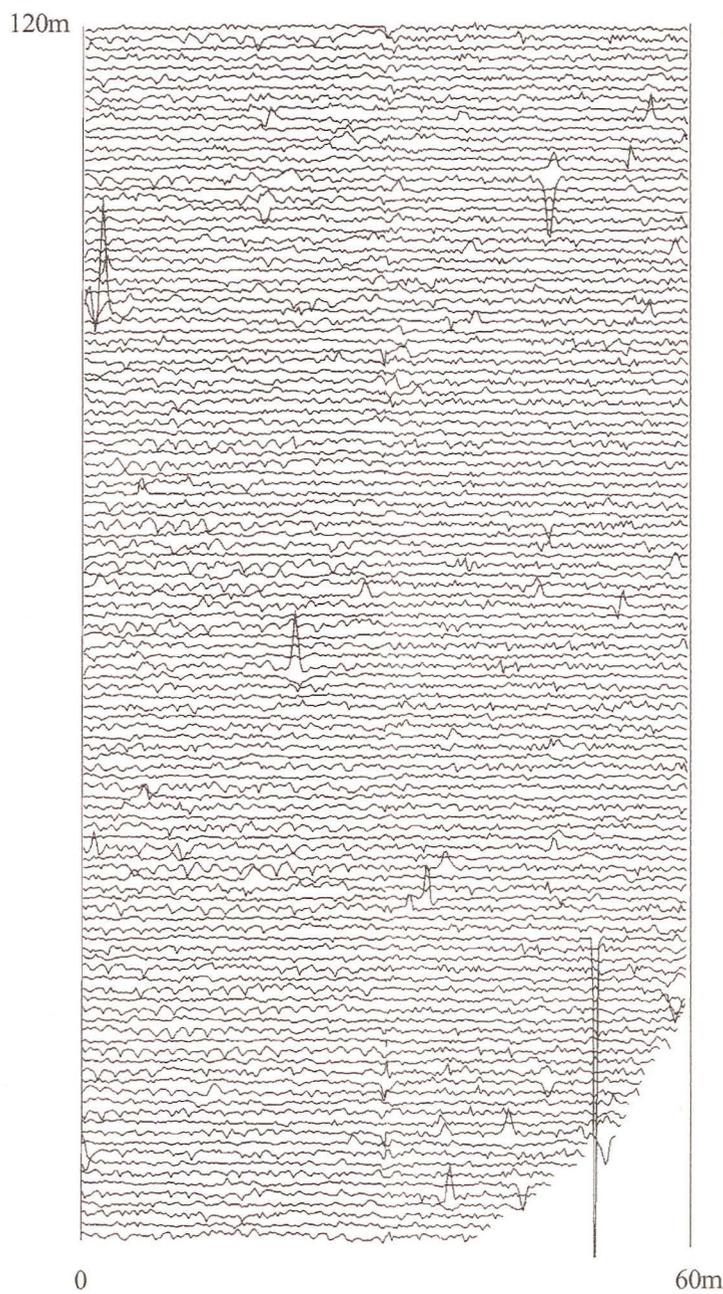


Welton Manor Golf Centre  
Welton Lincolnshire  
Gradiometer grey shade plot  
Interpretation

Gradiometer plot 1:1000

# Welton Manor Golf Centre, Welton Lincolnshire

Gradiometer stacked trace plot, raw data



Scale 1:1000

INTERNAL QUALITY CHECK

Survey Reference	0860596 / WEL / OTT		
Primary Author	<i>MJ</i>	Date	31/5/96
Checked By	APJ	Date	31.5.96
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Further Corrections		Date	

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