Cross Lane, Drighlington,

West Yorkshire,

Foul Sewer Requisition,

(SE 2096 2924 to 2180 2929)

Geophysical Survey

Contents

Summary

A geophysical survey, covering 3 hectares, was carried out along the proposed route of a foul water sewer. Anomalies caused by infilled field boundary ditches and modern/medieval ploughing have been identified. A large, isolated, dipolar anomaly could locate a bell pit. It is possible that several of the linear anomalies may have an archaeological origin but without other supporting evidence a more definitive interpretation cannot be given.

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1. Introduction & Archaeological Background

1.1 Archaeological Services WYAS was commissioned by Bradford Metropolitan District Council, Design and Construction Services, to carry out a geophysical (fluxgate gradiometer) survey along the proposed route of a foul water sewer (see Figs 1 and 2).

1.2 There is historical and archaeological significance in the proposed sewer route as it crosses part of the area designated by English Heritage as the site of the Battle of Adwalton Moor (June 30th 1643). This battle was, after Marston Moor, the most important in the north of England during the First Civil War (1642-1646).

1.3 The proposed sewer route crosses seven fields, from the B6135 in the east, to the Inmoor Dike on the western side of the A650. The original specification for archaeological work (see Appendix 4) required a series of test pits to be dug along the proposed route of the sewer. Following discussions between Archaeological Services WYAS, CBMDC and Yorkshire Water (Capital Investment Unit) it was decided to carry out a geophysical survey along the proposed sewer route in advance of the test pitting. It was agreed that, if the results of the geophysical survey warranted it and after consultation with Mr. I. Sanderson of the West Yorkshire Sites and Monuments Record, the test pits could be moved from their original specified locations to target geophysical anomalies of potential archaeological interest.

1.4 The geophysical survey covered the full length of the proposed sewer route that was amenable for survey and, unless the field conditions dictated otherwise, was a minimum of 40m wide. This complied with the English Heritage guidelines for geophysical survey which suggests that in order to reliably interpret the data survey blocks should not be less than 40m wide (David 1995). The line of the survey was located such that the approximate route of the proposed sewer, as supplied by the CBMDC Design and Construction Service, was central to each block (see specification in Appendix 4).

1.5 At the time of survey, between the 9th and 11th of February 2000, the site was under permanent pasture, with the majority of the internal field divisions having some form of ferrous fencing. On all days of the survey there was intermittent heavy rain which made the ground conditions difficult, particularly in the west of the site where the ground was prone to waterlogging.

1.6 The underlying geology of the site is Coal Measure sandstones and shales overlain by approximately 0.35m of sandy/clayey subsoils and topsoils (Keith *et al.* 1998).

1.7 An archaeological assessment of part of the designated battlefield area has previously been undertaken by Archaeological Services WYAS. This comprised an air photo assessment, sample gradiometer and metal detector surveys and test pitting (Keith *et al.* 1998). This assessment provided no evidence of a battlefield site within the area studied.

1.8 The objectives of the survey were to:

- establish the presence and extent of any geophysical anomalies
- to characterise any such anomalies.

2. Results & Discussion

2.1 The gradiometer data is presented in Figure 2 as a greyscale plot superimposed on an Ordnance Survey map base at a scale of 1:2500. Greyscale plots and interpretations are presented in Figures 3 to 6 at a scale of 1:1250. Large scale, 1:500, greyscale and X-Y trace plots of the data, on the Ordnance Survey base, are included as Appendix 5. Further details on the data processing are given in Appendix 1.

2.2 For ease of presentation the survey has been divided into two parts, each part showing two survey blocks.

2.3 Ubiquitous across all the survey blocks are the isolated dipolar responses. These 'iron spike' responses are usually caused by ferrous material in the topsoil and are not thought to be archaeologically significant (see Appendix 1).

2.4 Within each survey block there are groups of broadly parallel positive, linear anomalies that are believed to be caused by ridge and furrow ploughing. This method of ploughing was begun in the medieval period and used a moulder board (rather than a share which was a later development) to turn over the sod. Over time this resulted in the formation of distinctive ridges and furrows. Even after modern ploughing has destroyed any visible trace of these earthworks the magnetic 'signatures' of the ridges can still often be detected as parallel, positive anomalies.

