Land at Junction 10 M42, Dordon, Warwickshire

Archaeological Geophysical Survey

National Grid Reference: SK 24923 00929

AOC Project No: 40147

Survey Date: October 2020

Report Date: November 2020

AOC Archaeology Group

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Land at Junction 10 M42, Dordon, Warwickshire

Archaeological Geophysical Survey

On Behalf of:	**WSP** **The Mailbox** **Level 2** **100 Wharfside Street** **Birmingham** **B1 1RT**
National Grid Reference (NGR):	**SK 24923 00929**
AOC Project No:	**40147**
Prepared by:	**Alistair Galt and Sacha O'Connor**
Illustrations by:	**Alistair Galt and Laura O'Connor**
Date of survey:	**26/10/2020 – 30/10/2020**
Surveyors:	**Sacha O'Connor, Natalie Holt and Alistair Galt**

This document has been prepared in accordance with AOC standard operating procedures.

Author: Alistair Galt and Sacha O'Connor	**Date: 13th November 2020**
Quality Checked by: Susan Ovenden	**Date: 16th November 2020**
Report Stage: Final Version 2	**Date: 02nd December 2020**

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Non-Technical Summary

AOC Archaeology Group was commissioned by WSP to undertake an archaeological geophysical gradiometer survey on 26th October to 30th October 2020 to investigate the potential for buried archaeological remains ahead of a proposed development on land to the east of the M42 (centred at SK 24923 00929).

A total of 32 hectares were surveyed and the results of the survey have identified the following.

Multiple trends in the north and west of the survey area may relate to possible archaeological responses, which might be Prehistoric / Romano-British in date. In particular two square features forming a rectangular shape appear potentially archaeological in origin f.

However other possible archaeology features, due to their weak nature, may be related to the ploughing trends found across the site.

Also detected were unclear trends that do not respect any of the other features and which cannot definitively be given an anthropological or natural characterisation.

In addition, a former structure in the centre of the survey has been identified, along with former field boundaries. This corresponds with Second Edition Ordnance Survey (OS) historic mapping, known at the "Leisure Barn" at the time and appears on mapping until post 1990 mapping.

Areas of magnetic disturbance, most likely the result of modern activity and underground utilities, were also recorded.

1 Introduction

1.1 AOC Archaeology Group was commissioned by WSP to undertake an archaeological geophysical gradiometer survey on land to the east of the junction 10 of the M42, Dordon, Warwickshire. The survey was conducted from the 26th to the 30th October 2020 as part of a wider scheme of archaeological assessment in advance of the proposed development of the site.

1.2 Archaeological geophysical survey uses non-intrusive and non-destructive techniques to determine the presence or absence of anomalies likely to be caused by archaeological features, structures or deposits, as far as is reasonably possible (CIfA, 2014).

1.3 The survey was carried out to provide information on the extent and significance of potential buried archaeological remains within the proposed development site.

2 Site Location and Description

2.1 The proposed development site (hereafter 'the Site') is located to the east of junction 10 of the M42, Dordon, Warwickshire, centred at SK 24923 00929 (Figure 1).

2.2 The Site covers approximately 32 hectares (ha) across two fields consisting of arable ground (Figure 2). The Site is situated on undulating uneven ground, ranging from approximately 100m aOD (above Ordnance Datum) in the north, sloping towards the south to approximately 94m aOD.

2.3 The bedrock recorded geology within the Site consists of mudstone, siltstone and sandstone of the Halesowen Formation (BGS, 2020). These are overlain by freely draining slightly acid loamy soils (Soilscapes, 2020).

2.4 Gradiometer survey is suggested to provide a very variable response over the geology present on Site (David *et al.* 2008, 15). In this case, the clarity of the geophysical results were good, and the local geology was deemed not to have had a detrimental effect on the visibility of trends within the dataset.

3 Archaeological Background

3.1 The archaeological background below is drawn from a Written Scheme of Investigation prepared by WSP (2020). All references to the Warwickshire Historic Environment Record (WHER) within this document, are taken directly from the WSI, for further details of these, please see WSP (2020).

3.2 Cartographic comparison was done via the National Library of Scotland, mapping programme (NLS 2020)

Prehistoric (500,000 BC – AD 43)

3.3 There are no recorded remains of prehistoric date within the proposed development area itself.

3.4 Whilst there is limited evidence within the 500m study area as recorded on the HER, this may simply reflect the limited past archaeological investigation. Undated enclosures, a ring ditch and field system recorded during geophysical survey and trial trenching in 2014 and 2019 to the immediate south of the Site was interpreted as probably representing Iron Age activity (WHER MWA30377).

Romano-British (AD 43 – AD 410)

3.5 There are no known Romano-British remains located within the proposed development area.

3.6 The line of the modern A5 which form the southern boundary to the Site follows the alignment of Watling Street a major Roman road which linked London and Wroxeter, in Shropshire.

Archaeological observations during the construction of Junction 10 of the M42 in the 1980s reported three Romano-British post holes 75m to the west of the Site. Whilst the evidence was limited this suggested the potential for settlement in the vicinity albeit of unknown type and extent.

Medieval (AD 410 – AD 1540)

3.7 There are no known Medieval remains located within the proposed development area.

3.8 The principal centres of historic settlement lie some distance from the Proposed Scheme, and in all likelihood, the majority of the area was open fields in a landscape likely to have been dominated by dispersed farmsteads. This includes the Site of a possible late medieval or early post manor house, Hall End Hall, recorded 440m to the east of the Site (WHER MWA230) which may be associated with settlement along Watling Street further to the south where medieval pottery has been found (WHER MWA13161). The nature and extent of settlement in the vicinity of Watling Street is currently unknown.

