



AMBLESIDE ROMAN FORT, AMBLESIDE,

LAKE DISTRICT

Geophysical Survey Report



Oxford Archaeology North

June 2013

National Trust

Issue No:	2012-13/1407
OA North Job No	L10576
NGR:	NY 3725 0340

Document Title: AMBLESIDE ROMAN FORT, AMBLESIDE, LAKE DISTRICT

Document Type: Geophysical Survey Report

Client Name: National Trust

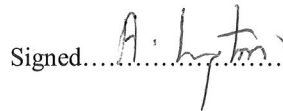
Issue Number: 2012-13/1407
OA Job Number: L10576
National Grid Reference: NY 3725 0340

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SUMMARY

Ambleside Roman Fort (NGR NY 3725 0340) dates to the late first and second centuries AD and is a scheduled monument (SM13567), owned and managed by the National Trust. The surviving features on the site relate to the second fort constructed on the site, although there is a possibility that elements of the earlier fort are also represented. Following a recent donation to the National Trust, funding became available to carry out a programme of geophysical survey, at the fort and the National Trust requested a project design outlining a methodology for the survey to be carried out with assistance from volunteers; this was part of 'Romans by the Rivers', one of nineteen projects that combine to form Windermere Reflections. Following acceptance of the project design, Oxford Archaeology North (OA North), were commissioned to carry out the survey, which was undertaken in several separate visits in February, March and April 2013. The first visit to the fort in February consisted of a one day trial survey using magnetometry, undertaken without volunteers, in order to assess the suitability of the technique and on the subsequent survey days this provided volunteers with a data set prior to carrying out the main survey.

The subsequent geophysical survey identified a number of responses that represent features associated with the Roman Fort, including internal structural remains, and external features, such as former defences. While both the magnetometry and resistivity surveys have identified features of archaeological potential, the resistivity survey was more successful in outlining the internal layout of the fort. Features such as buried structural remains, banks and ditches have been more easily identified using the resistance technique. The magnetometry survey was affected by large areas of magnetic debris/disturbance, particularly within the interior of the fort, which hindered the identification of features.

By combining the information from the two complementary datasets, the outline of the fort is visible, along with some internal structural elements, including the '*Via Principalis*' road and two of the corner turrets. Some of the defences and ramparts are also visible. Externally, the outer defences are particularly clear in the resistivity data, especially at the north-east corner. Settlement evidence may be present, particularly in the field to the north of the fort beyond the outcropping rock, but the nature of the responses makes interpretation difficult and conjectural.

A feature of particular interest is a linear response with wide halo just to the north of the fort platform. The general appearance of the feature appears to suggest that it is a buried structure but the nature of the response is difficult to explain. There is also evidence for the line of the road out of the fort that extends through Borrans Park. There may also be evidence for settlement in this area, although the data is complex and there are no obvious patterns. The exact cause for these responses may only properly be explained by archaeological intervention.

ACKNOWLEDGEMENTS

Oxford Archaeology North (OA North) would like to thank Jamie Lund, of the National Trust for commissioning the project and for his support and assistance in the course of the survey. OA North would also like to thank the many volunteers who assisted with the survey, for their unwavering enthusiasm.

The geophysical survey was undertaken by Mike Birtles and Karl Taylor with assistance from National Trust volunteers. The report was written by Karl Taylor, and the drawings were produced by Anne Stewardson and Karl Taylor. The project was managed by Jamie Quartermaine, who also edited the report.

1. INTRODUCTION

1.1 CIRCUMSTANCES OF THE PROJECT

- 1.1.1 Ambleside Roman Fort, Ambleside, Cumbria dates to the late first and second centuries AD and is a scheduled monument (SM13567), owned and managed by the National Trust. The surviving features on the site relate for the most part to the second fort that was constructed on the site. Following a recent donation to the National Trust, funding became available to carry out a programme of geophysical survey at the fort and Jamie Lund (National Trust Archaeologist), requested a project design outlining a methodology for the survey, which was to be carried out with assistance from National Trust volunteers. It was hoped that a geophysical survey would provide new information about the Roman fort that could be included in a new scheme of on-site interpretation to be developed with financial support from the Heritage Lottery Fund as part of 'Romans by the Rivers', one of nineteenth projects that combine to form the overarching Windermere Reflections Project.
- 1.1.2 Following acceptance of the project design, Oxford Archaeology North (OA North), were commissioned to carry out the survey, which was undertaken in the course of several separate visits during February, March and April 2013. The first visit to the fort in February consisted of a one day trial survey using magnetometry, without volunteers, in order to assess the suitability of the technique and to provide volunteers with a data set prior to carrying out the main survey. In the event, two episodes of survey were undertaken with the volunteers during March and April using both resistivity and magnetometry techniques.
- 1.1.3 This report sets out the results of the recent geophysical survey and provides an interpretation of the results, along with recommendations for further work.

1.2 LOCATION AND BACKGROUND TO THE AREA

- 1.2.1 **Location, Geology and Topography:** Ambleside Roman Fort is situated at the northern end of Windermere Lake, within the Lake District National Park, approximately 0.8km to the south-east of Ambleside town centre (NGR NY 3725 0340, Fig 1). The fort lies in a field between the River Brathay and Borrans Park.
- 1.2.2 The fort lies less than two metres above the level of the lake and is situated upon a sand and gravel platform that is clearly visible at ground level and is clearly shown on a LiDAR plot of the area (Fig 2). The field, known as Borrans Field, slopes gently up to the north from the lake shore. The southern and western edges of Borrans Field consist of marshy ground, the northern part of the field is dominated by outcropping rock and a standing barn. The northern and eastern boundaries of the field comprise drystone walls with gates allowing public access to and from the field. Fisher Beck, contained within an underground culvert, flows through the eastern part of the field to reach Windermere. The survey extended into the adjacent Borrans Park which is bounded by stone walls with some metal gates, where modern pathways cross the area.

- 1.2.3 The underlying bedrock consists of the Ordovician Lincomb Tarns Tuff Formation (Dicitic Lapilli-Tuff) and the overlying superficial deposits are of Alluvium (clay, silt, sand and gravel) (www.bgs.ac.uk). The soils consist of freely draining loamy floodplain soils (www.landis.org.uk).
- 1.2.4 **Background:** The National Trust acquired Borrans Field in 1913 because of a perceived threat of development on the site. A collection of money was raised to purchase the property, with significant support from local people including such notaries as RG Collingwood and Mary Armit and afterwards the property was then donated to the National Trust. Following acquisition, RG Collingwood commenced a series of excavations between 1913 and 1920 which were published in the Transactions of the Cumberland and Westmoreland Antiquarian and Archaeological Society (CWAAS), (Haverfield and Collingwood 1914; Collingwood 1915; 1916 and 1920).
- 1.2.5 Collingwood (1916) reported the discovery of two phases of fort on the site (Plate 1) and that most of the upstanding and visible remains belonged to the second phase. Collingwood (*ibid*) discovered burnt structures sealed below clay and gravel that was deposited when the second phase was constructed, and he also discovered that the outline of the earlier fort was not conventional (Plate 1). Collingwood suggested that the defences to this first fort comprised a pair of ditches separated by a central baulk of varying width.

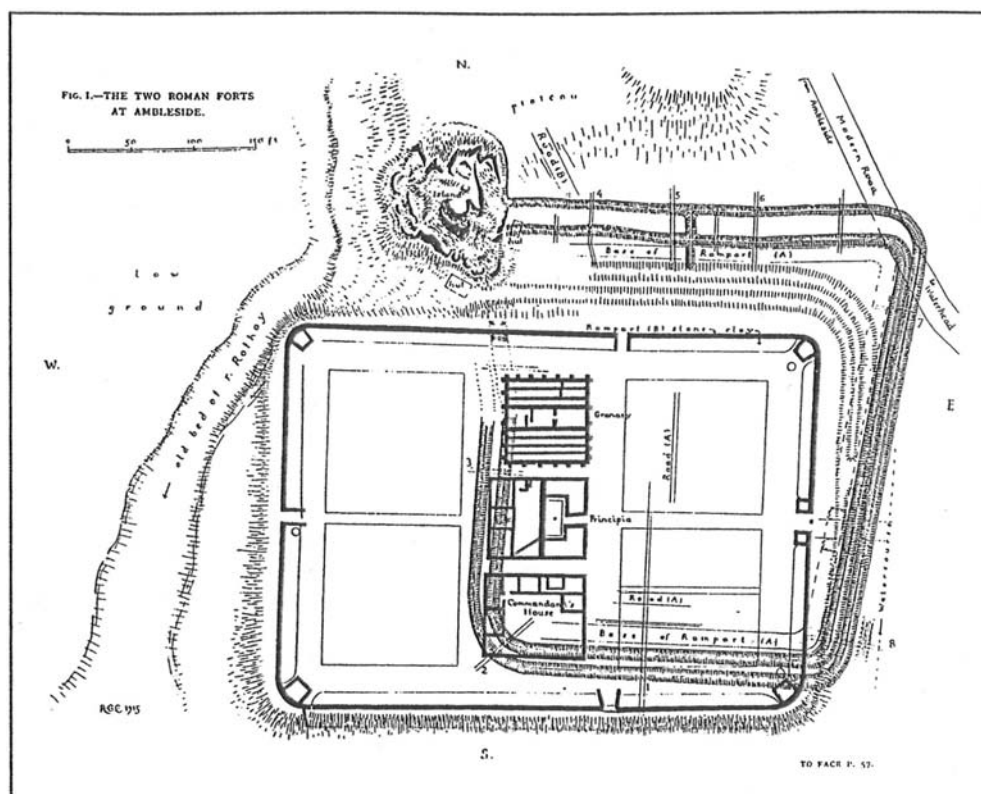


Plate 1: Plan of the two Roman Forts (after Collingwood 1916)

- 1.2.6 The first fort was probably constructed toward the end of the first century (Potter 1979), probably of late Flavian date, as it is now recognised that full Roman military occupation of the Lake District did not occur until at least AD 90 when Roman forces withdrew from Scotland following the Agricolan advance (Drury and Dunwell 2004; Shotter 1997). The second phase was

more conventional in plan being of the typical playing card layout. Collingwood states that there were no ditches on the south and west sides of the fort due to there being enough protection from the River Rothay and the lake (Haverfield and Collingwood 1914). Over several seasons, Collingwood excavated all of the corner turrets and gates of the second phase, as well as trenches along the line of the wall and across the north and east ditches. The central range of buildings were excavated and exposed in 1915 and 1916.

- 1.2.7 It was discovered that the main gate faced east and that the level of the fort was made up using imported material to create the platform seen today (Collingwood 1916). The south face of the rampart was discovered to be faced with cobbles and gravel, presumably for protection from flooding (Collingwood 1915). The internal buildings were found to comprise a central range of stone structures with the other buildings constructed from timber (*ibid*). There is little information regarding the later occupation of the fort, and a late fourth century coin is the latest evidence of Roman activity on-site; however, this may not be indicative of a formal military presence (Drury and Dunwell 2004).
- 1.2.8 Following Collingwood's work, the main focus of work on the fort has been upon the recording and consolidation of the site (RCHME 1998), with various surveys, including a photogrammetric survey in 1976, a ground survey in 1984 and a magnetic geophysical survey by the Ancient Monuments Laboratory (AML) in 1989 (*Appendix 2*). This geophysical survey was only found to have taken place after the present initial trial survey had already been carried out by OA North, and was not recorded on the National Trust Sites and Monuments Record or within the National Monuments Record.
- 1.2.9 In 1998 the RCHME carried out an extensive earthwork survey of Borrans Field and part of the adjacent Borrans Park. The results of the survey (Plate 2) provided a detailed 1:1000 scale plan of the earthworks. The survey highlighted a number of east/west furrows indicative of ploughing. Indeed, Collingwood discovered that some of the internal timber structures were plough damaged and he was informed that the site had been ploughed 40 years prior to his excavations (Haverfield and Collingwood 1914).

