highways england

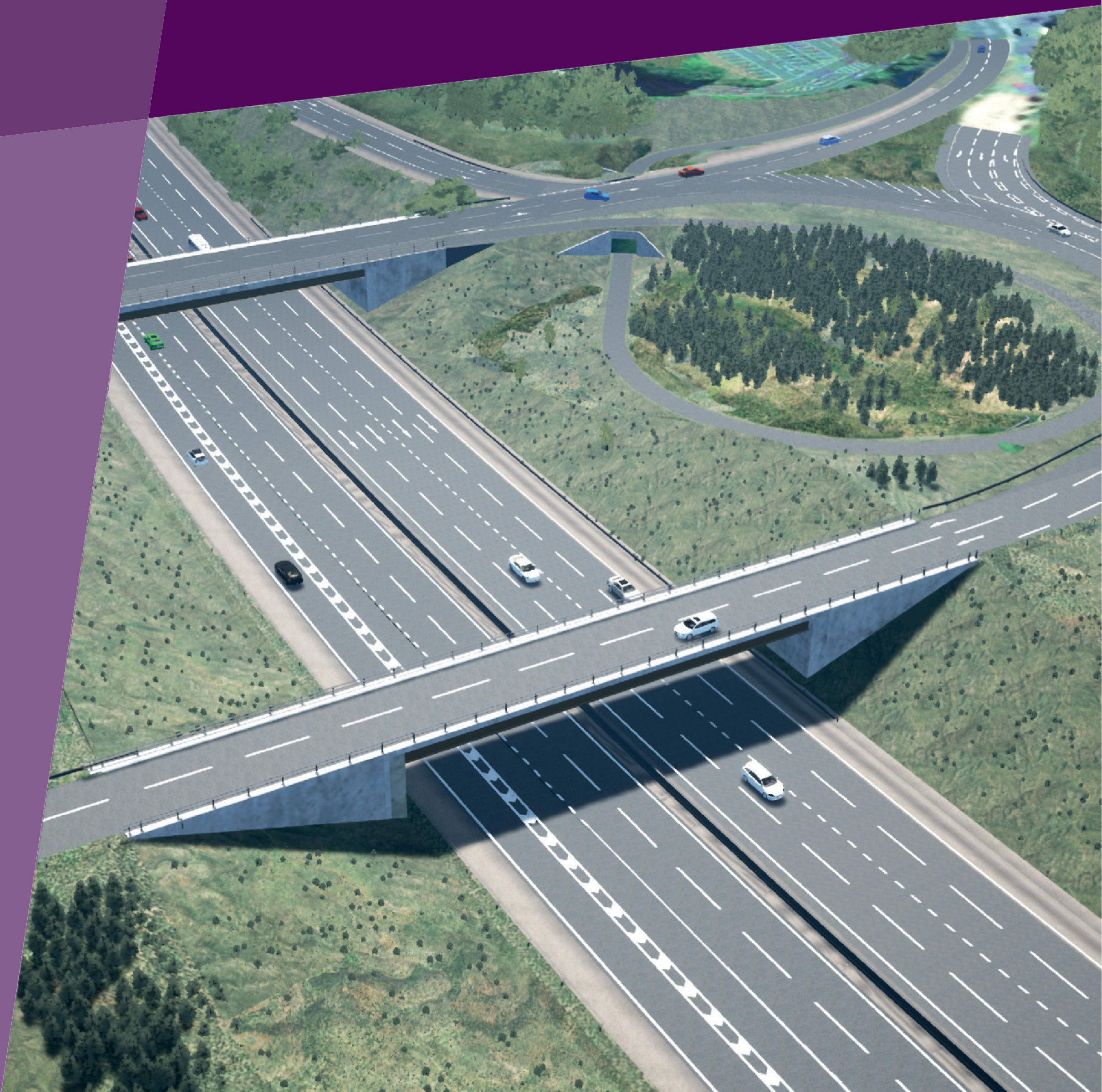
M3

junction 9 improvement scheme

Preliminary Environmental Information Report

Appendix 6.4 – Geophysical Survey Report

May 2021



Appendix 6.4 Geophyiscal Survey Report

SUMO Survey
GEOPHYSICS FOR ARCHAEOLOGY & ENGINEERING

GEOPHYSICAL SURVEY REPORT

M3 Junction 9, Winchester, Hampshire

Client

Jacobs UK

Document Number

HE551511-SUM-VES-0_00_00-RP-LE-0001

Revision

P01

Survey Report

15112

Date

July 2019

Survey Report 15112: M3 Junction 9, Winchester, Hampshire

Survey dates	4 - 5 July 2019
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Field Team	Andrew Bateman MSc Simon Lobel BSc
Report Date	23 July 2019
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1. LIST OF FIGURES

2. SURVEY TECHNIQUE

Detailed magnetic survey (magnetometry) was chosen as the most efficient and effective method of locating the type of archaeological anomalies which might be expected at this site.

Bartington Grad 601-2	Traverse Interval 1.0m	Sample Interval 0.25m
Bartington Cart System	Traverse Interval 1.0m	Sample Interval 0.125m

3 SUMMARY OF RESULTS

3.1 A detailed magnetometer survey was conducted over land at Junction 9 of the M3, near Winchester, Hampshire. No definite archaeological anomalies have been identified, however a number of linear and discrete responses of uncertain origin have been mapped. Former field boundaries are evident in the data, along with modern ploughing effects, areas of natural magnetic variation and underground services.

4 INTRODUCTION

4.1 **SUMO Geophysics Ltd** were commissioned to undertake a geophysical survey of an area outlined for development. This survey forms part of an archaeological investigation being undertaken by **Jacobs UK**.

