ARCHAEOLOGICAL SERVICES WYAS

Feeder No. 9
River Humber Pipeline Replacement Scheme
Paull
East Yorkshire

Geophysical Survey

Report no. 2658

October 2014

Client: Hyder Consulting (UK)

REGISTERED ORGANISATION IfA

Feeder No. 9
River Humber Pipeline Replacement Project
Paull
East Yorkshire

Geophysical Survey

Summary

A geophysical (magnetometer) survey covering 5.5 hectares was carried out on land that will be impacted by the construction of a replacement high pressure gas pipeline at Paull, East Yorkshire. The data is characterised by high levels of magnetic disturbance caused by pipes leading to/from the gas valve compound. Where the data is not effected by the pipes only anomalies indicative of geological variation are identified. No anomalies of archaeological potential have been recorded. On the basis of the survey, the archaeological potential of the site is considered to be low, confirming the conclusions of an earlier cultural heritage assessment.

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Report Information

Client:	Hyder Consulting (UK) Limited
Address:	The Mill, Brimscombe Port, Stroud, Gloucester GL5 2QG
Report Type:	Geophysical Survey
Location:	Paull
County:	East Yorkshire
Grid Reference:	TA 1820 2540
Period(s) of activity:	modern
Report Number:	2658
Project Number:	4300
Site Code:	HPR14
OASIS ID:	archaeol11-194063
Planning Application No.:	
HER Event No:	n/a
Museum Accession No.:	n/a
Date of fieldwork:	October 2014
Date of report:	October 2014
Project Management:	Alistair Webb BA MIfA
Fieldwork:	Mark Evans BA
	David Harrison BA MA MIfA
	Alex Schmidt BA
Report:	Sam Harrison BSc MSc MIfA
Illustrations:	David Harrison and Sam Harrison
Photography:	Site staff
Research:	n/a

Authorisation for distribution: ----------

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1 Introduction

Archaeological Services WYAS (ASWYAS) were commissioned by Jenny Wylie of Hyder Consulting (the Consultant) on behalf of National Grid (the Client), to undertake a geophysical (magnetometer) survey of land near Paull, East Yorkshire (see Fig. 1). The results of the survey will be used to support a planning application for the construction of a replacement high pressure pipeline. The work was undertaken in accordance with a Project Design (Webb 2014) supplied to and approved by the client and the Humber Archaeology Partnership, with guidance contained within the National Planning Policy Framework (NPPF 2012) and in line with current best practice (David *et al.* 2008). The survey was carried out on October 13th and October 14th 2014 to provide additional information on the archaeological potential of the site.

Site location, topography and land-use

The proposed development area (PDA) is located at Paull Holme, approximately 2km south-east of Paull and 2km south-west of Thorngumbald. The PDA is situated to the north and south of Thorngumbald Road, immediately surrounding the Paull Above Ground Installation (AGI), centred at TA 1820 2540. The site is situated on low lying ground at approximately 3m above Ordnance Datum (aOD). The PDA covers approximately 8 hectares, although only 5.5 hectares were available at the time of the survey. Field 1 and Field 3 were under a young arable crop with Field 2 and Field 4 under very rough pasture (see plates). Field 4 was not suitable for survey.

Soils and geology

The underlying bedrock comprises Flamborough Chalk which is overlain by Tidal Flat Deposits of clay and silt over most of the PDA and a small band of Till (diamicton) to the south-east of the AGI (British Geological Survey 2014).

The soils in this area are classified in the Agney association, characterised as deep, stoneless, calcareous fine and coarse silts (Soil Survey of England and Wales 1983).

2 Archaeological Background

As part of an Environmental Impact Assessment a Cultural Heritage Desk-Based Assessment (Hyder 2014) concluded that the site has been under agricultural production since at least the medieval period and that there is some potential for remains associated with agricultural activity (ploughed down remains of ridge and furrow earthworks) from that period to be present. It was also concluded that any remains pre-dating this are likely to be buried beneath '*considerable depths of alluvium*'. There is some limited evidence for prehistoric activity within the search area considered for the EIA but the research undertaken for this assessment recorded predominantly evidence for medieval and modern activity in the vicinity of the site.

3 Aims, Methodology and Presentation

The main aim of the geophysical survey was to provide sufficient information to enable an assessment to be made of the impact of potential sub-surface archaeological remains and for further evaluation or mitigation proposals, if appropriate, to be recommended. To achieve this aim a magnetometer survey covering all of the suitable area was undertaken.

The general objectives of the geophysical survey were:

- to provide information about the nature and possible interpretation of any magnetic anomalies identified;
- to therefore determine the presence/absence and extent of any buried archaeological features; and
- to prepare a report summarising the results of the survey.

Magnetometer survey

The site grid was laid out using a Trimble VRS differential Global Positioning System (Trimble 5800 model). Bartington Grad601 magnetic gradiometers were used during the survey, taking readings at 0.25m intervals on zig-zag traverses 1m apart within 30m by 30m grids, so that 3600 readings were recorded in each grid. These readings were stored in the memory of the instrument and later downloaded to computer for processing and interpretation. Geoplot 3 (Geoscan Research) software was used to process and present the data. Further details are given in Appendix 1.

Reporting

A general site location plan, incorporating the 1:50000 Ordnance Survey (OS) mapping, is shown in Figure 1. Figure 2 is a large scale (1:2000) location plan displaying the processed magnetic data whilst Figure 3 shows the overall interpretation of the magnetometer data, at the same scale. Large scale (1:1250) plots of the data in greyscale and XY trace plot formats together with interpretation graphics at the same scale are presented in figures 4 to 9 inclusive.

