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Hinton St Mary Roman Villa, Dorset

Report on Geophysical Surveys, April 2023

Megan Clements, Neil Linford, Paul Linford and Andrew Payne

Geophysics Team

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Summary

Earth Resistance and Ground Penetrating Radar (GPR) surveys were conducted at Hinton St Mary, Sturminster Newton, Dorset, as part of wider works to place the Hinton St Mary Roman Villa and mosaic into a greater landscape context. The earth resistance survey (1.1ha) identified two buildings along with several ditches, drains and a modern pipe in addition to areas of landscaped ground and geological variation. The vehicle towed GPR survey (2.4ha) identified a limited number of fragmented responses to features mainly identified as drains during the excavation.

Contributors

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

Acknowledgements

The authors are grateful for the landowners' permission to survey on the land. The cover image shows the earth resistance survey in progress in the foreground and the vehicle towed GPR acquisition underway in the background (photo taken by Megan Clements).

Archive location

Fort Cumberland, Fort Cumberland Road, Portsmouth, PO4 9LD.

Date of survey/research/investigation

The fieldwork was conducted between the 24th and 27th April 2023 and the report completed on 21st of June 2023.

Contact details

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Contents

Introduction

Earth Resistance and Ground Penetrating Radar (GPR) surveys were conducted at the Hinton St Mary Roman Villa, Hinton St Mary, Dorset to place the villa within a wider landscape context and extend the current geophysical survey coverage.

A Roman mosaic contained within a minor villa was discovered at Hinton St Mary in Dorset during the 1960s. Owing to the mosaic's importance as the earliest Romano-British depiction of Christ, it was listed (NHLE 1002433), excavated and purchased by the British Museum (BM). The monument has the Dorset Historic Environment Number MDO3992. A proposed loan of the mosaic as part of the redevelopment of Dorset Museum prompted new investigative work to better understand the extent and layout of the villa. This includes new excavations by the British Museum together with Vianova Archaeology & Heritage Services and Albion Archaeology. Historic England has supported this research through assessing the wider landscape context of the site with analysis of aerial photography and lidar (Carpenter 2022). Further geophysical surveys were also requested to investigate discrepancies between the 1960s excavation plans, an earlier 1996 geophysical survey, more recent GPR survey, and features revealed in the first season of new excavations (Payne 1996; Fry 2021; Guest *et al.* 2022). A combination of more detailed earth resistance and high sample density GPR survey were proposed to complement existing results and to extend the coverage into adjacent land parcels to better define the extent of the Roman activity.

The bedrock geology across the centre of the site is Newton Clay, a sandy sedimentary mudstone, changing to Todber Freestone limestone to the northeast and Sturminster Pisolite limestone to the southwest. No superficial geology is recorded (Geological Survey of Great Britain 1970). Soils are of the Sherborne (343d) association, shallow well drained brashy calcareous clayey soils over limestone, associated with slowly permeable calcareous clayey soils (Soil Survey of England and Wales 1983).

The weather began dry and sunny after heavy rain showers the preceding day and ground conditions became increasingly dry over the next two days. On the third day the weather became more overcast with rain showers in the afternoon as survey work was completed.

Method

Due to overgrown vegetation, the proposed area of investigation south of Forge Field was not surveyed (Figure 1).

Earth Resistance – Twin-Electrode Array

The earth resistance survey focused on and around the scheduled monument (NHLE 1002433) contained within Forge Field in addition to the adjacent fields of Happy and Little Crispin, to test for any evidence of Roman remains extending beyond the designated area.

Measurements were recorded over a 30m grid established with a Trimble R8s GNSS (Figure 1) using a Geoscan RM85 earth resistance meter, internal multiplexer, and a PA5 electrode frame in the Twin-Electrode configuration to allow two separate surveys, with electrode separations of 0.5m and 1.0m, to be collected simultaneously. The 0.5m electrode separation coverage was designed to detect near-surface anomalies in the upper 0.5m of the subsurface whilst the 1.0m separation survey allowed anomalies to a depth of about 1-1.25m to be detected. For the 0.5m electrode separation survey readings were taken at a density of 0.5m x 1.0m whilst for the 1.0m separation survey they were taken at a density of 1.0m x 1.0m.

Extreme values caused by high contact resistance were suppressed using an adaptive thresholding median filter with a radius of 1.0m (Scollar *et al.* 1990). The results for the near-surface 0.5m electrode separation survey are depicted as a greyscale image in Figure 3 superimposed on the base Ordnance Survey (OS) mapping data. Figure 5 shows the minimally processed data from both the 0.5m and 1.0m electrode separation data presented as trace plots and histogram equalised greyscale images following the suppression of extreme data values. Processed datasets are also presented as linear grayscale images after the application of Gaussian high pass filter with a radius of 5.0m to emphasise archaeological scale anomalies and suppress measurement noise respectively.

Earth Resistance – GST Ltd. SF 2 Array

An additional earth resistance survey was conducted using a GST Ltd. SF 2 trapezoidal array and Geoscan RM15 earth resistance meter, resurveying four of the grids over the scheduled area. Readings were taken every 1.0m with a 1.0m traverse separation. Figure 13 displays the comparison of data between the twin electrode and trapezoidal array datasets. The same processing steps and parameters were applied when processing the trapezoidal dataset as described above for the twin electrode survey.

Ground Penetrating Radar

A 3d-Radar MkIV GeoScope Continuous Wave Step Frequency (CWSF) Ground Penetrating Radar (GPR) system was used to conduct the survey collecting data with a multi-element DXG1820 vehicle towed, ground coupled antenna array (Linford *et al.* 2010; Eide *et al.* 2018). A roving Trimble R8s Global Navigation Satellite System (GNSS) receiver was mounted on the GPR antenna array, that together with a second R8s base station was used to provide continuous positional control for the survey collected along the instrument swaths shown on Figure 2. The GNSS base station receiver was adjusted to the National Grid Transformation OSTN15 using the Trimble VRS Now Network RTK delivery service. This uses the Ordnance Survey's GNSS correction network (OSNet) and gives a stated accuracy of 0.01-0.015m per point with vertical accuracy being half as precise.

Data were acquired at a 0.075m x 0.075m sample interval across a continuous wave stepped frequency range from 40MHz 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 75ns), 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 full GPR survey data set are shown on Figure 8. To aid visualisation amplitude time slices were created from the entire data set by averaging data within successive 2.5ns (two-way travel time) windows (eg Linford 2004). An average sub-surface velocity of 0.118m/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 therefore represents the variation of reflection strength through successive ~0.14m intervals from the ground surface, shown as individual greyscale images in Figures 4, 9 and 10. Additional visual representation of the data were also used for the interpretation, including amplitude time slices of the imaginary component of the recorded trace integrated over a 0.24ns (0.014m) time window (Figure 8 inset). Further details of both the frequency and time domain algorithms developed for processing this data can be found in Sala and Linford (2012).

Due to the size of the resultant data set a semi-automated algorithm has been employed to extract the vector outline of significant anomalies shown on Figure 12. The algorithm uses edge detection to identify bounded regions followed by a morphological classification based on the size and shape of the extracted anomalies. For example, the location of possible pits is made by selecting small, sub circular anomalies from the data set (Linford and Linford 2017).

Results

Earth Resistance Survey

A graphical summary of significant earth resistance anomalies [**r1-25**] discussed in the following text superimposed on the base OS mapping data is provided in Figure 11.

Two high resistance anomalies have been detected within Forge Field and are likely to be buildings [**r1**] and [**r2**]. Both have a distinct higher outer boundary response, although it is difficult to determine any possible internal detail due to likely spreads of debris material. Trench 5 of the British Museum (BM) excavations in 2021 was placed across the southern end of [**r1**] however no conclusive evidence of walls or floors were found (Guest *et al.* 2022). Building [**r2**] possibly extends south into Happy Field where anomaly [**r3**] is more enhanced than the surrounding fragmented responses [**r18**], and lies on the same orientation as [**r2**]. Two linear high resistance anomalies [**r4**] and [**r5**] are found between [**r1**] and [**r2**] perpendicular to the long axis of the buildings, and [**r5**] appears to curl inward, possibly indicating this anomaly once formed the southern wall of a building.

Two curvilinear ditch-type anomalies [**r6**] are found to the west of [**r1-5**] and are bisected by [**r7**], which is most likely a response to a limestone field drain excavated by the BM dating to the 18th or 19th century (Guest *et al.* 2022).

A large spread of high resistance material [**r8**] is found to the north of the survey area over the focus of the 1963-5 excavations (Guest *et al.* 2022). In addition, two recent bonfires in the northern most corner of Forge Field correspond with the location of low resistance anomalies [**r9**] and [**r10**].

Several linear high resistance anomalies orientated northeast-southwest across the survey area correlate with similar responses from the previous earth resistance survey and were interpreted as potential walls (Payne 1996). While no walls were found when excavated, areas of stone surfacing of a likely yard were recorded. A low resistance anomaly [**r11**] was also excavated and found to be a flat-bottomed trench or ditch, and filled with a firm clean silty clay. The BM interpreted this feature as a possible ditch, a drain where the stone linings and capstones have been completely removed, or perhaps the base for a robbed wall or partitions (Guest *et al.* 2022). The change in response from low to high resistance could indicate the drain retains its stone linings to the south, or that the drain is only filled with the firm clean silty clay to the north.

A sub-rectangular anomaly [**r12**] in the eastern corner of the survey is suggestive of wall footings, although no structural remains were identified here during the BM's excavation other than an irregular patch of compacted medium limestone fragments recorded in the location of the eastern most high resistance response (Guest 2022).

A low resistance linear anomaly [**r13**] is found on a north-south orientation across the eastern end of Forge Field and corresponds with a ferrous pipe identified in the 1996 fluxgate gradiometer data (Payne 1996). The pipe in all likely hood is a utility pipe associated with the modern house. In addition, a number of high resistance amorphous anomalies [**r14**] have been detected north and east of the pipe and are likely the result of building rubble, wall robbing, or landscaping.

Two linear high resistance anomalies [**r15**] along the north western boundary of the survey area are possibly associated with the construction or maintenance of the modern road between Little Crispin Field to the north, and Forge and Happy fields to the south.

Within Happy Field is a very strong high resistance anomaly [**r16**] which corresponds with a magnetic response in the 1996 survey that suggested the location of a possible building (see anomaly x in Payne 1996). However there is no indication of any structural remains in the current resistance data suggesting this may be an area of rubble spread.

A north-south linear low resistance ditch [**r17**] corresponds with a similar anomaly identified within the magnetometer survey (see anomaly q in Payne 1996).

Several high resistance anomalies have been identified in the north of Happy Field [**r3**] and [**r18**]. Anomaly [**r3**] may be associated with building [**r2**]. However, due to the fragmented nature of [**r18**] and their location at the edge of the surveyed area, it is not possible to suggest a more confident interpretation for this cluster of high resistance anomalies.

