



ARCHAEOLOGICAL
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Parish	6100
Rec'd	01/03/2004

**St James Business Park
Knaresborough
North Yorkshire**

Geophysical Survey

February 2004

Report No. 1217

CLIENT
St James Securities Limited

**St James Business Park,
Knaresborough,
North Yorkshire.**

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SNY	8750
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Geophysical Survey

Contents

1. Introduction and Archaeological Background
2. Methodology and Presentation
3. Results and Discussion
4. Conclusions

Bibliography

Acknowledgements

Figures

Appendices

Summary

A geophysical (fluxgate gradiometer) survey, covering 4 hectares, was carried out on the eastern outskirts of Knaresborough. The survey has identified a plethora of magnetic anomalies across all parts of the site although it is difficult to give a categoric interpretation for many of these anomalies. On the flood plain the majority of the identified anomalies are considered to have a natural, geological origin although the potential masking effect of the depth of the alluvial material means that the presence of deeply buried archaeological features cannot be discounted. On the higher ground of the river terrace the anomalies may be caused by archaeological activity but the complicated magnetic responses of the materials comprising the terrace means that, on balance, the anomalies are considered more likely to have a non-archaeological origin. Nevertheless an archaeological origin cannot be discounted on the basis of the geophysical survey results.

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Archaeological Services WYAS

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1. Introduction and Archaeological Background

- 1.1 Archaeological Services WYAS was commissioned by Mr Anthony Pringle of Philip Lees and Associates, on behalf of their clients St James Securities Ltd, to carry out a geophysical (fluxgate gradiometer) evaluation of an area of land east of Knaresborough (see Fig. 1), where a planning application (No. 6.100.2312.FULMAJ) has been received. The proposals are for the formation of infrastructure associated with the Phase II expansion of the St James Retail, Business and Industrial Park.
- 1.2 The proposed development area, centred at NGR SE 3677 5651, covers approximately 11 hectares and is bounded to the north by the River Nidd, to the east by the A658 and to the south-west by Phase I of the development. However, only the eastern end of the site was suitable for evaluation by geophysical methods as most of the area adjacent to the first phase development had been severely disturbed with the tipping of spoil and other household rubbish. The majority of the area that was suitable for survey comprised a single arable field left fallow after the last harvest although a small area of rough grazing was also sampled. No other problems were encountered during the fieldwork which was carried out on February 10th and 11th 2004.
- 1.3 Topographically the site slopes gradually down from the south-west towards the river with a break of slope indicating the first river terrace. The drift geology comprises alluvial deposits adjacent to the river and first river terrace gravels.
- 1.4 The archaeological potential of the site relates to the possibility of Iron Age/Romano-British settlement activity in the area as suggested by the discovery of three quern stones in the vicinity. Several soil and cropmark features have also been identified either just within or adjacent to the proposed development area. However, it is not clear whether these features are due to former river meanders, recent field boundaries or archaeological ditches.
- 1.5 Prior to the construction of the A658 bypass road that forms the southern edge of the site a magnetometer survey was carried out (GSB 1990) which identified several broad, diffuse anomalies. These anomalies were interpreted as probably being caused by former river channels. A circular anomaly was also identified which may have had an archaeological origin. Unfortunately no further work was undertaken to elucidate further the nature of these anomalies.

2. Methodology and Presentation

- 2.1 Following consultation Ms Gail Falkingham, of the North Yorkshire County Council Heritage Unit, advised that a geophysical evaluation of the site should be undertaken. It was recommended that due to the unsuitable nature of much of the site an area not exceeding four hectares should be surveyed concentrating in the north-eastern section of the site nearest the cropmark features.
- 2.2 The objectives of the geophysical evaluation were:-

- to establish the presence or absence of any archaeological anomalies within the proposed development area
 - to define the extent of any such anomalies
 - to characterise, if possible, any such anomalies.
- 2.3 The survey methodology and report comply with the recommendations outlined in the English Heritage Guidelines (David 1995) as a minimum standard. All figures reproduced from Ordnance Survey mapping are done so with the permission of the controller of Her Majesty's Stationery Office. © Crown copyright.
- 2.4 A general site location plan, incorporating the 1:50000 Ordnance Survey mapping, is shown in Figure 1. Figure 2 is a site location plan, showing the processed greyscale gradiometer data, superimposed onto a base map (local grid) provided by the client, at a scale of 1:5000. The processed data are displayed in greyscale format, at a scale of 1:1000 in Figures 3 and 6 with the accompanying interpretations shown at the same scale in Figures 5 and 8. The unprocessed ('raw') data is presented in XY trace plot format in Figures 4 and 7.
- N.b – all the figures with the exception of Figure 1 display the data on a local grid established by Archaeological Services.
- 2.5 Technical information on the equipment used, data processing and magnetic survey methodology is given in Appendix 1. Appendix 2 details the survey location information and Appendix 3 describes the composition and location of the archive.

The interpretations of the observed anomalies are based on information contained in all parts of the report including the appendices.

3. Results and Discussion

3.1 Survey Rationale

- 3.1.1 Initially a transect 60m wide was set out extending south-westwards from the river across the floodplain and the river terrace to the highest part of the site at the western end of the arable field. Further grids were then added to sample further the north-eastern part of the area, as required in the Written Scheme of Investigation, and to follow anomalies as they were identified. A single small block was surveyed in the paddock at the western end of the site.

3.2 General

- 3.2.1 Numerous isolated dipolar anomalies ('iron spikes' - see Appendix 1) have been identified across all parts of the survey area, being most frequent in the sample block located in the horse paddock at the western end of the site. Here there was evidence of recent tipping and ground disturbance. These 'iron spike' anomalies are indicative of ferrous objects or other magnetic material in the topsoil/subsoil and, although archaeological artefacts may cause them, they are more often caused by modern cultural debris that has been introduced into the topsoil. There is no apparent clustering to these anomalies and

consequently they are not considered to be archaeologically significant. Only the strongest of these responses have been shown on the interpretation figure.

