RPS Planning, Transport and Environment

INDEX DATA	RPS INFORMATION
Scheme Title A6 Clapham Bypass	Details Geophysical survey
Road Number	Date
Contractor WYAS Archaeological services	
County Bedfordshire	
OS Reference TL05	
Single sided ✓ Double sided A3 4 Colour 10	

A6 Clapham Bypass,

Clapham,

Bedford.

(TL 018 542 site centred)

Geophysical Survey

Contents

Summary

A geophysical survey was carried out along the road corridor of the proposed A6 Clapham Bypass. This comprised a rapid magnetic scan of the road corridor (25 hectares) followed by selected detailed gradiometer survey in six blocks covering 5 hectares. The scanning and subsequent detailed survey did not identify any anomalies thought to be indicative of archaeological features except in the two southernmost fields in the corridor. However, in this area anomalies indicative of infilled ditches, pits/post-holes, areas of burning/industrial activity and a possible kiln have been identified providing strong evidence of settlement/occupation.

At the northern end of the corridor the magnetic susceptibility was extremely low leading to the possibility that there may be archaeological features that could not be detected by conventional gradiometry in these areas.

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1. Introduction & Archaeological Background

1.1 Archaeological Services WYAS was commissioned by Mr S. Steadman of Bedfordshire County Archaeology Service, to carry out a geophysical (fluxgate gradiometer) survey along the proposed route of the A6 Clapham Bypass (see Figs 1 and 2). The survey was to comprise a rapid magnetic scan along the whole length of the corridor, followed by selected detailed survey based on the results of the scanning and other pertinent information.

1.2 The highest point on the road corridor is at Oakley Hill, near the northern end of the route, which has a dominating aspect in all directions. Cropmarks, interpreted as a rectilinear enclosure, have been identified adjacent to Judge's Spinney on the summit of the hill. North from Oakley Hill the land generally slopes down towards the end of the corridor where it rejoins the existing (A6) road, although it is undulating with one extremely pronounced ridge; Block 2 was located over this ridge. To the south of Oakley Hill the land slopes down gently for approximately 200m and then flattens out along the remainder of the corridor. The extreme southern end of the corridor is on the floodplain of the River Great Ouse.

1.3 The geology also changes along the corridor reflecting the topography. At the northern end Oxford Clays outcrop on the higher ground around Oakley Hill. Downslope, to the south, the clay is overlain by drift deposits of river gravels, particularly just to the north of Oakley Road. At the extreme southern end of the corridor the soil is predominantly alluvium due to the proximity of the river. These changes are reflected in the magnetic susceptibility data which are discussed and tabulated in Section 2.10.

1.4 Apart from the possible enclosure at the top of Oakley Hill there is no known archaeology along the projected route of the bypass. However, a fieldwalking evaluation along the corridor, carried out by Bedfordshire County Archaeology Service, located a significant cluster of pottery sherds in the (ploughed) field at the southern end of the corridor, which are thought to be of late Iron Age/Romano-British date. A smaller number of the same type of material was collected in the adjacent field immediately north of Oakley Road.

1.5 At the time of survey, between February 21st and 25th 2000, all of the fields within the corridor were under a short arable crop, with the exception of the most southerly field which had been ploughed and left fallow.

1.6 The objectives of the survey were to:

- identify areas of possible archaeological activity by magnetic scanning for further investigation by detailed magnetic survey
- to define the presence, extent and character of any archaeological geophysical anomalies within the sample detailed survey areas.

2. Results & Discussion

2.1 The location of the six blocks of detailed gradiometer survey (numbered from Block 1 in the north to Block 6 in the south) are shown on Figure 2. The data is presented in greyscale format at a scale of 1:1250, superimposed on a digital map base in Figures 3, 5, 7 and 9. The location of the magnetic susceptibility transects is also shown on these figures. Interpretations of the data, also at a scale of 1:1250, are presented in Figures 4, 6, 8 and 10. Large scale, 1:500, greyscale and X-Y trace plots of the data, on the Ordnance Survey base, are included in the accompanying Volume as Appendix 4. Details on the data processing are given in Appendix 1.

2.2 The Magnetic Scanning

2.2.1 The scanning was commenced in the areas surrounding Judge's Spinney, in an attempt to determine both the precise location of the archaeological features presumed to be causing the cropmarks (an interpreted rectilinear enclosure) and to assess the magnitude of the magnetic responses from them. It was hoped that establishing the strength of these potential archaeological anomalies would aid the identification of other anomalies during the remainder of the scanning. In this area the scanning traverses were aligned from west to east while along the remainder of the corridor scanning was parallel with the edge of the corridor. Further details on the scanning methodology are given in Appendix 1.

2.2.2 It was immediately apparent, given the very low magnetic background (soil 'noise') of +/- 0.5nT and the inability of the scanning to locate the features assumed to be causing the cropmarks, that it would be difficult to identify anomalies caused by infilled archaeological features on the soils/geology prevailing on the high ground around Oakley Hill. There is further discussion on the potential effect that a low soil magnetic background can have on the reliability that can be placed in the results of a gradiometer survey in the section discussing the data from the magnetic susceptibility transects. However, one large area of magnetic disturbance was identified.

2.2.3 To the north of Highfield Road the magnetic background was still extremely low but it did become stronger (more 'noisy') in the most northerly field, adjacent to the A6. An area of magnetic disturbance was located in this field. No other probable areas of archaeological activity were identified during the scanning north of Highfield Road.

2.2.4 To the south of Highfield Road the magnetic background remained low but a gradual increase was noted in the two fields immediately north of Oakley Road. It is thought that this increase reflected the transition onto the river gravels. Although no obvious linear anomalies were detected in the corridor between Judge's Spinney and Oakley Road many isolated responses were identified, predominantly in the two fields referred to above. However, it was not clear whether these responses were due to weakly magnetic pockets of gravel or to archaeological features.

2.2.5 South of Oakley Road the scanning was much more successful. Despite the perturbed magnetic background, due to the topsoil being mixed as a result of the ploughing, it was evident that there was a great deal of activity as evidenced by the number and strength of isolated anomalies identified during scanning and by the strength of several linear anomalies that were also identified.

2.2.6 On the basis of the results of the scanning, the fieldwalking exercise, the (limited) cropmark evidence and on topography, six areas (Blocks 1-6) were selected for detailed gradiometer survey. The reasoning for the location for each of the blocks is given in the respective sections below.

2.3 The Detailed Gradiometer Survey

2.4 **Block 1** (Figures 3 and 4)

2.4.1 This survey block was positioned around the area of magnetic disturbance identified during the magnetic scanning.

2.4.2 Other than the 'iron spike' anomalies, which are probably due to ferrous or strongly magnetised material in the topsoil, and which are common across most arable sites, there are no anomalies of probable archaeological origin in this block. It is possible that the cluster of 'spikes', identified during scanning, could be caused by archaeological ferrous material but, given the absence of other archaeological evidence, a modern origin is probable.

2.5 **Block 2** (Figures 3 and 4)

2.5.1 The location of this block was determined by its topographically favourable location straddling a ridge on the lee side of Oakley Hill.

2.5.2 No anomalies other than the ubiquitous 'iron spikes' have been identified in this block.

2.6 **Block 3** (Figures 5 and 6)

2.6.1 The location of this block was also determined by its dominating situation on the top of Oakley Hill, but also by the proximity of possible cropmarks and because of the identification, during scanning, of an area of magnetic disturbance.

2.6.2 Again no anomalies other than 'iron spikes' and confirmation of the location of the area of magnetic disturbance were identified. As in Block 1, this area of disturbance might have an archaeological origin but without supporting evidence a modern cause is thought probable.

2.7 **Block 4** (Figures 7 and 8)

2.7.1 The main reason for the position of Block 4 was the identification, during scanning, of an area of disturbance and of small localised areas of enhanced susceptibility.

2.7.2 The area of disturbance was identified but it is thought, due to its location immediately adjacent to an open drain, that it is probably caused by ferrous material cleared out of the drain. The localised enhanced background is probably due to the occurrence of pockets of slightly more magnetic material in the river gravels that comprise the drift geology in this part of the site.

2.8 **Block 5** (Figures 7 and 8)

2.8.1 This block was positioned to sample the area in which moderate quantities of pottery had been collected during the fieldwalking and to investigate the faint linear anomalies and localised areas of enhanced susceptibility that were identified during scanning.

