

STRATASCAN

Geophysical Survey Report

Norwich Road, Cromer

for

Archaeological Solutions Ltd

September 2010

Job ref. J2766

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Document Title: Geophysical Survey Report
Norwich Road, Cromer

Client: Archaeological Solutions Ltd

Stratascan Job No: J2766

Techniques: Detailed magnetic survey (gradiometry)

National Grid Ref: TG 226 404



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1 SUMMARY OF RESULTS

A detailed gradiometer survey was conducted over approximately 1.67 hectares of agricultural land off Norwich Road, Cromer. A number of features of a possible archaeological origin were identified within the gradiometer data including positive linear and area anomalies indicating the presence of cut features such as pits and ditches.

2 INTRODUCTION

2.1 Background synopsis

Stratascan were commissioned to undertake a geophysical survey of an area outlined for development. This survey forms part of an archaeological investigation being undertaken by Archaeological Solutions Ltd.

2.2 Site location

The site is located off Norwich Road, Cromer, Norfolk, OS grid reference TG 226 404.

2.3 Description of site

The survey area consists of approximately 1.67ha of relatively flat agricultural land currently used for arable.

2.4 Geology and soils

The underlying geology is Norwich Crag, Red Crag and Chillesford Clay (British Geological Survey South Sheet, Fourth Edition Solid, 2001). The drift geology is boulder clay (British Geological Survey South Sheet, First Edition Quaternary, 1977).

The overlying soils are known as Newport 4 which are typical brown sands. These consist of deep well drained sandy soils (Soil Survey of England and Wales, Sheet 4 Eastern England).

2.5 Site history and archaeological potential

No specific details have been made available to Stratascan.

2.6 Survey objectives

The objective of the survey was to locate any features of possible archaeological significance in order that they may be assessed prior to development.

2.7 Survey methods

Detailed magnetic survey (gradiometry) was used as an efficient and effective method of locating archaeological anomalies. More information regarding this technique is included in the Methodology section below.

3 **METHODOLOGY**

3.1 Date of fieldwork

The fieldwork was carried out over two days from 31st August 2010. Weather conditions during the survey were dry and sunny.

3.2 Grid locations

The location of the survey grids has been plotted in Figure 2 together with the referencing information. Grids were set out using a Leica 705auto Total Station and referenced to suitable topographic features around the perimeter of the site.

3.3 Survey equipment and gradiometer configuration

Although the changes in the magnetic field resulting from differing features in the soil are usually weak, changes as small as 0.2 nanoTesla (nT) in an overall field strength of 48,000nT, can be accurately detected using an appropriate instrument.

The mapping of the anomaly in a systematic manner will allow an estimate of the type of material present beneath the surface. Strong magnetic anomalies will be generated by buried iron-based objects or by kilns or hearths. More subtle anomalies such as pits and ditches can be seen if they contain more humic material which is normally rich in magnetic iron oxides when compared with the subsoil.

To illustrate this point, the cutting and subsequent silting or backfilling of a ditch may result in a larger volume of weakly magnetic material being accumulated in the trench compared to the undisturbed subsoil. A weak magnetic anomaly should therefore appear in plan along the line of the ditch.

The magnetic survey was carried out using a dual sensor Grad601-2 Magnetic Gradiometer manufactured by Bartington Instruments Ltd. The instrument consists of two fluxgates very accurately aligned to nullify the effects of the Earth's magnetic field. Readings relate to the difference in localised magnetic anomalies compared with the general magnetic background. The Grad601-2 consists of two high stability fluxgate gradiometers suspended on a single frame. Each gradiometer has a 1m separation between the sensing elements so enhancing the response to weak anomalies.

3.4 Sampling interval, depth of scan, resolution and data capture

3.4.1 Sampling interval

Readings were taken at 0.25m centres along traverses 1m apart. This equates to 3600 sampling points in a full 30m x 30m grid.

3.4.2 Depth of scan and resolution

The Grad 601 has a typical depth of penetration of 0.5m to 1.0m. This would be increased if strongly magnetic objects have been buried in the site. The collection of data at 0.5m centres provides an optimum methodology for the task balancing cost and time with resolution.

3.4.3 Data capture

The readings are logged consecutively into the data logger which in turn is daily downloaded into a portable computer whilst on site. At the end of each job, data is transferred to the office for processing and presentation.

