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Remote Sensing

Clandon Park House, West Clandon, Surrey Report on Geophysical Surveys, May 2015

Neil Linford, Paul Linford and Andrew Payne

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CLANDON PARK HOUSE, WEST CLANDON, SURREY

REPORT ON GEOPHYSICAL SURVEYS, MAY 2015

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SUMMARY

A geophysical survey was conducted over the east lawn and meadow at Clandon Park House, West Clandon, Surrey, to assist the National Trust establish on site storage and processing facilities following a devastating fire at the property. Vehicle towed ground penetrating radar and caesium magnetometer surveys were used, together with limited earth resistance coverage. Anomalies corresponding to the former layout of the 'gravell garden' were revealed, particularly within the radar data, and can be compared with C18th depictions of the garden layout.

CONTRIBUTORS

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

ACKNOWLEDGEMENTS

The authors are grateful to Robert Maxwell, Claire Nodder and their colleagues from the National Trust at Clandon Park who enabled the survey to take place at short notice.

ARCHIVE LOCATION

Fort Cumberland, Portsmouth.

DATE OF SURVEY

The fieldwork was conducted between 12th to 13th May 2015 and the report completed on 15th May 2015. The cover image shows the towed caesium magnetometer survey in progress.

CONTACT DETAILS

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CONTENTS

INTRODUCTION

Clandon House was built between 1725-31 in the Palladian style, for the fourth Earl of Onslow, with the grounds laid out in 1776 by Capability Brown (AMIE TQ 05 SW16). Both the current building and garden were built over a previous, possibly C12th hunting lodge, and more formal garden design shown on c1730 Estate map and detail of an oil painting of Clandon Park by Leonard Knyff from 1708 (Fretwell 1990 Fig 7; National Trust 2015). Following a devastating fire at the property on 29th April 2015 colleagues from the National Trust requested a geophysical survey to identify any significant archaeological remains prior to introducing heavy plant and processing facilities to assist with the ongoing salvage operation.

The site is laid mainly to well kept lawns interrupted by occasional planting and, at the time of the survey, temporary exclusion fencing. The meadow area to the NE was un-mown with much denser vegetation. Geological deposits within the area of investigation consist of well drained, mainly fine loamy soils of the Frilsham (571j) Association developed over a transition in the underlying geology from Upper Cretaceous Newhaven Chalk to Tertiary clays, silts and sands of the Lambeth group (Geological Survey of Great Britain 1949; Soil Survey of England and Wales 1983). Weather conditions were sunny and dry throughout the survey.

METHOD

Experience at similar sites in the past (Linford 2011; Linford and Payne 2011) suggested that a combination of three geophysical techniques should be applied: magnetometer survey to provide a rapid overview, identifying areas of disturbance and any brick rubble; Ground Penetrating Radar (GPR) survey to detect any buried surfaces or wall footings; and earth resistance survey, used in a more targeted manner as it is slower, to complement to the GPR survey by detecting volumes of buried stone/brick-work and any in-filled cut features.

Magnetometer survey

The magnetometer data was collected along the instrument swaths shown on Figure 1 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 25Hz and, given a typical average ATV travel speed of 3.2m/s, this provides a sampling density of ~0.12m 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 1.49m in front of the central sensor. 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 heading error caused by magnetic components in the system. A linear greyscale image of the combined magnetic data is shown superimposed over the base Ordnance Survey (OS) mapping on Figure 2 and minimally processed versions of the range truncated data (±50nT/m) are shown as a trace plot and a linear greyscale image on Figure 5.

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 GNSS receiver was mounted on the GPR antenna array to provide continuous positional control for the survey collected along the instrument swaths shown on Figure 2. 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 3ms. 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 2014).

Post-acquisition processing involved conversion of the raw data to time-domain profiles (through a time window of 0 to 50ns), 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 7. To aid visualisation amplitude time slices were created from the entire data set by averaging data within successive 1.2ns (two-way travel time) windows (e.g. Linford 2004). An average sub-surface velocity of 0.0864m/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 4, 8 and 9 therefore represents the variation of reflection strength through successive ~0.052m 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 (2010).

Earth resistance survey

Measurements were recorded over a series of 30m grids established with a Trimble R8 GNNS (Figure 1) using a Geoscan RM15 resistance meter, a PA5 electrode frame in the Twin-Electrode configuration and a MPX15 multiplexer, 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 by 1.0m whilst for the 1.0m separation survey they were taken at a density of 1.0m by 1.0m.

Extreme values caused by high contact resistance were removed from both datasets using an adaptive thresholding median filter with radius 1m then the variation in regional background level across the survey area was reduced using a Wallis filter with 15m window radius and edge-to-background ratio of 0.9. The results for the near-surface 0.5m electrode separation survey are depicted as a linear greyscale image in Figure 5 superimposed on the OS map and Figure 10 shows the minimally processed data from both the 0.5m and 1.0m electrode separated data, presented as both an X-Y trace plot and an equal area greyscale images.

RESULTS

Magnetometer survey

A graphical summary of the significant magnetic anomalies, [**m1-8**] discussed in this section is shown superimposed on the base OS map data on Figure 11.

The flat lawn area was for the most part ideal for the towed sledge system employed but around the edges of the survey area trees occluded satellite visibility to some extent resulting in poor GNSS fixes. This has caused some magnetic measurements to be misplaced in the survey data set giving a stippled appearance to the resulting plots around some of the edges.

As anticipated the magnetometer survey has responded to areas of disturbance, most clearly detecting anomalies caused by ferrous and thermoremanently magnetised materials; many likely to reflect the garden's more recent history. Two linear anomalies **[m1]** and **[m2]** composed of alternating extreme high and low measurements are likely to be caused by service pipes, apparently converging on the Maori meeting house known as Hinemihi transported from New Zealand by William Hillier, fourth Earl of Onslow in 1882 and moved to her current position during the 1930s, but as she is not connected to any services the relationship between the two is coincidental. A third linear anomaly **[m3]**, again of alternating extreme high and low measurements, runs parallel to **[m1]** and corresponds with an observed slight rise in topography. Intensities of magnetisation are typically less than those for **[m1]** and **[m2]**, ~10nT rather than >100nT and, given its alignment with the path running around the S side of the house it is likely to represent a grassed-over path running to Hinemihi composed of a material such as cinder or clinker. At the far eastern end of the survey area disturbance caused by the recent infilling of the ha-ha **[m4]** can be discerned.

Some anomalies possibly relating to the earlier Jacobean garden are also evident. In the NW corner of the survey is another area of alternating extreme magnetic measurements **[m5]** with magnitudes of ~2-10nT. Such a response is typical of buried brick rubble which may have originated from demolition of the former Jacobean house or brick walls surrounding the gravel garden noted on the garden conservation plan. In either case it suggests the location of the current C18th house has been shifted S relative to the earlier structure as this rubble area aligns with only the northern half of the building's E face. Within the rubble area a linear alignment can be discerned **[m6]** describing two sides of a rectangle which may mark the brick edging of a former garden area.

In the centre of the lawn a number of weaker intersecting linear anomalies have been detected **[m7]**, with typical magnitudes of 2-3 nT. These appear to correlate with anomalies detected by the GPR and earth resistance surveys and may indicate surviving gravel path surfaces from the earlier formal garden layout. A more tentative linear anomaly is that possibly defining a rectangular area at **[m8]**. Measurements vary in magnitude around its perimeter from ~0.4 to 6.0 nT and there is the hint of further very weak linear anomalies within it. It may possibly mark the footprint of a short-lived or temporary structure but whether contemporary with the Jacobean garden or dating from the recent past is impossible to determine.

Ground Penetrating Radar survey

A graphical summary of the significant GPR anomalies, [**gpr1-21**], discussed in the following text, are shown superimposed on the base OS map data on Figure 12.

Signal penetration has generally been good across the site through the full time window with significant reflections recorded to approximately 40ns (1.7m), although ground coupling of the antenna varied with the surface vegetation present. A number of anomalies related to extant features or of known origin were detected including: deep rutting [**gpr1**] from the fire tender accessing the site across the ha-ha, the pipe runs [**gpr2**] identified in the magnetic data, the recently filled ha-ha ditch and parallel path [**gpr3**], and the grassed over path [**gpr4**] to Hinemihi - the Maori meeting house.

