magnitude surveys

Geophysical Survey Report

Orsett Heath, Essex

For

L-P Archaeology

Magnitude Surveys Ref: MSTQ790A

OASIS Reference: magnitud1-416304

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Abstract

Magnitude Surveys Ltd was commissioned to assess the subsurface archaeological potential of a c.6.7ha area of land to the northeast of Orsett Heath, Grays, Essex. A fluxgate gradiometer survey was successfully completed across the entirety of the survey area. Anomalies of agricultural and modern origin have been identified in the form of ploughing trends and a historic field boundary as well as a network of drains. No anomalies of probable or possible archaeological origin were identified within the survey area. However, anomalies of undetermined origin have been detected, as such the presence of archaeological remains within the survey area cannot be ruled out. Modern interference can be seen in the form of magnetic haloes and data artefacts produced by extant rugby goal posts, metal fencing along the field edges and underground services.

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1. Introduction

1.1. Magnitude Surveys Ltd (MS) was commissioned by L-P Archaeology to undertake a geophysical survey on a c.6.7 ha area of land to the northeast of Orsett Heath, Grays, Essex (TQ 6337 7982).

1.2. The geophysical survey comprised hand-carried GNSS-positioned fluxgate gradiometer survey. Magnetic survey is the standard primary geophysical method for archaeological applications in the UK for its ability to detect a range of different features. The technique is particularly suited for detecting fired or magnetically enhanced features, such as ditches, pits, kilns, sunken earth houses, and industrial activity (David *et al*., 2008).

1.3. The survey was conducted in line with the current best practice guidelines produced by Historic England (David et al., 2008), the Chartered Institute for Archaeologists (CIfA, 2014) and the European Archaeological Council (Schmidt et al., 2015).

1.4. It was conducted in line with a WSI produced by MS (Dyulgerski, 2020).

1.5. The survey commenced on 28/10/2020 and took 2 days to complete.

2. Quality Assurance

2.1. Magnitude Surveys is a Registered Organisation of the Chartered Institute for Archaeologists (CIfA), the chartered UK body for archaeologists, and a corporate member of ISAP (International Society of Archaeological Prospection).

2.2. The directors of MS are involved in the cutting edge of research and the development of guidance/policy. Specifically, Dr. Chrys Harris has a PhD in archaeological geophysics from the University of Bradford, is a Member of CIfA and is the Vice-Chair of the International Society for Archaeological Prospection (ISAP); Finnegan Pope-Carter has an MSc in archaeological geophysics and is a Fellow of the London Geological Society, as well as a member of GeoSIG (CIfA Geophysics Special Interest Group); Dr. Kayt Armstrong has a PhD in archaeological geophysics from Bournemouth University, is a Member of CIfA, the Editor of ISAP News, and is the UK Management Committee representative for the COST Action SAGA; Dr. Paul Johnson has a PhD in archaeology from the University of Southampton, has been a member of the ISAP Management Committee since 2015, and is currently the nominated representative for the EAA Archaeological Prospection Community to the board of the European Archaeological Association.

2.3. All MS managers have relevant degree qualifications to archaeology or geophysics. All MS field and office staff have relevant archaeology or geophysics degrees and/or field experience.

3. Objectives

3.1. The objective of this geophysical survey was to assess the subsurface archaeological potential of the survey area.

4. Geographic Background

4.1. The survey area was located c.480m west of Orsett Heath, Grays, Essex (Figure 1). Gradiometer survey was undertaken across two separate fields, the northern most of which is currently used as a public recreation ground with rugby posts while the southern field was fallow at the time of survey. The northern survey area was bounded by Thurrock Athletic playgrounds to the north and west, an arable field to the east and the A1013 to the south. The southern survey area was bounded by the A1013 to the north, a pasture field to the east, and a housing estate to the south and west (Figure 2).