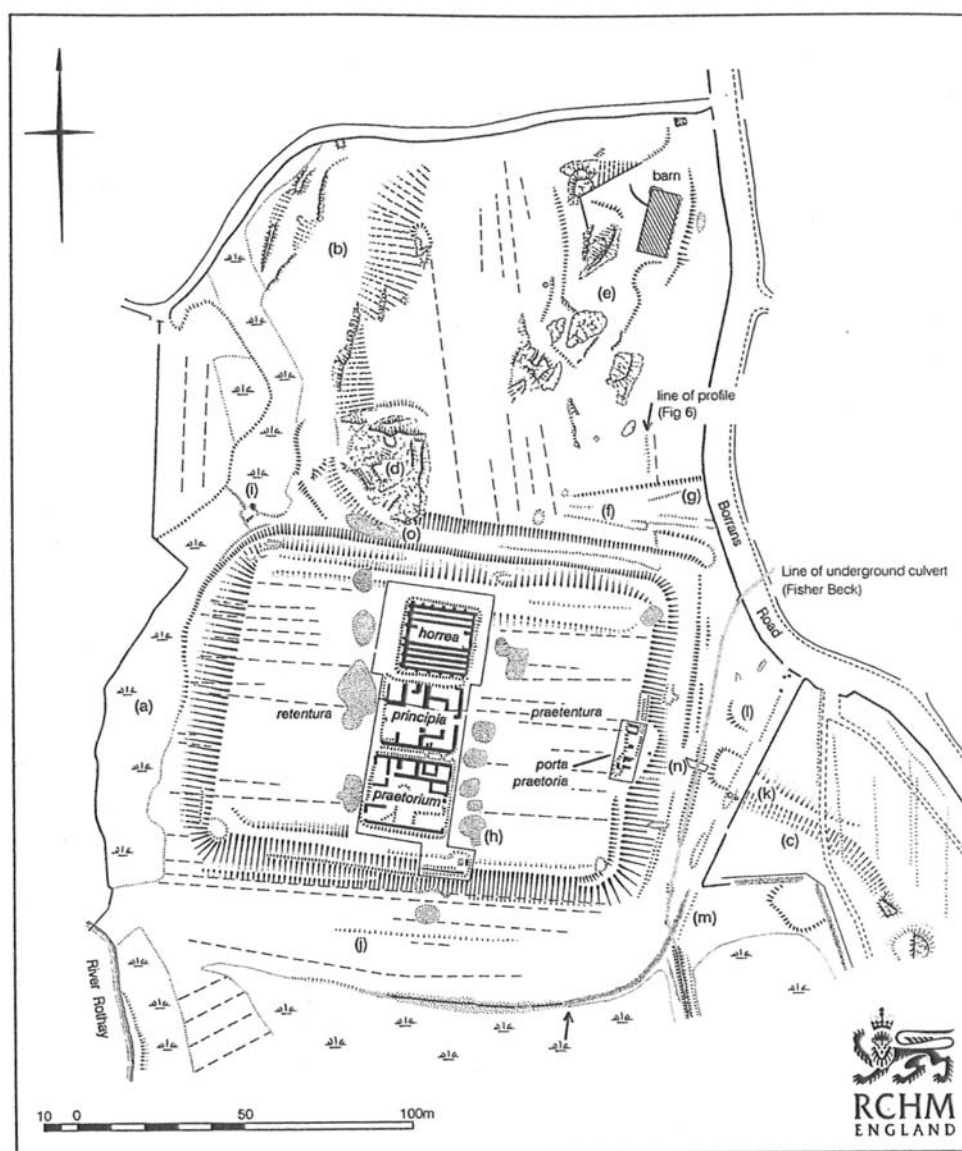


Plate 2: RCHME 1998 survey of Borrans Field

1.2.10 Evidence for the extramural settlement site around the fort has been discovered through several interventions, particularly on the east side and north side of the site in and around the area of Borrans Road. The earliest of these was a *corduroy* road found by Cowper in 1900 (Drury and Dunwell 2004). A corduroy road is one made by placing logs perpendicular to the direction of the road over a boggy area, and was particularly relevant to the area at the head of Windermere which is still poorly drained. Since then, numerous linear interventions, in the form of watching briefs have been carried out, mainly in the area to the north and east of the fort. Evidence suggests that the extramural settlement was abandoned before the end of the second century, probably in conjunction with the abandonment of the fort (*ibid*).

2. METHODOLOGY

2.1 PROJECT DESIGN

- 2.1.1 A project design was submitted by OA North (*Appendix 1*) to the National Trust. The project design was used as the basis for the survey, and the work was consistent with the relevant standards and procedures of English Heritage (English Heritage 2008) and the Institute for Archaeologists (IfA 2011), and generally accepted best practice.

2.2 GEOPHYSICAL SURVEY

- 2.2.1 **Magnetometer Survey:** the preferred geophysical technique in the detection of many archaeological remains is a magnetometer area survey, which is effective in locating 'positively magnetic' material, such as iron-based (or 'ferrous') features and objects, or those subjected to firing, such as kilns, hearths, and even the buried remains of brick walls. This technique is also widely used to locate more subtle magnetic features associated with settlement and funerary remains, such as boundary or enclosure ditches and pits or post-holes, which have been gradually infilled with more humic material. The breakdown of organic matter through micro-biotic activity leads to the humic material becoming rich in magnetic iron oxides when compared with the subsoil, allowing the features to be identified by the technique. In addition, variations in magnetic susceptibility between the topsoil, subsoil and bedrock have a localised effect on the Earth's magnetic field. This enables the detection of features, such as silted-up or backfilled pits, due to the fact that the topsoil has more magnetic properties than the subsoil or bedrock, resulting in a positive magnetic anomaly. Conversely, earthwork or embankment remains can also be identified with magnetometry as a 'negative' feature due to the action in creating the earthwork of depositing the relatively low magnetic subsoil on top of the more magnetic topsoil. In this way, magnetometry is a very efficient technique and is recommended in the first instance by English Heritage (2008) for such investigations.
- 2.2.2 **Magnetometry Equipment:** the strength of the present geomagnetic field in Great Britain is approximately 50,000nT (nanoTeslas). Most buried archaeological features usually result in very weak changes of less than 1nT to the magnetic field (Clark 1990, 65). The instrument used for this survey was a *Bartington* Grad 601-2 dual sensor fluxgate gradiometer, which has a sensitivity of 0.1nT when used in the 100nT range setting.
- 2.2.3 **Resistivity Survey:** the use of electrical resistance area survey is often seen as being complementary to magnetometry and is recommended by English Heritage where there is a strong presumption that buried structures or buildings are present that are not easily identifiable with magnetic methods. The technique requires injecting a small electric current into the ground via steel probes, and measuring the response with an earth resistance meter. The technique relies on the variable ability of the soil to resist an applied electrical current by the resistance meter from a pair of mobile probes to a corresponding pair of remote, static probes. The resulting resistance measurements (in ohms)

can be used identify buried features, which often have either a higher or lower resistance to the current than the background soil. Cut features that have been subsequently infilled, tend to be less resistant to the current flow and appear as low-resistance anomalies, whereas solid features such as structural remains tend to be more resistant to the current flow and appear as high-resistance anomalies. One of the main disadvantages of the technique, when compared with magnetometry, is that data collection over the same size of area is a much slower process.

- 2.2.4 **Resistivity Equipment:** the instruments used for this survey were a *Geoscan Research* RM85 Advanced resistance meter with PA20 frame and integral multiplexer and a *Geoscan Research* RM15-D Advanced resistance meter with PA20 frame system and MPX15 Multiplexer. Both the 0.5m single and 0.5m parallel twin modes were used. The 0.5m twin mode allows two parallel survey traverses to be collected simultaneously, the twin arrays being separated by 1m.
- 2.2.5 **Sampling Interval:** the survey area was divided into 30m x 30m grids. Magnetometry sampling was at 0.25m intervals, with inter-transect distances of 1m, equating to 3600 sample readings per grid. Resistivity sampling was at 1m intervals with inter-transect distances of 1m, equating to 900 sample readings per grid. Both surveys were carried out in 'zigzag' mode, with precautions to minimise any heading error during the magnetometry survey. In total, an area of 2.87ha was surveyed with magnetometry and 1.83ha was surveyed with resistivity (Fig 3). During the initial trial survey, an area of 1.9ha was surveyed with magnetometry, this was extended during the follow up work. All survey grid nodes were staked out with canes using a Leica 1200 series RTK GPS system. Survey guidelines and traverse canes were then staked out.
- 2.2.6 **Data Capture and Processing:** data were captured in the internal memories of the instruments and downloaded to a portable computer on-site and backed-up on to a USB drive. The individual grids were combined to produce an overall plan of the surveyed area, or 'composite'. The results were analysed and basic initial processing was carried out on-site using the software programme 'Terrasurveyor' by *DW Consulting*.
- 2.2.7 Final minimal processing of magnetometry raw data was undertaken off site in accordance with English Heritage guidelines (English Heritage 2008) to remove any instrument error or survey effects in order to enhance more subtle anomalies normally associated with archaeological features:
- Zero median traverse (ZMT) was applied to correct slight baseline shifts between adjacent survey lines;
 - The data were selectively 'de-staggered' where necessary, to remove any displacement caused by surveying in zigzag mode. This is sometimes required when surveys are carried out on boggy, wet, overgrown or steeply-sloped areas;
 - The data were de-spiked in order to remove random spikes. Random spikes are usually caused by erroneous small ferrous objects.

- 2.2.8 Final processing of the resistivity data was also undertaken in accordance with English Heritage guidelines (*ibid*):
- The data were de-spiked in order to remove high contact readings;
 - High pass filter was applied which removes variations in the background geological response.
 - The grids were periphery matched in order to correct for changes in the remote probes.
- 2.2.9 ***Presentation of the results and interpretation:*** the presentation of the data for the site involves a print-out of the minimally processed data as grey-scale plots (Figs 4 and 5). Anomalies have been identified, abstracted, interpreted and plotted onto Figures 6 and 7.

2.3 ARCHIVE

- 2.3.1 A full professional archive has been compiled in accordance with current IfA and English Heritage guidelines (English Heritage 1991). The paper and digital archive will be deposited with the National Trust on completion of the project. The project archive represents the collation and indexing of all the data and material gathered during the course of the project.
- 2.3.2 The deposition of a properly ordered and indexed project archive in an appropriate repository is considered an essential and integral element of all archaeological projects by the IfA in that organisation's code of conduct. OA North conforms to best practice in the preparation of project archives for long-term storage. OA North practice is to deposit the original record archive of projects with the appropriate repository.
- 2.3.3 The Arts and Humanities Data Service (AHDS) online database project *Online Access to index of Archaeological Investigations* (OASIS) will be completed as part of the archiving phase of the project.
- 2.3.4 The geophysical survey data will be archived with the Archaeology Data Service (ADS) in accordance with the guidelines published by the ADS (Schmidt 2002)

3. SURVEY RESULTS

3.1 GENERAL OBSERVATIONS

3.1.1 The magnetometry and resistivity surveys have produced complementary data of some complexity, there being responses in both data sets suggestive of below ground remains both inside and outside of the fort. In general, and as anticipated, the resistivity survey results provided clearer indication of surviving below ground structural remains within the fort than the magnetometry. The results of the magnetometry survey are largely consistent with those produced by the AML during the survey of 1989 (*Appendix 2*). This latter survey had been largely disregarded as it was felt that the large amount of magnetic disturbance within the interior of the fort limited the scope of the survey, and the report was limited to a brief letter and a small number of accompanying grey-scale and interpretation plots. Despite this, a number of linear responses were abstracted, many of which are visible in the present magnetometer survey (Fig 4). These were interpreted as internal unexcavated building structures and ditch anomalies. The *Via Pincipalis* was identified which, in common with the present survey, was visible as a 'quiet' area in the centre of the fort. The AML survey also identified a strong response to the north of the fort, which was interpreted as a possible external building. The present survey both duplicates and expands upon the survey carried out by the AML.