A broad rectilinear anomaly [**gpr5**] between 6 and 30ns (0.26 to 1.3m) corresponds with the layout of the 'gravell garden' paths shown on both the c1730 Estate map and the detail of the 1708 Knyff painting. The GPR suggests some additional detail [**gpr6**] within the centre of the paths, perhaps even more substantial structural remains surviving at depth, although it is unclear whether the second panel shown by the contemporary sources has survived. Some extension of the 'gravell garden' is suggested by a similar response [**gpr7**] to the NE, some potential wall footings [**gpr8**], and a number of discrete high amplitude reflectors [**gpr9-13**] that may, possibly, represent statue plinths or other ornamental garden features. One of these possible statue plinths, [**gpr9**], has a rectangular form of 1.5m x 2m and is found on the course of the former path [**gpr14**] extending S from [**gpr5**]. It is of interest to note that the response of [**gpr14**] changes along its course from a high to low amplitude anomaly, perhaps suggesting a change in the construction materials or later remodelling of the original path. A similar response to the 'gravell garden' is partially described in the available survey at [**gpr15**], but is difficult to interpret fully from the current data.

Some discrete low amplitude anomalies throughout the survey area may represent former planting pits and there is also some evidence for further wall footings [**gpr16**] extending towards the ha-ha, although they appear to either terminate or not survive beyond this point.

Ground conditions in the meadow to the NE beyond the ha-ha were slightly less favourable for GPR survey, due to the longer vegetation here, but some potentially significant anomalies have been revealed. In the near-surface data, between 4 and 15ns (0.17 to 0.6m), a low amplitude response [**gpr17**] is possibly a recent path across the meadow, whereas the long rectilinear anomaly [**gpr18**] appears to share the orientation of the 'gravell garden' and may well represent one of the long panels shown on the Estate map close to Clandon Church with some wall-type responses [**gpr19**] to the N.

A small area adjacent to the S elevation of the house was also surveyed, although access was limited to the unplanted areas of grass and the gravel paths. Some evidence has been found here for both the modern drains beneath the path [**gpr20**] as well as more significant structural remains [**gpr21**], possibly a former entrance to the house.

Earth resistance survey

A graphical summary of the significant earth resistance anomalies, [**r1-10**], discussed in the following text, are shown superimposed on the base OS map data on Figure 13.

The earth resistance survey across the lawn to the east of the house contains responses that replicate anomalies found in both the magnetometer and GPR data. Linear low [**r1**] and high resistance anomalies [**r2**] correspond to the line of a water pipe ([**m1**]/[**gpr2**])and the location of a disused path extending from the house towards Hinemihi ([**m3**]/[**gpr4**]). Immediately to the north of [**r2**] two localised high resistance responses [**r3**] and [**r4**] may relate to foundation plinths for statues or other ornamental garden features, as also suggested by the GPR data. A lower resistance linear anomaly [**r5**] aligned on [**r3**] may indicate a former pathway constructed from a more water retentive material (such as clay) or a planting trench and north of [**r5**] there appears to be a transition to more complex buried deposits.

To the north a regular rectilinear pattern of high and low resistance responses [**r6-8**] are probably indicative of the walls and pathways of a compartmentalised garden layout, possibly relating to the former 'gravell garden' design. Other walled boundaries such as [**r9**] also appear to fit well with the magnetometer and GPR survey results from this area. Further detail of possible garden features are visible at [**r10**] within the bounds of the adjoining broader high resistance responses [**r6-8**].

CONCLUSIONS

The geophysical survey successfully detected anomalies related to the previous formal 'gravell garden' design shown in contemporary records of the site. A summary of the most significant anomalies detected by the three different techniques is presented in Figure 14, annotated with putative interpretations. It can be seen that the data do not reveal the complete plan of the garden and it is unclear whether this is due to differential survival of the remains or, possibly, that earlier house was positioned slightly to the N of the central access of the current building. Should the latter interpretation prove correct then the remains detected would appear to correlate with panels of the garden layout depicted on the 1730s estate map.

Whilst all three geophysical techniques proved useful, GPR was conducted over the widest area producing very detailed results across the lawn and meadow areas. Furthermore, despite very limited access, it has suggested the survival of structural remains adjacent to the S elevation of the house.

LIST OF ENCLOSED FIGURES

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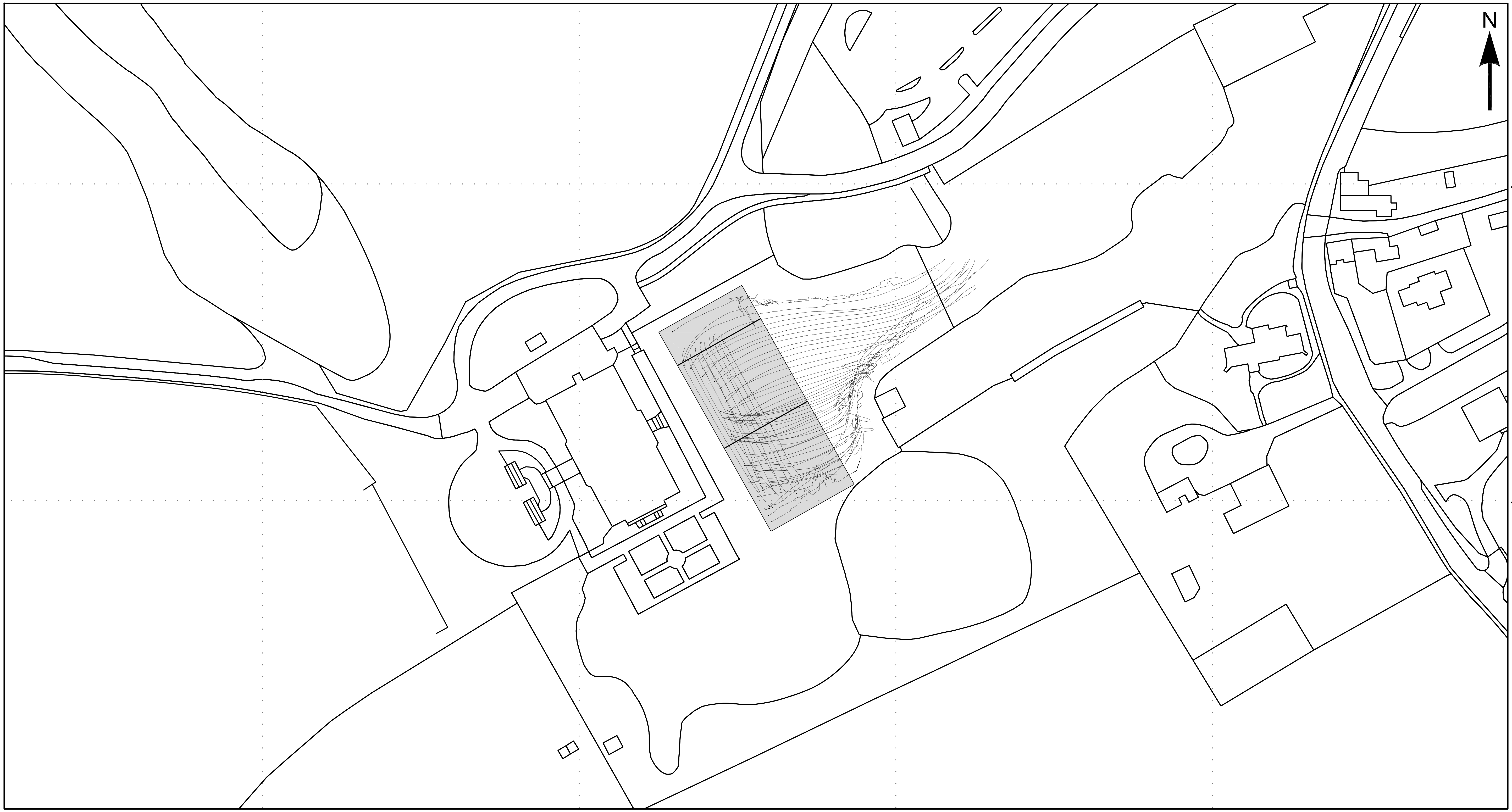
Figure 1

CLANDON PARK HOUSE, WEST CLANDON, SURREY
Location of magnetometer and earth resistance surveys, May 2015

