ARCHAEOLOGICAL SERVICES WYAS

Wentworth Castle and Stainborough Park Barnsley South Yorkshire

Geophysical Survey

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Report No. 1480

Purcell Miller Tritton

Wentworth Castle

and

Stainborough Park

Barnsley

South Yorkshire

Geophysical Survey

Contents

Summary

A geophysical evaluation, comprising both magnetic and earth resistance surveys, was undertaken at three locations as part of a wider scheme of archaeological investigation at Stainborough Park, South Yorkshire. Although no anomalies that are obviously caused by underlying archaeological features have been identified several anomalies of unknown potential have been located, one of which may locate the defensive ditch thought to encircle Stainborough Castle. Several service pipes have also been located.

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Archaeological Services WYAS

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1. Introduction and Archaeological Background

1.1 Archaeological Services WYAS was commissioned to carry out a geophysical (magnetometer and earth resistance) survey in advance of the proposed restoration of Stainborough Castle within the grounds of Wentworth Castle, about 3km south-west of Barnsley (see Fig. 1) by Mr Stephen Elliot of Purcell Miller Tritton. The site is centred at SE 319 035 and the survey blocks cover an area of approximately 0.3 hectares.

1.2 Two areas were outlined for geophysical survey; the approach to Stainborough Castle (see Fig. 2 - Block 1), that at the time of survey comprised a linear strip of short mown grass bounded by pathways to the south, east and west, and the area immediately to the north-east of Wentworth Castle (see Fig. 2 – Blocks 2 and 3). This latter area comprised two separate survey blocks separated by a tarmacced car park; Block 2 covered the front lawn of Wentworth Castle which was bounded by walls to the north, south and east and a gravel drive to the west, whilst Block 3 was located 50 metres to the north-east on pasture land. No problems were encountered during the fieldwork although the presence of rhododendrons restricted the survey area between the grassed area and the Wilderness. The fieldwork was carried out on April 11th 2005.

1.3 Stainborough Castle is an 18th-century folly that lies in the western corner (SE 3155 0305) of the grounds of Wentworth Castle, known as Stainborough Park. The ruins of Stainborough Castle, also a Grade II* listed building, lies approximately at the highest point of the park, 197m Above Ordnance Datum. It is believed that the castle occupies the site of an Iron Age hill fort, although the evidence for this is mostly circumstantial, and possibly an adapted medieval fortification. Evidence for this latter assertion is more tangible with limited investigation (Ashurst 1991), including a resistance survey, indicating the presence of a ditch up to 8m in width and 5m deep that encircled the foot of Stainborough Lowe.

1.4 Wentworth Castle and the Home Farm complex is also 18th-century in date but, like Stainborough Castle, the extant structures are thought to be the most recent in a sequence of buildings occupying the site, the earliest of which may have been a medieval manor house and its attendant ancillary buildings, including a chapel that may date to the period of the Norman Conquest.

1.5 The park itself is of recognised national and regional heritage importance and is Listed as a Grade I Park (GD1381) in English Heritage's 'Register of Historic Parks and Gardens (Roberts 2004). The groundworks attendant with the landscaping during the creation of the park and formal gardens may have had a detrimental impact on earlier archaeological features.

1.6 The solid geology comprises shales and sandstone of the Coal Measures (Institute of Geological Sciences 1979), overlain by soils of the Dale Association described as clayey loams interspersed with the better drained loams of the Rivington 1 Association (Soil Survey of England and Wales 1983).

2. Methodology and Presentation

2.1 The objectives of the geophysical survey were:

- to establish the presence, absence, extent and nature of any archaeological features including the possible defensive ditch surrounding Stainborough Castle and its precursors,
- to locate and characterise any archaeological features, including garden features, that may be associated with Wentworth Castle or earlier buildings.

2.2 To achieve the above objectives different strategies were employed in the two parts of the site. On the approach to Stainborough Castle a magnetometer survey was undertaken to locate the possible defensive ditches and any other infilled archaeological features. To the north-east of Wentworth Castle, on the front lawn (see Fig. 2 - Block 2) both magnetometer and earth resistance surveys were undertaken in order to increase the likelihood of identifying both buried stone features associated with the earlier manor house or more recent garden features and any infilled, cut features. The final area of survey (see Fig. 2 – Block 3) further to the east was designed to locate the Octagonal Pond that was created in the 1720s but infilled by William Wentworth in the 1750s (Roberts 2004). It is believed that this feature probably lies beneath the car park that separates the two survey blocks but may have extended further to the east. Block 3 was located on the advice of Hilary Taylor, the landscape consultant for the restoration project.

2.3 The survey methodology, report and any recommendations comply with guidelines outlined by English Heritage (David 1995) and by the IFA (Gaffney, Gater and Ovenden 2002). 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. A more detailed location plan showing the magnetometer data is presented in Figure 2 at a scale of 1:5000. The processed data are presented as greyscale images and the unprocessed data as XY trace plots. All data plots and interpretation graphics (Figs 3 – 11 inclusive) are presented at a scale of 1:500.

2.5 Information on the technical background to the two survey techniques as well as data processing and display information are given in Appendix 1 and Appendix 2. The survey location information is presented in Appendix 3 and the composition of the archive comprises Appendix 4.

The figures in this report have been produced following analysis of the data in 'raw' and processed formats and over a range of different display levels. All figures are presented to most suitably display and interpret the data from this site based on the experience and knowledge of Archaeological Services staff.

3. Results

3.1 Magnetometer Survey (Figs 2 – 8 inclusive)

Block 1

3.1.1 A linear band of magnetic disturbance can be seen along the southern limit of the survey block. Similar intermittent disturbance can be seen around the western edge of the block. In both cases this disturbance results from surveying across the gravel paths along the edge of the landscaped gardens. A linear, dipolar anomaly, aligned from north-west to south-east at the eastern end of the block is caused by a modern ferrous service pipe. The area of variable magnetic response at the northern end of the pipe is almost certainly due to modern activity and may be associated with the installation of the pipe.

