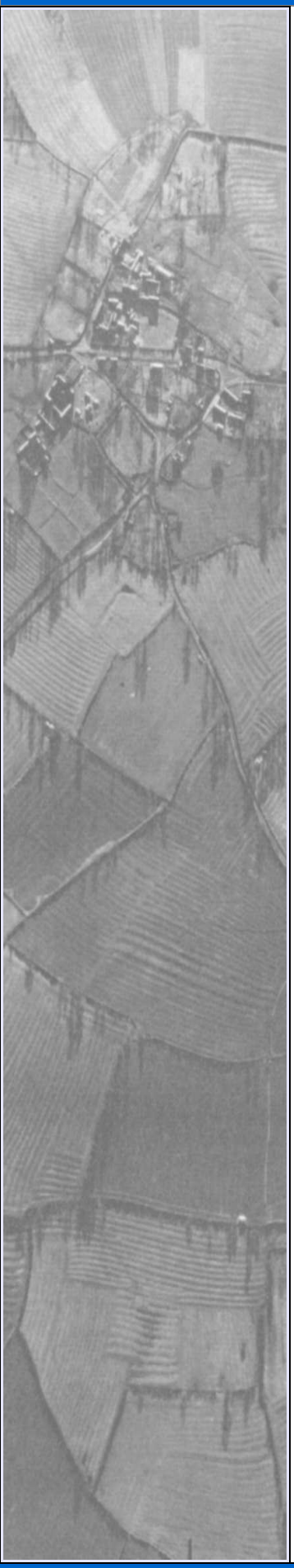

Bristol Airport
Site C
North Somerset

MAGNETOMETER SURVEY REPORT

for

Cotswold Archaeology

Kerry Donaldson & David Sabin

April 2016

Ref. no. 655

ARCHAEOLOGICAL SURVEYS LTD

Bristol Airport
Site C
North Somerset

Magnetometer Survey Report

for

Cotswold Archaeology

Fieldwork by David Sabin (Hons) MCIfA
Report by Kerry Donaldson BSc (Hons)
Report checked by David Sabin
Primary archive location - Archaeological Surveys Ltd, Yatesbury, Wiltshire

Survey dates – 11th & 12th April 2016
Ordnance Survey Grid Reference – **ST 499 647**

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SUMMARY

A magnetometer survey was carried out by Archaeological Surveys Ltd over the northern part of a pasture field to the south of Bristol Airport in North Somerset. The site has been outlined as a seasonal overflow carpark for the airport. There is evidence for the removal of topsoil and bedrock to at least a metre depth across much of the site, and the results of the magnetometry demonstrate that magnetically contaminated material has been incorporated into the reinstated topsoil. There are a group of positive rectilinear anomalies in the south-western part of the site that may have been partially truncated by quarrying. They may relate to ditch-like features associated with small enclosures. The site also contains a number of parallel linear anomalies, but it is not clear if these relate to cracks in the underlying limestone, or if they relate to cut features, or land drainage. In the north-eastern corner there are a number of positive linear and discrete anomalies, and again it is not possible to determine if they are natural or anthropogenic in origin.

1 INTRODUCTION

1.1 Survey background

1.1.1 Archaeological Surveys Ltd was commissioned by Cotswold Archaeology to undertake a magnetometer survey of an area of land to the south of Bristol Airport. The site has been outlined for a proposed development of a seasonal overflow carpark (known as Site C1 and Site C2) and the survey forms part of an archaeological assessment of the site.

1.1.2 The geophysical survey was carried out in accordance with a Written Scheme of Investigation (WSI) produced by Archaeological Surveys (2016).

1.2 Survey objectives and techniques

1.2.1 The objective of the survey was to use magnetometry to locate geophysical anomalies that may be archaeological in origin so that they may be assessed prior to development of the site. The methodology is considered an efficient and effective approach to archaeological prospection.

1.2.2 The survey and report generally follow the recommendations set out by: English Heritage (2008) *Geophysical survey in archaeological field evaluation;* and Institute for Archaeologists (2002) *The use of Geophysical Techniques in Archaeological Evaluations*. The work has been carried out to the Chartered Institute for Archaeologists (2014) *Standard and Guidance for Archaeological Geophysical Survey.*

1.3 Site location, description and survey conditions

1.3.1 The site is located on the southern edge of Bristol Airport, north east of Goblin Combe Farm within the parish of Wrington, North Somerset. It is centred on Ordnance Survey National Grid Reference (OS NGR) ST 49900 64740, see Figures 01 and 02.

1.3.2 The geophysical survey covers approximately 7.3ha within the northern part of a pasture field that contained cattle at the time of survey. The majority of the area is flat although the western side of the site slopes up gently towards the west. There is evidence for the field being quarried away along the northern and western edges (see Plate 1).

1.3.3 The ground conditions across the site were generally considered to be favourable for the collection of magnetometry data. Weather conditions during the survey were variable with periods of heavy rain.

Plate 1: Northern edge of site looking west

1.4 Site history and archaeological potential

1.4.1 The site does not contain any designated or undesignated heritage assets; however, there are several in the vicinity. Approximately 300m south of the survey area is a Neolithic chambered long barrow (Long barrow 350m south-west of Cornerpool Farm, scheduled monument no. 11008291/22819) and the site of a Neolithic flint axe recorded nearby on the Historic Environment Record (HER 662). A second scheduled long barrow on Redhill (no. 1108289/22820) is located 1km to the south and a Bronze Age barrow cemetery group is located at Redhill, 1km to the south-west (nos. 1011126/22831,1011127/22832, 1011128/22833 and 1011129/22834). Other

barrows are located on Felton Hill, including an oval barrow (no. 1008300/22812) and two confluent bowl barrows (no. 108361/22813), approximately 1.5km to the east.

1.4.2 A previous geophysical survey was undertaken by Archaeological Surveys in 2011 on land immediately to the east of the current survey area (Site U). The results show a number of positive linear anomalies, but they lacked a coherent morphology. A subsequent evaluation of these anomalies revealed that many were related to modern disturbance, agricultural activity and geological formations; however, a small number of undated linear ditches were also recorded (Cotswold Archaeology, 2011).

1.1.1 The survey area was sub-divided into a number of land parcels which have been removed during the 19th and 20th century. The Historic Landscape Characterisation of the site indicates that it lies within an area of medieval or earlier irregularly enclosed fields.

