Geophysical Survey Report

of

Eaton Leys Water Main Reinforcement Easements A and B

For

Oxford Archaeology

On Behalf Of

Anglian Water

Magnitude Surveys Ref: MSSP649

HER Event Number: EMK1417

OASIS Number: magnitud1-394163

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magnitude surveys

Unit 17, Commerce Court

Challenge Way

Bradford

BD4 8NW

01274 926020

info@magnitudesurveys.co.uk

Report By:

Megan Clements BA (Hons)

Alison Langston BA PCIfA

Report Approved By:

Dr Kayt Armstrong MCIfA

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Abstract

Magnitude Surveys was commissioned to assess the subsurface archaeological potential of two areas of land totalling c. 1.8 ha at Little Brickhill, Milton Keynes. A fluxgate gradiometer survey was successfully completed across the survey area; however, the narrow corridors forming the survey area have made interpreting anomalies more challenging. No anomalies suggestive of significant archaeological features were identified. The geophysical survey has primarily detected anomalies of an agricultural origin, in the form of possible ploughing regimes. Anomalies of an undetermined origin have also been identified across the survey area. Although they are likely to be of agricultural origin, an archaeological origin could not be ruled out. The impact of modern activity on the results is generally limited to the edges of the survey area in the northern area; a modern service is present within the southern area, producing haloes that further hindered interpretation.

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1. Introduction

1.1. Magnitude Surveys Ltd (MS) was commissioned by Oxford Archaeology on behalf of Anglian Water to undertake a geophysical survey on a c.1.8 ha area of land at two locations near to Little Brickhill, Milton Keynes (SP925311 & SP895328).

1.2. The geophysical survey comprised hand-carried 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. It was conducted in line with a WSI produced by MS (2020).

1.5. The survey commenced on 23/03/2020 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. The directors of MS are involved in the cutting edge of research and the development of guidance/policy. Specifically, Dr. Chrys Harris is the Vice-Chair of the International Society for Archaeological Prospection (ISAP); Finnegan Pope-Carter is a Fellow of the London Geological Society, as well as a member of GeoSIG (CIfA Geophysics Special Interest Group); Dr. Kayt Armstrong is the Editor of ISAP News, and is the UK Management Committee representative for the COST Action SAGA; Dr. Paul Johnson has been a member of the ISAP Management Committee since 2015, and is currently the nominated representative for the EAA Archaeological Prospection Community to the board of the European Archaeological Association.

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

3. Objective

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 northern survey area (Reinforcement B) was located c.1.4km north from Little Brickhill and the southern survey area (Reinforcement A) was located c.2.3km south from Little Brickhill (Figure 1). Survey was undertaken across three fields under arable agricultural use. The northern survey area was bound by the roundabout joining the A5 and the A4164 to the north, the A5 to the east, open fields to the south, and the A4146 to the west. The southern survey area was bound by Nun Wood to the north, open fields to the east and the A5 to the south and west (Figures 2 & 3).

4.2. Survey considerations:

Survey Area	Ground Conditions	Further Notes
1 (Part of Reinforcement B)	The area was an arable field with a young cereal crop. The terrain sloped gradually downhill northeast to southwest.	The area was bound to the north, east and south by hedgerow and trees, with wire fencing to the west. Pylons were located within the area, with overhead powerlines crossing the area northwest to southeast. Farm equipment was located in the southern end of the area.
2 (Part of Reinforcement B)	The area was an arable field with a young cereal crop. The field sloped downhill gradually northeast to southwest.	The area was bound to the west and east by hedgerows, and to the south and north by further field. A pylon was located within the survey area, with overhead powerlines crossing the area northwest to southeast.
3 (Part of Reinforcement A)	The area was an arable field with short cereal crop stubble. The field sloped gradually downhill northwest to southeast.	The area was bound to the west by hedgerows and the south, north and east by further fields. A tree and partial hedgerows bisected the survey area in the centre. Gas pipeline markers were seen in the hedgerow on the western edge.

