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Remote Sensing

Stonehenge Southern WHS Survey: West Amesbury, Wiltshire Report on Geophysical Surveys, October 2015

Neil Linford, Paul Linford and Andrew Payne

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STONEHENGE SOUTHERN WHS SURVEY, WEST AMESBURY, WILTSHIRE

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SUMMARY

Caesium magnetometer and Ground Penetrating Radar (GPR) surveys were conducted at West Amesbury Farm, Amesbury, Wiltshire, as part of the Stonehenge World Heritage Site (SWHS) Southern Landscape Project. The vehicle towed caesium magnetometer survey (21.7ha) enhanced the location of linear anomalies, mainly representing boundary, enclosure or field systems identified through aerial photography, and ditches associated with a square enclosure, the Coneybury Henge and two barrows. One of the barrow ring-ditches produced a very weak response and, potentially, represents a previously unknown monument. High sample density GPR survey (17.3ha) produced similar results, although the data was dominated by the strong response of the underlying geomorphology, and also indicates a wider pattern of linear anomalies. Both geophysical techniques identified an extensive distribution of discrete pit-type anomalies across the survey area, although some of these are likely to represent tree throws rather than deliberate cut features.

CONTRIBUTORS

The geophysical fieldwork was conducted by Neil Linford, Paul Linford and Andrew Payne.

ACKNOWLEDGEMENTS

The authors are grateful to Mr Philip Sawkill of West Amesbury Farm, who kindly allowed access for the survey to take place.

ARCHIVE LOCATION

Fort Cumberland, Portsmouth.

DATE OF SURVEY

The fieldwork was conducted between 5th to 7th and 20th to 21st October 2015 and the report completed on 29th January 2016. The cover image shows a view of the West Amesbury site in the distance taken from Normanton Down.

CONTACT DETAILS

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INTRODUCTION

Caesium magnetometer and Ground Penetrating Radar (GPR) surveys were conducted at West Amesbury Farm, Amesbury, Wiltshire, as part of the Stonehenge World Heritage Site (SWHS) Southern Landscape Project (RASMIS 7238, Historic England Action Plan 2.2.2. Discover our hidden heritage), which aims to provide advance intelligence of any potential nationally-important undesignated sites within the southern SWHS, following the Government announcement in December 2014 to prioritise a road improvement scheme for the A303 trunk road (Bowden 2015b). In addition, there are significant Heritage at Risk and Development Management drivers as our understanding of the resource within the southern SWHS is less well developed than that to the north of the current A303, where landscape-scale research projects have taken place within the recent past (Bowden 2015a).

The current survey was conducted during a first tranche of fieldwork in autumn 2015 that included available sites selected from within the Priority 1 study area (Figure 1, Linford *et al.* 2015a, 2015b, 2015c). This report provides an initial summary of the geophysical survey results for circulation before compilation of a more synthetic overview report, drawing out and integrating key findings from the project as a whole.

The West Amesbury Farm site contains known heritage assets including the Coneybury Neolithic Henge (SAM 1012376), a Neolithic pit (AMIE UID 962958), a possible Bronze Age barrow (AMIE UID 219866), fragments of a Roman or prehistoric field system (AMIE UID 959848), medieval ridge and furrow (AMIE UID 219581) and medieval droveways (AMIE UID 1120393), and a Type 22 Second World War pillbox (AMIE UID 1476738). Further research of the local Historic Environment Records revealed the likely location of three ring ditches (HER 12797-9) and a round mound (HER 12810) to the west of the survey area plotted by the Royal Commission on the Historical Monuments for England in 1995 from aerial photographs. The area was also covered by a high density fluxgate magnetometer survey during the Hidden Landscapes project.

The site is situated on Upper Cretaceous Seaford Chalk geology over which shallow well drained calcareous silty soils of the Andover 1 Association have developed, with deeper flinty calcareous silty soils in small coombes and valleys (Geological Survey of England and Wales 1950 ; Soil Survey of England and Wales 1983). The site slopes gently from the A303 and was down to grass bordering an arable field immediately to the south. Weather conditions during the field work were rather mixed with some unsettled periods of blustery rain.

Method

Magnetometer survey

The magnetometer data was collected along the instrument swaths shown on Figure 2 using an array of six high sensitivity Geometrics G862 caesium vapour magnetometer sensors mounted on a non-magnetic sledge. This sledge was towed behind a low impact, All Terrain Vehicle (ATV) which also provided the power supply and housed the data logging electronics. Five of the sensors were mounted in a linear array transverse to the direction of travel 0.5m apart and, vertically, ~0.2m above the ground surface. The sixth was fixed 1.0m directly above the central magnetometer in the array to act as a gradient sensor. The sensors were set to sample at a rate of 16Hz based on the typical average travel speed of the ATV (3.2m/s) giving a sampling density of ~0.2m by 0.5m along successive swaths. Each swath was separated from the last by approximately 2.5m, navigation and positional control being achieved using a Trimble R8 Global Navigation Satellite System (GNSS) receiver mounted on the sensor platform 1.75m in front of the central sensor and a second R8 base station receiver established using the Ordnance Survey VRS Now correction service. Sensor output and survey location was monitored during acquisition to ensure data quality and minimise the risk of gaps in the coverage due to the use of a grid-less system.

After data collection the corresponding readings from the gradient sensor were subtracted from the measurements made by the other five magnetometers to remove any transient magnetic field effects caused by the towing ATV. The median value of each instrument traverse was then adjusted to zero by subtracting a running median value calculated over a 60m 1D window. This operation corrects for slight biases added to the measurements owing to the diurnal variation of the Earth's magnetic field and any slight directional sensitivity of the sensors. A linear greyscale image of the combined magnetic data is shown superimposed over the base Ordnance Survey (OS) mapping on Figure 4 and minimally processed versions of the range truncated data ($\pm$150nT/m) are shown as a traceplot and a histogram equalised greyscale image on Figures 6 and 7 respectively.

Ground Penetrating Radar survey

A 3d-Radar MkIV GeoScope Continuous Wave Stepped-Frequency (CWSF) Ground Penetrating Radar (GPR) system was used to conduct the survey collecting data with a multi-element GX1820 vehicle towed, ground coupled antenna array (Linford *et al.* 2010). A roving Trimble R8 Global Navigation Satellite System (GNSS) receiver, together with a second R8 base station receiver established using the Ordnance Survey VRS Now correction service, was mounted on the GPR antenna array to provide continuous positional control for the survey collected along the instrument swaths shown on Figure 3. Data were acquired at a 0.075m x 0.075m sample interval across a continuous wave stepped frequency range from 60MHz to 2.99GHz in 4MHz increments using a dwell time of 2ms. A single antenna element was monitored continuously to ensure data quality during acquisition together with automated processing software to produce real time amplitude time slice representations of the data as each successive instrument swath was recorded in the field (Linford 2013).

Post acquisition processing involved conversion of the raw data to time-domain profiles (through a time window of 0 to 70ns), adjustment of time-zero to coincide with the true ground surface, background and noise removal, and the application of a suitable gain function to enhance late arrivals. Representative profiles from the GPR survey are shown on Figure 8. To aid visualisation amplitude time slices were created from the entire data set by averaging data within successive 2.4ns (two-way travel time) windows (e.g. Linford 2004). An average sub-surface velocity of 0.0968m/ns was assumed following constant velocity tests on the data, and was used as the velocity field for the time to estimated depth conversion. Each of the resulting time slices, shown as individual greyscale images in Figures 9, 10 and 11 therefore represents the variation of reflection strength through successive ~0.12m intervals from the ground surface. Further details of both the frequency and time domain algorithms developed for processing this data can be found in Sala and Linford (2012) .

RESULTS

Magnetometer survey

A graphical summary of the significant magnetic anomalies, [**m49-74**] discussed in the following text, superimposed on the base OS map data, is provided in Figure 12.

In general, the magnetic response at the site is relatively good, although some modern disturbance due to a high tension electricity pylon [**m49**] and a lower voltage domestic supply carried by extant telegraph poles [**m50, 51** and **52**] and then continuing as a less visibly intrusive buried cable [**m53**] from [**m52**], where it passes through the site of former support [**m54**]. An agricultural water pipe [**m55**] crosses the site to supply a drinking trough and appears to continue south in the vicinity of the Coneybury Henge. There are also a number of weak linear anomalies throughout the survey area due to vehicle ruts.

The pattern of ridge and furrow identified from aerial photography (AMIE UID 219581) is replicated by a series of weak linear responses [**m56**] and also contains an amorphous area of increased magnetic disturbance [**m57**] with some ill-defined narrow linear and arcing magnetic anomalies, possibly indicative of occupation activity or, perhaps, animal burrowing. The small rectangular enclosure (AMIE UID 1121042) investigated by Blore *et al.* (1995) appears as a square ditched response [**m58**] with rounded corners, approximately 18m across, but does not immediately offer any further interpretation to inform the results of the original evaluation. Several curvilinear ditch type responses [**m59-61**], correlate with the fragmentary traces of a presumed Prehistoric or Roman field system (AMIE UID 959848), although the less clearly resolved anomalies [**m62** and **m63**] do not appear to be visible as cropmarks on aerial photographs.

The curvilinear anomaly [**m64**] is similar to a response found at Diamonds Field where it was suggested this might relate to a down-slope erosion gully (Figure 11; Linford *et al.* 2015a, [m8]). Whilst [**m64**] is also orientated down a gentle slope, into the and steep sided dry valley [**m65**], it is also possible that this may represent a more significant ditch-type response, perhaps even one side of a partially resolved enclosure. The course of both the main dry valley [**m65**] and two lesser tributaries [**m66**] and [**m67**] appear as a diffuse magnetic response to the fine silts accumulated in the valley bottoms.

To the south [**m68**] replicates the previously recorded curvilinear anomalies over the Coneybury Henge ditch, with a similar magnitude of response (4-6 nT/m) and an entrance gap to the NE (Bartlett 1988). A less pronounced break in the ditch to the south appears to relate to the location of an excavation trench and it is unclear whether the internal magnetic anomalies mapped by the current survey are due to the invasive investigation or to a more significant origin, a more recent origin seems likely for the most intense response (Clark 1990 ; Richards 1990).

Two small ring-ditches [**m69**] and [**m70**], both approximately 13m in diameter, are probably indicative of ploughed out Bronze Age round barrows with [**m70**] producing a greater magnitude of response (2.5-3 nT/m) and corresponding with a recorded crop-mark (AMIE UID 1066506). However, it is unclear whether the more weakly defined response (1.5 nT/m) at [**m69**] represents the sight mis-location of a scheduled monument (SAM 1012390) on the southern field boundary or a hitherto unrecognised additional ring-ditch. Weak linear anomalies [**m71-73**] to the east share a similar orientation to [**m59**] and [**m62**] and correspond with the probable traces of a Prehistoric or Roman field system identified through cropmarks and lidar data (AMIE UID 1363287). A more tentative linear anomaly [**m74**] may also form part of this field system, possibly extending to meet [**m62**] to the north, but is not well resolved heading south from where it meets the outer bank of the Coneybury Henge to change course towards the segment correlating with a NS aligned cropmark (AMIE UID 959848).