1.5 Geology and soils

1.5.1 The underlying solid geology across the site is Blackrock Limestone (Carboniferous) (BGS, 2016).

1.5.2 The site lies on the junction of two soil associations, Nordrach to the south, which is a typical paleo-argillic brown earth and consists of well drained, and shallow silty soils over limestone and Crwbin to the north, which is a brown ranker and consists of very shallow, well drained soils over limestone with rock exposures common (Soil Survey of England and Wales, 1983).

1.5.3 Magnetometry survey carried out across similar soils has produced good results; however, it is highly likely that the shallow geology will produce geophysical anomalies that can be difficult to distinguish from cut features with an anthropogenic origin. The underlying geology and soils are, however, considered acceptable for magnetic survey.

2 METHODOLOGY

2.1 Technical synopsis

2.1.1 Magnetometry survey records localised magnetic fields that can be associated with features formed by human activity. Magnetic susceptibility and magnetic thermoremnance are factors associated with the formation of localised fields. Additional details are set out below and within Appendix A.

2.1.2 Iron minerals within the soil may become altered by burning and the break down of biological material; effectively the magnetic susceptibility of the soil is increased, and the iron minerals become magnetic in the presence of the

Earth's magnetic field. Accumulations of magnetically enhanced soils within features, such as pits and ditches, may produce magnetic anomalies that can be mapped by magnetic prospection.

2.1.3 Magnetic thermoremnance can occur when ferrous minerals have been heated to high temperatures such as in a kiln, hearth, oven etc. On cooling, a permanent magnetisation may be acquired due to the presence of the Earth's magnetic field. Certain natural processes associated with the formation of some igneous and metamorphic rock may also result in magnetic thermoremnance.

2.1.4 The localised variations in magnetism are measured as sub-units of the Tesla, which is a SI unit of magnetic flux density. These sub-units are nano Teslas (nT), which are equivalent to 10^{-9} Tesla (T).

2.2 Equipment configuration, data collection and survey detail

2.2.1 The detailed magnetic survey was carried out using a SENSYS MAGNETO®MXPDA 5 channel cart-based system. The instrument has 5 fluxgate gradiometers spaced 0.5m apart with readings recorded at 20Hz. The gradiometers have a range of recording data between 0.1nT and 10,000nT. The sensors are not zeroed in the field, as the vertical axis alignment is fixed using a tension band system. In order to produce visible, useful greyscale images a zero median traverse process is undertaken in TerraSurveyor. The system is linked to a Leica GS10 RTK GPS with data recorded by SENSYS MAGNETO®MXPDA software on a rugged computer.

2.2.2 Data are collected along a series of parallel survey tracks wherever possible. The length of each track is variable and relates to the size of the survey area and other factors including ground conditions. A visual display aids accurate placing of tracks and their separation.

2.2.3 Data are not collected within fixed grids and data points are considered to be random even though the data are collected in a systematic manner covering all accessible areas (Aspinall, Gaffney and Schmidt, 2009).

2.3 Data processing and presentation

2.3.1 Magnetic data collected by the MAGNETO®MXPDA cart-based system are initially prepared using SENSYS MAGNETO®DLMGPS software. Survey tracks are analysed and georeferenced raw data (UTM Z30N) are then exported in ASCII format for further analysis and display using TerraSurveyor.

2.3.2 The data are collected between limits of ±10000nT and clipped for display at ±5nT. Data are interpolated to a resolution of effectively 0.5m between tracks and 0.15m along each survey track. A zero median traverse function is required in order to remove fixed offset values present within the sensors which do not undergo a zeroing procedure in the field. The approach ensures that the gradiometer sensors are very accurately aligned and fixed to the

vertical magnetic field and are not influenced by localised magnetic fields or disturbed by vibration. Although a zero median traverse algorithm can remove anomalies aligned with the survey tracks, in practice this rarely occurs due to the use of long traverses, high resolution measurement and variability within the magnetic susceptibility of long linear features.

2.3.3 Appendix C contains metadata concerning the survey and data attributes and is derived directly from TerraSurveyor. Reference should be made to Appendix B for further information on any processes, such as clipping, carried out on the data.

2.3.4 A TIF file is produced by TerraSurveyor software along with an associated world file (.TFW) that allows automatic georeferencing (OSGB36 datum) when using GIS or CAD software. The main form of data display used in the report is the minimally processed greyscale plot.

2.3.5 The raster images are combined with base mapping using ProgeCAD Professional 2014, creating DWG (2010) file formats. All images are externally referenced to the CAD drawing in order to maintain good graphical quality. The CAD plots are effectively georeferenced facilitating relocation of features using GPS, resection method, etc.

2.3.6 An abstraction and interpretation is also drawn and plotted for all geophysical anomalies located by the survey. Anomalies are abstracted using colour coded points, lines and polygons. All plots are scaled to landscape A3 for paper printing.

2.3.7 A brief summary of each anomaly, with an appropriate reference number, is set out in list form within the results (Section 3) to allow a rapid and objective assessment of features within the area.

2.3.8 A digital archive is produced with this report, see Appendix D below. The main archive is held at the offices of Archaeological Surveys Ltd.

3 RESULTS

3.1 General assessment of survey results

3.1.1 The detailed magnetic survey was carried out within the northern part of a single pasture field covering approximately 7.3ha.

3.1.2 Magnetic anomalies located can be generally classified as positive anomalies of an uncertain origin, linear anomalies of an agricultural origin, areas of magnetic debris and disturbance and strong discrete dipolar anomalies relating to ferrous objects. Anomalies located within each survey area have been numbered and are described in 3.4 below.

3.2 Statement of data quality

3.2.1 Data are considered representative of the magnetic anomalies present within the site. There are no significant defects within the dataset. Magnetic disturbance along the northern edge of the survey area is related to ferrous objects within the airport. It is unlikely to obscure more significant anomalies of archaeological potential.

3.3 Data interpretation

3.3.1 The list of sub-headings below attempts to define a number of separate categories that reflect the range and type of features located during the survey. A basic explanation of the characteristics of the magnetic anomalies is set out for each category in order to justify interpretation, a basic key is indicated to allow cross referencing to the abstraction and interpretation plot. CAD layer names are included to aid reference to associated digital files (.dwg/.dxf). Sub-headings are then used to group anomalies with similar characteristics within the survey area.