3.1.2 Two areas of enhanced magnetic response have also been identified. Towards the western end of the block a short, discontinuous, linear anomaly aligned broadly from south-west to north-east has been identified. A second such anomaly can be seen immediately north of the gravel path along the southern edge of the block aligned from south-east to north-west. An infilled archaeological feature such as a ditch could cause these anomalies but the limited extent of both anomalies makes a confident interpretation difficult and modern intrusive activity could also produce the same magnetic response.

Block 2

3.1.3 A modern service pipe runs parallel and adjacent to the western edge of this block. An area of magnetic disturbance is also noted at the northern end of the block. No magnetic anomalies of archaeological potential have been identified in this block.

Block 3

3.1.4 Two service pipes have also been located at the northern end of Block 3 while a large area of magnetic disturbance, probably resulting from modern tipping or infilling, dominates the data across the southern third of the block. A single discrete area of magnetic enhancement has been identified that may have an archaeological origin. However, modern activity is considered to be an equally likely cause.

3.2 Resistance Survey (Figs 9, 10 and 11)

Block 2

3.2.1 Areas of high and low resistance can be seen in both survey blocks although there is no obvious or coherent pattern to suggest that the variation might be caused by sub-surface structures. In Block 2 a vague linear high resistance anomaly parallel with the western edge of the block probably correlates with the location of the service pipe identified as a linear magnetic anomaly. The main area of high resistance in Block 2 could be indicative of a spread of rubble or other structural material possibly associated with previous garden features. However, the observed variation might simply be due to the differential water content of the soil resulting from the preparation of the sub-soil prior to the creation of the lawn.

Block 3

3.2.2 The most obvious characteristic of the data from Block 3 is the massive change in resistance between the northern and southern halves of the block. As in Block 2 there is variation within the data from the northern half of the block and vague edges to the areas of slightly higher resistance can be discerned. These edges correlate with the position of service pipes as established by the magnetic survey. The areas of higher resistance could have an anthropogenic cause but whether it is due to archaeological activity or to modern disturbance is difficult to determine, particularly as there is no coherent pattern or linearity to the anomalies. In the southern half of the block the readings are extremely uniform suggesting that there has been little or no disturbance in this part of the site.

4. Discussion and Conclusions

4.1 On the approach to Stainworth Castle a short, intermittent linear anomaly that might be caused by an infilled feature has been interpreted. This anomaly is on approximately the correct alignment and in approximately the right location for the defensive ditch thought to have encircled the medieval fortification although the anomaly does not extend across the full width of the survey area and given the potential size and depth of the feature a stronger response might have been expected. Nevertheless this anomaly is considered to have archaeological potential.

4.2 Adjacent to Wentworth Castle the results from the survey of the lawned area are inconclusive. Whilst the areas of high resistance could be indicative of underlying archaeological features inevitably there will have been a certain amount of ground disturbance in preparation for the laying of the lawn and it is possible that the observed variation in resistance is entirely a result of differential water retention in the soil due to compaction.

4.3 In Block 3 the very noticeable change in readings along a distinct edge could suggest that there has been disturbance to the north of the block, although this may all be related to the installation of the two pipes that have been located by the magnetometer survey.

4.4 Overall the results from the surveys have proved inconclusive although the location of several service pipes has been confirmed.

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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Appendices

