

HS2 Phase 2a Early Environmental Works

Site 053 - Geophysics Survey Report Heritage Non-intrusive Survey Reports Group 016

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Methodology	Project Plan Site Code
Gradiometer (Magnetometer) Survey	2a20DWDHMG

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HS2 Ltd - Code 1 - Accepted

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1 Executive Summary

- 1.1.1 This document comprises a Final Report for a non-intrusive geophysical survey on the route of the proposed Phase 2a of High Speed Two (HS2) covering land proposed for development or likely to be impacted during the scheme as part of the Early Environmental Works (EEW) package. This report contains the results of a magnetometer survey undertaken on 15th July 2022 at Site 53 within Group 016.
- 1.1.2 The aim of the survey is to establish the presence/absence, extent and character of detectable archaeological remains within the proposed route of HS2 Phase 2a. The scope of the surveys is dependent upon securing access to the land and for the areas to be suitable for survey.
- 1.1.3 EEW Group 016 is situated between Baldwin's Gate and the southeast of Madeley, Staffordshire, centred on NGR 379384 341806. The area required for magnetometer survey consists of one irregular shaped parcel totalling c.1.8ha with proposed works entailing ancient woodland mitigation planting, the retention and protection of existing hedgerow, grassland habitat creation, and the creation of bird / bat boxes.
- 1.1.4 All suitable areas within the site were surveyed.
- 1.1.5 The survey has identified anomalies indicative of cultivation techniques in both parcels of land. In the south of the eastern parcel, anomalies identified as field drains are recorded, whereas in the western parcel, linear anomalies indicative of more modern ploughing techniques as well as slightly curvilinear anomalies consistent with older, post medieval 'ridge and furrow' are recorded.
- 1.2 High magnitude responses near or adjacent to existing field boundaries are caused by the presence of highly magnetic material either within the boundaries or as a spread of sub-surface material.
- 1.2.1 Occasional, discrete, low magnitude and dipolar 'spike' anomalies are of natural and modern causes respectively.

2 Introduction

2.1 Project Background

- 2.1.1 HS2 is a new railway network proposed by the Government to provide a new link between London, the West Midlands, the East Midlands, South Yorkshire, Leeds and Manchester. HS2 Phase 2a comprises approximately 36 miles of railway starting at Fradley at its southern end and connects with the West Coast Main Line (WCML), south of Crewe, to allow HS2 services to join the existing network and call at Crewe Station.
- 2.1.2 The overall framework within which archaeological work will be undertaken is set out in the draft Environmental Minimum Requirements (EMR) for HS2 Phase 2a. Accordingly, the nominated undertaker or any contractors will be required to implement certain control measures in relation to archaeology before construction work begins.
- 2.1.3 The works have been undertaken in accordance with Written Scheme of Investigation (WSI, HS2 2019) and conform with current best practice and guidance for geophysical surveys as outlined in the Chartered Institute for Archaeologists' (CIfA) Standard and Guidance for archaeological geophysical survey (CIfA 2014) and European Archaeologiae Consilium Guidelines for the use of Geophysics in Archaeology (EAC 2016).
- 2.1.4 The selection of areas required for geophysical survey included as part of this Early Environmental Works (EEW) package are set out in location specific Written Scheme of Investigations (WSIs) based on Groups containing individual sites. HS2 Ltd has provided each EEW site along the Phase 2a route with a unique identifier Site Code.
- 2.1.5 Within EEW Group 016 (HS2 2021) the Site Code for geophysical survey is:
• Site 53: 2a20DWDHMG

2.2 Scope of Document

- 2.2.1 This report presents a brief description of the methodology followed by the detailed survey results and the archaeological interpretation of the geophysical data.