Report sub-heading CAD layer names and plot colour	**Description and origin of anomalies**
Anomalies with an uncertain origin AS-ABST MAG POS LINEAR UNCERTAIN AS-ABST MAG POS DISCRETE UNCERTAIN	The category applies to a range of anomalies where there is not enough evidence to confidently suggest an origin. Anomalies in this category may well be related to archaeologically significant features, but equally relatively modern features, geological/pedological features and agricultural features should be considered. Positive anomalies are indicative of magnetically enhanced soils that may form the fill of 'cut' features or may be produced by accumulation within layers or 'earthwork' features; soils subject to burning may also produce positive anomalies. Negative anomalies are produced by material of comparatively low magnetic susceptibility such as stone and subsoil.
Anomalies with an agricultural origin AS-ABST MAG AGRICULTURAL	The anomalies are often linear and form a series of parallel responses or are parallel to extant land boundaries. They can relate to agricultural vehicle tracks within the field.
Anomalies associated with magnetic debris AS-ABST MAG DEBRIS AS-ABST MAG STRONG DIPOLAR	Magnetic debris often appears as areas containing many small dipolar anomalies that may range from weak to very strong in magnitude. It often occurs where there has been dumping or ground make-up and is related to magnetically thermoremnant materials such as brick or tile or other small fragments of ferrous material. This type of response is occasionally associated with kilns, furnace structures, or hearths and may therefore be archaeologically significant. It is also possible that the response may be caused by natural material such as certain gravels and fragments of igneous or metamorphic rock. Strong discrete dipolar anomalies are responses to ferrous objects within the topsoil.
Anomalies with a modern origin AS-ABST MAG DISTURBANCE	The magnetic response is often strong and dipolar indicative of ferrous material and may be associated with extant above surface features such as wire fencing, cables, pylons etc.. Often a significant area around such features has a strong magnetic flux which may create magnetic disturbance; such disturbance can effectively obscure low magnitude anomalies if they are present. Fluxgate sensors may respond erratically and with hysteresis adjacent to strong magnetic sources.

Table 1: List and description of interpretation categories

3.4 List of anomalies

Area centred on OS NGR 349900 164740, see Figs 03 - 08.

Anomalies with an uncertain origin

(1) - Located close to the south-western corner of the site are a number of rectilinear anomalies. It is possible that they have been truncated during the removal of material to the north and their morphology may indicate that they relate to cut features.

(2) - A group of discrete positive responses are located to the north-west of anomalies (1). It is possible that they relate to naturally formed pit-like features.

(3) - Located primarily in the centre and eastern part of the survey area are a series of parallel positive linear anomalies, oriented north-north-west to south-south-east. It is possible that they relate to cracks within the underlying geology; however, their regular and parallel appearance may indicate cut, linear ditches, or land drainage. Their origin is, therefore, uncertain.

(4) - In the north-eastern part of the survey area are a number of positive linear and discrete responses. They may relate to natural features within the underlying geology, but cut features cannot be completely ruled out.

Anomalies with an agricultural origin

(5) - Negative linear anomalies associated with vehicle tracks/ruts.

Anomalies associated with magnetic debris

(6) - The site contains widespread magnetic debris, with only the most concentrated areas abstracted. This indicates that magnetically contaminated material has been spread across the site.

(7) - Very widespread and numerous strong, discrete, dipolar anomalies are responses to ferrous and magnetically thermoremnant objects within the topsoil. Only the largest and strongest have been abstracted as the entire site is covered with them.

Anomalies with a modern origin

(8) - Magnetic disturbance from steel fencing surrounding the northern and western edges of the site.

4 CONCLUSION

4.1.1 The magnetometer survey indicates that widespread ferrous and magnetically thermoremnant material has been spread across the entire site. There is evidence that at least a metre of topsoil and bedrock has been removed from the site, most clearly seen at the northern and western edges. The magnetic material may have been spread across the field during the reinstatement of topsoil.

4.1.2 There are a number of positive linear and discrete anomalies within the site, with a series oriented north-north-west to south-south-east. While these may relate to cracks in the underlying limestone, cut features or land drains should also be considered.

4.1.3 In the south-western corner of the survey area a number of positive rectilinear anomalies may have been partly truncated during quarrying to the north. It is possible that these relate to ditch-like features associated with small enclosures.

5 REFERENCES

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Cotswold Archaeology, 2011. *Site U Bristol Airport Development, Broadfield Down, North Somerset: Archaeological Evaluation,* CA Report No. 11118.

English Heritage, 2008. *Geophysical survey in archaeological field evaluation. Research and Professional Service Guideline No.1.* 2nd ed. Swindon: English Heritage.

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Appendix A – basic principles of magnetic survey

Iron minerals are always present to some degree within the topsoil and enhancement associated with human activity is related to increases in the level of magnetic susceptibility and thermoremnant material.

Magnetic susceptibility is an induced magnetism within a material when it is in the presence of a magnetic field. This can be thought of as effectively permanent due to the presence of the Earth's magnetic field.

Thermoremnant magnetism occurs when ferrous material is heated beyond a specific temperature known as the Curie Point. Demagnetisation occurs at this temperature with re-magnetisation by the Earth's magnetic field upon cooling.

Enhancement of magnetic susceptibility can occur in areas subject to burning and complex fermentation processes on biological material; these are frequently associated with human settlement. Thermoremnant features include ovens, hearths, and kilns. In addition thermoremnant material such as tile and brick may also be associated with human activity and settlement.

Silting and deliberate infilling of ditches and pits with magnetically enhanced soil can create an area of enhancement compared with surrounding soils and subsoils into which the feature is cut. Mapping enhanced areas will produce linear and discrete anomalies allowing an assessment and characterisation of hidden subsurface features.

It should be noted that areas of negative enhancement can be produced from material having lower magnetic properties compared to the topsoil. This is common for many sedimentary bedrocks and subsoils which were often used in the construction of banks and walls etc. Mapping these 'negative' anomalies may also reveal archaeological features.

Magnetic survey or magnetometry can be carried out using a fluxgate gradiometer and may be referred to as gradiometry. The SENSYS gradiometer is a passive instrument consisting of two fluxgate sensors mounted vertically 65cm apart. The instrument is carried about 10-20cm above the ground surface and the upper sensor measures the Earth's magnetic field as does the lower sensor but this is influenced to a greater degree by any localised buried field. The difference between the two sensors will relate to the strength the magnetic field created by the buried feature.