3.2 RESULTS

- 3.2.1 **Magnetometry:** the results of the magnetometry survey are plotted in Figures 4 and 6. In general, the data is *noisy*, particularly the area within the fort and along the east boundary of Borrans Field (which is probably due to the road). The fort is manifested as a rectangular, playing card-shaped area of magnetic noise in the southern half of Borrans Field. The outline of the fort can be seen in the grey-scale plot (Fig 4), its extent being comparable with the physical extents of the fort platform seen on the ground (Plate 1 Collingwood 1916; Plate 2 RCHME 1998; Fig 2 LiDAR plot).
- 3.2.2 There are several positively magnetic linear responses visible in the data, which are most noticeable at the north-west and south-east corners of the fort (Fig 4). The responses at the north-east corner of the fort coincide with the platform and may be evidence of ramparts in this area. The responses at the south-east corner are away from the platform and appear to be evidence of defence ditches. Other positively magnetic linear responses below the south-west corner of the fort platform are also probable evidence for defence ditches. There is, however, no evidence for ditches at the central southern side of the fort (Haverfield and Collingwood 1914).
- 3.2.3 Although the general outline of the fort is visible, individual internal features are more difficult to discern, due to the high level of magnetic noise present. This level of noise is most likely to be due to internal debris such as rubble, burnt or imported material when the platform was initially built up. There are, however, some linear responses suggestive of structural remains situated in

both the eastern and western halves of the fort (Fig 6). No clearly defined building outlines can be seen, however, and the presence of structures is speculative. Collingwood states that, although the central range (those visible on the site) of buildings were of stone construction, other buildings were of timber (Collingwood 1915). A strong magnetic response is present at the north-east corner turret, together with a response of lower amplitude in the south-west corner. The south-west corner turret was more clearly visible in the AML survey of 1989 (*Appendix 2*). All of the turrets were excavated by Collingwood (Collingwood 1915), which may have affected the nature of the responses.

- 3.2.4 In the centre of the fort, crossing from east to west on either side of the excavated central range, are two linear swathes of less noisy data that are approximately 5.3m wide. These appear to coincide with what may have been the '*Via Principalis*', the road that linked the *Principia* with the east gate and a similar gate on the west side. A high resistance linear response following the same route can be seen in the resistivity data (Figs 5 and 7). Interestingly, a negatively magnetic linear north/south response crosses the western part of the road and appears to be an earlier feature. The survey was extended into Borrans Park to the east in order to try to detect a postulated eastern route for the road out of the fort. In Borrans Park a strip of 'quiet' data is visible which coincides with a ridge highlighted on the RCHME survey of 1998 (RCHME 1998; Plate 2 (k)); this may be evidence for the line of the road passing through Borrans Park. Additionally, an area of magnetic enhancement to the north of this may be indicative of evidence for settlement.
- 3.2.5 Beyond the fort platform, the evidence for surviving below ground remains is difficult to abstract and there are large areas of strong magnetic disturbance, particularly on the east side of the survey area. There are several areas of lower amplitude magnetic disturbance, within which there are numerous discrete responses that form no discernible pattern. Responses such as these may either be due to natural geology or to settlement activity, and an exact interpretation is impossible to ascertain. There are, however, some obvious discrete and linear responses that may represent buried features. Several discrete responses forming a linear pattern cross the northern part of the survey area and appear to extend in a line on either side of an area of outcropping rock to the very northern edge of the site (Fig 7). To the left of a negatively magnetic linear response is a collection of positively magnetic discrete responses, that are suggestive of features with archaeological potential. Other discrete responses (highlighted on Fig 7) may also represent buried features associated with the fort.
- 3.2.6 To the north of the fort is a north/south-aligned linear response with a very strong halo. The shape of this is reminiscent of a building and there even appears to be evidence of internal divisions. However, the nature of the strong magnetic response is difficult to explain as the response do not have the characteristic of burning or industrial activity; the feature is fairly discrete and there is no evidence of any spread of magnetic material. The southern part of this was surveyed by AML and was interpreted as a possible external building. To the left of this feature are two curvi-linear, positively magnetic, responses that may not be associated with it.

- 3.2.7 **Resistivity:** the resistivity survey was carried out over a smaller area than the magnetometry (Fig 5), concentrating upon the fort itself. In many respects, the internal nature of the fort, as well as external earthworks, are more clearly visible in the resistivity data, and the interpretation of the results is relatively straight forward. Similar to the magnetometry survey results, the outline of the fort is visible as several high resistance linear responses (Fig 7); the east gate and the north-east turret are also clearly visible as a high resistance response with a central low resistance response. Some, but not all, of these responses align with linear responses seen within the magnetometry data (*Section 3.2.2*) (Fig 8).
- 3.2.8 Within the interior of the fort several high resistance linear responses are clearly visible that appear to suggest the presence of buried structural remains. These are mainly aligned north/south, although there are also some east/west examples. Some of these coincide with both positively and negatively magnetic responses that were abstracted from the magnetometry data; the best correlation is within the western half of the fort. The possible location of the '*Via Principalis*', as interpreted from the magnetometry results, is reinforced by the presence of an intermittent high resistance linear response in the same position. The high resistance response probably reflects that the road was metalled or compacted.
- 3.2.9 There are several discrete areas of high, medium-high and low resistance responses in the centre of the survey area adjacent to the post and wire fence surrounding the excavated area. These are potentially due to the edge of the buried parts of the central range of excavated buildings extending beyond the fence slightly, although they could in part be attributable to the soil heaps from Collingwood's excavations. There are other discrete high resistance responses within the interior of the fort which probably represent fort structures. Other high resistance responses can be seen to be present around the south and east gates and were probably structural elements associated with these buildings.
- 3.2.10 Outside of the fort, the most visible responses appear to be associated with the outer defences of the fort. There are a series of very high and very low resistance linear responses following a course up the eastern side of the fort platform before turning through ninety degrees at the north east corner. The north/south responses seem to represent the defences of the later phase of fort. The northernmost east/west orientated anomaly in the north-eastern part of the data set corresponds with a line of the defences of the conjectured early fort (Collingwood 1916). However, there is some uncertainty if this is the early fort as this ditch may in fact be secondary defences for the second fort (RCHME 1998). Interestingly, the strong responses at the north-east corner are truncated at an acute angle suggesting that parts of the defences have been removed. There are some weaker responses continuing toward the outcropping rock at the north-western corner of the survey area that may represent remnants of the defences, although they are somewhat weak. A crescent-shaped medium-high resistance response, just outside the south-west corner of the fort, corresponds with a positively magnetic linear response and appears to reflect defence features in this area.
- 3.2.11 Two discrete high resistance responses at the extreme eastern edge of the survey area were probably evidence for a building platform, identified during

the RCHME survey in 1998 (RCHME 1998) (l and k, Plate 2), and a postulated *agger*, which is a raised and cambered embankment that most typically carries a road.

- 3.2.12 One of the high resistance linear responses extends up the eastern side of the fort platform and corresponds with a culverted stream (Fisher Beck) that runs below the site. This high resistance response is probably due to the structural capping of the culvert.

4. CONCLUSIONS

4.1 DISCUSSION

- 4.1.1 The geophysical survey has identified a number of responses that represent features associated with the Roman Fort at Ambleside. While both techniques have identified features of archaeological potential, the resistivity survey was more successful in outlining the internal layout of the fort. On this particular site, features such as buried structural remains, banks and ditches have been more easily identified using the resistance technique. The magnetometry survey was affected by large areas of magnetic debris/disturbance, particularly within the interior of the fort, and this is not surprising given how such forts developed over time, with potentially several phases of demolition and rebuilding, as well as periods of burning and possibly industrial processing taking place. This has, therefore, made the identification of features more difficult.
- 4.1.2 Despite this, the outline of the fort is visible in the magnetometer data and some internal structural elements are visible within both data sets (Figs 8-10), particularly the '*Via Principalis*' and two of the corner turrets. Some of the defences and ramparts are also visible in both data sets. Externally, the outer defences are particularly clear in the resistivity data, especially so at the north-east corner. Settlement evidence may be present, particularly in the field to the north of the fort beyond the outcropping rock (Fig 10), but the nature of the responses makes interpretation difficult and conjectural.
- 4.1.3 A feature of particular interest was the linear magnetic response with a wide halo just to the north of the fort platform. The general appearance of the feature appears to suggest it is a buried structure, but the nature of the response is difficult to explain as it does not have the magnetic characteristics of burning or industrial activity. The exact cause for this response may only properly be explained by archaeological intervention.
- 4.1.4 There is potential evidence for the route of the road out of the fort and through Borrans Park. There may also be evidence for settlement in this area, although the data is complex and there is no obvious pattern.

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5.2 ONLINE SOURCES

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Land Information System www.landis.org.uk

APPENDIX 1: PROJECT DESIGN

1. INTRODUCTION

1.1 PROJECT BACKGROUND

- 1.1.1 Jamie Lund from National Trust has requested a project design for a proposed programme of geophysical survey to be carried out at Ambleside Roman Fort, Ambleside, Cumbria (NY 372 034). Funding for the survey has been provided by a donor and the survey will be carried out with the assistance of volunteers. The survey will combine the two complementary techniques of magnetometry and earth resistance. National Trust has requested proposals for an initial survey over the area of the fort field, of approximately 6.13ha in area, of which between 3ha and 3.5ha appears to be suitable for survey. Further adjacent areas, including Borrans Park to the east and a meadow to the north may be surveyed at a later date.

2. METHOD STATEMENT

2.1 THE PROJECT TEAM

- 2.1.1 The project will be under the management of **Jamie Quartermaine** (OA North senior project manager) to whom all correspondence should be addressed. Jamie has been recording industrial landscapes across the north-west since 1986 both as project officer and as project manager.

- 2.1.2 The geophysical survey would be undertaken by **Karl Taylor BSc** (OA North Project Officer). Karl is a very experienced geophysicist, and has worked as a project manager for Stratascan and Phase Site Investigations, and also has undertaken numerous geophysical surveys for Archaeological Research Services and Oxford Archaeology North. He is presently working again for OA North.

2.2 GEOPHYSICAL SURVEY

- 2.2.1 **Introduction:** the most commonly used geophysical survey techniques for the location of many archaeological remains are magnetic and electrical resistance. These allow below-ground remains to be located in a non-intrusive manner, and may be applied to the same site as they produce complementary results. However, the results are very much dependent upon a number of variables which vary from site to site but are generally based on the objectives of the survey, as set out in the project brief. There are also external influencing factors including the local geographical positioning of the site and topographic features, current and past land use, the solid and drift geology, and available resources such as time and budget. .

- 2.2.2 **Magnetic Survey:** magnetic survey (magnetometry) using a gradiometer is the preferred technique for geophysical survey owing to its ability to survey large areas relatively quickly and is, therefore, one of the most cost effective. Consequently, magnetometry is a very efficient technique and is recommended in the first instance by the English Heritage Guidelines (2008) for such investigations.

- 2.2.3 Magnetometry will usually locate 'positively magnetic' material such as iron-based features and objects, or those subjected to firing such as kilns, hearths, and even the buried remains of brick walls. Therefore, this technique is suitable in the detection of features associated with industrial activity. This technique can also be widely used to locate the more subtle magnetic features associated with settlement and funerary remains, such as boundary or enclosure ditches and pits or postholes, which have been gradually infilled with more humic material. The breakdown of organic matter through microbiotic activity leads to the humic material becoming rich in magnetic iron oxides when compared with the subsoil, allowing the features to be identified. Conversely, earthwork or embankment remains can also be identified with magnetometry as a 'negative' feature due to the action in creating the earthwork of upturning the relatively low magnetic subsoil on to the more magnetic topsoil. Magnetometry is classed as a passive technique as it relies on measuring the physical attributes, or the magnetic field, of features that exist in the absence of a measuring device, such as a kiln or ferrous object (Schmidt 2001, 6).

