GEOPHYSICAL SURVEY REPORT

STRATASCAN™

SUMO Survey Services
SUMO Group Member

Project name:

Land North of the Viaduct, Ledbury, Herefordshire

Client:

Cotswold Archaeology

Job ref:

J9808

April 2016

GEOPHYSICAL SURVEY REPORT

Project name: **Land North of the Viaduct, Ledbury, Herefordshire** Client: **Cotswold Archaeology**	Job ref: **J9808**
Survey date: **6th-8th April 2016**	Report date: **April 2016**
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1 SUMMARY OF RESULTS

A detailed gradiometry survey was conducted over approximately 29 hectares of arable land. The survey has not identified any anomalies of archaeological origin. A former mill race and 19th century farmhouse have been detected, as well as a number of former field boundaries, a former pond and areas of ploughing. Three areas of possible archaeological activity have been identified, however these could equally relate to post-medieval agriculture. The remaining anomalies are natural or modern in origin, relating to underground services, scattered magnetic debris, ferrous objects, and fencing.

2 INTRODUCTION

2.1 Background synopsis

Stratascan were commissioned to undertake a geophysical survey of an area outlined for residential development. This survey forms part of an archaeological investigation being undertaken by Cotswold Archaeology.

2.2 Site Details

NGR / Postcode	SO 701 394 HR8 1NS
Location	The site lies to the south of the B4214 (Bromyard Road), Ledbury, Herefordshire.
HER	Herefordshire
District	Ledbury
Parish	Ledbury
Topography	The site lies on a gentle south-west facing slope, dropping from c.60m AOD in the north to c.50m AOD in the south-west
Current Land Use	Arable
Weather Conditions	Overcast
Soils	The overlying soils are known as Bromyard, which are typical argillic brown earths. These consist of reddish fine silty soils over shale and siltstone (Soil Survey of England and Wales, Sheet 3 Midland and Western England).
Geology	The underlying geology is Raglan Mudstone Formation – interbedded siltstone and mudstone. There is no recorded drift geology for the majority of the site, however an area of Head – clay, silt, sand, and gravel is present in the central field with Alluvial deposits of clay, silt, sand, and

	gravel along the river forming the western boundary of the site (British Geological Survey website).
Archaeology	A desk-based assessment has not found any firm evidence for potential buried archaeological remains within the site other than a post-medieval mill race, a 19th century farmhouse, and other post-medieval agricultural activity. Whilst the area may have been an attractive location for prehistoric and Roman settlement, only a low level of prehistoric material is recorded in the surrounding area with none on the site itself (Cotswold Archaeology 2016).
Survey Methods	Gradiometry
Study Area	29ha

2.3 Aims and objectives

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

3 METHODS, PROCESSING & PRESENTATION

3.1 Standards & Guidance

This report and all fieldwork have been conducted in accordance with the latest guidance documents issued by Historic England (2008) and the Chartered Institute for Archaeologists (2002 & 2014).

Stratascan Ltd are a Registered Organisation with the CIfA and are committed to upholding its policies and standards.

3.2 Survey methods

Detailed magnetic survey was used as an efficient and effective method of locating archaeological anomalies.

More information regarding this technique is included in Appendix A.

3.3 Processing

The following schedule shows the basic processing carried out on the data used in this report:

1. *Destripe*
2. *Destagger*

3.4 Presentation of results and interpretation

The presentation of the data for each site involves a plot of the minimally processed data as a greyscale plot and a colour plot showing extreme magnetic values. Magnetic anomalies have been identified and plotted onto the 'Interpretation of Anomalies' drawing.

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 very specific known features documented in other sources, this is done (for

example: Abbey Wall, Roman Road). For the generic categories levels of confidence are indicated, 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".

4 RESULTS

The detailed magnetic gradiometer survey conducted at Ledbury has identified a small number of anomalies that have been characterised as being of a *possible* archaeological origin. The following list of numbered anomalies refers to numerical labels on the interpretation plots.

4.1 Probable Archaeology

No probable archaeology has been identified within the survey area.

4.2 Possible Archaeology

1-2 Positive linear anomalies in the centre and south of the site. These are indicative of former cut features, and may related to archaeological activity. However, they could equally relate to post-medieval agricultural activity such as field boundaries or land drains.

3 An area of magnetically strong positive linear anomalies in the south of the site. These are indicative of former cut features, and may relate to archaeological activity. However, their strength is similar to that of former field boundaries and the mill race (Anomalies 4-11) suggesting that they could relate to the post-medieval landscape.

4.3 Medieval/Post-Medieval Agriculture

4 Linear areas of magnetic disturbance in the centre of the site, becoming weaker in the north. These are related to a post-medieval mill race present on available mapping 1816-1964.

5-12 Linear anomalies across the site. These relate to former field boundaries present on available mapping. Anomaly 5 is present from 1816-1841, Anomaly 6 1816-1905, Anomalies 7-9 1816-1964, Anomalies 10-11 1816-1974, and Anomaly 12 1904-1905.

13 An area of strong magnetic debris in the north of the site. This is the site of the 19th century Winster Elms farmhouse and its remains are likely to include rubble debris.

14 Areas of closely spaced parallel linear anomalies across the west of the site. These are indicative of modern agricultural activity, such as ploughing.

15 An area of strong magnetic debris in the south of the site. This is related to a former pond, visible on mapping from 1816 to 1841.

4.4 Other Anomalies

16 Magnetically strong linear anomalies across the site. These are indicative of underground services, such as pipes or cables.

