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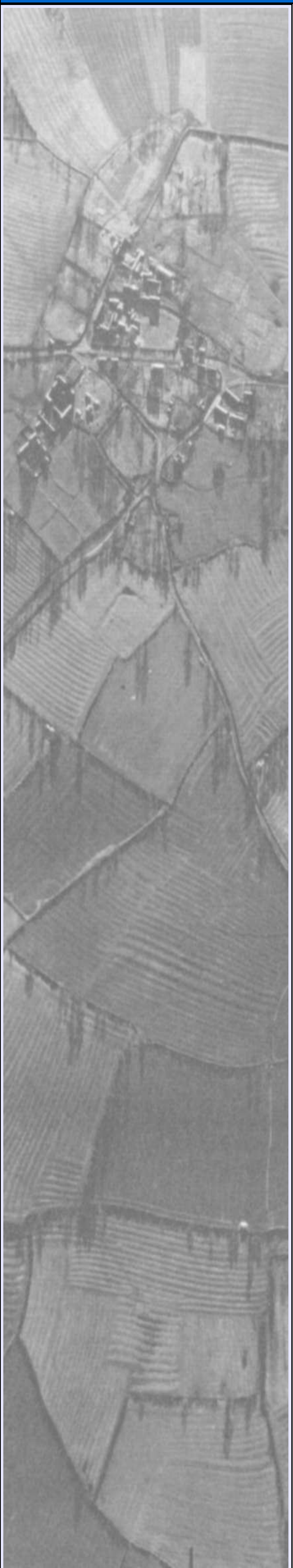

Treswarrow Farm
St Endellion
Cornwall
(Additional Survey)

MAGNETOMETER SURVEY REPORT

for

Mr & Mrs R Jones

David Sabin and Kerry Donaldson

January 2013

Ref. no. 454

ARCHAEOLOGICAL SURVEYS LTD

Treswarrow Farm
St Endellion
Cornwall
(Additional Survey)

Magnetometer Survey Report

for

Mr & Mrs R Jones

Fieldwork by David Sabin
Report by David Sabin BSc (Hons) MIFA and Kerry Donaldson BSc (Hons)

Survey dates – 7th & 8th January 2013
Ordnance Survey Grid Reference – **SW 98445 78050**

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SUMMARY

A detailed magnetometer survey was carried out over 5ha at Treswarrow Farm near St Endellion in Cornwall, as part of an HLS agreement between Natural England and the landowners. A previous geophysical survey, carried out by Archaeological Surveys in 2011 on land immediately to the south, located a number of former field boundaries, enclosures and ring ditches indicative of prehistoric settlement. The current survey revealed a continuation of several of the boundary ditches to the north forming a rectilinear enclosure with dimensions of 110m by 80m. One of the boundary ditches extends for at least 270m and there is some evidence for fossilisation within the current field boundary layout. Numerous other positive linear, rectilinear, curvilinear and discrete anomalies were located throughout the survey areas; however, due to their weak or fragmented nature and lack of coherent morphology they cannot be confidently interpreted. The underlying Polzeath Slate is likely to have formed many geophysical anomalies, which appear ditch-like and pit-like in form.

1 INTRODUCTION

1.1 Survey background

1.1.1 Archaeological Surveys Ltd was commissioned by Mr & Mrs Jones of Treswarrow Farm, near St Endellion to undertake a magnetometer survey of an area of land at the farm. Treswarrow Farm has entered into a Higher Level Stewardship (HLS) agreement with Natural England. The geophysical survey has been carried out within three fields as a condition of the HLS agreement.

1.1.2 A previous geophysical survey was carried out within four fields immediately to the south of the survey area ahead of a potential solar farm development (Archaeological Surveys, 2011). This survey revealed widespread archaeological features including evidence for several phases of land division and a group of ring ditches, which may indicate prehistoric settlement.

1.1.3 The survey was carried out in accordance to a brief for a geophysical survey at the site issued by Cornwall Historic Environment Service.

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 Institute for Archaeologists (2011) *Standard and Guidance for Archaeological Geophysical Survey.*

1.3 Site location, description and survey conditions

1.3.1 The site is located at Treswarrow Farm in the parish of St Endellion and lies less than 3km to the south west of Port Issac in Cornwall, see Figures 01 and 02. The central OS Grid Reference is SW 98445 78050.

1.3.2 The geophysical survey covers approximately 5ha within three fields (Areas 1, 2 and 3) and a smaller enclosure (Area 2a). The fields generally slope down towards the south and are utilised for grazing.

1.3.3 The ground conditions across the site were generally considered to be favourable for the collection of magnetometry data. The land surface was saturated due to exceptionally high levels of rainfall in 2012 and parts of the site were boggy and waterlogged. Weather conditions during the survey were initially fine with rain on the second day of fieldwork.

1.4 Site history and archaeological potential

1.4.1 The previous detailed magnetometer survey undertaken by Archaeological Surveys in 2011 located at least three possible phases of land division immediately to the south of the site. This is indicated by two different orientations of linear and rectilinear boundary ditches and enclosures, and a subsequent phase of construction, and then removal, of Cornish Hedges. The survey also located at least five ring ditches with diameters of between 9m and 15m, some of which contain geophysical evidence for internal pits or areas of burning. Many of the archaeological features had been disturbed by the construction of Cornish Hedges. The site contained evidence of widespread pit-like and ditch-like anomalies, possibly indicating further cut features; however, due to underlying naturally formed anomalies and a lack of coherent morphology, these were not readily characterised as archaeology.

1.4.2 The close proximity of the additional survey area to the archaeological features discovered by the previous magnetometry survey would tend to indicate a high potential to locate further archaeology. It is likely that some of the boundary ditches previously identified extend north eastwards into the additional survey area.

1.5 Geology and soils

1.5.1 The underlying solid geology across the site is from the Polzeath Slate Formation, mudstone, siltstone and sandstone (BGS 2011).

1.5.2 The overlying soil across the survey area is from the Powys association, which is a brown ranker. It consists of a shallow, well drained, loamy soil over rock (Soil Survey of England and Wales, 1983).

1.5.3 The geological and pedological conditions are considered suitable for magnetometry. The potential for natural anomalies, caused by shallow rock formations, is considered to be high and often these can be difficult to distinguish from cut features with an anthropogenic origin.

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 Bartington Grad 601-2 gradiometers. The instruments effectively measure a magnetic gradient between two fluxgate sensors mounted vertically 1m apart. Two sets of sensors are mounted on a single frame 1m apart horizontally.

2.2.2 The instruments are extremely sensitive and are able to measure magnetic variation to 0.01nanoTesla (nT), with an effective resolution of 0.03nT. The data are limited to ±100nT when surveying with the highest sensitivity. All readings are saved to an integral data logger for analysis and presentation.

2.2.3 The instruments are operated according to the manufacturer's instructions with consideration given to the local conditions. An adjustment procedure is required, prior to collection of data, in order to balance the sensors and remove the effects of the Earth's magnetic field; further adjustment is required during the survey due to instrument drift often associated with temperature change.

2.2.4 It can be very difficult to obtain optimum balance for the sensors due to localised magnetic vectors that may be associated with large ferrous objects, geological/pedological features, 'magnetic debris' within the topsoil and natural temperature fluctuations. Imperfect balance results in a heading error often visible as striping within the data; this can be effectively removed by software processing and generally has little effect on the data unless extreme.

2.2.5 The Bartington gradiometers undergo regular servicing and calibration by the manufacturer. A current assessment of the instruments is shown in Table 1 below.

Sensor type and serial numbers	Bartington Grad - 01 – 1000 Nos. 084, 085, 242 and 396
Date of certified calibration/service	Sensors 084 and 085 - 17th August 2012 (due Aug 2014) Sensors 242 and 396 - 14th October 2011 (due Oct 2013)
Bandwidth	12Hz (100nT range) both sensors
Noise	<100pT peak to peak
Adjustable errors	<2nT

Table 1: Bartington fluxgate gradiometer sensor calibration results

The instruments were considered to be in good working order prior to the survey, with no known faults or defects.