A more complex response of high resistance [**r19**] is likely to have a geological origin. Due to this and the largely masking effect of the response, it is not possible to determine if the linear anomalies identified within the spread are of archaeological significance.

Within the final field surveyed, Little Crispin Field, is a curvilinear low resistance anomaly [**r20**] which corresponds to a re-filled trench observed at the time of the survey. Additionally, the very high resistance anomalies detected are probably the result of compacted hardcore in the field entrance in the southern corner [**r21**], and landscaped ground from installing a wooden fence along the western boundary [**r22**]. The low resistance amorphous anomaly [**r23**] is likely to be an in-filled pit.

A large high resistance band [**r24**] has been recorded across Happy and Little Crispin Fields. An additional band of low resistance across Fields 1 and 4 with a further area along the north eastern boundary of Happy Field [**r25**] has also been detected. These anomalies are likely due to geological variation, noted as soil changes during the survey.

Comparison of Twin Electrode and GST Ltd. SF 2 Earth Resistance surveys

The half metre twin electrode and trapezoidal array survey results are compared in Figure 13. Bearing in mind the difference in sample density, 0.5m x 1.0m for the twin electrode and 1.0m x 1.0m for the trapezoidal array there is a high degree of correlation between the two surveys. Indeed, linear correlation of just the left-hand twin electrode measurement at each station with the equivalent trapezoidal measurement gives $r^2 = 0.80$ suggesting that about 80% of the observed variance is common to both datasets.

Some differences are apparent. The north-northwest to south-southeast post medieval boundary wall footing discovered in excavation trench 5 of which only a short fragment is detected as linear anomaly [**r7**] in the twin electrode dataset has been resolved across the entire width of the trapezoidal survey. It is detected as a high resistance anomaly in the stretch exposed in the excavation trench but as a low resistance anomaly further south. This may be due to differences in the compaction of the stones comprising the wall footing with a looser more conductive fill towards the south. Furthermore, linear high resistance anomalies are visible correlating with the positions of excavation trenches 2, 3 and 6 which are not apparent in the twin electrode survey. Interestingly, all these additional anomalies result from near-surface features suggesting that the trapezoidal array may be more sensitive to near-surface anomalies than the twin electrode configuration.

Ground Penetrating Radar Survey

A graphical summary of the significant GPR anomalies, [**gpr1-26**] discussed in the following text, superimposed on the base OS map data, is provided in Figure 12.

Forge Field

The very near-surface data shows a band of high amplitude response [**gpr1**] that corresponds with an area of apparently more water retentive soil to the south of the field. From 2.5ns (0.15m) onwards there is evidence for ground disturbance associated with some of the previous excavation trenches [**gpr2**] and the hard core [**gpr3**] close to the Forge buildings. Two linear anomalies [**gpr4**] and [**gpr5**] are found between 7.5 and 17.5ns and (0.44 to 1.03m) seem most likely to represent recent services, with [**gpr4**] falling to the south from the buildings along the course of the ferrous pipe (cf [**r13**]). It is unclear whether [**gpr5**] represents a non-ferrous service as this does not correspond to any similar response in the magnetic or earth resistance data sets. In addition, there are several linear anomalies on both similar [**gpr6**] and differing [**gpr7**] orientations to [**gpr5**] that are, perhaps, more suggestive of agricultural field patterns or drains.

A series of weak high amplitude rectilinear anomalies [**gpr8-10**] are found between 12.5 and 20.0ns and (0.74 to 1.18m) and correlate with [**r11**], and although the radar response is fragmentary it does, possibly, suggest more structural remains. Other linear high amplitude anomalies are found at [**gpr11**] over the course of the limestone drain [**r7**] revealed by the 2021 excavation. Some more fragmentary responses [**gpr12**] are found to the west of the field. An area of high amplitude response adjacent to the southern field boundary [**gpr13**] corresponds with the location of a small pond shown on historic mapping (OS Historic County Mapping Series: 1843-93 Epoch 1).

In comparison to the previous GPR survey there is no evidence for the broad linear anomalies on an approximately NW-SE orientation that appeared throughout the data set (Fry 2021, gpr02 on Figure3). As these anomalies followed the direction of data acquisition and the previous survey was conducted in May 2021 after a prolonged period of heavy rain, the current results support the interpretation that these responses were most likely data collection artefacts due to the variation in soil moisture. Some near-surface anomalies [**gpr14**] in the current data are possibly associated with the drainage features revealed by the excavation (cf [**r12**]), but are not readily apparent in all visual representations of the data (Figure 8).

Happy Field

The signal appears to be highly attenuated in this field with few, if any, identifiable anomalies. A highly tentative ditch-type response [**gpr15**] is found in the vicinity of [**r16**] and an amorphous area of high amplitude reflections [**gpr16**], may be associated with [**r19**], although few if any of the other magnetic or earth resistance anomalies have been replicated in the radar data. The dipping linear anomaly [**gpr17**] against the field boundary to the south east seems most likely to be an air-wave reflection from the metal fence line. An area of higher amplitude reflection [**gpr18**] to the north of the field could, possibly, be associated with the band of higher resistance [**r24**]. There is also a possible continuation [**gpr19**] of the field boundary from the land parcel to the north, although there is no record of this on the historic mapping.

Little Crispin Field

The very near-surface data contains a band of high amplitude response [**gpr20**], possibly a continuation of the more water retentive soil [**gpr1**] in the adjacent Forge Field, a sinuous linear anomaly [**gpr21**] due to a ditch cut visible on the surface, and vehicle ruts [**gpr22**] to the west of the field. A former field boundary [**gpr23**] is apparent from 2.5ns (0.15m) shown on the historic mapping (OS Historic County Mapping Series: 1843-93 Epoch 1) and a service pipe [**gpr24**] falling from the northwest corner of the field to the south. There are a number of pit-type anomalies [**gpr25**] which coincide with surface depressions that may indicate evidence for small scale quarrying activity. The dipping linear anomaly [**gpr26**] found in the north east corner of the survey is again most likely to represent an air-wave reflection from the adjacent ferrous fence line.

Conclusions

The earth resistance survey has successfully detected a number of anomalies of archaeological, modern and geological origin. The survey identified two buildings, several ditches, drains and a modern pipe. Additional, areas of made or landscaped ground and geological variation were also recorded. Unfortunately, the Ground Penetrating Radar (GPR) survey proved less successful and only identified a limited number of fragmented responses to features mainly identified as drains during the excavation. These results are similar to the previous GPR surveys at the site and suggest a limited dielectric contrast between the structural remains and the subsoil, perhaps also reflected in the limited range of the earth resistance readings too.

List of Enclosed Figures

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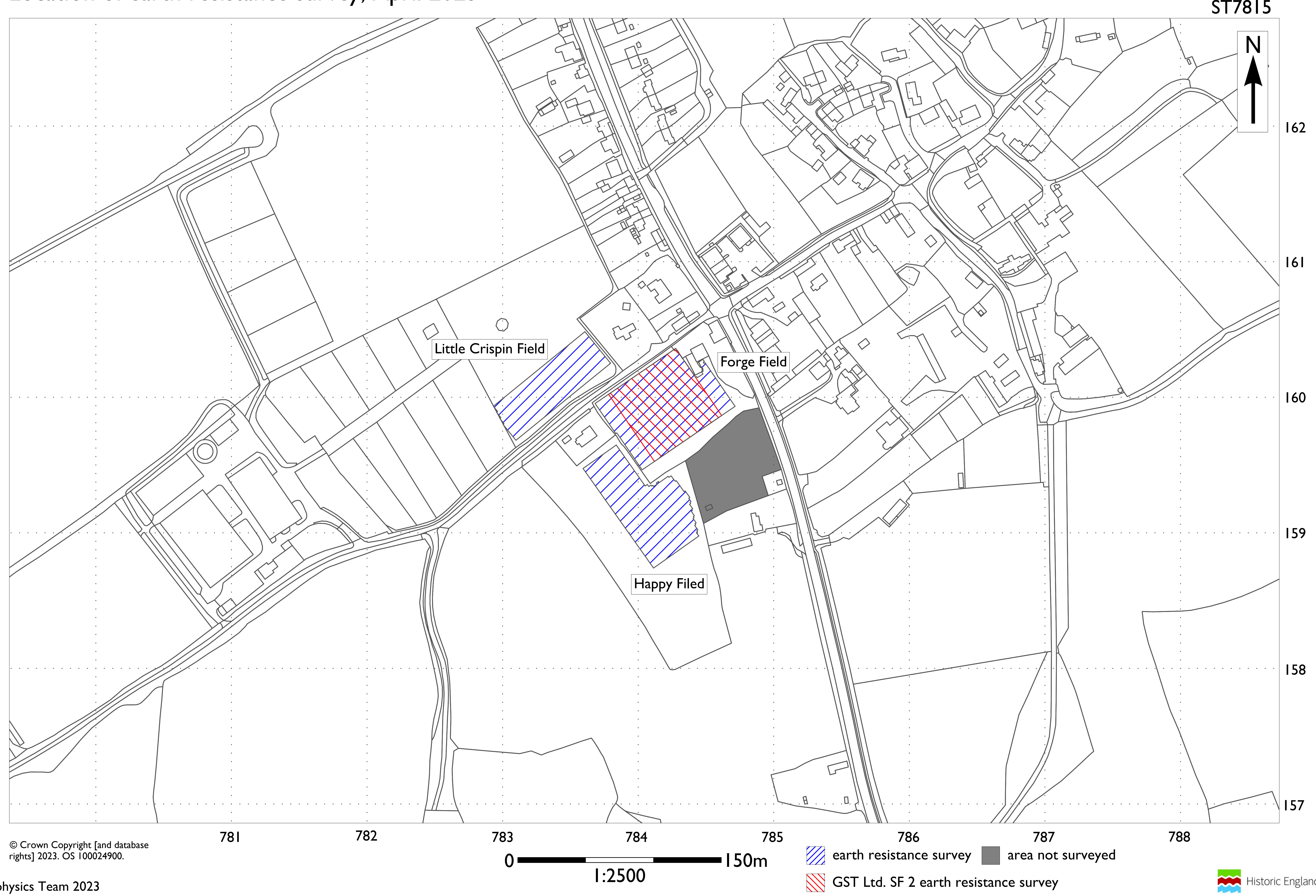
HINTON ST MARY, ROMAN VILLA, DORSET
Location of earth resistance survey, April 2023



