Substrata
Archaeological Geophysical Surveyors

An archaeological gradiometer and earth resistance survey

Land at Dumpdon Camp, Luppitt, East Devon NGR ST 17620401

Report: 120209
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Accompanying CD-ROM

1 Survey description and summary

Type of survey: twin-sensor fluxgate gradiometer
twin probe earth resistance with parallel twin log mode 2(4P)
Date of survey: February and March 2012
Area surveyed: gradiometer survey 1.55ha
earth resistance survey 0.93ha
Lead surveyor: Ross Dean BSc MSc MA MIfA

Clients
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Site

Location:	Land at Dumpdon Camp
Parish:	Luppitt
District:	East Devon
County:	Devon
NGR:	ST 17620401
Scheduled Monument:	SM 29661, HA 1018851
Section 42 licence:	case number SL00024405
OASIS number:	substrat1-122151

This survey was commissioned as part of a Natural England funded Higher Level Stewardship Scheme. The site is a Scheduled Monument (National Monument Number: 29661) in the ownership of the National Trust. The brief was prepared by the National Trust in consultation with Natural England and English Heritage.

Survey purpose
The purpose of the survey was to record the extent and the interpretation of potential buried archaeological features as revealed by geophysical survey to inform the management and interpretation of the hillfort.

Survey objectives
1. Complete a gradiometer and earth resistance survey across the whole interior followed by an earth resistance survey 0.5ha in extent, selected as the most promising area to produce results.
2. Identify any magnetic and resistance 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 archaeological investigation of the location and possible archaeological character of the recorded anomalies.

Results Summary
Referring to figure 3 in appendix 1, both the gradiometer and earth resistance surveys show evidence of possible past subdivision of the internal area of the hillfort. The anomaly patterns concerned may reflect both stony banks or wall footings and ditches that have been disrupted by later phases of ploughing across the site.

There is some evidence for ditches along the internal side of the inner ramparts and across the inner side of the entrance. An alternative explanation is that these anomaly patterns reflect the

later build-up of soils along the ramparts perhaps as a result of ploughing. However, the relevant resistance anomalies in particular are well defined and some of these anomaly groups may reflect a different phase of human activity at the site.

The gradiometer data contains evidence of possible human activity in the form of craft or industrial production such as iron production or pottery production on the eastern side of the internal area of the hillfort.

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 Schmidt (2002). The document text was written using the house style of the Institute for Archaeologists (Institute for Archaeologists, undated).

2 Site description

Landscape
Dumpdon Camp is an Iron Age hillfort located at the southern end of a steep sided ridge at a height of approximately 260m O.D. The hillfort defences enclose a separated triangular-shaped plateau. The northern side, easiest of approach, is most heavily defended with two substantial ramparts and ditches separated by a wide berm. The other sides are protected by a single rampart and ditch and steeper slopes with the only original entrance being a single inturned entrance in the north east part of the site.

Land use
The southern part of the hillfort contains a plantation which probably dates from the early 19th century. The plantation is separated from the rest of the hillfort interior by a low field bank along which now runs a stock proof fence.

The interior of the hillfort has been ploughed in the past but is currently managed as permanent pasture, grazed and cut for silage or hay

Geology
The site is located on a solid geology of Cretaceous Upper Greensand under clay with flints and chert (in part Eocene) (Institute of Geological Sciences, 1984)

Soils
The soils in the survey area are defined as typical brown earths of the Bromsgrove association (Soil Survey of England and Wales, 1983). A typical soil profile is:

0 - 30cm:	dark reddish brown, stoneless sandy loam
30 - 60cm:	reddish brown, stoneless sandy loam; weak coarse subangular blocky structure
60 - 90cm:	reddish brown, slightly stony sandy loam; single grain structure
At 90cm:	soft, weathered reddish brown sandstone

(Findley et al, 1983: 110).

Known archaeological sites in the survey area
The Historic Environment Record used to create the summaries below was provided by Devon County Historic Environment Service in March 2012.