TQ0451



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1:1250

Caesium magnetometer survey swaths

Earth resistance survey

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Figure 2

CLANDON PARK HOUSE, WEST CLANDON, SURREY
Location of GPR survey, May 2015

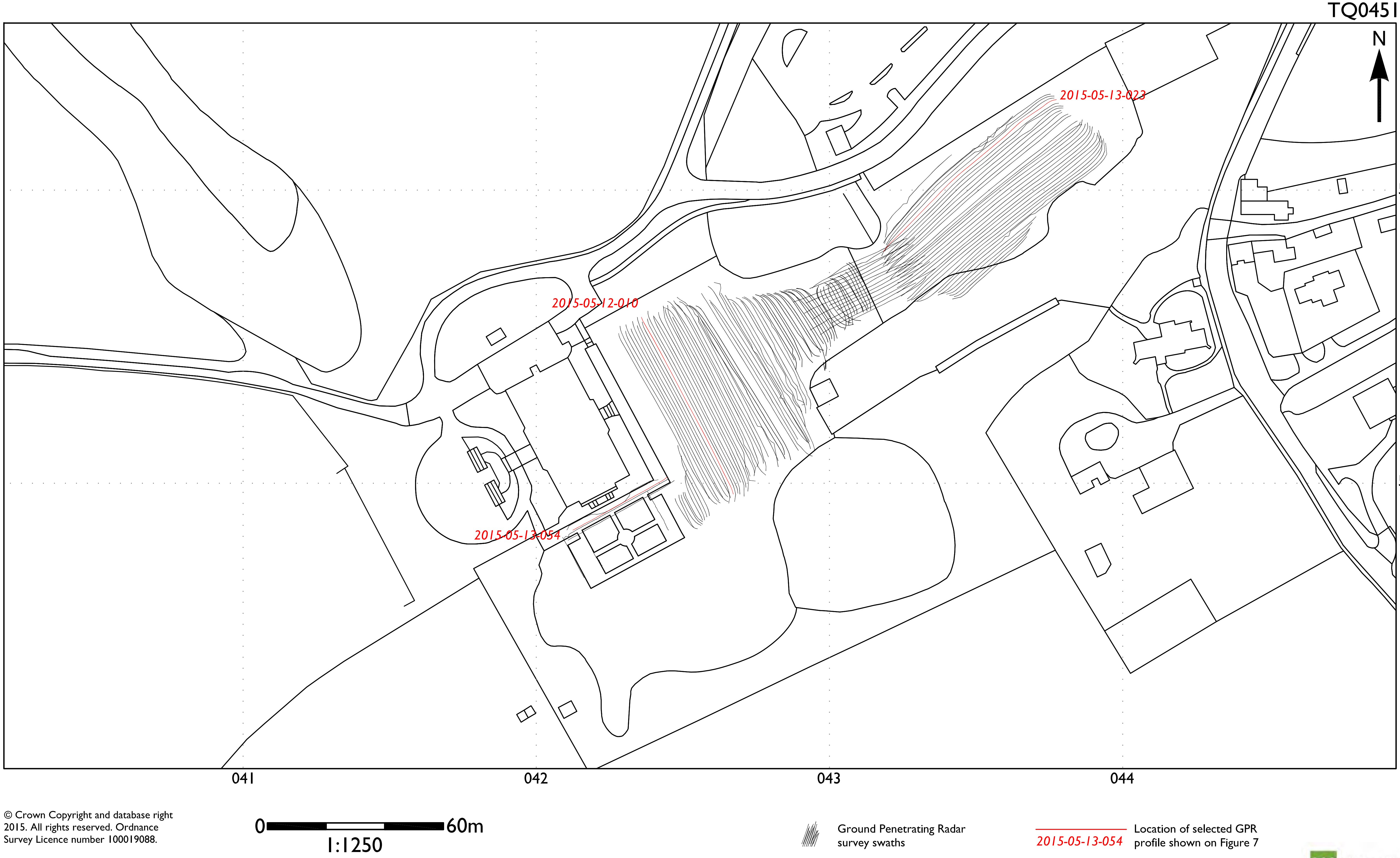

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Figure 3

CLANDON PARK HOUSE, WEST CLANDON, SURREY

Location of caesium magnetometer survey, May 2015

TQ0451

0 60m

1:1250

Geophysics Team 2015

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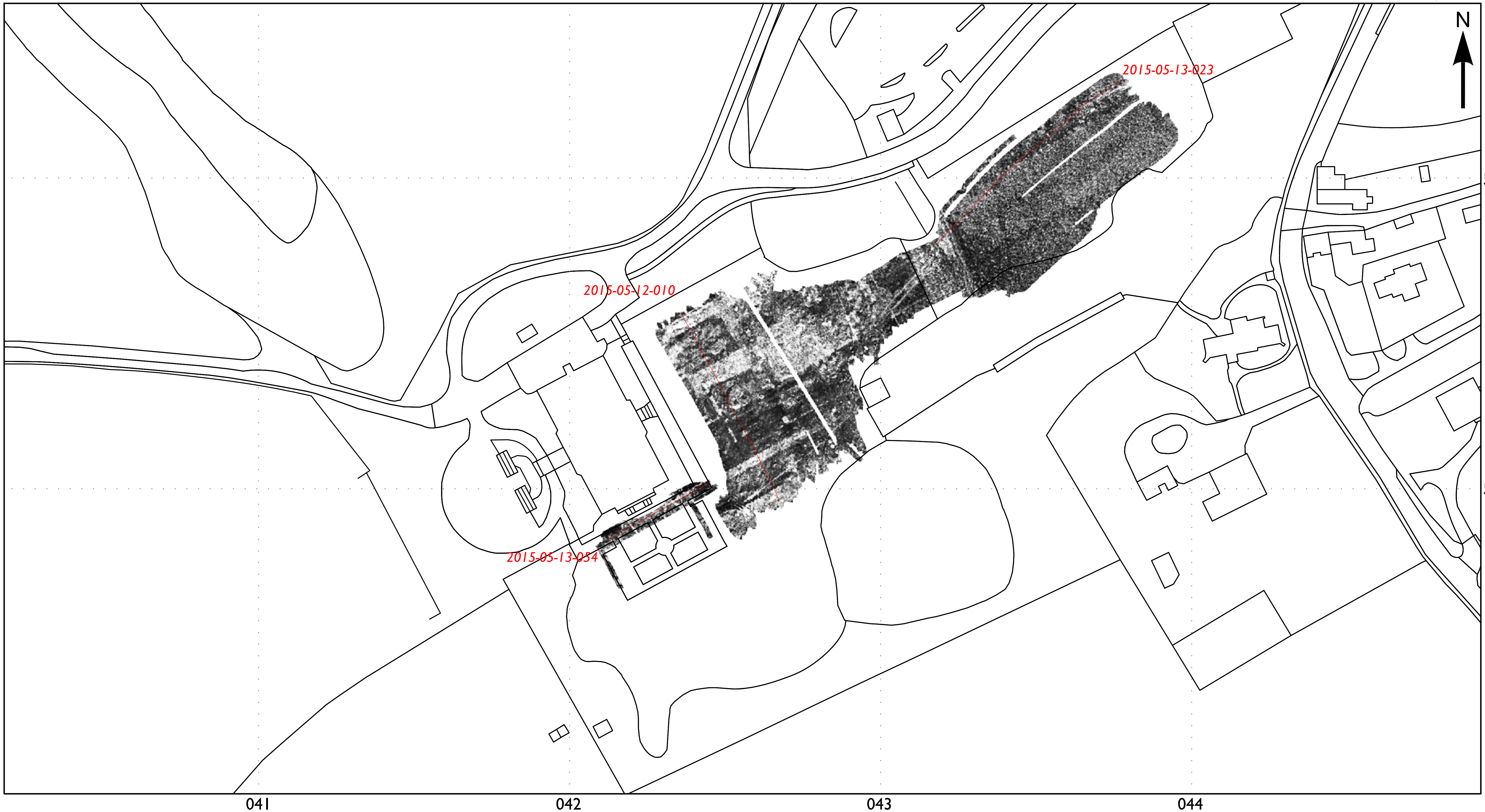
Figure 4

CLANDON PARK HOUSE, WEST CLANDON, SURREY
GPR amplitude time slice between 10.8 - 12.0ns (0.45 - 0.5m), May 2015