2.5 **Block 1** (Figures 3 and 4)

2.5.1 This survey block lies within the area previously studied by Archaeological Services WYAS (see Keith *et al.* 1998), although only parts of Block 1 were covered during this earlier survey.

2.5.2 Weak, positive, linear anomalies are present with a north-east to south-west orientation. These anomalies correspond with anomalies identified in the 1998 survey which were interpreted as being either ridge and furrow or field drains. Based on the evidence from this survey it is now thought these anomalies are probably caused by ridge and furrow ploughing (see Section 2.4) rather than field drains.

2.6 **Block 2** (Figures 3 and 4)

2.6.1 A small area in the western part of this block was also surveyed during the 1998 assessment (Keith *et al.*). Anomalies attributed to ridge and furrow were detected.

2.6.2 It can be seen that the ridge and furrow identified in Block 1 continues into Block 2 and that the alignment of the anomalies is gradually trending towards a more north/south orientation.

2.6.3 There is a strong, dipolar, linear anomaly, also on the same alignment as the ridge and furrow. This anomaly is caused by wire fencing along a ditched field boundary.

2.6.4 Perpendicular to this ditched boundary there is a strong, positive, linear anomaly. It can be seen that this anomaly is on the same alignment as a current field boundary and may represent the remains of a continuation of this boundary. The 'spiky' response of this anomaly, as seen in the X-Y trace plot indicates sub-surface ferrous or fired material (see Appendix 1) and may indicate that the anomaly is caused by a drain leading into the ditched field boundary.

2.6.5 On the same orientation as this 'spiky' response, but offset to the south-west, there is a weak, positive, linear anomaly. This anomaly is also perpendicular to, and appears to terminate near, an extant ditched field boundary. It can therefore be surmised that this anomaly is probably associated with a modern agricultural regime and is caused by either a field drain or an infilled ditched field boundary. However, the response is also indicative of an infilled archaeological ditch and an archaeological origin cannot be ruled out.

2.7 **Block 3** (Figures 5 and 6)

2.7.1 The most noticeable attribute of this data block is the large number of iron spikes coupled with the very strong areas of magnetic disturbance. In the area where the disturbance is strongest there was visual evidence of building rubble on the surface. The building rubble looked relatively recent and mixed in with it there was modern ferrous and non-ferrous material. It seems probable from the make-up of the rubble and the spread of ferrous material, as indicated by the adjacent concentrations of iron spikes, that the building rubble is *in situ,* although it is possible that the material has been tipped here.

2.7.2 Ridge and furrow is present within Block 3 although it is now has a north-west to south-east orientation. This possibly indicates that the current ditched field boundary between Blocks 2 and 3 re-uses a field boundary that was present at the time of the ridge and furrow.

2.7.3 There are two other positive, linear anomalies with the same orientation as the ridge and furrow. One of these lies directly over the north-eastern field boundary of a narrow field and the other is on the same alignment as the south-western boundary. The north-eastern boundary is a lynchet, sloping to the north-east, and although there is no extant earthwork at the south-western boundary, it is possible that there was at one time. The geophysical survey may therefore be detecting the magnetic vestiges of a ploughed out boundary.

2.8 **Block 4** (Figures 5 and 6)

2.8.1 There are a number of areas of magnetic disturbance at the eastern end of Block 4. The disturbance is generally not as strong as that encountered in Block 3 and there is no evidence of building rubble. Within the areas of disturbance there is a large, isolated, dipolar response. This response indicates the presence of either a very large near-surface ferrous object or a bell pit. Isolated cut features were identified in this area in the 1998 air photo assessment (Keith *et al.*) and, as the local geology is Coal Measures (see section 1.6), then it would not be unreasonable to suggest that these isolated crop-marked features are probably caused by bell pits. It is also probable, therefore, that the isolated magnetic response is caused by a bell pit with the surrounding areas of disturbance being caused by associated industrial activity.

2.8.2 Ridge and furrow is present in Block 4 with the same general orientation as in Block 3.

2.8.3 There is also a series of weaker, parallel, positive, linear anomalies oblique to the ridge and furrow. The relative weakness of these anomalies and the fact that they appear to be much more closely spaced together tends to indicate that they are caused by a modern ploughing regime, or possibly a system of field drains, and are not caused by ridge and furrow.

