Archaeology South-East

ASE

Earth Resistance Survey at Dominican Friary Ruins, Arundel, West Sussex

NGR 501983 107080
(TQ 01983 07080)

ASE Project No: 4362

Sitecode: DFA 11
ASE Report No: 2011175
OASIS ID: archaeol6-105429

John Cook BSc (Hons) AIfA

with Simon Stevens MA MIfA

July 2011

Geophysics Surveys at Dominican Friary Ruins Arundel, West Sussex

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Abstract

Archaeology South East was commissioned by Alistair Hunt Architect and Conservation Consultants, on behalf of their client, Angmering Park Estate Trust, to undertake an earth resistance survey and ground penetrating radar (GPR) survey at Arundel Friary, Mill Road, Arundel. The Earth Resistance survey area consisted of approximately 600m^2 of land covered with short grass within an overall survey area of approximately 2,500m^2.

The survey aimed to identify anomalies potentially relating to the Dominican Friary Ruins.

Both the GPR survey undertaken by Arrow Geophysics and the earth resistance survey successfully identified evidence for archaeological remains, although this evidence was limited to areas with associated surviving above ground structural remains. Both surveys also indicated disturbance across the site relating to the construction of buildings, roads and footpaths that limit the effectiveness of geophysical survey techniques.

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1.0 INTRODUCTION

1.1 Site Background

1.1.1 Archaeology South-East was commissioned by Alistair Hunt Architect and Conservation Consultants, on behalf of their client, Angmering Park Estate Trust to undertake a resistivity survey and ground penetrating radar (GPR survey) at Dominican Friary Ruins, Arundel henceforth referred to as 'the site' (NGR TQ 01983 07080; Figure 1). The area surveyed consisted of a level area of approximately 600m^2 of short grass to the north of Mill Road (Figure 2).

1.2 Geology and Topography

1.2.1 According to the British Geological Survey (BGS 2011) the geology consists of Raised Marine Deposits – clay, silt, sand and gravel (shingle) over Spetisbury Chalk Member – firm white chalk with regular large flint seams.

1.2.2 The site was bounded to the south by footpaths along Mill Road, on the east by the castle entrance buildings, to the north by a club house and to the west by public toilets and a post office building. Several trees were located within the survey area as well as ruin walls.

1.2.3 A pathway from the club house to Mill Road also ran through the survey area.

1.3 Aims of Geophysical Investigation

1.3.1 The aim of project was to carry a detailed archaeological geophysical survey of the site and produce an interpretative report on the potential of the site for archaeological remains. The site specific objective was to answer the following question,

- Are there any features potentially relating to the Dominican Friary ruins.

1.4 Scope of Report

1.4.1 This report details the findings of the surveys with a view to contributing to the overall and ongoing assessment of the archaeological potential of the site. The resistivity survey was conducted by John Cook with the assistance of Chris Russel. The GPR survey was undertaken by Arrow Geophysics, whose report forms Appendix 1 of this document. The geophysical survey was project managed by Neil Griffin (fieldwork) and by Dan Swift (post-excavation).

2.0 BACKGROUND

2.1 Overview

2.1.1 Prior to the earth resistance survey, ASE had commissioned Arrow Geophysics to undertake a Ground Probing Radar (GPR) survey of the site (report included as an appendix to this report).

2.1.2 The GPR survey identified limited evidence for archaeological remains. Evidence for archaeological features included two sets of footings within the south range, one of which appears to be a previously unrecorded dividing wall. Three further anomalies have been identified as potential footings from the north range of the Friary.

3.0 SURVEY METHODOLOGY

3.1 Summary of Methodology

3.1.1 Using a 30m x 30m grid, a RM15 resistance meter attached to a PA1 twin probe frame with 0.5m probe separation was used to record sample readings at every 0.5m along 1.0m traverses.

3.2 Geophysical Survey Methods Used

3.2.1 The area covered by the resistivity survey is shown Figure 2.

3.2.2 The survey grid consisted of a 30 x 30 metre grid. The grid was surveyed with 1.0m traverses and samples were taken every 0.5m. The survey was undertaken over the course of one day with sunshine and showers, following a prolonged period of dry weather.

3.3 Applied Geophysical Instrumentation

3.3.1 The resistance survey was carried out using a twin probe array fitted with a Geoscan RM15 data logger. The twin probe array is popular within archaeology and combines convenience with ease of use. The two probes of the array had 0.5m spacing and were connected to two remote probes placed at least thirty times this distance from the array (15m). This is done to lessen the effect on the results of probe separation and to improve depth penetration (Clark 1996: 44). The penetration of the survey is dependent on the probe spacing, usually reaching a depth relative to half the probe space, in this case 0.25m.

3.3.2 The resistance survey uses an electric current to measure the relative water content of buried features. Features such as pits and ditches contain looser material than the surrounding geology and have an enhanced water-bearing capacity, allowing the current to pass through them more freely. These are measured as low resistance anomalies on the results. Stone and brick wall foundations prove a barrier to the electrical current and are shown as higher resistance anomalies (Gaffney & Gater 2003: 26). Resistance survey relies on detecting differences in water content between archaeological features and the surrounding geology and are ineffective in waterlogged or highly arid conditions. The SI unit of measurement for resistance is ohms.

3.4 Instrumentation Used for Setting out the Survey Grid

3.4.1 It is vitally important for the survey grid to be accurately set out. The English Heritage guidelines (David 1995) state that no one corner of any given survey grid square should have more than a few centimetres of error. The survey grid for the site was set out using a Leica TCRA 1205 total station. The grid points were then geo-referenced using a Leica System 1200 Differential Global Positioning System (DGPS). The GPS base station collects satellite position to determine its position. This data is processed in survey specific software to provide a sub centimetre Ordnance Survey position and height for the base station. The survey grid is then tied in to this known accurate position by using a roving satellite receiver that has its position corrected by the static base station. Each surveyed grid point has an Ordnance Survey position; therefore the geophysical survey can be directly referenced to the Ordnance Survey National Grid.

3.5 Data Processing

3.5.1 The resistance data was processed using Geoplot V3. The first step was to perform a DESPIKE to remove any spurious readings. The next step was to pass the results through a HIGH PASS FILTER which removed any low frequency spatial data and then a LOW PASS FILTER was applied, removing high frequency spatial data and enhancing larger weak features. The data was then INTERPOLATED in both the X and Y axes, improving the data presentation.

3.6 Survey Limitations

3.6.1 Several trees, significant paved areas, a hedge and Mill Road all formed barriers to the geophysical survey. These were omitted from the survey and only areas where meaningful results could be obtained were surveyed.

3.6.2 Due to the spatial limitations of the survey area there were limited options for matching readings between remote probe moves. The data has been adjusted to account for variations in background resistance readings.

4.0 GEOPHYSICAL SURVEY RESULTS (Figures 3-5)

4.1 Introduction to Results

4.1.1 The results should be read in conjunction with the figures at the end of this report. The types of features likely to be identified are discussed below.

4.1.2 Positive Resistance Anomalies

These are areas where the current from the array has passed less easily due to relative scarcity of water content. They may relate to stone or brick foundations or rubble in an archaeological context.

4.1.3 Negative Resistance Anomalies

These are areas where the current from the array has passed more easily due to relatively high water content. Low resistance anomalies may equate to pits or ditches in an archaeological context.

4.2 Interpretation of Resistance Survey Results

4.2.1 High resistance anomalies were observed across the area surveyed. It is difficult to elucidate much from the data. However, a greater concentration of high resistance anomalies is noted within the area defined by upstanding remains in the west of the survey.

4.2.2 High Resistance Results

Significant moderately high resistance anomalies (MHR1) are observed forming a possible rectilinear feature in the north of the survey. Due to the possible undisturbed nature of this part of the survey area, this anomaly may relate to features of archaeological origin. An area bounded by upstanding remains in the north west of the survey area contains moderately high resistance area anomalies (MHR2). These area anomalies line up well with an area shown as gravelled in 1968 (Evans 1969). In addition discrete high resistance anomalies (HR1) may relate to features of archaeological origin such as floor surfaces, fallen masonry or below ground structural remains. Further discrete high resistance anomalies (HR2) are observed in an L-shape outside of the area of MHR2 that may relate to structural remains or robbed out walls. However, several of these responses may be caused by roots from the tree located within the area. A discrete high resistance anomaly (HR3) can be seen adjacent to the footpath that runs from the club house to Mill Road. This anomaly may be due to below ground remains although its proximity to the footpath may indicate a more modern cause. Several moderately high resistance anomalies (MHR3) are observed between the hedge and Mill Road. These anomalies are more likely due to modern disturbance associated with nearby services.

4.2.3 Low Resistance Results

No low resistance anomalies were observed within the survey.

5.0 CONCLUSIONS

5.0.1 The Earth resistance survey at Mill Road, Arundel has successfully revealed anomalies of possible archaeological origin. Moderately high and high resistance anomalies in the north of the survey may relate to structural footings, or robbed out features.

5.0.2 Several of the anomalies observed in the Earth resistance survey are also observed within the GPR survey (Figures 6 and 7). The GPR survey provided an indicative depth to these anomalies of 1.0m to 1.2m suggesting a significant level of overburden on the site. As carrying out a twin probe Earth resistance survey with a probe separation of 0.5m will generally only provide a practical survey depth of 0.5m it is possible that features at greater depth would not be identified within the resistance survey.

5.0.3 Both the Earth resistance survey and the GPR survey also indicate a significant level of disturbance that has probably occurred from the robbing out of structural features to the construction of several buildings and associated services as well as the construction of Mill Road itself. Therefore a considered excavation approach would be required in order to assess the survival of the Friary remains and to make a meaningful interpretation.

5.1 Statement of Indemnity

5.1.1 Geophysical survey is the collection of data that relate to subtle variations in the form and nature of soil and which relies on there being a measurable difference between buried archaeological features and the natural geology. Geophysical techniques do not specifically target archaeological features and anomalies noted in the interpretation do not necessarily relate to buried archaeological features. As a result, magnetic and earth resistance detail survey may not always detect sub-surface archaeological features. This is particularly true when considering earlier periods of human activity, for example those periods that are not characterised by sedentary social activity.

6.0 OVERVIEW by Simon Stevens

6.1 The current site has traditionally thought to be the location of the medieval hospital of the Holy Trinity, or *Maison Dieu,* founded in 1395 on the orders of Richard, earl of Arundel to care for the physical and spiritual needs of the aged and poor (Page, 1905, 97-98). However, recent research has provided compelling evidence that the site is actually that of the town's Dominican Friary, occupying a low-lying position typical of the order's urban houses (Hudson 1993).

6.2 The early thirteenth century saw the emergence of a new group of monastic orders, the mendicant friars (Platt 1995, 123), an attempt *'to return to the austere lifestyle of earlier religious groups',* with teaching and preaching as important aspects, hence the need to site the friaries near centres of population rather than in 'traditional' monastic rural isolation (Aston 2000, 96). The orders included the Dominicans (Black Friars or Friars Preacher), the Franciscans (Grey Friars or Minorites), the Carmelites (White Friars) and the Austins (Hermit Friars of St. Augustine) (Platt *op. cit.*).

6.3 The Dominican order was founded by a Spanish monk, St. Dominic in southern France, and had established a friary at Canterbury in the 1220s (Greene 1992, 167). Some of their other early establishments include London (by 1224), Northampton (1226), York (1227), Shrewsbury (1232) and Exeter (also 1232) (Aston 2000, 97). The order had arrived in Arundel by 1253, when a friary is mentioned in the will of St. Richard of Chichester (Page 1905, 93). It was the earliest Dominican foundation in Sussex, to be followed by houses at Chichester and Winchelsea (*ibid.,* Taylor 2003*)*

6.4 Further documentary references to royal visitations in 1297 and 1324, suggest that there were twenty-two and twenty brethren respectively at the Arundel establishment at those dates (*ibid.*). Despite some known modest gifts the house always appears to have been relatively poor (in keeping with the aspirations of the Dominicans), and when the friary was dissolved in 1538 the establishment was found to be inhabited by three brethren and was too poor to pay the expenses of the visiting Bishop of Dover (*ibid.).*

6.5 As noted by Greene (1992, 169), the paucity of documentary record is problematic in any study of the mendicant orders, as is the scarcity of published excavation reports, and (as at Arundel) the vulnerability of buildings to urban development (Butler 1984, 126). Clearly the scant above- and below-ground remains at Arundel fit the known relatively simple layout of friaries, with buildings laid out around a central cloister (cf. Linlithgow, a Carmelite house; Greene 1992, Fig. 77; Butler *op. cit.*). The results of the geophysical survey partially confirm the layout evident from the standing remains, especially the alignment of the buildings of the northern and western ranges, as previously seen during a small-scale excavation in the 1960s (Evans 1969).