17 A negative linear anomaly in the west of the site. This is likely related to a service trench or non-ferrous pipe.

18 Linear areas of magnetic variation across the centre and west of the site. These are likely to be geological or pedological in origin.

19 An area of scattered magnetic debris in the south of the site. This is likely to be modern in origin.

20 An area of magnetically strong responses in the south of the site. These are of an unknown origin, however their strength being similar to that of field boundaries and the mill race suggests that they are modern, or at least post-medieval, in origin.

21 Areas of magnetic disturbance are the result of substantial nearby ferrous metal objects such as fences and underground services. These effects can mask weaker archaeological anomalies, but on this site have not affected a significant proportion of the area.

22 A number of magnetic 'spikes' (strong focussed values with associated antipolar response) indicate ferrous metal objects. These are likely to be modern rubbish.

5 DATA APPRAISAL & CONFIDENCE ASSESSMENT

Siltstone and mudstone geologies, such as those at the Ledbury site, can give variable responses to magnetic survey, whilst overlying deposits of alluvium and head can mask archaeological features. There is little difference between the areas covered by superficial deposits and the rest of the site, suggesting that they are not deep enough to be masking archaeological anomalies. A number of post-medieval features have been identified, in keeping with the known history of the site, however a number of these give relatively weak responses. Therefore, the survey can be said to have been effective, however there is a possibility that small, weakly magnetic archaeological features may not be detected.

6 CONCLUSION

The survey at Ledbury has not identified any anomalies of archaeological origin. A former mill race and 19th century farmhouse have been detected, which were the only recorded features identified on the site by the desk-based assessment. A number of former field boundaries, a former pond and areas of ploughing suggest that the area has been used for agricultural purposes since at least the post-medieval period, in keeping with the known history of the site. Three areas of possible archaeological activity have been identified, however these could equally relate to post-medieval agriculture. The remaining anomalies are modern or natural in origin. The modern anomalies relate to underground services, scattered magnetic debris, ferrous objects, and fencing.

7 REFERENCES

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Appendix A - Technical Information: Magnetometer Survey Method

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 (Destagger)	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.

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 response 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 will often lead and empty into larger diameter pipes and 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. They are presumed to be modern.
Service	Magnetically strong anomalies usually forming linear features indicative of ferrous pipes/cables. Sometimes other materials (e.g. pvc) cause weaker magnetic responses and can be identified from their uniform linearity crossing large expanses.
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* and *Possible Natural* or (in the case of linear responses) *Possible Archaeology* and *Possible 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 0.2 nanoTeslas (nT) in an overall field strength of 48,000nT, 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 and 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 field. The difference between the two sensors will relate to the strength of a magnetic field created by a buried 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, disturbance from modern services etc.

Amendments

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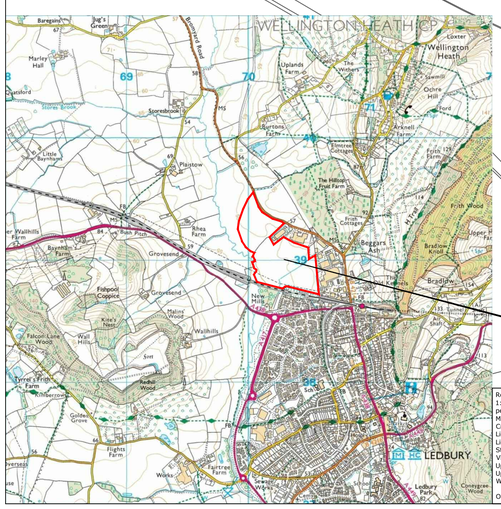
Site centred on NGR SO 701 394



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OS 100km square = SO

OS REFERENCING INFORMATION

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Job No.	Survey Date
J9808	APR 16

