



PHASE
SITE INVESTIGATIONS

**Pitt Street, Darfield
South Yorkshire**

Archaeological geophysical survey

Project No. ARC/2809/1054

February 2020



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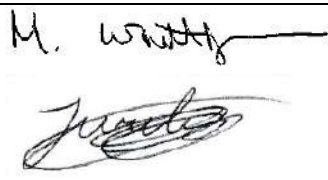
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1. SUMMARY

Phase Site Investigations Ltd was commissioned to carry out a magnetic gradient survey at a site at Pitt Street, Darfield, South Yorkshire. The aim of the survey was to help establish the presence / absence, extent, character, relationships and date (as far as circumstances and the inherent limitations of the technique permits) of archaeological features within the survey area.

The survey was undertaken using a combination of a Phase Site Investigations Ltd multi-sensor array cart system (MACS). The MACS comprised 8 Foerster 4.032 Ferex CON 650 gradiometers with a control unit and data logger. The MACS data was collected on profiles spaced 0.5 m apart with readings taken at between 0.1 and 0.15 m intervals.

The survey has identified several linear / curvi-linear positive responses that are suggestive of infilled archaeological features. The responses are fragmented and intermittent and so the exact relationships, if any, between them is not certain. It is possible that some of these anomalies could be related to relatively modern features / activity.

Two sub-circular responses are present. The cause of these is not certain and whilst they could be related to sub-surface features it is also possible that they are related to compacted ground caused by tethered horses. Recent air photos of the site indicate the presence of numerous circular worn patches which would suggest that the latter interpretation, of a relatively modern surface feature, is most likely.

A number of other linear / curvi-linear trends of uncertain origin are present. Generally these are weak, fragmented or irregular and do not form any obvious relationships or patterns to allow their cause to be determined with any certainty. The majority, if not all of them, are probably caused by agricultural, other relatively modern activity or natural features / variations, but it is possible that some responses could be related to sub-surface features (of unknown date and function).

Several isolated responses have been identified that could be related to infilled discrete features. It is possible that some of these could be related to mining features, such as pits or shafts but the responses could also be related to other, relatively modern features / material.

The remainder of the anomalies identified by this survey relate to modern material / objects, agricultural activity (including possible ridge and furrow), possible drains or other modern non-magnetic features and geological / pedological variations.

2. INTRODUCTION

2.1 Overview

Phase Site Investigations Ltd was commissioned by Blaise Vyner Consultancy on behalf of Enzygo Ltd to carry out an archaeological geophysical survey at a site at Pitt Street, Darfield, South Yorkshire, utilising magnetic gradiometers.

The aim of the survey was to help establish the presence / absence, extent, character, relationships and date (as far as circumstances and the inherent limitations of the technique permits) of archaeological features within the survey area.

The location of the site is shown in drawing ARC_2809_1054_01.

2.2 Site description

The site is situated at Pitt Street, Darfield, South Yorkshire (centred at NGR SE 405 041), approximately 6 km to the south-east of Barnsley, and covered an area of approximately 2.8 ha.

The site encompassed a single field under 'scrub' vegetation and is shown in drawing ARC_2809_1054_02.

The majority of the field had been cleared of the 'scrub' vegetation at the time of the survey, although a few areas of dense vegetation were still present. The majority of the site was relatively soft underfoot and an area in the north-west of the field was very uneven and boggy and was not suitable for survey. The field sloped gradually upwards to the north. The field was bounded in the north and west by post and wire fencing, by dense vegetation and a wooden fence in the east and a ditch in the south. The remains of a structure were present on the south-western edge of the field.

The geology in the north of the site consists of mudstone, siltstone and sandstone of the Pennine Middle Coal Measures Formation and the geology in the south of the site consists of Ackton Rock sandstone (British Geological Survey, 2020). The soils of the site are described as freely draining slightly acid loamy soils (Soilscapes, 2020).

2.3 Archaeological background

An archaeological desk-based assessment for the site at Pitt Street, Darfield (no reference - in prep.) indicates that the site has '*retained a Greenfield character from the mid-19th century to the present day.*'

There are no known archaeological or heritage sites within the site.

Darfield Main Colliery was located approximately 300 m to the west of the site.

2.4 Scope of work

The survey area was specified by the client.

Due to the presence of uneven and boggy ground conditions and dense vegetation the area accessible / suitable for survey was reduced to approximately 2.1 ha, the extent of which is shown in drawing ARC_2809_1054_02.

No other problems were encountered during the survey which was carried out on 19 February 2020.

3. SURVEY METHODOLOGY

3.1 Magnetic survey

The survey was undertaken using a Phase Site Investigations Ltd multi-sensor array cart system (MACS).

The MACS comprised 8 Foerster 4.032 Ferex CON 650 gradiometers with a control unit and data logger. The Foerster gradiometers do not require balancing as each sensor is automatically 'zeroed' using the control unit software.

The MACS utilises an RTK GNSS system which means that survey grids do not have to be established. Instead an area is surveyed over a series of continuous profiles and the position of each data point is recorded using an RTK GNSS system. The sensors have a separation of 0.5 m which means that data was collected on profiles spaced at 0.5 m apart. Readings were taken at between 0.1 m and 0.15 m intervals.

Data is collected on zig-zag profiles along the full length or width of a field, although fields can be sub-divided if they are particularly large. Marker canes are set-out along field boundaries at set intervals and these are used to align the profiles. The survey profiles are usually offset from field boundaries, buildings and other metallic features by several metres to reduce the detrimental effect that these surface magnetic features have on the data. The location of the MACS data is converted direct to Ordnance Survey co-ordinates using the UK OSTN 02 projection. As the survey is referenced direct to Ordnance Survey National Grid co-ordinates temporary survey stations are not established.