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

The survey methodology, report and any recommendations comply with the Project Design (Webb 2014) and guidelines outlined by English Heritage (David *et al.* 2008), the Institute for Archaeologists (IfA 2013) and the Humber Archaeology Partnership. All figures reproduced from Ordnance Survey (OS) mapping are with the permission of the controller of Her Majesty's Stationery Office (© Crown copyright).

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.

4 Results and Discussion

The survey data is dominated by modern activity within the PDA. Where there has been no modern disturbance anomalies of probable geological origin can discerned. These and other anomalies fall into different types and categories according to their origin, that are discussed below and cross-referenced to specific anomalies shown in the interpretative figures.

Ferrous and Modern Anomalies

Ferrous responses, visible either as individual 'spike' anomalies or more extensive areas of magnetic disturbance, are typically caused by modern ferrous (magnetic) debris, either on the ground surface or in the plough-soil, or are due to the proximity of magnetic material in field boundaries, buildings or other above ground features. Little importance is normally given to such anomalies, unless there is any supporting evidence for an archaeological interpretation. Ferrous debris or material is common on rural sites, often being present as a consequence of manuring or tipping/infilling. Throughout the PDA individual iron 'spike' anomalies are common and generally there is no obvious pattern or clustering to their distribution to suggest anything other than a random background scatter of ferrous debris in the soil.

Three notable areas of magnetic disturbance are identified within the survey area, **A**, **B** and **C**. Anomaly **A,** located in Field 2, is a large area of magnetic disturbance caused by the adjacent AGI, any anomalies of note in this area have been masked by the high magnetic readings of the AGI. Within Field 1, anomaly **B** is a large area of dispersed magnetic disturbances, caused by the reinstatement of agricultural land after the area had been in use as a compound area during the AGI construction. An area of magnetic disturbance, anomaly **C**, is located immediately south of two service pipes (see below) and is thought to be caused by ferrous debris from the construction of the AGI.

Ten high magnitude dipolar linear trend anomalies (**D** to **M** inclusive) are due to high pressure gas pipes heading towards/away from the AGI.

Agricultural Anomalies

Two linear trend anomalies aligned south-west/north-east are identified in the east of Field 1. These anomalies are interpreted as probable field drains.

Geological Anomalies

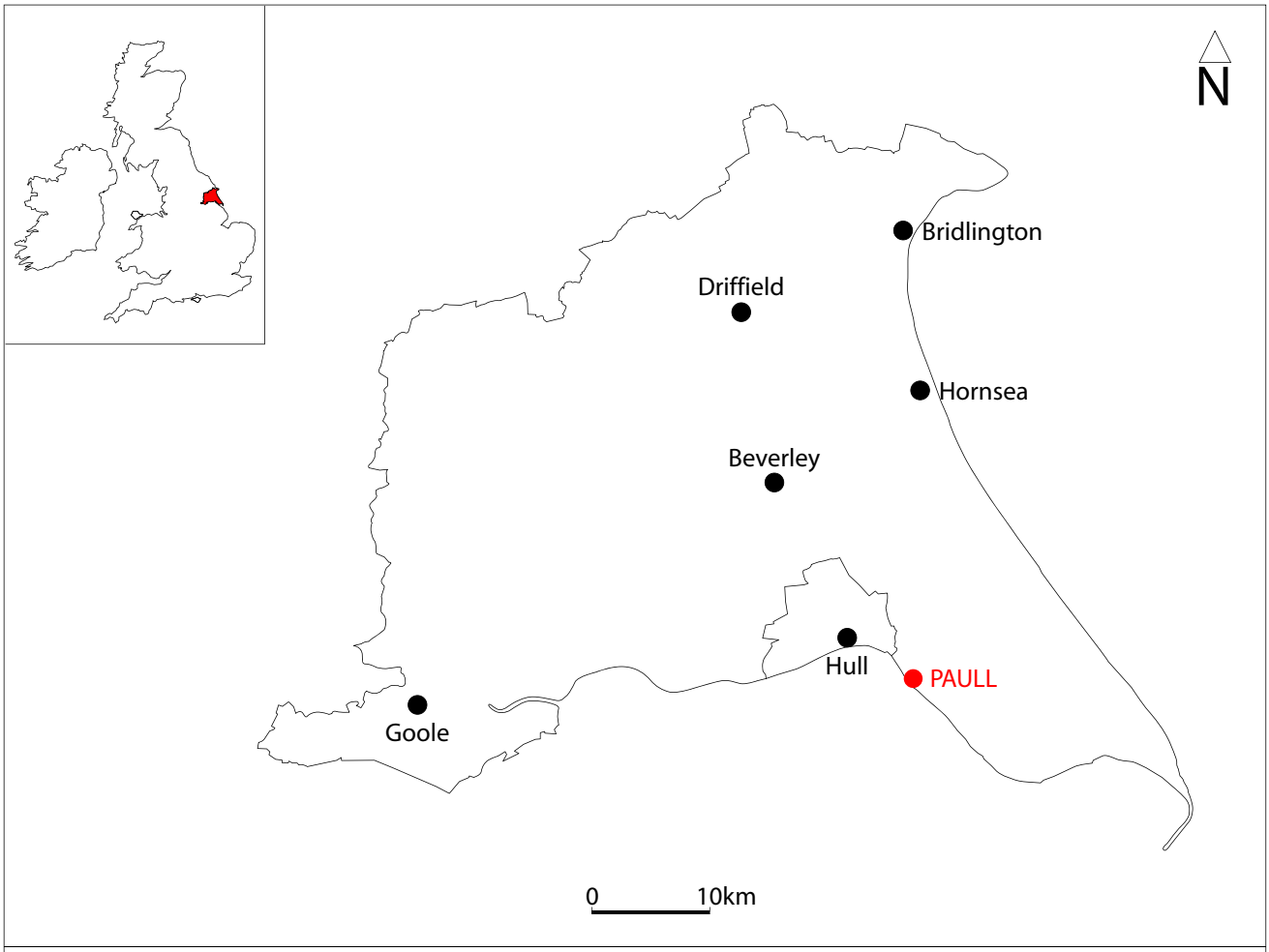
In the limited areas where the data is not dominated by the high magnitude responses from the pipes and modern disturbance clusters of anomalies of enhanced magnetic response are identified. These anomalies are of geological origin being due to the prevailing superficial geology; tidal flat deposits in Field 1 and till in Field 3.

