Archaeological Services
University of Durham

Land at Eastgate Renewables Village, Weardale, Co Durham

geophysical surveys

on behalf of
Entec UK Ltd

Report 1808
January 2008

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Canon Court North, Abbey Lawn, Abbey Foregate, Shrewsbury SY2 5DE

Contents

1. Summary

The project

1.1 This report presents the results of geophysical surveys conducted in advance of the proposed development of land to the south of the former Blue Circle Cement Works at Eastgate, Weardale, County Durham. The works comprised ten geomagnetic surveys covering a total area of 5ha.

1.2 The works were commissioned by Entec UK Ltd and conducted by Archaeological Services.

Results

1.3 Several probable former pit features (and possible ditches) have been identified, although given the previous quarrying and mining works on the site they are more likely to relate to these activities than earlier archaeological activities.

1.4 Areas of probable mining waste and recent former field boundaries have also been detected.

1.5 An intrusive igneous dyke has been identified in Areas 1 and 9.

2. Project background

Location (Figure 1)

2.1 The study area is located to the south of the former Blue Circle cement works at Eastgate, Weardale, Co Durham (NGR centre: NY 950380) and is bounded by the River Wear to the north, farmland and former quarrying works to the south and farmland to the east and west. The ten survey areas are located on the north-facing slope of the valley.

Development proposal

2.2 The proposed development comprises a Renewable Energy Village at the old cement works. As part of the development trees and scrub will be planted on the hillside.

Objective

2.3 The principal aim of the surveys was to assess the nature and extent of any sub-surface features of potential archaeological significance within the proposed development area, so that an informed decision may be made regarding the nature and scope of any further scheme of archaeological works that may be required in advance of development.

Methods statement

2.4 The surveys have been undertaken in accordance with a specification provided by Entec UK Ltd and a written scheme of investigation (WSI) provided by Archaeological Services and approved by the County Archaeology Officer.

Dates

2.5 Fieldwork was undertaken between 10th and 16th January 2008. This report was prepared between 17th and 25th January 2008.

Personnel

2.6 Fieldwork was conducted by Edward Davies and Richie Villis (Supervisor). This report was prepared by Richie Villis with illustrations by Janine Wilson and edited by Duncan Hale, the Project Manager.

Archive/OASIS

2.7 The site code is **DEW08**, for **D**urham, **E**astgate, **W**eardale 20**08**. The survey archive will be supplied on CD to Entec UK Ltd for deposition with the project archive. Archaeological Services is registered with the **O**nline **A**cces**S** to the **I**ndex of archaeological investigation**S** project (OASIS). The OASIS ID number for this project is **archaeol3-36845**.

Acknowledgements

2.8 Archaeological Services is grateful for the assistance of tenants and personnel of Lafarge in facilitating this scheme of works.

3. Archaeological and historical background

3.1 Previous archaeological surveys have identified low earthwork features on the hillside. These relate to former lead mining remains, settlements and field systems.

3.2 To the north of the survey areas is the former site of the Weardale Cement Works. Limestone quarrying was also carried out on the hillside.

4. Landuse, topography and geology

4.1 Ten surveys were undertaken in eight land parcels, on a north-facing slope, as shown below.

Area	Grid reference at centre (NGR)	Height at centre (m OD)	Land use	Comments
1	NY 944 378	308	pasture/moorland	very hilly and steep; concrete and metal base and metal and wooden industrial waste
2	NY 941 379	287	pasture/moorland	steep and hilly
3	NY 938 376	305	pasture/moorland	very wet and muddy, including a stream
4	NY 952 379	319	pasture/moorland	very steep, rough terrain
5	NY 951 379	321	pasture/moorland	very steep, rough terrain
6	NY 953 376	360	pasture/moorland	waterlogged area with high vegetation
7	NY 954 378	323	pasture/moorland	steep with old drystone wall field boundary running east to west
8	NY 955 379	306	pasture/moorland	steep rough terrain with waterlogged areas to south at bottom of slope
9	NY 951 380	286	pasture/moorland	very steep and rolling terrain with waterlogged areas and metal field boundaries to south and east
10	NY 950 381	258	pasture/moorland	very steep and rough terrain with waterlogged areas

				and trees

4.2 The underlying solid geology of the area comprises Carboniferous Limestone Series, with an intrusive igneous dyke aligned approximately east-west.

5. Geophysical survey

Standards

5.1 The surveys and reporting were conducted in accordance with English Heritage Research and Professional Services Guideline No.1, *Geophysical survey in archaeological field evaluation* (David 2008 forthcoming); the Institute of Field Archaeologists Technical Paper No.6, *The use of geophysical techniques in archaeological evaluations* (Gaffney, Gater & Ovenden 2002); and the Archaeology Data Service *Geophysical Data in Archaeology: A Guide to Good Practice* (Schmidt 2001).