Client

COTSWOLD ARCHAEOLOGY

Project Title

LAND NORTH OF THE VIADUCT, LEDBURY, HEREFORDSHIRE

Subject

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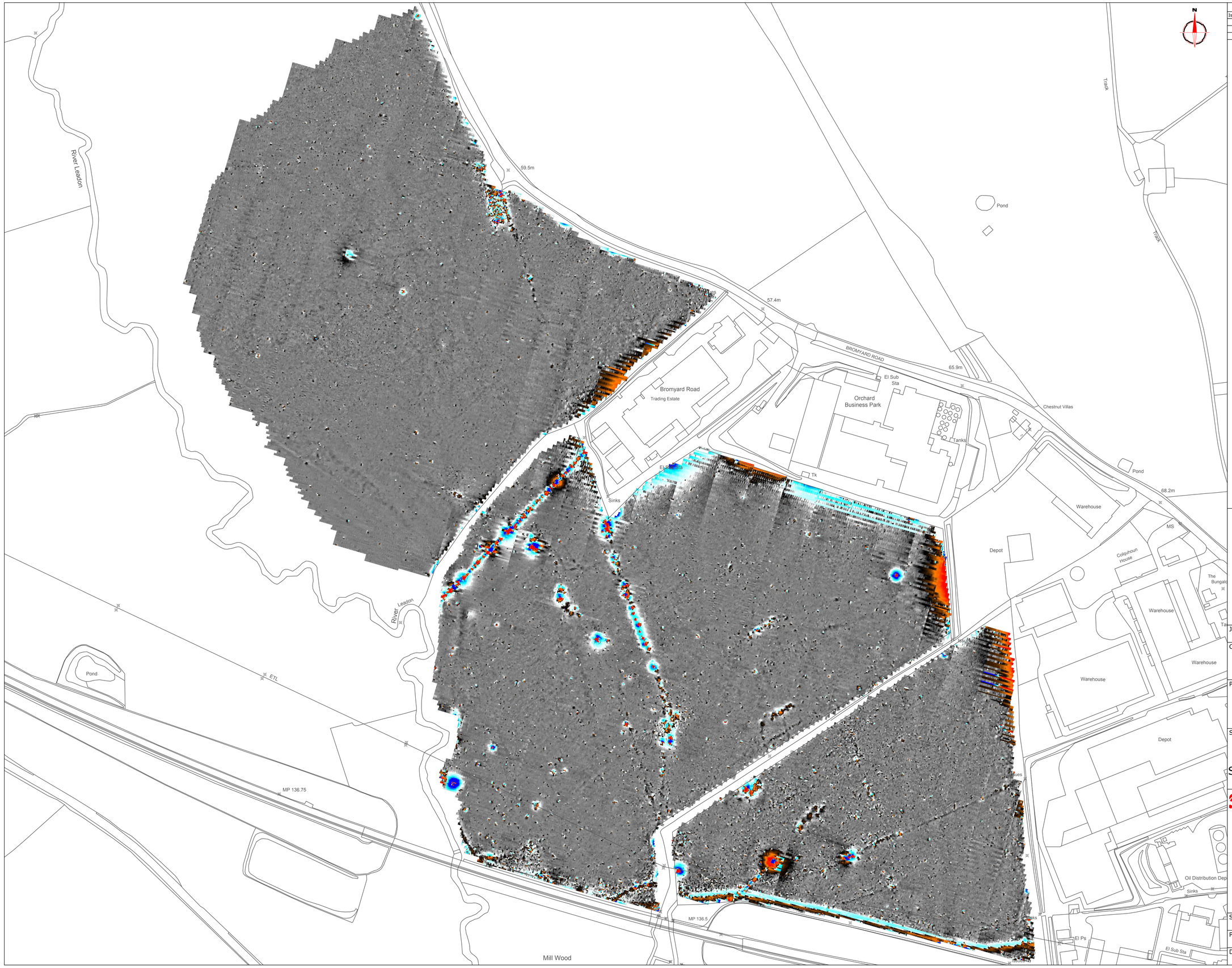

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Client

COTSWOLD ARCHAEOLOGY

Project Title

LAND NORTH OF THE VIADUCT, LEDBURY, HEREFORDSHIRE

Subject

COLOUR PLOT OF GRADIOMETER DATA SHOWING EXTREME VALUES - OVERVIEW

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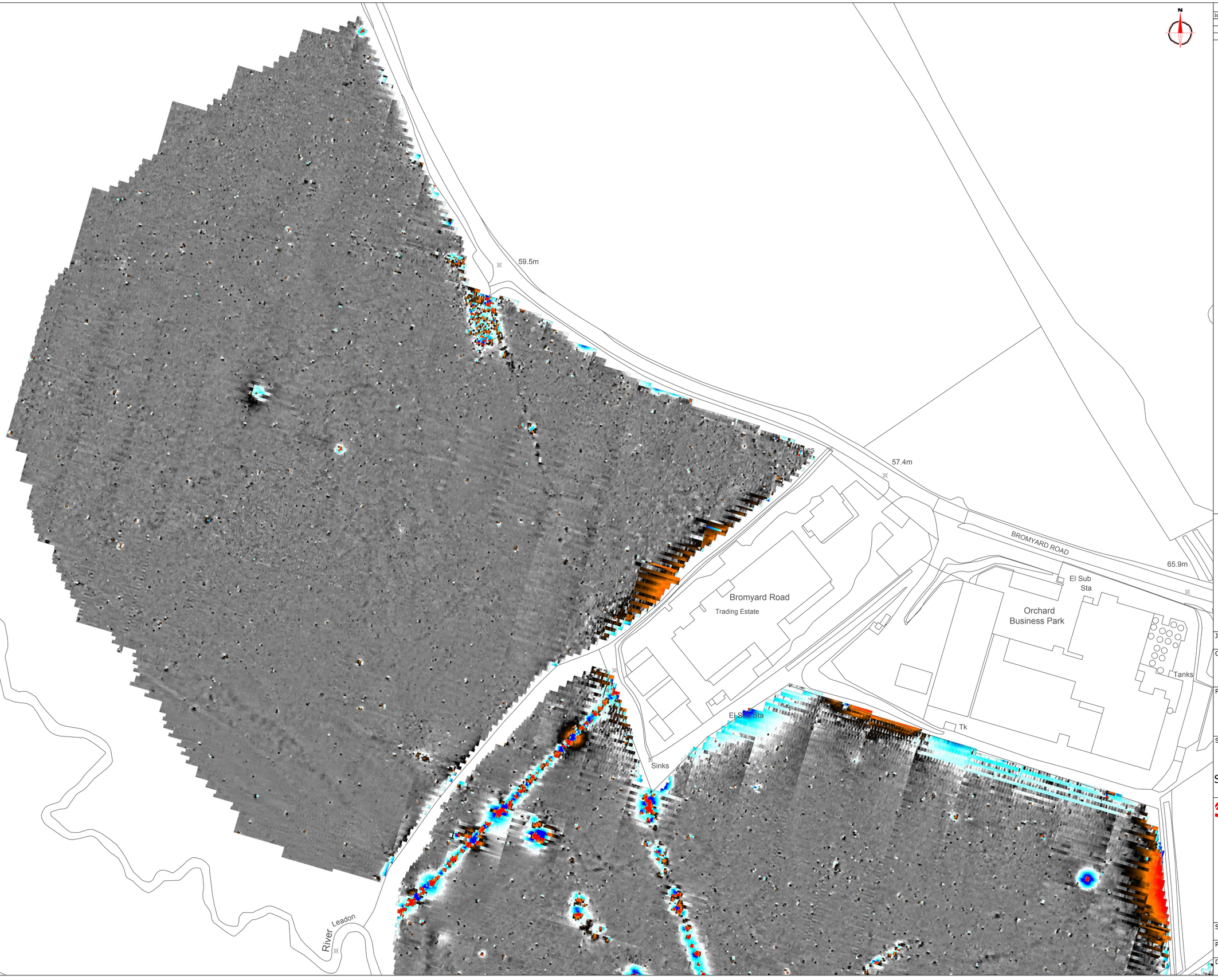