6.6 In this formalised pattern it is expected that the church would occupy the north range, with the other ranges *'commonly consisting of separate two-storey blocks'* (Greene 1992, 171), a phenomena noted from a drawing dating from 1780 of the now mostly demolished west range (Hudson 1993, 114 and Fig. 2). The intriguing possibility that there are burials to the north of this range (Evans 1969, 70) also fits the known friary blueprint as at Linlithgow (Greene *op. cit.*). This area is now occupied by the Norfolk Centre car-park. It is also possible that benefactors could be buried within the church itself (*ibid.*). Unfortunately the geophysical survey results were not able to confirm this.

6.7 However, there are other potentially significant results from the north range, obviously the most important building at the site, reflected in its comparative grandeur. The church had a high and a low altar in 1382 (Hudson 1997, 100), but little is known of the building's history, liturgical layout or even full extent. It would undoubtedly have been relatively simple in plan with a chancel containing the high altar at the eastern end, but with adequate space for a lay audience in the nave, drawn by the friar's reputation for preaching (Greene, *op. cit.*). The frustratingly limited excavations in the 1960s showed the presence of decorated tiles (Evans 1969, 75; Fig. 2), and it is possible that the geophysics showed evidence of such a floor within the church, although it is equally likely to be tumble from the collapsed walls, located both within and also outside of the building.

6.8 Unfortunately friary ranges did not always follow the long-established monastic pattern of regulated positions for the other claustral buildings e.g. refectory to the south (Greene *op. cit.*), so the identification of the role of individual elements would be unwise on currently available evidence. The geophysics shows an internal division in the south range, but is not indicative of function.

6.9 The question of the east range is potentially difficult. The geophysics results show that it was either systematically robbed with some thoroughness or that it actually never existed. Arguably, based on sites such as Linlithgow and elsewhere (Butler *op. cit.*) there was presumably an east range to complete the enclosure of the cloister, an area needing a degree of privacy and seclusion. There is also clear evidence for the presence of the cloister-walk on the north wall of the south range. Hence it would appear, based on currently available evidence, that the range was methodically removed prior to, or during the construction of the road in the 1890s (Hudson 1993, 114).

6.10 The manual excavation of test-pits would be an appropriate and efficient method for assessing the quality and level of preservation of any such floors or other features, or for investigating the anomalies highlighted in either, or both of the surveys. A test-pit excavated within the northern part of the surveyed area might even pick up evidence of the robbed eastern range. This work would represent only the second recorded campaign of archaeological excavation at the site (cf. Evans 1969) and could add valuable extra information which might then be used in the presentation of the remains to the public.

6.11 In conclusion, although there is *'no such thing as a typical monastery'* (Coppack 1990, 12), the geophysical survey has highlighted some facets of the site which place it firmly within the tradition of Dominican houses in Britain.

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OASIS Form

OASIS ID: archaeol6-105429

Project details	
Project name	Resistivity Survey at Dominican Friary Ruins, Arundel
Short description of the project	Archaeology South East was commissioned by Alistair Hunt Architect and Conservation Consultants, on behalf of their client, Angmering Park Estate Trust, to undertake an earth resistance survey and ground penetrating radar (GPR) survey at Arundel Friary, Mill Road, Arundel. The Earth Resistance survey area consisted of approximately 600m2 of land covered with short grass within an overall survey area of approximately 3000m². The survey aimed to identify anomalies potentially relating to the Dominican Friary Ruins. Both the GPR survey undertaken by Arrow Geophysics and the Earth resistance survey successfully identified evidence for archaeological remains. Although this evidence was limited to areas with surviving above ground structural remains. Both surveys also indicated disturbance across the site relating to the construction of buildings, roads and footpaths that limit the effectiveness of geophysical survey techniques.
Project dates	Start: 15-06-2011 End: 30-06-2011
Type of project	Field evaluation
Site status	Conservation Area
Current Land use	Other 3 - Built over
Methods & techniques	'Geophysical Survey'
Development type	Not recorded
Prompt	Voluntary/self-interest
Position in the planning process	Not known / Not recorded
Solid geology	CHALK (INCLUDING RED CHALK)
Drift geology	RAISED BEACH AND MARINE DEPOSITS
Techniques	Resistivity and GPR - area
Project location	
Country	England
Site location	WEST SUSSEX ARUN ARUNDEL Dominican Friary Ruins, Arundel

Postcode	BN18 9AS
Study area	900.00 Square metres (resistivity) 2500.00 square metres (GPR)
Site coordinates	TQ 198 708 51.4230301658 -0.276769094676 51 25 22 N 000 16 36 W Point

Project creators

Name of Organisation	Archaeology South-East
Project brief originator	Consultant
Project design originator	Archaeology South-East
Project director/manager	Neil Griffin
Project supervisor	John Cook
Type of sponsor/funding body	Client

Project archives

Physical Archive Exists?	No
Digital Archive recipient	local museum
Digital Archive ID	4362
Digital Contents	'Survey'
Digital Media available	'Geophysics','Survey','Text'
Paper Archive recipient	Local Museum
Paper Archive ID	4362
Paper Media available	'Miscellaneous Material','Survey '

Project bibliography 1

Grey literature (unpublished document/manuscript)

Publication type	
Title	Earth Resistance Survey at Dominican Friary Ruins, Arundel. W Sussex
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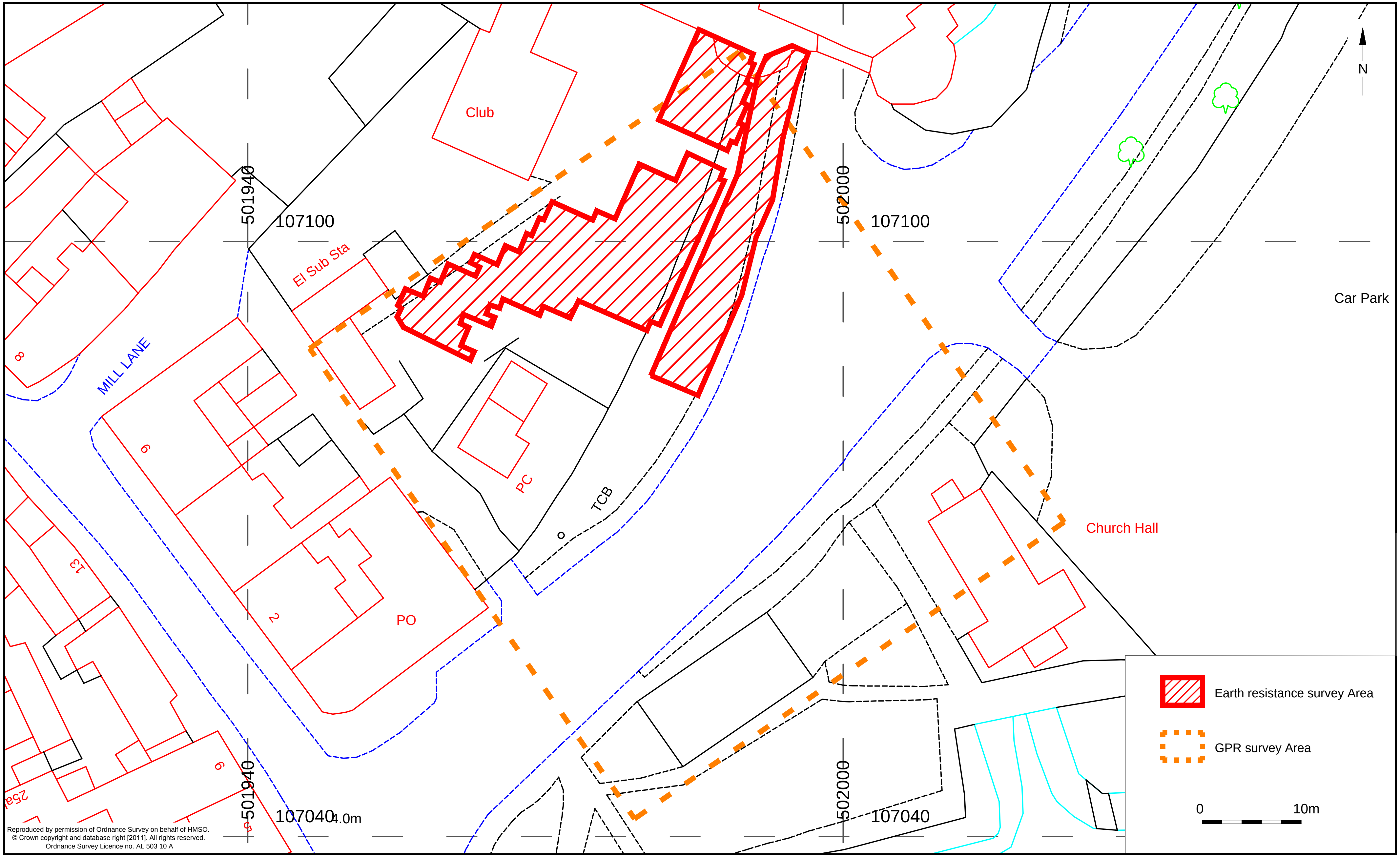
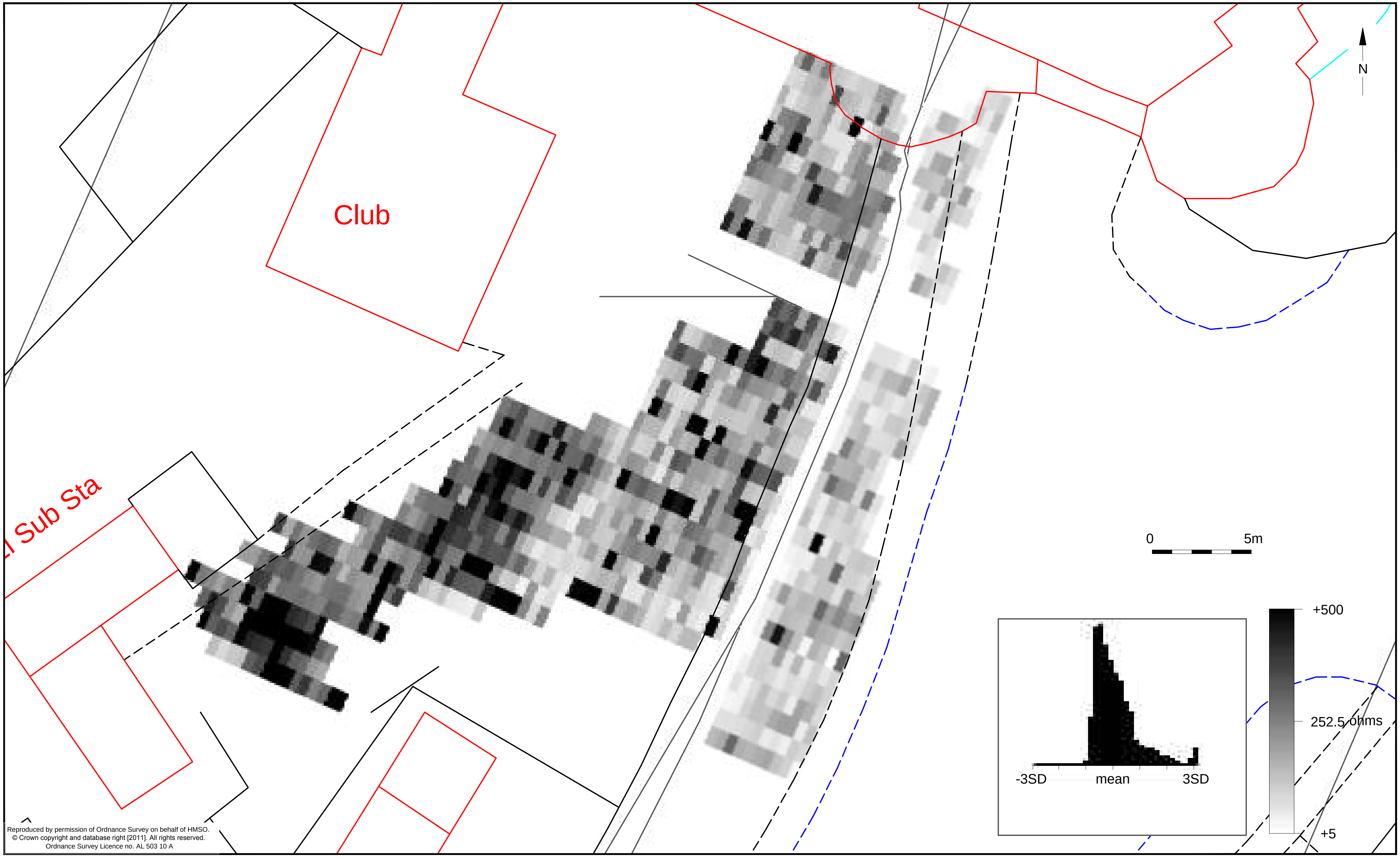
Description	grey lit bound report
Entered by	John Cook (j.cook@ucl.ac.uk)
Entered on	19 July 2011