HER records of sites within or immediately adjacent to the survey area:

1877 Dumpdon Hillfort; a small multivallate hillfort of late Iron Age date. Flat topped and triangular shaped with two substantial ramparts and ditches on the northern side and single ramparts on the east and west side.

1878	Possible site of Luppitt Beacon. The visible mound was probably created by the Ordnance Survey.
56629	Two pieces of tap slag found along a footpath 10m south of the car park on the east side of Dumpdon hill. Elsewhere on the Blackdown Hills, this type of slag has been found to date from Roman (1st century AD) to medieval periods.

Historical Landscape Characterisation

Rough ground with prehistoric remains: earthworks in this rough grazing ground, heathland or moorland preserve the remains of a prehistoric landscape (Devon County Council, undated).

Previous archaeological investigations at the site

Small scale archaeological excavations in the area of the southern plantation were undertaken in 1990 after storm damage by tree fall (Todd, M., The Hillfort of Dumpdon, Devon Archaeological Society Proceedings No 50, 1992). The results of this and other observations led the excavator to suggest that the hillfort was never completed or fully occupied (after Blaylock, 2011).

3. Results, discussion and conclusions

The survey was designed to record magnetic and earth resistance 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 attempts to identify and characterise anomalies and anomaly groups that may pertain to archaeological deposits and structures.

The survey methodology is presented in appendix 2. The steep sides of the ramparts in the entrance meant that achieving a high degree of positional accuracy on the earth resistance survey traverses across these earthworks was impossible. While the east-west positioning was accurate, it must be presumed that the north-south positioning could be out by as much as +/- 0.75m on the rampart sides.

The reader is referred to section 4.

3.1 Results

3.1.1 Gradiometer survey

Figure 1 shows details of the interpretation of the gradiometer survey. Table 1 is an extract from a detailed analysis of the data provided in the attribute tables of the GIS project on the accompanying CD-ROM.

Figure 1 and table 1 comprise the analysis and interpretation of the gradiometer survey data.

The processed gradiometer data is presented in figure 4 and a plot of the unprocessed data can be found on the accompanying CD-ROM.

The magnetic contrast across the survey areas was sufficient to be able to differentiate between anomalies representing possible archaeological features and background magnetic responses. Twenty-three anomaly groups representing potential archaeological features or deposits were recorded as shown in figure 1.

Survey data analysis

Site: Land at Dumpdon Camp, Luppitt, East Devon
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anomaly group	associated anomaly group	characterisation certainty	anomaly class	anomaly form	archaeological characterisation	comments	period	supporting evidence
1	2 11	possible	positive	curvilinear	ditch	ditch or build up of soil at edge of bank		
2	1 11	possible	positive	linear	ditch			
3	4 5 6 7	possible	positive		disrupted linear or pits	anomaly trends similar to ploughing trends but standing out in the data and so included as possible archaeology		
4	3 5 6 7	possible	negative	linear		anomaly groups may represent ploughing but they are included as potential archaeology as they stand out in the data		
5	3 4 6 7	possible	positive		disrupted linear or pits	anomaly trends similar to ploughing trends but standing out in the data and so included as possible archaeology		
6	3 4 5 7	possible	positive		disrupted linear or pits	anomaly trends similar to ploughing trends but standing out in the data and so included as possible archaeology		
7	3 4 5 6	possible	positive		disrupted linear or pits	anomaly trends similar to ploughing trends but standing out in the data and so included as possible archaeology		
8		possible	positive		disrupted linear or pits	anomaly trends similar to ploughing trends but standing out in the data and so included as possible archaeology		
9		possible	positive	ovals				
10		possible	positive	subcircular				
11	1 2	possible	positive	linear	ditch	ditch or build up of soil at edge of bank		
12		possible	positive	disrupted linear				
13		possible	positive	disrupted linear		anomaly trends similar to ploughing trends but standing out in the data and so included as possible archaeology		
14		possible	high contrast	irregular	industrial/craft deposits	anomaly group in strong contrast with the rest of the site		
15		possible	positive	irregular				
16	17 18 19	possible	positive	linear	ditch	former Devon bank field boundary disrupted by ploughing		
17	16 18 19	possible	negative	linear	stony deposit	former Devon bank field boundary disrupted by ploughing		
18	16 17 19	possible	positive	linear	ditch	former Devon bank field boundary disrupted by ploughing		
19	16 17 18	possible	mixed	irregular	stony material	likely to be associated with former Devon bank		
20		possible	positive	disrupted linear				
21		likely	negative	linear	stony bank	rampart		extant earthwork
22		possible	negative	subcircular	stony mound	trig point mound		
23		possible	high contrast	irregular	industrial/craft deposits	anomaly group in strong contrast with the rest of the site		
24		possible	dipole		ferrous material			
1001		possible	repeated parallels		cultivation traces (ploughing)			