Technique selection

5.2 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 resistance, 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.

5.3 In this instance, based on previous archaeological survey work, it was considered likely that cut features, such as ditches and pits, might be present on the site, and that other types of feature such as former land boundaries, trackways, wall foundations and fired structures (for example kilns and hearths) might also be present.

5.4 Given the anticipated shallowness of targets and predominantly non-igneous geological environment of the study area a geomagnetic technique, fluxgate gradiometry, was considered appropriate for detecting each of the types of feature mentioned above. This technique involves the use of hand-held magnetometers to detect and record minute anomalies in the vertical component of the Earth's magnetic field caused by variations in soil magnetic susceptibility or permanent magnetisation; such anomalies can reflect archaeological features.

Field methods

5.5 Ten areas were surveyed, each measuring approximately 0.5ha.

5.6 A 20m grid was established across each survey area and tied-in to known, mapped Ordnance Survey points using a Trimble Pathfinder Pro XRS global positioning system (GPS) with real-time correction.

5.7 Measurements of vertical geomagnetic field gradient were determined using Bartington Grad601-2 dual fluxgate gradiometers. A zig-zag traverse scheme was employed and data were logged in 20m grid units. The instrument sensitivity was set to 0.1nT, the sample interval to 0.25m and the traverse interval to 1.0m, thus providing 1600 sample measurements per 20m grid unit.

5.8 Data were downloaded on site into a laptop computer for initial processing and storage and subsequently transferred to a desktop computer for processing, interpretation and archiving.

Data processing

5.9 Geoplot v.3 software was used to process the geophysical data and to produce both continuous tone greyscale images and trace plots of the raw (unfiltered) data. The greyscale images and interpretations are presented in Figures 2-7; the trace plots are provided in Figure 8. In the greyscale images, positive magnetic anomalies are displayed as dark grey and negative magnetic anomalies as light grey. A palette bar relates the greyscale intensities to anomaly values in nanoTesla.

5.10 The following basic processing functions have been applied to each dataset:

clip	clips, or limits data to specified maximum or minimum values; to eliminate large noise spikes; also generally makes statistical calculations more realistic.
zero mean traverse	sets the background mean of each traverse within a grid to zero; for removing striping effects in the traverse direction and removing grid edge discontinuities.
destagger	corrects for displacement of anomalies caused by alternate zig-zag traverses.
interpolate	increases the number of data points in a survey to match sample and traverse intervals. In this instance the gradiometer data have been interpolated to 0.25 x 0.25m intervals.

Interpretation: anomaly types

5.11 Colour-coded geophysical interpretation plans are provided. Three types of geomagnetic anomaly have been distinguished in the data:

positive magnetic	regions of anomalously high or positive magnetic field gradient, which may be associated with high magnetic susceptibility soil-filled structures such as pits and ditches.
negative magnetic	regions of anomalously low or negative magnetic field gradient, which may correspond to features of low magnetic susceptibility such as wall footings and other concentrations of sedimentary rock or voids.
dipolar magnetic	paired positive-negative magnetic anomalies, which typically reflect ferrous or fired materials (including

fences and service pipes) and/or fired structures such as kilns or hearths.

Interpretation: features

General comments

5.12 Colour-coded archaeological interpretation plans are provided.

5.13 Except where stated otherwise in the text below, positive magnetic anomalies are taken to reflect relatively high magnetic susceptibility materials, typically increased soil thicknesses or sediments in cut archaeological features (such as furrows, ditches or pits) whose magnetic susceptibility has been enhanced by decomposed organic matter or by burning.

5.14 Small, discrete dipolar magnetic anomalies have been detected in all of the survey areas. These almost certainly reflect items of near-surface ferrous and/or fired debris such as mining debris, horseshoes and brick fragments, and in most cases have little or no archaeological significance. A sample of these is shown on the geophysical interpretation plans, however, they have been omitted from the archaeological interpretation plans and the following discussion.

Area 1

5.15 Two amorphous positive magnetic anomalies have been detected in the eastern half of the area and one sub-circular anomaly in the north. These could represent soil-filled archaeological features such as pits, however, they are probably associated with the former quarrying works on the site.

5.16 The majority of the central part of the area contains a large amorphous dipolar magnetic anomaly; this corresponds to the location of a known intrusive igneous dyke.