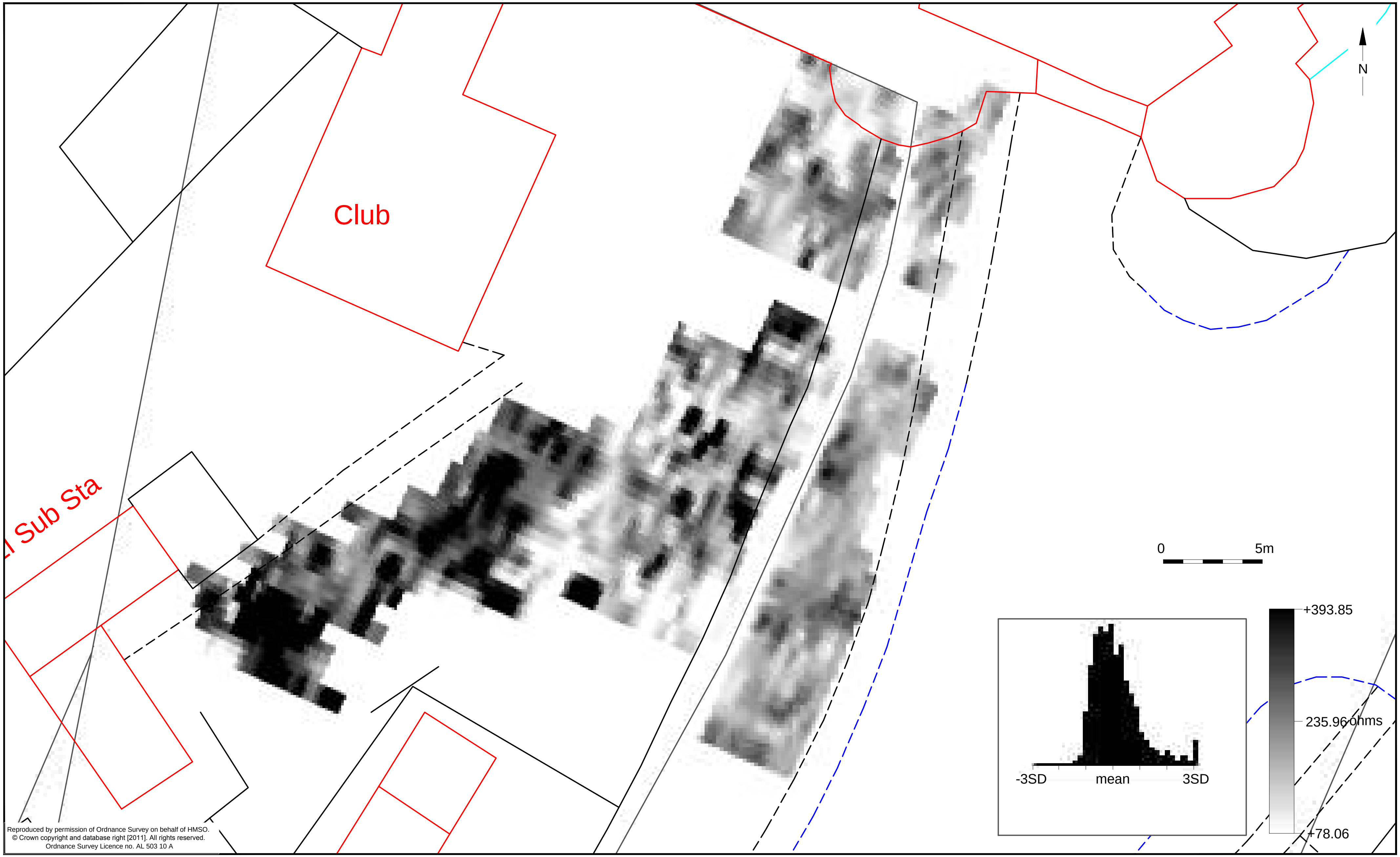
© Archaeology South-East		Dominican Friary Ruins, Arundel	Fig. 1
Project Ref: 4362	July 2011	Site location	
Report Ref: 2011175	Drawn by: JLR		



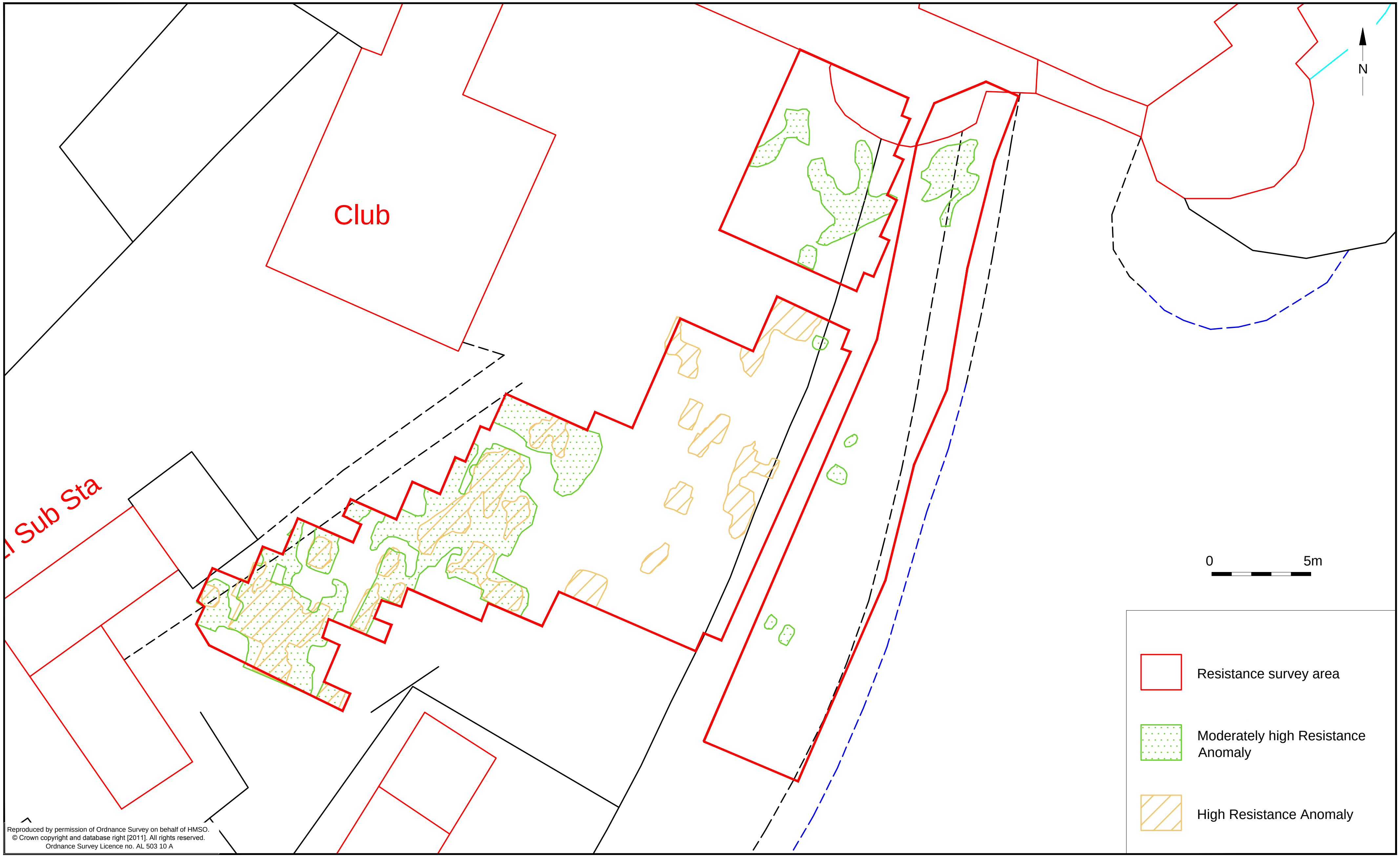
© Archaeology South-East		Dominican Friary Ruins, Arundel	Fig. 2
Project Ref: 4362	July 2011	Survey area	
Report Ref: 2011175	Drawn by: JC		



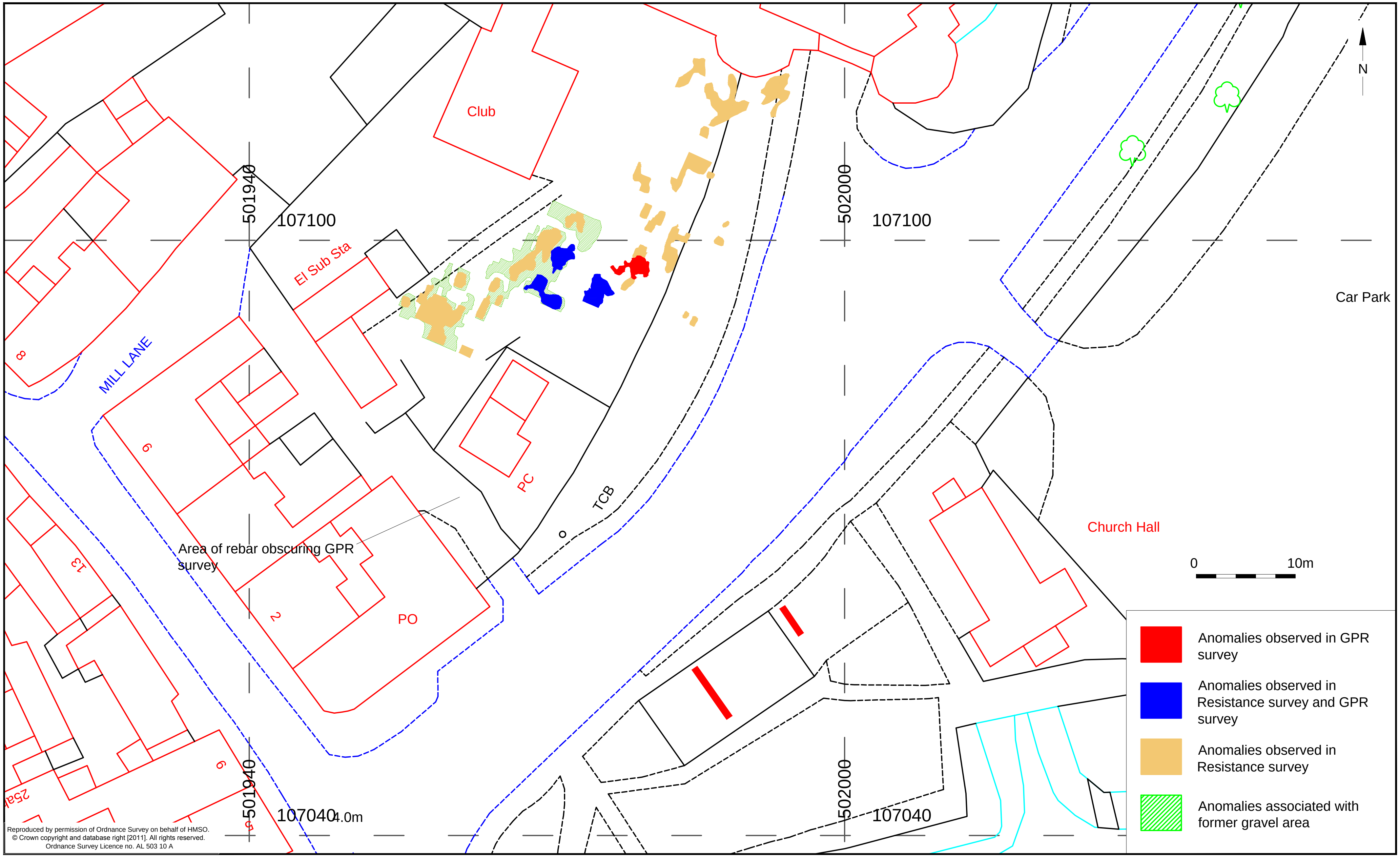
© Archaeology South-East		Dominican Friary Ruins, Arundel	Fig. 3
Project Ref: 4362	July 2011	Raw shade plot	
Report Ref: 2011175	Drawn by: JC		



