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Appendix C – Geophysics Report

GEOPHYSICAL SURVEY REPORT

Project

Geophysical surveys to locate mineshafts

Location

Leconfield Industrial Estate, Cleator Moor, Cumbria

Client

WYG

Unit 1
Link Trade Park
Penarth Road
Cardiff
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Job reference: 6891-23
Date: October 2020
Version: 1

GEOPHYSICAL SURVEY REPORT

Project

Geophysical surveys to locate mineshafts

Location

Leconfield Industrial Estate, Cleator Moor, Cumbria

Client

WYG

Project Geophysicist	Christian Bird	
Report Author	Jim Whiteley	
Reviewer	Simon Hughes	
Job Reference	6891-2	
Date	October 2020	

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Figures

Appendices

1 EXECUTIVE SUMMARY

TerraDat were commissioned to conduct a geophysical survey by WYG (the Client) at Leconfield Industrial Estate, Cleator Moor, Cumbria. The survey work took place between the 3rd and 6th of August 2020. The aim of the survey was to confirm the presence of potential mineshafts located on the site.

A significant thickness of made ground is likely to dominate the results of the magnetic and ground conductivity survey data, hampering the detectability of underlying mineshafts.

The gravity surveys have identified two significant low-density anomalies adjacent to historically recorded mineshaft locations. These are thought to indicate the presence of shallow zones of low-density material and are recommended for further intrusive investigation.

Three additional, subordinate geophysical anomalies are also recommended for further intrusive investigation. All anomalies of interest have been digitised, tabulated, and are presented in the results.

2 INTRODUCTION

This report describes a geophysical survey that was conducted at Leconsfield Industrial Estate, Cleator Moor, Cumbria, by TerraDat UK Ltd. The location of the site is shown in Plate 1, and the extents of the survey areas are shown in Plate 2. The survey work was commissioned by WYG (the Client) and took place between the 3rd and 6th of August 2020. The geophysical surveys targeted four historical mineshaft locations, as identified by the Coal Authority. The aim of the geophysical survey was to identify anomalous features thought to be associated with the mineshafts.

***Plate 1** – Site location.*

2.1 Site description

The site forms the northwestern half of the Leconsfield Industrial Estate, which is located to the west of the centre of Cleator Moor in Cumbria (Plate 1). Coal Authority records indicate that there are seven mineshafts within the site boundary, and these are thought to be associated with the former Wyndham Pit workings. The site is subdivided into four survey areas, centred on the coordinates of four of the mineshafts provided by the Coal Authority (Plate 2). These four locations were targeted as they were not obstructed by significant amounts of vegetation. At the time of the survey, the site comprised of a mixture of scrubland, vegetated areas, waterlogged ground, and hardstanding.

The oldest available historic maps from the 1860s show a 'haematite ironworks' at the site. The survey areas are located in an area with a reservoir in its centre, surrounded by railway tracks and engine sheds. The ironworks and associated infrastructure continued to develop over many decades, and by the 1920s, several large piles of material (later labelled 'slag heaps') can be observed, along with the central reservoir.