3.2 Data processing and presentation

The MACS data was stored direct to a laptop using in-house software which automatically corrects for instrument drift and calculates a mean value for each profile. A positional value is assigned to each data point based on the sensor number and recorded GNSS co-ordinates. The data is gridded using in-house software and parameters are set based on the sensor spacing and mean values. No additional processing is required. The gridded data is then displayed in Surfer 9 (Golden Software) and image files of the data are created.

The data was exported as greyscale raster images (PNG files) and is shown with an accompanying interpretation at a scale of 1:1000. The greyscale plot has been clipped at -2 nT to 3 nT. The plot has been 'smoothed' using a visual interpolation but the data itself has not been interpolated.

The data has been displayed relative to a digital base plan provided by the client as drawing '*Topo.dwg*'. The base plan was in the Ordnance Survey National Grid co-ordinate system and as the survey grids / data were referenced directly to National Grid co-ordinates the data could be simply superimposed onto the base plan in the correct position.

X-Y trace plots were examined for all of the data and overlain onto the greyscale plot to assist in the interpretation, primarily to help identify dipolar and bipolar responses that will probably be associated with surface / near-surface iron objects. However, X-Y trace plots have not been presented here as they do not show any additional anomalies that are not visible in the greyscale data. A digital drawing showing the X-Y trace plot overlain on the greyscale plot is provided in the digital archive.

All isolated responses have been assessed using a combination of greyscale and X-Y trace plots. There are a large number of 'iron spike', isolated dipolar anomalies present in the data.

There is no evidence to suggest that they are associated with archaeological features and so have not been shown in the interpretation.

Anomalies associated with agricultural regimes are present in the data but each individual anomaly has not been shown on the interpretation. Instead the general orientation of the regime is indicated.

The data was examined over several different ranges during the interpretation to ensure that the maximum information possible was obtained from the data.

The anomalies have been categorised based on the type of response that they exhibit and an interpretation as to the cause(s) or possible cause(s) of each anomaly type is also provided.

A general discussion of the anomalies is provided for the entire site. A discussion of the general categories of anomaly which have been identified by the survey is provided in Appendix 1.5.

The geophysical interpretation drawing must be used in conjunction with the relevant results section and appendices of this report.

4. RESULTS

4.1 General

The data quality across the majority of the survey area is very good allowing the data to be viewed at a narrow range of readings to better identify weak anomalies. There are areas that have a more disturbed / variable magnetic background but this is due to the presence of magnetic material in the topsoil or sub-surface, rather than low data quality.

The categories of anomaly, and their possible causes, which have been identified by the survey are discussed in detail below.

4.2 Anomaly types and further discussion

There are numerous **isolated dipolar** responses (iron spikes) across the survey area. These contain a strong positive and negative component and are indicative of ferrous or fired material on or near to the surface. **Isolated bipolar** responses are also present. These have strong positive and negative components but are not technically magnetic dipoles. They tend to be caused by ferrous or fired material on or near to the surface and are usually produced from larger, or more strongly magnetic, objects (compared to dipolar anomalies) or a concentration of strongly magnetic smaller objects. In the large majority of cases these two types of isolated responses will be caused by modern material. However, the potential for some of these to be associated with archaeological features / material may be increased slightly by their proximity to other anomalies / features. The data at this site is too disturbed and there are too many isolated dipolar responses to be able to highlight isolated dipolar responses but it is highly likely that all of these responses will be caused by modern material and will not be of archaeological significance.

Several larger **isolated bipolar responses** have been shown on the interpretation because they are considered to be more likely to be associated with more significant sub-surface features or material (although in this instance they are not thought to be of archaeological interest). For these responses the main positive or negative component(s) of the response is shown (as this will better represent where an underlying feature / material may be located) and the overall extent of the response is also shown. The latter will usually extend well beyond the underlying feature but may indicate an area where the strong bipolar anomaly could mask responses from any other underlying features.

Isolated bipolar responses can also be caused by relatively modern infilled features, such as shafts or pits. The site is partly located on coal measures and a colliery was present relatively close to the site and so there is potential for some of the isolated bipolar responses to be related to infilled mining features, although they could also be caused by other modern features / material. **Anomalies A** have been highlighted as these are stronger responses and may have greater potential to be related to mining activity.

Areas of **magnetic disturbance** are present. These are areas of strong bipolar and dipolar responses and are usually associated with concentrations of near-surface relatively modern magnetic material.

A number of **negative linear anomalies** are present. Negative anomalies at this site, based on the underlying geology, will not relate to archaeological features and they will probably be caused by drains, plastic pipes, other relatively modern non-magnetic features or agricultural activity.

There are two series of **broadly parallel positive linear anomalies** that are associated with agricultural regimes. They could be related to the remnants of ridge and furrow, but the spacing between some of the responses is relatively close and they could be caused by later ploughing activity, or a combination of both.

A number of linear / curvi-linear **trends** have been identified. Some of these could be related to infilled sub-surface features, which have either been truncated to a greater extent in some parts (where trends are present, rather than well-defined positive responses) or in which the infill material has varying magnetic properties and produces clear strong responses in some parts (producing positive anomalies) and weaker more diffuse responses in others (shown as trends). Where a trend has been shown adjoining a stronger response it is uncertain if the feature is still present or has been severely truncated or removed.

Other trends are present that do not clearly correspond with other features / anomalies and the cause of these responses is not certain. They could relate to sub-surface anthropogenic features or they could be caused by natural features / variations, agricultural or other modern activity.

