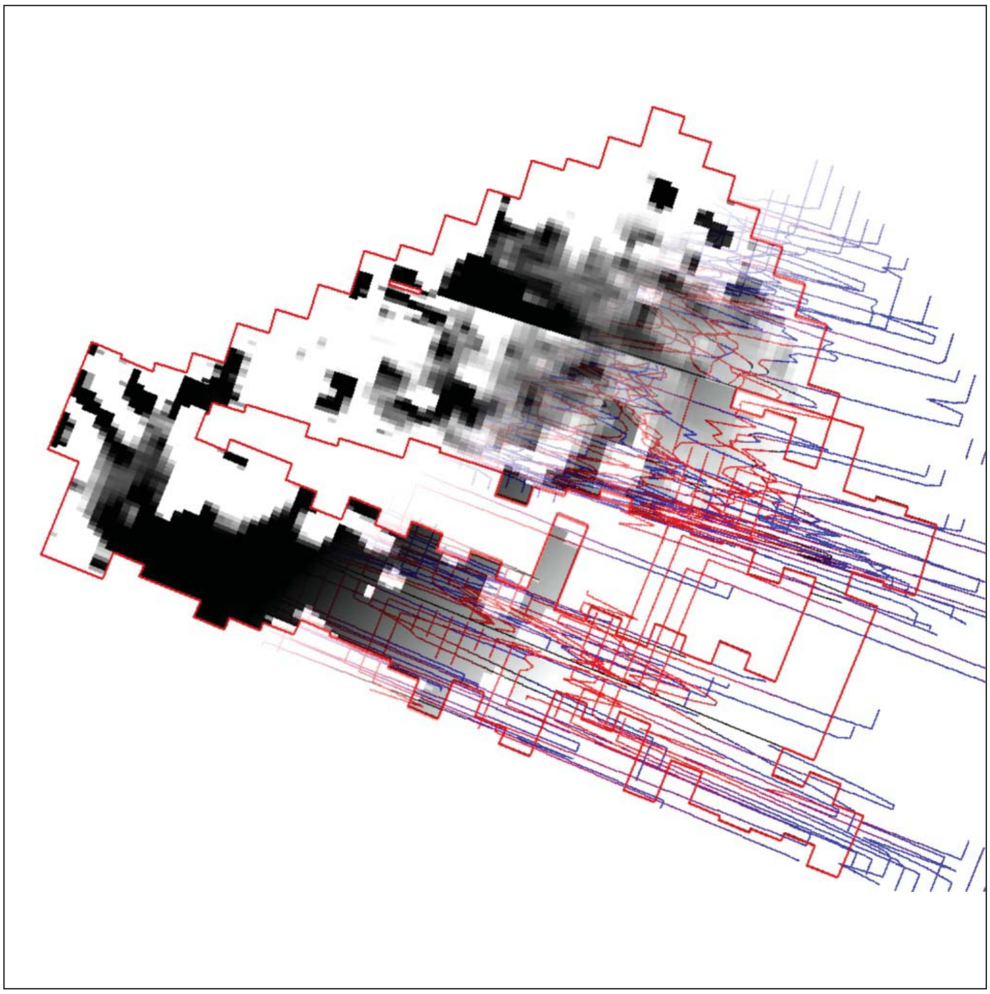
making sense of heritage

RNLI station, Selsey
West Sussex

Detailed Gradiometer Survey Report



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geoservices

RNLI Station, Selsey, West Sussex

Detailed Gradiometer Survey Report

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* I = Internal Draft; E = External Draft; F = Final

RNLI Station, Selsey, West Sussex

Detailed Gradiometer Survey Report

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Summary

A detailed gradiometer survey was conducted over land at RNLI Station, Selsey, West Sussex. The project was commissioned by Ramboll UK with the aim of establishing the presence, or otherwise, and nature of detectable archaeological features on the Site ahead of a proposed development.

The Site comprises a boatyard and adjacent tarmac driveway divided by buildings, approximately 770m east of the centre of Selsey and 5.1 km southwest of Pagham. The Site lies at approximately 3m above Ordnance datum (aOD) and occupies an area of relatively flat land with a very shallow gradient which slopes to the north-west. Gradiometer and Ground Penetrating Radar (GPR) surveys were undertaken over all accessible parts of the Site. The GPR survey was successful in identifying anomalies of probable and possible archaeological interest, along with other anomalies and responses of uncertain origin.

The gradiometer survey did not return useful results, given the context of the Site. Widespread magnetic disturbance is visible throughout the dataset, most likely associated with the creation of the buildings and boatyard. No discernible anomalies of possible archaeological interest were able to be identified.

The GPR survey successfully located the foundations of a probable structure, showing rectilinear footings and a perpendicular continuation at approximately 400mm below the present ground level. An amorphous anomaly at the same depth is consistent with the remnants of a buried surface.

RNLI Station, Selsey, West Sussex

Detailed Gradiometer Survey Report

Acknowledgements

The detailed gradiometer survey was commissioned by Ramboll UK. and the assistance of Caroline Russell and the crew of RNLI Selsey are gratefully acknowledged in this regard.

The fieldwork was directed by Rachel Chester. Jen Smith processed and interpreted the geophysical data. Rachel Chester and Jen Smith wrote this report. The geophysical work was quality controlled by Dr. Paul Baggaley. Illustrations were prepared by Karen Nichols. The project was managed on behalf of Wessex Archaeology by Dr Paul Baggaley.

RNLI Station, Selsey, West Sussex

Detailed Gradiometer Survey Report

1 INTRODUCTION

1.1 Project background

1.1.1 Wessex Archaeology was commissioned by Ramboll UK to carry out a geophysical survey on land at RNLI Station, Selsey, West Sussex (**Figure 1**), hereafter "the Site" (centred on NGR 486184 92781). The survey forms part of an ongoing programme of archaeological works being undertaken ahead of proposed development at the Site.