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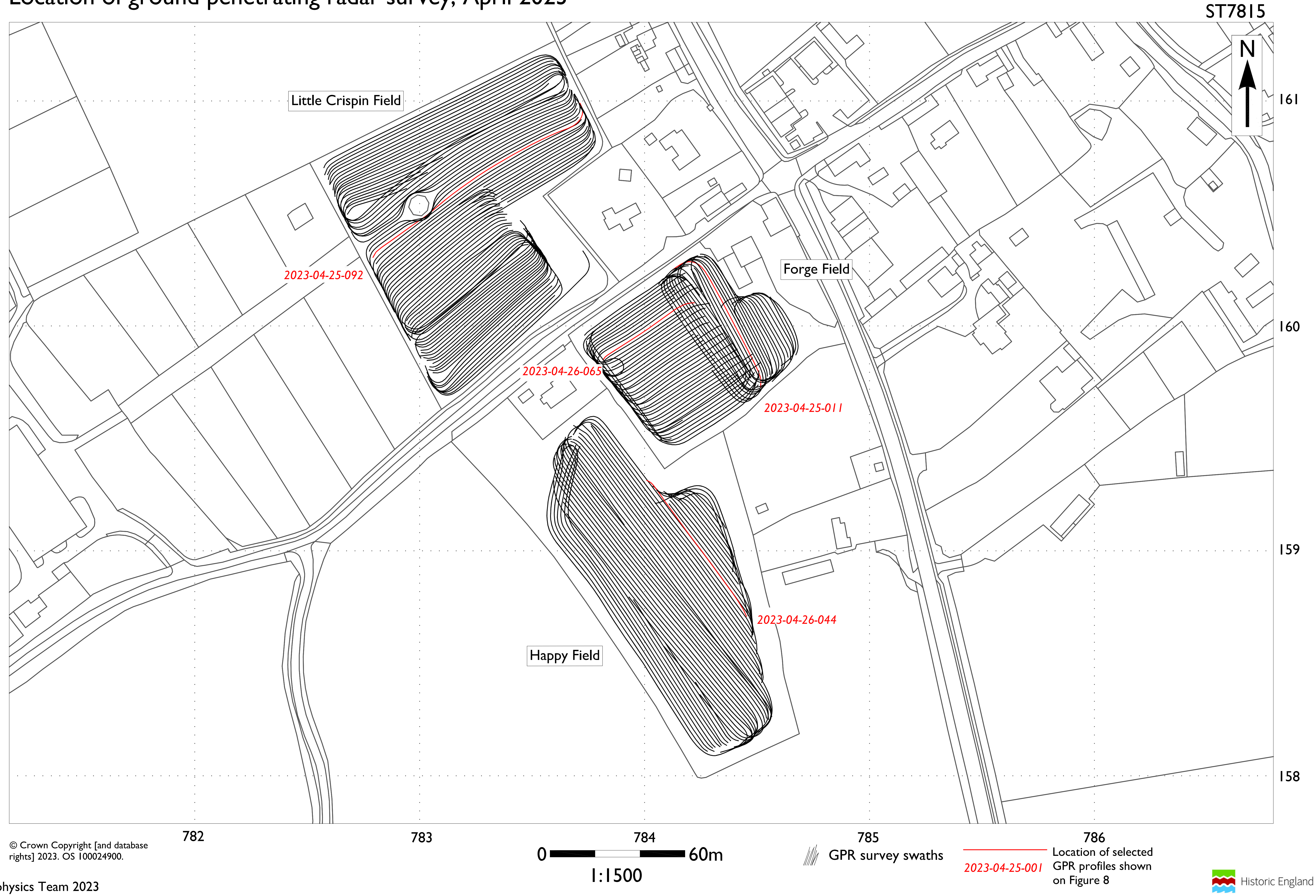
Historic England

Figure 2

HINTON ST MARY, ROMAN VILLA, DORSET
Location of ground penetrating radar survey, April 2023



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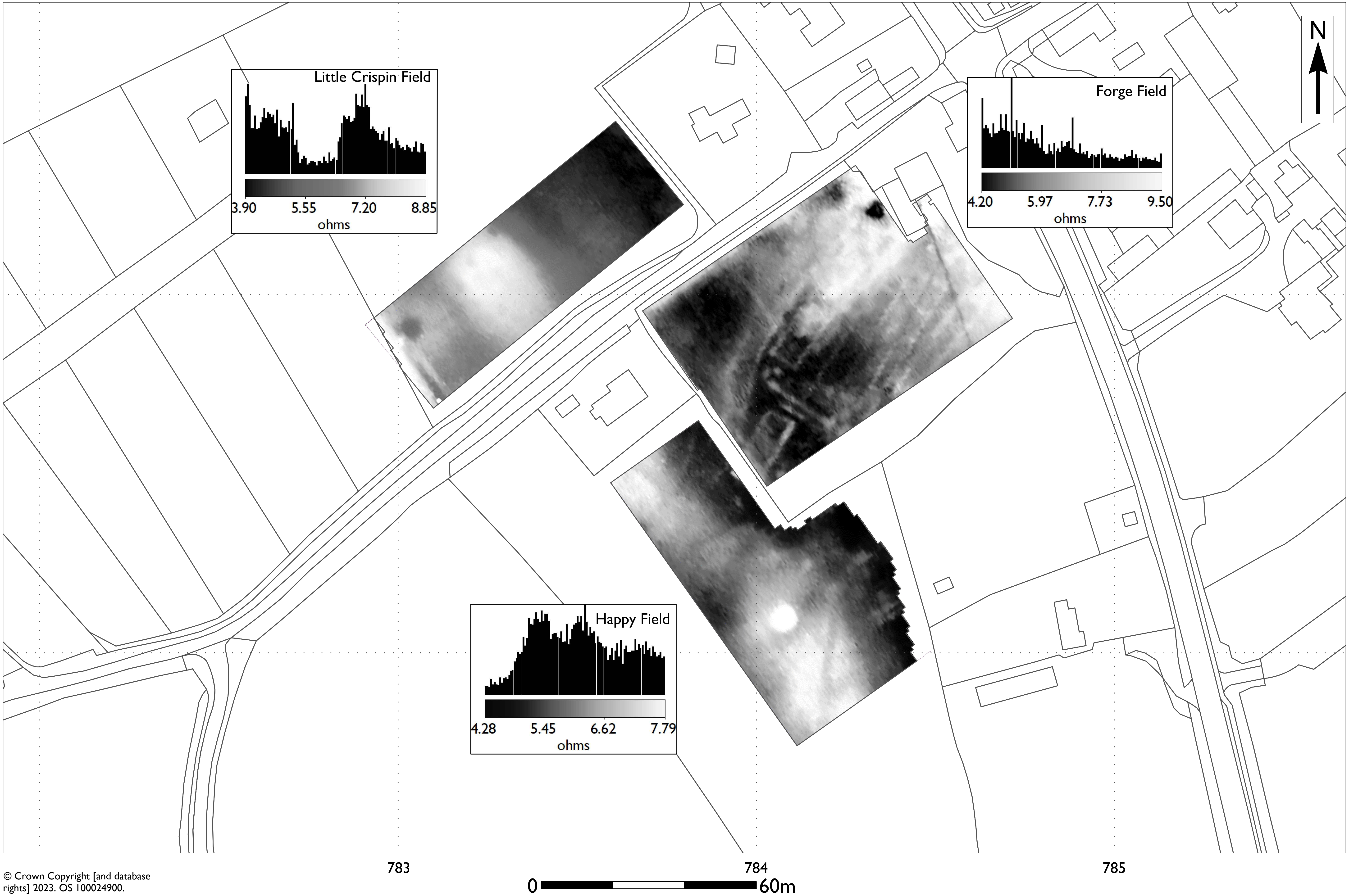
Historic England

Figure 3

HINTON ST MARY, ROMAN VILLA, DORSET
Location of 0.5m electrode separation earth resistance survey, April 2023



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Historic England

Figure 4

HINTON ST MARY, ROMAN VILLA, DORSET
Location of GPR amplitude time slice between 15.0ns and 17.5ns (0.89 to 1.03m), April 2023

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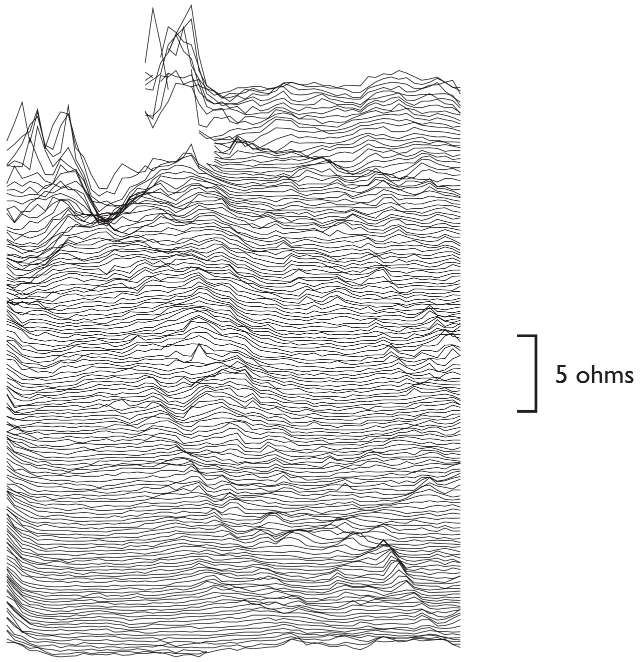
Figure 5

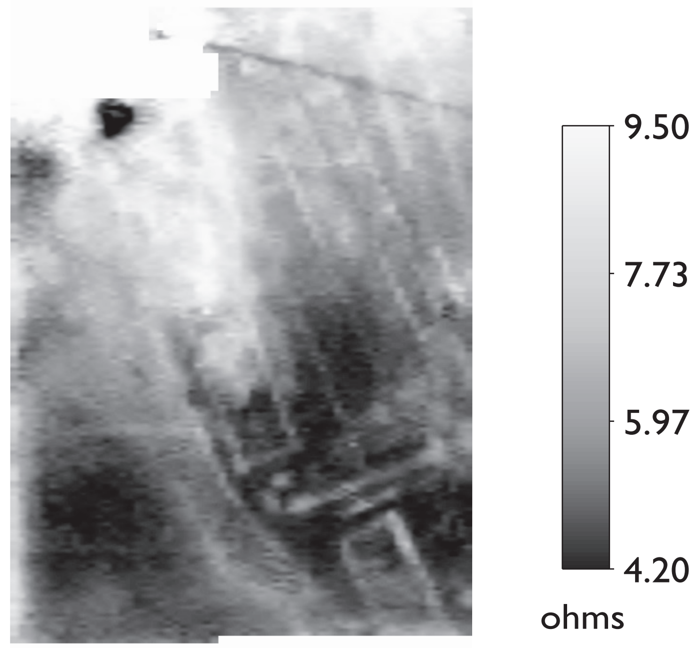
HINTON ST MARY, ROMAN VILLA, DORSET
Earth resistance survey of Field 1, April 2023