- 3.2.2 In the arable field magnetic anomalies have been identified across all parts of the surveyed areas. However, there is an obvious change both in the level of background soil noise (magnetic background) and the type and distribution of the anomalies between the flood plain and the river terrace. These variations are described and explained below.

3.3 The Floodplain

- 3.3.1 On the flood plain adjacent to the river the level of soil noise is very low. Against this very flat magnetic background several very broad anomalies can be readily identified. These anomalies are interpreted as having a natural origin being caused by compositional changes within the alluvium.
- 3.3.2 A series of very faint linear striations, aligned broadly from north to south, are probably caused by recent agricultural practice, although a natural origin is also considered possible. In the outlying sample block nearest the sewage works similar weak linear anomalies aligned from east to west probably have a similar origin.
- 3.3.3 Also noted in this block is a more prominent linear anomaly aligned broadly from north to south. It appears to align with a similar anomaly in the main survey block. An infilled archaeological feature such as a ditch could be the cause of this anomaly. On balance, however, a modern origin is considered more likely. Adjacent to this linear anomaly a series of small rectilinear and discrete anomalies have been identified. These anomalies might also have an archaeological origin although again a more recent cause is considered probable.
- 3.3.4 It should be noted that the magnetometer (fluxgate gradiometer) used for this survey has an effective 'penetration' of about 1m dependent on the strength of the fill of any underlying feature. Consequently alluvial deposits greater than 1m in depth may potentially mask the response from any deeply buried archaeological features.

3.4 The Terrace Edge

- 3.4.1 The point at which the floodplain ends and the land begins to rise onto the first river terrace is very pronounced being marked both by an increase in the general background soil noise and by an increase in the number and type of magnetic anomalies present. Within this generally confusing picture linear trends within the data set can be discerned as can other discrete areas of magnetic enhancement and disturbance. Most of these anomalies exhibit responses that are typical of infilled features that may have an archaeological origin and may even be suggestive of occupational activity. However, it is recognised that sand and gravel deposits can be particularly complex and that 'some soils contain bands of magnetic sands and gravels that produce anomalies similar in character and strength to archaeological anomalies' (Gaffney, Gater and Ovenden 2002). In this case the areas of magnetic disturbance may be due to undifferentiated magnetic pebbles. A third possible interpretation is that the observed anomalies could be caused by, or result from, small scale quarrying activity that is known to have occurred on or adjacent to the area under evaluation.

4. Conclusions

- 4.1 The detailed magnetic survey has identified a plethora of magnetic anomalies across all parts of the site although it is difficult to give a categoric interpretation for many of these anomalies.
- 4.2 The exception to the above statement is in the horse paddock at the western end of the site where the ferrous responses are almost certainly the result of modern intrusive activity. Consequently this part of the site is considered to have low archaeological potential.
- 4.3 On the flood plain the majority of the identified anomalies are considered to have a natural, geological, origin although the potential masking effect of the depth of the alluvial material means that the presence of deeply buried archaeological features cannot be discounted.
- 4.4 Interpreting with any degree of certainty the anomalies identified on the higher ground of the river terrace presents the greatest problem on this site. The anomalies may be caused by archaeological activity but as stated the complicated magnetic responses of the materials comprising the terrace means that, on balance, the anomalies are considered more likely to have a non-archaeological origin. Nevertheless an archaeological origin should not be discounted on the basis of the geophysical survey results.

The results and subsequent interpretation of data from 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.

Bibliography

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Acknowledgements

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Report

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Graphics

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Figures

- | | |
|----------|---|
| Figure 1 | Site location (1:50000) |
| Figure 2 | Site location showing greyscale gradiometer data (1:5000) |
| Figure 3 | Greyscale plot of gradiometer data (1:1000) |
| Figure 4 | XY trace plot of gradiometer data (1:1000) |
| Figure 5 | Interpretation of gradiometer data (1:1000) |
| Figure 6 | Greyscale plot of gradiometer data (1:1000) |
| Figure 7 | XY trace plot of gradiometer data (1:1000) |
| Figure 8 | Interpretation of gradiometer data (1:1000) |

Appendices

- | | |
|-------------------|--|
| Appendix 1 | Magnetic Survey: Technical Information |
| Appendix 2 | Survey Location Information |
| Appendix 3 | Geophysical Archive |