4.2 Site details

NGR / Postcode	SU 498 307 / SO23 7TY
Location	The site is located on the north-eastern edge of Winchester, either side of the M3 motorway, immediately north of Junction 9. The A34, Winchester Bypass, bounds the site to the west.
HER	Winchester HER
District	Winchester City Council / Hampshire CC
Parish	Itchen Valley CP
Topography	Mostly level
Current Land Use	Arable / pasture
Geology (BGS 2019)	Bedrock: Seaford Chalk Formation - chalk. Superficial: none recorded.
Soils (CU 2019)	Soilscape 6: freely draining lime-rich loamy soils.
Archaeology	Extensive prehistoric and Romano-British settlement has been identified in the surrounding landscape, and a number of cropmarks are recorded within close proximity to the site (WSP 2017). A previous geophysical survey on land immediately adjacent to the site (SUMO 2018) identified a possible partial ring ditch, former field boundaries and evidence of modern ploughing.
Survey Methods	Magnetometer survey (fluxgate gradiometer)
Study Area	*c.* 9 ha - approximately 0.6 ha in Area 5 could not be surveyed due to being under crop.

4.3 **Aims and Objectives**

To locate and characterise any anomalies of possible archaeological interest within the study area.

5 RESULTS

The survey has been divided into five survey areas (Areas 1-5) and specific anomalies have been given numerical labels [1] [2] *which appear in the text below, as well as on the Interpretation Figure(s).*

5.1 *Probable / Possible Archaeology*

5.1.1 No magnetic responses have been recorded that could be interpreted as being of archaeological interest.

5.2 *Uncertain*

5.2.1 A series of linear ditch-type anomalies [1] are visible in the south of Area 1 and are of uncertain origin. The anomalies appear on varying alignments, and it is possible that they are archaeological; perhaps related to a former field system. However, they could equally be a result of more recent field boundaries not marked on available mapping.

5.2.2 Further linear anomalies [2-4] have been detected in Areas 3 and 4; these are also of undetermined origin. Their alignment at right-angles to the current field layout suggests that they could be related to former field boundaries; however, there is no evidence of such features on historic maps and their proximity to a possible ring ditch identified in a previous survey (SUMO 2018) means an archaeological explanation cannot be ruled out.

5.2.3 A wide and sinuous linear anomaly [5] can be seen in the south of Area 1. The response could be indicative of a former cut feature, such as a ditch, though the exact origin of the anomaly remains unclear. It is possible that the response is related to a former watercourse / stream channel given that a large number are recorded on mapping to the west of the area.

5.2.4 A cluster of discrete positive anomalies [6] have been identified in the south of Area 1. The tentative rectilinear form of the responses suggests that they could have an archaeological explanation; however, they lie in close proximity to a former chalk pit and it is feasible that they are a result of former quarrying activity, related to a former watercourse or have other natural origins.

5.3 *Former Field Boundary*

5.3.1 A number of linear anomalies [7-9] have been detected in Area 3. These all correspond with the locations of former field boundaries, visible on historic OS maps from 1892. Anomaly [8] appears to form a continuation of the corroborated boundary detected in the previous geophysical survey (SUMO 2018).

5.4 *Agricultural – Ploughing*

5.4.1 Evidence of modern agricultural activity is visible in Area 4, in the form of magnetically weak, closely spaced, parallel linear anomalies.

5.5 *Natural / Geological / Pedological / Topographic*

5.5.1 A few amorphous areas of increased magnetic response can be seen in the northern half of the site. These are likely to be natural in origin and reflect localised variations in the underlying geology.

5.6 *Ferrous / Magnetic Disturbance*

5.6.1 Strongly magnetic and bipolar linear anomalies are visible in Areas 1 and 3. They are indicative of underground services, such as pipes or cables. It is possible that the response in the south of Area 3 may form part of the former field boundary [9].

5.6.2 Ferrous responses close to boundaries are due to adjacent fences and gates. Smaller scale ferrous anomalies ("iron spikes") are present throughout the data and are characteristic of small pieces of ferrous debris (or brick / tile) in the topsoil; they are commonly assigned a modern origin. Only the most prominent of these are highlighted on the interpretation diagram.

6 DATA APPRAISAL & CONFIDENCE ASSESSMENT

6.1 Historic England guidelines (EH 2008) Table 4 states that the typical magnetic response on the local soils / geology is generally good. The results from this survey indicate the presence of several linear anomalies of uncertain origin, along with former field boundaries. Consequently, the technique is likely to have detected any archaeological features, if present.

7 CONCLUSION

7.1 The survey at Winchester has not identified any anomalies of definite archaeological origin, however a number of responses of uncertain origin have been mapped. These include linear ditch-type responses, possibly associated with former boundaries or stream channels, along with discrete anomalies which could relate to former quarrying activity. A few corroborated boundaries have been identified, along with modern ploughing effects. underground services, areas of natural magnetic response and disturbance from nearby ferrous objects.

