magnitude surveys

Geophysical Survey Report

of

Land at Green Lane Orchard, Norwich

For

Orion Heritage

On Behalf Of

Landform Norwich Ltd

Magnitude Surveys Ref: MSTQ366

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Unit 17, Commerce Court

Challenge Way

Bradford

BD4 8NW

01274 926020

info@magnitudesurveys.co.uk

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Abstract

Magnitude Surveys was commissioned to assess the subsurface archaeological potential of a c. 10.5 ha area of Land at Green Lane Orchard, Norwich. A fluxgate magnetometer survey was successfully completed and no anomalies of probable or possible archaeological origin have been identified. The geophysical results primarily reflect demolished buildings and infilled agricultural features associated with Smee House, including a possible well and pond feature, as well as a number of probable field boundaries which are recorded on historic mapping. A number of probable drainage features and buried services have also been identified.

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1. Introduction

1.1. Magnitude Surveys Ltd (MS) was commissioned by Orion Heritage on behalf of Landform Norwich Ltd to undertake a geophysical survey on a c.10.5 ha area of the Land at Green Lane Orchard, Norwich, Norfolk (TG 2871 0975).

1.2. The geophysical survey comprised a hand-pulled, cart-mounted 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 Norfolk County Council (Robertson et al., 2018).

1.4. The survey commenced on 28/08/18 and took three days to complete.

2. Quality Assurance

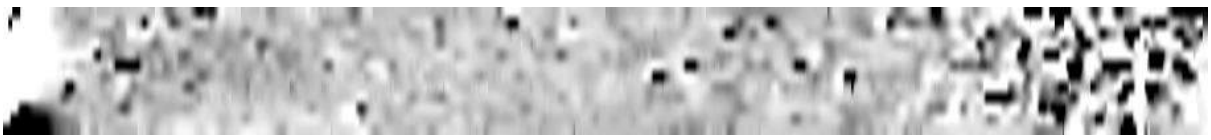
2.1. Magnitude Surveys is a Registered Organisation of the Chartered Institute for Archaeologists (CIfA), the chartered UK body for archaeologists, and a corporate member of ISAP (International Society of Archaeological Prospection).

2.2. Director Graeme Attwood is a Member of CIfA, as well as the Secretary of GeoSIG, the CIfA Geophysics Special Interest Group. 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. Director Chrys Harris has a PhD in archaeological geophysics from the University of Bradford and is the Vice-Chair of the International Society for Archaeological Prospection.

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. Per the requirements of the brief issued by Norfolk County Council Environment Service, data collection was repeated over the same traverses to demonstrate the consistency and reliability of the geophysical survey. These are presented below:

2.5. Traverses 26, 27 and 28:



2.6. Traverses 26, 29 and 28:

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 on Land at Green Lane Orchard, north of Smee Lane, Great Plumstead, approximately five kilometres from the centre of Norwich (Figure 1). Survey was undertaken over five areas of flat arable land to the east of Green Lane and north of Smee Lane (Figure 2), totalling 10.32ha. A sixth area, c.0.6ha in size, was unable to be surveyed due to adverse field conditions (see 4.2 below)

4.2. Survey considerations:

Survey Area	Ground Conditions	Further Notes
1	Flat arable stubble	Bounded by hedgerows to the west, north and east, and a trackway to the south
2	Flat arable stubble	Bounded by hedgerows to the west, a trackway to the north, and hedgerows containing wire fencing to the east. In the north of the survey area was a plastic Fossett valve cover 20cmx20cm.
3	Flat arable stubble	Bounded by trees to the south and west, and wire fencing to the north and east. A metal gate was located in the south-west corner of the area
4	Flat arable stubble	Bounded by hedgerows to the south and west, and trees to the north and east. A manhole was positioned in the centre of the survey area.
5	Flat arable stubble	Bounded by hedgerows to the west and east, hedgerows containing wire fencing to the north, and trees to the south.
6	Tall grass and weeds	This area was not able to be surveyed; tall thick vegetation prevented movement of the hand-pulled cart system.

4.3. The underlying geology consists of Crag Group sands and gravels across the site. Superficial deposits comprise diamicton of the Happisburg Glacigenic Formation (British Geological Survey, 2018).