There are a number of factors that may affect the magnetic survey and these include soil type, local geology and previous human activity. Situations arise where magnetic disturbance associated with modern services, metal fencing, dumped waste material etc., obscures low magnitude fields associated with archaeological features.

Appendix B – data processing notes

Clipping

Minimum and maximum values are set and replace data outside of the range with those values. Extreme values are removed improving colour or greyscale contrast associated with data values that may be archaeologically significant. It has been found that clipping data to ranges between ±5nT and ±3nT often improves the appearance of features associated with archaeology. Different ranges are applied to data in order to determine the most suitable for anomaly abstraction and display.

Zero (destripe) Median/Mean Traverse

The median (or mean) of each traverse is calculated ignoring data outside a threshold value, the median (or mean) is then subtracted from the traverse. The process is used to equalise differences between the baseline value of gradiometer sensors.

High Pass Filtering

A mathematical process used to remove low frequency anomalies relating to survey tracks and modern agricultural features.

Appendix C – survey and data information

COMPOSITE
Filename: J655-mag-proc.xcp
Description: Imported as Composite from: J655-mag.asc
Instrument Type: Sensys DLMGPS
Units: nT
UTM Zone: 30U
Survey corner coordinates (X/Y): OSGB36
Northwest corner: 349645.826959653, 164837.434996941 m
Southeast corner: 350162.726959653, 164614.834996941 m
Collection Method: Randomised
Sensors: 5
Dummy Value: 32702

Source GPS Points: 2374600

Dimensions
Composite Size (readings): 3446 x 1484
Survey Size (meters): 517 m x 223 m
Grid Size: 517 m x 223 m
X Interval: 0.15 m
Y Interval: 0.15 m

Stats
Max: 5.00
Min: -5.00
Std Dev: 1.65
Mean: 0.04
Median: 0.01
Composite Area: 11.506 ha
Surveyed Area: 7.2954 ha

PROGRAM
Name: TerraSurveyor
Version: 3.0.23.0

Processes: 2
1 Base Layer
2 Clip from -5.00 to 5.00 nT

GPS based Proce4
1 Base Layer.
2 Unit Conversion Layer (Lat/Long to OSGB36).
3 DeStripe Median Traverse:
4 Clip from -5.00 to 5.00

Appendix D – digital archive

Archaeological Surveys Ltd hold the primary digital archive at their offices in Wiltshire. Data are backed-up onto an on-site data storage drive and at the earliest opportunity data are copied to CD ROM for storage on-site and off-site.

A PDF copy will be supplied to the North Somerset Historic Environment Record with printed copies on request. The report will also be uploaded to the Online AccesS to the Index of archaeological investigationS (OASIS).

Archive contents:

Geophysical data - path: J655 Bristol Airport\Data				
Path and Filename	**Software**	**Description**	**Date**	**Creator**
bristair1\MX\ .prm .dgb .disp	Sensys MXPDA	Proprietary data formats representing magnetometer survey traverses logged to a PDA.	11/04/16	D.J.Sabin
bristair1\MX\J655-mag.asc	Sensys DLMGPS	ASCII CSV (tab) file representing survey Area 1 in eastings, northings (UTM Z30N), magnetic measurement, traverse file and sensor number.	13/04/16	D.J.Sabin
Mag\comps\J655-mag.xcp	TerraSurveyor 3.0.23.0	Composite data file derived from ASCII CSV.	13/04/16	D.J.Sabin
Mag\comps\J655-mag-proc.xcp	TerraSurveyor 3.0.23.0	Processed composite data file (zmt and clipping to ±5nT).	13/04/16	D.J.Sabin
Graphic data - path: J655 Bristol Airport\Data				
Mag\graphics\ J655-mag-proc.tif	TerraSurveyor 3.0.23.0	TIF file showing a minimally processed greyscale plot clipped to ±5nT.	13/04/16	K.T.Donaldson
Mag\graphics\ J655-mag-proc.tfw	TerraSurveyor 3.0.23.0	World file for georeferencing TIF to OSGB36.	13/04/16	K.T.Donaldson
CAD data - path: J655 Bristol Airport\CAD				
J655 version 1.dwg	ProgeCAD 2016	CAD file for creating plots of greyscales, abstraction, interpretation and mapping. Grid coordinates as OSGB. AutoCAD 2010 format.	08/04/16	K.T.Donaldson
Text data - path: J655 Bristol Airport\Documentation				
J655 report.odt	OpenOffice.org 3.0.1 Writer	Report text as an Open Office document.	12/04/16	K.T.Donaldson