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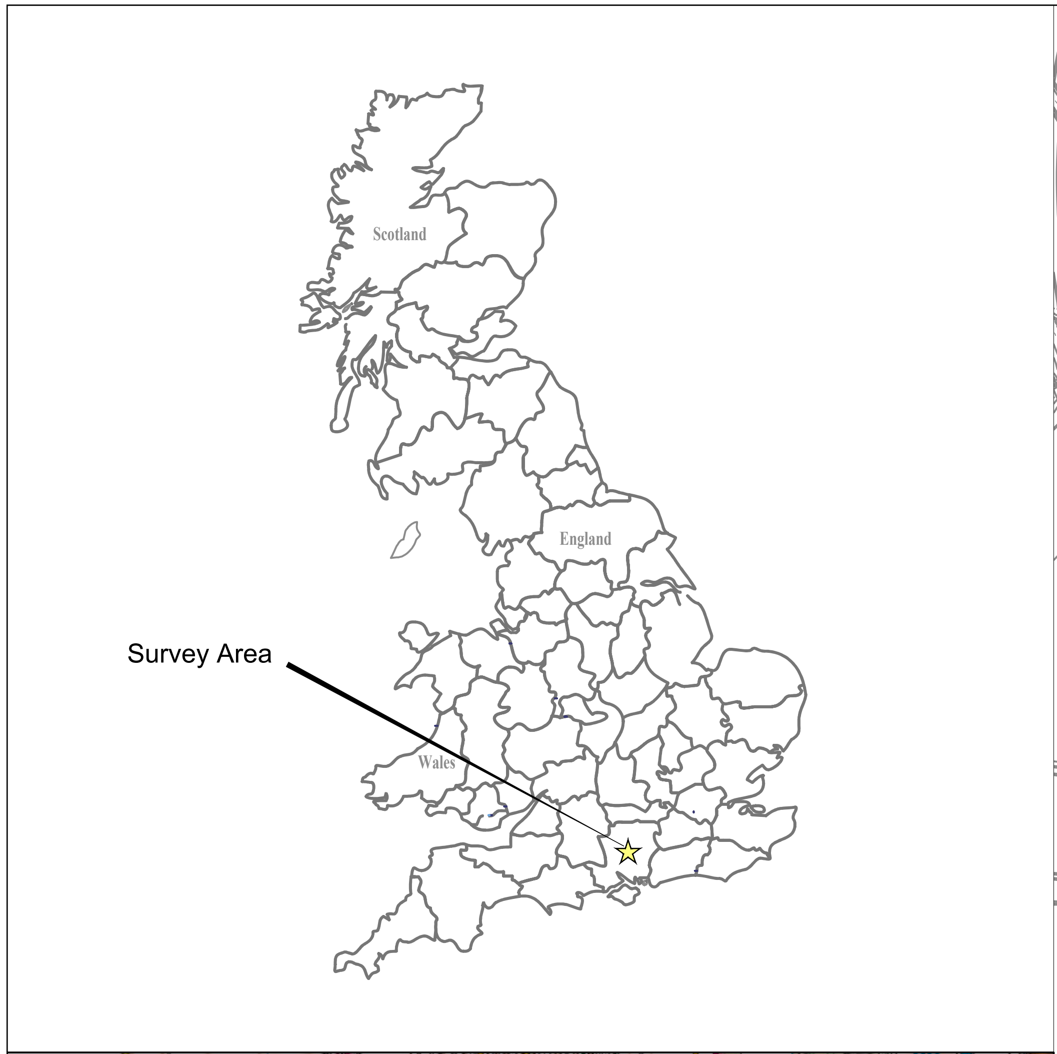
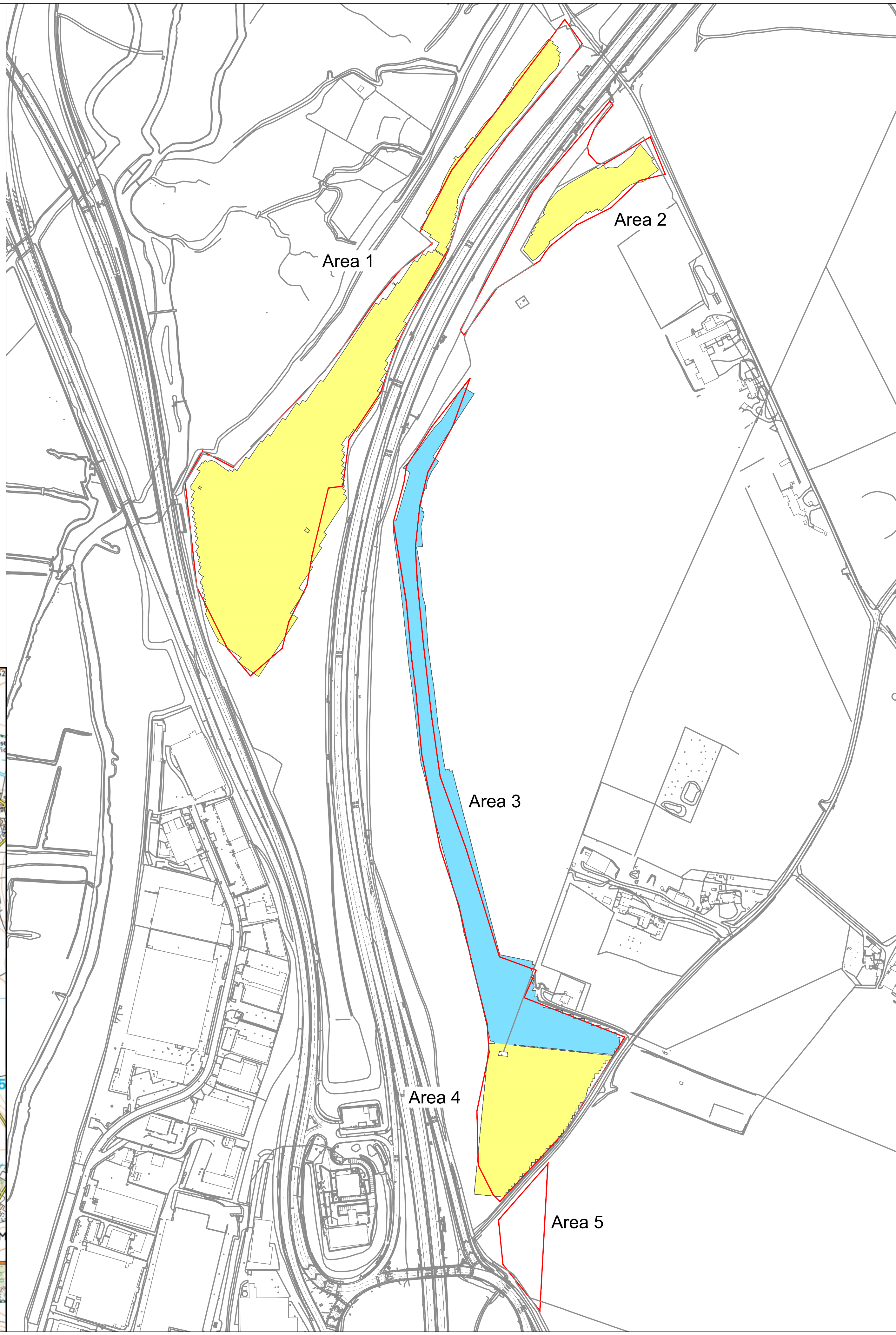