2.3 The Site

- 2.3.1 EEW Group 016 is situated between Baldwin's Gate and the southeast of Madeley, Staffordshire, centred on NGR 379384 341806. The area required for magnetometer survey consists of one irregular shaped parcel totalling c.1.8ha with proposed works entailing ancient woodland mitigation planting, the retention and protection of existing hedgerow, grassland habitat creation, and the creation of bird / bat boxes.
- 2.3.2 The survey area was pasture at the time of survey and full coverage was achieved except for hedgerows and in the location of a pond. Track matting partially extended across the survey area at the time of survey.

- 2.3.3 EEW Group 16 lies within an agricultural landscape which also features Whitmore Woods, which little change occurring upon the sites since the production of the mid-19th century Tithe and Estate mapping. The known assets from the Environmental Statement reflect this with a 19th century farm and area of ridge and furrow recorded.
- 2.3.4 Site 53 is split between two fields, with Heath Road running N-S between them. The site slopes downwards from approximately 165m OD to the west to approximately 155m OD at the eastern edge of the site. The nearest watercourse run adjacent to the eastern edge of the site.
- 2.3.5 The solid geology across the Site is recorded as mudstone, sandstone and conglomerate of the Salop Formation. This area is overlain by deposits of till, diamicton. No overlying superficial deposits are recorded at the Site (BGS 2022).
- 2.3.6 The soils covering the Site are classified in Soilscape 18 Association described as slowly permeable acid but base-rich loams and clays (Cranfield University 2022).
- 2.3.7 Magnetometer survey can generally be recommended over any sedimentary geologies however the average responses of surveys over sandstones and mudstones are generally poor but results can be variable depending on the nature and depth of the overlying deposits if present (English Heritage 2008; Table 4). It remains that magnetometry was the most appropriate geophysical technique for evaluating the Site taking account of the limitations noted in Section 4.3 below.

3 Archaeological Background

3.1 Summary of the archaeological resource

- 3.1.1 The following archaeological background summarises details from the Location Specific Written Scheme of Investigation (LSWSI, HS2 2021) together with information from publicly available online resources and other in-house resources.
- 3.1.2 The Recognised Archaeological Zones (RAZ) represent a high-level indication of likely concentrations of archaeological remains across the Phase 2a route. The location and spatial extent of RAZs has been determined using HS2 Environmental Statement (ES) Cultural Heritage information and subsequent survey data.
- 3.1.3 Site 53 lies outside of any RAZs.
- 3.1.4 No heritage assets were identified by the ES or Staffordshire Historic Environment Record (HER) as being within the site boundary. However, Site 53 is adjacent to Dab Green Farm, a non-designated low value farmhouse established by the late 19th century.
- 3.1.5 The Whitmore Enclosure Map from 1846 and the Whitmore Tithe Map from 1859 illustrate Site 53 as being comparable to the way as it presently appears. This remains the case throughout the 19th – early 20th century Ordnance Survey (OS) Mapping, with no features of heritage interest being recorded.
- 3.1.6 No geophysical survey work has been undertaken to date within Site 53.
- 3.1.7 LiDAR / remote sensing survey data did not identify any features within Site 53.

4 Methodology

4.1 Magnetometry

Magnetic survey methods rely on the ability of a variety of instruments to measure very small magnetic fields associated with buried archaeological remains. A feature such as a ditch, pit or kiln can act like a small magnet, or series of magnets, that produce distortions (anomalies) in the earth's magnetic field. In mapping these slight variations, detailed plans of sites can be obtained as buried features often produce reasonably characteristic anomaly shapes and strengths (Gaffney and Gater 2003). Further information on soil magnetism and the interpretation of magnetic anomalies is provided in Annex 1 and Annex 2 respectively.

4.2 Aims and Objectives

4.2.1 The aims of the survey comprise the following:

- To determine, as far as is reasonably possible, the nature of the detectable archaeological resource within a specified area using appropriate methods and practices; and
- To inform either the scope and nature of any further archaeological work that may be required; or the formation of a mitigation strategy (to offset the impact of the development on the archaeological resource); or a management strategy.