- 2.2.4 The main drawback to magnetic surveys is that some non-thermoremnant features, such as stone foundations, or those features with magnetic susceptibility levels similar to those of the background (particularly in areas where the parent material of the topsoil has very low magnetic susceptibility levels) will fail to be seen in the magnetic survey results. Therefore, a complementary or more suitable technique, such as an earth resistance survey, should be considered in addition.
- 2.2.5 **Resistivity Survey:** this technique is classed as an active technique as it requires physically injecting a current into the ground and measuring the response (*ibid*). An earth resistance meter relies on the properties of the moisture retained within the soil to pass an electrical current through the ground from a pair of mobile probes, mounted on a frame, to a pair of remote probes. The resistance is measured between the probes and can identify buried remains when compared to the background resistance. Cut features that have been subsequently infilled tend to be more moisture retentive and thereby less resistant to the current. These features manifest as low resistance anomalies. Structural remains or buried megaliths are more resistant to the current flow and are seen as high resistance features.
- 2.2.6 Resistivity surveys are slower compared to magnetometry and much smaller areas are able to be covered in the same time scales, so in this instance, targeted resistance will be carried out over specific areas of interest identified by the magnetometry survey.
- 2.2.7 **Method Statement:** in the first instance, a one day magnetometer survey area will be staked out using GPS and carried out with magnetometry over the surveyable area of the fort. Approximately 2ha can be surveyed in one day depending on the ground conditions. This will be carried out by OA North prior to any involvement with volunteers in order to acquire and process the data set and assess the suitability of the technique. Should the technique prove suitable, the remaining areas (up to approximately 3 - 3.5ha) will be surveyed. Following this, the data will be assessed and specific areas will then be targeted with resistance survey which will be carried out with the assistance and involvement from volunteers. The volunteers will have opportunity to see the processed magnetic data prior to carrying out the targeted resistance survey and the reasoning behind the areas chosen for targeted resistance will be explained. The amount of resistance survey able to be carried out in a day with volunteers is approximately 0.2ha depending on ground conditions and number of volunteers, this could be less if a large number of volunteers were to take part.
- 2.2.8 Previous experience in carrying out surveys with volunteers shows that the resistance technique is the easiest to carry out by people with little or no experience. The volunteers do not need to wear non-magnetic clothing and the method of collection allows for easy transition of volunteers during survey if needed.
- 2.2.9 The detailed magnetic and targeted resistance survey will be carried out using a Bartington Grad601-2 gradiometer and a Geoscan RM15 resistance meter with a single PA5 twin probe array; both of these instruments have internal automatic data loggers. Data will be collected in zig-zag mode over 30m by 30m grids, the magnetic data being collected at 0.25m intervals on profiles 1m apart (3600 readings per grid) whilst the resistance survey data will be collected at 1m intervals on profiles 1m apart (900 readings per grid).
- 2.2.10 The survey grid nodes will be staked out and surveyed using either the survey grade GPS system or total station to Ordnance Survey co-ordinates to at least 0.05m accuracy. Bamboo canes will be placed at grid node points and survey ropes and canes will be used to mark out the survey traverses.
- 2.2.11 All data will be downloaded immediately following collection using specialist survey software (*Archaeosurveyor*) and will be minimally processed on site where applicable. Raster images will be exported, usually in .png or .jpg format for presentation and dissemination. These images will be imported into CAD software and overlain on a geo-referenced base plan. An interpretation of the anomalies will be presented in CAD and a non-technical summary and discussion of the results will be included in a report which will accompany the interpretation.
- 2.2.12 During the course of the survey data will be downloaded on site at suitable intervals and the process will be demonstrated to all interested volunteers, following the above methodology. Volunteers will then be given the opportunity to download and process data themselves should they wish and if time permits.

2.2.13 The survey will be carried out in accordance with English Heritage guidelines, 'Geophysical Survey in Archaeological Field Evaluation', 2008 and Institute for Archaeologists standards, 'Standard and Guidance for archaeological geophysical survey', 2010, a copy of which will be made available on site.

2.3 REPORT

2.3.1 **Reporting:** the report will include the results of the survey, along with a historical development of the study area. The report will present, summarise, and interpret the results of the programme, and will include a full index of archaeological features identified in the course of the project. The reports will consist of an acknowledgements statement, lists of contents, summary, introduction summarising the brief and project design and any agreed departures from them. The report will also include sections on the following:

- Historical and archaeological background
- Methodology
- Survey Results, incorporating a description of the extant remains and the geophysics data
- Index to the archive
- Bibliography
- Copies of project brief and project design

2.4.2 The report will incorporate appropriate illustrations reduced to an appropriate scale (1:1000). The site mapping will be based upon the CAD base. The report will be accompanied by photographs and historic illustrations illustrating the principal elements of the landscape. The report illustrations will include the following:

- Location Plan
- Outline and extent of survey areas
- Plot of minimally processed magnetic survey results
- Plot of minimally processed resistance survey results
- Interpretation plot of magnetic survey results
- Interpretation plot of resistance survey results
- Combined plot of both magnetic and resistance survey results

2.4.3 **Editing and submission:** the report will be subject to the OA North's stringent editing procedure and then a draft will be submitted to National Trust for consultation.

2.4.4 **Output:** two hard and one digital copies and of the full report will be submitted to the National Trust. Each report will be illustrated with plans,

2.4.5 **Publication:** a summary report of the results will be submitted to a regional journal, and information from the project will be fed into the OASIS project (On-line Access to Index of Archaeological Investigation).

2.5 PROJECT MANAGEMENT

2.5.1 **Timing:** it is anticipated that the project will commence on Monday 18th March and will run for approximately 5 days depending upon the amount of survey carried out.

3. OTHER MATTERS

3.1 ACCESS

3.1.1 It is assumed that National Trust will obtain access to undertake the survey from land owners and tenants.

3.2 HEALTH AND SAFETY

- 3.2.1 Full regard will, of course, be given to all constraints (services) during the excavation, as well as to all Health and Safety considerations. The OA North Health and Safety Statement conforms to all the provisions of the SCAUM (Standing Conference of Unit Managers) Health and Safety manual, as well as the OA Health and Safety Statement. Risk assessments are undertaken as a matter of course for all projects, and will anticipate the potential hazards arising from the project.

3.3 INSURANCE

- 3.3.1 The insurance in respect of claims for personal injury to or the death of any person under a contract of service with the Unit and arising in the course of such person's employment shall comply with the employers' liability (Compulsory Insurance) Act 1969 and any statutory orders made there under. OA carries an appropriate level of insurance for covering liabilities on major projects. These are currently Employers Liability Insurance (£10,000,000 any one occurrence), Public Liability Insurance (£10,000,000 any one occurrence), Professional Indemnity Insurance (£5,000,000 any one claim and in all) and Contractors All Risks Insurance (£1,500,000).

APPENDIX 2: ANCIENT MONUMENTS LABORATORY (AML) GEOPHYSICAL SURVEY REPORT



English Heritage

Fortress House 23 Savile Row London W1X 1AB Telephone 071-973 3000 Fax 071-973 3001

Philip Claris,
National Trust,
Spitalgate Lane,
Cirencester,
GLOS GL7 2DE

15th January 1991

Dear Philip,

AML GEOPHYSICAL SURVEY AT AMBLESIDE ROMAN FORT, JULY 1989

David Sherlock has asked me to send you copies of our results from this survey. Although a formal AML Report has not been compiled, I am able to enclose preliminary plots and plans:

- 1) location plan of our survey grid (1:2500).
- 2) a grey-tone computer plot of the magnetometer data (1:1000).
- 3) a computer-drawn trace-plot of the same data (1:500).
- 4) the grey-tone plot with some (possibly) significant features coloured in.

In the time available to us, we were only able to manage magnetometer coverage. Ideally, a thorough resistivity survey would also be required but we have, so far, been unable to find time for this.

The magnetometer results are disappointing. Although archaeological disturbance is widespread, it is difficult to distinguish any patterns. The magnetic activity is most effectively seen on the trace plot, whilst whatever patterns are visible are perhaps best identified on the grey-tone plot. In each case the outline of the fort is scarcely distinguishable, but magnetic interference is noticeably increased in its interior. Much of this latter activity is probably the response to magnetic stones in the Roman foundations, and generally scattered about. In places this magnetic disturbance resolves itself into a rectilinear pattern, visible on the grey-tone plot, but this is nowhere very clear.

cont/

Results from areas outside the fort are similarly unclear, but there are anomalies which could be archaeological. I have indicated some of these in colour on a copy of the grey-tone plot. Of interest is a general area of activity south of the fort which could well be archaeological (eg occupation), but absolutely lacks any pattern. To the west of the fort there are extremely weak linear anomalies which might be the ditches of a second fort. To the north, amongst a scatter of possibly significant anomalies, is a zone of strong disturbance which could be modern, geological or Roman (industrial or a structure made of magnetic igneous/metamorphic stones).

As you can now see, the survey is not particularly helpful and the above comments are necessarily non-committal. We have foreborne writing them up formally in the hope that one day we shall be able to return to provide equivalent resistivity coverage. The latter might well be more informative, and the two sets of data, together, should complement and enlarge upon each other.

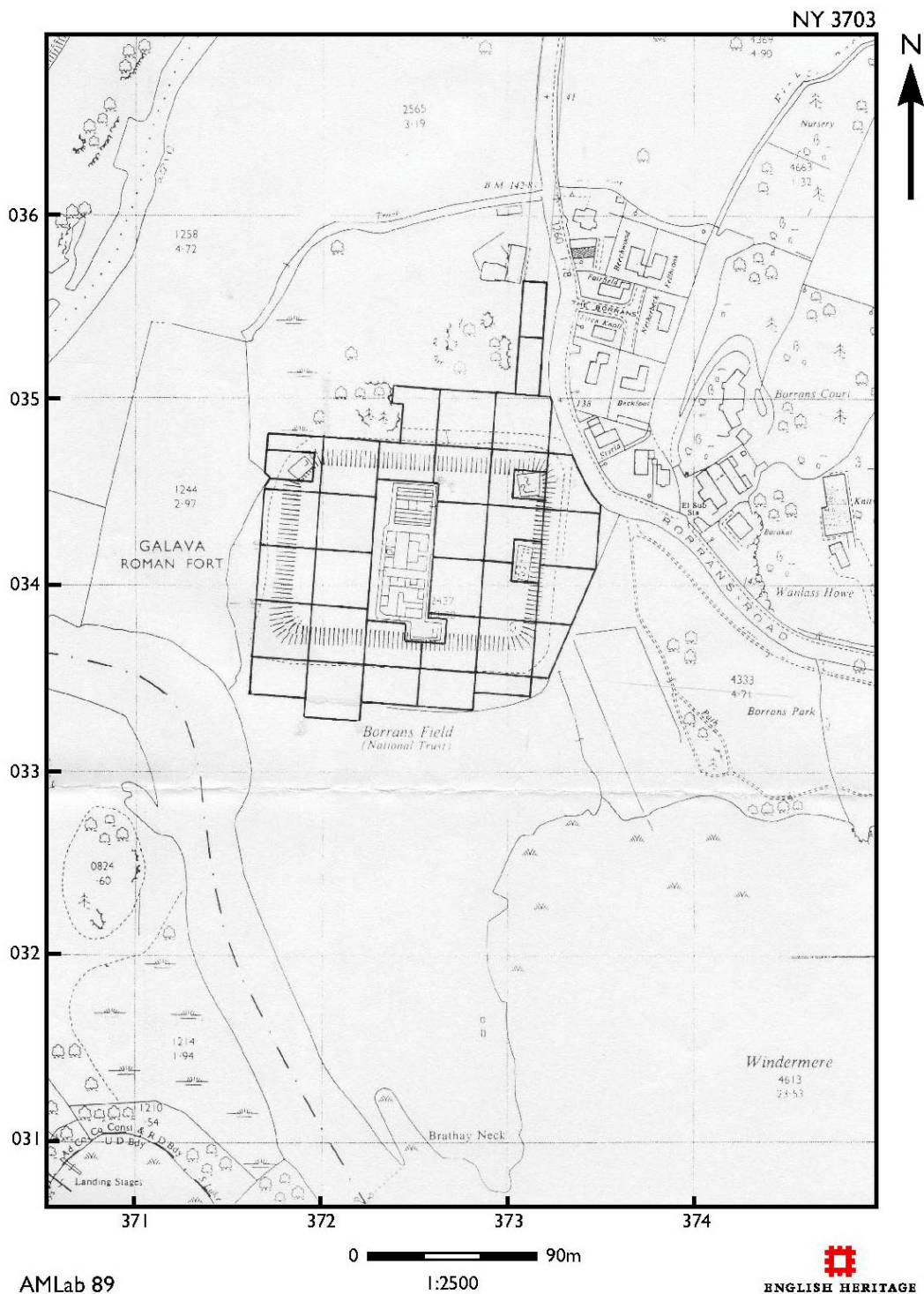
In the meantime I hope this is of some help, and please let me know if you have any particular queries.

