Appendix: Cultural Heritage

Annex 1: Archaeological Desk-Based Assessment

Annex 2: Geophysical Survey Report 2022

Annex 3: Geophysical Survey Report 2023

Annex 4: Written Scheme of Investigation for Archaeological Trial Trenching

magnitude surveys

Geophysical Survey Report

for

Culham Battery Storage

For

Oxford Archaeology

On Behalf Of

Statera Energy Ltd

Magnitude Surveys Ref: MSSU1357

HER Event Number: TBC

OASIS Number: TBC

September 2022

magnitude surveys

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Abstract

Magnitude Surveys was commissioned to assess the subsurface archaeological potential of a c. 16.8ha area of land off Thame Lane in Culham, Oxfordshire. A fluxgate magnetometer survey was successfully completed across the survey area. A coherent area of archaeological activity was identified in the southern part of the survey area, demonstrated by a group of rectilinear enclosures situated either side of a track or drove way. Further possible ditches were identified extending across the northern part of the site, which are indicative of a possible field system. Areas of magnetic disturbance, likely resulting from a combination of modern and historical land uses, complicate the interpretation of other anomaly types in central, eastern and western parts of the survey area. Some of this disturbance may be associated with a section of the site being used as a former woodland. Numerous anomalies appear to relate to this historical land use and sub-division. Additionally, an area of possible ridge and furrow cultivation was detected in the northern part of the survey. Several different buried services were identified as well.

Contents

List of Figures

1. Introduction

1.1. Magnitude Surveys Ltd (MS) was commissioned by Oxford Archaeology on behalf of Statera Energy Ltd to undertake a geophysical survey over a c. 16.8ha area of land north of the Culham Science Centre, Oxfordshire (SU 52879 96551).

1.2. The geophysical survey comprised quad-towed GNSS-positioned fluxgate gradiometer survey. Magnetic survey is the standard primary geophysical method for archaeological applications in the UK due to its ability to detect a range of different features. The technique is particularly suited for detecting fired or magnetically enhanced features, such as ditches, pits, kilns, 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 (Dyulgerski 2022).

1.5. The survey commenced on August 8, 2022 and took two 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 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 is to assess the subsurface archaeological potential of the survey area.

4. Geographic Background

4.1. The survey area is located directly north of Culham Science Centre, Oxfordshire (Figure 1). Magnetometer survey was undertaken across three fields under short grass. The survey area is bordered by a woodland to the north, railway to the west and further arable fields to the south and east (Figure 2).

4.2. Survey considerations:

Survey Area	Ground Conditions	Further Notes
1	Short grass.	The field sloped down to the west. A pylon was located in the centre of the field, towards its northern end. Powerlines ran north-south through the centre.
2	Short grass.	The field sloped down to the south-west. A pylon was located in the centre of the field. Powerlines ran north-south through the centre. A track bounded the field to the north-east and road separated survey areas 2 and 3.
3	Short grass with areas of tall grass and scrub at the eastern and southern end.	The field sloped down to the south-west. A pylon was located in the centre of the field, towards its southern end. Powerlines ran north-east to south-west through the eastern and southern parts of the field.

4.3. The underlying geology comprises sandstone from the Lower Greensand Group. No superficial deposits have been recorded within the survey area. A band of clay silt, sand and gravel deposited by the River Thames have been recorded to the north of the survey area (British Geological Survey, 2022).

4.4. The soils consist of freely draining slightly acid sandy soils (Soilscapes, 2022).

5. Archaeological Background

5.1. The following is a summary of a geophysical survey report produced by Headland Archaeology and provided by Oxford Archaeology (Webb, 2016).

5.2. The survey area is located within an area of high archaeological potential. A review of the Thames Valley National Mapping Programme has identified a series of cropmarks indicative of multi-period activity ranging from the Bronze Age to the post-medieval period. Enclosures, barrows, trackways, field systems and ridge and furrow cultivation have been identified to the southwest, southeast, south and north.