Survey Areas - hand-held data

Survey Areas - cart data

N

SUMO Survey
GEOPHYSICS FOR ARCHAEOLOGY & ENGINEERING

Title: Site Location

Client: Jacobs UK

Project: 15112 - M3 Junction 9, Winchester, Hampshire

Scale: NOT TO SCALE

Fig No: 01

Title: Magnetometer Survey - Greyscale Plots - Overview

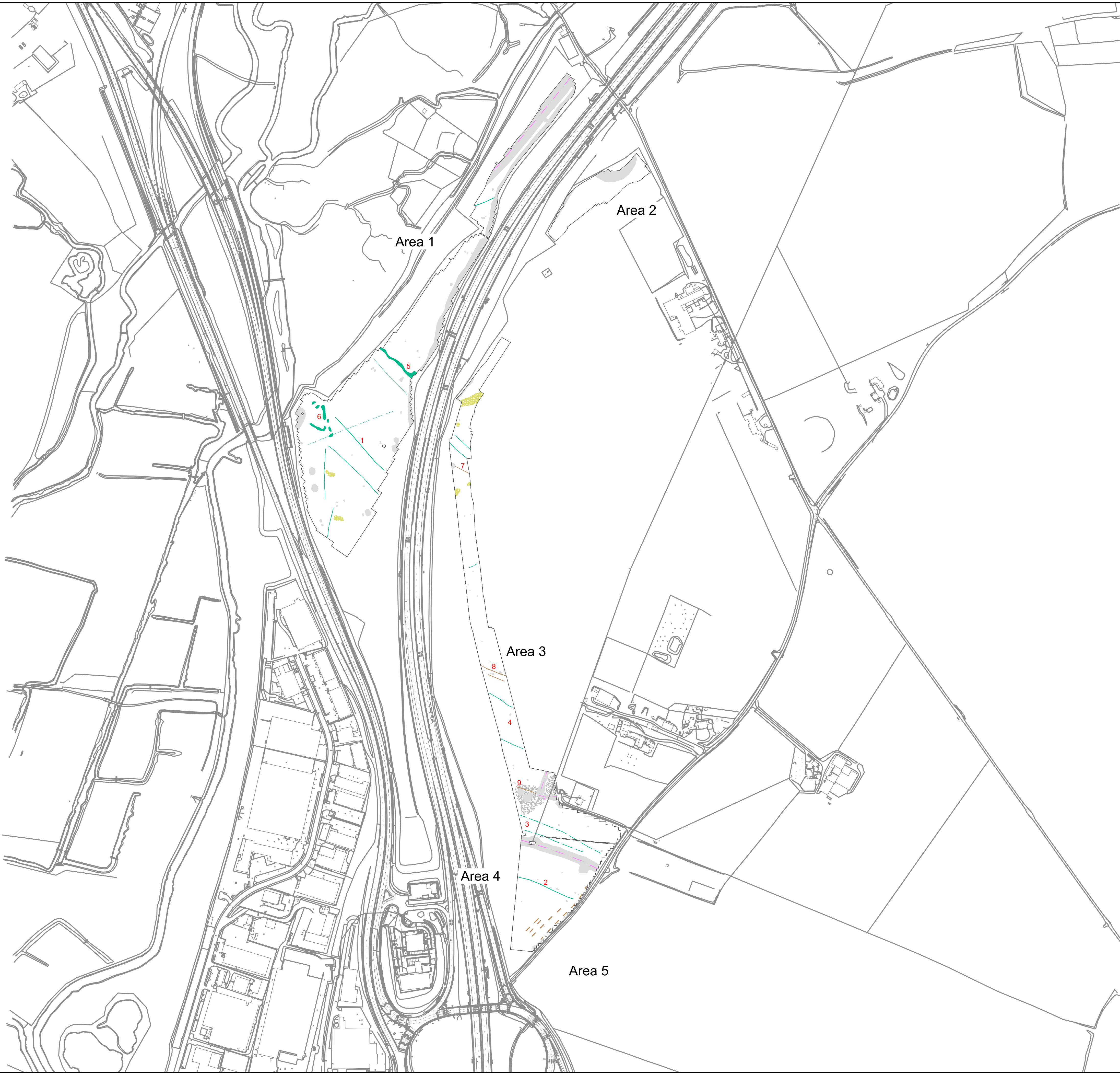
Client: Jacobs UK

Project: 15112 - M3 Junction 9, Winchester, Hampshire

Scale: 0 metres 300
1:6000 @ A3

Fig No: 02

SUMO Survey
GEOPHYSICS FOR ARCHAEOLOGY & ENGINEERING



KEY

	Uncertain Origin (discrete anomaly / trend)
	Former field boundary (corroborated)
	Agriculture (plough)
	Natural (e.g. geological / pedological)
	Magnetic disturbance
	Service
	Ferrous

