PROPOSED WESTON BYPASS, NR. SPALDING, LINCOLNSHIRE

Topsoil Magnetic Susceptibility Survey

(Survey Ref : 2160400/WEL/LCC)

MAY 2000

Produced by

OXFORD ARCHAEOTECHNICS LIMITED

under the direction of

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Commissioned by

Lincolnshire County Council Conservation Services

OXFORD ARCHAEOTECHNICS

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EVENT 411890
SOURCE 416636
negative

Specialist Archaeological Field Evaluation

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SUMMARY

Topsoil magnetic susceptibility mapping was carried out at both the western and eastern terminals of the proposed Weston Bypass, near Spalding, Lincolnshire (from NGR 528100 324450 to 528200 324720 and 529500 325230 to 529870 325030).

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).

10 m topsoil magnetic susceptibility survey produced weak and unremarkable patterning showing no obvious magnetic indications for underlying horizons of anthropogenic origin.

1. INTRODUCTION

1.1 Topsoil magnetic susceptibility mapping was commissioned by Lincolnshire County Council Conservation Services on land at both the western and eastern terminals of the proposed Weston Bypass, near Spalding, Lincolnshire. The location is shown on Fig. 1. The fieldwork was carried out in April 2000.

1.2 The proposed bypass route crosses farmland to the north of the village of Weston. The western survey strip, 40 m wide, extends for a distance of 280 m northeastwards from the proposed roundabout junction on the existing A151 High Road immediately east of the Anglian Water Services Pumping Station (from NGR 528100 324450 to 528200 324720); the land was mainly prepared seed bed, with strawberry beds at the northern end. The eastern survey strip runs parallel and immediately north of High Road, extending southeastwards east of Wimberley Hall Cottages for a distance of 360 m before rejoining the existing road (from NGR 529500 325230 to 529870 325030), reaching a maximum width of 40 m, tapering both northwest- and southeast-wards; the land was sheep pasture at the time of survey.

1.3 The survey area lies upon marine silts and clays of probable post Roman date (LCC Project Brief). The soils are reported as predominantly Stockwith and Wisbech Series calcareous alluvial gley soils (Albone 2000). The land is level, at 3 - 4 m AOD.

1.4 The objective of the survey was to complement the fieldwalking and archaeological assessment of the proposed route undertaken by the City of Lincoln Archaeology Unit (Trimble 2000) by investigating land which had been unavailable / unsuitable for fieldwalking. Proposed detailed magnetometer (gradiometer) survey within the central part of the route, close to the church, where fairly dense surface scatters of pottery sherds dating from the 12th century to the modern period had been recorded during fieldwalking could not be undertaken because of adverse ground conditions.

1.5 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 Scanning by gradiometer was attempted, but proved unproductive owing to strong signals from the underlying geology.

2.5 The topsoil magnetic susceptibility colour shade plots (Figs. 2 & 3) show contours at 5 SI intervals.

3. TOPSOIL MAGNETIC SUSCEPTIBILITY SURVEY RESULTS

3.1 225 *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 10 and 25 (x 10^{-5}) SI units. The mean for the survey area was 15.5 SI units and the standard deviation calculated against the mean was 2.8 SI units.

3.3 The topsoil magnetic susceptibility map shows little variation in the pattern of soil susceptibility across either of the survey strips.

4. CONCLUSIONS

4.1 Comparison with topsoil magnetic susceptibility measurements from a nearby site north of High Road (Johnson 2000) indicates that the readings recorded from both terminals of the proposed bypass route are below average for the area, showing no particular foci or patterns of enhancement to suggest any magnetic evidence for underlying anthropogenically modified horizons. Recent detailed magnetometer (gradiometer) survey at three locations in close proximity have suggested that the greatest dynamic in the magnetic environment is a product of natural variations in the underlying geology. Whilst it is possible that some dispersed and ephemeral archaeological activity may not register in these conditions, it is nevertheless felt that had underlying archaeological sites associated with former settlement (particularly associated with industrial processes involving burning or firing) been present, they should have been visible to magnetic survey.

REFERENCES

CLARK, A.J. 1990. *Seeing Beneath the Soil.* B.T. Batsford Ltd: London.

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").

JOHNSON, A.E. 2000. Land North of High Road, Weston, Nr. Spalding, Lincolnshire: *Topsopil Magnetic Susceptibility & Magnetometer (gradiometer) Survey.* Report by Oxford Archaeotechnics (Survey Ref: 2150400/WEL/APS) commissioned by Archaeological project Services, April 2000.