There are numerous **isolated positive responses** across the survey area, some of which are relatively large or strong. This type of anomaly can have a variety of causes including natural features / variations, deeper buried ferrous or fired material, accumulations of topsoil related to agricultural activity, infilled features or areas of burning. At this site is possible that some of the isolated positive responses are caused by infilled discrete features but there is no obvious pattern or relationship to their distribution that would indicate an archaeological origin and it is considered more likely that they are caused by natural variations or deeper buried relatively modern, ferrous or fired material. A number of isolated positive responses stand out due to their relative large size and strength (**Anomalies B**). These are probably related to relatively modern material but, if there is mining activity at this site they could be associated with infilled pits or shafts.

There are several **linear / curvi-linear positive responses** across the site (**Anomalies C**). These are indicative of infilled ditches and are suggestive of archaeological features, such as enclosure or field boundary ditches. The responses are fragmented and intermittent and so the exact relationships, if any, between them is not certain. It is possible that some of these anomalies could be related to relatively modern features / activity.

A sub-circular response, with strong positive components and weaker trends, is present in the north-west of the area (**Anomaly D**). This type of response can be caused by archaeological features, such as ring ditches, but this anomaly is very regular and in parts has a stronger negative response. It is known that horses have been recently grazed at this site and if a horse is tethered to a single point for a prolonged period it can create a worn and compacted circular path which can produce an anomaly consistent with Anomaly D. The cause of Anomaly D cannot be determined with certainty but it may be related to a surface feature caused by a tethered horse rather than a sub-surface archaeological feature. Recent air photos of the site (Google Earth, dated 06/05/2016) indicate the presence of numerous circular worn patches which would suggest that the interpretation of a relatively modern surface feature is most likely.

In the south of the area there is a suggestion of another sub-circular anomaly (**Anomaly E**), although this is less clear and more fragmented. Again the cause of this is not certain but it could be related to compacted ground or agricultural activity although an archaeological cause cannot be completely ruled out.

5. DISCUSSION AND CONCLUSIONS

The survey has identified several linear / curvi-linear positive responses that are suggestive of infilled archaeological features. The responses are fragmented and intermittent and so the exact relationships, if any, between them is not certain. It is possible that some of these anomalies could be related to relatively modern features / activity.

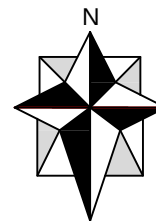
Two sub-circular responses are present. The cause of these is not certain and whilst they could be related to sub-surface features it is also possible that they are related to compacted ground caused by tethered horses. Recent air photos of the site indicate the presence of numerous circular worn patches which would suggest that the latter interpretation is most likely.

A number of other linear / curvi-linear trends of uncertain origin are present. Generally these are weak, fragmented or irregular and do not form any obvious relationships or patterns to allow their cause to be determined with any certainty. The majority, if not all of them, are probably caused by agricultural, other relatively modern activity or natural features / variations, but it is possible that some responses could be related to sub-surface features (of unknown date and function).

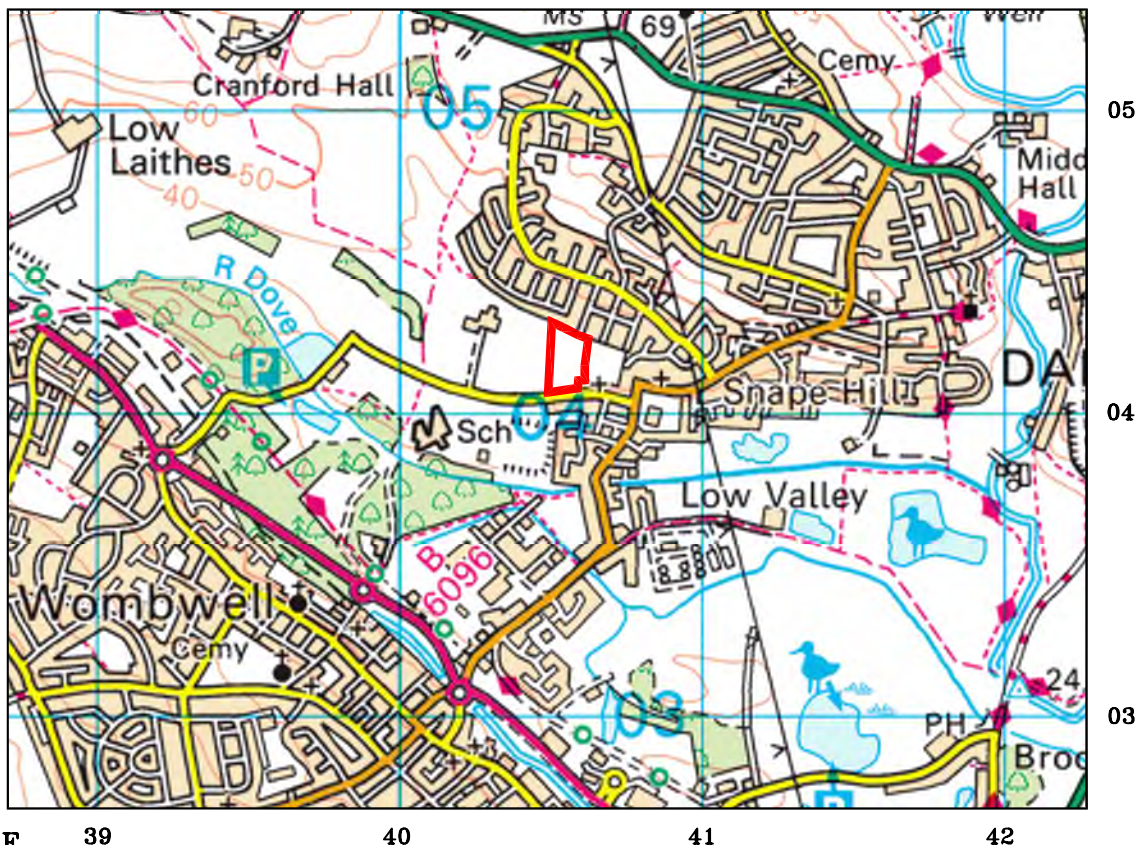
Several isolated responses have been identified that could be related to infilled discrete features. It is possible that some of these could be related to mining features, such as pits or shafts but the responses could also be related to other, relatively modern features / material.