Ground Penetrating Radar survey

A graphical summary of the significant GPR anomalies, [**gpr41-69**] discussed in the following text, superimposed on the base OS map data, is provided in Figure 13.

Significant reflections have been recorded throughout the 70ns two-way travel time window, although later reflections beyond ~40ns become more highly attenuated. The local geomorphology, presumably gently dipping bands of weathering, marl or flint bedding within the chalk appear as series of high amplitude, amorphous reflectors [**gpr41**] that migrate laterally throughout the amplitude time slices, following the contours of the local topography. A predominantly EW orientated plough pattern is also visible in the near-surface data together with some vehicle ruts, particularly pronounced along a track [**gpr42**] to north. A series of four discrete anomalies, approximately 2m x 5m most visible in the time slice between 17.5 - 20.0ns (0.80 - 0.92m), follow the boundary of the site along [**gpr42**] and seem most likely to be recent in origin.

Whilst the radar has not been affected by the ferrous disturbance associated with the electricity pylon and telegraph poles, the buried cable [**gpr43**] has been detected as a high-amplitude reflector between 10 and 27.5ns (0.46 to 1.26m), and later returns have been compromised by interference [**gpr44**] from the radio modem in the immediate vicinity of the GNSS base station. The water pipe [**gpr45**] is also evident from between 7.5 and 17.5ns (0.34 to 0.8m) with an apparent fall of approximately 0.5m from north to the water trough in the southern field boundary. It is possible that the high amplitude anomaly at [**gpr46**] might represent the base of the Type 22 Second World War pillbox.

A very weak response to the ridge and furrow [**gpr47**] is found between 7.5 and 15.0ns (0.34 to 0.69m) as a series of linear reflectors, although in general this field system is better represented in the magnetic data (*cf* [**m49**]). A wider series of high amplitude linear reflectors [**gpr48-64**] occurs through a similar depth range, between 7.5 and 27.5ns (0.34 to 1.26m), across the survey area and these anomalies are not entirely replicated in either the magnetic data or cropmark evidence. There is some difficulty in separating more significant responses from the geomorphology [**gpr41**] and many of the ditch-type responses from the magnetic data are most evident as slightly later, low amplitude reflections from approximately 15ns (0.69m) onwards. These include fragments of the Prehistoric or Roman field system [**gpr65**] and [**gpr66**] (*cf* [**m59-61**]), the curvilinear anomaly [**gpr57**] corresponding to [**m62**], and the course of the dry valley [**gpr67**] (*cf* [**m65-67**]).

Some of the linear anomalies may, in part, represent more recent land division, for example [**gpr49**] correlates with a field boundary shown on the historic mapping (OS Historic County Mapping Series: Wiltshire 1919 - 1939 Epoch 4), although [**gpr49**] does appear to bifurcate to the north suggesting a more complex relationship, perhaps also reflected in the magnetic data at [**m57**]. Other anomalies, for example [**gpr52**] and [**gpr53**] and [**gpr56-58**], appear to represent a wider field system but again these are difficult to interpret fully or fully explain the significance of these responses in the absence of supporting evidence from the cropmarks or magnetic results. There is a more complex near surface response [**gpr54**] from 5ns (0.26m) onwards that resolves itself into a high-amplitude rectangular reflector approximately 3m x 7m between 10 and 22.5ns (0.46 and 1.03m) and it is, perhaps, more likely that this represents the site of a previous water trough associated with [**gpr45**] rather than any more significant association with [**gpr53**].

The square enclosure has produced an incomplete anomaly [**gpr55**] compared to the magnetic data (*cf* [**m58**]), which appears most clearly between 10 and 15ns (0.46 to 0.69m), and again the radar results offer little additional information to suggest a more confident interpretation. A number of linear anomalies [**gpr59**] run down the slope into the dry valley [**gpr67**], which is represented by a low amplitude reflections bounded by a more complex of high amplitude geomorphological response [**gpr41**]. This has certainly led to some difficulty in determine the significance of other anomalies, for example [**gpr58**], in this area.

To the west of the dry valley and the linear ditch-type anomaly [**gpr66**] the underlying geomorphological response [**gpr41**] again follows the contours of the local topography, and is intercut with a series of potentially more significant high amplitude reflectors [**gpr61-64**]. Anomaly [**gpr63**] meets a curious, predominantly low amplitude, circular response [**gpr68**] approximately 10m in diameter which coincides with a round mound plotted by the Royal Commission on the Historical Monuments for England in 1995 from aerial photographs (HER 12810). There is some tentative evidence for internal anomalies within [**gpr68**] but it is, perhaps, more likely to be related to the geomorphology. A similar, ovoid low amplitude anomaly [**gpr69**] is found on the side of the dry valley and, again, suggests a geological origin. As with the magnetic data, there is no apparent indication in the radar survey for the three ring ditches (HER 12797-9) recorded by the RCHME immediately to the south of [**gpr68**] running east to meet [**gpr66**] (*cf* Figure 14).

CONCLUSIONS

Both the caesium magnetometer and GPR surveys have produced useful information to enhance the known evidence at the site from aerial photography, previous geophysical coverage and invasive evaluations. Whilst largely reflecting the cropmark evidence the magnetic survey has provided some additional detail and, in particular, has indicated one potentially unrecognised weakly magnetised ring-ditch in the vicinity of Coneybury Henge. Neither technique provides any additional evidence for the three ring-ditches plotted from cropmarks to the west of the site, although some further investigation would be required to determine the survival of these monuments. The GPR has produced a more complex response, often dominated by the underlying geomorphology, but has also revealed a more subtle pattern of linear anomalies, possibly an extension to the known prehistoric or Roman field systems. Numerous discrete anomalies recorded by both techniques provide evidence for wide spread distribution of pits or tree throw hollows across the down land.