4.2. Survey considerations:

Survey Area	Ground Conditions	Further Notes
1	The survey area consisted of flat fallow ground.	The survey area was bound to the north and east by metallic and concrete fencing. A housing estate bounded the survey area to the south and west. A metal gate was located in the southeast corner.
2	The survey area consisted of flat grass field used as a public recreation area with rugby posts present.	Metal fencing bounded the survey area to the north. Hedgerow bounded the survey area to the east, south and west. A road lay beyond the hedge to the south. A pylon was located along the western boundary. Several rugby goal posts were located within the survey area.

4.3. The underlying geology comprises Thanet formation sand to the south and Lambert Group clay, silt and sand to the north. This is overlain by superficial deposits of the Boyn Hill gravel member (British Geological Survey, 2020).

4.4. The soils consist of freely draining, slightly acidic loamy soils (Soilscapes, 2021).

5. Archaeological Background

5.1. The following is a summary of a Desk Based Assessment produced by RSK (RSK, 2019) and supplied by L-P Archaeology.

5.2. There are no designated heritage assets within the survey area.

5.3. There are no known archaeological remains of prehistoric, Bronze Age, Iron Age or Romano-British origin within the survey area.

5.4. Within the wider study area there is a single recorded medieval asset, located 240m south of the survey area. This is a scheduled monument comprising of more than 70 shafts used for mining flint and chalk.

5.5. In the post-medieval period, the survey area was under agricultural use with no change in field boundaries. The site remained in agricultural use until the northernmost field was turned into a rugby pitch for the local rugby club in the 1960s.

6. Methodology

6.1. Magnetometer surveys are generally the most cost effective and suitable geophysical technique for the detection of archaeology in England. Therefore, a magnetometer survey should be the preferred geophysical technique unless its use is precluded by any specific survey objectives or the site environment. For this site, no factors precluded the recommendation of a standard magnetometer survey. Geophysical survey therefore comprised the magnetic method as described in the following section.

6.2. Data Collection

6.2.1. Geophysical prospection comprised the magnetic method as described in the following table.

6.2.2. Table of survey strategies:

Method	Instrument	Traverse Interval	Sample Interval
Magnetic	Bartington Instruments Grad-13 Digital Three-Axis Gradiometer	1m	200Hz reprojected to 0.125m

6.2.3. The magnetic data were collected using MS' bespoke hand-carried GNSS-positioned system.

6.2.3.1. MS' hand-carried system was comprised of Bartington Instruments Grad 13 Digital Three-Axis Gradiometers. Positional referencing was through a multi-channel, multi-constellation GNSS Smart Antenna RTK GPS outputting in NMEA mode to ensure high positional accuracy of collected measurements. The RTK GPS is accurate to 0.008m + 1ppm in the horizontal and 0.015m + 1ppm in the vertical.

6.2.3.2. Magnetic and GPS data were stored on an SD card within MS' bespoke datalogger. The datalogger was continuously synced, via an in-field Wi-Fi unit, to servers within MS' offices. This allowed for data collection, processing and visualisation to be monitored in real-time as fieldwork was ongoing.

6.2.3.3. A navigation system was integrated with the RTK GPS, which was used to guide the surveyor. Data were collected by traversing the survey area along the longest possible lines, ensuring efficient collection and processing.

6.3. Data Processing

6.3.1. Magnetic data were processed in bespoke in-house software produced by MS. Processing steps conform to Historic England's standards for "raw or minimally processed data" (see sect 4.2 in David et al., 2008: 11).

Sensor Calibration – The sensors were calibrated using a bespoke in-house algorithm, which conforms to Olsen et al. (2003).

Zero Median Traverse – The median of each sensor traverse is calculated within a specified range and subtracted from the collected data. This removes striping effects caused by small variations in sensor electronics.

Projection to a Regular Grid – Data collected using RTK GPS positioning requires a uniform grid projection to visualise data. Data are rotated to best fit an orthogonal grid projection and are resampled onto the grid using an inverse distance-weighting algorithm.

Interpolation to Square Pixels – Data are interpolated using a bicubic algorithm to increase the pixel density between sensor traverses. This produces images with square pixels for ease of visualisation.