Post medieval – Industrial Period (AD 1540 – present)

3.9 The Site of a probable 19th century small field barn, known as Leisure Barn, is recorded within the Site (WHER HWA16506). The remainder of the Site is thought to have been agricultural fields during this period.

3.10 Hall End Hall, located 440m to the east of the Site, existed by the late 16th century possibly associated with a small garden (WHER MWA12541). The Hall was demolished circa 1945.

3.11 Birch Coppice Colliery and associated tramway existed by the late 19th century 400m to the north of the Site. The small settlement of Birchmoor immediately to the north of the Site may have originated as a miners' settlement associated with the colliery.

4 Aims

4.1 The aim of the geophysical survey was to identify any potential archaeological anomalies that would enhance the current understanding of the archaeological resource within the proposed survey area.

4.2 Specifically, the aims of the gradiometer survey were;

- To locate, record and characterise any surviving sub-surface archaeological remains within the survey area,
- To help determine the next stage of works as per the client's instruction,
- To provide an assessment of the potential significance of any identified archaeological remains in a local, regional and (if relevant) national context,
- To produce a comprehensive Site archive (Appendix 2) and report.

5 Methodology

5.1 The geophysical survey was undertaken between the 26th and 30th October 2020.

5.2 All geophysical survey work was carried out in accordance with recommended good practice specified in the EAC guideline documents published by Historic England (Schmidt et al. 2016) and the Chartered Institute for Archaeologists Standard and Guidance for archaeological geophysical survey (2014).

5.3 Parameters and survey methods were selected that were suitable for the prospective aims of the survey and in accordance with recommended professional good practice (Schmidt et al. 2016).

5.4 Digital photographs of every survey parcel were taken before, during and after geophysical survey to show any changes to field conditions following the programme of works. The photos were downloaded and stored off site.

5.5 The gradiometer survey was carried out using a Bartington Non-Magnetic Cart. The cart system utilises three sets of Grad-01 fluxgate gradiometers mounted upon a carbon fibre frame, along with data logging equipment and batteries (see Appendix 3). Before each session of use, the cart system was balanced around a single set up point within the Site specifically chosen for being magnetically quiet. In balancing the machine around this point, it produces a more uniform dataset throughout and allows all data to be plotted with ease.

5.6 Data was collected using zig-zag traverses alongside a constant stream of GPS data collected through a Trimble R10 GPS, enabling the collected data to be spatially georeferenced without the need for a pre-determined grid system. The data was collected through a laptop mounted to the cart using Geomar MLGrad601 software.

5.7 A total of 32ha were surveyed using the Bartington cart.

5.8 Care was taken to attempt to avoid metal obstacles present within the survey area, such as metal fencing around hedge boundaries as gradiometer survey is affected by 'above-ground noise' and avoiding these improves the overall data quality and results obtained.

5.9 The data was downloaded from MLGrad601 and converted into a .xyz file in Geomar MultiGrad601 before being processed along with the GPS data in TerraSurveyor v3.0.36. The details of these processed can be found in Appendices 3 and 4.

5.10 Interpretations of the data were created in ArcGIS Pro and the technical terminology used to describe the identified features can be found in Appendix 5.

6 Results and Interpretation

6.1 The gradiometer survey results have been visualised as greyscale plots, with the minimally processed data plotted at -1nT to 2nT in Figure 3. The processed data is also plotted at -1nT to 2nT and can be seen in Figure 4. An interpretation of the data is provided in Figure 5 and an individual characterisation of the identified anomalies is listed in Appendix 1.

6.2 Field 1 identified as the larger dataset to the west of the footpath Field 2 is identified as the smaller dataset to the east of the footpath.

6.3 For the most part, only trends of a possible archaeological or historical origin have been assigned an anomaly number on the interpretation figure. Trends that are integral to the discussion have also been assigned anomaly numbers.

Archaeology

6.4 No remains of a definitive archaeological provenance have been identified in the dataset.

Possible Archaeology

6.5 Several linear trends of possible archaeological origin have been identified in the dataset which could possibly be archaeological in origin (**A1-A3**). The trends are suggestive of archaeological settlement activity tentatively related to Prehistoric or Romano-British date.

6.6 **A1** comprises two adjoining square features, which form a magnetically weak rectilinear enclosure located on a relatively flat area of ground. Five linear trends (**A2**), with a similar magnetic response to the possible enclosure (**A1**), appear to emanate from its eastern and western edges.

6.7 The roughly rectangular shape of **A1**, combined with the additional linear features (**A2**), suggests an archaeological origin which may tentatively indicate Prehistoric / Romano-British activity.

6.8 The second area of possible archaeology is located to the west of the site. These are positioned on the more gently undulating terrain of the Site.

6.9 These comprise of a series of curvilinear trends forming a tentative enclosure (**A3**). Although not clearly forming a feature which corresponds with known archaeological character, it is possible that its location, on more undulating terrain along with more recent ploughing trends have truncated the magnetic responses and archaeology in this location.

6.10 Overall, A1-A3 possible archaeological trends and enclosures are difficult to characterise and assign a date, although they are tentatively thought to relate to a Prehistoric or Romano-British date.

6.11 No possible archaeological features were identified in Field 2.

Unclear Origins

6.12 A number of trends are visible across Field 1 which have unclear origins.

6.13 A strong dipolar magnetic pair of linear trends have also been detected in the south of Field 1 and continue into Field 2. (**A4**). This feature runs across the whole of the southern area of the dataset, stopping near the south west corner of Field 2. A north/south linear trend adjoins this linear trend and terminates at a juncture between two known historic boundaries. The similarity in the magnetic strength, to some of the comparably magnetic recorded historic field boundaries alongside their orientation, strongly suggests that their origins are contemporary. The parallel nature of the feature (**A4**) at its western extent in Field 1 and its eastern extent in Field 2 suggest a possible trackway.