With best wishes,

A. David.
Archaeometry Section
Ancient Monuments Laboratory

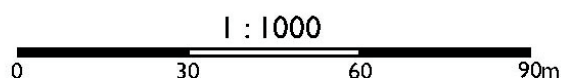
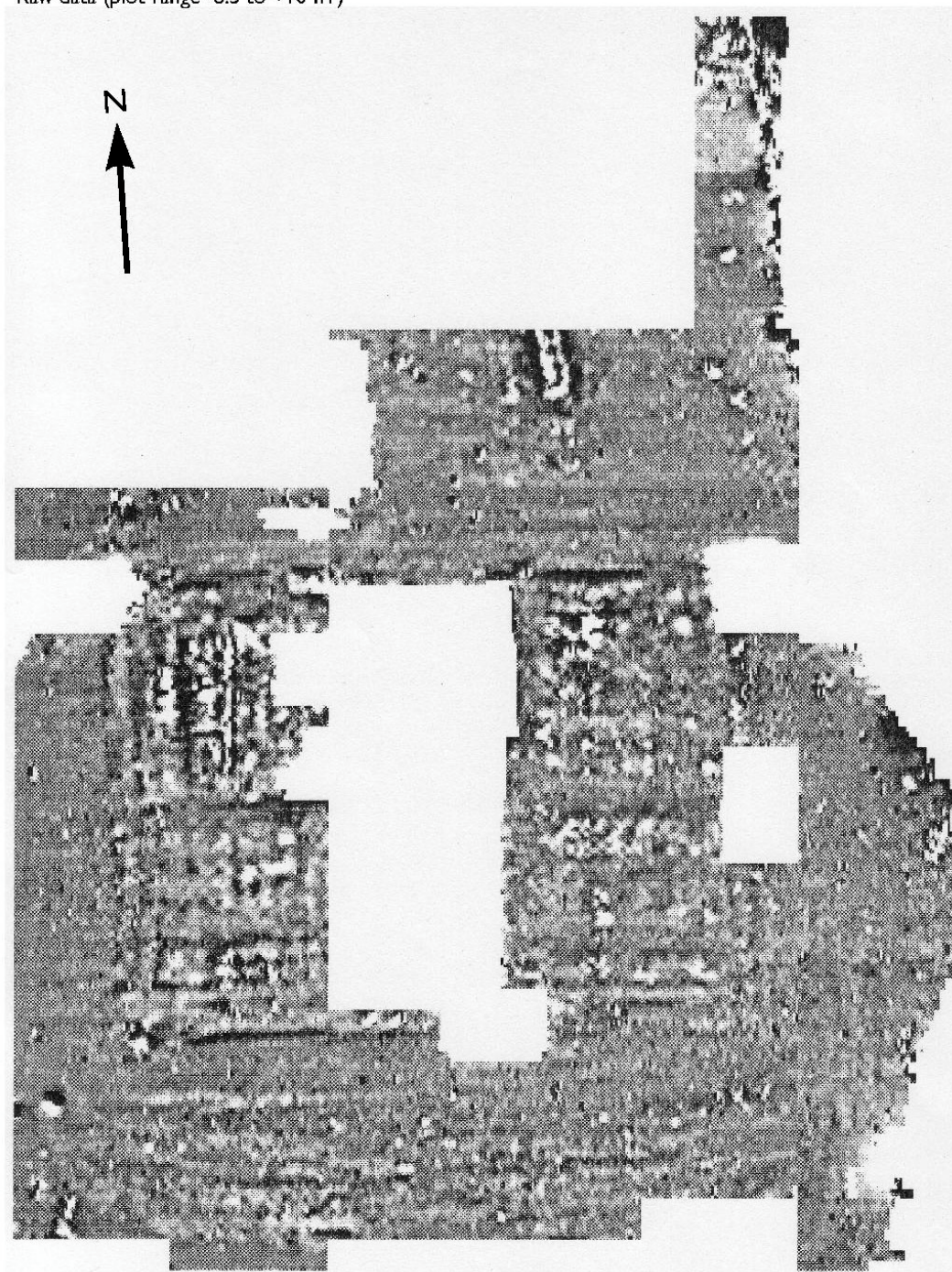
cc D Sherlock

AMBLESIDE ROMAN FORT, CUMBRIA Location of magnetometer survey, July 1989



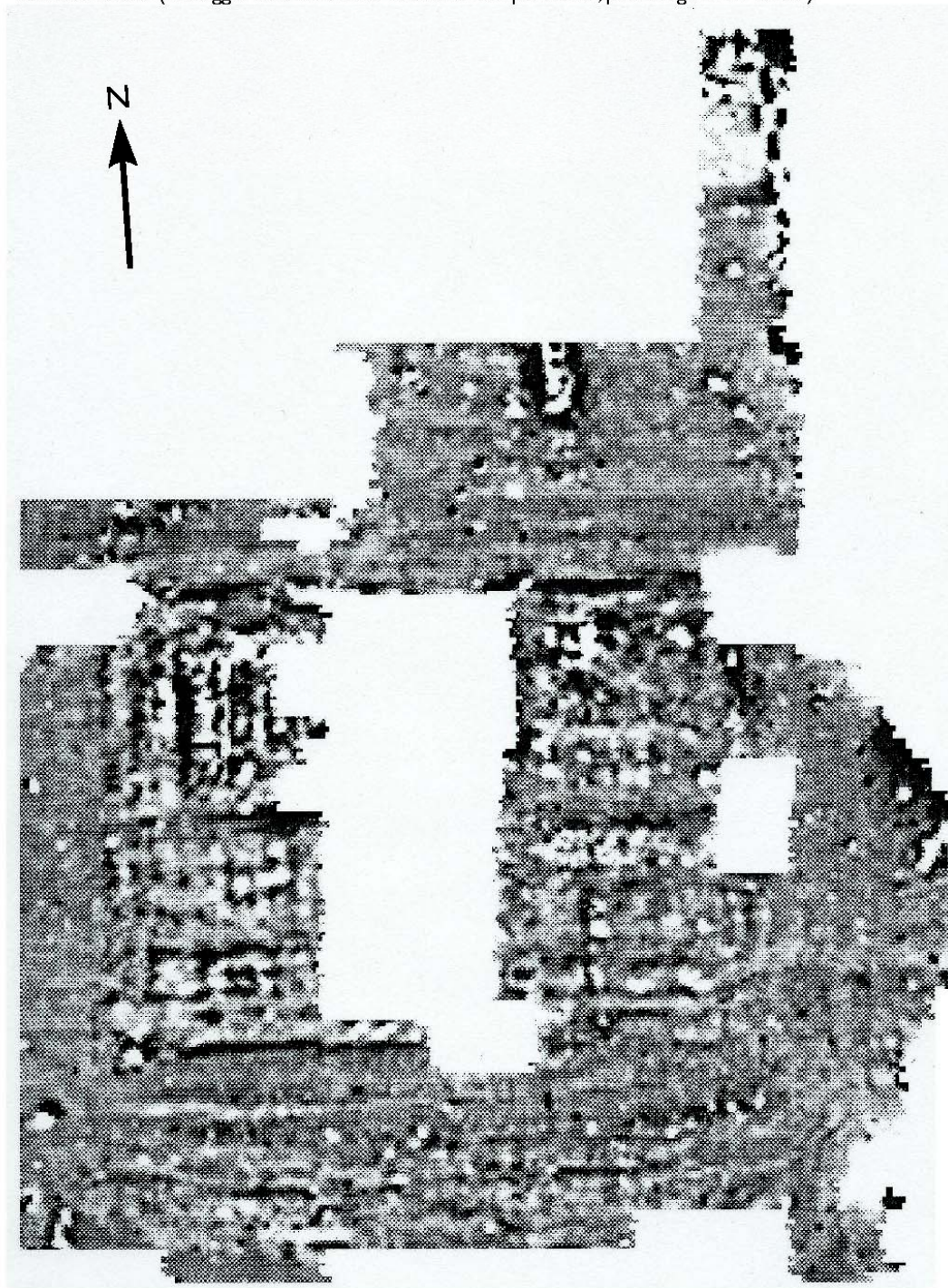
AMBLESIDE ROMAN FORT (GALAVA), CUMBRIA Fluxgate gradiometer survey, July 1989

Raw data (plot range -8.5 to +10 nT)



AMBLESIDE ROMAN FORT (GALAVA), CUMBRIA Fluxgate gradiometer survey, July 1989

Processed data (destagger and 1m radius Gaussian low-pass filter; plot range -5 to +5 nT)



AMBLESIDE ROMAN FORT (GALAVA), CUMBRIA Fluxgate gradiometer survey, July 1989

Raw data (plot range -8.5 to +10 nT)



0 30 60 90m

ILLUSTRATIONS

LIST OF FIGURES

Figure 1: Location Map

Figure 2: Geophysical survey areas superimposed on the LiDAR data

Figure 3: Extent of area surveyed by geophysical survey

Figure 4: Grey-scale plot of magnetometer survey

Figure 5: Grey-scale plot of the resistance survey

Figure 6: Interpretation plot of the magnetometer survey

Figure 7: Interpretation plot of the resistance survey

Figure 8: Combined Interpretation plot of the magnetometer and resistance survey

Figure 9: Combined Interpretation plot superimposed on the RCHME 1998 survey

Figure 10: Combined Interpretation plot superimposed onto the LiDAR data

LIST OF PLATES

Plate 1: Plan of the two Roman Forts (after Collingwood 1916)