LIST OF ENCLOSED FIGURES

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Figure 1

STONEHENGE SOUTHERN WHS SURVEY: WEST AMESBURY, WILTSHIRE

Location of geophysical survey within Priority 1 project area, October 2015

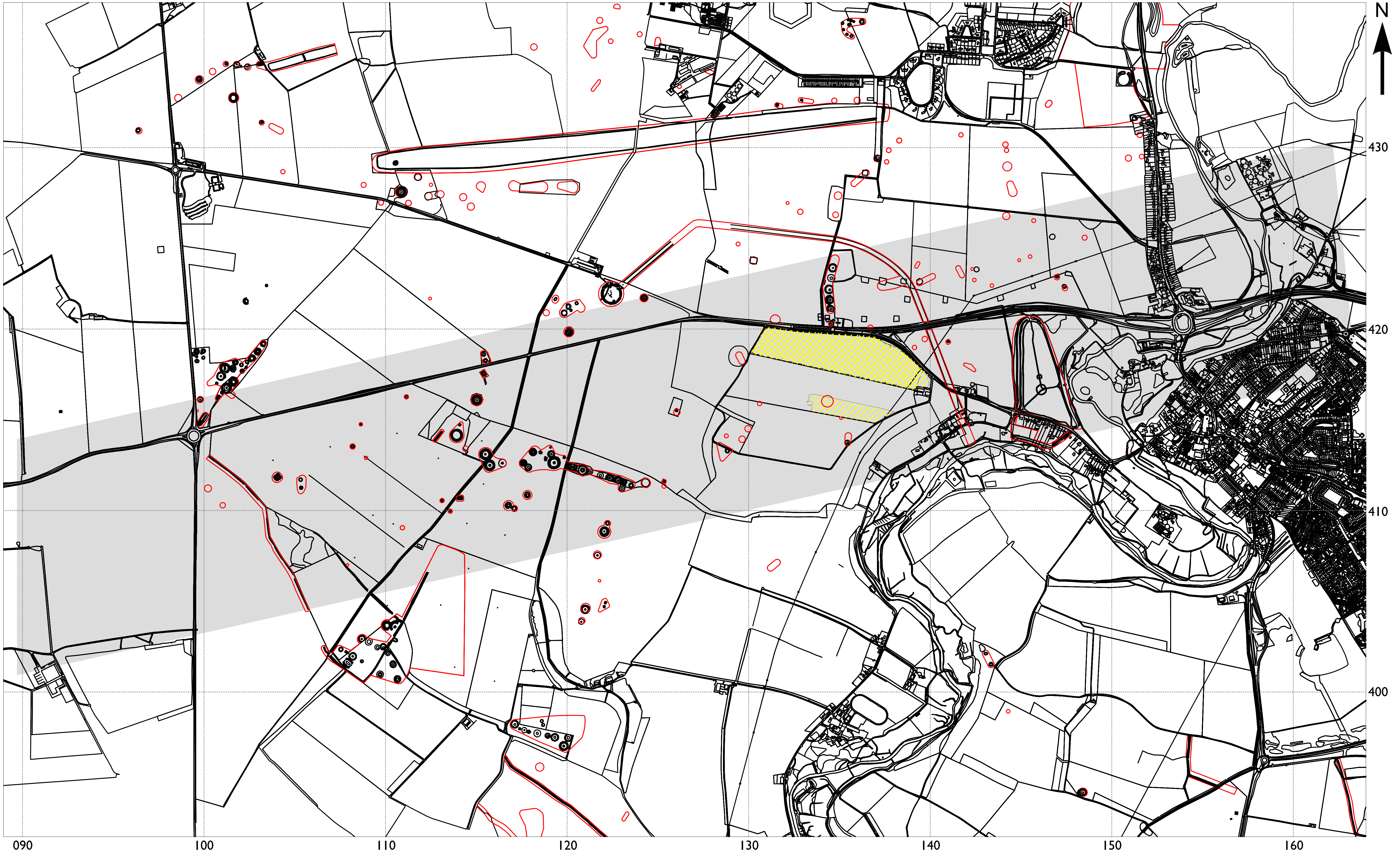

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Figure 2

STONEHENGE SOUTHERN WHS SURVEY: WEST AMESBURY, WILTSHIRE

Location of caesium magnetometer survey swaths, October 2015

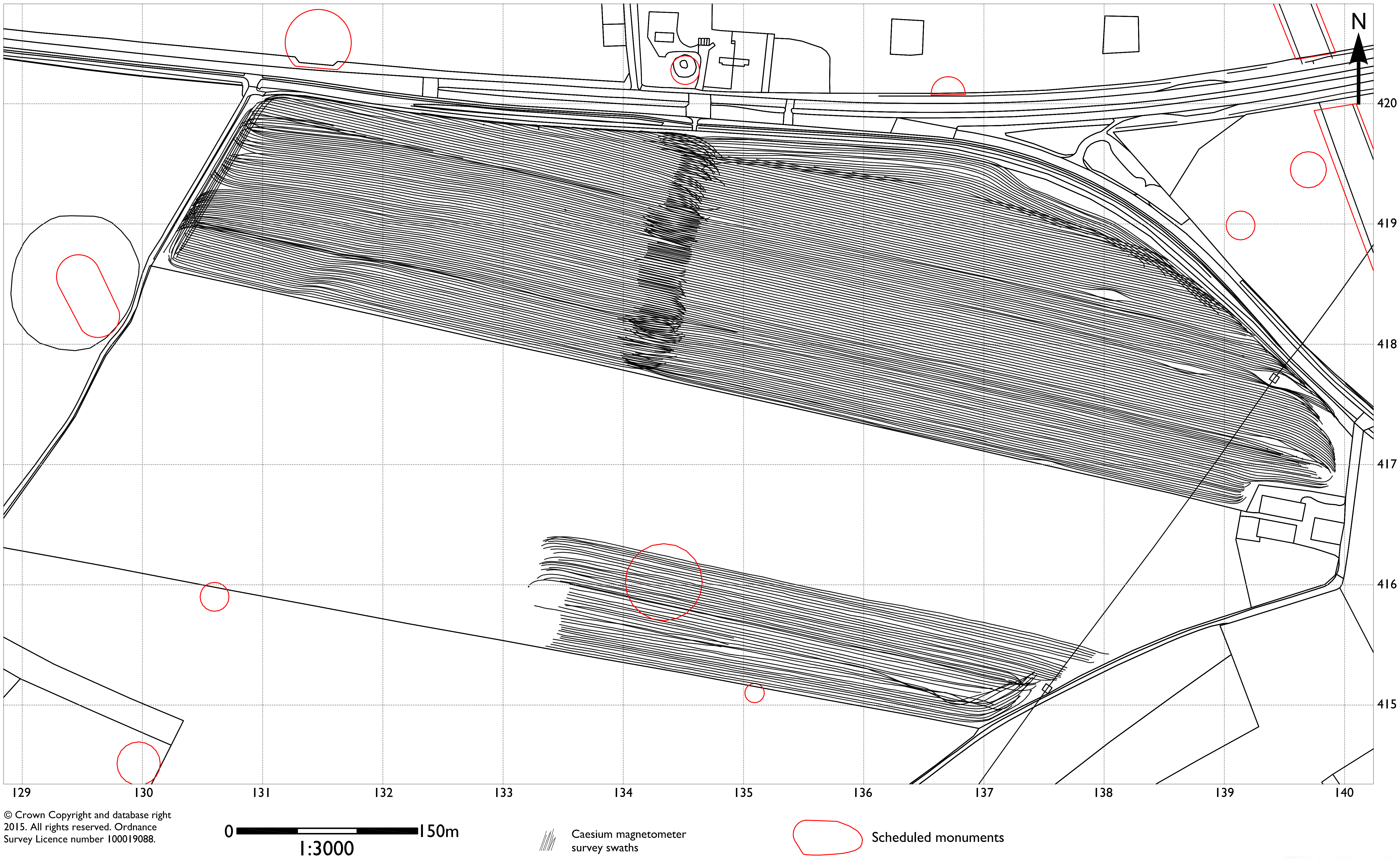

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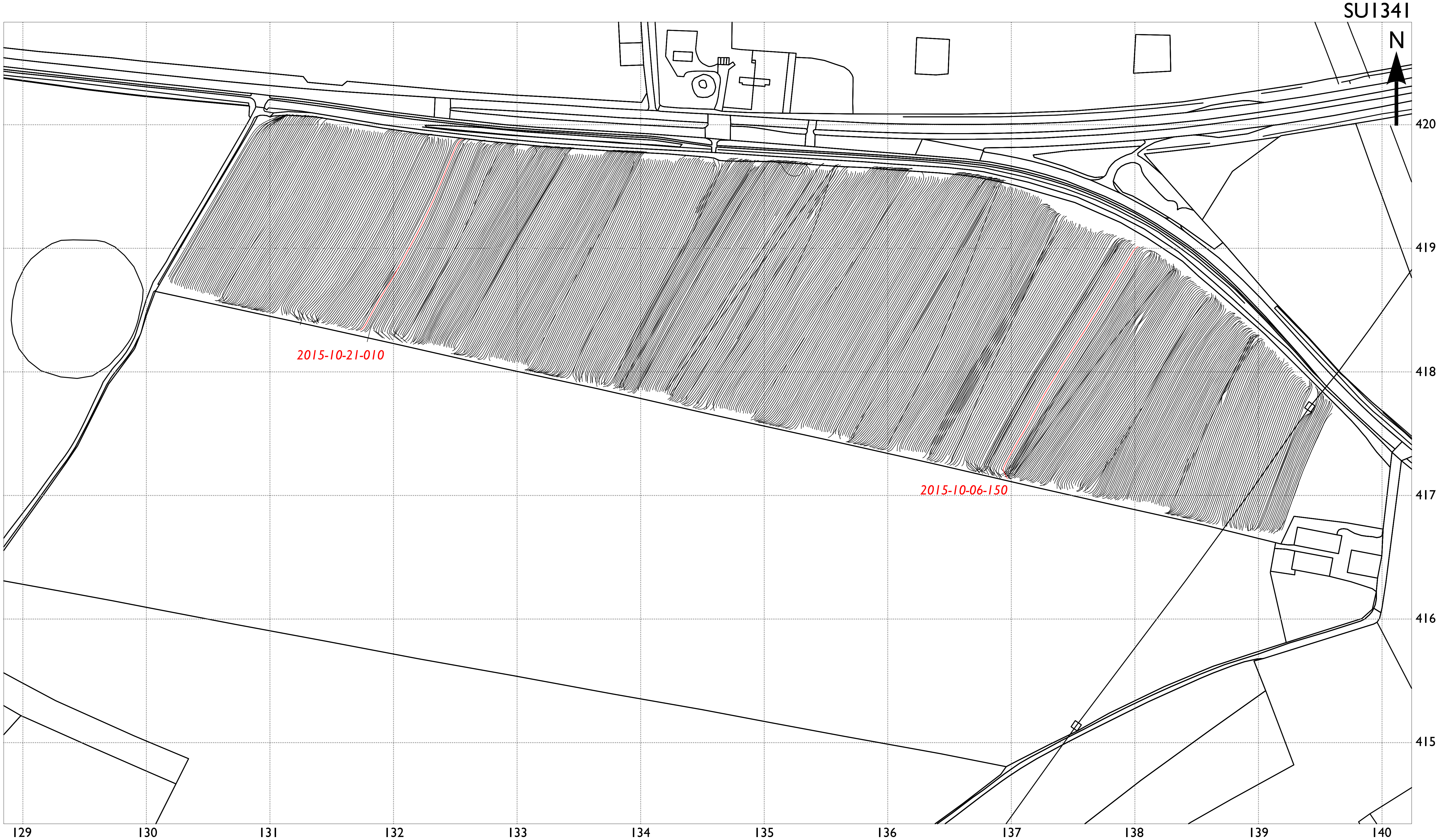
Figure 3

STONEHENGE SOUTHERN WHS SURVEY: WEST AMESBURY, WILTSHIRE
Location of GPR survey swaths, October 2015



0 150m

1:3000

2015-10-06-150 Location of selected GPR profile shown on Figure 8

Ground Penetrating Radar survey swaths

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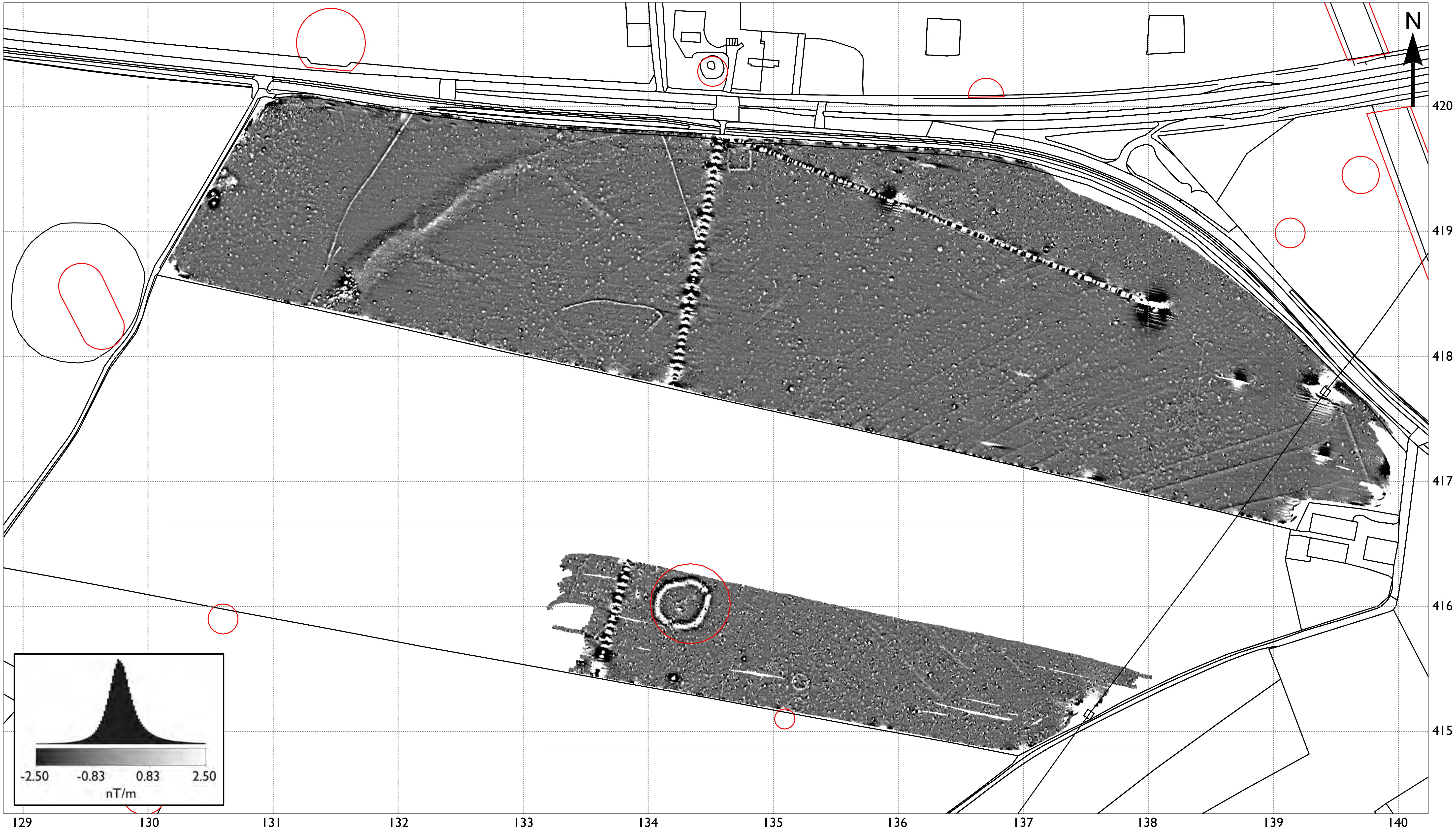
Figure 4

