Queen Elizabeth Barracks
Strensall Camp
Strensall
York

Geophysical Survey

Report no.2749

April 2015

Client: Mott MacDonald

Queen Elizabeth Barracks
Strensall Camp
Strensall
York

Geophysical Survey

Summary

A geophysical (magnetometer and earth resistance) survey covering 1.2 hectares was carried out on three parcels of land at the Queen Elizabeth Barracks, Strensall, prior to the proposed development of the site. No anomalies of archaeological potential have been identified by either technique. Anomalies have been identified which are due to modern services pipes and/or cables and modern landscaping. Consequently, on the basis of the survey, the archaeological potential of the site is considered to be low.

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SERVICES
WYAS

Report Information

Client:	Mott MacDonald Ltd and Defence Infrastructure Organisation (DIO)
Address:	2nd Floor, 2 Brewery Wharf, Kendell Street, Leeds, LS10 1JR
Report Type:	Geophysical Survey
Location:	York
County:	North Yorkshire
Grid Reference:	SE 632 592
Period(s) of activity:	Modern
Report Number:	2749
Project Number:	4383
Site Code:	STH15
OASIS ID:	archaeol11- 209822
Planning Application No.:	
Museum Accession No.:	n/a
Date of fieldwork:	April 2015
Date of report:	April 2015
Project Management:	Sam Harrison BSc MSc MCIfA
Fieldwork:	Alex Schmidt BA
	Marina Rose BA
Report:	David Harrison BA MSc MCIfA
Illustrations:	David Harrison
Photography:	Alex Schmidt
Research:	n/a

Authorisation for distribution: --

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Contents

List of Figures

List of Plates

1 Introduction

Archaeological Services WYAS (ASWYAS) was commissioned by Mott MacDonald Ltd and Defence Infrastructure Organisation (DIO) (The Client), to undertake a geophysical (magnetometer and earth resistance) survey of land proposed for development at Queen Elizabeth Barracks, Strensall (see Fig. 1). The work was undertaken in accordance with policy contained within the National Planning Policy Framework (DCLG 2012), in line with current best practice (CIfA 2014; David *et al.* 2008) and to a RAMS (Richardson 2015) approved by the Client. The survey was carried out on April 13th and April 14th 2015 to provide additional information on the archaeological resource of the site.

Site location, topography and land-use

The proposed development area (PDA) comprises three areas (Area 1 to Area 3) which are located between existing buildings and infrastructure within the Queen Elizabeth Barracks at Strensall, in the unitary authority of the City of York, North Yorkshire, centred at NGR SE 632 592 (see Fig. 1). At the time of the survey the areas were under short grass. Existing buildings, temporary building footings and military apparatus restricted the survey areas (see plates).

Soils and geology

The underlying bedrock geology comprises sandstone of the Sherwood Sandstone Group overlain by sand of the Sutton Sand Formation (British Geological Survey 2015). The soils are classified in the Everingham association, characterised as deep, stone-less permeable sandy soils (Soil Survey of England and Wales 1983).

2 Archaeological Background

A Heritage Assessment (Mott MacDonald Ltd 2014) undertaken by the client concluded that:

'There is moderate potential for remains of prehistoric and medieval to post medieval date. The likely function of the medieval/post-medieval remains is agricultural, due to the close proximity of ridge and furrow earthworks and evidence of peat cutting within the area.'

3 Aims, Methodology and Presentation

The aim of the geophysical survey is to, as far as possible, identify the presence or absence, and extent and layout, of buried archaeological remains across the site, through the interpretation of anomalies identified following the processing of data gathered during the magnetometer and earth resistance surveys.

Magnetometer Survey

Magnetic survey methods rely on the ability of a variety of instruments to measure very small magnetic fields associated with buried archaeological remains. Features such as a ditch, pit or kiln can act like a small magnet, or series of magnets, that produce distortions (anomalies) in the Earth’s magnetic field. In mapping these slight variations, detailed plans of sites can be obtained as buried features often produce reasonably characteristic anomaly shapes and strengths (Gaffney and Gater 2003). Further information on types of anomaly is provided as Appendix 1.

On this site Bartington Grad601 magnetic gradiometers were used. These instruments are calibrated to take readings at 0.25m intervals on zig-zag traverses 1m apart within a series of 30m by 30m grids resulting in 3600 readings per 30m grid square. The data is stored in the memory of the instrument before being downloaded to a lap-top computer every day for data processing and interpretation.