3.5 Processing, presentation of results and interpretation

3.5.1 Processing

Processing is performed using specialist software known as *Geoplot 3*. This can emphasise various aspects contained within the data but which are often not easily seen in the raw data. Basic processing of the magnetic data involves 'flattening' the background levels with respect to adjacent traverses and adjacent grids. 'Despiking' is also performed to remove the anomalies resulting from small iron objects often found on agricultural land. Once the basic processing has flattened the background it is then possible to carry out further processing which may include low pass filtering to reduce 'noise' in the data and hence emphasise the archaeological or man-made anomalies.

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

1. *Despike* (useful for display and allows further processing functions to be carried out more effectively by removing extreme data values)

Geoplot parameters:

X radius = 1, y radius = 1, threshold = 3 std. dev.
Spike replacement = mean

2. *Zero mean traverse* (sets the background mean of each traverse within a grid to zero and is useful for removing striping effects)

Geoplot parameters:

Least mean square fit = off

3.5.2 Presentation of results and interpretation

The presentation of the data for the site involves a print-out of the raw data as a greyscale plot (Figure 3), trace plots (Figures 4 and 5) and a colour plot showing extreme magnetic values (Figure 6), together with a greyscale plot of the processed data (Figure 7). Magnetic anomalies have been identified and plotted onto the 'Abstraction and Interpretation of Anomalies' drawing for the site (Figure 8).

4 RESULTS

The detailed gradiometer survey undertaken over approximately 1.67ha of agricultural land off Norwich Road, Cromer has identified a number of anomalies of a possible archaeological origin.

Positive linear and area anomalies representing cut features such as pits and ditches are evident throughout the survey area. The majority of these anomalies are amorphous and do not conform to any recognisable pattern of archaeological activity (1); however some curvilinear anomalies (2) are identifiable within the site and a rectilinear feature (3) can be noted in the southern region of the survey area which may indicate the presence of a former small enclosure.

A number of discrete positive anomalies (4) are also evident within the survey area. These features have been interpreted as pits of a possible archaeological origin. It is interesting to note that one of these pits is located within the rectilinear feature. Further investigation would be necessary however to ascertain as to whether these features are contemporary with each other.

A positive linear anomaly (5) can be seen running parallel with the line of the dismantled railway to the east of the site. This feature has been interpreted as being related to a possible former field boundary. Alternatively this feature may represent further evidence of ploughing activity within the survey area.

Parallel sets of positive linear anomalies (6) in the central region of the survey area may indicate former agricultural activity such as ploughing.

Ferrous fences enclosing the site have created a perimeter of magnetic disturbance (7). This disturbance may mask subtle features of an archaeological origin in places.

Bipolar anomalies (8) identified throughout the survey area have been interpreted as buried ferrous objects.

5 CONCLUSION

The gradiometer survey undertaken at Norwich Road, Cromer has identified a number of positive linear and area anomalies that may be of an archaeological origin. The features with the most archaeological potential and which may warrant further investigation would include the rectilinear anomaly in the southern region of the site and the curvilinear anomalies in the northern and central areas.

6 REFERENCES

British Geological Survey, 2001. *Geological Survey Ten Mile Map, South Sheet, Fourth Edition (Solid)*. British Geological Society.

Soil Survey of England and Wales, 1983. *Soils of England and Wales, Sheet 4 Eastern England*.

British Geological Survey South Sheet, 1977. *Geological Survey Ten Mile Map, South Sheet First Edition (Quaternary)*. Institute of Geological Sciences.

APPENDIX A – Basic principles of magnetic survey

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.

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.

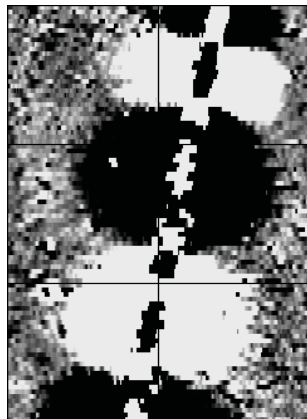
Silting and deliberate infilling of ditches and pits with magnetically enhanced soil creates a relative contrast against the much lower levels of magnetism within the subsoil into which the feature is cut. Systematic mapping of magnetic anomalies will produce linear and discrete areas of enhancement 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 either 0.5 or 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.

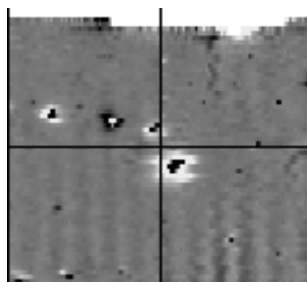
APPENDIX B – Glossary of magnetic anomalies

Bipolar



A bipolar anomaly is one that is composed of both a positive response and a negative response. It can be made up of any number of positive responses and negative responses. For example a pipeline consisting of alternating positive and negative anomalies is said to be bipolar. See also dipolar which has only one area of each polarity. The interpretation of the anomaly will depend on the magnitude of the magnetic field strength. A weak response may be caused by a clay field drain while a strong response will probably be caused by a metallic service.