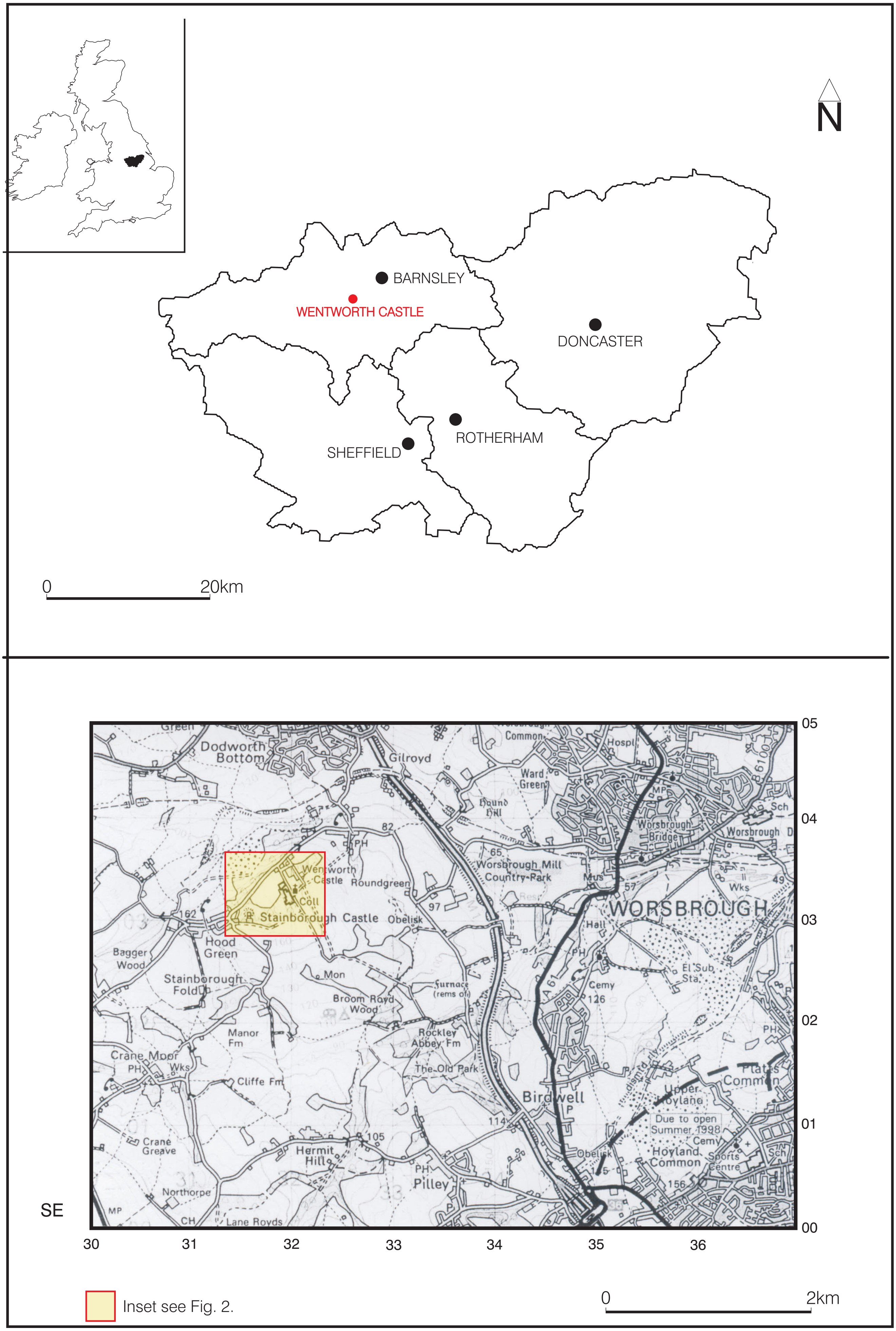

Fig. 1. Site location

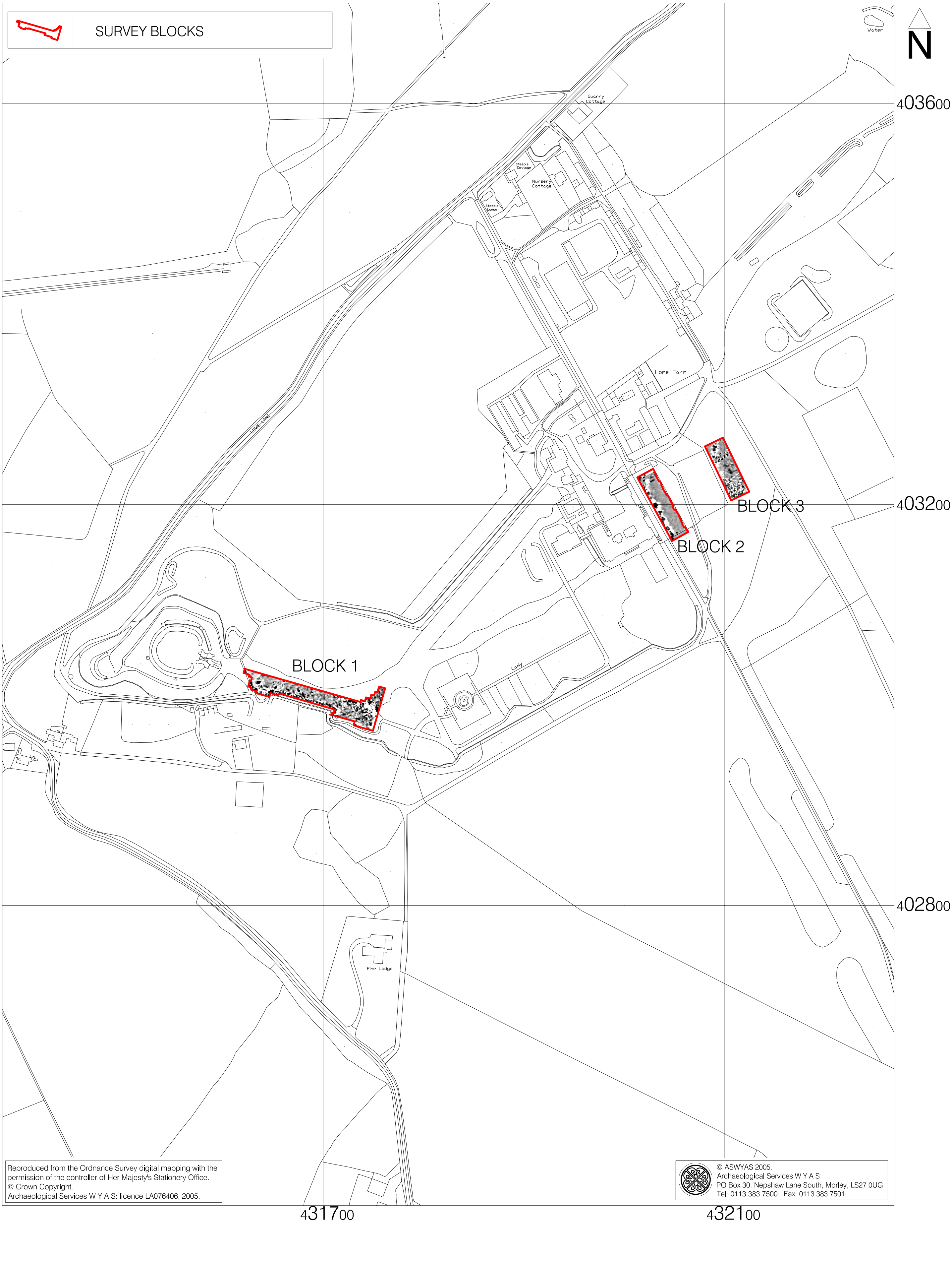

Fig. 2. Site location showing greyscale magnetometer data.