6.4.Data Visualisation and Interpretation

6.4.1. This report presents the gradient of the sensors' total field data as greyscale images, as well as the total field data from the upper and/or lower sensors. The gradient of the sensors minimises external interferences and reduces the blown-out responses from ferrous and other high contrast material. However, the contrast of weak or ephemeral anomalies can be reduced through the process of calculating the gradient. Consequently, some features can be clearer in the respective gradient or total field datasets. Multiple greyscale images of the gradient and total field at different plotting ranges have been used for data interpretation. Greyscale images should be viewed alongside the XY trace plot (Figure 7). XY trace plots visualise the magnitude and form of the geophysical response, aiding in anomaly interpretation.

6.4.2. Geophysical results have been interpreted using greyscale images and XY traces in a layered environment, overlaid against open street maps, satellite imagery, historic maps, LiDAR data, and soil and geology maps. Google Earth (2021) was consulted as well, to compare the results with recent land usages.

6.4.3. Geodetic position of results - All vector and raster data have been projected into OSGB36 (ESPG27700) and can be provided upon request in ESRI Shapefile (.SHP) and Geotiff (.TIF) respectively. Figures are provided with raster and vector data projected against OS Open Data.

7. Results

7.1. Qualification

7.1.1. Geophysical results are not a map of the ground and are instead a direct measurement of subsurface properties. Detecting and mapping features requires that said features have properties that can be measured by the chosen technique(s) and that these properties have sufficient contrast with the background to be identifiable. The interpretation of any identified anomalies is inherently subjective. While the scrutiny of the results is undertaken by qualified, experienced individuals and rigorously checked for quality and consistency, it is often not possible to classify all anomaly sources. Where possible an anomaly source will be identified along with the certainty of the interpretation. The only way to improve the interpretation of results is through a process of comparing excavated results with the geophysical reports. MS actively seek feedback on their reports as well as reports of further work in order to constantly improve our knowledge and service.

7.2. Discussion

7.2.1. The geophysical results are presented in consideration with satellite imagery and historic maps (Figure 6).

7.2.2. The geophysical survey was successfully completed across the entirety of the survey area. The magnetometer survey has responded well to the survey area, however the presence of extant rugby goal posts has caused large data artefacts. Interference from modern material, such as fencing, is otherwise limited to the borders of the survey area. The fluxgate gradiometer survey has revealed a varied magnetic background. There is a scattering of weakly magnetic anomalies most likely related to the continued anthropogenic use of the survey area. The survey has primarily identified anomalies of agricultural and modern origins across the two survey areas.

7.2.3. Agricultural activity has been detected in both survey areas in the form of ploughing trends. In the south of the survey area a historic field boundary has also been identified that corresponds to second edition OS historic mapping. A network of drains has been detected across Area 2. It is unclear whether these drains relate to the historic agricultural use of the land or are associated with the use of the survey area by the rugby club. Two services are located in the south of Area 2 and stretch from a pylon towards the road that separates the two survey areas.

7.2.4. Several undetermined anomalies have been identified within the survey area. It is likely that these anomalies relate to the agricultural or recreational use of the survey area. A confident interpretation of these anomalies cannot be made due to the limited context in which the anomalies are set, as well as the anomalies individual shapes, sizes and magnetic enhancement. However, an archaeological origin cannot be dismissed.

7.3.Interpretation

7.3.1. General Statements

7.3.1.1. Geophysical anomalies will be discussed broadly as classification types across the survey area. Only anomalies that are distinctive or unusual will be discussed individually.

7.3.1.2. **Data Artefact** – Data artefacts usually occur in conjunction with anomalies with strong magnetic signals due to how the sensors respond to very strong point sources. These are usually visible as minor 'streaking' following the line of data collection. While these artefacts can be reduced in post-processing through data filtering, this would risk removing real features. Therefore, these artefacts are indicated as necessary to preserve the data as 'minimally processed'.

