magnitude surveys

Geophysical Survey Report

of

Land at Green Lane East, Rackheath, Norfolk

For

RPS

On Behalf Of

Halsbury Homes Ltd

Magnitude Surveys Ref: MSTG560

HER Event Number: ENF146695

OASIS Number: magnitud1-371741

NGR: TG 2865 1196

LPA: Broadland District Council

Planning Application Number: 20191421

Consultation Number: CNF48824_2

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magnitude surveys

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Abstract

Magnitude Surveys was commissioned to assess the subsurface archaeological potential of a c. 7ha area of land at Green Lane East, Rackheath, Norfolk. A fluxgate gradiometer survey was successfully completed across the site. The identified geophysical anomalies are characterised by weak magnetic enhancement in comparison to the surrounding background. Possible archaeological activity has been identified as very weak anomalies that that correspond with cropmarks previously interpreted as enclosures and linear features. Anomalies related to historical agricultural use have been detected and have been interpreted as ridge and furrow features, a plough headland and a former field boundary. Natural variations have also been identified, with superficial sand and gravel deposits creating a mottled affect across the site, as well a possible paleochannel detected in the south. The impact of modern activity on the results is generally limited to magnetic disturbance along the field edges.

Contents

List of Figures

1. Introduction

1.1. Magnitude Surveys Ltd (MS) was commissioned by RPS on behalf of Halsbury Homes Ltd to undertake a geophysical survey on a c. 7ha area of land at Green Lane East, Rackheath, Norfolk (TG 2865 1196).

1.2. The geophysical survey comprised hand-pulled, cart-mounted GNSS-positioned fluxgate gradiometer survey.

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. The survey was conducted in line with a Written Scheme of Investigation produced by MS (2019).

1.5. The survey commenced on 16/10/2019 and took one day 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. Director Dr. Chrys Harris is a Member of CIfA, has a PhD in archaeological geophysics from the University of Bradford and is the Vice-Chair of ISAP. Director Finnegan Pope-Carter is a Fellow of the London Geological Society, the chartered UK body for geophysicists and geologists, as well as a member of GeoSIG, the CIfA Geophysics Special Interest Group. Reporting Analyst Dr. Kayt Armstrong has a PhD in archaeological geophysics from Bournemouth University, is the Vice Conference Secretary and Editor of ISAP News for ISAP, and is the UK Management Committee representative for the COST Action SAGA.

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 is to assess the subsurface archaeological potential of the survey area.

4. Geographic Background

4.1. The site is located to the immediate south from the village of New Rackheath, Norfolk (Figure 1). Survey was undertaken across one arable field. The site is bounded by Broad Lane the northeast, the Bittern Rail line to the southeast, the A1270 to the southwest and the Salhouse road to the northwest (Figure 2).

4.2. Survey considerations:

Survey Area	Ground Conditions	Further Notes
1	The area consisted of flat arable land, with stubble from a maize crop. Soil was damp and uneven, interspersed with tractor tracks.	The survey area was bounded by a road and housing to the northeast, which was also the site entrance. Bounded to the south-west by wire fencing and a public footpath, to the northwest by wire fencing and a steep sloped embankment of a road bridge and to northwest by a coppice of trees and an adjoining field in the north-western corner of the survey area.

4.3. The underlying geology comprises sand and gravel of the Crag Group. Superficial deposits consist of Diamicton of the Happisburgh Glacigenic Formation underlie the southern and eastern parts of the survey area and sand and gravel of the Sheringham Cliffs Formation underlie the north-western part of the survey area (British Geological Survey, 2019).

4.4. The soils consist of freely draining slightly acid loamy soils (Soilscapes, 2019).

5. Archaeological Background

5.1. The following is a summary of an archaeology background from an archaeological desk-based assessment produced by CgMs Ltd (2019), which was provided by RPS.

5.2. Early prehistoric activity has been recorded in the wider environs as an unprovenanced Palaeolithic hand axe (NHER 8151) in a field to the east of the survey area. Further prehistoric activity is recorded as a Mesolithic or possibly later quartzite mace head (NHER 8169) c.330m to the east, a Neolithic axe head and flint implements (NHER 8153) c.500m to the west, and an early Bronze Age arrowhead c.670m to the north of the survey area.