5 Conclusions

The magnetic survey has not identified any anomalies of archaeological potential. The majority of the anomalies identified in the survey are due to the construction of the Above Ground Installation and the associated gas pipelines. Two distinct areas of geological anomalies have been identified, recording the differing superficial deposits across the site. The anomalies identified in the survey confirm the conclusions of the Cultural Heritage Desk-based Assessment.

On the basis of the geophysical survey the archaeological potential of the site is assessed as low.

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.



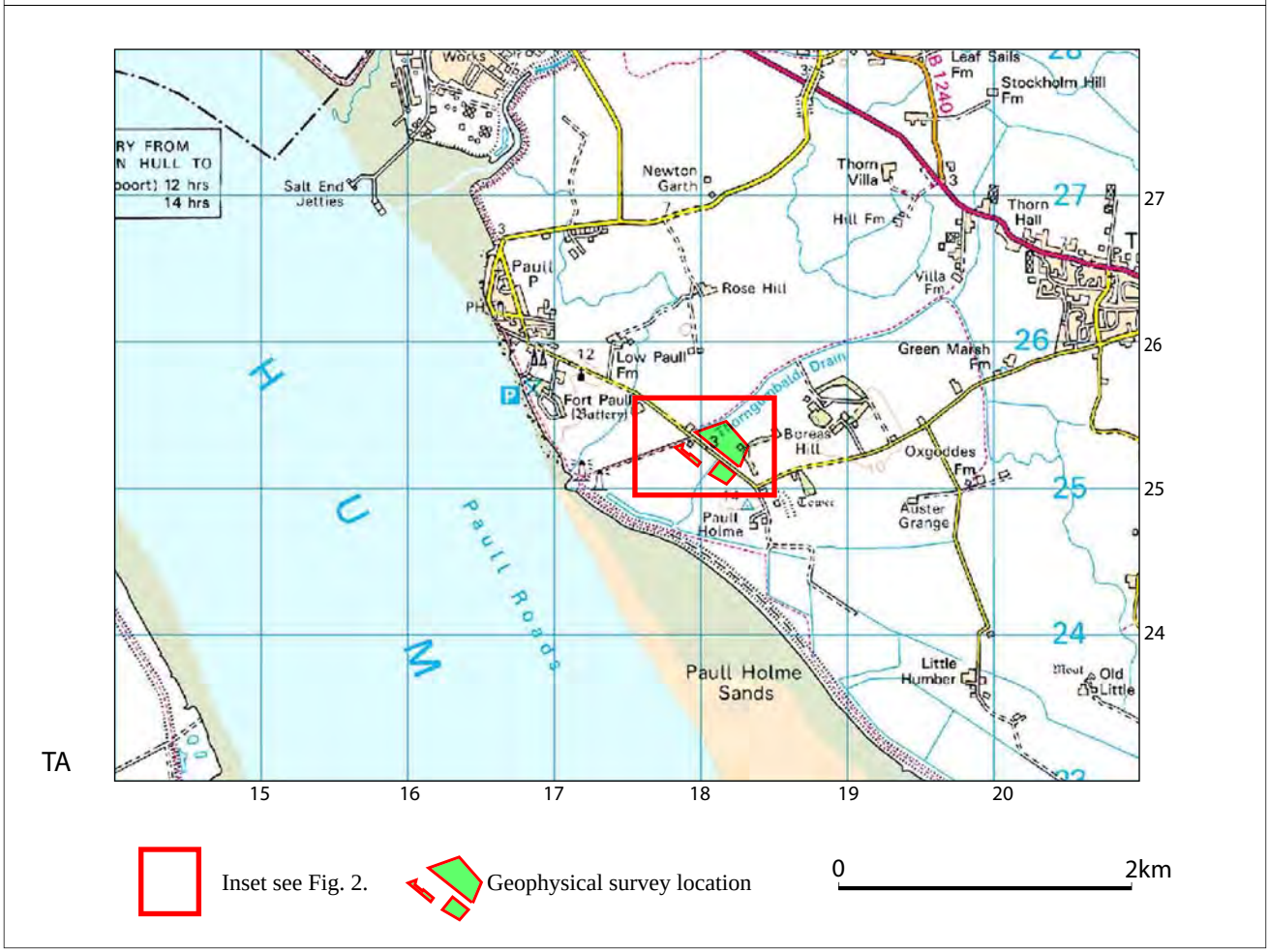


Fig. 1. Site location

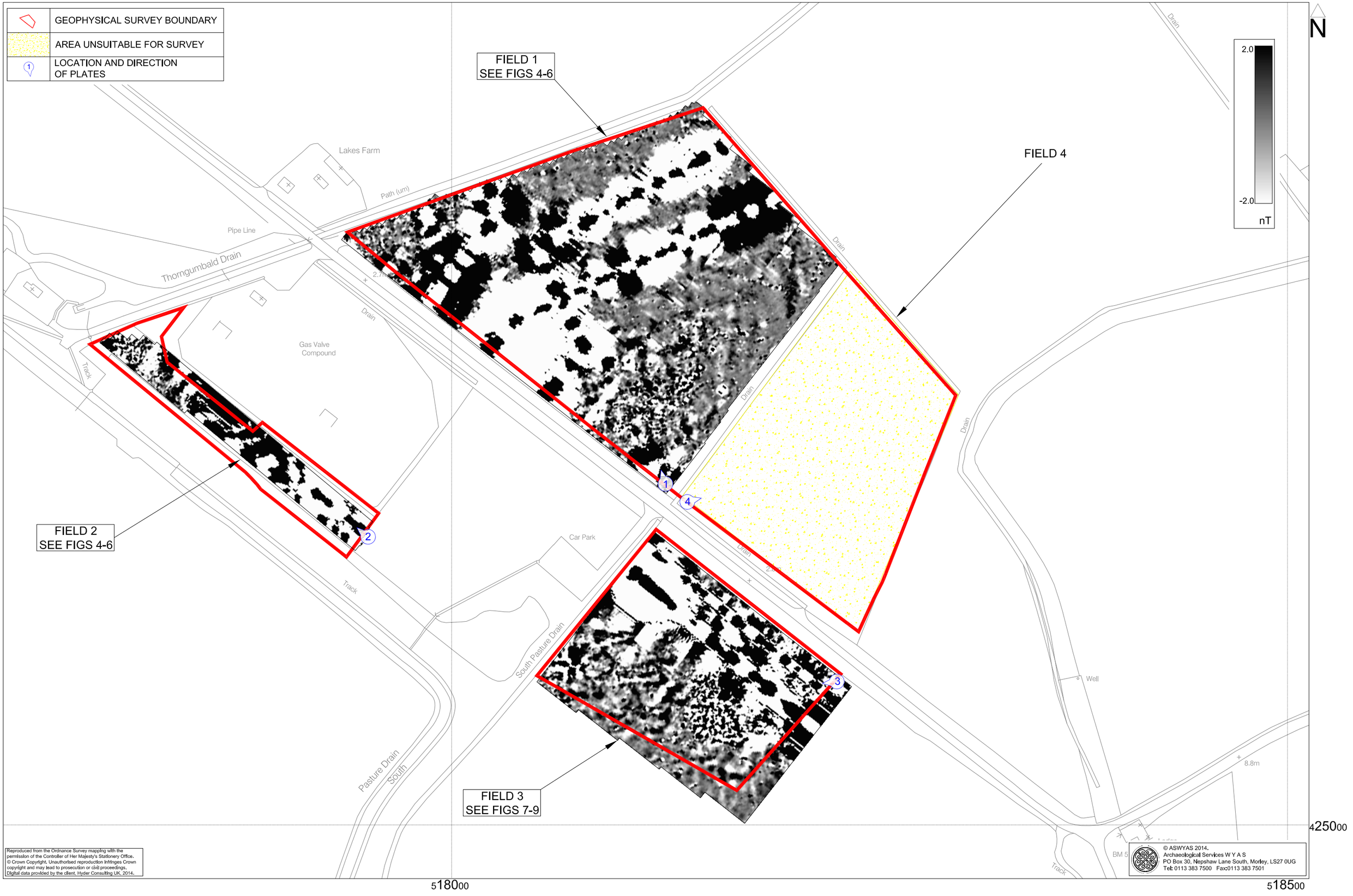


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Fig. 2. Survey location showing greyscale magnetometer data (1:2000 @ A3)