The remainder of the anomalies identified by this survey relate to modern material / objects, agricultural activity (including possible ridge and furrow), possible drains or other modern non-magnetic features and geological / pedological variations.

It should be noted that a geophysical survey does not directly locate sub-surface features - it identifies variations or anomalies in the background response caused by features. The interpretation of geophysical anomalies is often subjective and it is rarely possible to identify the cause of all such anomalies. Not all features will produce a measurable anomaly and the effectiveness of a geophysical survey is also dependant on the site-specific conditions. The main factors that may limit whether a feature can be detected are the composition of a feature, its depth and size and the surrounding material. It is not possible to guarantee that a geophysical survey will identify all sub-surface features. Confirmation on the identification of anomalies and the presence or absence of sub-surface features can only be achieved by intrusive investigation.



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SITE LOCATION

SCALE



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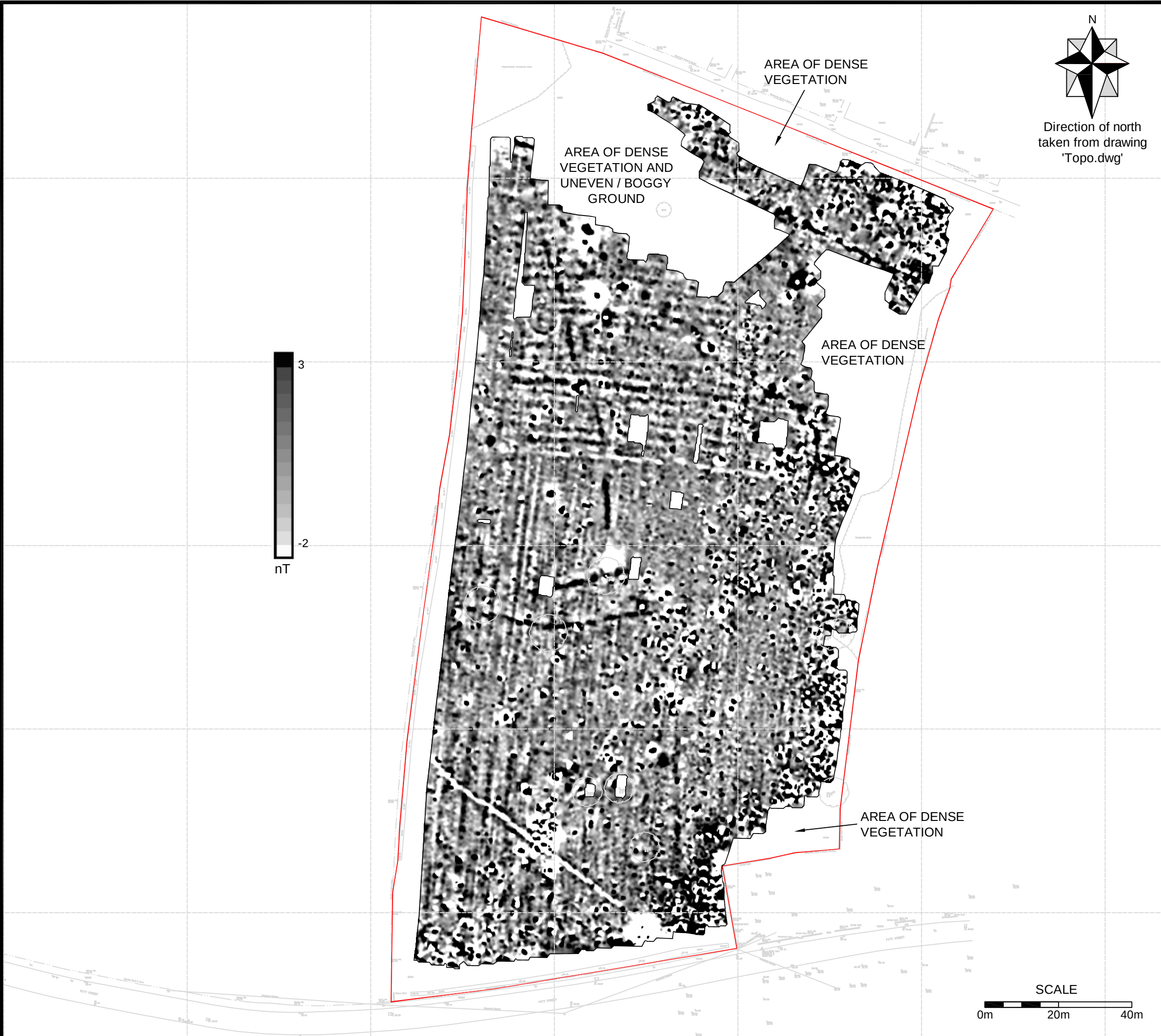


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Scale [A4 Sheet]	Drawing	Status
AS SHOWN	ARC_2809_1054_01	FINAL
Client	ENZYGO LTD SHEFFIELD	
Site	PITT STREET, DARFIELD SOUTH YORKSHIRE	
Title	SITE LOCATION MAP	
Job No	ARC_2809_1054	
Chk.	MW	Drawn JW
		Date 27/02/2020



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Scale	[A3 Sheet]	Drawing	Status
1:1000		ARC_2809_1054_02	FINAL