2.2.6 Data were collected at 0.25m centres along traverses 1m apart. The survey area was separated into 30m by 30m grids (900m²) giving 3600 recorded measurements per grid. This sampling interval is very effective at locating archaeological features and is the recommended methodology for archaeological prospection (English Heritage, 2008).

2.2.7 The survey grids were set out to the Ordnance Survey OSGB36 datum using a Penmap RTK GPS. The GPS is used in conjunction with Leica's SmartNet service, where positional corrections are sent via a mobile telephone link. Positional accuracy of around 10 – 20mm is possible using the system. The instrument is regularly checked against the ETRS89 reference framework using Ordnance Survey ground marker C1ST7784 (Horton).

2.2.8 The fixed orientation of survey grids based on the OSGB36 datum was considered appropriate given that the orientation of land boundaries was variable and consequently partial survey grids were unavoidable. A fixed grid across the site also simplifies its relocation should that be required.

2.3 Data processing and presentation

2.3.1 Magnetometry data downloaded from the Grad 601-2 data logger are analysed and processed in specialist software known as ArcheoSurveyor. The software allows greyscale and trace plots to be produced for presentation and display. Survey grids are assembled to form an overall composite of data (composite file) creating a dataset of the complete survey area. Appendix C contains specific information concerning the survey and data attributes and is derived directly from ArcheoSurveyor; this should be used in conjunction with information provided by Figure 02.

2.3.2 Only minimal processing is carried out in order to enhance the results of the survey for display. Raw data are always analysed, as processing can modify anomalies. The following schedule sets out the data and image processing used in this survey:

- clipping of the raw data at ±30nT to improve greyscale resolution,
- clipping of processed data at ±5nT to enhance low magnitude anomalies,
- de-stagger is used to enhance linear anomalies,
- zero median/mean traverse is applied in order to balance readings along each traverse.

Reference should be made to Appendix B for further information on the specific processes carried out on the data. Appendix C metadata includes details on the processing sequence used for each survey area.

2.3.3 An abstraction and interpretation is offered for all geophysical anomalies located by the survey. 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 each survey area. Where further interpretation is possible, or where a number of possible origins should be considered, more subjective discussion is set out in Section 4.

2.3.4 The main form of data display prepared for this report is the greyscale plot. Both 'raw' and 'processed' data have been shown followed by an abstraction and interpretation plot. Anomalies are abstracted using colour coded points, lines and polygons. All plots are scaled to landscape A3 for paper printing.

2.3.5 Graphic raster images in bitmap format (.BMP) are initially prepared in ArcheoSurveyor. Regardless of survey orientation, data captured along each traverse are displayed and processed by ArcheoSurveyor from left to right; this corresponds to a direction of west to east in the field.

2.3.6 The raster images are combined with base mapping using ProgeCAD Professional 2009 and AutoCAD LT 2007, creating DWG file formats. All images are externally referenced to the CAD drawing in order to maintain good graphical quality.

2.3.7 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 over a total of three survey areas covering approximately 5ha.

3.1.2 Magnetic anomalies located can be generally classified as positive linear anomalies of archaeological potential, positive and negative anomalies of an uncertain origin, anomalies associated with land management, linear anomalies of an agricultural origin, areas of magnetic debris and disturbance and strong discrete dipolar anomalies relating to ferrous objects.

3.1.3 Anomalies located within each survey area have been numbered and are described below with subsequent discussion in Section 4.

3.2 Statement of data quality

3.2.1 Data are considered representative of the magnetic anomalies present within the site. No significant defects are present within the dataset. Some minor positional adjustment was carried out across a small number of survey grids and this is likely to relate to poor surface conditions. The data are clearly influenced by the underlying geology.

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 for each survey area.

Report sub-heading CAD layer names and plot colour	**Description and origin of anomalies**
Anomalies with archaeological potential AS-ABST MAG POS LINEAR ARCHAEOLOGY	Anomalies have the characteristics (mainly morphological) of a range of archaeological features such as pits, ring ditches, enclosures, etc..
Anomalies with an uncertain origin AS-ABST MAG POS LINEAR UNCERTAIN AS-ABST MAG NEG LINEAR UNCERTAIN AS-ABST MAG POS DISCRETE UNCERTAIN AS-ABST MAG POS AREA 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

AS-ABST MAG NEG AREA UNCERTAIN	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 relating to land management AS-ABST MAG BOUNDARY	Anomalies are mainly linear and may be indicative of the magnetically enhanced fill of cut features (i.e. ditches). The anomalies may be long and/or form rectilinear elements and they may relate to topographic features or be visible on early mapping. Cornish Hedges have distinctive characteristics of a negative linear anomaly, flanked by two positive linear anomalies.
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. Where the response is broad, former ridge and furrow is likely; narrow response is often related to modern ploughing.
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 2: List and description of interpretation categories

3.4 List of anomalies - Area 1

Area centred on OS NGR 198355 77985, see Figures 04 & 05.

Anomalies of archaeological potential

(1) – A positive linear anomaly, associated with anomalies (2) and (3), relates to a former boundary ditch. It appears to underlie a removed Cornish hedge and extends north eastwards from a similar anomaly located to the south west in the previous survey.

(2) – A positive linear anomaly of similar strength (>30nT) to anomalies (1) and (3). The feature is likely to form the northern side of a rectilinear enclosure.

(3) – A positive linear anomaly extends north eastwards and is a continuation of a

similar anomaly seen to the south in the previous survey. It is parallel with, and approximately 80m east of anomaly (1). It appears to have a deliberate 2.3m gap along its edge and also can be seen to continue north eastwards as anomaly (18) in Area 2 to the north.

Anomalies with an uncertain origin

(4) – A broad positive anomaly that appears to form a fragmented, sinuous feature across the centre of the survey area. Although it has a similar orientation to anomaly (2), it is similar in form and magnitude (12-14nT) to anomaly (6). It may relate to a cut feature, but a natural origin should also be considered.

(5) – A strongly magnetic discrete anomaly appears pit-like in form; however, it has a response of up to 65nT, which may indicate ferrous or other magnetically thermoremnant material is associated with it.

(6) – Fragmented positive anomalies with some rectilinear elements appear similar to cut features, although this is not certain.

(7) – Positive curvilinear anomalies (7-9nT), close to or adjoining anomaly (2). It is possible that they relate to ring ditches; however, their response is either incomplete or obscured by other features preventing confident abstraction and interpretation.

(8) – Positive linear anomalies appear to form rectilinear features. They have a response of 7-9nT and although they may relate to cut features, a natural origin is possible.

(9) – Positive linear anomalies roughly parallel to anomalies (1) and (2). It is possible that these relate to cut features.

(10) – The survey area contains a number of positive linear and discrete anomalies. They do not have a coherent pattern or morphology, and although they may relate to ditch-like and pit-like features, their origin is uncertain.

(11) – Negative linear anomalies may relate to pipes, drains, or wall foundations.

(12) – Sinuous or curvilinear negative anomalies relate to material with low magnetic susceptibility, such as subsoil or stone.

Anomalies associated with land management.

(13) – A series of broad positive and negative anomalies extends through the centre of the survey area and relates to a former Cornish Hedge boundary removed between 1963 and 1974.

Anomalies with an agricultural origin

(14) – A series of parallel linear anomalies appear to relate to cultivation or possible land drainage.

Anomalies associated with magnetic debris

(15) – Patches of magnetic debris are located close to the north western edge of the survey area. They have a strong dipolar response indicating ferrous and other magnetically thermoremnant material and it may relate to material dumped or used for ground consolidation.

(16) – Each survey area contains a number of strong, discrete dipolar anomalies which relate to ferrous objects within the topsoil.