Dipolar

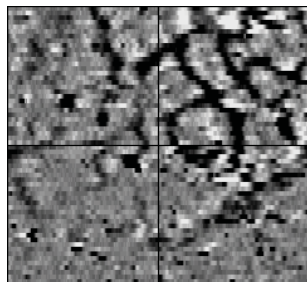


This consists of a single positive anomaly with an associated negative response. There should be no separation between the two polarities of response. These responses will be created by a single feature. The interpretation of the anomaly will depend on the magnitude of the magnetic measurements. A very strong anomaly is likely to be caused by a ferrous object.

Positive anomaly with associated negative response

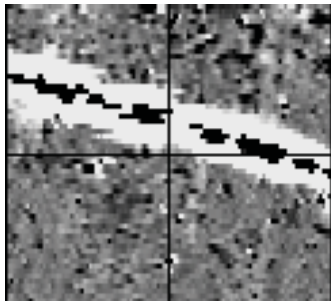
See bipolar and dipolar.

Positive linear



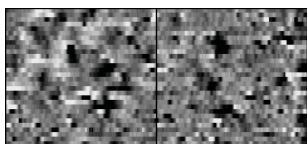
A linear response which is entirely positive in polarity. These are usually related to in-filled cut features where the fill material is magnetically enhanced compared to the surrounding matrix. They can be caused by ditches of an archaeological origin, but also former field boundaries, ploughing activity and some may even have a natural origin.

Positive linear anomaly with associated negative response



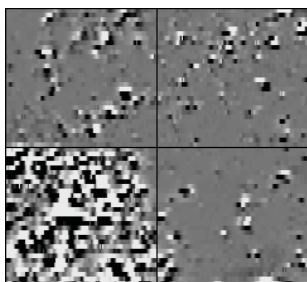
A positive linear anomaly which has a negative anomaly located adjacently. This will be caused by a single feature. In the example shown this is likely to be a single length of wire/cable probably relating to a modern service. Magnetically weaker responses may relate to earthwork style features and field boundaries.

Positive point/area



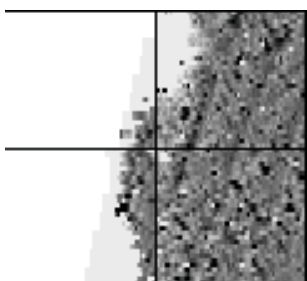
These are generally spatially small responses, perhaps covering just 3 or 4 reading nodes. They are entirely positive in polarity. Similar to positive linear anomalies they are generally caused by in-filled cut features. These include pits of an archaeological origin, possible tree bowls or other naturally occurring depressions in the ground.

Magnetic debris



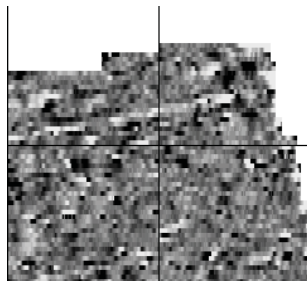
Magnetic debris consists of numerous dipolar responses spread over an area. If the amplitude of response is low ($\pm 3nT$) then the origin is likely to represent general ground disturbance with no clear cause, it may be related to something as simple as an area of dug or mixed earth. A stronger anomaly ($\pm 250nT$) is more indicative of a spread of ferrous debris. Moderately strong anomalies may be the result of a spread of thermoremanent material such as bricks or ash.

Magnetic disturbance



Magnetic disturbance is high amplitude and can be composed of either a bipolar anomaly, or a single polarity response. It is essentially associated with magnetic interference from modern ferrous structures such as fencing, vehicles or buildings, and as a result is commonly found around the perimeter of a site near to boundary fences.

Negative linear

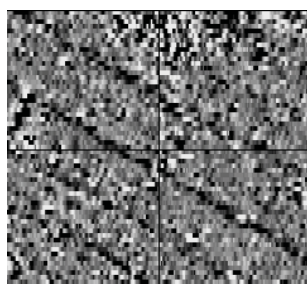


A linear response which is entirely negative in polarity. These are generally caused by earthen banks where material with a lower magnetic magnitude relative the background top soil is built up. See also ploughing activity.

Negative point/area

Opposite to positive point anomalies these responses may be caused by raised areas or earthen banks. These could be of an archaeological origin or may have a natural origin.