Resistance Survey

The resistance survey was undertaken using a Geoscan RM15 and MPX15 instrument set as a Twin Probe array to take readings at 1m intervals on traverses 1m apart, allowing 900 readings to be recorded in each grid square. The mobile probe spacing of 0.5m gives an approximate depth penetration of 1m for most archaeological features. These readings are stored in the memory of the instrument and were later downloaded for processing and interpretation. Geoplot 3 (Geoscan Research) software will be used to process and present the data.

The survey grid was laid out using a Trimble VRS differential Global Positioning System (Trimble 5800 model) providing an accuracy greater than 0.01m. The locations of the survey grid and anomalies are available as a DXF file. The survey grids were then super-imposed onto a base map provided by the client to produce the displayed block locations. However, it should be noted that Ordnance Survey positional accuracy for digital map data has an error of 0.5m for urban and floodplain areas, 1.0m for rural areas and 2.5m for mountain and moorland areas. This potential error must be considered if co-ordinates are measured off hard copies of the mapping rather than using the digital co-ordinates.

Data Processing

The 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. 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. 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'. The data in the greyscale images has been interpolated and selectively filtered, using Geoplot 3 (Geoscan Research) software to remove the effects of drift in instrument calibration and other artificial data constructs and to maximise the clarity and interpretability of the archaeological anomalies.

Reporting

A general site location plan, incorporating the 1:50000 Ordnance Survey (OS) mapping, is shown in Figure 1. A large scale (1:2500) survey location plan, showing the processed magnetometer data, is provided as Figure 2. The processed and minimally processed data, together with an interpretation of the survey results are presented in Figures 3 to 8 inclusive, at a scale of 1:1000.

Technical information on the equipment used, data processing and survey methodologies are given in Appendix 1 and Appendix 2. Appendix 3 describes the composition and location of the archive. A copy of the OASIS form is in Appendix 4.

The survey methodology, report and any recommendations comply with guidelines outlined by English Heritage (David *et al.* 2008) and by the Chartered Institute for Archaeologists (CIfA 2014). All figures reproduced from Ordnance Survey mapping are with the permission of the controller of Her Majesty's Stationery Office (© Crown copyright).

Disclaimers

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.

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.

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

4 Results and Discussion (see Figures 3 to 8 inclusive)

For ease of discussion the results are presented by technique rather than by area. Unless stated otherwise any variation in resistance is assumed to be due to changes in soil compaction, geology, water retention or a combination of all these factors

Magnetometer survey

The magnetic data is dominated by high magnitude anomalies and areas of magnetic disturbance throughout. Disturbance of this magnitude (in excess of 50nT) is typically caused by modern ground disturbance, infilling and the spreading of magnetic material (including rubble, gravel, concrete etc) throughout the topsoil. Anomalies of archaeological potential, if present, are typically recorded in the range of 2-4nT and are unlikely to be visible within this elevated background. Highly magnetic dipolar linear anomalies, **A** – **E**, are recorded within Area 2 and Area 3 on a north-south alignment. These are caused by service pipes and/or cables.

Earth resistance survey

Generally, the resistance survey has recorded a variable background response within each of the three survey areas. This is due to the difference in the depth and composition of the topsoil and subsoils and the resultant varying moisture content. Broad areas of high resistance are typically identified at the perimeters of the surveyed areas and are likely to be due to building foundations, and areas of compacted rubble. North/south aligned linear anomalies, **F**, **G**, **I**, **J** and **K** correspond to highly magnetic anomalies **A** – **E** and are due to service pipes and/or cables. The north-east/south-west aligned low resistance anomaly, **H**, within the north of Area 2 is caused by the accumulation of moisture along the route of a surfaced pathway (see Plate 2). No anomalies of obvious archaeological potential have been identified.

5 Conclusions

The survey has detected anomalies which reflect the existing use of the site, the provision of services and modern landscaping. No anomalies have been identified which can confidently be ascribed an archaeological origin and therefore, on the basis of the survey, the archaeological potential of the site is considered to be low.