STONEHENGE SOUTHERN WHS SURVEY: WEST AMESBURY, WILTSHIRE

Location of caesium magnetometer survey, October 2015



0 150m

1:3000

Scheduled monuments

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Figure 5

STONEHENGE SOUTHERN WHS SURVEY: WEST AMESBURY, WILTSHIRE
GPR amplitude time slice between 27.5 - 30.0ns (1.26 - 1.38m), October 2015

SU1341

0 150m
1:3000

2015-10-06-150 Location of selected GPR profile shown on Figure 8

Low High
relative reflector strength

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STONEHENGE SOUTHERN WHS SURVEY: WEST AMESBURY, WILTSHIRE

Caesium magnetometer survey, October 2015

Figure 6

Traceplot of minimally processed caesium magnetometer data

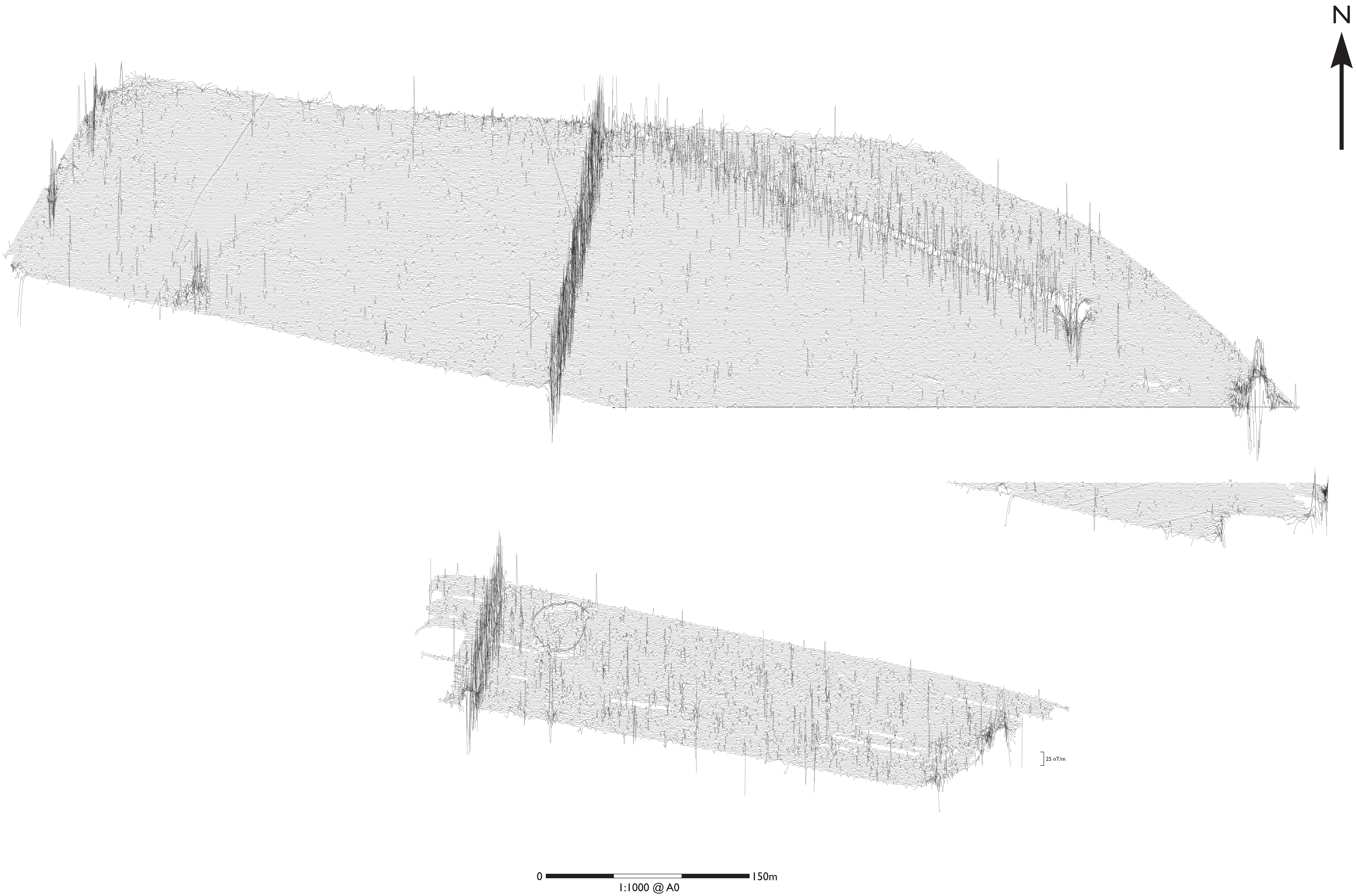

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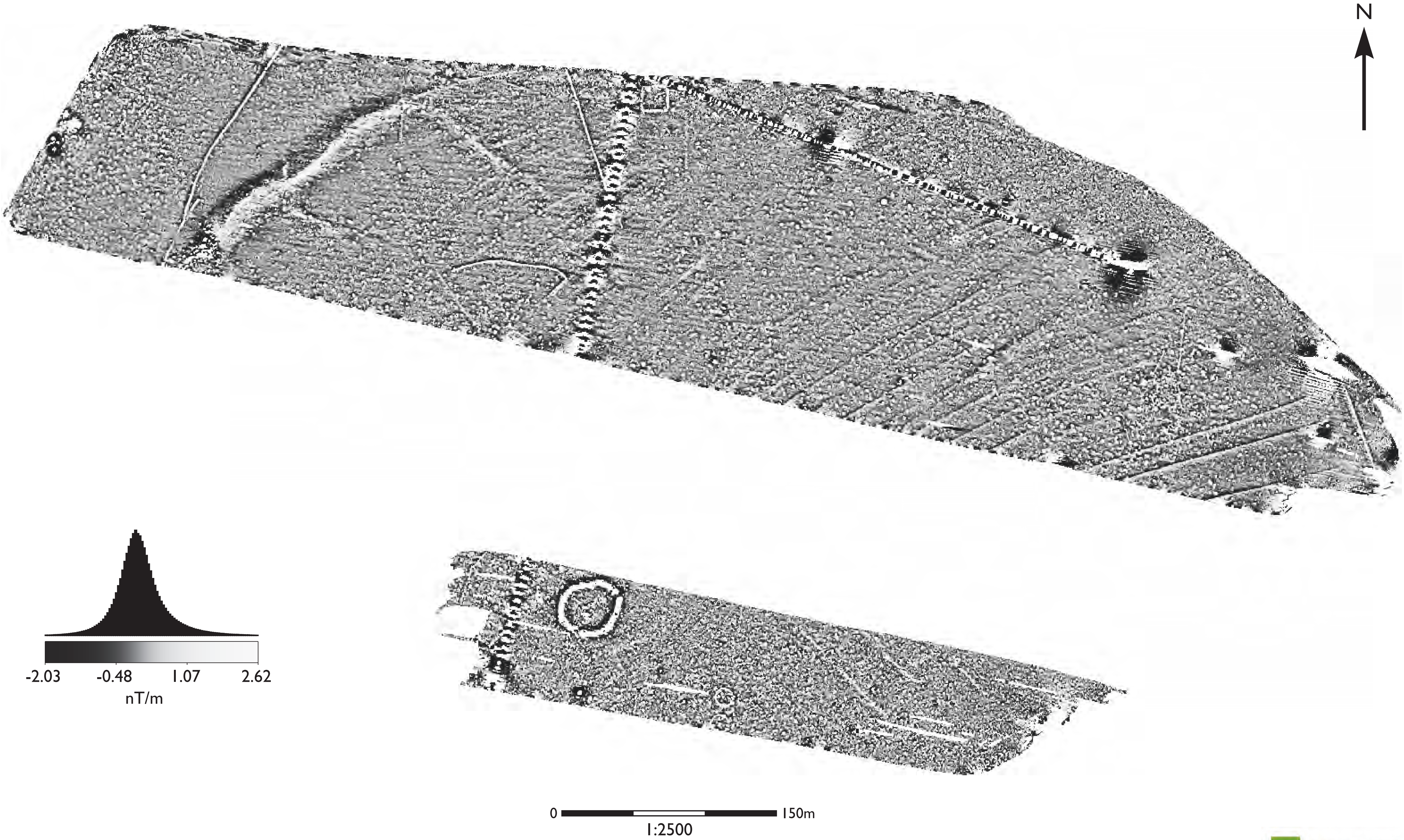
Figure 7

STONEHENGE SOUTHERN WHS SURVEY: WEST AMESBURY, WILTSHIRE
Caesium magnetometer survey, October 2015