4.2.2 In order to achieve the above aims, the objectives of the geophysical survey are:

- To conduct a geophysical survey covering as much of the specified area as possible, allowing for on-site obstructions;
- To clarify the presence/absence of anomalies of archaeological potential; and
- Where possible, to determine the general nature of any anomalies of archaeological potential.

4.3 Assumptions and limitations

Magnetometry is the most widely used geophysical survey technique in archaeology as it can quickly evaluate large areas and, under favourable conditions, identify a wide range of archaeological features including infilled cut features such as large pits, gullies and ditches, hearths, and areas of burning and kilns and brick structures. It is therefore good at locating settlements of all periods, prehistoric field systems and enclosures and areas of industrial or modern activity, amongst others. It is less successful in identifying smaller features such as post-holes and small pits (except when using a non-standard sampling interval), unenclosed (prehistoric) settlement sites and graves/burial grounds. Magnetometry has the potential to rapidly confirm the presence/absence of a wide range of potential archaeological remains within

the site and was thus chosen as the most appropriate technique in this instance.

4.4 Fieldwork Methodology

4.4.1 The survey was undertaken using four Bartington Grad601 sensors mounted at 1m intervals (1m traverse interval) onto a rigid carrying frame. The system was programmed to take readings at a frequency of 10Hz (allowing for a 10-15cm sample interval) on roaming traverses (swaths) 4m apart (Figure 1). These readings were stored on an external weatherproof laptop and later downloaded for processing and interpretation. The system was linked to a Trimble R8s Real Time Kinetic (RTK) differential Global Positioning System (dGPS) outputting in NMEA mode to ensure a high positional accuracy for each data point, in accordance with EAC guidelines (EAC 2016).

4.4.2 Unenclosed areas were surveyed using the co-ordinates of the pre-determined Site boundary visible as an outline on the MLGrad601 software during data collection.

4.4.3 MLGrad601 (Geomar Software Inc.) software was used to collect the data.

4.5 Data processing

4.5.1 Data collected using RTK GPS-based methods cannot be produced without minimal processing of the data. The minimally processed data has been interpolated to project the data onto a regular grid and de-striped to correct for slight variations in instrument calibration drift and any other artificial data.

4.5.2 A high pass filter has been applied to the greyscale plots to remove low frequency anomalies (relating to survey tracks and modern agricultural features) to maximise the clarity and interpretability of the archaeological anomalies.

4.5.3 The data has also been clipped to remove extreme values and to improve data contrast.

4.5.4 MultiGrad601 (Geomar Software Inc.) software was used to export the survey data files.

4.5.5 Terrasurveyor V3.0.37.0 (DWConsulting) software was used to process and export graphical plots the data.

5 Geophysical Survey Results and Interpretation

5.1 Gradiometer survey results and interpretation

- 5.1.1 The magnetometer survey was carried out on the 15th July 2022. All the suitable areas required for magnetometer survey within the Site were surveyed amounting to 1.8ha.
- 5.1.2 Fully processed (greyscale) data, minimally processed data (XY trace plot) and interpretative plans are presented at a scale of 1:1,000 in Figures 2 – 4 inclusive.
- 5.1.3 The magnetic background is relatively homogenous across the site containing few occasional discrete, low magnitude anomalies of natural origin.
- 5.1.4 Magnetically enhanced linear anomalies in the south of the eastern parcel identify field drains. Magnetic disturbance caused by fences is recorded at the periphery of the individual parcels. Linear anomalies consistent with modern and post-medieval cultivation techniques are present within the western parcel.

6 Discussion

- 6.1 The survey has identified anomalies indicative of cultivation techniques in both parcels of land. In the south of the eastern parcel, anomalies identified as field drains are recorded, whereas in the western parcel, linear anomalies indicative of more modern ploughing techniques as well as slightly curvilinear anomalies consistent with older, post medieval 'ridge and furrow' are recorded.
- 6.2 High magnitude responses near or adjacent to existing field boundaries are caused by the presence of highly magnetic material either within the boundaries and/or a spread of sub-surface material.
- 6.3 Occasional, discrete, low magnitude and dipolar 'spike' anomalies are of natural and modern causes respectively.
- 6.4 The survey findings where no anomalies of archaeological or possible archaeological potential have been identified, are consistent with the known limited archaeological potential of the Site located outside of a RAZ and where no heritage assets were identified by the ES or within the Staffordshire HER.