5.3. Within the survey area, a series of cropmark features have been identified from remote sensing data. These features have been interpreted as ditches, enclosures and a subcircular feature of Bronze Age date (NHER 51933-34, NHER 52295).

5.4. Later prehistoric activity has been recorded in the wider environs as cropmarks of potential barrows or small subcircular enclosures c750m east of the site (NHER 51929) and c.700m south (NHER 51939), a sub-square enclosure c.750m south-east (NHER 51940, and a double ditched enclosure c.700m south-east (NHER 51941). The sub-square enclosure and double ditch enclosure are within a wider complex (NHER 51942). A further concentration of cropmark ditches is recorded c 300 - 400m east of the site (NHER 51930-32) as well as a long straight ditch recorded west of the survey area (NHER 51918).

5.5. Roman activity has been recorded in the wider environs as findspots of a brooch and coin (NHER 29707) c.500m west of the survey site. Further Roman activity is present in the form of cropmarks delineating a small Romano-British settlement site (NHER 39886) c.1km north of the site and a roundhouse gully (NHER 51923-4) south of the site.

5.6. Medieval activity has been recorded in the wider environs as a road (NHER 8166) which formed the boundary been Rackworth and Plumstead Parishes and marked the northern boundary of the site.

6. Methodology

6.1. Data Collection

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

6.1.2. 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

6.1.3. The magnetic data were collected using MS' bespoke hand-pulled cart system GNSS-positioned system.

6.1.3.1. MS' cart 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.

6.1.3.2. 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.

6.1.3.3. 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.

6.2.Data Processing

6.2.1. 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.

6.3.Data Visualisation and Interpretation

6.3.1. 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 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.

6.3.2. 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 (2019) was consulted as well, to compare the results with recent land usages.

6.3.3. 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 client provided CAD mapping.

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 fluxgate gradiometer survey is characterised by an overall variable magnetic background, with the sand and gravel geology and makeup of the natural soils contributing to a speckled look. The nature of the magnetic background has complicated the interpretation of the anomalies detected due to an overall poor magnetic enhancement of the site. As such the following interpretations are tentative. Though distinct anomalies were identified in the interpretation process, ordinarily these would have been classified as undetermined; meaning no one explanation is preferred over another due to the uncertainty created by their weak appearance and the mottled, relatively noisy background. However, when these anomalies are considered in the light of the cropmark interpretation recorded in (CgMs Ltd, 2019), then they can be tentatively interpreted as discussed below. However, with reference to this supplementary sources, very weak linear and discrete anomalies were picked out from the background variation, which may reflect archaeological, agricultural and natural features.

7.2.3. Modern interference is limited to magnetic disturbance along the field boundaries, especially to the southeast along the railway. Natural variations have been identified as a scattering of small, discrete deposits across the survey area, with broader, deeper bands evident in the magnetic total field. A band of slightly stronger, positive magnetic material runs roughly east-west through the southern part of the survey area, matching a broad sinuous cropmark visible on recent satellite imagery, which may indicate the course of a paleochannel.

7.2.4. Possible archaeological activity is limited to very ephemeral linear anomalies, a few of which appear to align with the cropmark features of the double enclosure (see Section 5.3). A further positive linear anomaly orientated approximately east - west, is recorded in the southern corner of the survey area. This closely matches the location of a linear

cropmark feature, which was recorded as an undated ditch during previous excavations in the field to the immediate west of the survey area. However, there are other similar anomalies in this location, which may indicate other unrelated activity.

7.2.5. Agricultural activity has been identified in the eastern part of the survey area as ridge and furrow trends with an associated ploughing headland. These anomalies collocate with more apparent cropmarks features visible on satellite imagery. A former field boundary has been identified running northwest-southeast through the western part of the survey area, which matches a tree lined boundary depicted on early editions of OS mapping.

