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MULTI-TECHNIQUE GEOPHYSICAL SURVEY AT LULLINGSTONE ROMAN VILLA IN KENT

English Heritage

National grid reference: TQ 530 650

Survey dates: 13 and 27 September 2007

Job number: 090-07

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Plotting scale is 1:500 unless otherwise indicated

1. Introduction

1.1. Terms of reference

1.1.1. In September 2007, Archaeological Surveys Ltd and Arrow Geophysics carried out a multi-technique geophysical survey at Lullingstone Roman Villa near Eynsford, Kent. Ground penetrating radar, earth resistance (where possible) and fluxgate gradiometer data were acquired across a survey area of approximately 900m^2.

1.1.2. The aims of the survey were to define the course of a valley sewer shown on a Ministry of Works plan (Drawing No. D.B. 1/1, March 1961) and to characterise any detectable archaeology within the survey area.

1.1.3. The survey forms part of a programme of revitalisation of the visitor facilities at the villa complex, which has been commissioned by English Heritage and is scheduled for completion by May 2008.

1.2. Location, description and survey conditions

1.2.1. Figure 1 shows the survey area in its regional context.

1.2.2. The geophysical survey area is immediately adjacent to the south eastern side of the building housing the villa remains (Figure 2). The area crosses a small metalled lane, a metalled entrance way to a car park and several small areas of mown grass. The metalled surfaces are separated from grassed areas by concrete kerbing.

1.2.3. The survey was undertaken in fine weather conditions. Ground conditions were dry due to relatively fine weather prevailing through the late summer period, it is of note that many areas of the UK received well above average rainfall through most of the early summer period.

1.2.4. Earth resistance survey was restricted to grassed areas within the site. A metalled lane running through the survey area was in frequent use by traffic which resulted in a significant hazard to the execution of the survey. A number of steel objects within or adjacent to the survey area were considered likely to create significant magnetic disturbance to the magnetometer. The roadway kerbing introduced noise to the ground penetrating radar data and degraded its positional accuracy.

1.3. Subsurface geology

1.3.1. The bedrock geology of the survey area is mapped as Chalk including Red Chalk (BGS, 1979). The site is located over deposits of Undivided and Flood Plain Gravel.

1.3.2. The site was found to be well-drained, a prerequisite for effective earth resistance survey, and desirable for both magnetic and ground penetrating radar survey.

1.3.3. Significant reworking of the immediate subsurface was expected due to the proximity of the villa complex, and the presence of the roadway with its associated drainage requirements.

1.4. Archaeological potential

1.4.1. Occupation of the area is believed to pre-date the Roman Invasion of AD 43, with an abundance of early pottery (bread-rim native fabric, pseudo-Belgic ware, and Gallo-Belgic material) together with two *speculum* coins discovered on the villa site. The increasing density of pottery fragments towards the north of the villa site may suggest that the earlier establishment was located close to that vicinity (Meates 1979, 18; 19; SMR TQ 57 NW 45; SMR TQ 56 NW 24).

1.4.2. In c. AD 100 the oldest surviving elements of the villa (SAM KE251) were constructed. A large winged house, the villa consisted of a west corridor, a central block of rooms and an eastern veranda between two projecting rooms. The northern projecting room was provided with a deep cellar. The villa's mortared flint and tile foundation walls probably supported a timber-framed superstructure. A circular building (interpreted by its excavator as a shrine) was constructed north west of the villa (Fulford, 24).

1.4.3. In the second half of the 2nd century the villa was remodelled, with ranges being added to the north and south of the existing block. In c. AD 180 the south range was altered when a new bath-suite was constructed. A kitchen was built to the west of the villa and a well was sunk to the south (Fulford, 25).

1.4.4. In c. AD 275 the north range of the villa was demolished and a new range built in its place. This new range housed a suite of heated rooms. The bath-suite at the south end of the villa was altered and extended (Fulford, 26-27). In c. AD 300 a large granary was constructed to the northeast of the villa and a mausoleum to the west of the house (Meates 1979, 23; Fulford, 27).

1.4.5. The central rooms of the villa were remodelled in c. AD 350 when a large apsed room constructed and mosaics laid. In c. AD 360 some of the heated rooms in the north range and the room above the deep room received decoration indicative of use as a Christian house church (Meates 1979, 23; Fulford, 29).

1.4.6. The villa was apparently abandoned after a fire in the early years of the 5th century (Meates 1979, 23; 42).

1.4.7. Elements of the mausoleum were incorporated into the later parish church of St. John the Baptist, Lullingstane (Meates 1979, 123). Although first recorded in AD 1115, the church was probably a Saxon foundation. Remains of the church were still visible in the late 18th century when they were described by John Thorpe in his *Custumale Roffense* of 1788. He thought the ruins "to be of Saxon architecture, and built with flints and Roman bricks" (Duncombe, 11). It is possible that the local parish boundaries, running east – west across the Darent valley follow the Roman estate boundaries (Meates 1984, 63). The parishes of Lullingstane and Lullingstone were united in 1412. The exact location and size of the medieval settlement of Lullingstane has not been established (Meates 1979, 123; 133; SMR TQ 56 NW 8). Other than the remains of the church only one medieval building has been discovered, to the south of the Roman villa (Meates 1979, 132).

1.4.8. A desk-based assessment of the study area was undertaken in July 2007 by English Heritage. After assessment of the available evidence it was considered that the area through which the foul drainage will pass has high potential for the recovery of archaeological remains. Situated between the villa remains and the River Darent, current understanding of the use of the site during the Roman period is limited. There is potential for evidence associated with the entrance to the villa, ancillary buildings and the cultivation of the environment around the villa. There is also some potential for evidence associated with the post-Roman history of the site.

1.4.9. The desk-based assessment concluded that, if possible, the new foul drainage should be laid in previously disturbed ground, taking advantage of the existing storm drain and the site of the former sewer running north-south on the east side of Lullingstone Lane. This would limit potential impact to unexcavated areas. Such action is dependent, however, on the successful location and utilisation of existing drainage systems and associated areas of ground disturbance.

1.4.10. The above synopsis of archaeological potential was provided in the Invitation to Tender for this project (EH, 2007), and is gratefully acknowledged. References to third party publications are listed in that document.

2. Acquisition

2.1. Positioning

2.1.1. The survey grids were set out using a Topcon GTS802 robotic total station and Penmap RTK GPS. A baseline parallel to the south eastern side of the villa housing was referenced to suitable topographic features. The GPS was used to obtain additional referencing using the Ordnance Survey National Grid OSGB36 datum. Positional accuracy achievable using RTK GPS is considered as better than 10cm. Grid nodes were marked out using wooden pegs and polypropylene ropes with 1m markers were used to establish grid traverses.

2.1.2. Earth resistance data (once plotted) appears to indicate some error in the mapping of features within the site as there is a significant mismatch between grassed areas where data were collected and the position of boundaries to those areas as indicated on the base map. The error is clearly visible where data overlaps into metalled surfaces. The survey grid has been set out using measurements obtained directly from the villa housing, and it is considered unlikely that any significant gross error could occur. Three RTK GPS points were measured on the grid (points A, E and F on Figure 2). These tend to indicate an error of approximately +1m on the easting and northing of the grid as compared to base mapping.

2.1.3. **It is therefore recommended that if ground measurements to geophysical anomalies are required, then these should be taken from a baseline established at a constant offset of 0.70 metres from the south-eastern side of the villa housing, and using a grid origin located 1.74m from the villa housing's north-eastern corner (distance A-C on Figure 2), rather than relying on coordinates or scaled measurements derived from the base mapping.**

2.1.4. It should also be noted that the edge of the radar grid does not coincide with the edge of the magnetometry/earth resistance grid. Ground measurements to radar anomalies should be carried out with reference to Figure 11, onto which the baseline described in the previous paragraph has been superimposed.

2.2. Magnetometry

2.2.1. The detailed magnetic survey was carried out using a Bartington Grad601-2 gradiometer. This instrument effectively measures a magnetic gradient between two fluxgate sensors mounted vertically 1m apart. Two sets of sensors are mounted on a single frame 1m apart horizontally. The instrument is extremely sensitive and is able to measure magnetic variation to 0.1 nanoTesla (nT). All readings are saved to an integral data logger for analysis and presentation.