Anomalies with a modern origin

(17) – Magnetic disturbance at the north eastern corner of the survey area is a response to a ferrous object or material in the vicinity.

3.5 List of anomalies - Area 2

Area centred on OS NGR 198415 78110, see Figures 04 & 05.

Anomalies of archaeological potential

(18) – A positive linear anomaly with a response of up to 37nT extends through the eastern part of the survey area. This is a continuation of anomaly (3) seen within Area 1 to the south, and extends as a single ditch-like feature for 270m. It is possible that it continues northwards and has become incorporated into the current field boundary.

Anomalies with an uncertain origin

(19) – Fragmented positive linear anomalies (2-8nT) that may represent former ditch-like features.

(20) – A broad positive response parallel to the eastern field boundary may have been formed by former cultivation.

(21) – Broad linear or amorphous positive anomalies may have a natural or agricultural origin but this is uncertain.

(22) – Several short positive linear anomalies have located within the survey area and lack a coherent morphology which prevents confident interpretation.

(23) – Discrete positive anomalies may relate to pit-like features; however, it is possible that they are natural in origin.

Anomalies with an agricultural origin

(24) – A series of linear anomalies appear to relate to former agricultural activity.

3.6 List of anomalies - Area 3

Area centred on OS NGR 195550 78110, see Figures 04 & 05.

Anomalies with an uncertain origin

(25) – Positive linear anomalies extending across the survey area with a general east to west orientation. It is possible that these anomalies relate to cut features, such as ditches, although this is not certain.

(26) – A broad negative curvilinear anomaly flanked by positive linear anomalies is located in the south eastern part of the survey area. It is not possible to determine its origin.

(27) – The survey area contains a number of broad linear and amorphous positive responses, primarily in the east. It is possible that these relate to natural features.

(28) – Positive linear, rectilinear and curvilinear anomalies have been located in the survey area; however, they lack a coherent morphology and a natural origin is possible.

(29) – Discrete positive anomalies appear to relate to pit-like features, but a natural origin is possible.

Anomalies associated with magnetic debris

(30) – A patch of magnetic debris is located close to the southern edge of the survey area and is possible that it relates to magnetically thermoremnant material used within the infill of a former pond or depression.

4 DISCUSSION

4.1.1 Within Area 1, three positive linear anomalies form an enclosure with dimensions of 110m by 80m. The south eastern corner extends into the previous survey area, and the south western corner may have been incorporated into an extant field boundary. The ditch that defines the eastern edge extends northwards into Area 2 and measures at least 270m. It is also possible that it has been incorporated into the current field boundary at the northern end of the site.

4.1.2 Within each of the survey areas are numerous discrete, linear, curvilinear, rectilinear and amorphous responses. Although many may appear ditch-like and pit-like, the majority lack a clear and coherent morphology and it is possible that many relate to the underlying geology. In Area 1 there is some weak evidence for curvilinear ring ditch-like anomalies close to or adjoining one boundary ditch feature (anomalies 7), although their weak and fragmented response, together with the other anomalies obscuring them, prevents confident interpretation.

5 CONCLUSION

5.1.1 The geophysical survey located a number of positive linear anomalies that relate to former boundary ditches which extend north eastwards from the previous survey area immediately to the south. One boundary ditch is visible for over 270m and contains a deliberate gap. There is evidence for this, and other former boundary features, to have in places become incorporated into the current field boundary layout. The boundary ditches form a rectilinear enclosure approximately 110m by 80m.

5.1.2 Many other positive linear, rectilinear, curvilinear and discrete anomalies may indicate former cut features; however, they are often weak and fragmented preventing confident interpretation. The underlying geology has caused many naturally formed anomalies, which often appear ditch-like and pit-like, and it is possible that many anomalies classified as uncertain in origin are related to features within the underlying bedrock.

6 REFERENCES

Archaeological Surveys, 2011. *Treswarrow Farm, St Endellion, Cornwall. Magnetometer Survey Report.* Ref 358. Unpublished typescript document.

British Geological Survey, 2011. *Geology of Britain viewer, 1:50 000 scale [online]* available from http://maps.bgs.ac.uk/geologyviewer/ [accessed 14/4/2011].

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

Institute for Archaeologists, 2002. *The use of Geophysical Techniques in Archaeological Evaluations*. IfA Paper No. 6. IfA, University of Reading.

Institute for Archaeologists, 2011. *Standard and Guidance for archaeological geophysical survey*. IfA, University of Reading.

Soil Survey of England and Wales, 1983. *Soils of England and Wales, Sheet 5 South West England.*

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 gradiometer is a passive instrument consisting of two fluxgate sensors mounted vertically 1m apart. The instrument is carried about 30cm 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. If no enhanced feature is present the field measured by both sensors will be similar and the difference close to zero.

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 ±1nT 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 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 slight differences between the set-up and stability of gradiometer sensors and can remove striping. The process can remove archaeological features that run along a traverse so data analysis is also carried out prior its application.

De-stagger

Compensates for small positional errors within data collection by shifting the position of the readings along each traverse by a specified amount. Data lost at the end of each traverse are extrapolated from adjacent value in the same row.

Deslope

Corrects for striping and distortion caused by metal objects/services etc.. The process calculates a curve based on a polynomial best fit mathematical function for each traverse. This curve is then subtracted from the actual data.

Edge Match

Calculates the mean of the 2 lines (rows or columns) of data either side of the edge to match. It then subtracts the difference between the means from all datapoints in the selected area.

FFT (Fast Fourier Transform) spectral filtering

A mathematical process used to determine the frequency components of a traverse. Repetitive features, such as plough marks, produce characteristic spectral zones that can be suppressed allowing greyscale images to appear clearer.

Appendix C – survey and data information

Area 1 raw magnetometer data

COMPOSITE
Filename: J454-mag-Area1-raw.xcp
Instrument Type: Bartington (Gradiometer)
Units: nT
Surveyed by: on 07/01/2013
Assembled by: on 07/01/2013
Direction of 1st Traverse: 90 deg
Collection Method: ZigZag
Sensors: 2 @ 1.00 m spacing.
Dummy Value: 32702

Dimensions
Composite Size (readings): 840 x 210
Survey Size (meters): 210 m x 210 m
Grid Size: 30 m x 30 m
X Interval: 0.25 m
Y Interval: 1 m

Stats
Max: 30.00
Min: -30.00
Std Dev: 5.08
Mean: 2.23
Median: 2.32
Composite Area: 4.41 ha
Surveyed Area: 2.3283 ha

PROGRAM
Name: ArcheoSurveyor
Version: 2.5.19.3

Processes: 2
1 Base Layer
2 Clip from -30.00 to 30.00 nT

Source Grids: 41
1 Col:0 Row:1 grids\01.xgd
2 Col:0 Row:2 grids\02.xgd
3 Col:0 Row:3 grids\03.xgd
4 Col:0 Row:4 grids\04.xgd
5 Col:1 Row:0 grids\05.xgd
6 Col:1 Row:1 grids\06.xgd
7 Col:1 Row:2 grids\07.xgd
8 Col:1 Row:3 grids\08.xgd
9 Col:1 Row:4 grids\09.xgd
10 Col:1 Row:5 grids\10.xgd
11 Col:2 Row:0 grids\11.xgd
12 Col:2 Row:1 grids\12.xgd
13 Col:2 Row:2 grids\13.xgd
14 Col:2 Row:3 grids\14.xgd
15 Col:2 Row:4 grids\15.xgd
16 Col:2 Row:5 grids\16.xgd
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25 Col:4 Row:1 grids\25.xgd
26 Col:4 Row:2 grids\26.xgd
27 Col:4 Row:3 grids\27.xgd
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32 Col:5 Row:1 grids\32.xgd
33 Col:5 Row:2 grids\33.xgd
34 Col:5 Row:3 grids\34.xgd
35 Col:5 Row:4 grids\35.xgd
36 Col:5 Row:5 grids\36.xgd
37 Col:6 Row:1 grids\37.xgd
38 Col:6 Row:2 grids\38.xgd
39 Col:6 Row:3 grids\39.xgd
40 Col:6 Row:4 grids\40.xgd
41 Col:6 Row:5 grids\41.xgd