0.5m electrode separation data

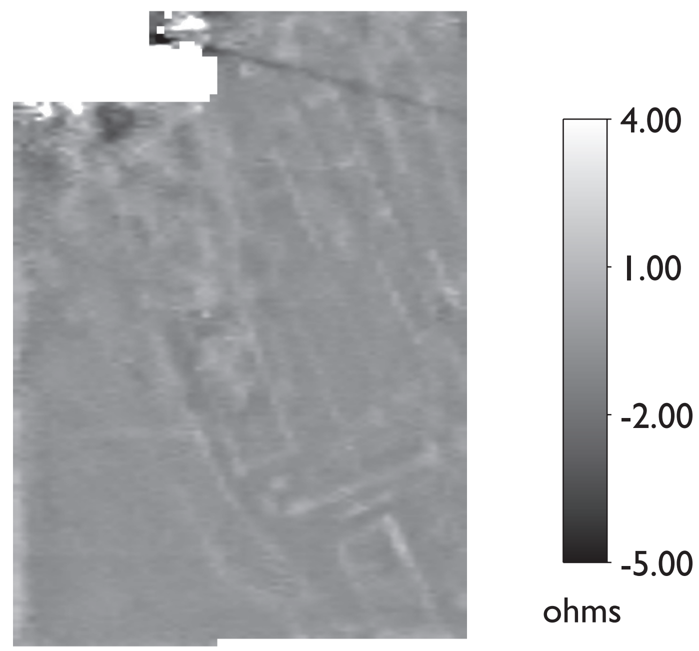
(A) Trace plot of minimally processed data



(B) Histogram equalised greyscale image of minimally processed data after noise removal

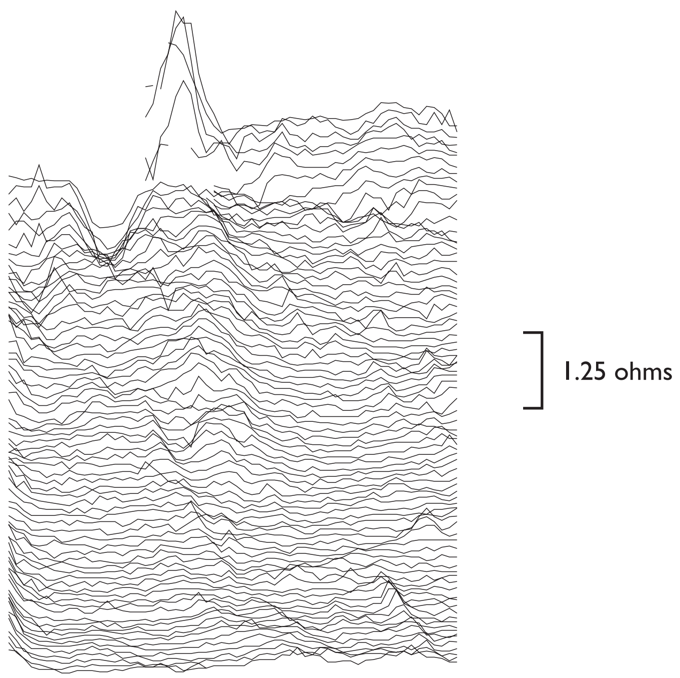


(C) Linear greyscale image of high pass filtered data after noise removal

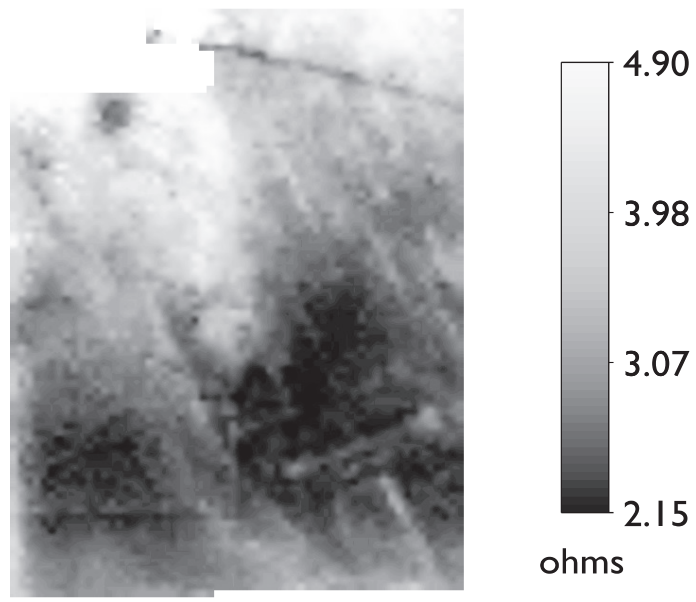


1.0m electrode separation data

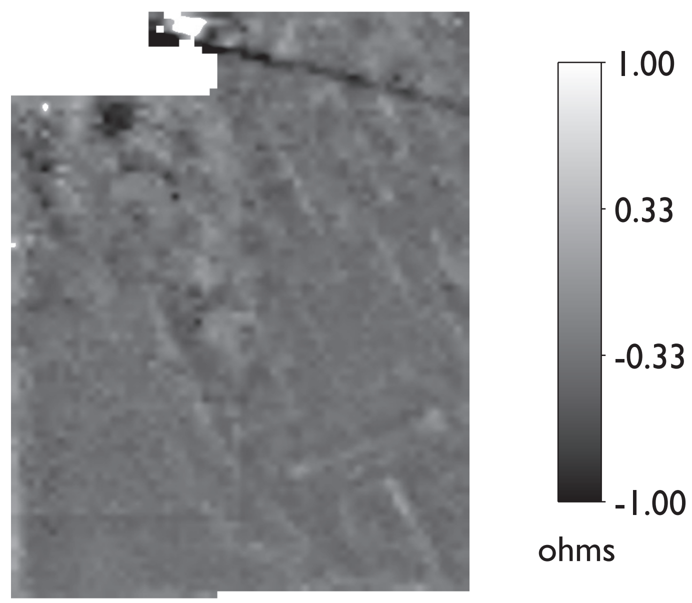
(D) Trace plot of minimally processed data



(E) Histogram equalised greyscale image of minimally processed data after noise removal



(F) Linear greyscale image of high pass filtered data after noise removal



N

0 90m

1:1000

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Historic England

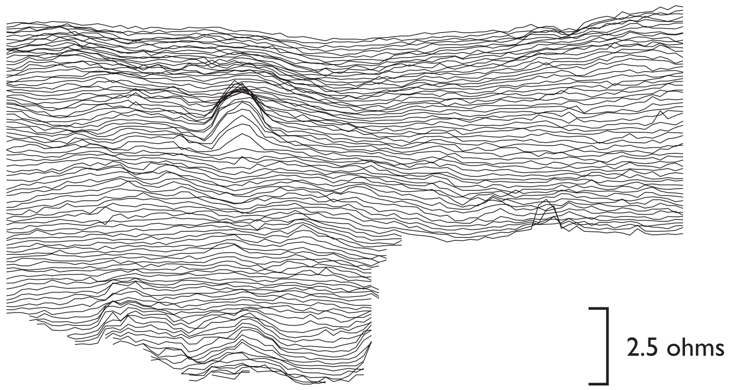
Figure 6

HINTON ST MARY, ROMAN VILLA, DORSET
Earth resistance survey of Happy Field, April 2023

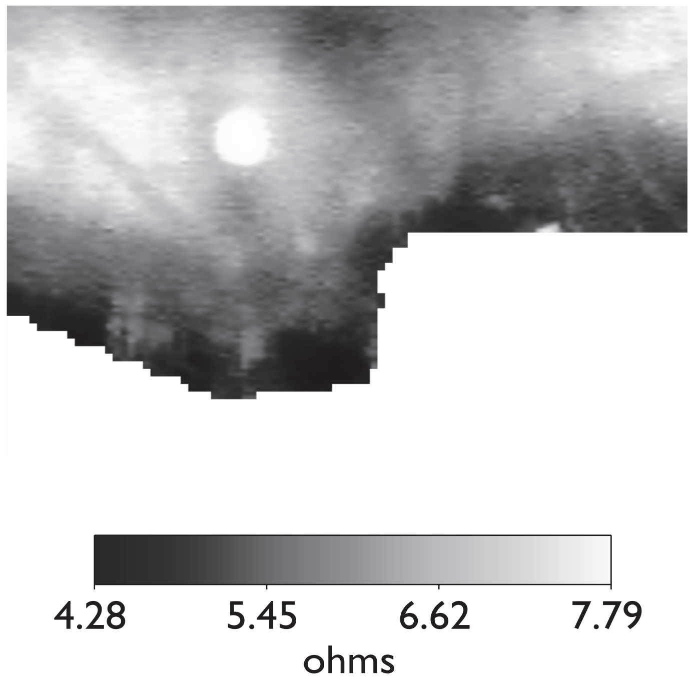
N

0.5m electrode separation data

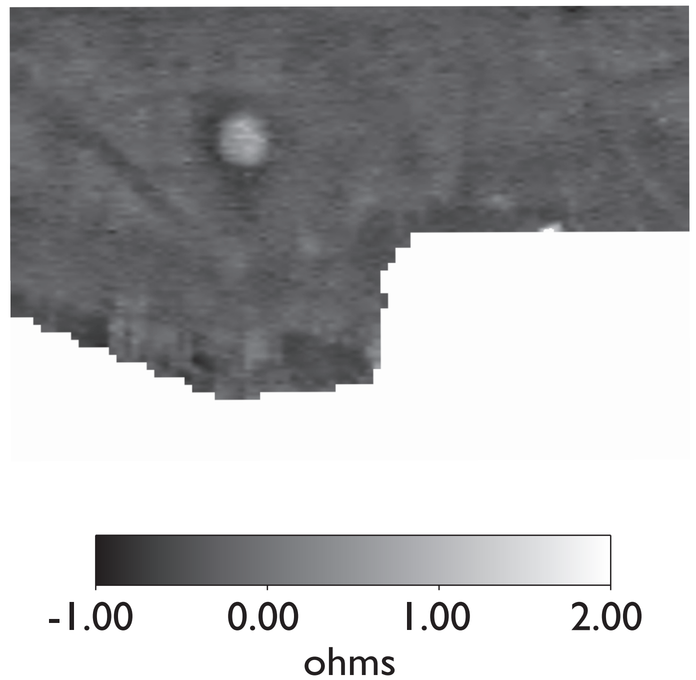
(A) Trace plot of minimally processed data



(B) Histogram equalised greyscale image of minimally processed data after noise removal

