



**magnitude
surveys**

**Geophysical Survey Report
Knowsley, Liverpool, Merseyside**

**For
Orion Heritage**

Magnitude Surveys Ref: MSSJ1405

HER Event Number: TBC

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Abstract

Magnitude Surveys was commissioned to access the subsurface archaeological potential of a c.6.8ha of land at Knowsley, Liverpool. A fluxgate gradiometer survey was successfully completed across the majority of the survey area, with c. 0.9ha unable to be surveyed due to raised ground and ditches. No anomalies suggestive of significant archaeological features were identified, however some anomalies were detected of an undetermined classification. Anomalies related to agricultural use have been identified and interpreted as drainage features and modern cultivation methods. The survey environment was disturbed by spreads of ferrous material, likely related to the nearby quarry, and a former railway/trackway.

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1. Introduction

- 1.1. Magnitude Surveys Ltd (MS) was commissioned by Orion Heritage to undertake a geophysical survey over a c. 6.8ha area of land at Knowsley, Liverpool.
- 1.2. The geophysical survey comprised quad-towed fluxgate gradiometer survey. Magnetic survey is the standard primary geophysical method for archaeological applications in the UK due to sunken featured buildings (SFBs) 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, 2020) and the European Archaeological Council (Schmidt et al., 2015).
- 1.4. It was conducted in line with a WSI produced by MS (Carli 2022).
- 1.5. The survey commenced on 06.10.2022 and was completed the same day.

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 for Archaeological Prospection).
- 2.2. The directors of MS are involved in cutting edge 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 Paul Johnson has a PhD in archaeology from the University of Southampton, is a Fellow of the Society of Antiquaries of London and a Member of CIfA, 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, field and office staff have degree qualifications relevant to archaeology or geophysics 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. 700m northeast of Tarbock Green, Knowsley (Figure 1). Gradiometer survey was undertaken across one grass field. The survey area is located south of the M62 and east of the M57 (Figure 2). A total of c. 0.9ha was not surveyed due to a drainage ditch and raised ground.

Survey Area	Ground Conditions	Further Notes
1	The survey area consisted of a flat grassland field.	The field was bordered by trees to the south, west and northeast. A quarry was present on the northern boundary with no physical boundaries to the field. A raised path was orientated north to south at the eastern end of the survey area. A large drainage ditch was present orientated southwest to northeast in the centre of the area.

- 4.2. The underlying geology comprises mudstone, siltstone, and sandstone with a Pennine middle coal measures formation. The superficial deposit comprises of diamicton of till Devensian deposits. (British Geological Survey, 2022).
- 4.3. The soils consist of slowly permeable seasonally wet and slightly acid but base-rich loamy and clayey soils (Soilscapes, 2022).

5. Archaeological Background

- 5.1. The following is a summary of an Archaeological background assessment produced and provided by Orion Heritage (Orion Heritage, 2022).
- 5.2. Prehistoric activity has been recorded in the wider landscape of the survey area in the form of Neolithic flint axe heads c. 1km to the north and c. 450m to the east respectively. A Bronze Age spear head was identified c. 400m to the northwest.
- 5.3. A scatter of medieval pottery has been identified across the wider study area, indicating agricultural use of the landscape as part of the increasing influence of manorial estates, namely Halsnead and Whiston to the north, Tarbock to the southwest and Shaw to the northeast.
- 5.4. Ordnance Survey Maps from 1849 onwards show the survey area as part of the Halsnead Estate with extraction pits within the survey area. The railway connecting Liverpool and Cronton Colliery was constructed in 1927, which was used for the transportation of minerals.

6. Methodology

6.1. Data Collection

- 6.1.1. 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.

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

6.1.3. 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

6.1.4. The magnetic data were collected using MS' bespoke quad-towed cart.

6.1.4.1. 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.

6.1.4.2. 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.

6.1.4.3. 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 the EAC and Historic England guidelines for 'minimally enhanced data' (see Section 3.8 in Schmidt *et al.*, 2015: 33 and Section IV.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 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 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, historical maps, LiDAR data, and soil and geology maps. Google Earth (2022) was also consulted, to compare the results with recent land use.

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 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 from further work, in order to constantly improve our knowledge and service.