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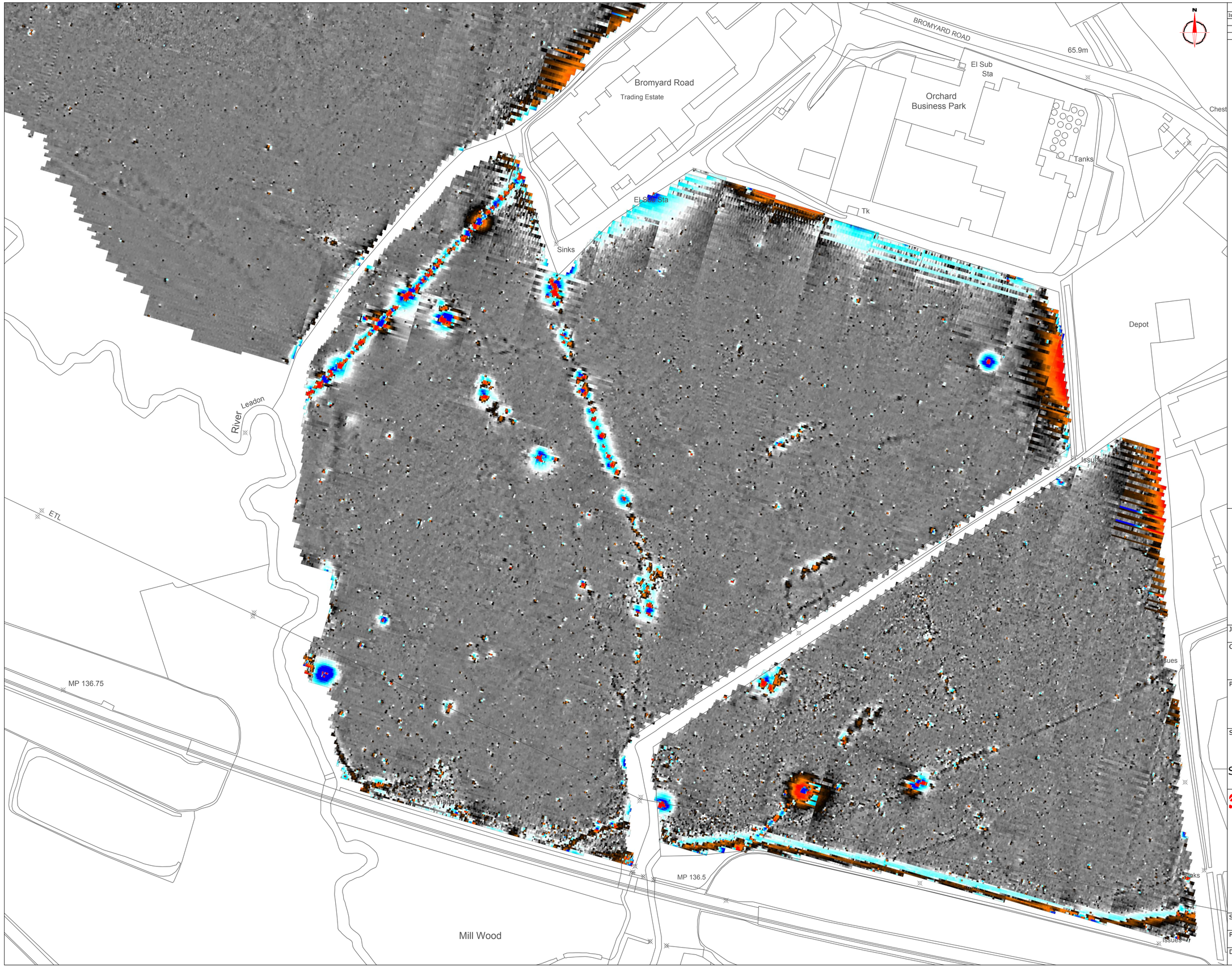

