magnitude surveys

Geophysical Survey Report

Of

Darlington Crematorium,

County Durham

For

Solstice Heritage LLP

On Behalf Of

Align Property Partners

Magnitude Surveys Ref: MSNZ613

January 2020

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Issue Date:

24 January 2020

Abstract

Magnitude Surveys was commissioned to assess the subsurface archaeological potential of a c.2.24ha area of land at Darlington Crematorium, Darlington, County Durham. A fluxgate gradiometer survey was successfully completed across the site. No anomalies suggestive of significant archaeological features were identified. Anomalies related to historical agricultural use have been detected and interpreted as former field boundaries. The impact of modern activity on the results consists of ferrous 'haloes' caused by proximity to properties bordering the site and magnetic spread due to debris in the area at the time of survey. A series of pit-like and linear anomalies have been identified to the north-east of the survey area but are of undermined origin.

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1. Introduction

1.1. Magnitude Surveys Ltd (MS) was commissioned by Solstice Heritage LLP on behalf of Align Property Partners to undertake a geophysical survey on a c.2.24ha area of land at Darlington Crematorium, Darlington, County Durham (NZ 2685 1388).

1.2. The geophysical survey comprised hand-carried GNSS-positioned fluxgate gradiometer survey.

1.3. The survey was conducted in line with the current best practice guidelines produced by Historic England (David et al., 2008), the Chartered Institute for Archaeologists (CIfA, 2014) and the European Archaeological Council (Schmidt et al., 2015).

1.4. It was conducted in line with a WSI produced by MS (Magnitude Surveys, 2020). The survey was undertaken in accordance with the county guidelines for archaeological survey (Geophysics) (DCCAS, 2019).

1.5. The survey commenced on 20/01/2020 and took one day to complete.

2. Quality Assurance

2.1. Magnitude Surveys is a Registered Organisation of the Chartered Institute for Archaeologists (CIfA), the chartered UK body for archaeologists, and a corporate member of ISAP (International Society of Archaeological Prospection).

2.2. Director Dr. Chrys Harris is a Member of CIfA, has a PhD in archaeological geophysics from the University of Bradford and is the Vice-Chair of ISAP. Director Finnegan Pope-Carter is a Fellow of the London Geological Society, the chartered UK body for geophysicists and geologists, as well as a member of GeoSIG, the CIfA Geophysics Special Interest Group. Reporting Analyst Dr. Kayt Armstrong has a PhD in archaeological geophysics from Bournemouth University, is the Vice Conference Secretary and Editor of ISAP News for ISAP, and is the UK Management Committee representative for the COST Action SAGA.

2.3. All MS managers have relevant degree qualifications to archaeology or geophysics. All MS field and office staff have relevant archaeology or geophysics degrees and/or field experience.

3. Objectives

The objective of this geophysical survey is to assess the subsurface archaeological potential of the survey area.

4. Geographic Background

4.1. The site is located c.1.9Km west from Darlington, County Durham (Figure 1). Survey was undertaken across one grass field. The site is bounded by Darlington Crematorium to the north and east, by a work yard to the south-east, by rear of housing to the south and allotments to the west (Figure 2). A small area of 0.08ha has not been surveyed due to a pile of large logs and branches present.

4.2. Survey considerations:

Survey Area	Ground Conditions	Further Notes
1	The area was an undulating area of grassland in a suburban setting. The area was predominantly flat with a small, waterlogged depression in the centre of the field, leading to high points in the north and south.	The area was bound to the north by metal railings, separating the area from a cemetery. The area was bound to the east by a brick wall, and to the west by metal fencing and brambles, separating the area from allotments. The area was bound to the south by wooden fencing which separated the area from housing along Salutation Road. A working yard and metal shed were situated within the redline along the eastern boundary. Forestry waste (large logs and branches) were present along the eastern boundary, south of the yard, making this small area unsurveyable. Deep tractor ruts ran across the area leading to patches of recently disturbed ground and boreholes. A small manhole was located along the eastern boundary.

4.3. The underlying geology comprises mudstone from the Edlington formation. The superficial deposits across the survey area consist of dimitic glacial deposits comprising: silt, sand and gravel (British Geological Survey, 2020).

4.4. Soils have not been classified for this area (Soilscapes, 2020).

5. Archaeological Background

5.1. The following is a summary of a Heritage Impact Assessment produced by Solstice Heritage LLP, summarising an HER search of the survey area and a wider 1km area (Snowden 2019).