Table 1: gradiometer data analysis

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Legend

- gradiometer survey area

gradiometer potential archaeology

certainty, class

- likely, negative anomaly
- possible, positive anomaly
- possible, negative anomaly
- possible, high contrast anomalies
- possible, mixed anomalies
- possible, dipole (2, 4)

gradiometer potential archaeological trends

- possible, repeated parallels

Notes:
1. All interpretations are provisional and represent potential archaeological deposits.
2. Representative of trends; only anomalies relevant to potential archaeology are recorded.
3. Anomalies likely to represent very recent ground disturbance are not highlighted.
4. Filled circles used to define anomalies are symbols and do not indicate possible circular archaeological features unless specifically indicated in the text.

0 12.5 25 50
Meters

Figure 1: gradiometer survey interpretation, potential archaeology

3.1.2 Earth resistance survey

Figure 2 shows details of the interpretation of the earth resistance survey. Table 2 is an extract from a detailed analysis of the data provided in the attribute tables of the GIS project on the accompanying CD-ROM.

Figure 2 and table 2 comprise the analysis and interpretation of the earth resistance survey data.

The processed resistance data is presented in figures 5 and 6. A plot of the unprocessed data can be found on the accompanying CD-ROM.

The resistance contrast across the survey areas was sufficient to be able to differentiate between anomalies representing possible archaeological features and background responses. Twenty-eight anomaly groups representing potential archaeological features or deposits were recorded as shown in figure 2.

Survey data analysis
Site: Land at Dumpdon Camp, Luppitt, East Devon
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anomaly group	associated anomaly g	characterisation certainty	anomaly class	anomaly form	archaeological characterisation	comments	period	supporting evidence
25		likely	high	linear	stony bank	edge of rampart		extant earthwork
26		possible	low	linear	ditch	disrupted by NW -SE trending low resistance anomalies		
27		possible	low	curvilinear	ditch			
28		possible	low	ovals		uncertain whether anomalies represent archaeology such as a series of pits or natural deposits		
29		possible	high	subcircular		uncertain whether anomalies represent archaeology or natural deposits		
30		possible	low	ovals		uncertain whether anomalies represent archaeology such as a series of pits or natural deposits		
31		possible	high	linear				
32		possible	low	linear	ditch	tenuous		
33		possible	low					
34		likely	high	curvilinear	stony bank	rampart		extant earthwork
35		possible	low	curvilinear				
36		likely	high	subcircular	stony bank	rampart - unusual shape may be archaeologically sound but centre of feature disrupted by tree bole removal		extant earthwork
37		possible	low	oval		possibly damage caused by tree bole removal		
38		likely	high	linear	stony bank	rampart		extant earthwork
39		possible	low					
40		likely	high	linear	stony bank	rampart		extant earthwork
41		possible	low	linear	ditch			
42		likely	high	linear	stony bank	rampart		extant earthwork
43		possible	low	subcircular		uncertain whether anomalies represent archaeology such as a series of pits or natural deposits		
44		possible	low	subcircular				
45		possible	low	ovals		uncertain whether anomalies represent archaeology such as a series of pits or natural deposits		
46		possible	high	subcircular		sequence of anomalies representing possible archaeology disrupted by ploughing		
47		possible	low	ovals		uncertain whether anomalies represent archaeology such as a series of pits or natural deposits		
48		possible	low	subcircular				
49		possible	low	linear		anomalies may represent a ditch or build up of soil against the extant earthworks		
50		possible	high	subcircular				
51		possible	high	subcircular				
52		possible	high	subcircular	trig point mound	anomalies indicate stony material		
1002		possible	repeated parallels		cultivation traces (ploughing)			
1003		possible	repeated parallels		cultivation traces (ploughing)			

