



Geophysical Survey Report

of

Land off Norwich Common,

Wymondham, Norfolk

For Pegasus Group

On Behalf Of Gladman Developments Ltd

Magnitude Surveys Ref: MSTG452

HER Event Number: ENF145846

March 2019



Unit 17, Commerce Court

Challenge Way

Bradford

BD4 8NW

01274 926020

info@magnitudesurveys.co.uk

Version	Purpose/Revision	Author	Interpretation/Figures	Approved By	Date Issued
Draft 1.0	Initial draft to line	Marta Fortuny BA	Marta Fortuny BA MA	Julia Cantarano	12
	manager	MA		Ingénieur PCIfA	March
		Alison Langston			2019
		BA PCIfA			
Draft 1.1	First draft	Marta Fortuny BA	n/a	Kayt Armstrong	13
	internal QA	MA		BA MSc PhD	March
		-		MCIfA	2019
Draft 1.2	Second draft	Marta Fortuny BA	Julia Cantarano	Kayt Armstrong	14
	internal QA	MA	Ingénieur PCIfA	BA MSc PhD	March
				MCIfA	2019
Draft 1.3	Draft Report to	Marta Fortuny BA	n/a	Kayt Armstrong	14
	Client	MA		BA MSc PhD	March
				MCIfA	2019
Final	Minor corrections	Marta Fortuny BA	Marta Fortuny BA MA	Finnegan Pope-	21
	from client	MA		Carter BSc MSc	March
				FGS	2019

Abstract

Magnitude Surveys was commissioned to assess the subsurface archaeological potential of a c. 38.9ha area of land off Norwich Common, Wymondham, Norfolk. A fluxgate magnetometer survey was successfully completed across most of the area; a small c.0.8ha size field was not surveyable due to overgrown vegetation. Two separate groups of anomalies of possible archaeological origin have been identified to the north-east of the survey area. One is possibly related to the Roman Road identified from satellite imagery, although the geophysical data has not identified the Road itself. Another group has been linked to Post-Medieval Millyard activities. The geophysical results are further characterised by extensive drainage features and weak broad bands of natural variation in the soils. Former field boundaries, ponds and anomalies of undetermined origin have also been identified.

Contents

Abstract	2
List of Figures	4
List of Appendix	4
1. Introduction	5
2. Quality Assurance	5
3. Objectives	5
4. Geographic Background	6
5. Archaeological Background	7
6. Methodology	8
6.1. Data Collection	8
6.2. Data Processing	8
6.3. Data Visualisation and Interpretation	9
7. Results	10
7.1. Qualification	
7.2. Discussion	10
7.3. Interpretation	11
7.3.1. General Statements	11
7.3.2. Magnetic Results - Specific Anomalies	11
8. Conclusions	13
9. Archiving	13
10. Copyright	13
11. References	14

List of Figures

Figure 1:	Site Location	1:25,000 @ A4
Figure 2:	Location of Survey Areas	1:5,000 @ A3
Figure 3:	Magnetic Gradient (Narrow Plotting Range) (Overview)	1:3,500 @ A3
Figure 4:	Magnetic Interpretation Over Historic Mapping (Overview)	1:3,500 @ A3
Figure 5:	Magnetic Interpretation Over Satellite Imagery (Overview)	1:3,500 @ A3
Figure 6:	Magnetic Gradient (North)	1:1,500 @ A3
Figure 7:	Magnetic Interpretation (North)	1:1,500 @ A3
Figure 8:	XY Trace Plot (North)	1:1,500 @ A3
Figure 9:	Magnetic Gradient (West)	1:1,500 @ A3
Figure 10:	Magnetic Interpretation (West)	1:1,500 @ A3
Figure 11:	XY Trace Plot (West)	1:1,500 @ A3
Figure 12:	Magnetic Gradient (East)	1:1,500 @ A3
Figure 13:	Magnetic Interpretation (East)	1:1,500 @ A3
Figure 14:	XY Trace Plot (East)	1:1,500 @ A3
Figure 15:	Magnetic Gradient (South)	1:1,500 @ A3
Figure 16:	Magnetic Interpretation (South)	1:1,500 @ A3
Figure 17:	XY Trace Plot (South)	1:1,500 @ A3

List of Appendix

Appendix 1 – Comparison Geophysical Survey – 2010 Survey

Appendix 2 – Comparison Geophysical Survey – 2019 Survey

1. Introduction

- 1.1. Magnitude Surveys Ltd (MS) was commissioned by Pegasus Group on behalf of Gladman Developments Ltd to undertake a geophysical survey on a c.38.9ha area of land off Norwich Common, Wymondham, Norfolk (TG 1349 0295).
- 1.2. The geophysical survey comprised hand-pulled, cart-mounted and hand-carried GNSS-positioned fluxgate magnetometer 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), the European Archaeological Council (Schmidt et al., 2015) and the Norfolk County Council guidelines (Robertson et al. 2018).
- 1.4. The survey was conducted in line with a Written Scheme of Investigation produced by MS and approved by the client.
- 1.5. The survey commenced on 27th February 2019 and was completed on 6th March 2019.