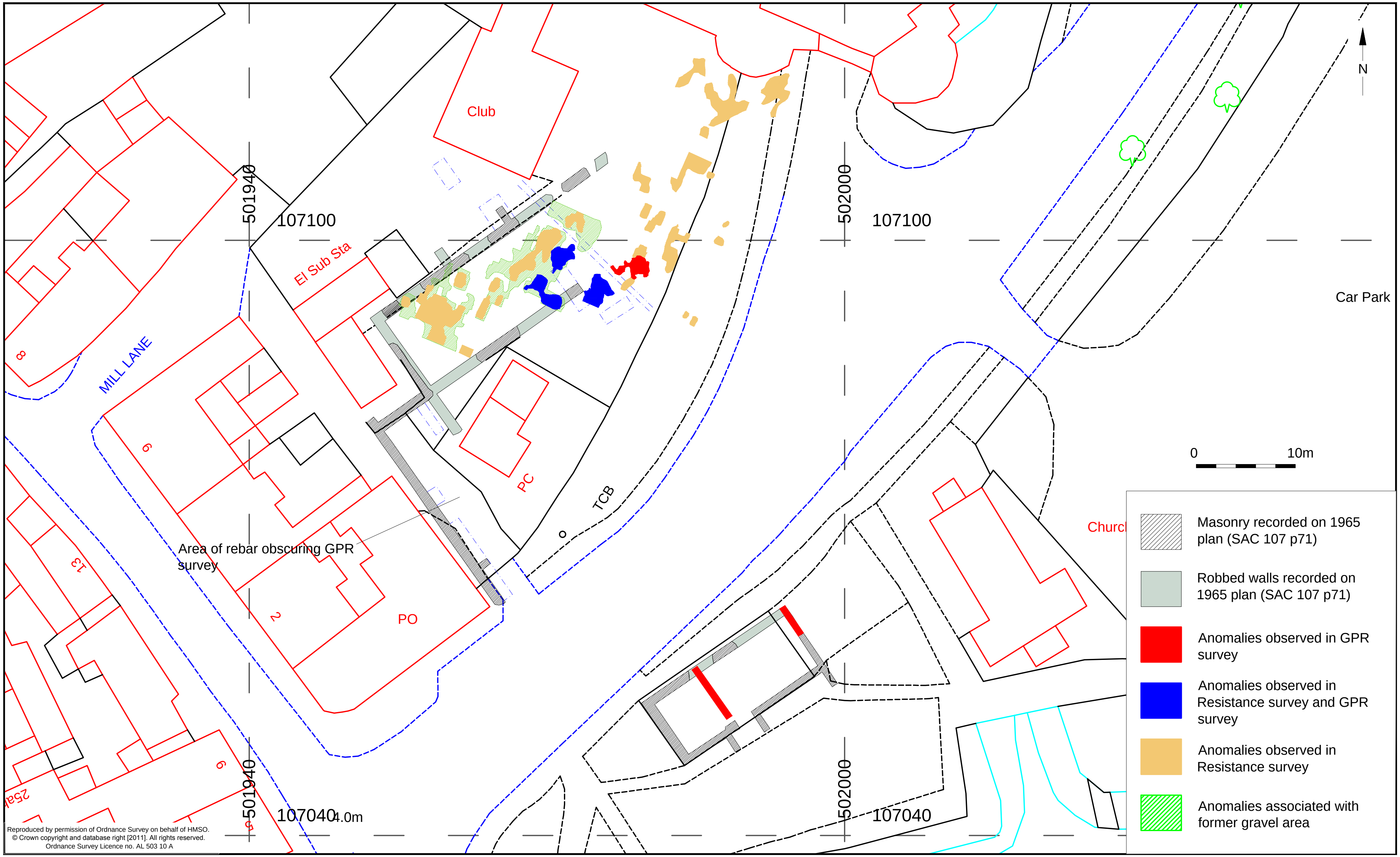
© Archaeology South-East		Dominican Friary Ruins, Arundel	Fig. 4
Project Ref: 4362	July 2011	Processed shade plot	
Report Ref: 2011175	Drawn by: JC		



© Archaeology South-East		Dominican Friary Ruins, Arundel	Fig. 5
Project Ref: 4362	July 2011	Earth resistance interpretation	
Report Ref: 2011175	Drawn by: JC		



© **Archaeology South-East**		Dominican Friary Ruins, Arundel	Fig. 6
Project Ref: 4362	July 2011	Combined Earth Resistance and GPR interpretation	
Report Ref: 2011175	Drawn by: JC		



© **Archaeology South-East**		Dominican Friary Ruins, Arundel	Fig. 7
Project Ref: 4362	June 2011	Combined interpretation and 1965 excavation information overlaid onto OS tile	
Report Ref: 2011175	Drawn by: JC	(OS tile data accurate to +/- 0.4m, ASE survey data accurate to +/- 0.04m)	

HIGH-RESOLUTION GROUND PENETRATING RADAR SURVEY AT ARUNDEL FRIARY

Archaeology South-East

National grid reference: TQ 020 071

Survey date: June/July 2011

Job number: 192-11

Report author: Tim Archer

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Appendix: Ground penetrating radar for archaeological prospection

LIST OF FIGURES

Plotting scale is 1:300 unless otherwise indicated

Figure 1: Location of survey area (1:50,000)
Figure 2: Location of survey profiles
Figure 3: Depth slices from surface to 2000 mm (ten pages)
Figure 4: Interpretation of survey results

1. Introduction

1.1. Terms of reference

1.1.1. In June/July 2011, Arrow Geophysics Ltd carried out a high-resolution ground penetrating radar survey across the former site of Arundel Friary in Arundel, West Sussex.

1.1.2. The survey was commissioned by Archaeology South-East, with the aim of locating possible underground remains of the former friary across the whole of its conjectured footprint.

1.2. Site description

1.2.1. Figure 1 shows the location of the survey area.

1.2.2. The survey area consisted of several small survey blocks, separated from each other by hedges, fences, walls and kerbs, and bisected by an active two-lane roadway.

1.2.3. Survey access was hampered in places by trees, street furniture and standing masonry. Traffic management was used to provide safe and systematic access to the active roadway.

Plate 1: South-westward view along the active roadway

Plate 2: South-eastward view across the south range of the friary

Plate 3: North-westward view across the lawned area north of the active roadway (the north range of the friary is visible in the background)

2. Acquisition

2.1. Positioning

2.1.1. The survey blocks were set out on a common grid, with the exception of data collected within the active roadway, for which a second grid was used. Both grids were tied in to the OS National Grid using RTK GPS.

2.2. GPR survey

2.2.1. Ground penetrating radar data were collected using a cart-mounted MALÅ GeoScience RAMAC/GPR system consisting principally of a shielded 500 MHz antenna, CUII control unit and XV11 monitor. Data were also collected within the active roadway using a shielded 250 MHz antenna, but these data are not included in this survey report.

2.2.2. Profiles were collected at a line spacing of 0.5 metres and a sample spacing of two centimetres. The location of each survey profile is shown in Figure 2.

2.2.3. The time window for reflection measurement was set to 74.6 nanoseconds, which corresponds to a potential penetration depth of approximately 3.0 metres at a radar wave propagation velocity of 8.0 cm/ns. Because of signal attenuation and scattering due to conductive and heterogeneous subsurface conditions, practical penetration depth is often significantly less than this theoretical maximum.

3. Processing

3.1. Stacked profiles

3.1.1. DC offset correction and time gain were applied to the GPR data to correct for low frequency noise and increase mid- to late-time signal amplitudes respectively. Profiles were then stacked for feature interpretation.

3.2. Depth slices

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

3.2.2. The resultant profile dataset was sliced at a vertical interval of 200 mm to produce depth slices suitable for feature interpretation. Depth slices from surface to 2000 mm were gridded to produce the images shown in Figure 3.

3.2.3. Radar reflectance in these images grades from low (black) to high (yellow). Amplitude thresholding has been applied to enhance feature interpretability.

3.3. Software

3.3.1. Processing was mainly carried out using Shakespeare[a] and Geosoft Target.

4. Interpretation

4.1. General comments

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

4.1.2. At this site, effective ground penetration was obtained to a maximum depth of approximately 1.9 metres below surface. Beneath the active roadway, penetration depth was substantially reduced, presumably due to the presence of clay-rich fill.

4.2. Specific features

4.2.1. Several underground services are visible in the depth slices produced for this survey, and the most obvious of these have been included in our interpretation plan (Figure 4).

4.2.2. An area of ground to the west of the survey area lies beneath an access roadway. This access roadway is heavily used by post office vehicles, and has been steel-reinforced throughout, which greatly reduces deeper signal penetration. The positioning of this steel reinforcement is unfortunate, as it corresponds almost directly with the projected alignment of the friary's west range. Excavation within this area may be a necessary substitute for geophysical investigation.

[a] Proprietary software for processing GPR data developed by Arrow Geophysics Ltd.

4.2.3. Within the footprint of the upstanding friary remains to the south of the active roadway, two further masonry footings have been interpreted from the GPR dataset. Anomaly 1 is a logical NNW-SSE extension of an existing wall line, but anomaly 2 appears to mark an internal division extending in the same direction. The interior of the upstanding remains is characterised generally by a high reflectance subsurface, which may indicate the original hardcore or (perhaps more likely) a poorly consolidated spread of demolition rubble.

4.2.4. To the north of the active roadway, three further anomalies have been identified as possibly due to archaeological remains. Anomaly 3 has a concave upward base, which may indicate a cut and fill feature, or possibly an area of robbed masonry. The anomaly extends down from surface to a depth of approximately 1100 mm.

4.2.5. Anomalies 4 and 5 are fairly similar to each other, and have the broad overlapping reflectance signatures that sometimes characterise buried masonry. Both of these features top out at approximately 600 mm below surface.

4.2.6. As within the south range, the subsurface within the vicinity of these three northern anomalies exhibits a generally high reflectance, possibly indicative of either original hardcore or late-stage demolition rubble. Rather misleadingly, areas of bright yellow that appear to the west of the three northern anomalies in the depth slices below 1400 mm indicate radar “ringing” over uneven ground rather than high subsurface reflectance.

5. Conclusion

5.1.1. A high-resolution ground penetrating radar survey carried out at Arundel Friary has revealed little evidence of archaeological remains.

5.1.2. Several underground services have been identified, and this is perhaps indicative of the extent to which older signatures have been obliterated by more recent ground disturbance.

5.1.3. The construction of the roadway that bisects the survey area (and the conjectured outline of the former friary) has introduced clay-rich material to this part of the site which has prevented signal penetration to possible deeper features.

5.1.4. Evidence for two masonry footings has been interpreted within the upstanding remains of the friary's south range.

5.1.5. Three areas of strong subsurface reflectance close to the upstanding remains of the friary's north range have been interpreted as masonry footings, perhaps robbed out after the friary's dissolution.

Disclaimer: Arrow Geophysics Ltd makes no guarantee that the record of buried services supplied for this GPR survey is either accurate or complete. To properly locate such features, a dedicated survey using an appropriate suite of non-intrusive techniques can be carried out upon request.

APPENDIX: GROUND PENETRATING RADAR FOR ARCHAEOLOGICAL PROSPECTION

Ground Penetrating Radar for Archaeological Prospection

Ground penetrating radar has a generally poor reputation in UK archaeology. The reasons for this include an over-optimistic exposé of the technique in a 1989 *Antiquity* paper, some poorly thought-out surveys in the early 1990s, and the technique's complete lack of suitability for many archaeological applications.

So why should we consider it now?

Radar has undergone a quiet revolution since the early 1990s - not in fundamental technology, but in packaging. In summary, hardware has become extremely portable and increasingly robust, and software is able to present survey results in a more easily understood format. When combined with a good understanding of the technique's strengths and limitations, these advances make radar a thoroughly viable alternative to more established geophysical techniques.

Advantages

Radar enjoys a number of significant advantages over other geophysical techniques:

Brownfield and urban sites
Magnetic techniques tend to fail when there is significant site contamination due to modern ironwork

Hard surfaces
Conventional resistivity cannot be carried out on concrete, tarmac or stone floors.

Vertical faces
Magnetic and resistivity techniques are seldom suitable for surveying walls and other standing structures – they lack the resolving power and are cumbersome in small spaces.

Three dimensions
Radar can provide direct information on feature depth, enabling successive archaeological contexts to be distinguished and complex structural changes to be resolved.

Deep penetration
Under suitable conditions, radar energy can penetrate to depths of more than ten metres, whereas conventional magnetic and resistivity techniques typically sample the top half metre of the subsurface.

Disadvantages

Radar suffers from three significant disadvantages:

Unconstrained sites
Radar detects background clutter as well as features of archaeological importance. Without some idea of what is being sought, survey results can be extremely difficult to interpret.

Conductive geology
Clay-rich and saline soils severely limit the effective penetration of radar energy.

Broken ground
Poor antenna coupling with the ground surface reduces horizontal continuity of genuine reflections and introduces data artefacts.

Cost

Until now, radar has suffered from a fourth significant disadvantage: cost. Expensive hardware, slow rates of data acquisition, and time-consuming processing and interpretation have conspired to make radar surveys a luxury affordable to very few archaeological projects.