7.2.6. Several discrete linear anomalies have been identified across the survey area. These appear to have characteristics of cut features; however, the strength of the magnetic signal is very weak and disjointed, making it difficult to be certain whether they relate to archaeological, agricultural or natural features. An Undetermined origin has therefore been ascribed.

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. **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.

7.3.1.3. **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. **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

Possible Archaeology – In the centre of survey area, a series of linear anomalies [**1a**] have been identified. They exhibit a positive magnetic signal that is very weak, but are evident as a rectilinear configuration in the XY Trace plot (Figure 7). Some of the anomalies within this cluster match the location and orientation

of the cropmarks of the possible double enclosure (see Section 5.3). This correlation infers a higher level of potential significance for these anomalies. The signal strength of these anomalies is similar to the natural background variation, indicating the fill of these features is not strongly differentiated from the surrounding soils. This could be a result of either a generally low Fe content in the soil and parent geology (making strong magnetic enhancement difficult) or a combination of less intensive past human activity, or the influence of waterlogging, reducing or inhibiting the magnetic enhancement.

7.3.2.1. **Ridge and Furrow –** To the south of [**1a**], a parallel series of weak slightly curved linear anomalies [**1b**] have been identified in the south-eastern part of the survey area. The anomalies are orientated on an approximate northwest-southeast alignment and have been interpreted as ridge and furrow cultivation features as they match the orientation of ridge and furrow cropmark features visible on satellite imagery dated from 1999 (Google Earth, 2019). A weak linear anomaly delimits the western edge of the ridge and furrow, possibly a ploughing headland, which is also visible on the satellite imagery.

7.3.2.2. **Undetermined** – In the north-eastern end of the survey area, at least two weak linear trend anomalies [**1c**] have been identified running approximately parallel on a north-south alignment. Due to the ephemeral and disjointed nature of the anomalies it is difficult to attribute to a specific period of origin; however, they do lie on a similar orientation to the possible ploughing headland (see Section 1) to the immediate south, which may suggest a track or broad plough headland separating the different regimes of ploughing activity that are visible as cropmarks on the 1999 satellite imagery (Google Earth, 2019).

7.3.2.3. **Agricultural** – Further anomalies associated with more recent agricultural activity were identified. of A linear trend of positive and dipolar discrete anomalies [**1d**] have been identified running through the south-western part of the survey area, on a northwest-southeast alignment. This matches the location of a former field boundary depicted on historic mapping. On early editions of the OS map, the boundary is depicted as tree lined; therefore, the linear trend of discrete anomalies may relate to the removal of the trees. At the northern end of the linear feature the magnetic signal becomes strongly ferrous (Figure 7), which is a typical response of a modern drainage feature.

7.3.2.4. **Undetermined/Natural** – The other specific anomalies identified in the site are less conclusive in origin. In the southern corner of the survey area a short linear anomaly, measuring c. 12m long by c 2m wide, [**1e**] has been identified. This anomaly aligns with a linear cropmark feature that was recorded as an undated ditch during previous archaeological excavations in the field to the immediate west of the survey area. However, this anomaly is not typical of what would be expected of ditch-cut features and is more similar to the adjacent anomalies indicative of a natural origin.

8. Conclusions

8.1. A fluxgate gradiometer survey has successfully been undertaken across the site. Modern interference is limited to magnetic disturbance along the field edges. Natural changes have been identified as bands of weak magnetic enhancement across the site; as well as a stronger band of enhancement running east-west across the southern part of the site, which is suggestive of a paleochannel. The geophysical survey has detected a range of different very weak anomalies that may relate to features of an archaeological, natural and agricultural origin. The underlying geology and soils have contributed to the weak, variable enhancement of the magnetic data, making interpretation of the respectively weak anomalies identified difficult.

8.2. Anomalies of a possible archaeological origin have been identified as weak linear anomalies that collocate with cropmark features previously interpreted as a double enclosure. In the southwest, a short linear anomaly has been identified which may be a continuation of an undated ditch which was excavated immediately west of the survey area. The ephemeral nature of the magnetic signal of these anomalies may suggest either less intensive archaeological activity, or a generally lower FE content of the soil.

