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STONEHENGE RIVERSIDE PROJECT, WEST AMESBURY AND GREATER CURSUS, WILTSHIRE
REPORT ON GEOPHYSICAL SURVEYS, JULY 2006

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ARCHAEOLOGICAL SCIENCE

ENGLISH HERITAGE

STONEHENGE RIVERSIDE PROJECT, WEST AMESBURY AND GREATER CURSUS, WILTSHIRE

Report on Geophysical Surveys, July 2006

Introduction

Geophysical surveys were conducted over part of the western section of the Stonehenge Greater Cursus and the possible continuation of the Stonehenge Avenue at West Amesbury in support of the Stonehenge Riverside Project. This landscape research project focuses on the significance of the River Avon in relation to Stonehenge and surrounding monuments, including the henges and timber circles of Woodhenge and Durrington Walls (Parker-Pearson 2000; Parker-Pearson and Ramilisonina 1998; Parker-Pearson *et al.* 2004).

The aim of the survey at West Amesbury was to investigate the course of the Stonehenge Avenue (SAM 10390) in the vicinity of the River Avon (centred on NGR SU 142414). A survey over the western section of the Greater Cursus (SAM 10324) immediately to the east of the Fargo Plantation (centred on NGR SU 113429) was also conducted to explore the environs of a small henge monument (SAM 10363; NGR SU 11244279), situated just within the boundary of the wood, and examine an area where finds of blue-stone chips have previously been reported (Richards 1990; Stone 1947).

Both sites lie on well drained calcareous silty soils of the Andover 1 and Upton 1 associations (Soil Survey of England and Wales 1983) developed over Cretaceous Upper Chalk at the Cursus and drift deposits of Valley Gravel over chalk at West Amesbury (Geological Survey of England and Wales 1950, Geological Survey of Great Britain 1959). The sites were both under grass at the time of the survey, as an extended garden at West Amesbury and grazed by cattle at the Cursus, and were conducted during a prolonged period of warm and dry sunny weather which had caused considerable moisture loss from the soil.

Method

Magnetometer surveys were carried out at both the West Amesbury and Greater Cursus sites with Bartington Grad601 fluxgate gradiometers over a series of 30m grid squares (Figures 1 and 9) set out using a Trimble 4800 series differential Global Positioning System (GPS). Readings were recorded at intervals of 0.25m along north-south orientated traverses spaced 1.0m apart using the 200 nanotesla per metre (nT/m) range setting of the magnetometer. Minimal post acquisition processing was applied to the data beyond setting each traverse to a zero mean, to remove directional sensitivity and instrument drift, and reduction of extreme values in the data caused by iron objects using range truncation (cutting off values above and below the limits of +/- 150 nT/m). The resulting data is presented on Figures 2, 5 and 10-13 in the form of trace and greyscale plots. The magnetic data from the Cursus survey presented in Figure 12 was further processed to remove localised strongly magnetic responses from near surface ferrous material (iron “spikes”) by the use of a 2m by 2m thresholding median filter (Scollar *et al.* 1990) to improve the definition of weaker anomalies.

In addition, a trial earth resistance survey was undertaken over 5 of the 30m grid squares at the Avenue site (Figure 1) using a Geoscan MSP40 wheeled square array system (Walker *et al.* 2005; Walker and Linford 2006). Two electrode orientations of the square array (alpha and beta data-sets with a 0.75m electrode separation) were collected simultaneously using a multiplexer at 0.5m sample intervals along parallel traverses separated by 1.0m.

Data-sets acquired with the square array can exhibit some directional sensitivity, especially to near surface structures (Aspinall and Saunders 2005) and were compared with a subsequent twin electrode earth resistance survey (Figures 6 and 8) conducted by Bournemouth University (Welham in prep.).

The earth resistance data contains a considerable amount of noise due to high contact resistance between the ground surface and the wheeled electrodes, caused by the very dry conditions prevailing at the time of the survey. This has led to numerous extreme values in the data that have been suppressed by the application of a 1.0m radius ‘despiking’ median thresholding filter for noise removal (Scollar *et al.* 1990). The data from both alpha and beta probe configurations is presented in the form of trace and greyscale plots on Figure 6 with the equivalent twin electrode data supplied by Bournemouth University for comparison. An additional 1.0m radius Gaussian low pass filter was also applied to reduce the influence of high frequency noise and emphasize larger scale anomalies (Figures 3, 6(ii) and 6(iv)).

Results

Graphical summaries of the significant geophysical anomalies discussed in the text are provided on Figures 7 and 14. Specific magnetic and earth resistance anomalies are identified in the text and interpretation plans by the prefixes **[m]** and **[r]** respectively.

The Avenue

For some 167m at the eastern end, between the river Avon and the site of George Smith’s 1973 excavation north of West Amesbury House, the course of the Avenue is imprecise (Cleal *et al.* 1995; Smith 1973). The scheduling records (monument record 10390) state that the banks of the Avenue are preserved within an area of post-Medieval garden earthworks south of West Amesbury House running to within 20m of the River Avon, but this later activity is likely to obscure any traces of the earlier monument in this area. Where previously excavated the Avenue ditches have been found to vary considerably in width and depth and the less well preserved sections would present difficult targets for geophysical detection (Clay 1927; Vatcher and Vatcher 1968), particularly if overlain by later earthworks.

Given the above conditions, not unexpectedly the geophysical evidence for the presence of the Avenue at West Amesbury is largely inconclusive.

Magnetometer survey

A linear magnetic anomaly [Figure 7, **m1**] follows the approximate (NNW-SSE) alignment of the Avenue recorded to the north of the survey (Figure 5). However, **[m1]** is suggestive of a relatively modern feature, such as a buried brick wall foundation and not the expected response from the Avenue, unless the ditches had been previously excavated and back-filled with modern material. A similar anomaly **[m2]** heads west from **[m1]** and subsequent twin electrode earth resistance survey by Bournemouth University produced a high resistance response in the case of **[m1]** and a low resistance response over **[m2],** suggesting a buried wall foundation and a service trench of relatively modern origin.

A number of weaker ditch-type (positive linear) responses [**m3-6**] are present in the magnetometer survey, but are not apparently related to the presumed course of the parallel Avenue ditches extrapolated from observations of the monument to the north. These anomalies are more likely to represent property or field boundaries or drainage features of more recent, perhaps Medieval, origin. To the east of the survey area **[m4]** and **[m5]** coincide with a linear topographic feature that appears to be associated with Medieval or post-Medieval occupation indicated on the RCHME earthwork plan (Figure 7). Other magnetic anomalies recorded in the area include a number of localised positive pit type responses **[m7-10**], possibly also associated with earthwork platforms or hollows (Figure 7).

Several slight approximately parallel linear topographic features recorded in the south of the survey area, roughly on the expected line of the Avenue, have no discernable geophysical response. Further to the north the geophysical evidence for a more recent brick wall foundation suggested by [**m1**] is likely to have obscured the survival of any prehistoric earthworks.

Some large scale and strongly magnetic ferrous responses are also present [**m11-14**] and are characteristic of large near surface iron objects, including a steel fenced enclosure constructed to protect a tree from livestock [**m12**]. Further strong magnetic disturbance occurs over the course of a ferrous pipe at [**m15**], parallel to the modern road through West Amesbury, and concentrations of smaller intense magnetic responses at [**m16-17**] may relate to areas of burning (possibly recent bonfire sites) or dumps containing ferrous waste. Extensive areas of ferrous magnetic disturbance [**m18-19**] appear to coincide with recent dump deposits identified on the earthwork plan directly north of the hollow containing the spring feeding the Avon (Figure 7).

Earth resistance

The success of this survey was limited on account of the high contact resistance caused by the very dry ground conditions, resulting in poor probe contact which introduced a large amount of noise spikes into the data. Given these adverse conditions very little information can be gleaned from the square array data, but some concordance can be found between these results, the earthwork evidence and the subsequent Bournemouth University twin electrode survey.

In the square array survey, the only significant geophysical response is a low resistance linear anomaly at **[r1]** that corresponds with a prominent north-south linear scarp visible in the hachured RCHME plan (Figure 7), interpreted as a Medieval field or later garden layout boundary (D Field *pers. comm.*). To the south, close to the river Avon, an area of slightly raised resistance **[r2]** is found that contrasts with lower background values. It is difficult to attach too much significance to **[r2]**, but the anomaly lies approximately in the centre of the projected alignment of the Avenue towards the river.

Comparison of the MSP40 data with the twin-electrode survey, conducted at a later date, suggests the wheeled electrode system is less well suited to dry sites on free draining river gravels when soil moisture conditions are poor. This is particularly evident over areas of more undulating terrain where the surface topography and free draining gravel may also have contributed to poor electrode contact with the ground. Correlation of anomalies between the two surveys is limited and it is of interest to note that whilst the anomaly at **[r1]** is resolved in both surveys, the low resistance response in the square array data is reversed in the twin electrode data (Figure 6). This may well be due to a "paradoxical" geophysical response where a high resistive feature close to the ground surface has constrained the lines of current flow to pass under the structure. The resulting drop in current density at the surface produces a low resistance response when the probe array is centred over the resistive structure (Scollar *et al* 1990, 350-51). The square array system may, perhaps, be more prone to such paradoxical responses due to the close proximity of the four probes compared to the twin electrode system. This is an area that would require more study to demonstrate conclusively however.

The Stonehenge Greater Cursus

The Cursus was first recorded by William Stukeley in 1723 and his drawings show the full length of the earthwork with the Amesbury 42 long barrow lying beyond the eastern end. A combination of agricultural erosion and more deliberate destruction have since levelled approximately 40% of the length of the Cursus, particularly the section both within and east of Stonehenge Bottom. A section of the Cursus east of Fargo Plantation is well preserved for a distance of 1100m including the area covered by the current survey.

Magnetometer survey

The magnetic data from the area immediately south of the Cursus and directly east of the Fargo Plantation is dominated by a high density of small scale intense dipole responses, characteristic of a considerable quantity of ferrous litter having been discarded over the area during the relatively recent past (Figures 10, 11 and 12). This material could be linked to previous more widespread military activity on Salisbury Plain or the previous use of the area as a temporary camp site by convoys of vehicles visiting Stonehenge for the summer solstice festivities. Figure 13 shows the data following processing to remove the iron "spikes" and improve the identification of weaker magnetic anomalies in this area, including a number of linear negative magnetic responses **[m20]** that correspond to vehicle ruts in the ground.