Arrow Geophysics perceives high cost as a major stumbling block to the general acceptance of radar as a mainstream geophysical technique. Since April 2007, our unique RapidRadar™ methodology has enabled multi-hectare radar survey to be offered at commercially realistic rates.

Suggested applications

Radar can in principle be used to investigate a range of archaeological targets, including the following:

Masonry
- Walls
- Foundations
- Burial vaults
- Kilns

Voids
- Cellars
- Caves
- Tunnels

Earthworks
- Earth-cut graves
- Garden features
- Moats and ditches

Standing structures
- Brick
- Concrete
- Wattle-and-daub
- Plaster and mosaic murals

Stratigraphy
- Geological layering
- Context evaluation
- Water table mapping

An important, if obvious, question to ask when considering a radar survey is whether the material to be investigated exhibits a contrast with its surroundings. Considering the above list, one can see that the answer to this question is not always straightforward!

Handle with care…

Radar was not the universal panacea for archaeological uncertainty in the 1990s; it is not the universal panacea for archaeological uncertainty now. What has changed is the practicality of available hardware and the power of available software. Notwithstanding, radar surveys need to be planned and executed with care in order to maximise the advantages and minimise the disadvantages of this extremely powerful geophysical technique.

FIGURES

Figure 1

ARROW GEOPHYSICS

Scale 1:50000

500 0 500 1000 1500 2000 2500 3000

metres

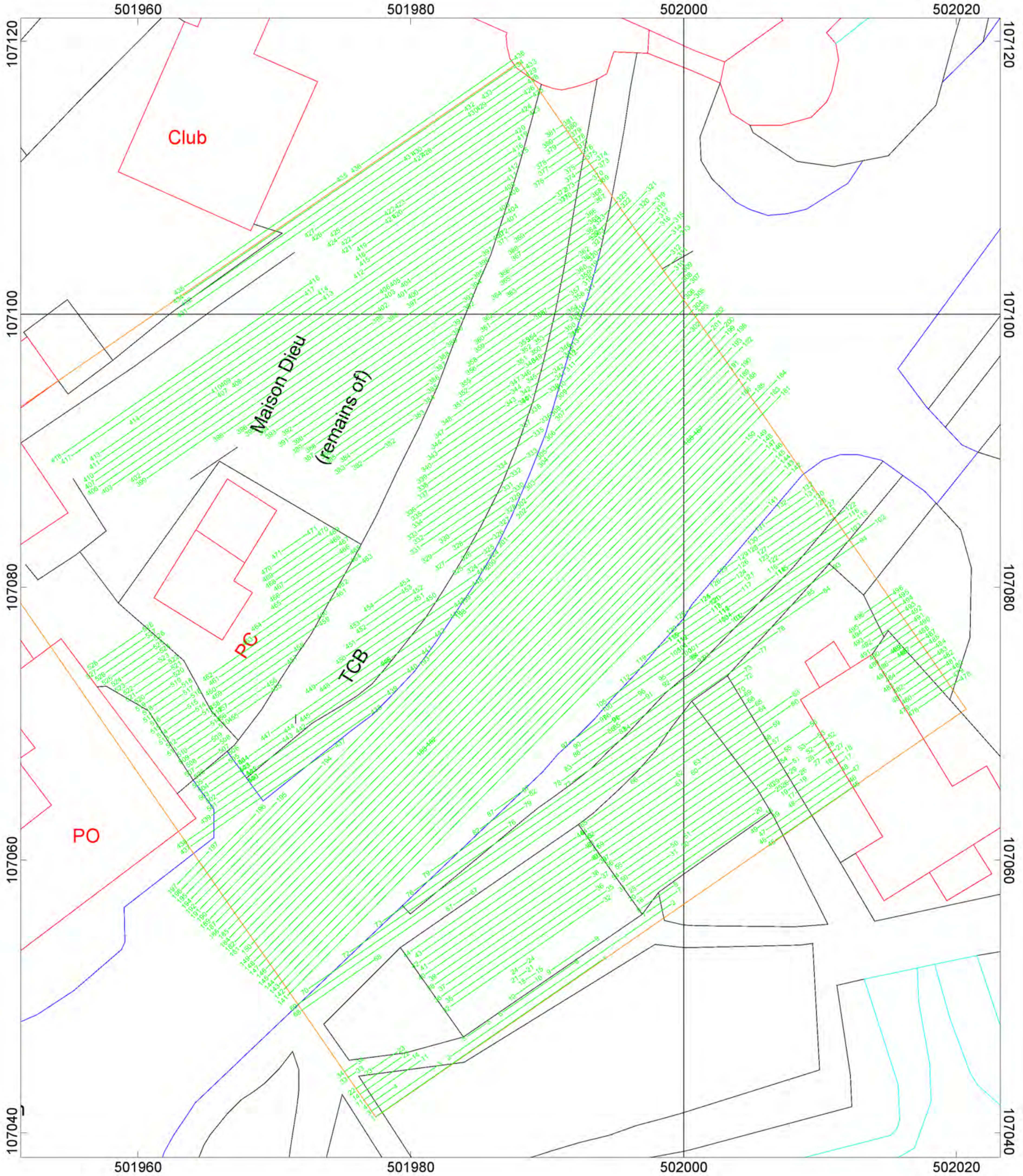
OSGB 1936 / British National Grid

Archaeology South-East

Arundel Friary, Arundel, West Sussex
High-resolution GPR Survey

location of survey area

Arrow Geophysics Ltd



Scale 1:300

5 0 5 10

metres

OSGB 1936 / British National Grid

Base plan courtesy of Archaeology South-East

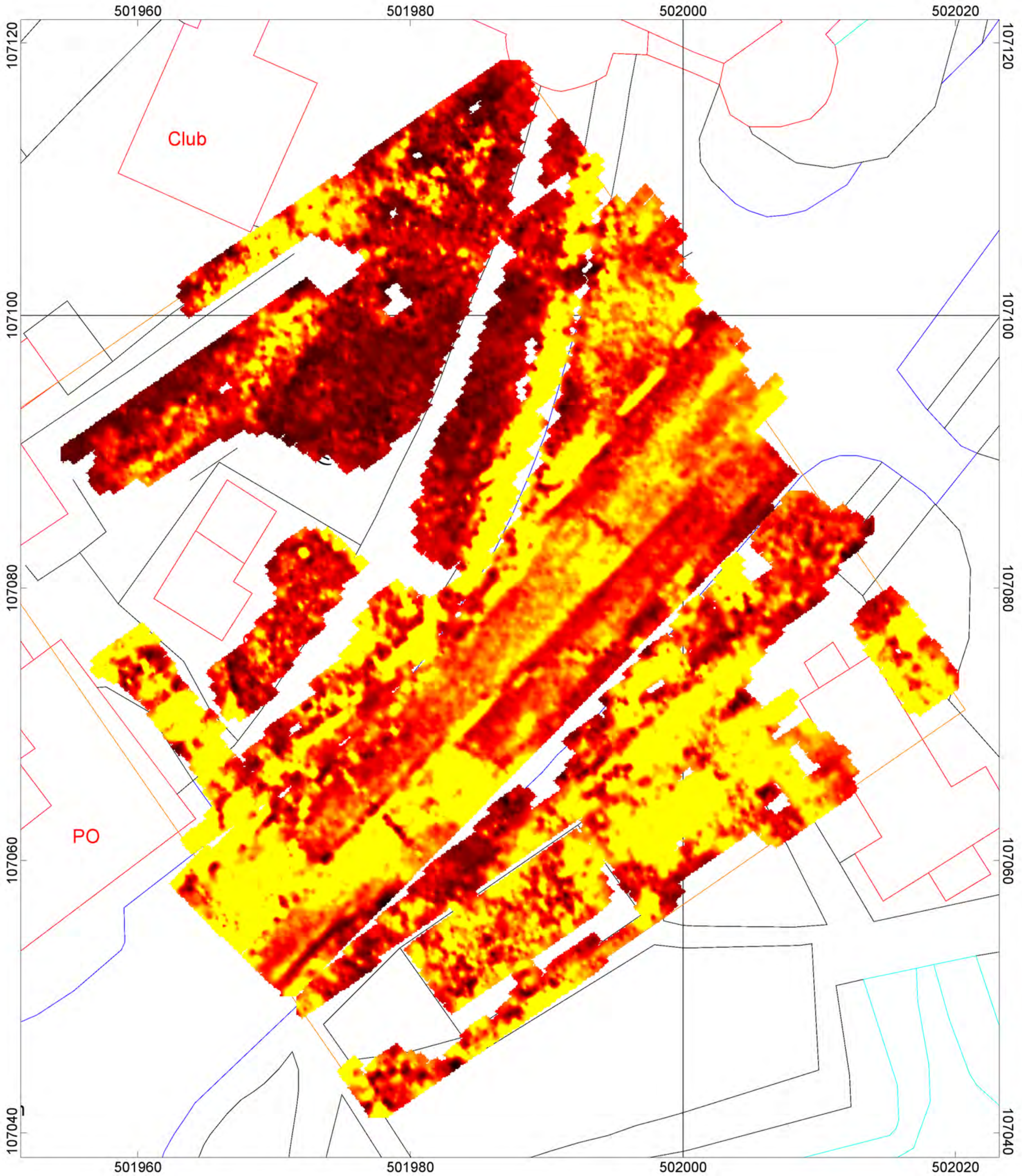
Archaeology South-East

Arundel Friary, Arundel, West Sussex
High-resolution GPR Survey

location of survey profiles

Arrow Geophysics Ltd

Figure 2



Scale 1:300

5 0 5 10

metres

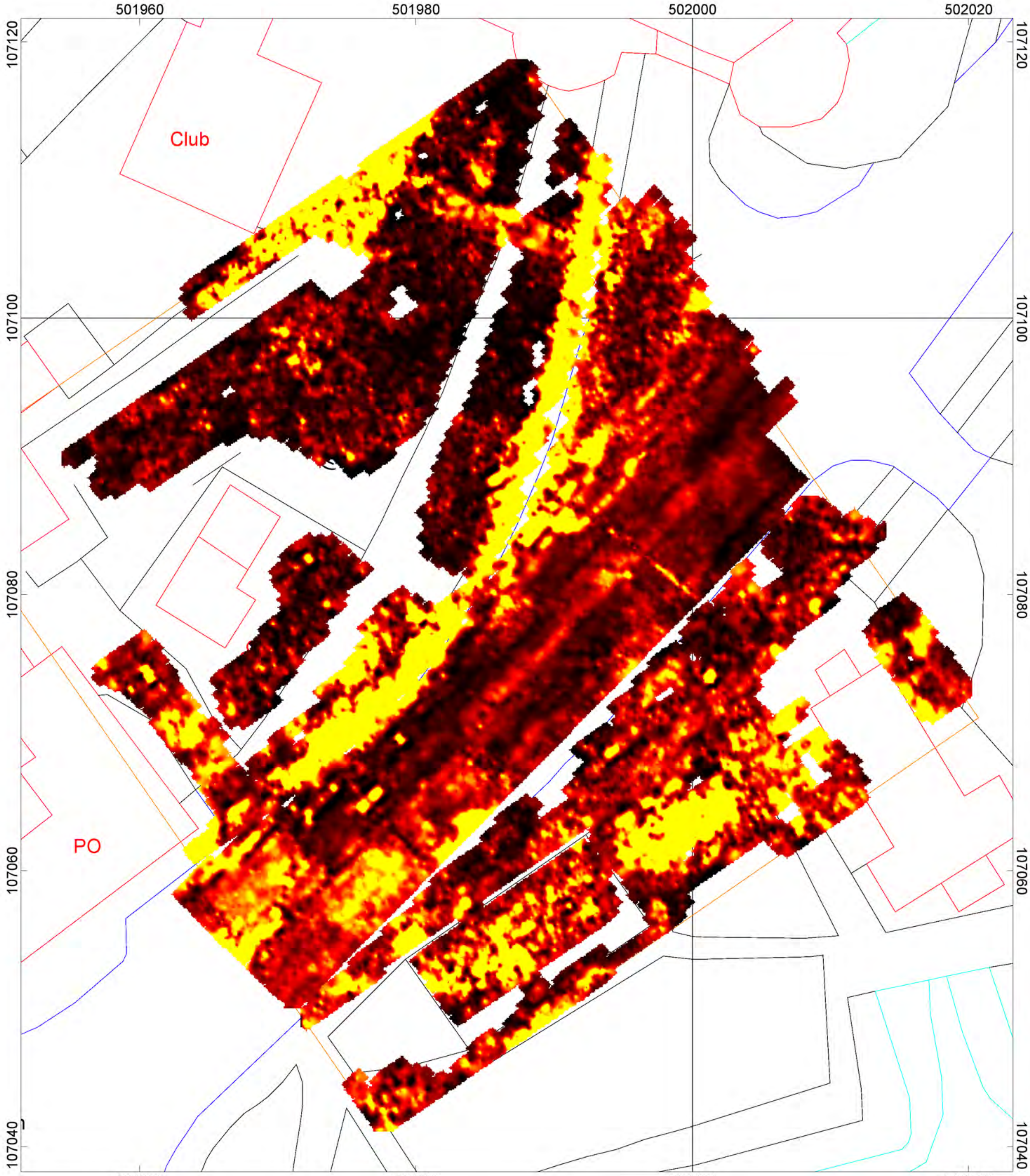
OSGB 1936 / British National Grid

ARROW GEOPHYSICS

Base plan courtesy of Archaeology South-East

Archaeology South-East
Arundel Friary, Arundel, West Sussex High-resolution GPR Survey
depth slice from surface to 200 mm
Arrow Geophysics Ltd