Fig. 3. Greyscale plot of magnetometer data; Block 1.

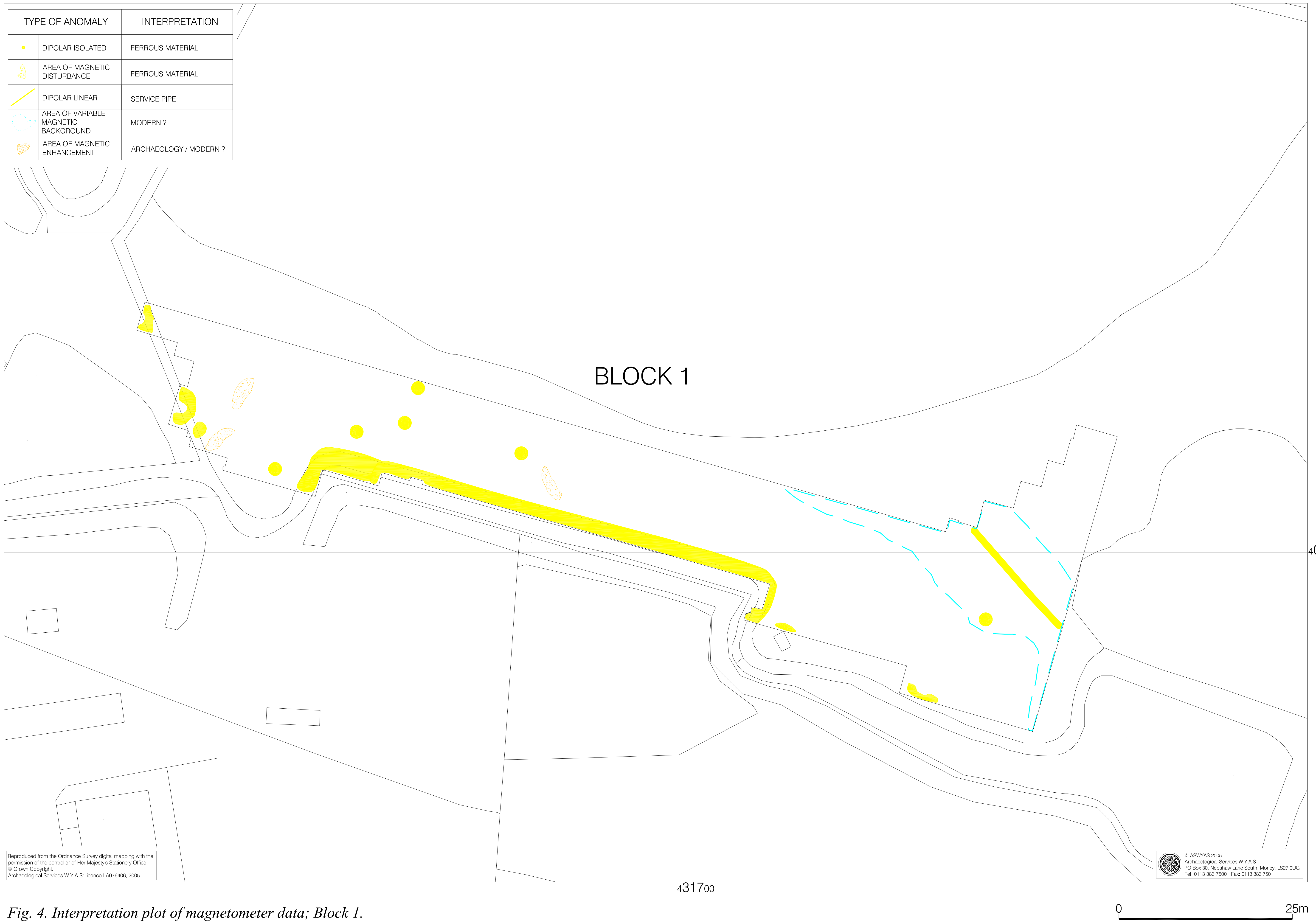

Fig. 4. Interpretation plot of magnetometer data; Block 1.