To the north the Cursus can clearly be seen as two well defined and largely continuous positive linear magnetic anomalies [**m21** and **m22**] that corroborate the representation of the earthworks on the Ordnance Survey mapping (Figures 13 and 14). A series of more diffuse positive linear magnetic responses [**m23-24**] running parallel to the course of the south ditch may represent the remnants of the internal bank of the southern side of the Cursus, or possibly a negative lynchet similar to a feature identified to the west within the former area of the Fargo Plantation (Richards 1990). A more tentative linear anomaly [**m25**] is present inside the northern Cursus ditch.

Within the area bounded by the two ditches of the Cursus, a cluster of localised positive pit-type anomalies [**m26**] are found. However, due to the concentration of ferrous disturbance to the south of the monument and through the Fargo Plantation it is difficult to determine whether similar weakly magnetic responses exist in the area of the survey beyond the Cursus. Such anomalies are relatively common over chalk and have, in the past, been proved through excavation to be of either significant archaeological or natural origin (Richards 1990; 109-116, 159-163).

Where the Cursus extends west through the cleared area of Fargo Wood, the amount of ferrous disturbance increases, but the intense magnetic anomalies are larger and more widely spaced. These are possibly indicative of the former positions of cleared trees and ferrous contamination linked to their removal. The response to the former boundary fence along the eastern side of Fargo Plantation is also evident as a wide linear band of intense magnetic disturbance [**m27**], suggesting that the ferrous footings of the fence are still in situ. Whilst still visible the ditches of the Cursus are less well defined in proximity to the boundary fences of the Fargo Plantation to the north and south. The remnants of a metal fence that once ran along the southern side of the Cursus produce an intense linear ferrous magnetic response [**m28**], running for a distance of approximately 50m east from the eastern boundary of Fargo Wood before fading out. Finally, a broad weak curvilinear positive magnetic anomaly [**m29**] to the north-east may be of archaeological significance, but is not fully described by the extent of the current survey coverage.

Conclusions

Evidence for the extension of the Avenue in the field between the River Avon and West Amesbury House is inconclusive and is not supported by the current geophysical survey data. Although ditch-type archaeological anomalies are present in the magnetic data, the position and orientation of these anomalies would strongly suggest that they represent a combination of recent service trenches, drainage features and later, possibly Medieval to post-Medieval, land boundaries and garden layouts. The earth resistance data are similarly uninformative; where the only obvious linear anomalies in the data relate to extant earthworks of probable Medieval or later origin and a recent property boundary. It seems likely that the extremely dry ground conditions did not favour the use of a wheeled earth resistance system and the subsequent twin-electrode survey conducted by Bournemouth University provided better correlation with the extant earth work features. However, the variation between the resistance results may also be due to increased rain fall at the site between the two surveys and, perhaps, the differing response of the systems over undulating terrain.

More success was encountered during the magnetic survey over the Cursus where significant archaeological anomalies were detected despite the recent litter of small scale magnetic disturbance typical of the Stonehenge area, boundary fences and tree felling disturbance through the Fargo Plantation. Both the north and south ditches of the Greater Cursus appear to be continuous in this section of the monument and were identified together with a possible loose cluster of pits. The position of these pit-type anomalies on the line of the Cursus may be significant, although due to the wider ferrous disturbance it is difficult to establish whether similar responses, perhaps of natural origin, are not more prevalent elsewhere throughout the survey. Despite being close to a scattered group of Bronze Age round barrows (SAM Nos. 10338, 10339 and 10340) located to the south, east and west of the southern limit of the survey coverage, the site of a henge monument in Fargo Wood (SAM 10363) and a scatter of blue-stone chips, there is no evidence in the magnetometer data for any significant anomalies in the area to the south of the Cursus.

Note

Due to errors introduced by the copying process it was not possible to achieve a precise match between the non-digital RCHME survey and the geophysical results tied to the modern digital OS mapping, but the two plans could be overlain sufficiently well to assess the relationship between the two sets of evidence.

Surveyed by: L Martin
A Payne

Date of survey: 24-28/7/2006

Reported by: A Payne

Date of report: 21/6/2007

Geophysics Team,
English Heritage.

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Figure 14 Graphical summary of significant magnetic anomalies from the Stonehenge Greater Cursus area superimposed over the base OS map (1:2500).

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Figure 1

STONEHENGE AVENUE, WEST AMESBURY, WILTSHIRE

Location of Geophysical Surveys, July 2006

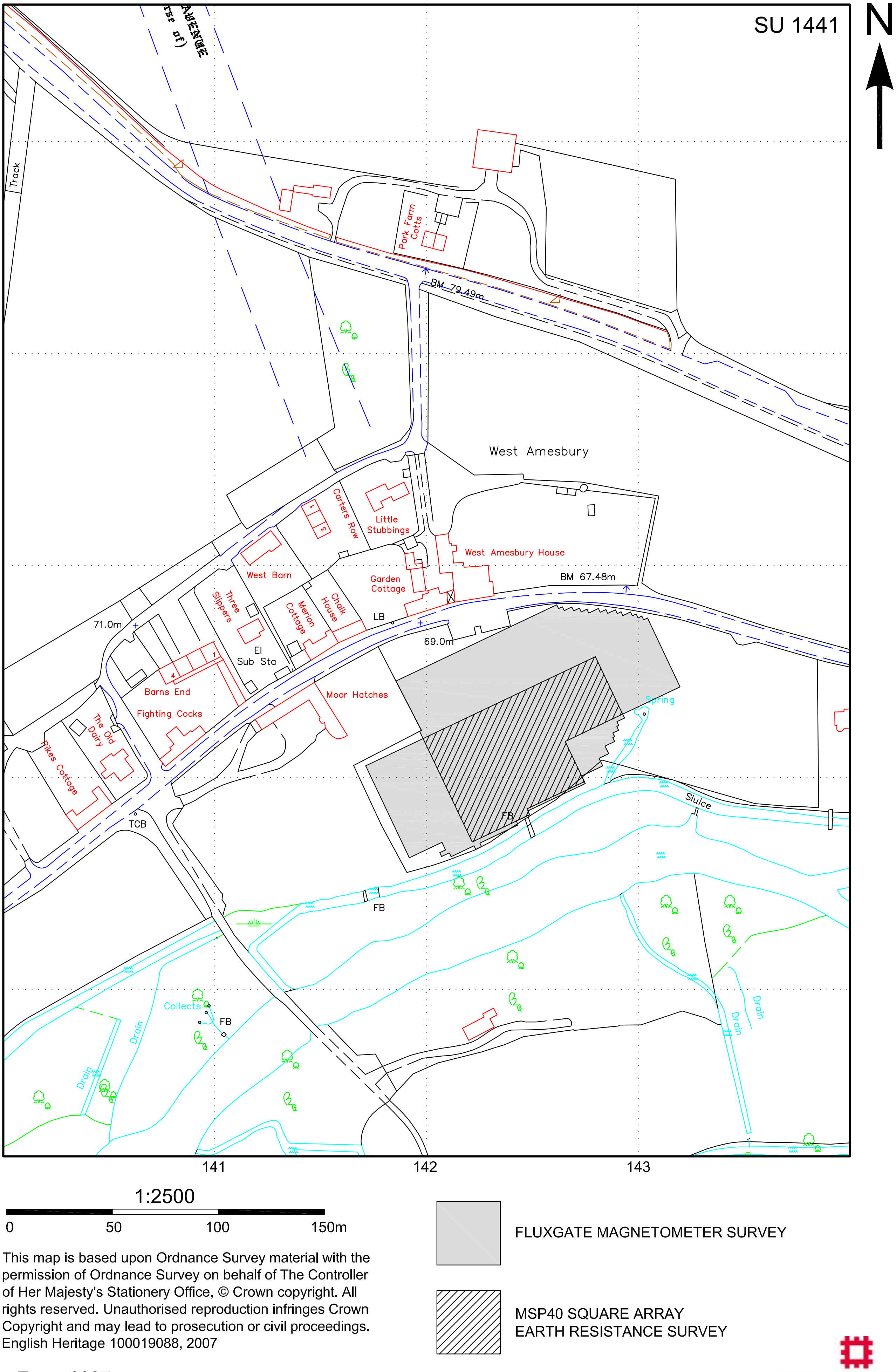

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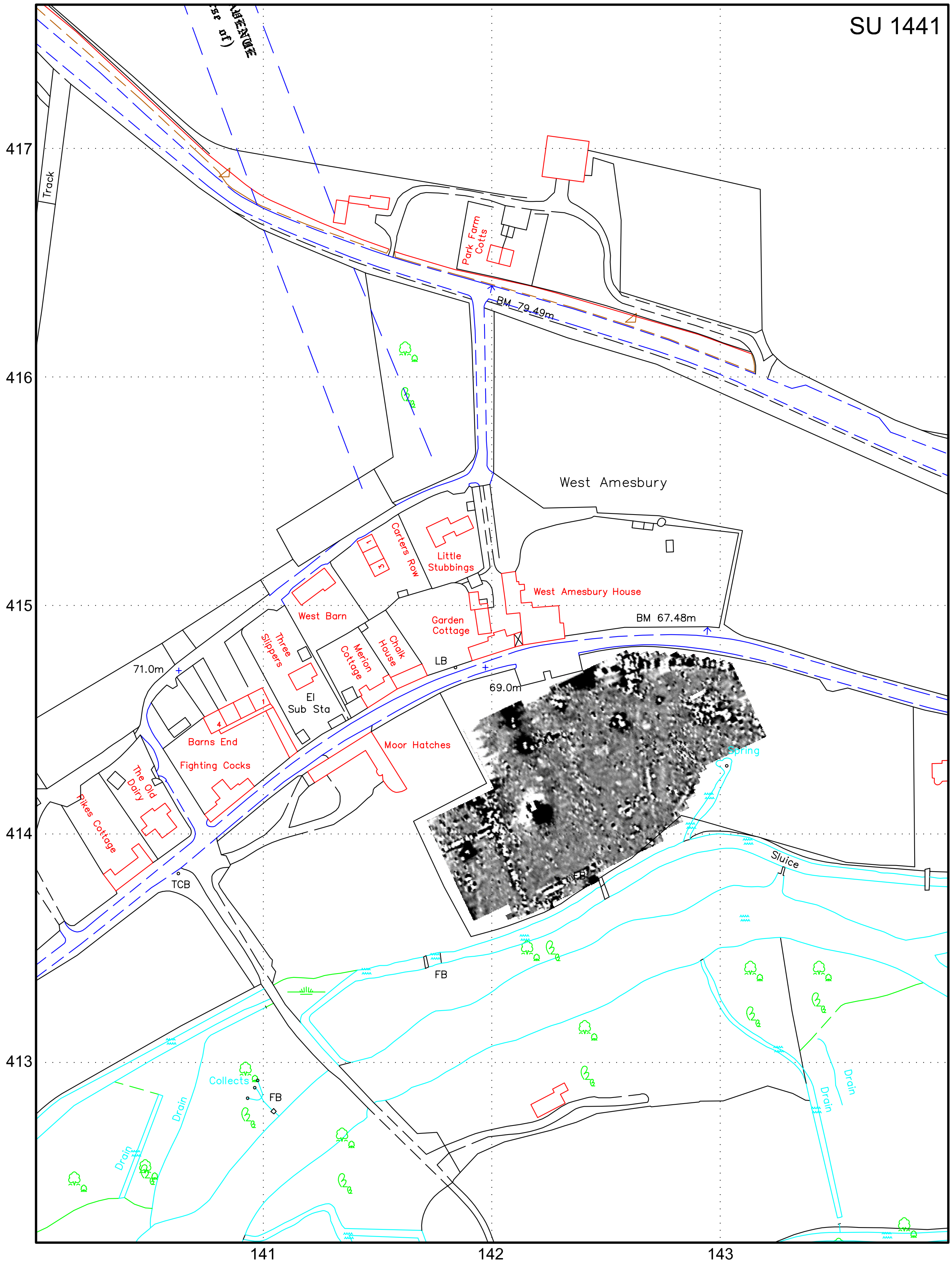
Figure 2