6.14 However, this trend is not marked on any historical mapping, which suggests that it is older than the documented boundaries noted on historic mapping (NLS, 2020).

6.15 Linear trends are visible in the dataset running south-west to north-east as well as one shorter feature running north–south and another running on an alignment east-west (**A5** and **A6**). These comprise of both positive and negative trends. It is unclear if the trends relate to geological variations or agricultural activities. These are for the most part regularly spaced, approximately 20m to 30m apart. They do not conform to ridge and furrow cultivation trends which are narrower in width.

6.16 The informed interpretation of these anomalies is that they form strip plough headlands, of an earlier agricultural field system of an unknown date, but potentially Prehistoric / Medieval in date. Likewise, a more recent agricultural provenance cannot be dismissed.

6.17 Along the western boundary of Field 1, close to the possible archaeology **A3** a number of curvilinear trends have been identified **(A7).** These are potentially associated with **A3**, however, they could also relate to the above potential field divisions **A5** and **A6** or more recent agricultural activity.

6.18 An area of unclear disturbance in the north-west of the dataset has been detected (**A8**), Located along the western boundary of the Site is visible on historic mapping as a pond-like feature (NLS 2020). This feature has probably been infilled with modern material for agricultural purposes, as the topography was flat when it was surveyed.

6.19 The second discrete unclear feature **(A9)** is located centrally to the west of the large modern service (discussed later). It also has a similar response to **A8** but it does not follow any historic mapping features associated with it. Therefore, whilst it could have an archaeological provenance it seems likely to be associated to other agricultural/historic features. Without any other supporting evidence this cannot be definitively be given a characterisation.

6.20 **A10** is a curvilinear trend to the east of Field 1. It is weakly positive, so it is difficult to follow the extent of this feature. Additionally, the eastern end of the trend is truncated by a modern utility pipe. The shape, as it is mapped, could have an archaeological origin although a former field boundary or more recent agricultural activity could also be the cause.

Historical and Agricultural

6.21 The remains of a former building in the centre of the large field, known as the "Leisure Barn" (**A11**) have been detected. This is a discrete area of large dipolar anomalies, indicative of foundations or material from a structure. There was also some evidence of coarse building material on the ground, in approximately this location, suggesting that some remains of this structure are still present under the ground.

6.22 A number of former field boundaries, (**A12 – A16)** which directly adjoin to the "Leisure Barn", divide the field along north-south and east-west axes. These linear trends vary in magnetic strength, with the strongest being **A12** to the east which is also a trackway to the original "Leisure Barn". **A13** is much weaker in response overall but its course can be tracked west and north-west up to the western boundary of the Site from **A11**.

6.23 **A14** is harder to discern due to the very strong responses being caused by **A11** but a slight change in direction can be made out which correlates with the historic mapping.

6.24 **A15** and **A16** have a similar weaker magnetic response to **A13**. **A15** is a north-south running linear trend which heads to the northern boundary and connects the northern boundary to the trackway and linear anomaly **A12**. Anomaly **A16**, by contrast, runs south from **A11** towards the southern boundary of the Site.

6.25 There are also field boundaries that are not directly connected to the "Leisure Barn" but are associated with field boundary **A16**.

6.26 The first of these is **A17** which runs east to west and bisects **A16** and runs across Fields 1 to its boundary. Adjoined to **A17**, at the western end, is **A18,** a curvilinear field boundary which runs east to west before turning south-westerly towards the south-western corner of the Site.

6.27 Two other trends are present in the east of the dataset which also match with former field boundaries seen on historic mapping, crossing between Fields 1 and 2 (**A19**). These are obscured to some extent by the modern disturbance and the modern ferrous features.

6.28 All of the above historic features all correlate with historic mapping (NLS 2020). Although **A18** is partially seen in the data, at its eastern end it should turn northwards according to the historic mapping (NLS 2020), but no magnetic response has been recorded.

6.29 Ploughing trends have been detected which run across the dataset (**A20**, **A21** and **A22**). These are both positive and negative trends, which appear to respect the old field boundaries noted on historic mapping (NLS 2002).

6.30 These anomalies are potentially evidence of ridge and furrow cultivation, related to the former field systems and boundaries as seen on historic mapping. The former field boundaries appear to have been removed in the 1980's (NLS 2020). This recent date means that some of these anomalies may in fact be more indicative of recent ploughing rather than earlier ridge and furrow cultivation hence the unclear ridge and furrow characterisation.

6.31 An area of magnetic disturbance in the south-east of the dataset of Field 1, is likely related to a former area used as a sheep-wash (**A23**) located close to the north of the upstanding former car parking area. (NLS 2020).

Non - Archaeology

6.32 Magnetic disturbance is visible along the peripheries of the dataset.

6.33 In addition, a number of areas of disturbance within the dataset could relate to modern upstanding telegraph poles in the field. Unusually some of these, in the south-west of the dataset, have particularly strong magnetic responses that, although likely to be related, are different in magnetic character to the norm.

6.34 Two modern services run parallel to each other through the dataset. The first is in Field 1, whilst the other is located along the eastern boundary of Field 2. These are characterised by their distinctive magnetic signature.

6.35 Isolated dipolar anomalies (ferrous / iron spikes) are visible throughout the dataset which are likely modern in origin, which are especially prevalent in the centre and edges of the dataset.

7 Conclusion

7.1 The gradiometer survey has not identified any anomalies or features of a definitive archaeological nature.

7.2 Across the survey area a number of linear and curvilinear trends were identified which could have a possible Prehistoric or Romano-British archaeological origin. However their weak nature and possible alignment to ploughing trends may suggest an alternative interpretation is possible. It is plausible that these features may be more confidently interpreted following additional investigation

7.3 A number of unclear trends have also been detected, which are difficult to characterise as either archaeological or natural.