Area 1 processed magnetometer data

COMPOSITE
Filename: J454-mag-Area1-proc.xcp

Stats
Max: 5.00
Min: -5.00
Std Dev: 2.73
Mean: 0.05
Median: 0.00

Processes: 5
1 Base Layer
2 DeStripe Median Traverse: Grids: All
3 De Stagger: Grids: 20.xgd Mode: Both By: 1 intervals
4 De Stagger: Grids: 39.xgd Mode: Both By: 1 intervals
5 Clip from -5.00 to 5.00 nT

Area 2 raw magnetometer data

COMPOSITE
Filename: J454-mag-Area2-raw.xcp
Instrument Type: Bartington (Gradiometer)
Units: nT
Surveyed by: on 09/01/2013
Assembled by: on 09/01/2013
Direction of 1st Traverse: 90 deg
Collection Method: ZigZag
Sensors: 2 @ 1.00 m spacing.
Dummy Value: 32702

Dimensions
Composite Size (readings): 600 x 210
Survey Size (meters): 150 m x 210 m
Grid Size: 30 m x 30 m
X Interval: 0.25 m
Y Interval: 1 m

Stats
Max: 30.00
Min: -30.00
Std Dev: 5.76
Mean: 0.39
Median: 0.21
Composite Area: 3.15 ha
Surveyed Area: 1.0606 ha

Processes: 2
1 Base Layer
2 Clip from -30.00 to 30.00 nT

Source Grids: 23
1 Col:0 Row:2 grids\21.xgd
2 Col:0 Row:3 grids\22.xgd
3 Col:0 Row:4 grids\23.xgd
4 Col:1 Row:0 grids\15.xgd
5 Col:1 Row:1 grids\16.xgd
6 Col:1 Row:2 grids\17.xgd
7 Col:1 Row:3 grids\18.xgd
8 Col:1 Row:4 grids\19.xgd
9 Col:1 Row:5 grids\20.xgd
10 Col:2 Row:0 grids\09.xgd
11 Col:2 Row:1 grids\10.xgd
12 Col:2 Row:2 grids\11.xgd
13 Col:2 Row:3 grids\12.xgd
14 Col:2 Row:4 grids\13.xgd
15 Col:2 Row:5 grids\14.xgd
16 Col:3 Row:2 grids\05.xgd
17 Col:3 Row:3 grids\06.xgd
18 Col:3 Row:4 grids\07.xgd
19 Col:3 Row:5 grids\08.xgd
20 Col:3 Row:6 grids\04.xgd
21 Col:4 Row:4 grids\01.xgd
22 Col:4 Row:5 grids\02.xgd
23 Col:4 Row:6 grids\03.xgd

Area 2 processed magnetometer data

COMPOSITE
Filename: J454-mag-Area2-proc.xcp

Stats
Max: 5.00
Min: -5.00
Std Dev: 3.01
Mean: 0.02
Median: 0.00
Composite Area: 3.15 ha
Surveyed Area: 1.0602 ha

Processes: 7
1 Base Layer
2 Clip from -30.00 to 30.00 nT
3 DeStripe Median Traverse: Grids: All
4 De Stagger: Grids: 07.xgd Mode: Outbound By: 1 intervals
5 De Stagger: Grids: 08.xgd Mode: Outbound By: 1 intervals
6 De Stagger: Grids: 04.xgd Mode: Outbound By: 1 intervals
7 Clip from -5.00 to 5.00 nT

Area 2a raw magnetometer data

COMPOSITE
Filename: J454-mag-Area2a-raw.xcp
Description:
Instrument Type: Bartington (Gradiometer)
Units: nT
Surveyed by: on 09/01/2013
Assembled by: on 09/01/2013
Direction of 1st Traverse: 90 deg
Collection Method: ZigZag
Sensors: 2 @ 1.00 m spacing.
Dummy Value: 32702

Dimensions
Composite Size (readings): 240 x 60
Survey Size (meters): 60 m x 60 m
Grid Size: 30 m x 30 m
X Interval: 0.25 m
Y Interval: 1 m

Stats
Max: 30.00
Min: -30.00
Std Dev: 9.80
Mean: -2.06
Median: -2.38
Composite Area: 0.36 ha
Surveyed Area: 0.0257 ha

Processes: 2
1 Base Layer
2 Clip from -30.00 to 30.00 nT

Source Grids: 4
1 Col:0 Row:0 grids\03.xgd
2 Col:0 Row:1 grids\04.xgd
3 Col:1 Row:0 grids\01.xgd
4 Col:1 Row:1 grids\02.xgd

Area 2a processed magnetometer data

COMPOSITE
Filename: J454-mag-Area2a-proc.xcp

Stats
Max: 5.00
Min: -5.00
Std Dev: 3.55
Mean: 0.07
Median: 0.00
Composite Area: 0.36 ha
Surveyed Area: 0.0257 ha

Processes: 4
1 Base Layer
2 Clip from -30.00 to 30.00 nT
3 DeStripe Median Traverse: Grids: All
4 Clip from -5.00 to 5.00 nT

Area 3 raw magnetometer data

COMPOSITE
Filename: J454-mag-Area3-raw.xcp
Description:
Instrument Type: Bartington (Gradiometer)
Units: nT
Surveyed by: on 08/01/2013
Assembled by: on 09/01/2013
Direction of 1st Traverse: 90 deg
Collection Method: ZigZag
Sensors: 2 @ 1.00 m spacing.
Dummy Value: 32702

Dimensions
Composite Size (readings): 720 x 180
Survey Size (meters): 180 m x 180 m
Grid Size: 30 m x 30 m
X Interval: 0.25 m
Y Interval: 1 m

Stats
Max: 30.00
Min: -30.00
Std Dev: 4.21
Mean: 1.27
Median: 1.06
Composite Area: 3.24 ha
Surveyed Area: 1.7129 ha

Processes: 2
1 Base Layer
2 Clip from -30.00 to 30.00 nT

Source Grids: 30
1 Col:0 Row:1 grids\30.xgd
2 Col:0 Row:2 grids\01.xgd
3 Col:0 Row:3 grids\02.xgd
4 Col:0 Row:4 grids\03.xgd
5 Col:0 Row:5 grids\04.xgd
6 Col:1 Row:1 grids\29.xgd
7 Col:1 Row:2 grids\05.xgd
8 Col:1 Row:3 grids\06.xgd
9 Col:1 Row:4 grids\07.xgd
10 Col:1 Row:5 grids\08.xgd
11 Col:2 Row:1 grids\28.xgd
12 Col:2 Row:2 grids\09.xgd
13 Col:2 Row:3 grids\10.xgd
14 Col:2 Row:4 grids\11.xgd
15 Col:2 Row:5 grids\12.xgd
16 Col:3 Row:0 grids\26.xgd
17 Col:3 Row:1 grids\27.xgd
18 Col:3 Row:2 grids\13.xgd
19 Col:3 Row:3 grids\14.xgd
20 Col:3 Row:4 grids\15.xgd
21 Col:3 Row:5 grids\16.xgd
22 Col:4 Row:0 grids\24.xgd
23 Col:4 Row:1 grids\25.xgd
24 Col:4 Row:2 grids\17.xgd
25 Col:4 Row:3 grids\18.xgd
26 Col:4 Row:4 grids\19.xgd
27 Col:4 Row:5 grids\20.xgd
28 Col:5 Row:2 grids\21.xgd
29 Col:5 Row:3 grids\22.xgd
30 Col:5 Row:4 grids\23.xgd

Area 3 processed magnetometer data

COMPOSITE
Filename: J454-mag-Area3-proc.xcp

Stats
Max: 5.00
Min: -5.00
Std Dev: 2.58
Mean: 0.10
Median: 0.00
Composite Area: 3.24 ha
Surveyed Area: 1.7129 ha

Processes: 4
1 Base Layer
2 Clip from -30.00 to 30.00 nT
3 DeStripe Median Traverse: Grids: All
4 Clip from -5.00 to 5.00 nT

Appendix D – digital archive

Archaeological Surveys Ltd hold the primary digital archive at their offices in Wiltshire (see inside cover for address). 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.