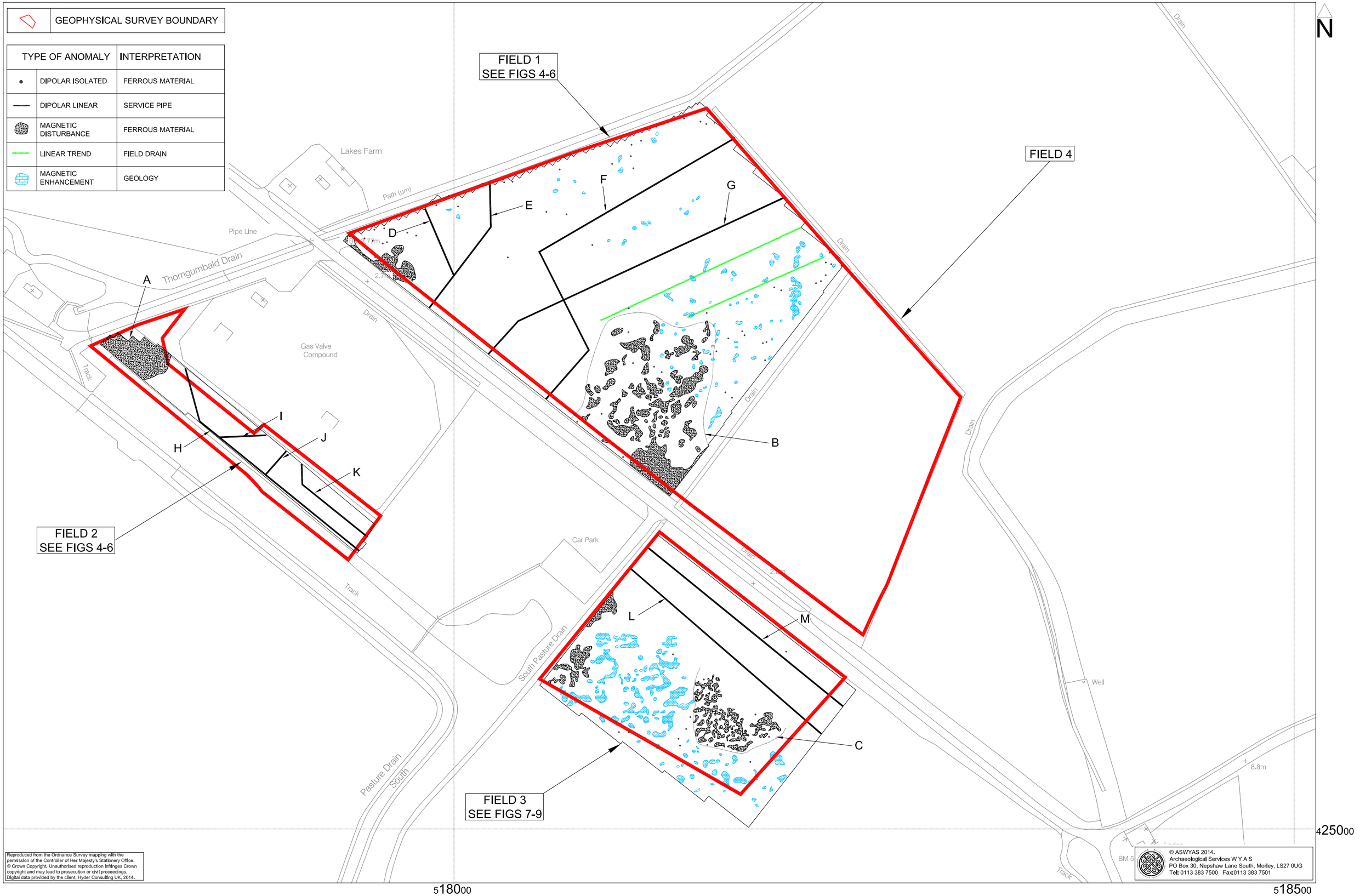

Fig. 3. Overall interpretation of magnetometer data (1:2000 @ A3)

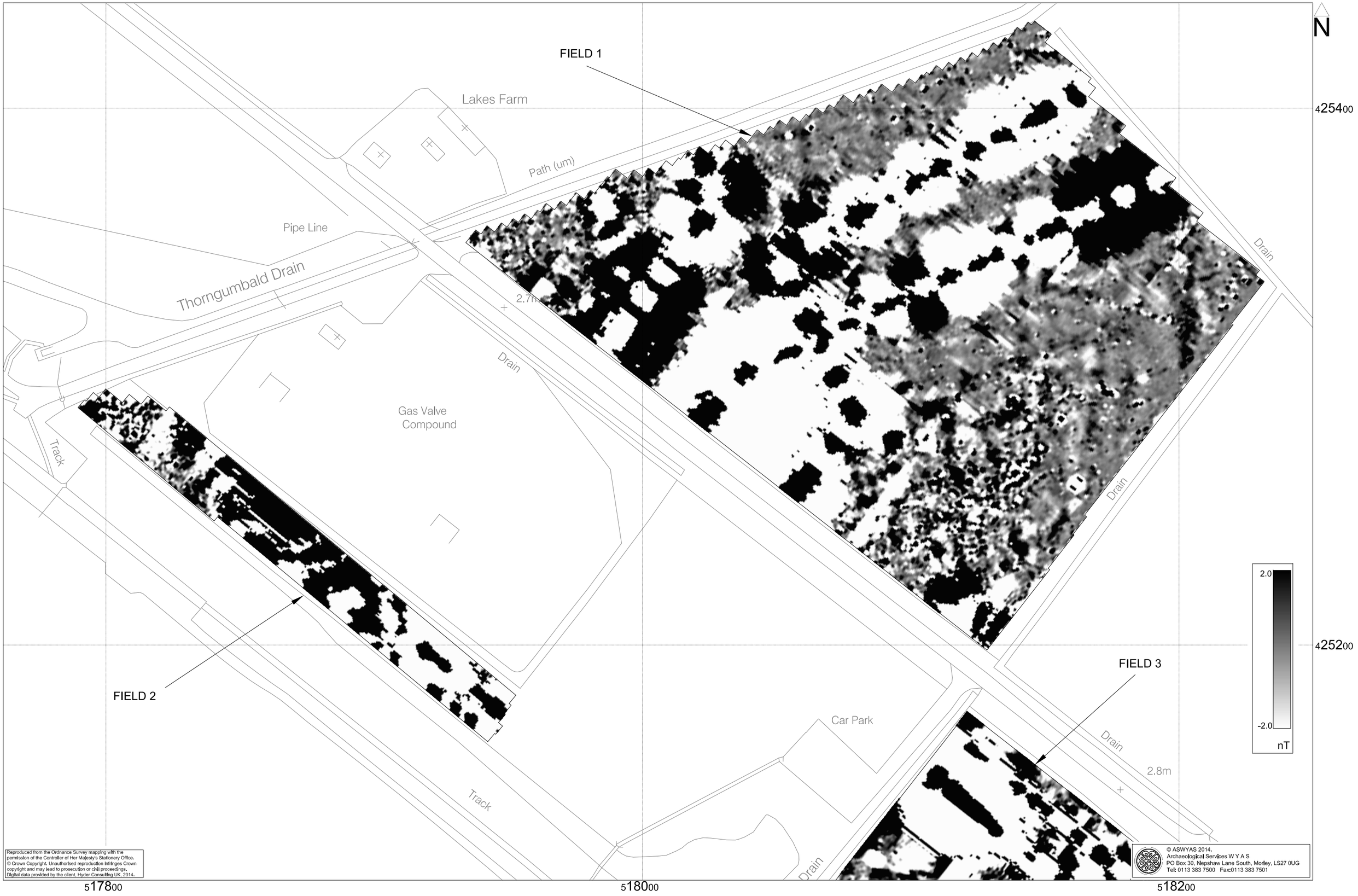

Fig. 4. Processed greyscale magnetometer data; Field 1 and Field 2 (1:1250 @ A3)