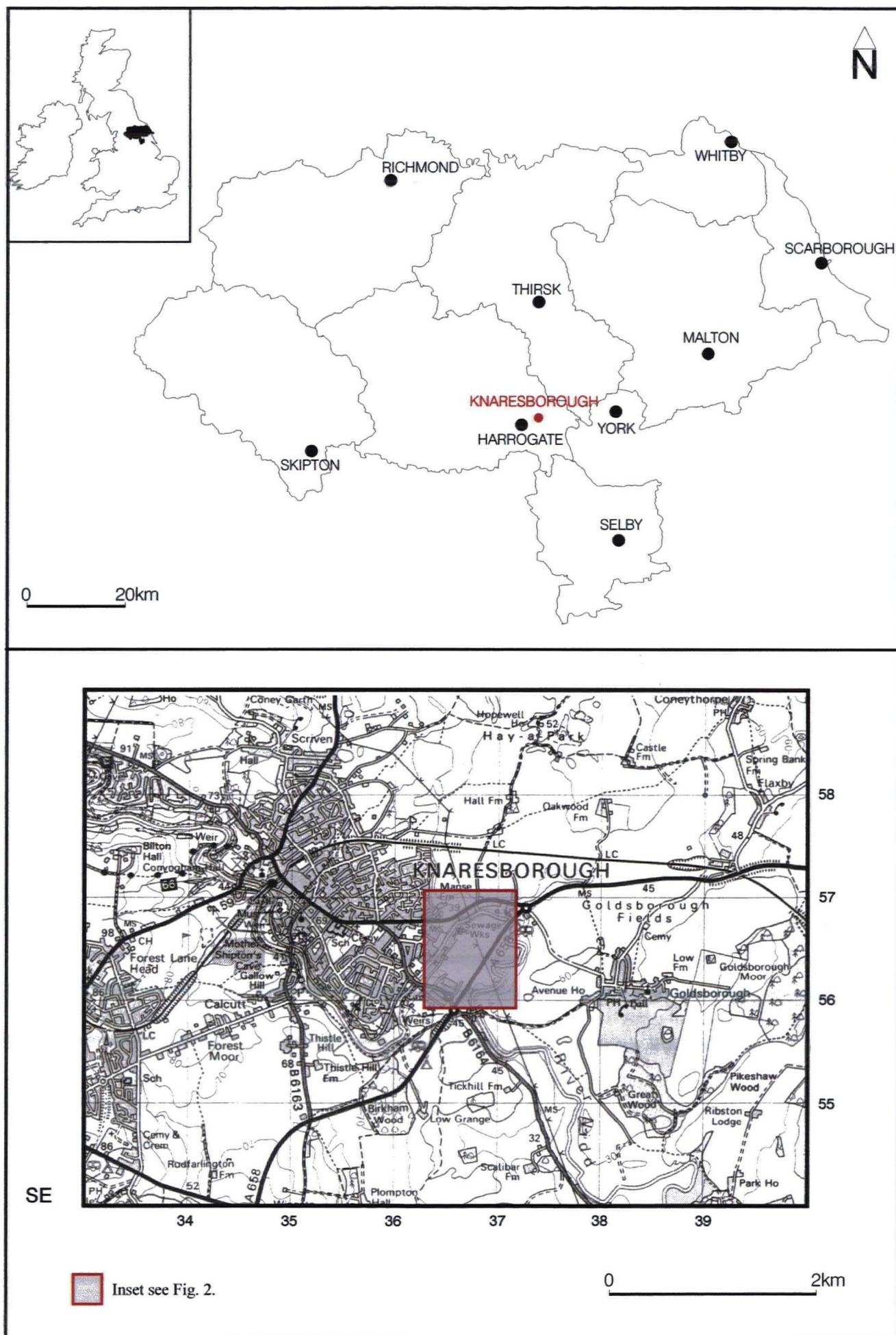


Fig. 1. Site location

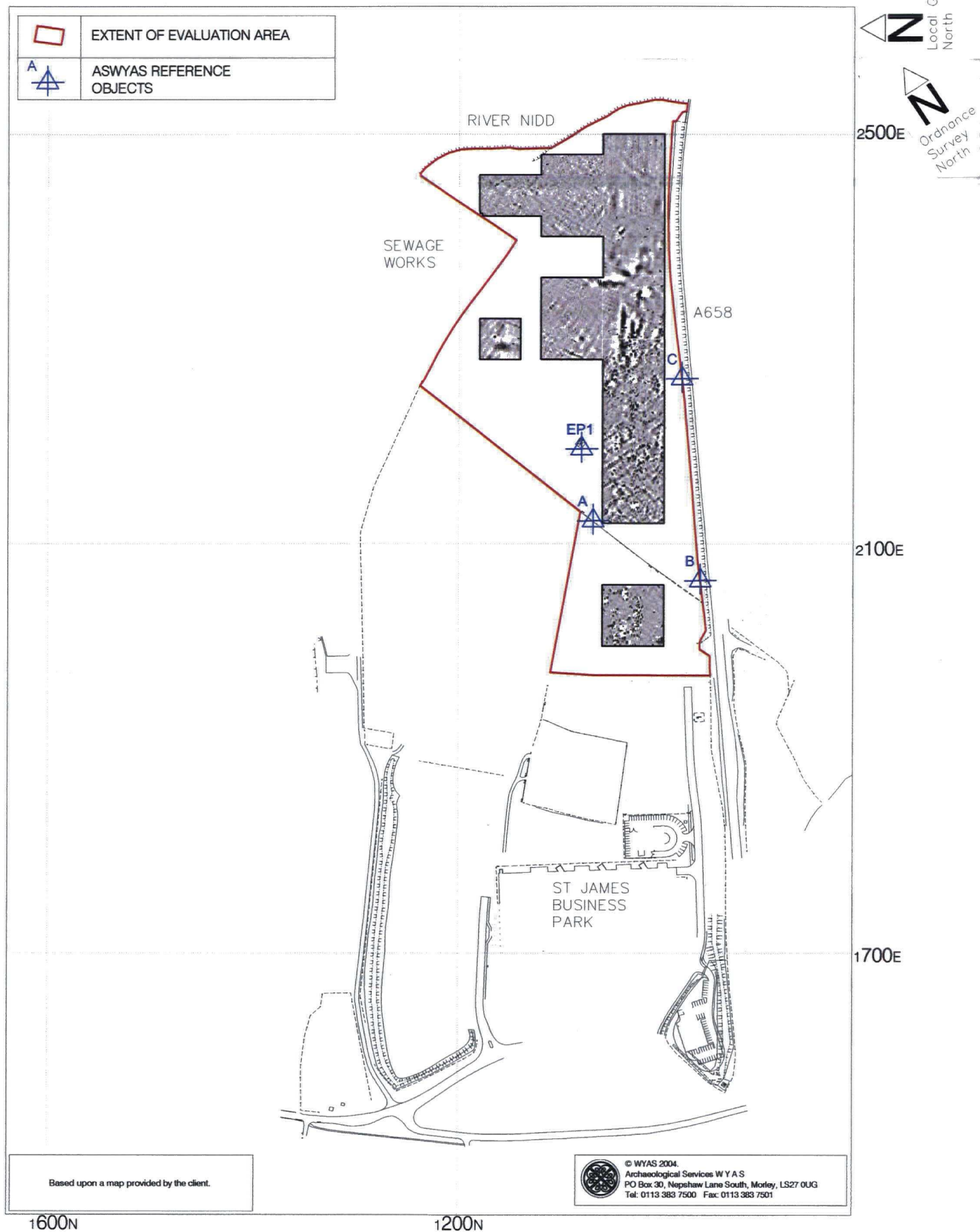


Fig. 2. Site location showing greyscale gradiometer data