7.2. Discussion

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

7.2.2. A fluxgate gradiometer survey was successfully completed across all but c. 0.9ha of the survey area. The survey environment was disturbed in the north of the area by spreads of ferrous material, likely related to the quarry visible at the northwest end of the survey area. On the north-eastern boundary of the survey area a strong spread of magnetic disturbance has been identified, related to the former railway and trackway visible on the 1890 Ordnance Map (Figure 6). This ferrous spread caused a magnetically enhanced background against which smaller, weaker anomalies were difficult to pick out (Figures 3 & 4).

7.2.3. Further magnetic disturbance is visible in the data in the form of ferrous debris, which correlates with two groves visible on 1890 OS Map. It is likely that the high magnetic response is due to the practice of burning down tree stumps to clear the land, however this cannot be confidently concluded with geophysical data alone.

7.2.4. Extensive drainage regimes have been identified throughout the survey area, consisting of herringbone shape drains suggesting the land has primarily been used for agricultural purposes. Further anomalies identified as agricultural trends illustrate the cultivation of the survey area.

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 the way in which the sensors respond to very

strong point sources. They 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' anomalies. These artefacts are therefore indicated as necessary in order to preserve the data as 'minimally processed'.

- 7.3.1.3. **Ferrous (Spike)** – Discrete dipolar anomalies are likely to be the result of isolated pieces of modern ferrous debris on or near the ground surface.
- 7.3.1.4. **Ferrous/Debris (Spread)** – A ferrous/debris spread refers to a concentration of multiple discrete, dipolar anomalies usually resulting from highly magnetic material such as rubble containing ceramic building materials and ferrous rubbish.
- 7.3.1.5. **Magnetic Disturbance** – The strong anomalies produced by extant metallic structures, typically including fencing, pylons, vehicles, and service pipes, have been classified as 'Magnetic Disturbance'. These magnetic 'haloes' will obscure weaker anomalies relating to nearby features, should they be present, often over a greater footprint than the structure causing them.
- 7.3.1.6. **Undetermined** – Anomalies are classified as Undetermined when the origin of the geophysical anomaly is ambiguous and there is no supporting contextual evidence to justify 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 distinct from those caused by ferrous sources.

7.3.1. Magnetic Results - Specific Anomalies

- 7.3.1.1. **Agricultural (Trend)** – Across the survey area a series of parallel linear anomalies have been detected which exhibit a weak magnetic signal (Figure 4). These are very closely spaced and only a few indicative linear trends have been picked out to give an idea of direction and presence across the site. The orientation is well matched with modern cultivation visible in recent satellite imagery and are interpreted as agricultural trends caused by modern ploughing (Figure 7).
- 7.3.1.2. **Drainage** – A series of linear anomalies have been detected across the survey area. These anomalies have a strong magnetic response indicative of a cut drain and are of mixed alignment (Figure 3 & 4). Some appear to be arranged in a pattern.
- 7.3.1.3. **Undetermined** – Anomalies classified as "Undetermined" within the survey area have weak, positive magnetic signals (Figure 4). There is no corroborative evidence to confirm an agricultural or archaeological origin for these features: because they do not correspond with any mapped features on available historic maps (Figure 7). Whilst these do not present a clear layout, the defined edges of the anomalies suggest they should be considered to have anthropogenic potential; however, no confident interpretation can be provided.

8. Conclusions

- 8.1. A fluxgate gradiometer survey was successfully completed across all but c.0.9ha of the survey area. The survey has detected a range of anthropogenic anomalies including agricultural activity in the form of drains and modern cultivation. In addition, anomalies of undetermined origin have been interpreted where a specific origin or date is uncertain. The anomalies ascribed an 'Undetermined' classification lack any distinctive archaeological shape or pattern; as such, no anomalies indicative of significant archaeological activity has been identified.
- 8.2. The survey area was impacted by ferrous debris related to a quarry located on the northern end of the survey area and a disused railway and path to the northeast. Further disturbance has been detected which correlates with removed groves visible on historical mapping.



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 any dictated time embargoes.

10. Copyright

- 10.1. Copyright and 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, 2022. Geology of Britain. Knowsley, Liverpool City Region.
[<http://mapapps.bgs.ac.uk/geologyofbritain/home.html/>]. Accessed 06/10/2022.