7.4 Agricultural ploughing trends have been identified, alongside evidence of historic agricultural remains such as former field boundaries and farm buildings in relation to “Leisure Barn”.

7.5 Several areas of magnetic disturbance of a likely modern date were also detected, relating to service pipes and telegraph poles to the south and west. Strong magnetic trends are present around the edge and centre of the dataset.

7.6 In assessing the results of the geophysical survey against the specific aims set out in Section 4;

- The survey has succeeded in locating, recording and characterising anomalies suggestive of possible surviving sub-surface remains within the Site, though more remains may be present that are not suitable for detection through magnetometry;
- The survey will help in determining the next stage of works as it has provided evidence that remains of an uncertain origin are most likely present on site, and has provided a number of targets for further investigation;
- It is not possible to provide an assessment of the potential significance of the identified remains in a local, regional or national context as it has not been possible to definitively characterise the nature of the anomalies identified through survey alone;
- The survey has resulted in a comprehensive report and archive.

7.7 The geophysical survey has produced good quality gradiometer results which have successfully helped to clarify whether archaeological or uncertain remains are present across the Site. There is a high confidence level that the methodology and survey strategy chosen were appropriate to assess the archaeological potential across the Site.

8 Statement of Indemnity

8.1 Although the results and interpretation detailed in this report have been produced as accurately as possible, it should be noted that the conclusions offered are a subjective assessment of collected data sets.

8.2 The success of a geophysical survey in identifying archaeological remains can be heavily influenced by several factors, including geology, seasonality, field conditions and the properties of the features being detected. Therefore, the geophysical interpretation may only reveal certain archaeological features and not produce a complete plan of all the archaeological remains within a survey area.

9 Archive Deposition

9.1 In accordance professional standard practice an 'Online Access to the Index of archaeological investigations' ('OASIS') record will be completed for submission to the HER and Archaeological Data Service (ADS) (Appendix 2).

9.2 One digital and hard copy of the report and data will be submitted to the relevant Historic Environment Record (HER) at the Client's discretion.

9.3 A digital copy of the report and data will also be submitted to the ADS at the Client's discretion.

10 Bibliography

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11 Plates

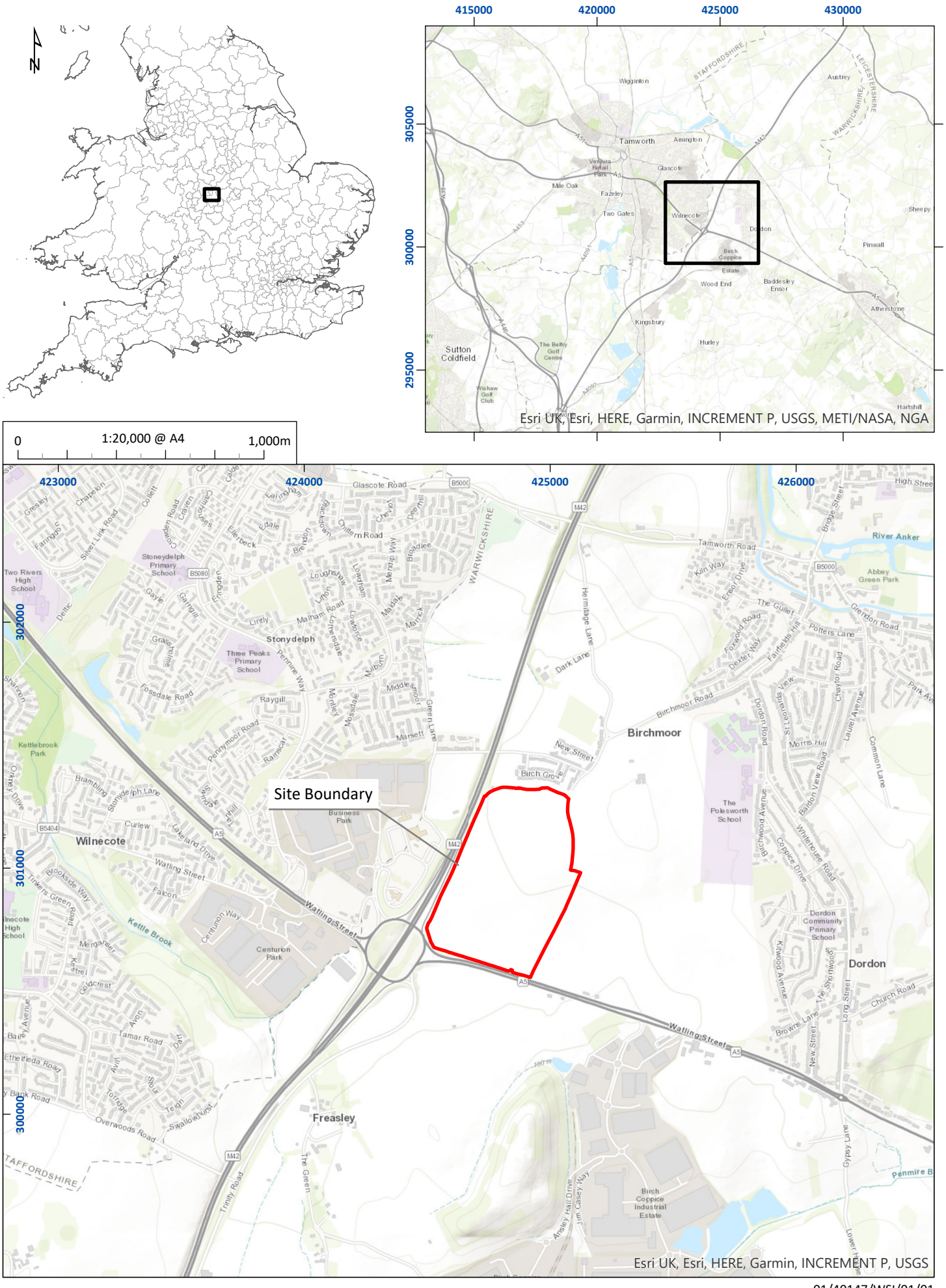
Plate 1. Field 1 facing west from the footpath