References

Bibliography

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HS2 2019 HS2 Phase 2a Written Scheme of Investigation for EI-711 Surveys Package 1: Magnetometry (HS2-HS2-EV-MST-A000001)

HS2, 2021, Phase 2a LS-WSI: EEW Group 016, EEW Sites 53, 54 & 81 (HS2 Document no: 2EE01-BAF-PRO-A000-000006, Revision: 05)

Annex 1: Magnetometer survey

Magnetic susceptibility and soil magnetism

Iron makes up about 6% of the earth's crust and is mostly present in soils and rocks as minerals such as maghaemite and haematite. These minerals have a weak, measurable magnetic property termed magnetic susceptibility. Human activities can redistribute these minerals and change (enhance) others into more magnetic forms so that by measuring the magnetic susceptibility of the topsoil, areas where human occupation or settlement has occurred can be identified by virtue of the attendant increase (enhancement) in magnetic susceptibility. If the enhanced material subsequently comes to fill features, such as ditches or pits, localised isolated and linear magnetic anomalies can result whose presence can be detected by a magnetometer (fluxgate gradiometer).

In general, it is the contrast between the magnetic susceptibility of deposits filling cut features, such as ditches or pits, and the magnetic susceptibility of the topsoil, subsoil and rock, into which these features have been cut, which causes the most recognisable responses. This is primarily because there is a tendency for magnetic ferrous compounds to become concentrated in the topsoil, thereby making it more magnetic than the subsoil or the bedrock. Linear features cut into the subsoil or geology, such as ditches, that have been silted up or have been backfilled with topsoil will therefore usually produce a positive magnetic response relative to the background soil levels. Discrete feature, such as pits, can also be detected.

The magnetic susceptibility of a soil can also be enhanced by the application of heat. This effect can lead to the detection of features such as hearths, kilns, or areas of burning.

Annex 2: Geophysical Interpretation

Most anomalies are termed 'positive'. This means that they have a positive magnetic value relative to the magnetic background on any given site. However, some features can manifest themselves as 'negative' anomalies that, conversely, means that the response is negative relative to the mean magnetic background.

Where it is not possible to give a probable cause of an observed anomaly a '?' is appended. It should be noted that anomalies interpreted as modern in origin might be caused by features that are present in the topsoil or upper layers of the subsoil. Removal of soil to an archaeological or natural layer can therefore remove the feature causing the anomaly.

The types of response mentioned above can be divided into five main categories that are used in the graphical interpretation of the magnetic data:

Isolated dipolar anomalies (iron spikes)

These responses are typically caused by ferrous material either on the surface or in the topsoil. They cause a rapid variation in the magnetic response giving a characteristic 'spiky' trace. Although ferrous archaeological artefacts could produce this type of response, unless there is supporting evidence for an archaeological interpretation, little emphasis is normally given to such anomalies, as modern ferrous objects are common on rural sites, often being introduced into the soil during manuring.

Areas of magnetic disturbance

These responses can have several causes often being associated with burnt material, such as slag waste or brick rubble or other strongly magnetised/fired material. Ferrous structures such as pylons, mesh or barbed wire fencing and buried pipes can also cause the same disturbed response. A modern origin is usually assumed unless there is other supporting information.

Lightning-induced remnant magnetisation (LIRM)

LIRM anomalies are thought to be caused in the near surface soil horizons by the flow of an electrical current associated with lightning strikes. These observed anomalies have a strong bipolar signal which decreases with distance from the spike point and often appear as linear or radial in shape.