2.8.2 As in Block 4, the localised areas of enhanced magnetic background are thought to be caused by natural variations in the magnetic properties of the subsoil, although an archaeological origin cannot be completely discounted.

2.8.3 Most of the linear anomalies, which are parallel with the field boundary, are due to recent agricultural practice, reflecting the most recent orientation of ploughing/seeding. However, one faint linear anomaly has been identified which could be caused by an infilled archaeological ditch.

2.9 **Block 6** (Figures 9 and 10)

2.9.1 All of the corridor was surveyed in the ploughed field at the southern end of the site, with the exception of an area around the base of a high voltage electricity pylon, because of the very strong anomalies that were detected in this field during the scanning and because of the cluster of pot sherds that were recovered during the fieldwalking exercise.

2.9.2 Several strong linear anomalies indicative of infilled archaeological ditches have been identified. The strongest magnetic response is exhibited by **Anomaly A**, which runs from north to south bisecting the survey area. Further similar, but less strong anomalies, both on the same alignment, and perpendicular to it, have been identified to the east and west of this spinal ditch. The presence of possible agricultural anomalies, particularly at the northern end of the field, on similar alignments to those of the archaeological anomalies makes definitive interpretation of the weaker or less obvious anomalies difficult. It is therefore, possible that some of the anomalies identifed as possibly having an agricultural origin could also be archaeological ditches.

2.9.3 On the eastern edge of the survey area, immediately north-west of **Anomaly A**, is a very broad, irregular anomaly, **Anomaly B**, aligned approximately from north-west to south-east. The breadth of the response may indicate a geological origin (part of palaeochannel?) although it could be attributable to an area of burning possibly associated with the large, positive isolated anomaly, **Anomaly C**, immediately to the south. Plough damage of a ditch, possibly the continuation of **Anomaly A**, might also account for this anomaly.

2.9.4 The large, positive, isolated anomaly referred to above, **Anomaly C**, has a response suggestive of a large, infilled pit although the breadth and strength of the response could also indicate a kiln.

2.9.5 Towards the southern end of the survey area are two parallel anomalies, **Anomaly D**, thought to be ditches forming the corner of a rectilinear enclosure. There may be an entrance in this double ditch although this gap may be caused by the differential preservation of ditches. To the east of this 'enclosure' are many isolated responses typical of pits/areas of burning which may locate an area of industrial activity. Within the 'enclosure' there is a broad alignment of isolated responses which may represent a pit alignment or a series of post-holes.

2.9.6 To the south of the 'enclosure' the magnetic background is much quieter. This partly reflects the fact that this part of the field had not been ploughed and partly the fact that this is the edge of the floodplain and that there is an increasing depth of alluvium which may, in fact, be 'masking' the magnetic response from other, unidentified, archaeological anomalies nearer the river.

2.9.7 Over the whole of this survey block are a number of positive, isolated anomalies that are suggestive of archaeological pits or small areas of burning. However, as these responses can also be caused by geological features they have only been classed as probably archaeological when they are particularly strong or are located adjacent to anomalies interpreted as archaeological ditches. An archaeological origin cannot be ruled out for the other positive, isolated responses. As the general magnetic background is quite perturbed, due to the ploughing, it is extremely likely that there are other, weaker, unidentified, isolated anomalies whose magnetic response is masked by the noisy background.

2.10 The Magnetic Susceptibility Data

2.10.1 In order to try to gauge the reliability with which the gradiometer might be able to identify archaeological features on the different soils and geology that are present at different parts of the site, topsoil (volume specific) magnetic susceptibility readings were taken at 20m intervals on transects along the midpoint of each sample block. The results are tabulated on the folowing pages.

Topsoil Magnetic Susceptibility Data

Transect MS1: south-west (0m)/north-east (120m)

Distance (m)	Magnetic Susceptibility (SI units)
0	21
20	20
40	24
60	43
80	32
100	26
120	33

Transect MS2: south-west (0m)/north-east (180m)

Distance (m)	Magnetic Susceptibility (SI units)
0	15
20	11
40	10
60	24
80	13
100	9
120	18
140	13
160	16
180	10

Transect MS3: west (0m)/east 160m)

Distance (m)	Magnetic Susceptibility (SI units)
0	11
20	10
40	12
60	4
80	11
100	12
120	9
140	9
160	11

Transect MS4:south-west (0m)/north-east (120m)

Distance (m)	Magnetic Susceptibility (SI units)
0	27
20	24
40	23
60	43
80	34
100	33
120	57

Transect MS5: south-west (0m)/north-east (120m)

Distance (m)	Magnetic Susceptibility (SI units)
0	40
20	50
40	39
60	44
80	43
100	40
120	43

Transect MS6: south-east (0m)/north-west (260m)

Distance (m)	Magnetic Susceptibility (SI units)
0	31
20	30
40	35
60	51
80	53
100	62
120	67
140	68
160	59
180	67
200	62
220	49
240	44
260	55

2.10.2 Whilst these measurements cannot in themselves be taken as indicators as to whether infilled archaeological features may or may not be detected on any given soil/geology (a ditch filled predominantly with strongly magnetised material such as slag or pottery wasters is always likely to be identified irrespective of a lack of magnetic contrast between the topsoil and the soil fill of the archaeological feature) they can help explain why cropmarks may not be detected as magnetic anomalies on certain sites or why anomalies may be particularly weak.

N.b Only by physically taking samples of topsoil and subsoil at specific locations and establishing whether there is a measurable susceptibility contrast between the two can a more reliable assessment be made as to whether archaeological features can be detected. However, it is likely that it will be more difficult to detect infilled features on sites where the topsoil susceptibility is very low.

2.10.3 From the tables it can be seen that the susceptibility is extremely low (between 4 and 12 SI units) in Block 3 (Transect MS3) on the top of Oakley Hill. This may explain the inability to identify the cropmark 'enclosure'. In Block 2 (Transect MS2) the susceptibility is slightly higher and more variable (between 9 and 24 SI units) and higher again in Block 1, varying between 20 and 33 SI units.

2.10.4 At the southern end of the site the susceptibility is generally much higher reflecting the change in geology from the outcropping clays to the river gravels. Thus in Block 4 the susceptibility varies between 23 and 57 SI units and in Block 5 from 39 to 50 SI units. In Block 6 the readings range between 30 SI units, on the alluvium at the extreme southern end of the field, to 68 SI units in the middle of the field. In this middle section it is more likely that the readings reflect the presence of magnetically enhanced material associated with the archaeological features rather than the unenhanced magnetic susceptibility of the topsoil.

3. Conclusions

3.1 Over the majority of the road corridor there is little or no evidence from the geophysical survey for archaeological activity. The very low topsoil magnetic susceptibility, particularly around Oakley Hill at the northern end of the corridor, suggests that there might be insufficient magnetic contrast to enable archaeological features to be detected by conventional gradiometer survey. The possibility therefore remains of there being undetected archaeological features, as suggested by the undetected cropmarks, in this part of the site, particularly in the the more topographically suitable locations.

3.2 At the southern end of the corridor there is very strong geophysical evidence for human activity/settlement. Anomalies have been identified in Block 6 that are thought to indicate enclosure and/or boundary ditches, pits or post-holes, areas of burning or industrial activity and a possible kiln. Although only one possible archaeological ditch type anomaly was identified north of Oakley Road in Block 5, there may be further archaeological remains in the land immediately east of Block 5 in the paddock and allotment areas where scanning and detailed survey was inappropriate.

The results and subsequent interpretation of geophysical surveys should not be treated as an absolute representation of the underlying archaeological and non-archaeological remains. Confirmation of the presence or absence of archaeological remains can only be achieved by direct investigation of sub-surface deposits. This can be undertaken by means of targeted trial trenching.