2.8.4 On the same orientation as these modern agricultural anomalies there are two stronger, positive, linear anomalies. These anomalies may have the same origin as the agricultural anomalies described above and give a stronger response due to better preservation or more favourable soil conditions. However, the responses are more indicative of those anomalies that are caused by field boundaries. It is possible, therefore, that the anomalies represent the remains of former field boundaries.

2.8.5 There are two discontinuous, positive, linear anomalies that have differing orientations to the other linear anomalies. It can be seen that there is a complex pattern of differing agricultural regimes and evidence of industrial activity within this survey block and it is therefore possible that these linear anomalies are associated with any of these differing phases of activity. However, the responses can also be indicative of infilled archaeological ditches and an archaeological origin cannot be completely ruled out.

3. Conclusions

3.1 There has been a great deal of relatively modern activity across the site as evidenced by the high numbers of iron spikes and the areas of magnetic disturbance.

3.2 The magnetic disturbance in the central part of the site (Block 3) is thought to be caused by modern, probably *in situ*, building rubble. The areas of disturbance in the west of the site (Block 4) are thought to be associated with a probable bell pit.

3.3 Anomalies characteristic of different ploughing techniques are present in all parts of the site. There is evidence for ridge and furrow ploughing on two different alignments; some of the current field boundaries still respect these orientations.

3.4 There are linear anomalies present that may have an archaeological origin but they could just as easily be caused by modern features. Without further supporting evidence a more definitive interpretation on the origins of these linear anomalies cannot be made.

The results and subsequent interpretation of geophysical surveys should not be treated as an absolute representation of the underlying archaeological and non-archaeological remains. Confirmation of the presence or absence of archaeological remains can only be achieved by direct investigation of sub-surface deposits. This can be undertaken by means of targeted trial trenching.

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Bibliography

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Figures

Appendices

Appendix 1

Magnetic Survey: Technical Information

1. Magnetic Susceptibility and Soil Magnetism
Iron makes up about 6% of the Earth's crust and is mostly present in soils and rocks as minerals such as maghaemite and haemetite. These minerals have a weak, measurable magnetic property termed magnetic susceptibility. Human activities can redistribute these minerals and change (enhance) others into more magnetic forms so that by measuring the magnetic susceptibility of the topsoil, areas where human occupation or settlement has occurred can be identified by virtue of the attendant increase (enhancement) in magnetic susceptibility. If the enhanced material subsequently comes to fill features, such as ditches or pits, localised isolated and linear magnetic anomalies can result whose presence can be detected by a magnetometer (fluxgate gradiometer).

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 magnetic susceptibility of the soil can also be enhanced significantly by heating. This can lead to the detection of features such as hearths, kilns or burnt areas.

2. Types of Magnetic Anomaly
The types of response mentioned above can be divided into five main categories:

Isolated Dipolar Anomalies (Iron Spikes)
These responses are typically caused by ferrous objects on the surface or in the topsoil. Whilst they could be caused by archaeological artefacts, unless there is supporting evidence for an archaeological interpretation, then little emphasis is given to such anomalies, as modern ferrous objects are common on rural sites, often being present as a consequence of manuring.

Areas of Magnetic Disturbance
These responses can have several causes and are often associated with burnt material, such as industrial waste or other strongly magnetised/fired material. They are usually assumed to have a modern origin unless there is other supporting information. Ferrous fencing can be a major source of magnetic disturbance as they produce very strong magnetic responses that can mask weaker archaeological anomalies.

Positive Curvi/Linear Anomalies
They are commonly caused by infilled ditches which may be archaeologically significant. Former or current agricultural practice can also result in these anomalies.

Isolated Positive Anomalies
These anomalies can exhibit a magnitude of response of between 2nT and 300nT and can be caused by pits or post holes, ovens or kilns. They can also be caused by natural/geological features on certain geologies. It can often be very difficult to establish an anthropogenic origin without intrusive investigation.

Negative Linear Anomalies
These are normally very faint and are commonly caused by features such as plastic water pipes which are less magnetic than the surrounding soils and geology. They too can be caused by natural features on some geologies.

