Substrata
Archaeological Geophysical Surveyors

An archaeological gradiometer survey

Land at Penbetha Farm, Grampound Truro, Cornwall

Ordnance Survey (E/N): 192976,48902 (point)

Report: 141124

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24 November 2014

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1 Survey description and summary

1.1 Survey

Type:	twin-sensor fluxgate gradiometer
Date:	7 November 2014
Area:	1.4ha
Lead surveyor:	Ross Dean BSc MSc MA MIfA

1.2 Client

Timothy Dart Ltd, Little Resparveth Farm, Grampound Rd TR2 4EF

1.3 Location

Site:	Land at Penbetha Farm
Civil parish:	Grampound with Creed
County:	Cornwall
Nearest Postcode:	TR2 4RW
NGR:	SW 929 489
Ordnance Survey E/N:	192976,48902 (point)

1.4 Archive

OASIS number:	substrat1-196129
Archive:	At the time of writing, the archive of this survey will be held by Substrata.

1.5 Introduction

This report was commissioned by Timothy Dart Ltd. on behalf of clients. It has been prepared as part of a programme of work in support of a forthcoming planning application at the above site. The location of the proposed development area is shown in Figure 4.

1.6 Summary

The magnetic contrast across the area was sufficient to be able to differentiate between anomalies representing possible archaeological features and background magnetic responses. Nineteen magnetic anomaly groups were identified as relating to possible archaeological deposits or features. Of these, one group may represent a linear group of pits. A spatially relatively concentrated set of irregular magnetically positive anomalies could signify an in-situ but mainly ploughed-out archaeological deposit. A set of linear anomalies is likely to represent a former Cornish bank field boundary not mapped on any historical Ordnance Survey map. A possible sub-circular group of anomalies, highly disrupted by relatively recent ploughing, may denote an archaeologically significant sub-circular deposit such as a filled ring ditch or round -house. The place-name element 'bethow' of the local Early-Medieval/Medieval settlement Penbetha suggests the site of a barrow (HER 22892.10) which could have relevance here. In the southern part of the survey area a group of adjacent oval-shaped anomalies may represent a cluster of archaeological deposits such as pits or large postholes although a natural origin cannot be ruled out. The remaining anomalies mapped as potentially archaeologically significant are likely to relate to field boundaries or other enclosures of more than one phase of previous land management.

2 Survey aims and objectives

2.1 Aims

1. Define and characterise and detectable archaeological remains on the site.
2. Inform any future archaeological investigation of the area.

2.2 Objectives

1. Complete a gradiometer survey across agreed parts of the application area.
2. Identify any magnetic anomalies that may be related to archaeological deposits, structures or artefacts.
3. Within the limits of the techniques and dataset, archaeologically characterise any such anomalies or patterns of anomalies.

4. Accurately record the location of the identified anomalies.
5. Produce a report based on the survey that is sufficiently detailed to inform any subsequent development on the site about the location and possible archaeological character of the recorded anomalies.

3 Standards

The standards used to complete this survey are defined by the Institute for Archaeologists (2011). The codes of approved practice that were followed are those of the Institute for Archaeologists (2008 and 2009) and Archaeology Data Service/Digital Antiquity Guides (undated). The document text was written using the house style of the Institute for Archaeologists (Institute for Archaeologists, undated).

4 Site description

4.1 Landscape and land use

The application area lies within a single field (the 'application field') to the north-west of the village of Grampound in Cornwall and lies at approximately 80m O.D. on a spur of land between a stream and the River Fal (Figure 4). At the time of the survey the land was under grass.

4.2 Geology

The application area is located on a solid geology of mudstone and sandstone of the Devonian Gramscatho Group. The superficial geology was not recorded in the source used (British Geological Survey, undated).

5 Archaeological background

The following is a short summary of information obtained from the Cornwall and Scilly Historic Environment Record (HER) within 500m of the survey area and deemed relevant to the understanding of the gradiometer survey. Except where specifically stated, this information was obtained using the Heritage Gateway (English Heritage, undated).

The reader is advised that this summary should not be used outside the context of this report and is referred to the Cornwall and Scilly Historical Environment Record for informed provision of the record.

5.1 Heritage Assets within the Survey Area

There are no heritage assets recorded within the survey are.

5.2 Heritage Assets close to the Survey Area

The Early Medieval/Medieval settlement of Penbetha is first recorded in 969 lies adjacent to the application field with its location centred at the south-western corner of the field (HER number 22892). The place-name element bethow suggests the site of a barrow but there are no visible remains (HER 22892.10). The modern Penbetha Farm lies to the north-west of the application field (Figure 4). A Medieval fulling mill was recorded at Penbetha in 1378. No extant remains are recorded (HER 22983). The remains of a Medieval/Post-medieval rectilinear field system are situated on the western bank of the Fal to the south-east of the application field and are visible as low earth banks on air photographs (HER 50969).