Chartered Institute for Archaeologists, 2020. 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, 2022. Google Earth Pro V 7.1.7.2606.

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.

Orion Heritage, 2022. Mercury 62: Historic Environment Desk-Based Assessment. July 2022.

Schmidt, A. and Ernenwein, E., 2013. Guide to good practice: geophysical data in archaeology (2nd edition). 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, 2022. Knowsley, Liverpool City Region. Cranfield University, National Soil Resources Institute. [<http://landis.org.uk>]. Accessed 06/10/2022.

12. Project Metadata

MS Job Code	MSSJ1405
Project Name	Knowsley, Liverpool
Client	Orion Heritage
Grid Reference	SJ4674989351
Survey Techniques	Magnetometry
Survey Size (ha)	6.8ha Magnetometry
Survey Dates	06.10.2022
Project Lead	Isabella Carli BA MA PCIfA
Project Officer	Isabella Carli BA MA PCIfA
HER Event No	N/A
OASIS No	N/A
S42 Licence No	N/A
Report Version	0.5

13. Document History

Version	Comments	Author	Checked By	Date
0.1	Initial draft for Geophysical Services Manager to Review	DY	LAG	02 November 2022
0.2	Comments from Geophysical Services Manager	DY, LAG	LAG	03 November 2022
0.3	Corrections following Director Check	ED	FPC	21 November 2022
0.4	Further corrections from Director	IC	IC	21 November 2022
0.5	Comments from Client	IC	IC	2 December 2022



MSSJ1405 - Knowsley, Liverpool

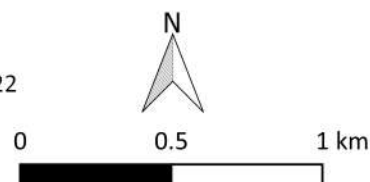
Figure 1 - Site Location

1:25,000 @ A4

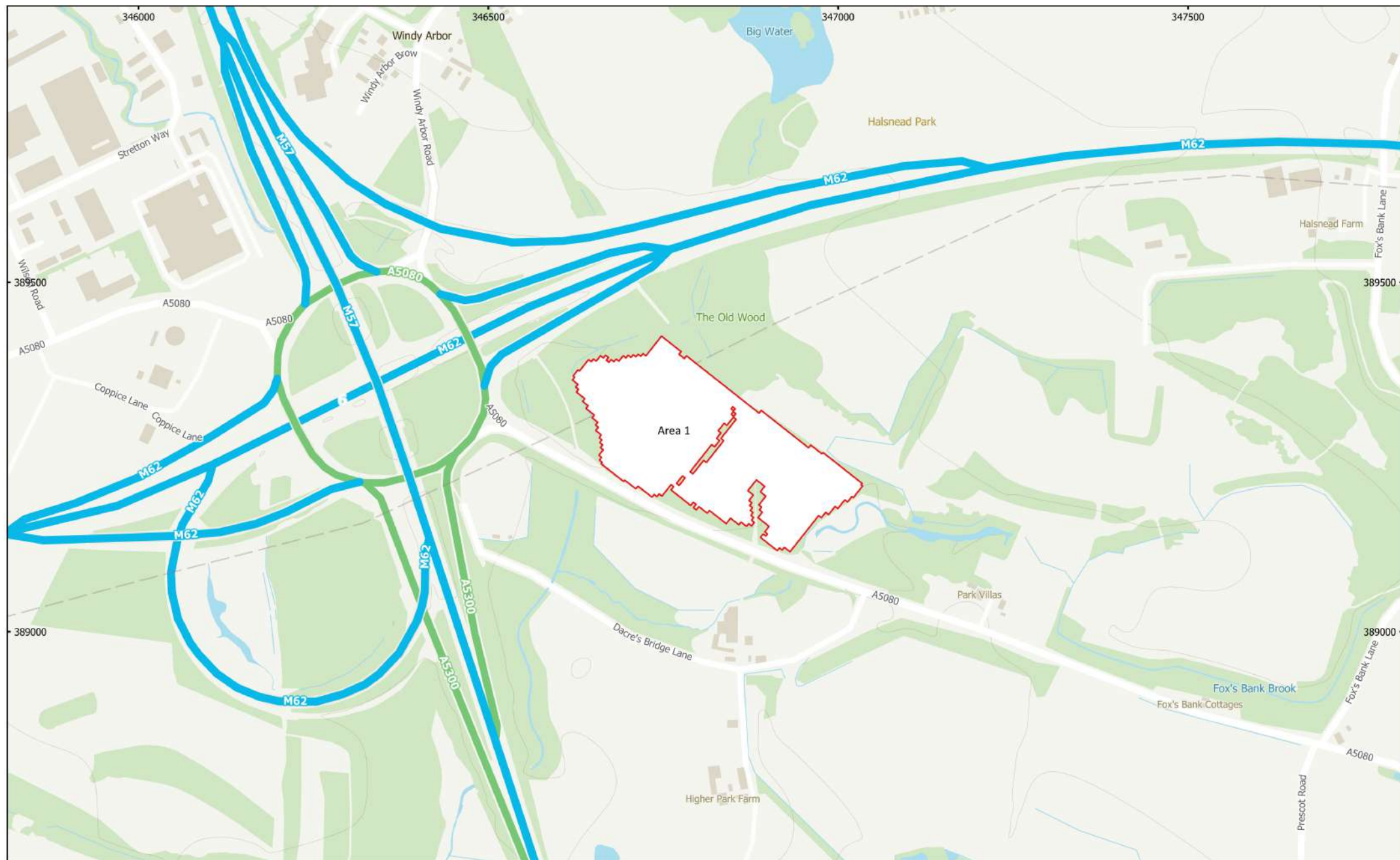
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 Site Boundary