SCOLLAR, I., TABBAGH, A., HESSE, A. & HERZOG, I. 1990. *Archaeological Prospecting and Remote Sensing.* Cambridge University Press.

THOMPSON, R. & OLDFIELD, F. 1986. *Environmental Magnetism.* Allen & Unwin: London.

TRIMBLE, R. 2000. *The proposed by-pass at Weston, Spalding, Lincs. Archaeological desk-top assessment and fieldwalking.* Report by the City of Lincoln Archaeological Unit (CLAU Report No:412.

Topsoil magnetic susceptibility mapping and magnetometer survey by Oxford Archaeotechnics Limited under the direction of A.E. Johnson *BA(Hons)*, with S. Pelipenko and G. Marcantuono. The project was co-ordinated by A.P. Johnson *BA, PhD, MIFA.*

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).

Proposed Weston Bypass, Lincolnshire

Topsoil Magnetic Susceptibility Survey

Location

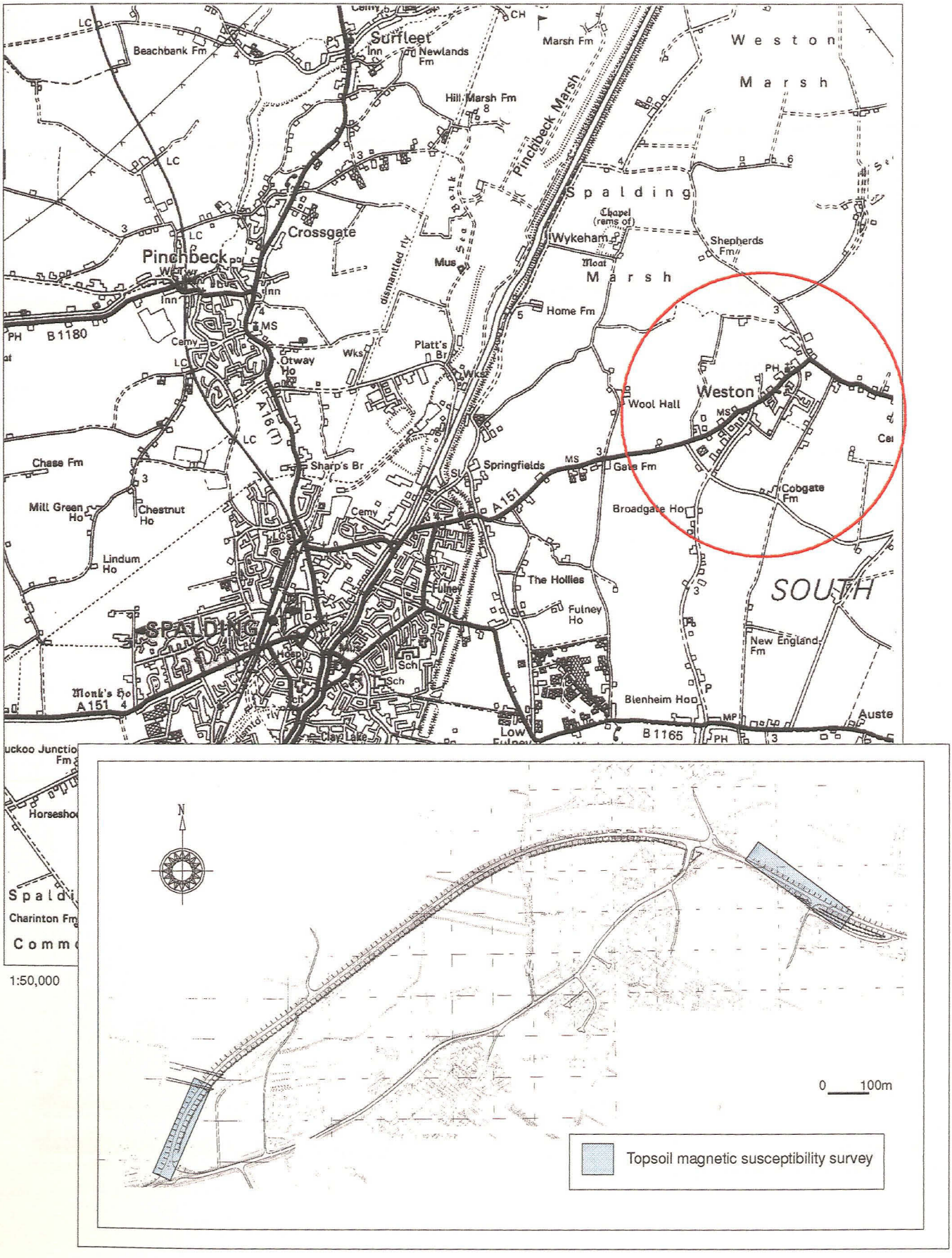

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Fig. 1

Proposed Weston Bypass,Lincolnshire

Topsoil Magnetic Susceptibility Survey

Topsoil Magnetic Susceptibility Survey: colour contour plot

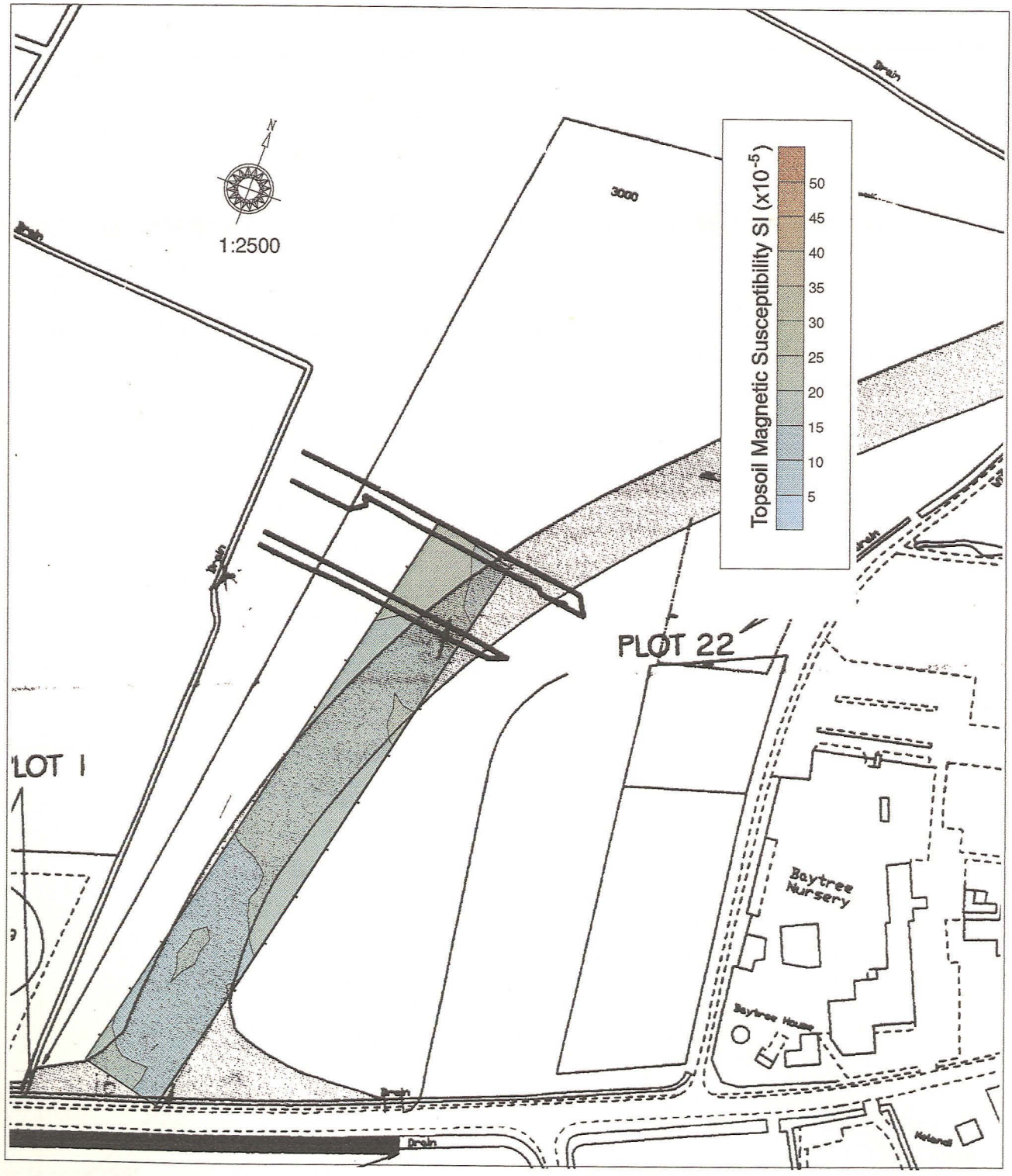