The Early Medieval/Medieval settlement of Tredinnick lies to the north-west of the application field (Figure 4) and was first recorded in 1404. The name is Cornish and contains the elements tre meaning 'estate, farmstead' (which implies a settlement of early medieval origin), and eithin meaning 'furze, gorse' (HER 22988) The name was incorrectly thought to mean fortified homestead (HER 22988.10).

Wheal Trevillick was a lead mine which was in operation in 1854 as a trial. It lay to the north-east of the application field and shown as "Old Shaft" on the 1st Edition OS 1:2500.

6 Results, discussion and conclusions

This survey was designed to record magnetic anomalies. The anomalies themselves cannot be regarded as actual archaeological features and the dimensions of the anomalies shown do not represent the dimensions of any associated archaeological features. The analysis presented below identifies and characterises anomalies and anomaly groups that may relate to archaeological deposits and structures.

The reader is referred to section 7.

6.1 Results

Figure 1 shows the interpretation of the survey data. It includes the anomaly groups identified as relating to archaeological deposits along with their numbers. Table 1 is an extract from a detailed analysis of the survey data provided in the attribute tables of the GIS project on the accompanying CD-ROM.

Figure 1 along with Table 1 comprises the analysis of the survey data. Plots of the processed data are provided in Figures 2 and 3.

6.2 Discussion

Not all anomalies or anomaly groups identified in Table 1 are necessarily discussed below. All identified anomaly groups are recorded in the GIS project on the accompanying CD-ROM.

General points

Anomalies though to relate to natural features were not mapped. Recent man-made objects such as manholes, water management equipment, drains, cables and other services were only mapped where they comprised significant magnetic responses across the dataset that needed clarification. If mapped, they are listed in Table 1 but are not discussed below.

Data collection along the field edges was restricted as shown in Figures 1 to 3 due to the presence of magnetic materials in and adjacent to the field boundaries. Strong magnetic responses mapped close to the field boundaries are likely to relate to these materials except where indicated otherwise in Figure 1.

The closely spaced, parallel anomaly trends trending north-west to south-east are likely to be the result of ground disturbance caused by relatively recent ploughing. The same is true of a much fainter set of parallel anomalies trending west-south-west to east-north-east across the data set.

Data relating to historical maps and other records

No recorded magnetic anomaly groups coincide with features recorded on historical Ordnance Survey maps.

Data with no previous archaeological provenance

One magnetic anomaly group (group **1**) in the north-western corner of the survey area may represent a linear group of pits although a less likely but still feasible explanation is that they represent a linear deposit disrupted by later ploughing.

A spatially relatively concentrated set of irregular magnetically positive anomalies (group **3**) could signify in-situ but mainly ploughed-out archaeological deposits although, in this case, a natural origin for the anomalies cannot be ruled out.

Anomaly group **4** comprises a set of linear anomalies that are likely to represent the traces of a former Cornish bank field boundary usually comprising a bank of earth-set stones build up with smaller stones and in-filled with sub-soil usually from flanking ditches which are present in this case.

Anomaly group **8** is highly disrupted by relatively recent ploughing but may denote an archaeologically significant sub-circular deposit such as a filled ring ditch or round-house. The application field lies within the Early Medieval/Medieval settlement of Penbetha with the settlement location centred at the south-western corner of the field (HER number 22892). The place-name element 'bethow' suggests the site of a barrow (HER 22892.10) which could have relevance here.

A group of adjacent oval-shaped anomalies (group **13**) may represent a cluster of archaeological deposits such as pits or large postholes. An apparently similar group to the north as seen in Figure 2 is shown in Figure 3 to be less distinct and probably the result of natural deposits disturbed by relatively recent ploughing. Whether group 13 is significant or also due to natural deposits can only be decided by further archaeological investigations.

The remaining magnetic anomaly groups identified as representing potential archaeological deposits or structures have characteristics typical of anomalies reflecting former field and other enclosure boundaries. In this case a number of possible phases of unknown date may be present.