Plate 2. Field 1 facing north-west

Plate 3. Field 2 facing south

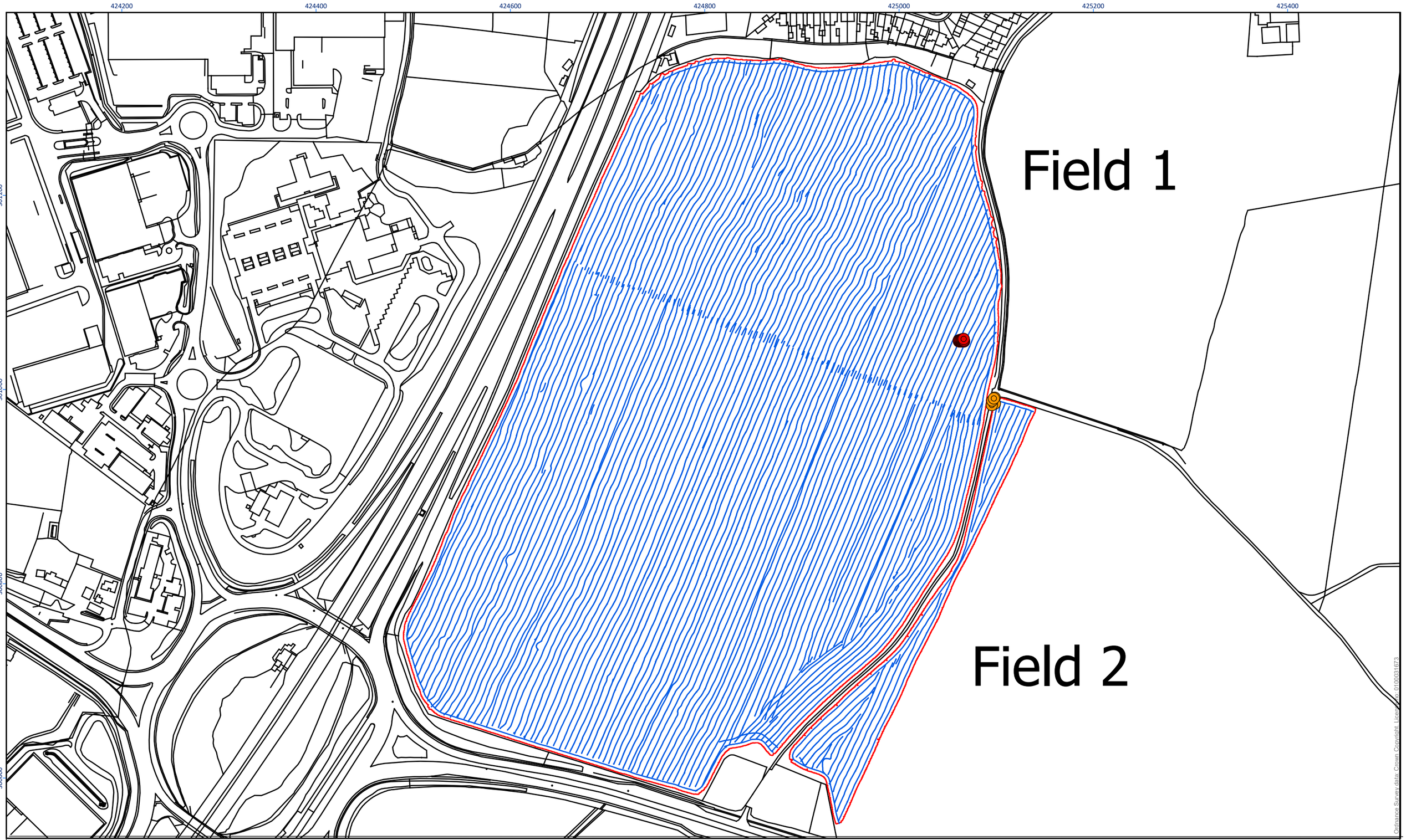
Plate 4. Field 1 facing south-west

12 Figures



01/40147/WSI/01/01

Figure 1: Site location plan



GNSS Swaths, Equipment Calibration Point and Photo Positions

Figure 2

Red Line Boundary
Zero position
Photo Position

N

0 60m

Scale: 1:3,500 @ A3

Drawing Number: 05/40147/GEO/01/02	
Created by: AG	Date: 16/11/2020
Checked by: JL	Date: 16/11/2020
Approved by: JL	Date: 16/11/2020

AOC Archaeology Group

424200 424400 424600 424800 425000 425200 425400

301200

301000

300800

300600

Field 1

Field 2

Minimally Processed Gradiometer Survey Results (Bartington) - Greyscale Plot

Figure 3

10nT

-10nT

Red Line Boundary

N

0 60m

Scale: 1:3,500 @ A3

Drawing Number: 05/40147/GEO/01/03	
Created by: AG	Date: 16/11/2020
Checked by: JL	Date: 16/11/2020
Approved by: JL	Date: 16/11/2020