2.2.2. The instrument is operated according to the manufacturer's instructions with consideration given to the local conditions. An adjustment procedure is required prior to collection of data in order to balance the sensors and remove the effects of the Earth's magnetic field, further adjustment is required during the survey due to instrument drift often associated with temperature change. It is often very difficult to obtain optimum balance for the sensors due to localised magnetic vectors that can be associated with large ferrous objects, geological/pedological features, 'magnetic' debris within the topsoil and natural temperature fluctuations. Imperfect balance results in a heading error often visible as striping within the data; this can be effectively removed by software processing and generally has little effect on the data unless extreme. Archaeological Surveys use a non-magnetic tripod with an additional supporting structure to raise the instrument during the set-up procedure, this has been found to improve the sensor balance.

2.2.3. The Bartington gradiometer undergoes regular servicing and calibration which is carried out by the manufacturer. A current assessment of the instrument is shown in Table 1 below.

Date of calibration/service	May 2007
Sensor type	Bartington Grad - 01 - 1000
Bandwidth	12Hz (100nT range) both sensors
Noise	<100pT peak to peak
Adjustable errors	<2nT

Table 1: Bartington fluxgate gradiometer sensor calibration results

2.2.4. The instrument was considered to be in good working order prior to the survey with no known faults or defects.

2.2.5. Magnetometry data was collected in parallel at 0.25m centres along traverses 1m apart. The survey area was separated into 20m by 20m grids giving 1600 recorded measurements per grid. This sampling interval is very effective at locating archaeological features and is the recommended methodology for archaeological prospection (English Heritage, 1995).

2.3. Earth resistance

2.3.1. The earth resistance survey was carried out using TR Systems Ltd Resistance Meter TRCIA 1.31 using a mobile Twin Probe array. The Twin Probe configuration used in this survey is favoured for archaeological prospection and can give a response to features up to 1m in depth with a mobile probe separation of 0.5m. By increasing the separation between the mobile electrodes to 1m the response becomes stronger to deeper features. Both 0.5m and 1m separation were used for this survey, the wider spacing may help to locate deeper features.

2.3.2. The resistance meter was operated according to the manufacturer's instructions. No calibration or adjustment is required. The stability of measurements is monitored on site prior to collecting data in order to assess whether any stray earth currents are interfering with the instrument. The instrument can be set to filter stray currents, at this site measurements were considered stable and no additional filtering was used. The position of remote probes is critical to correct resistance measurement, there was no difficulty achieving the minimum 15m required between the remote probes and the survey area.

2.4. Ground penetrating radar

2.4.1. Radar data were collected using a MALÅ GeoScience RAMAC/GPR system consisting principally of a shielded antenna, CUII control unit and XV11 monitor. Following onsite testing, the decision was taken to proceed with an antenna centre frequency of 500 MHz. The improved spatial resolution afforded by this antenna more than compensated for its reduced depth penetration, particularly as the valley sewer cross-cutting the survey area was clearly visible at this centre frequency (tests were also carried out with a 250 MHz centre frequency antenna – the responses can be compared in Figure 12).

2.4.2. Profiles were collected at a line spacing of 0.5 metres and a sample spacing of two centimetres.

2.4.3. The time window for reflection measurement was set to 74.6 nanoseconds, which corresponds to a potential penetration depth of approximately 2.6 metres at a radar wave propagation velocity of 7.0 cm/ns[1].

3. Processing

3.1. Magnetometry

3.1.1. Magnetometry data downloaded from the Grad 601-2 data logger is analysed and processed in specialist software known as ArcheoSurveyor. The software allows greyscale and trace plots to be produced for presentation and display. Survey grids are assembled to form an overall composite of data (composite file) creating a dataset of the complete survey area. Appendix A contains specific information concerning the survey and data attributes and is derived directly from ArcheoSurveyor, this should be used in conjunction with information provided by Figure 2.

[1] This velocity is estimated from profile measurement

3.1.2. Only minimal processing is carried out in order to enhance the results of the magnetometry survey for display. The raw data logged during this survey have been clipped at ±100nT due to very high levels of magnetic disturbance.

3.1.3. Further processing details are provided in Appendix A.

3.2. Earth resistance

3.2.1. Data logged by the resistance meter is downloaded and processed within ArcheoSurveyor software. Survey grids are used to create a composite file in a similar manner to the magnetometry data. Raw data are analysed and displayed within the report as well as processed data. The following processing has been carried out on data collected with 0.5m and 1m probe separations:

- raw earth resistance data have been clipped at 2SD to improve greyscale resolution,
- processed data have been despiked in order to remove spurious high contact resistance responses,
- a high pass Gaussian filter is passed across the data in order to enhance anomalies,
- processed data have been clipped at 1SD after filtering.

3.2.2. Further processing details are provided in Appendix A.

3.2.3. For both magnetometry and earth resistance, the main form of data display used in this report is the greyscale plot (high magnitude magnetic disturbance precluded the use of a trace plot for the magnetometer data). Both 'raw' and 'processed' data have been shown for the earth resistance data, followed by an abstraction and interpretation plot.

3.2.4. Graphic raster images in BMP format are initially prepared in ArcheoSurveyor. These images are combined with base mapping using AutoCAD LT 2007 creating DWG file formats. Images are externally referenced to the CAD drawing in order to maintain good graphical quality. Quality can be compromised by rotation of graphics in order to allow the data to be orientated with respect to grid north; this is considered acceptable as the survey results are effectively georeferenced allowing relocation of features using GPS, resection method etc.. A digital archive including raster images is produced with this report allowing separate analysis if necessary.

3.3. Ground penetrating radar

3.3.1. DC offset correction and time gain were applied to the radar data to correct for low frequency noise and increase mid- to late-time signal amplitudes respectively.

3.3.2. Profiles were then stacked to produce the image included in the digital data archive which accompanies this report.

3.3.3. A Kirchhoff migration algorithm was applied to each profile to position features more accurately in section, and in particular to collapse hyperbolic reflections to their source locations.

3.3.4. Signal amplitudes were then squared to improve signal-to-noise ratio and reduce the effect of transmitter waveform shape.

3.3.5. The profile dataset was sliced at a vertical interval of 200 mm to produce depth slices suitable for feature interpretation. Depth slices from surface to 1200 mm[2] were gridded using a kriging algorithm to produce the images shown in Figures 10a-10f. Radar reflectance in these images grades from low (black) to high (white). Amplitude thresholding has been applied to enhance feature interpretability.

3.3.6. Radar processing was mainly carried out using Shakespeare[3] and Geosoft Target.

4. Interpretation

4.1. Magnetometry

4.1.1. The magnetometer survey was carried out using parallel traverses crossing the site from north west to south east. This direction was favoured as the most effective given the shape and position of the survey area. In addition, this orientation was considered safest given the metalled lane running through the survey area was in frequent use.

4.1.2. Magnetometer data has been severely affected by a number of ferrous objects including: a steel/iron drainage grill running adjacent to the villa housing, ferrous material or services within the south eastern boundary, a steel gate within the south eastern boundary, inspection chambers and signs. An abstraction and interpretation plot has not been included for the magnetometer survey. It is not possible to confidently determine the presence of buried features within the magnetometer data.

4.2. Earth resistance

4.2.1. Earth resistance survey data were likely to have been influenced by the presence of variable surface conditions within the survey area. Metalled surfaces were unsurveyable and resistance data have been influenced by kerbs, trees and other modern structures.

4.2.2. Several earth resistance anomalies have been identified. These are shown in Figures 8 and 9, and are summarised below:

(1) – A high resistance linear anomaly clearly visible within both the 0.5m and 1m probe separation earth resistance surveys. The anomaly is very likely to have been caused by the former valley sewer and confirms the route mapped by the Ministry of Works in 1961.

(2) – Amorphous areas of high resistance are of uncertain origin. Survey using 1m probe spacing tends to indicate an increase in the area of high resistance suggesting that this is unlikely to be a shallow surface effect. It should be considered that the anomaly may relate to masonry remains, rubble etc. of archaeological potential.

[2] Most of the useful survey information was recorded within this depth range
[3] Proprietary software for processing radar data developed by Arrow Geophysics

(3) – Area of high resistance of uncertain origin. As for anomaly (2), there is an increase in the area of the anomaly within the resistance data collected using the 1m probe separation.

(4) – A broad high resistance linear anomaly abstracted from the 0.5m probe separation survey is of uncertain origin.

(5) – Areas of high resistance associated with kerbs and modern building foundations.