6.3 Conclusions

The magnetic contrast across the area was sufficient to be able to differentiate between anomalies representing possible archaeological features and background magnetic responses. Nineteen magnetic anomaly groups were identified as relating to possible archaeological deposits or features. Of these, one group may represent a linear group of pits. A spatially relatively concentrated set of irregular magnetically positive anomalies could signify an in-situ but mainly ploughed-out archaeological deposit. A set of linear anomalies is likely to represent a former Cornish bank field boundary not mapped on any historical Ordnance Survey map. A possible sub-circular group of anomalies, highly disrupted by relatively recent ploughing, may denote an archaeologically significant sub-circular deposit such as a filled ring ditch or round-house. The place-name element 'bethow' of the local Early-Medieval/Medieval settlement Penbetha suggests the site of a barrow (HER 22892.10) which could have relevance here. In the southern part of the survey area a group of adjacent oval-shaped anomalies may represent a cluster of archaeological deposits such as pits or large postholes although a natural origin cannot be ruled out. The remaining anomalies mapped as potentially archaeologically significant are likely to relate to field boundaries or other enclosures of more than one phase of previous land management.

7 Disclaimer and copyright

The description and discussion of the results presented in this report are the authors, based on his interpretation of the survey data. Every effort has been made to provide accurate descriptions and interpretations of the geophysical data set. The nature of archaeological geophysical surveying is such that interpretations based on geophysical data, while informative, can only be provisional. Geophysical surveys are a cost-effective early step in the multi-phase process that is archaeology. The evaluation programme of which this survey is part may also be informed by other archaeological assessment work and analysis. It must be presumed that more archaeological features will be evaluated than those specified in this report.

8 Acknowledgements

Substrata would like to thank Tim Dart of Timothy Dart Ltd. for commissioning us to complete this survey.

9 Bibliography

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Appendix 1 Analysis table and supporting plots

General Guidance

The anomalies represented in the survey plots provided in this appendix are magnetic anomalies. The apparent size of such anomalies and anomaly patterns are unlikely to correspond exactly with the dimensions of any associated archaeological features.

A rough rule for interpreting magnetic anomalies is that the width of an anomaly at half its maximum reading is equal to the width of the buried feature, or its depth if this is greater (Clark, 2000: 83). Caution must be applied when using this rule as it depends on the anomalies being clearly identifiable and distinct from adjacent anomalies. In northern latitudes the position of the maximum of a magnetic anomaly will be displaced slightly to the south of any associated physical feature.