Surveys are reported on in hardcopy (recycled paper) using A4 for text and A3 for plots (all plots are scaled for A3). Copies of the report will be sent to the Natural England Historic Environment Advisor at Exeter, two copies to the Natural England Project Officer at Truro and one copy deposited with the Cornwall Historic Environment Record.

This report has been prepared using the following software on a Windows XP platform:

- ArcheoSurveyor version 2.5.19.3 (geophysical data analysis),
- ProgeCAD Professional 2009 (report graphics),
- AutoCAD LT 2007 (report figures),
- OpenOffice.org 3.0.1 Writer (document text),
- PDF Creator version 0.9 (PDF archive).

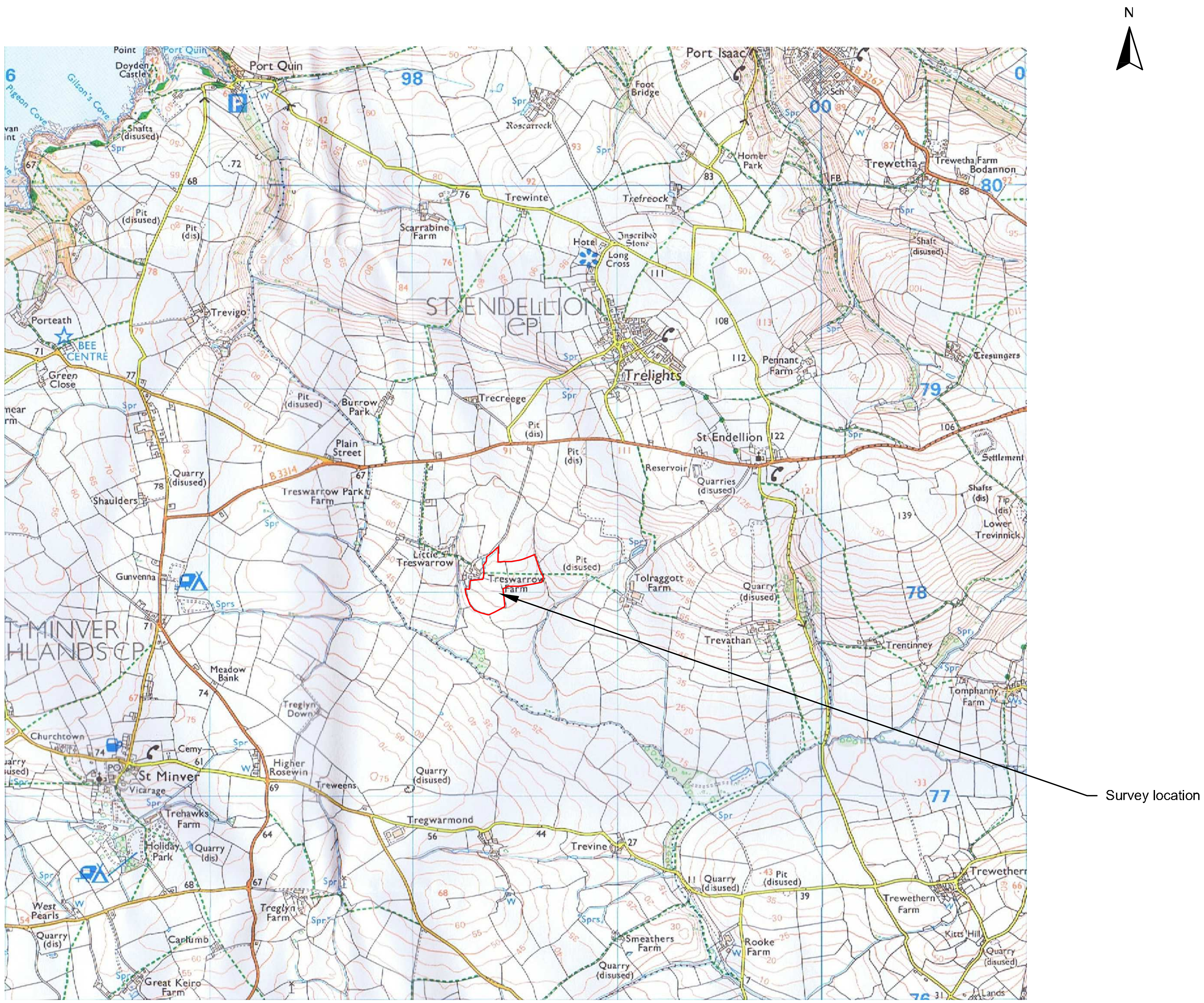
Digital data produced by the survey and report include the following files:

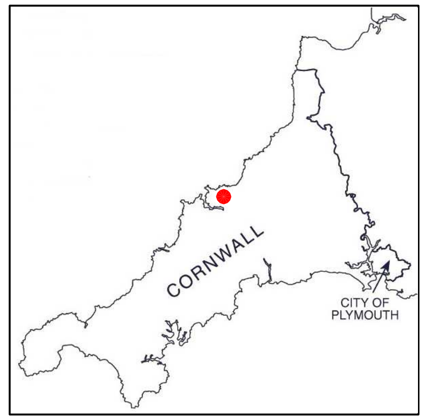
- ArcheoSurveyor grid and composite files for all geophysical data,
- CSV files for raw and processed composites,
- geophysical composite file graphics as Bitmap images,
- AutoCAD DWG files in 2000 and 2007 versions,
- report text as OpenOffice.org ODT file,
- report text as Word 2000 doc file,
- report text as rich text format (RTF),
- report text as PDF,
- PDFs of all figures.