(6) - A variable but generally high resistance anomaly likely to be caused by and associated with an area of trees.

(7) – A small area of high resistance associated with an inspection chamber.

4.3. Ground penetrating radar

4.3.1. The advantage of radar depth slices is that the *spatial relationship* of individual features can be appreciated in plan view. The advantage of radar profiles is that the *changing character* of individual features can be studied profile by profile. A combined approach - identifying features on depth slices, and ascertaining their characteristics from profiles when necessary - is usually the best method of radar interpretation in an archaeological context.

4.3.2. The interpretation of radar results is summarised in Figure 11, and discussed below.

4.3.3. Radar has successfully imaged a number of utility lines (probably drainage runs) within the survey area. Approximate invert levels to some of these features (including invert levels within two manholes) are shown in Figure 11.

4.3.4. In particular, a utility line has been located along approximately the same alignment as the valley sewer shown on the 1961 Ministry of Works plan. We share English Heritage's assumption that the large diameter of this sewer (24") as well as its intended use would suggest a significantly deeper burial than is indicated by the radar (and earth resistance) results. The key to resolving this dilemma may lie in Figure 12. Here, we see that a feature with top edge at 1500 mm and bottom edge at 2200 mm may indicate the valley sewer, and that another utility line appears to have been laid in the same trench at a shallower depth and (presumably) a later date. The "deep" sewer only appears on radar profiles over a horizontal distance of approximately 4.5 metres, and may well be defunct.

***

4.3.5. There are four features of potential archaeological interest in the radar dataset. Two of these are regarded as high priority targets and two are regarded as low priority targets.

4.3.6. Target 1 (high priority – Figure 13) is a sub-horizontal, high-amplitude reflection located at a depth of approximately 500 mm. It is interpreted to represent a living surface, possibly the floor of a room. The horizontal extent of this feature is not known, as it extends south-eastwards beyond the survey boundary.

4.3.7. Target 2 (high priority – Figure 13) is a broad zone of elevated reflectance located at a depth of approximately 900 mm. Its curvilinear alignment and similarity of reflectance signature to the modem metalled roadway suggest that this may be a former road alignment, but one which must pre-date Target 1.

4.3.8. Target 3 (low priority) is a zone of elevated reflectance probably related to ground hardening and differential moisture content beneath overhanging trees. It has been selected for interpretive comment because of its well-defined edges, and may represent a former living surface or a feature associated with the adjacent roadway.

4.3.9. Target 4 (low priority) is probably a utility line, but has been selected for interpretive comment because of its unexpected location and sharp change of direction.

5. Conclusion

5.1.1. Several features of possible engineering and archaeological interest have been located by this multi-technique geophysical survey.

5.1.2. These features include a number of utility lines (probably drainage runs), several zones of high earth resistance, and four radar targets (two of which are regarded as high priority targets).

6. Acknowledgements

Ordnance Survey base mapping for this survey was supplied by English Heritage.

7. References

British Geological Survey, 1979. Geological Map of the United Kingdom, South. 1:625,000.

English Heritage, 2007. Invitation to Tender for the Production of a Geophysical Survey at Lullingstone Roman Villa, Eynsford, Kent.

Disclaimer: Archaeological Surveys Ltd and Arrow Geophysics make no guarantee that the record of buried utilities supplied for this survey is either accurate or complete. To properly locate such features, a dedicated survey using an appropriate suite of geophysical and other techniques is recommended, and can be carried out upon request.

APPENDIX A: SURVEY AND DATA INFORMATION

Raw resistance data (0.5m probe)

COMPOSITE
Filename: Res0.5-raw.xcp
Description:
Instrument Type: TR/CIA (Resistance)
Units: Ohm
Direction of 1st Traverse: SE
Collection Method: ZigZag
Dummy Value: -2147483648
Origin: Zero

Dimensions
Composite Size (readings): 40 x 120
Grid Size: 20 x 20
X Interval: 0.5
Y Interval: 0.5

Stats
Max: 114.07
Min: 34.67
Std Dev: 21.56
Mean: 66.56

Processes: 2
1 Base Layer
2 Clip at 2 SD

Source Grids: 3
1 Col:0 Row:0 grids\03.asg
2 Col:0 Row:1 grids\01.asg
3 Col:0 Row:2 grids\02.asg

Processed resistance data (0.5m probe)

COMPOSITE
Filename: Res0.5-proc.xcp
Description:
Instrument Type: TR/CIA (Resistance)
Units: Ohm
Direction of 1st Traverse: SE
Collection Method: ZigZag
Dummy Value: -2147483648
Origin: Zero

Dimensions
Composite Size (readings): 40 x 120
Grid Size: 20 x 20
X Interval: 0.5
Y Interval: 0.5

Stats
Max: 12.03
Min: -10.75
Std Dev: 7.15
Mean: -0.36

Processes: 5
1 Base Layer
2 Clip at 2 SD
3 Despike Threshold: 3 Window size: 3x3
4 High pass Gaussian filter: Window: 15 x 15
5 Clip at 1 SD

Source Grids: 3
1 Col:0 Row:0 grids\03.asg
2 Col:0 Row:1 grids\01.asg
3 Col:0 Row:2 grids\02.asg

Raw resistance data (1m probe)

COMPOSITE
Filename: Res1m-raw.xcp
Instrument Type: TR/CIA (Resistance)
Units: Ohm
Direction of 1st Traverse: SE
Collection Method: ZigZag
Dummy Value: -2147483648
Origin: Zero

Dimensions
Composite Size (readings): 40 x 120
Grid Size: 20 x 20
X Interval: 0.5
Y Interval: 0.5
Stats
Max: 52.07
Min: 23.07
Std Dev: 7.69
Mean: 34.55

Processes: 2
1 Base Layer
2 Clip at 2 SD

Source Grids: 3
1 Col:0 Row:0 grids\01.asg
2 Col:0 Row:1 grids\02.asg
3 Col:0 Row:2 grids\03.asg

Processed resistance data (1m probe)

COMPOSITE
Filename: Res1m-proc.xcp
Instrument Type: TR/CIA (Resistance)
Units: Ohm
Direction of 1st Traverse: SE
Collection Method: ZigZag
Dummy Value: -2147483648
Origin: Zero

Dimensions
Composite Size (readings): 40 x 120
Grid Size: 20 x 20
X Interval: 0.5
Y Interval: 0.5

Stats
Max: 4.03
Min: -3.81
Std Dev: 2.53
Mean: -0.17

Processes: 5
1 Base Layer
2 Clip at 2 SD
3 Despike Threshold: 3 Window size: 3x3
4 High pass Gaussian filter: Window: 21 x 21
5 Clip at 1 SD

Source Grids: 3
1 Col:0 Row:0 grids\01.asg
2 Col:0 Row:1 grids\02.asg
3 Col:0 Row:2 grids\03.asg

Raw magnetometer data

COMPOSITE
Filename: Mag-raw.xcp
Instrument Type: Grad 601 (Magnetometer)
Units: nT
Direction of 1st Traverse: SE
Collection Method: Parallel
Sensors: 2 @ 1.00 m spacing.
Dummy Value: 32702
Origin: One

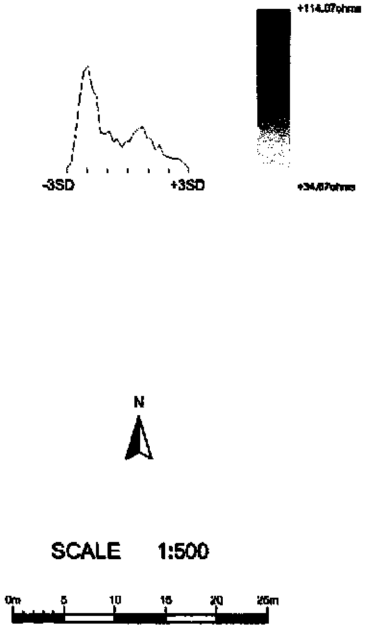
Dimensions
Composite Size (readings): 80 x 60
Grid Size: 20 x 20
X Interval: 0.25
Y Interval: 1

Stats
Max: 100.00
Min: -100.00
Std Dev: 64.02
Mean: -5.44

Processes: 2
1 Base Layer
2 Clip from -100 to 100

Source Grids: 3
1 Col:0 Row:0 grids\01.asg
2 Col:0 Row:1 grids\02.asg
3 Col:0 Row:2 grids\03.asg