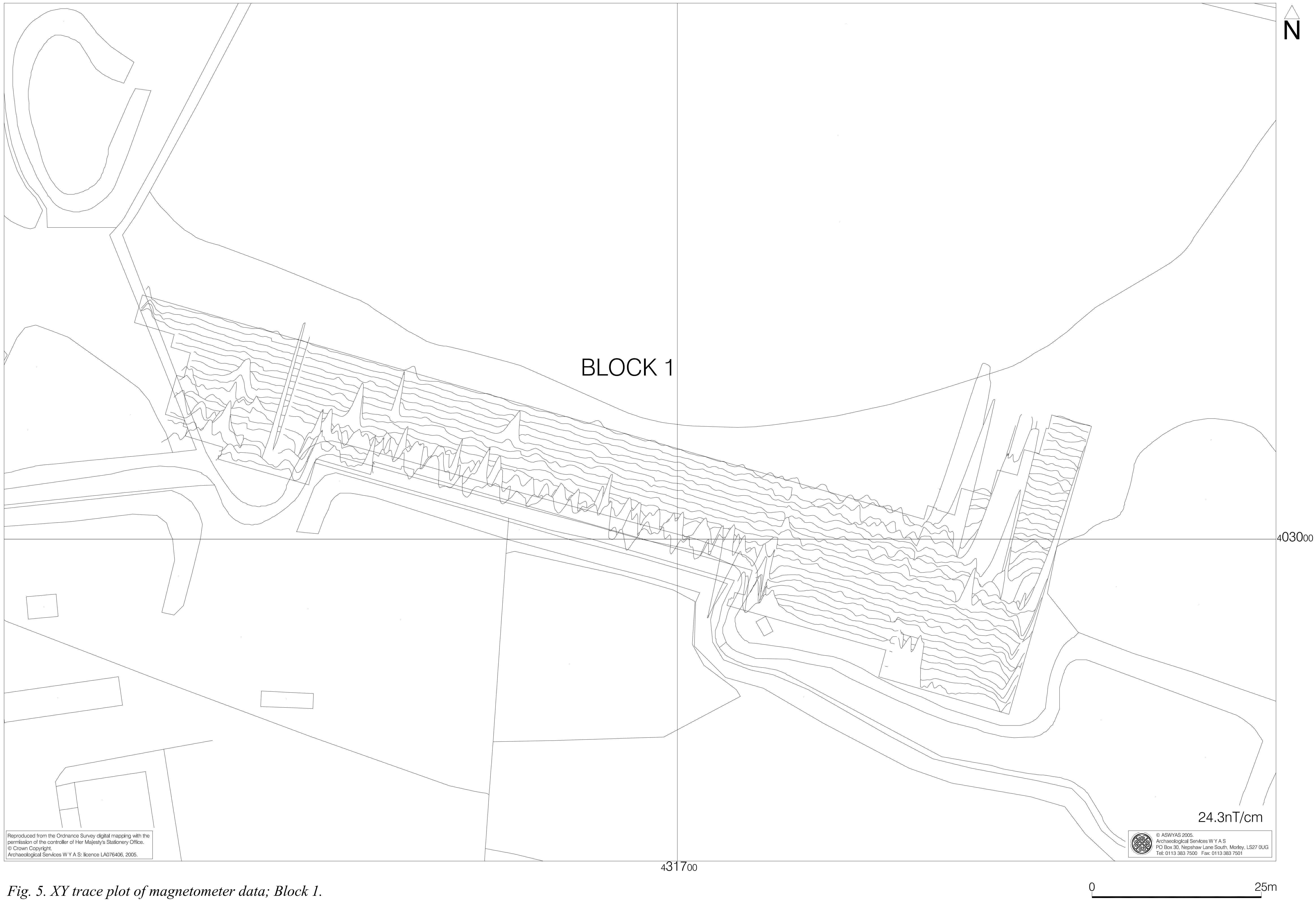

Fig. 5. XY trace plot of magnetometer data; Block 1.

Fig. 6. Greyscale plot of magnetometer data; Blocks 2 and 3.

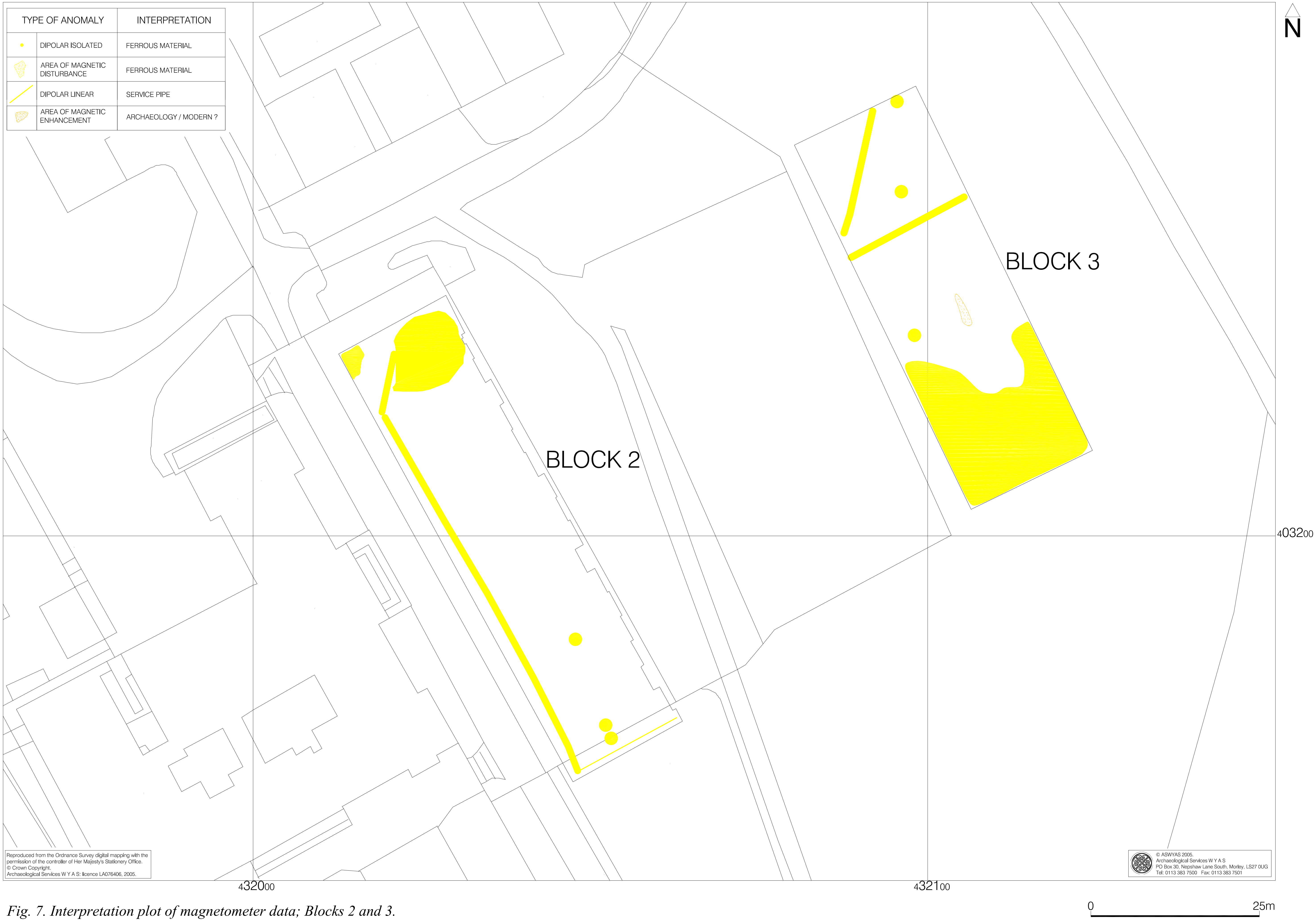

Fig. 7. Interpretation plot of magnetometer data; Blocks 2 and 3.