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Fig. 2

Proposed Weston Bypass,Lincolnshire

Topsoil Magnetic Susceptibility Survey

Topsoil Magnetic Susceptibility Survey: colour contour plot

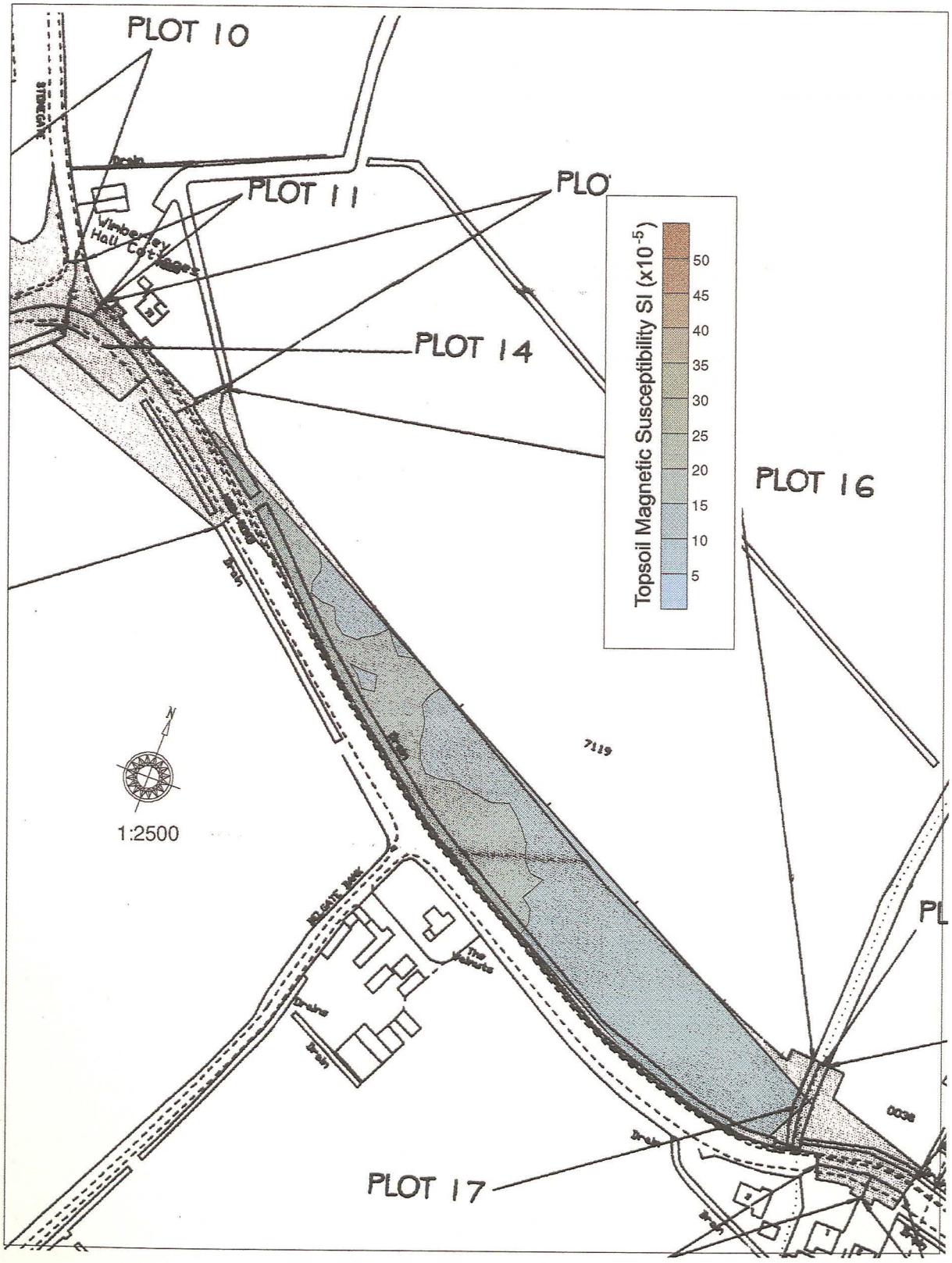

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Fig. 3

INTERNAL QUALITY CHECK

Survey Reference	2160400/WEL/LCC	
Primary Author		Date
Checked By	AEJ	Date 31.05.00
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Further Corrections		Date

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