1:5000

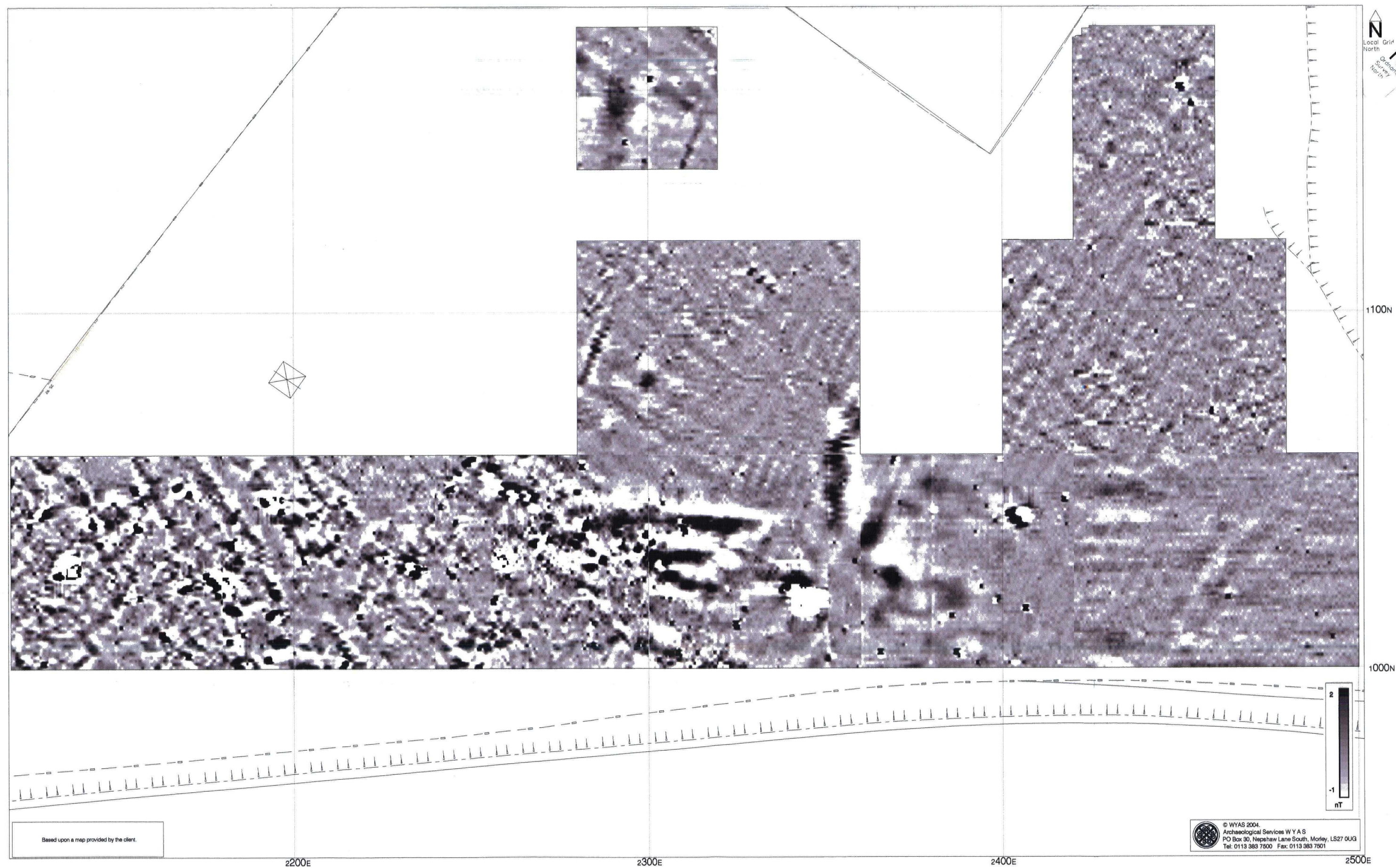


Fig. 3. Greyscale plot of gradiometer data; main survey block

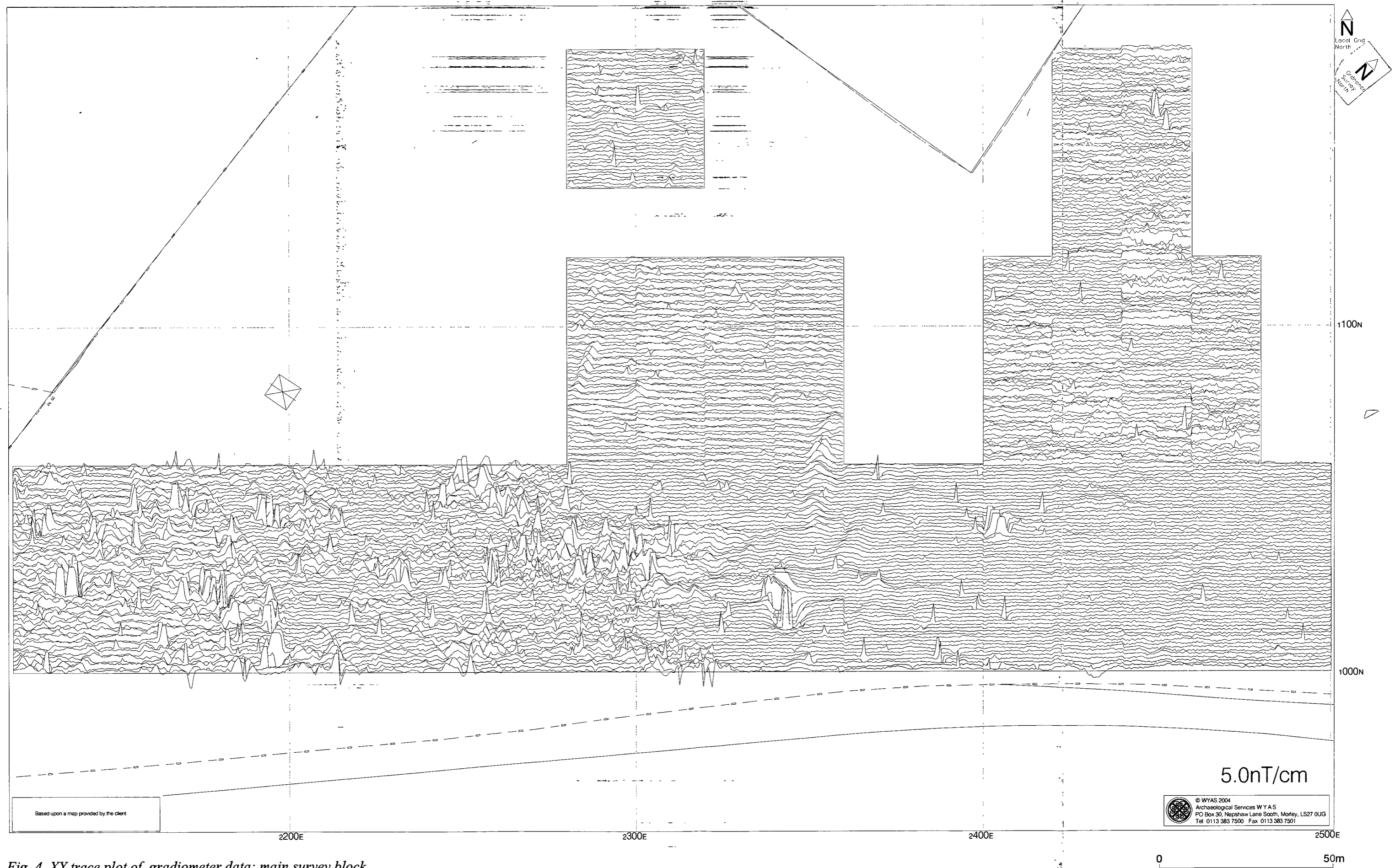