4.3. The underlying geology of the northern survey areas comprises mudstone of the West Walton Formation, and sandstone of the Woburn Sand Formation for the southern survey area. Superficial deposits of river terrace sand and gravel deposits are located towards the southern half of Area 1, and Head clay, silt, sand and gravel cross the centre of Area 1 and the northern half of Area 2. In the southern survey area superficial geology comprises diamicton of the Oadby Member (British Geological Survey, 2020).

4.4. The soils consist of slightly acidic loamy and clayey soils with impeded drainage in the northern survey areas and slowly permeable seasonally wet slightly acidic but base-rich loamy and clayey soils in the southern survey area (Soilscapes, 2020).

5. Archaeological Background

5.1. The following section summarises the archaeological background of the survey area and the surrounding area (1km radius) following a search of Heritage Gateway (2020).

5.2. Prehistoric activity has been recorded in the wider environs with an Iron age site consisting of pits, ditches, a hearth and a late iron age burial (MBD344748) c.1km-west of the northern

survey area, findspots of Palaeolithic handaxes c.1km north and west (MBD344748), and a possible sub-rectangular cropmark enclosure c.1km southeast (MBD3199) of the southern survey area.

5.3. Roman activity in the wider landscape is identified with Magiovinium Roman town with visible earthworks located 650m northwest of the northern survey area. Further evidence comes from a building excavated with a coin hoard, 44 burials and a ditch, along with a settlement with five phases of occupation, both located c.1km northwest of the northern survey area.

5.4. Medieval activity in the wider landscape has been identified, with a trackway c.700m north of the southern survey area (MBD9965), a moated site c.1km northeast of the southern survey area (MBD27), a strip settlement of possible Medieval date c.1km east of the southern survey area (MBD8767), a possible Medieval rabbit warren c.1km east of the southern survey area (MBD9957), and a moated enclosure defined by ditches with 12th to 13th century pottery c.1km west of the northern survey area (MBD344748). Post Medieval activity is identified in the form of a sand extraction pit located c.750m north-northeast of the southern survey area (MBD9960).

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-carried GNSS-positioned system.

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

6.1.3.2. 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 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 & 12). 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 (2020) 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 mapping provided by the client.

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 and satellite imagery (Figures 7 & 13).

7.2.2. The fluxgate gradiometer survey has responded well to the environment of the survey area; however, the narrow nature of the survey corridor has reduced the context available for assessing anomalies, making the interpretation more challenging. The geophysical survey has primarily detected agricultural activity in the form of possible ploughing regimes, along with anomalies of an undetermined origin. Modern interference has been produced by the effects from nearby roads in the northwest and southwest of the survey area, along with a service across the southeast of the survey area.

7.2.3. Agricultural activity has been identified in the northern survey area, in the form of modern ploughing trends and possible earlier ploughing regimes, distinguished by the slightly different orientations of these anomalies.

7.2.4. In both survey areas, a series of anomalies of an undetermined origin have been identified. These are possibly of agricultural or archaeological origin, but due to the limits of the survey areas, a more specific origin could not be determined.

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

7.3.2.1. **Agriculture (Weak/Trend)** – In the northeast of Area 1, a series of weak, parallel curvilinear anomalies have been identified, running approximately east to west, with another series of weak parallel linear anomalies identified in the centre of Area 1 (Figure 11). The anomalies to the northeast of the area have a slightly more curved appearance and are on a slightly different alignment to the trends c.25m to the southwest, which are characteristic of modern ploughing features. It is possible that these anomalies to the northeast are previous ploughing regimes.

7.3.2.2. **Undetermined** – Across Areas 1 and 2, a series of strong and weak linear and curvilinear anomalies and spreads have been identified (Figure 11). These do not align with any mapped field boundaries, and due to the lack of any archaeological features in the surrounding area and the limited survey extent, these have been classified as undetermined. A spread of disturbed signal in area 1 is in the same location as a footpath in the historic maps, but the restricted survey area does not allow for a definitive interpretation.