AOC Archaeology Group

424200 424400 424600 424800 425000 425200 425400

301200 301000 300800 300600

Field 1

Field 2

Processed Gradiometer Survey Results (Bartington) - Greyscale Plot

Figure 4

2nT
-1nT

Red Line Boundary

N

0 60m

Scale: 1:3,500 @ A3

Drawing Number: 05/40147/GEO/01/04	
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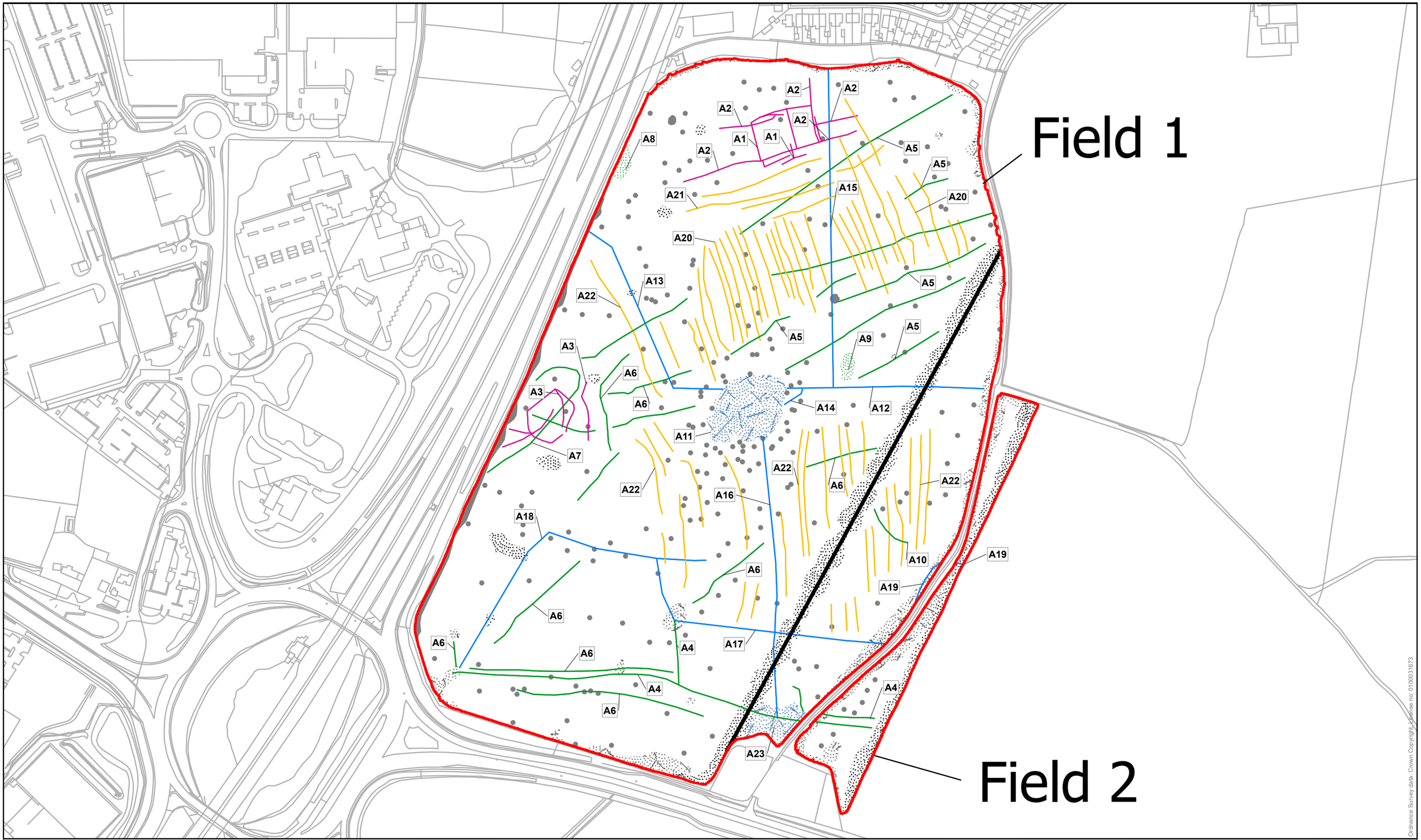
Checked by: JL	Date: 16/11/2020
Approved by: JL	Date: 16/11/2020

AOC Archaeology Group



Interpretation of greyscale gradiometer plot

Figure 5

- Surveyed Area
- Linear Trend (Historic Feature)
- Linear Trend (Ploughing)
- Trend (Possible Archaeology)
- Linear Trend (Utility)
- Trend (Unclear Origin)
- Enhanced Magnetism (Historic Feature)
- Enhanced Magnetism (Modern - Non Archaeology)
- Ferrous/Iron Spike
- Enhanced Magnetism (Unclear Origin)
- Enhanced Magnetism (Utility - Non Archaeology)
- Ferrous/Iron Spike

N

0 60m

Scale:1:3,500 @ A3

Drawing Number:	05/40147/GEO/01/05
Created by: AG	Date: 02/12/2020
Checked by: JL	Date: 02/12/2020
Approved by: JL	Date: 02/12/2020

AOC Archaeology Group

Appendix 1: Characterisation of Anomalies

Gradiometer survey

Anomaly	Type of Anomaly
A1	Linear trends – Possible Archaeology
A2	Linear trends – Possible Archaeology
A3	Linear trends – Possible Archaeology
A4	Linear trends – Unclear
A5	Linear trends – Unclear
A6	Linear trends – Unclear
A7	Linear trends – Unclear
A8	Discrete feature – Historical feature
A9	Linear trend – Historical feature
A10	Linear trend – Historical feature
A11	Discrete feature – Agricultural
A12	Linear trend – Old Field Boundary
A13	Linear trend – Old Field Boundary
A14	Linear trend – Old Field Boundary
A15	Linear trend – Old Field Boundary
A16	Linear trend – Old Field Boundary
A17	Linear trend – Old Field Boundary
A18	Linear trend – Old Field Boundary
A19	Linear trend – Old Field Boundary
A20	Ploughing trends
A21	Ploughing trends
A22	Ploughing trends
A23	Discrete feature – Historical feature