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COTSWOLD ARCHAEOLOGY

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LAND NORTH OF THE VIADUCT, LEDBURY, HEREFORDSHIRE

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COLOUR PLOT OF GRADIOMETER DATA SHOWING EXTREME VALUES - SOUTH EAST

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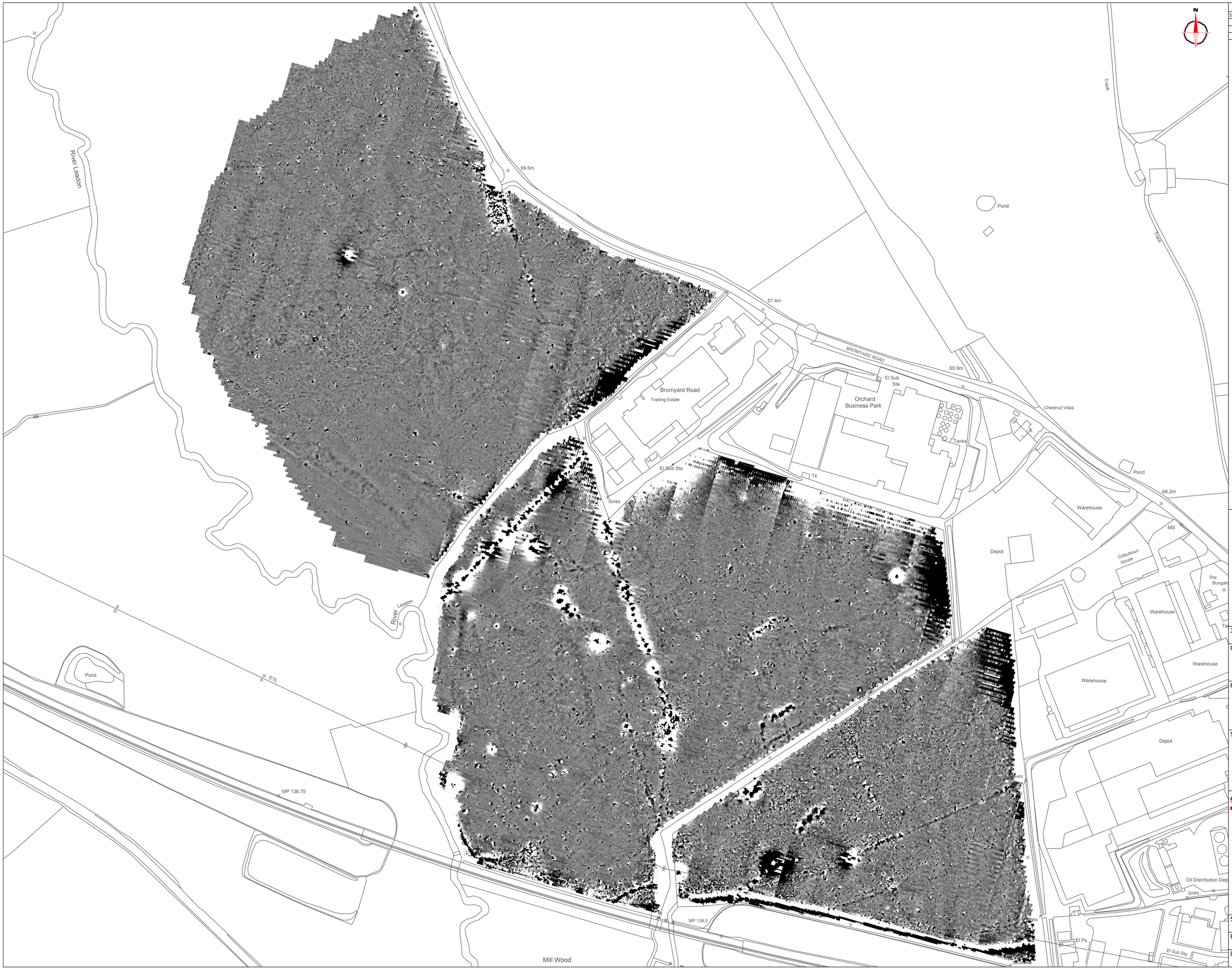

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-2nT +2nT

+2nT

-2nT

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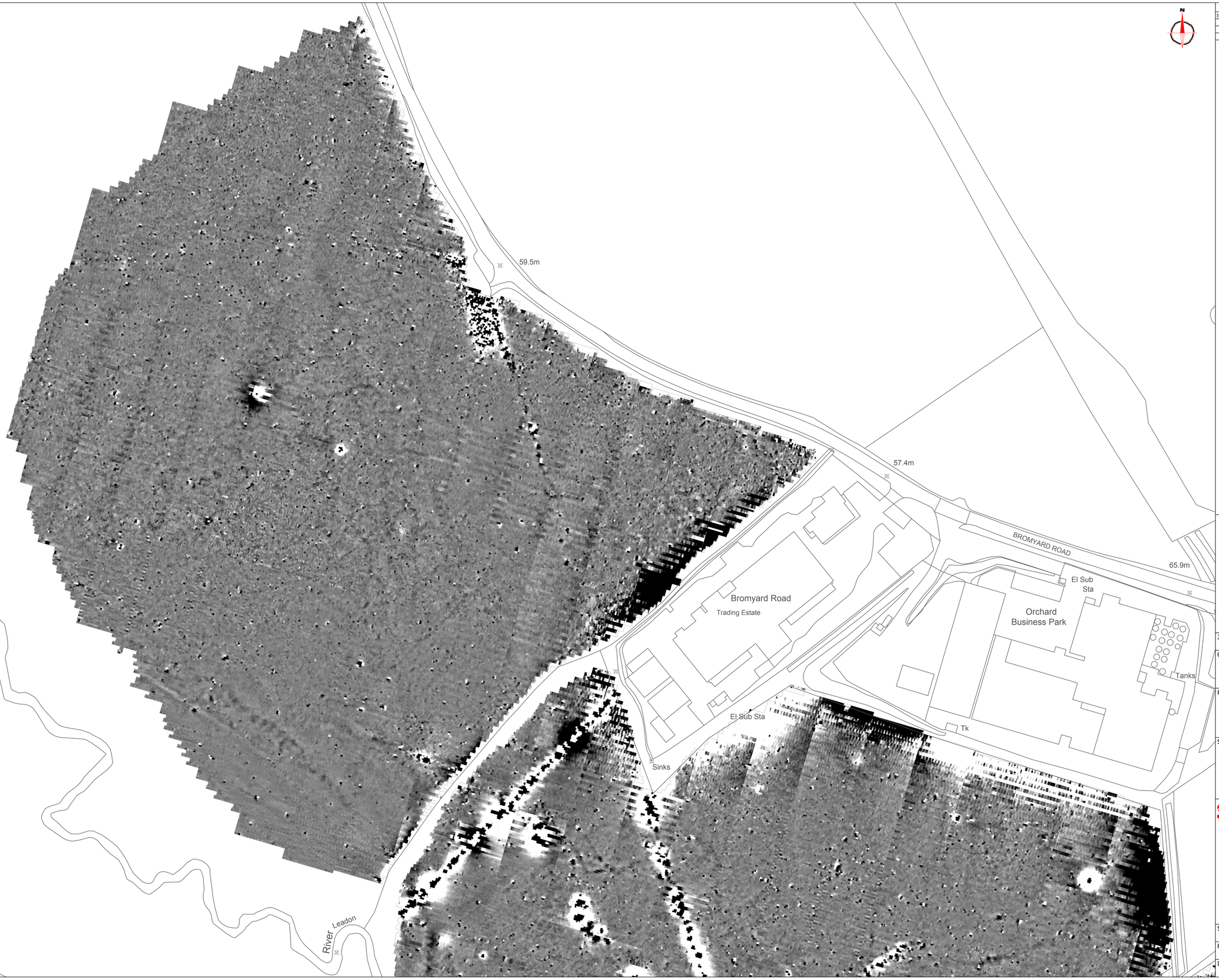