Plate 2: RCHME 1998 survey of Borrans Field

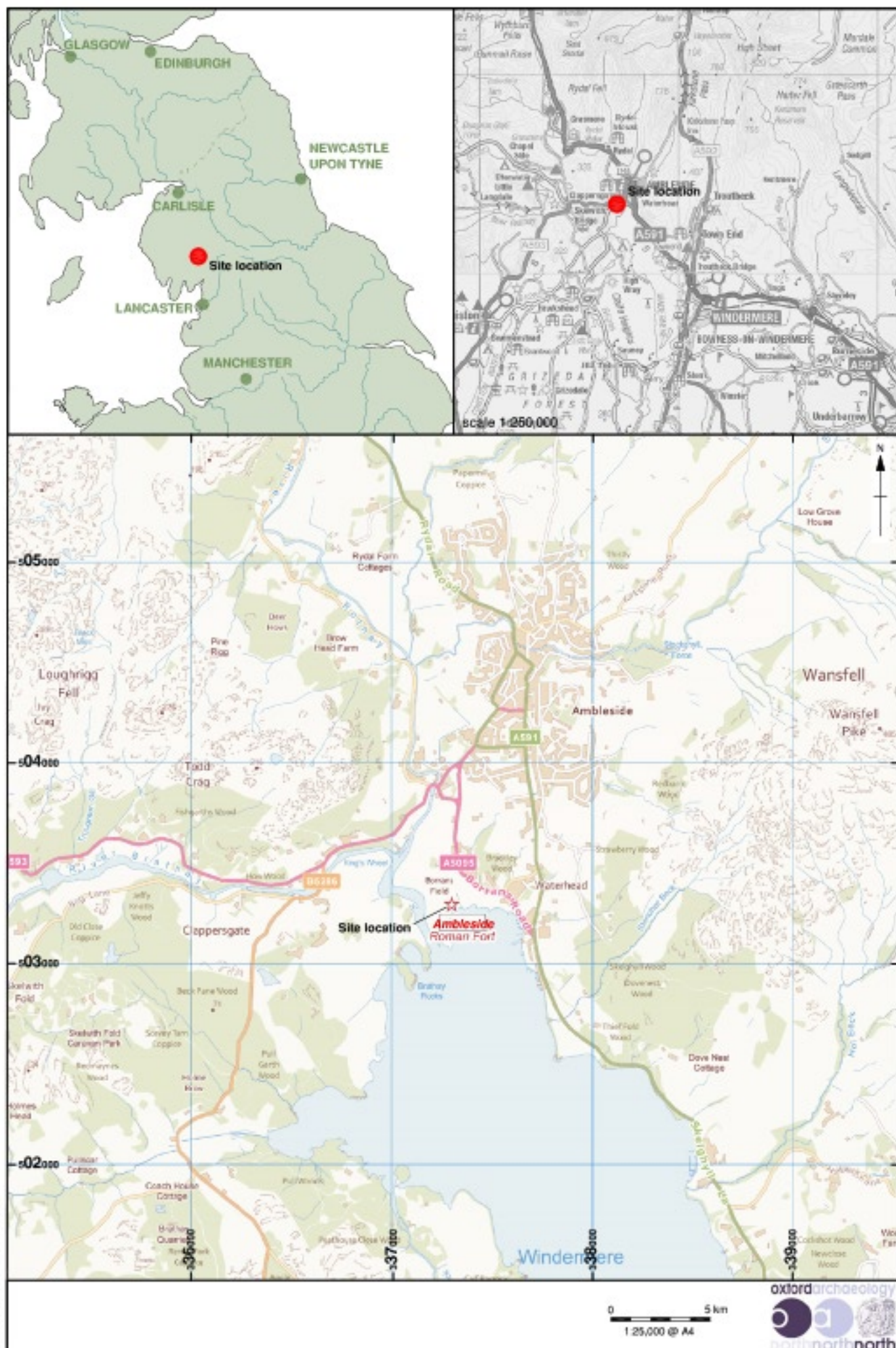


Figure 1: Site location

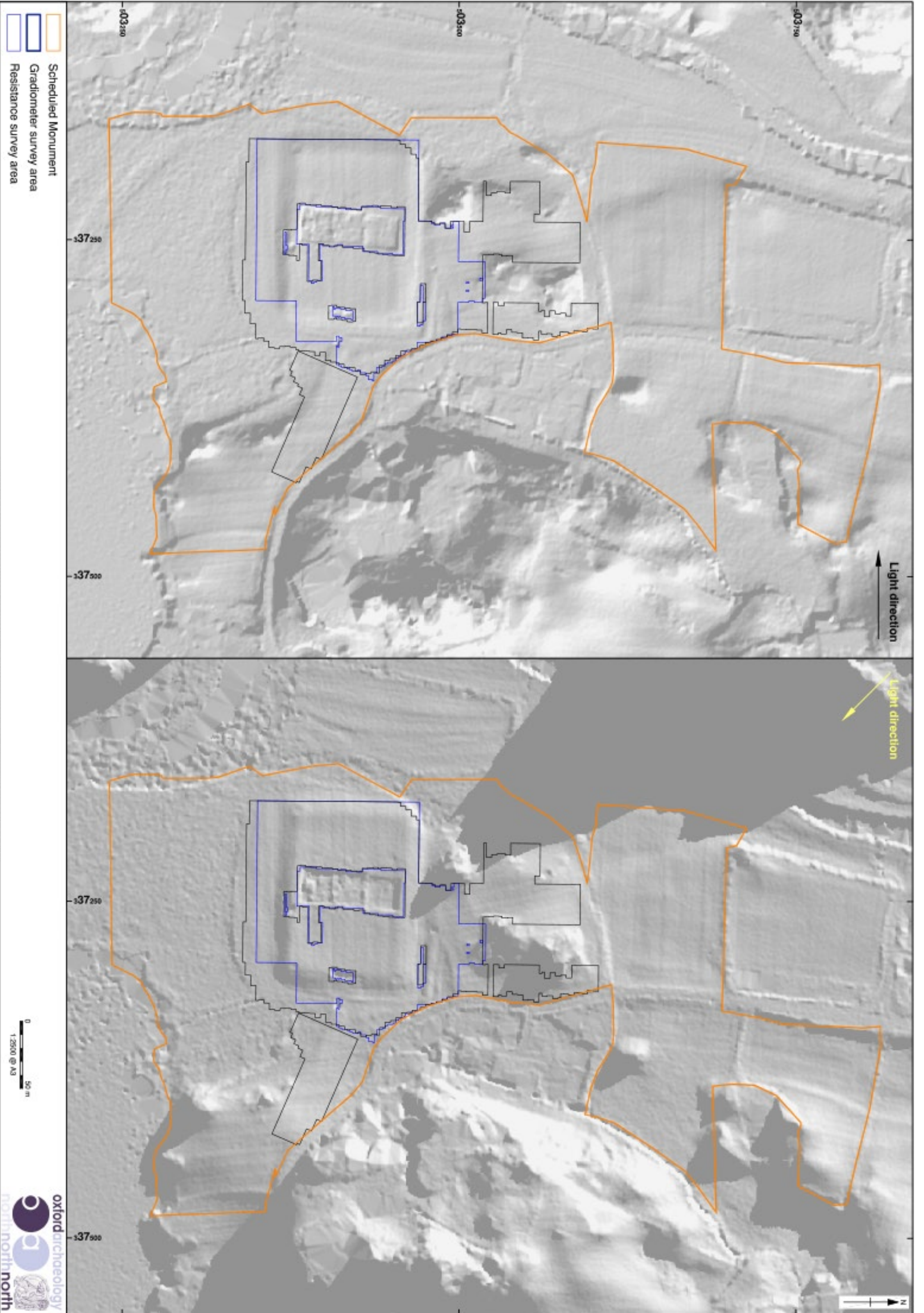
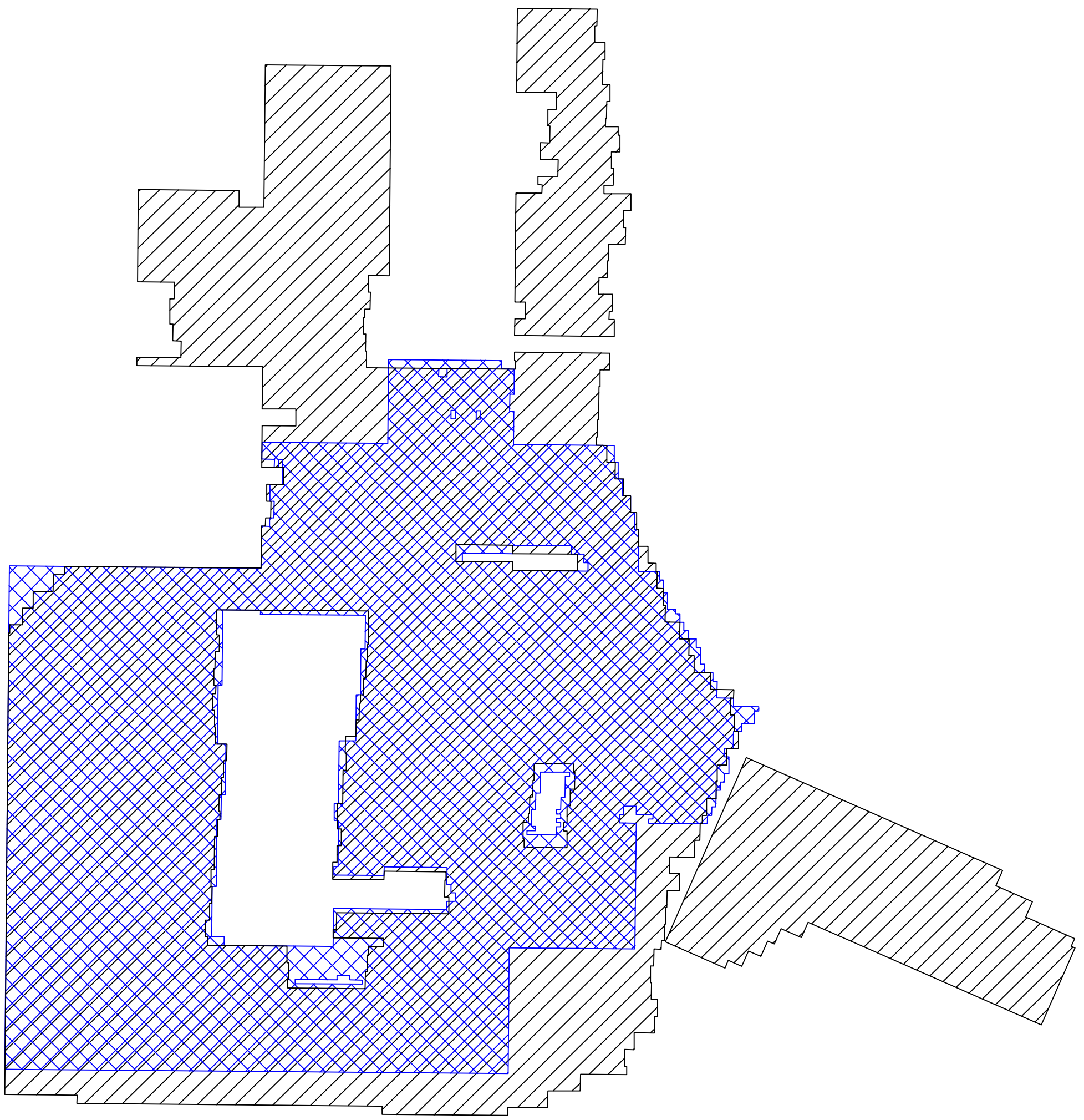