1.1.2 An archaeological Desk-Based Assessment (DBA, Ramboll 2014) describes the majority of the archaeological and historical baseline for the Site and will be summarised with reference to the geophysical interpretation where appropriate.

1.1.3 The aim of the geophysical survey was to establish the presence/absence, extent and character of detectable archaeological remains within the survey area.

1.1.4 This report presents a brief description of the methodology followed, the detailed survey results and the archaeological interpretation of the geophysical data.

1.2 The Site

1.2.1 The Site lies on the coastline of Selsey some 770m to the east of the centre of Selsey, 5.1 km south-west of Pagham (**Figure 1**). It comprises two areas; a tarmac driveway and an adjacent grass field which is being used to house boats. Geophysical survey was undertaken over all accessible parts of the Site, a total of c. 0.11 ha.

1.2.2 The Site occupies an area of relatively flat land with a very shallow slope increasing to the north-west away from the coastline. The land lies at a height of approximately 3m above the Ordnance datum (aOD). The survey extents are defined by a surrounding metal fence for the northern area, as well as numerous boatyard buildings to the south-west and Kingsway road to the north.

1.2.3 The soils underlying the Site are unsurveyed as this area is mostly urbanised (Soil Survey of England and Wales, 1983). The bedrock geology is predominantly the Selsey Sand Formation consisting of sand, silt and clay with superficial deposits of undifferentiated river terrace deposits (BGS, 2014).

1.2.4 The Site and its surrounding area has had numerous recorded Historic Environment Records (HER). The DBA (Ramboll 2014) declared the area to have high potential to contain buried archaeological remains associated with a possible Roman Villa as a result of the numerous Roman sites that are in the vicinity. Key finds include a pot of Roman coins dating from AD 220 to 270, Roman pins found 160m west of the Site and Roman pottery located 75m to the southwest.

1.2.5 There is a low to moderate archaeological potential for below the ground deposits of prehistoric date due to items that have been exposed by coastal erosion such as flints and mammoth bone. There is low potential for post-Roman periods (Ramboll 2014).

2 METHODOLOGY

2.1 Introduction

2.1.1 The gradiometer survey was undertaken by Wessex Archaeology's in-house geophysics team on 14th April 2014. The boatyard was still housing boats during the time of the survey due to the inability to remove them completely offsite. The survey was conducted in accordance with English Heritage guidelines (2008).

2.1.2 The Ground Penetrating Radar (GPR) survey was directed by Wessex Archaeology's in-house geophysics team on 14th April 2014.

2.1.3 The GPR survey was considered to be the most suitable technique for establishing the presence or absence of remains associated with the previous phases of buildings at the Site. However, gradiometer survey was conducted to provide an additional dataset, despite the likelihood that the technique would not prove to be informative due to high magnetic disturbance.

2.2 Method

2.2.1 Individual survey grid nodes were established at 20m x 20m intervals using a Leica Viva RTK GNSS instrument, which is precise to approximately 0.02m and therefore exceeds English Heritage recommendations (2008).

2.2.2 The gradiometer survey was conducted using a Bartington Grad601-2 fluxgate gradiometer instrument, which has a vertical separation of 1m between sensors. Data were collected at 0.25m intervals along transects spaced 1m apart with an effective sensitivity of 0.03nT, in accordance with EH guidelines (2008). Data were collected in the zigzag method.

2.2.3 Data from the survey was subject to minimal data correction processes. These comprise a zero mean traverse function (±5nT thresholds) applied to correct for any variation between the two Bartington sensors used, and a de-step function to account for variations in traverse position due to varying ground cover and topography. These two steps were applied to all survey areas, with no interpolation applied.

2.2.4 The GPR survey was conducted using a cart-mounted MALA GeoScience system consisting principally of a 500 MHz shielded antenna, CUII control unit and XV11 monitor. Data were collected at 0.02m intervals along profiles spaced 0.5m apart (**Figure 4**).

2.2.5 The time window for reflector measurement was set to 75.1ns, which corresponds to a potential penetration depth of approximately 3m at a radar wave propagation velocity of 8.0 cm/ns[a]. Because of signal attenuation and scattering due to conductive and heterogeneous subsurface conditions, practical penetration depth is often significantly less that this theoretical maximum.

2.2.6 Data from the GPR survey were subject to standard processing, including gain and wobble correction, before being sliced and regridded to produce 3D timeslices of the dataset. These are effectively horizontal groupings of data of equal depth, as determined by the two way travel time and the effective velocity of the radar pulse through the ground.

2.2.7 The advantage of GPR depth slices is that the *spatial* relationship of individual features can be appreciated in plan view.

2.2.8 Further details of the geophysical and survey equipment, methods and processing are described in **Appendix 1**.

3 GEOPHYSICAL SURVEY RESULTS AND INTERPRETATION

3.1 Introduction

3.1.1 Gradiometer results are presented as a series of greyscale and XY plots, and archaeological interpretations, at a scale of 1:500 (**Figure 2 and 3**). The data is displayed at -40nT (white) to +60nT (black) for the greyscale image and ±100nT at 50nT per cm for the XY trace plots.

3.1.2 The Ground Penetrating Radar (GPR) results are presented as a series of depthslices and archaeological interpretations at a scale of 1:250 (**Figure 6**). Radar reflectance of the dataset has been graded from low (black) to high (yellow). Amplitude thresholding has been applied to enhance feature interpretability (**Figure 5**).

3.1.3 The interpretation of the gradiometer datasets did not highlight the presence of any potential archaeological anomalies, burnt or fired objects, nor magnetic trends. However; the interpretation of the GPR datasets highlights the presence of potential archaeological anomalies and trends. Full definitions of the interpretation terms used in this report are provided in **Appendix 2**.