Client
ENZYGO LTD SHEFFIELD

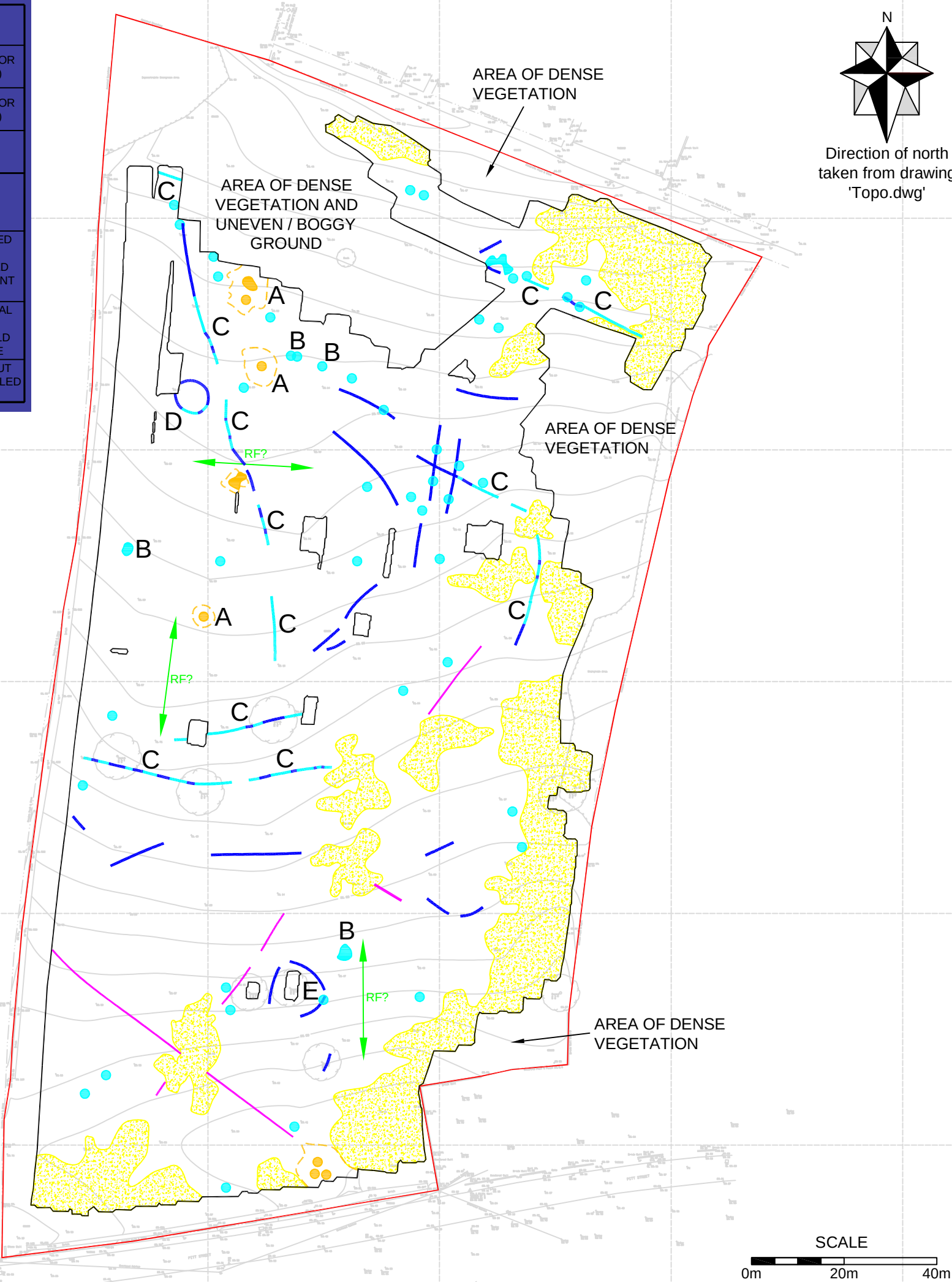
Site
PITT STREET, DARFIELD SOUTH YORKSHIRE

Title
LOCATION OF SITE SHOWING MAGNETIC GRADIENT DATA

Job No
ARC_2809_1054

Surveyed	JW, CA	Drawn	JW
Chk.	MW	Date	19/02/2020

ANOMALY TYPE	INTERPRETATION
 ISOLATED BIPOLAR RESPONSE (SHOWING POSITIVE COMPONENT AND EXTENT OF ANOMALY)	SURFACE / NEAR-SURFACE FERROUS OR FIRED MATERIAL (PROBABLE MODERN)
 AREA OF STRONG DIPOLAR / BIPOLAR RESPONSES (MAGNETIC DISTURBANCE)	SURFACE / NEAR-SURFACE FERROUS OR FIRED MATERIAL (PROBABLE MODERN)
 NEGATIVE LINEAR	PROBABLE MODERN FEATURE, SUCH DRAIN PIPE OR RELATED TO AGRICULTURAL ACTIVITY
 APPROXIMATE ORIENTATION OF STRONG BROADLY PARALLEL POSITIVE LINEARS	AGRICULTURAL FEATURES. POSSIBLE RIDGE AND FURROW BUT COULD BE RELATED TO LATER AGRICULTURAL ACTIVITY
 LINEAR / CURVI-LINEAR TREND (WEAK OR DIFFUSE RESPONSE)	UNCERTAIN ORIGIN. COULD BE RELATED TO DRAINAGE OR AGRICULTURAL ACTIVITY BUT SOME COULD BE CAUSED BY A SUB-SURFACE FEATURE / REMNANT OF FEATURE
 ISOLATED POSITIVE RESPONSE	PROBABLE GEOLOGICAL / PEDOLOGICAL VARIATION OR DEEPER BURIED FERROUS / FIRED MATERIAL BUT COULD ALSO BE INFILLED ISOLATED FEATURE
 LINEAR / CURVI-LINEAR POSITIVE RESPONSE	POSSIBLE AGRICULTURAL FEATURE BUT COULD ALSO BE FIELD DRAIN OR INFILLED LINEAR / CURVI-LINEAR FEATURE



