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SPANIEL FARM, WEAVERTHORPE, MALTON.

REPORT ON AN ARCHAEOLOGICAL GEOPHYSICAL SURVEY.

OSA REPORT No: OSA11EV15 (Geophysics).

April 2011.

OSA

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Report Summary.

PROJECT NO:	OSA11EV15 (Geophysics)
SITE NAME:	Spaniel Farm, Weaverthorpe, Malton
COUNTY:	North Yorkshire
NATIONAL GRID REFERENCE:	SE 9869 7006
PLANNING REFERENCE:	N/A
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1.0 Abstract.

A geophysical survey was carried out by On-Site Archaeology *in advance of the submission of a planning application for an Enercon E-33 wind turbine measuring 37.18m to hub. As the archaeological implications of the proposals could not be adequately assessed on the basis of currently available information, in accordance with the recommendations of Planning Policy Statement 5 a scheme of archaeological evaluation by geophysical survey was carried out.*

Several types of feature have been identified, of which some are likely to be of geological origin. However, in the northern part of the site two strongly-indicated curvilinear enclosures were found along with a series of further possible cut archaeological features.

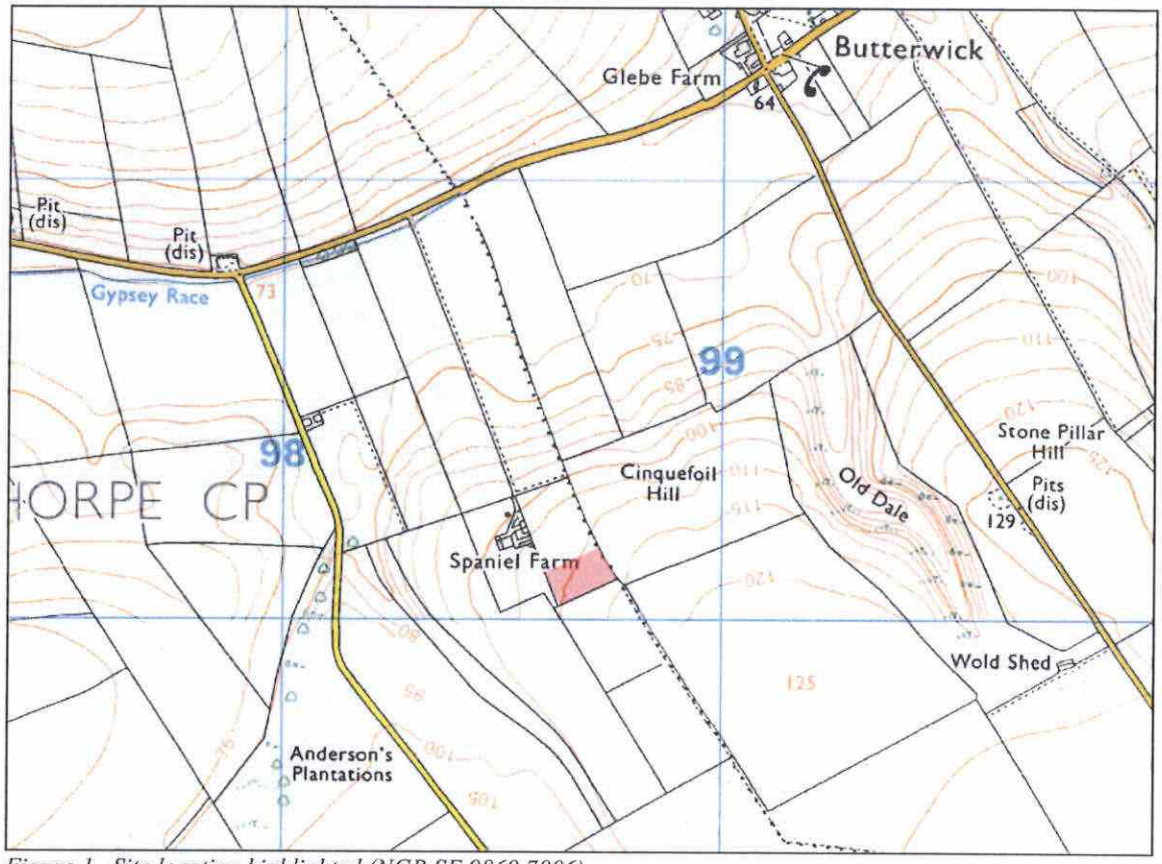

Figure 1. Site location highlighted (NGR SE 9869 7006)

2.0 Site Location, Geology, Topography and Land Use.

The site considered by this report, centred at NGR SE 9869 7006, lies to the southeast of Spaniel Farm, Weaverthorpe, Malton, North Yorkshire (Figure 1). The proposed turbine will be sited in agricultural land.

The proposed turbine site is within an agricultural field to the southeast of the farmhouse. The ground cover is short grass and the land lies at approximately 115m above Ordnance Datum (Figure 2).

The underlying geology is Welton chalk formation and Burnham chalk formation (undifferentiated) (British Geological Survey http://www.bgs.ac.uk/). No drift geology is present. The response of magnetometer survey to Cretaceous chalk is good (English Heritage 2008).