Figure 3a



Scale 1:300

5 0 5 10

metres

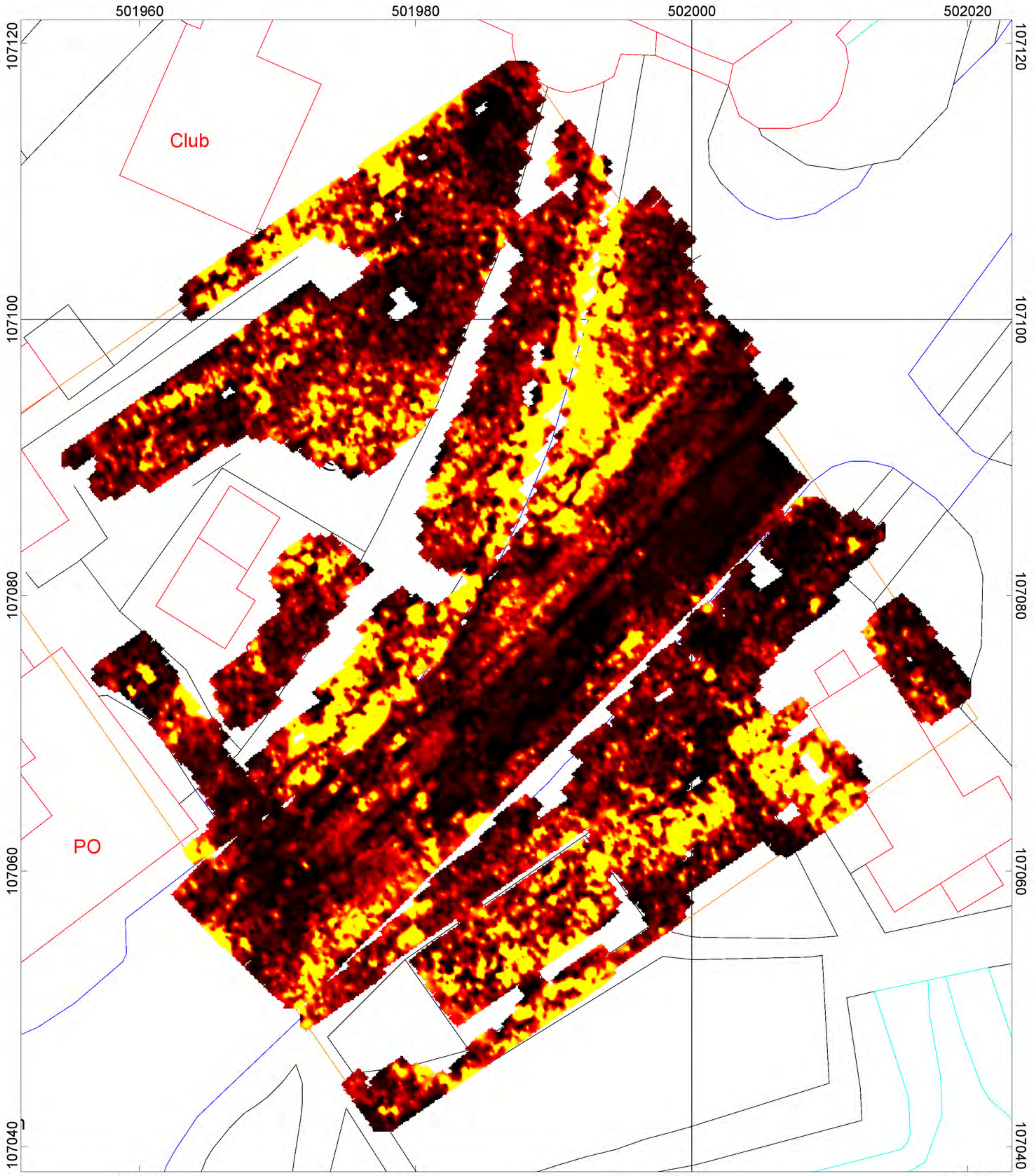
OSGB 1936 / British National Grid

Base plan courtesy of Archaeology South-East

ARROW GEOPHYSICS

Archaeology South-East
Arundel Friary, Arundel, West Sussex **High-resolution GPR Survey**
depth slice from 200 mm to 400 mm
Arrow Geophysics Ltd