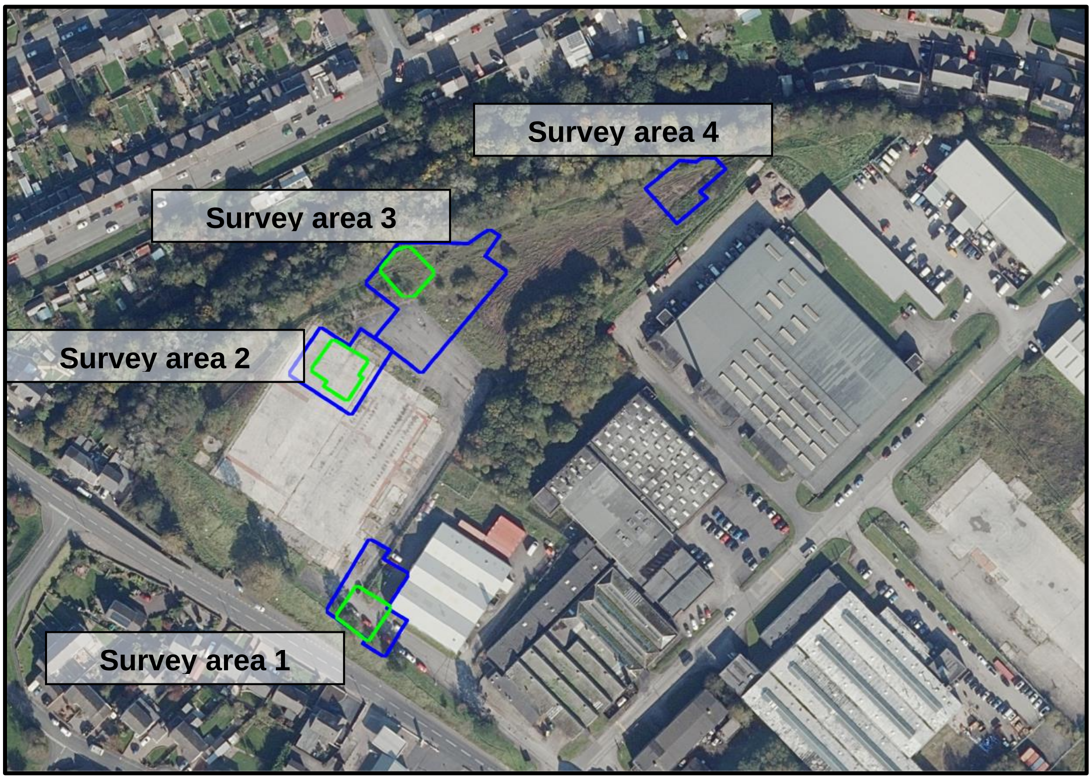


***Plate 2** – location and extent of the geophysical surveys (magnetic and ground conductivity survey areas in blue, gravity survey areas in green) areas at the Leconsfield Industrial Estate.*

By the 1960s, most of the ironworks and rail infrastructure has been removed, and the reservoir is no longer present, suggesting that a degree of filling and levelling has taken place across the survey area. By the 1970s, the majority of the current structures are present, and further levelling seems to have taken place. Some of the buildings indicated on maps in the 1970s were present at the time of the geophysical survey. However, in some locations (notably the former 'zip fastener factory' in the southwest of the survey area), the building has been removed, and only the concrete pad foundation remains. At the time of the survey, the location of the former mineral railway bounding the site to the north and west was densely vegetated.

2.2 Geological setting

The majority of the southern part of the site is underlain by the Pennine Middle Coal Measures Formation, described by the British Geological Survey (BGS) as: *'Interbedded grey mudstone, siltstone, pale grey sandstone and commonly coal seams.'* Several north-south orientated inferred coal seams are present within this unit towards the western edge of the site. An inferred fault orientated west-northwest to east-southeast separates the Pennine Middle Coal Measure Formation from the Whitehaven Sandstone Formation, located in the north of the site, and described by the BGS as: *'Red to purple-brown, cross-bedded sandstones with vari-coloured mudstone and siltstone'.* Superficially, the site and the surrounding area are overlain almost exclusively by deposits of Devensian Till. BGS records indicate significant amounts of artificial ground occupying the former extents of the former ironworks.