Table 2: earth resistance data analysis

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Figure 2: earth resistance survey interpretation, potential archaeology

3.2 Discussion

The points discussed below are illustrated in figures 1 and 2. Figure 3 in appendix 1 presents the combined interpretations of the gradiometer and earth resistance surveys.

It should be noted that the Ordnance Survey map of the area shown in many of the figures shows only an approximation of the extant earthworks position and shape.

Not all anomalies or anomaly groups characterised in this report are discussed below. All anomaly groups are characterised in tables 1 and 2.

<u>Possible subdivision across the site</u>

Across the survey area a number of gradiometer and earth resistance anomaly patterns hint at former subdivision of the interior of the hillfort. These are the gradiometer anomaly groups 4, 5, 6, 7, 8, 12, 13. 16, 17, 18 and 20 (figure 1) and the closely corresponding resistance anomaly groups 45, 46 and 47 (figure 2). The gradiometer anomalies suggest a pattern of disrupted linear features. The resistance anomaly groups seem to reflect more discrete possible features such as pits or large postholes although this is by no means certain and they too may represent disrupted linear features. This disruption could be due to later ploughing at the site. Of the anomaly patterns, the combined gradiometer anomaly groups 3, 4, 5 and 6 and 16, 17 and 18 are of a pattern normally indicative of the footings and ditches of former Devon Bank field boundaries.

No indications of field boundaries or other subdivisions of the hillfort interior are recorded on the 1842 Tithe Map or any of the later Ordnance Survey maps of the area.

<u>Areas of possible archaeological activity</u>

The large, irregular gradiometer anomaly groups 14 and 23 (figure 1) show a relatively high contrast in anomaly patterns. Such groups can be indicative of past human activity involving industrial or craft activities such as metal working or clay firing for pottery or brick production. Within the context of these anomalies, it should be noted that pieces of tap slag from early iron smelting have been found on the eastern skirts of the hill. Elsewhere on the Blackdown Hills, this type of slag has been found to date from Roman (1st century AD) to medieval periods (Blaylock, 2011).

Gradiometer anomaly group 19 is relatively mixed compared to the rest of the site and may represent deposits of rubble from the possible former Devon Bank indicated by groups 16, 17 and 18 (figure 1).

<u>Entrance area and ramparts</u>

The earth resistance survey completed over the entrance to the hillfort shows a more complex set of banks and ditches than indicated by the extant earthworks. Some of this complexity is likely to be the result of tree root action (resistance anomaly 37 and possibly anomaly 39, figure 2). The apparent return in resistance anomaly 35 may indicate a genuine return in one of the ditches or the anomaly group may indicate the combination of a ditch and the build-up of relatively loose, low resistance material in the entrance over time.

Resistance anomaly groups 27 and 43 (figure 2) are a puzzle. The anomaly group 27 is strongly indicative of a ditch and 43 could be indicative of a disrupted ditch or series of large pits. If they indeed reflect such features then they run across the entrance on its inner side and are contrary to accepted wisdom about the construction of hillforts. Further resistance anomaly groups also appear to reflect short or disrupted ditches on the inner side of the ramparts (resistance groups 26, 32 and possibly 49). A similar situation seems to be the case with the gradiometer anomaly groups 1, 2 and 11 (figure 1). Given the evidence for past ploughing in the resistance and gradiometer data, it is possible that all these groups represent the build-up of soils along the inner ramparts as a consequence of ploughing. Alternatively, if some or all of the anomaly groups do represent former ditches then it may be that the survey has highlighted evidence of a different phase or phases of past human activity separate from the construction of the ramparts still seen today as earthworks.