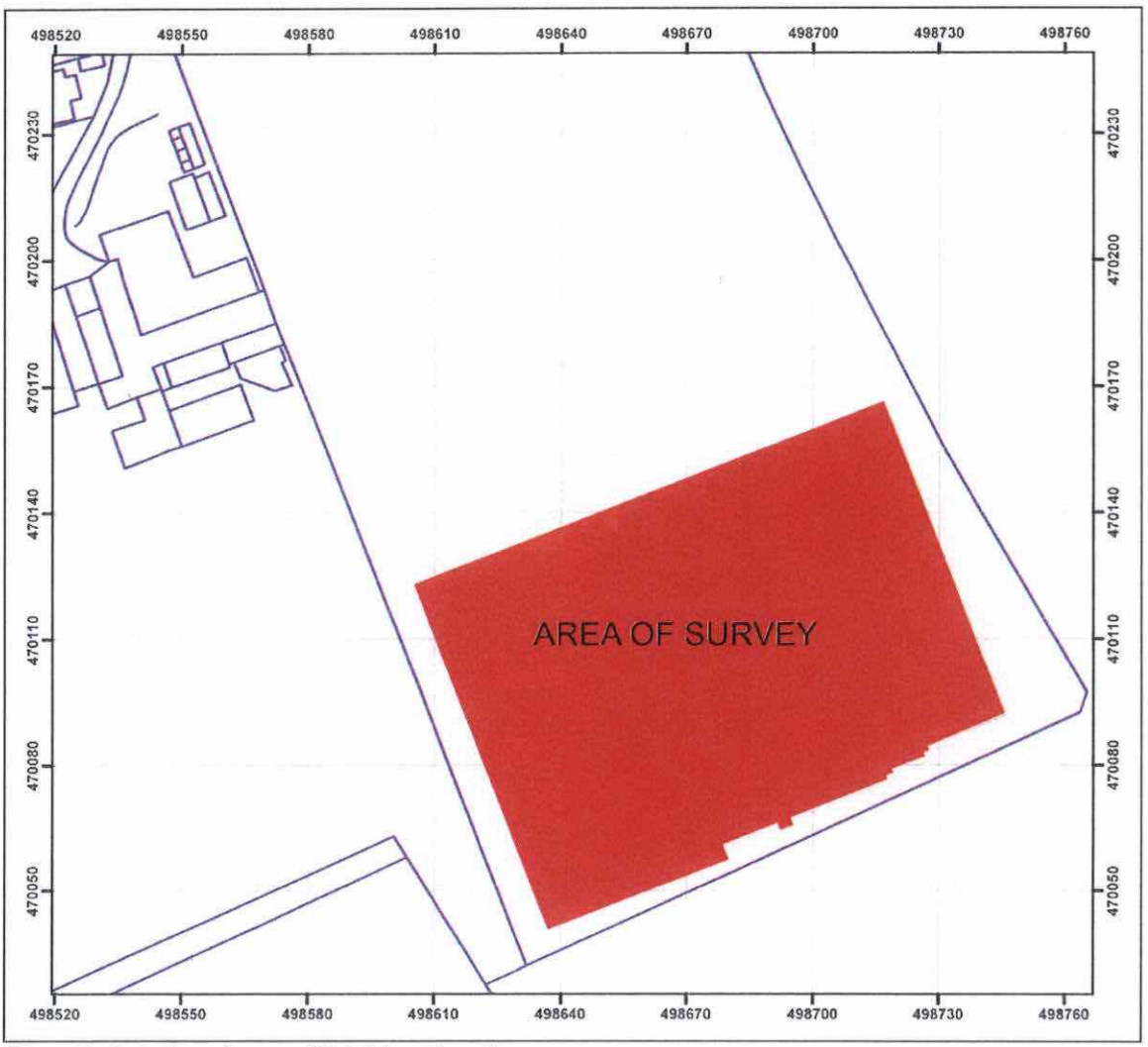

Figure 2. Location of survey (highlighted in red)

3.0 Archaeological Background.

The proposed development lies within an area of archaeological potential. To the north of the development lies a scheduled round barrow and to the northeast of the site is the scheduled settlement site at Butterwick. Additionally, the landscape is rich in undesignated archaeological remains, including ladder settlements, trackways and enclosures (see Stoertz 1997).

4.0 Methodology.

4.1 General

The surveys and reporting were conducted in accordance with the current professional guidelines (English Heritage 2008 and Institute for Archaeologists 2010).

Geophysical surveying enables the relatively rapid and non-invasive identification of potential archaeological features within landscapes and can involve a variety of complementary techniques such as magnetometry, electrical resistivity, ground-penetrating radar and electromagnetic survey. Some techniques are more suitable than others in particular situations, depending on a variety of site-specific factors including the nature of likely targets; depth of likely targets; ground conditions; proximity of buildings, fences or services and the local geology and drift.

In this instance, based on existing knowledge of sites in the vicinity, it was considered likely that cut features, such as ditches and pits, may be present on the site, and that other types of feature such as trackways, and possibly fired (such as kilns and hearths) might also be present (see Stoertz 1997).

Given the anticipated shallowness of potential targets and the calcareous geological environment of the study area fluxgate gradiometry (a geomagnetic technique) was considered appropriate for the detection of most of the likely subsurface features mentioned above. The technique involves the use of a specific type of hand-held magnetometers called a gradiometer which detects and records minute variations in the vertical component of the local magnetic field at a given sample interval over the extent to of the survey area. These variations are often caused by changes in soil magnetic susceptibility or permanent thermo-remnant magnetisation that in many cases can reflect archaeological activity and the form and extent of discrete features.