Fig. 4. XY trace plot of gradiometer data; main survey block

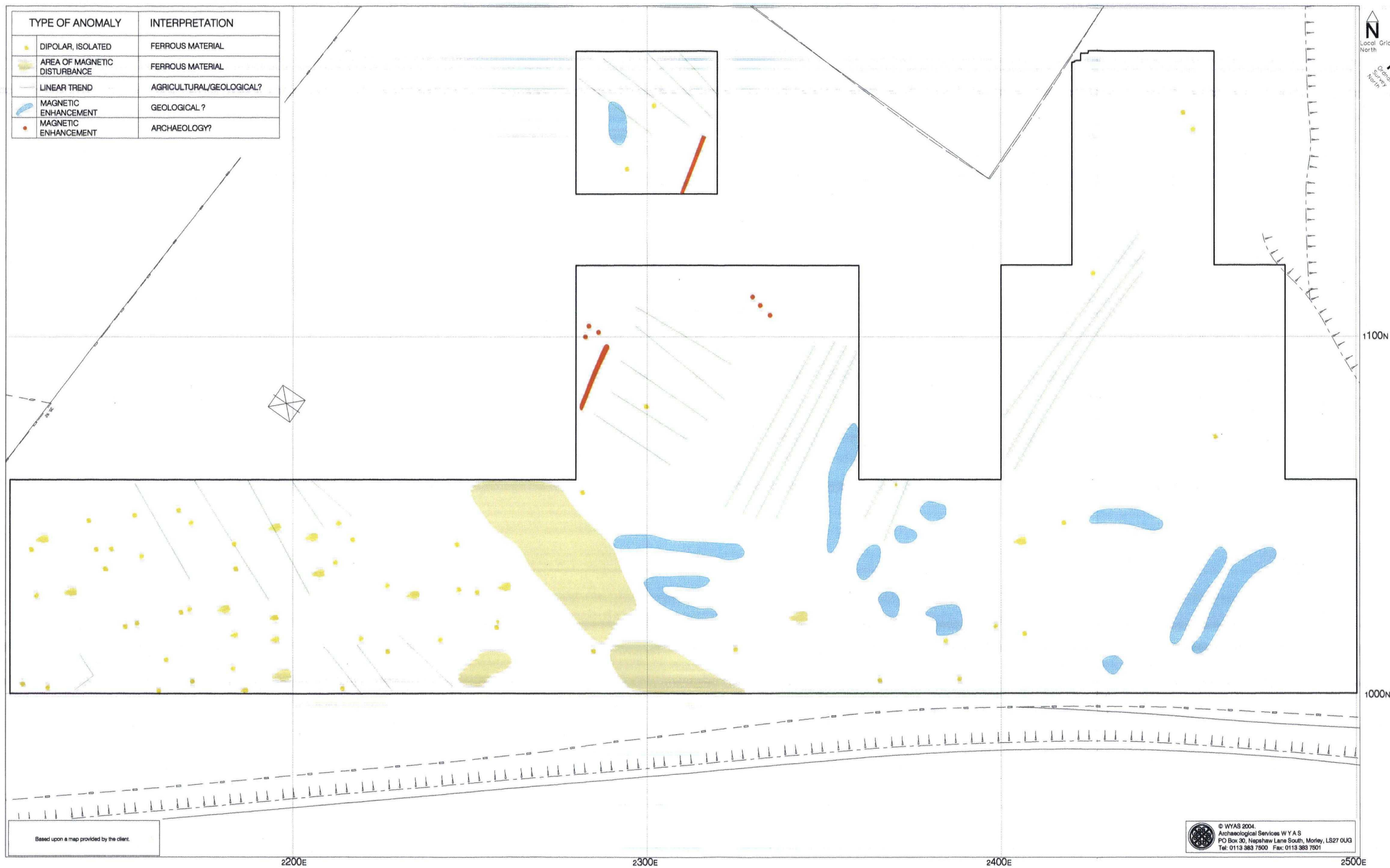


Fig. 5. Interpretation of gradiometer data; main survey block.