Acknowledgements

Project Management
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Graphics
Mark Whittingham BSc MA

Fieldwork
Robert McNaught BSc PIFA
Adam Smith BSc
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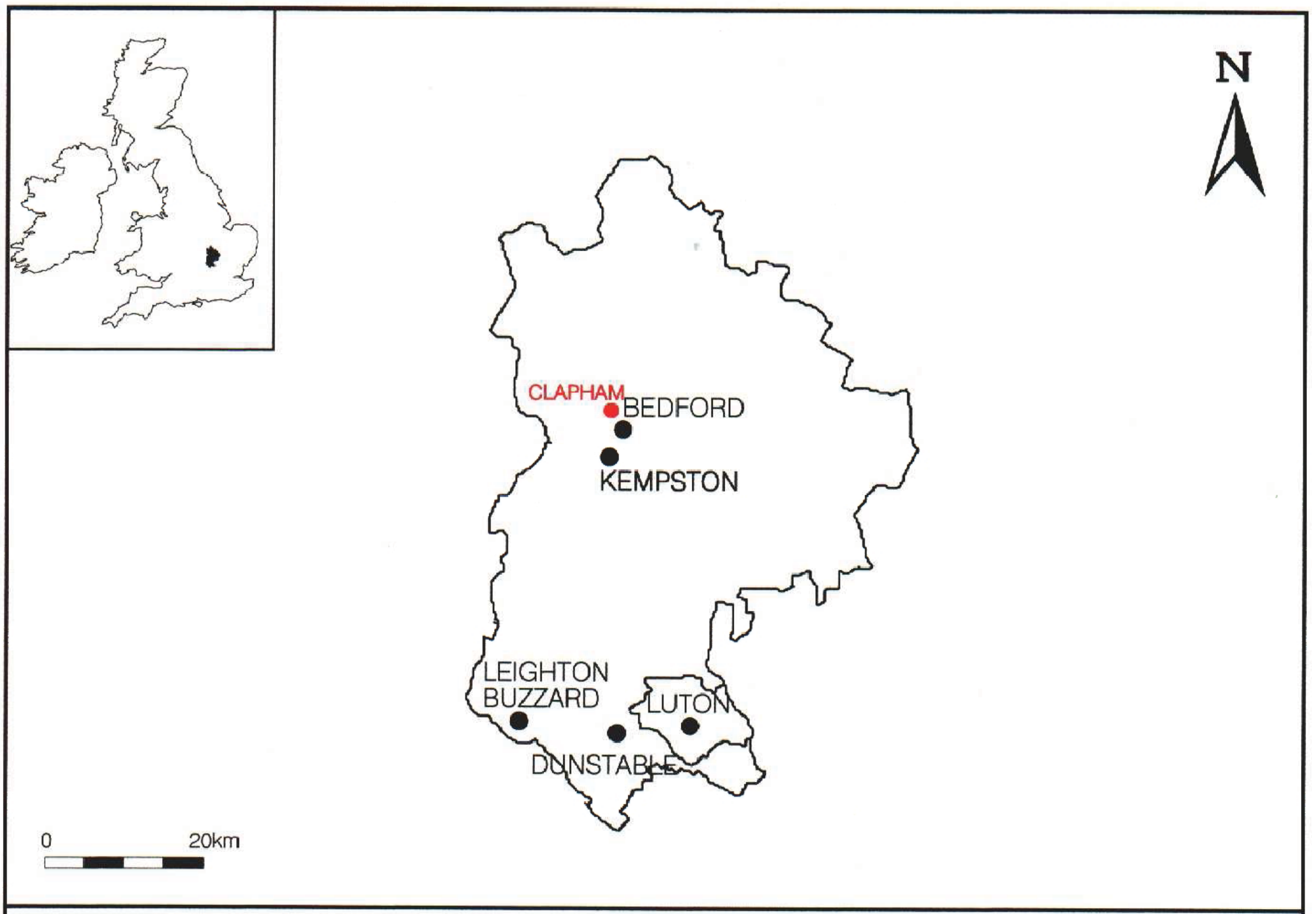
Figures

Appendices



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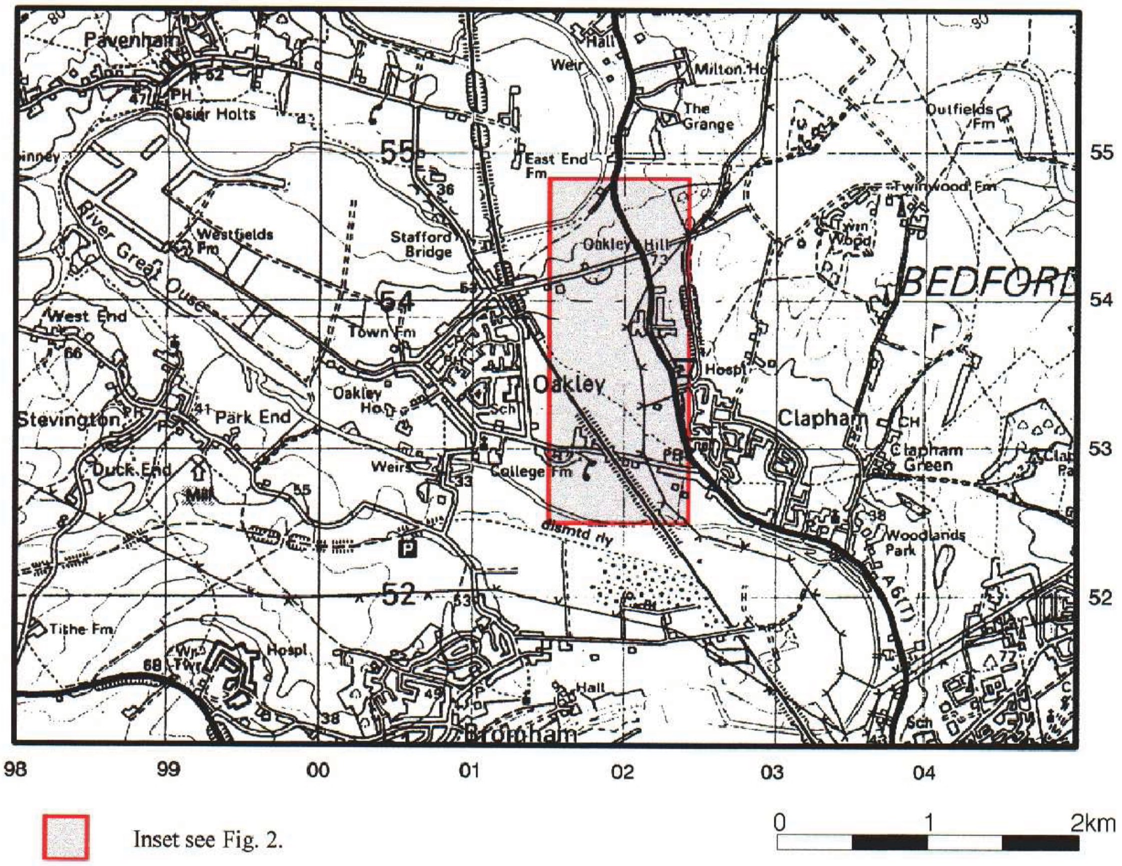