Equal area greyscale images of minimally processed data



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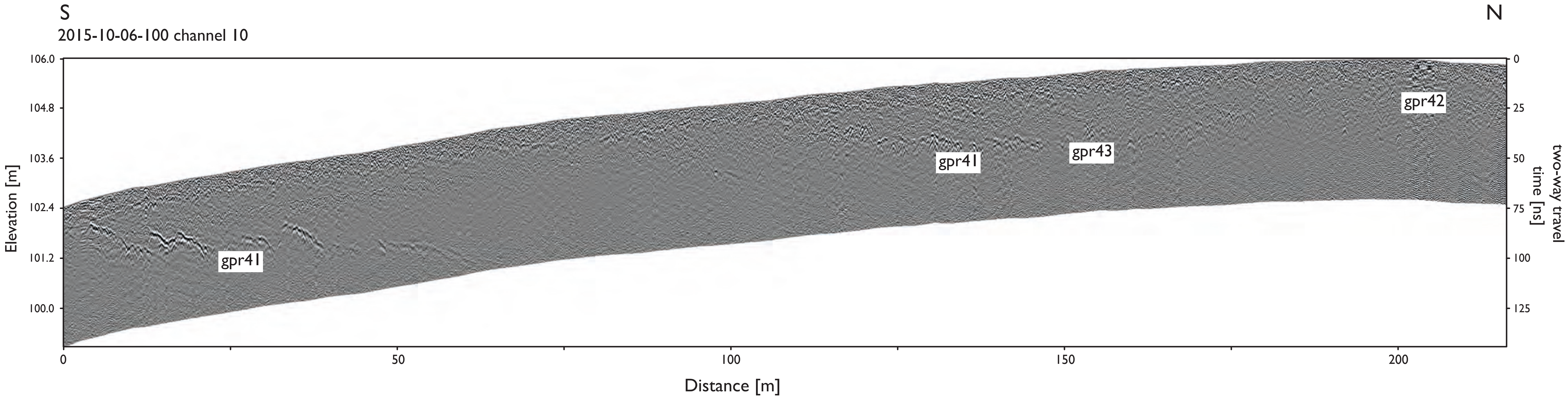
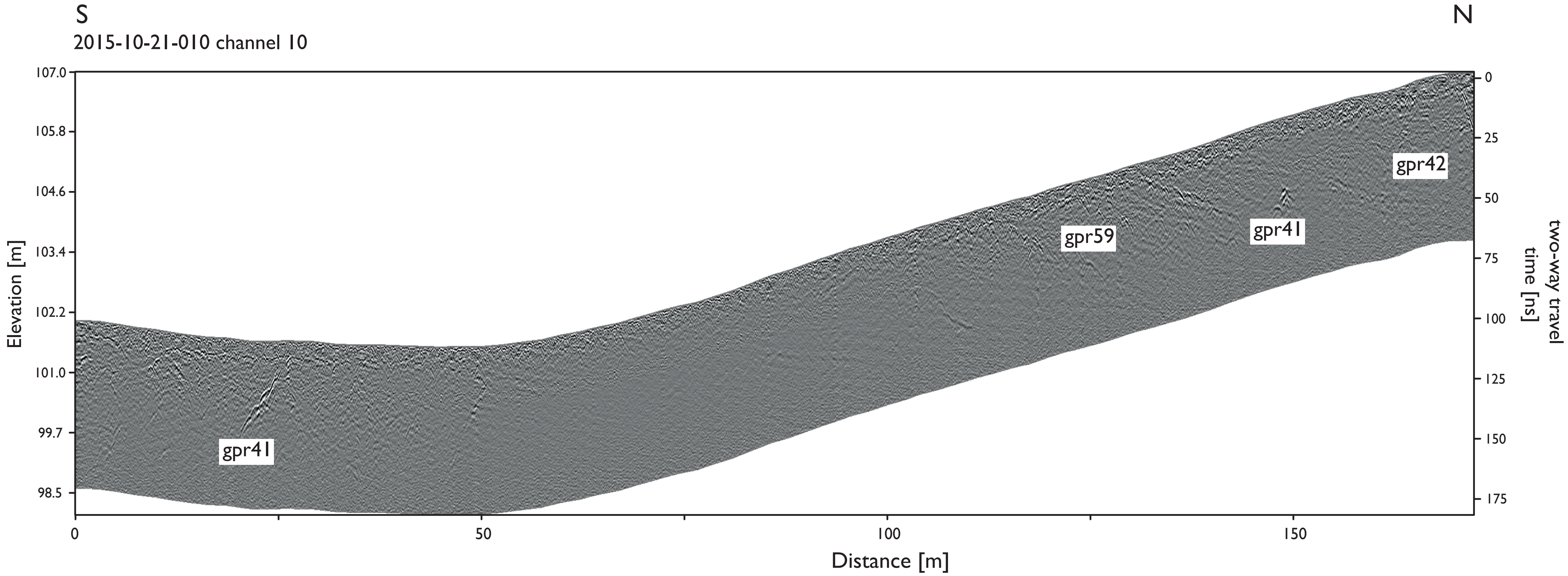
STONEHENGE SOUTHERN WHS SURVEY: WEST AMESBURY, WILTSHIRE
Topographically corrected GPR profiles, October 2015

Figure 8





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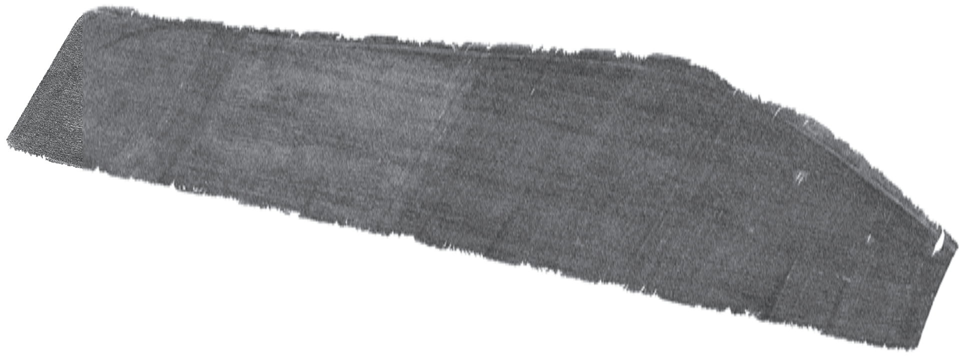
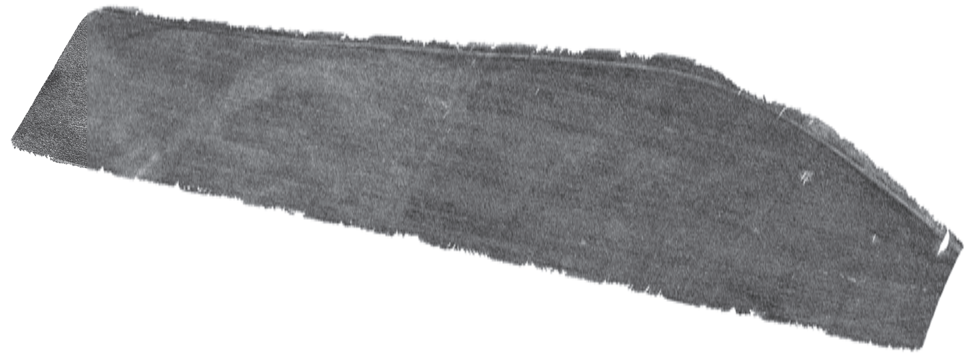
STONEHENGE SOUTHERN WHS SURVEY: WEST AMESBURY, WILTSHIRE
GPR amplitude time slices between 0.0 and 22.5ns (0.0 - 1.03m), October 2015

Figure 9

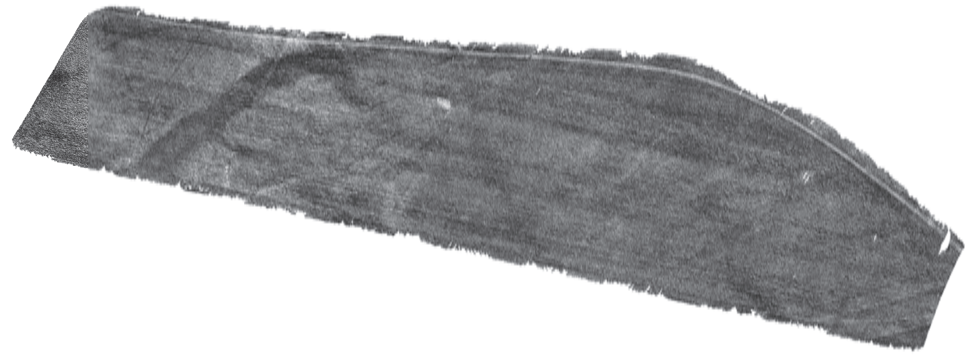
0 - 2.5ns (0.0 - 0.11m)



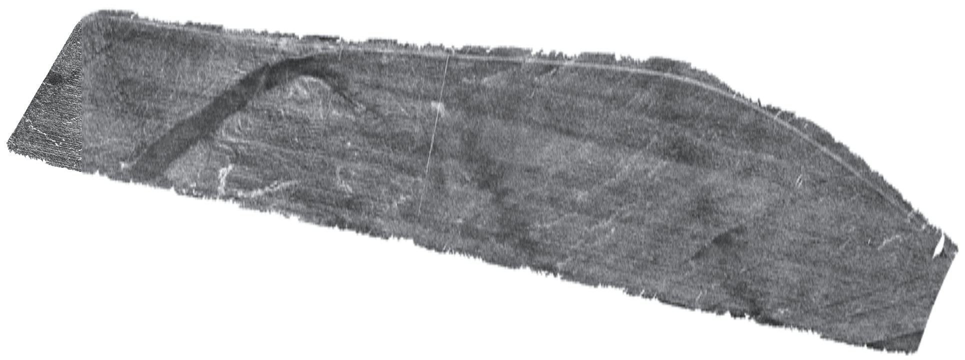
2.5 - 5.0ns (0.11 - 0.23m)



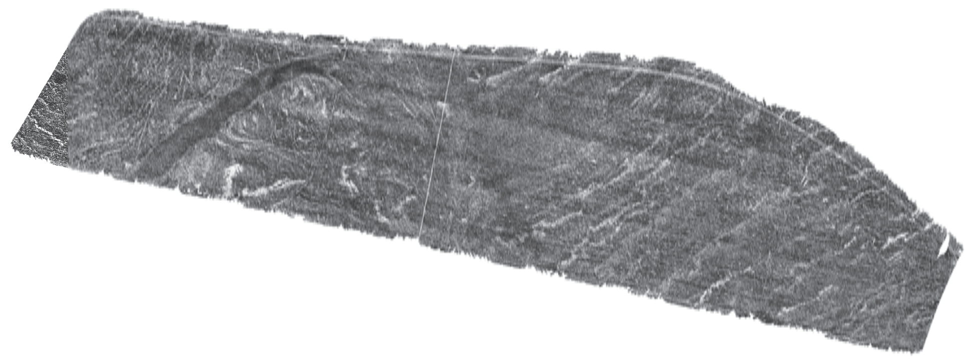
5.0 - 7.5ns (0.23 - 0.34m)



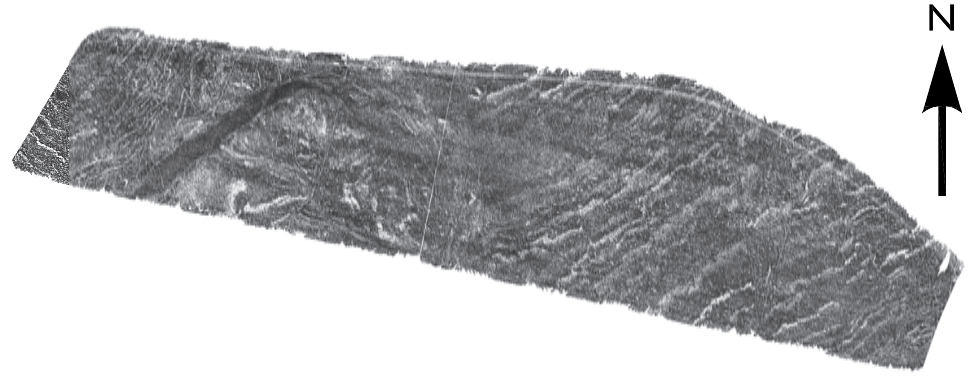
7.5 - 10.0ns (0.34 - 0.46m)