7.3.1.3. **Ferrous (Spike)** – Discrete ferrous-like, dipolar anomalies are likely to be the result of isolated modern metallic debris on or near the ground surface.

7.3.1.4. **Ferrous/Debris (Spread)** – A ferrous/debris spread refers to a concentrated deposition of discrete, dipolar ferrous anomalies and other highly magnetic material.

7.3.1.5. **Magnetic Disturbance** – The strong anomalies produced by extant metallic structures along the edges of the field have been classified as 'Magnetic Disturbance'. These magnetic 'haloes' will obscure the response of any weaker underlying features, should they be present, often over a greater footprint than the structure they are being caused by.

7.3.1.6. **Undetermined** – Anomalies are classified as Undetermined when the anomaly origin is ambiguous through the geophysical results and there is no supporting or correlative evidence to warrant a more certain classification. These anomalies are likely to be the result of geological, pedological or agricultural processes, although an archaeological origin cannot be entirely ruled out. Undetermined anomalies are generally not ferrous in nature.

7.3.2. Magnetic Results - Specific Anomalies

7.3.2.1. **Agricultural (Strong)** – In the southeast corner of Area 1 a dipolar linear anomaly that correlates to a historic field boundary has been identified (Figure 6). From looking at historic satellite imagery, it can be seen that the southeast corner of Area 1 has been used previously as a car park (Google Earth Pro, 2020). The strong magnetic response is most likely due to the infill of modern debris into the ditch of the historic field boundary. The anomaly can be seen most explicitly in the XYs (Figure 7) and Total Field (Figure 3).

7.3.2.2. **Agricultural Trend** – Across Area 1 and in the northeast corner of Area 2, parallel weak linear anomalies that display a positive magnetic enhancement have been detected. The anomalies in both areas are orientated on a north-southeast direction and most likely relate to agricultural ploughing. The anomalies can be most clearly seen in the grayscale (Figure 4).

7.3.2.3. **Drains** – Within Area 2 a series of linear anomalies have been identified [**2a**]. The anomalies have a strong positive magnetic signal and are most explicit in the gradient (Figure 4). Due to their positive magnetic enhancement, straight shape, interaction with each other and location within the rugby field, they have been interpreted as a network of drains likely associated with the maintenance of the pitch.

7.3.2.4. **Service** – In the south of Area 2 a strong linear dipolar anomaly is orientated northwest-southeast and exhibits the magnetic response of a buried service. The anomaly connects a pylon along the western border of the survey area to the A1013 road (Figure 6). A second service, which runs parallel to the southern boundary of Area 2, has been identified in southwest corner.

7.3.2.5. **Magnetic Disturbance** – Within Area 2 several strong ferrous anomalies have been identified [**2b**]. They are the result of extant rugby goal posts. Due to the strong magnetic enhancement, data artefacts have been produced surrounding these anomalies (Figures 3 & 4).

7.3.2.6. **Undetermined** – In the south of Area 1 a weak negative curvilinear has been identified [**1b**] and can be most clearly seen in the XYs (Figure 7). Due to the anomaly's weak magnetic enhancement and a lack of context it has been ascribed an undetermined classification. In the northeast corner of Area 2, two parallel negative linear anomalies have been detected [**2c**]. These anomalies are orientated north-southeast and appear to 'contain' the identified agricultural trends. Even though the anomalies are on a similar alignment they do not correlate to past rugby pitches seen on historic satellite Imagery. However, given the long history of landscaping in Area 2, a modern interpretation cannot be dismissed (Google Earth Pro, 2020). In addition, along the southern edge of Area 2 a weak curvilinear anomaly has been identified [**2d**]. The isolated location, differing magnetic enhancement and its size makes it difficult to confidently interpret the origin of the anomaly. A discrete weakly positive anomaly is located in the centre-south of Area 2 [**2e**]. Due to its small size, limited context and location next to a source of large magnetic interference and an identified drain, a confident interpretation of [**2e**] cannot be made. Anomalies [**2c**, **2d** & **2e**] can be most clearly seen in the Total Field (Figure 3).