Archaeological Surveys Ltd

Geophysical Survey
Treswarrow Farm
St Endellion
Cornwall

Map of survey area





● Survey location

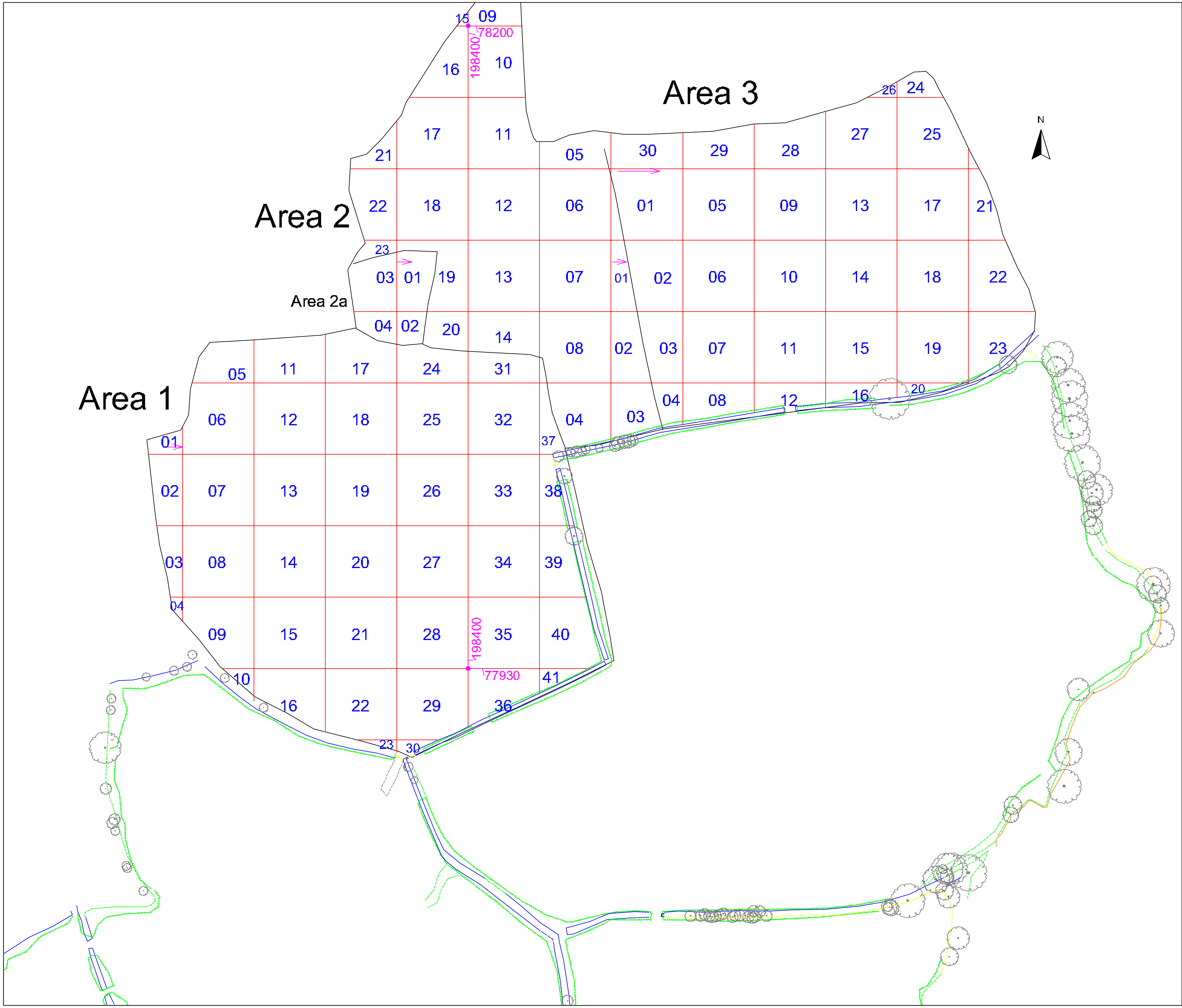
Site centred on OS NGR SW 98445 78050

SCALE 1:25 000

0m 500m 1000m

SCALE TRUE AT A3

FIG 01



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Geophysical Survey
Treswarrow Farm
St Endellion
Cornwall

Referencing information

Grid coordinates based on Ordnance Survey OSGB36 datum

Grids set out using RTK GPS with Leica SmartNet correction data RTCMv2 format OSTN02 transformation

Survey grid size = 30m

Survey start and traverse direction

01 Grid reference number and filename

SCALE 1:1500

0m 10 20 30 40 50m

FIG 02

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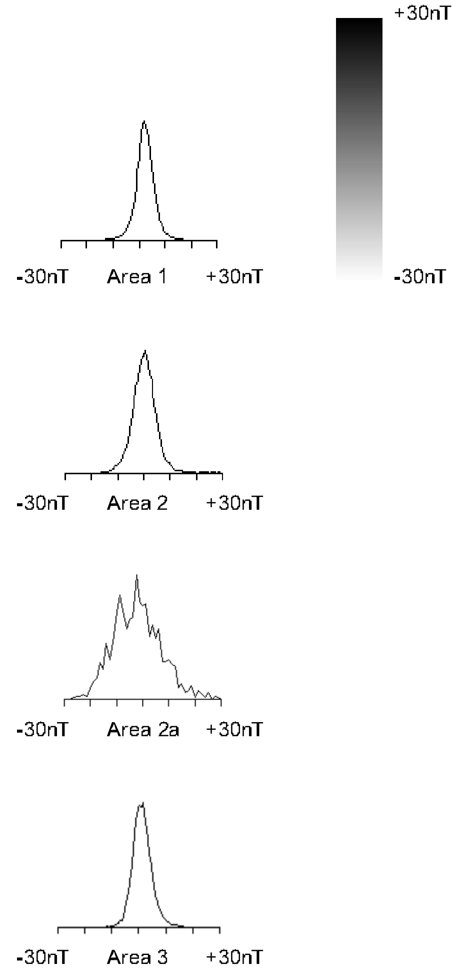
Treswarrow Farm
St Endellion
Cornwall

Greyscale plot of raw magnetometer data



SCALE 1:1500

0m 10 20 30 40 50m

FIG 03

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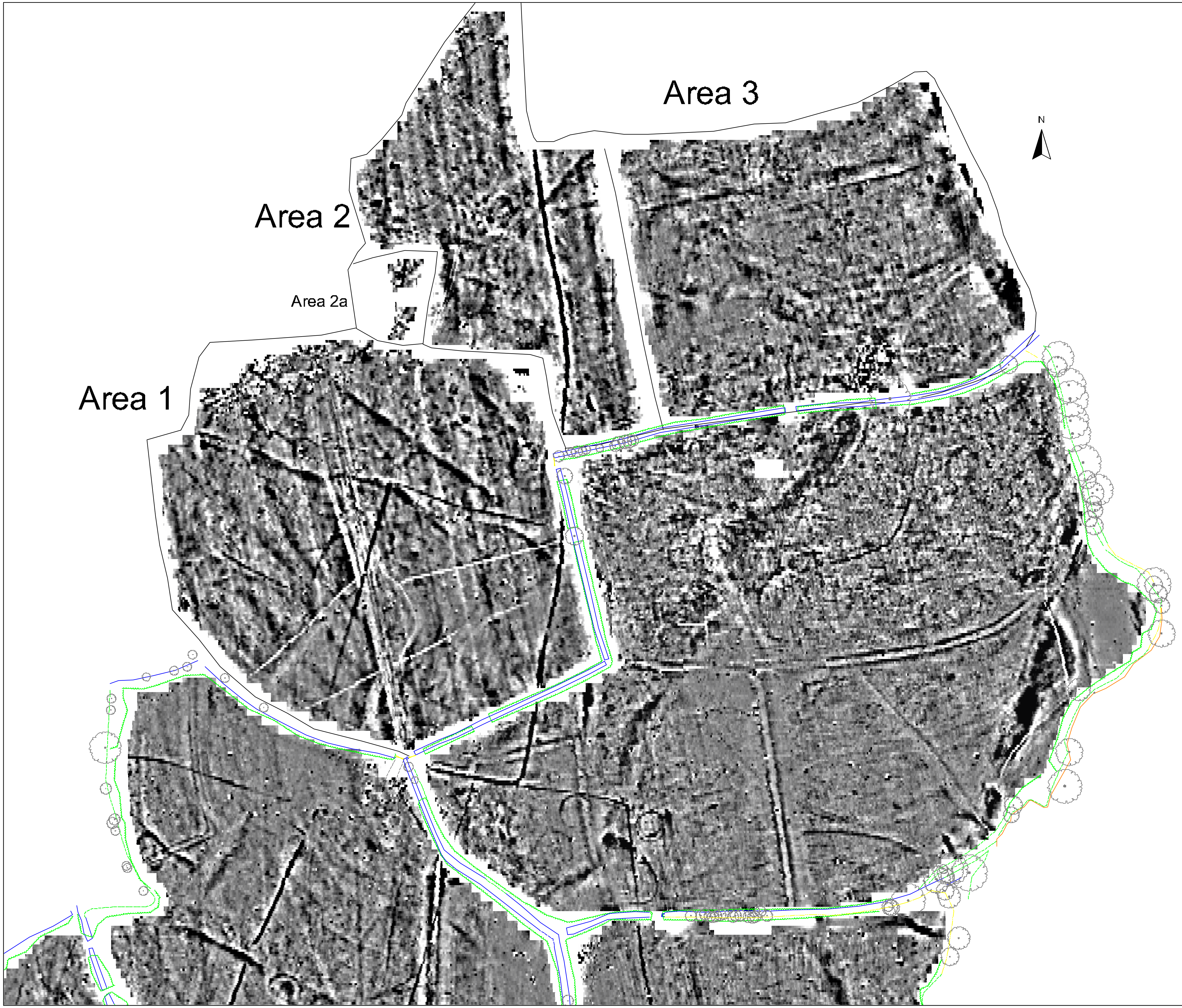
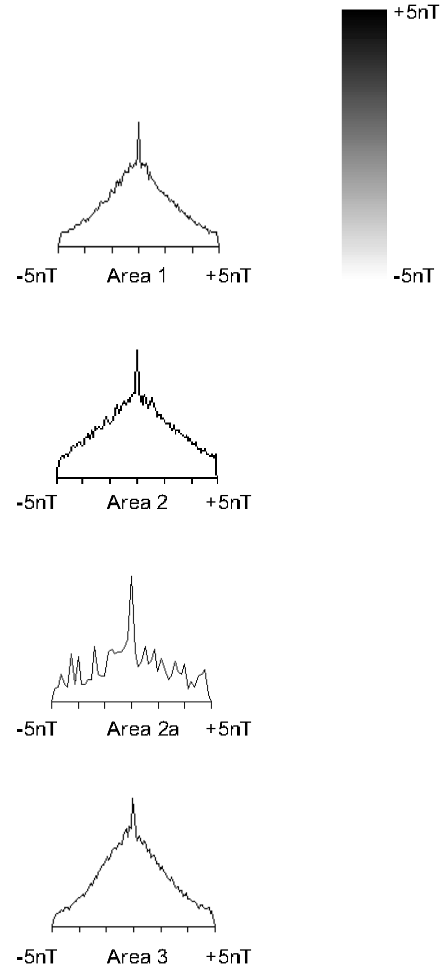
Geophysical Survey
Treswarrow Farm
St Endellion
Cornwall