0 60m
1:1250

Low *High*
relative reflector strength

2015-05-13-054 Location of selected GPR profile shown on Figure 7

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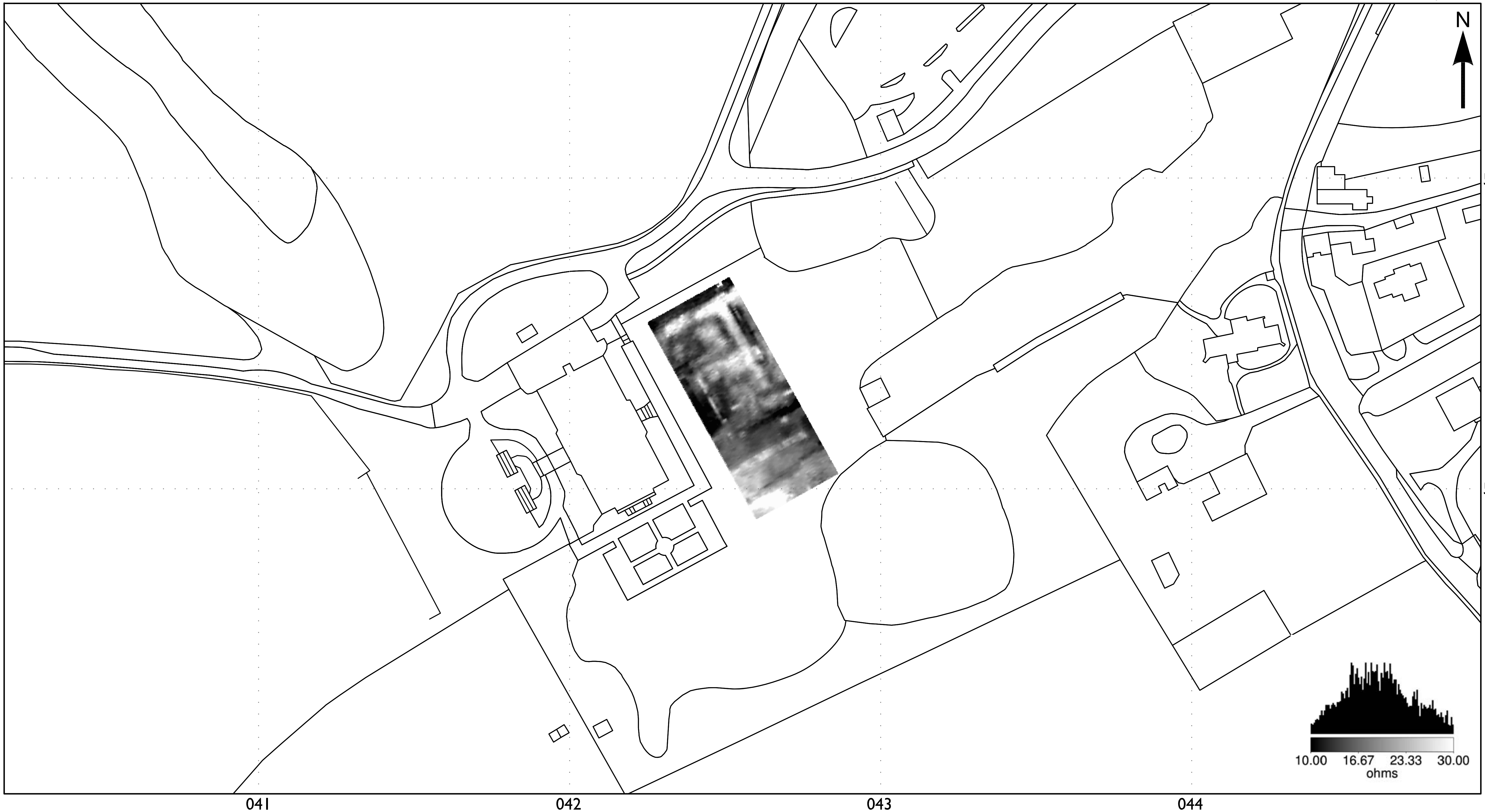
Figure 5

CLANDON PARK HOUSE, WEST CLANDON, SURREY

Location of earth resistance survey, May 2015



0 60m
1:1250

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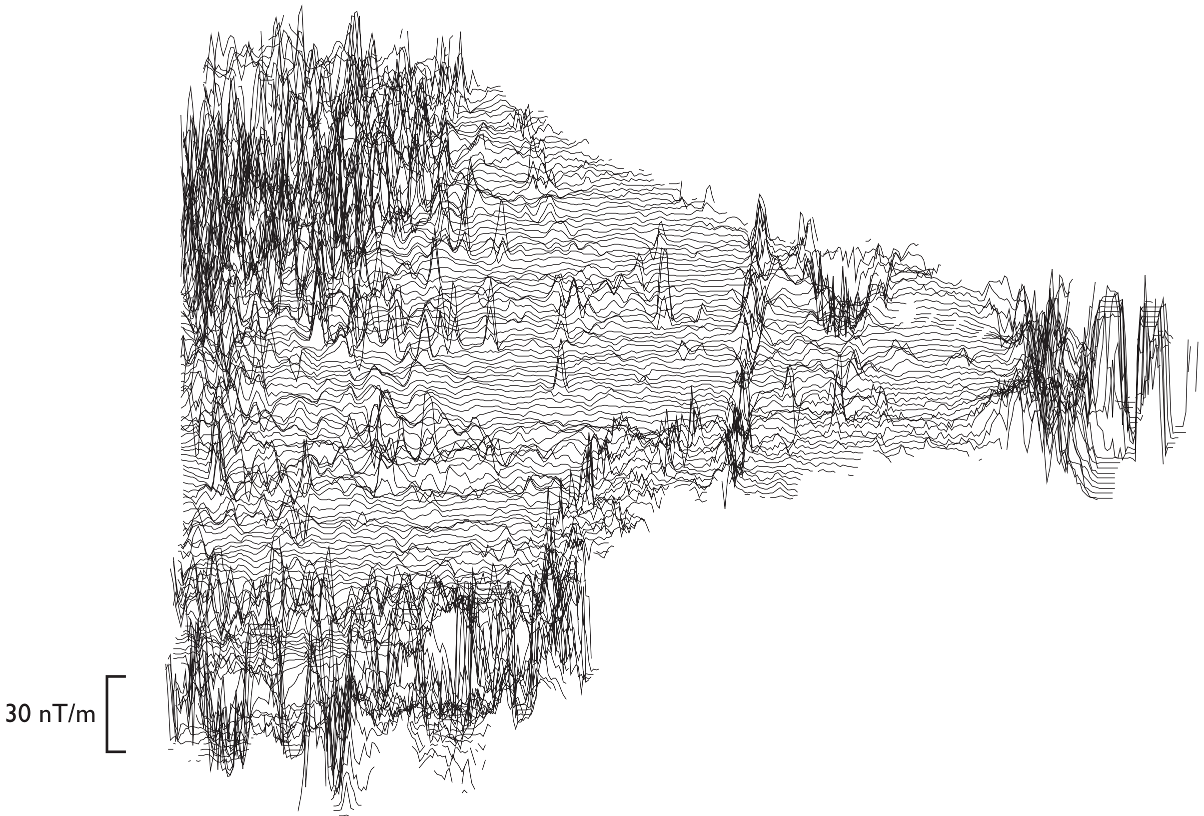
CLANDON PARK HOUSE, WEST CLANDON, SURREY