Figure 3



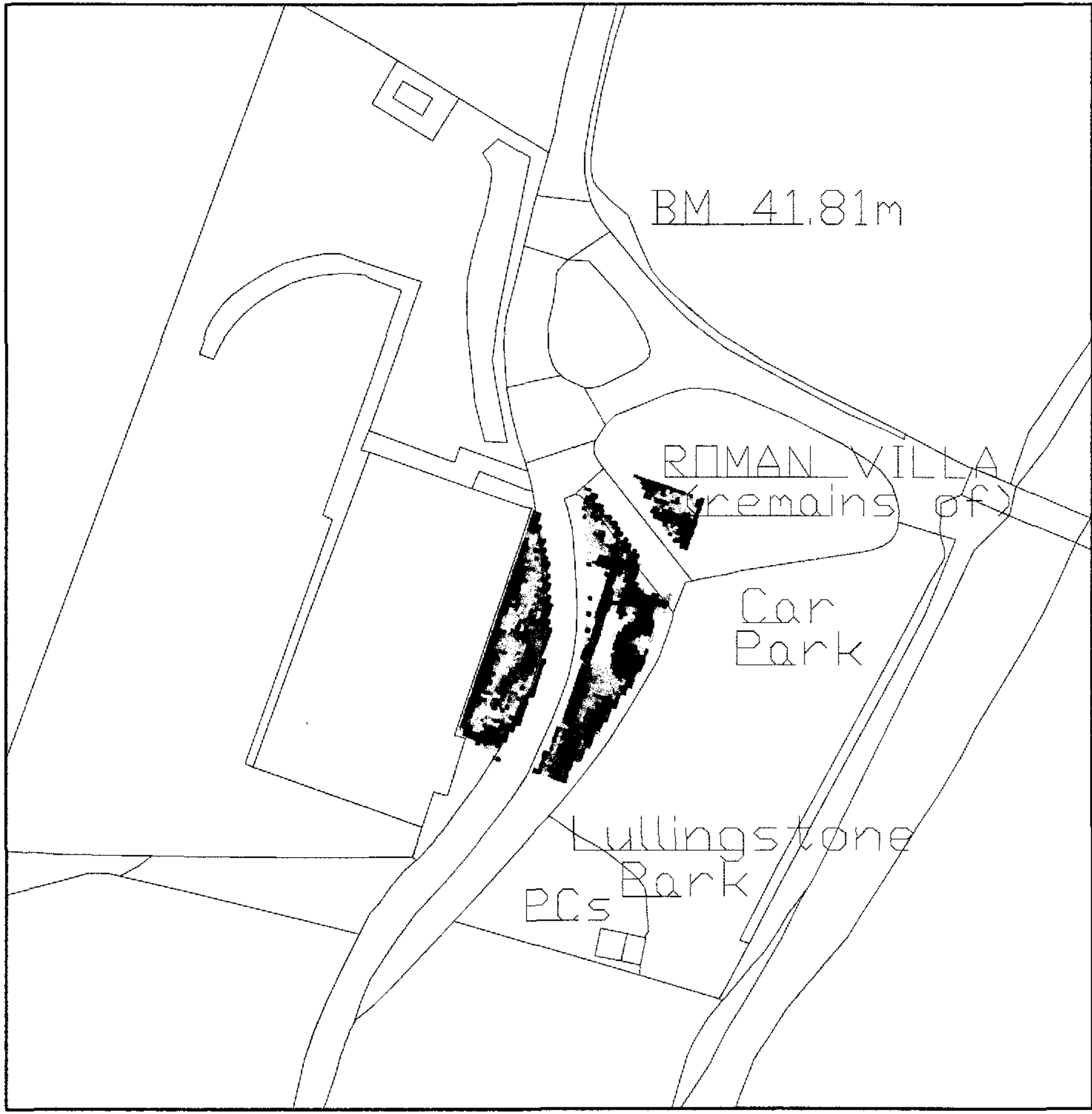
English Heritage

Lullingstone Roman Villa

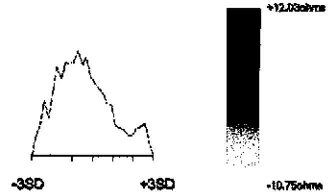
raw resistance data (0.5m probes)

Archaeological Surveys Ltd

Figure 4



Greyscale plot of processed resistance data



N

SCALE 1:500

0m 5 10 15 20 25m

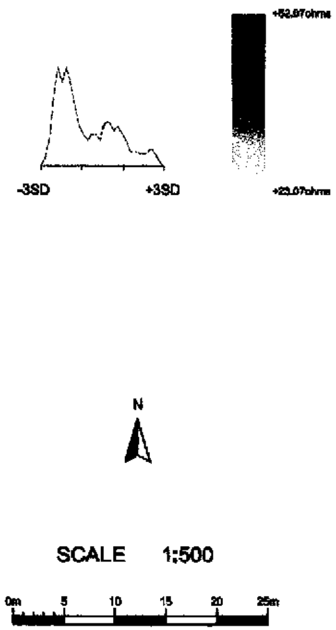
English Heritage

Lullingstone Roman Villa

processed resistance data (0.5m probes)

Archaeological Surveys Ltd

Figure 5



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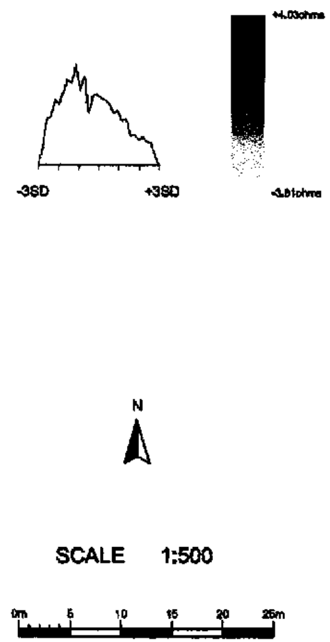
English Heritage

Lullingstone Roman Villa

raw resistance data (1m probes)

Archaeological Surveys Ltd

Figure 6



English Heritage

Lullingstone Roman Villa

processed resistance data (1m probes)

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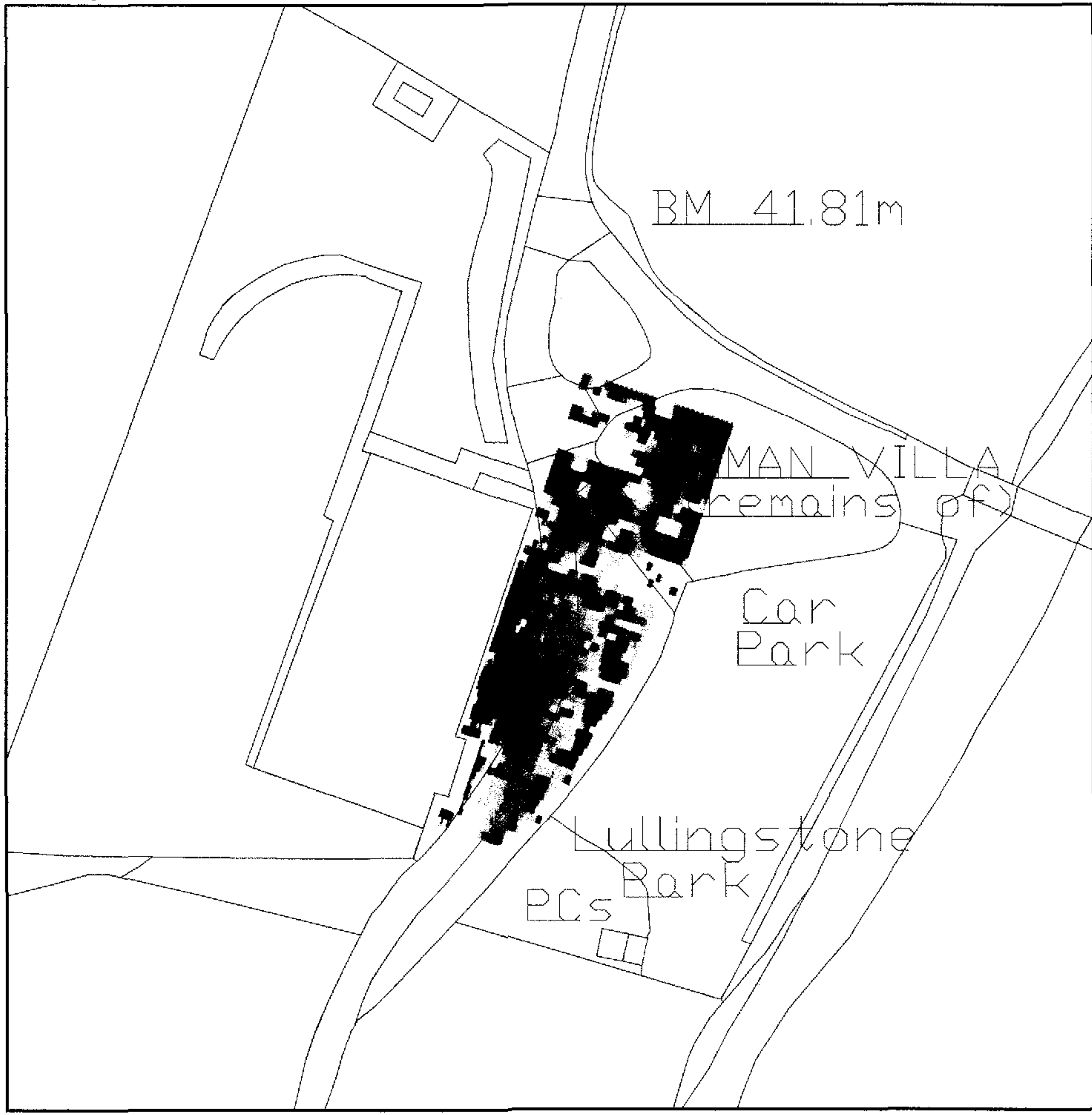
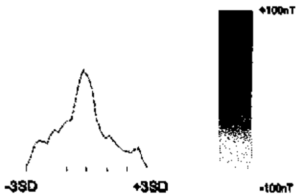
Figure 7