- ### NOTES
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Scale	[A3 Sheet]	Drawing	Status
1:1000		ARC_2809_1054_03	FINAL
Client	ENZYGO LTD SHEFFIELD		
Site	PITT STREET, DARFIELD SOUTH YORKSHIRE		
Title	INTERPRETATION OF MAGNETIC GRADIENT DATA		
Job No	ARC_2809_1054		
Surveyed	JW, CA	Drawn	JW
Chk.	NF, MW	Date	19/02/2020

BIBLIOGRAPHY AND REFERENCES

Archaeological desk-based assessment for a site at Pitt Street, Darfield (no reference - in prep)

British Geological Survey, 2020, online resource - www.bgs.ac.uk

Soilscapes, 2020, online resource - www.landis.org.uk/soilscapes

APPENDIX 1

Magnetic survey: technical information

1.1 Theoretical background

- 1.1.1 Magnetic instruments measure the value of the Earth's magnetic field; the units of which are nanoTeslas (nT). The presence of surface and sub-surface features can cause variations or anomalies in this magnetic field. The strength of the anomaly is dependent on the magnetic properties of a feature and the material that surrounds it. The two magnetic properties that are of most interest are magnetic susceptibility and thermoremanent magnetism.
- 1.1.2 Magnetic susceptibility indicates the amount of ferrous (iron) minerals that are present. These can be redistributed or changed (enhanced) by human activity. If enhanced material subsequently fills in features such as pits or ditches then these can produce localised increases in magnetic responses (anomalies) which can be detected by a magnetic gradiometer even when the features are buried under additional soil cover.
- 1.1.3 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 topsoils, subsoils and rocks 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. Less magnetic material such as masonry or plastic service pipes which intrude into the topsoil may give a negative magnetic response relative to the background level. The strength of magnetic responses that a feature will produce will depend on the background magnetic susceptibility, how rapidly the feature has been infilled, the level and type of human activity in the area and the size and depth of a feature. Not all infilled features can be detected and natural variations can also produce localised positive and negative anomalies.
- 1.1.4 Thermoremanent magnetism indicates the amount of magnetism inherent in an object as a result of heating. Material that has been heated to a high temperature (fired), such as brick, can acquire strong magnetic properties and so although they may not appear to have a high iron content they can produce strong magnetic anomalies.
- 1.1.5 The magnetic survey method is highly sensitive to interference from surface and near-surface magnetic 'contaminants'. Surface features such as metallic fencing, reinforced concrete, buildings or walls all have very strong magnetic signatures that can dominate readings collected adjacent to them. Identification of anomalies caused by sub-surface features is therefore more difficult, or even impossible, in the vicinity of surface magnetic features. The presence of made ground also has a detrimental effect on the magnetic data quality as this usually contains magnetic material in the form of metallic scrap and brick. Identification of features beneath made ground is still possible if the target feature is reasonably large and has a strong magnetic response but smaller features or magnetically weak features are unlikely to be identified.
- 1.1.6 The interpretation of magnetic anomalies is often subjective and it is rarely possible to identify the cause of all magnetic anomalies. Not all features will produce a measurable magnetic response and the effectiveness of a magnetic survey is also dependant on the site-specific conditions. The main factors that may limit whether a feature can be detected are the

composition of a feature, its depth and size and the surrounding material. It is not possible to guarantee that a magnetic survey will identify all sub-surface features.

- 1.1.7 Most high resolution, near surface magnetic surveys utilise a magnetic gradiometer. A gradiometer is a hand-held instrument that consists of two magnetic sensors, one positioned directly above the other, which allows measurement of the magnetic gradient component of the magnetic field. A gradiometer configuration eliminates the need for applying corrections due to natural variations in the overall field strength that occur during the course of a day but it only measures relative variations in the local magnetic field and so comparison of absolute values between sites is not possible.
- 1.1.8 Features that are commonly located using magnetic surveys include archaeological ditches and pits, buried structures or foundations, mineshafts, unexploded ordnance, metallic pipes and cables, buried piles and pile caps. The technique can also be used for geological mapping; particularly the location of igneous intrusions.

1.2 Instrumentation

- 1.2.1 A multi-sensor array cart system (MACS) utilising 8 Foerster 4.032 Ferex CON 650 gradiometers, spaced at 0.5 m intervals, with a control unit and data logger was used for the magnetic survey.

1.3 Survey methodology

- 1.3.1 The MACS utilises an RTK GNSS system which means that survey grids do not have to be established. Instead an area is surveyed over a series of continuous profiles and the position of each data point is recorded using an RTK GNSS system. The sensors have a separation of 0.5 m which means that data was collected on profiles spaced at 0.5 m apart. Readings were taken at between 0.1 m and 0.15 m intervals.
- 1.3.2 Data is collected on zig-zag profiles along the full length or width of a field, although fields can be sub-divided if they are particularly large. Marker canes are set-out along field boundaries at set intervals and these are used to align the profiles. The survey profiles are usually offset from field boundaries, buildings and other metallic features by several metres to reduce the detrimental effect that these surface magnetic features have on the data. The location of the MACS data is converted direct to Ordnance Survey co-ordinates using the UK OSTN 02 projection. As the data is related direct to Ordnance Survey National Grid co-ordinates temporary survey stations are not established.
- 1.3.3 The Foerster gradiometers have a resolution of 0.2 nT but the stability of the cart system significantly reduces noise caused by instrument tilt and movement when compared with a traditional hand-held gradiometer system and the increased data intervals provide a higher resolution data set. The sensors have a range of $\pm 10,000$ nT and readings are taken at 0.1 nT resolution.