4.4. The soils consist of freely draining slightly acid loamy soils (Soilscapes, 2018).

5. Archaeological Background

5.1. The following section provides an overview of the archaeological environment in the immediate vicinity of the survey areas, summarising information produced by CgMs Heritage Ltd (Petric, 2018).

5.2. Early Prehistoric activity, in close proximity to the survey areas, comprises the recovery of a Lower Palaeolithic flint hand axe (MNF50041). The hand axe was discovered in a pit during excavations at Laurel Farm, to the immediate west of the survey areas. Several field walking exercises, in the surrounding area, have discovered various possible flint tools and debitage from the Mesolithic (MNF30932, 54598 31108 66374 9619).

5.3. Late Prehistoric activity, within the environs of the survey areas, is similarly illustrated by surface field walking finds, which included several possible Neolithic flints (MNF24240, 24239, 22223, 30932, 55694, 55693, 67975, 67974, 67973, 54596) and an Iron Age harness fitting (MNF31109). A series of possible archaeological features have been identified using cropmarks, which include a ring ditch, 70m south of the survey areas, tentatively dated to Late Neolithic/Early Bronze Age (MNF57947. The archaeological excavations at Laurel Farm, as stated above, also revealed a Late Neolithic/Early Bronze Age curvilinear feature and pit features, as well as a series of enigmatic features consisting of a hearth, several postholes dated to the Middle to Late Bronze Age (ENF118672 MNF50041).

5.4. Romano-British activity, in the local vicinity, was discovered at the archaeological excavation at Heath Farm, 250m to the south-west of the survey areas, where three Romano-British pottery kilns dated to the 2nd Century AD and other associated anthropogenic features were revealed (ENF122342). The archaeological excavations at Laurel Farm, also illustrate the presence of Romano-British activity. A large quantity of Romano-British jars was discovered in a layer possibly eroded from a roadside cremation cemetery. Cropmarks have similarly demonstrated the presence of Late Iron Age/Romano British archaeological features with a series of linear features and pits (MNF57948 31108) visible 150m to the south of the survey areas, possibly associated with the kilns discovered at Heath Farm.

5.5. Medieval activity is demonstrated at Laurel Farm where features associated with small-scale industrial ironworking were discovered, while evaluation trenches and subsequent archaeological excavations conducted 50m to the north-east revealed a possible medieval enclosure (OAE, 2015).

5.6. Post-Medieval to Modern activity within the site is illustrated by the 1797 Faden's Map of Norfolk, which shows a road running on a north to south alignment leading to a dwelling, later referred to as Smee House. This dwelling appears on Ordnance Survey maps until 1994, when Smee House has been demolished. The 1914 Ordnance Survey shows other structures, possibly associated with a plant nursey appearing, which are developed and reconfigured later (Petric 2018: Figures 2-7).

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-mounted 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 (2018) was consulted as well, to compare the results with recent land usages.

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 (Figure 5) and historic maps (Figure 6).

7.2.2. The fluxgate magnetometer survey has responded well to the survey areas' environment. Interference from modern activity is limited to the peripheries of the survey areas, as well as two possible drains in the south-east of the site, services in areas 3, 4 and 5, and specifically a manhole in the centre of area 4.

7.2.3. Historic mapping has aided in the discrimination and interpretation of strong and ferrous responses in the north-east of the site. These are likely to be associated with features relating to Smee House and its subsequent demolition. several agricultural features in the immediate vicinity which may be associated with Smee House. These include several probably field boundaries which have been identified as strong linear

anomalies, as well as a possible infilled pond and well, all of which are recorded in historic mapping.

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. **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.

7.3.1.3. **Ferrous (Discrete/Spread)** – Discrete ferrous-like, dipolar anomalies are likely to be the result of modern metallic disturbance on or near the ground surface. A ferrous spread refers to a concentrated deposition of these discrete, dipolar anomalies. Broad dipolar ferrous responses from modern metallic features, such as fences, gates, neighbouring buildings and services, may mask any weaker underlying archaeological anomalies should they be present.