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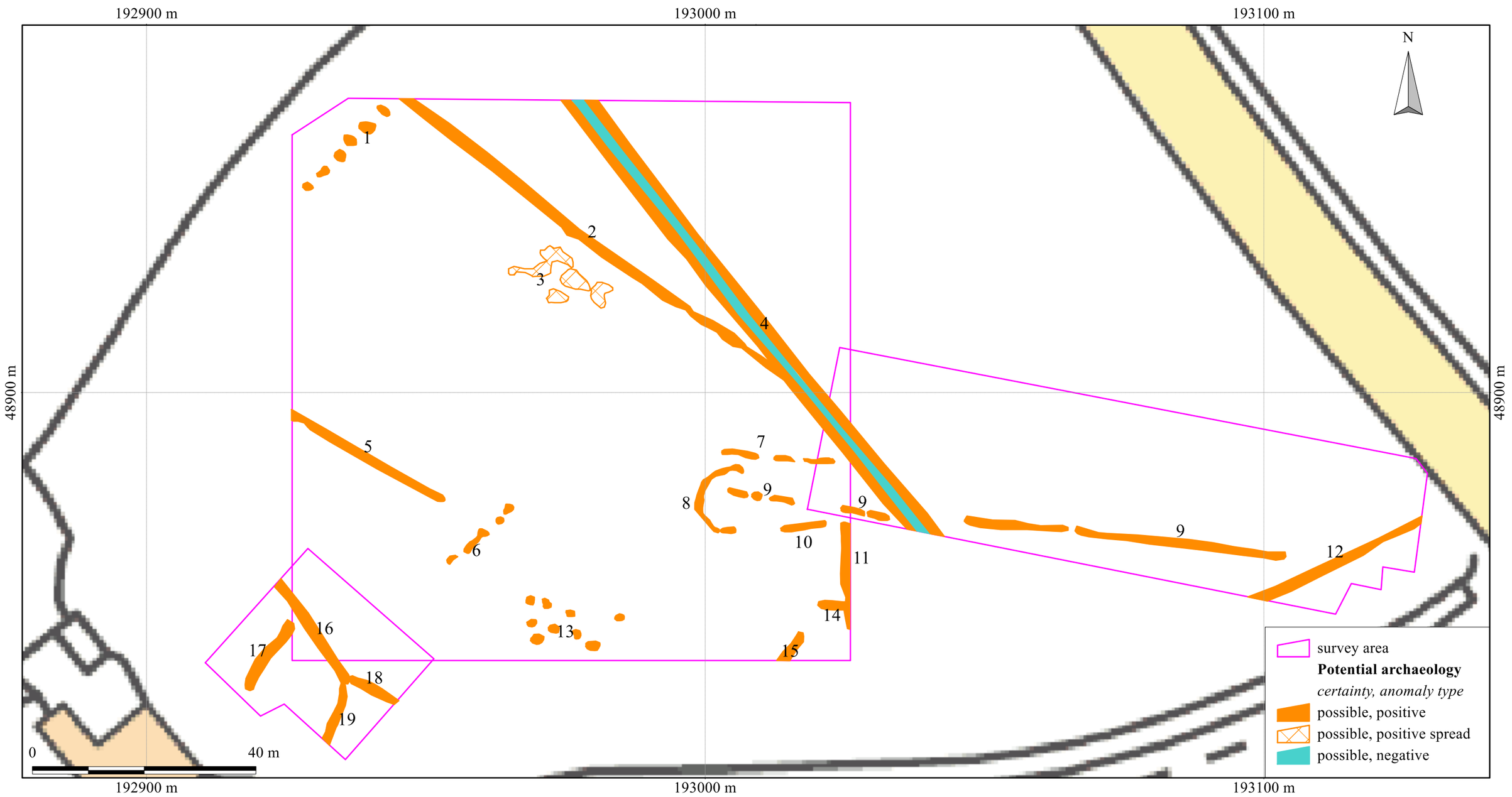
anomaly group	associated anomalies	anomaly characterisation certainty & class	anomaly form	additional archaeological characterisation	comments
1		possible, positive	linear group	pits or disrupted linear	anomaly group may represent a linear group of pits although a less likely but feasible explanation is that they represent a linear deposit disrupted by ploughing
2		possible, positive	linear		
3		possible, positive spread	irregular	area of archaeological activity	this group of anomaly groups stand out in the data set as being a distinct concentration of positive anomalies which can represent archaeological deposits although a natural origin cannot be ruled out
4		possible, pos/neg/pos	linear	field boundary	anomaly groups are typical of those representing the traces of a former Cornish bank field boundary comprising a bank with earth-set stones build up with smaller stones and in-filled with sub-soil usually from flanking ditches
5		possible, positive	linear		
6		possible, positive	disrupted linear		
7		possible, positive	disrupted linear		
8		possible, positive	partial sub-circle	ring ditch, round house or similar	anomaly group displays a sub-circular pattern highly disrupted by ploughing but nevertheless may be archaeologically significant
9		possible, positive	disrupted linear		
10		possible, positive	disrupted linear		
11		possible, positive	apparent linear		anomaly group is on edge of survey area but its form seems clear
12		possible, positive	linear		
13		possible, positive	group of ovals	pits or large postholes	anomaly group represents an apparent group of anomalies that are clear in the data set and may represent archaeological deposits
14		possible, positive	linear		
15		possible, positive	linear		
16		possible, positive	linear		
17		possible, positive	linear		
18		possible, positive	linear		
19		possible, positive	linear		

Table 1: data analysis



British Grid
centre X: 193009.10 m, centre Y: 48898.39 m

Scale: 1:700 @ A3. Spatial Units: Meter. Do not scale off this drawing

Notes:
1. All interpretations are provisional and represent potential archaeological deposits.
2. Anomalies designated "likely archaeology" have supporting evidence e.g. historical maps and or visible earthworks.
3. Anomalies likely to represent geological or other natural deposits are not mapped unless relevant to potential archaeological events or deposits.

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Figure 1: survey interpretation