Fig. 1. Site location

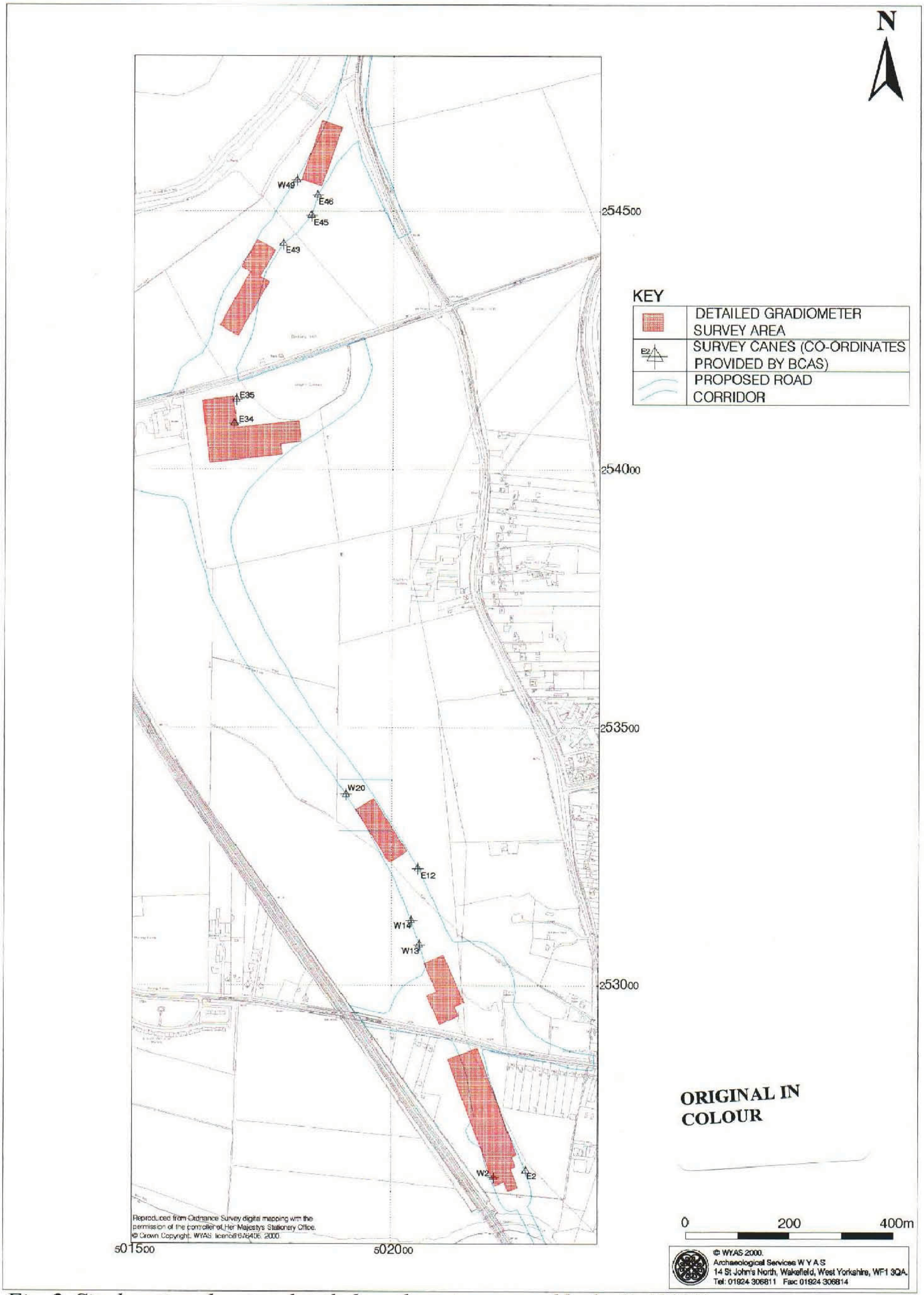

Fig. 2. Site location showing detailed gradiometer survey blocks (1:10000)

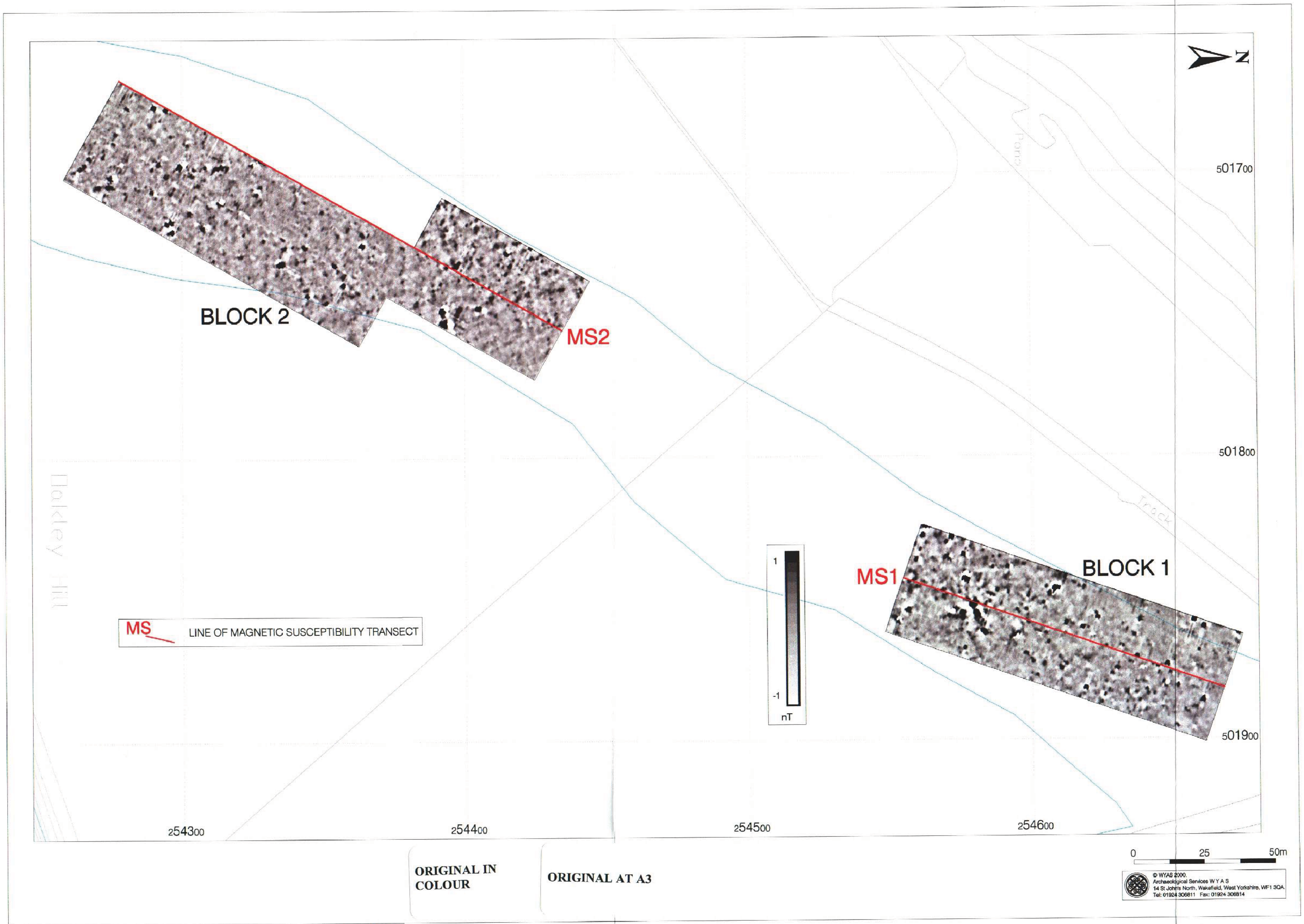

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Fig. 3. Greyscale gradiometer data; Blocks 1 and 2 (1:1250)