c 1:1000

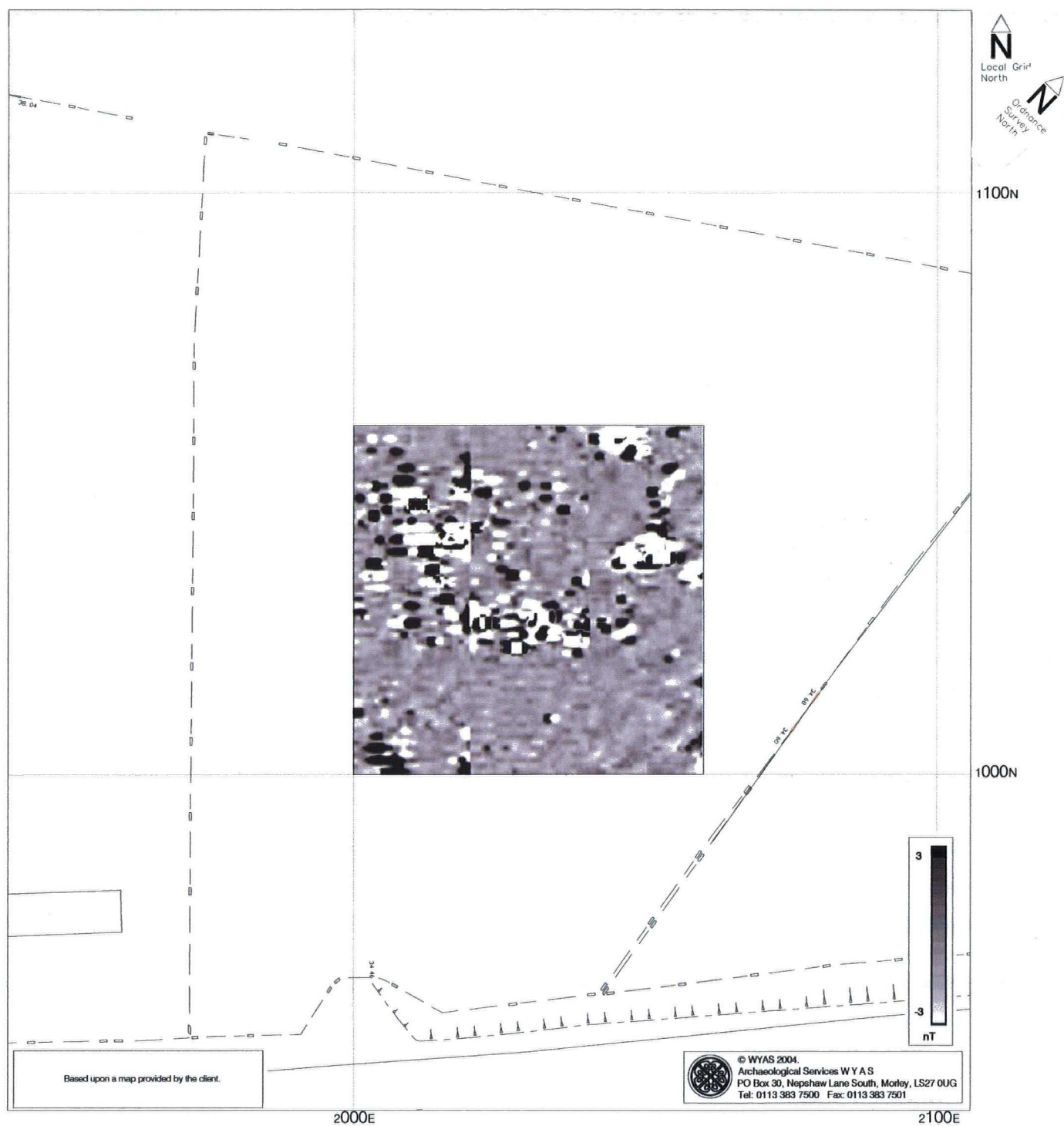


Fig. 6. Greyscale plot of gradiometer data; horse paddock

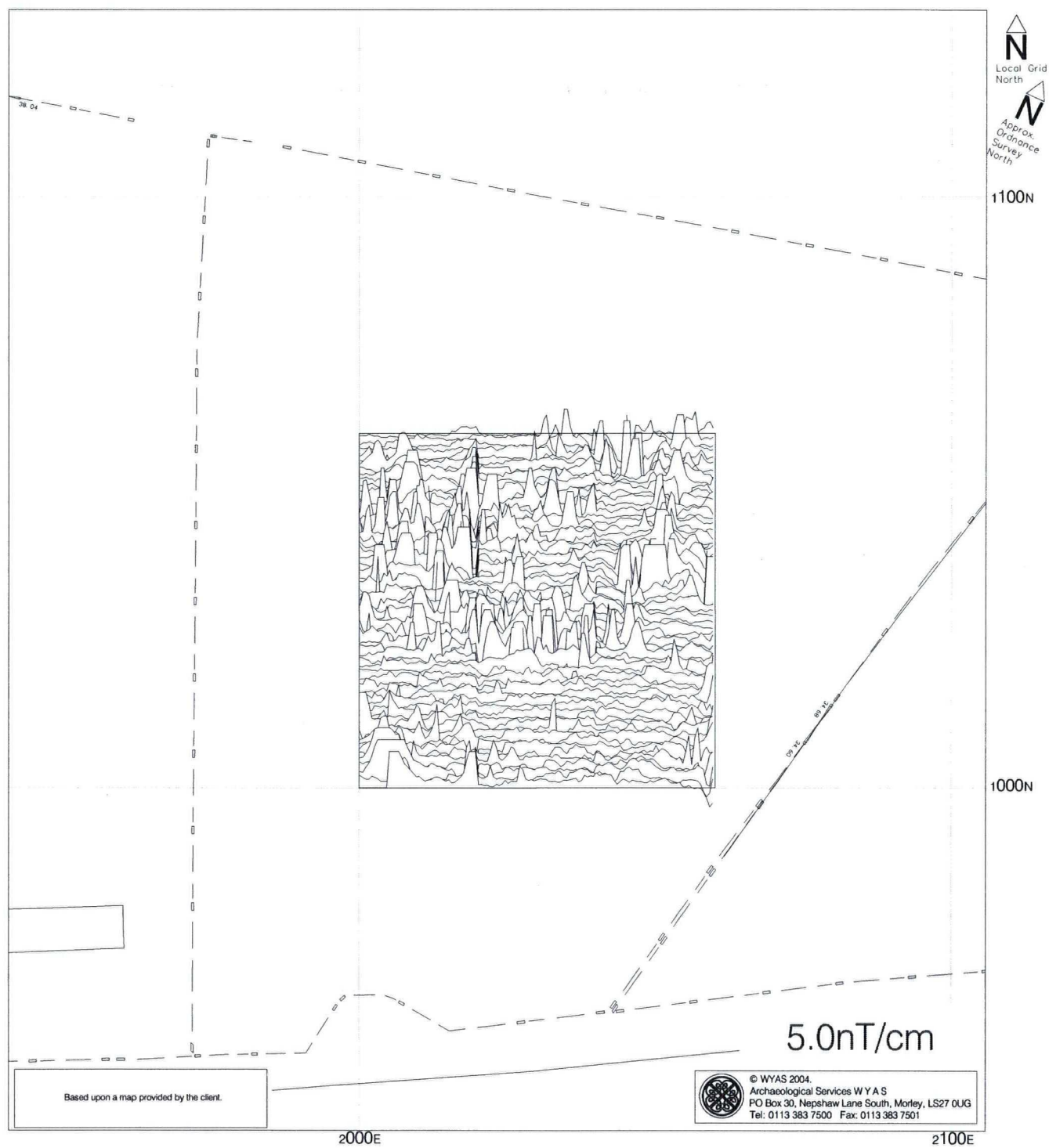