Ploughing activity



Ploughing activity can often be visualised by a series of parallel linear anomalies. These can be of either positive polarity or negative polarity depending on site specifics. It can be difficult to distinguish between ancient ploughing and more modern ploughing, clues such as the separation of each linear, straightness, strength of response and cross cutting relationships can be used to aid this, although none of these can be guaranteed to differentiate between different phases of activity.

Polarity

Term used to describe the measurement of the magnetic response. An anomaly can have a positive polarity (values above 0nT) and/or a negative polarity (values below 0nT).

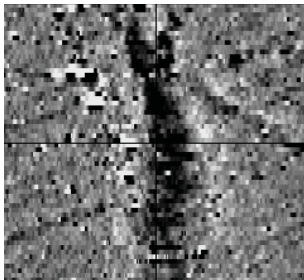
Strength of response

The amplitude of a magnetic response is an important factor in assigning an interpretation to a particular anomaly. For example a positive anomaly covering a 10m² area may have values up to around 3000nT, in which case it is likely to be caused by modern magnetic interference. However, the same size and shaped anomaly but with values up to only 4nT may have a natural origin. Trace plots are used to show the amplitude of response.

Thermoremanent response

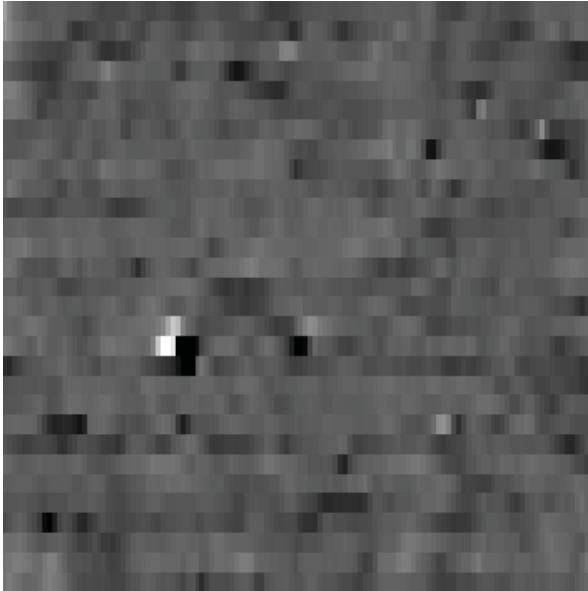
A feature which has been subject to heat may result in it acquiring a magnetic field. This can be anything up to approximately +/-100 nT in value. These features include clay fired drains, brick, bonfires, kilns, hearths and even pottery. If the heat application has occurred in situ (e.g. a kiln) then the response is likely to be bipolar compared to if the heated objects have been disturbed and moved relative to each other, in which case they are more likely to take an irregular form and may display a debris style response (e.g. ash).

Weak background variations

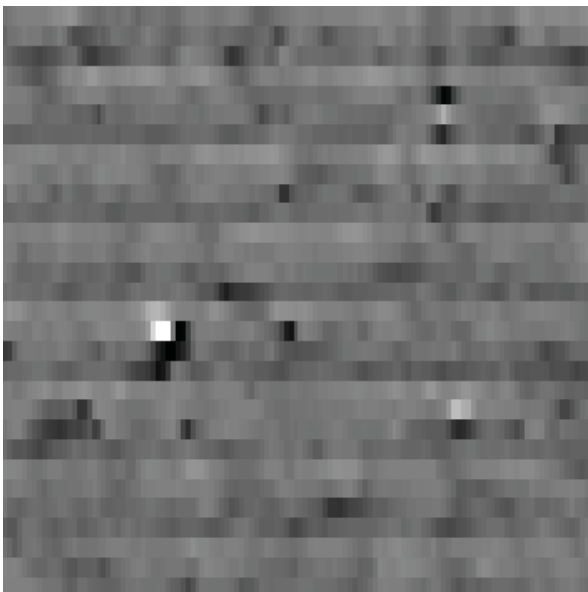


Weakly magnetic wide scale variations within the data can sometimes be seen within sites. These usually have no specific structure but can often appear curvy and sinuous in form. They are likely to be the result of natural features, such as soil creep, dried up (or seasonal) streams. They can also be caused by changes in the underlying geology or soil type which may contain unpredictable distributions of magnetic minerals, and are usually apparent in several locations across a site.