Figure 2: Geophysical survey areas superimposed upon the LiDAR data





503600

503400



37200

37400

-  Gradiometer survey area
-  Resistance survey area

0 25 m
1:1000 @ A3



Figure 3: Extent of area surveyed by geophysical survey

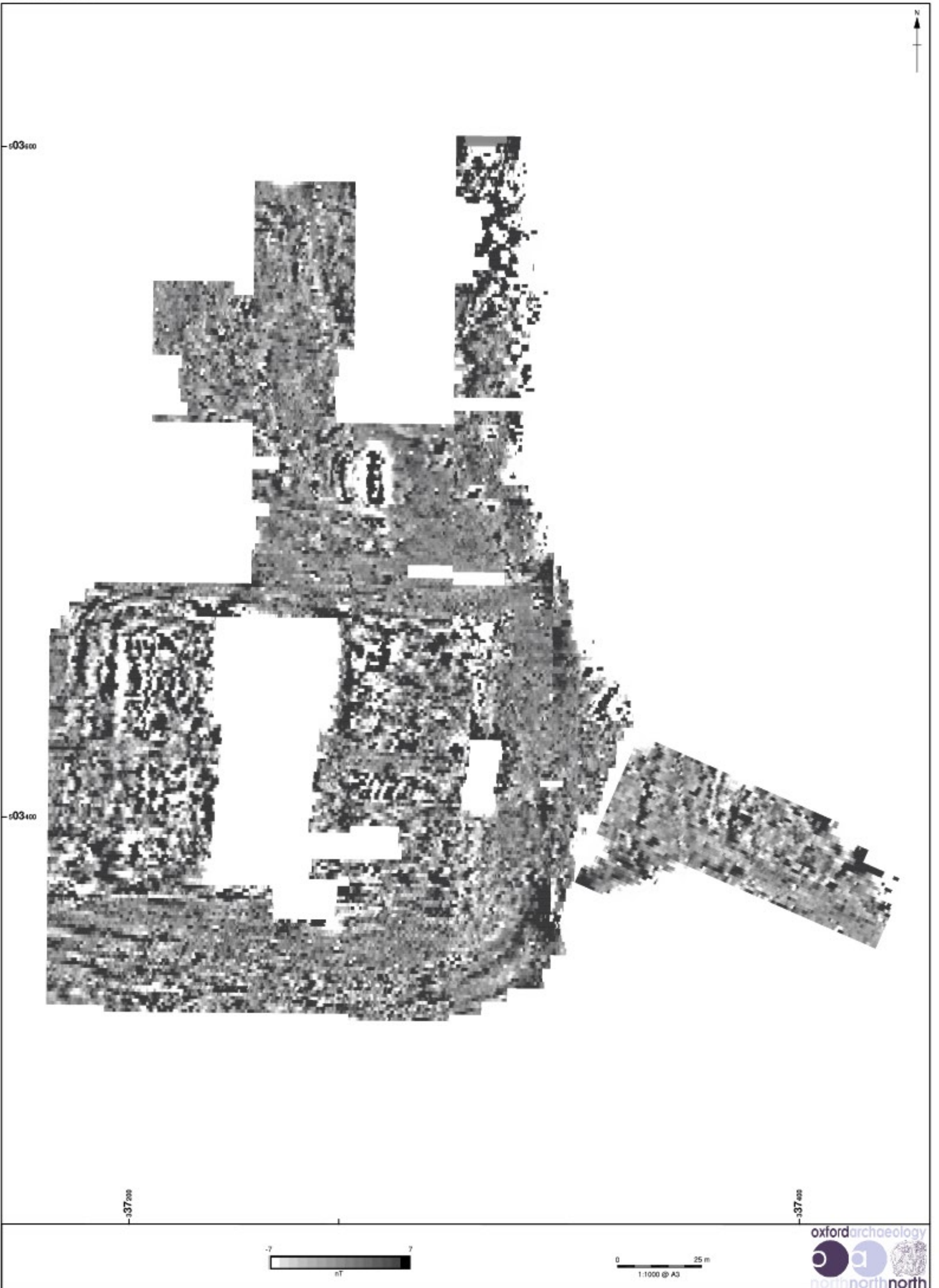
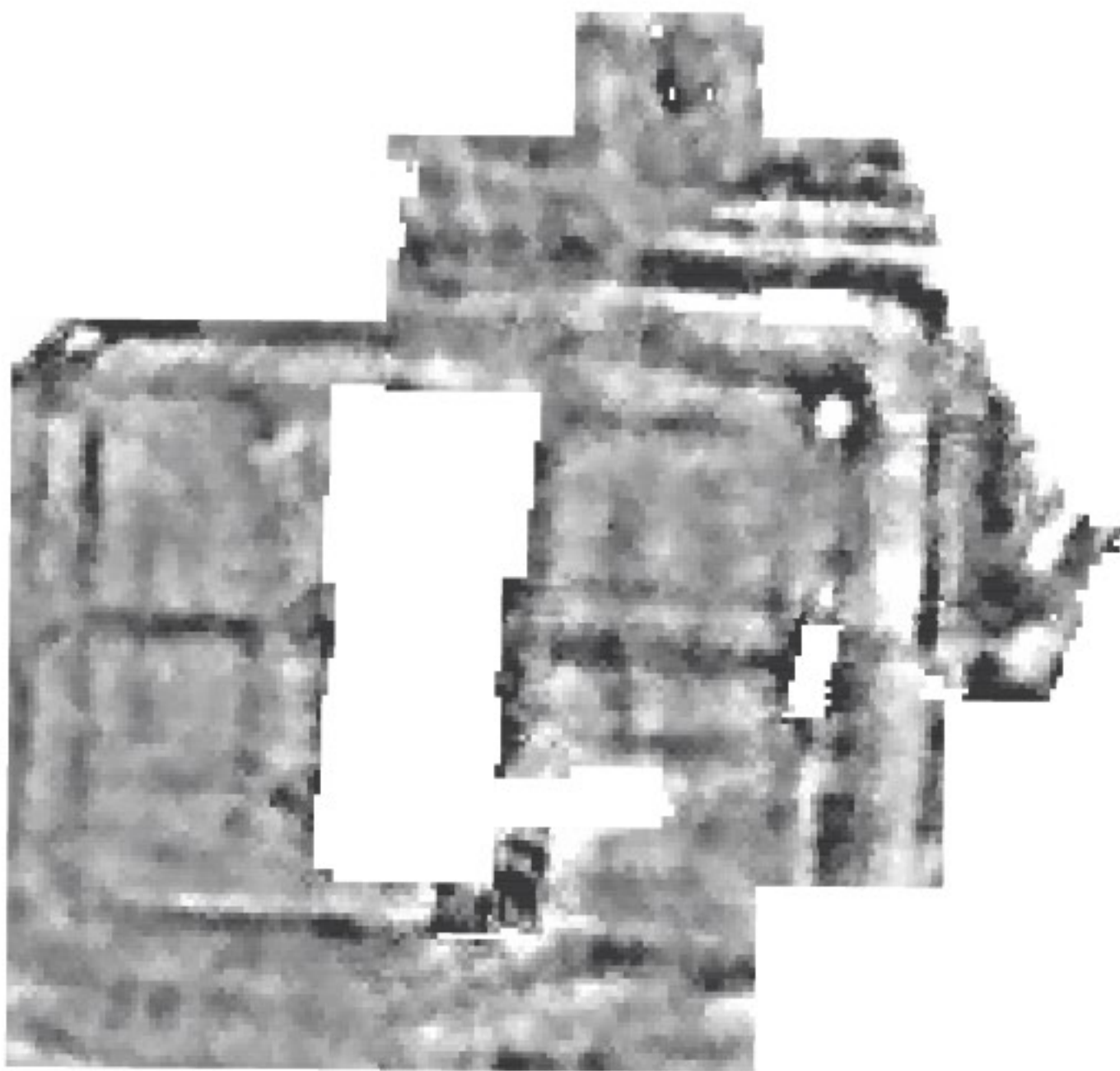


Figure 4: Grey-scale plot of the magnetometer survey



03400

03400



037000

037000

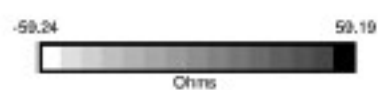


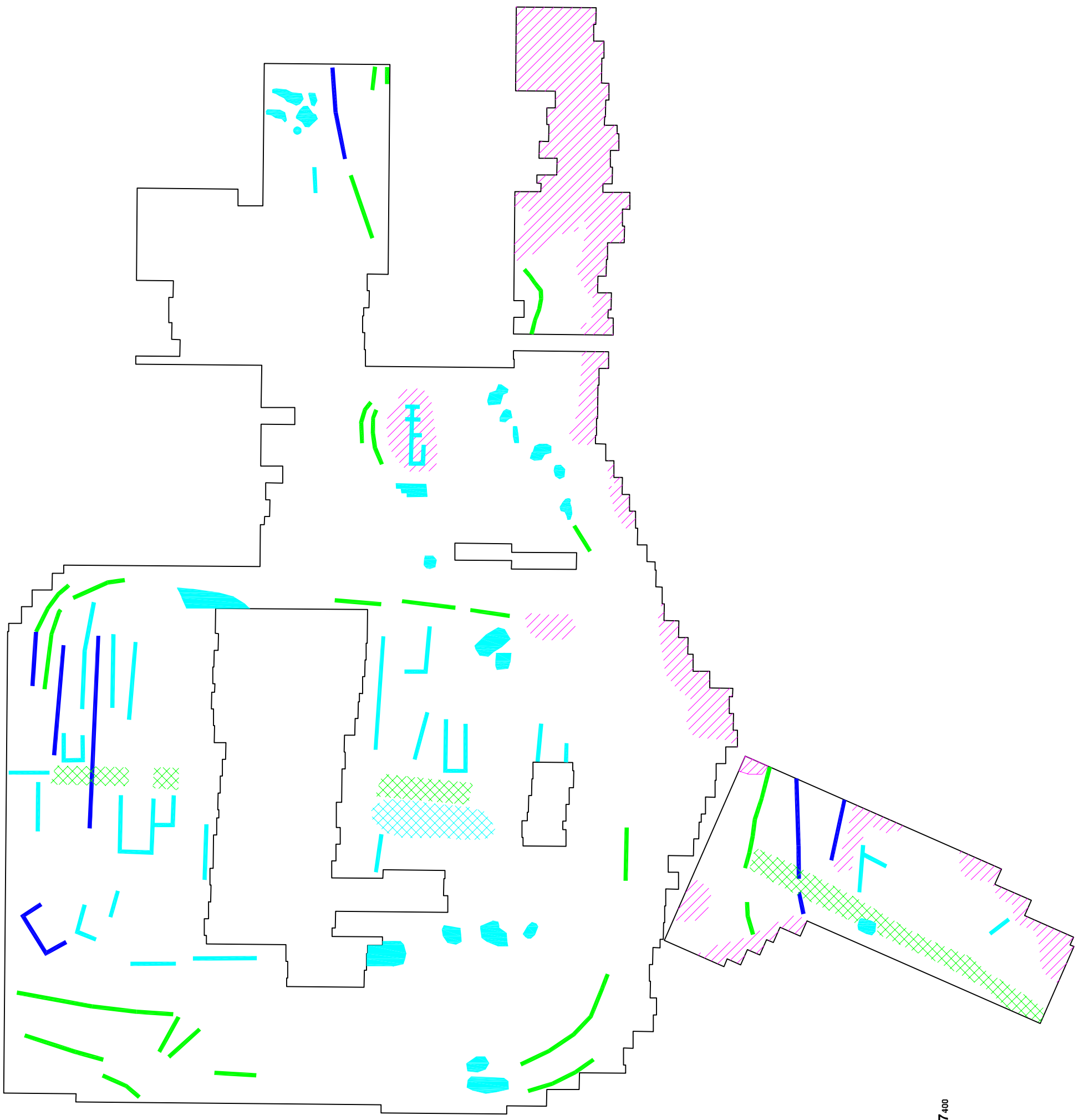
Figure 5: Grey-scale plot of the resistance survey








503600

503400

337200

337400



-  Magnetic disturbance - ferrous or thermo-remnant material
-  Discrete Magnetic response - possible archaeological features
-  Linear magnetic responses-remains of structural features
-  Area of magnetic debris - remains of structure
-  Linear magnetic responses - probable cut features
-  Linear negatively magnetic responses
-  Magnetically 'quiet' area - possible roadway or 'Via Principalis'

0 25 m
1:1000 @ A3

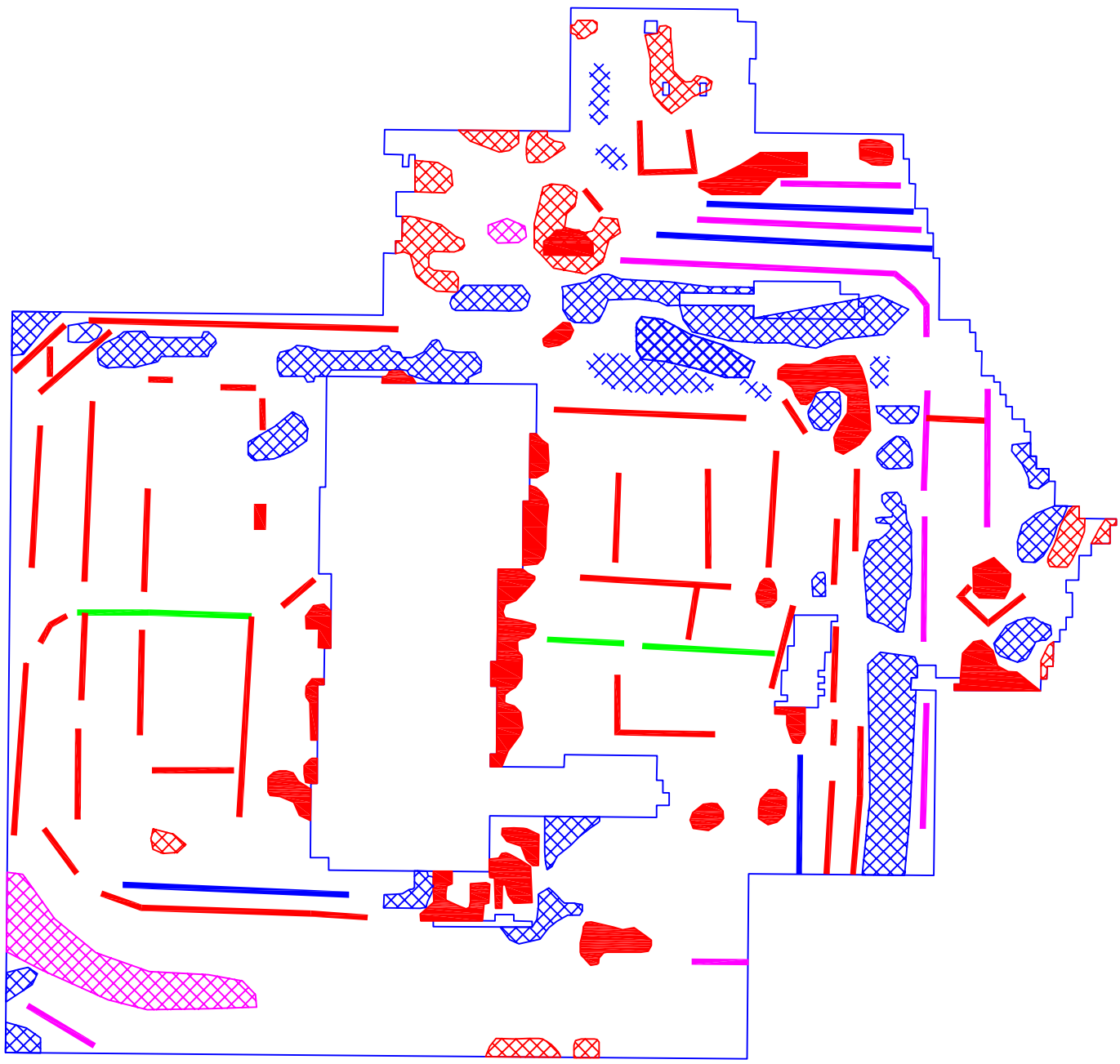


Figure 6: Interpretation plot of the gradiometer survey



503600

503400



337200

337400

- High resistance responses - possible structural features
- High resistance linear responses - structural features
- High resistance linear responses - 'Via Principalis'
- High resistance responses - possibly geological
- Medium-high resistance linear responses - possible defences
- Medium-high resistance responses - possible defences
- Low resistance responses - features associated defences
- Low resistance responses - mainly associated with defences