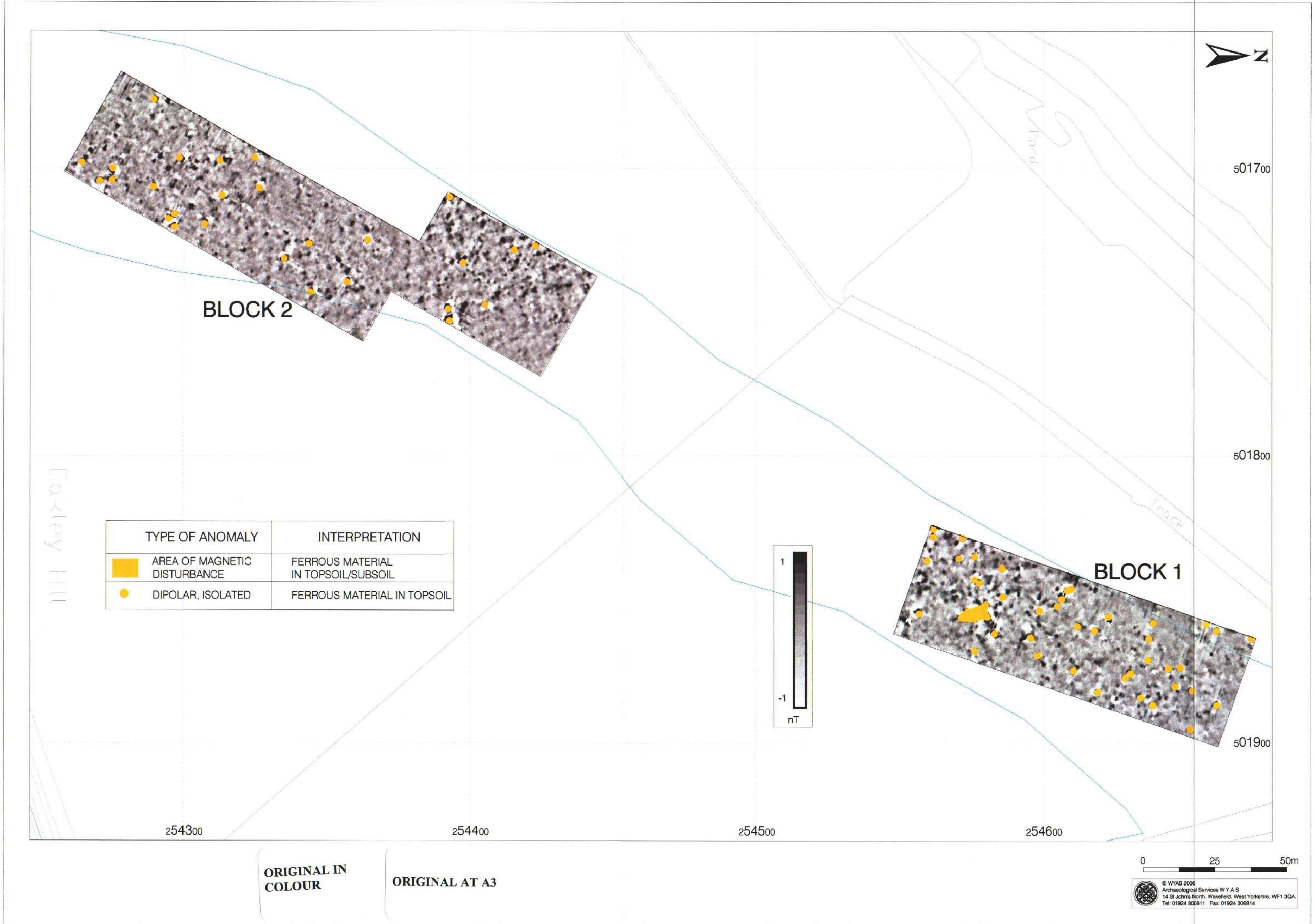
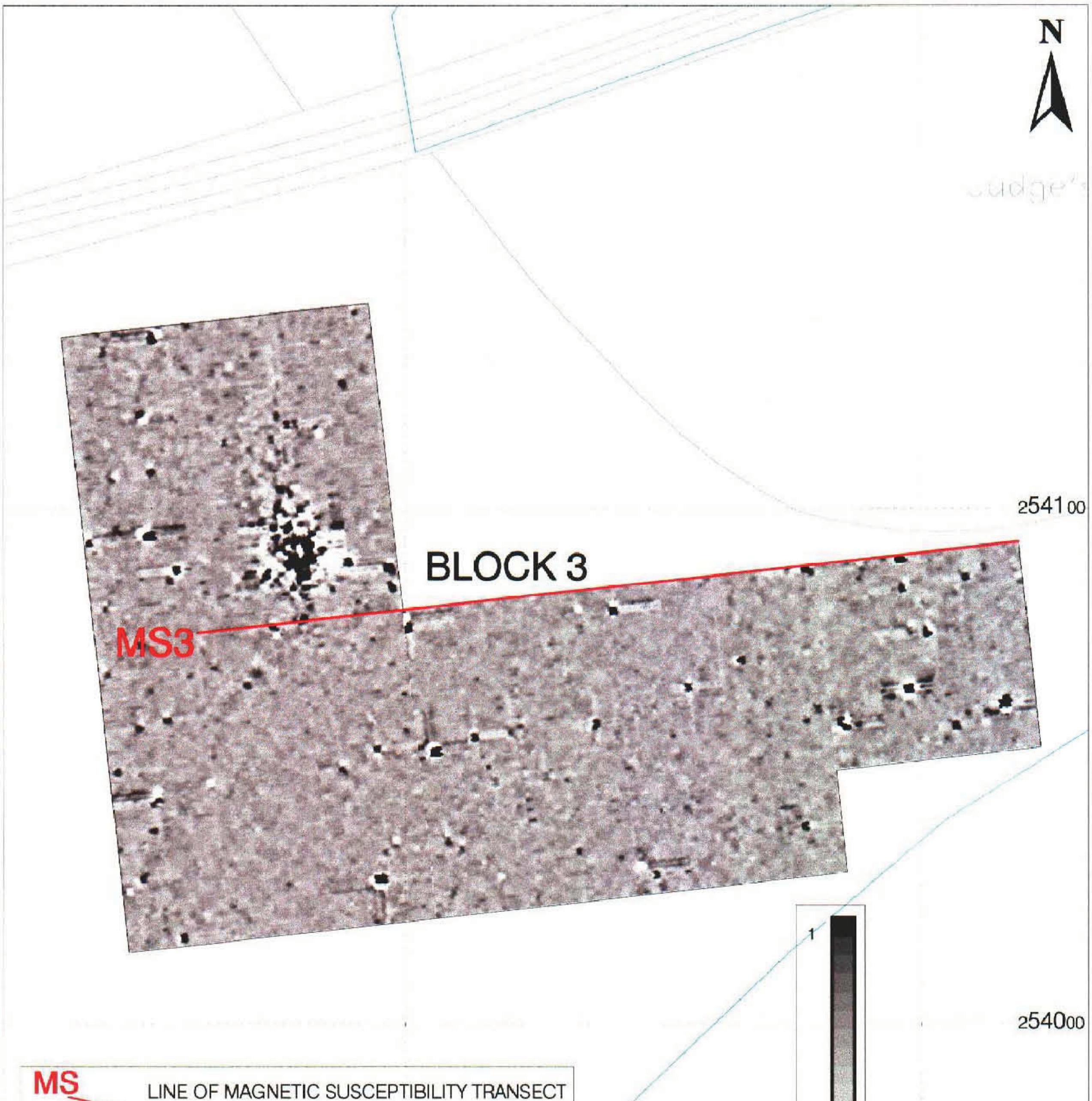


Fig. 4. Interpretation of gradiometer data; Blocks 1 and 2 (1:1250)



ORIGINAL IN COLOUR

0 25 50m

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Fig. 5. Greyscale gradiometer data; Block 3 (1:1250)