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 ClfA, 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 ClfA Geophysics Special Interest Group. Reporting Analyst Dr. Kayt Armstrong is a Member of ClfA, 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.
- 2.4. As per guidelines from Norfolk County Council Environment Service to ensure good practice, data collection was repeated over the same traverses to demonstrate the consistency and reliability of the geophysical survey. These are presented below:
- 2.5. Duplicate of traverses 22 and 38:



3. Objectives

3.1. The geophysical survey aimed to assess the subsurface archaeological potential of the survey area.

4. Geographic Background

4.1. The site is located at the eastern end of Wymondham, Norfolk, c. 3km east of the town centre and approximately 13km south-west of Norwich, Norfolk (Figure 1). Survey was undertaken over 8 parcels of land bounded by housing and the B1172 to the north and north-west, by housing to the west, by the A11 to the south and by arable fields to the east (Figure 2).

4.2. Survey considerations:

Survey	Ground Conditions	Further Notes		
Area				
1	Grass pasture, flat.	Bounded by a hedgerow to all sides, with a water-		
		filled ditch along the southern boundary. A		
		drainage pond was located in the south-western		
		corner of the field, with a soil drainage test hole		
		just to its northeast.		
2	Grass pasture, flat.	Bounded by a hedgerow to the north, east and		
		west, with a ditch along the southern boundary.		
3	Very tall grass, overgrown area,	Survey was attempted but couldn't be completed		
	flat.	due to the density of the overgrown vegetation.		
4	Arable, young oilseed crop, flat.	Bounded by trees and a ditch to the north, a ditch		
1		to the west and south, with a track running north-		
		south along the eastern boundary.		
5	Arable, grass crop, with a small	Bounded by a hedgerow to the north, with no		
	area to the south which wasn't	boundary into Area 3 to the northwest. A deep		
	cultivated, flat.	ditch bounded the field to the east and south,		
		with a slight bank running along the western		
		boundary. Two soil drainage test holes were		
		located in the northwest and southwest.		
6	Arable, grass crop, flat.	Bounded by a ditch on all sides, except for a small		
		section along the north-western boundary which		
		was tree-lined. A hedgerow also ran along the		
		northern and southern boundaries. Two soil		
		drainage test holes were located in the northeast		
)		and southeast. A drainage pond was located at		
		the northern end of the eastern boundary.		
7	Arable, young oilseed crop, flat.	Bounded by a ditch to the north, a hedgerow and		
		a ditch to the east and south, with a wire fence		
		also present to the south. The western boundary		
		consisted of a mixture of trees and boundaries		
		with residential properties. A small area in the		
		south-western corner outside of the arable field		
		was unsurveyable as the area was overgrown		
		with grass and brambles.		
8	Arable, young oilseed crop, flat.	Bounded by a ditch and trees to the north, a ditch		
		to the east, a ditch and a hedgerow to the west,		
		and a wire fence to the south.		
		and a wife felice to the south.		

4.3. The underlying geology across the survey area comprises chalk from the Nodular Formation, Seaford Formation, Newhaven Formation, Culver Formation and Portsdown Formation while

superficial deposits consist of diamicton from the Lowestoft Formation (British Geological Survey, 2019).

4.4. The survey area is characterised by slowly permeable, seasonally wet and slightly acidic but base-rich loamy and clayey soils (Soilscapes, 2019).