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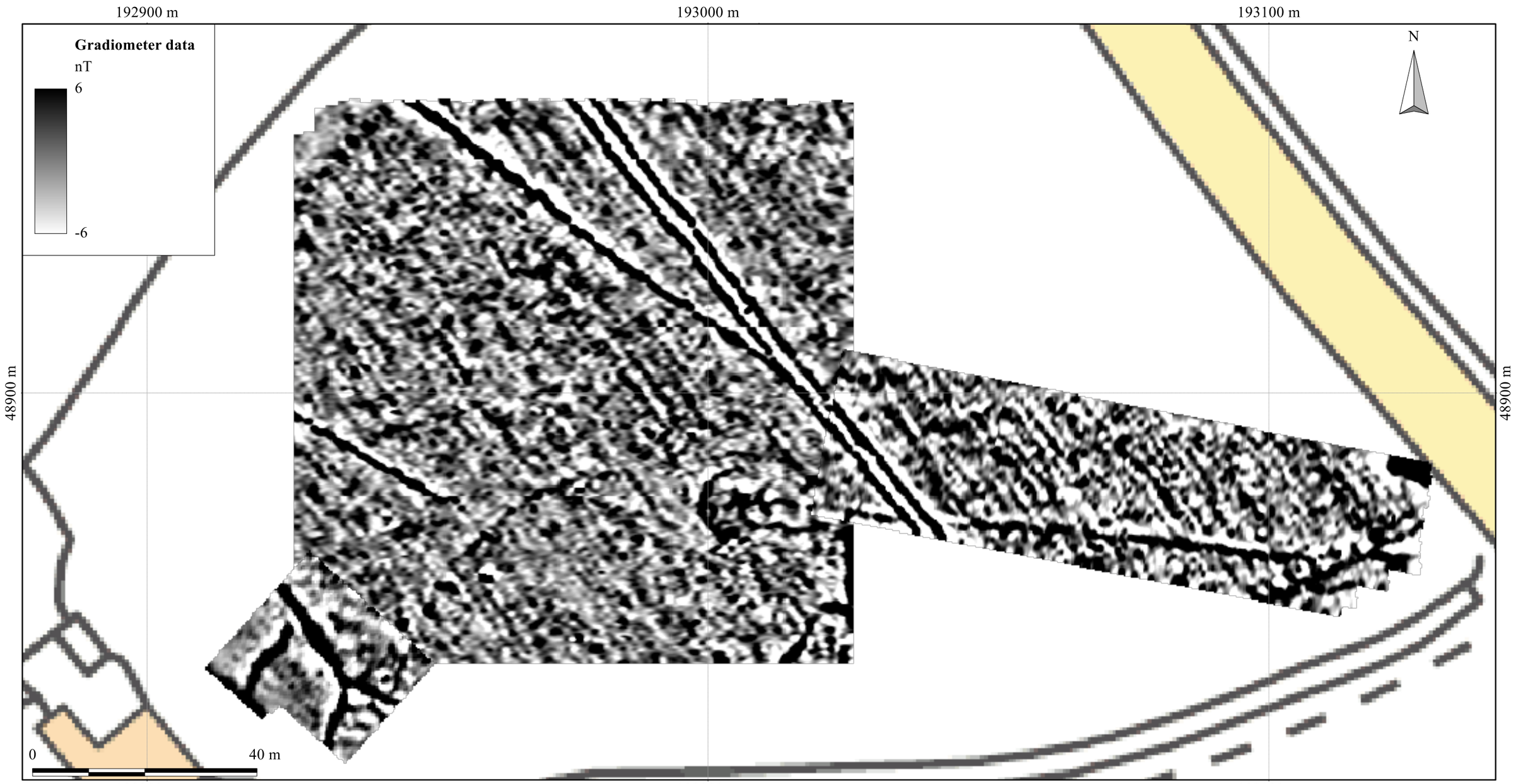

British Grid
centre X: 193009.10 m, centre Y: 48898.39 m

Scale: 1:700 @ A3. Spatial Units: Meter. Do not scale off this drawing

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Figure 2: shade plot of processed data