Figure 6

Caesium magnetometer survey, May 2015

N

(A) traceplot of minimally processed caesium magnetometer data



(B) linear greyscale image of minimally processed caesium magnetometer data

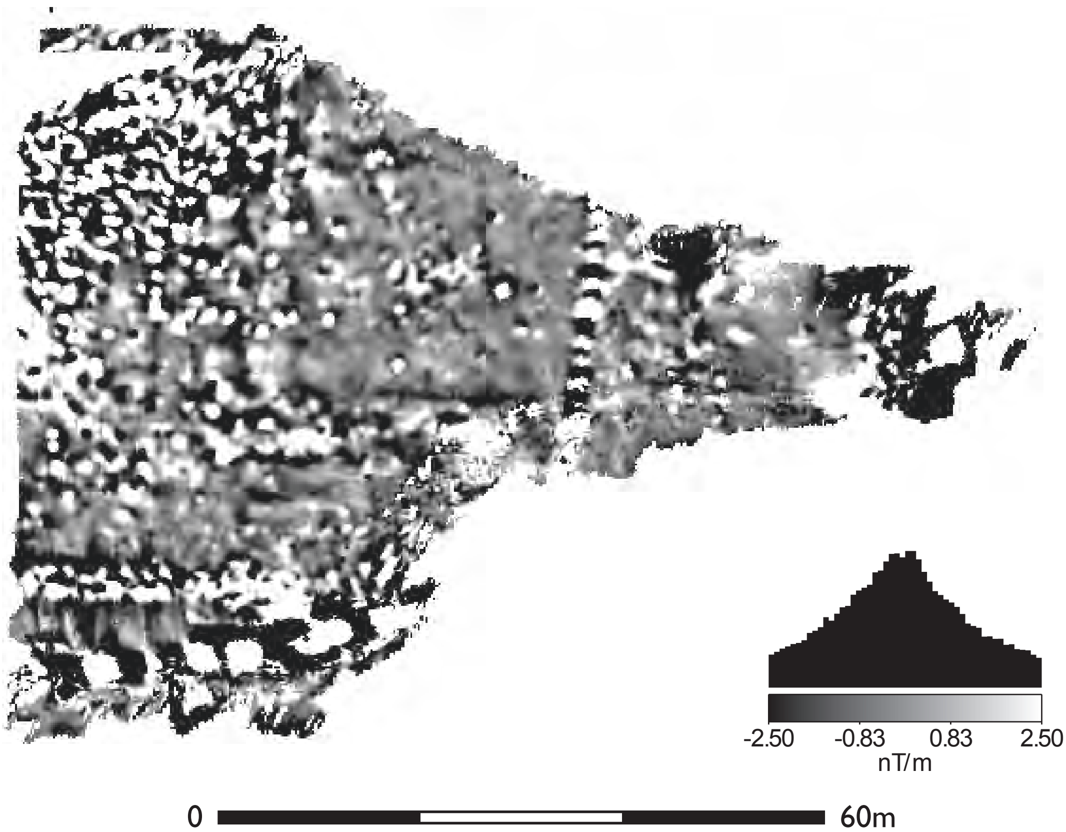


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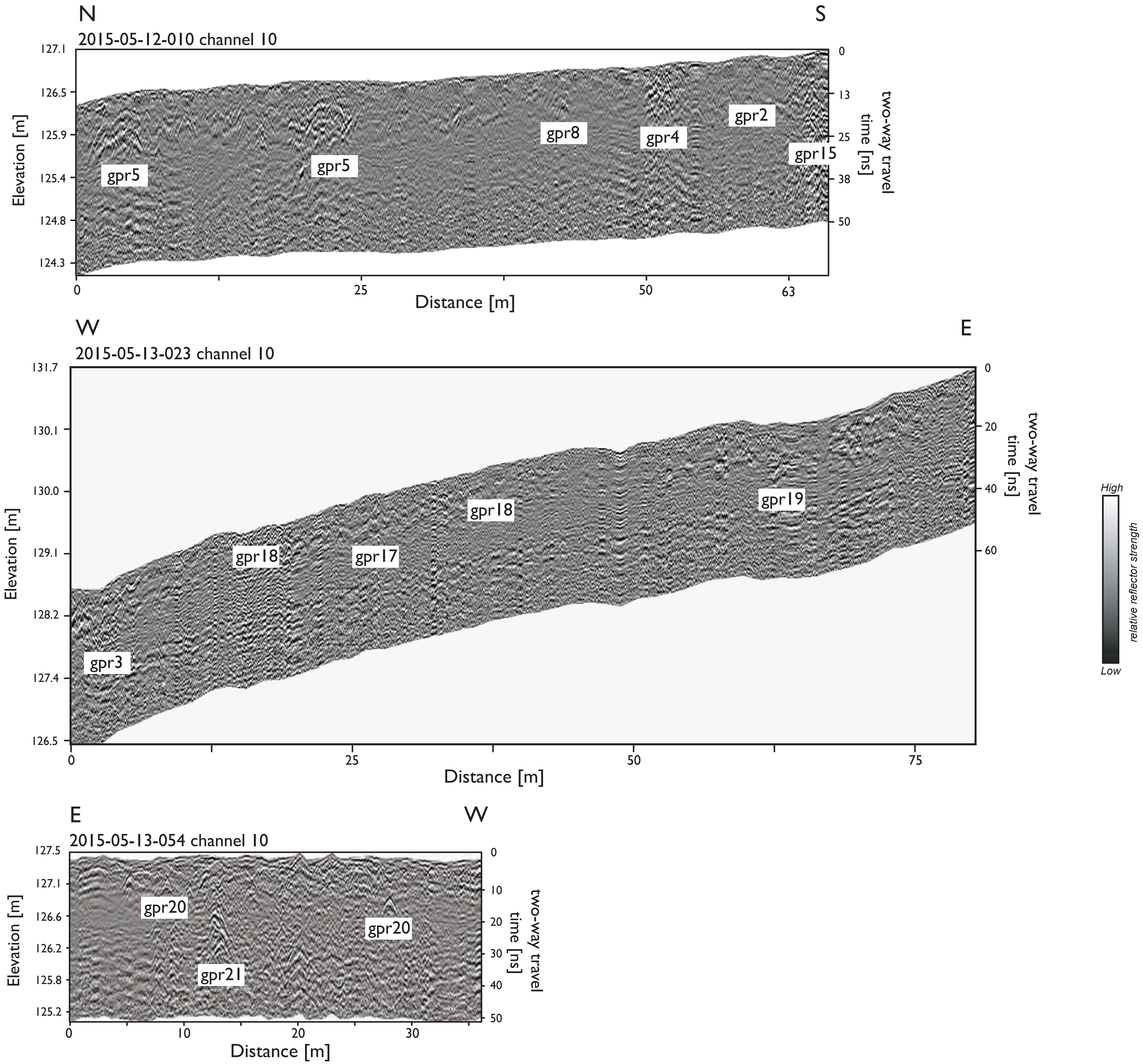
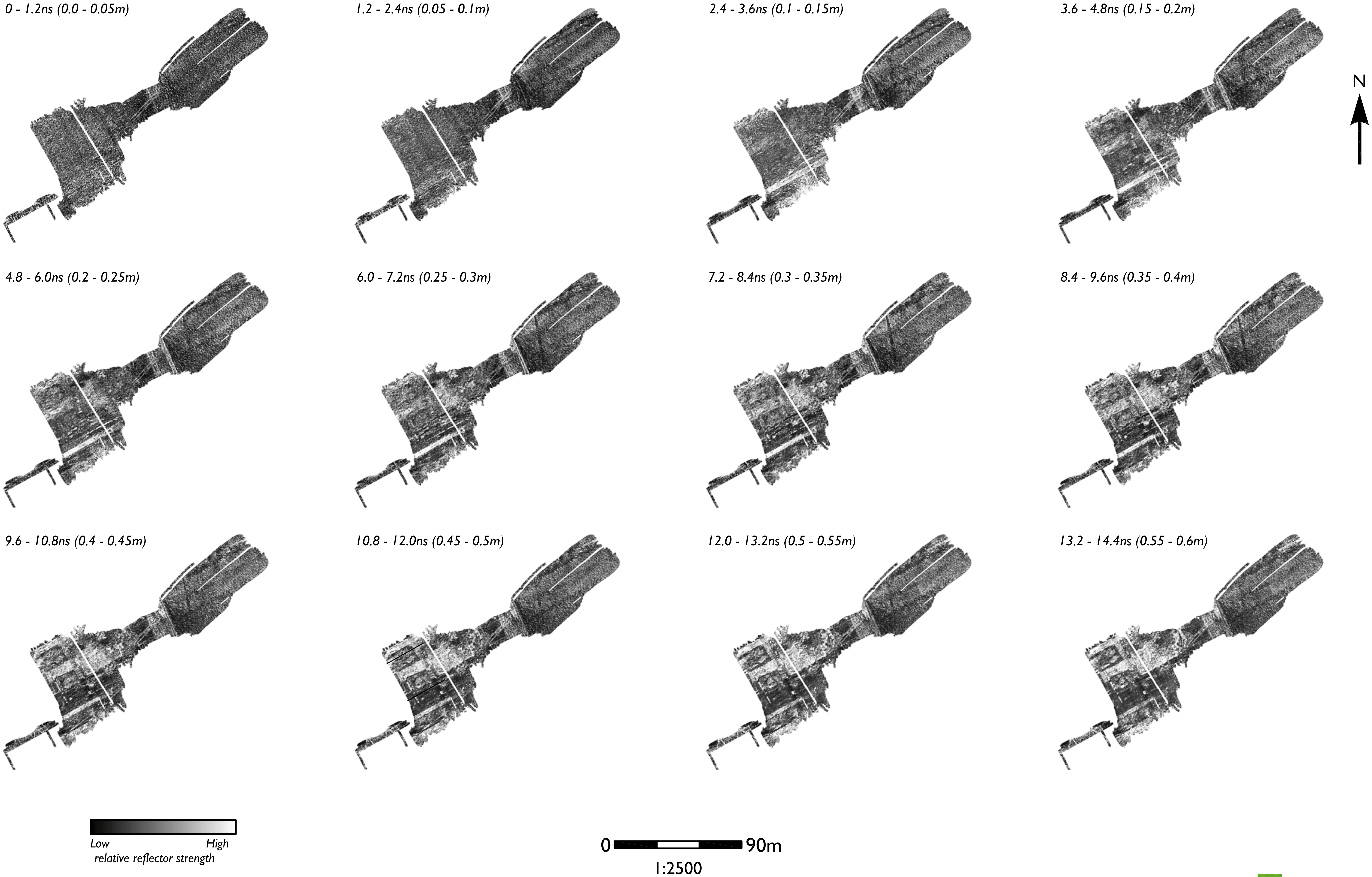
Figure 7