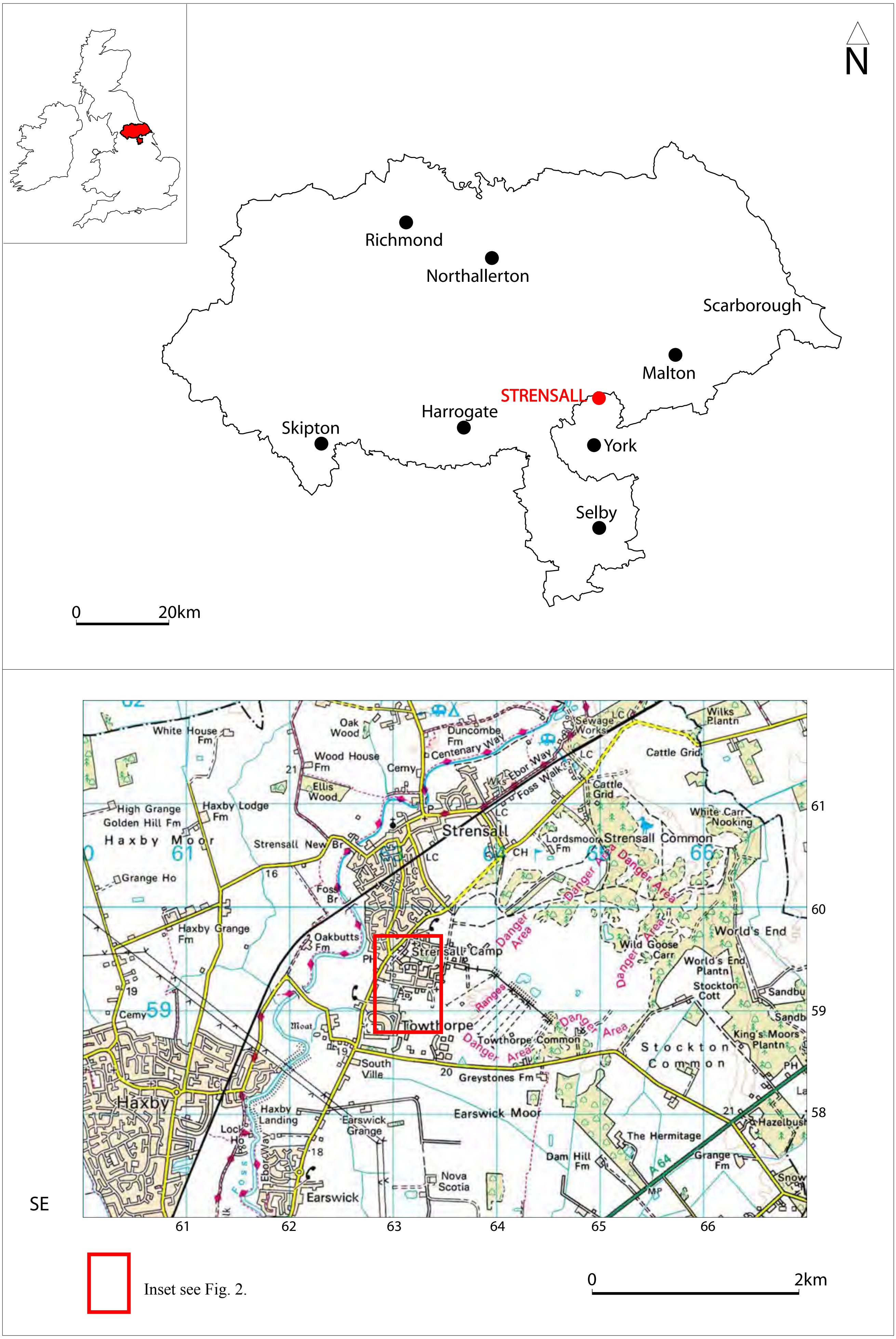

Fig. 1. Site location

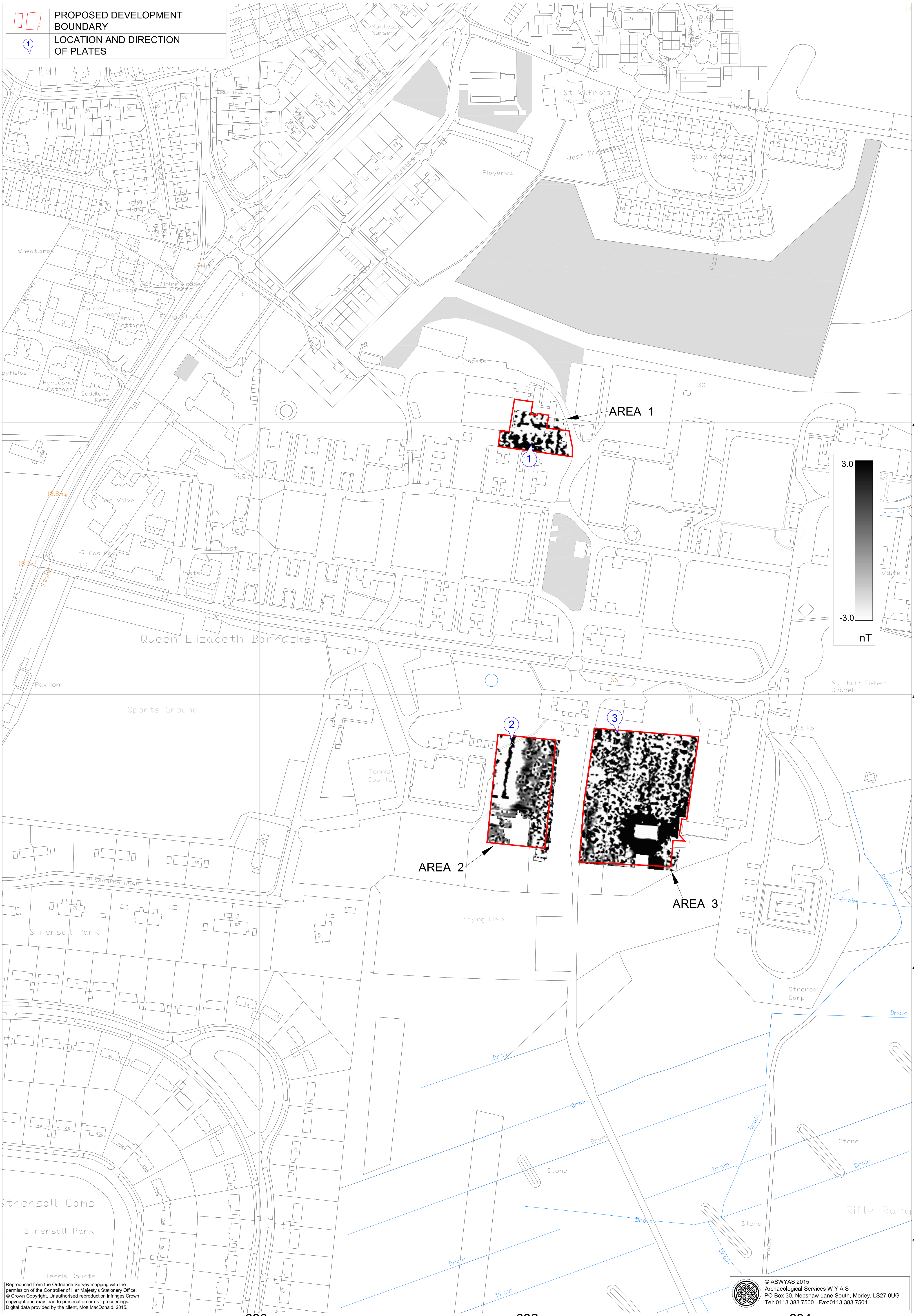

Fig. 2. Survey location showing greyscale magnetometer data (1:2500 @ A3)

Fig. 3. Processed greyscale magnetometer data (1:1000 @ A3)

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Fig. 4. XY trace plot of minimally processed magnetometer data (1:1000 @ A3)

Fig. 5. Interpretation of magnetometer data (1:1000 @ A3)

0 30m

Fig. 6. Unprocessed greyscale earth resistance data (1:1000 @ A3)

Fig. 7. Processed greyscale earth resistance data (1:1000 @ A3)