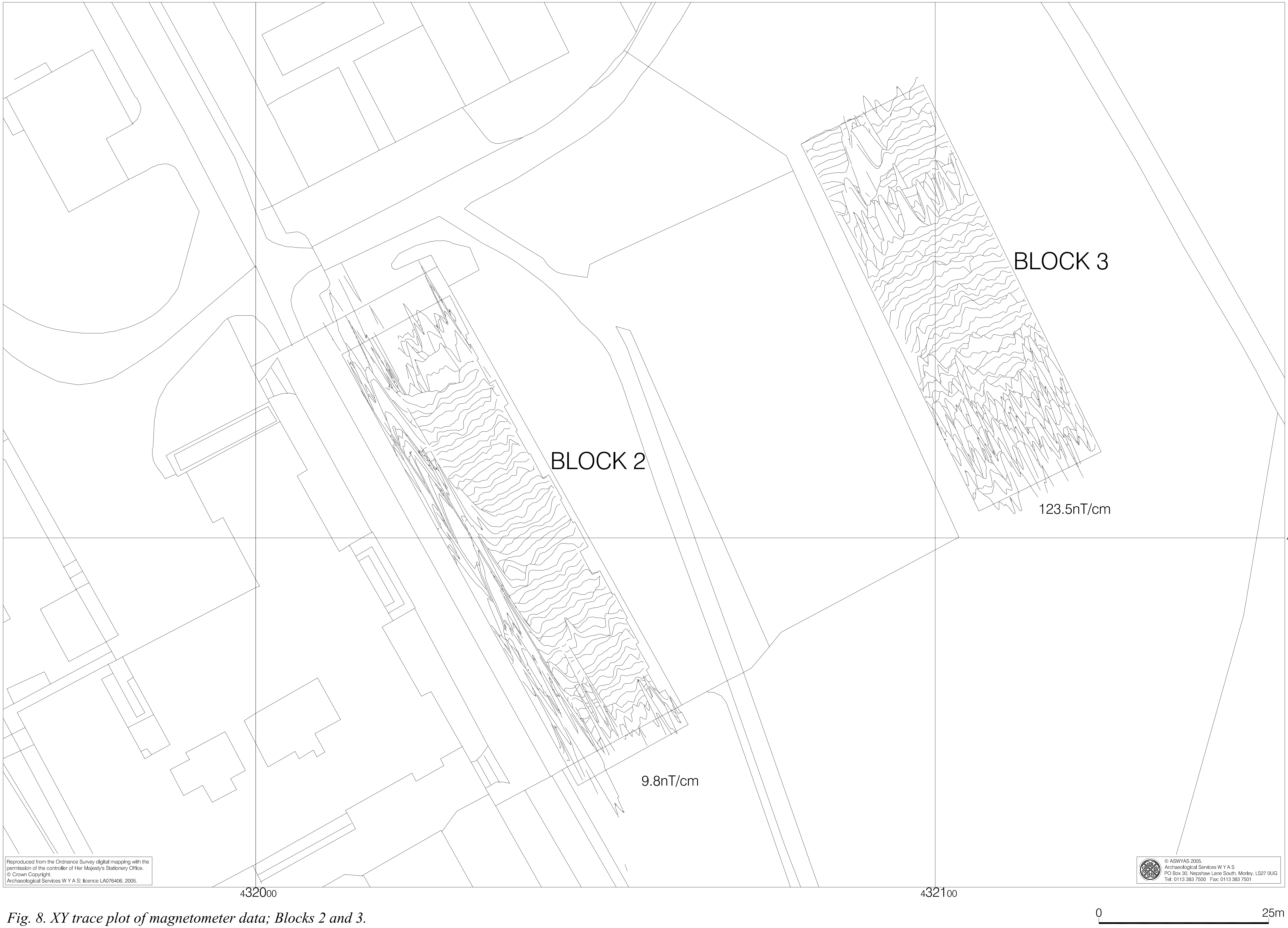

Fig. 8. XY trace plot of magnetometer data; Blocks 2 and 3.

Fig. 9. Greyscale plot of earth resistance data; Blocks 2 and 3.