It should be noted that this technique, whilst capable of identifying possible archaeological anomalies, is also responsive to changes in the magnetic gradient caused by ferrous material in the soil and above the surface. This means that service points, conduits, metal fences, and modern ferrous objects in the topsoil all yield elevated magnetic responses, and where these features exist in the survey area, more subtle fluctuations resulting from archaeological features can sometimes be masked.

4.2 Fieldwork methodology

The data collection for the survey was carried out using a continuous grid of 30m squares across the southern end of the field between Spaniel Farm and the proposed turbine site on the top of Cinqefoil Hill, dividing it into squares of 30m. In total, 12 grid squares comprising 10800m^2 were surveyed.

The survey grid was tied-in to known, mapped Ordnance Survey points using a Leica GPS900. The GPS900 is an RTK GPS unit providing survey quality location information accurate to around 10mm. The extent and position of the survey is shown on Figure 2.

The data collection was carried out using Bartington Grad 601-2 fluxgate gradiometer with automatic datalogging facilities, and a zigzag traverse scheme used within the 30m grid units was employed. Samples were recorded using an interval of 0.25 x 1 m in accordance with current archaeological guidelines (English Heritage 2008), yielding 3600 measurements per 30m square. The instrument sensitivity was set to 0.03nT within a +/- 100nT range ensuring the accurate recording of small variation in the local magnetic gradient.

4.3 Processing and data treatment.

Following initial field survey, data is prepared and processed using a series of different tools to eliminate any data defects resulting from local conditions or collection problems. Once defects have been identified, images are prepared using greyscale and trace plots of the survey data.

For processing, Geoscan *Geoplot 3.0* software was used for initial data processing and Golden Software's *Surfer* used for the production of both raw and processed data plots (Figures 3-10).

The following processing and image enhancement functions have been applied to Weaverthorpe, Spaniel Farm dataset (see Appendix 1 for details):

Clip – Clips or limits data to specified maximum or minimum values; to eliminate large noise spikes; also generally makes statistical calculations more realistic for the determination of potential archaeological anomalies (which generally produce lower responses than those for large ferrous features).

In this survey raw data was extremely clean of magnetic interference from modern features thanks to the rural location and the non-magnetic nature of the background geology. Data was clipped to –2/+2nT for processed graphics plots and interpretation in order to best highlight subtle variations in the magnetic response (see Figure 4 and 5).

Despiking – Used to locate and reduce the effects of random ferrous responses in the survey area largely resulting from iron object near to the surface. NB Some features cannot and should not be eliminated using despike and the setting should be applied appropriately. This is typically a result of the strength and shape of the magnetic anomaly.

Some anomalies in the survey area are of this type and despike parameters were chosen accordingly. (The parameters used for the despike process were a radius of X1x Y1 reading for local averaging with a threshold of 3.0. A 'mean spike replacement method' was applied using the despike filter in Geoplot 3.0 software).

Zero Mean Traverse – For removing striping effects in the traverse direction caused by variations in readings caused by the orientation of the sensors; also removes traverse striping caused by abnormally strong responses caused by ferrous pollution. NB the use of Zero

Mean Traverse can sometimes mask or remove natural linear anomalies that run parallel to the traverse direction, and thus it is only applied after reviewing the clipped date for any such responses. For settings see Appendix 2 below.

Interpolation – Increases the number of data points in a survey on one or both axes. In this instance survey data was collected using a 0.25 x 1m sampling interval, and for final graphic preparation clipped and processed data was interpolated on the Y-axis resulting in a smoothed greyscale plot. Geoplot's *sin x/x* interpolation method was used for this process.

5.0 Results.

The raw data is presented here in both *x/y*-trace (Figure 3) and greyscale plots (Figure 4) to give an impression of the full range data statistics. In greyscale representation darker greys to black have been used to represent *nT* values in the higher ranges and lighter greys to represent lower values. Most archaeological and geological responses are of relatively low magnitude with respect to the survey zero. Thus they occupy only a small portion of the total possible range of -100/ +100 nT detected by the gradiometer.

Responses of very high magnitude in the top and bottom end of this usually result from major ferrous objects, and there are only a small number of these in the survey area, mainly along the farm track. The raw data range then spans the range of approximately –60 to +70nT and the raw data plots represent this range.