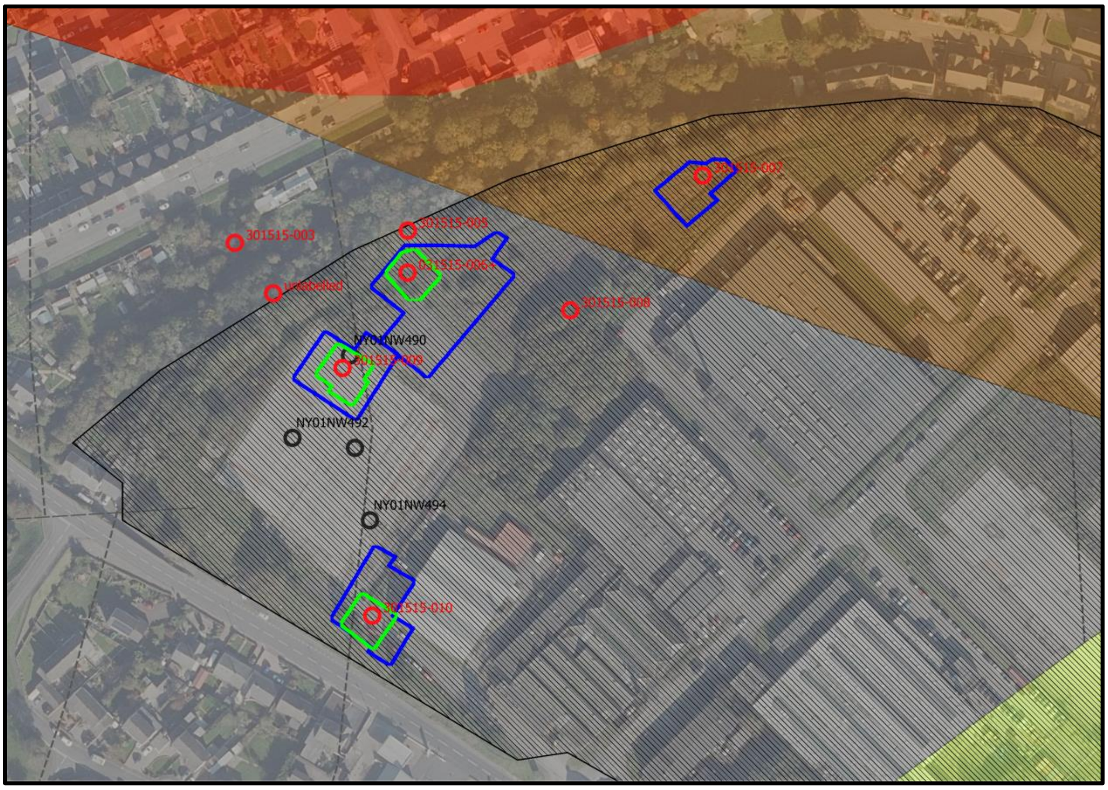


***Plate 3** – geological setting at the survey area, with the Pennine Middle Coal Measures (grey) in the south, fault-bounded with the Whitehaven Sandstone Formation (brown) to the north. Several small coal seams (dashed lines) orientated north-south are located in the southwest corner of the site. The hatched area indicates the extents of made ground recorded by the BGS, along with the location of historic borehole records (black) and the historical mineshaft locations (red) provided by the Client.*

Several historical boreholes are located on-site (Plate 3) and record significant thicknesses of made ground. The BGS holds four records of boreholes drilled within the survey area in the 1960s, all log made ground to their maximum depth of 6.1 m. It is not clear whether the ground levels have changed; however, it seems unlikely that they would have reduced. All of these boreholes indicate between 2.1 m and 4 m of ‘slag’ underlain by ‘ash and small stones’. An intrusive investigation conducted by the Client in August 2020 has mapped between 6 and 9m of made ground, generally comprising sands, clay and slag-rich gravels, across the survey area.

2.3 Survey objective

The primary survey objective is to confirm the location of the recorded mineshafts.

2.4 Survey design

Given the survey brief, it was decided to adopt an integrated survey approach comprising of the following techniques*:*

- ***Magnetic surveying (Geometrics G858)*** **–** to map distortions in the Earth’s magnetic field due to the presence of buried ferrous material that may be related to mine workings.
- ***Electromagnetic surveying (Geophex GEM-2*****)** – to map variations in the near-surface ground conductivity associated with different shallow materials/structures.
- ***Microgravity (Scintrex CG-5)*** - to confirm the presence of mass deficiency within the subsurface, that may be associated with voiding or less dense in-fill material.