5.2. No features of archaeological origin were identified within the survey area itself; however, archaeological activity has been recorded in the wider landscape.

5.3. Within 1km of the survey area, prehistoric findspots have been recorded (H1500; H1504).

5.4. Medieval activity has also been identified in the wider environs in the form of the site of Castle Hill, Blackwell earthwork mount (H1507), and of a state plaque (H1501).

5.5. Three mid 19th century buildings comprising the cemetery lodge and the west and east chapels (formerly Nonconformist and Anglican chapel respectively) lie c.520m north-east of the survey area. These buildings represent the oldest surviving parts of the original early-Victorian West Cemetery. Small sections of the boundary walls of the original and late 19th century versions of the cemetery still survive to the east of the survey area.

6. Methodology

6.1.Data Collection

6.1.1. Geophysical prospection comprised the magnetic method as described in the following table.

6.1.2. Table of survey strategies:

Method	Instrument	Traverse Interval	Sample Interval
Magnetic	Bartington Instruments Grad-13 Digital Three-Axis Gradiometer	1m	200Hz reprojected to 0.125m

6.1.3. The magnetic data were collected using MS' bespoke hand-carried GNSS-positioned system.

6.1.3.1. MS' hand-carried system was comprised of Bartington Instruments Grad 13 Digital Three-Axis Gradiometers. Positional referencing was through a multi-channel, multi-constellation GNSS Smart Antenna RTK GPS outputting in NMEA mode to ensure high positional accuracy of collected measurements. The RTK GPS is accurate to 0.008m + 1ppm in the horizontal and 0.015m + 1ppm in the vertical.

6.1.3.2. Magnetic and GPS data were stored on an SD card within MS' bespoke datalogger. The datalogger was continuously synced, via an in-field Wi-Fi unit, to servers within MS' offices. This allowed for data collection, processing and visualisation to be monitored in real-time as fieldwork was ongoing.

6.1.3.3. A navigation system was integrated with the RTK GPS, which was used to guide the surveyor. Data were collected by traversing the survey area along the longest possible lines, ensuring efficient collection and processing.

6.2.Data Processing

6.2.1. Magnetic data were processed in bespoke in-house software produced by MS. Processing steps conform to Historic England's standards for "raw or minimally processed data" (see sect 4.2 in David et al., 2008: 11).

Sensor Calibration – The sensors were calibrated using a bespoke in-house algorithm, which conforms to Olsen et al. (2003).

Zero Median Traverse – The median of each sensor traverse is calculated within a specified range and subtracted from the collected data. This removes striping effects caused by small variations in sensor electronics.

Projection to a Regular Grid – Data collected using RTK GPS positioning requires a uniform grid projection to visualise data. Data are rotated to best fit an orthogonal grid projection and are resampled onto the grid using an inverse distance-weighting algorithm.

Interpolation to Square Pixels – Data are interpolated using a bicubic algorithm to increase the pixel density between sensor traverses. This produces images with square pixels for ease of visualisation.

6.3.Data Visualisation and Interpretation

6.3.1. This report presents the gradient of the sensors' total field data as greyscale images. The gradient of the sensors minimises external interferences and reduces the blown-out responses from ferrous and other high contrast material. However, the contrast of weak or ephemeral anomalies can be reduced through the process of calculating the gradient. Multiple greyscale images at different plotting ranges have been used for data interpretation. Greyscale images should be viewed alongside the XY trace plot (Figure 6). XY trace plots visualise the magnitude and form of the geophysical response, aiding in anomaly interpretation.

6.3.2. Geophysical results have been interpreted using greyscale images and XY traces in a layered environment, overlaid against open street maps, satellite imagery, historic maps, LiDAR data, and soil and geology maps. Google Earth (2020) was consulted as well, to compare the results with recent land usages.

6.3.3. Geodetic position of results - All vector and raster data have been projected into OSGB36 (ESPG27700) and can be provided upon request in ESRI Shapefile (.SHP) and Geotiff (.TIF) respectively. Figures are provided with raster and vector data projected against OS Open Data.