5.17 The northern part of the area contains two large areas of dipolar magnetic anomalies. The western anomaly corresponds to a reinforced concrete slab and ferrous waste visible on the ground, probably associated with former quarrying. The eastern anomaly almost certainly reflects further sub-surface ferrous waste and quarry spoil.

Area 2

5.18 An alignment of dummy readings indicates where it was not possible to collect data due to a sudden steep break in slope.

5.19 Two curvilinear positive magnetic anomalies have been detected in this area. These anomalies reflect relative increases in high magnetic susceptibility materials and could represent increased depths of topsoil, as opposed to ditches, since both correspond to sharp breaks of slope noted on the ground.

Area 3

5.20 A relatively strong linear positive magnetic anomaly, oriented broadly northwest-southeast, was detected in the western part of the area. This could

represent a soil-filled feature such as a ditch and corresponds to an old field boundary shown on 1970s OS maps.

5.21 A weaker linear positive magnetic anomaly also traverses the area northwest-southeast and a second positive magnetic anomaly is aligned perpendicular to it, forming a T-shape. These probably represent soil-filled features, possibly ditches. Quarrying and mining features have previously been identified within the survey area and it is likely that these anomalies relate to those activities.

5.22 An alignment of weak positive magnetic anomalies has been detected in the northwestern corner of the area; these anomalies correspond to the location of an unmetalled track noted on the ground.

5.23 Several amorphous and sub-circular positive magnetic anomalies have been detected throughout the area; these are likely to reflect soil-filled pits, probably related to the former quarrying or mining works.

5.24 Two large dipolar magnetic anomalies have been identified, one in the west and one in the east. These are likely to reflect ferrous waste associated with the former mining or quarrying works.

Area 4

5.25 Two weak linear positive magnetic anomalies were detected, which could reflect topographic variation noted during survey; both relate to steep changes in the terrain.

5.26 A large sub-circular area of dipolar magnetic anomalies was detected in a slight hollow in the northern half of the site. These anomalies almost certainly reflect ferrous debris. This feature has previously been identified as former quarrying or mining works.

Area 5

5.27 A large dipolar magnetic anomaly was detected in the northwest of the area. This location corresponds to the northern end of a clearly visible earthwork containing large stones. This is almost certainly a former quarry/mining feature.

5.28 A linear positive magnetic anomaly was detected oriented broadly east-west. This could reflect a soil-filled ditch, possibly associated with quarrying.

5.29 A series of parallel, extremely weak, positive magnetic anomalies here may reflect soil-creep.

Area 6

5.30 Very little was detected in this area. A number of small dipolar magnetic anomalies was detected; these anomalies are likely to reflect ferrous waste.

Area 7

5.31 The east-west oriented line of dummy readings fringed by small dipolar magnetic anomalies corresponds to a former field boundary clearly evident as a collapsed dry-stone wall.

Area 8

5.32 Two amorphous concentrations of small dipolar magnetic anomalies were detected. These are likely to represent former quarrying or mining waste.

Area 9

5.33 This area is characterized by large dipolar magnetic anomalies, which correspond to a known igneous dyke, also detected in Area 1.

Area 10

5.34 A number of small sub-circular positive magnetic anomalies have been detected across the area. These could be soil-filled features such as pits.

5.35 A series of dummy readings in the eastern half of the area corresponds to a line of trees and shrubs.

6. Conclusions

6.1 Ten geomagnetic surveys have been conducted on land at Eastgate, Weardale, County Durham, in order to identify possible areas of archaeological potential in advance of proposed tree-planting.

6.2 Several probable former pit features (and possible ditches) have been identified, although given the previous nature of the quarrying and mining works on the site they are more likely to relate to these activities than earlier archaeological activities.

6.3 Areas of probable mining waste and recent former field boundaries have also been detected.

6.4 An intrusive igneous dyke has been identified in Areas 1 and 9.

7. Sources

David, A, 2008 forthcoming *Geophysical survey in archaeological field evaluation,* Research and Professional Services Guideline **1**, English Heritage

Gaffney, C, Gater, J, & Ovenden, S, 2002 *The use of geophysical techniques in archaeological evaluations*, Technical Paper **6**, Institute of Field Archaeologists

Schmidt, A, 2001 *Geophysical Data in Archaeology: A Guide to Good Practice*, Archaeology Data Service, Arts and Humanities Data Service

Appendix I: Written Scheme of Investigation

Archaeological Services
University of Durham

ref. **DH 07.361**
20th December 2007

Land at Eastgate Renewables Village, Weardale, Co Durham
Written Scheme of Investigation for geophysical survey

On behalf of:
Entec UK Ltd, FAO Mr Simon Atkinson
Canon Court North, Abbey Lawn, Abbey Foregate, Shrewsbury SY2 5DE

1. Introduction

1.1 Entec have requested a written scheme of investigation (WSI) for undertaking detailed geomagnetic surveys on land at Eastgate in Weardale, prior to possible development.