1.4 Data processing and presentation

- 1.4.1 The MACS data is stored direct to a laptop using in-house software which automatically corrects for instrument drift and calculates a mean value for each profile. A positional value is assigned to each data point based on the sensor number and recorded GNSS co-ordinates. The data is gridded using in-house software and parameters are set based on the sensor spacing and mean values. No additional processing is required. The gridded data is then displayed in Surfer 9 (Golden Software) and image files of the data are created.

- 1.4.2 The data was exported as raster images (PNG files), and are presented in greyscale format at 1:1000.
- 1.4.3 The data has been displayed relative to a digital base plan provided by the client as drawing 'Topo.dwg'. The base plan was in the Ordnance Survey National Grid co-ordinate system and as the survey grids were set-out directly to National Grid co-ordinates the data could be simply superimposed onto the base plan in the correct position.

1.5 Interpretation

- 1.5.1 The anomalies have been categorised based on the type of response that they have and an interpretation as to the cause(s) or possible cause(s) of each anomaly type is also provided. The following anomaly types may be present within the data:

Dipolar, bipolar and strong responses

Dipolar and bipolar responses are those that have a sharp variation between strongly positive and negative components.

In the majority of cases these responses are usually caused by modern ferrous features / objects, although fired material (such as brick), some ferrous or industrial archaeological features and strongly magnetic gravel could also produce dipolar and bipolar responses.

Isolated dipolar responses are those that have a single positive and negative element. They are usually caused by isolated, ferrous or fired material on or near to the surface. The objects that cause dipolar responses are usually relatively small, such as spent shotgun cartridges, iron nails and horseshoes (hence they are often referred to as 'iron spikes') or pieces of modern brick or pot. Some types of archaeological artefacts can also produce this type of response but unless there is strong supporting evidence to the contrary they are assumed not to be of archaeological significance.

Bipolar anomalies have strong positive and negative components but are not technically magnetic dipoles. The majority of **isolated bipolar responses** are caused by ferrous or fired material on or near to the surface. These responses tend to be produced from larger objects, compared to dipolar anomalies, or a concentration of smaller objects. Some archaeological features/ activity, including areas of burning or industrial activity can also produce this type of response but unless there is strong supporting evidence to the contrary they are assumed not to be of archaeological significance.

Smaller isolated dipolar and bipolar responses have not been shown on the interpretation as there is no evidence to suggest that they are related to archaeological activity. Several larger isolated bipolar responses have been shown as these could be associated with more significant sub-surface features or material (although in this instance they are not thought to be of archaeological interest).

Bipolar linear anomalies are usually produced by buried pipes / cables that are usually metallic, although in some instances ceramic pipes can also produce popular anomalies. In some instances the anomaly can extend for a significant distance beyond the feature that produces the anomaly. Bipolar anomalies are often very strong and can potentially mask responses from other sub-surface features in the vicinity of the pipe or cable.

There are no bipolar linear anomalies in this data set.

Areas containing numerous **strong dipolar / bipolar responses (magnetic disturbance)** are usually caused by greater concentrations of ferrous or fired material and are often found adjacent to field boundaries where such material tends to accumulate. Above

ground metallic or strongly magnetic features, such as fences, gates, pylons and buildings can also produce very strong bipolar responses. If an area of magnetic disturbance is located away from existing field boundaries then it could indicate a former field boundary, several large isolated objects in close proximity, an area where modern material has been tipped or an infilled cut feature, such as a quarry pit. Areas of dipolar / bipolar response can occasionally be caused by features / material associated with archaeological industrial activity or natural deposits that have varying magnetic properties but they are usually caused by modern activity. Responses in areas of magnetic disturbance can sometimes be so strong that archaeological features located beneath them may not be detected.

Very strong responses, notably bipolar anomalies, from modern features can dominate the data for a significant distance beyond the feature. The extent of these areas is usually shown either as part of the bipolar anomaly or as a **limit of very strong response**. It should be noted that this effect extends beyond the feature and so the limit of the response does not correspond to the actual size or location of the feature within it. In many cases where these strong responses are present at the edge of survey area the feature causing the anomaly be actually be located beyond the survey area. It should be recognised that other sub-surface features located within these areas may not be detected.

There are no very strong responses in this data set.

Negative linear anomalies

Negative linear anomalies occur when a feature has lower magnetic readings than the surrounding material and can often be associated with ploughing regimes or plastic / concrete pipes or natural features.

They can also indicate the presence of a feature that cuts into magnetic soils or bedrock and which is infilled with less magnetic material and in certain geologies can be associated with archaeological features. The negative anomalies in this dataset are not of archaeological significance.

Linear / curvi-linear anomalies (probable agricultural)

In many geological / pedological conditions agricultural features / regimes can produce magnetic anomalies due to the accumulation / alignment of magnetic topsoil. In most cases these are exhibited as a series of **broadly parallel positive linear** anomalies. The majority of these responses are associated with modern ploughing regimes but in some instances, where the responses are broader and more widely spaced, they can indicate the presence of the remnants of ridge and furrow.

Field drain systems can also produce linear anomalies, usually where the drains are made from fired ceramic or infilled with magnetic gravels.

Where a series of parallel anomalies are present then the approximate orientation of the anomalies are shown on the interpretation drawing to indicate the direction of the agricultural regime but for the sake of clarity individual anomalies have not been shown.

Individual anomalies may be shown if the response is not part of a regime.

Broad area of positive / negative responses

Broad areas of positive / negative responses can have a variety of causes. If the areas are generally quite large and irregular in shape then they are usually suggestive of natural features, such as lenses of sand and gravel deposits, palaeochannels or other natural

features / variations where the natural material differs from the surrounding sub-surface. In some instances anomalies of this type can be associated with anthropogenic (usually modern) activity.

There are no anomalies of this type in this data set.