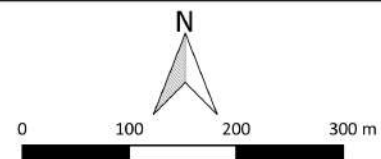


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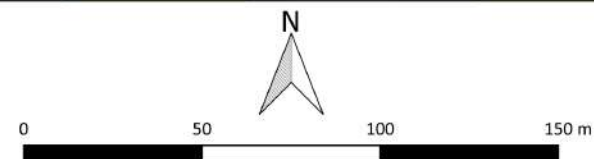
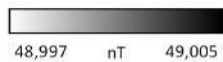
MSSJ1405 - Knowsley, Liverpool
 Figure 2 - Location of Survey Area
 1:5,000 @ A3
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 Survey Extent



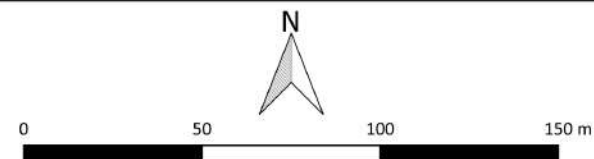


MSSJ1405 - Knowsley, Liverpool
Figure 3 - Magnetic Total Field (Lower Sensor)
1:1,500 @ A3
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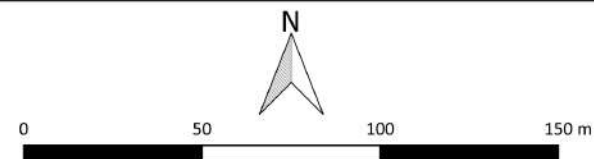
MSSJ1405 - Knowsley, Liverpool
Figure 4 - Magnetic Gradient
1:1,500 @ A3
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MSSJ1405 - Knowsley, Liverpool
 Figure 5 - Magnetic Interpretation
 1:1,500 @ A3
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- Magnetic Disturbance
- Ferrous/Debris (Spread)
- Undetermined (Weak)
- Agricultural (Trend)
- Drainage Feature





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Figure 6 - XY Trace Plot
30nT/cm at 1:1,500 @ A3
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MSSJ1405 - Knowsley, Liverpool
 Figure 7 - Magnetic Interpretation Over Historical Maps and Satellite Imagery
 1:3,000 @ A3
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 Contains historical mapping © CLS Data 2022: Ordnance Survey, 6" 2nd
 edition c. 1882-1913
 Contains satellite imagery © Bing Satellite 2022

- Magnetic Disturbance
- Ferrous/Debris (Spread)
- Undetermined (Weak)
- Agricultural (Trend)
- Drainage Feature