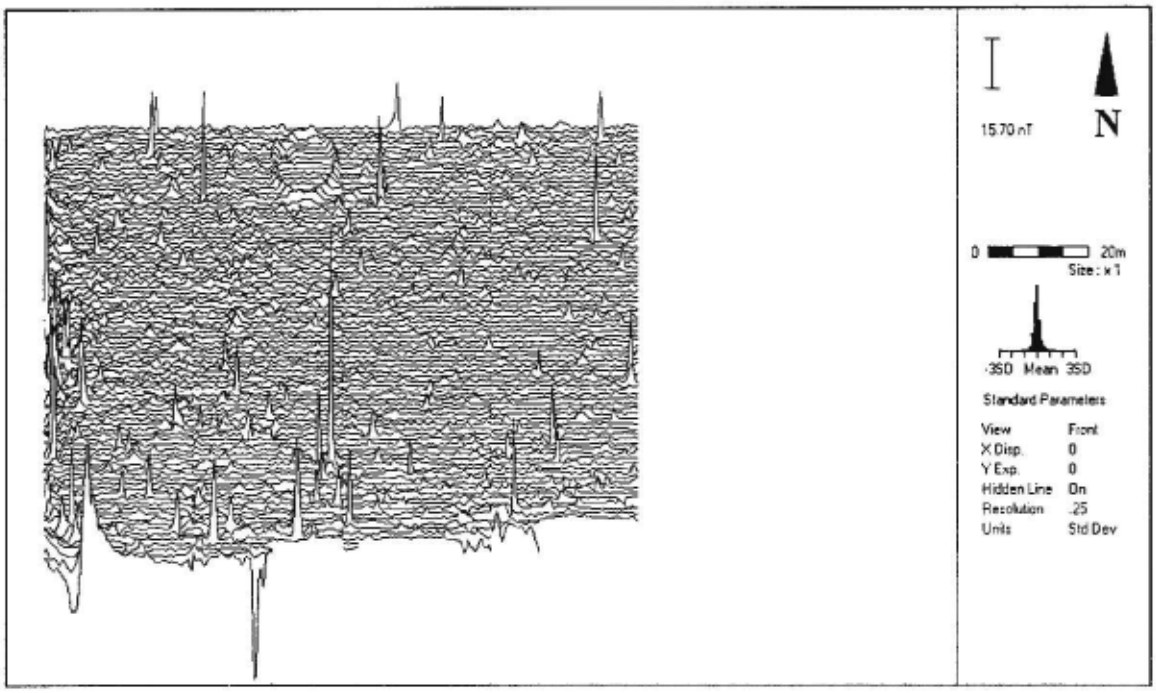

Figure 3. xy-*trace plot of raw results*

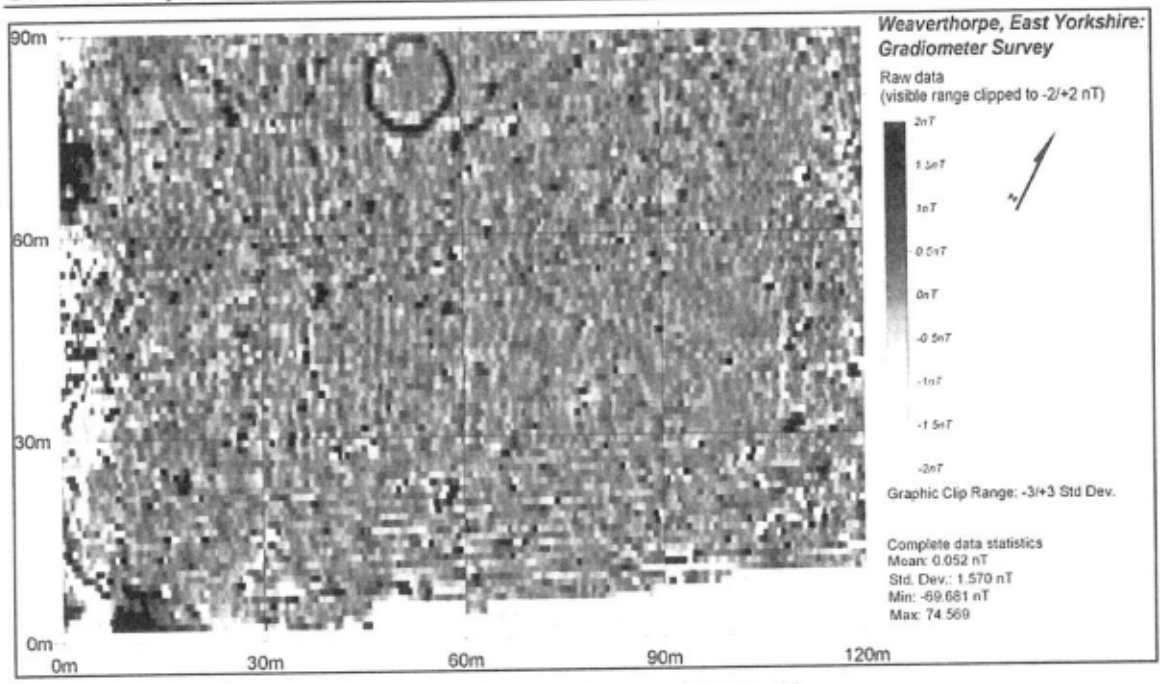

Figure 4. Greyscale plot of raw results (visible greyscale range -25/ +25 nT)

Processing of results was undertaken to eliminate data anomalies. As outlined above, *Data Clip, Despike, ZMT interpolate* were applied initially. The results are displayed in Figures 5 and 6 (data clipped to –1.5/ +1.5nT).