STONEHENGE AVENUE, WEST AMESBURY, WILTSHIRE

Fluxgate Magnetometer Survey, July 2006



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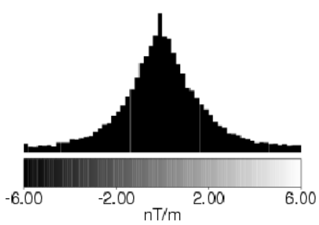

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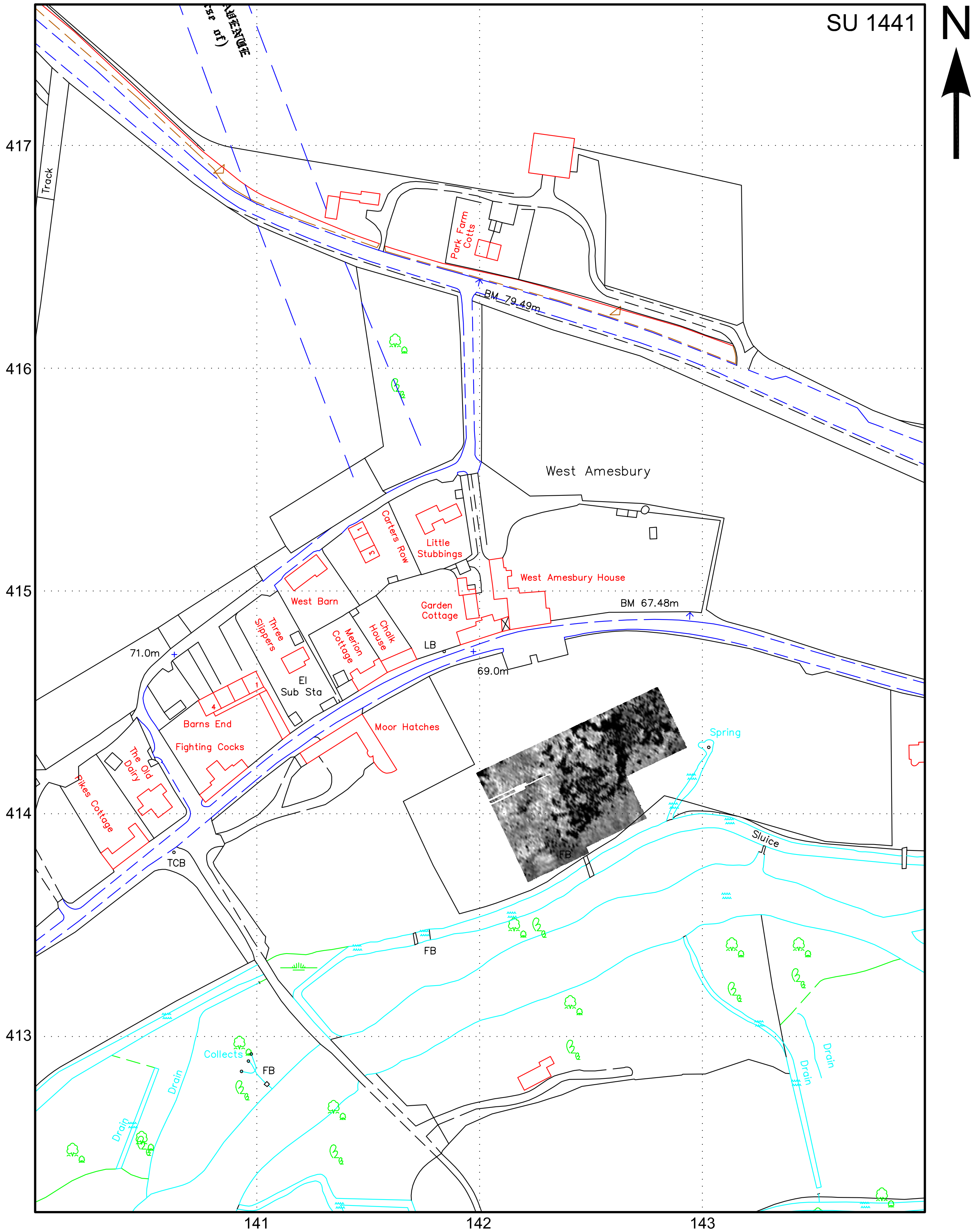
STONEHENGE AVENUE, WEST AMESBURY, WILTSHIRE

Square Array Earth Resistance Survey (beta data-set), July 2006



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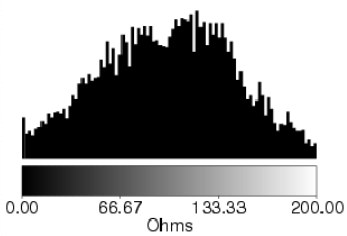

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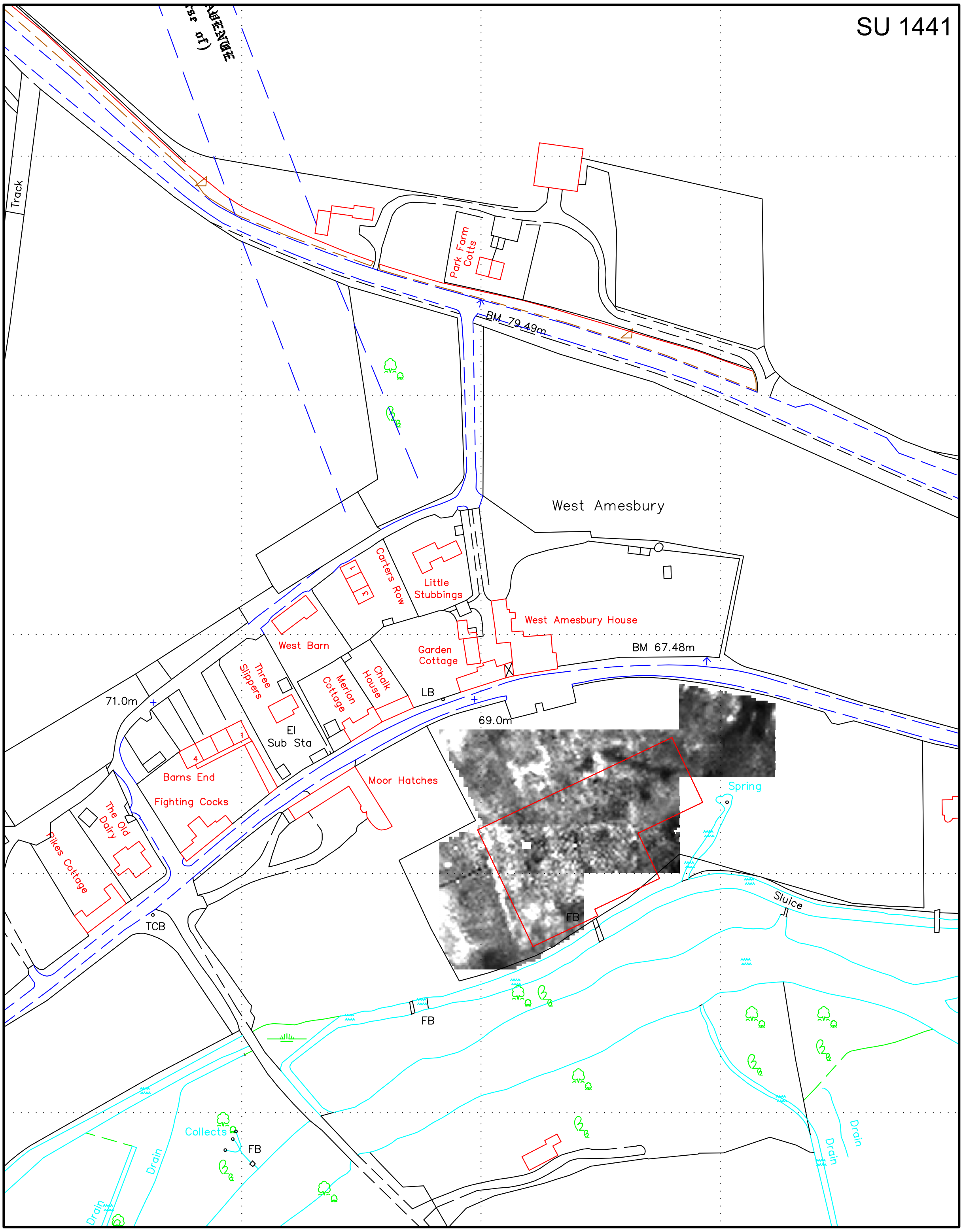
Figure 4