Fig. 5. XY trace plot of minimally processed magnetometer data; Field 1 and Field 2 (1:1250 @ A3)

TYPE OF ANOMALY		INTERPRETATION
•	DIPOLAR ISOLATED	FERROUS MATERIAL
——	DIPOLAR LINEAR	SERVICE PIPE
	MAGNETIC DISTURBANCE	FERROUS MATERIAL
	LINEAR TREND	FIELD DRAIN
	MAGNETIC ENHANCEMENT	GEOLOGY

N

4254 00

4252 00

5178 00

5180 00

5182 00

FIELD 1

FIELD 2

FIELD 3

A

B

D

E

F

G

H

I

J

K

L

M

Lakes Farm

Path (um)

Pipe Line

Thorngumbald Drain

BM 3.77m

2.7m

Drain

Gas Valve Compound

Track

Car Park

2.8m

0 50m

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Fig. 6. Interpretation of magnetometer data; Field 1 and Field 2 (1:1250 @ A3)

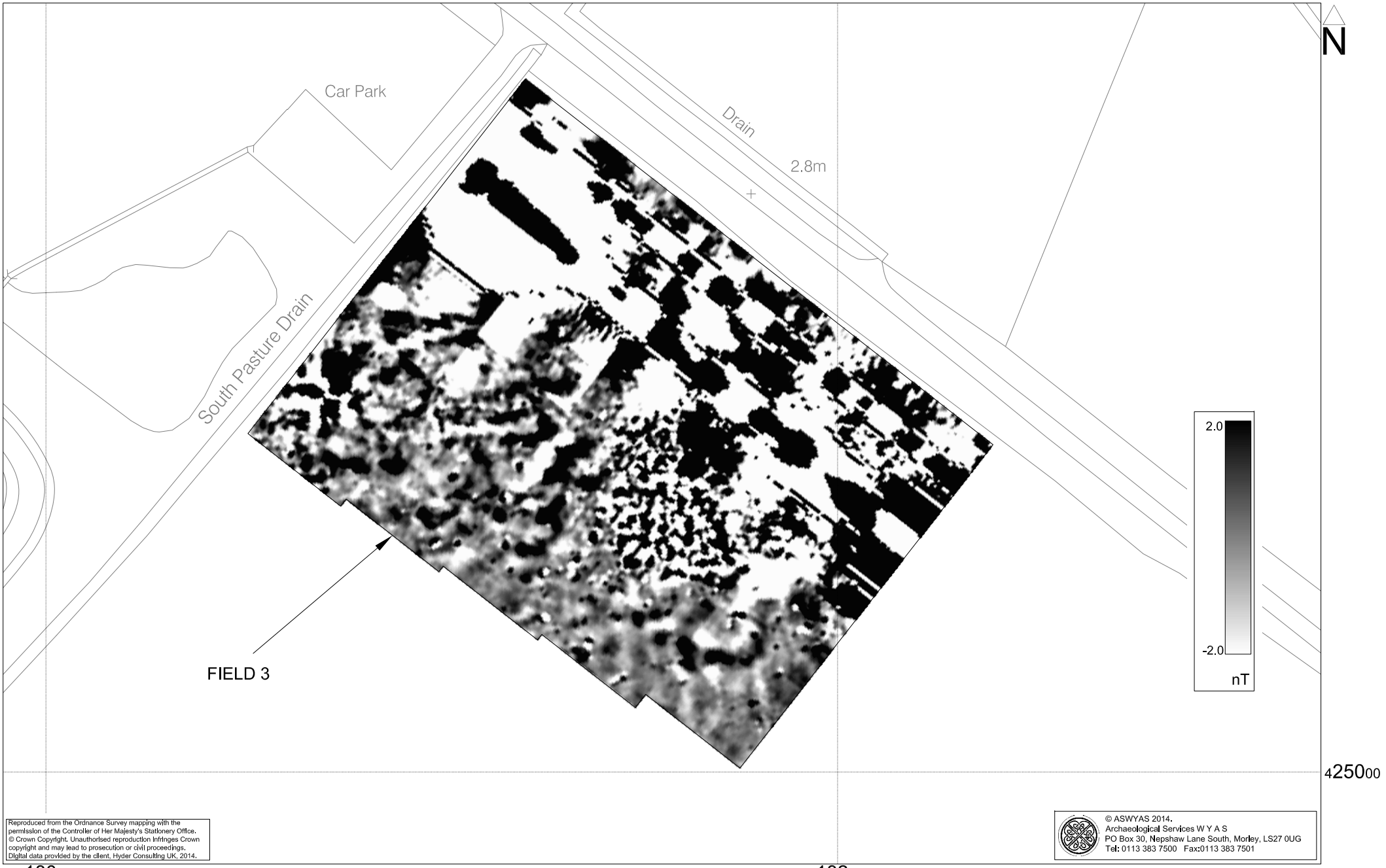

Fig. 7. Processed greyscale magnetometer data; Field 3 (1:1250 @ A4)