Figure 3b



Scale 1:300

5 0 5 10

metres

OSGB 1936 / British National Grid

Base plan courtesy of Archaeology South-East

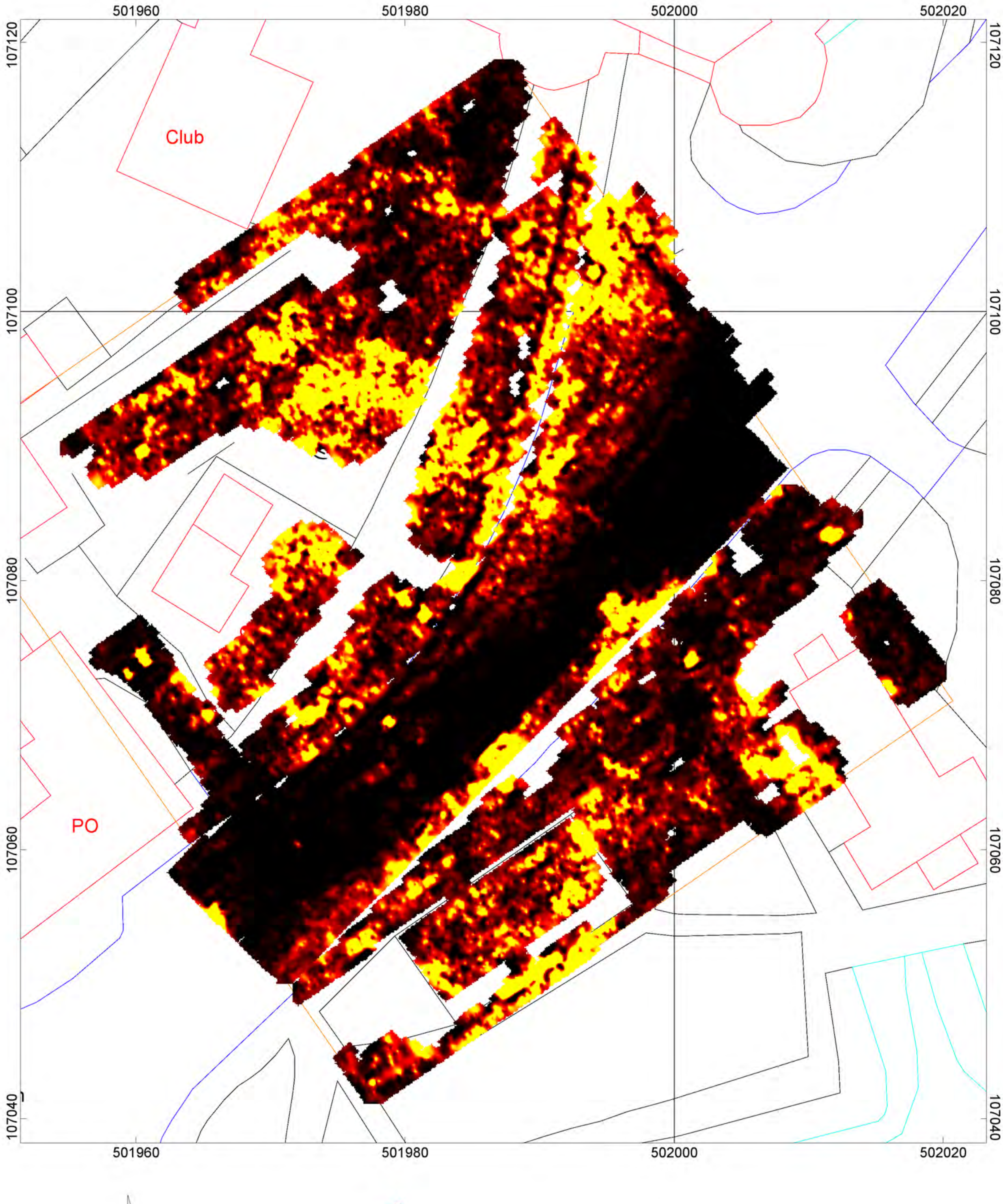
Archaeology South-East

Arundel Friary, Arundel, West Sussex
High-resolution GPR Survey

depth slice from 400 mm to 600 mm

Arrow Geophysics Ltd

Figure 3c



Base plan courtesy of Archaeology South-East

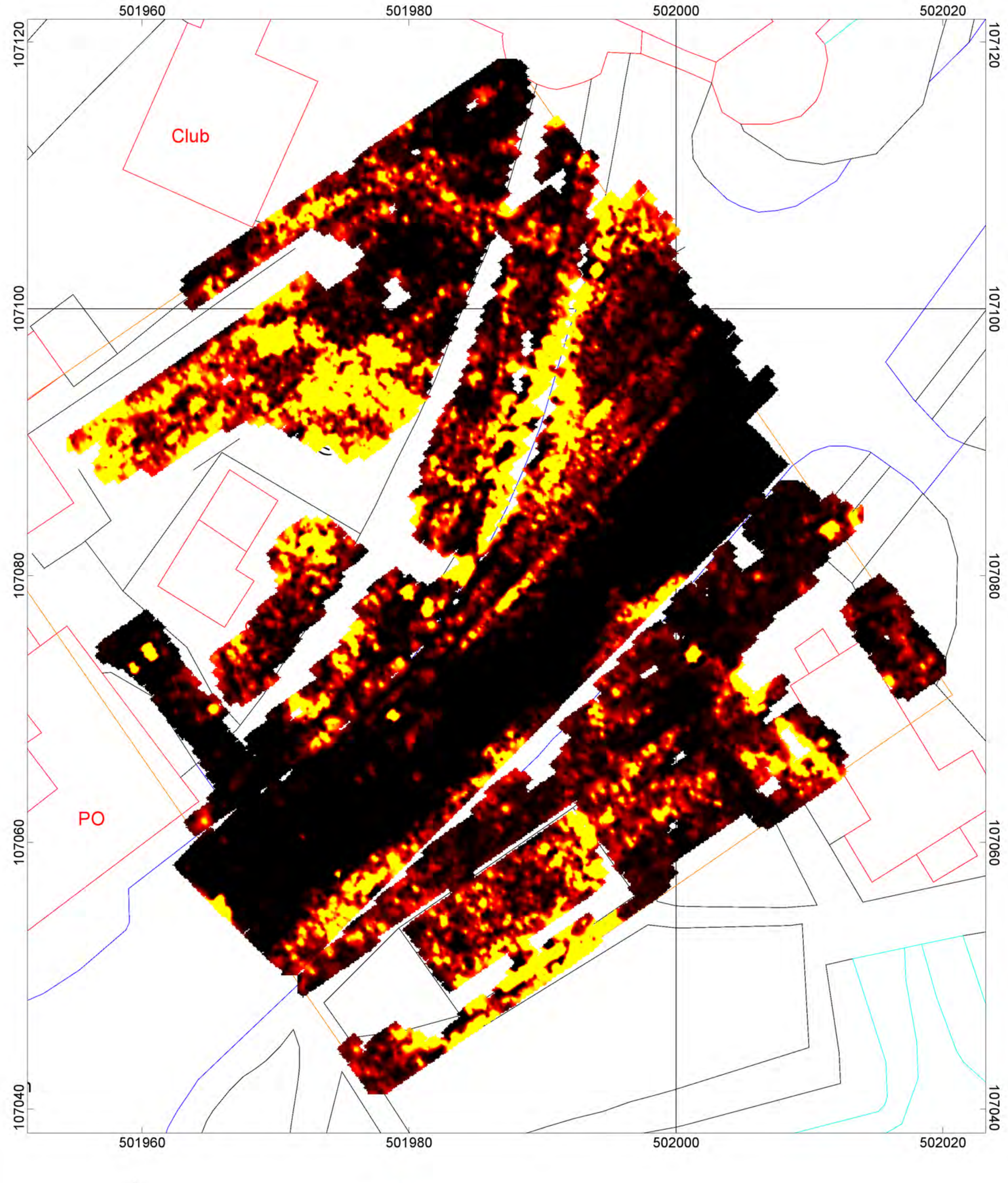
Archaeology South-East

Arundel Friary, Arundel, West Sussex
High-resolution GPR Survey

depth slice from 600 mm to 800 mm

Arrow Geophysics Ltd

Figure 3d



Base plan courtesy of Archaeology South-East

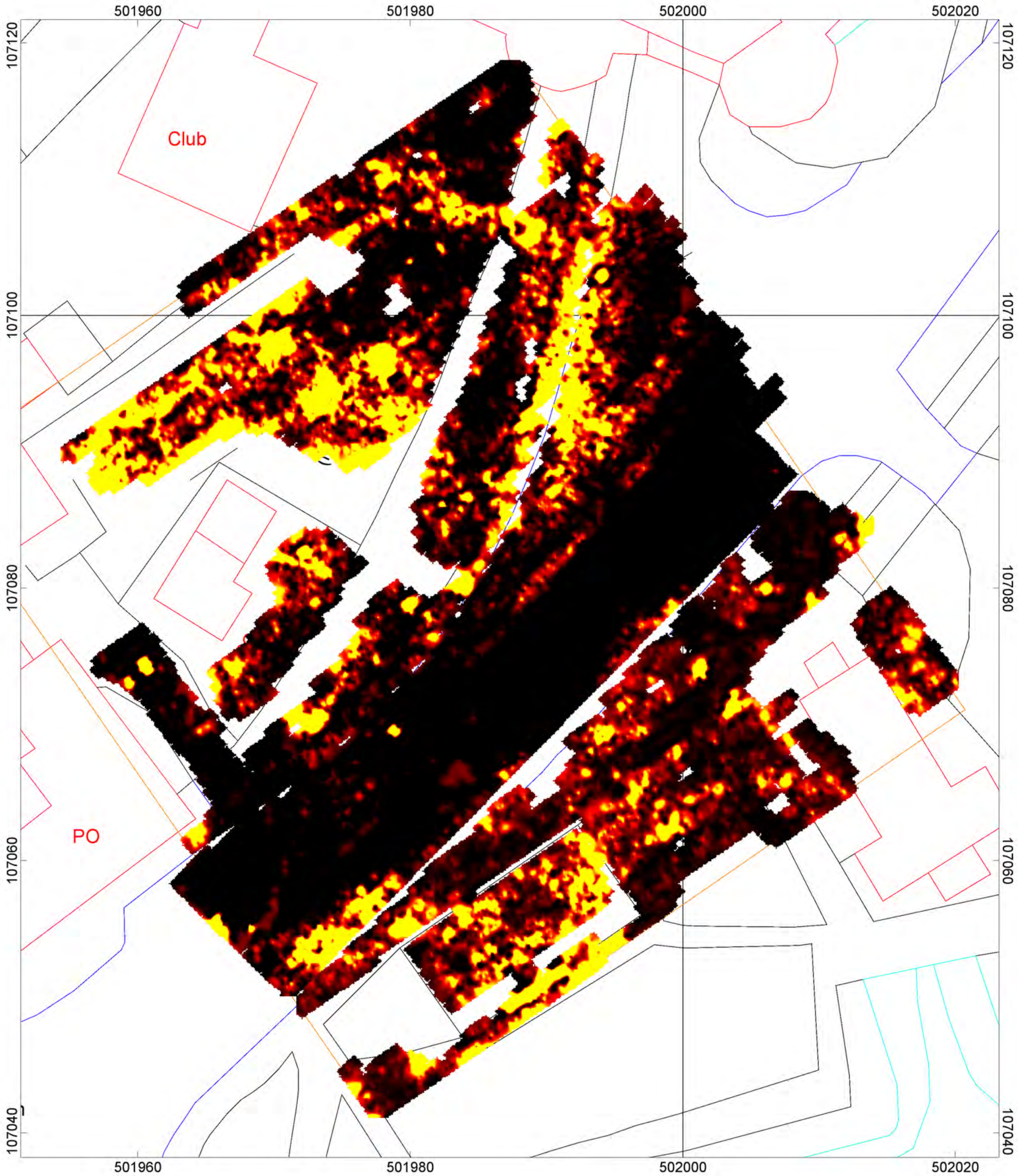
Archaeology South-East

Arundel Friary, Arundel, West Sussex
High-resolution GPR Survey

depth slice from 800 mm to 1000 mm

Arrow Geophysics Ltd

Figure 3e



Scale 1:300

5 0 5 10

metres

OSGB 1936 / British National Grid

ARROW GEOPHYSICS

Base plan courtesy of Archaeology South-East

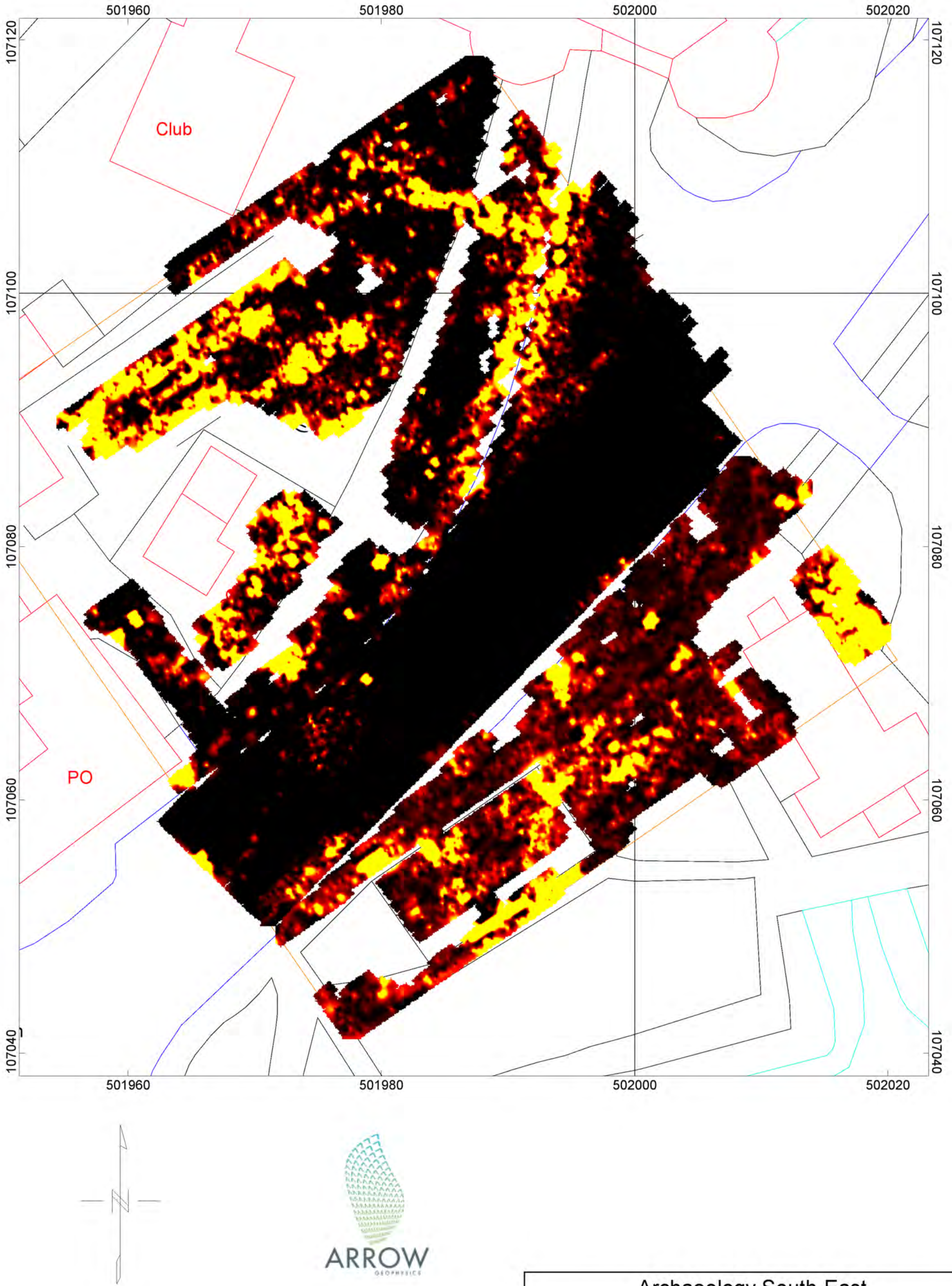
Archaeology South-East

Arundel Friary, Arundel, West Sussex
High-resolution GPR Survey

depth slice from 1000 mm to 1200 mm

Arrow Geophysics Ltd

Figure 3f



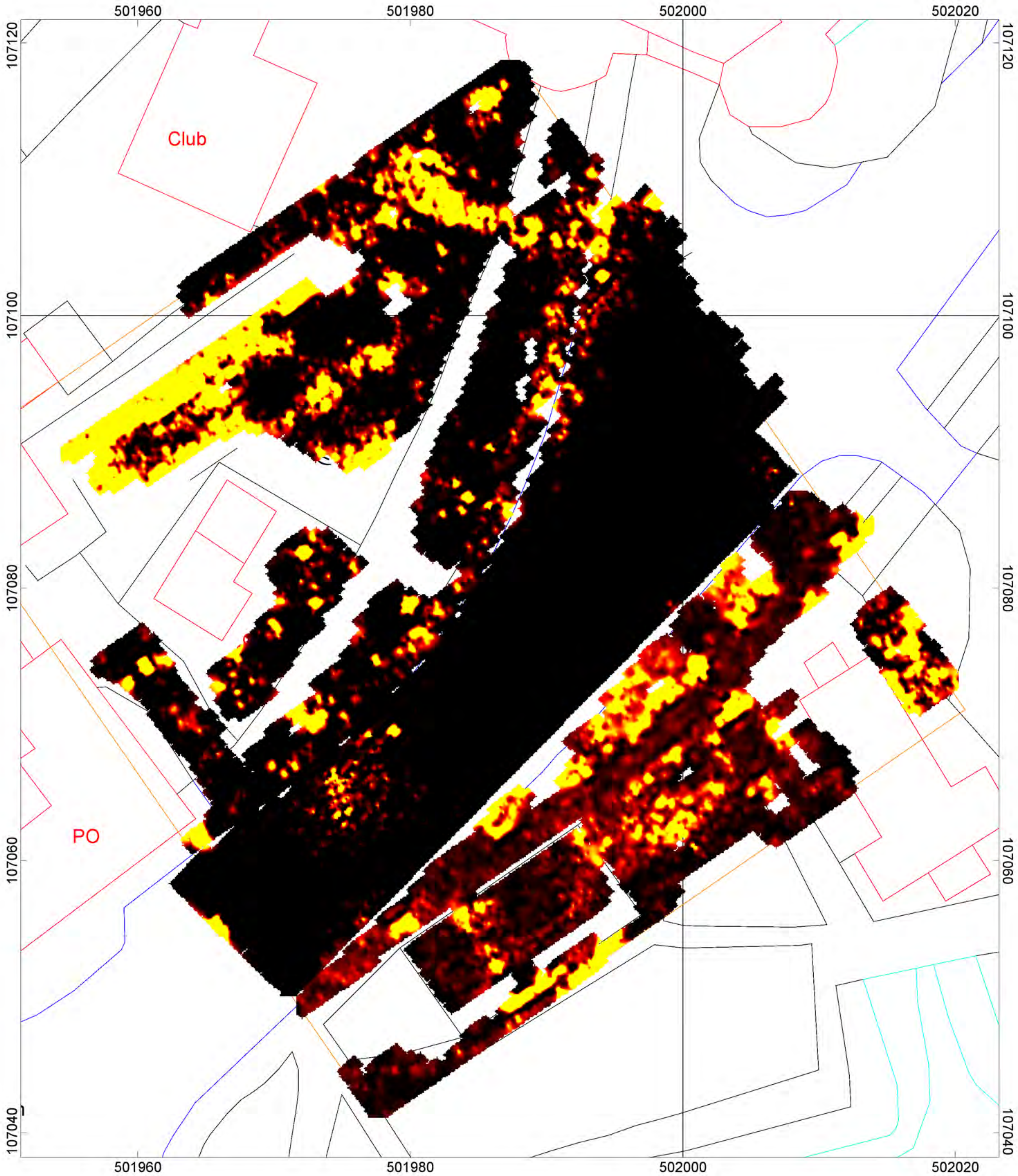
Archaeology South-East

Arundel Friary, Arundel, West Sussex