Appendix 2: Survey Metadata

Oasis ID: aocarcha1-407484

Field	Description
Surveying Company	AOC Archaeology
Data collection staff	Sacha O'Connor, Natalie Holt, Alistair Galt
Client	WSP
Site name	Land at Junction 10 M42, Dordon, Warwickshire
County	Warwickshire
NGR	SK 24923 00929
Land use/ field condition	Arable (ploughed)
Duration	26/10/20 - 30/10/20
Weather	Overcast/Rain
Survey type	Gradiometer Survey
Instrumentation	Bartington cart survey: Bartington Non-Magnetic Cart, three Bartington Grad 601-2, Trimble R10 GNSS System
Area covered	Approximately 32 ha
Download software	Grad601 PC Software v313 / MLGrad601 /
Processing software	Geomar, MultiGrad601 and TerraSurveyor /
Visualisation software	ArcGIS Pro
Geology	Mudstone, siltstone and sandstone of the Halesowen Formation (BGS, 2020).
Soils	Freely draining slightly acid loamy soils (Soilscapes, 2020).
Scheduled Ancient Monument	No
Known archaeology on Site	None
Historical documentation/ mapping on site	None
Report title	Land at Junction 10 M42, Dordon, Warwickshire: Archaeological Geophysical Survey
Project number	40147
Report Author	Sacha O'Connor and Alistair Galt
Quality Checked by	Chris Sykes and Susan Ovenden and James Lawton

Appendix 3: Archaeological Prospection Techniques, Instrumentation and Software Utilised

Gradiometer Survey

Gradiometer surveys measure small changes in the earth's magnetic field. Archaeological materials and activity can be detected by identifying changes to the magnetic values caused by the presence of weakly magnetised iron oxides in the soil (Aspinall et al., 2008, 23; Sharma, 1997, 105). Human inhabitation often causes alterations to the magnetic properties of the ground (Aspinall et al, 2008, 21). There are two physical transformations that produce a significant contrast between the magnetic properties of archaeological features and the surrounding soil: the enhancement of magnetic susceptibility and thermoremnant magnetization (Aspinall et al., 2008, 21; Heron and Gaffney 1987, 72).

Ditches and pits can be easily detected through gradiometer survey as the topsoil is generally suggested to have a greater magnetisation than the subsoil caused by human habitation. Areas of burning or materials which have been subjected to heat commonly also have high magnetic signatures, such as hearths, kilns, fired clay and mudbricks (Clark 1996, 65; Lowe and Fogel 2010, 24).

It should be noted that negative anomalies can also be useful for characterising archaeological features. If the buried remains are composed of a material with a lower magnetisation compared to the surrounding soil, the surrounding soil will consequently have a greater magnetization, resulting in the feature in question displaying a negative signature. For example, stone materials of a structural nature that are composed of sedimentary rocks are considered non-magnetic and so will appear as negative features within the dataset.

Ferrous objects – i.e. iron and its alloys - are strongly magnetic and are typically detected as high-value peaks in gradiometer survey data, though it is not usually possible to determine whether these relate to archaeological or modern objects.

Although gradiometer surveys have been successfully carried out in all areas of the United Kingdom, the effectiveness of the technique is lessened in areas with complex geology, particularly where igneous and metamorphic bedrock is present or thick layers of alluvium or till. All magnetic geophysical surveys must therefore take the effects of background geological and geomorphological conditions into account.

Bartington Non-Magnetic Cart Instrumentation and Software

AOC Archaeology's cart-based surveys are carried out using a Bartington Non-Magnetic Cart. The cart enables multiple traverses of data to be collected at the same time, increasing the speed at which surveys may be carried out and offers the benefits of reduced random measurement noise and rapid area coverage (Schmidt et al 2015, 60-62, David et al. 2008, 21).

The cart uses a configuration of four Grad-01-1000L sensors mounted upon a carbon fibre frame along with two DL601 dataloggers and one BC601 battery cassette. The sensors are normally positioned at 1m intervals on a horizontal bar, with the datalogger taking readings every 12.5cm along each traverse, though this can be altered to increase / reduce resolution if required. The data is georeferenced via a Trimble R10 Real Time Kinematic (RTK) VRS Now GNSS GPS which streams data throughout survey and allows the data to be recorded relative to a WGS1984 UTM coordinate system.

The gradiometer data is collected through Geomar MLGrad601 software on a laptop in real-time during the survey. The data is downloaded and converted into a .xyz file in Geomar MultiGrad601 before being processed along with the GPS data in TerraSurveyor v3.0.36 (see Appendix 4 for a summary of the processes used in Geoplot to create final data plots).

Appendix 4: Summary of Data Processing

Process	Effect
Clip	Limits data values to within a specified range
De-spike	Removes exceptionally high readings in the data that can obscure the visibility of archaeological features. In resistivity survey, these can be caused by poor contact of the mobile probes with the ground. In gradiometer survey, these can be caused by highly magnetic items such as buried ferrous objects.
De-stagger	Corrects a misalignment of data when the survey is conducted in a zig-zag traverse pattern.
Discard Overlap (TerraSurveyor)	Removes datapoints which occur too closely together and can cause digital artefacts in the data which are caused by the overlapping of parallel traverses.
Edge Match	Counteracts edge effects in grid composites by subtracting the difference between mean values in the two lines either side of the grid edge.
Filter (MAGNETO)	Much like a zero mean traverse, it resets the median value of each point to zero, in order to address the effect of striping in the data and counteract edge effects. In MAGNETO the individual values take into account the value of all uncorrected points within a certain distance to create its own median.
GPS Filter (MAGNETO)	Used to either remove or reduce the appearance of constant and reoccurring features that are not consistent with the GPS signal in use by the cart system.
High pass filter	Removes low-frequency, large scale detail in order to remove background trends in the data, such as variations in geology.
Interpolate	Increases the resolution of a survey by interpolating new values between surveyed data points, creating a smoother overall effect.
Low Pass filter	Uses a Gaussian filter to remove high-frequency, small scale detail, typically for smoothing the data.
Periodic Filter	Used to either remove or reduce the appearance of constant and reoccurring features that distort other anomalies, such as plough lines.
Remove Turns (TerraSurveyor)	Uses analysis of the direction of travel derived from the GNSS data to break continuous streams of data into individual traverses.
Zero Mean Grid	Resets the mean value of each grid to zero, in order to counteract grid edge discontinuities in composite assemblies.
Zero Mean Traverse	Resets the mean value of each traverse to zero, in order to address the effect of striping in the data and counteract edge effects.