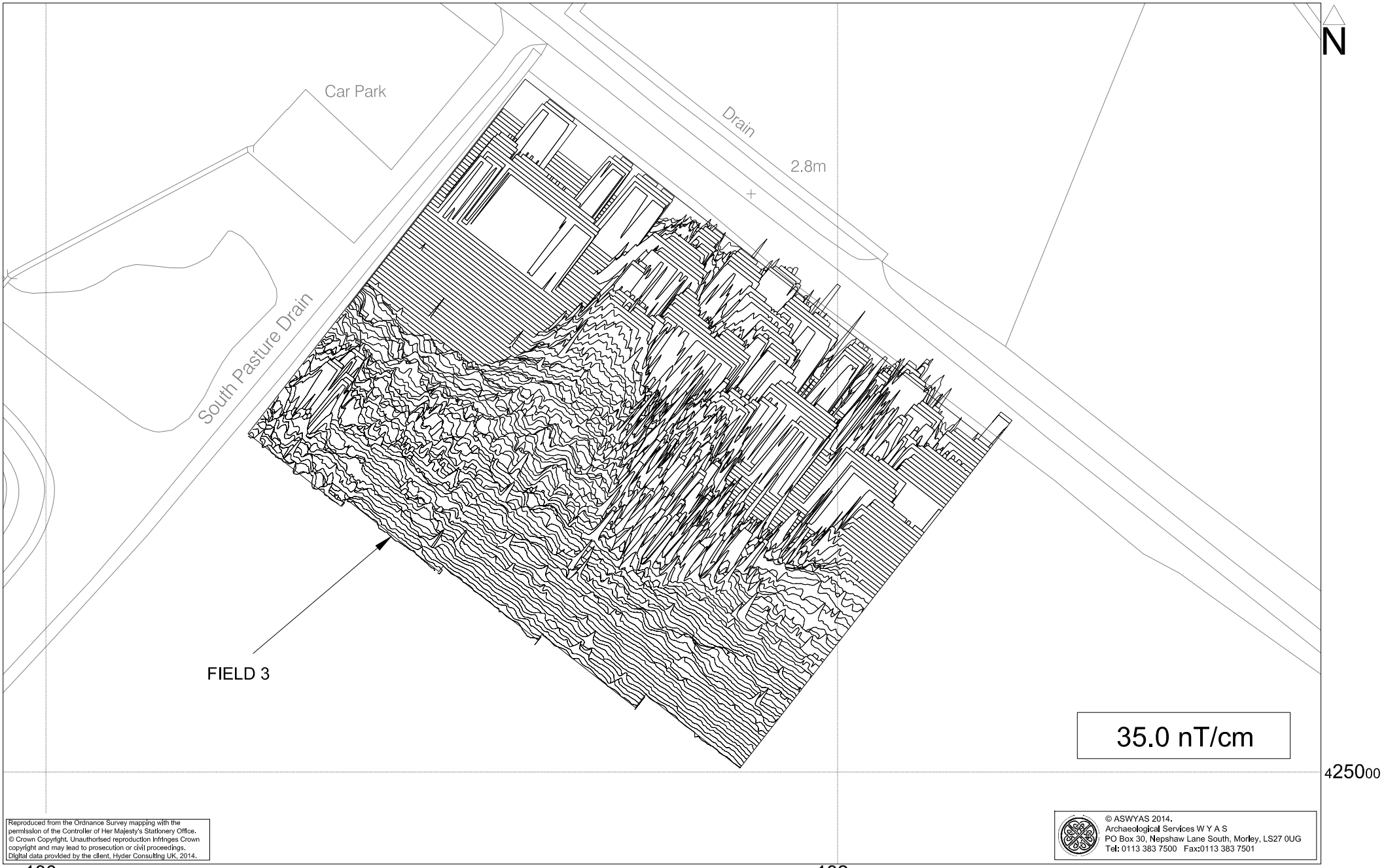

Fig. 8. XY trace plot of minimally processed magnetometer data; Field 3 (1:1250 @ A4)