N

SCALE 1:500

0m 5 10 15 20 25m

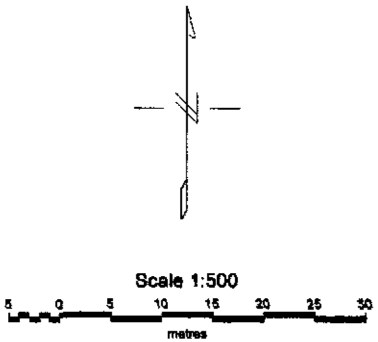
English Heritage

Lullingstone Roman Villa

raw magnetometer data

Archaeological Surveys Ltd

Figure 10a



English Heritage
Lullingstone Roman Villa
radar depth slice from surface to 200 mm
Arrow Geophysics

Figure 10b

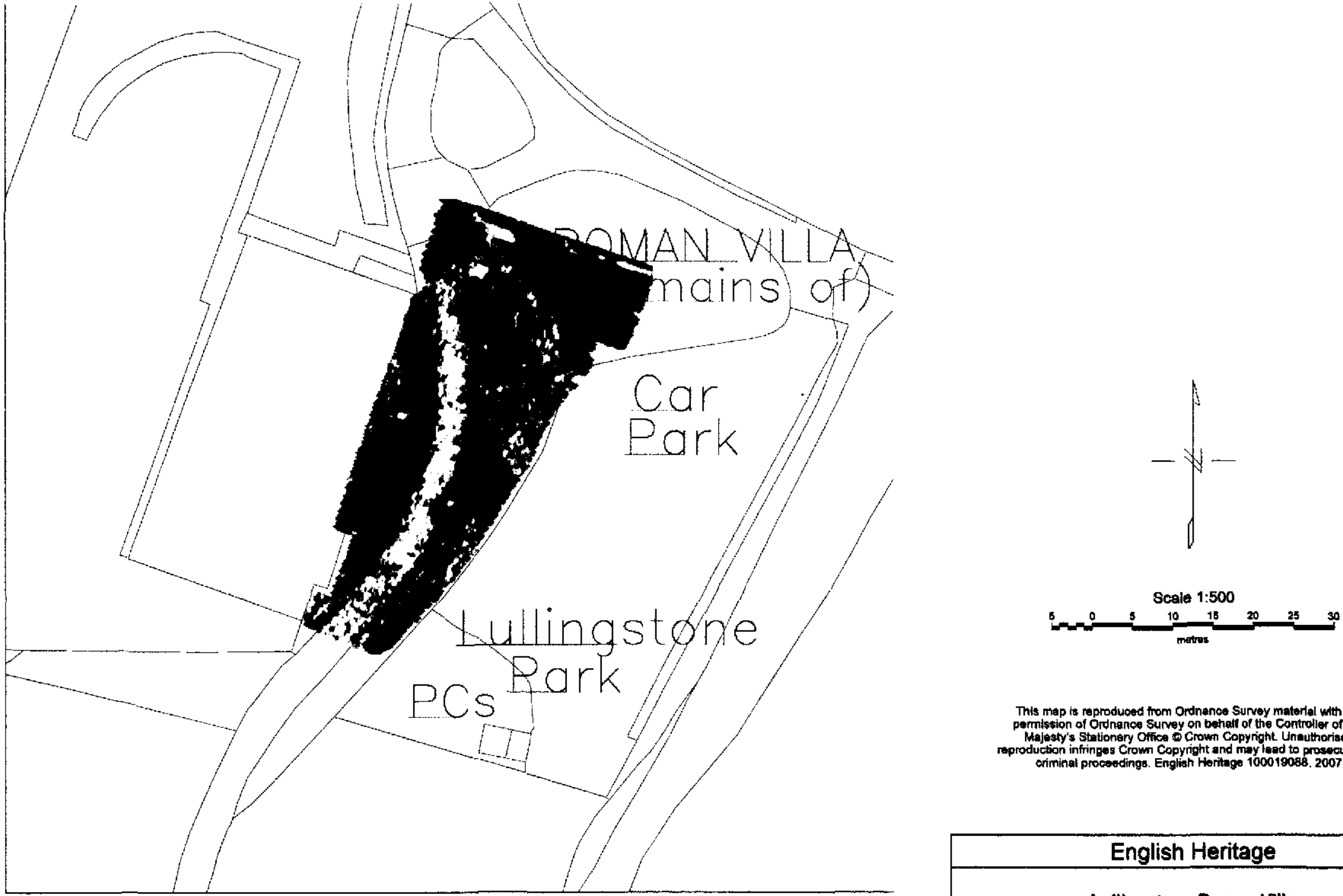
Scale 1:500

5 0 5 10 15 20 25 30

metres

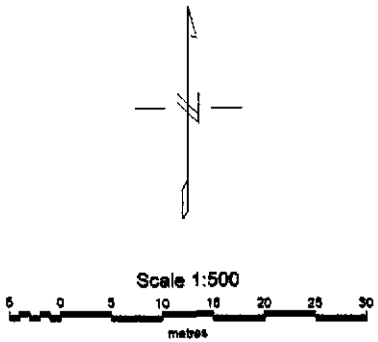
English Heritage
Lullingstone Roman Villa
radar depth slice from 200 mm to 400 mm
Arrow Geophysics

Figure 10c



English Heritage
Lullingstone Roman Villa
radar depth slice from 400 mm to 600 mm
Arrow Geophysics

Figure 10d



English Heritage

Lullingstone Roman Villa

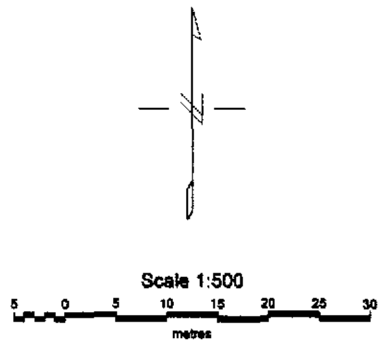
radar depth slice from 600 mm to 800 mm

Arrow Geophysics

Figure 10e

English Heritage
Lullingstone Roman Villa
radar depth slice from 800 mm to 1000 mm
Arrow Geophysics