High-resolution GPR Survey

depth slice from 1200 mm to 1400 mm

Arrow Geophysics Ltd

Figure 3g



Scale 1:300

5 0 5 10

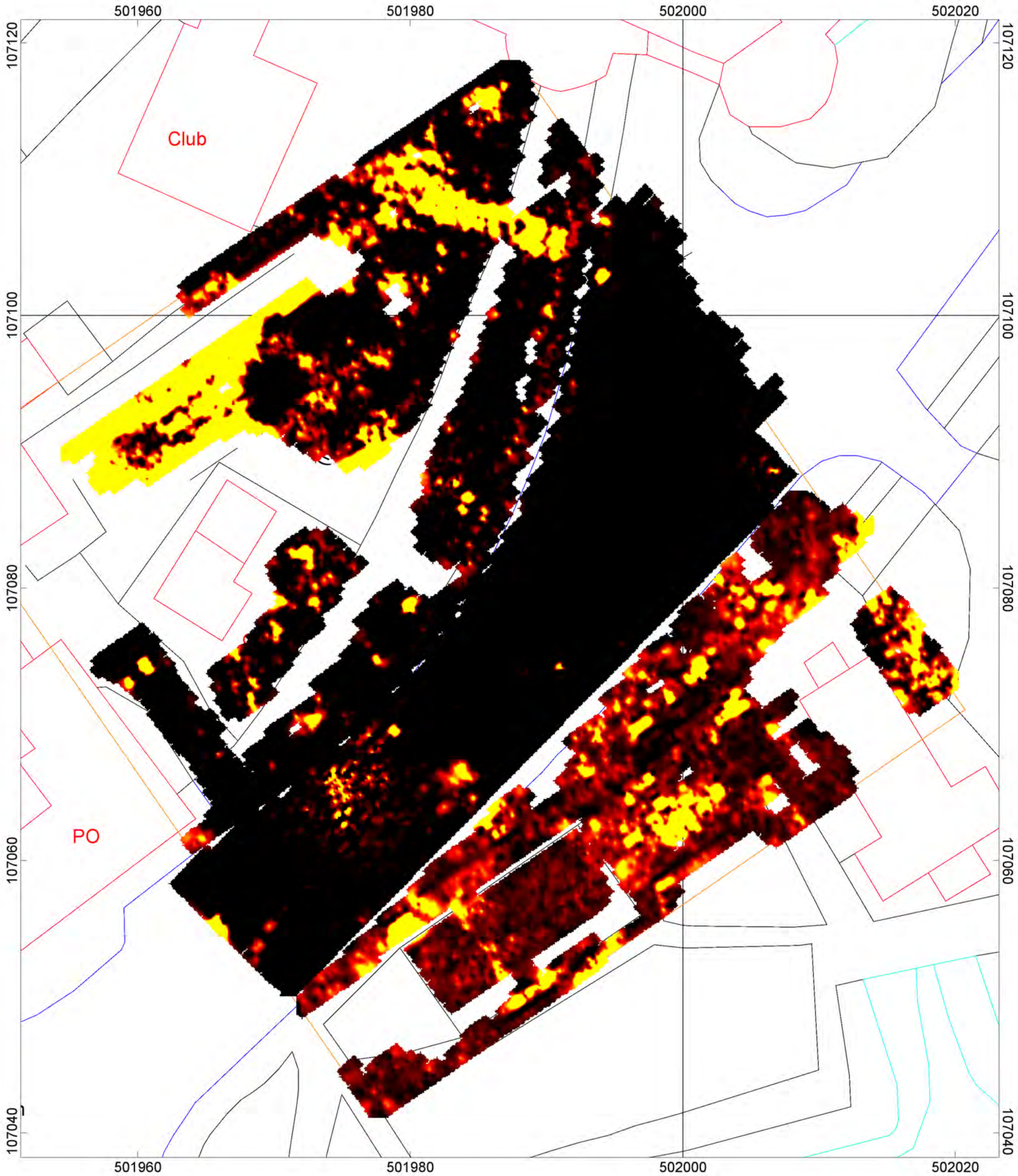
metres

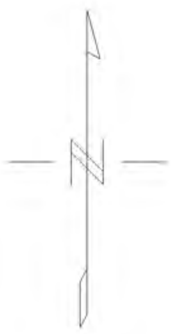
OSGB 1936 / British National Grid

Base plan courtesy of Archaeology South-East

Archaeology South-East
Arundel Friary, Arundel, West Sussex **High-resolution GPR Survey**
depth slice from 1400 mm to 1600 mm
Arrow Geophysics Ltd

Figure 3h





Scale 1:300

5 0 5 10

metres

OSGB 1936 / British National Grid

Base plan courtesy of Archaeology South-East

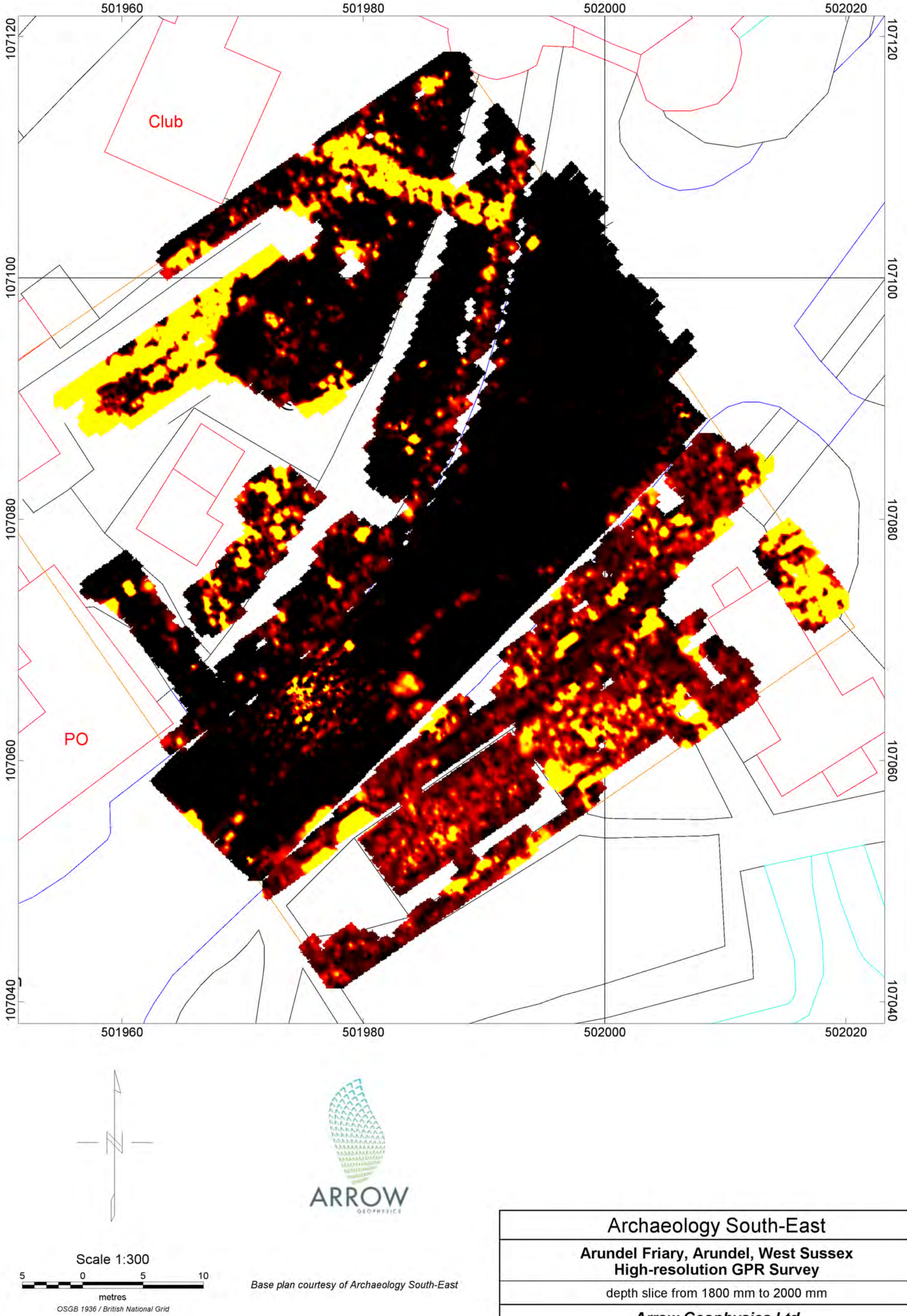
Archaeology South-East

Arundel Friary, Arundel, West Sussex
High-resolution GPR Survey

depth slice from 1600 mm to 1800 mm

Arrow Geophysics Ltd

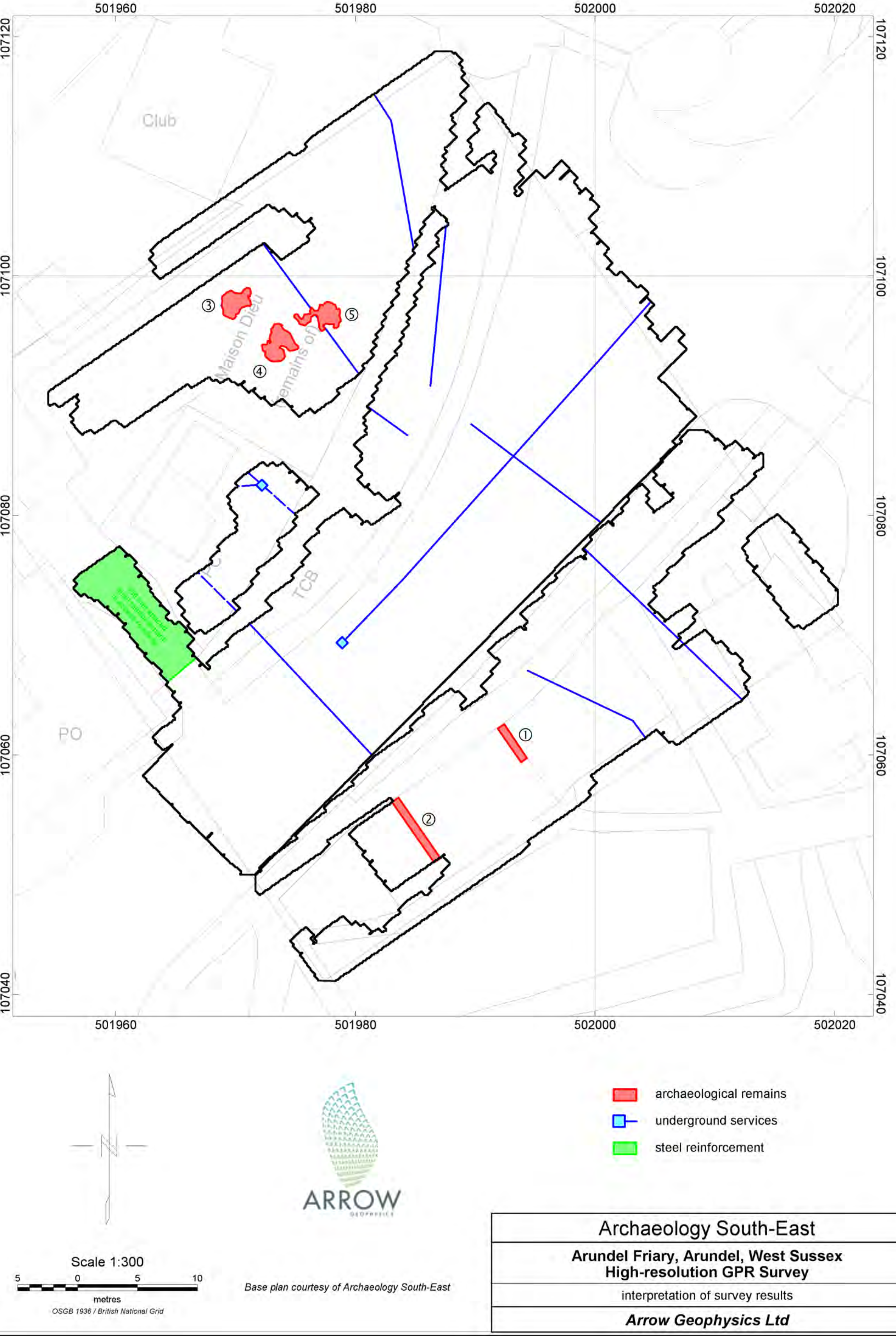
Figure 3i



Base plan courtesy of Archaeology South-East

Archaeology South-East
Arundel Friary, Arundel, West Sussex **High-resolution GPR Survey**
depth slice from 1800 mm to 2000 mm
Arrow Geophysics Ltd

Figure 3i



Base plan courtesy of Archaeology South-East

Archaeology South-East

Arundel Friary, Arundel, West Sussex
High-resolution GPR Survey

interpretation of survey results

Arrow Geophysics Ltd

Figure 4

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