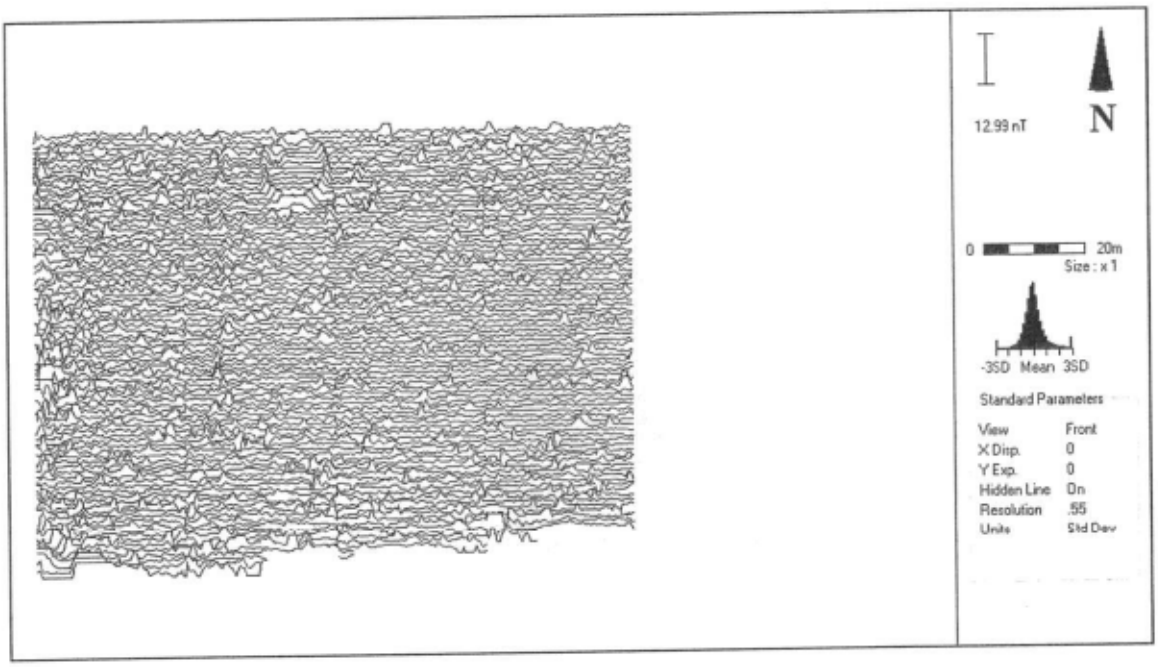

Figure 5. XY Trace plot clipped to –1.5/+1.5 nT

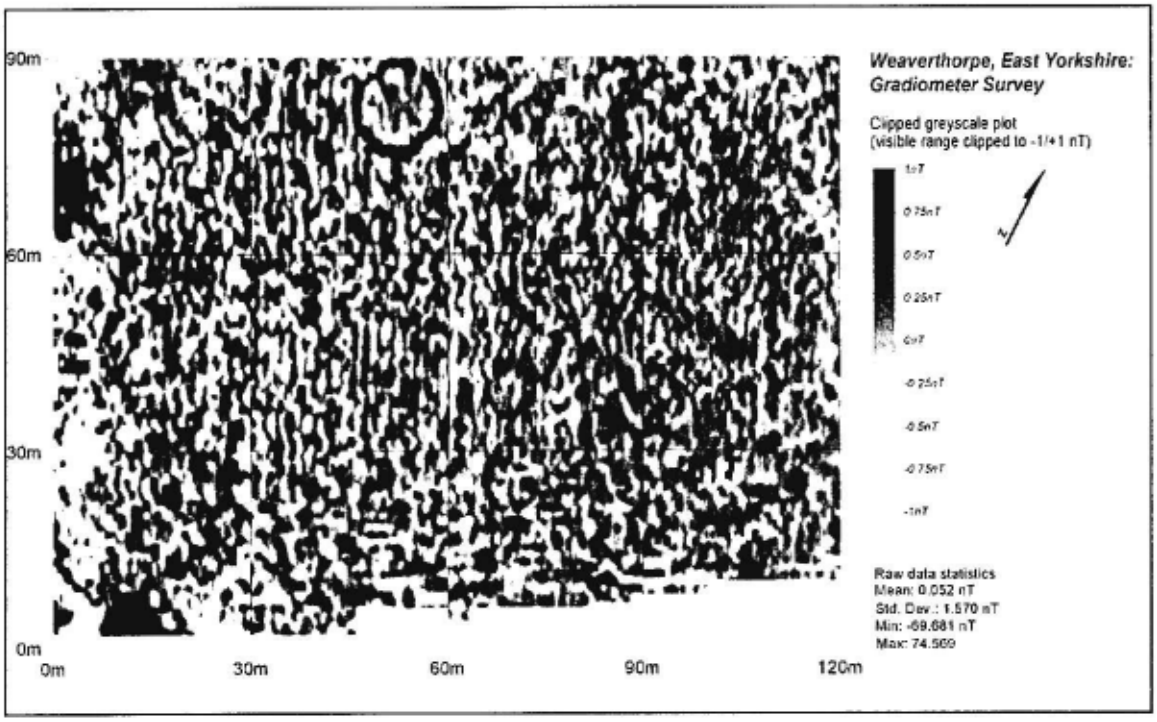

Figure 6. Greyscale plot clipped to –1.5/+1.5 nT

6.0 Interpretation.