10.0 - 12.5ns (0.46 - 0.57m)

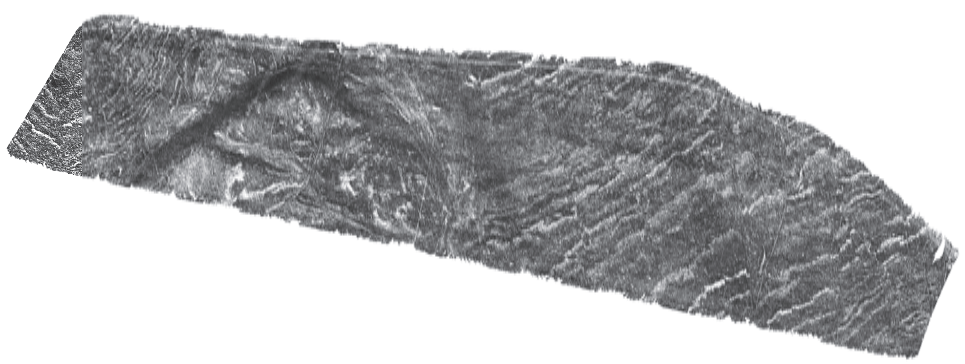


12.5 - 15.0ns (0.57 - 0.69m)

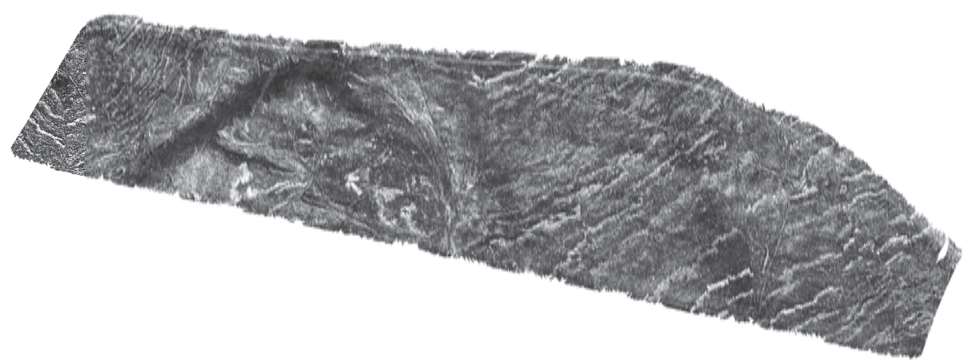


N

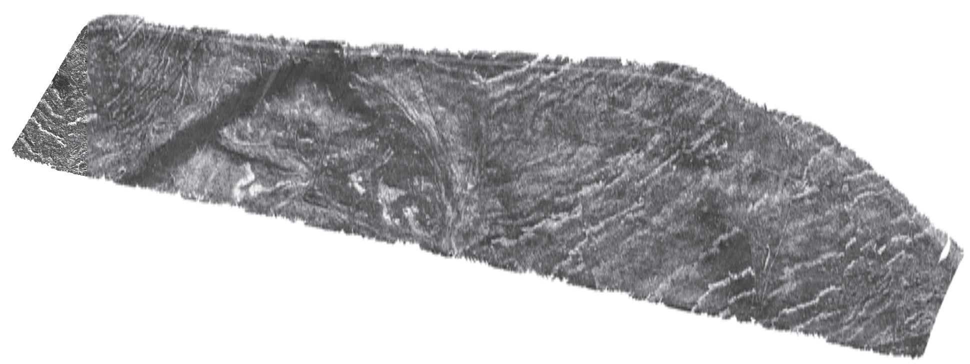
15.0 - 17.5ns (0.69 - 0.80m)



17.5 - 20.0ns (0.80 - 0.92m)



20.0 - 22.5ns (0.92 - 1.03m)



Low *High*
relative reflector strength

0 300m
1:7500

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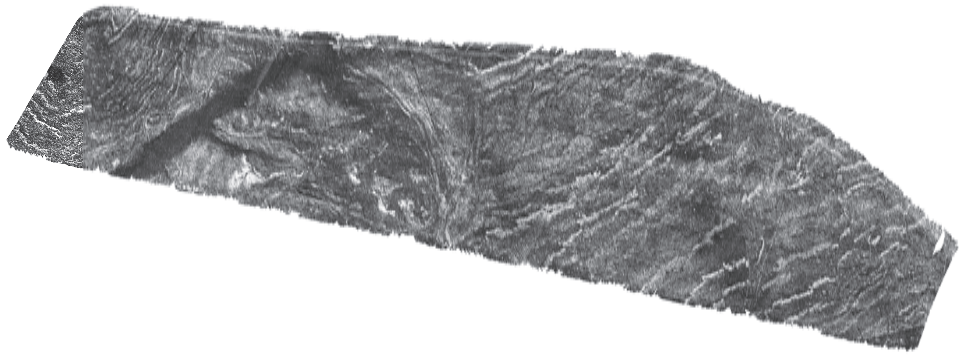
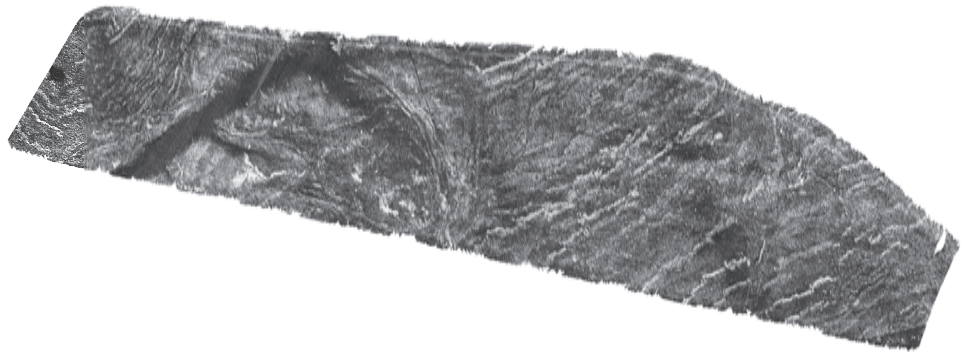
STONEHENGE SOUTHERN WHS SURVEY: WEST AMESBURY, WILTSHIRE
GPR amplitude time slices between 22.5 and 45.0ns (1.03 - 2.06m), October 2015

Figure 10

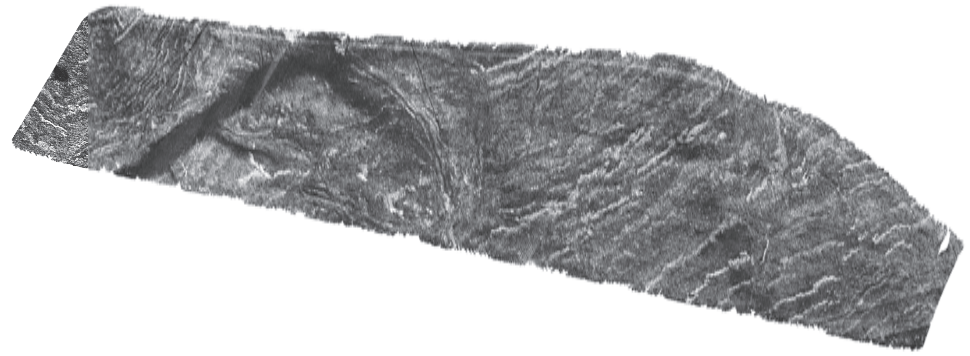
22.5 - 25.0ns (1.03 - 1.15m)



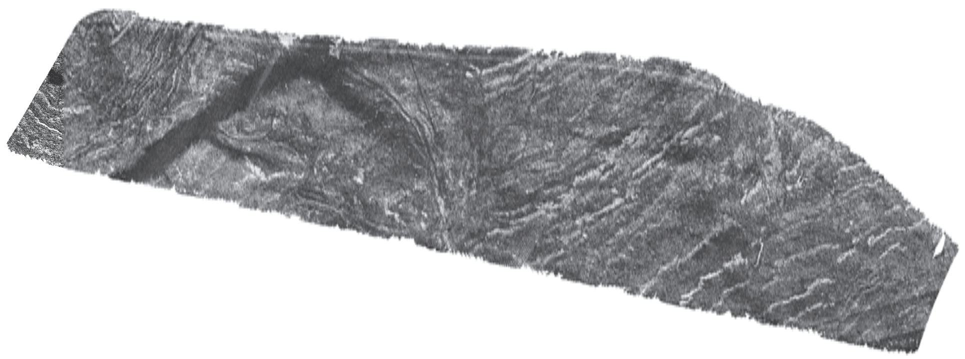
25.0 - 27.5ns (1.15 - 1.26m)



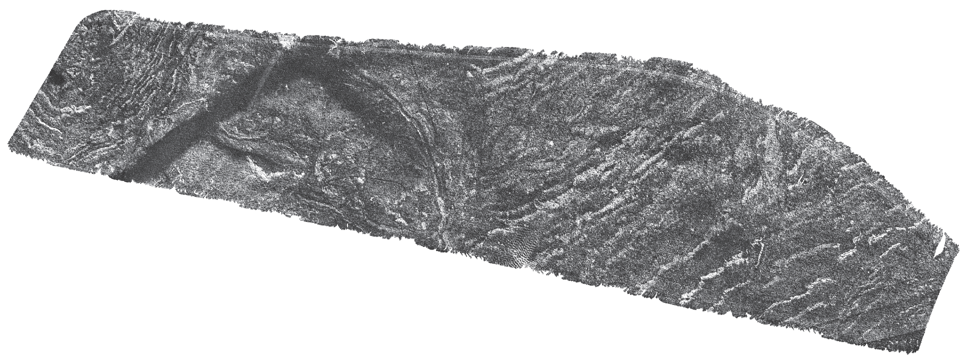
27.5 - 30.0ns (1.26 - 1.38m)