7.3.2. Magnetic Results - Specific Anomalies

7.3.2.1. **Agricultural (Strong) --** In Area 2, three strong linear responses, [**2a**], have been detected. These are aligned with recorded agricultural field boundaries illustrated on historic Ordnance Survey maps. Similarly, in Area 5, a linear response [**5a**] corresponds with a recorded agricultural field boundary on the same alignment as the modern southern boundary.

7.3.2.2. **Modern (Spread), Smee House –** In the north-east of Area 2, a modern ferrous spread, [**2c**], has been detected. This spread is likely associated with Smee House illustrated on historic maps adjacently to the west, possibly as a result of the spreading of demolished fired building material by subsequent ploughing.

7.3.2.3. **Modern (Strong), Well –** Within spread [**2c**], is a strong response [**2b**]. This strong ferrous response may relate to a well feature depicted on historic maps, associated with Smee House. If so, it is unclear whether the strong ferrous response would have been caused by material used in the well's construction, or material used to infill it.

7.3.2.4. **Ferrous (Dipolar), Pond –** A large ferrous response [**1a**], in the south-east of Area 1, collocates with a pond recorded on historic maps. Its strong ferrous response could relate to material used to infill the pond, which could contain fired or metallic debris. A possible drainage feature extends westward from this anomaly and may be associated with a potential pond.

7.3.2.5. **Drainage Feature –** A linear anomaly, which varies in strength and appears 'broken' in shape in greyscale plots, intersects anomaly [**1a**] on an east-west orientation. Based on its intersection with the possible pond feature and its distinct response pattern, which is markedly different from anomalies arising from recorded field boundaries, it has been interpreted as a possible drainage feature, leading into the pond.

7.3.2.6. **Drainage Feature –** Linear negative anomalies have been identified in Areas 1, 2, 3, and 5. All the anomalies oriented SW-NE, apart from one anomaly on a NW-SE orientation in Area 5. These have been interpreted as drainage features.

7.3.2.7. **Ferrous (Dipolar), Manhole –** Anomaly [**4a**] collocates with a raised manhole cover, which was identified during survey.

7.3.2.8. **Ferrous (Spread) –** A ferrous spread north and west of anomaly [**2a**] may represent the spread of demolished material from Smee House, or, alternatively, debris from the construction of modern extant buildings immediately to the north-west.

8. Conclusions

8.1. The fluxgate magnetometer survey has responded well to the survey areas' environment, with minimal magnetic interference from modern boundaries and buried services. No anomalies were detected which were probably or possibly archaeological in origin.

8.2. A number of anomalies have been identified which have been interpreted as structures and spreads of material relating to Smee House and nearby agricultural features, including a possible well and pond. Their discrimination and specific interpretations have been aided by the use of historic mapping and XY trace plots.

8.3. Across the remainder of the site, the geophysical results primarily include drainage features and buried services.

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 will upload a copy of this report to OASIS, following acceptance by Norfolk County Council. MS contributes reports to the ADS Grey Literature Library upon permission from the client, subject to the any dictated time embargoes.