2.5 Quality control

The geophysical data were collected in line with normal operating procedures as outlined by the instrument manufacturer and TerraDat company policy. On completion of the survey, the data were downloaded from the survey instrument onto a computer and backed up appropriately. The acquired data set was initially checked for errors that may be caused by instrument noise, low batteries, positional discrepancies, etc. and any field notes were either written up or incorporated in the initial data processing stage. The dataset was then processed using standard processing routines, and once completed, the resulting plots were subject to peer review to ensure the integrity of the interpretation. Our quality control standards are BS EN ISO 9001: 2015 certified.

3 SURVEY DESCRIPTION

The survey was carried out using the following geophysical techniques:

- Magnetics *(Geometrics G-858)*
- Electromagnetics *(Geophex GEM-2)*
- Microgravity *(Scintrex CG-5)*

A survey, comprising magnetic and electromagnetic ground conductivity mapping techniques, was conducted at four separate survey grids that were located and orientated to encompass the four most accessible historical mineshaft locations. Three other mineshaft locations at the site were inaccessible due to the presence of dense vegetation. The details of the mineshafts surveyed are presented in Table 1. The survey areas are labelled 1 – 4, and the locations and extents of these areas are indicated in Plate 2.

Once the magnetic and electromagnetic surveys were completed, the data were analysed with reference to the historical shaft locations provided by the Client, and any anomalies thought to be of significance were targeted using microgravity surveying. Where no significant anomalies were present, microgravity surveys were centred on the historical locations provided by the Client. It was not possible to conduct any microgravity surveying at survey area 4, due to the excessively wet and soft ground conditions in this area (Plate 4).

Mineshaft ID	Survey area ID	Easting	Northing	Geophysical methods
301515-010	1	301361	515484	Magnetics, electromagnetic ground conductivity, gravity
301515-009	2	301349	515583	Magnetics, electromagnetic ground conductivity, gravity
301515-006	3	301375	515621	Magnetics, electromagnetic ground conductivity, gravity
301515-007	4	301493	515660	Magnetics, electromagnetic ground conductivity

Table 1 *– details of mineshafts surveyed during the survey.*

Plate 4 *– Survey area 4 at the time of the geophysical survey. The ground was too wet and disturbed to conduct a reliable gravity survey at the mineshaft location.*

3.1 Survey layout and topographic survey

Four orthogonal survey grids were set out using a network RTK GPS. The electromagnetic and magnetic data were acquired under the positional control of a *Novatel AgStar* DGPS. For the microgravity survey, topographic survey control points were established using the network RTK GPS, and a *Trimble S3* robotic EDM was used to locate the survey stations accurately. All survey work was conducted using OSGB coordinates to allow transposition to the Client's site plan.

3.2 Magnetic survey

Magnetic surveys are designed to exploit the deviation in the Earth's magnetic field caused by the presence of buried ferrous objects. Data are acquired on a survey grid covering the area of interest, and a plan image showing the variation in the magnetic field is produced. Buried items such as tanks, drums, unexploded ordnance (UXO), reinforced slabs, shaft caps, and some archaeological features can be identified on a magnetic survey plan as localised anomalous high and low values.

3.2.1 Magnetic survey - field activity

A *Geometrics G-858* magnetometer (Plate 5) was used to acquire total field data in "near-continuous" walking mode along a series of 2m spaced parallel survey lines across the survey grids.

Plate 5 *– G858 magnetometer (library photo).*

3.2.2 Magnetic survey – data processing

The magnetic data were downloaded to a computer and edited for positional errors and rogue values. The data were then exported as an 'XYZ' file and translated into the OSGB36 coordinate system using the OSTN02 transformation. The dataset was then imported into *Oasis montaj*, where it was edited and manipulated to enhance any features of interest. The colour contour plots were then integrated with the base plan information, and the resulting plans were exported to *CorelDRAW* for final annotation.

3.3 Electromagnetic survey

An electromagnetic ground conductivity survey involves the transmission of an electromagnetic field into the subsurface and then recording the returning signal via a receiver in the same instrument. Data are acquired on a grid covering the area of interest, and a contoured plan of the variation in ground conductivity response across the site is produced. The presence of conductive materials in the subsurface such as clay, water, mudstone, ash, metal, rebar, leachate, etc. will be evident as regions of high values on the ground conductivity plan. Materials such as coarse-grained sediments, dry zones, and many bedrock types will appear as regions of low values.