7. Results

7.1.Qualification

7.1.1. Geophysical results are not a map of the ground and are instead a direct measurement of subsurface properties. Detecting and mapping features requires that said features have properties that can be measured by the chosen technique(s) and that these properties have sufficient contrast with the background to be identifiable. The interpretation of any identified anomalies is inherently subjective. While the scrutiny of the results is undertaken by qualified, experienced individuals and rigorously checked for quality and consistency, it is often not possible to classify all anomaly sources. Where possible an anomaly source will be identified along with the certainty of the interpretation. The only way to improve the interpretation of results is through a process of comparing excavated results with the geophysical reports. MS actively seek feedback on their reports as well as reports of further work in order to constantly improve our knowledge and service.

7.2.Discussion

7.2.1. The geophysical results are presented in consideration with historic maps and satellite imagery (Figure 5).

7.2.2. The fluxgate gradiometer survey has responded well to the environment of the survey area. However due to recent modern use of the site and the amount of surface debris noted at the time of survey (see Section 4) the strength and density of the ferrous waste and debris materials (Figure 3) does not allow for weaker underlying features to be discerned in some areas. No anomalies suggestive of significant archaeological features were identified.

7.2.3. Agricultural activity is visible in the magnetic survey that relate to modern ploughing regimes, drainage and former field boundaries which are noted at different stages on historic mapping (Figure 5).

7.2.4. A series of pit-like and linear anomalies have been identified to the north-east of the survey area. The concentration of anomalies is suggestive of archaeological features however the lack of prehistoric activity in the area or support from historic mapping along with magnetic disturbance potentially obscuring further anomalies means that an origin cannot be determined.

7.3.Interpretation

7.3.1. General Statements

7.3.1.1. Geophysical anomalies will be discussed broadly as classification types across the survey area. Only anomalies that are distinctive or unusual will be discussed individually.

7.3.1.2. **Magnetic Disturbance** – The strong anomalies produced by extant metallic structures along the edges of the field have been classified as ‘Magnetic Disturbance’. These magnetic ‘haloes’ will obscure the response of any weaker

underlying features, should they be present, often over a greater footprint than the structure they are being caused by.

7.3.1.3. **Ferrous (Spike)** – Discrete ferrous-like, dipolar anomalies are likely to be the result of isolated modern metallic debris on or near the ground surface.

7.3.1.4. **Ferrous/Debris (Spread)** – A ferrous/debris spread refers to a concentrated deposition of discrete, dipolar ferrous anomalies and other highly magnetic material.

7.3.1.5. **Undetermined** – Anomalies are classified as Undetermined when the anomaly origin is ambiguous through the geophysical results and there is no supporting or correlative evidence to warrant a more certain classification. These anomalies are likely to be the result of geological, pedological or agricultural processes, although an archaeological origin cannot be entirely ruled out. Undetermined anomalies are generally not ferrous in nature.

7.3.2. Magnetic Results - Specific Anomalies

7.3.2.1. **Agricultural** – In the central survey area, a linear anomaly [**1a**] has been identified running west-east (Figure 4). It exhibits a positive weak and strong magnetic signal, typical of a ditch-type feature (Figure 3). It is well correlated with a former field boundary depicted on the 1899 historic OS mapping (Figure 5). A similar anomaly running parallel to the north, though weaker in response, also collates with a field boundary from the earlier 1856 historic OS mapping. Further linear anomalies have been recorded in both an east to west and roughly north to south orientation that respect the current field boundaries and are representative of modern ploughing trends, as they present a much weaker and diffused magnetic signal (Figure 4).

7.3.2.2. **Services** – A strong dipolar linear response has been detected running through the southern half of the survey area in a roughly east to west orientation; this is indicating the path of a buried service. This interpretation is based on the strong positive XY response along the course of this anomaly added to the orientation with nearby housing estate and the proximity to manholes and other modern disturbances at the time of survey.

7.3.2.3. **Undetermined** – A series of pit-like and linear anomalies have been recorded in the north-east of the survey area. Whilst these do not present a clear layout, their slightly stronger magnetic enhancement, defined edges, and concentration in just a portion of the survey area, means that these should be considered to have archaeological potential; however, an accurate origin cannot be ascribed from the magnetic data.

8. Conclusions

8.1. A fluxgate gradiometer survey has successfully been undertaken across the site. The geophysical survey has detected anomalies of agricultural and modern origin. Modern interference consists of ferrous 'haloes' causes by proximity to properties bordering the site, magnetic spread due to debris in the area at the time of survey and a buried service.

8.2. No anomalies suggestive of significant archaeological features were identified.

8.3. Agricultural activity has been detected across the site in the form of two former field boundaries, modern ploughing regimes and drains.