STONEHENGE AVENUE, WEST AMESBURY, WILTSHIRE

Twin electrode earth resistance survey in relation to square array survey area

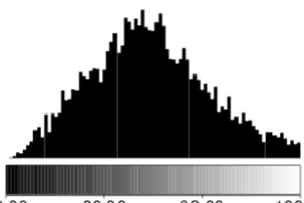


SQUARE ARRAY EARTH RESISTANCE SURVEY AREA

Twin electrode data reproduced courtesy of Bournemouth University

1 : 2500

0 50 100 150m



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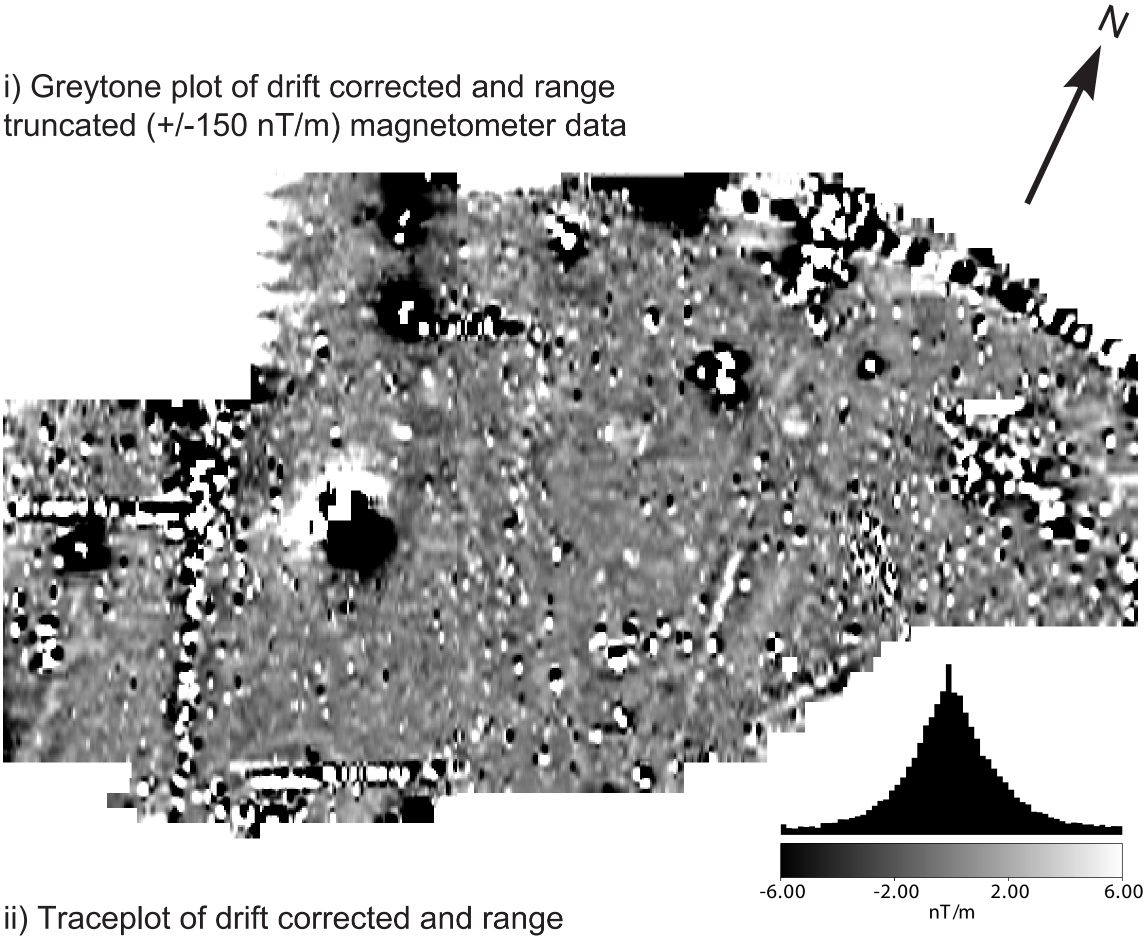
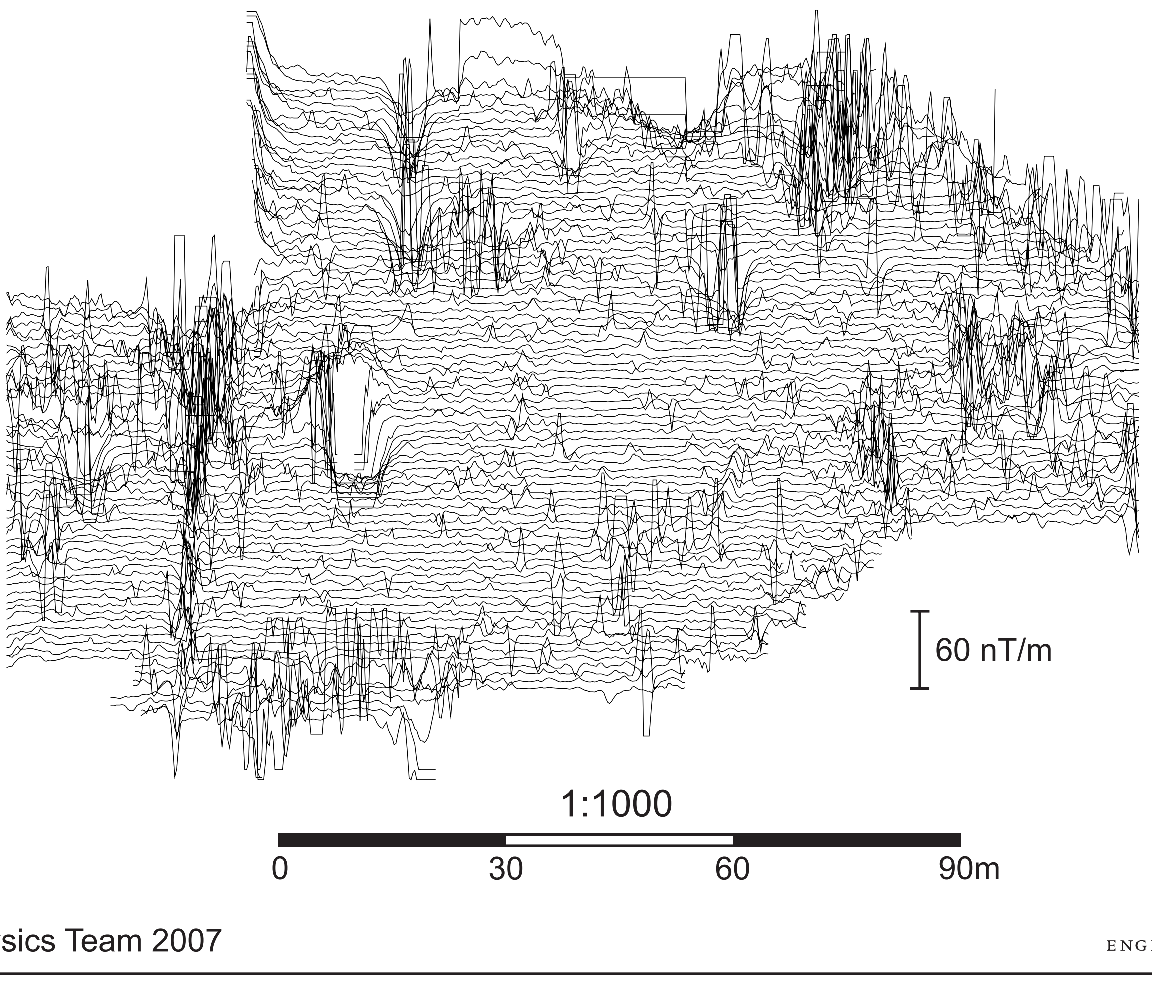
STONEHENGE AVENUE, WEST AMESBURY, WILTSHIRE
Fluxgate Magnetometer Survey, July 2006

i) Greytone plot of drift corrected and range truncated (+/-150 nT/m) magnetometer data



ii) Traceplot of drift corrected and range truncated (+/-150 nT/m) magnetometer data



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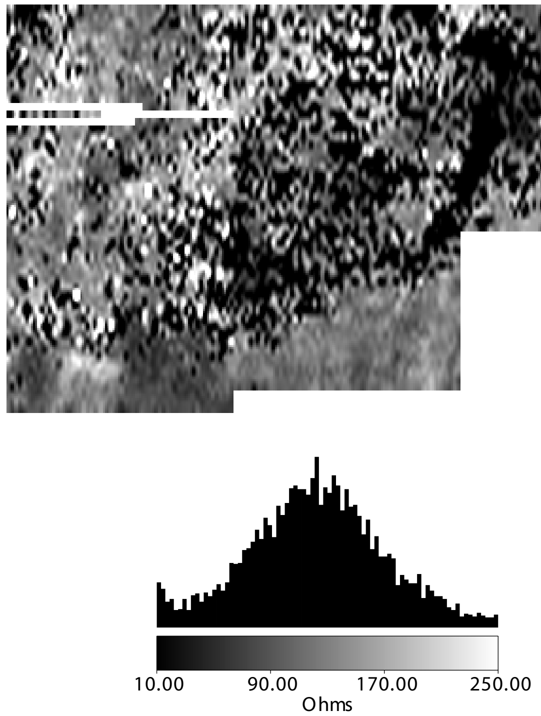
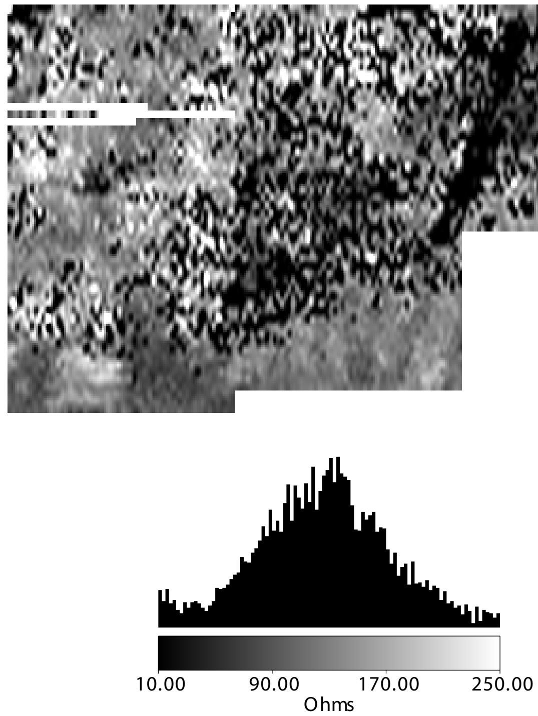
STONEHENGE AVENUE, WEST AMESBURY, WILTSHIRE Earth Resistance Surveys, July and September 2006