0 25 m
1:1000 @ A3



Figure 7: Interpretation plot of the resistance survey

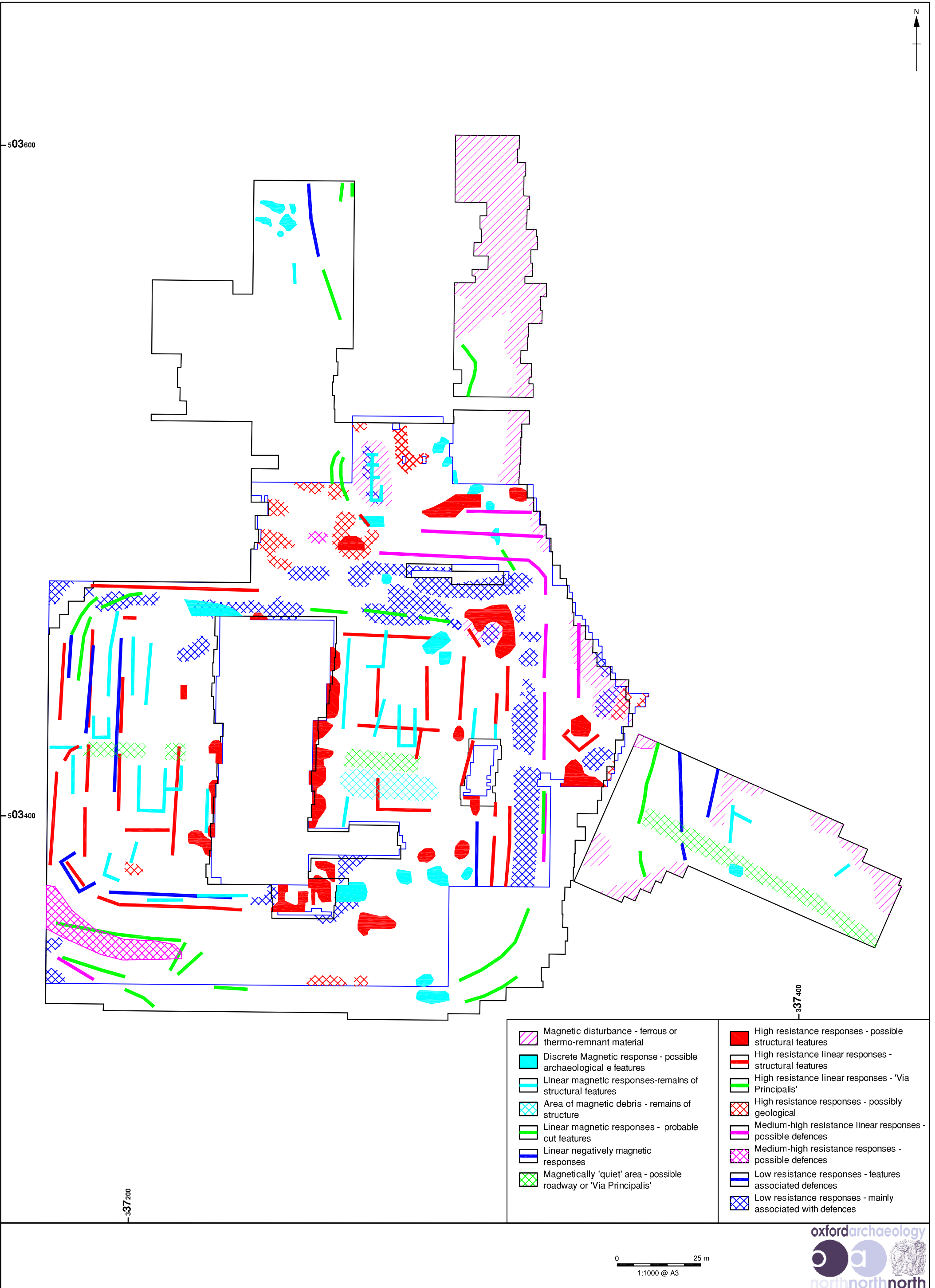


Figure 8: Combined Interpretation plot of the magnetometer and resistance surveys

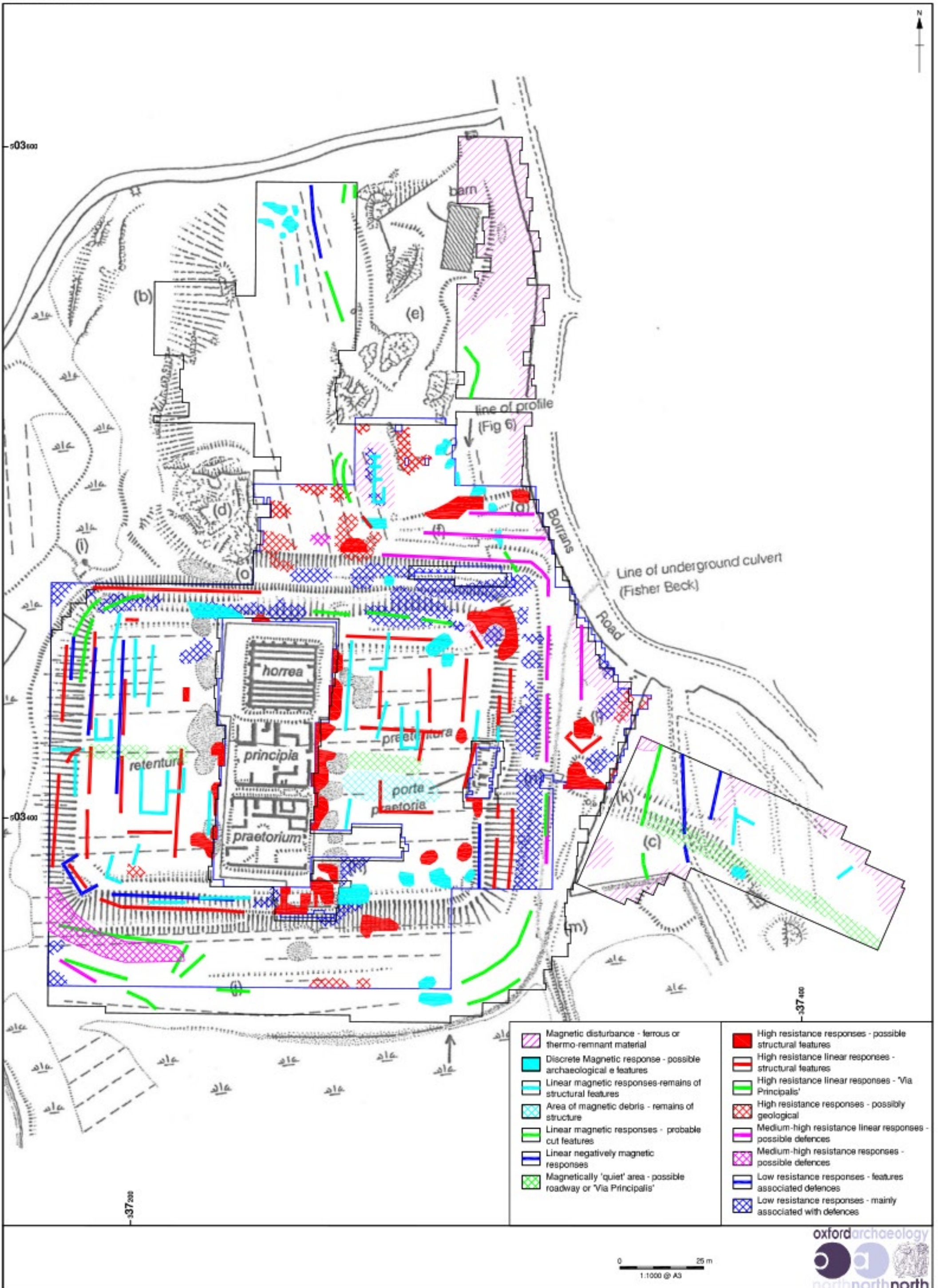


Figure 9: Combined Interpretation plot superimposed onto the RCHME plan

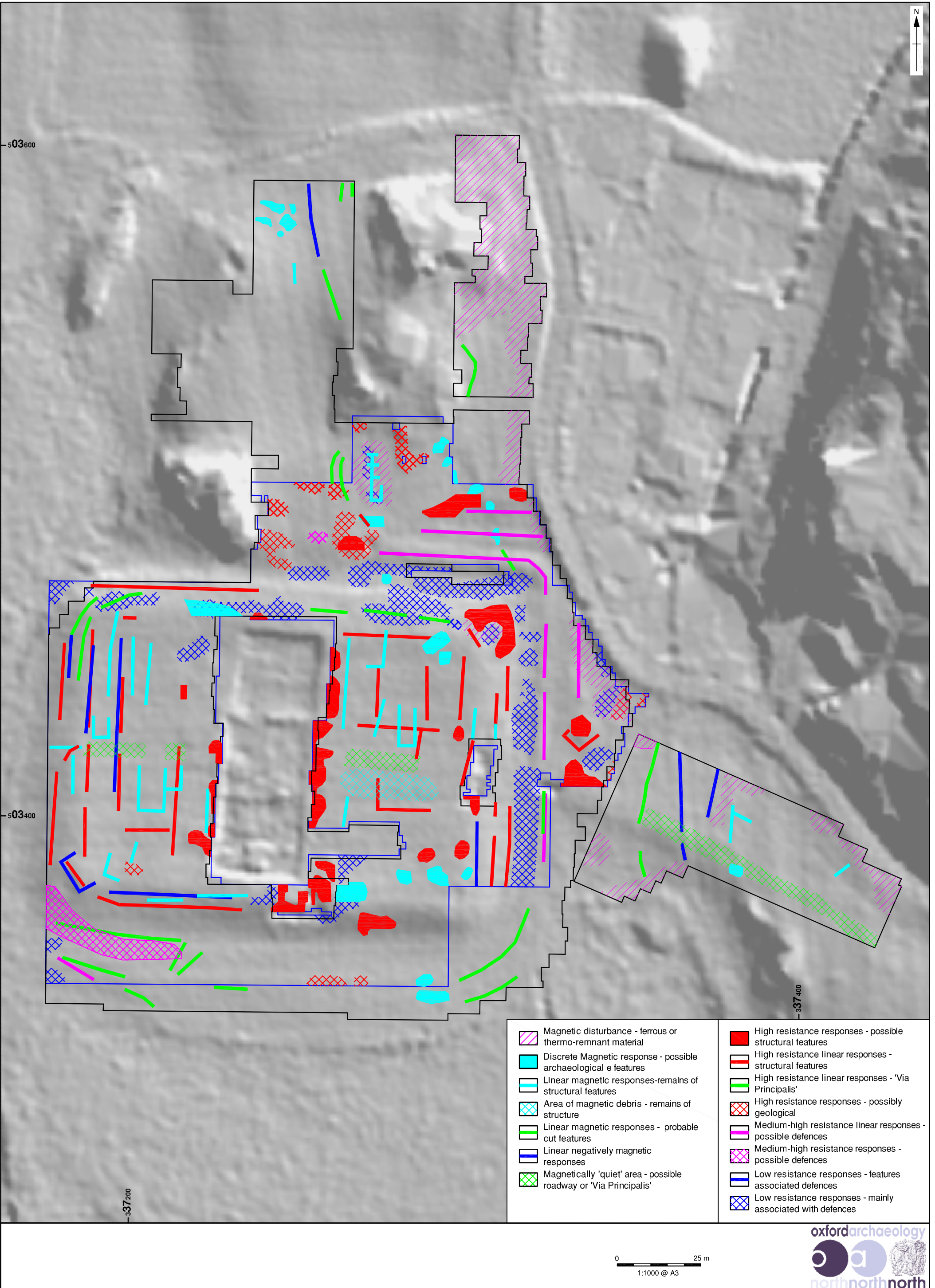


Figure 10: Combined Interpretation plot superimposed onto the LiDAR data