Greyscale plot of processed magnetometer data



SCALE 1:1500

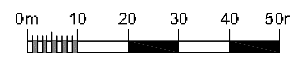
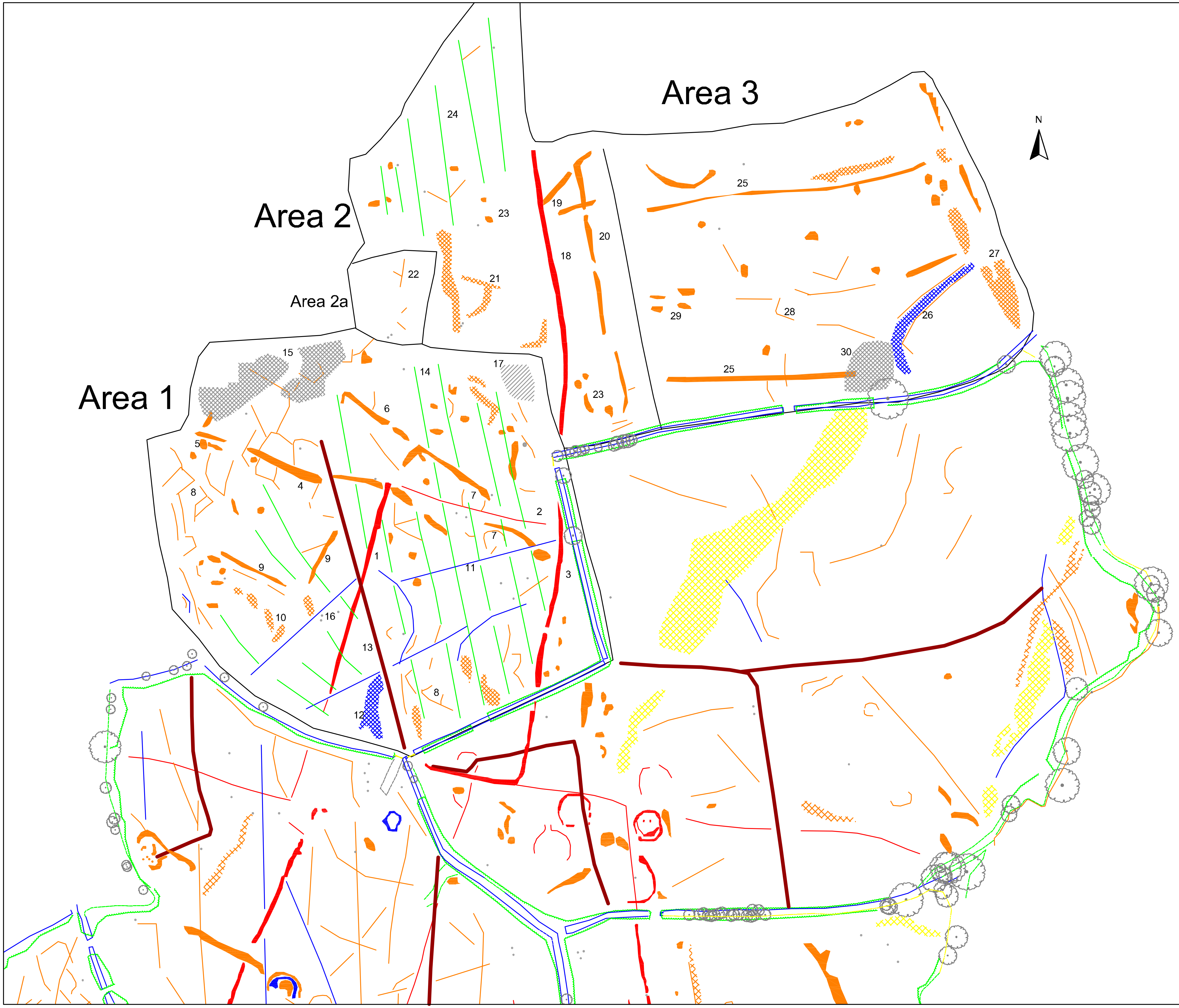


FIG 04



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Geophysical Survey
Treswarrow Farm
St Endellion
Cornwall