5. Archaeological Background

- **5.1.** The following section summarises the Archaeology & Built Heritage Assessment provided by the client (Pegasus Group, 2019).
- 5.2. A geophysical survey was previously undertaken within the central and southern areas of the survey area in 2010 (HER ref. ENF 125229). Former field boundaries and modern field drains were recorded during the survey. Trench evaluations have also taken place in the immediate vicinity of the survey area (HER ref. ENF 126711, 132616).
- 5.3. Evidence of Prehistoric activity within the survey area consists of findspots of prehistoric flint tools and a Middle Bronze Age copper alloy chisel (HER refs. MNF 30069, 29286). There have been numerous findspots of prehistoric date close to the survey area, including worked lithics and pot boilers (HER refs. MNF 31269, 22752, 47933, 31988, 31303, 15765, 66894, 33779 & ENF 13556). A prehistoric ditch with nearby Neolithic flint fragments was identified immediately to the west of the survey area during trial trenching (HER ref. MNF 64434, ENF 126711). Iron Age charcoal-rich pits were also recorded during the trenching.
- 5.4. A Roman road runs east-west across the north-eastern extent of the site, within Area 6, previously identified on aerial photographs as cropmarks (HER ref. MNF 19725). Other evidence of Romano-British activity within the survey area consists of findspots of metal coins (HER ref. MNF 30069). During trial trench excavations c. 270m to the north of the survey area nine pits of Romano-British date were investigated, these consisted of waste disposal pits and small-scale extraction pits. Numerous other findspots have been recorded nearby the site, including coins, brooches, pottery sherds, and a lead weight (HER refs. MNF 41753, 31269, 31988, 31302, 31303, 15765, 66894, 28410, and ENF 13556).
- 5.5. Evidence of early medieval to medieval activity within the survey area is limited to two findspots, a medieval spur rowel 'box' along the north-western site boundary and various copper alloy medieval artefacts within the south-western area of the survey area (HER refs. MNF 29286, 30069). Numerous other findspots have been recorded near to the survey area, including coins, pottery sherds and horse-related metal finds.
- 5.6. A map regression has shown that the current field layout was previously sub-divided into smaller fields, with the land parcels along Norwich Common notably being arranged in small strips until the start of the 19th century.

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 and hand-carried, GNSS-positioned system.
 - 6.1.3.1. MS' cart and hand-carried systems were 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).

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

 $\underline{\text{Zero Median Traverse}}$ — 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.

<u>Projection to a Regular Grid</u> — 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.

<u>Interpolation to Square Pixels</u> – 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 (Figures 8, 11, 14, and 17). 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 will be 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 historic mapping (Figure 4) and satellite imagery (Figure 5).
- 7.2.2. The fluxgate magnetometer survey has responded well to the environment of the survey area. Magnetic disturbance from modern sources is limited to the field edges, services to the south-western part of the survey area and a large spread of ferrous debris throughout Area 2. The survey results are characterised by a relatively quiet background. As a result, the identification of weaker, more ephemeral responses has been possible. Natural variations have been identified with greater clarity in the magnetic gradient of narrow plotting range (Figure 3) and correspond to changes of composition within the superficial deposits of diamicton.
- 7.2.3. Cropmarks identified in aerial photographs and satellite images (Figure 5) had been previously linked to the speculated route of the Roman road running west-east across the north-eastern part of the site (see 5.5 Archaeological Background). The geophysical survey has not recorded anomalies characteristic of road, trackway or roadside settlement activities. Only two weak, ephemeral possible ditches have been recorded in the location and alignment of the projected road. Therefore, these have been classified as being of possible rather than probable archaeological origin.
- 7.2.4. In the north-eastern part of the survey area and in close proximity to the mill yard depicted in the 2nd ed. Ordnance Survey map (Figure 4), activity likely related to post medieval millyard activities has been identified.
- 7.2.5. The agricultural utilisation of the survey area has left a drainage network across the survey area. A number of former field boundaries and ponds, recorded on 2nd edition Ordnance Survey maps (Figure 4) have been identified as part of this landscape.
- 7.2.6. Across all surveyed areas, equally spaced and regular parallel linear anomalies have been recorded. These exhibit a weak yet distinct magnetic pattern and are likely to

represent drainage features. The anomalies are aligned on angles against the ploughing trends and field boundaries. The drainage features recorded to the south-east of Area 5 exhibit a distinct dipolar response; these are likely to be caused by ceramic field drains (Figure 12).

- 7.2.7. A number of linear trends have been identified in the north-eastern part of the survey area, in close proximity to the anomalies of possible archaeological origin. These have been classified as 'Undetermined' because from their magnetic properties, it is not possible to discriminate between archaeological and agricultural features. There are further amorphous undetermined anomalies scattered throughout the survey area.
- 7.2.8. Appendix 1 & 2 include geophysical data collected by Northamptonshire Archaeology (Walford & Fisher, 2010). These allow for the comparison between these two magnetic datasets. There is a variation in the number of drainage-type features detected. This may reflect changes in land use between the surveys and/or differences in the data collection strategy and data processing.