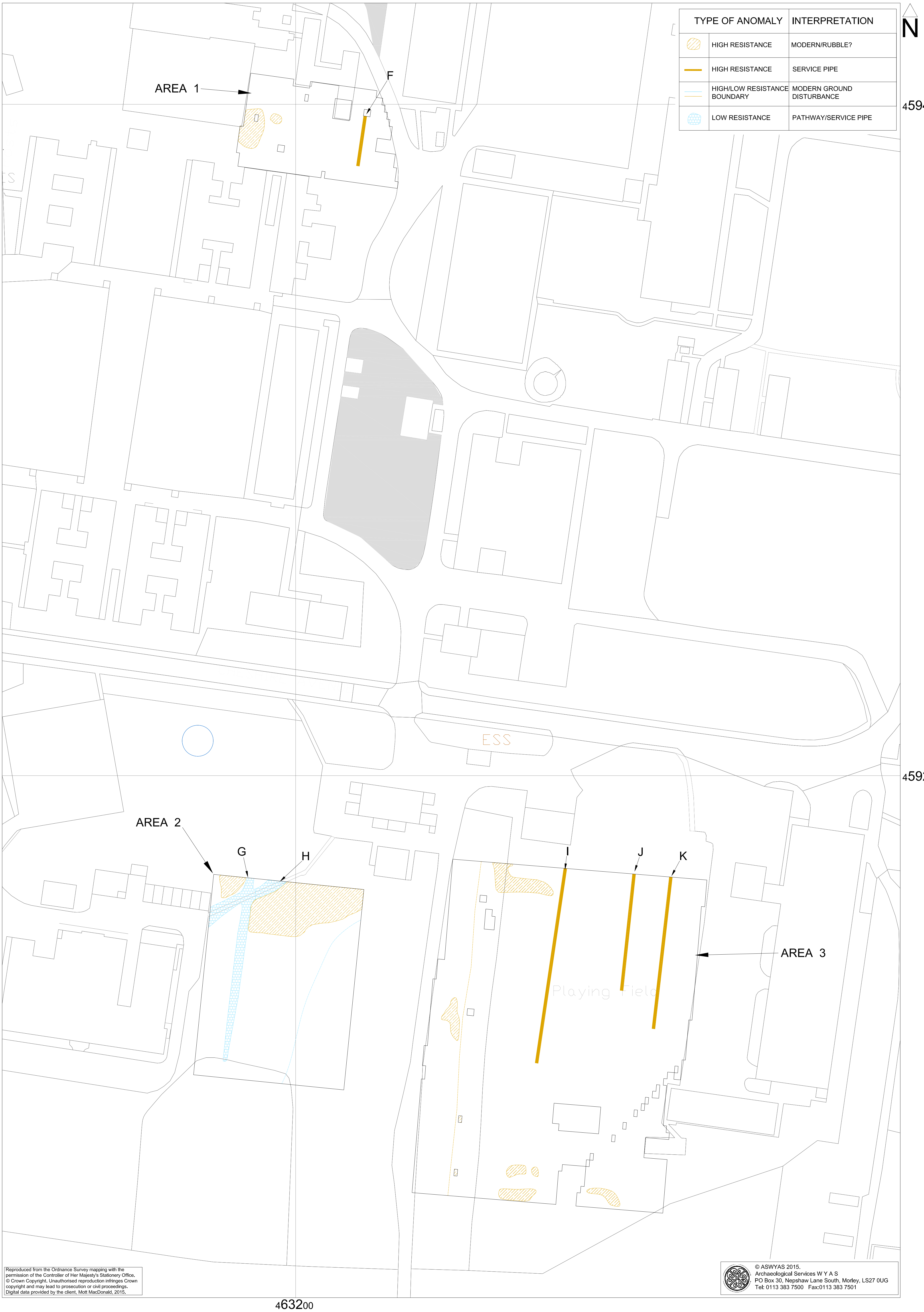

Fig. 8. Interpretation of earth resistance data (1:1000 @ A3)

0 30m

Plate 1. General view of Area 1, looking north

Plate 2. General view of Area 2, looking south

Plate 3. General view of Area 3, looking south

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. Areas of human occupation or settlement can then be identified by measuring the magnetic susceptibility of the topsoil because 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. The magnetic susceptibility of a soil can also be enhanced by the application of heat and the fermentation and bacterial effects associated with rubbish decomposition. The area of enhancement is usually quite large, mainly due to the tendency of discard areas to extend beyond the limit of the occupation site itself, and spreading by the plough. An advantage of magnetic susceptibility over magnetometry is that a certain amount of occupational activity will cause the same proportional change in susceptibility, however weakly magnetic is the soil, and so does not depend on the magnetic contrast between the topsoil and deeper layers. Susceptibility survey is therefore able to detect areas of occupation even in the absence of cut features. On the other hand susceptibility survey is more vulnerable to the masking effects of layers of colluvium and alluvium as the technique, using the Bartington system, can generally only measure variation in the first 0.15m of ploughsoil.