Gradiometer anomaly groups 3 to 8 and resistance anomaly groups 44 to 47 may represent linear features leading from the entrance (figures 1, 2 and 3). It is impossible to say whether they are related archaeologically to each other or to the entrance but their relative positions invite further archaeological investigation.

Gradiometer anomaly group 22 (figure 1) and resistance anomaly group 52 (figure 2) represent the mound on which an Ordnance Survey triangulation point is placed. While both groups are indicative of a stony mound, there was no evidence of an other archaeological feature in the vicinity of the mound.

3.3 Conclusions

Referring to figure 3 in appendix 1, both the gradiometer and earth resistance surveys show evidence of possible past subdivision of the internal area of the hillfort. The anomaly patterns concerned may reflect both stony banks or wall footings and ditches that have been disrupted by later phases of ploughing across the site.

There is some evidence for ditches along the internal side of the inner ramparts and across the inner side of the entrance. An alternative explanation is that these anomaly patterns reflect the later build-up of soils along the ramparts perhaps as a result of ploughing. However, the relevant resistance anomalies in particular are well defined and some of these anomaly groups may reflect a different phase of human activity at the site.

The gradiometer data contains evidence of possible human activity in the form of craft or industrial production such as iron production or pottery production on the eastern side of the internal area of the hillfort.

4 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.

5 Acknowledgements

Substrata would like to thank Shirley Blaylock of the National Trust for commissioning the survey and for her advice and guidance throughout.

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Appendix 1 Supporting plots

General Guidance

The anomalies represented in the survey plots provided in this appendix are magnetic or earth resistance 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.

A rough rule for interpreting resistance anomalies is that if an x-y trace is drawn of the resistance over an anomaly, then the width of an anomaly at half its maximum height is equal to the width of the buried feature. Caution must be applied when using this rule as it depends on the anomalies being clearly identifiable and distinct from adjacent anomalies and it should be noted that the relationship between change in resistance response and depth is not linear (Gaffney and Gater 2003, 112).

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N

Legend

gradiometer survey area
resistance survey area

gradiometer potential archaeology

certainty, class

- likely, negative anomaly
- possible, positive anomaly
- possible, negative anomaly
- possible, high contrast anomalies
- possible, mixed anomalies
- possible, dipole (2, 4)

gradiometer potential archaeological trends

- possible, repeated parallels

resistance potential archaeology

certainty, class

- likely, high anomaly
- possible, high anomaly
- possible, low anomaly

resistance potential archaeological trends

- possible, repeated parallels (2)

Notes:
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0 12.5 25 50 Meters

Figure 3: gradiometer and resistance survey interpretation, potential archaeology