3.1.4 Extensive ferrous anomalies are visible throughout the detailed gradiometer survey dataset. These are presumed to be modern in provenance and are not referred to, unless considered relevant to the archaeological interpretation.

3.2 Gradiometer Survey Results and Interpretation

3.2.1 Only ferrous anomalies can be seen within the dataset and all are most likely to be modern in origin (**Figure 3**). No other features or anomalies are detectable due to the nature of the Site as a boatyard that is located in a relatively urbanised area. The driveway area is most likely to be reinforced concrete, with the northern area surrounded by a chain-link fence; both would have caused high magnetic responses.

3.2.2 On the day of the survey the boats that were being housed to the north of the Site were unable to be sufficiently moved and so were still within several meters of the sensitive survey equipment when the survey was being conducted. This means that the boats were still detectable and caused high magnetic halos, which are seen within the dataset. The extent of magnetic disturbance associated with the boatyard and the frequency of small and large-scale ferrous anomalies have significantly reduced the area in which it is possible to detect any archaeological features.

3.3 Ground Penetrating Radar Survey Results and Interpretation

3.3.1 Effective ground penetration at this Site was obtained to a maximum depth of approximately 1m below surface. This poor signal penetration is attributed to a significant proportion of clay within the Selsey Sand Formation and overlying river terrace deposits that have been mapped at this location (BGS, 2014). The Site’s close proximity to the sea may also have increased the salinity of the shallow subsurface, from approximately 1m below surface downwards, resulting in reduced signal penetration below this depth.

3.3.2 Two shallow anomalies of archaeological potential were identified from the GPR data (**Figure 6**): a shallow footing and an amorphous area.

3.3.3 A possible shallow footing was interpreted at a depth of approximately 400mm below present ground level within the boatyard. This interpreted footing lacks substantial depth extent (200mm), and is therefore unlikely to have supported a heavy superstructure.

3.3.4 The other anomaly of archaeological potential was located in the same area and depth and may, being amorphous in plan, represent the remains of a former living surface, or alternatively a shallow geological interface.

3.3.5 A putative Roman Villa is believed to extend within the survey area (Heron-Allen 1933, 153) and the possible association of these two anomalies could indicate its remains. The Roman Villa was described as extending from 'Pagham Harbour to where the Lifeboat slip ekes out'. However due to the small size of the survey area and the ambiguity of the dataset, these footings and associated surface may be associated with a post-Roman structure.

3.3.6 A series of modern services (**Figure 6**) were identified across the survey area. A service trench running approximately north-south was identified in the southern portion of the boatyard with no clearly identifiable extension further north.

3.3.7 Several linear anomalies (**Figure 6**) beneath the tarmac roadway are interpreted as service trenches. These anomalies correlate with iron gratings present on the tarmac surface.

4 CONCLUSION

4.1.1 The geophysical surveys have been successful in identifying anomalies of probable and possible archaeological interest, along with regions of variation that might prove to be of some interest.

4.1.2 The results of the gradiometer survey did not produce a particularly edifying dataset, demonstrating that widespread magnetic disturbance has effectively masked any weaker anomalies, such as those associated with archaeological remains.

4.1.3 In despite of the limited ground penetration of the Ground Penetrating Radar (GPR) survey due to the conductive subsurface conditions, the survey was successful in detecting elements of an earlier structure, particularly with both anomalies of archaeological potential being identified at the same depth of approximately 400mm. These features may be associated with the aforementioned Roman Villa, but due to the ambiguity of the results it is possible that they may also be associated with other structures, modern or otherwise.

4.1.4 Whilst the GPR survey has provided an estimate of the depth extent to be 200mm for the anomalies identified in the datasets, it should be emphasised that these approximations have not yet been tested. It is likely that the approximations could be refined given further information through invasive work, such as determining the depth of buried and extents of the remnant foundations.

4.1.5 A series of modern services run through the survey area. The tarmacked driveway contains the majority of these services and they run near-parallel with the current buildings. A single service is located within the boatyard which runs perpendicular to the other services.

4.1.6 It should be noted that small, weakly magnetised features may produce responses that are below the detection threshold of magnetometers. It may therefore be the case that more archaeological features may be encountered than have been identified through geophysical survey.

5 REFERENCES

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APPENDIX 1: SURVEY EQUIPMENT AND DATA PROCESSING

Survey Methods and Equipment - Gradiometer

The magnetic data for this project was acquired using a Bartington 601-2 dual magnetic gradiometer system. This instrument has two sensor assemblies fixed horizontally 1m apart allowing two traverses to be recorded simultaneously. Each sensor contains two fluxgate magnetometers arranged vertically with a 1m separation, and measures the difference between the vertical components of the total magnetic field within each sensor array. This arrangement of magnetometers suppresses any diurnal or low frequency effects.

The gradiometers have an effective resolution of 0.03nT over a ±100nT range, and measurements from each sensor are logged at intervals of 0.25m. All of the data are stored on an integrated data logger for subsequent post-processing and analysis.

Wessex Archaeology undertakes two types of magnetic surveys: scanning and detail. Both types depend upon the establishment of an accurate 20m or 30m site grid, which is achieved using a Leica Viva RTK GNSS instrument and then extended using tapes. The Leica Viva system receives corrections from a network of reference stations operated by the Ordnance Survey and Leica Geosystems, allowing positions to be determined with a precision of 0.02m in real-time and therefore exceed the level of accuracy recommended by English Heritage (2008) for geophysical surveys.