3. Methodology
There are two main methods of using the fluxgate gradiometer for commercial evaluations. The first of these is referred to as *scanning* and requires the operator to visually identify anomalous responses on the instrument display panel whilst covering the site in widely spaced traverses, typically 10-15m apart. The instrument logger is not used and there is therefore no data collection. Once anomalous responses are identified they are marked in the field with bamboo canes and approximately located on a base plan. This method is usually employed as a means of selecting areas for detailed survey when only a percentage sample of the whole site is to be subject to detailed survey. In favourable circumstances scanning may be used to map out the full extent of features located during a detailed survey.

The second method is referred to as *detailed survey* and employs the use of a sample trigger to automatically take readings at predetermined points, typically at 0.5m intervals, on zig-zag traverses 1m apart. These readings are stored in the memory of the instrument and are later dumped to computer for processing and interpretation.

The Geoscan FM36 fluxgate gradiometer and ST1 sample trigger were used for the detailed gradiometer survey. Readings were taken, on the 0.1nT range, at 0.5m intervals on zig-zag traverses 1m apart within 20m by 20m square grids.

4. Data Processing and Presentation
The detailed gradiometer data has been presented in this report in X-Y trace and greyscale formats. The former option shows the ‘raw’ data with no processing other than grid biasing whilst in the latter the data has been selectively filtered to remove spurious errors such as striping effects and edge discontinuities caused by instrument drift and inconsistencies in survey technique caused by poor field conditions.

An X-Y plot presents the data logged on each traverse as a single line with each successive traverse incremented on the Y-axis to produce a stacked plot. A hidden line algorithm has been employed to block out lines behind major ‘spikes’ and the data has been clipped at 10nT. The main advantage of this display option is that the full range of data can be viewed, dependent on the clip, so that the shape of individual anomalies can be discerned and potentially archaeological anomalies differentiated from ‘iron spikes’. In-house software (XY3) was used to create the X-Y trace plots.

In-house software (Geocon 9) was used to interpolate the data so that 1600 readings were obtained for each 20m by 20m grid. Contors software was used to produce the greyscale images in which maximum and minimum cut-off limits have been chosen to best present the data; in both these display options the data is displayed using a linear incremental scale.

Appendix 2

Survey Location Information

The approximate route of the proposed sewer, as supplied by the CBMDC Design and Construction Service (see specification in Appendix 4), was digitised onto an Ordnance Survey digital map base.

The line of the geophysical was then located such that the approximate route of the proposed sewer, as supplied by the CBMDC Design and Construction Service, was central to each survey block. Ordnance Survey co-ordinates were thus obtained for the corners of each survey block. Temporary marker pegs, with known and Ordnance Survey co-ordinates were present in the site from the 1998 archaeological assessment (Keith *et al.*). Using these marker pegs as reference points the geophysical survey grid was set out using a Geotronics Geodimeter 600 series total station theodolite.

The location of the temporary marker pegs and geophysical survey blocks is shown on an Ordnance Survey digital map base in Figure 2. Ordnance Survey grid co-ordinates are supplied for the temporary marker pegs.

Archaeological Services WYAS cannot accept responsibility for errors of fact or opinion resulting from data supplied by a third party.

Appendix 3

Geophysical Archive

The geophysical archive comprises:-

- an archive disk containing the raw data, grid location information, report text (Word 6), and compressed (AutoCAD 2000) files of the graphics
- a full copy of the report

At present the archive is held by Archaeological Services WYAS although it is anticipated that it will eventually be lodged with the Archaeology Data Service (ADS). Brief details will also be forwarded for inclusion on the English Heritage Geophysical Survey Database (no information on the client shall be included) after the contents of the report are deemed to be in the public domain (*i.e.* available for consultation in the relevant Sites and Monument Record Office).

Appendix 4

Specification for archaeologically controlled test pitting

This is included as Appendix IV in Smith, A., 2000, 'Cross Lane Drighlington, West Yorkshire, Foul Sewer Requisition, Archaeological Evaluation', West Yorkshire Archaeology Service, Unpubl. (WYAS R789).

Appendix 5

Geophysical Data Plots (1:500)