5.3. The previous geophysical survey, which covered an area of c.242ha including areas within the current survey area has confirmed and expanded upon the available cropmark data (Webb, 2016). The survey has identified eight distinct areas of archaeological activity. These areas are located across all parts of the site and range in size from individual barrows and small enclosures to extensive areas of conjoining enclosures, some with evidence for structures (roundhouses), and many with discrete internal features indicative of settlement activity; the largest area extends some c. 750m^2 along the first terrace edge. The feature types are indicative of multi-

period activity, a pattern repeated in the wider landscape. To the south of the survey area, a complex of rectilinear enclosures with internal divisions was identified. These anomalies, which were not previously identified on the cropmark data extend to the southwest, beyond the railway.

5.4. In the modern period, a more significant change in the landscape was recorded directly to the south-east of the survey area with the construction of the Royal Naval Air Station. The airfield was constructed in 1944 and was operational until the 1953, when it was used as a storage facility and subsequently was converted to a nuclear and atomic research centre.

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 system.

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 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 plots. 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 5).

7.2.2. The survey has identified areas of probable and possible archaeological activity in the southern and northern parts of the site. In the southern part, a discernible configuration of rectilinear enclosures off a central track or drove way was detected, with associated pits or other small discrete features. In the northern part, a curvilinear ditch and possible field system was detected as well.

7.2.3. Delineating the full extent of the archaeological activity has likely been hampered by areas of magnetic disturbance and ferrous/debris spread. A buried service produces a large halo through the eastern part of the site, intersecting some of the archaeological enclosures. A strong, variable magnetic background in the central, eastern and western parts of the site likely results from debris associated with modern and historical land uses. In particular, a woodland is mapped on historical OS maps extending roughly north-west to south-east through the centre of the survey area. The removal of trees can create strong, discrete dipolar anomalies, similar to those which were detected in this area; although the area of ferrous/debris spread, and other magnetic disturbance extends beyond the mapped extent of this woodland, suggesting input from other sources.

7.2.4. Other ferrous anomalies associated with modern tracks and roads are identifiable running along the boundaries of individual fields. The pylons on site have also produced ferrous haloes. However, the overall impact of these extant metallic features on interrogating the results as a whole is relatively minimal. Subsurface disturbances have made more of an impact.

7.2.5. Linear anomalies were detected that abut or respect former field boundaries and historical paths associated with the woodland. Other sets of linear parallel anomalies were interpreted as possible historical and modern agricultural regimes.

7.2.6. Anomalies classified as ‘Natural’ in the northern part of the site appear to run in the direction of the slope, which is steeper in this part of the site. Other smaller discrete anomalies marked as ‘Natural’ are indicative of minor natural variations in the soil.

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. **Ferrous (Spike)** – Discrete dipolar anomalies are likely to be the result of isolated pieces of modern ferrous debris on or near the ground surface.

7.3.1.3. **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.

7.3.1.4. **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.

7.3.1.5. **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.

7.3.2. Magnetic Results - Specific Anomalies

7.3.2.1. **Archaeology Probable** – At the southern end of the survey area, two strong parallel linear anomalies spaced c. 16m apart form an apparent track or drove way [**3a**]. Abutting this track/drove way are a series of rectilinear enclosures to the north-east and south-west. While these anomalies exhibit a strong magnetic enhancement from the background, determining the full extent of these ditches and enclosures is limited by areas of strong magnetic interference from a buried service, ferrous debris, and haloes from the modern road.

7.3.2.2. **Archaeology Probable** – The most coherent of the enclosures, [**3b**], measures at least 38m x 40m in size; although its south-eastern end is obscured by a large ferrous halo from a buried service. Within this enclosure are a couple strong positive anomalies that may represent pits. Other weaker linear and curvilinear anomalies were classified as ‘Undetermined’, as it equally possible they relate to more recent activity, given their juxtaposition to modern field boundaries and other services.

7.3.2.3. **Archaeology Probable** – The enclosures [**3c**] to the south-west of [**3a**] are also difficult to fully comprehend, due to interference from ferrous debris and other highly magnetic material. What is evident, however, are a series of smaller enclosures or subdivisions and further strong circular anomalies indicative of pits.

7.3.2.4. **Ferrous/Debris (Spread)** – The possible track or drove way [**3a**] appears to extend further into Area 2 but is hard to delineate due to the highly magnetic and variable background in this area. The exact origin of this background cannot be determined through the geophysical data alone, but a contextual understanding of the site, from historical maps and satellite imagery, suggests its result from a combination of modern and historical land uses.