7.3.2.3. **Ferrous/Debris (Spread)** – In the northeast of Area 2, a zone of concentrations of dipolar anomalies likely caused by a spread of magnetic material in the topsoil has been identified, most visible in the XYs (Figure 13). A former field boundary has been recorded in that location in the 2nd Edition OS map, and on satellite imagery this anomaly aligns with a division in the field (Figure 12). The strong ferrous signal suggests the infilling of this field boundary with a more magnetically enhanced material.

7.3.2.4. **Service** – Two strong positive linear anomalies have been identified running northwest to southeast and approximately northeast to southwest across the whole of Area 3 (Figure 10). The anomaly is characteristic of a service running through the area and has created a magnetic disturbance ‘halo’ which would have obscured any weaker underlying features, should they be present.

8. Conclusions

8.1. A fluxgate gradiometer survey has successfully been undertaken across the survey area, although the narrow survey extent has made identifying and interpreting anomalies more challenging. The geophysical survey has detected a range of different types of anomalies of agricultural, undetermined and modern origin. Modern interference is produced by roads at the edges of the survey area in the northwest and southwest, along with a modern service running through the survey area in the southeast. In the northwest, a strong dipolar ferrous signal has been produced by ferrous debris, possibly attributed to the infilling of a former field boundary with a more magnetically enhanced material.

8.2. No anomalies suggestive of significant archaeological features were identified.

8.3. Agricultural activity has been detected in the southwest in the form of modern ploughing trends, and a series of possible earlier ploughing regimes.

8.4. Undetermined anomalies have been identified in the northwest and southwest. These are likely to be related to an agricultural origin, although an archaeological origin cannot be ruled out.

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	MSSP649
Project Name	Eaton Leys Water Main Reinforcement Easements A and B
Client	Oxford Archaeology
Grid Reference	SP925311 & SP895328
Survey Techniques	Magnetometry
Survey Size (ha)	1.8ha (Magnetometry)
Survey Dates	23/03/2020
Project Manager	Julia Cantarano Ingénieur PCIFA
Project Officer	Finnegan Pope-Carter BSc (Hons) MSc FGS
HER Event No	EMK1417
OASIS No	magnitud1-394163
S42 Licence No	N/A
Report Version	1.0

13. Document History

Version	Comments	Author	Checked By	Date
0.1	Initial draft for Project Officer to Review	MC, AL	JC	31 March 2020
0.2	Corrections from Project Officer	AL	KA	01 April 2020
0.3	Adding HER Event Number on Front Page	N/A	JC	13 May 2020
1.0	Issued as Final	N/A	FPC	08 June 2020

MSSP649 - Eaton Leys Water Main Reinforcement Easements A and B
Figure 1 - Site Location
1:25,000 @ A4

Site Boundary

N

0 0.5 1 km

magnitude surveys

492000
492500
493000
493500
231500
231000
230500
Nun Wood
Aspen Farm Cottages
Sheeplane Belt
Area 3
A5
Rammamere Farm
Sheeplane
Sheeplane
Sheeplane

MSSP649 - Eaton Leys Water Main Reinforcement Easements A and B
Figure 2 - Location of Survey Area (Reinforcement A)
1:5,000 @ A3