Figures 7,8 and 9 illustrate interpretation of anomalies within the survey area

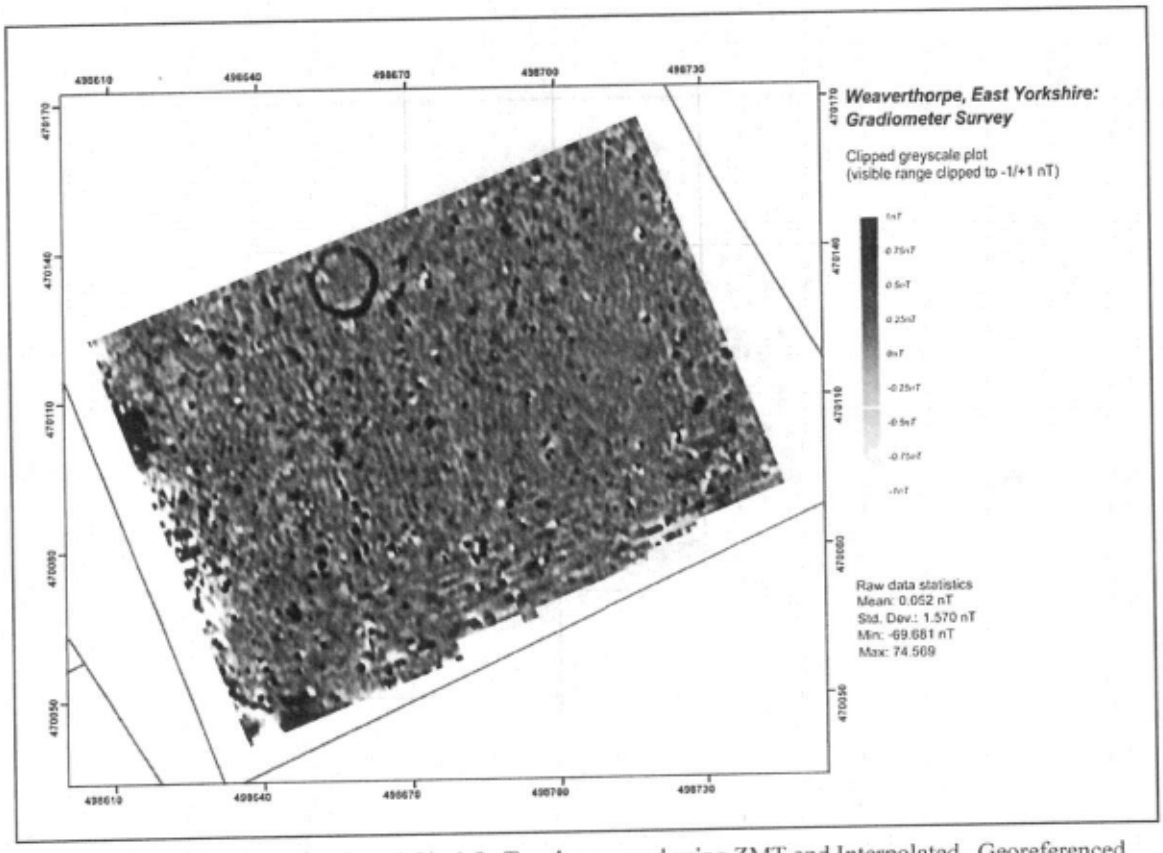

Figure 7. Greyscale plot clipped to –1.5/ +1.5 nT and processed using ZMT and Interpolated. Georeferenced and overlain on OS grid location