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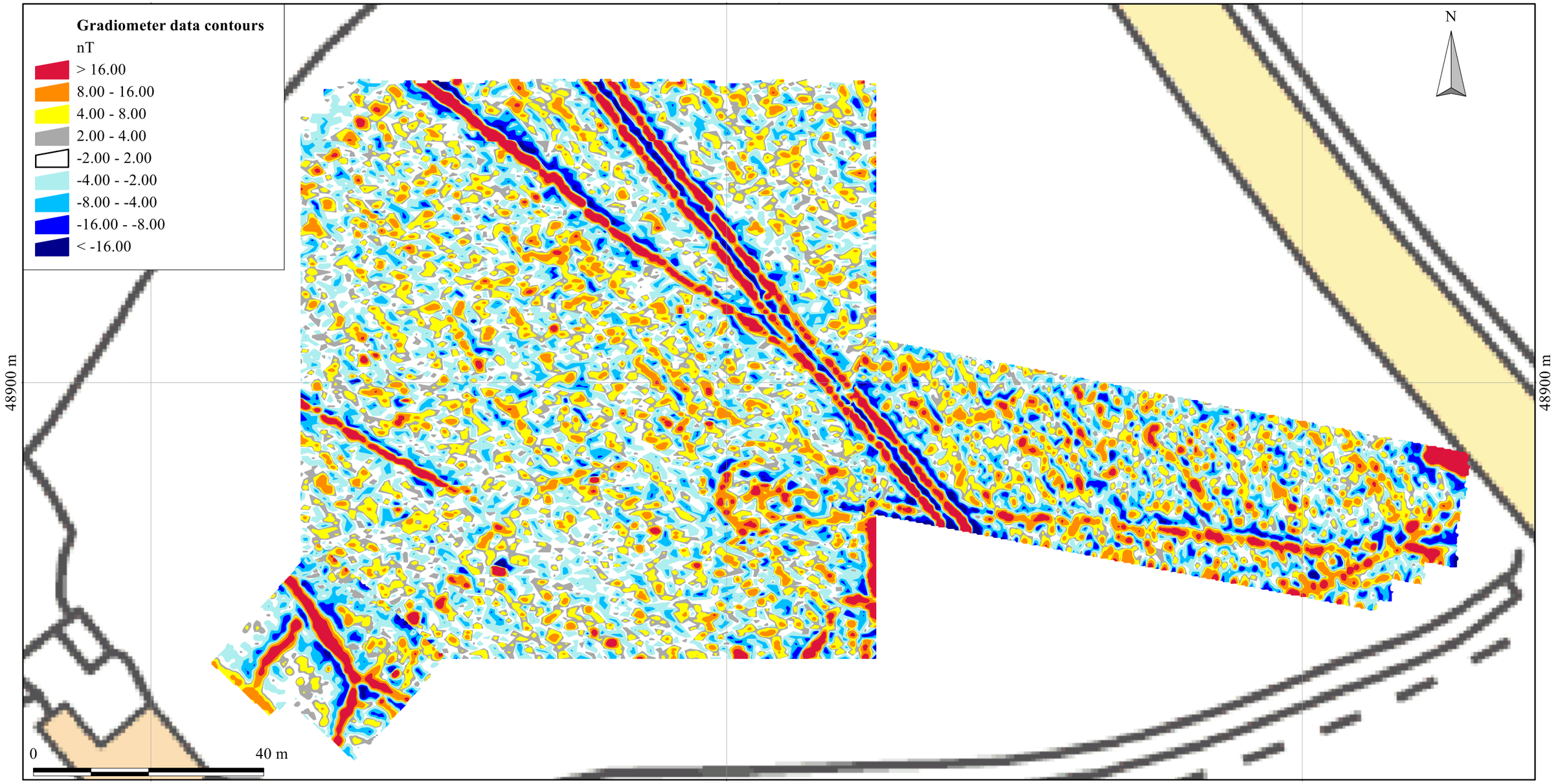

British Grid
centre X: 193009.10 m, centre Y: 48898.39 m

Scale: 1:700 @ A3. Spatial Units: Meter. Do not scale off this drawing

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Figure 3: contour plot of processed data