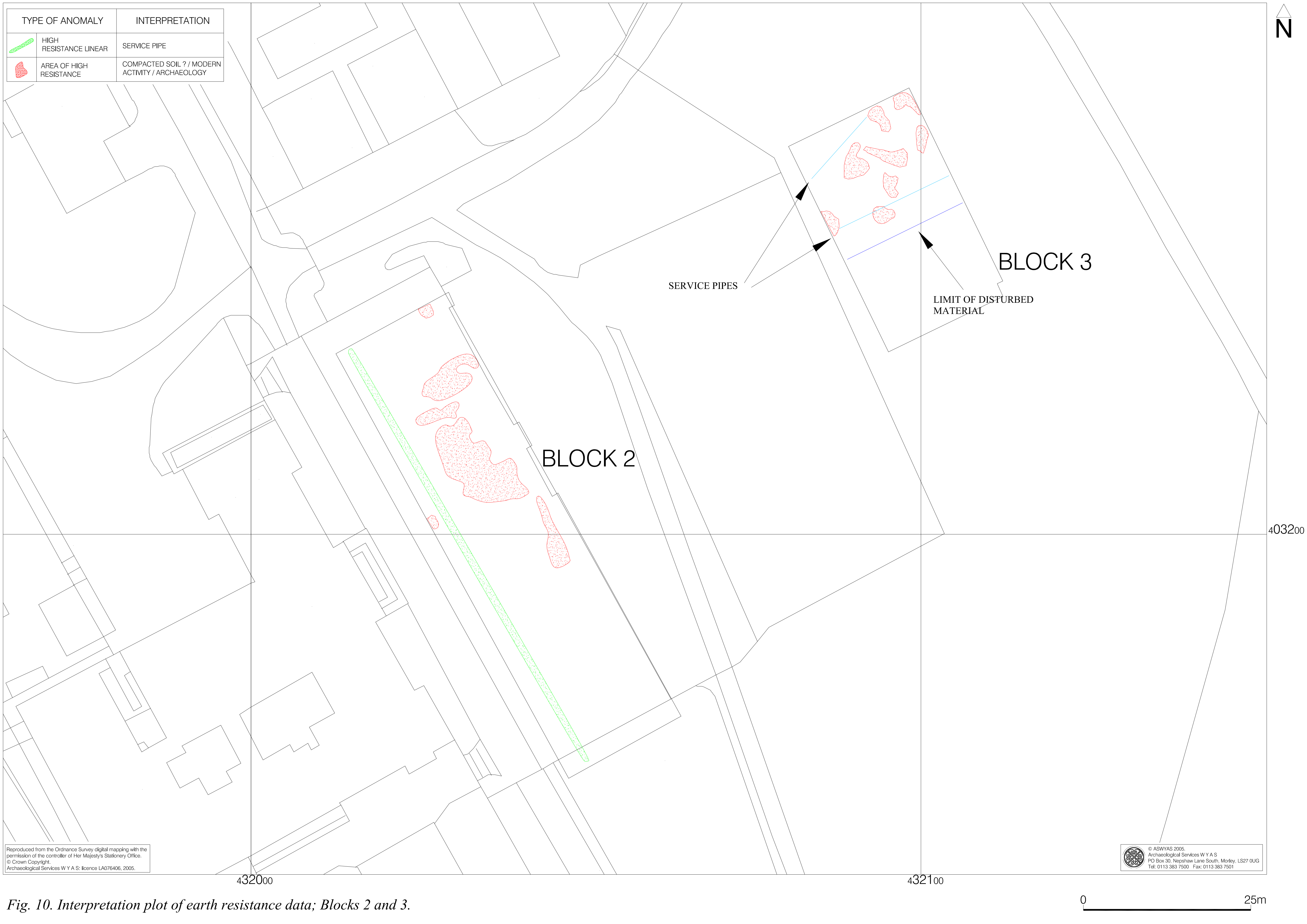

Fig. 10. Interpretation plot of earth resistance data; Blocks 2 and 3.