Appendix E – copyright and intellectual property

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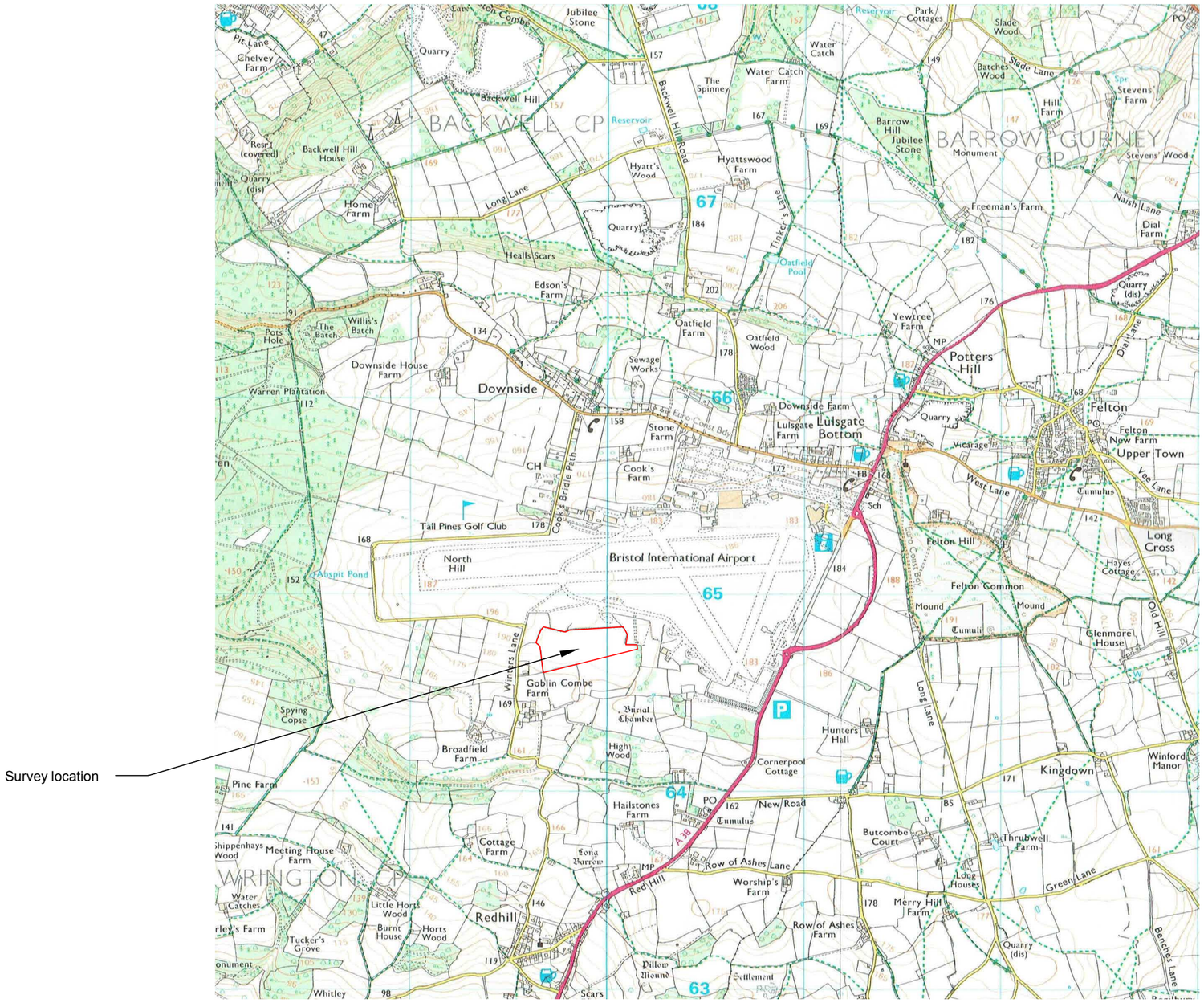


Survey location

Archaeological Surveys Ltd

Geophysical Survey
Bristol Airport
Site C
North Somerset

Map of survey area

Survey location

Site centred on OS NGR
ST 49900 64740

SCALE 1:25 000

0m 500m 1000m

SCALE TRUE AT A3

FIG 01

Archaeological Surveys Ltd

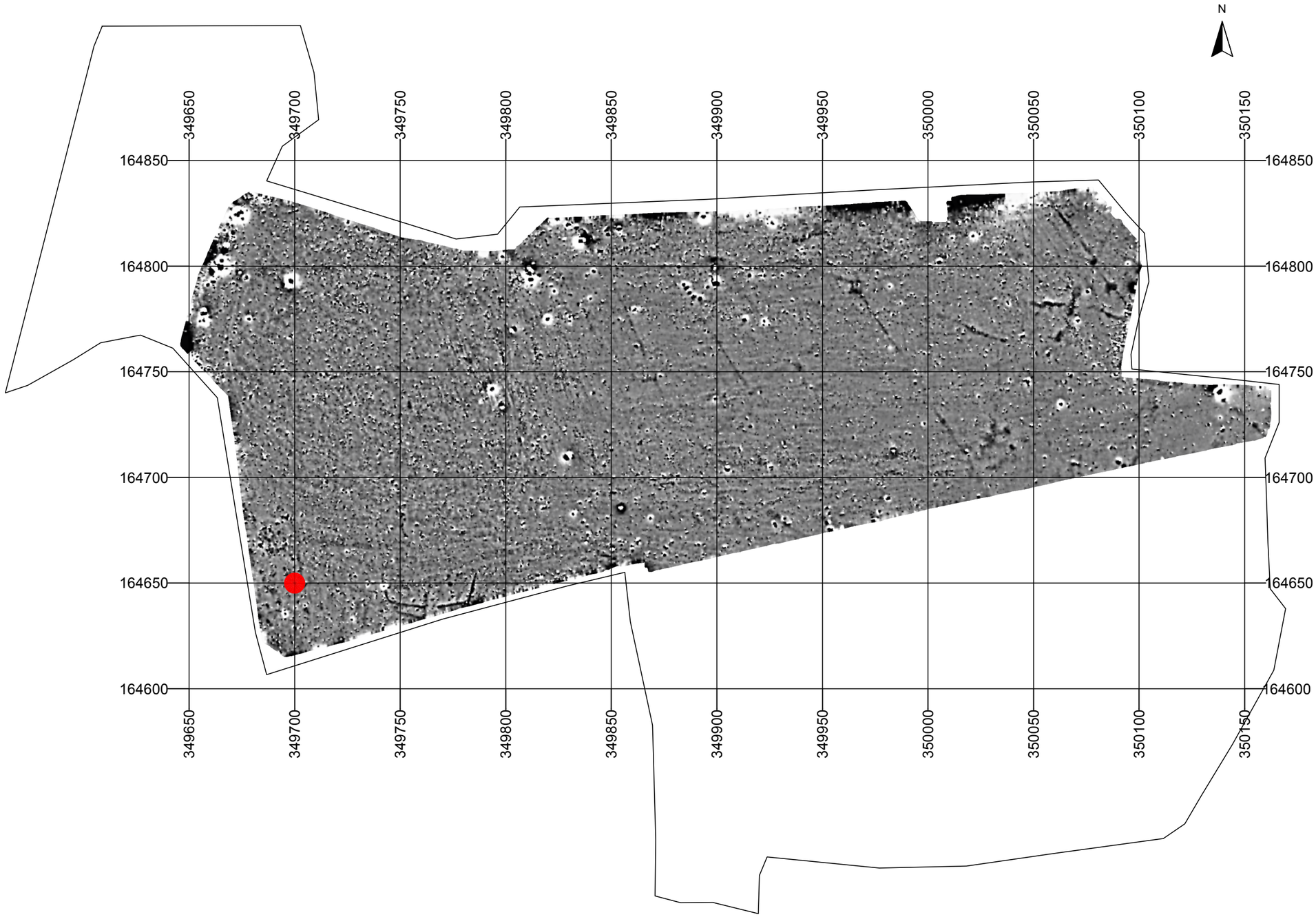
Geophysical Survey
Bristol Airport
Site C
North Somerset