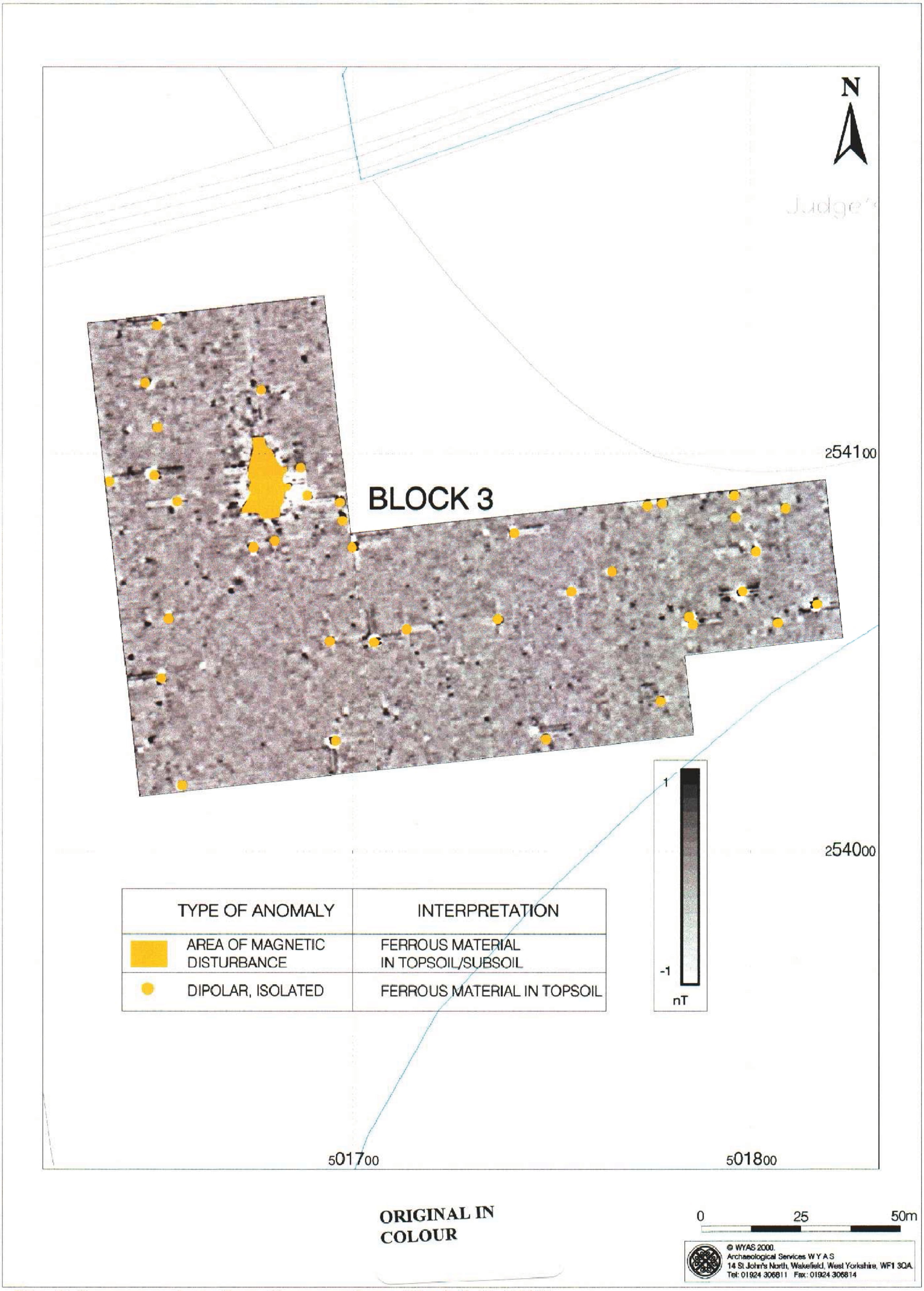

Fig. 6. Interpretation of gradiometer data; Block 3 (1:1250)

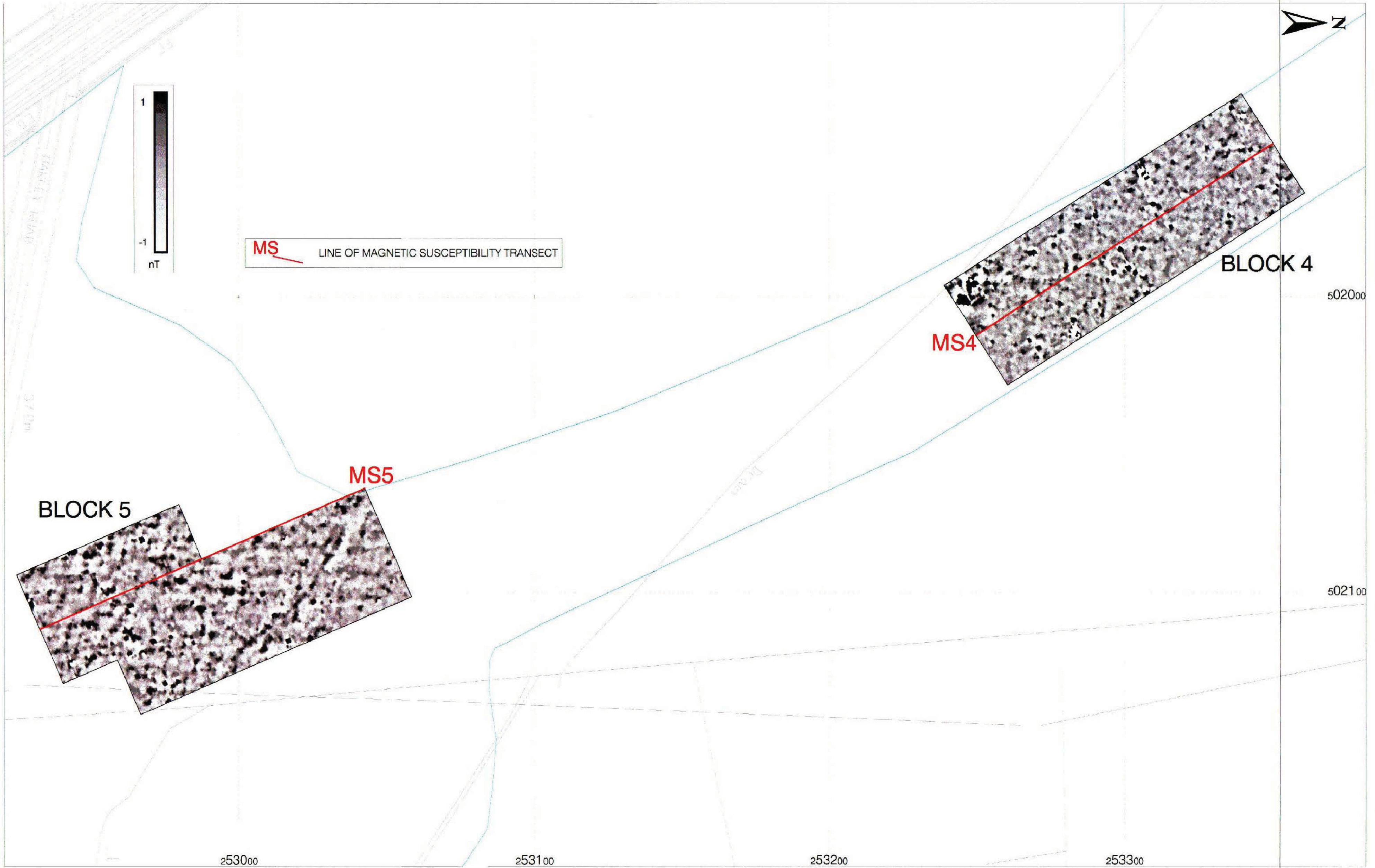

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Fig. 7. Greyscale gradiometer data; Blocks 4 and 5 (1:1250)