Figure 10f



English Heritage

Lullingstone Roman Villa

radar depth slice from 1000 mm to 1200 mm

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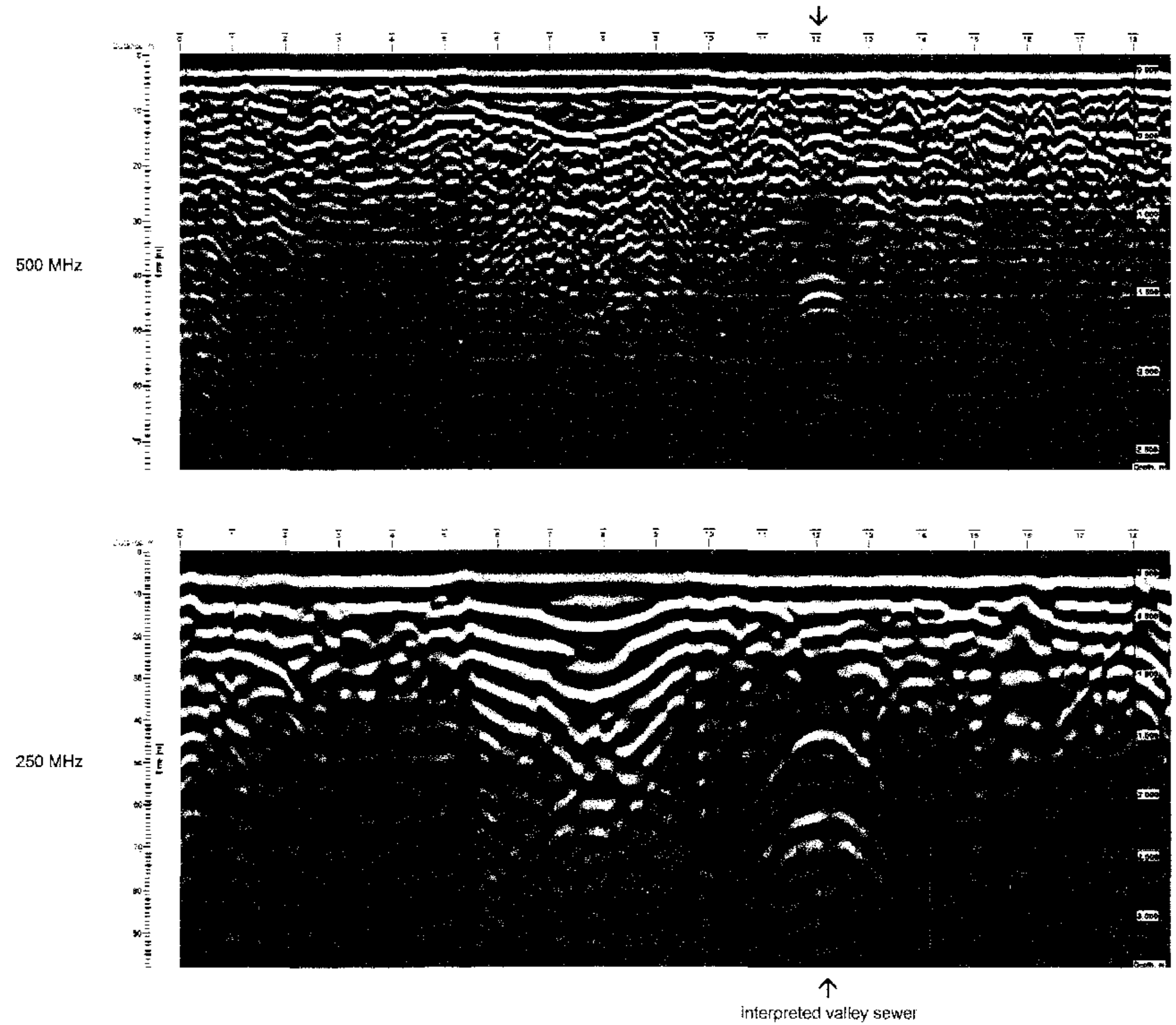
Figure 12



English Heritage

Lullingstone Roman Villa

500 MHz and 250 MHz radar profiles over interpreted valley sewer

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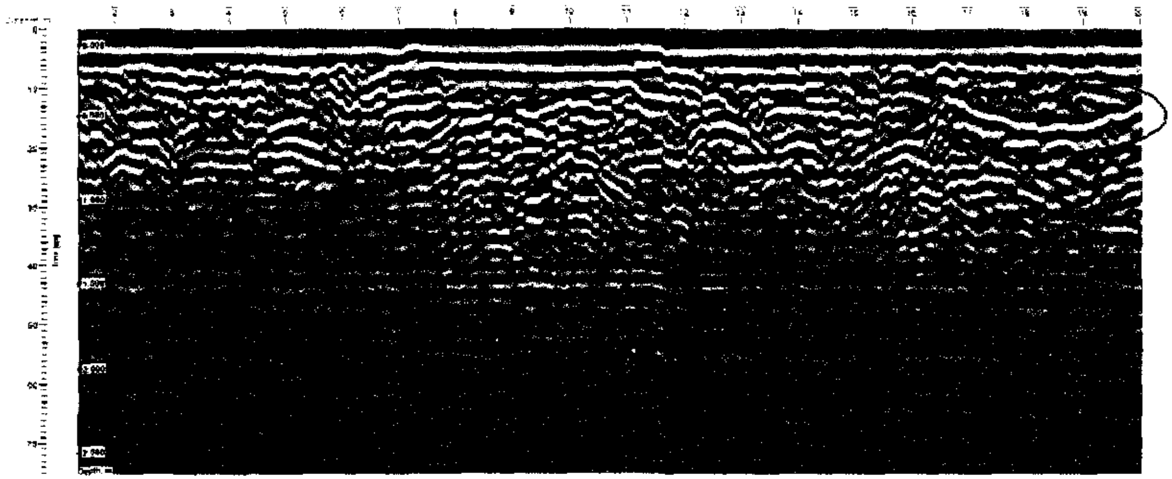
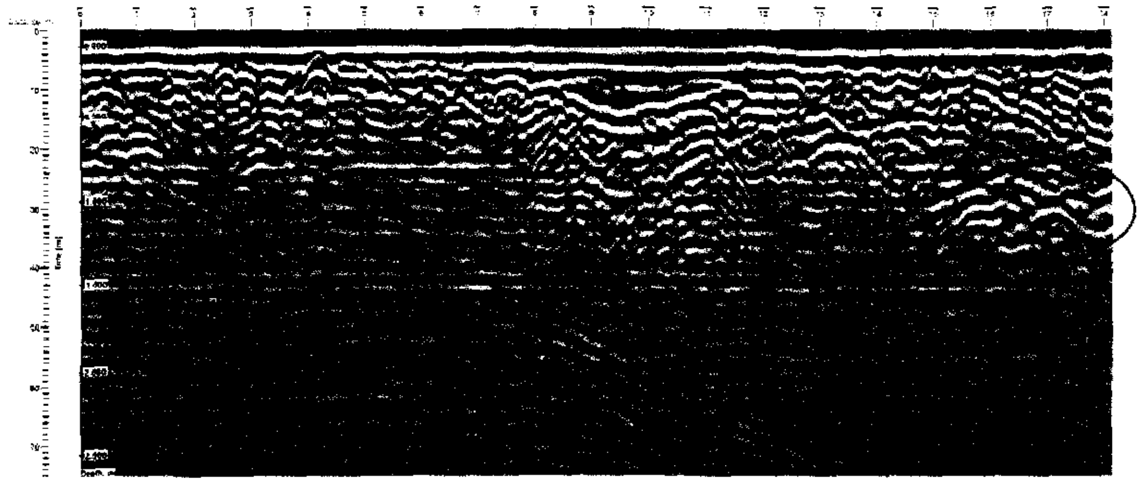
Figure 13

Target One



Target Two



English Heritage
Lullingstone Roman Villa
500 MHz radar profiles over high priority targets
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Figure 1