Referencing information

Referencing grid to OSGB36 datum at 50m intervals

Data collected at 20Hz and georeferenced to ETRS89 zone 30 with conversion to OSGB36 using OSTN02

● 349700 164650



SCALE 1:2000

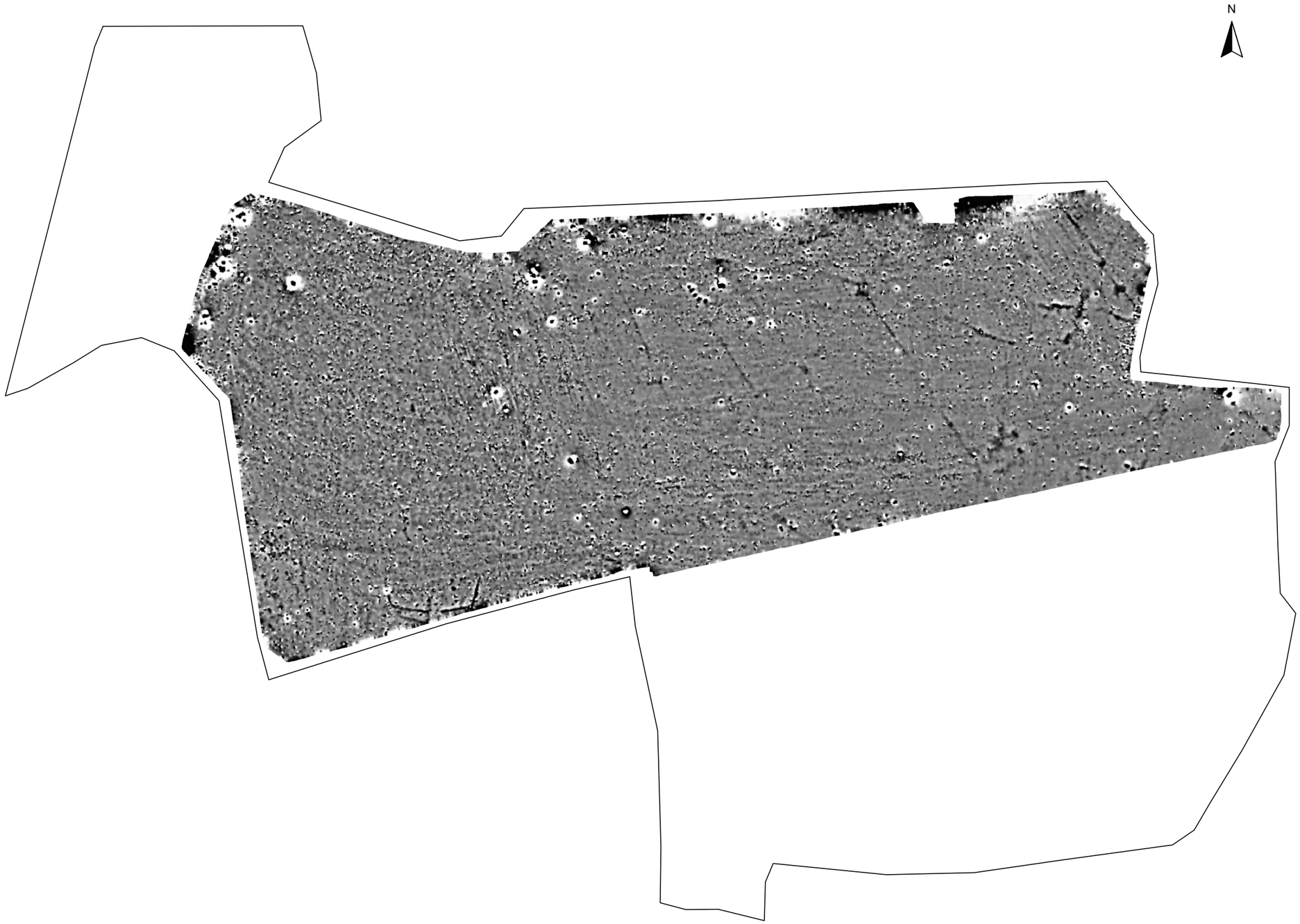
0m 20 40 60 80 100m

SCALE TRUE AT A3

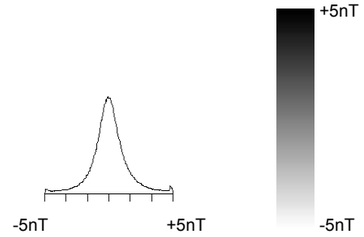
FIG 02

Archaeological Surveys Ltd

Geophysical Survey
Bristol Airport
Site C
North Somerset



Greyscale plot of minimally processed magnetometer data



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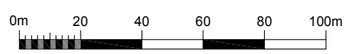