SUMO Survey
GEOPHYSICS FOR ARCHAEOLOGY & ENGINEERING

Title: Magnetometer Survey - Interpretation - Overview

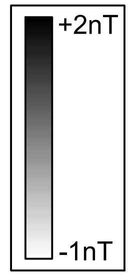
Client: Jacobs UK

Project: 15112 - M3 Junction 9, Winchester, Hampshire

Scale: 0 metres 300
1:6000 @ A3

Fig No: 03

N



GEOPHYSICS FOR ARCHAEOLOGY & ENGINEERING

Title: Magnetometer Survey - Greyscale Plots - Viewport 1

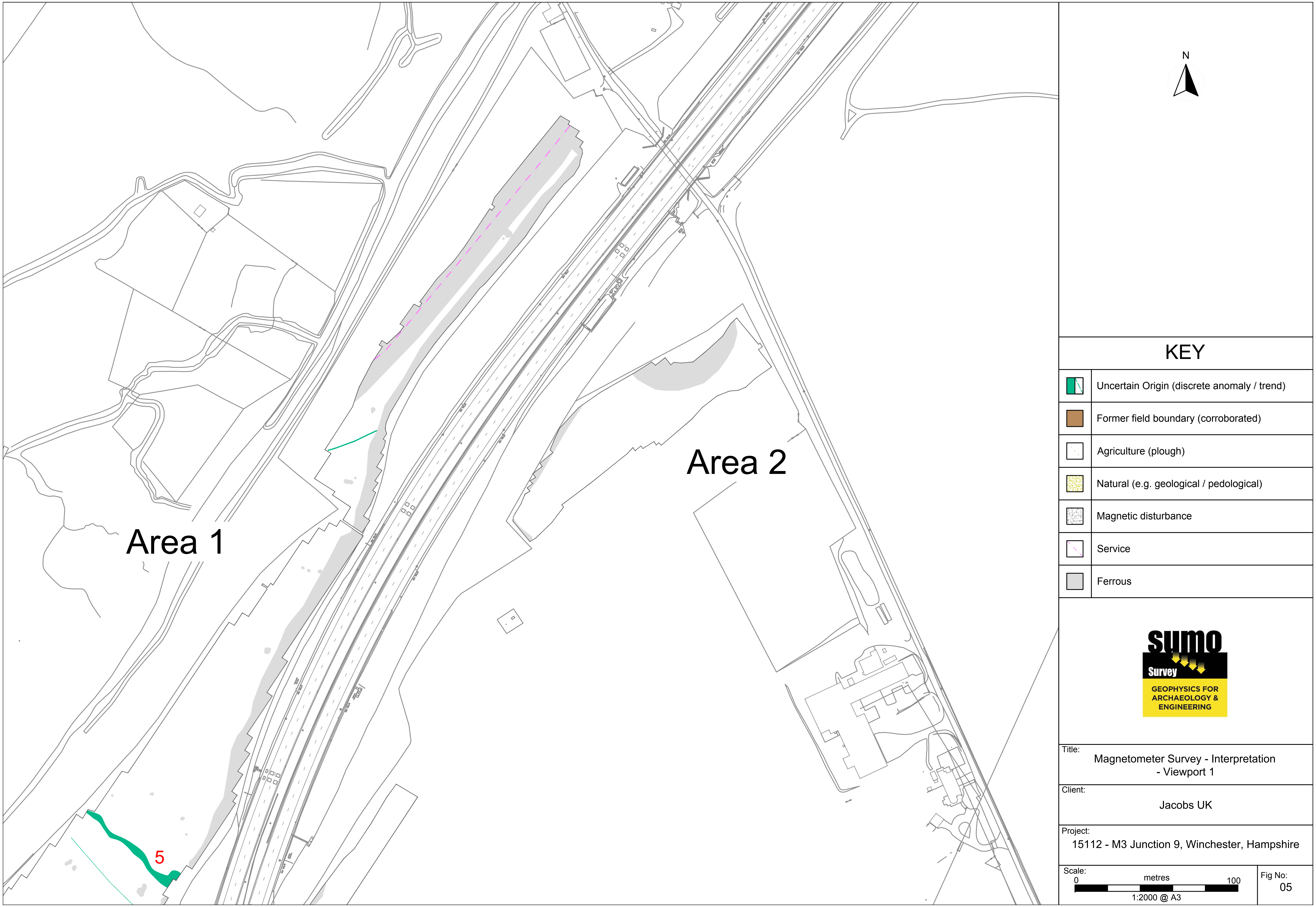
Client: Jacobs UK

Project: 15112 - M3 Junction 9, Winchester, Hampshire

Scale: 0 metres 100

1:2000 @ A3

Fig No: 04



Area 1
Area 2
5
N
KEY
Uncertain Origin (discrete anomaly / trend)
Former field boundary (corroborated)
Agriculture (plough)
Natural (e.g. geological / pedological)
Magnetic disturbance
Service
Ferrous
Title:
Magnetometer Survey - Interpretation - Viewport 1
Client:
Jacobs UK
Project:
15112 - M3 Junction 9, Winchester, Hampshire
Scale:
0
metres
100
1:2000 @ A3
Fig No:
05