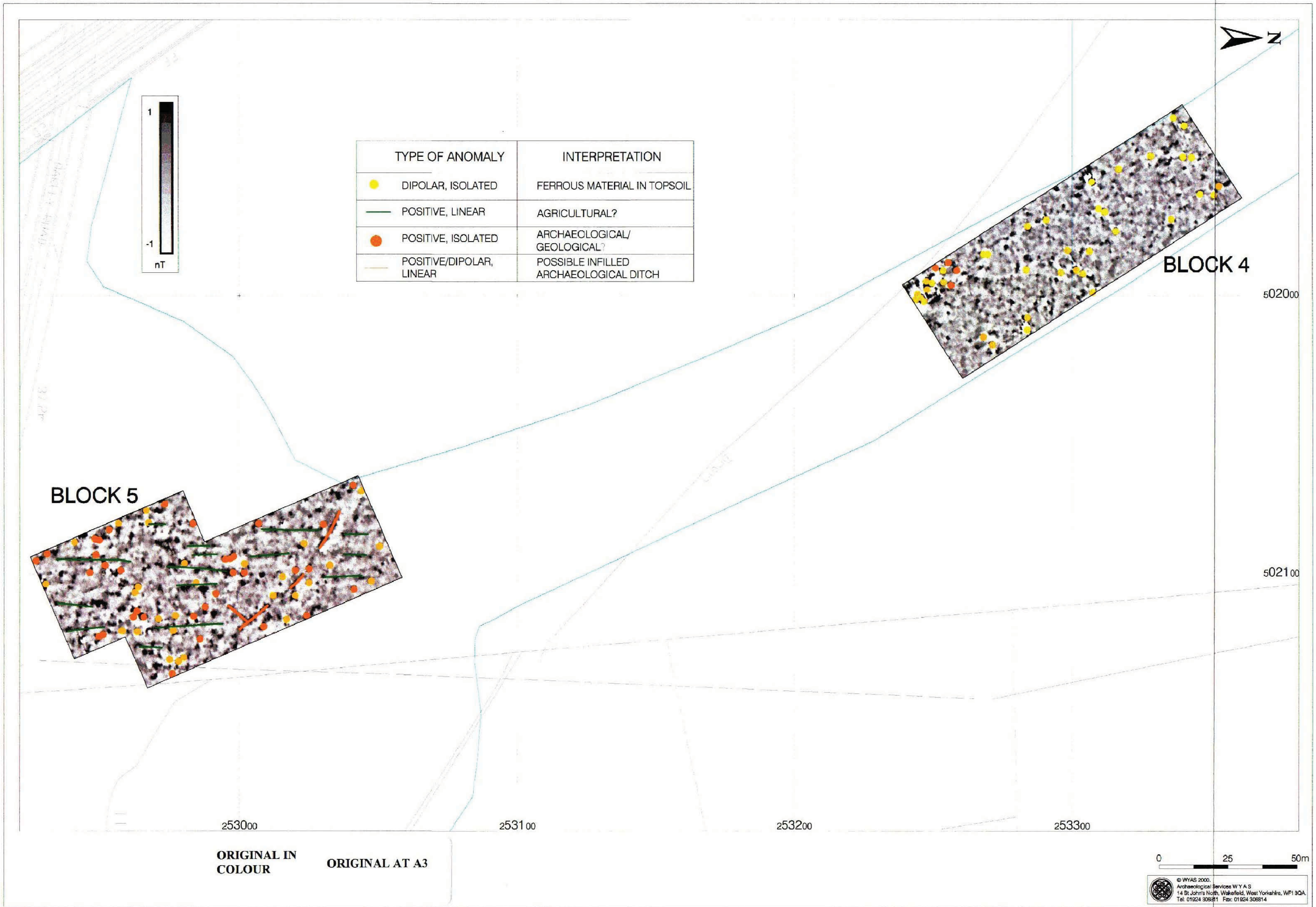

Fig. 8. Interpretation of gradiometer data; Blocks 4 and 5 (1:1250)

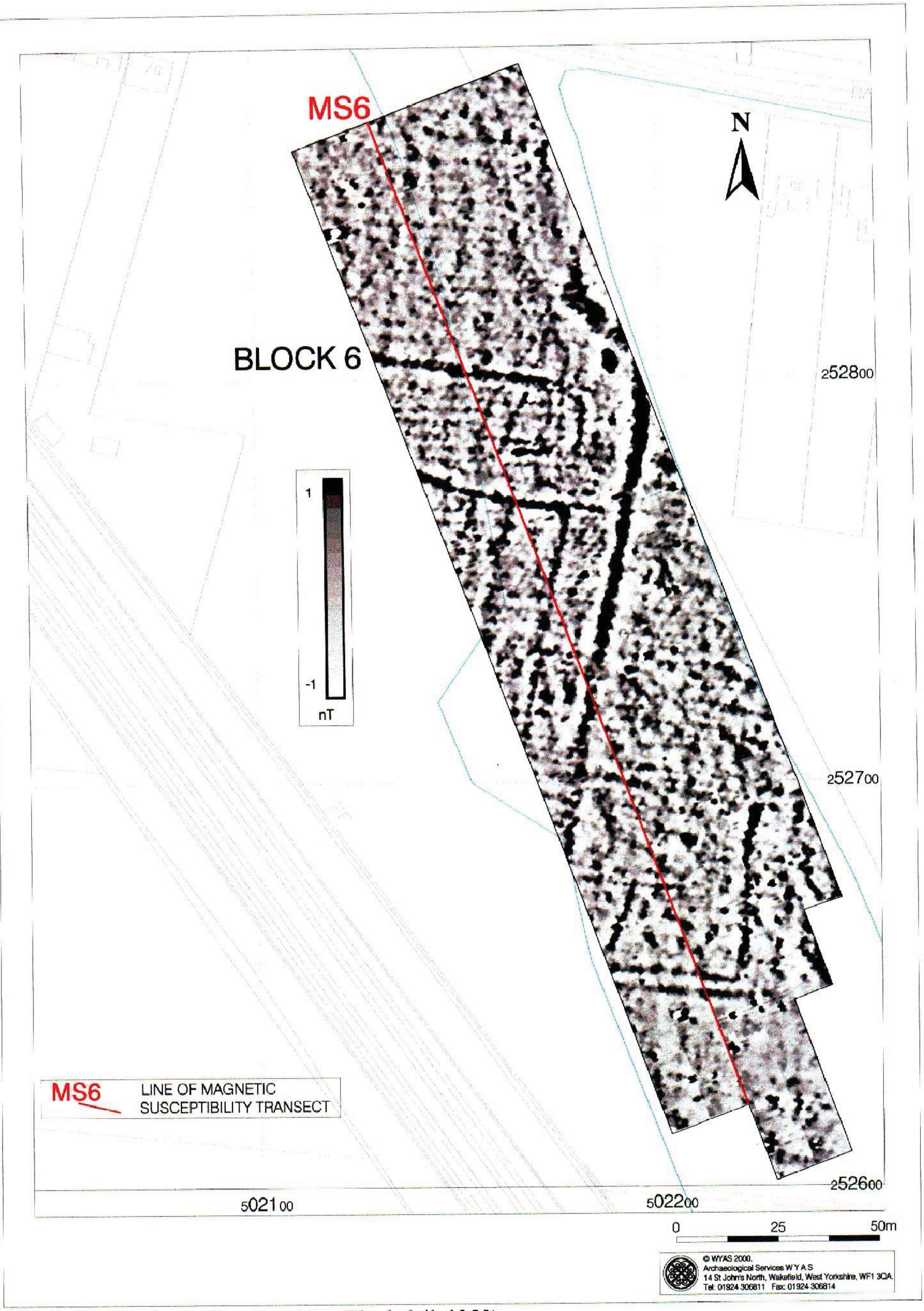

Fig. 9. Greyscale gradiometer data; Block 6 (1:1250)

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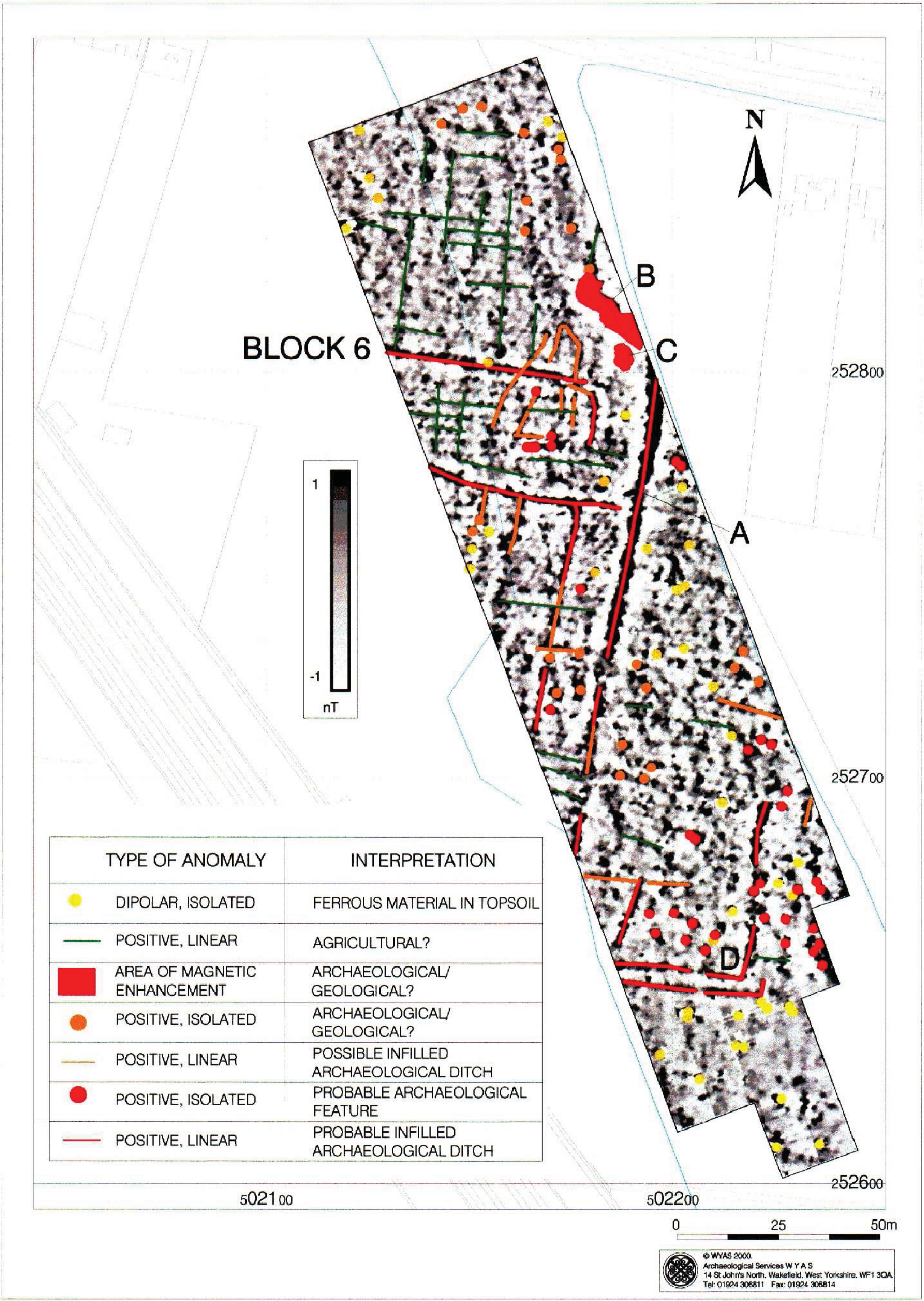