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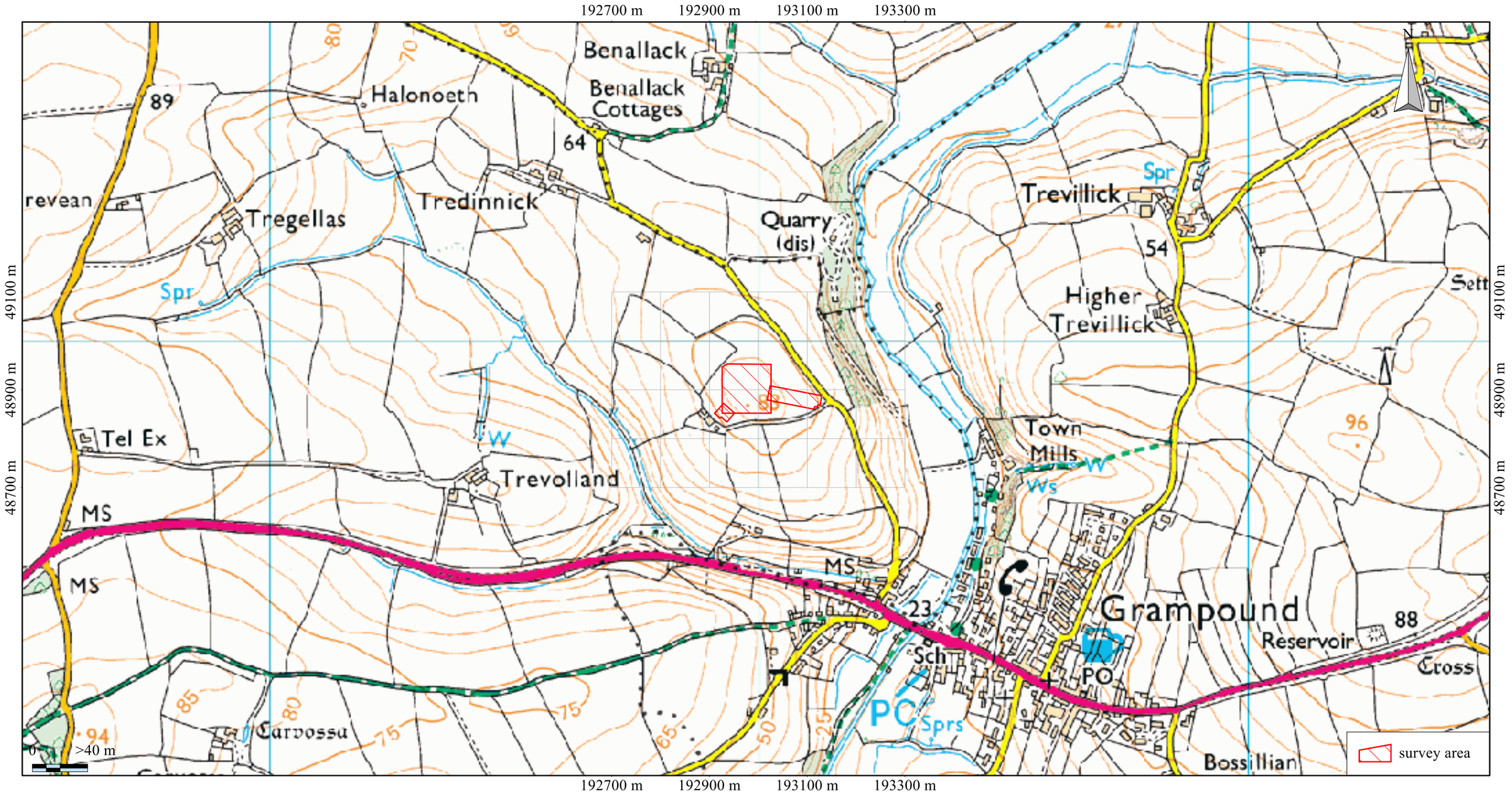

British Grid
centre X: 192995.24 m, centre Y: 48881.49 m

Scale: 1:8000 @ A3. Spatial Units: Meter. Do not scale off this drawing

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Figure 4: location map

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Appendix 2 Methodology Summary

Table 2: methodology summary	
Documents Survey methodology statement: Dean (2014)	
Methodology 1. The work was undertaken in accordance with the survey methodology statement. The geophysical (gradiometer) survey was undertaken with reference to standard guidance provided by the Institute for Archaeologists (2011) and Archaeology Data Service/Digital Antiquity Guides (undated). 2. The survey grid location information and grid plan was recorded as part of the project in a suitable GIS system. 3. Data processing was undertaken using appropriate software, with all anomalies being digitised and geo-referenced. The final report included a graphical and textual account of the techniques undertaken, the data obtained and an archaeological interpretation of that data and conclusions about any likely archaeology.	
Grid *Method of Fixing:* DGPS set-out using pre-planned survey grids and Ordnance Survey coordinates. *Composition:* 30m by 30m grids *Recording:* Geo-referenced and recorded using digital map tiles. *DGPS used:* Spectra Precision PM5V2 GPS with external antenna and survey pole and DigiTerra Explorer 7 as the survey control program.	
Equipment *Instrument:* Bartington Instruments grad601-2 *Firmware:* version 6.1	**Data Capture** *Sample Interval:* 0.25-metres *Traverse Interval:* 1 metre *Traverse Method:* zigzag *Traverse Orientation:* GN0
Data Processing, Analysis and Presentation Software IntelliCAD Technology Consortium IntelliCAD 7.2 DW Consulting TerraSurveyor3 Manifold System 8 GIS Microsoft Corp. Office Excel 2013 Microsoft Corp. Office Publisher 2013 Adobe Systems Inc Adobe Acrobat 9 Pro Extended	

Appendix 3 Data processing

Table 3: gradiometer survey - processed data metadata

SITE
Instrument Type: Bartington Grad 610
Units: nT
Direction of 1st Traverse: 0 deg
Collection Method: ZigZag
Sensors: 2 @ 1.00 m spacing.
Dummy Value: 32702

PROGRAM
Name: TerraSurveyor
Version: 3.0.25.1

Turbine location
Stats
Max: 73.28
Min: -46.54
Std Dev: 6.84
Mean: 0.64
Median: 0.04
Surveyed Area: 1.0005 ha

Processes: 6
1 Base Layer
2 Clip at 5.00 SD
3 De Stagger: Grids: All Mode: Both By: -2 intervals
4 De Stagger: Grids: p12.xgd Mode: Both By: -2 intervals
5 DeStripe Median Sensors: All
6 Interpolate: Match X & Y Doubled.