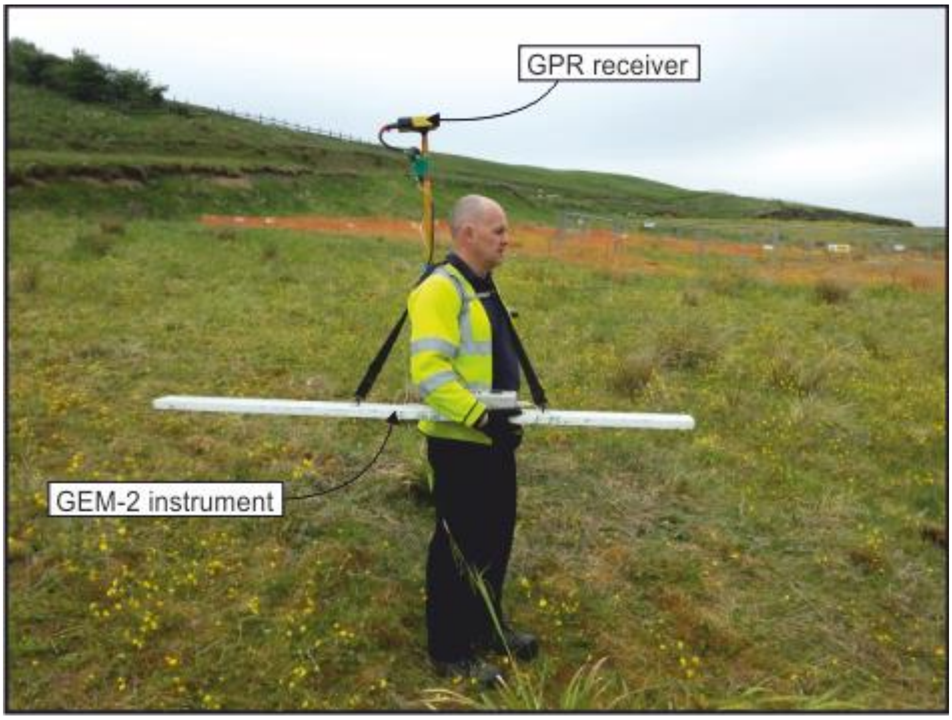


Plate 6 *- GEM-2 (electromagnetic) ground conductivity meter*

3.3.1 Electromagnetic survey - field activity

The conductivity data were acquired using a multi-frequency *Geophex GEM-2* instrument (Plate 3), and data were acquired under the control of an EGNOS corrected dGPS (accuracy +/- 0.5m) at a nominal 0.2m interval along a series of parallel 2m spaced survey lines. The instrument was primarily configured to investigate depths of 3 – 5 m below ground level.

3.3.2 Electromagnetic survey – data processing

The conductivity data were downloaded from the data logger and compiled using dedicated software *WINGEM-3*. Initial editing was then carried out to remove positional errors and rogue values. The data were then exported as an ‘XYZ’ file and translated into the OSGB36 coordinate system using the OSTN02 transformation. The next step was to import the data set into *Oasis montaj*, where it was compiled, edited, and manipulated to enhance any features of interest. The colour contour plots were then integrated with the base plan information and the resulting plans exported to *CorelDRAW* for final annotation.

3.4 Microgravity survey

The density contrast between different Earth materials provides a useful means for mapping subsurface structures and voids through the measurement of associated localised variations in the Earth’s gravitational field. The presence of an anomalously high (or low) density body in the subsurface causes a localised high (or low) anomaly in the measured gravitational field. The gravity effects described are small; However, detection is enabled by modern instrumentation and sophisticated data processing techniques.

An increase in both the size of a body and the density contrast with its host material proportionally increases its detectability using gravitational methods. However, there is a reduction in both spatial resolution and detectability with increased depth of burial. Typical targets for a microgravity survey include the location of buried channels, solution features, voiding, mine shafts, vertical structures, geological lineations, and groundwater movement through monitoring with time.