APPENDIX C- Gradiometer Data Recollection



Grid 10.
+/- 5nT
Surveyed PM 31st August 2010
30m x 30m
1m x 0.25m
Data Collected by Allen Wright
Using Stratascan Bartington Grad 601-2 No.6



Grid 10.
+/- 5nT
Surveyed AM 1st September 2010
30m x 30m
1m x 0.25m
Data Collected by Allen Wright
Using Stratascan Bartington Grad 601-2 No. 6

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 OS 100km square = TG



Survey area



42

41

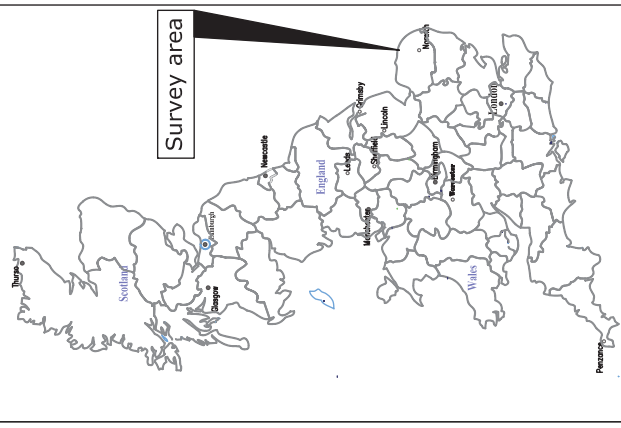
40

39

38

21 22 23 24 25

Issue No.	Date	Description
-	-	-
-	-	-



Site centred on NGR TG 226 404

Client
 ARCHAEOLOGICAL SOLUTIONS LTD

Project title
 GEOPHYSICAL SURVEY -
 NORWICH ROAD CROMER

Subject

LOCATION PLAN OF SURVEY AREA

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Scale 1:25 000
 0m 500 1000m

Plot	A3	Checked by	PPB	Issue No.	01
Survey date	AUG 10	Drawn by	RAJS	Figure No.	01

Amendments	
Issue No.	Date
-	-
-	-
-	-

REFERENCING INFORMATION			
A-B	210m	A-C	61.32m
A-D		A-D	136.88m
A-E	232.89m	B-C	212.77m
B-D		B-D	165.17m
B-E	23.20m		
A-B	Base line		
C, D, E	Referencing points		
2	Grid number		

Client
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Project Title
GEOLOGICAL SURVEY - NORWICH ROAD, CROMER