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N

Legend

gradiometer processed data

Value

High : 2.5

nT

Low : -2.5

0 12.5 25 50 Meters

Figure 4: shade plot of processed gradiometer survey data

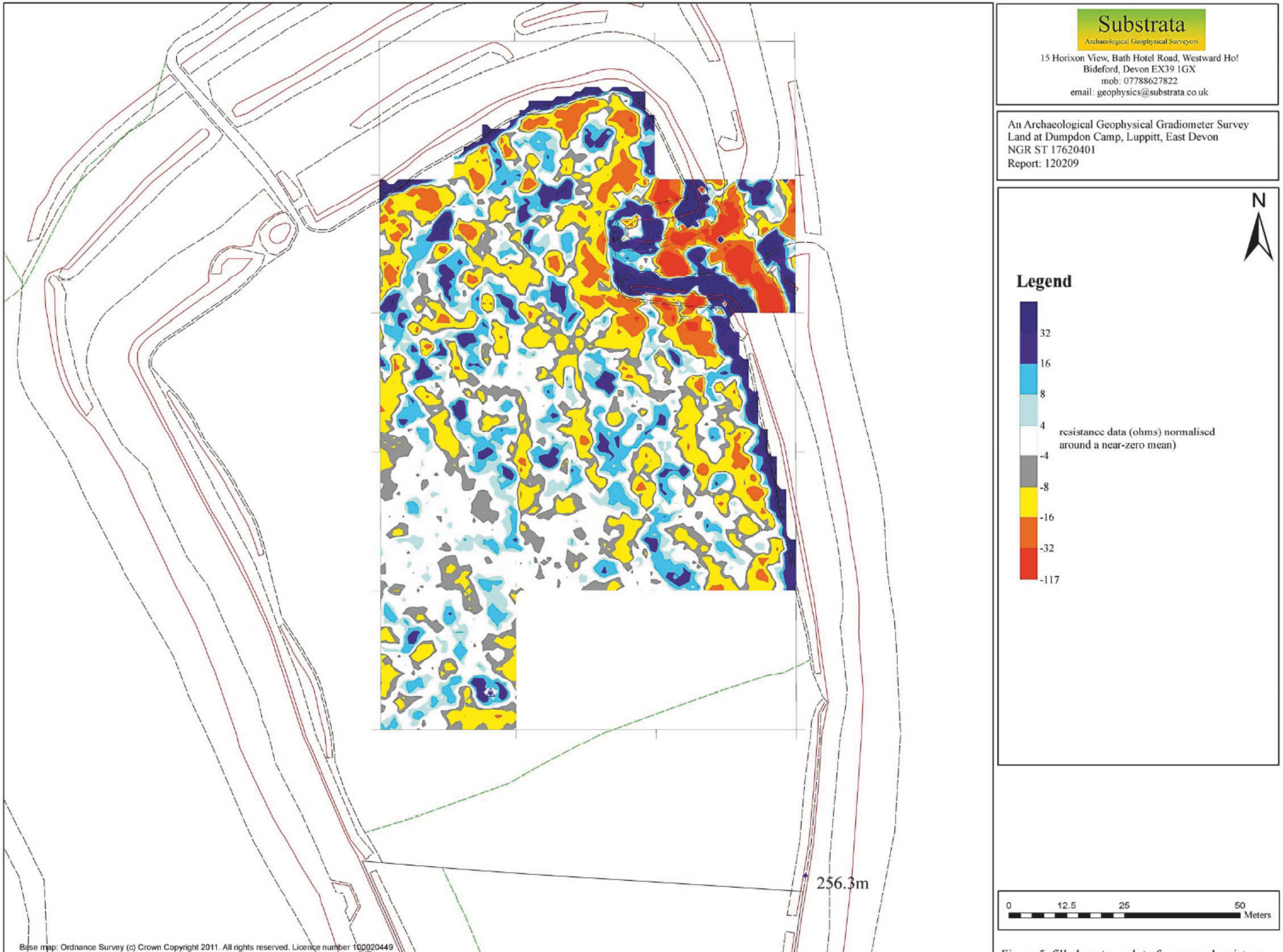

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Figure 5: filled contour plot of processed resistance survey data

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N

Legend

resistance processed data

Value

High : 130

ohms

Low : 60

0 12.5 25 50 Meters

Figure 6: shade plot of processed resistance survey data

Appendix 2 Survey methodology

Table 3: survey methodology	
Documents Brief and minimum specification: supplied by the National Trust (Blaylock, 2011) Project design: Dean (2011)	
Methodology 1. The work was undertaken in accordance with the project design. The geophysical (gradiometer) survey was undertaken with reference to standard guidance provided by the Institute for Archaeologists (2011) and Schmidt (2002). 2. The survey used a temporary survey grid accurately positioned using a suitable DGPS system, co-registered to the Ordnance Survey National Grid using a digital map. The survey grid was composed of continuous 30m by 30m sub-grids. 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:* 30–metre by 30-metre grids *Recording:* Geo-referenced and recorded using digital map tiles. *Traverse Orientation:* grid north	
Data processing, analysis and presentation software DW Consulting ArcheoSurveyor2 ArcGIS 9.3 Golden Software Inc. Surfer 8 Autodesk AutoCAD 2004LT Microsoft Corp. Office Publisher 2003.	
Gradiometer survey equipment and data capture *Instrument:* Bartington Instruments grad601-2, *Firmware:* version 6.1 *Sample Interval:* 0.125-metres, *Traverse Interval:* 1-metre, *Traverse Method:* zig-zag	
Earth resistance survey equipment and data capture *Instrument:* Geoscan Research RM15/MPX15 twin probe earth resistance with parallel twin log mode 2(4P), *Firmware:* RM15 Adv. 30000 Version 2.00 *Sample Interval:* 1-metres, *Traverse Interval:* 1- metre, *Traverse Method:* zigzag	
Earth resistance instrument settings: *Gain*: x 1 *Current:* 1 mA *Frequency:* 137 Hz *Output voltage:* 40 V *Auto-log speed:* medium *High pass filter:* 13 Hz *Mains frequency:* 50 Hz	 *Hardware:* PA5 *Interface:* MPX15 *Log mode:* parallel twin *Parallel reads:* 2(4P) *Baud rate:* 9600 *Data separator:* no space