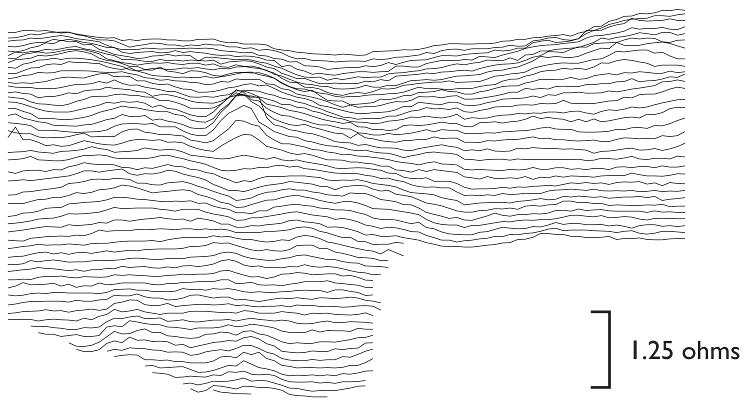


(C) Linear greyscale image of high pass filtered data after noise removal

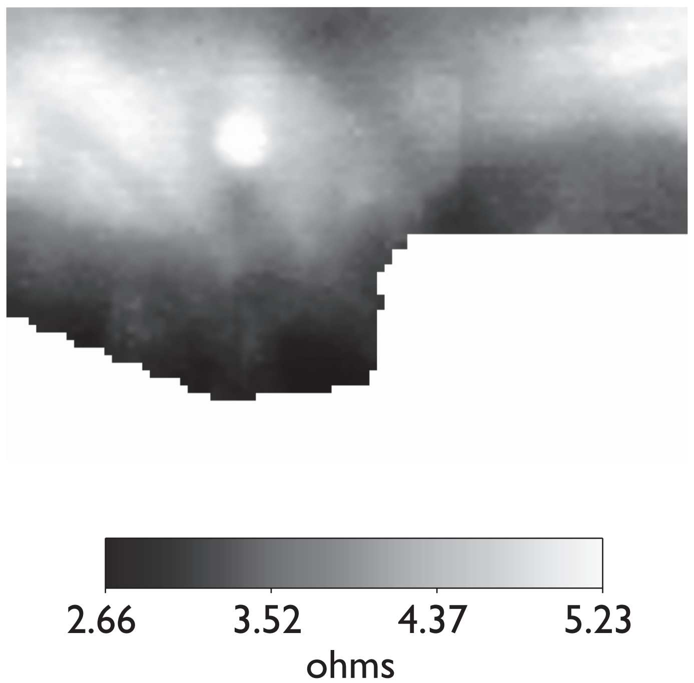


1.0m electrode separation data (D)

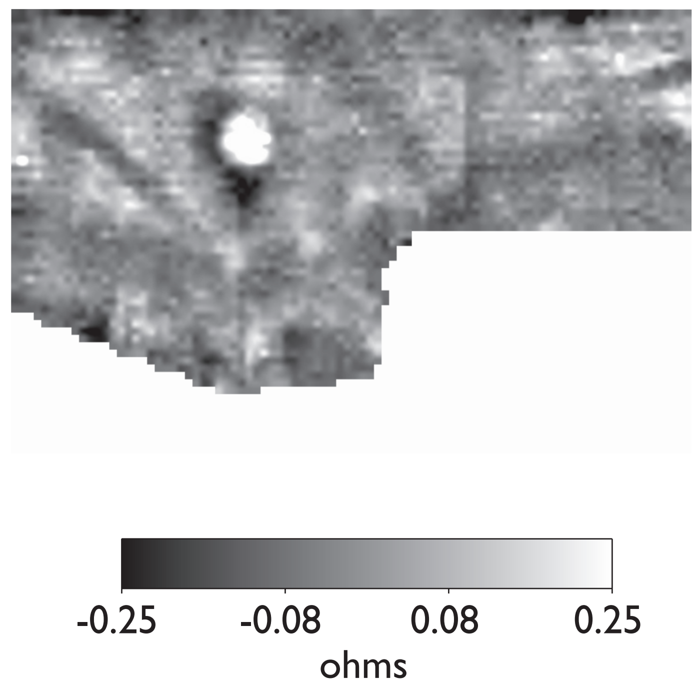
Trace plot of minimally processed data



(E) Histogram equalised greyscale image of minimally processed data after noise removal



(F) Linear greyscale image of high pass filtered data after noise removal



0 90m

1:1000

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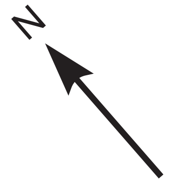
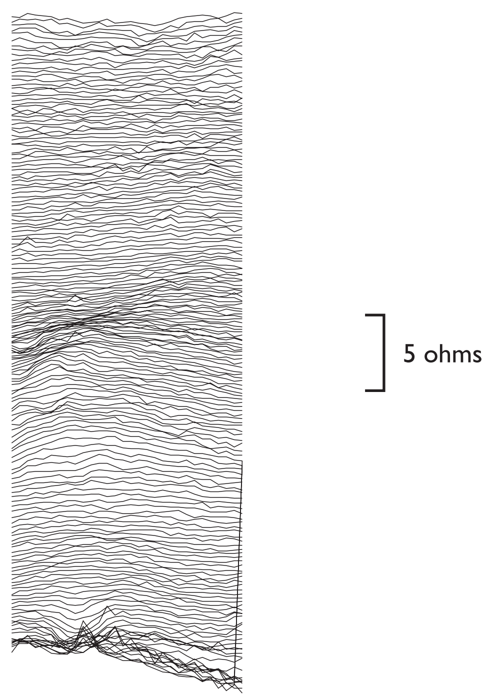
Historic England

HINTON ST MARY, ROMAN VILLA, DORSET Earth resistance survey of Little Crispin Field, April 2023

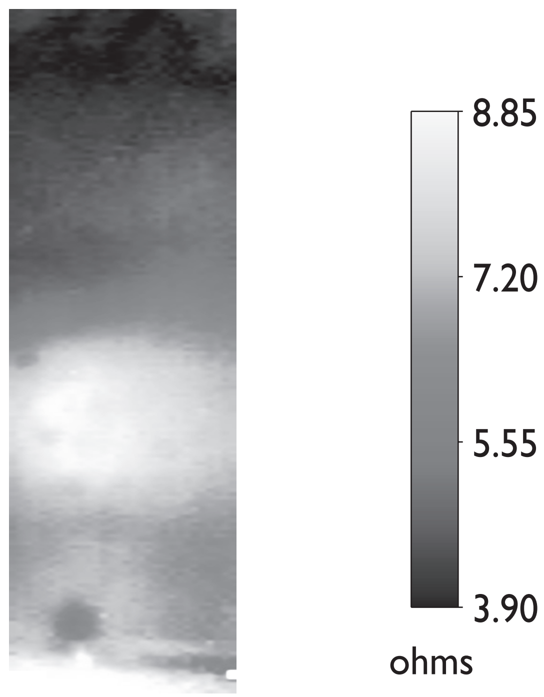


0.5m electrode separation data

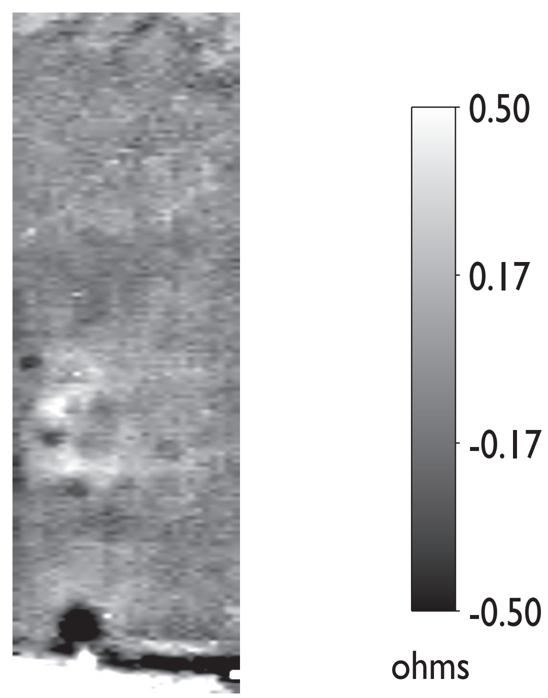
(A) Trace plot of minimally processed data



(B) Histogram equalised greyscale image of minimally processed data after noise removal

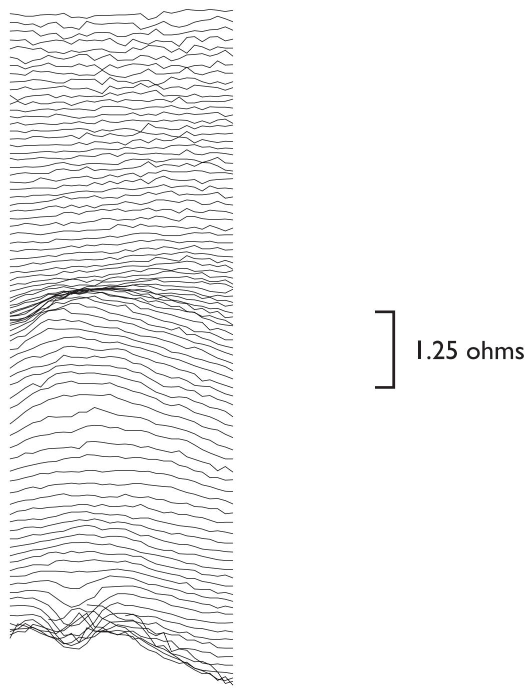


(C) Linear greyscale image of high pass filtered data after noise removal

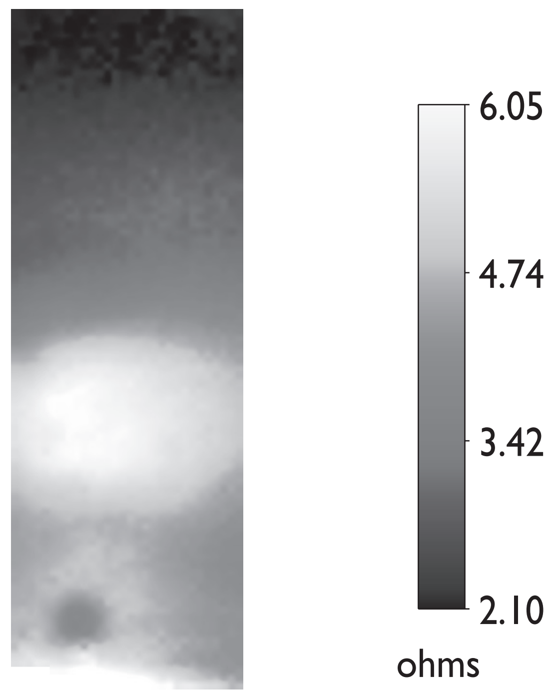


1.0m electrode separation data

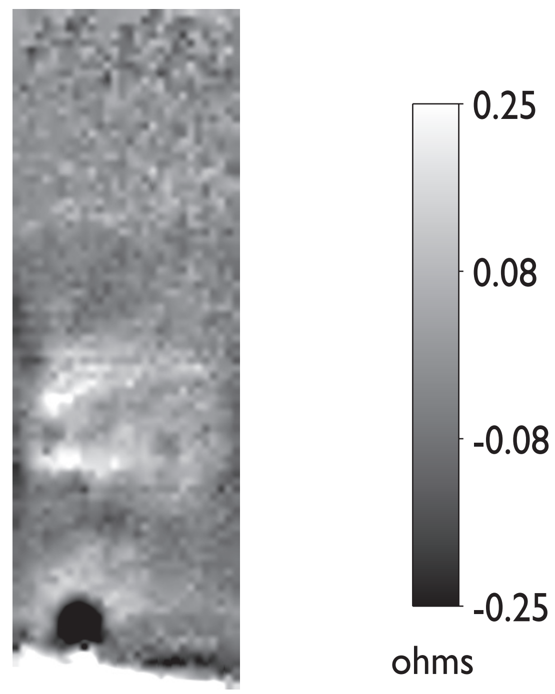
(D) Trace plot of minimally processed data