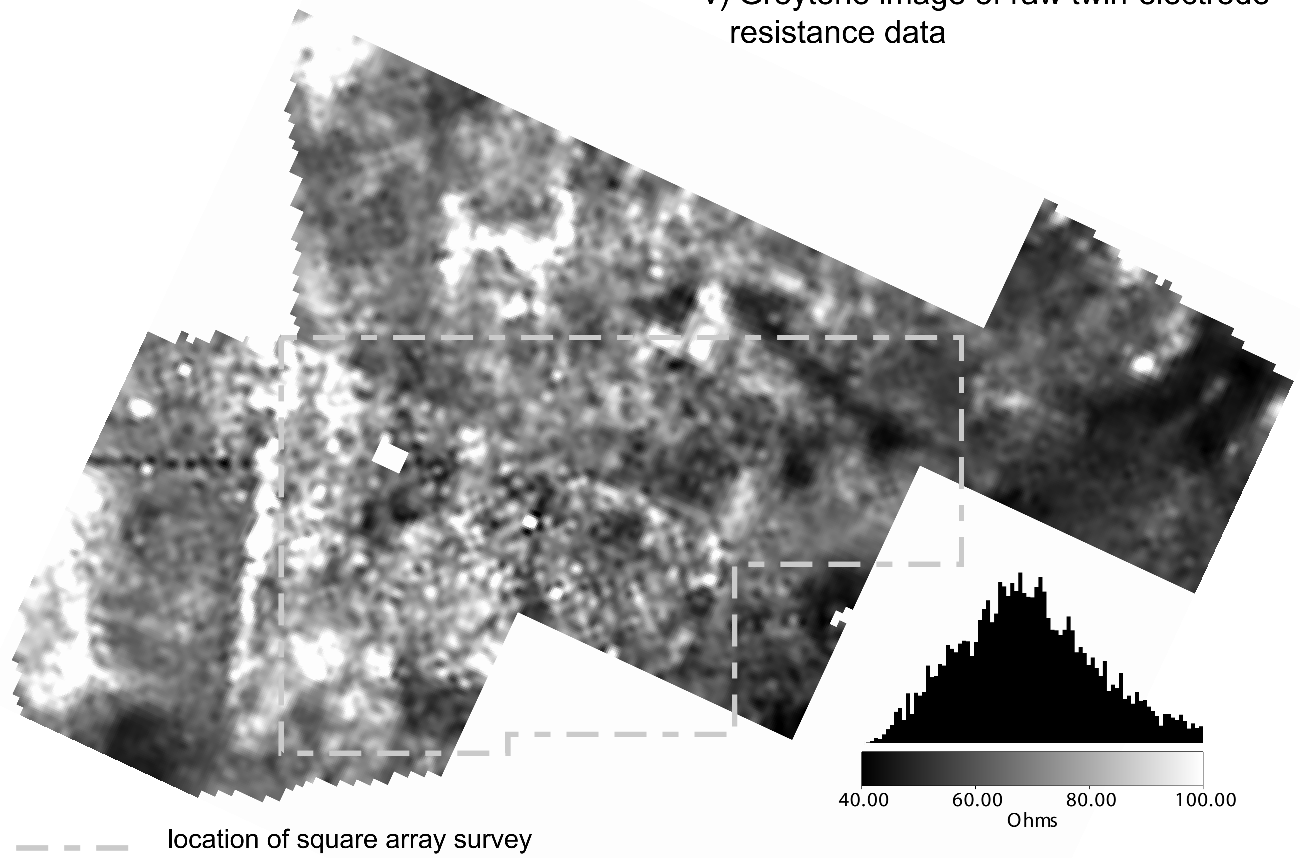
i) Greytone image of 'despiked' alpha square-array resistance data



iii) Greytone image of 'despiked' beta square-array resistance data

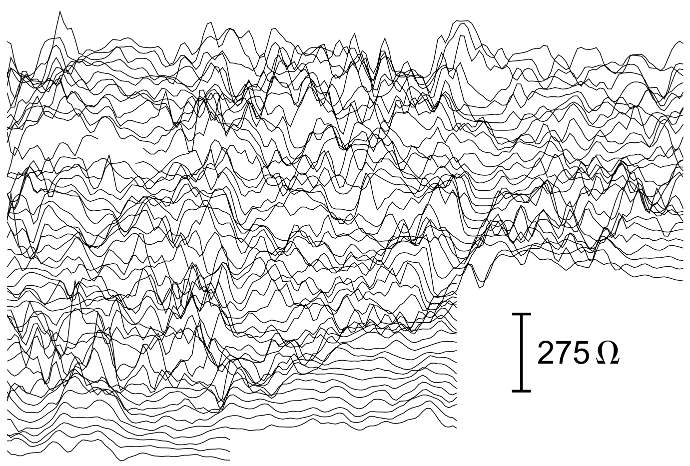


v) Greytone image of raw twin-electrode resistance data

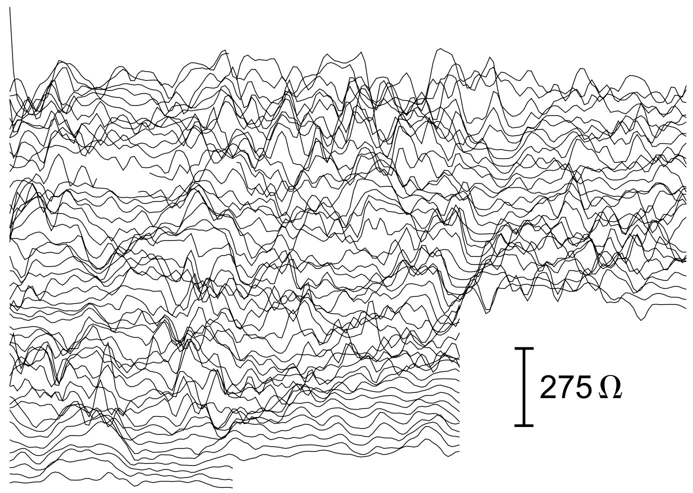


location of square array survey relative twin electrode coverage

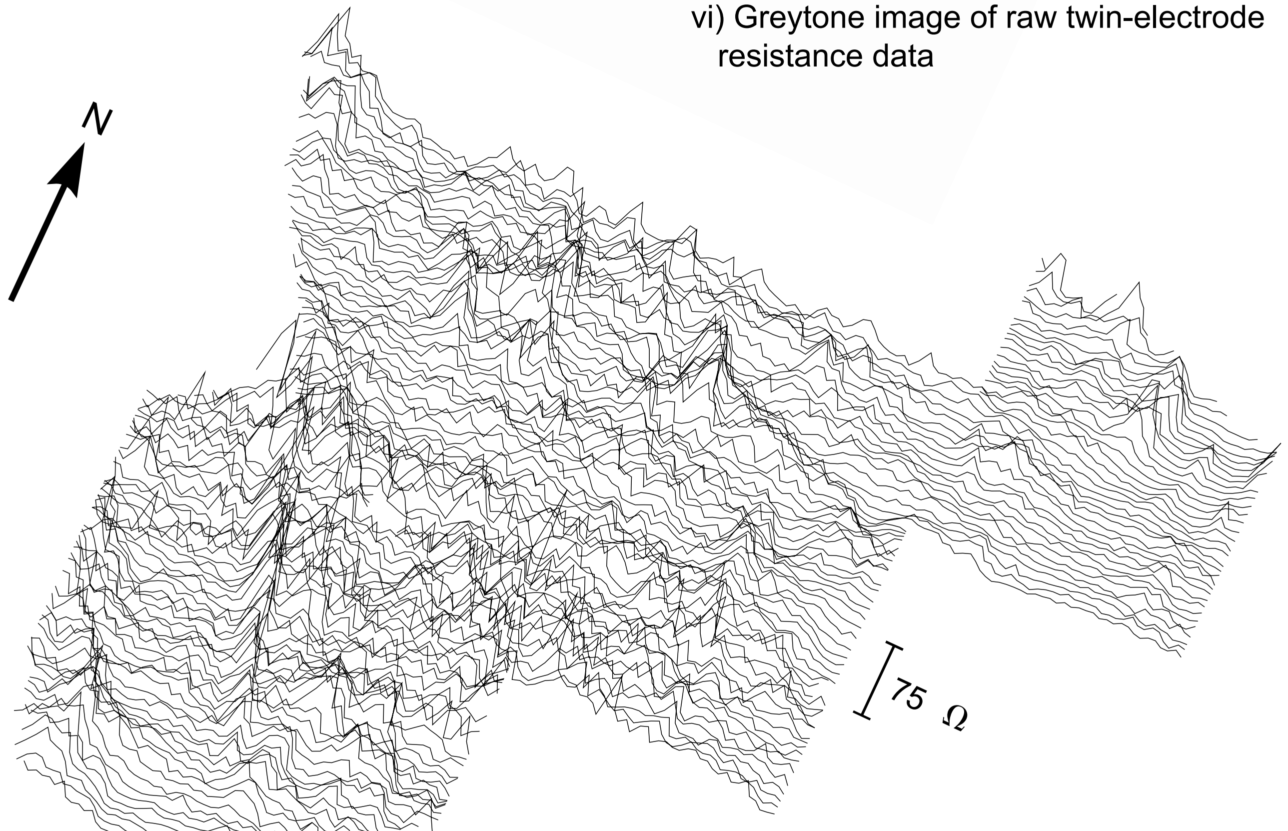
ii) Traceplot of 'despiked' and low pass filtered alpha square-array resistance data

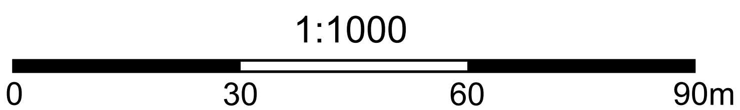


iv) Traceplot of 'despiked' and low pass filtered beta square-array resistance data