Linear trend

This is usually a weak or broad linear anomaly of unknown cause or date. These anomalies are often caused by agricultural activity, either ploughing or land drains being a common cause.

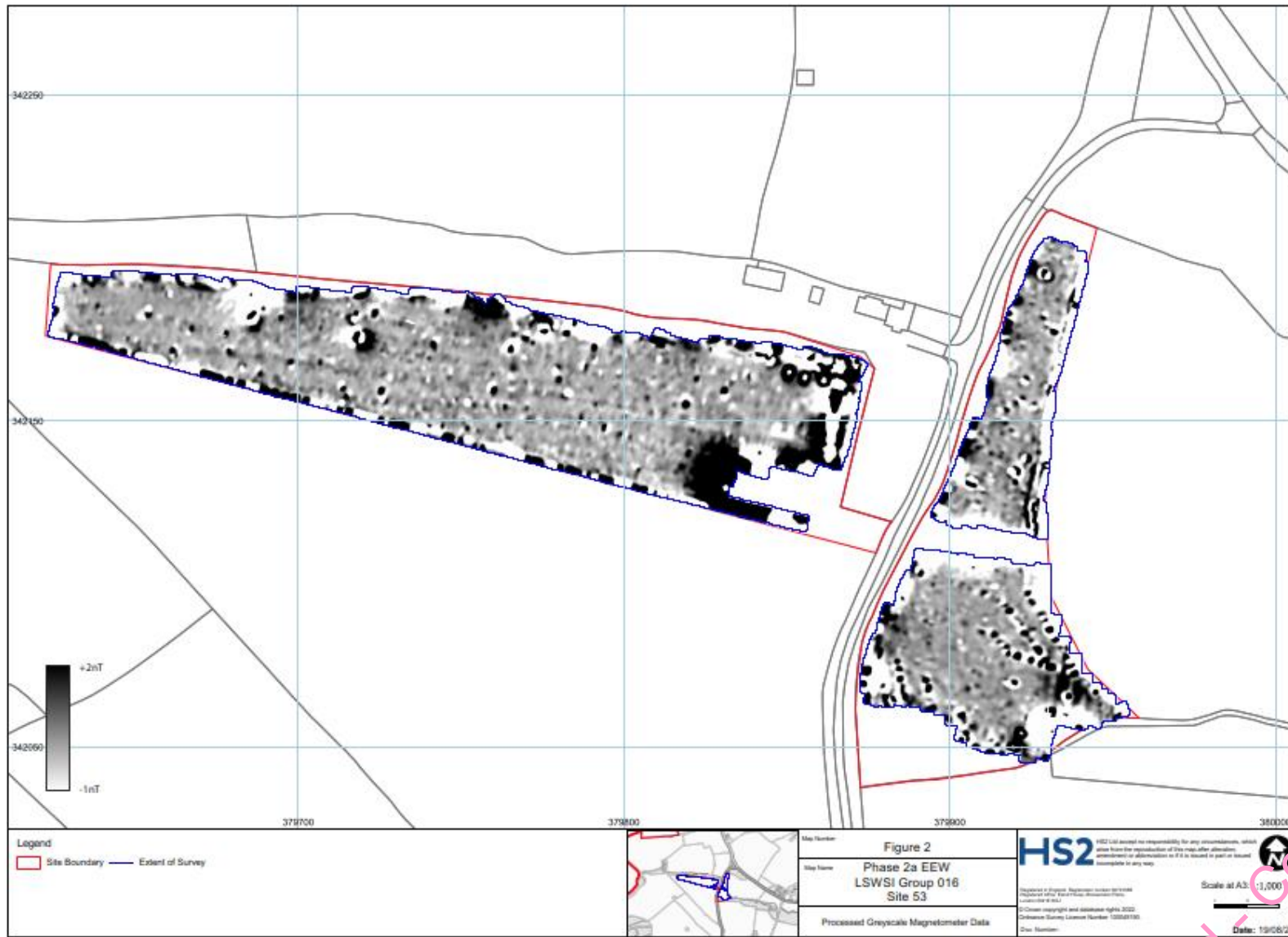
Areas of magnetic enhancement/positive isolated anomalies