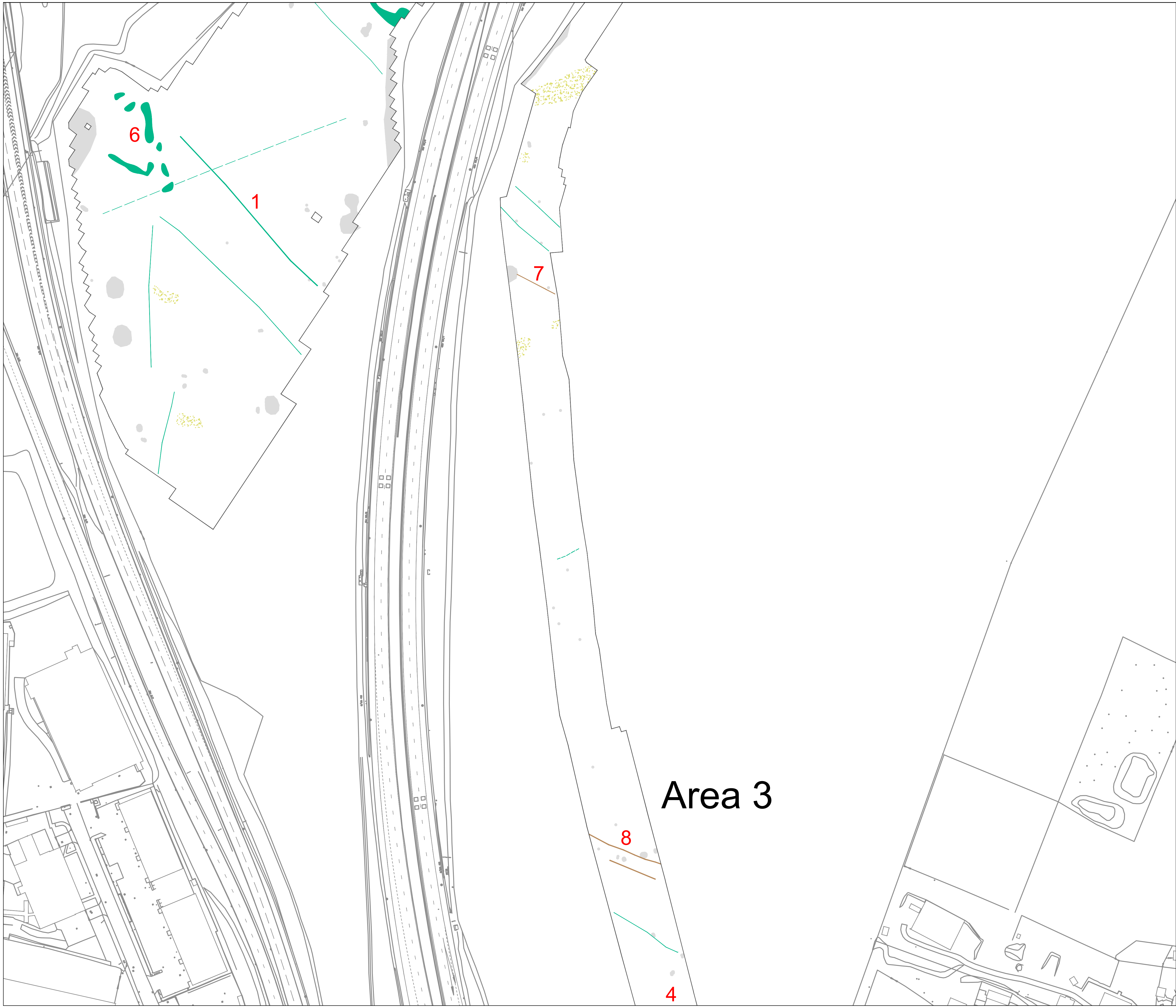
Title: Magnetometer Survey - Greyscale Plots - Viewport 2

Client: Jacobs UK

Project: 15112 - M3 Junction 9, Winchester, Hampshire

Scale: 0 metres 100 1:2000 @ A3

Fig No: 06



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KEY

	Uncertain Origin (discrete anomaly / trend)
	Former field boundary (corroborated)
	Agriculture (plough)
	Natural (e.g. geological / pedological)
	Magnetic disturbance
	Service
	Ferrous

SUMO Survey
GEOPHYSICS FOR ARCHAEOLOGY & ENGINEERING

Title:
Magnetometer Survey - Interpretation - Viewport 2

Client:
Jacobs UK

Project:
15112 - M3 Junction 9, Winchester, Hampshire

Scale:
0 metres 100
1:2000 @ A3

Fig No:
07

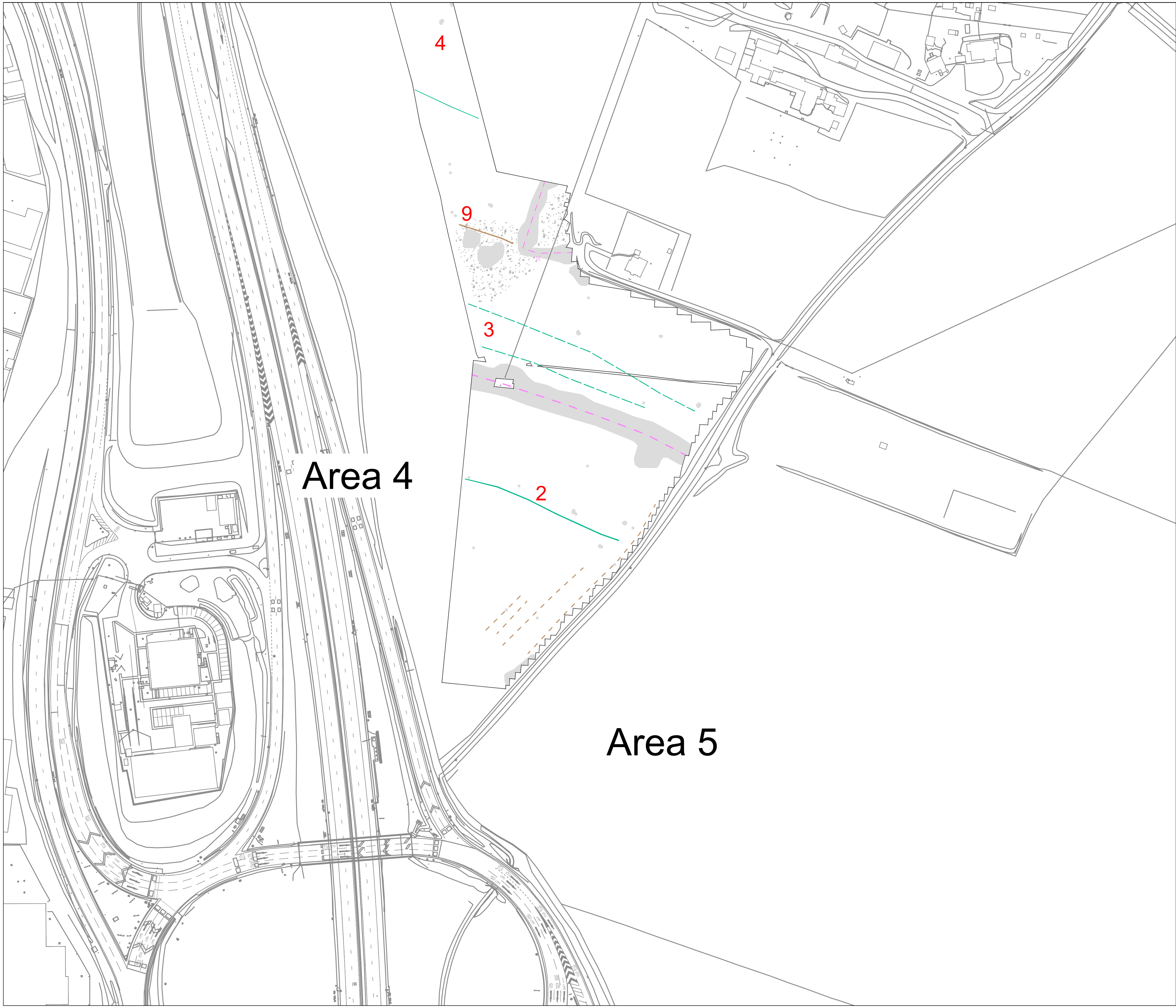
Title: Magnetometer Survey - Greyscale Plots - Viewport 3