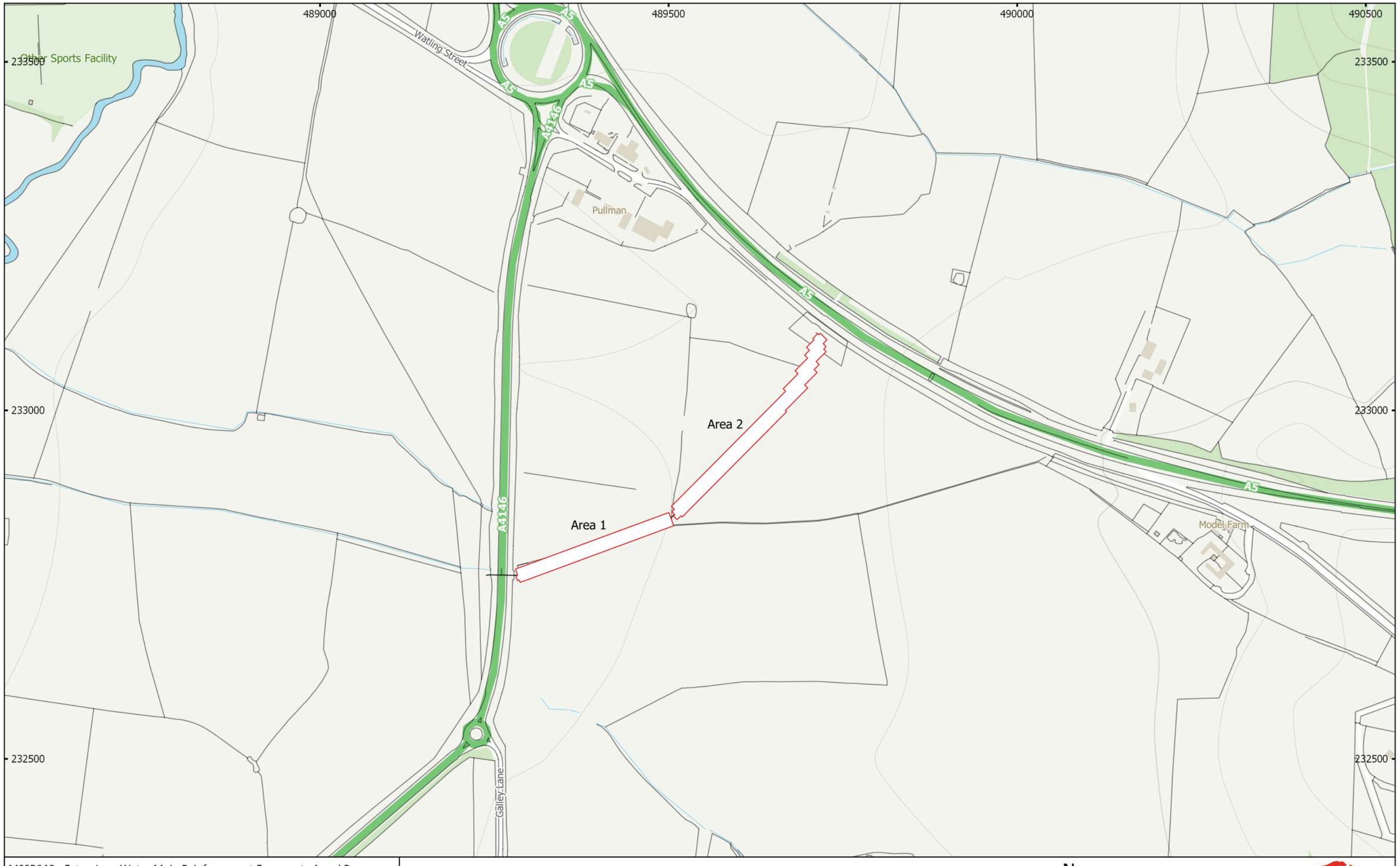
Mapping Provided by Client

Survey Extent

N

0 100 200 300 m

magnitude surveys



MSSP649 - Eaton Leys Water Main Reinforcement Easements A and B
Figure 3 - Location of Survey Areas (Reinforcement B)
1:5,000 @ A3

Mapping Provided by Client

Survey Extent

N

0 100 200 300 m

magnitude surveys

492500

493000

231000

231000

493000

Area 3

230800

MSSP649 - Eaton Leys Water Main Reinforcement Easements A and B
Figure 4 - Magnetic Total Field (Lower Sensor) Reinforcement A
1:1,500 @ A3

Mapping Provided by Client

48,997 nT 49,005

N

0 40 80 120 m

magnitude surveys

492500

493000

231000

231000

493000

Area 3

230800

MSSP649 - Eaton Leys Water Main Reinforcement Easements A and B
Figure 5 - Magnetic Gradient Reinforcement A
1:1,500 @ A3