7.3.2.5. **Agricultural** – Anomalies classified as 'Agricultural' in Areas 2 and 3 are represented by linear, positive anomalies that are indicative of soil filled cut features. Analysis of historical maps show that many of these anomalies appear to respect or run parallel to historical boundaries, footpaths and tree plantings marked on historical maps (Figure 5).

7.3.2.6. **Ridge and Furrow** – At the northern end of Area 2, a series of weak, parallel linear anomalies spaced between 7m-10m apart are typical of ridge and furrow cultivation.

7.3.2.7. **Archaeology Possible** – A weak, positive curvilinear anomaly [**2a**] appears to intersect the ridge and furrow cultivation, extending from the northern end of the survey area, in Area 1, down into Area 3, towards the eastern end of the survey area. Several other linear anomalies appear to abut this ditch in Area 1, forming a shape indicative of a field system [**1a**].

7.3.2.8. **Ferrous/Debris (Spread)** – An area of ferrous/debris spread in the eastern end of the survey area [**3c**] corresponds with a building marked as 'Abingdon Lodge' on historical maps.

8. Conclusions

8.1. Magnitude Surveys successfully completed a c. 16.8ha fluxgate magnetometer survey across three fields to the north of Thame Lane in Culham, Oxfordshire. The survey has detected anomalies that have been interpreted as resulting from archaeological, agricultural and modern activity, with a few Undetermined anomalies of an uncertain anthropogenic origin.

8.2. Evaluating the archaeological potential for weaker or more ephemeral features is limited, or precluded, in some parts of the due to strong ferrous anomalies associated with buried services, ferrous debris/made ground, and a strong, variable magnetic background probably due to a combination of modern and historical land uses. Determining the depth extent of these subsurface ferrous disturbances is not possible through the magnetic data.

8.3. Still, archaeological activity was identified in the northern and southern parts of the site. At the southern end of the site, a group of rectilinear enclosures, some with internal sub-divisions, was detected abutting a track or drove way feature. These anomalies were relatively strong and coherent from the background, despite a more variable and enhanced background in this part

of site. The possible archaeological anomalies in the northern part of the site are weaker in signal, but a weaker, and more consistent, background in this part of the site allows for the detection of weaker anomalies.

8.1. Most of the anomalies interpreted as agricultural in origin appear to abut, respect, or relate to field boundaries, footpaths, and other woodland features marked on historical OS maps. An area of possible ridge and furrow cultivation was identified in the northern part of the site as well.

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

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12. Project Metadata

MS Job Code	MSSU1357
Project Name	Culham Battery Storage
Client	Oxford Archaeology
Grid Reference	SU 52879 96551
Survey Techniques	Magnetometry
Survey Size (ha)	16.8ha
Survey Dates	2022-08-08 to 2022-08-09
Project Lead	Krasimir Dyulgerski BA MRes
Project Officer	Krasimir Dyulgerski BA MRes
HER Event No	TBC
OASIS No	TBC
S42 Licence No	N/A
Report Version	0.3

13. Document History

Version	Comments	Author	Checked By	Date
0.1	Initial draft for Project Lead to Review	CH	KD	31 August 2022
0.2	Draft Report for Director Sign Off	CH	FPC	1 September 2022
0.3	Report amended after client corrections	KD	KD	14 September 2022


451000
452000
453000
454000
197000
196000
Play Space
Barton Lane
Thrupp Farm
River Isis
Lock Wood
New Cottage
Keeper's Cottage
Area 1
Area 2
Area 3
Ewer's Copse
Blacklands Plantation
New Covert
The Old Stables
Furze Brake
Warren Farm House
High Lodge
Culham Science Centre
Thame Lane
B4015
Warren Cottage
Tennis Court
C1
Playing Field
Watery Lane
Allotments
St Michael And All Angels' Church
Clifton Hampden
European School Of Culham
Other Sports Facility
Station House
A415
South Cottage
High Street
Fullamoor Farm
Warren Farm Cottage
MSSU1357: Culham Battery Storage
Figure 2 - Location of Survey Area
1:10,000 @ A3
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Survey Area
N
0
250
500
750 m
magnitude surveys