8.3. Agricultural activity has been detected in the eastern part of the survey area, interpreted as ridge and furrow, perhaps delineated to the west by an associated plough headland. A former field boundary, which matches the location of a boundary depicted on historic mapping, has also been identified running across the west of the survey area, part of which has been utilised for modern drainage.

8.4. Several anomalies forming linear trends have been classified as ‘Undetermined’. Due to the ephemeral, disjointed nature of these anomalies, it is difficult to draw a correlation between them and more certain features. However, some of the anomalies match the orientation of features identified as cropmarks of ridge and furrow ploughing regimes and headlands, which may suggest a possible association.

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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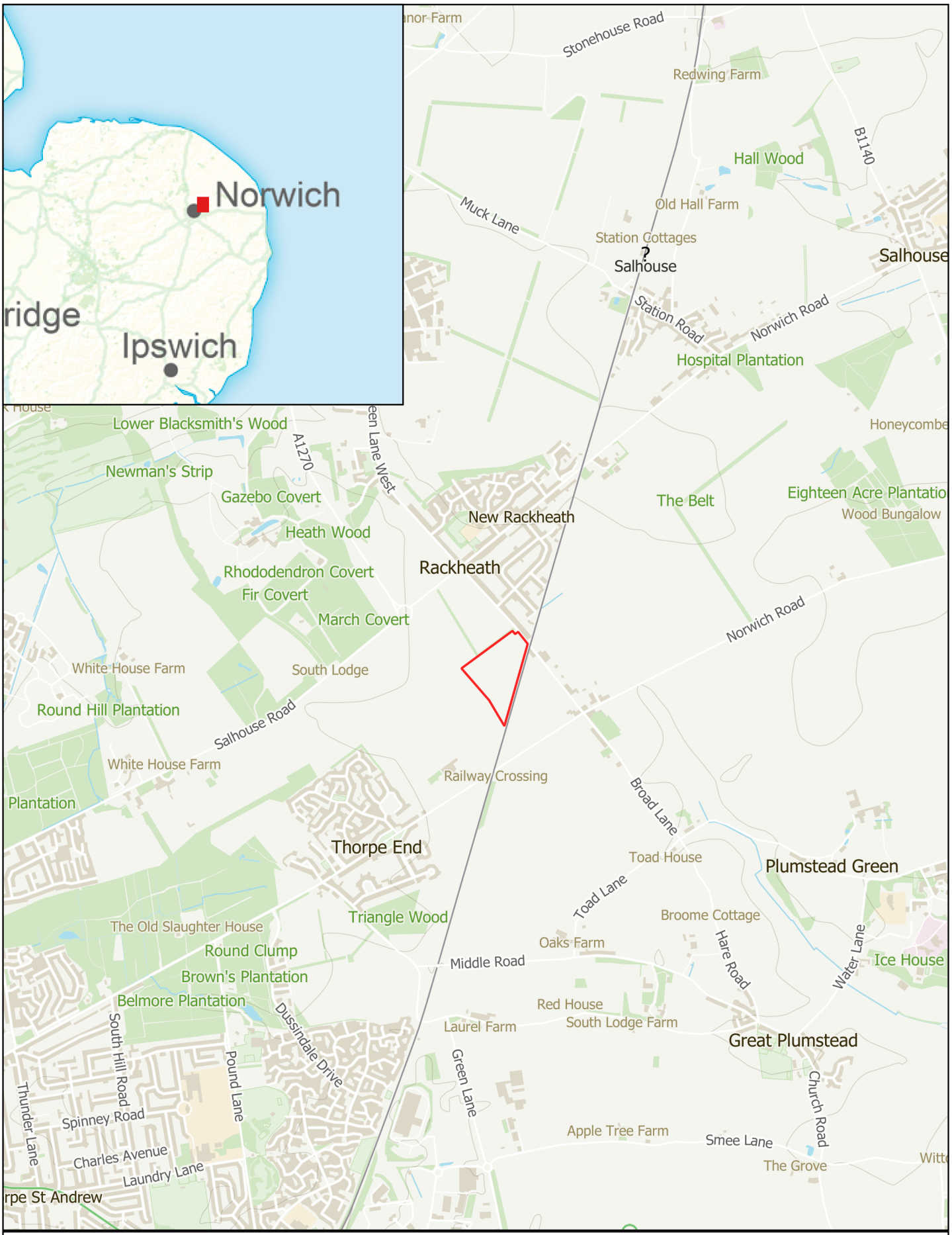
12. Project Metadata