8. Conclusions

8.1. A fluxgate gradiometer survey was successfully completed across the entirety of the survey area. The fluxgate gradiometer survey has revealed a varied magnetic background while the presence of extant rugby goal posts has resulted in data artefacts being produced. There has been limited interference from modern ferrous material such as extant field boundaries and identified underground services.

8.2. Anomalies of agricultural origin in the form of ploughing trends and a historic field boundary have been identified within the survey area as well as a network of drains.

8.3. Anomalies of undetermined classification have been detected. Due to the limited context of the anomalies a confident classification cannot be ascribed but this does not disqualify an archaeological, agricultural or modern origin.

9. Archiving

9.1. MS maintains an in-house digital archive, which is based on Schmidt and Ernenwein (2013). This stores the collected measurements, minimally processed data, georeferenced and un-georeferenced images, XY traces and a copy of the final report.

9.2. MS contributes reports to the ADS Grey Literature Library upon permission from the client, subject to the any dictated time embargoes.

10. Copyright

10.1. Copyright and the intellectual property pertaining to all reports, figures, and datasets produced by Magnitude Services Ltd. is retained by MS. The client is given full licence to use such material for their own purposes. Permission must be sought by any third party wishing to use or reproduce any IP owned by MS.

11. References

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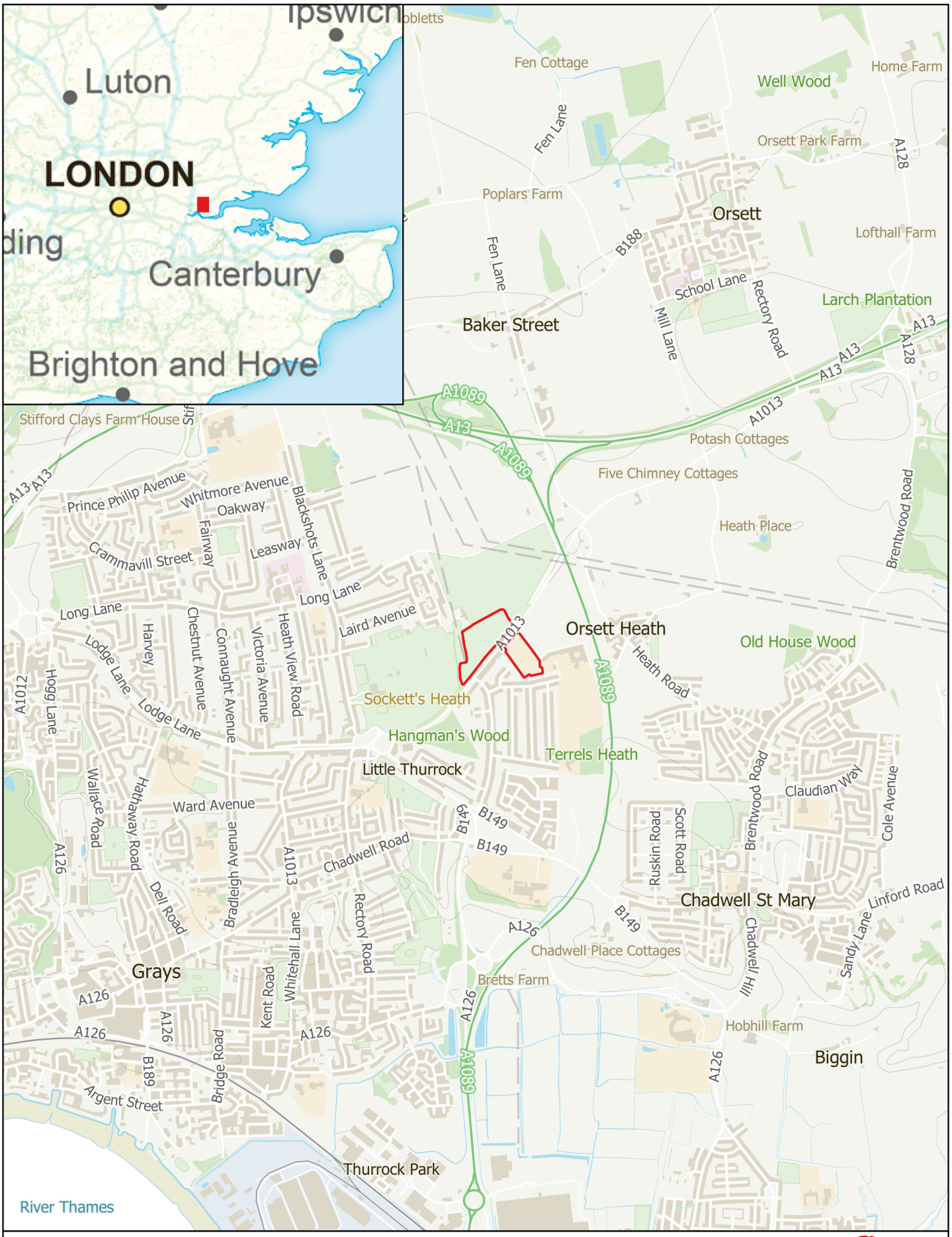
12. Project Metadata