vi) Greytone image of raw twin-electrode resistance data





Twin electrode data reproduced courtesy of Bournemouth University

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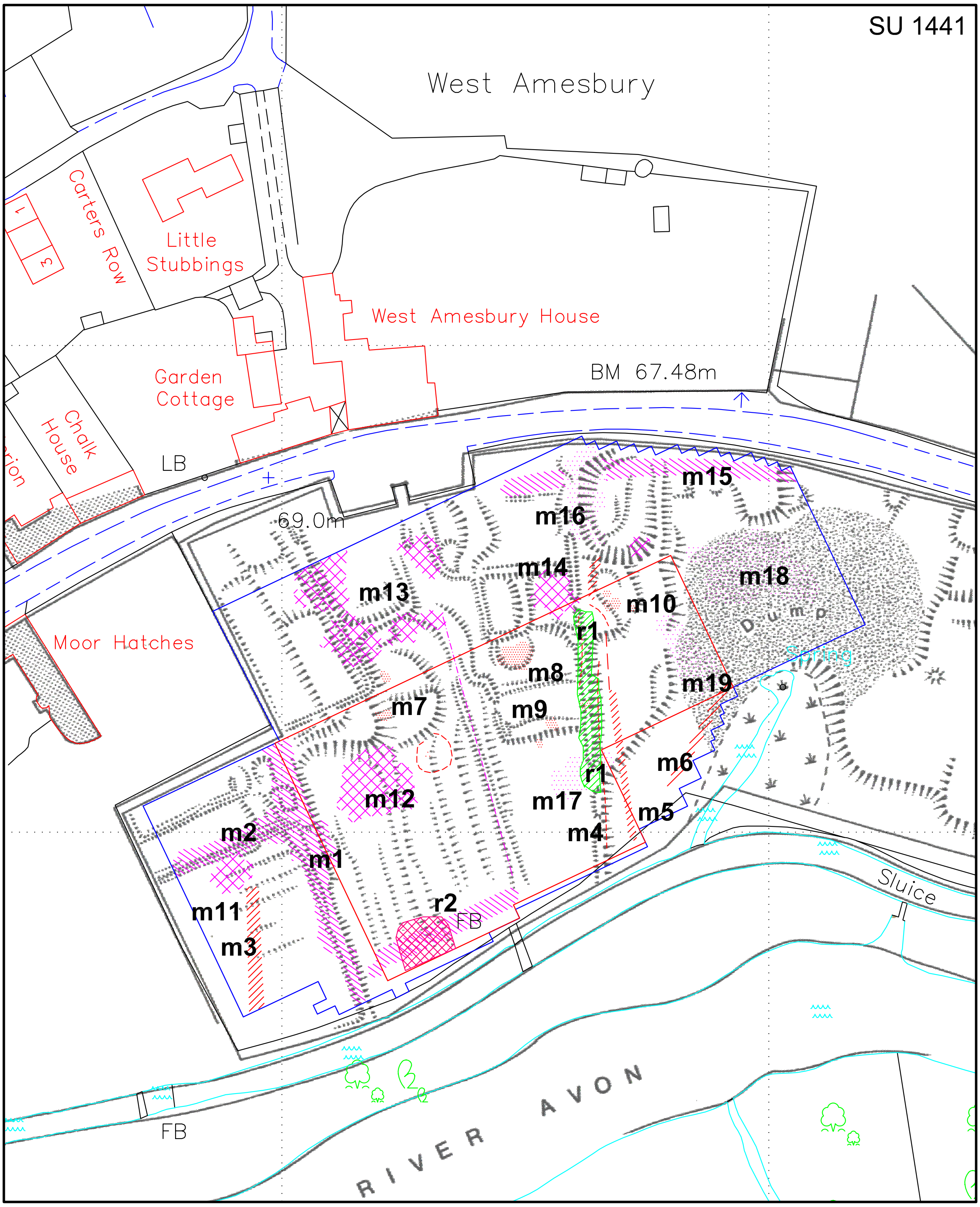
Figure 7

STONEHENGE AVENUE, WEST AMESBURY, WILTSHIRE

Earthwork evidence and geophysical interpretation combined



MAGNETOMETER SURVEY AREA

EARTH RESISTANCE SURVEY AREA

1:1250

0 25 50 75m

m1-19 : magnetic anomalies, **r1-2 :** resistance anomalies

- areas of large scale ferrous magnetic disturbance
- areas of less substantial ferrous magnetic disturbance
- intense linear magnetic disturbance
- weak linear magnetic disturbance
- positive linear magnetic anomalies
- localised positive magnetic anomalies
- weakly positive linear and curvilinear magnetic anomalies
- linear low resistance
- area of moderately increased resistance

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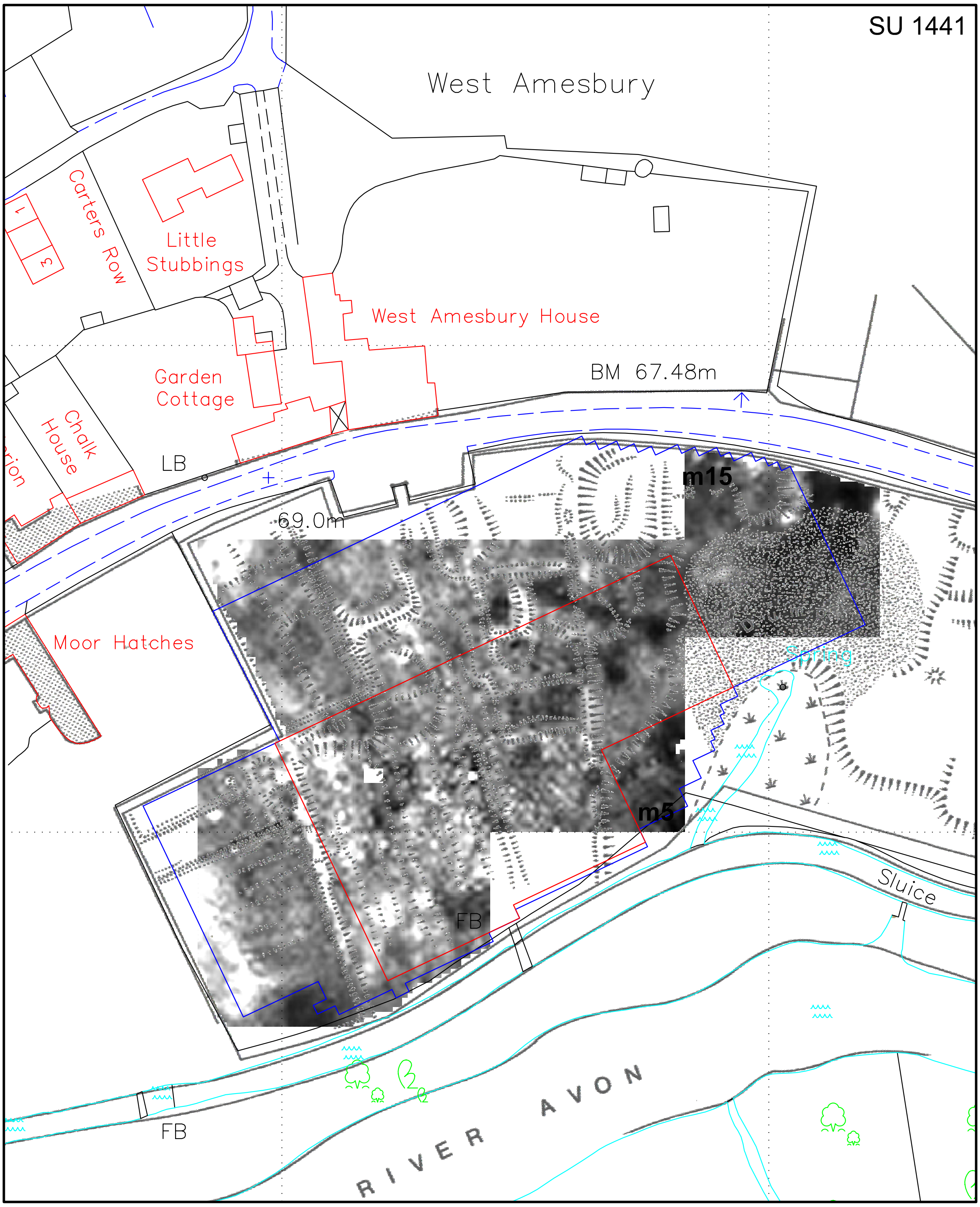
Figure 8

STONEHENGE AVENUE, WEST AMESBURY, WILTSHIRE

Earthwork evidence in relation to twin electrode earth resistance survey



ENGLISH HERITAGE MAGNETOMETER SURVEY AREA

ENGLISH HERITAGE EARTH RESISTANCE SURVEY AREA

1 : 1250

0 25 50 75m

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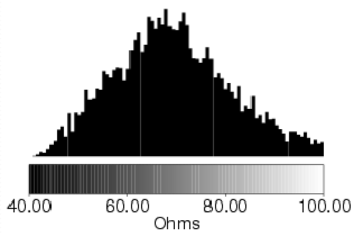
Twin electrode data reproduced courtesy of Bournemouth University



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STONEHENGE CURSUS EAST OF FARGO PLANTATION, WILTS Location of Magnetometer Survey, July 2006