(E) Histogram equalised greyscale image of minimally processed data after noise removal



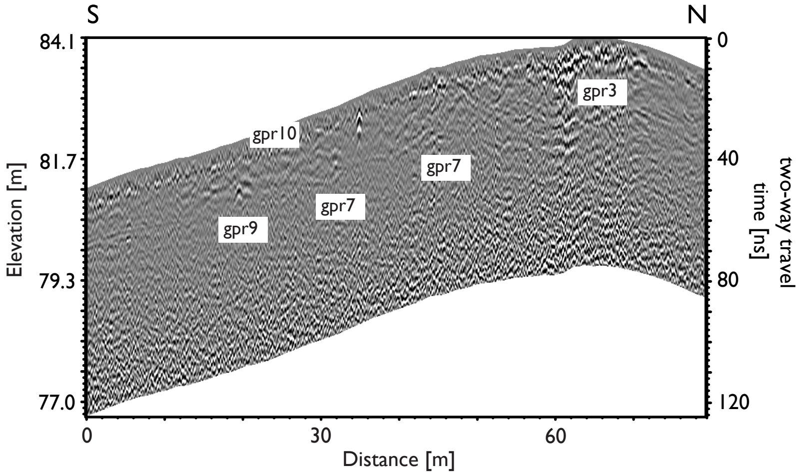
(F) Linear greyscale image of high pass filtered data after noise removal



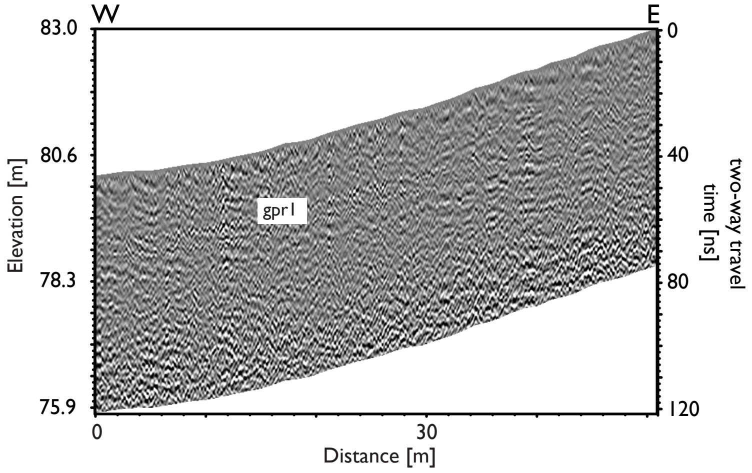
HINTON ST MARY, ROMAN VILLA, DORSET
Topographically corrected GPR profiles, April 2023