452400
452600
452800
453000
453200
453400
196800
196600
196400
196200
River Thames
River Isis
Area 1
Area 2
Area 3
MSSU1357: Culham Battery Storage
Figure 3 - Magnetic Total Field (Lower Sensor)
1:3000 @ A3
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48,990
nT
49,020
N
0
50
100
150 m
magnitude surveys

452400 452600 452800 453000 453200 453400

196800 196600 196400 196200

River Thames
River Isis

Area 1
Area 2
Area 3

MSSU1357: Culham Battery Storage
Figure 4 - Magnetic Gradient
1:3000 @ A3

-1 nT 2

N

0 50 100 150 m

magnitude surveys

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Figure 5 - Magnetic Interpretation Over Historical Maps
1:3000 @ A3

Agricultural (Strong)
Agricultural (Weak)
Archaeology Possible (Strong)
Archaeology Possible (Weak)
Archaeology Probable (Strong)
Archaeology Probable (Weak)
Magnetic Disturbance
Ferrous/Debris (Spread)
Natural (Weak)
Undetermined (Strong)
Undetermined (Weak)
Agricultural (Trend)
Undetermined (Trend)
Ridge and Furrow (Trend)
Service
Ferrous (Spike)

N

0 50 100 150 m

magnitude surveys

196400 452800 196600 196800

196800

Area 2

453000

196200

452800

Thame Lane

Area 3

453200

MSSU1357: Culham Battery Storage
Figure 6 - Magnetic Gradient (South-East)
1:1500 @ A3

-1 nT 2

0 25 50 75 m

magnitude surveys

196400 452800 196600 196800

196800

Area 2

453000

196200

452800

Thame Lane

3c

3a

3b

Area 3

453200

3c

MSSU1357: Culham Battery Storage
Figure 7 - Magnetic Interpretation (South-East)
1:1500 @ A3

Agricultural (Strong)
Agricultural (Weak)
Archaeology Possible (Strong)
Archaeology Possible (Weak)
Archaeology Probable (Strong)
Archaeology Probable (Weak)
Magnetic Disturbance
Ferrous/Debris (Spread)
Natural (Weak)
Undetermined (Strong)
Undetermined (Weak)
Agricultural (Trend)
Undetermined (Trend)
Service
Ridge and Furrow (Trend)
Ferrous (Spike)

0 25 50 75 m

magnitude surveys

196400
452800
196600
196800
Area 2
453000
196200
452800
Area 3
453200
Thorpe Lane
MSSU1357: Culham Battery Storage
Figure 8 - Magnetic Gradient XY Trace Plot (South-East)
30nT/cm at 1:1500 @ A3

0 25 50 75 m
magnitude surveys

196600
452600
196800
196400
452800
Area 1
452600
Area 2
196800
453000
Thorpe Lane
MSSU1357: Culham Battery Storage
Figure 9 - Magnetic Gradient (North)
1:1500 @ A3

-1 nT 2
0 25 50 75 m
magnitude surveys

196600
452600
196800
196400
452800
452600
196800
453000
1a
Area 1
2a
Area 2
3c
Thame Lane

Agricultural (Strong)
Agricultural (Weak)
Archaeology Possible (Strong)
Archaeology Possible (Weak)
Archaeology Probable (Strong)
Archaeology Probable (Weak)
Magnetic Disturbance
Ferrous/Debris (Spread)
Natural (Weak)
Undetermined (Strong)
Undetermined (Weak)
Agricultural (Trend)
Undetermined (Trend)
Service
Ridge and Furrow (Trend)
Ferrous (Spike)
0 25 50 75 m

MSSU1357: Culham Battery Storage
Figure 10 - Magnetic Interpretation (North)
1:1500 @ A3

magnitude surveys

196600
452600
196800
196400
452800
452600
196800
453000
Area 1
Area 2
Thame Lane
0 25 50 75 m

MSSU1357: Culham Battery Storage
Figure 11 - Magnetic Gradient XY Trace Plot (North)
30nT/cm at 1:1500 @ A3

magnitude surveys