Client: Jacobs UK

Project: 15112 - M3 Junction 9, Winchester, Hampshire

Scale: 0 metres 100
1:2000 @ A3

Fig No: 08



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KEY

	Uncertain Origin (discrete anomaly / trend)
	Former field boundary (corroborated)
	Agriculture (plough)
	Natural (e.g. geological / pedological)
	Magnetic disturbance
	Service
	Ferrous

GEOPHYSICS FOR ARCHAEOLOGY & ENGINEERING

Title: Magnetometer Survey - Interpretation - Viewport 3

Client: Jacobs UK

Project: 15112 - M3 Junction 9, Winchester, Hampshire

Scale: 0 metres 100 1:2000 @ A3

Fig No: 09

sumo Survey
GEOPHYSICS FOR ARCHAEOLOGY & ENGINEERING

Title: Magnetometer Survey - Greyscale Plots with Previous Survey Data

Client: Jacobs UK

Project: 15112 - M3 Junction 9, Winchester, Hampshire

Scale: 0 metres 300
1:6000 @ A3

Fig No: 10

sumo Survey
GEOPHYSICS FOR ARCHAEOLOGY & ENGINEERING

Title:
Minimally Processed Data - Greyscale Plots

Client:
Jacobs UK

Project:
15112 - M3 Junction 9, Winchester, Hampshire

Scale:
0 metres 300
1:6000 @ A3

Fig No:
11

Appendix A - Technical Information: Magnetometer Survey Method, Processing and Presentation

Standards & Guidance

This report and all fieldwork have been conducted in accordance with the latest guidance documents issued by Historic England (EH 2008) (then English Heritage), the Chartered Institute for Archaeologists (CIfA 2014) and the European Archaeological Council (EAC 2016).

Grid Positioning

For hand held gradiometers the location of the survey grids has been plotted together with the referencing information. Grids were set out using a Trimble R8 Real Time Kinematic (RTK) VRS Now GNSS GPS system.

An RTK GPS (Real-time Kinematic Global Positioning System) can locate a point on the ground to a far greater accuracy than a standard GPS unit. A standard GPS suffers from errors created by satellite orbit errors, clock errors and atmospheric interference, resulting in an accuracy of 5m-10m. An RTK system uses a single base station receiver and a number of mobile units. The base station re-broadcasts the phase of the carrier it measured, and the mobile units compare their own phase measurements with those they received from the base station. This results in an accuracy of around 0.01m.

Technique	Instrument	Traverse Interval	Sample Interval
Magnetometer	Bartington Grad 601-2	1m	0.25m

Instrumentation: Bartington *Grad* 601-2

Bartington instruments operate in a gradiometer configuration which comprises fluxgate sensors mounted vertically, set 1.0m apart. The fluxgate gradiometer suppresses any diurnal or regional effects. The instruments are carried, or cart mounted, with the bottom sensor approximately 0.1-0.3m from the ground surface. At each survey station, the difference in the magnetic field between the two fluxgates is measured in nanoTesla (nT). The sensitivity of the instrument can be adjusted; for most archaeological surveys the most sensitive range (0.1nT) is used. Generally, features up to 1m deep may be detected by this method, though strongly magnetic objects may be visible at greater depths. The Bartington instrument can collect two lines of data per traverse with gradiometer units mounted laterally with a separation of 1.0m. The readings are logged consecutively into the data logger which in turn is daily down-loaded into a portable computer whilst on site. At the end of each site survey, data is transferred to the office for processing and presentation.

Data Processing

Zero Mean Traverse	This process sets the background mean of each traverse within each grid to zero. The operation removes striping effects and edge discontinuities over the whole of the data set.
Step Correction (De-stagger)	When gradiometer data are collected in 'zig-zag' fashion, stepping errors can sometimes arise. These occur because of a slight difference in the speed of walking on the forward and reverse traverses. The result is a staggered effect in the data, which is particularly noticeable on linear anomalies. This process corrects these errors.

Display

Greyscale/ Colourscale Plot	This format divides a given range of readings into a set number of classes. Each class is represented by a specific shade of grey, the intensity increasing with value. All values above the given range are allocated the same shade (maximum intensity); similarly, all values below the given range are represented by the minimum intensity shade. Similar plots can be produced in colour, either using a wide range of colours or by selecting two or three colours to represent positive and negative values. The assigned range (plotting levels) can be adjusted to emphasise different anomalies in the data-set.

Presentation of results and interpretation

The presentation of the results includes a 'minimally processed data' and a 'processed data' greyscale plot. Magnetic anomalies are identified, interpreted and plotted onto the 'Interpretation' drawings.