CLANDON PARK HOUSE, WEST CLANDON, SURREY
Selected GPR profiles, May 2015



CLANDON PARK HOUSE, WEST CLANDON, SURREY
GPR amplitude time slices between 0.0 and 14.4ns (0.0 - 0.6m), May 2015

Figure 8



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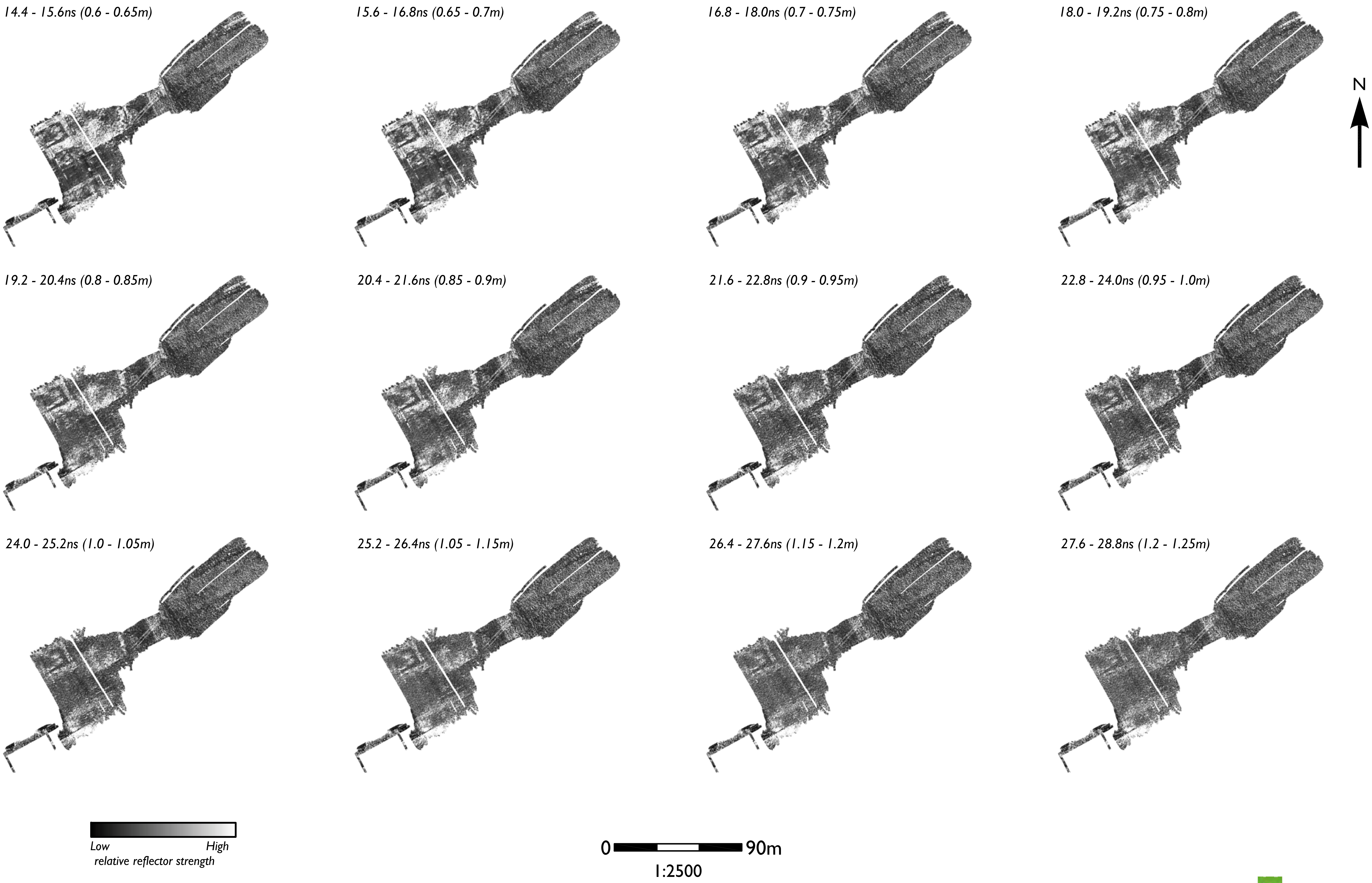
CLANDON PARK HOUSE, WEST CLANDON, SURREY

GPR amplitude time slices between 14.4 and 28.8ns (0.6 - 1.25m), May 2015

Figure 9



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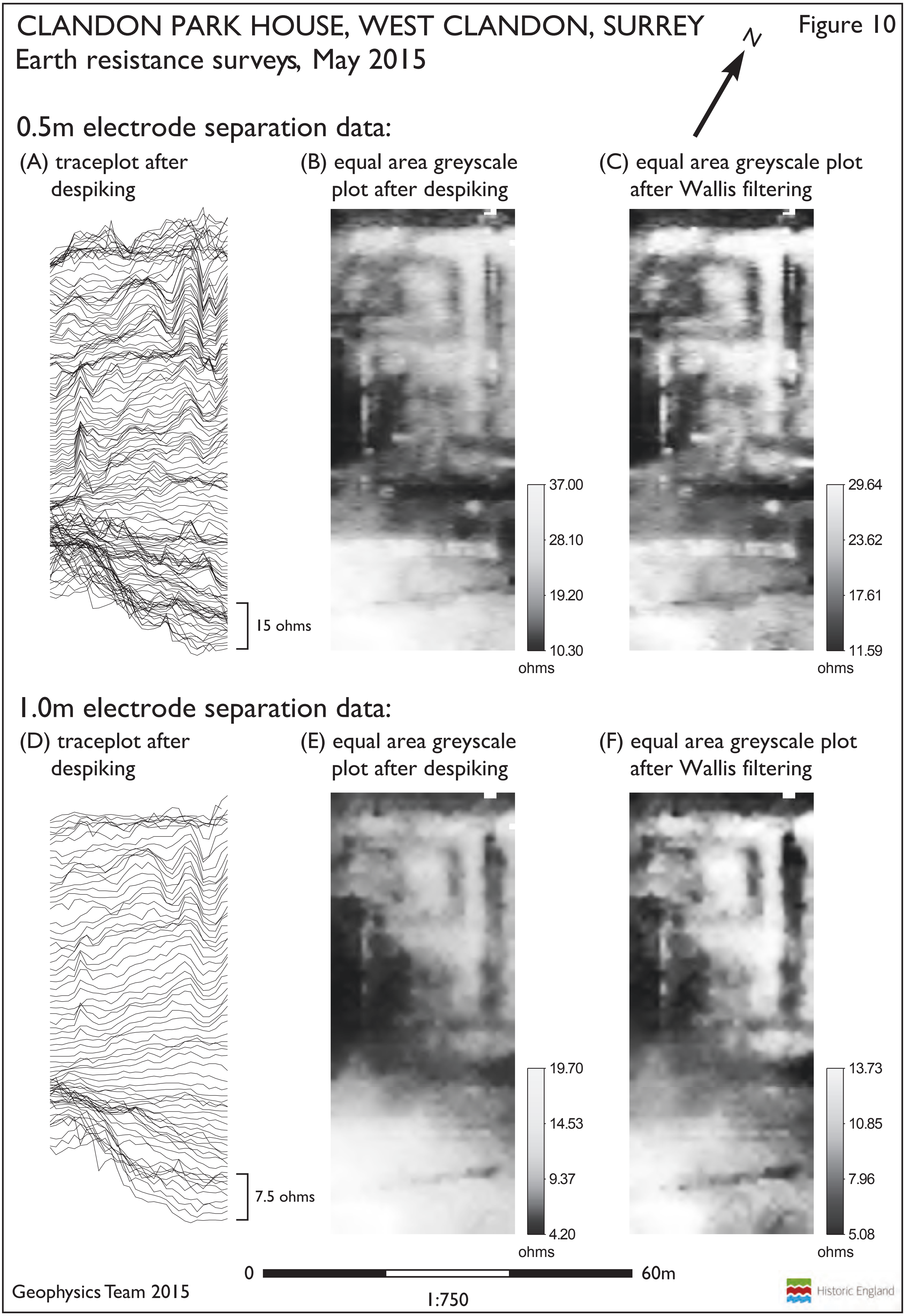
CLANDON PARK HOUSE, WEST CLANDON, SURREY
Earth resistance surveys, May 2015
Figure 10
N
0.5m electrode separation data:
(A) traceplot after despiking
15 ohms
(B) equal area greyscale plot after despiking
37.00
28.10
19.20
10.30
ohms
(C) equal area greyscale plot after Wallis filtering
29.64
23.62
17.61
11.59
ohms
1.0m electrode separation data:
(D) traceplot after despiking
7.5 ohms
(E) equal area greyscale plot after despiking
19.70
14.53
9.37
4.20
ohms
(F) equal area greyscale plot after Wallis filtering
13.73
10.85
7.96
5.08
ohms
0
60m
1:750
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Figure 11