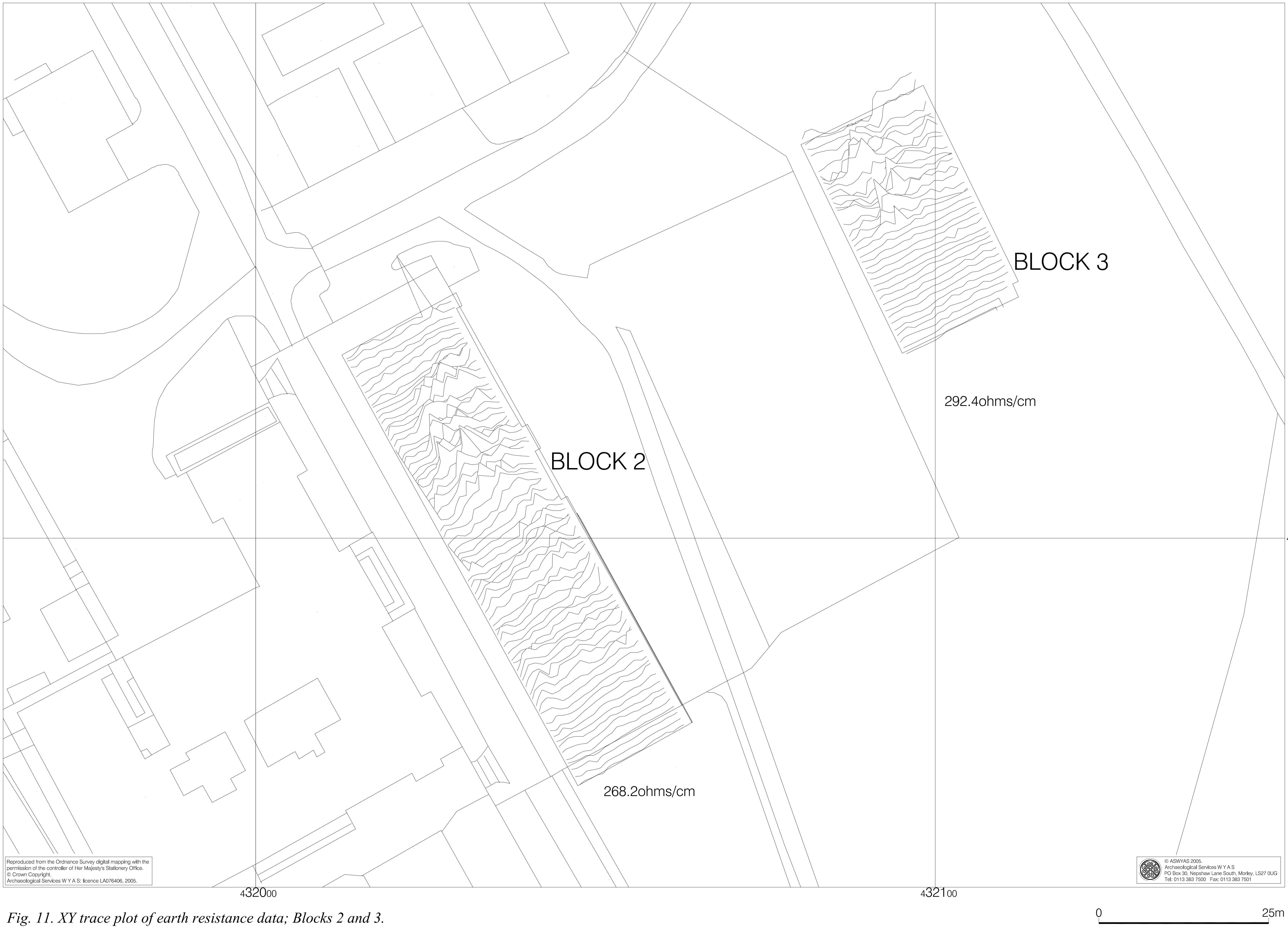

Fig. 11. XY trace plot of earth resistance data; Blocks 2 and 3.

Appendix 1

Magnetic Survey: Technical Information

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 that intrude into the topsoil may give a negative magnetic response relative to the background level.

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.

Types of Magnetic Anomaly

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.

Where it is not possible to give a probable cause of an observed anomaly a '?' is appended.

It should be noted that anomalies interpreted as modern in origin might 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.

The types of response mentioned above can be divided into five main categories that 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 XY 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.

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.

Methodology: Gradiometer Survey

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.

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).

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 or 0.25m 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.

During this survey a Bartington Grad601 magnetic field gradiometer was used. Readings were taken, on the 0.1nT range, at 0.25m 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 and calibrated as necessary. The drift from zero was not logged.

Data Processing and Presentation

The detailed gradiometer data has been presented in this report in XY 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.

An XY 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’. Geoplot 3 software was used to create the XY trace plots.

Geoplot 3 software was used to interpolate the data so that 1600 readings were obtained for each 20m by 20m grid. The same program was used to produce the greyscale images. All greyscale plots are displayed using a linear incremental scale.

Appendix 2

Resistance Survey: Technical Information

Soil Resistance

The electrical resistance of the upper soil horizons is predominantly dependant on the amount and distribution of water within the soil matrix. Buried archaeological features, such as walls or infilled ditches, by their differing capacity to retain moisture, will impact on the distribution of sub-surface moisture and hence affect electrical resistance. In this way there may be a measurable contrast between the resistance of archaeological features and that of the surrounding deposits. This contrast is needed in order for sub-surface features to be detected by a resistance survey.

The most striking contrast will usually occur between a solid structure, such as a wall, and water-retentive subsoil. This shows as a resistive high. A weak contrast can often be measured between the infill of a ditch feature and the subsoil. If the infill material is soil it is likely to be less compact and hence more water retentive than the subsoil and so the feature will show as a resistive low. If the infill is stone the feature may retain less water than the subsoil and so will show as a resistive high.

The method of measuring variations in ground resistance involves passing a small electric current (1mA) into the ground via a pair of electrodes (current electrodes) and then measuring changes in current flow (the potential gradient) using a second pair of electrodes (potential electrodes). In this way, if a structural feature, such as a wall, lies buried in a soil of uniform resistance much of the current will flow around the feature following the path of least resistance. This reduces the current density in the vicinity of the feature, which in turn increases the potential gradient. It is this potential gradient that is measured to determine the resistance. In this case, the gradient would be increased around the wall giving a positive or high resistance anomaly.

In contrast a feature such as an infilled ditch may have a moisture retentive fill that is comparatively less resistive to current flow. This will increase the current density and decrease the potential gradient over the feature giving a negative or low resistance anomaly.

Survey Methodology

The most widely used archaeological technique for earth resistance surveys uses a twin probe configuration. One current and one potential electrode (the remote or static probes) are fixed firmly in the ground a set distance away from the area being surveyed. The other current and potential electrodes (the mobile probes) are mounted on a frame and are moved from one survey point to the next. Each time the mobile probes make contact with the ground an electrical circuit is formed between the current electrodes and the potential gradient between the mobile and remote probes is measured and stored in the memory of the instrument.

A Geoscan RM15 resistance meter was used during this survey, with the instrument logging each reading automatically at 1m intervals on traverses 1m apart. The mobile probe spacing was 0.5m with the remote probes 15m apart and at least 15m away from the grid under survey. This mobile probe spacing of 0.5m gives an approximate depth of penetration of 1m for most archaeological features. Consequently a soil cover in excess of 1m may mask, or significantly attenuate, a geophysical response.

Data Processing and Presentation

All of the illustrations incorporating a digital map base were produced in AutoCAD 2000 (© Autodesk).

The resistance data is presented in this report in greyscale format with a linear gradation of values and was obtained by exporting a bitmap from the processing software (Geoplot v3.0; Geoscan Research) into AutoCAD 2000. The data has been processed and has also been interpolated by a value of 0.5 in both the X and Y axes using a sine wave (x)/x function to give a smoother, better defined plot.

Appendix 3

Survey Location Information

The site grid was laid out using a Geodimeter 600s total station theodolite and tied in to permanent structures. The survey grids were then superimposed onto an Ordnance Survey digital map base using common boundary walls 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 ±1.0m. However, it should be noted that Ordnance Survey co-ordinates for 1:2500 map data have an error of ±1.9m at 95% confidence. This potential error must be considered if co-ordinates are measured off for relocation purposes. Local grid co-ordinates can be supplied if required.

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 4

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 may 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).