Processing Steps

Bartington Cart survey – Field 1	
Process	**Extent**
Base Settings	Interval 0.2m, Track Radius 1.15m
Remove Turns	Threshold Angle 90°, Cut Length 5m
Discard Overlap	Threshold Distance 0.2m, Minimum Track 5, Newest
Despike	Mean Diameter 3 Threshold 1
Destripe	Minimum -5nT, maximum 5nT
High Pass Filter	Uniform (Gaussian) 12
Clip	-100/100

Bartington Cart survey – Field 2	
Process	**Extent**
Base Settings	Interval 0.2m, Track Radius 1.05m
Remove Turns	Threshold Angle 90°, Cut Length 5m
Discard Overlap	Threshold Distance 0.2m, Minimum Track 5, Newest
Despike	Mean Diameter 11 Threshold 1
Destripe	Minimum -10nT, maximum 10nT
High Pass Filter	Uniform (Gaussian) 11
Clip	-100/100

Appendix 5: Technical Terminology

Type of Anomaly	Description
Archaeology	*Interpretation is supported by the presence of known archaeological remains or by other forms of evidence such as HER records, LiDAR data or cropmarks identified through aerial photography.*
Trend	Linear / curvilinear / rectilinear anomalies either characterised by an increase or decrease in values compared to the magnetic background.
Area of enhanced magnetism	A zone of enhanced magnetic responses over a localised area. These anomalies do not have the high dipolar response which are manifested in an 'iron spike' anomaly and likely have a relationship with nearby archaeological trends.
Pit	An anomaly composed of an increase in magnetic values with a patterning on the XY trace plot that is pit-like in appearance.
Possible Archaeology	*Trends are likely to have an archaeological origin, however without supporting evidence from known archaeological remains, HER records, LiDAR or aerial photography, they can only be classed as having a possible archaeological origin.*
Trend	Linear / curvilinear / rectilinear anomalies either characterised by an increase or decrease in values compared to the magnetic background.
Area of enhanced magnetism	A zone of enhanced magnetic responses over a localised area. These anomalies do not have the high dipolar response which are manifested in an 'iron spike' anomaly but lacks definitive records to be classed as being archaeological.
Pit-like anomaly	An anomaly composed of an increase in magnetic values with a patterning on the XY trace plot that is pit-like in appearance.
Burnt area	An anomaly with a patterning on the XY trace plot that is suggestive of industrial activity such as a kiln or hearth.
Unclear Origin	*Trends are magnetically weak, fractured or isolated and their context is difficult to ascertain. Whilst an archaeological origin is possible, an agricultural, geological or modern origin is also likely.*
Trend	Linear / curvilinear / rectilinear anomalies which are composed of a weak or different change in magnetic values. The trends do not appear to form a patterning that is suggestive of archaeological remains, such as enclosures or trackways.
Area of enhanced magnetism	A zone of enhanced magnetic responses which lack context for a conclusive interpretation. They do not appear to have a relationship with nearby trends of an archaeological origin. Can often be caused by areas of former woodland, geological variations or agricultural activity.
Agricultural	*Trends associated with agricultural activity, either historical or modern.*
Old Field Boundary	These isolated long linear anomalies, most often represented as a negative or fractured magnetic trend, relate to former field boundaries when their positioning is cross referenced with historical mapping.
Historical Features	Features observed on historical mapping that correspond with anomalies or trends in the data. Areas of enhanced magnetism could relate to former buildings, trackways, quarries or ponds.
Ridge and Furrow / Rig and Furrow	A series of regular linear or curvilinear anomalies either composed of an increased or decreased magnetic response compared to background values. The wide regular spacing between the anomalies is consistent with that of a ridge and furrow / rig and furrow ploughing regime. The

	anomalies often present as a positive 'ridge' trend adjacent to a negative 'furrow' trend.
Ploughing Trends	A series of regular linear anomalies either composed of an increased or decreased magnetic response compared to background values. Anomalies seen parallel to field edges are representative of headlands caused by ploughing.
Field Drainage	A series of magnetic linear anomalies of an indeterminate date, usually with a regular or herringbone patterning.
Non - Archaeology	*Trends which are likely to have derived from non-archaeological processes or activities.*
Geology / Natural	An area of enhanced magnetism that is composed of irregular weak increases or decreases in magnetic values compared with background readings. It is likely to indicate natural variations in soil composition or reflect variations in the bedrock or superficial geology.
Possible Modern Service	Anomalies of a linear form often composed of contrasting high positive and negative dipolar values. Such anomalies usually signify a feature with a high level of magnetisation and are likely to belong to modern activity such as pipes or modern services.
Magnetic Disturbance	A zone of highly magnetic disturbance that has been caused by or is a reflection of modern activity, such as metallic boundary fencing, gateways, roads, boreholes, adjacent buildings, rubbish at field edges or a spread of green waste material.
Isolated Dipolar Anomalies / Ferrous (iron spikes) and Ferrous Zones	A response caused by ferrous materials on the ground surface or within the subsoil, which causes a 'spike' in the data representing a rapid variation in the magnetic response. These generally represent modern material often re-deposited during manuring.

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