8.4. A series of pit-like and linear anomalies have been identified to the north-east of the survey area but are of undetermined origin.

9. Archiving

9.1. MS maintains an in-house digital archive, which is based on Schmidt and Ernenwein (2013). This stores the collected measurements, minimally processed data, georeferenced and un-georeferenced images, XY traces and a copy of the final report.

9.2. MS contributes reports to the ADS Grey Literature Library upon permission from the client, subject to the any dictated time embargoes.

10. Copyright

10.1. Copyright and the intellectual property pertaining to all reports, figures, and datasets produced by Magnitude Services Ltd. is retained by MS. The client is given full licence to use such material for their own purposes. Permission must be sought by any third party wishing to use or reproduce any IP owned by MS.

11. References

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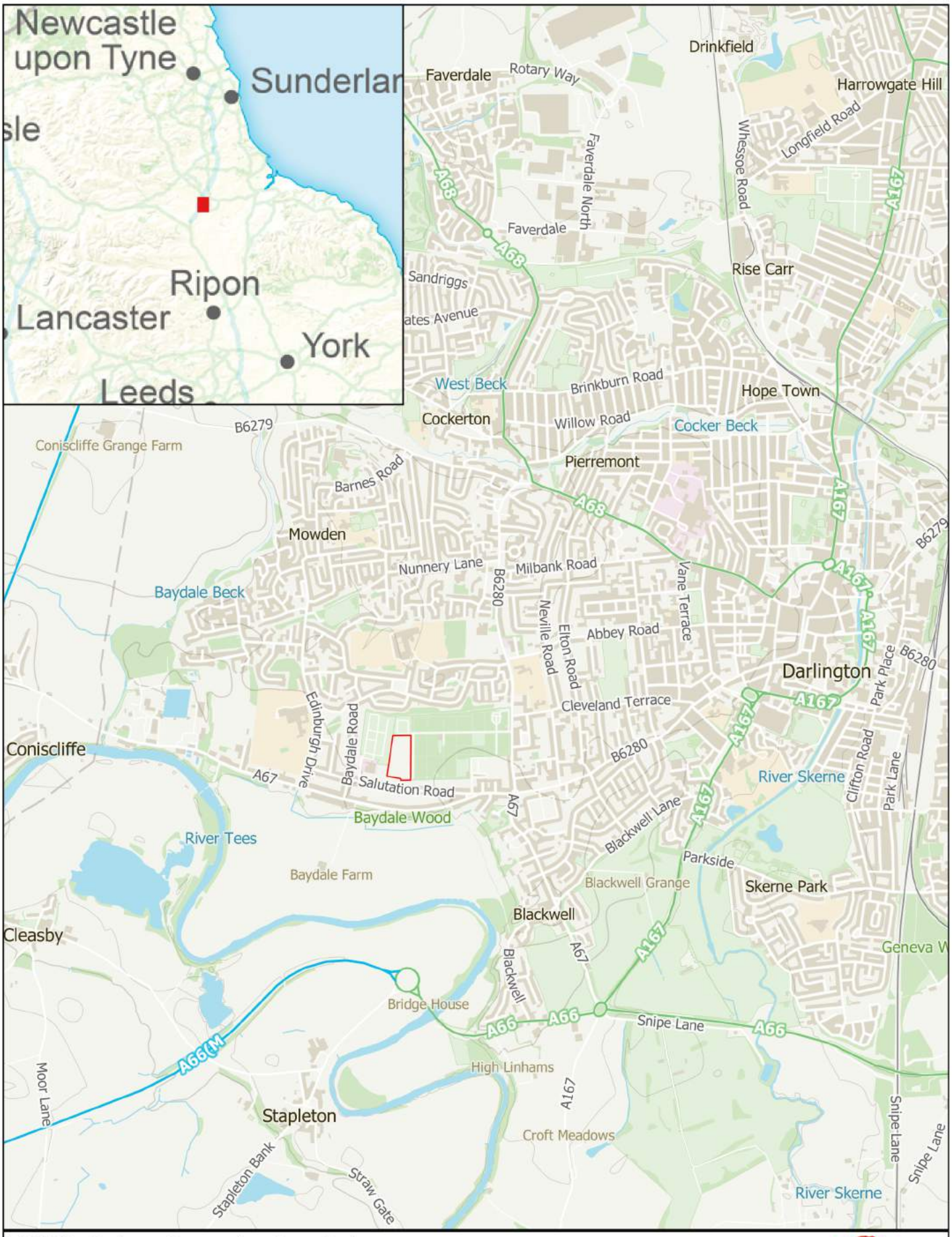
12. Project Metadata