10. Copyright

11. References

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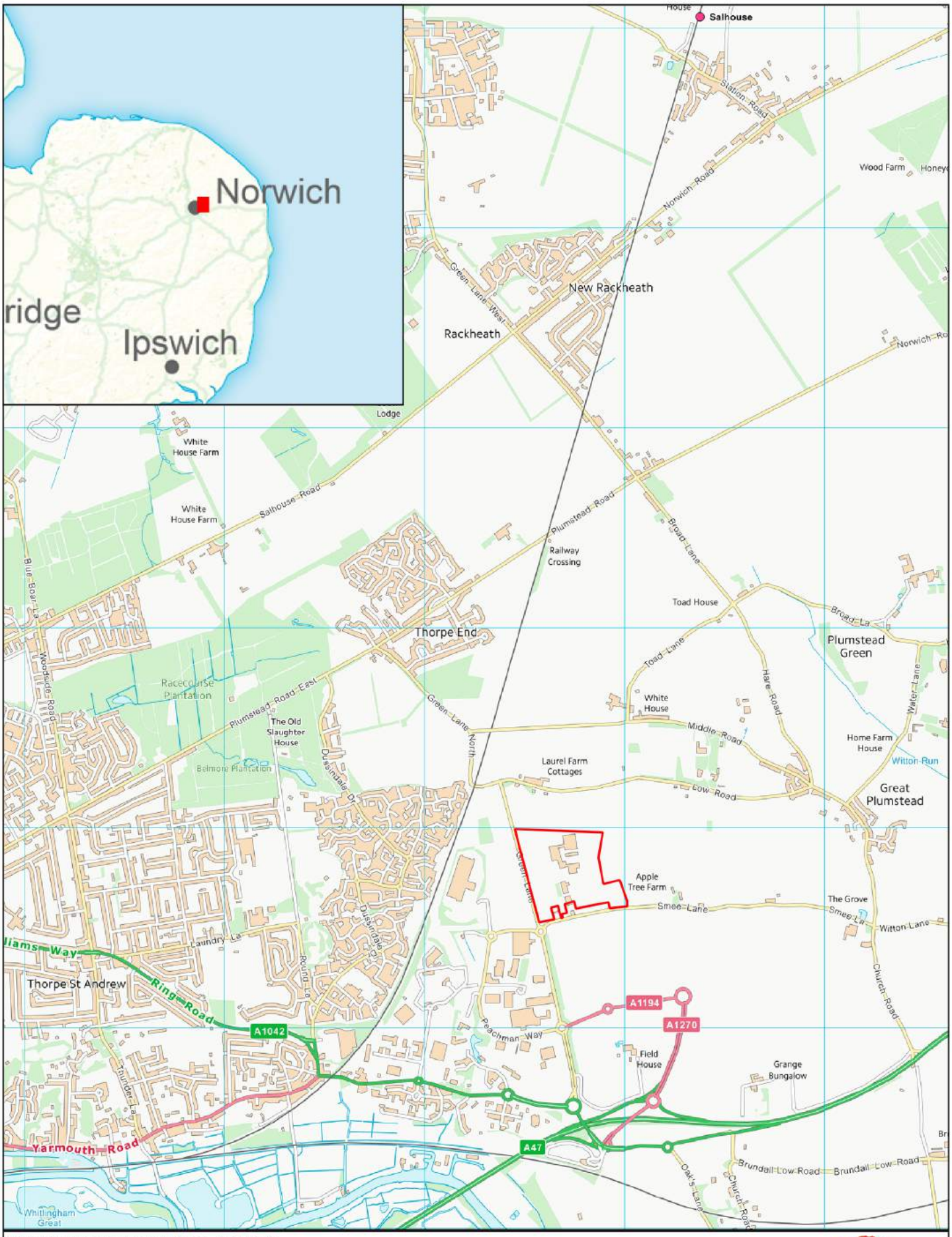

Land at Green Lane Orchard, Norwich
Figure 1 - Site Location
1:25,000 @ A4

Site Boundary

N

0 0.5 1 km

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628000

629000

North

Laurel Farm
Cottages

Low Road

310000

Area 5

Area 1

Area 2

Area 4

Area 3

Green Lane

Apple
Tree Farm

Smee Lane

Dussindale Dr

Land at Green Lane Orchard, Norwich
Figure 2 - Location of Survey Areas
1:5,000 @ A3

Survey Extents

N

0 100 200 300 m

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Land at Green Lane Orchard, Norwich
Figure 3 - Magnetic Gradient
1:2,500@ A3

Land at Green Lane Orchard, Norwich
Figure 4 - Magnetic Interpretation
1:2,500 @ A3

Agricultural (Strong)
Drainage Feature
Modern (Spread)
Modern
Ferrous (Dipolar)
Ferrous (Spread)
Service

N

0 50 100 150 m

magnitude surveys

Land at Green Lane Orchard, Norwich
Figure 5 - Magnetic Interpretation Over Satellite Imagery
1:2,500 @ A3

Agricultural (Strong)
Drainage Feature
Modern (Spread)
Modern
Ferrous (Dipolar)
Ferrous (Spread)
Service