When interpreting the results, several factors are taken into consideration, including the nature of archaeological features being investigated and the local conditions at the site (geology, pedology, topography etc.). Anomalies are categorised by their potential origin. Where responses can be related to other existing evidence, the anomalies will be given specific categories, such as: Abbey Wall or Roman Road. Where the interpretation is based largely on the geophysical data, levels of confidence are implied, for example: Probable, or Possible Archaeology. The former is used for a confident interpretation, based on anomaly definition and/or other corroborative data such as cropmarks. Poor anomaly definition, a lack of clear patterns to the responses and an absence of other supporting data reduces confidence, hence the classification Possible.

Interpretation Categories

In certain circumstances (usually when there is corroborative evidence from desk-based or excavation data) very specific interpretations can be assigned to magnetic anomalies (for example, *Roman Road, Wall,* etc.) and where appropriate, such interpretations will be applied. The list below outlines the generic categories commonly used in the interpretation of the results.

Archaeology / Probable Archaeology	This term is used when the form, nature and pattern of the responses are clearly or very probably archaeological and /or if corroborative evidence is available. These anomalies, whilst considered anthropogenic, could be of any age.
Possible Archaeology	These anomalies exhibit either weak signal strength and / or poor definition, or form incomplete archaeological patterns, thereby reducing the level of confidence in the interpretation. Although the archaeological interpretation is favoured, they may be the result of variable soil depth, plough damage or even aliasing as a result of data collection orientation.
Industrial / Burnt-Fired	Strong magnetic anomalies that, due to their shape and form or the context in which they are found, suggest the presence of kilns, ovens, corn dryers, metal-working areas or hearths. It should be noted that in many instances modern ferrous material can produce similar magnetic anomalies.
Former Field Boundary (probable & possible)	Anomalies that correspond to former boundaries indicated on historic mapping, or which are clearly a continuation of existing land divisions. Possible denotes less confidence where the anomaly may not be shown on historic mapping but nevertheless the anomaly displays all the characteristics of a field boundary.
Ridge & Furrow	Parallel linear anomalies whose broad spacing suggests ridge and furrow cultivation. In some cases, the response may be the result of more recent agricultural activity.
Agriculture (ploughing)	Parallel linear anomalies or trends with a narrower spacing, sometimes aligned with existing boundaries, indicating more recent cultivation regimes.
Land Drain	Weakly magnetic linear anomalies, quite often appearing in series forming parallel and herringbone patterns. Smaller drains may lead and empty into larger diameter pipes, which in turn usually lead to local streams and ponds. These are indicative of clay fired land drains.
Natural	These responses form clear patterns in geographical zones where natural variations are known to produce significant magnetic distortions.
Magnetic Disturbance	Broad zones of strong dipolar anomalies, commonly found in places where modern ferrous or fired materials (e.g. brick rubble) are present.
Service	Magnetically strong anomalies, usually forming linear features are indicative of ferrous pipes/cables. Sometimes other materials (e.g. pvc) or the fill of the trench can cause weaker magnetic responses which can be identified from their uniform linearity.
Ferrous	This type of response is associated with ferrous material and may result from small items in the topsoil, larger buried objects such as pipes, or above ground features such as fence lines or pylons. Ferrous responses are usually regarded as modern. Individual burnt stones, fired bricks or igneous rocks can produce responses similar to ferrous material.
Uncertain Origin	Anomalies which stand out from the background magnetic variation, yet whose form and lack of patterning gives little clue as to their origin. Often the characteristics and distribution of the responses straddle the categories of *Possible Archaeology* / *Natural* or (in the case of linear responses) *Possible Archaeology* / *Agriculture*; occasionally they are simply of an unusual form.

Where appropriate some anomalies will be further classified according to their form (positive or negative) and relative strength and coherence (trend: weak and poorly defined).

Appendix B - Technical Information: Magnetic Theory

Detailed magnetic survey can be used to effectively define areas of past human activity by mapping spatial variation and contrast in the magnetic properties of soil, subsoil and bedrock. Although the changes in the magnetic field resulting from differing features in the soil are usually weak, changes as small as 0.1 nanoTeslas (nT) in an overall field strength of 48,000 (nT), can be accurately detected.

Weakly magnetic iron minerals are always present within the soil and areas of enhancement relate to increases in *magnetic susceptibility* and permanently magnetised *thermoremanent* material.

Magnetic susceptibility relates to the induced magnetism of a material when in the presence of a magnetic field. This magnetism can be considered as effectively permanent as it exists within the Earth's magnetic field. Magnetic susceptibility can become enhanced due to burning and complex biological or fermentation processes.

Thermoremanence is a permanent magnetism acquired by iron minerals that, after heating to a specific temperature known as the Curie Point, are effectively demagnetised followed by re-magnetisation by the Earth's magnetic field on cooling. Thermoremanent archaeological features can include hearths and kilns; material such as brick and tile may be magnetised through the same process.

Silting and deliberate infilling of ditches and pits with magnetically enhanced soil creates a relative contrast against the much lower levels of magnetism within the subsoil into which the feature is cut. Systematic mapping of magnetic anomalies will produce linear and discrete areas of enhancement allowing assessment and characterisation of subsurface features. Material such as subsoil and non-magnetic bedrock used to create former earthworks and walls may be mapped as areas of lower enhancement compared to surrounding soils.

Magnetic survey is carried out using a fluxgate gradiometer which is a passive instrument consisting of two sensors mounted vertically 1m apart. The instrument is carried about 30cm above the ground surface and the top sensor measures the Earth's magnetic field whilst the lower sensor measures the same field but is also more affected by any localised buried feature. The difference between the two sensors will relate to the strength of a magnetic field created by this feature, if no field is present the difference will be close to zero as the magnetic field measured by both sensors will be the same.

Factors affecting the magnetic survey may include soil type, local geology, previous human activity and disturbance from modern services.

- Archaeological
- Geophysical
- Laser Scanning
- Measured Building
- Topographic
- Utility Mapping

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