Scanning surveys consist of recording data at 0.25m intervals along transects spaced 10m apart, acquiring a minimum of 80 data points per transect. Due to the relatively coarse transect interval, scanning surveys should only be expected to detect extended regions of archaeological anomalies, when there is a greater likelihood of distinguishing such responses from the background magnetic field.

The detailed surveys consist of 20m x 20m or 30m x 30m grids, and data are collected at 0.25m intervals along traverses spaced 1m apart. These strategies give 1600 or 3600 measurements per 20m or 30m grid respectively, and are the recommended methodologies for archaeological surveys of this type (EH, 2008).

Data may be collected with a higher sample density where complex archaeological anomalies are encountered, to aid the detection and characterisation of small and ephemeral features. Data may be collected at up to 0.125m intervals along traverses spaced up to 0.25m apart, resulting in a maximum of 28800 readings per 30m grid, exceeding that recommended by English Heritage (2008) for characterisation surveys.

Post-Processing

The magnetic data collected during the detail survey are downloaded from the Bartington system for processing and analysis using both commercial and in-house software. This software allows for both the data and the images to be processed in order to enhance the results for analysis; however, it should be noted that minimal data processing is conducted so as not to distort the anomalies.

As the scanning data are not as closely distributed as with detailed survey, they are georeferenced using the GPS information and interpolated to highlight similar anomalies in adjacent transects. Directional trends may be removed before interpolation to produce more easily understood images.

Typical data and image processing steps may include:

- Destripe – Applying a zero mean traverse in order to remove differences caused by directional effects inherent in the magnetometer;
- Destagger – Shifting each traverse longitudinally by a number of readings. This corrects for operator errors and is used to enhance linear features;
- Despike – Filtering isolated data points that exceed the mean by a specified amount to reduce the appearance of dominant anomalous readings (generally only used for earth resistance data)

Typical displays of the data used during processing and analysis:

- XY Plot – Presents the data as a trace or graph line for each traverse. Each traverse is displaced down the image to produce a stacked profile effect. This type of image is useful as it shows the full range of individual anomalies.
- Greyscale – Presents the data in plan view using a greyscale to indicate the relative strength of the signal at each measurement point. These plots can be produced in colour to highlight certain features but generally greyscale plots are used during analysis of the data.

Survey Methods and Equipment - GPR

The ground penetrating radar (GPR) data were collected using a cart-mounted MALA GeoScience system consisting principally of a 500 MHz shielded antenna, CUII control unit and XV11 monitor. This configuration consists of the antenna in a plastic tray between the three wheels of the cart, one of which has an odometer attached to measure distance travelled. The combined viewer and datalogger unit is affixed to the top of the handle, and the GPR control unit and batteries are coupled up between the antenna and datalogger.

The depth of penetration of GPR systems is determined by the central frequency of the antenna and the relative dielectric permittivities (RDP) of the material through which the GPR signal passes. In general, soils in floodplain settings may have a wide range of RDPs, although around 8 may be considered average, resulting in a maximum depth of penetration *c*. 2.5m with the GPR signal having a velocity of approximately 0.1m/ns.

The GPR beam is conical in shape, however, and whilst most of the energy is concentrated in the centre of the cone, the GPR signal illuminates a horizontal footprint which becomes wider with increasing depth. At the maximum depth of the antenna, it becomes impossible to resolve any feature smaller than the horizontal footprint for the corresponding depth. The size of the footprint is dependent upon central frequency, and its size increases as the central frequency decreases.

The vertical resolution is similarly dependent upon the central frequency; for the 500MHz antenna, features of the order of 0.05m may be resolved vertically. Antennae with lower frequencies can therefore penetrate more deeply but are less resolute in both horizontal and vertical directions. Choice of antenna frequency is guided largely by the anticipated depth to the target and the required resolution.

Given the restrictions of the survey area, data were collected along traverses of varying length separated by 0.5m. The data sampling resolution is governed by the datalogger and in this case, traces were collected c. 0.02m apart along the traverses and over a 75ns time window.

Post-Processing

The radar data collected during the detail survey are downloaded from the GPR system for processing and analysis using both commercial and in-house software. This software allows for both the data and the images to be processed in order to enhance the results for analysis; however, it should be noted that minimal data processing is conducted so as not to distort the anomalies.

Typical data and image processing steps may include:

- Destripe – Applying a zero mean traverse in order to remove differences caused by directional effects inherent in the gradiometer;
- Destagger – Shifting each gradiometer traverse forward or backward by a number of readings. This corrects for operator errors and is used to enhance linear features;
- Despike – Filtering isolated data points that exceed the mean by a specified amount to reduce the appearance of dominant anomalous readings (generally only used for earth resistance data);
- Gain – Amplifies GPR data based upon its position in the profile, which boosts the contrast between anomalies and background;
- Bandpass – Removes GPR data lying outside a specified range, which removes high- and low-frequency noise.

Typical displays of the data used during processing and analysis:

- Depth Slices – Presents the data in slices of depth using a colour scale to indicate the relative strength of the signal at each measurement point. Radar reflectance in these images grades from low (black) to high (yellow).

APPENDIX 2: GEOPHYSICAL INTERPRETATION

The interpretation methodology used by Wessex Archaeology separates the anomalies into two main categories: archaeological and unidentified responses.