CLANDON PARK HOUSE, WEST CLANDON, SURREY
Graphical summary of significant magnetic anomalies

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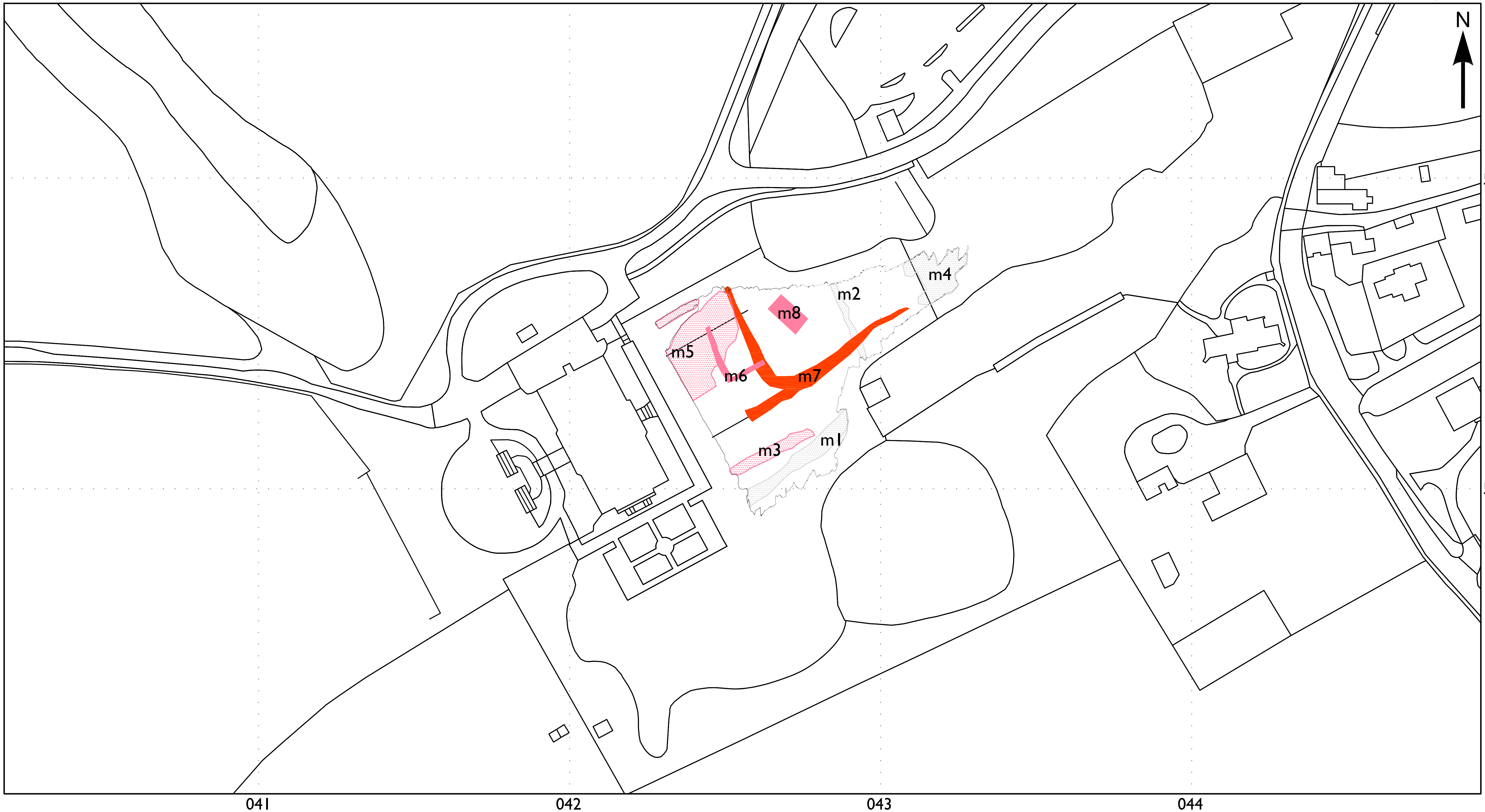

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1:1250

positive magnetic
negative magnetic
raised magnetic
magnetic noise

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Figure 12

CLANDON PARK HOUSE, WEST CLANDON, SURREY
Graphical summary of signficant GPR anomalies