N

0 50 100 150 m

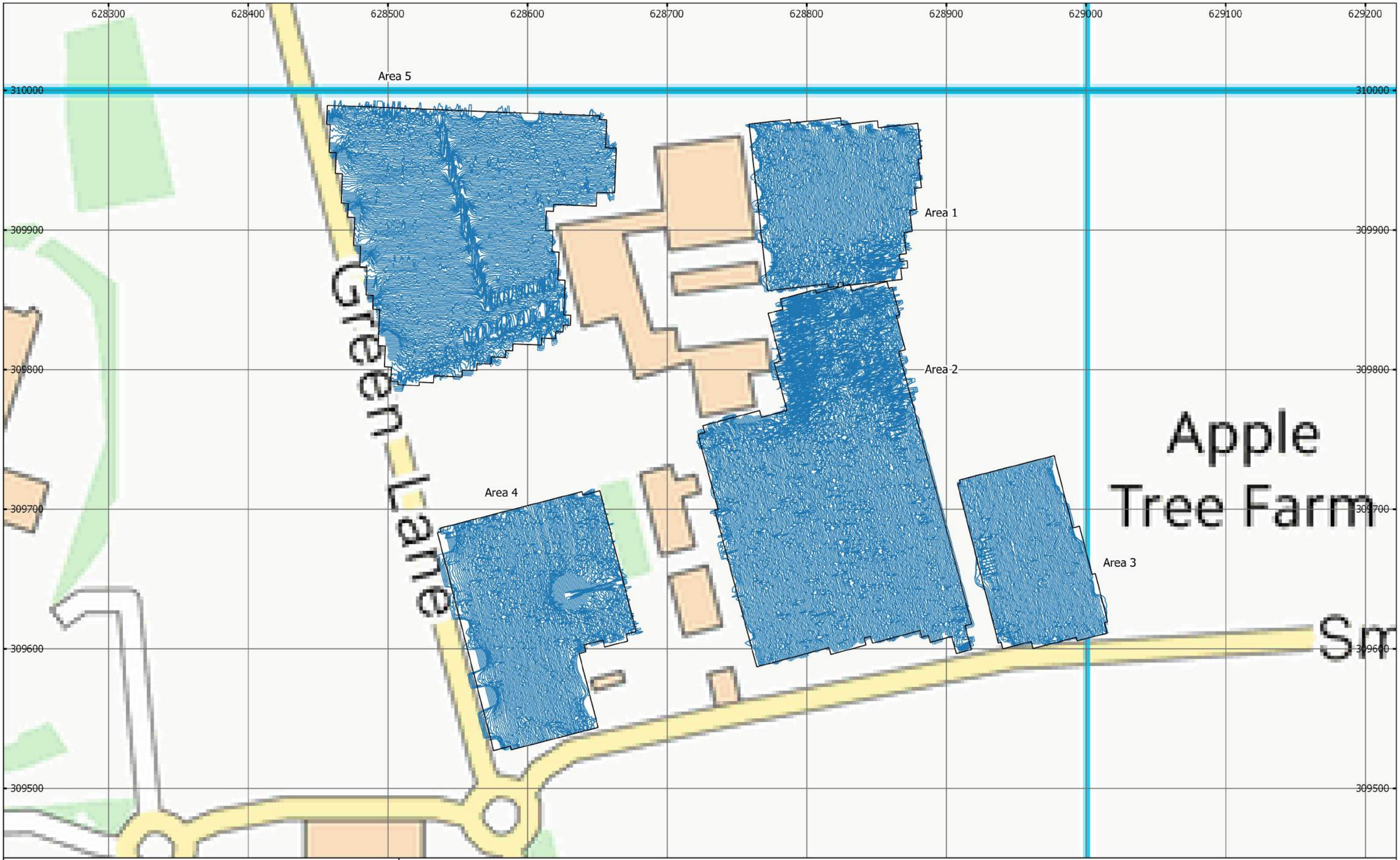
magnitude surveys

Land at Green Lane Orchard, Norwich
Figure 6 - Magnetic Interpretation Over Historic Maps
1:4,000 @ A3

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

- Agricultural (Strong)
- Drainage Feature
- Modern (Spread)
- Modern
- Ferrous (Dipolar)
- Ferrous (Spread)
- Service

magnitude surveys



Land at Green Lane Orchard, Norwich
Figure 7 - XY Trace Plot
50nT/cm at 1:2,500 @ A3

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