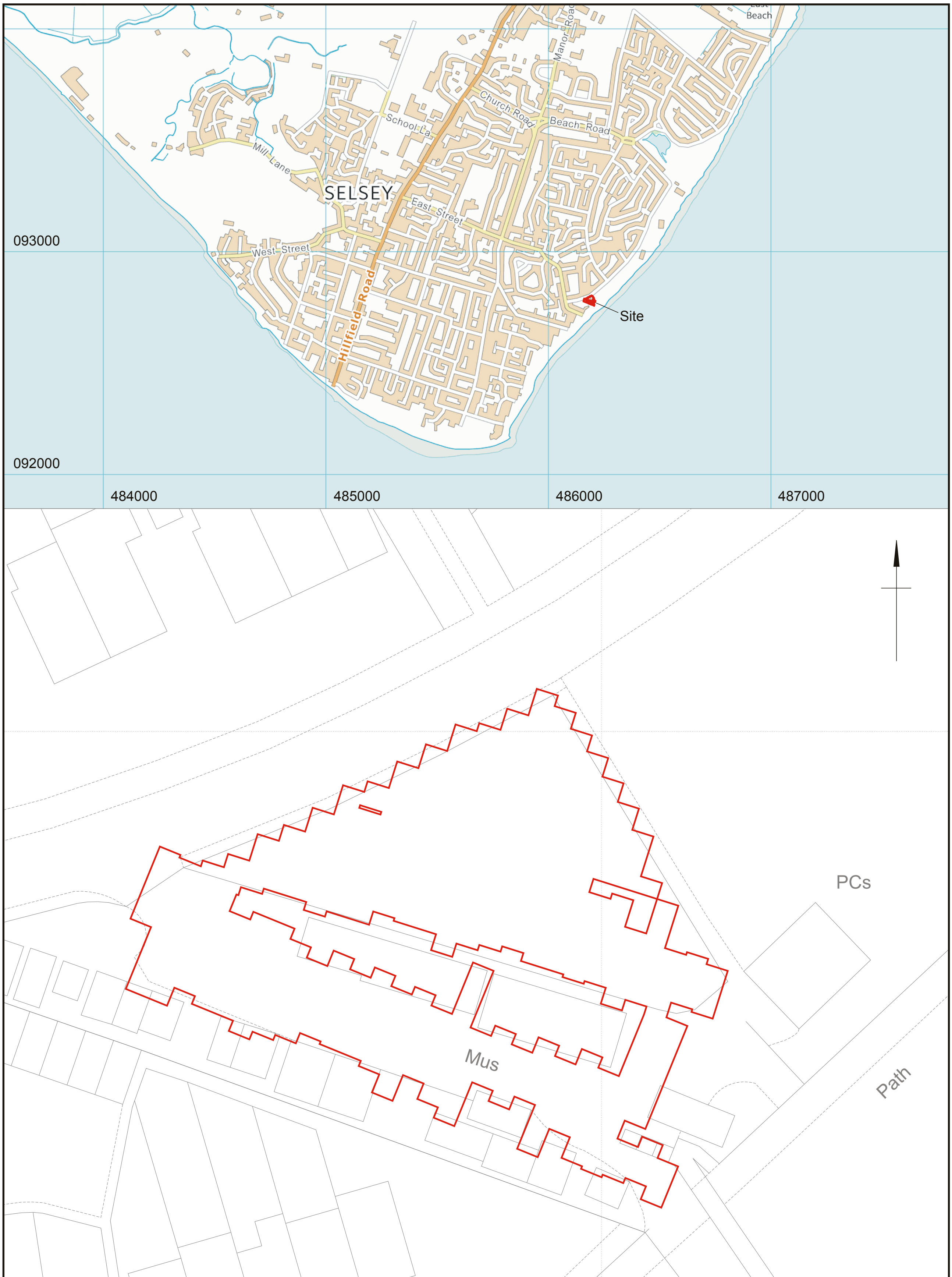
The archaeological category is used for features when the form, nature and pattern of the anomaly are indicative of archaeological material. Further sources of information such as aerial photographs may also have been incorporated in providing the final interpretation. This category is further sub-divided into three groups, implying a decreasing level of confidence:

- Archaeology – used when there is a clear geophysical response and anthropogenic pattern.
- Probable archaeology – used for features which give a clear response but which form incomplete patterns.
- Possible archaeology – used for features which give a response but which form no discernible pattern or trend.

The unidentified category is used for features when the form, nature and pattern of the anomaly are not sufficient to warrant a classification as an archaeological feature. This category is further sub-divided into:

- Increased magnetic response – used for areas dominated by indistinct anomalies which may have some archaeological potential.
- Trend – used for low amplitude or indistinct linear anomalies.
- Ferrous – used for responses caused by ferrous material. These anomalies are likely to be of modern origin.

Finally, services such as water pipes are marked where they have been identified.