Abstraction and interpretation of magnetometer anomalies

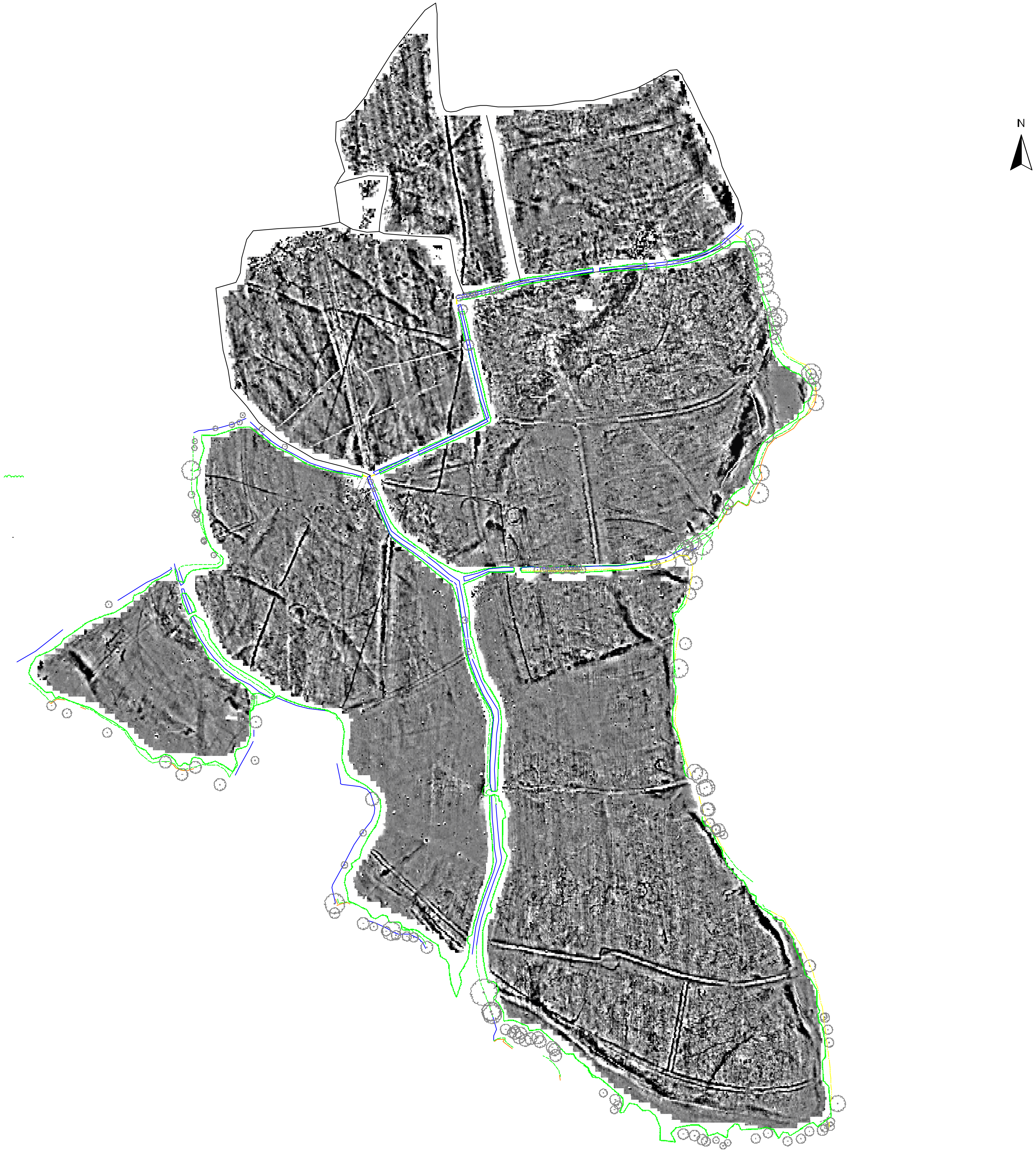
- Positive linear anomaly - cut feature of archaeological potential
- Positive linear anomaly - possible ditch-like feature
- Linear anomaly - of agricultural origin
- Positive linear anomaly - possible former field boundary
- Negative linear anomaly - material of low magnetic susceptibility
- Discrete positive response - possible pit-like feature
- Positive anomaly - magnetically enhanced material
- Negative anomaly - material with low magnetic susceptibility
- Magnetic debris - spread of magnetically thermoremnant/ferrous material
- Magnetic disturbance from ferrous material
- Strong dipolar anomaly - ferrous object

SCALE 1:1500

0m 10 20 30 40 50m

SCALE TRUE AT A3

FIG 05



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Geophysical Survey
Treswarrow Farm
St Endellion
Cornwall

Greyscale plot of processed magnetometer data - entire site

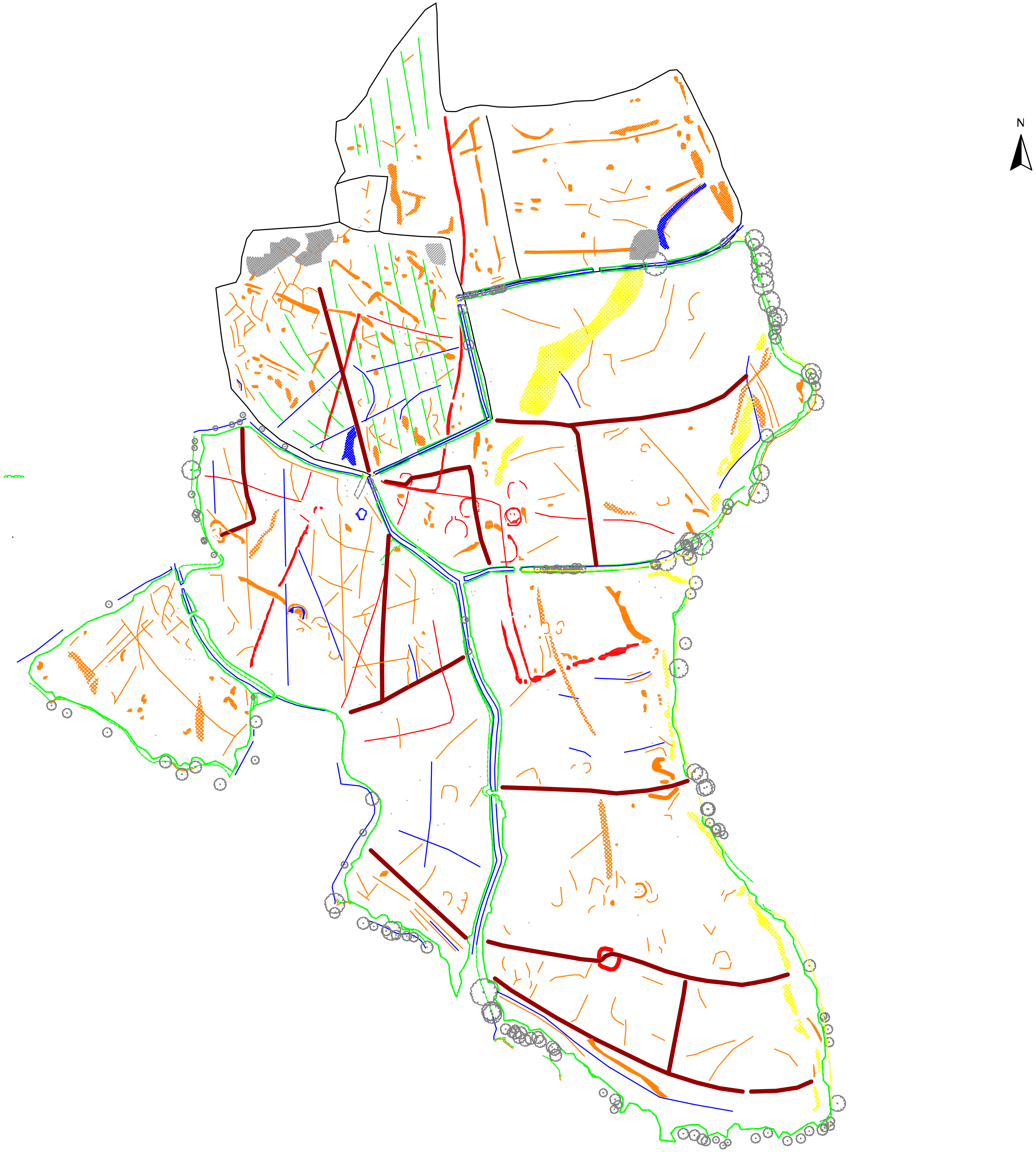
+5nT

-5nT

SCALE 1:3000

0m 20 40 60 80 100m

FIG 06



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Geophysical Survey
Treswarrow Farm
St Endellion
Cornwall

Abstraction and interpretation of magnetometer anomalies - entire site

- Positive linear anomaly - cut feature of archaeological potential
- Positive linear anomaly - possible ditch-like feature
- Linear anomaly - of agricultural origin
- Positive linear anomaly - possible former field boundary
- Negative linear anomaly - material of low magnetic susceptibility
- Discrete positive response - possible pit-like feature
- Positive anomaly - magnetically enhanced material
- Negative anomaly - material with low magnetic susceptibility
- Variable magnetic response - of natural origin
- Magnetic debris - spread of magnetically thermoremnant/ferrous material
- Magnetic disturbance from ferrous material
- Strong dipolar anomaly - ferrous object

SCALE 1:3000

0m 20 40 60 80 100m

SCALE TRUE AT A3

FIG 07