Access route
Stats
Max: 83.07
Min: -47.86
Std Dev: 8.85
Mean: 0.62
Median: 0.04
Surveyed Area: 0.31495 ha

Processes: 5
1 Base Layer
2 Clip from -41.74 to 37.21 nT
3 De Stagger: Grids: All Mode: Both By: -2 intervals
4 DeStripe Median Sensors: All
5 Interpolate: Match X & Y Doubled.

Cable route
Stats
Max: 60.82
Min: -34.62
Std Dev: 9.14
Mean: 1.24
Median: -0.10
Surveyed Area: 0.0776 ha

Processes: 4
1 Base Layer
2 De Stagger: Grids: All Mode: Both By: -2 intervals
3 DeStripe Median Sensors: All
4 Interpolate: Match X & Y Doubled.

Appendix 4 Geophysical surveying techniques

1 Introduction

Substrata offers magnetometer and earth resistance surveying. We also provide other archaeology-specific geophysical surveys such as ground penetrating radar and resistivity. The particular method or combination of methods used depends on local soil conditions and the survey requirements. These methods are capable of delivering fast and accurate assessments of the archaeology of both large and small sites.

Further details can be found on our website at www.substrata.co.uk.

2 Magnetometer surveying

Standard magnetometer surveys are the workhorse of archaeological surveying when speed and cost-effectiveness are important. Identifiable archaeological features include areas of occupation, hearths, kilns, furnaces, ditches, pits, post-holes, ridge-and-furrow, timber structures, wall footings, roads, tracks and similar buried features.

Magnetometer surveying is used to detect and map small changes in the earth's magnetic field caused by concentrations of ferrous-based minerals within the soil and subsoil, and by materials buried beneath the surface. While most of these changes are too small to affect a compass needle, they can be detected and mapped by sensitive field equipment. During surveys the different magnetic properties of top-soils, sub-soils, rock formations and archaeological features are recorded as variations against a background value. Subsequently magnetic anomalies resulting from potential archaeology can be identified and interpreted.

Bartington grad601-2 gradiometers

A gradiometer is a type of magnetometer and is sensitive to relatively small changes in the earth's magnetic field. Our primary surveying instruments are Bartington Grad601-2 (dual sensor) fluxgate gradiometers with automatic data loggers. They are specifically designed for field use by archaeologists. The Bartington gradiometers provide proven technology in archaeological magnetic surveying and offer fast, accurate set-up and survey rates. They are sensitive to depths of between 0 and 1.5m below ground level, with optimum sensitivity at depths of 1m or less.

Multiple sensor arrays

A technique relatively new to commercial archaeological surveying but well understood in academic circles involves the use of multiple magnetometer sensors towed behind a quad bike or similar vehicle. With multiple sensors and the use of on-board GPS units, it is possible to achieve faster survey rates at competitive commercial rates when compared to the use of multiple instruments and the techniques discussed above provided the ground is suitable for the vehicle and array. Substrata is pleased to announce that we now offer this service on suitable larger sites

3 Earth resistance surveying

Earth resistance surveying is an excellent tool for detecting buried archaeology. Its relatively slow rate of survey compared to magnetometer surveys means that it usually employed in commercial surveys when a detailed understanding of buried building remains is required. This technique measures changes in the electrical resistance of the ground being surveyed. In practice, the recording of differences in the electrical resistance of near-surface deposits and structures allows the detection and interpretation of masonry and brick foundations, paving and floors, drains and other cavities, large pits, building platforms, robber trenches, ditches, graves and similar buried features.

Resistance to electrical current flow in the ground depends on the moisture content and structure of the soil and other materials buried beneath the surface. For example, the higher the moisture content of a soil, the less resistant it is to electrical current flow. A ditch completely buried beneath the present ground surface is likely to have an infill soil different to that surrounding the ditch in terms of compactness and composition. As a result, the soil filling the buried ditch will retain moisture in a different way to the surrounding soil which means it will

have an electrical resistance at variance with the surrounding environment. By passing a small current through the ground it is possible to detect, record, plot and interpret such changes in electrical resistance.

For earth resistance surveying Substrata uses the Geoscan Research RM15 series multi-probe resistance meters and purpose-built automatic data-loggers. The Geoscan MPX15 multiplexer is an integral part to the instrument configuration and facilitates multi-probe arrays which speed up survey area coverage rates and, if required, facilitate simultaneous multiple-depth data collection.