MS Job Code	MSTG560
Project Name	Land at Green Lane East, Rackheath, Norfolk.
Client	RPS
Grid Reference	TG 2865 1196
Survey Techniques	Magnetometry
Survey Size (ha)	7ha (Magnetometry)
Survey Dates	2019-10-16 to 2019-10-17
Project Manager	Chrys Harris BA MSc PhD MCIfA
Project Officer	Frederick Salmon BSc FGS
HER Event No	ENF146695
OASIS No	magnitud1-371741
S42 Licence No	N/A
Report Version	1.0

13. Document History

Version	Comments	Author	Checked By	Date
0.0	Initial draft for Project Officer to Review	CN	LS	2019-10-22
0.1	Corrections from Project Officer	CN	CH	2019-10-23
0.2	Review for Project Manager. Report issued to client.	CN	CH	2019-10-25
1.0	Addition of reference numbers to front cover and issued as final.	LS	LS	2019-11-05



MSTG560 - Land at Green Lane East, Rackheath, Norfolk
Figure 1 - Site Location
1:25,000 @ A4

Site Boundary

N

0 0.5 1 km

magnitude surveys

628000
629000
312000
312000
A1270
A1270
Salhouse Road
March Covert
Green Lane East
Lonsdale Road
Vera Road
Vera Close
Bernard Close
Broad Lane
Norwich Road
Plumstead Road
Padgate

MSTG560 - Land at Green Lane East, Rackheath, Norfolk
Figure 2 - Location of Survey Area
1:4,000 @ A3

Survey Extent

N

0 100 200 300 m

magnitude surveys

628400
628500
628600
628700
311800
311700
311600
312200
312100

MSTG560 - Land at Green Lane East, Rackheath, Norfolk
Figure 3 - Magnetic Gradient
1:1,500 @ A3