Fig. 10. Interpretation of gradiometer data; Block 6 (1:1250)

ORIGINAL IN COLOUR

Appendix 1

Magnetic Survey: Technical Information

1. Magnetic Susceptibility and Soil Magnetism

Iron makes up about 6% of the Earth's crust and is mostly present in soils and rocks as minerals such as maghaemite and haemetite. These minerals have a weak, measurable magnetic property termed magnetic susceptibility. Human activities can redistribute these minerals and change (enhance) others into more magnetic forms so that by measuring the magnetic susceptibility of the topsoil, areas where human occupation or settlement has occurred can be identified by virtue of the attendant increase (enhancement) in magnetic susceptibility. If the enhanced material subsequently comes to fill features, such as ditches or pits, localised isolated and linear magnetic anomalies can result whose presence can be detected by a magnetometer (fluxgate gradiometer).

In general, it is the contrast between the magnetic susceptibility of deposits filling cut features, such as ditches or pits, and the magnetic susceptibility of topsoils, subsoils and rocks into which these features have been cut, which causes the most recognisable responses. This is primarily because there is a tendency for magnetic ferrous compounds to become concentrated in the topsoil, thereby making it more magnetic than the subsoil or the bedrock. Linear features cut into the subsoil or geology, such as ditches, that have been silted up or have been backfilled with topsoil will therefore usually produce a positive magnetic response relative to the background soil levels. Discrete feature, such as pits, can also be detected. Less magnetic material such as masonry or plastic service pipes which intrude into the topsoil may give a negative magnetic response relative to the background level.

The magnetic susceptibility of the soil can also be enhanced significantly by heating. This can lead to the detection of features such as hearths, kilns or burnt areas.

2. Types of Magnetic Anomaly

The types of response mentioned above can be divided into five main categories:

Isolated Dipolar Anomalies (Iron Spikes)

These responses are typically caused by ferrous objects on the surface or in the topsoil. Whilst they could be caused by archaeological artefacts, unless there is supporting evidence for an archaeological interpretation, then little emphasis is given to such anomalies, as modern ferrous objects are common on rural sites, often being present as a consequence of manuring.

Areas of Magnetic Disturbance

These responses can have several causes and are often associated with burnt material, such as industrial waste or other strongly magnetised/fired material. They are usually assumed to have a modern origin unless there is other supporting information. Ferrous fencing can be a major source of magnetic disturbance as they produce very strong magnetic responses that can mask weaker archaeological anomalies.

Positive Curvi/Linear Anomalies
They are commonly caused by infilled ditches which may be archaeologically significant. Former or current agricultural practice can also result in these anomalies.

Isolated Positive Anomalies
These anomalies can exhibit a magnitude of response of between 2nT and 300nT and can be caused by pits or post holes, ovens or kilns. They can also be caused by natural/geological features on certain geologies. It can often be very difficult to establish an anthropogenic origin without intrusive investigation.

Negative Linear Anomalies
These are normally very faint and are commonly caused by features such as plastic water pipes which are less magnetic than the surrounding soils and geology. They too can be caused by natural features on some geologies.

3. Methodology

Magnetic Susceptibility Survey

There are two methods of measuring the magnetic susceptibility of a soil sample. The first involves the measurement of a given volume of soil, which will include any air and moisture that lies within the sample, and is termed volume specific susceptibility. This method results in a bulk value that it not necessarily fully representative of the constituent components of the sample. The second technique overcomes this potential problem by taking into account both the volume and mass of a sample and is termed mass specific susceptibility. However, mass specific readings cannot be taken in the field where the bulk properties of a soil are usually unknown and so volume specific readings must be taken. Whilst these values are not fully representative they do allow general comparisons across a site and give a broad indication of susceptibility changes. This is usually enough to assess the susceptibility of a site and evaluate whether enhancement has occurred.

A Bartington MS2D magnetic susceptibility system was used to carry out the magnetic susceptibility survey. Readings were taken every 20m and the data tabulated.

Gradiometer Survey

There are two main methods of using the fluxgate gradiometer for commercial evaluations. The first of these is referred to as *scanning* and requires the operator to visually identify anomalous responses on the instrument display panel whilst covering the site in widely spaced traverses, typically 10-15m apart. The instrument logger is not used and there is therefore no data collection. Once anomalous responses are identified they are marked in the field with bamboo canes and approximately located on a base plan. This method is usually employed as a means of selecting areas for detailed survey when only a percentage sample of the whole site is to be subject to detailed survey. In favourable circumstances scanning may be used to map out the full extent of features located during a detailed survey.

The second method is referred to as *detailed survey* and employs the use of a sample trigger to automatically take readings at predetermined points, typically at 0.5m intervals, on zig-zag traverses 1m apart. These readings are stored in the memory of the instrument and are later dumped to computer for processing and interpretation.

The Geoscan FM36 fluxgate gradiometer and ST1 sample trigger were used for the detailed gradiometer survey. Readings were taken, on the 0.1nT range, at 0.5m intervals on zig-zag traverses 1m apart within 20m by 20m square grids.

4. Data Processing and Presentation

The detailed gradiometer data has been presented in this report in X-Y trace and greyscale formats. The former option shows the 'raw' data with no processing other than grid biasing whilst in the latter the data has been selectively filtered to remove spurious errors such as striping effects and edge discontinuities caused by instrument drift and inconsistencies in survey technique caused by poor field conditions.

An X-Y plot presents the data logged on each traverse as a single line with each successive traverse incremented on the Y-axis to produce a stacked plot. A hidden line algorithm has been employed to block out lines behind major 'spikes' and the data has been clipped at 10nT. The main advantage of this display option is that the full range of data can be viewed, dependent on the clip, so that the shape of individual anomalies can be discerned and potentially archaeological anomalies differentiated from 'iron spikes'. In-house software (XY3) was used to create the X-Y trace plots.

In-house software (Geocon 9) was used to interpolate the data so that 1600 readings were obtained for each 20m by 20m grid. Contors software was used to produce the greyscale images in which maximum and minimum cut-off limits have been chosen to best present the data; in both these display options the data is displayed using a linear incremental scale.

Appendix 2

Survey Location Information

The detailed survey blocks were set out using a Geotronics Geodimeter 600 series total station theodolite. These blocks were then tied into numbered survey canes that delineated the edge of the road corridor. The Ordnance Survey co-ordinates for these survey canes that were referenced are given in the table below. These co-ordinates were supplied by Bedfordshire County Archaeology Service.

SURVEY CANE	X CO-ORDINATE	Y CO-ORDINATE
E2	50226131	25264151
E12	50205142	25322683
E34	50169474	25408847
E35	50169831	25413470
E43	50178843	25443780
E45	50184246	25449131
E46	50185435	25453085
W2	50219844	25262788
W13	50205446	25307881
W14	50203861	25312596
W20	50191187	25337069
W49	50181424	25455959

Archaeological Services WYAS cannot accept responsibility for errors of fact or opinion resulting from data supplied by a third party.

Appendix 3

Geophysical Archive

The geophysical archive comprises:-

- an archive disk containing the raw data, grid location information, report text (Word 6), and compressed (AutoCAD 2000) files of the graphics
- a full copy of the report

At present the archive is held by Archaeological Services WYAS although it is anticipated that it will eventually be lodged with the Archaeology Data Service (ADS). Brief details will also be forwarded for inclusion on the English Heritage Geophysical Survey Database (no information on the client shall be included) after the contents of the report are deemed to be in the public domain (*i.e.* available for consultation in the relevant Sites and Monument Record Office).