Survey Area

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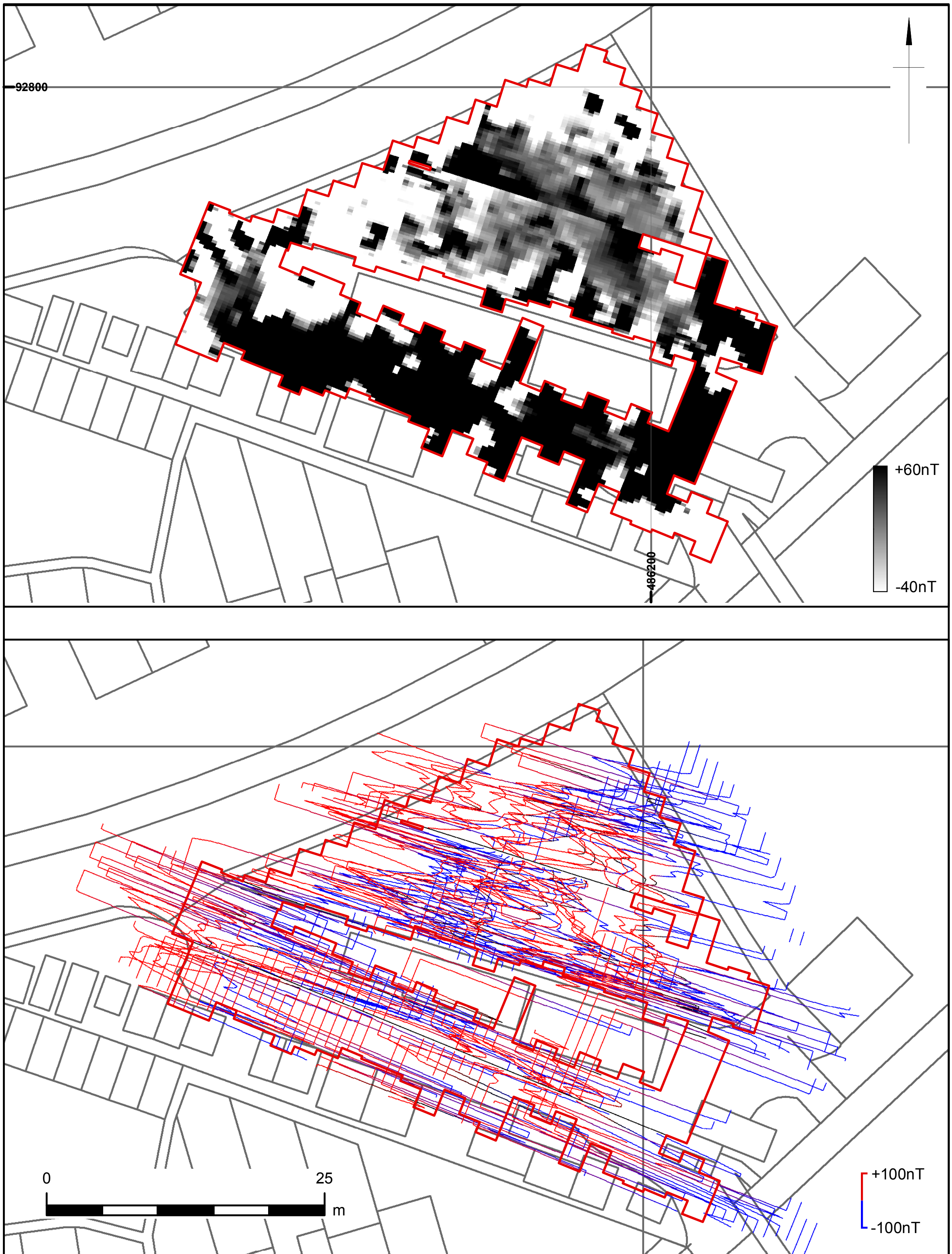
Site location

Figure 1



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Gradiometer, Greyscale plot and XY trace

Figure 2

Gradiometer Survey Extents

Ferrous

0 25 m

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Gradiometer, Interpretation

Figure 3

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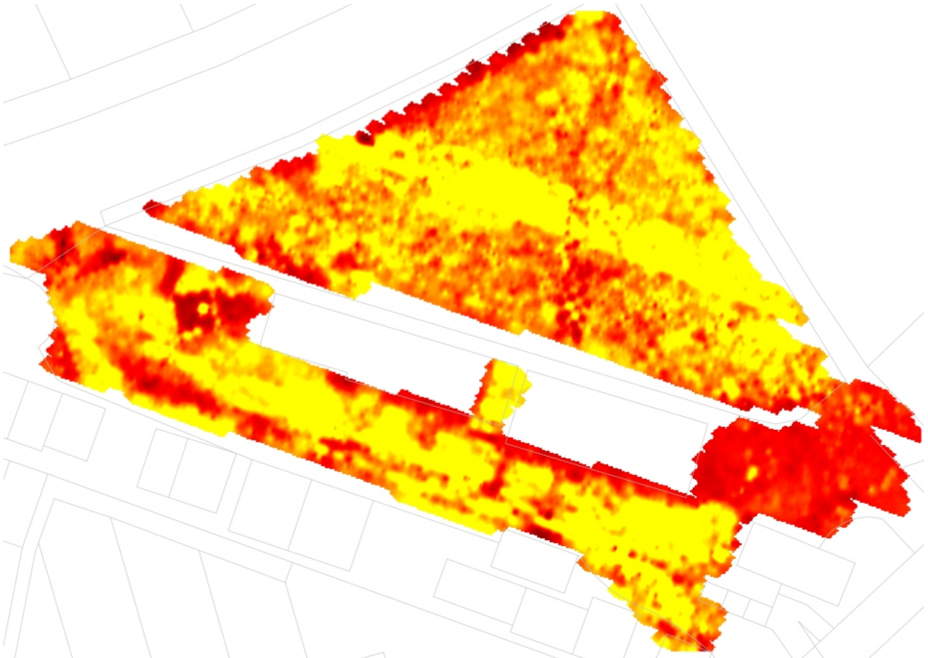
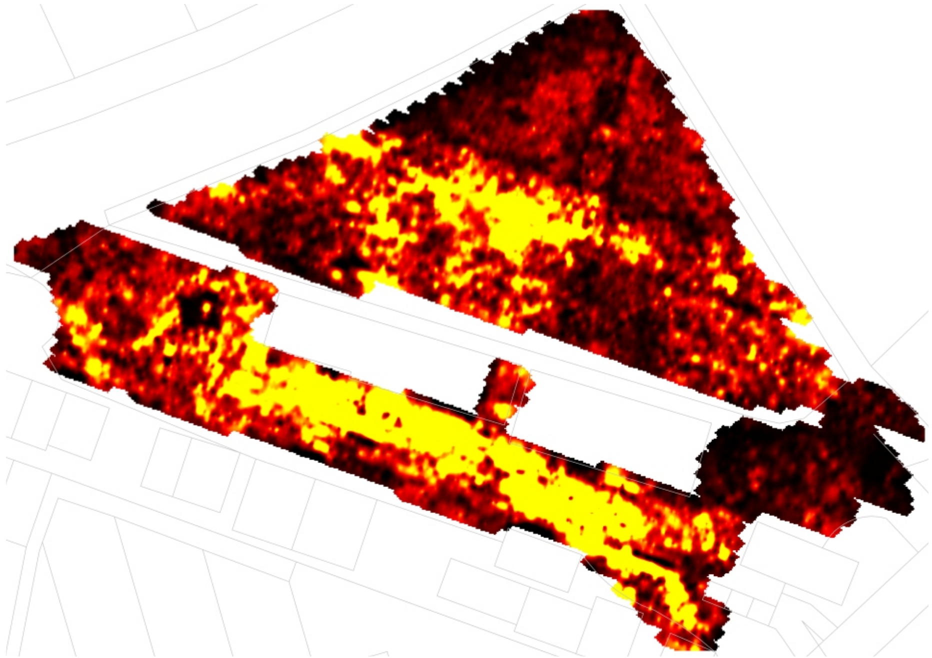
Ground Penetrating Radar Survey