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+2nT

-2nT

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BROMYARD ROAD

65.9m

Bromyard Road
Trading Estate

El Sub Sta

Orchard
Business Park

Tanks

Chest

El Sub Sta

Tk

Sinks

Depot

River Leadon

ETL

MP 136.75

Issues

Issues

Issues

Issues

MP 136.5

Mill Wood

N

Amendments

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Plotting parameters

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Minimum -2nT (white)

Zero Mean

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+2nT

-2nT

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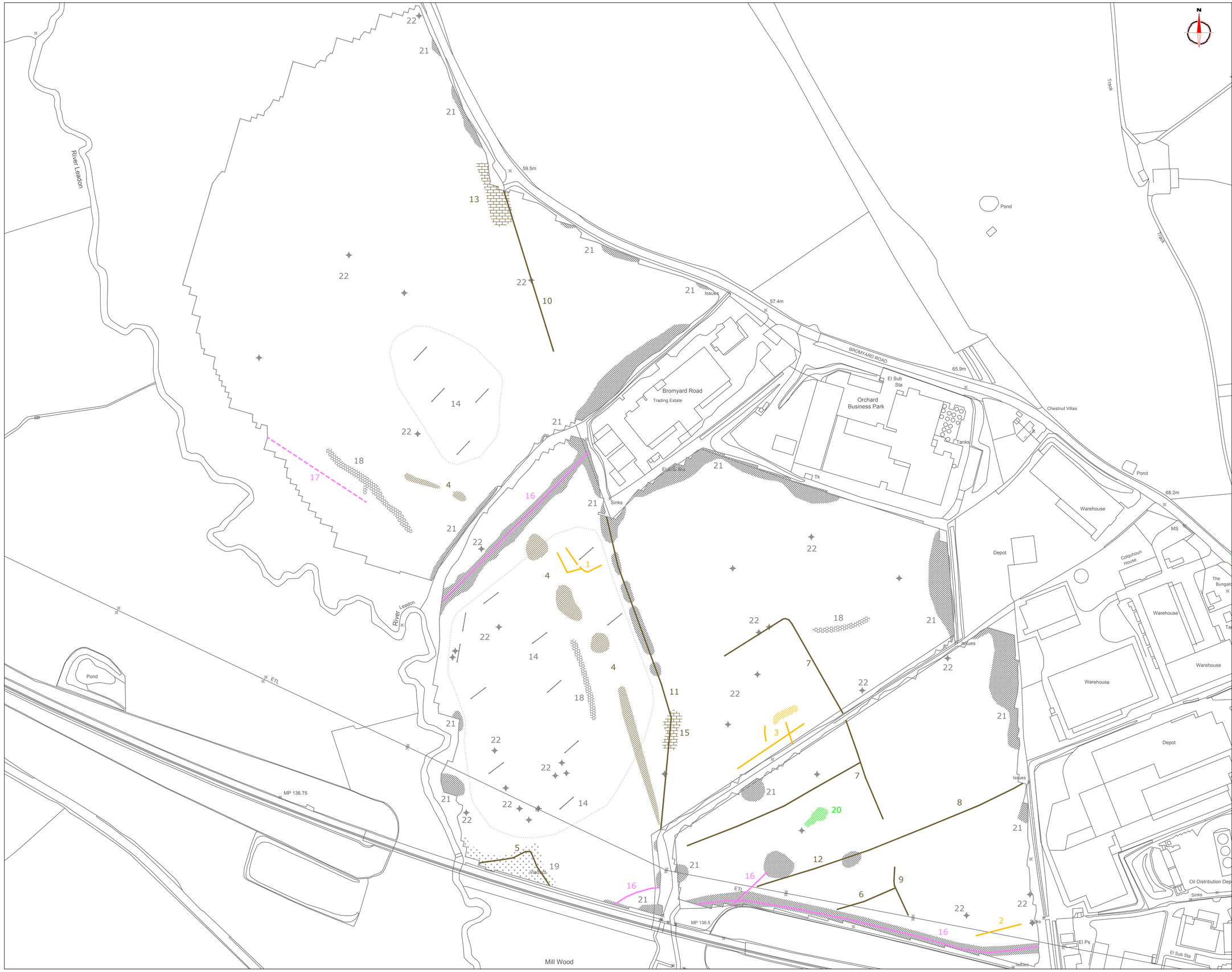