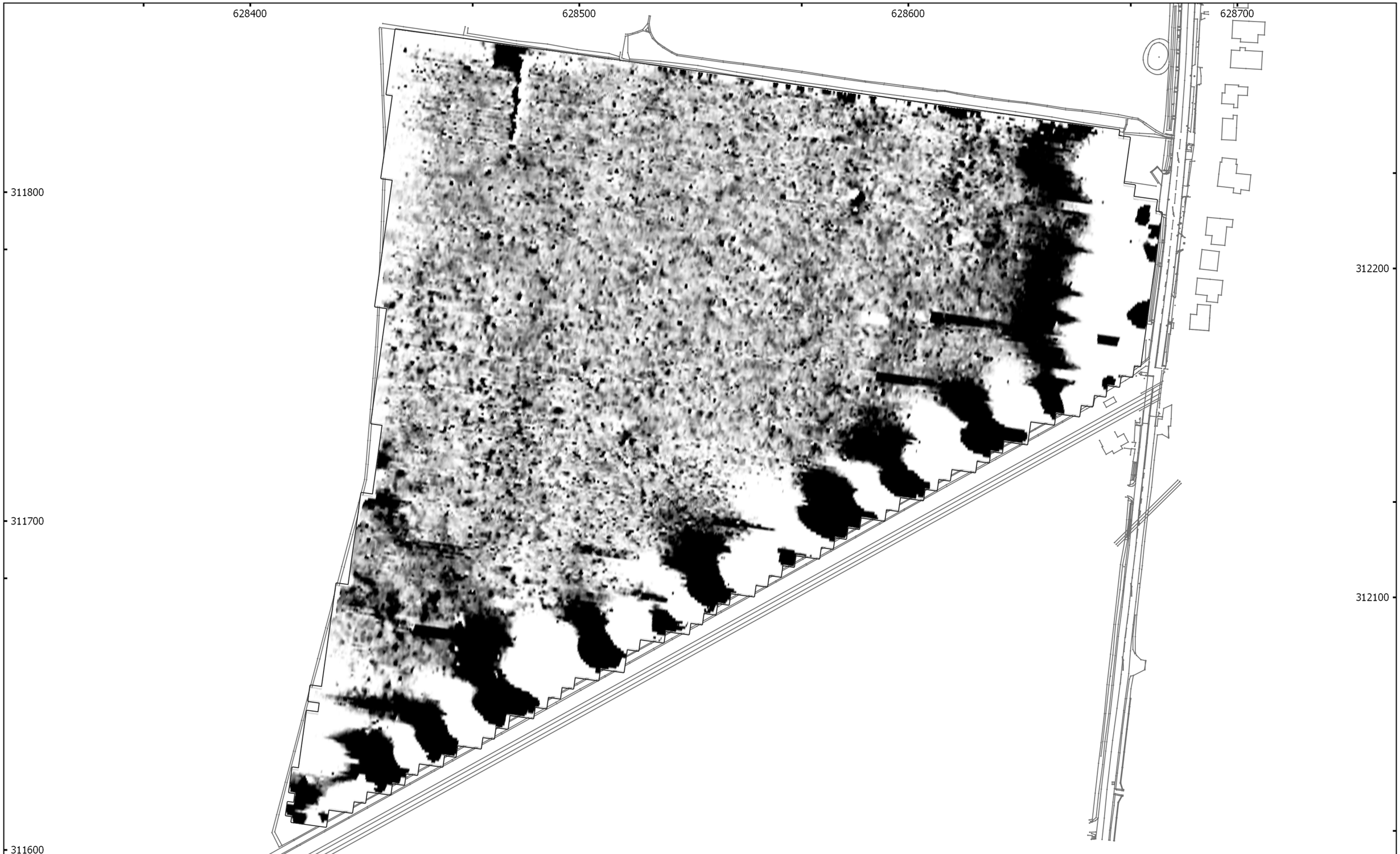
-1 nT 2

N

0 25 50 75 m

magnitude surveys

628400
628500
628600
628700
311800
312200
311700
312100
311600



MSTG560 - Land at Green Lane East, Rackheath, Norfolk
Figure 4 - Magnetic Total Field (Lower Sensor)
1:1,500 @ A3

48,998 nT 49,003

N

0 25 50 75 m

magnitude surveys

628400
628500
628600
628700
311800
311700
311600
312200
312100
1a
1b
1c
1d
1e
1f

MSTG560 - Land at Green Lane East, Rackheath, Norfolk
Figure 5 - Magnetic Interpretation
1:1,500 @ A3

Archaeology Possible
Agricultural
Magnetic Disturbance
Natural
Undetermined
Ridge and Furrow (Trend)
Agricultural (Trend)
Drainage Feature
Undetermined (Trend)
Ferrous Spike

N
0 25 50 75 m

magnitude surveys

628200 628400 628600 628800 629000 629200

312200 312000 311800

B.M. 86·3

77 79 74 W

1a 1b 1c 1d 1e 1f

R. E. G. NORFOLK

Union

B.M. 78·0

G.P

B.P

Mouseho

MSTG560 - Land at Green Lane East, Rackheath, Norfolk
Figure 6 - Magnetic Interpretation Over Historic Maps
1:3,000 @ A3

Contains historic maps: Ordnance Survey, 6" 2nd edition c. 1882-1913 © National Library of Scotland

Archaeology Possible
Agricultural
Magnetic Disturbance
Natural
Undetermined
Ridge and Furrow (Trend)
Agricultural (Trend)
Drainage Feature
Undetermined (Trend)
Ferrous Spike

N

0 50 100 150 m

magnitude surveys

628400
628500
628600
628700
311800
312200
311700
312100
311600

MSTG560 - Land at Green Lane East, Rackheath, Norfolk
Figure 7 - XY Trace Plot
30nT/cm at 1:1,500 @ A3

N

0 25 50 75 m

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