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 and by services that cross the survey area 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 that 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. The debris causing this spread of dipolar anomalies is likely to be an accumulation of agricultural material added to the track to consolidate it.
- 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

7.3.2.1. **Archaeology Possible** – In the northern part of Area 6, two parallel weak positive linear anomalies has been identified running east to west [6a] (Figure

- 7). These anomalies measures c.50m long and appears to be respected by the surrounding drainage features. Anomaly [6a] is in a similar location and orientation as the projected Roman road. However, due to the lack of further adjoining anomalies, more characteristic of road related activities, it has been interpreted as possibly archaeological in origin, rather than probably. It is possible that the drainage ditches are interrupted in this location because the remains of the road were too dense to cut through to place them. The lack of substantial anomalies related to earthworks such as ditches along the road suggests that in this location the road structure is somewhat disturbed or concatenated, with only the 'hardcore' remaining.
- 7.3.2.2. Archaeology Possible Towards the north-west corner of Area 6, a series of weak and strong linear and pit anomalies have been identified [6b] (Figure 7). The linear anomalies are quite ephemeral and small scale, with stronger magnetic responses to the west. Considering their magnetic strength and close proximity to the 'Millyard' that is recorded on numerous historic maps, it is possible these anomalies are related to such activity.
- 7.3.2.3. **Agricultural** Agricultural trends related to recent ploughing are visible across some of the surveyed areas.
- 7.3.2.4. **Undetermined** To the north-centre part of Area 8, a rectangular weak magnetic anomaly has been identified [8a] (Figure 13). This anomaly is possibly related to the pond recorded on historic maps just north of Area 8. However, the XY trace plot (Figure 14) is not characteristic of a pond infilled with ferrous materials.
- 7.3.2.5. **Ferrous/Debris (Spread)** Two elongated responses [**7a**] & [**7b**] have been recorded in the western part of Area 7 (Figure 16). These closely follow the route of a former field boundary, which can be seen on the 2nd edition OS map (Figure 4). Anomaly [**7a**] exhibits a dipolar linear response along it, which indicates it has also been reused for the location of a service.

8. Conclusions

- 8.1. The geophysical survey responded well to the survey area's environment. Broad, wavy bands of slightly more magnetic deposits have been recorded across the site which correspond variation in the superficial geology. Magnetic disturbance of modern origin is limited to the boundaries of the survey areas and services were detected. The survey detected a variety of anomalies of archaeological, agricultural, and natural origin across the areas.
- 8.2. The Roman Road or roadside settlement activity, previously recorded from cropmarks, hasn't been identified in the magnetic data. Only two parallel linear anomalies has been linked to possibly related to the Roman Road, as it correlates in location and orientation.
- **8.3.** A group of probable ditches and pits related to post-medieval mill yard activities have been identified to the north-eastern part of the survey area.
- 8.4. Agricultural activity has been identified in the form of extensive drainage features. Former field boundaries, some of which have been reutilised for the collocation of modern services, ponds and ploughing trends are also recorded across the site; these are denoted in the 2nd ed OS map.

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 ungeoreferenced 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

British Geological Survey, 2019. Geology of Britain. [Wymondham, Norfolk]. [http://mapapps.bgs.ac.uk/geologyofbritain/home.html/]. [Accessed 06/03/2019].

Chartered Institute for Archaeologists, 2014. Standards and guidance for archaeological geophysical survey. CIfA.

David, A., Linford, N., Linford, P. and Martin, L., 2008. Geophysical survey in archaeological field evaluation: research and professional services guidelines (2nd edition). Historic England.

Google Earth, 2019. Google Earth Pro V 7.1.7.2606.

Magnitude Surveys Ltd, 2019. Written Scheme of Investigation For a Geophysical Survey of Norwich Common Wymondham, Norfolk. Ref: MSTG452, February 2019.

Olsen, N., Toffner-Clausen, L., Sabaka, T.J., Brauer, P., Merayo, J.M.G., Jorgensen, J.L., Leger, J.M., Nielsen, O.V., Primdahl, F., and Risbo, T., 2003. Calibration of the Orsted vector magnetometer. *Earth Planets Space* 55: 11-18.

Pegasus Group, 2019. Land off Norwich common, Wymondham: Archaeology and Built Heritage Assessment. Pegasus Group.

Robertson, D., et al., 2018. Standards for development-led archaeological projects in Norfolk. Norfolk County Council. Environment Service

Schmidt, A. and Ernenwein, E., 2013. Guide to good practice: geophysical data in archaeology. 2nd ed., Oxbow Books, Oxford.

Schmidt, A., Linford, P., Linford, N., David, A., Gaffney, C., Sarris, A. and Fassbinder, J., 2015. Guidelines for the use of geophysics in archaeology: questions to ask and points to consider. EAC Guidelines 2. European Archaeological Council: Belgium.

Soilscapes, 2019. [Wymondham, Norfolk]. Cranfield University, National Soil Resources Institute [http://landis.org.uk]. [Accessed 06/03/2019].

Walford, J., & Fisher, I. 2010. Archaeological Geophysical Survey on Land to the East of Wymondham, Norfolk. Northamptonshire Archaeology. Unpublished Report provided by Client.





