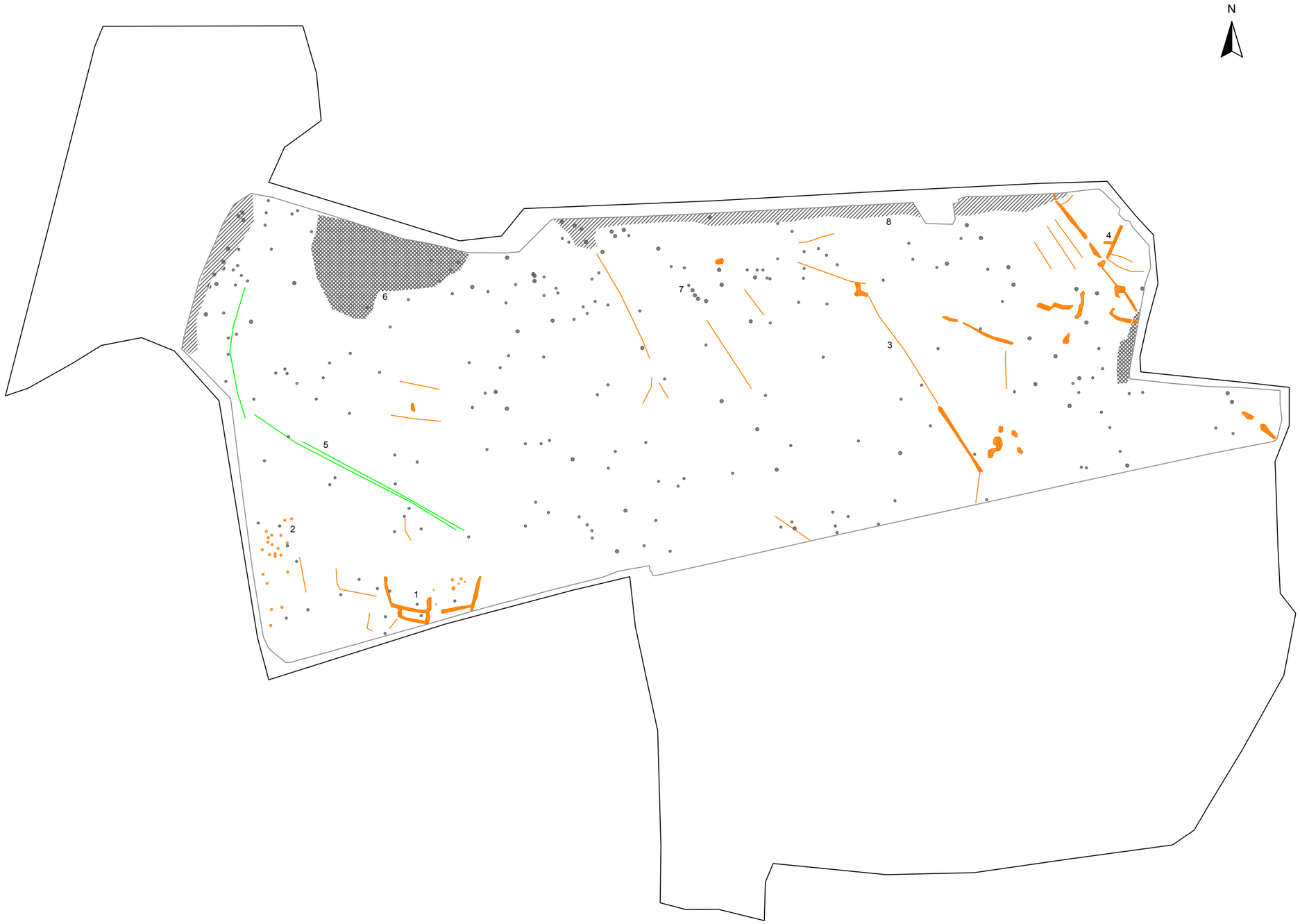
SCALE TRUE AT A3

FIG 03

Archaeological Surveys Ltd

Geophysical Survey
Bristol Airport
Site C
North Somerset

Abstraction and interpretation of magnetometer anomalies



- Positive linear anomaly - possible ditch-like feature
- Linear anomaly - of agricultural origin
- Discrete positive response - possible pit-like feature
- Magnetic debris - spread of magnetically thermoremnant/ferrous material
- Magnetic disturbance from ferrous material
- Strong dipolar anomaly - ferrous object

SCALE 1:2000

0m 10 20 30 40 50m

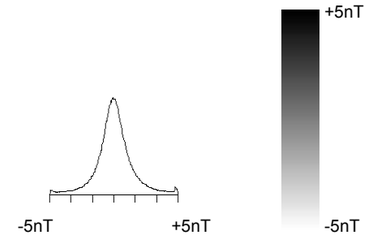
SCALE TRUE AT A3

FIG 04

Archaeological Surveys Ltd

Geophysical Survey
Bristol Airport
Site C
North Somerset

Greyscale plot of minimally processed magnetometer data - western half



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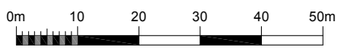

SCALE TRUE AT A3

FIG 05

Archaeological Surveys Ltd

Geophysical Survey
Bristol Airport
Site C
North Somerset

Abstraction and interpretation of magnetometer anomalies - western half

- Positive linear anomaly - possible ditch-like feature
- Linear anomaly - of agricultural origin
- Discrete positive response - possible pit-like feature
- Magnetic debris - spread of magnetically thermoremnant/ferrous material
- Magnetic disturbance from ferrous material
- Strong dipolar anomaly - ferrous object

SCALE 1:1000

0m 10 20 30 40 50m

SCALE TRUE AT A3

FIG 06

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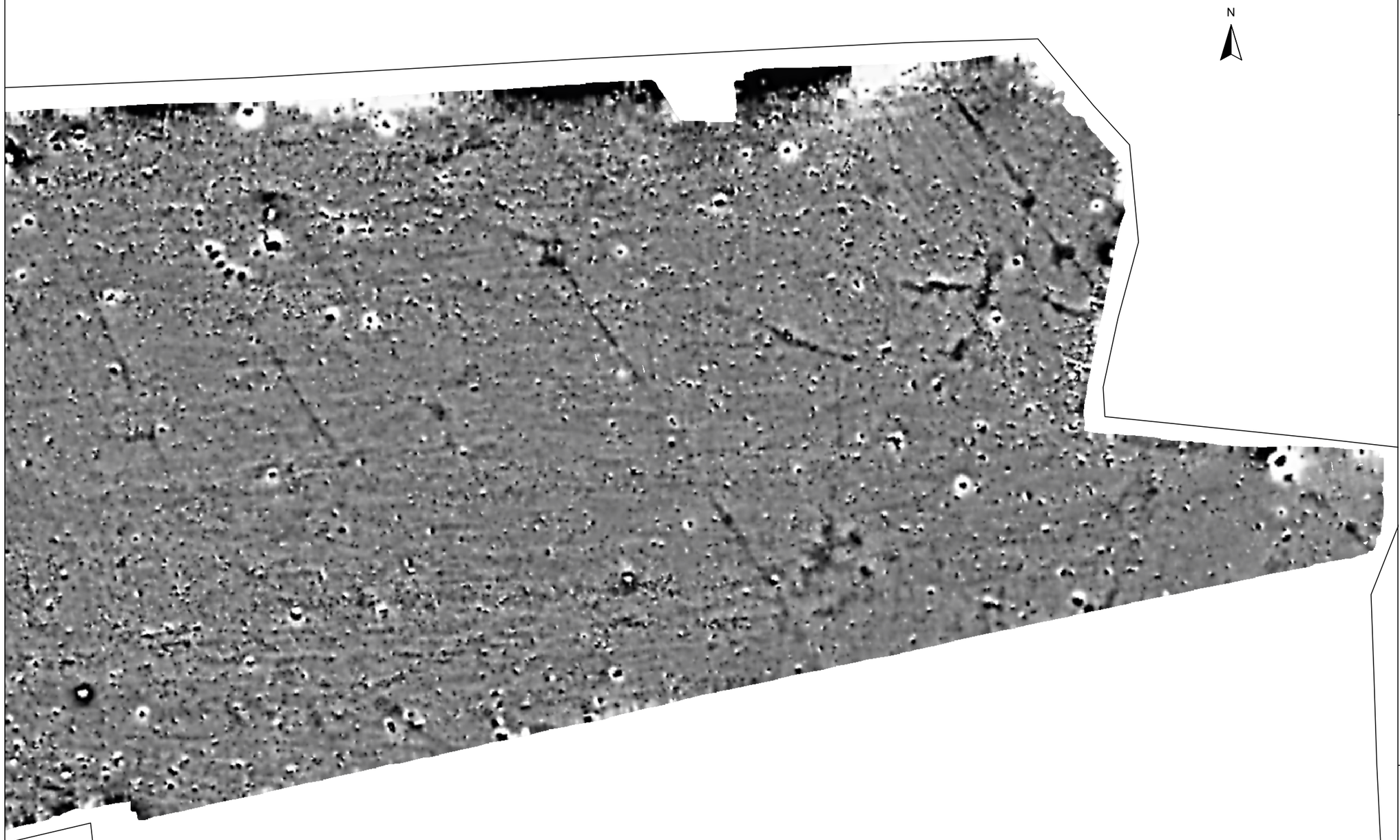
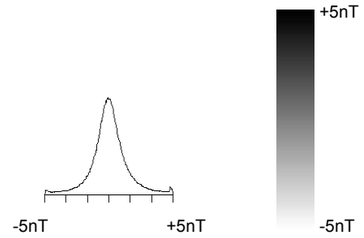
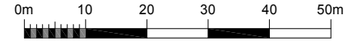
Site C
North Somerset