Mapping Provided by Client

-10 nT 20

N

0 40 80 120 m

magnitude surveys

492500

493000

231000

231000

493000

Area 3

230800

MSSP649 - Eaton Leys Water Main Reinforcement Easements A and B
Figure 6 - Magnetic Interpretation Reinforcement A
1:1,500 @ A3

Mapping Provided by Client

Undetermined (Weak)
Magnetic Disturbance
Service
Ferrous Spike

N

0 40 80 120 m

magnitude surveys

492500
493000
231200
231200
231000
231000
230800
230800
230600
Nun Wood
Brickhill
Dunstable
Area 3
Parly. Co. Div. Union & R.D. By.
B.M. 494·9
487
Sand Pit
F.P.
St. John's School
Rammamere Farm
B.M. 458·7
B.M. 473·3
Union & R. D.

MSSP649 - Eaton Leys Water Main Reinforcement Easements A and B
Figure 7 - Magnetic Interpretation Over Satellite Imagery and Historic Maps
Reinforcement A
1:3,000 @ A3

Contains historic maps: Ordnance Survey, 6" 2nd edition c. 1882-1913 © National Library of Scotland
Contains Satellite Imagery© 2020 Bing Satellite

Magnetic Disturbance
Undetermined (Weak)
Service
Ferrous Spike

N

0 90 180 270 m

magnitude surveys

492500

493000

231000

231000

493000

Area 3

230800

MSSP649 - Eaton Leys Water Main Reinforcement Easements A and B
Figure 8 - XY Trace Plot Reinforcement A
30nT/cm at 1:1,500 @ A3

Mapping Provided by Client

N

0 40 80 120 m

magnitude surveys

489400

489600

489800

233000

233000

Area 2

Area 1

232800

232800

MSSP649 - Eaton Leys Water Main Reinforcement Easements A and B
Figure 9 - Magnetic Total Field (Lower Sensor) Reinforcement B
1:1,500 @ A3

Mapping Provided by Client

48,997 nT 49,005

N

0 40 80 120 m

magnitude surveys

489400
489600
489800
233000
233000
Area 2
Area 1
232800
232800

MSSP649 - Eaton Leys Water Main Reinforcement Easements A and B
Figure 10 - Magnetic Gradient Reinforcement B
1:1,500 @ A3

Mapping Provided by Client

-1 nT 2

N

0 40 80 120 m

magnitude surveys

489400
489600
489800
233000
233000
Area 2
Area 1
232800
232800

MSSP649 - Eaton Leys Water Main Reinforcement Easements A and B
Figure 11 - Magnetic Interpretation Reinforcement B
1:1,500 @ A3

Mapping Provided by Client

- Agricultural (Weak)
- Undetermined (Strong)
- Undetermined (Weak)
- Undetermined (Spread)
- Magnetic Disturbance
- Ferrous/Debris (Spread)
- Agricultural (Trend)
- Ferrous (Spike)

N

0 40 80 120 m

magnitude surveys

489000
489500
490000
233200
233000
232800
232600
F.P.
F.P.
F.B.
B.R.
B.R.
B.M. 295·6
B.M. 247·4
M.S. Stony Stratford 8
Brickhill 1
Area 1
Area 2

MSSP649 - Eaton Leys Water Main Reinforcement Easements A and B
Figure 12 - Magnetic Interpretation Over Satellite Imagery and Historic Maps
Reinforcement B
1:3,000 @ A3

Contains historic maps: Ordnance Survey, 6" 2nd edition c. 1882-1913 © National Library of Scotland
Contains Satellite Imagery© 2020 Bing Satellite

Agricultural (Weak)
Undetermined (Strong)
Undetermined (Weak)
Undetermined (Spread)
Ferrous/Debris (Spread)
Magnetic Disturbance
Agricultural (Trend)
Ferrous (Spike)

N
0 90 180 270 m

magnitude surveys

489500

233000

233000

Area 2

Area 1

232800

232800

MSSP649 - Eaton Leys Water Main Reinforcement Easements A and B
Figure 13 - XY Trace Plot Reinforcement B
30nT/cm at 1:1,500 @ A3

Mapping Provided by Client

N

0 40 80 120 m

magnitude surveys