1.2 A number of visible earthwork features have previously been identified in an area destined for tree-planting. The planting can be designed to avoid known archaeological remains but the extent of the sub-surface remains has yet to be determined.

1.3 Entec have suggested geophysical survey of sample blocks on the periphery of the known archaeological features to record anomalies associated with them and then to determine whether or not these extend beyond the known areas. Provision is also made for further survey depending on initial results. Initial surveys are to cover 5ha, with provision for a further 5ha.

1.4 It is understood that access arrangements and digital mapping will be supplied by Entec.

2. Capability statement

Archaeological Services

2.1 Archaeological Services Durham University is geared towards both research and commercial projects, particularly for the environmental and development industries, and has an established record of working with English Heritage, Historic Scotland, CADW, Ministry of Defence, Highways Agency, The National Trust, National Park Authorities, County and City Councils and many private corporations, developers, architects and environmental consultants.

2.2 We have considerable experience in managing and conducting projects of any scale, and have successfully completed over 1,600 projects during the last thirteen years.

2.3 Archaeological Services incorporates a range of in-house specialist services and laboratories, which are regularly employed by other archaeological and environmental contractors. Geophysical surveying is one such service.

Geophysical Survey Services

2.4 We undertake geophysical surveys for a wide variety of commercial and academic clients throughout the UK and abroad. We conduct several hundred hectares of geophysical survey each year for proposed developments including utilities, mineral extraction schemes, road improvements, flood alleviation schemes, wind farms and housing and industrial developments. The largest of these recent schemes has entailed the detailed survey of over 230ha along the A1(T) road between Dishforth and Barton in North Yorkshire.

2.5 The service is managed by Duncan Hale BA AIFA (Project Manager), an expert in works of this type, who has conducted some 650 geophysical survey projects during the past sixteen years across the UK, Ireland and Egypt, with some projects involving over 100 separate surveys. Duncan is a consultant for the forthcoming revised edition of the English Heritage geophysical survey guidelines. He is assisted by Graeme Attwood BA, Lorne Elliott BSc and Natalie Swann BSc, who have been conducting surveys of this type for Archaeological Services over recent years. These project leaders are supported by qualified, experienced members of our team using state-of-the-art field instruments and software; an additional six members of our field team are specifically trained in geophysical survey techniques, data processing and interpretation. This provides a sound resource base and enables a rapid response to clients' requirements.

2.6 The majority of our surveys have involved the use of fluxgate gradiometers (magnetic) and/or electrical resistance meters (resistivity). We can also conduct electromagnetic surveys using EM31 meters, ground-penetrating radar (GPR) surveys and electrical resistivity profiling.

2.7 All our geophysical work is carried out in accordance with English Heritage Research and Professional Services Guideline No.1, *Geophysical survey in archaeological field evaluation* (revised edition, forthcoming); the Institute of Field Archaeologists Paper No.6, *The use of geophysical techniques in archaeological evaluations* (Gaffney *et al*. 2002); and the Archaeology Data Service *Geophysical Data in Archaeology: A Guide to Good Practice* (Schmidt 2001).

2.8 Recent examples of large geophysical survey projects include:

- 2007 Edwalton, Nottingham, 60ha
- 2007 East Swindon Development, 37ha
- 2007 Radlett, St Albans, Herts, 50ha
- 2007 Butterwick Moor, Co Durham, 33ha
- 2007 Whitehill Gas Storage Project, East Yorkshire, 86ha
- 2004-07 A1 Dishforth to Barton, North Yorkshire, 232ha
- 2006 Potland Burn, Northumberland, 110ha
- 2006 Dallington Grange, Northampton, 100ha
- 2006 Wilburton, Cambridgeshire, 85ha
- 2006 Swindon, Wiltshire, 45ha
- 2006 Seghill, Northumberland, 30ha
- 2006 Steads Burn, Northumberland, 30ha
- 2005 Innsworth, Gloucester, 75ha
- 2005 Harlow, Essex, 40ha
- 2004-05 Northallerton FAS, North Yorkshire, 90ha

2.9 All our survey reports are available in county Historic Environment Record (HER) offices and through OASIS (the Online AccesS to the Index of archaeological investigationS project); some are also published in journals, monographs and books.

3. Timetable

3.1 Archaeological Services could commence survey in the week beginning 1st January 2008, or at an agreed date thereafter .