Site

• Survey Location

Site centred on TQ 530 650

N

SCALE 1:50 000

0km 1 2km

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Lullingstone Roman Villa

location map

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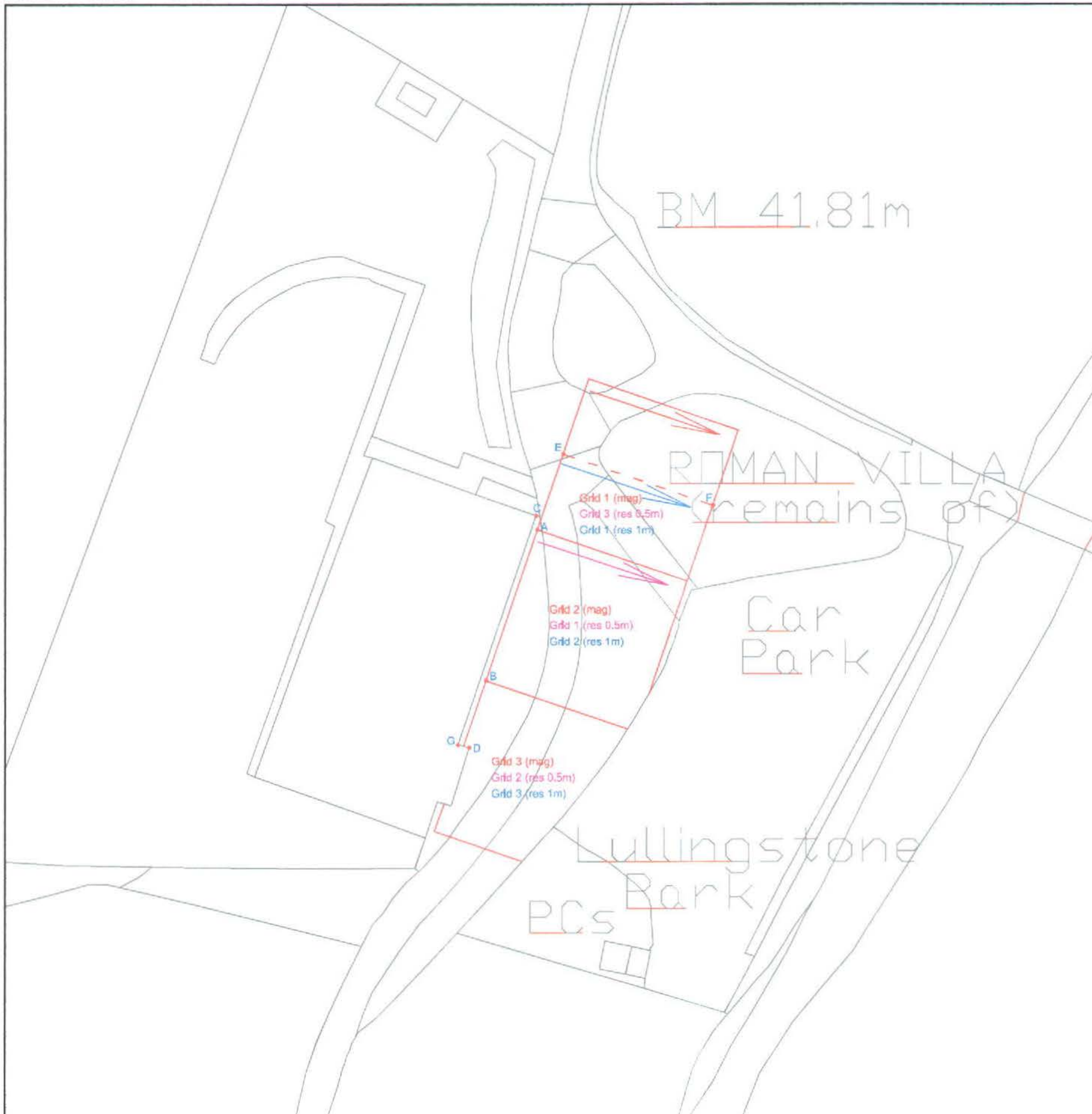

Figure 2

A Grid node on baseline
B Grid node on baseline
C Corner of building
D Corner of building
E Northern extent of resistance survey
F Northern extent of resistance survey
G Corner of building

A-B 20m
A-C 1.74m
B-D 8.98m
A-E 10m
E-F 20m

AB = CG 0.7m parallel

RTK GPS coordinates (OSGB36)

A 553019.82, 165076.19
E 553023.12, 165085.69
F 553042.06, 165079.25

Magnetometer survey start & direction
Resistance survey start & direction (0.5m)
Resistance survey start & direction (1m)

N

SCALE 1:500

0m 5 10 15 20 25m

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Lullingstone Roman Villa

referencing

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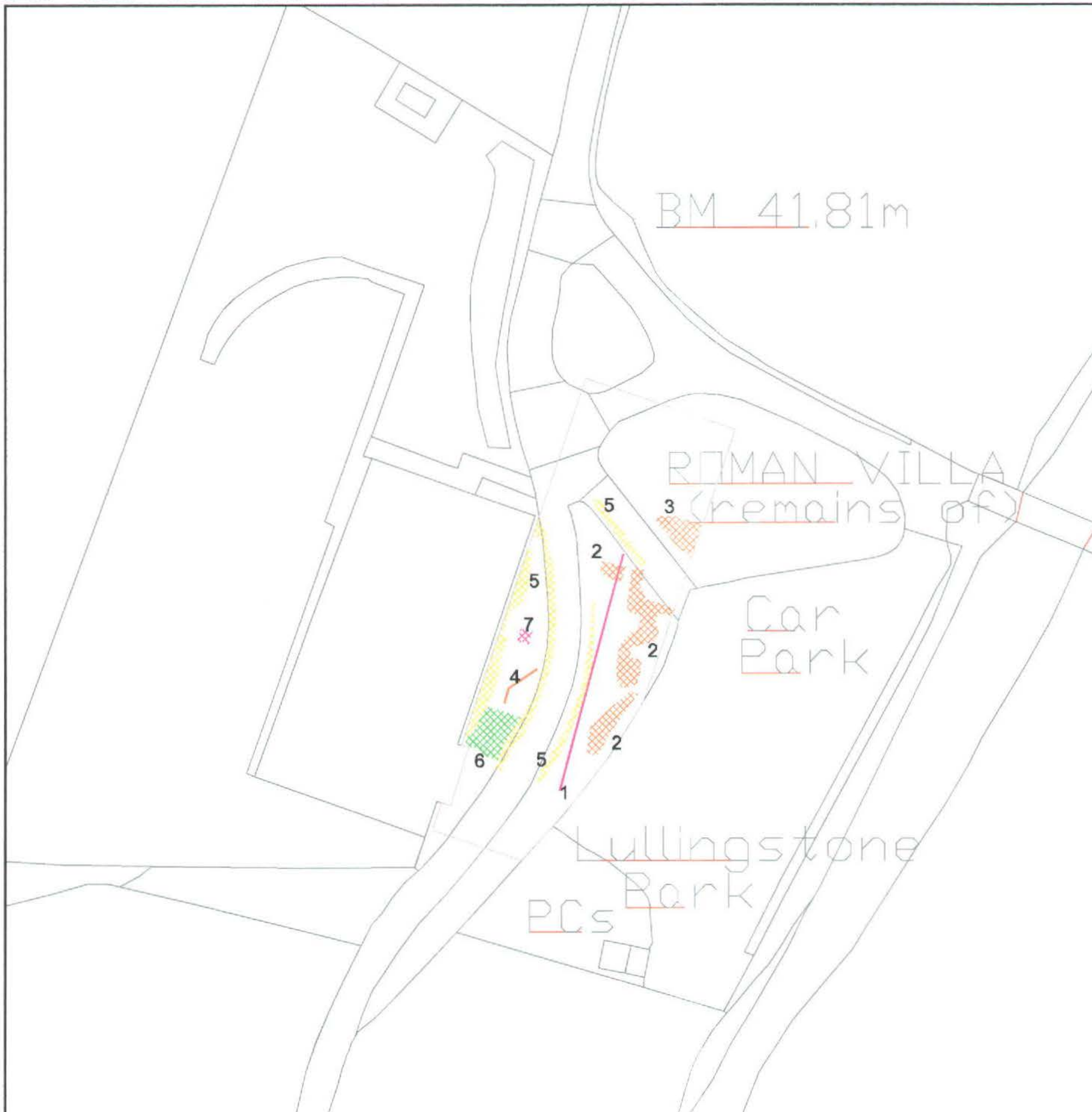
Figure 8



- High resistance linear anomaly - uncertain origin
- High resistance linear anomaly - former pipeline
- Area of high resistance - associated with inspection chamber
- Area of high resistance - associated with modern building/kerb
- Variable response caused by trees
- Area of high resistance - uncertain origin

N

SCALE 1:500

0m 5 10 15 20 25m

English Heritage

Lullingstone Roman Villa

resistance abstraction and interpretation (0.5m probes)