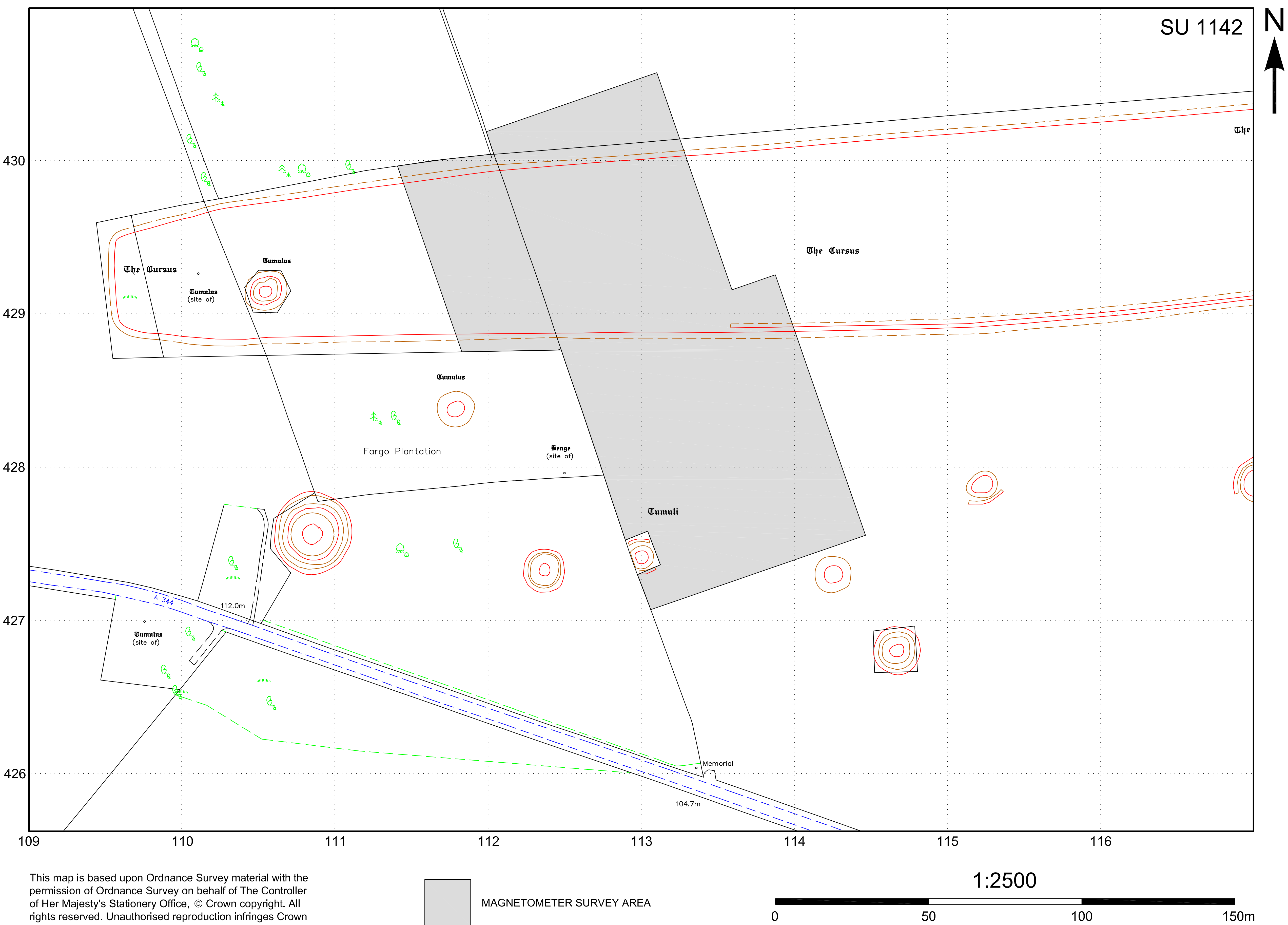

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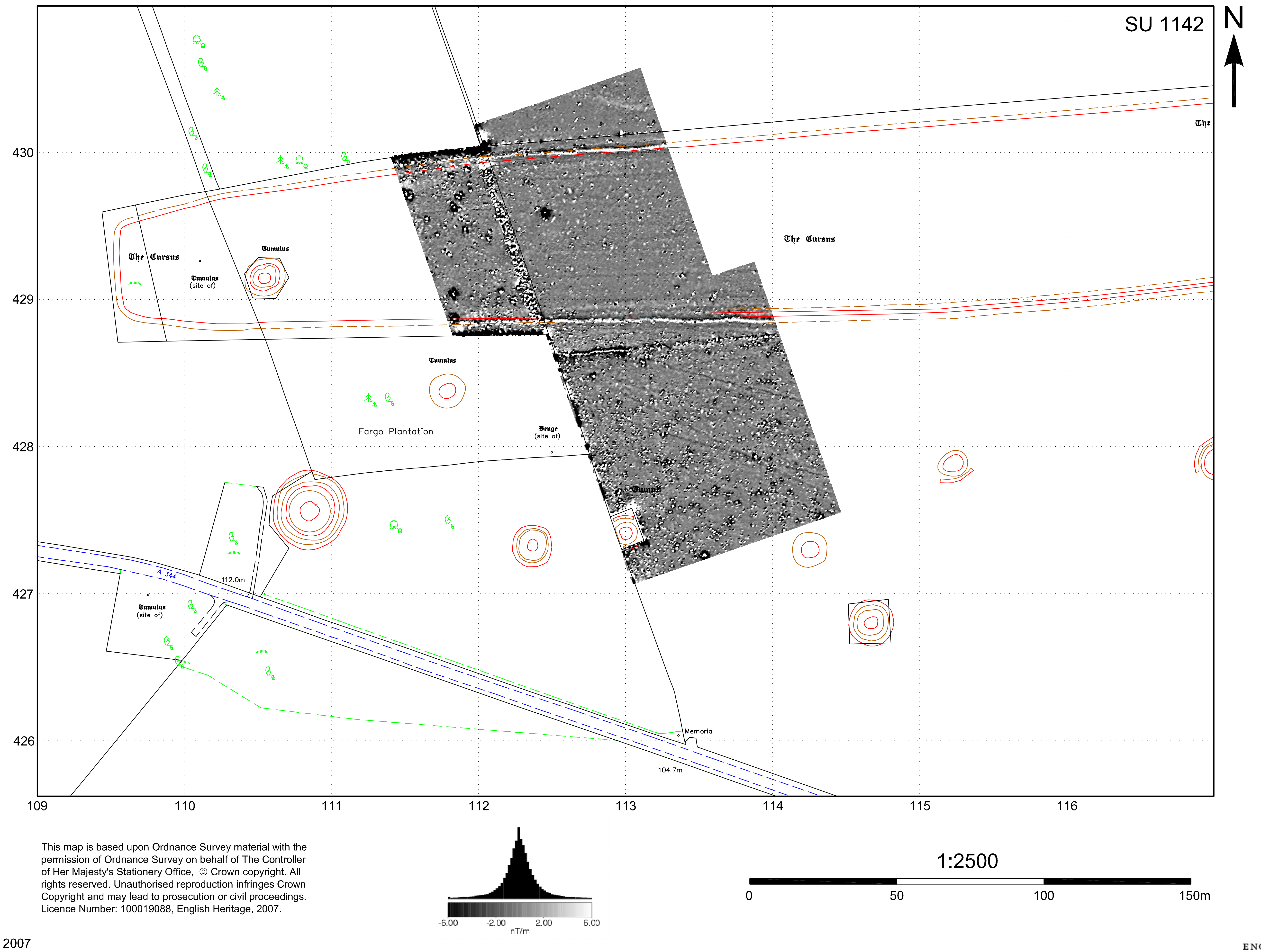
Figure 10

STONEHENGE CURSUS EAST OF FARGO PLANTATION, WILTS Magnetometer Survey, July 2006



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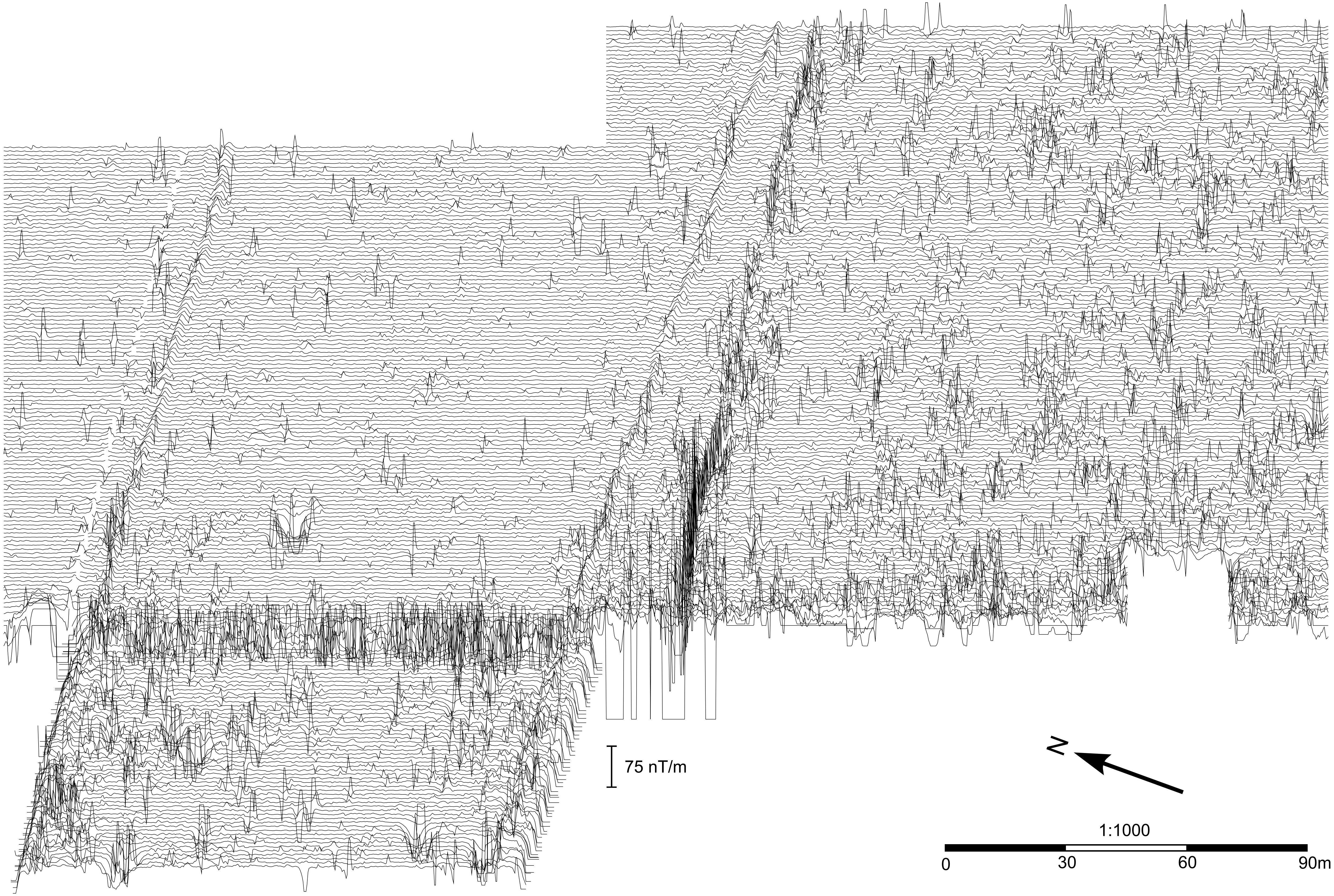
STONEHENGE CURSUS EAST OF FARGO PLANTATION, WILTS Magnetometer Survey, July 2006

Traceplot of magnetometer data (values outside range +/- 150 nT/m truncated)