Areas of enhanced response are characterised by a general increase in the magnetic background over a localised area whilst discrete anomalies are manifest by an increased response (sometimes only visible on an XY trace plot) on two or three successive traces. In neither instance is there the intense dipolar response characteristic exhibited by an area of magnetic disturbance or of an 'iron spike' anomaly (see above). These

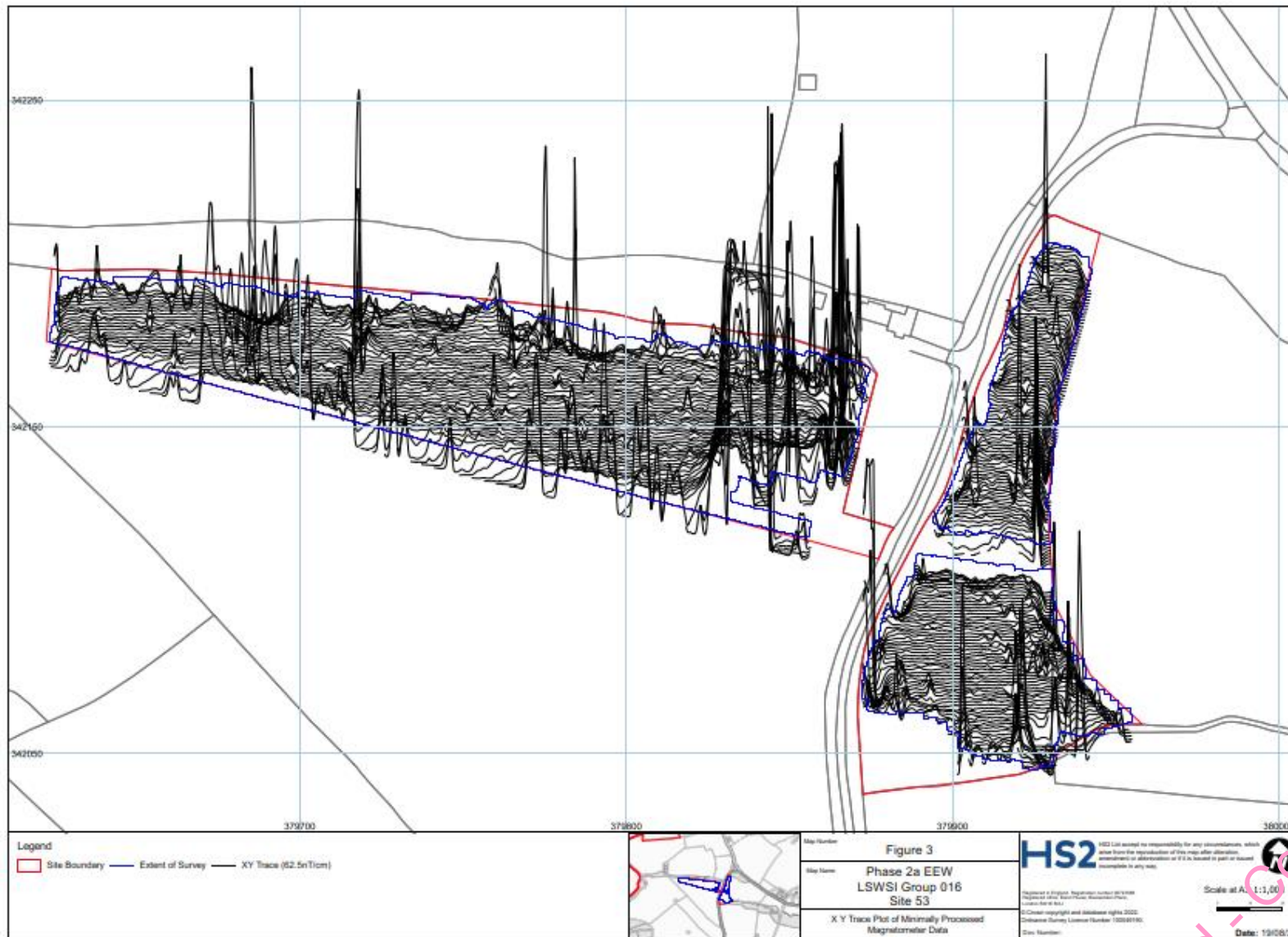
anomalies can be caused by infilled discrete archaeological features such as pits or post-holes or by kilns. They can also be caused by pedological variations or by natural infilled features on certain geologies. Ferrous material in the subsoil can also give a similar response. It can often therefore be very difficult to establish an anthropogenic origin without intrusive investigation or other supporting information.