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PROBABLE ARCHAEOLOGY

- Positive anomaly / weak positive anomaly - probable cut feature of archaeological origin
- Negative anomaly / weak negative anomaly - probable bank or earthwork of archaeological origin

POSSIBLE ARCHAEOLOGY

- Positive anomaly / weak positive anomaly - possible cut feature of archaeological origin
- Negative anomaly / weak negative anomaly - possible bank or earthwork of archaeological origin

MEDIEVAL/POST-MEDIEVAL AGRICULTURE

- Widely spaced curving parallel linear anomalies - probably related to ridge-and-furrow
- Closely spaced parallel linear anomalies - probably related to agricultural activity such as ploughing
- Linear anomaly - probably related to a former field boundary not present on available mapping
- Linear anomaly - related to a former field boundary present on available mapping
- Areas of disturbance related to a former mill race present on available mapping
- Strong magnetic debris related to 19th century farmhouse

OTHER ANOMALIES

- Linear anomaly - probably related to pipe, cable or other modern service
- Linear anomaly - possibly related to service trench
- Linear anomaly - possibly related to land drain
- Positive anomaly - unknown origin, likely modern
- Magnetic disturbance associated with nearby metal object such as service or field boundary
- Scattered magnetic debris
- Area of amorphous magnetic variation - probable natural (e.g. geological or pedological) origin
- Magnetic spike - probable ferrous object

Job No.	Survey Date
J9808	APR 16

Client

COTSWOLD ARCHAEOLOGY

Project Title

LAND NORTH OF THE VIADUCT, LEDBURY, HEREFORDSHIRE

Subject

ABSTRACTION AND INTERPRETATION OF GRADIOMETER ANOMALIES - OVERVIEW

STRATASCAN™
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EUROPEAN GPR ASSOCIATION

SUMO GROUP MEMBER

Scale		
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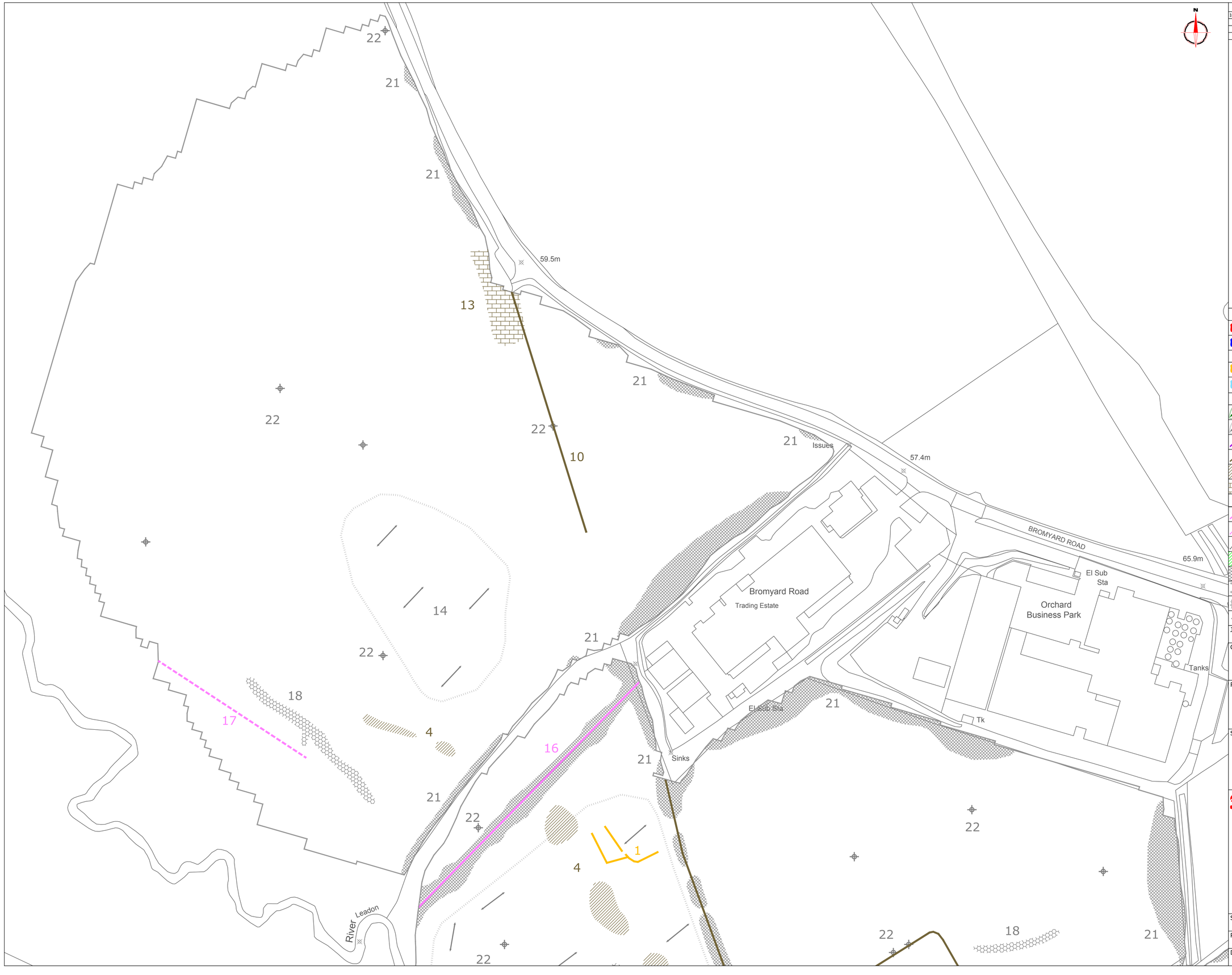
Plot	Checked by	Issue No.
A1	DGE	01
Date	Drawn by	Figure No.
MAY 16	TR	08