MS Job Code	MSTQ790A
Project Name	Orsett Heath, Essex
Client	L-P Archaeology
Grid Reference	TQ 6337 7982
Survey Techniques	Magnetometry
Survey Size (ha)	6.7ha (Magnetometry)
Survey Dates	28/10/2020 – 29/10/2020
Project Lead	Krasimir Dyulgerski BA MRes
Project Officer	Frederick Salmon BSc FGS ACIfA
HER Event No	N/A
OASIS No	N/A
S42 Licence No	N/A
Report Version	1.0

13. Document History

Version	Comments	Author	Checked By	Date
0.1	Initial draft for Project Lead to Review	MC	KD	04 November 2020
0.2	Corrections after initial Project Lead Review	MC	KD	04 November 2020
0.3	Draft for Director review	MC, KD	KA	05 November 2020
0.4	Corrections after Director review	MC	KA	06 November 2020
1.0	Report Issued as Final	KD	KA	25 February 2020



MSTQ790A: Orsett Heath, Essex
Figure 1 - Site Location
1:25,000 @ A4

Site Boundary

N

0 0.5 1 km

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MSTQ790A: Orsett Heath, Essex
Figure 2 - Location of Survey Areas
1:5,000 @ A3

Survey Extent

N

0 150 300 450 m

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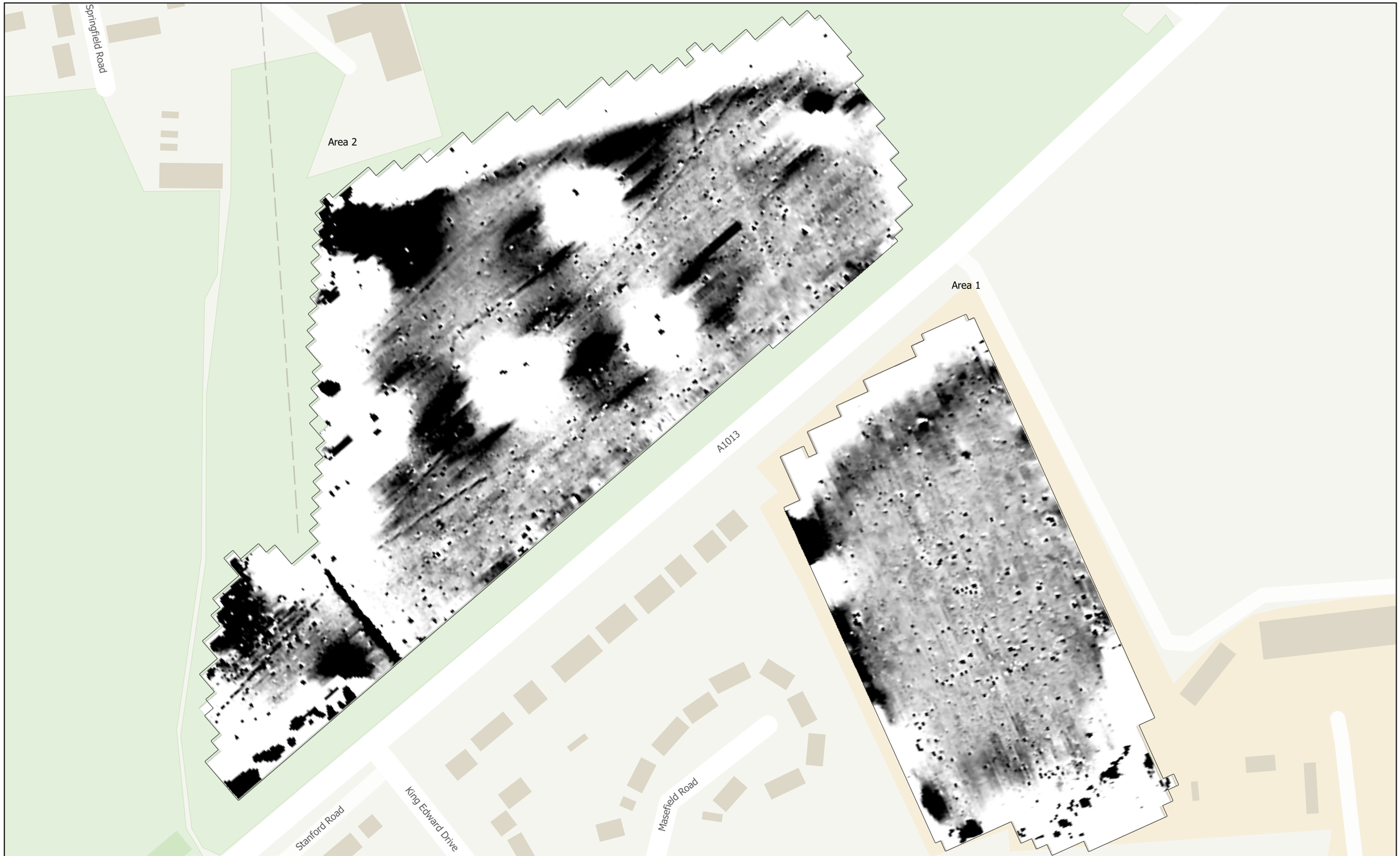

MSTQ790A: Orsett Heath, Essex
Figure 3 - Magnetic Total Field (Lower Sensor)
1:1,500 @ A3