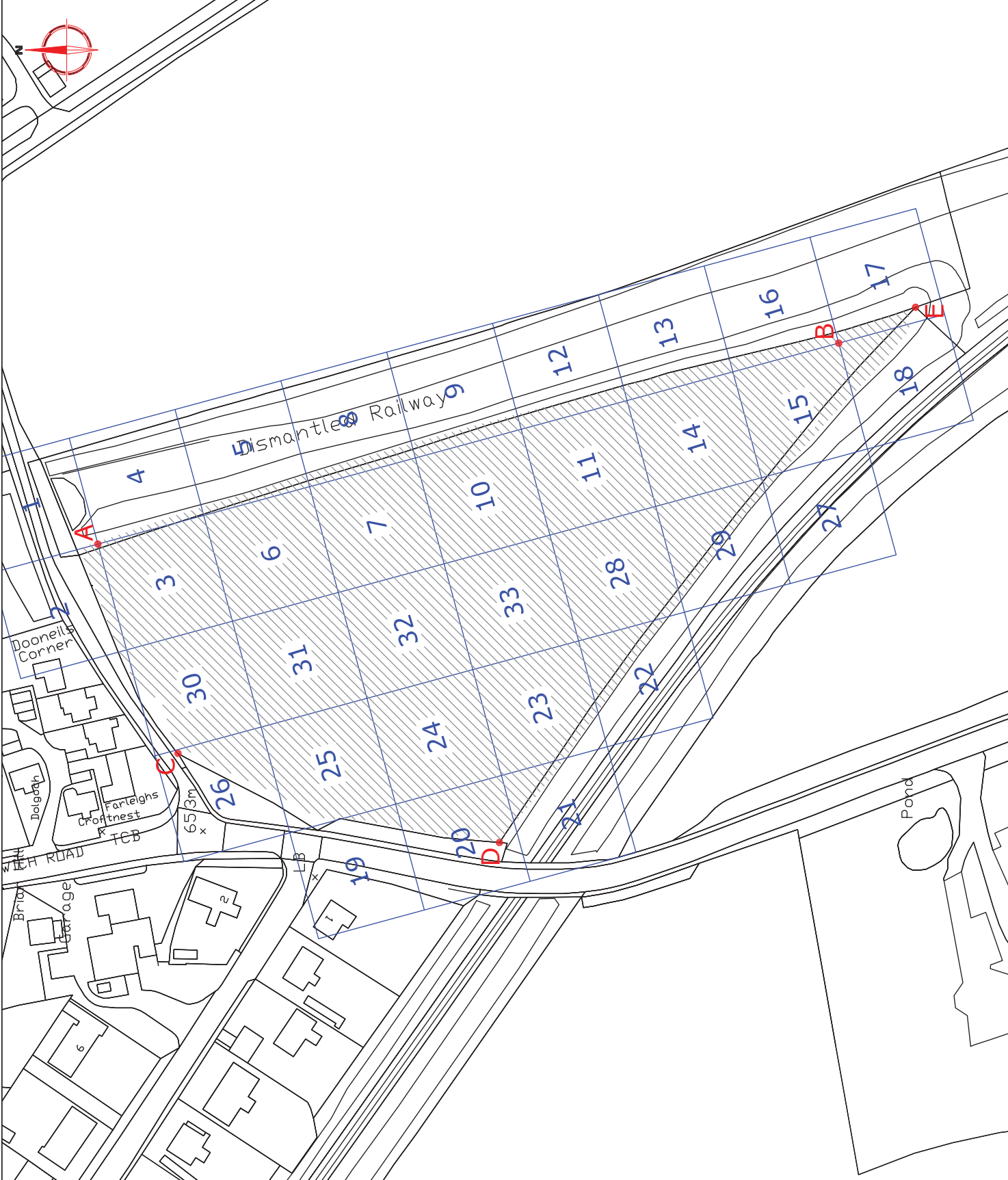
Job No. 2766

Subject
SITE PLAN SHOWING LOCATION OF SURVEY GRIDS AND REFERENCING

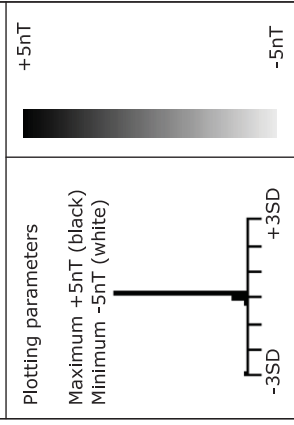


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Scale	1:1250	0m	10	20	30	40	50m
Plot	A3	Checked by	PPB	Issue No.	01		
Survey date	AUG 10	Drawn by	RAJS	Figure No.	02		



Amendments	
Issue No.	Date
-	-
-	-
-	-



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Project Title
GEOPHYSICAL SURVEY - NORWICH ROAD, CROMER

Job No. 2766

Subject
PLOT OF RAW GRADIOMETER DATA

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REGISTERED ORGANISATION
IFA

Scale 1:1000

Plot	A3	Checked by	PPB	Issue No.	01
Survey date	AUG 10	Drawn by	RAJS	Figure No.	03



Amendments	
Issue No.	Date
-	-
-	-
-	-

Plotting parameters
+40nT
(Positive values *displace above the trace line.*
Hidden values *have not been plotted*)