Fig. 7. XY Trace plot of gradiometer data; horse paddock.

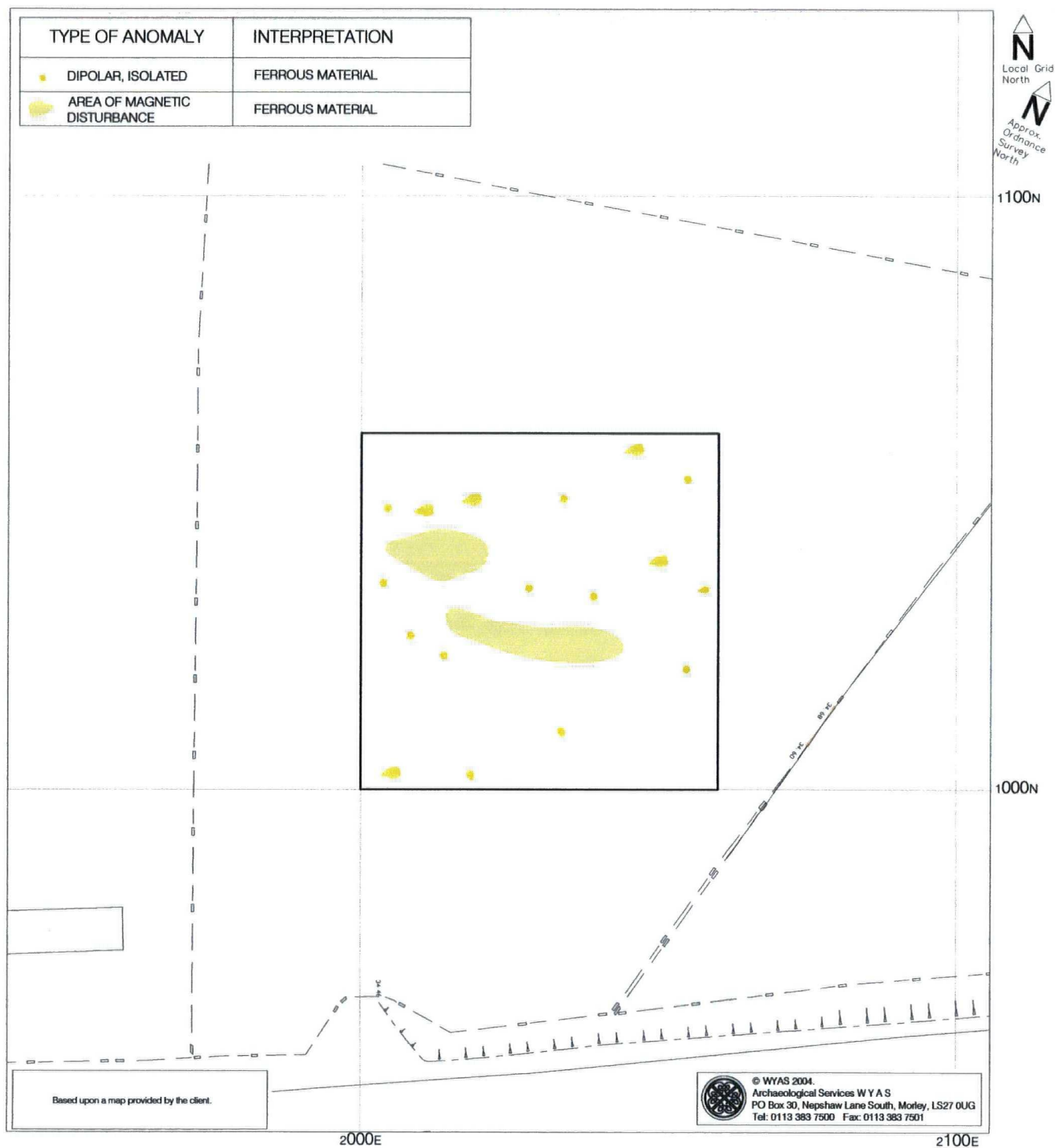


Fig. 8. Interpretation of gradiometer data; horse paddock.