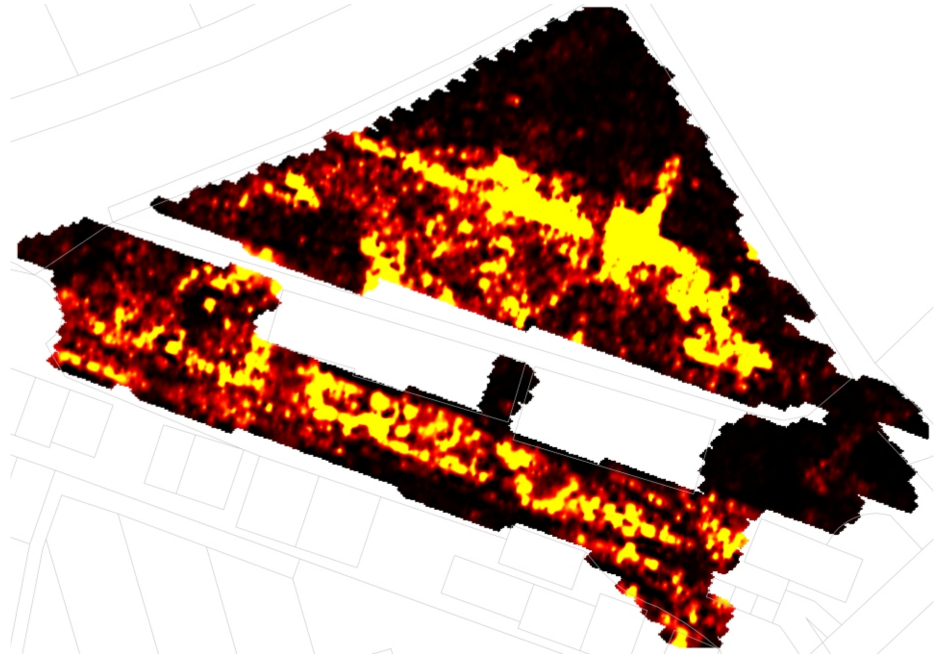
Figure 4



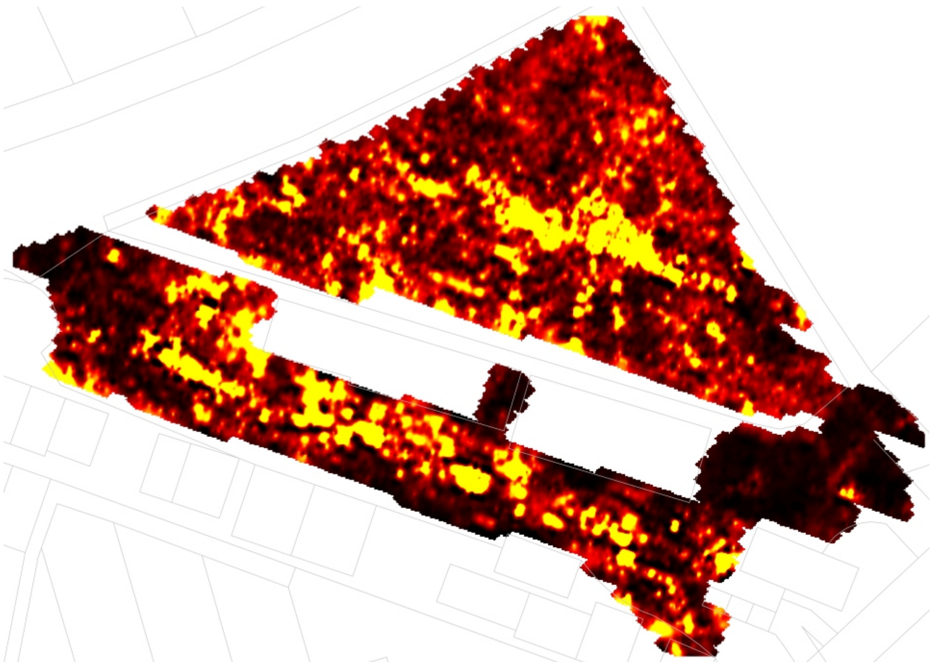
A: Depth slice from surface to 200 mm



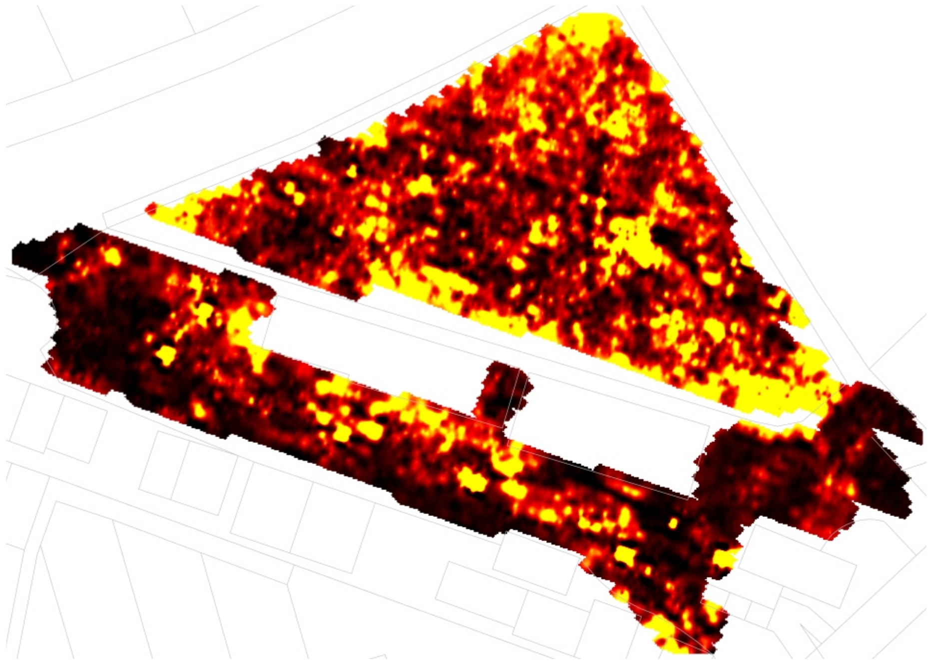
B: Depth slice from 200 mm to 400 mm



C: Depth slice from 400 mm to 600 mm



D: Depth slice from 600 mm to 800 mm



E: Depth slice from 800 mm to 1000 mm