Greyscale plot of minimally processed magnetometer data - eastern half



SCALE 1:1000



SCALE TRUE AT A3

FIG 07

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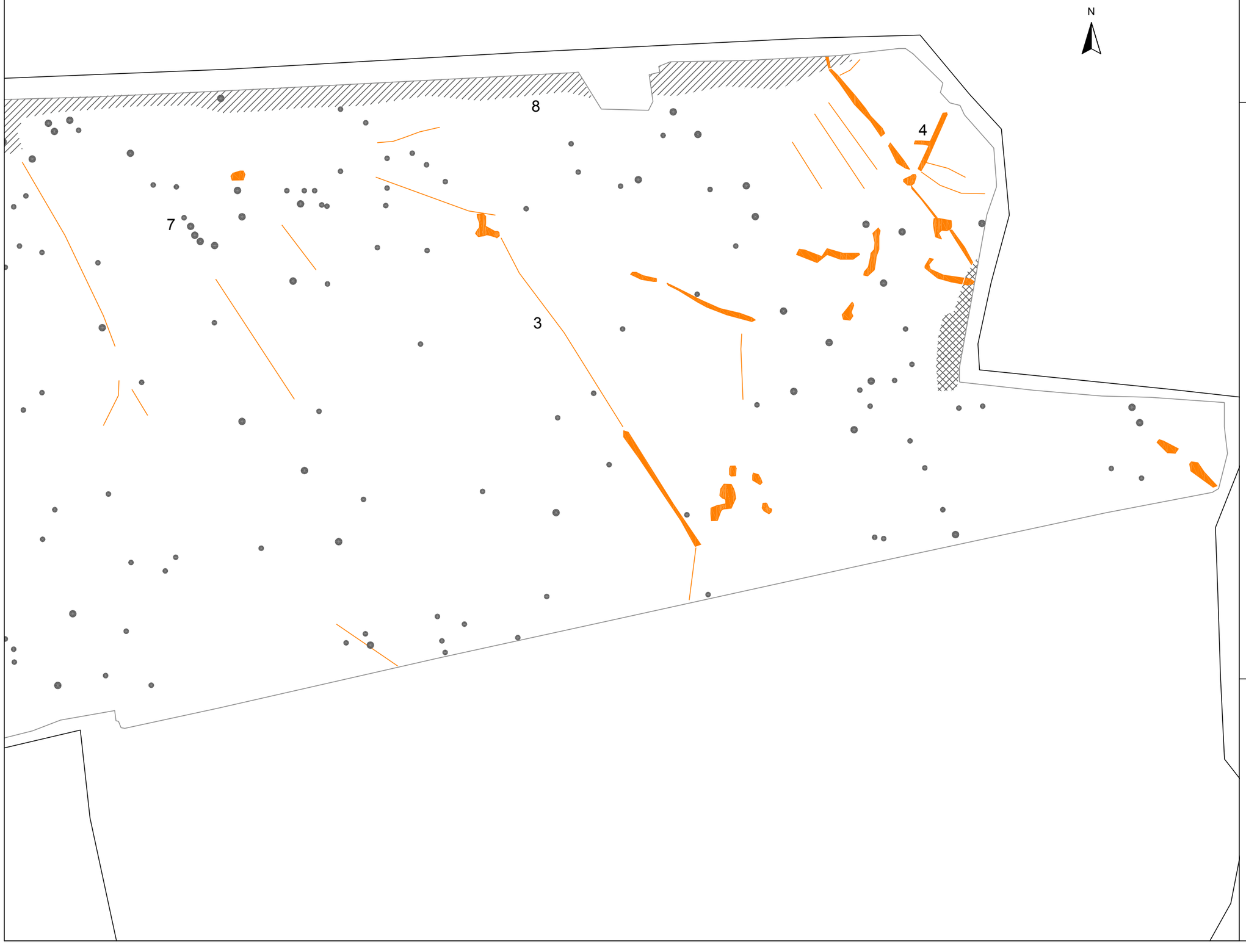
Bristol Airport
Site C
North Somerset

Abstraction and interpretation of magnetometer anomalies - eastern half



- Positive linear anomaly - possible ditch-like feature
- Linear anomaly - of agricultural origin
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- Magnetic debris - spread of magnetically thermoremnant/ferrous material
- Magnetic disturbance from ferrous material
- Strong dipolar anomaly - ferrous object

SCALE 1:1000

0m 10 20 30 40 50m

SCALE TRUE AT A3

FIG 08