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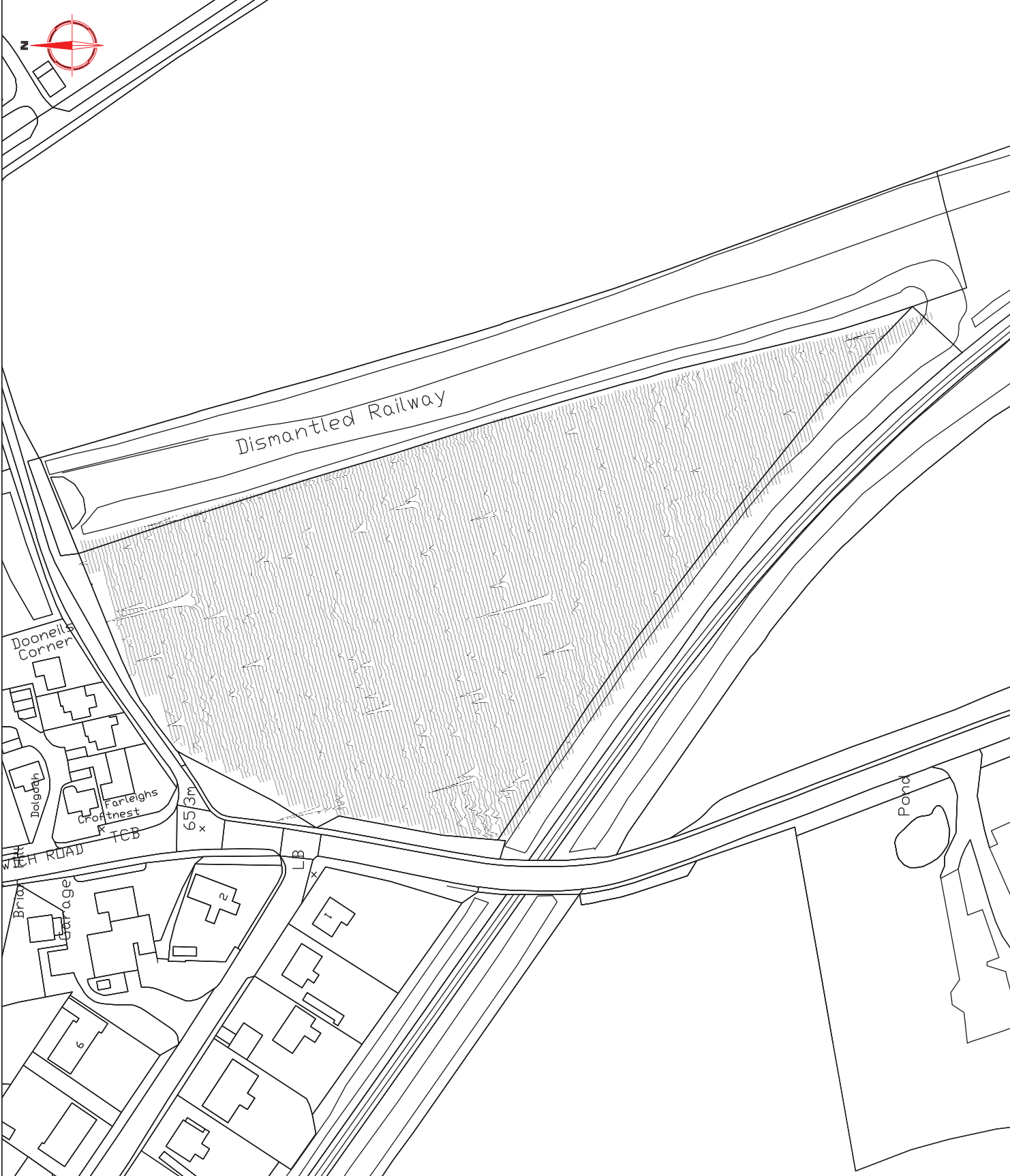
Project Title
Job No. 2766
GEOPHYSICAL SURVEY - NORWICH ROAD, CROMER

Subject
TRACE PLOT OF GRADIOMETER DATA SHOWING POSITIVE VALUES

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Scale
1:1000
0m 10 20 30 40 50

Plot	A3	Checked by	PPB	Issue No.	01
Survey date	AUG 10	Drawn by	RAJS	Figure No.	04



Amendments	
Issue No.	Date
-	-
-	-
-	-

Plotting parameters
 -40nT
 (Negative values
 displace above the trace
 line. Hidden values
 have not been plotted)

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Project Title
 GEOPHYSICAL SURVEY - NORWICH
 ROAD, CROMER