Linear and curvilinear anomalies

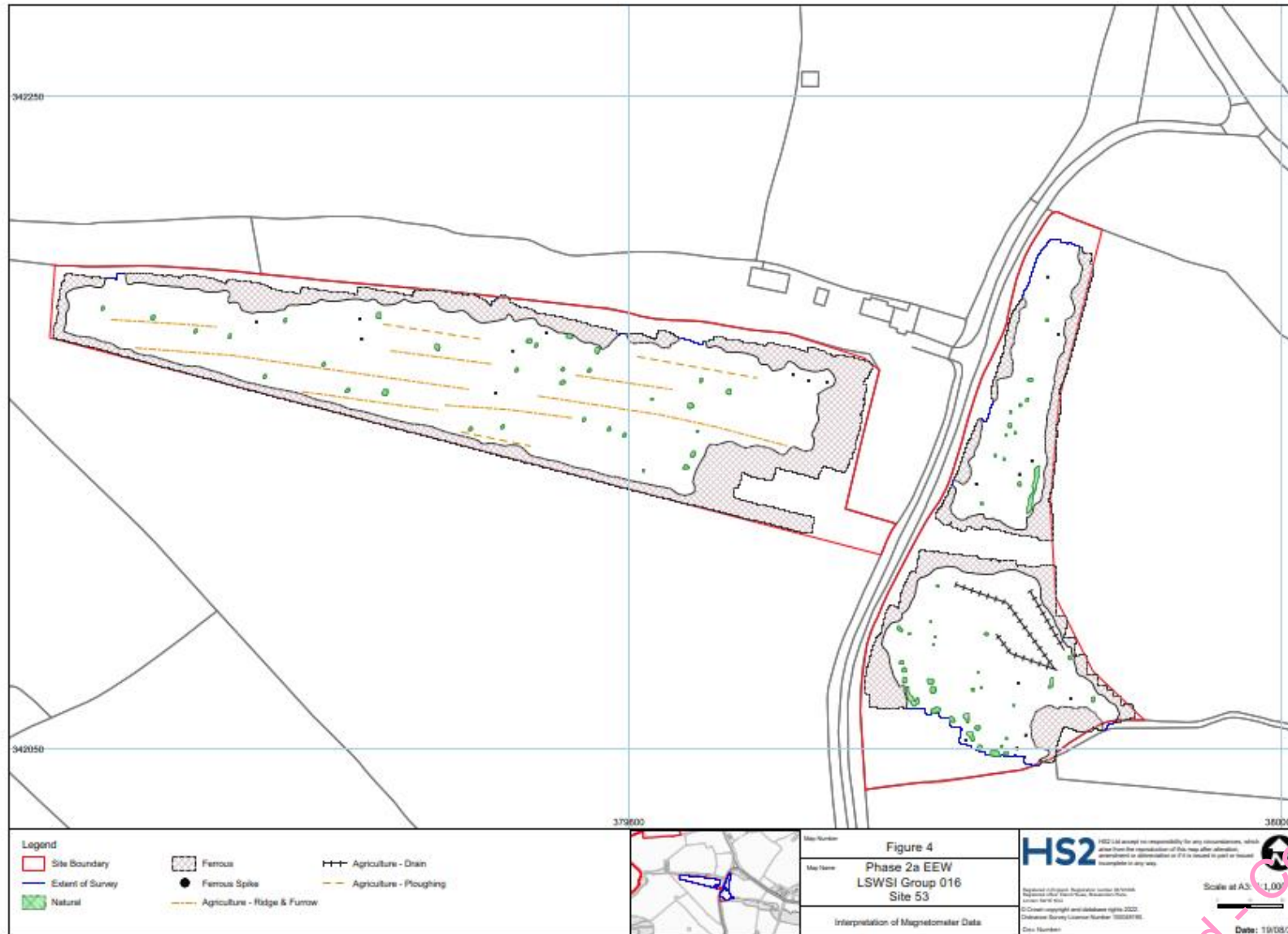
Such anomalies have a variety of origins. They may be caused by agricultural practice (recent ploughing trends, earlier ridge and furrow regimes or land drains), natural geomorphological features such as palaeochannels or by infilled archaeological ditches.