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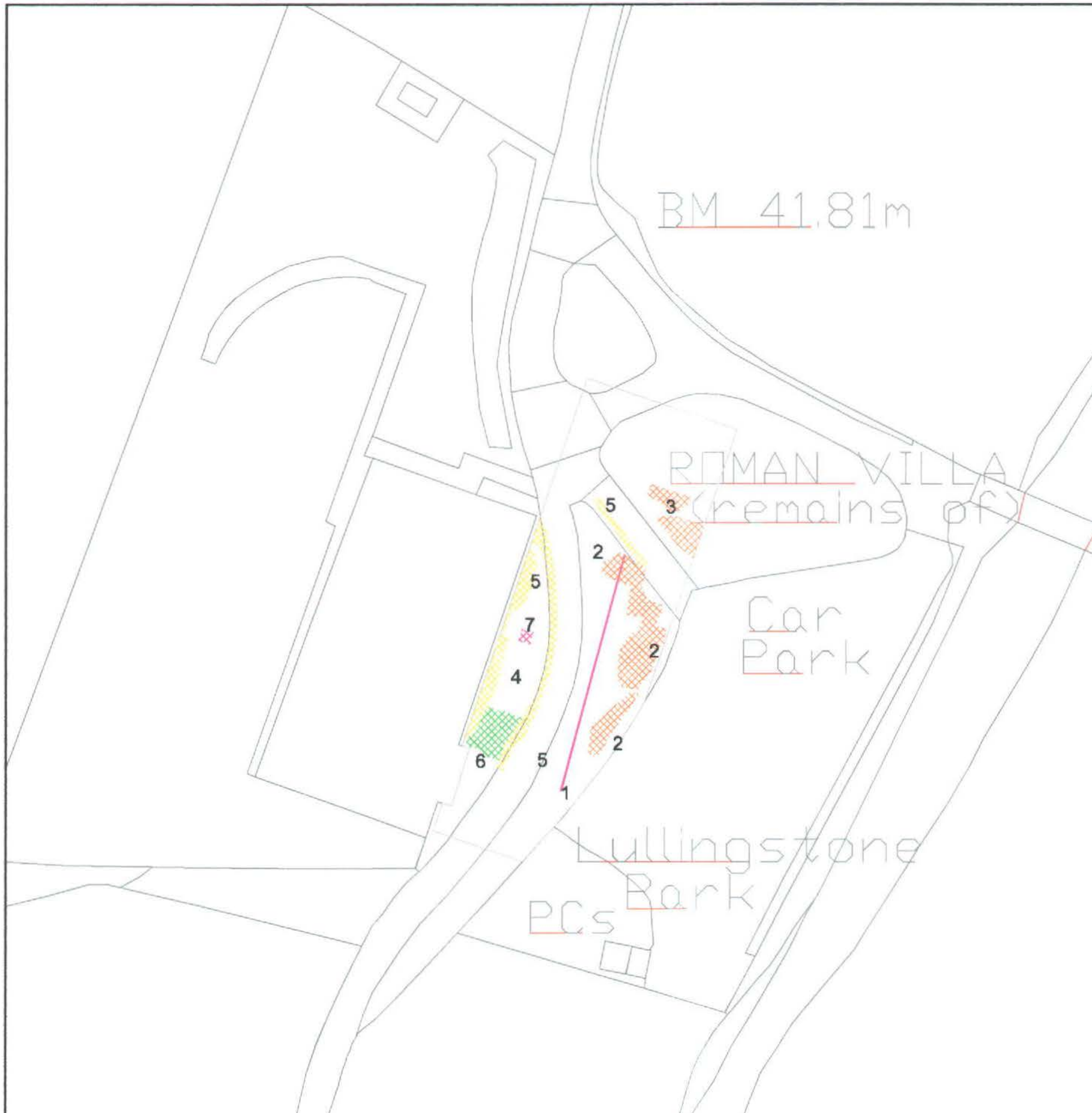
Figure 9



— High resistance linear anomaly - former pipeline

Area of high resistance - associated with inspection chamber

Area of high resistance - associated with modern building/kerb

Variable response caused by trees

Area of high resistance - uncertain origin

N

SCALE 1:500

0m 5 10 15 20 25m

English Heritage

Lullingstone Roman Villa

resistance abstraction and interpretation (1m probes)

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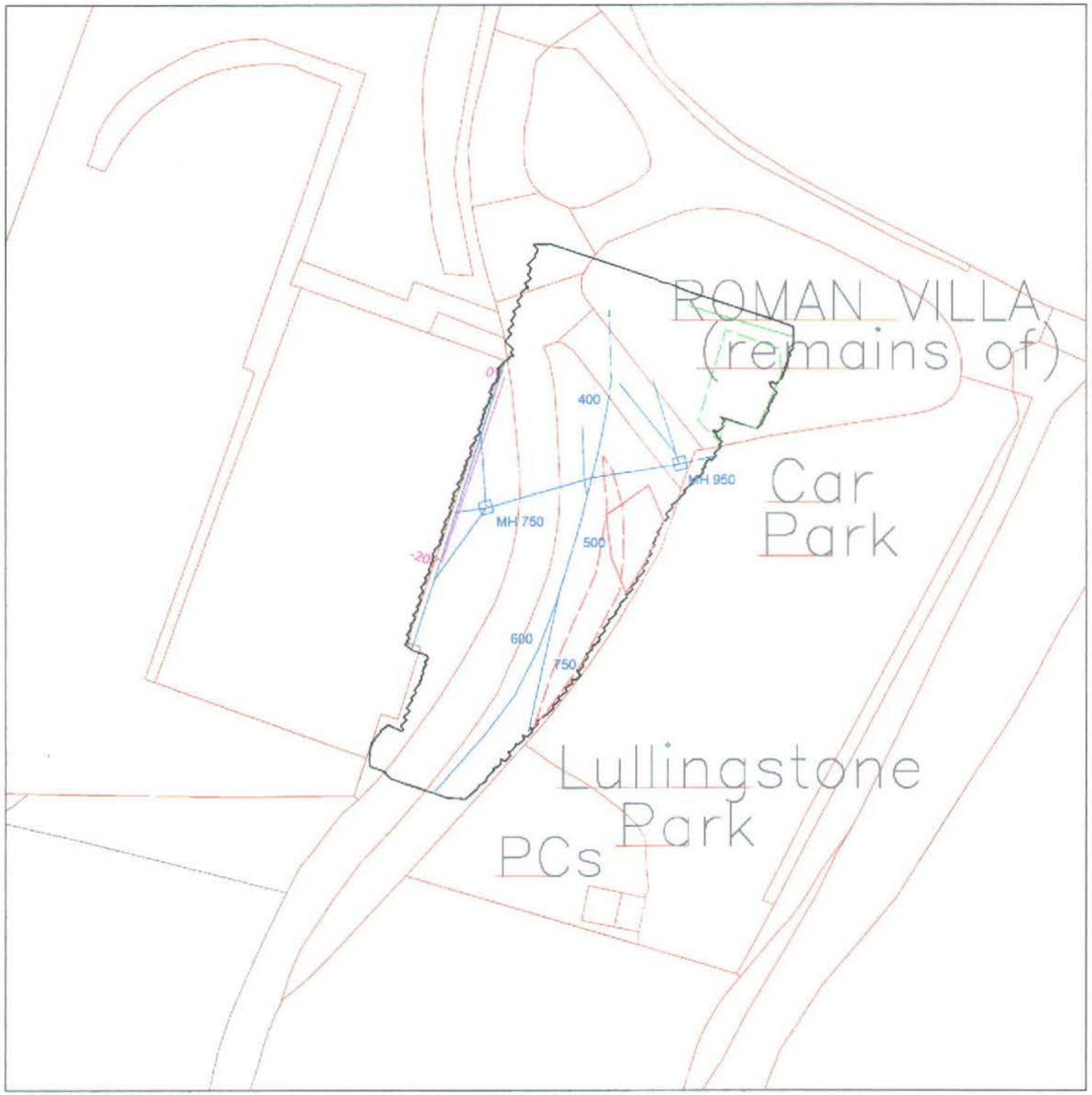
Figure 11



utility line (approximate invert levels in mm)
high priority archaeological target
low priority archaeological target
recommended baseline

dotted lines indicate approximate locations

Scale 1:500

5 0 5 10 15 20 25 30

metres

English Heritage
Lullingstone Roman Villa
interpretation of radar results
Arrow Geophysics