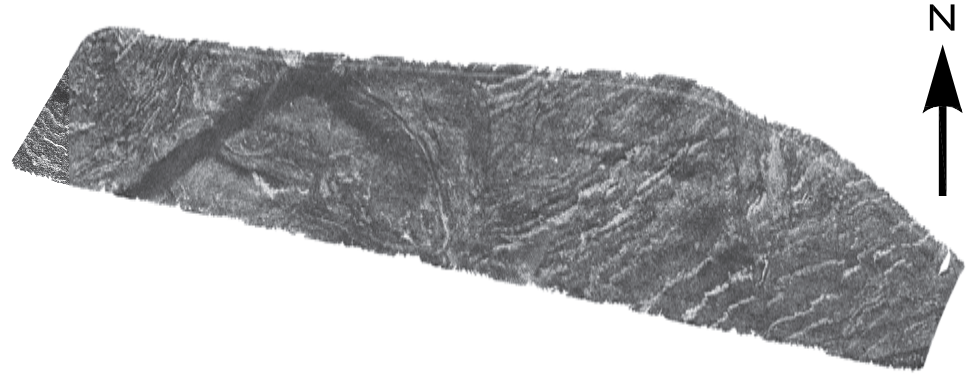
30.0 - 32.5ns (1.38 - 1.49m)



32.5 - 35.0ns (1.49 - 1.6m)

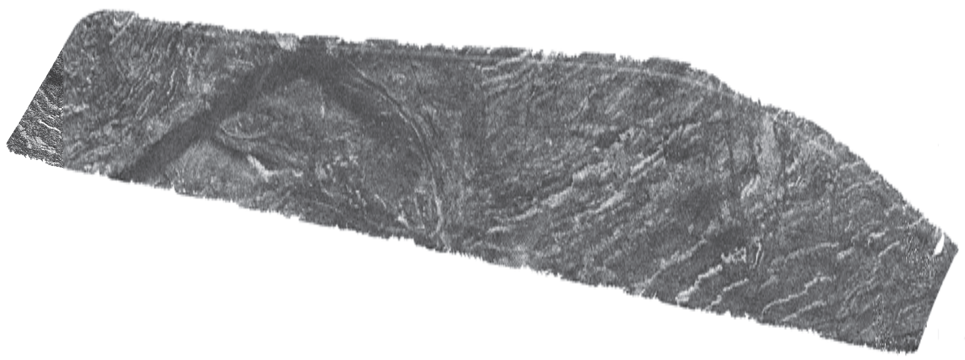


35.0 - 37.5ns (1.6 - 1.72m)

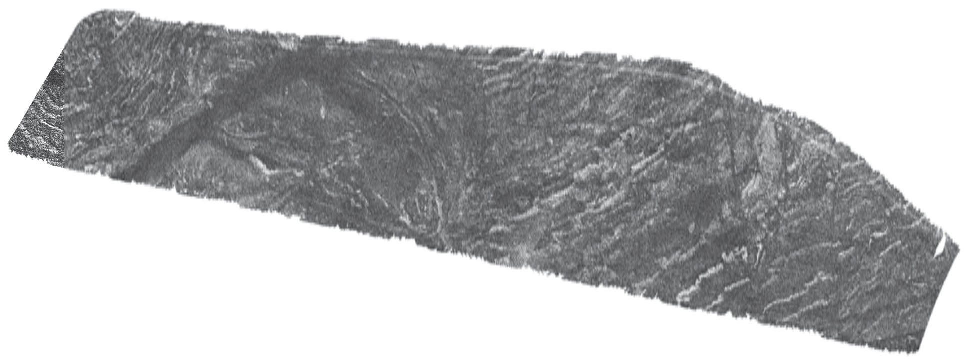


N

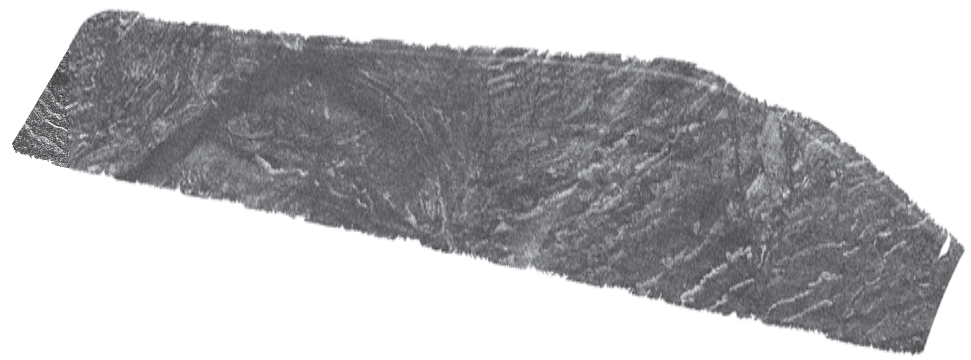
37.5 - 40.0ns (1.72 - 1.83m)



40.0 - 42.5ns (1.83 - 1.95m)



42.5 - 45.0ns (1.95 - 2.06m)



Low *High*
relative reflector strength

0 300m
1:7500

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STONEHENGE SOUTHERN WHS SURVEY: WEST AMESBURY, WILTSHIRE
GPR amplitude time slices between 45.0 and 67.5ns (2.06 - 2.99m), October 2015

Figure 11

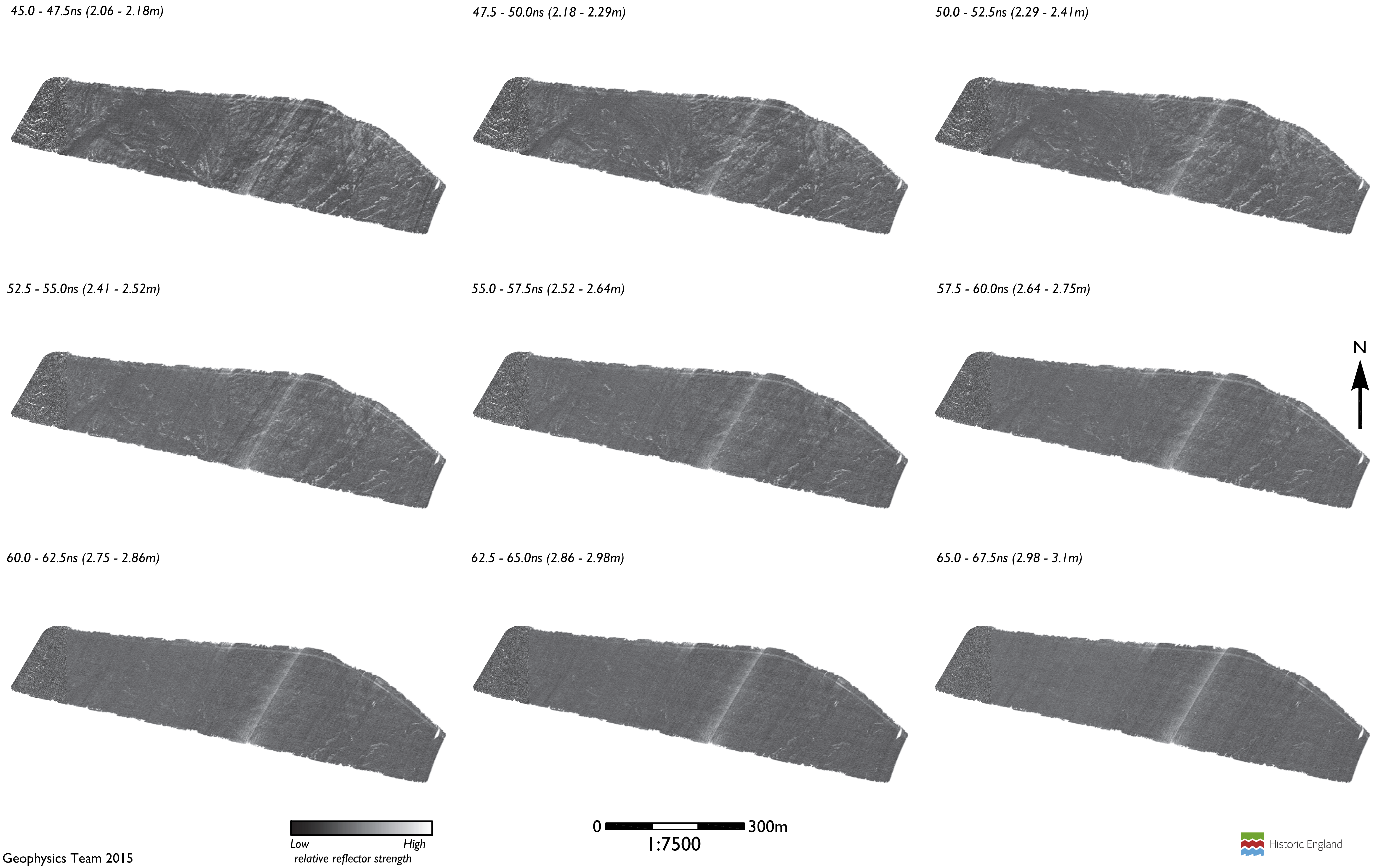

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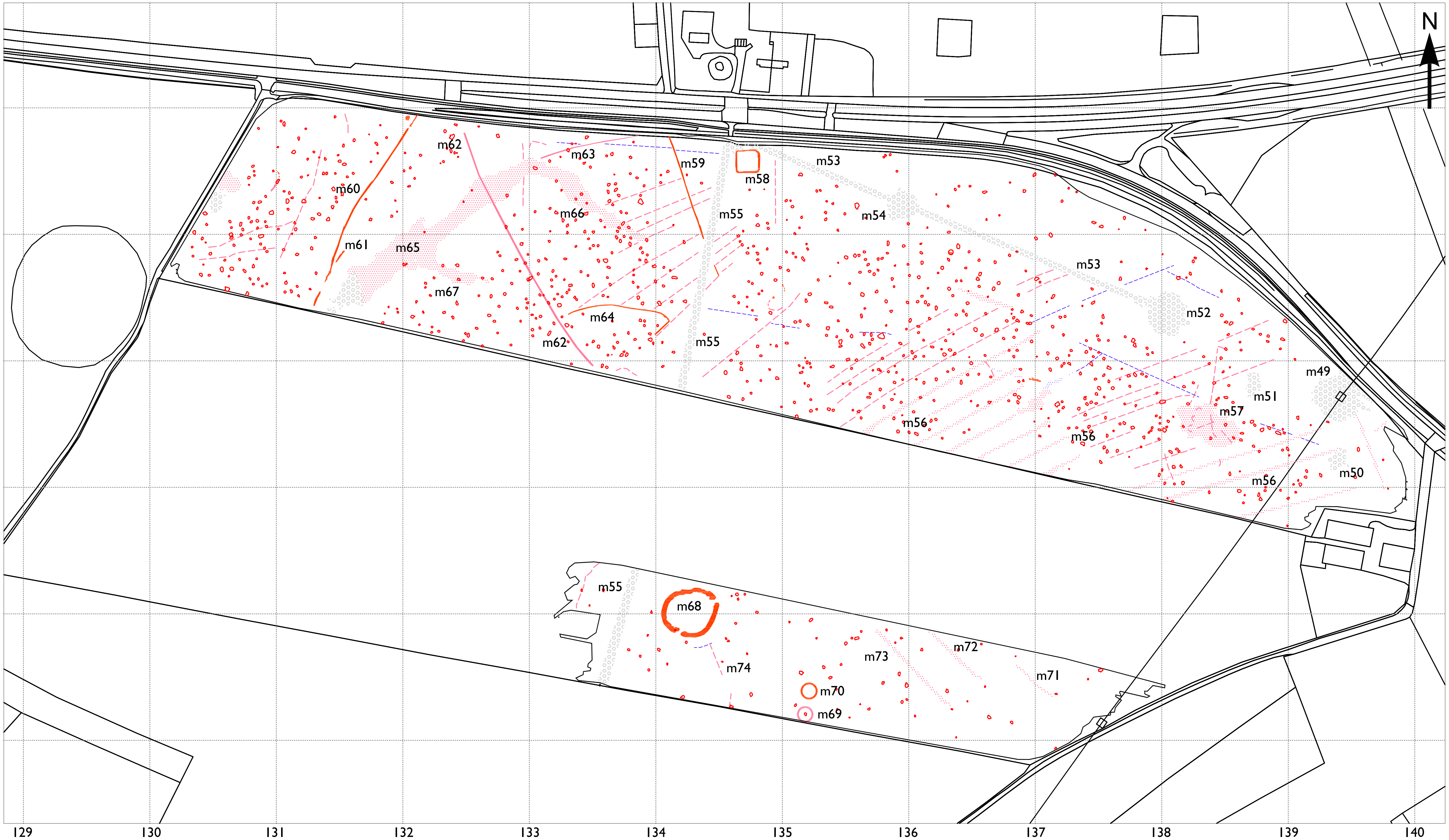
Figure 12