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Annex 3: OASIS Form

Project Details:

Project name	Geophysical Survey at Group 016 Site 53	
Type of project	Geophysical Survey, MAGNETOMETRY SURVEY	
Project description	<p>The survey was undertaken using four Bartington Grad601 sensors mounted at 1m intervals (1m traverse interval) onto a rigid carrying frame. The system was programmed to take readings at a frequency of 10Hz (allowing for a 10-15cm sample interval) on roaming traverses (swaths) 4m apart. These readings were stored on an external weatherproof laptop and later downloaded for processing and interpretation. The system was linked to a Trimble R8s Real Time Kinetic (RTK) differential Global Positioning System (dGPS) outputting in NMEA mode to ensure a high positional accuracy for each data point, in accordance with EAC guidelines (EAC 2016).</p> <p>The survey has identified anomalies indicative of cultivation techniques in both parcels of land. In the south of the eastern parcel, anomalies identified as field drains are recorded, whereas in the western parcel, linear anomalies indicative of more modern ploughing techniques as well as slightly curvilinear anomalies consistent with older, post medieval 'ridge and furrow' are recorded. High magnitude responses near or adjacent to existing field boundaries are caused by the presence of highly magnetic material either within the boundaries or as a spread of sub-surface material. Occasional, discrete, low magnitude and dipolar 'spike' anomalies are of natural and modern causes respectively.</p>	
Project dates	Start: 15-Jul-2022	End: 15-Jul-2022
Previous work	N/A	

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Future work		N/A			
Project Code:	Group 016 Site 53	HER event no.			

		NMR no.		OASIS form ID:	hs2headl1-509465
		SM no.			
Planning Application Ref.					
Site Status		None			
Land use		Arable and pasture			
Monument type		N/A	Period	N/A	

Project Location:

Site Address	situated between Baldwin's Gate and the southeast of Madeley, Staffordshire			Postcode	
County	Staffordshire	District	Newcastle-under-Lyme	Parish	Whitmore
Study Area	1.8ha	Height OD	Between 155 and 165m Above Ordnance Datum	NGR	SJ 79767 42162 SJ 79913 42109

Project Creators:

Name of Organisation	HS2 Headland Archaeology (UK) Ltd				
Project brief originator	HS2	Project design originator	HS2		
Project Manager	Alistair Webb	Project Supervisor	Matt Berry		
Sponsor or funding body	Balfour Beatty	Type of Sponsor	Client		

Project Archive and Bibliography:

Physical archive	N/A	Digital Archive	Geophysical survey and report	Paper Archive	N/A
Report title	Phase 2a Heritage Non-intrusive Surveys Report: Group 016 Site 53 Geophysics survey report			Date	31/10/2022
Author	Headland Archaeology	Description	PDF/A	Report ref.	