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.

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. These anomalies are often caused by agricultural activity, either ploughing or land drains being 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: Gradiometer Survey

The main method of using the fluxgate gradiometer for commercial evaluations is referred to as ***detailed survey*** and requires the surveyor to walk at an even pace carrying the instrument within a grid system. A sample trigger automatically takes readings at predetermined points, typically at 0.25m intervals, on traverses 1m apart. These readings are stored in the memory of the instrument and are later dumped to computer for processing and interpretation.

During this survey a Bartington Grad601 magnetic gradiometer was used taking readings on the 0.1nT range, at 0.25m intervals on zig-zag traverses 0.5m apart within 30m by 30m 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 interpolated and selectively filtered to remove the effects of drift in instrument calibration and other artificial data constructs and to maximise the clarity and interpretability of the archaeological anomalies.

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. 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 3600 readings were obtained for each 30m by 30m grid. The same program was used to produce the greyscale images. All greyscale plots are displayed using a linear incremental scale.

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.

Appendix 2: Earth 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 2008 (© 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 2008. 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: Geophysical archive

The geophysical archive comprises:-

- an archive disk containing compressed (WinZip 8) files of the raw data, report text (Microsoft Word 2000), and graphics files (Adobe Illustrator CS2 and AutoCAD 2008) files; and
- 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 City of York Historic Environment Record).

Appendix 4: OASIS Form

OASIS DATA COLLECTION FORM: England

Printable version

OASIS ID: archaeol11-209822

Project details

Project name	Queen Elizabeth Barracks
Short description of the project	A geophysical (magnetometer and earth resistance) survey covering 1.2 hectares was carried out on three parcels of land at the Queen Elizabeth Barracks, Strensall, prior to the proposed development of the site. No anomalies of archaeological potential have been identified by either technique. Anomalies have been identified which are due to modern services pipes and/or cables and modern landscaping. Consequently, on the basis of the survey, the archaeological potential of the site is considered to be low.
Project dates	Start: 13-04-2015 End: 14-04-2015
Previous/future work	Not known / Not known
Any associated project reference codes	STH15 - Sitecode
Any associated project reference codes	4383 - Contracting Unit No.
Type of project	Recording project
Site status	None
Current Land use	Grassland Heathland 2 - Undisturbed Grassland
Monument type	NONE None
Significant Finds	NONE None
Investigation type	"Geophysical Survey"
Prompt	National Planning Policy Framework - NPPF
Solid geology (other)	Sherwood Sandstone Group
Drift geology (other)	Everingham association
Techniques	Magnetometry

Project location

Country	England

Site location	NORTH YORKSHIRE YORK STRENSALL Queen Elizabeth barracks
Study area	1.20 Hectares
Site coordinates	SE 632 592 54.0247326264 -1.03516454647 54 01 29 N 001 02 06 W Point
Height OD / Depth	Min: 10.00m Max: 11.00m

Project creators

Name of Organisation	Archaeological Services WYAS
Project brief originator	Mott MacDonald
Project design originator	Archaeological Services WYAS
Project director/manager	Harrison, S.
Project supervisor	Schmidt, A.
Type of sponsor/funding body	Consultant
Name of sponsor/funding body	Mott MacDonald

Project archives

Physical Archive Exists?	No
Digital Archive recipient	N/A
Digital Contents	"none"
Digital Media available	"Geophysics"
Paper Archive Exists?	No

Project bibliography 1

Publication type	Grey literature (unpublished document/manuscript)
Title	Queen Elizabeth Barracks, Strensall Camp, Strensall, York: Geopyhiscal Survey
Author(s)/Editor(s)	Harrison, D.
Other bibliographic details	Report No. 2749
Date	2015
Issuer or publisher	Archaeological Services WYAS
Place of issue or publication	Morley
Description	A4 Bound report

Entered by	Zoe Horn (zhorn@aswyas.com)
Entered on	24 April 2015

OASIS:

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