STONEHENGE SOUTHERN WHS SURVEY: WEST AMESBURY, WILTSHIRE
Graphical summary of significant magnetic anomalies, October 2015

SU1341



0 150m
1:3000

positive magnetic
negative magnetic
pit/tree throw hollow
raised magnetic
magnetic noise

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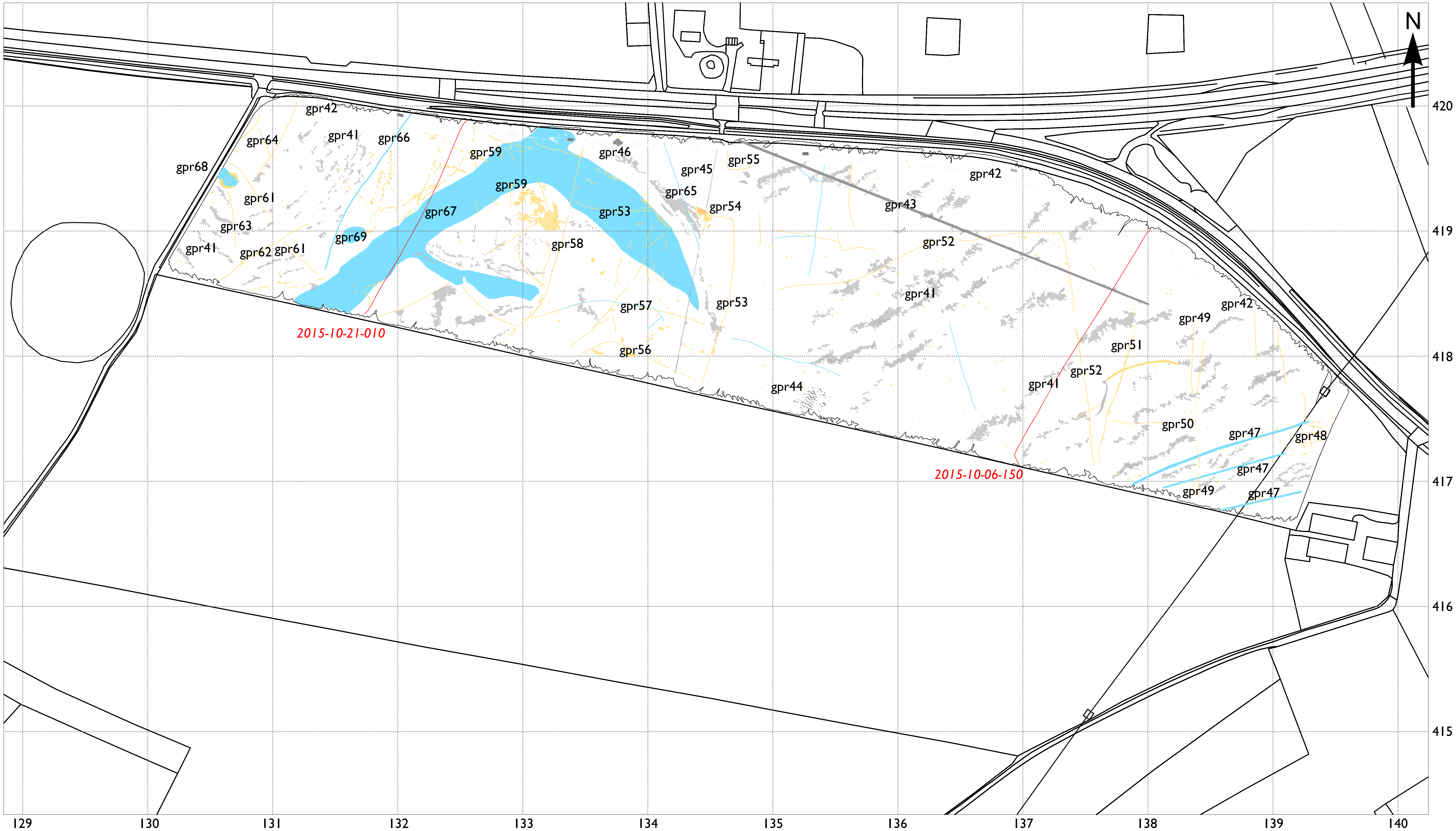
Figure 13

STONEHENGE SOUTHERN WHS SURVEY: WEST AMESBURY, WILTSHIRE
Graphical summary of significant GPR anomalies, October 2015



0 150m
1:3000

low amplitude reflectors
high amplitude reflectors
anomalies of known or recent origin
2015-10-06-150 Location of selected GPR profile shown on Figure 3

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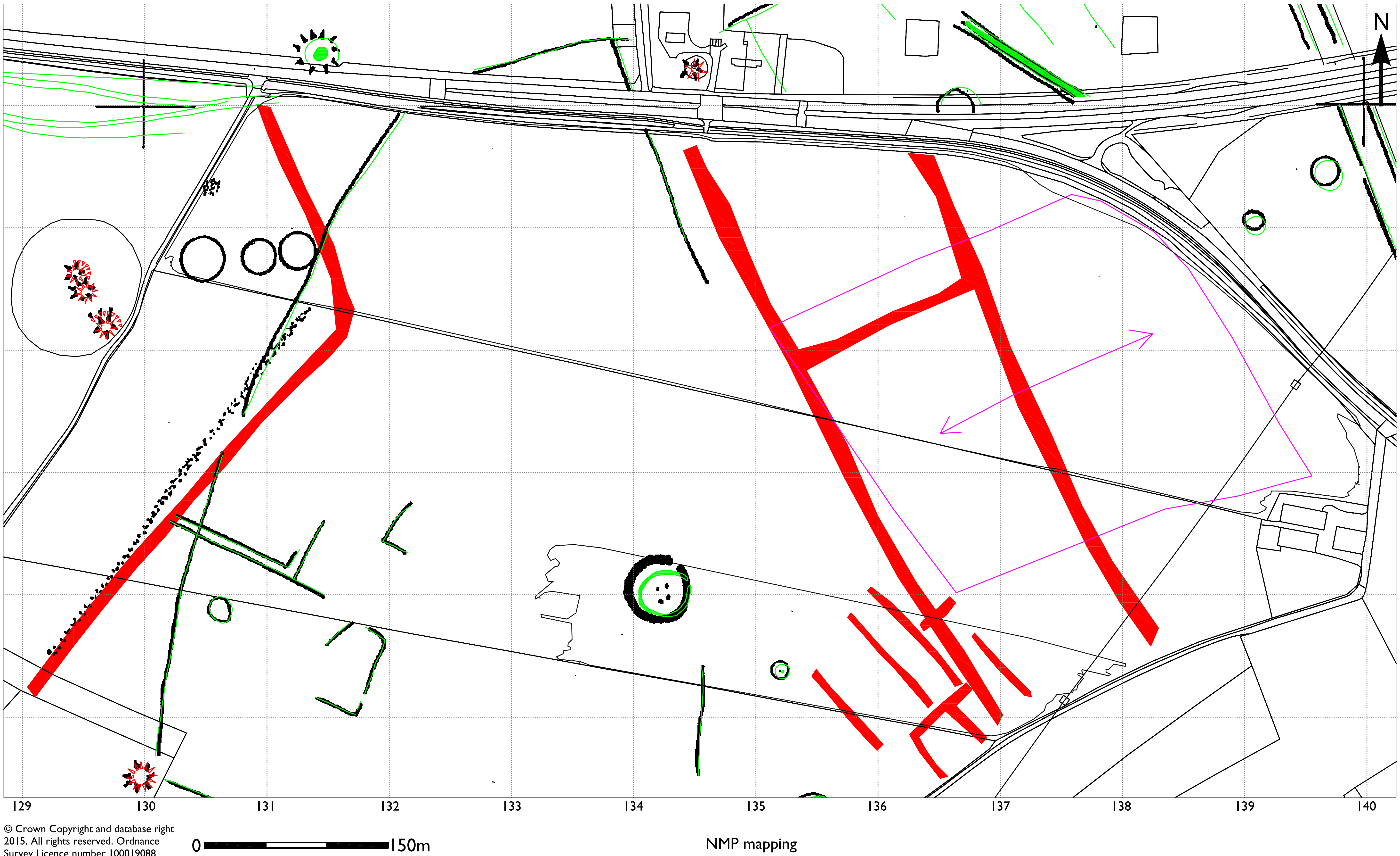
Figure 14

STONEHENGE SOUTHERN WHS SURVEY: WEST AMESBURY, WILTSHIRE

Graphical summary of the NMP aerial survey evidence



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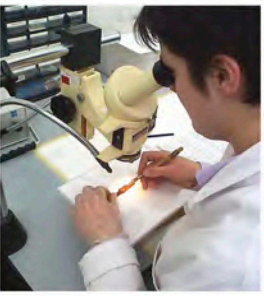



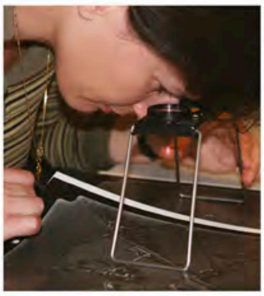


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