Figure 8

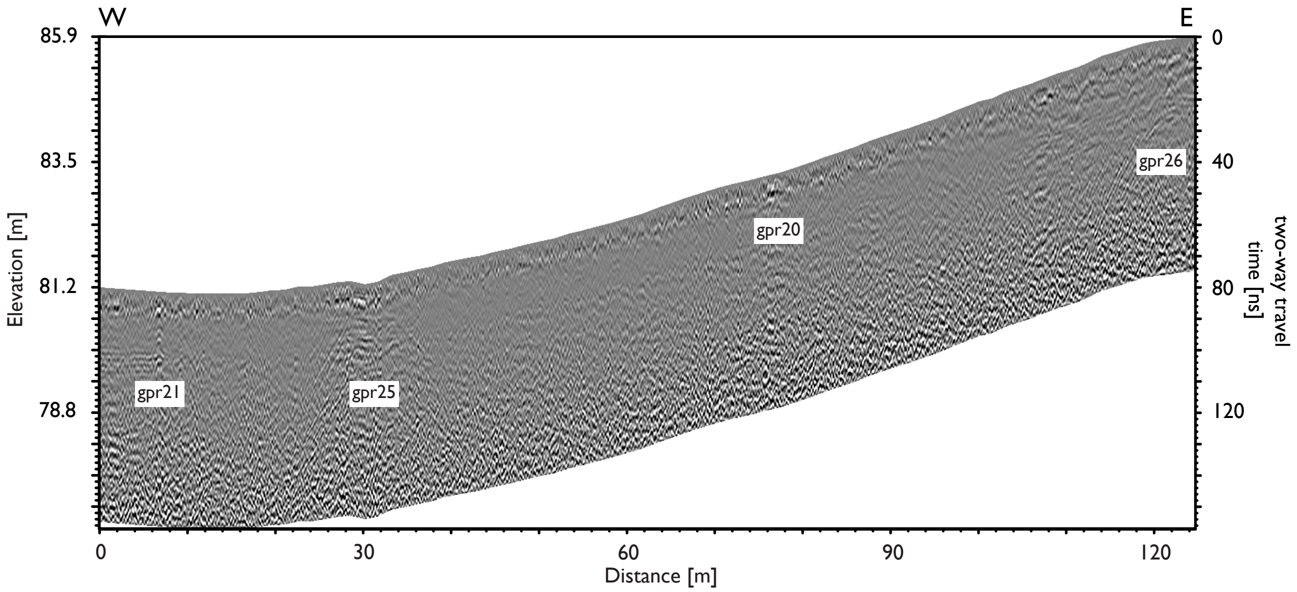
2023-04-25-011 channel 19



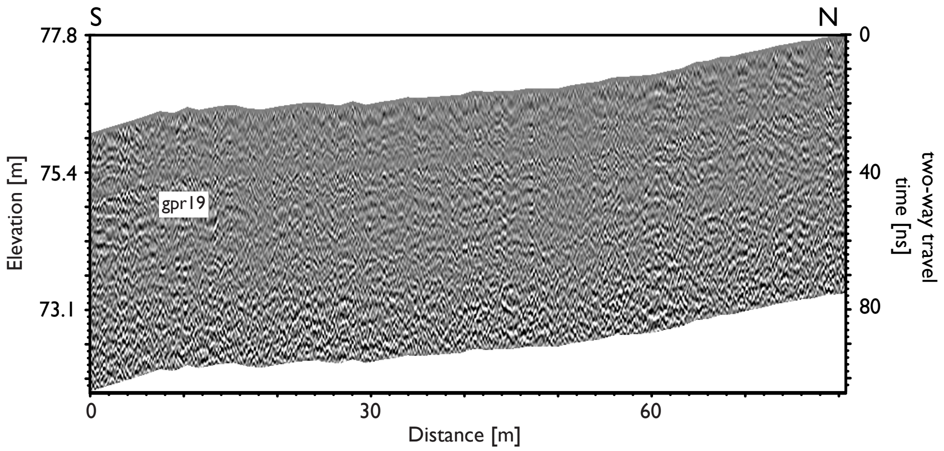
2023-04-26-065 channel 10



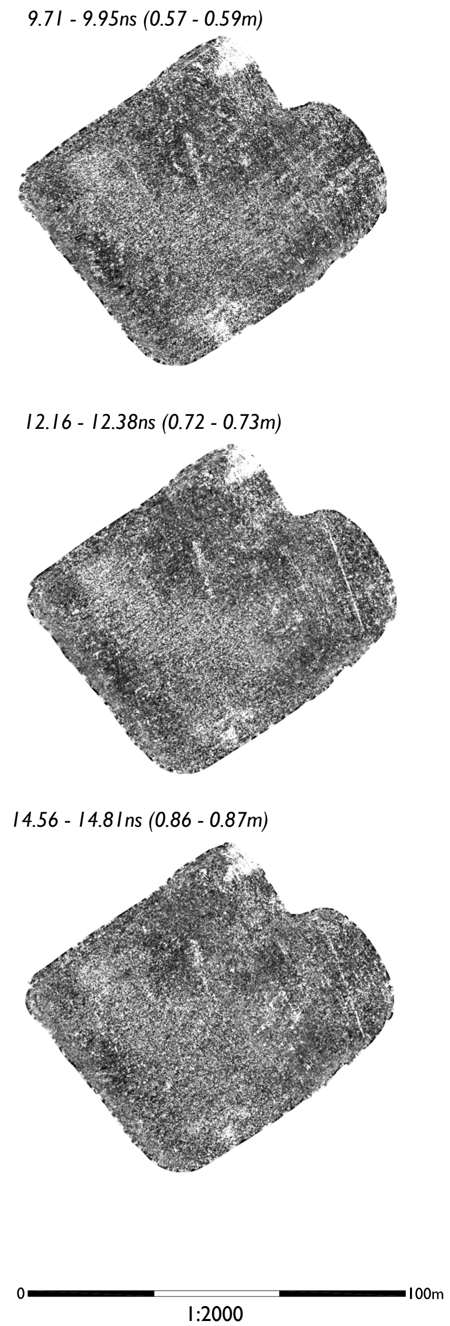
2023-04-25-092 channel 19



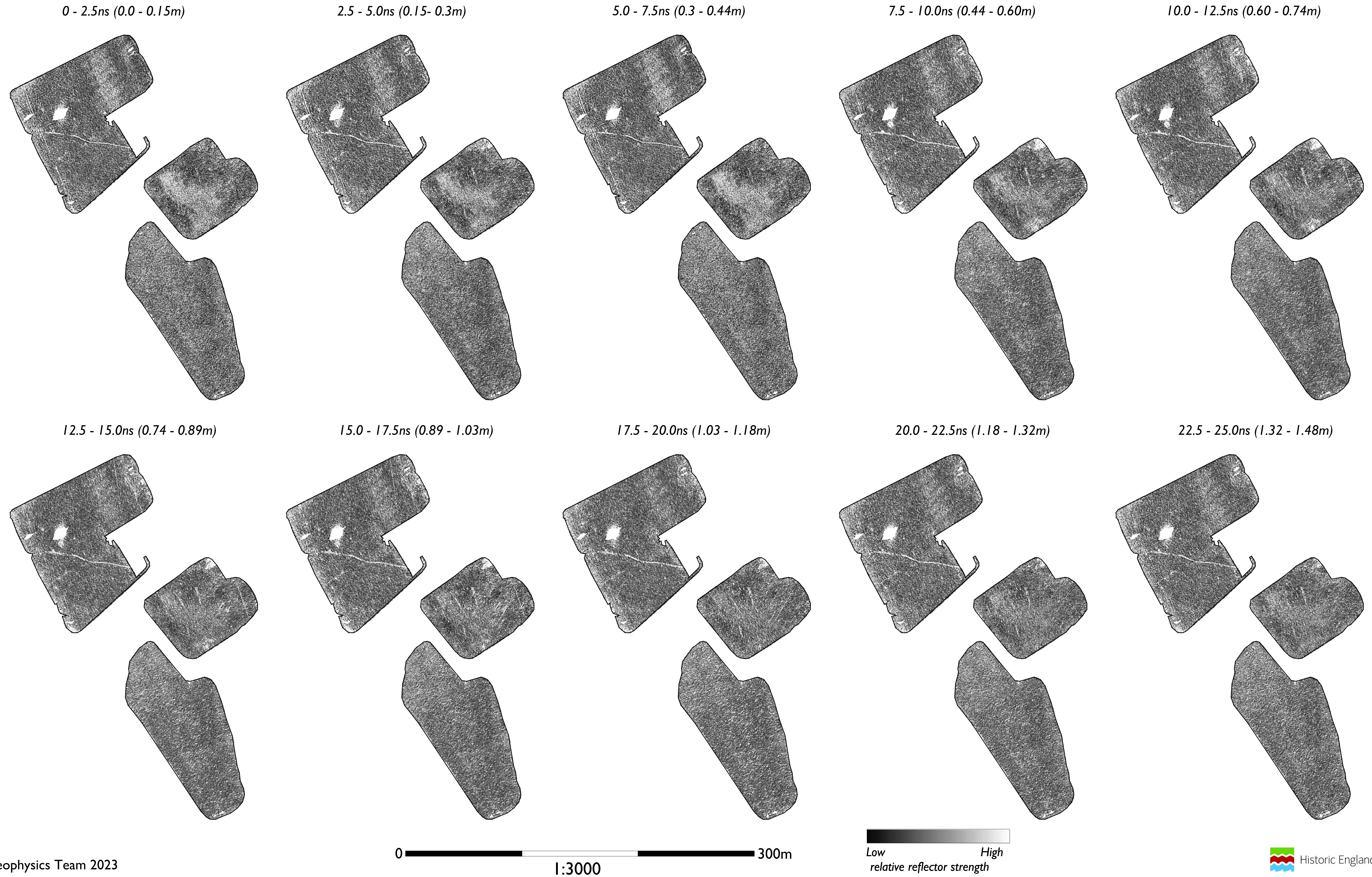
2023-04-26-044 channel 10



Forge Field
GPR amplitude time slice detail



HINTON ST MARY, ROMAN VILLA, DORSET
GPR amplitude time slices between 0.0 and 25.0ns (0.0 to 1.48m), April 2023



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Historic England

Figure 10

HINTON ST MARY, ROMAN VILLA, DORSET
GPR amplitude time slices between 25.0 and 50.0ns (1.48 to 2.95m), April 2023

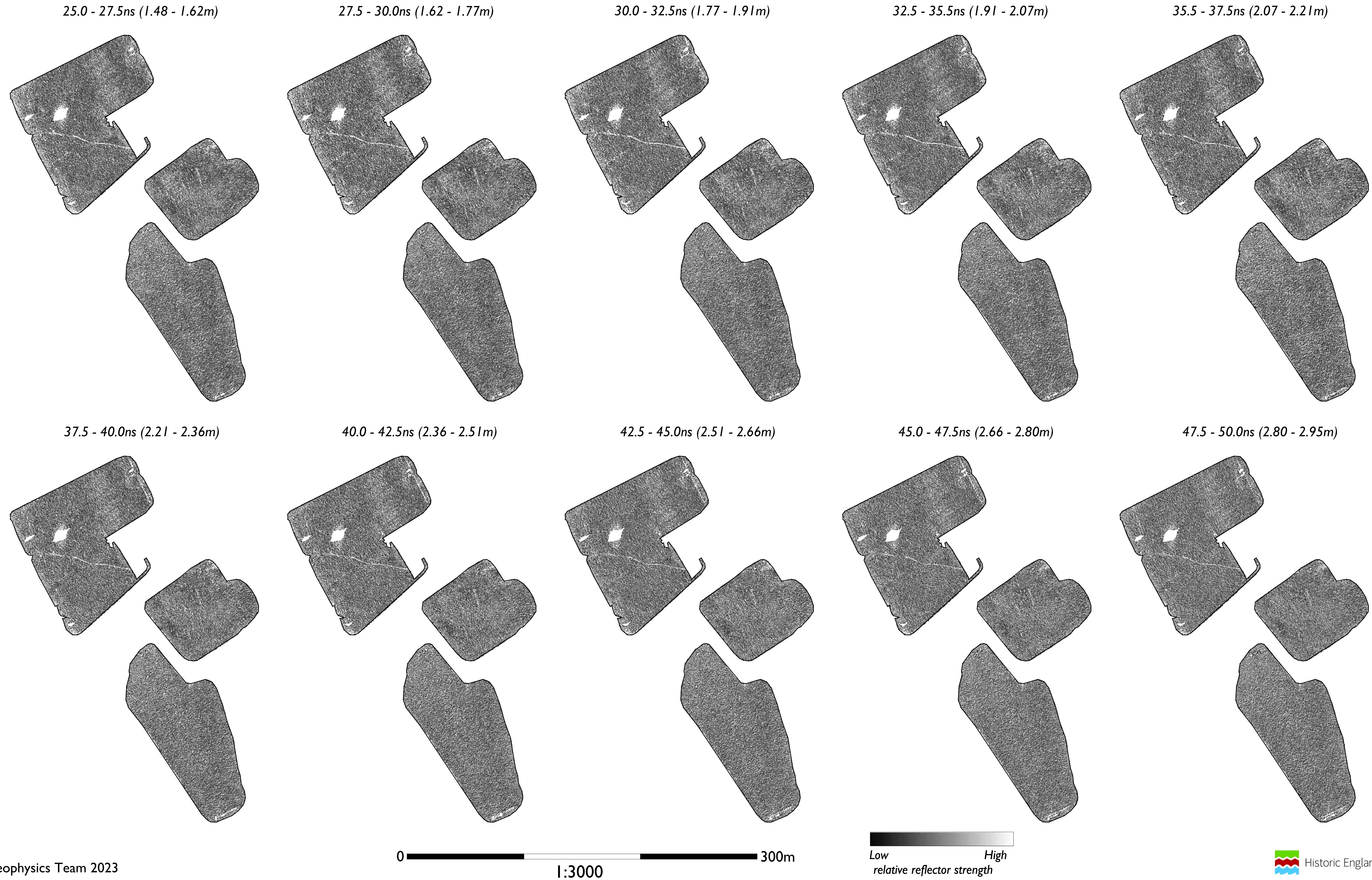

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Figure 11

HINTON ST MARY, ROMAN VILLA, DORSET
Graphical summary of significant earth resistance anomalies, April 2023

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Figure 12

HINTON ST MARY, ROMAN VILLA, DORSET
Graphical summary of significant GPR anomalies, April 2023