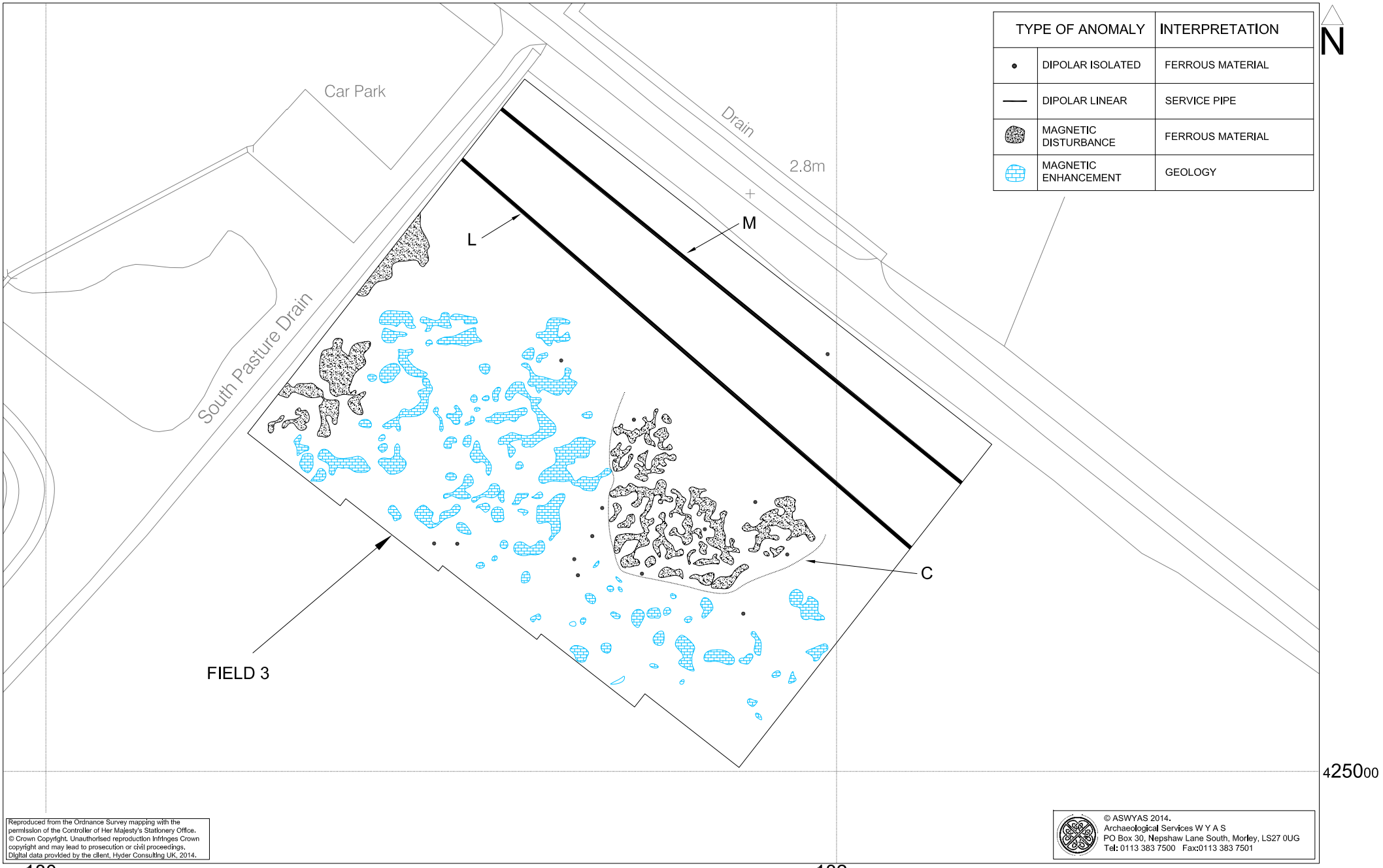

Fig. 9. Interpretation of magnetometer data; Field 3 (1:1250 @ A4)

Plate 1. General view of Field 1, looking north-west

Plate 2. General view of Field 2, looking north-west

Plate 3. General view of Field 3, looking south-west

Plate 4. General view of Field 4, looking north-east

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. 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: 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. For field surveys a Bartington MS2 meter with MS2D field loop is used due to its speed and simplicity. 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 a ‘negative’ scanning result should be validated by 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 0.25m 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 gradiometer was used taking readings on the 0.1nT range, at 0.25m intervals on zig-zag traverses 1m 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: Survey location information

The site grid was laid out using a Trimble VRS differential Global Positioning System (Trimble 5800 model). The accuracy of this equipment is better then 0.01m. 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.

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 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 East Yorkshire Historic Environment Record).

Appendix 4: OASIS Form

OASIS DATA COLLECTION FORM: England

Printable version

OASIS ID: archaeol11-194063

Project details

Project name	Feeder No. 9, River Humber Pipeline Replacement Project
Short description of the project	A geophysical (magnetometer) survey covering 5.5 hectares was carried out on land that will be impacted by the construction of a replacement high pressure gas pipeline at Paull, East Yorkshire. The data is characterised by high levels of magnetic disturbance caused by pipes leading to/from the gas valve compound. Where the data is not effected by the pipes only anomalies indicative of geological variation are identified. No anomalies of archaeological potential have been recorded. On the basis of the survey, the archaeological potential of the site is considered to be low, confirming the conclusions of an earlier cultural heritage assessment.
Project dates	Start: 13-10-2014 End: 14-10-2014
Previous/future work	Not known / Not known
Any associated project reference codes	HPR14 - Sitecode
Any associated project reference codes	4300 - Contracting Unit No.
Type of project	Field evaluation
Site status	None
Current Land use	Cultivated Land 4 - Character Undetermined
Monument type	N/A None
Monument type	N/A None
Significant Finds	N/A None
Significant Finds	N/A None
Methods & techniques	"Geophysical Survey"
Development type	Service infrastructure (e.g. sewage works, reservoir, pumping station, etc.)
Prompt	National Planning Policy Framework - NPPF
Position in the planning process	Not known / Not recorded
Solid geology	Flamborough Chalk

(other)	
Drift geology (other)	Tidal Flat Deposits of clay and silt and a small band of Till (diamicton)
Techniques	Magnetometry

Project location

Country	England
Site location	EAST RIDING OF YORKSHIRE EAST RIDING OF YORKSHIRE PAULL Feeder No. 9, River Humber Pipeline Replacement Project
Study area	5.50 Hectares
Site coordinates	TA 1820 2540 53.7113790226 -0.208887686223 53 42 40 N 000 12 32 W Point

Project creators

Name of Organisation	Archaeological Services WYAS
Project brief originator	Archaeological Services WYAS
Project design originator	Archaeological Services WYAS
Project director/manager	Webb, A.
Project supervisor	Harrison, D.
Type of sponsor/funding body	Consultant

Project archives

Physical Archive Exists?	No
Digital Archive recipient	N/A
Digital Contents	"other"
Digital Media available	"Geophysics"
Paper Archive recipient	N/A
Paper Contents	"other"
Paper Media available	"Report"

Project bibliography 1

Publication type	Grey literature (unpublished document/manuscript)
Title	Feeder No. 9, River Humber Pipeline Replacement Project
Author(s)/Editor(s)	Harrison, S.
Other bibliographic	Report Number 2658

details	
Date	2014
Issuer or publisher	ASWYAS
Place of issue or publication	Morley
Description	A4 blue comb bound report
Entered by	Sam Harrison (sharrison@aswyas.com)
Entered on	3 November 2014

OASIS:

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