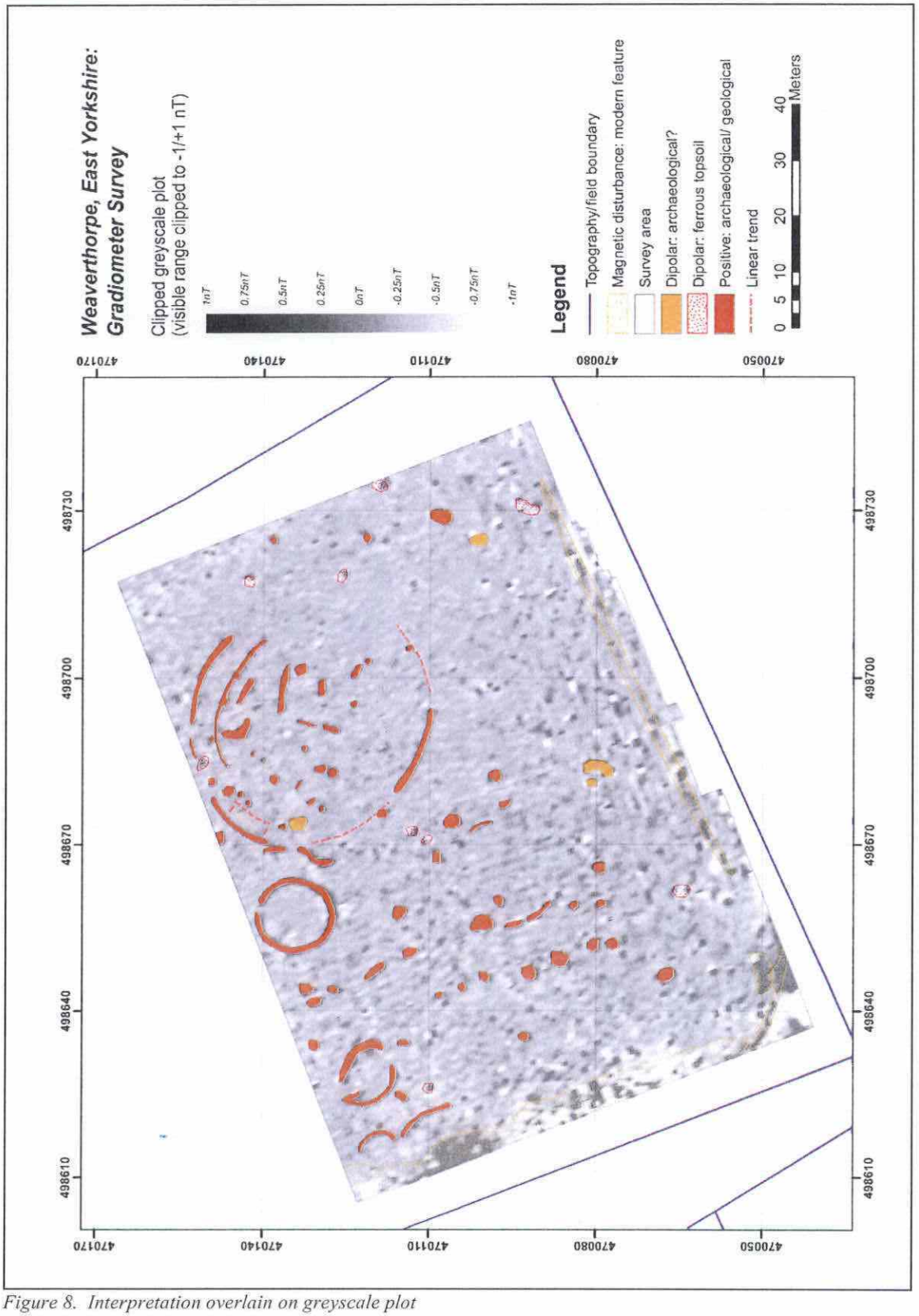

Figure 8. Interpretation overlain on greyscale plot

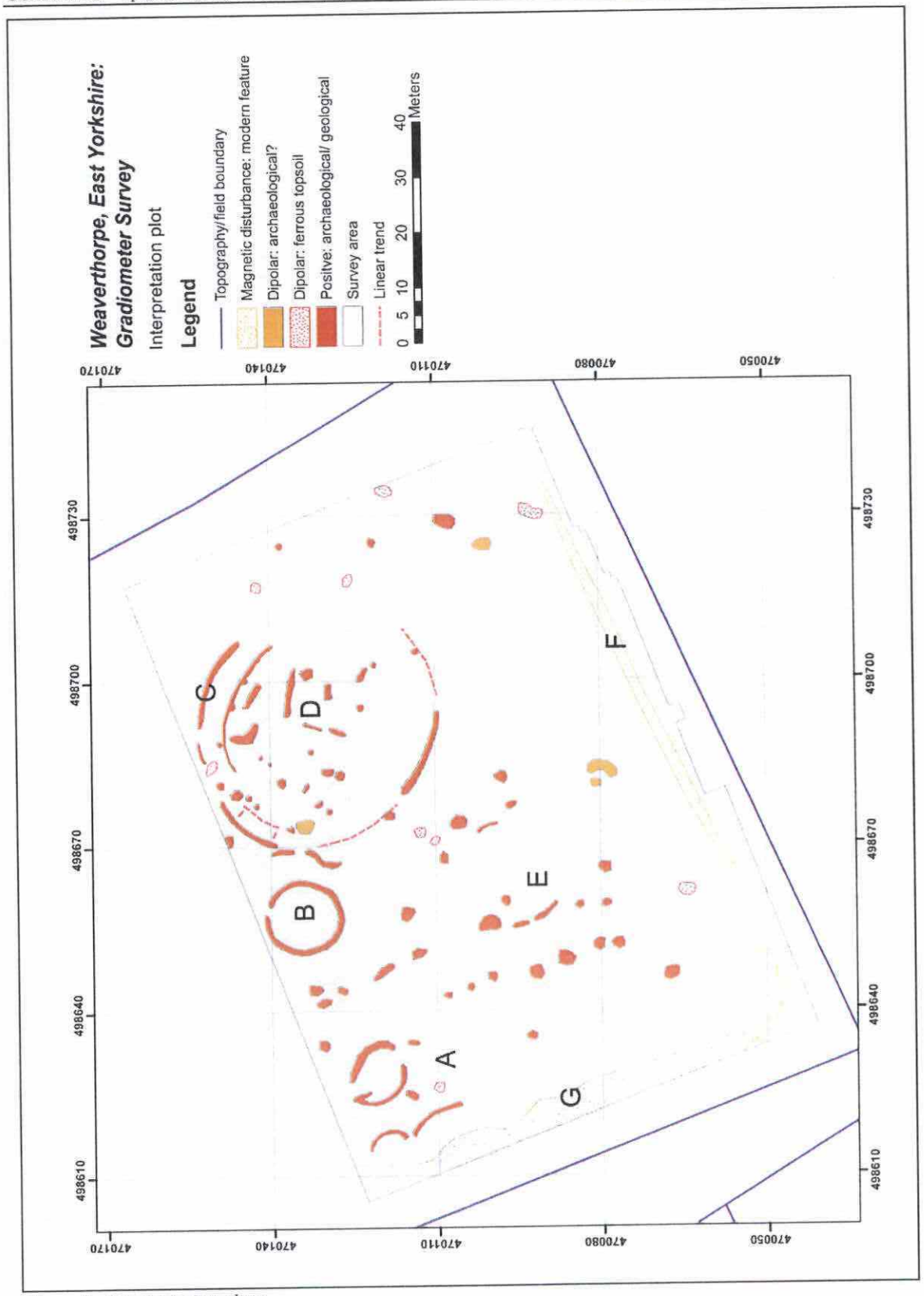

Figure 9. Interpretation alone

The categories of response evident in the survey are a relatively limited due to the relatively 'quiet' magnetic character of the chalk geology and the local environment. Archaeological and geological features are subsequently particularly clear in this chalk landscape, because

even subtle variations in magnetic enhancement can be detected and plotted with accuracy. The associated legend in Figures 8 and 9 contains four categories of response in the survey.

There are several categories of response evident in the survey and they are outlined in the associated legend. In magnetic survey, responses are described by their *nT* value in relation to the survey *zero* or *mean*. Therefore, *positive* refers to elevated or enhanced magnetic values, *negative* refers to lower values, and *dipolar* refers to responses that consist of an elevated peak and a negative trough. Depending on their origin and cause, each of these can exist as linear features, as isolated features, or as area features.