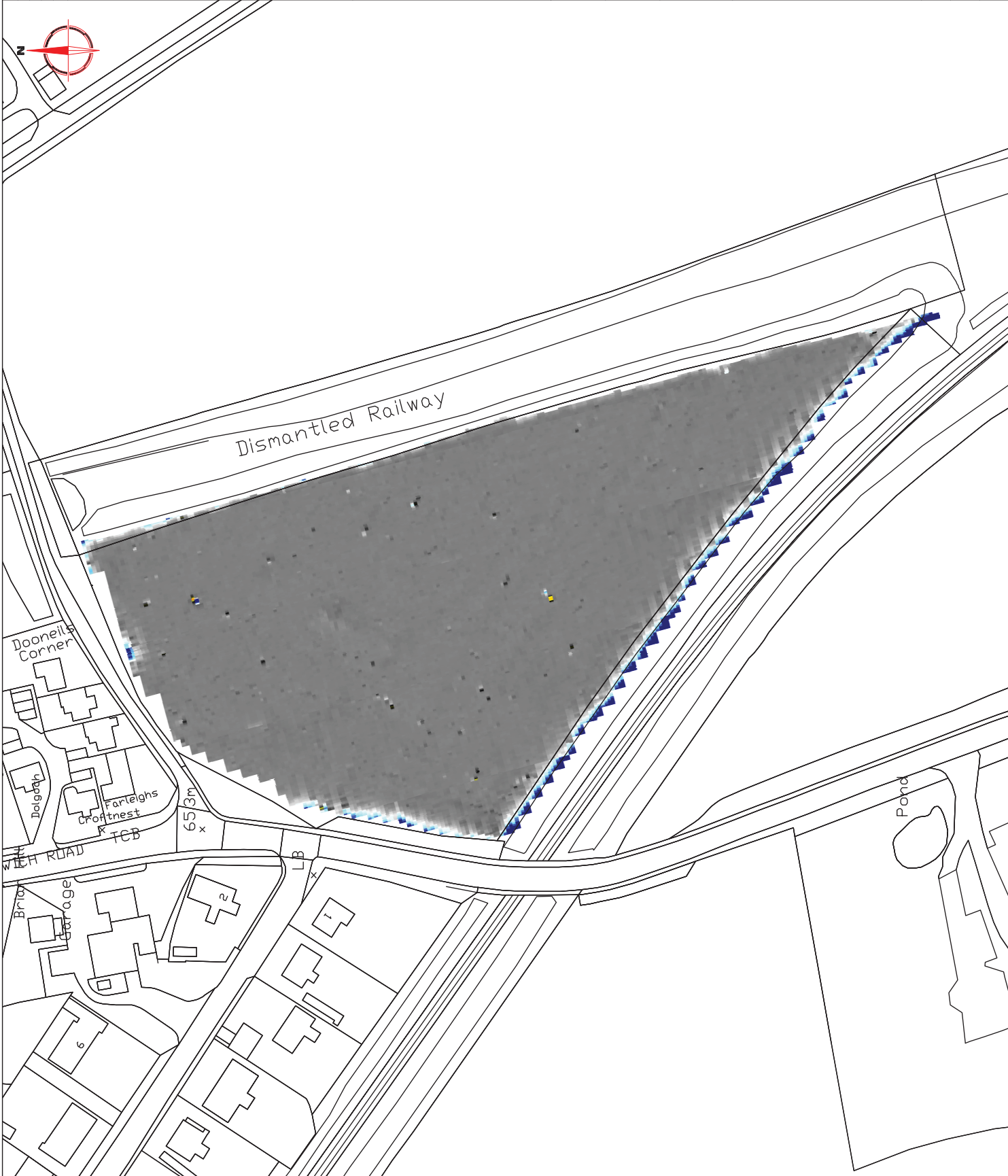
Subject
 TRACE PLOT OF GRADIOMETER DATA
 SHOWING NEGATIVE VALUES

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Scale 1:1000	0m 10 20 30 40 50
Plot A3	Checked by PPB
Issue No. 01	Drawn by RAJS
Figure No. 05	Survey date AUG 10



Issue No.	Date	Description
-	-	-
-	-	-
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Plotting parameters

Maximum +250nT (red)
Minimum -250nT (blue)

+250nT

-250nT

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Project Title
Job No. 2766
GEOPHYSICAL SURVEY - NORWICH
ROAD, CROMER

Subject
COLOUR PLOT OF GRADIOMETER
DATA SHOWING EXTREME VALUES

STRATASCANTM
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Scale 1:1000
0m 10 20 30 40 50

Plot A3
Checked by PPB
Issue No. 01

Survey date AUG 10
Drawn by RAJS
Figure No. 06

Amendments	
Issue No.	Date
-	-
-	-
-	-
-	-

Plotting parameters

Maximum +2nT (black)
Minimum -2nT (white)

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Project Title
GEOPHYSICAL SURVEY - NORWICH ROAD, CROMER

Job No. 2766

Subject
PLOT OF PROCESSED
GRADIOMETER DATA

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IFA

Scale 1:1000

Plot	A3	Checked by	PPB	Issue No.	01
Survey date	AUG 10	Drawn by	RAJS	Figure No.	07



Issue No.	Date	Description
-	-	-
-	-	-
-	-	-

KEY	
	Discrete positive anomaly - possible pit
	Positive anomaly with associated negative response - ferrous object
	Positive linear anomaly - agricultural mark
	Positive linear anomaly - possibly related to former field boundary
	Positive linear anomaly - cut feature of possible archaeological origin
	Positive area anomaly - cut feature of possible archaeological origin
	Weak positive area anomaly
	Area of magnetic disturbance related to ferrous objects such as fences etc
3	Anomaly ID number

Client
ARCHAEOLOGICAL SOLUTIONS LTD

Project Title
GEOPHYSICAL SURVEY - NORWICH ROAD, CROMER

Job No. 2766

Subject
ABSTRACTION AND INTERPRETATION OF GRADIOMETER ANOMALIES

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Scale **1:1000**
 0m 10 20 30 40 50

Plot **A3** Checked by **PPB** Issue No. **01**
 Survey date **AUG 10** Drawn by **RAJS** Figure No. **08**