MS Job Code	MSNZ613
Project Name	Darlington Crematorium, County Durham
Client	Solstice Heritage LLP
Grid Reference	NZ 2685 1388
Survey Techniques	Magnetometry
Survey Size (ha)	2.16ha (Magnetometry)
Survey Dates	2020-01-20
Project Manager	Finnegan Pope-Carter BSc (Hons) MSc FGS
Project Officer	Frederick Salmon BSc FGS
HER Event No	N/A
OASIS No	N/A
S42 Licence No	N/A
Report Version	0.3

13. Document History

Version	Comments	Author	Checked By	Date
0.1	Initial draft for Project Officer to Review	CN, LG	FS	23 January 2020
0.2	Corrections from Project Officer	LG	FS	24 January 2020
0.3	Corrections from Project Manager	LG	FPC	24 January 2020



MSNZ613 - Darlington Crematorium, County Durham
Figure 1 - Site Location
1:25,000 @ A4

Site Boundary

N

0 0.5 1 km

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514500 426000 426500 427000 427500 514500

Tees Grange Avenue
Greyfriars Close
West View
Leith Road
Carmel Roman Catholic College
Spruce Grove
Abbey Road
Westbourne Grove
Holyrood Avenue
Pentland Grove
Carroll Road
Barrett Road
St Hild Close
The Headlands
Brompton Walk
Ivycroft
Federation of Abbey Schools
Neville Road
Elton Road
Elton Grove
Treelands
Hummersknott Avenue
Caedmon Crescent
Hummersknott
B6280
Cleveland Terrace
Edinburgh Drive
Hummersknott Academy
514000
Allotments
West Cemetery
Area 1
Elton Parade
Linden Avenue
Coniscliffe Mews
Teesdale Avenue
Baydale Road
The Gardens
Play Space
Knoll Avenue
Salutation Road
Pine Grove
B6280
A67
Baydale Wood
Elm Ridge Methodist Church
513500
River Tees
Carmel Grove
Ravensdale Road
Glenfield Road
Ayton Drive
All Saint's Church
Baydale Farm

MSNZ613 - Darlington Crematorium, County Durham
Figure 2 - Location of Survey Area
1:5,000 @ A3

Survey Extent

N

0 100 200 300 m

magnitude surveys

426600
426800
427000
514000
514000
513800
513800
Allotments
Area 1
Baydale Road
Pond Field Close
The Gardens
Salutation Road

MSNZ613 - Darlington Crematorium, County Durham
Figure 3 - Magnetic Gradient
1:1,500 @ A3

-1 nT 2

N

0 50 100 150 m

magnitude surveys

426600
426800
427000
514000
514000
513800
513800
Allotments
Area 1
1a
Baydale Road
Pond Field Close
The Gardens
Salutation Road

MSNZ613 - Darlington Crematorium, County Durham
Figure 4 - Magnetic Interpretation
1:1,500 @ A3

Agricultural (Strong)
Agricultural (Weak)
Magnetic Disturbance
Ferrous/Debris (Spread)
Undetermined (Strong)
Undetermined (Weak)
Agricultural (Trend)
Service
Drainage Feature
Ferrous (Spike)

N

0 50 100 150 m

magnitude surveys

426500

427000

514000

514000

Area 1

1a

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Figure 5 - Magnetic Interpretation Over Historic Maps and Satellite Imagery
1:3,000 @ A3

Contains historic maps: Ordnance Survey, 6" 2nd edition c. 1882-1913 © National Library of Scotland
Contains satellite imagery © Bing Satellite

- Agricultural (Strong)
- Agricultural (Weak)
- Magnetic Disturbance
- Ferrous/Debris (Spread)
- Undetermined (Strong)
- Undetermined (Weak)
- Agricultural (Trend)
- Service
- Drainage Feature
- Ferrous (Spike)

N

0 100 200 300 m

magnitude surveys

427000

514000

514000

Allotments

Area 1

Baydale Road

The Gardens

Pond Field Close

513800

513800

Salutation Road

MSNZ613 - Darlington Crematorium, County Durham
Figure 6 - XY Trace Plot
30nT/cm at 1:1,500 @ A3

N

0 50 100 150 m

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