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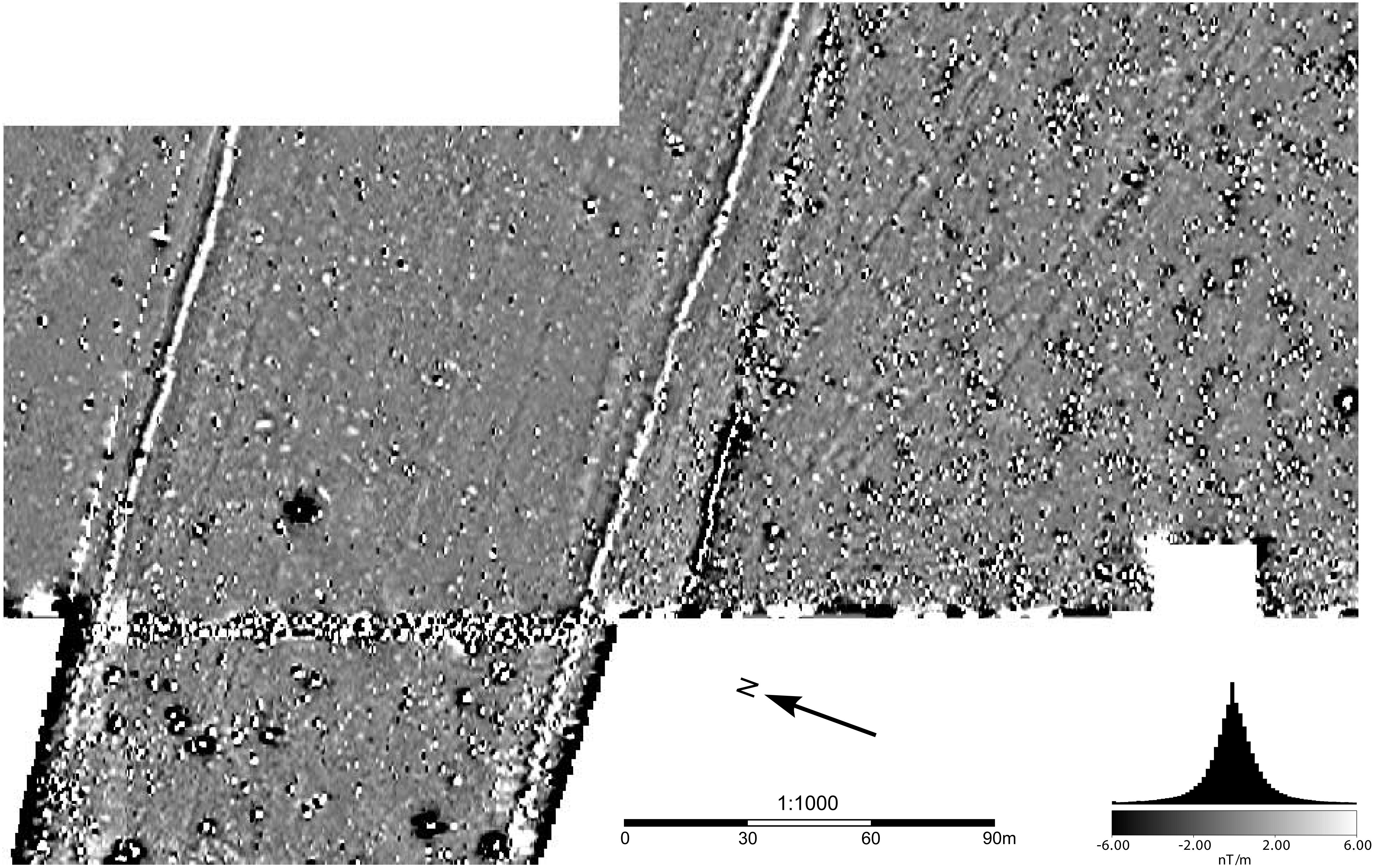
STONEHENGE CURSUS EAST OF FARGO PLANTATION, WILTS Magnetometer Survey, July 2006

Greyscale plot of drift corrected magnetometer data



STONEHENGE CURSUS EAST OF FARGO PLANTATION, WILTS Magnetometer Survey, July 2006

Greyscale plot of "despiked" magnetometer data

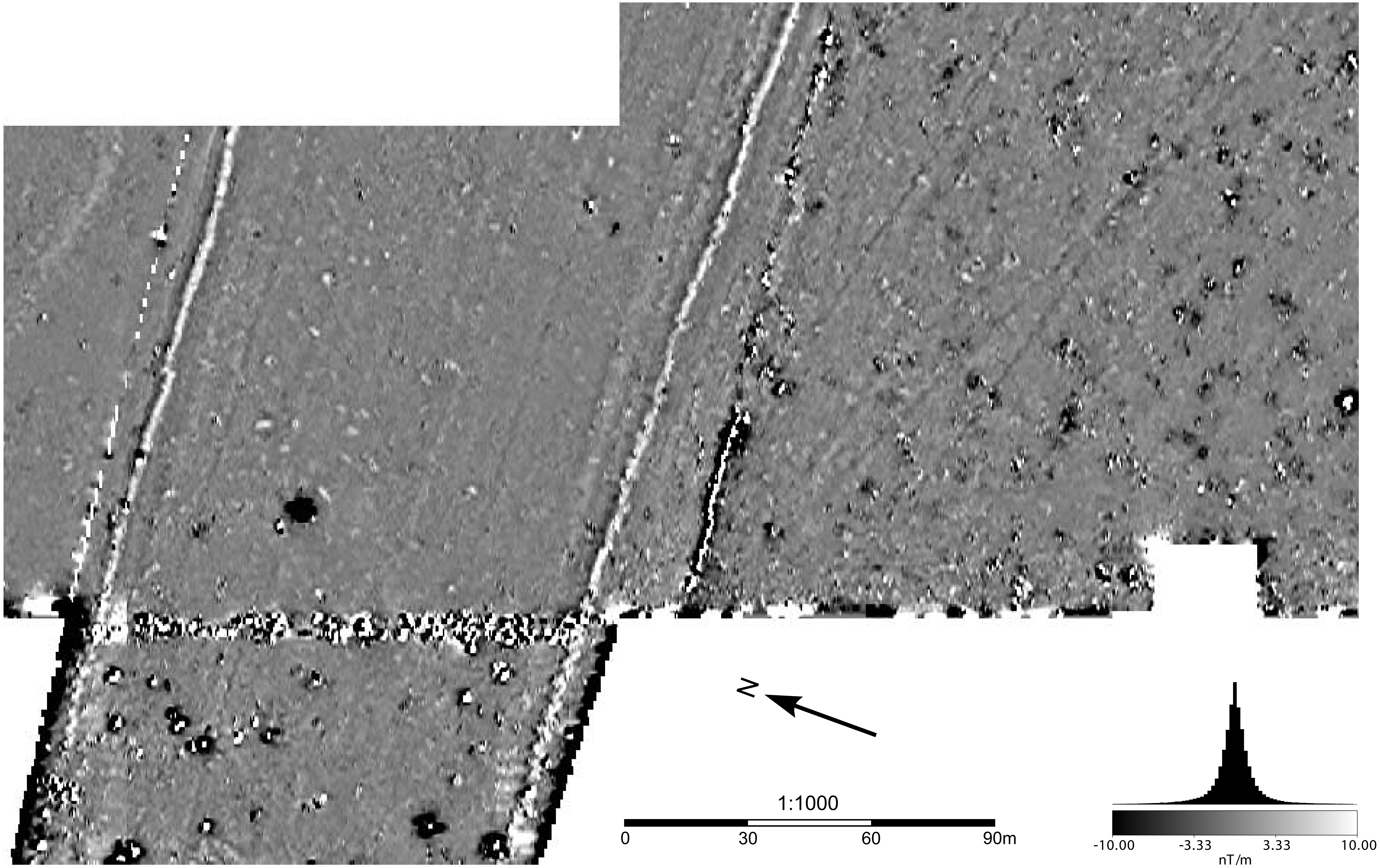
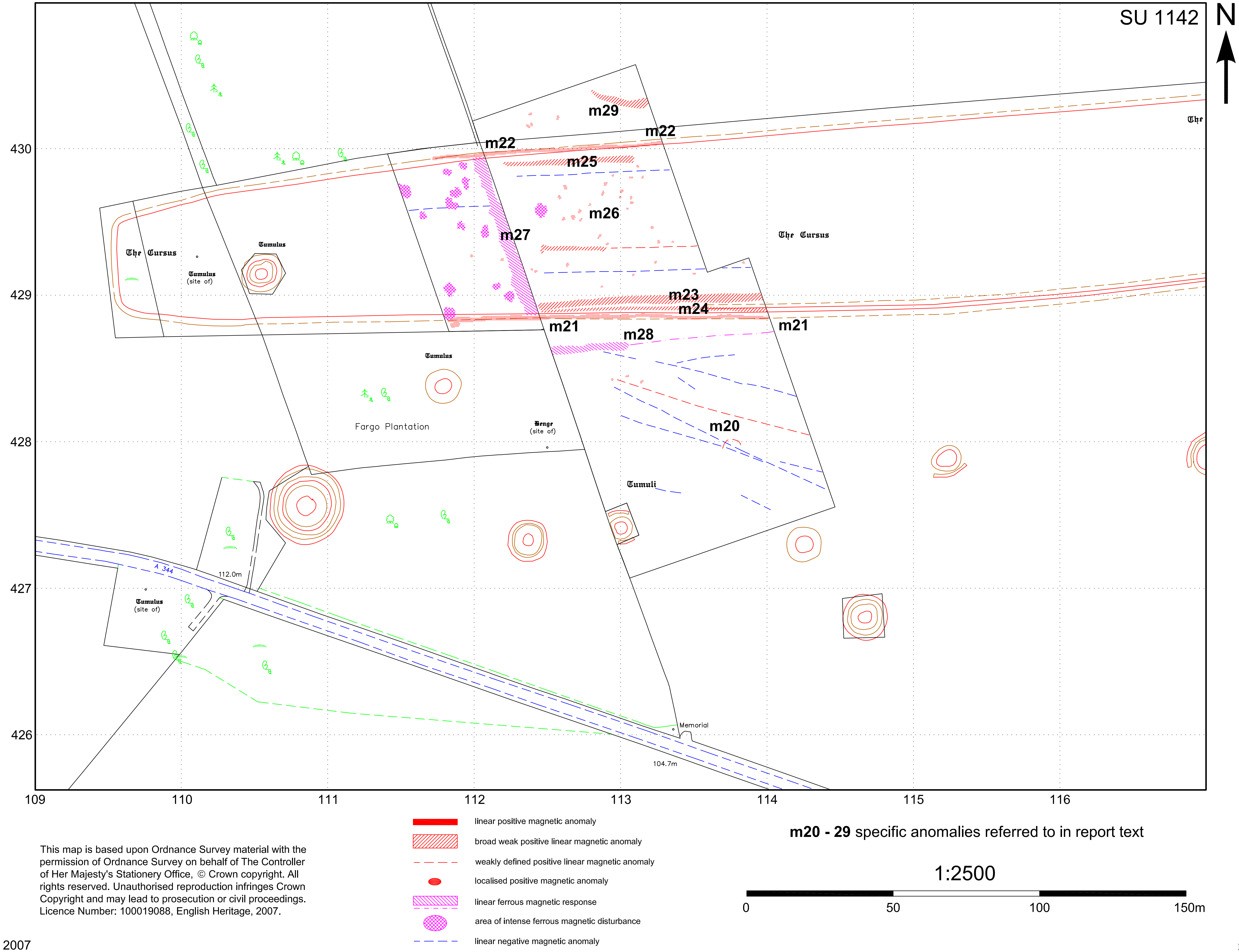


Figure 14

STONEHENGE CURSUS EAST OF FARGO PLANTATION, WILTS Interpretation of Magnetometer Survey



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