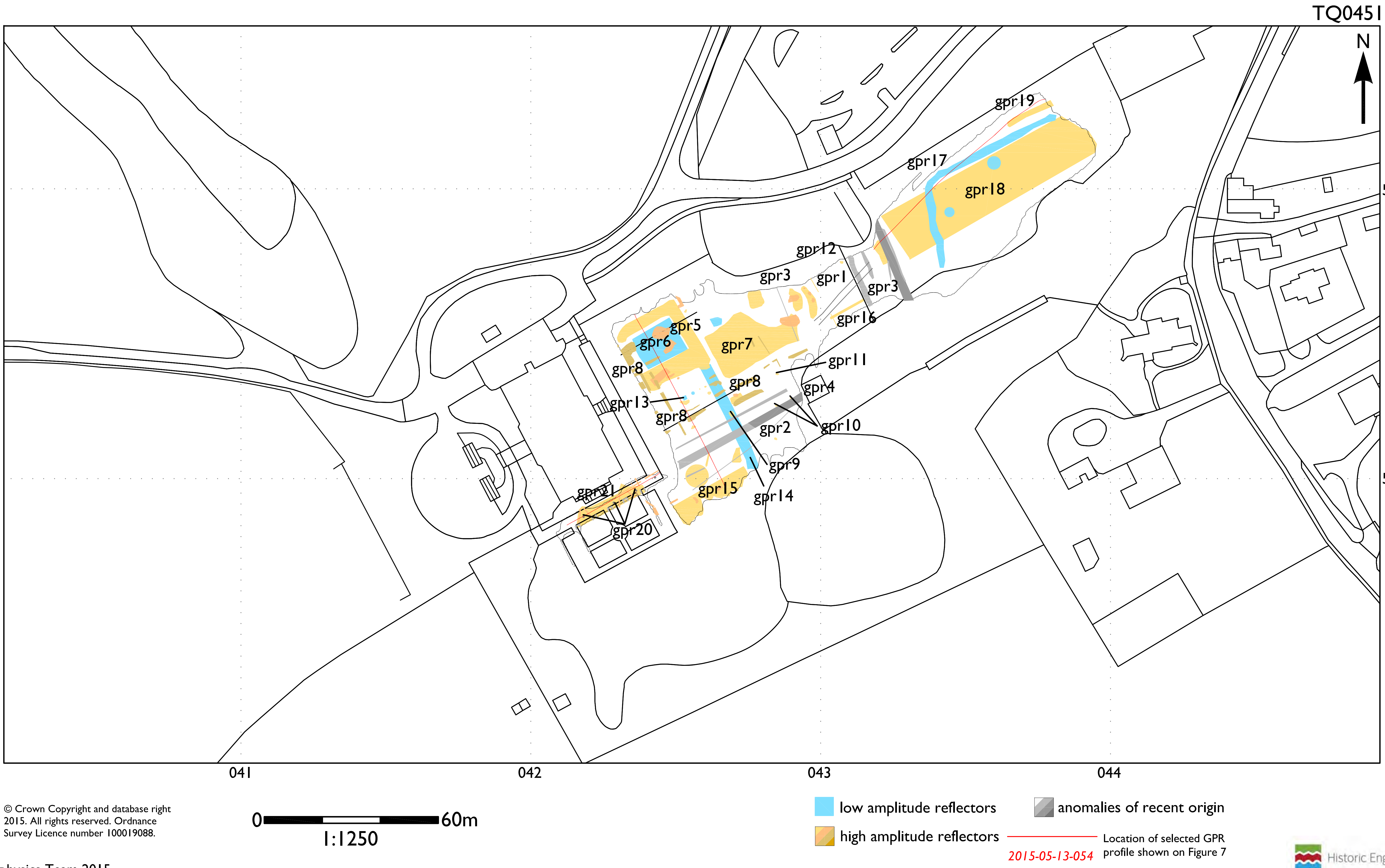

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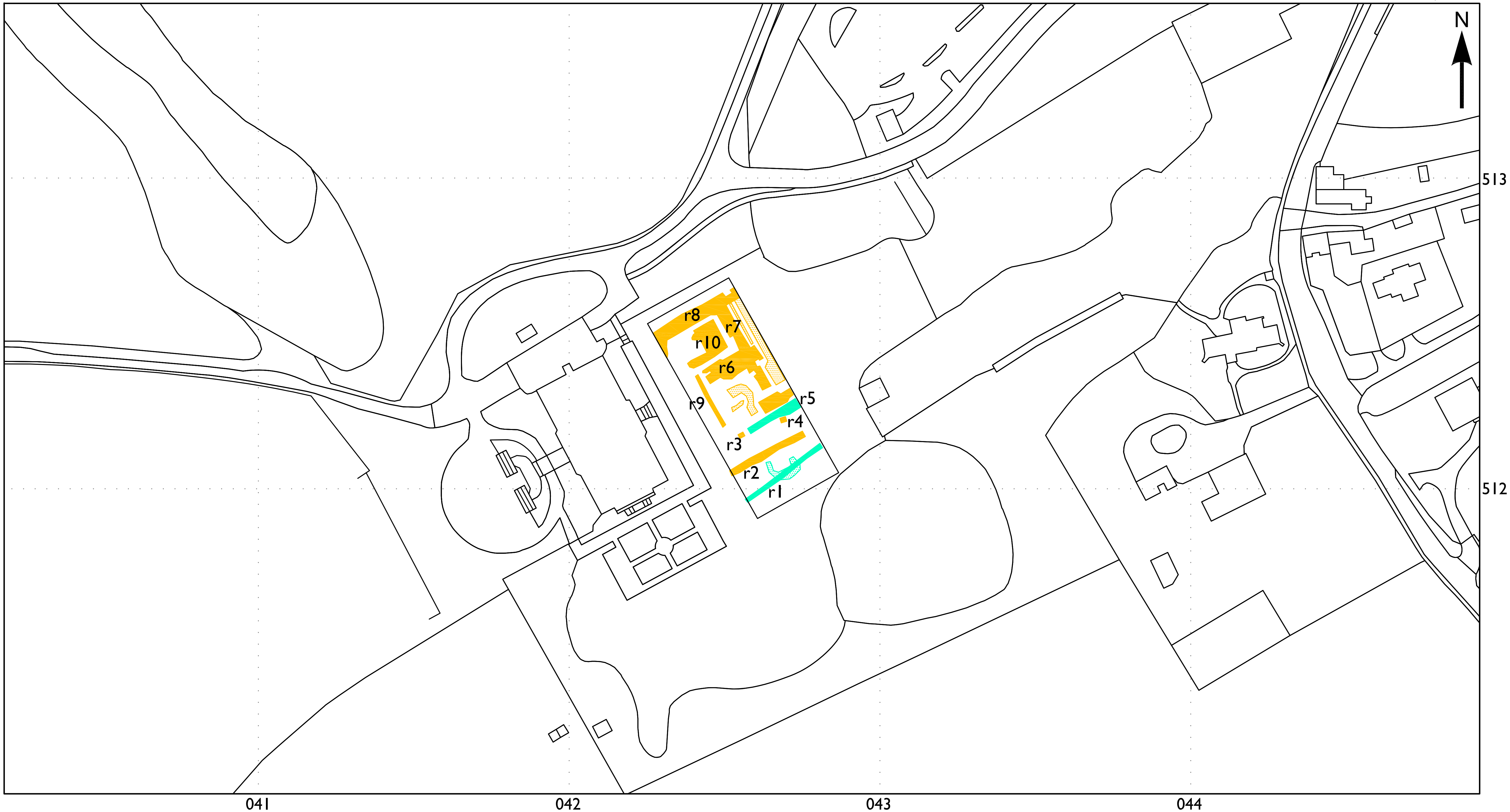
Figure 13

CLANDON PARK HOUSE, WEST CLANDON, SURREY
Graphical summary of earth resistance anomalies



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high resistance
low resistance

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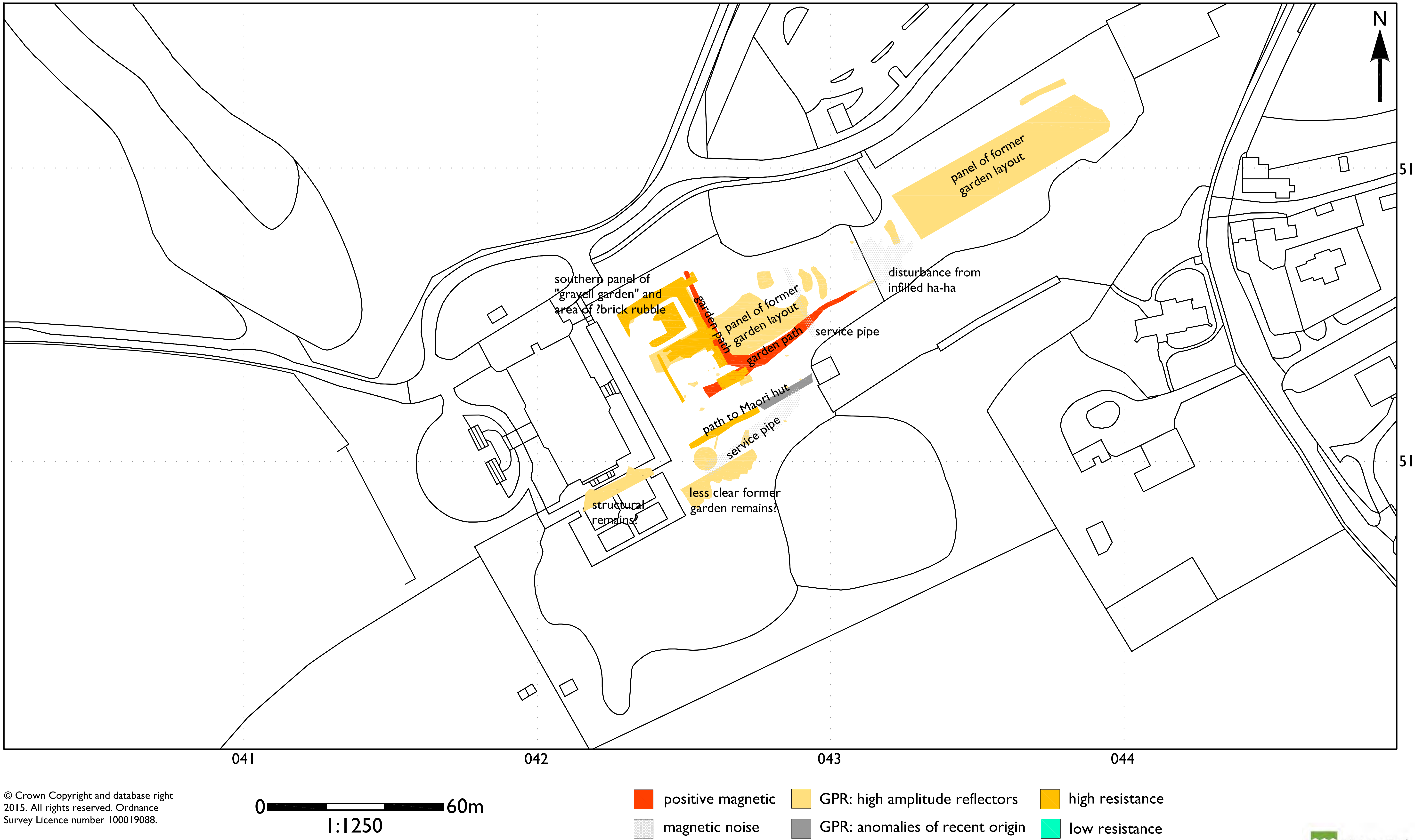
Figure 14

CLANDON PARK HOUSE, WEST CLANDON, SURREY

Graphical summary of most significant anomalies with possible interpretations



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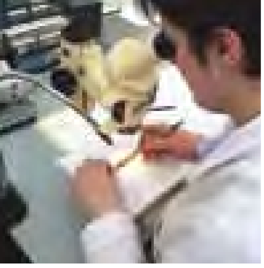
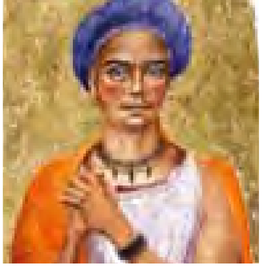

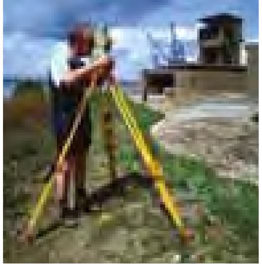
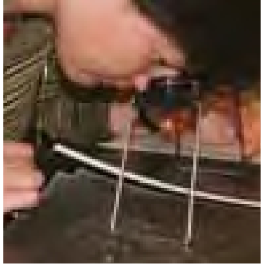


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