0 10 20 m

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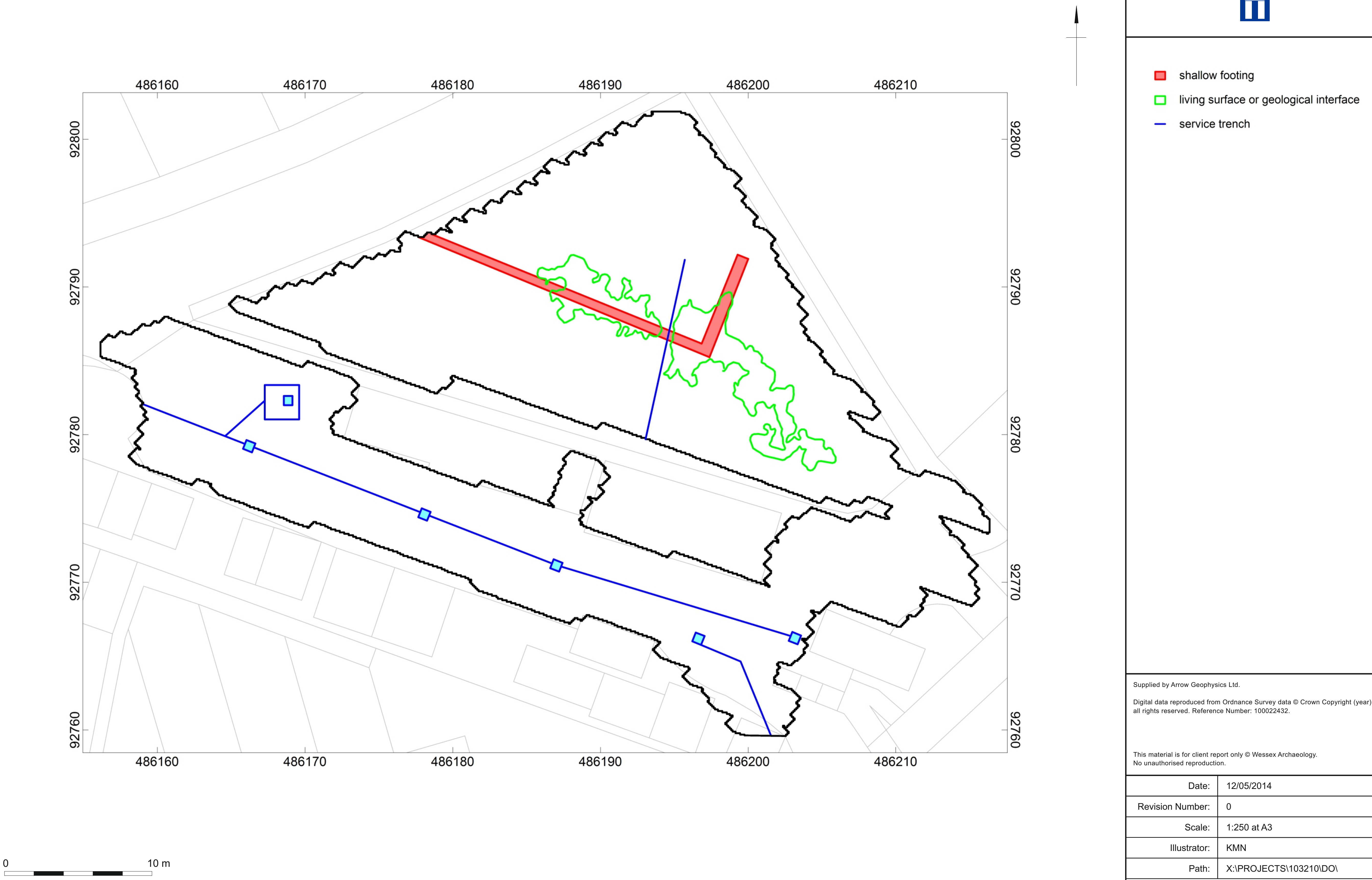

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Ground Penetrating Radar Interpretation

Figure 6

salisbury rochester sheffield edinburgh

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