48,995 nT 49,010

N

0 50 100 150 m

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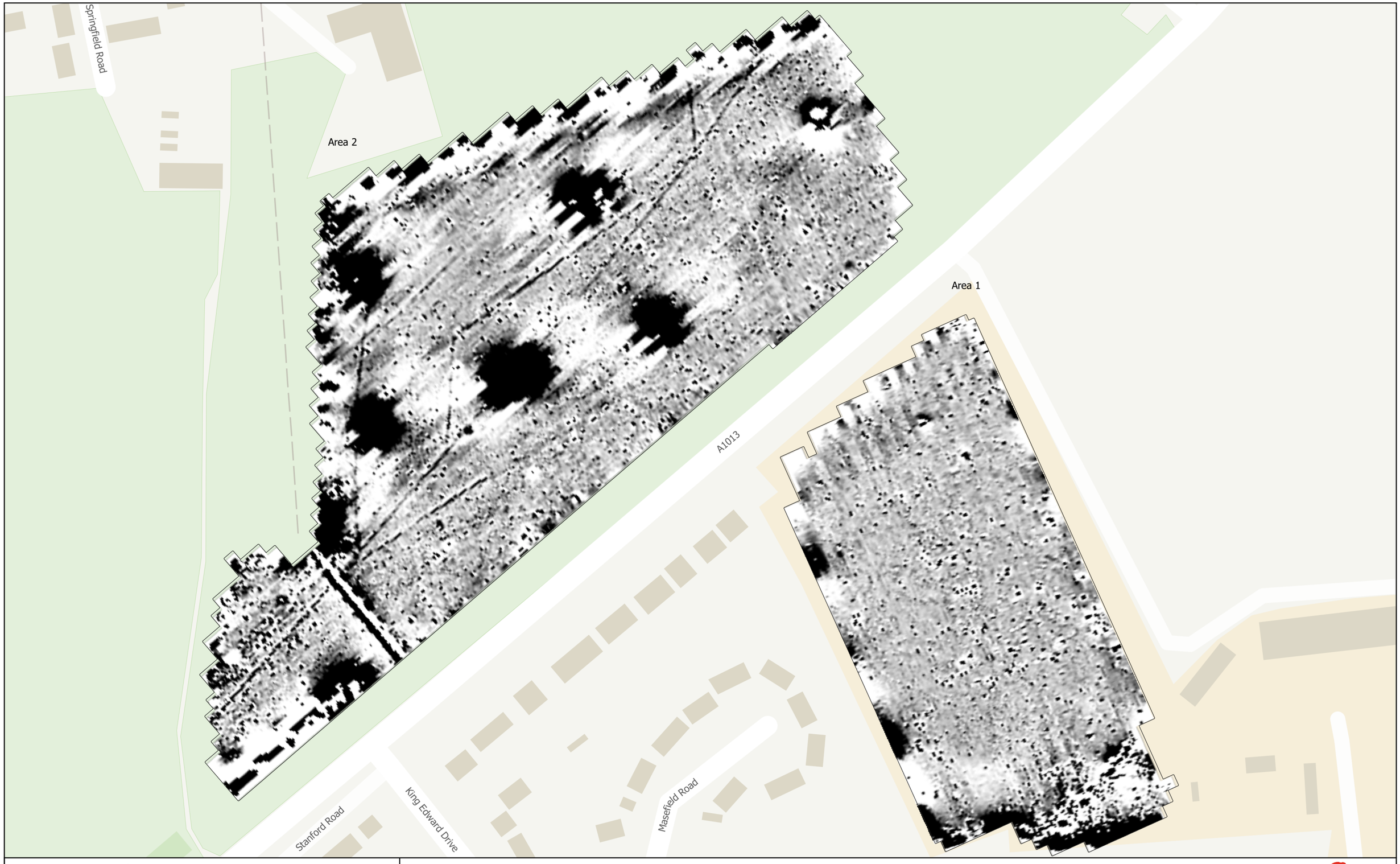

MSTQ790A: Orsett Heath, Essex
Figure 4 - Magnetic Gradient
1:1,500 @ A3

-1 nT 2

N

0 50 100 150 m

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MSTQ790A: Orsett Heath, Essex
Figure 5 - Magnetic Interpretation
1:1,500 @ A3

- Agricultural (Strong)
- Magnetic Disturbance
- Ferrous/Debris (Spread)
- Undetermined (Weak)
- Agricultural (Trend)
- Service
- Data Artefact
- Drainage Feature
- Ferrous (Spike)

N

0 50 100 150 m

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563000
563500
180000
179500
Area 2
Area 1
Gravel Pit
Heath Farm
F.P.
B.T.

MSTQ790A: Orsett Heath, Essex
Figure 6 - Magnetic Interpretation Over Historic Maps and Satellite Imagery
1:3,000 @ A3

- Agricultural (Strong)
- Magnetic Disturbance
- Ferrous/Debris (Spread)
- Undetermined (Weak)
- Agricultural (Trend)
- Service
- Modern/Industrial (Trend)
- Drainage Feature
- Ferrous (Spike)

N

0 90 180 270 m

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MSTQ790A: Orsett Heath, Essex
Figure 7 - XY Trace Plot
30nT/cm at 1:1,500 @ A3

N

0 50 100 150 m

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