3.2 Interim results will be provided within five days of completion of the initial surveys. Following discussion with Entec, either additional survey will be undertaken or a full report will be produced.

4. Methods statement

Technique selection

4.1 Geophysical surveying enables the relatively rapid and non-invasive identification of potential archaeological features 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.

4.2 Given the anticipated depth of targets, and the non-igneous strata of the study area, a geomagnetic technique (fluxgate gradiometry) is considered appropriate in this instance. Fluxgate gradiometry involves the use of hand-held magnetometers to detect and record minute anomalies in the vertical component of the Earth's magnetic field caused by variations in soil magnetic susceptibility or permanent magnetisation; such anomalies can reflect archaeological features.

Fieldwork

4.3 The surveys will be conducted on a 30m grid, which will be established and recorded using a Trimble Pathfinder Pro XRS global positioning system (GPS) with real-time correction.

4.4 Measurements of vertical geomagnetic field gradient will be determined using Bartington Grad601-2 dual fluxgate gradiometers. A zig-zag traverse scheme will be employed and data logged in 30m grid units. The sample interval will be set to 0.25m and the traverse interval to 1m, thus providing 3600 measurements per 30m grid unit.

4.5 Data will be downloaded on-site into laptop computers for verification, initial processing and storage and subsequently transferred to a desktop computer for further processing, interpretation and archiving. Geoplot software will be used to process and interpolate the data to form arrays of regularly-spaced values at 0.25m x 0.25m intervals and to produce continuous-tone greyscale images and trace plots of the raw (unfiltered) data, as appropriate.

Reporting

4.6 Interim reports can be provided during the project, on request. At the end of fieldwork a full report will be prepared suitable for submission to Entec, their client and the local authority. Two bound copies of the final report, together with a digital version in pdf format, will be provided to Entec. One hard copy and a digital version of the report will also be supplied to the county HER office. An OASIS form will also be submitted.

4.7 The greyscales will be presented by importing the images directly into digital plans of the area, to be supplied by the client. Palette bars relating the greyscale/trace intensities to anomaly values in nanoTesla will be included with each image. Other types of plots may also be provided, if they aid presentation or interpretation. Colour-coded geophysical and archaeological interpretation plans will be provided. The survey report will also include a detailed discussion and interpretation, explaining the likely nature of the anomalies, along with their implications. Modern services and other potential hazards will be clearly distinguished.

4.8 The report will be based on the following format:

1. Executive summary
    - 1.1 The project
    - 1.2 Results
    - 1.3 Recommendations
2. Project background
    - 2.1 Location
    - 2.2 Development proposal
    - 2.3 Objective
    - 2.4 Specification summary
    - 2.5 Dates
    - 2.6 Personnel
    - 2.7 Acknowledgements
    - 2.8 Archive
3. Archaeological and historical background
4. Landuse, topography and geology
5. Geophysical survey
    - 5.1 Technique selection
    - 5.2 Field methods
    - 5.3 Data processing
    - 5.4 Interpretation: anomaly types
    - 5.5 Interpretation: features
6. Discussion
7. Recommendations
8. References

Appendix I: Trace plots of geomagnetic data

Archive

4.9 A survey archive will be produced on CD containing copies of the report, raw data files and metadata. This will be lodged with client for deposition with the project archive in due course.

5. Insurance details

5.1 Durham University is a member of UM Association Limited and maintains the following covers:

- Employer's liability £25,000,000 Cert. no. ELY108951496/050
- Public & products liability £25,000,000 Cert. no. UM050/00
- Professional indemnity £10,000,000 Cert. no. UM050/00
- Contractor's 'all risks' £ 1,000,000 Cert. no. UM0 50/00

6. Health & Safety

6.1 Archaeological Services abides by the 1974 Health and Safety Act, its subsequent amendments, and the 2007 Construction Design and Management Regulations. All Archaeological Services field projects are carried out in accordance with the

SCAUM manual Health and Safety in Field Archaeology (2007), and with the University of Durham's Health and Safety Policy and Code of Practice for Safety in Fieldwork.

6.2 Archaeological Services provides health and safety training for all our field personnel in first aid, manual handling, cable detection, site safety and risk assessment. Archaeological Services ensures that all personnel pass the CITB Construction Skills Health and Safety Test and subsequently become CSCS card-carriers (Construction Skills Certification Scheme).

6.3 Archaeological Services will provide qualified First Aiders and First Aid supplies at all times during work. All staff members are supplied with appropriate safety clothing and equipment. A Risk Assessment will be completed before works commence, and all personnel will receive an appropriate Health and Safety induction talk before starting on site.

7. Copyright

7.1

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