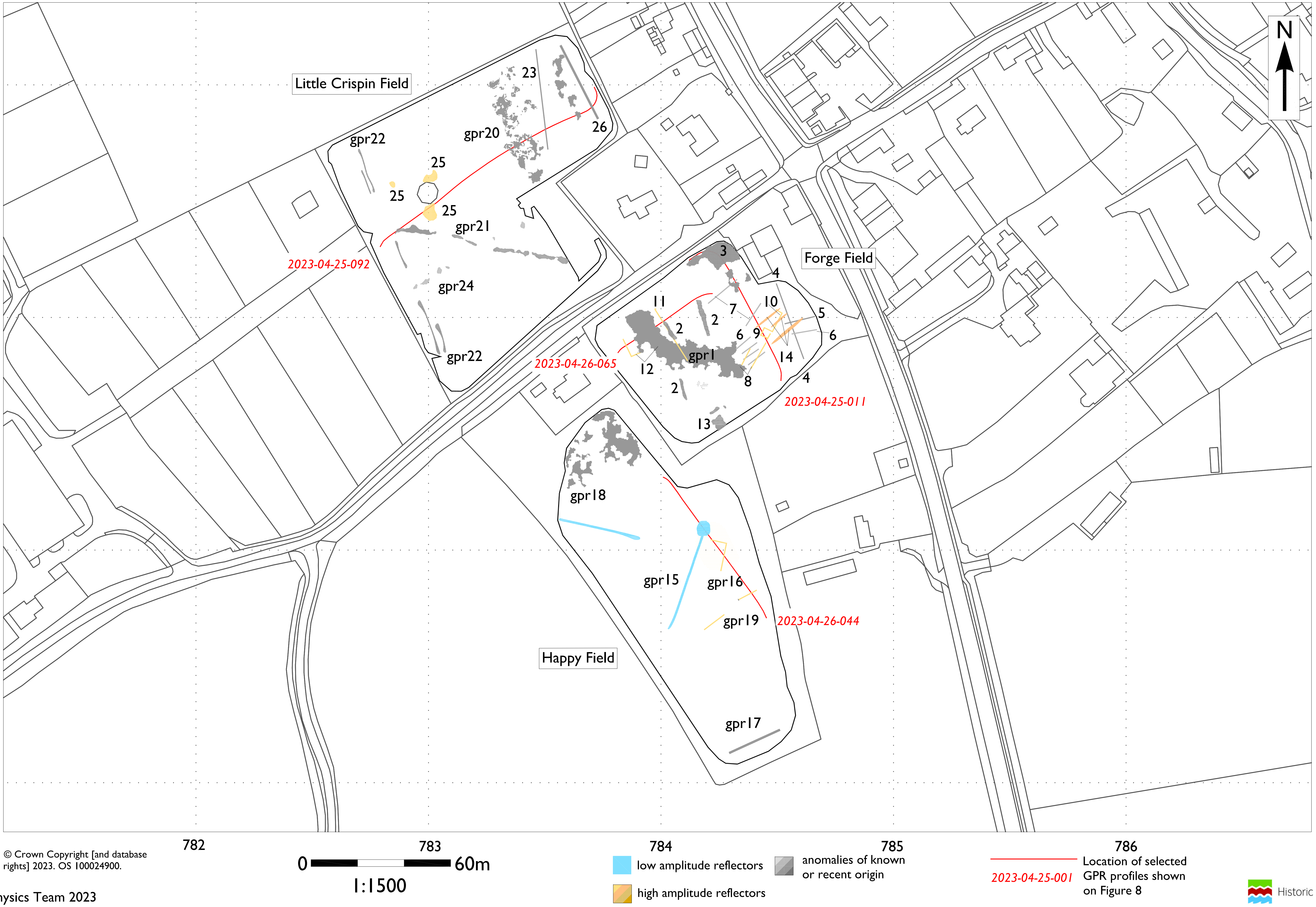

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Figure 13

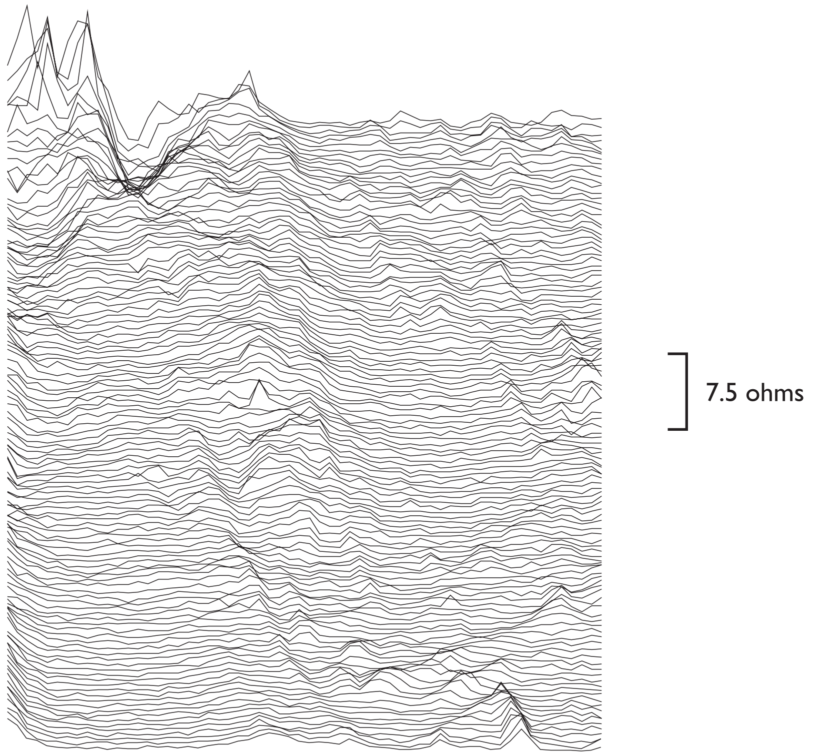
HINTON ST MARY, ROMAN VILLA, DORSET

Comparison of earth resistance survey data of Forge Field, April 2023

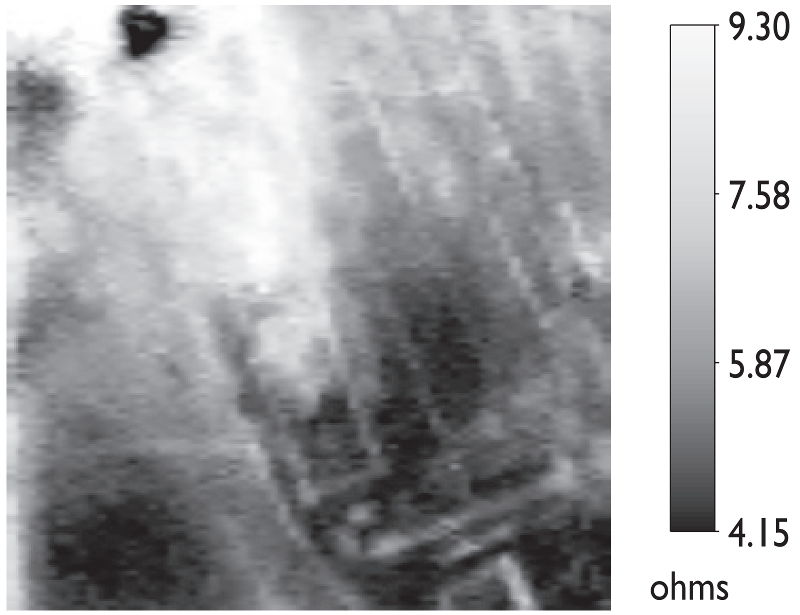
N

Twin 0.5m electrode separation data

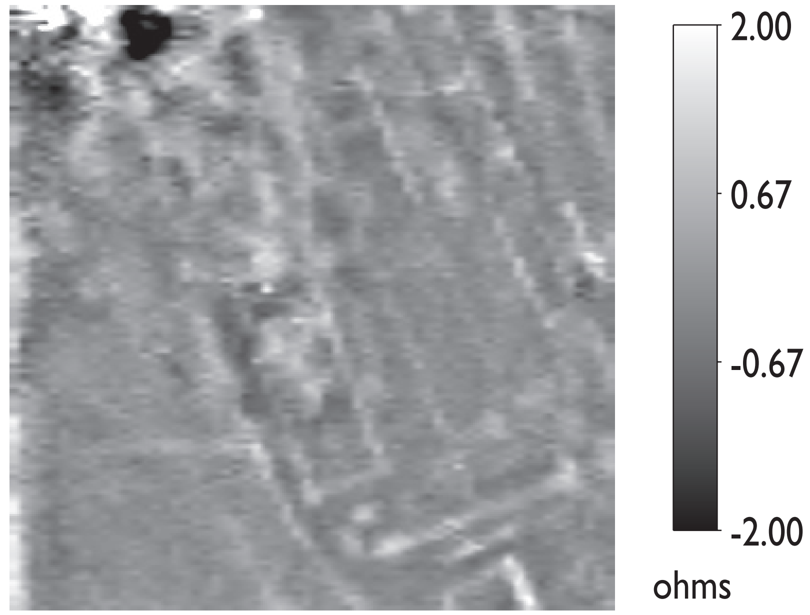
(A) Trace plot of minimally processed data



(B) Histogram equalised greyscale image of minimally processed data after noise removal

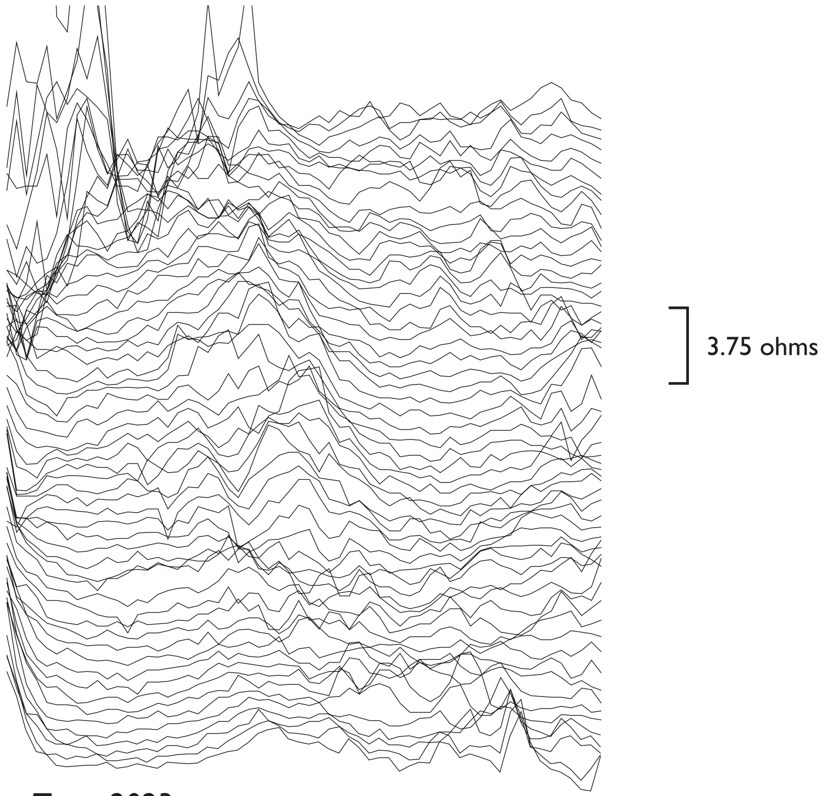


(C) Linear greyscale image of high pass filtered data after noise removal

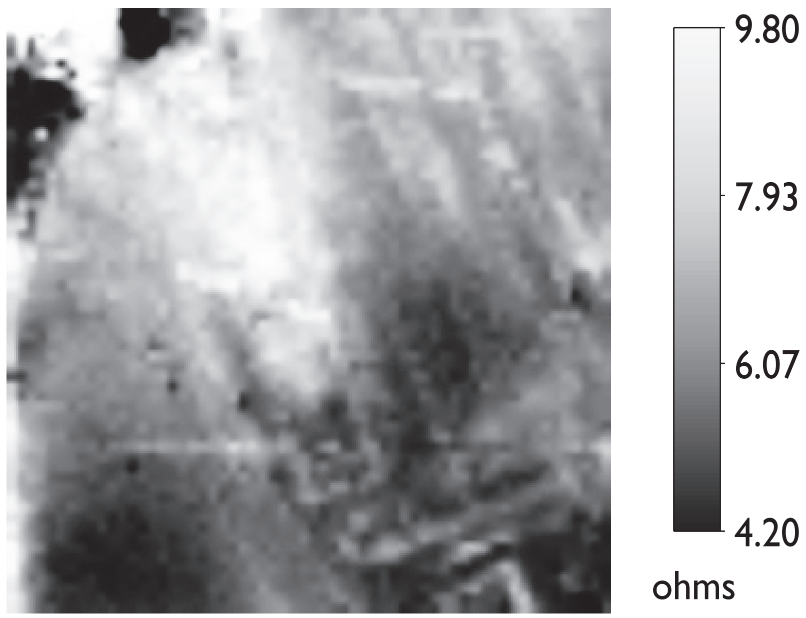


GST Ltd SF 2 earth resistance data

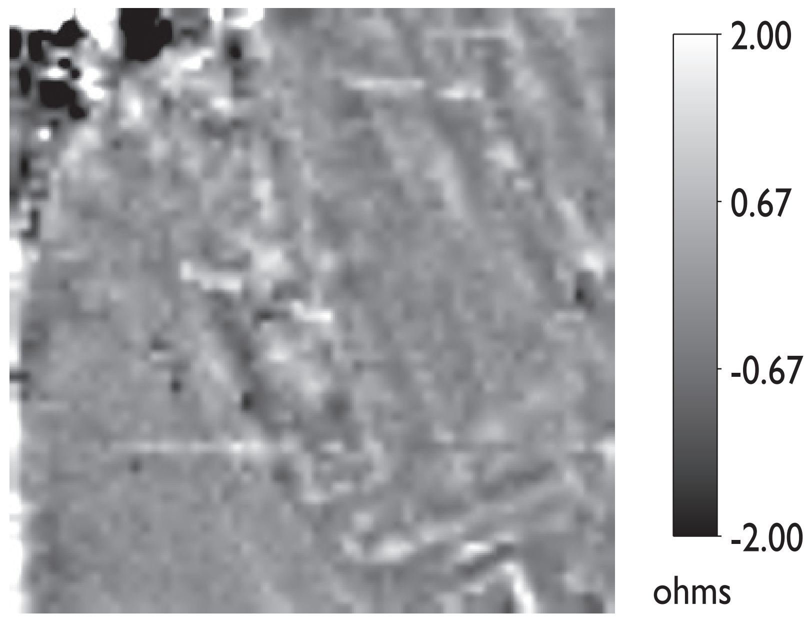
(D) Trace plot of minimally processed data



(E) Histogram equalised greyscale image of minimally processed data after noise removal



(F) Linear greyscale image of high pass filtered data after noise removal



0 60m

1:750

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