Appendix 1

Magnetic Survey: Technical Information

1. Magnetic Susceptibility and Soil Magnetism

- 1.1 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).
- 1.2 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 that intrude into the topsoil may give a negative magnetic response relative to the background level.
- 1.3 The magnetic susceptibility of a soil can also be enhanced by the application of heat. This effect can lead to the detection of features such as hearths, kilns or areas of burning.

2. Types of Magnetic Anomaly

- 2.1 In the majority of instances anomalies are termed '*positive*'. This means that they have a positive magnetic value relative to the magnetic background on any given site. However some features can manifest themselves as '*negative*' anomalies that, conversely, means that the response is negative relative to the mean magnetic background. Such negative anomalies are often very faint and are commonly caused by modern, non-ferrous, features such as plastic water pipes. Infilled natural features may also appear as negative anomalies on some geological substrates.
- 2.2 Where it is not possible to give a probable cause of an observed anomaly a '?' is appended.
- 2.3 It should be noted that anomalies that are interpreted as modern in origin may be caused by features that are present in the topsoil or upper layers of the subsoil. Removal of soil to an archaeological or natural layer can therefore remove the feature causing the anomaly.
- 2.4 The types of response mentioned above can be divided into five main categories which are used in the graphical interpretation of the magnetic data:

Isolated dipolar anomalies (iron spikes)

These responses are typically caused by ferrous material either on the surface or in the topsoil. They cause a rapid variation in the magnetic response giving a characteristic 'spiky' trace. Although ferrous archaeological artefacts could produce this type of response, unless there is supporting evidence for an archaeological interpretation, little emphasis is normally 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 often being associated with burnt material, such as slag waste or brick rubble or other strongly magnetised/fired material. Ferrous structures such as pylons, mesh or barbed wire fencing and buried pipes can also cause the same disturbed response. A modern origin is usually assumed unless there is other supporting information.

Linear trend

This is usually a weak or broad linear anomaly of unknown cause or date. An agricultural origin, either ploughing or land drains is a common cause.

Areas of magnetic enhancement/positive isolated anomalies

Areas of enhanced response are characterised by a general increase in the magnetic background over a localised area whilst discrete anomalies are manifest by an increased response (sometimes only visible on an X-Y trace plot) on two or three successive traverses. In neither instance is there the intense dipolar response characteristic exhibited by an area of magnetic disturbance or of an 'iron spike' anomaly (see above). These anomalies can be caused by infilled discrete archaeological features such as pits or post-holes or by kilns. They can also be caused by pedological variations or by natural infilled features on certain geologies. Ferrous material in the subsoil can also give a similar response. It can often therefore be very difficult to establish an anthropogenic origin without intrusive investigation or other supporting information.

Linear and curvilinear anomalies

Such anomalies have a variety of origins. They may be caused by agricultural practice (recent ploughing trends, earlier ridge and furrow regimes or land drains), natural geomorphological features such as palaeochannels or by infilled archaeological ditches.

3. Methodology

3.1 Magnetic Susceptibility Survey

- 3.1.1. 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 is 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.

3.2 Gradiometer Survey

- 3.2.1. There are two main methods of using the fluxgate gradiometer for commercial evaluations. The first of these is referred to as **magnetic scanning** and requires the operator to visually identify anomalous responses on the instrument display panel whilst covering the site in widely spaced traverses, typically 10m 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.
- 3.2.2. The disadvantages of magnetic scanning are that features that produce weak anomalies (less than 2nT) are unlikely to stand out from the magnetic background and so will be difficult to detect. The coarse sampling interval means that discrete features or linear features that are parallel or broadly oblique to the direction of traverse may not be detected. If linear features are suspected in a site then the traverse direction should be perpendicular (or as close as is possible within the physical constraints of the site) to the orientation of the suspected features. The possible drawbacks mentioned above mean that negative results from magnetic scanning should **always** be checked with at least a sample detailed magnetic survey (see below).
- 3.2.3. 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. Detailed survey allows the visualisation of weaker anomalies that may not have been detected by magnetic scanning.
- 3.2.4. 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. The instrument was checked for electronic and mechanical drift at a common point after every three grids and calibrated as necessary. The drift from zero was not logged.

3.3 Data Processing and Presentation

- 3.3.1. The detailed gradiometer data has been presented in this report in X-Y trace and greyscale formats. In the former format the data shown is 'raw' with no processing other than grid biasing having been done. The data in the greyscale images has been selectively filtered.
- 3.3.2. 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.

- 3.3.3. 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. All greyscale plots are displayed in the range -1nT to 2nT, unless otherwise stated, using a linear incremental scale.

Appendix 2

Survey Location Information

1. A Trimble Geodimeter 600s total station theodolite was used to set out the survey grid which was then tied-in to 'permanent' landscape features, such as field boundaries, the electricity pylon and to temporary reference objects (wooden stakes) using the theodolite. The locations of the temporary reference objects are shown on Figure 2 and the **local grid** co-ordinates tabulated below.
2. The survey grids were then superimposed onto a digital map base supplied by the client using the common field boundaries and other fixed points. Overall there was a good correlation between the local survey and the digital map base and it is estimated that the average 'best fit' error is better than $\pm 1.5\text{m}$.

Station	Easting	Northing
A		
B		
C		

Archaeological Services WYAS cannot accept responsibility for errors of fact or opinion resulting from data supplied by a third party or for the removal of any of the survey reference points.

Appendix 3

Geophysical Archive

The geophysical archive comprises:-

- an archive disk containing compressed (WinZip 8) files of the raw data, report text (Word 2000), and graphics files (CorelDraw6 and AutoCAD 2000) files.
- a full copy of the report

At present the archive is held by Archaeological Services WYAS although it is anticipated that it may eventually be lodged with the Archaeology Data Service (ADS). Brief details will also be forwarded for inclusion on the English Heritage Geophysical Survey Database 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).