Each type of response results from a combination of the subsurface/ surface conditions, by the depth of the anomaly and by its material composition. In this survey the following general categories of magnetic anomaly were observed:

1. *Dipolar responses associated with ferrous material in topsoil* - A range of isolated dipolar responses across the survey area indicate the likely presence of ferrous objects near the surface in the topsoil. The despike process eliminated many of the smaller responses of this type, but the interpretive plot shows that particularly in the southern half of the survey, many of the responses are of this category. (Typical range -25/+25 *nT* or lower).

2. *Dipolar: service manhole cover, monitoring well, or conduit* – not applicable in this survey.

3. *Dipolar linear: wall or track* - The survey area is bordered on the south and west sides by a farm track which gives off a mixed magnetic response. This has been classified as an area of *Magnetic Disturbance.*

4. *Magnetic enhancement: geological/ archaeological?* - Features of a slightly elevated response with respect to the background mean, and be traced in parts of the survey. They are sometimes of a non-distinct form and may represent either natural or archaeological features, although there are certain responses that can definitely be associated with archaeological features. They are treated individually below where applicable.

5. *Linear tend: archaeological or geological* – Where the response is so subtle as not to show significant contrast with background soils, but where the form or alignment of a feature can be traced in a meaningful way thanks to the uniformity of results, a classification of linear trend has been assigned. This is only the case in a limited context in this survey.

Specific anomalies of note are labelled alphabetically in figure 9. They are as follows:

A. **A series of curvilinear responses**, some of them overlapping. Responses range between 0 nT and 2.5 nT. Very likely archaeological given the proximity to other archaeological features in the survey area. Responses probably represent shallow fills of cut features in chalk geology.

B. **Distinct curvilinear response in from of a ring 15m in diameter**. Results range between +2 and +5 nT and there is a break in the ring on its northern side. Very likely

archaeological, and as in A, represents the elevated magnetic response of soil fills in a feature cut into chalk.

C. **Low magnitude curvilinear response.** Results here are much less clearly defined than B, but their form is traceable nonetheless. This feature appears to constitute an enclosed area with two curvilinear responses defining its boundary. There are several internal features (see D).

D. **Internal features to C.** A series of distinct elevated responses of limited extent. Most range between 2- 4m in diameter. Likely cut features with enhanced fills. Also likely archaeological.

E. **Series of responses similar to D** but arranged roughly in alignment on N/S axis. Likely cut features with elevated magnetic fills.

F. **Area of magnetic disturbance resulting from farm track.** Responses may mask more subtle magnetic variations.

G. **Area of magnetic disturbance resulting from farm track.** Responses may mask more subtle magnetic variations.

7.0 Discussion and Conclusions.

The evaluation has revealed the presence of a number of potentially archaeological anomalies as well as several which likely can be associated with the geological nature and topographic situation of the site.

Of specific note are the curvilinear features in the northern part of the survey area. The likelihood of these being of archaeological significance is high, and given their presence, it is advisable to treat other less clear-cut anomalies of a similar nature as potentially archaeological. These have been indicated on Figure 9.

8.0 Appendix 1: Methodology.

Survey area	Spaniel Farm, Weaverthorpe, East Yorks	
Crop types	Winter barley	
Geology	Cretaceous chalk	
Instrumentation	Bartington Grad 601-2 Leica GPS900	
Software	Geoplot 3.00, ArcGIS 9.3, AutoCAD 2004, ArcGIS 9.3 Surfer	
Survey	Resolution: Sample Interval: Traverse interval: Grid Size: Cell size: Traverse method Survey Date	0.03nT/m used in 100nT range 0.5m 1m 30x30m 1x0.25m Zig-Zag March 2011
Processing	Using Geoplot 3.0 software: Clip, Despike, Zero Mean Grid, Zero Mean Traverse, Interpolation	
Coordinate system	GB Ordnance Survey	
Staff	Ben Gourley, Nick Pearson	

9.0 Appendix 2: Processing Methodology.

All processing and image preparation was done using Geoplot 3.00 software

Data Statistics: min/ max/mean and std dev:

Mean: 0.052 nT

Std. Dev.: 1.57 nT

Min: 69.681

Max: 74.569

Despike: Search radius X=1 Y=1, Threshold: 2.5, Replacement method: Mean

Zero mean traverse: using Threshold Standard Deviation= 0.25

Zero mean traverse: using Geoplot Presets Grid=All, LMS=On. Pos.Threshold = +5, Neg.Threshold = -5.

Interpolate Using Geoplot Sin X/X on y-axis.

10.0 Appendix 3: Equipment used.

Bartington Grad 601- 2 dual fluxgate gradiometer. Data is stored in a non-volatile memory.

Full technical specification is available via http://www.bartington.com/templates/asset-relay.cfm?frmAssetFileID=102

Geoscan Geoplot 3.0 software http://www.geoscan-research.co.uk/page9.html

Leica GPS900 RTK dual frequency GPS. The GPS900 is a dual-frequency, geodetic, real-time RTK receiver with a potential accuracy of Kinematic (phase) Horizontal: 10mm + 1ppm and moving mode after initialisation Vertical: 20mm + 1ppm.

Full technical data and specification for the GPS900 may be obtained from http://www.leica-geosystems.com/en/downloads-downloads-search_74590.htm?search=true&product=GPS900

11.0 Appendix 4: Bibliography.

British Geological Survey *OpenGeoscience* http://maps.bgs.ac.uk/geologyviewer_google/googleviewer.html

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