Appendix 3 Data processing

Table 4: survey data processing - gradiometer processed data metadata (figure 4)
Software: DW Consulting ArcheoSurveyor2 v 2.5.11.0
Stats Max: 244.77 Min: -243.84 Std Dev: 6.51 Mean: 0.18 Median: 0.00 Surveyed Area: 1.5498 ha Processes: 6 1 Base Layer 2 Clip at 4.00 SD 3 De Stagger: Grids: dg10.xgd dg18.xgd dg11.xgd dg17.xgd dg12.xgd dg15+dg16.xgd dg13.xgd dg14.xgd Mode: Both By: -6 intervals 4 De Stagger: Grids: dg19.xgd Mode: Both By: -6 intervals 5 De Stagger: Grids: dg26.xgd dg27.xgd Mode: Both By: -6 intervals 6 DeStripe Median Sensors: All

Table 5: survey data processing - earth resistance processed data - high pass filter metadata (figure 5)
Software: DW Consulting ArcheoSurveyor2 v 2.5.11.0
Stats Max: 198.74 Min: -116.57 Std Dev: 21.19 Mean: 1.02 Median: -1.93 Surveyed Area: 0.934 ha Processes: 4 1 Base Layer 2 Despike Threshold: 1 Window size: 3x3 3 Clip from 60.00 to 330.00 Ohm 4 High pass Gaussian filter: Window: 21 x 21

Table 6: survey data processing - earth resistance processed data metadata (figure 6)	
Software: DW Consulting ArcheoSurveyor2 v 2.5.11.0	
Stats	
Max:	330.00
Min:	60.00
Std Dev:	39.01
Mean:	107.59
Median:	96.81
Surveyed Area:	0.934 ha
Processes:	3
1 Base Layer	
2 Despike Threshold: 1 Window size: 3x3	
3 Clip from 60.00 to 330.00 Ohm	

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. The gradiometers (a type of magnetometer) and resistance meters employed are sensitive to depths of between 0 and 1.5m below ground level, with maximum sensitivity at depths of 1m or less.

2 Magnetometer surveying

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 magnetised 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. 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.

A gradiometer is a type of magnetometer and is sensitive to relatively small changes in the earth's magnetic field. Substrata uses two types of gradiometer both specifically designed for field use by archaeologists. Our primary surveying instruments are Bartington *Grad*601-2 (dual sensor) fluxgate gradiometers with automatic data loggers. We also use a Geoscan FM36 fluxgate gradiometer with the option of either manual or automatic sampling triggers. The Bartington gradiometers provide proven technology in archaeological magnetic surveying and offer fast, accurate set-up and survey rates. The Geoscan FM36 provides an effective, if older, solution when surveys are required within woodland and other areas of limited accessibility.

3 Earth resistance surveying

This method measures changes in the electrical resistance of the ground being surveyed. In practice, differences in the electrical resistance of materials facilitates the detection and interpretation of masonry and brick foundations, paving and floors, drains and other cavities, large pits, building platforms, robber trenches, timber structures, 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 multi-probe resistance meters and purpose-built automatic data-loggers. The MPX15 multi-probe facility can be used to speed up standard surveys and it is also useful when simultaneous multiple-depth analysis is required.