Amendments

Issue No.	Date	Description
	-	-
-	-	-

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Job No.	Survey Date
J9808	APR 16

Client

COTSWOLD ARCHAEOLOGY

Project Title

LAND NORTH OF THE VIADUCT, LEDBURY, HEREFORDSHIRE

Subject

ABSTRACTION AND INTERPRETATION OF GRADIOMETER ANOMALIES - NORTH WEST

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SUMO GROUP MEMBER

Scale		
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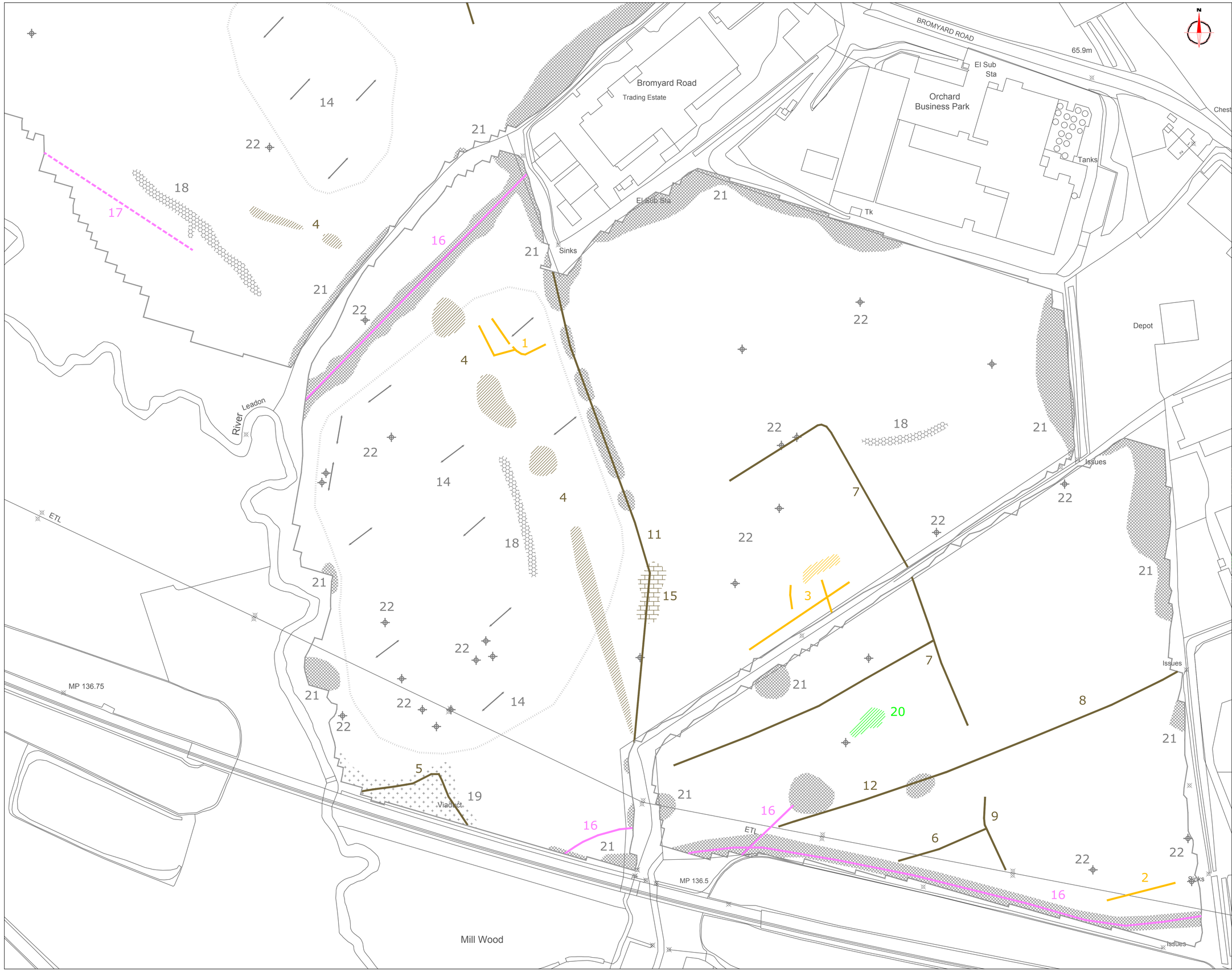
Date: MAY 16	Drawn by: TR	Figure No.: 09



Amendments

Issue No.	Date	Description
-	-	-
-	-	-

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Job No.	Survey Date
J9808	APR 16

Client

COTSWOLD ARCHAEOLOGY

Project Title

LAND NORTH OF THE VIADUCT, LEDBURY, HEREFORDSHIRE

Subject

ABSTRACTION AND INTERPRETATION OF GRADIOMETER ANOMALIES - SOUTH EAST

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Plot	Checked by	Issue No.
A1	DGE	01
Date	Drawn by	Figure No.
MAY 16	TR	10

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