Linear / curvi-linear trends

An anomaly is categorised as a **trend** if it is not certain that the response is associated with an extant sub-surface feature. Trends are usually weak, irregular, diffuse or discontinuous and it is usually not certain what their cause is, if they represent significant sub-surface features or even if they are associated with definite features.

It is possible that some of the trends are associated with geological / pedological variations. Others may be produced by artificial constructs within the data, either caused by processing or in some instances by intersecting anomalies (usually different agricultural regimes) that give the appearance of curving or regular shapes. Many trends are a product of weak, naturally occurring responses that happen to form a regular pattern but which are not associated with a sub-surface feature.

In some instances former features that have been severely truncated can still produce broad, diffuse or weak responses even if the underlying feature has been removed. This is due to the presence of magnetic soils associated with the former feature still being present along its route. In other instances the magnetic properties of the soils filling a feature may vary and so the magnetic signature of the feature can change, even if the sub-surface feature itself remains uniform. If a response from a feature becomes significantly weak or diffuse then part of the anomaly may be shown as a trend as it is uncertain if the feature is still present or has been severely truncated or removed.

Isolated positive responses

Isolated positive responses can occur if the magnetism of a feature, area or material has been enhanced or if a feature is naturally more magnetic than the surrounding material. It is often difficult to determine which of these factors causes any given responses and so the origin of this type of anomaly can be difficult to determine. They can have a variety of causes including geological variations, infilled archaeological features, areas of burning (including hearths), industrial archaeological features, such as kilns, or deeper buried ferrous material and modern fired material.

The large number of isolated responses and lack of an obvious pattern to their distribution suggests that the majority of these anomalies are probably associated with geological / pedological variations or deeper buried ferrous or fired material. Only the larger or stronger areas of positive response have been shown on the interpretation. The majority, if not all of these responses, will be related to natural variations or relatively modern material but have been shown as their exact cause cannot be determined with certainty.

Positive linear / curvi-linear anomalies

Positive magnetic anomalies indicate an increase in magnetism and if the resulting anomaly is linear or curvi-linear then this can indicate the presence of a man-made feature.

Positive or enhanced linear / curvi-linear anomalies can be associated with agricultural activity, drainage features but they can also be caused by ditches that are infilled with magnetically enhanced material and as such can indicate the presence of archaeological features. Some natural infilled features can also produce positive anomalies.

- 1.5.2 Several different ranges of data were used in the interpretation to ensure that the maximum information possible is obtained from the data.
- 1.5.3 X-Y trace plots were examined for all of the data and overlain onto the greyscale plot to assist in the interpretation, primarily to help identify dipolar / bipolar responses that will probably be associated with surface / near-surface iron objects. X-Y trace plots have not been used in the report as they do not show any additional anomalies that are not visible in the greyscale data. A digital drawing showing the X-Y trace plot overlain on the greyscale plot has been provided in the digital archive.
- 1.5.4 All isolated responses have been assessed using a combination of greyscale and X-Y trace plots.
- 1.5.5 Anomalies associated with agricultural regimes are present in the data. The general orientation of these regimes has been shown on the interpretation but, for the sake of clarity, each individual anomaly has not been shown.
- 1.5.6 The greyscale plots and the accompanying interpretations of the anomalies identified in the magnetic data are presented as 2D AutoCAD drawings. The interpretation is made based on the type, size, strength and morphology of the anomalies, coupled with the available information on the site conditions. Each type of anomaly is displayed in separate, easily identifiable layers annotated as appropriate.

1.6 Limitations of magnetic surveys

- 1.6.1 The magnetic survey method requires the operator to walk over the site at a constant walking pace whilst holding the instrument. The presence of an uneven ground surface, dense, high or mature vegetation or surface obstructions may mean that some areas cannot be surveyed.
- 1.6.2 The depth at which features can be detected will vary depending on their composition, size, the surrounding material and the type of magnetometer used for the survey. In good conditions large, magnetic targets, such as buried drums or tanks can be located at depths of more than 4 m. Smaller targets, such as buried foundations or archaeological features can be located at depths of between 1 m and 2 m.
- 1.6.3 A magnetic survey is highly sensitive to interference from surface and near-surface magnetic 'contaminants'. Surface features such as metallic fencing, reinforced concrete, buildings or walls all have very strong magnetic signatures that can dominate readings collected adjacent to them. Identification of anomalies caused by sub-surface features is therefore more difficult or even not possible in the vicinity of surface and near-surface magnetic features.
- 1.6.4 The presence of made ground also has a detrimental effect on the magnetic data quality as this usually contains magnetic material in the form of metallic scrap and brick. Identification of features beneath made ground is still possible if the target feature is reasonably large and has a strong magnetic response but smaller features or magnetically weak features are unlikely to be identified.
- 1.6.5 It should be noted that anomalies that are interpreted as modern in origin may 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.
- 1.6.6 A magnetic survey does not directly locate sub-surface features - it identifies variations or anomalies in the local magnetic field caused by features. It can be possible to interpret the cause of anomalies based on the size, shape and strength of response but it should be recognised that a magnetic survey produces a plan of magnetic variations and not a plan of all

sub-surface features. Interpretation of the anomalies is often subjective and it is rarely possible to identify the cause of all magnetic anomalies. Geological or pedological (soil) variations or features can produce responses similar to those caused by man-made (anthropogenic) features.

- 1.6.7 Anomalies identified by a magnetic survey are located in plan. It is not usually possible to obtain reliable depth information on the features that cause the anomalies.
- 1.6.8 Not all features will produce a measurable magnetic response and the effectiveness of a magnetic survey is also dependant on the site-specific conditions. It is not possible to guarantee that a magnetic survey will identify all sub-surface features. A magnetic survey is often most-effective at identifying sub-surface features when used in conjunction with other complementary geophysical techniques.