3.4.1 Microgravity survey - field activity

The microgravity survey was conducted out using very high precision *Scintrex CG-5* instrument (Plate 7, over survey grids centred on either significant anomalies identified by the magnetic and electromagnetic surveys or, where these were absent, the historical shaft locations provided by the Client. The gravity readings were acquired on a staggered 2m x 2m spaced grid. For each reading station, the elevations of the gravity meter were acquired using a Total Station to a precision better than 3mm.

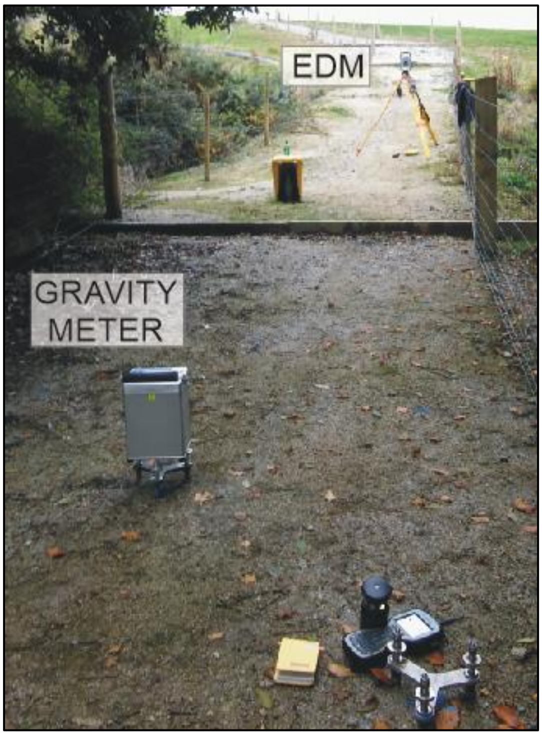


Plate 7 *– Scintrex CG-5 gravity meter (library photo).*

3.4.2 Microgravity survey – data processing

To remove background gravitational effects, i.e., those that do not originate from the target features a series of processing steps were applied to the acquired dataset using a combination of internal CG-5 software and TerraDat proprietary software *GRED* (a process known as 'data reduction') *.* The applied corrections include:

- Earth Tide, Temperature & Tilt Correction
- Un-modelled Temporal Residual Correction
- Latitude Correction
- Free-air Correction
- Bouguer Correction

The resulting reduced gravity dataset (Bouguer Anomaly) is then presented as an annotated colour contour plot overlain by the base plan information before being exported for final annotation in *CorelDRAW*.

4 RESULTS AND DISCUSSION

Background information for each of the survey methods is provided in the appendices, and descriptions of the actual survey work carried out on the site are provided in the sections below. The results of the geophysical surveys are presented as a series of interpreted colour contour plots in Figures 2 - 5. A general description of the interpretation process and a broad discussion of the results for each technique is given below. Anomalous features/zones identified by the various techniques, and considered to be of significance have been transposed onto the Client's site plan to create a CAD anomaly location plan, highlighted in Figure 6. The CAD drawing has also been provided in digital DXF format (*TD-6891-RESULTS.DXF)*.

A brief explanation of the data presentation and interpretation criteria is given in sections 4.1. A more detailed discussion of the results is provided in Sections 4.2. A summary of the key anomalies and a table is presented in Table 1 in Section 4.3.

4.1 Method background

4.1.1 Magnetic survey

The results of the magnetic survey are presented as the total magnetic field (Figures 2a – 5a) and the analytic signal (Figures 2b – 5b). The total magnetic field records deviations superimposed onto the Earth's naturally occurring magnetic field by the presence of ferrous material within the subsurface. Several factors determine the character of a total field magnetic anomaly; magnetic susceptibility, size, and orientation of the causative body all have an effect. The interpretation of a magnetic anomaly is based on observing the type (monopole/dipole), amplitude, and wavelength of the anomalous feature.

Commonly, bodies of ferrous material are characterised by both high and low values (a 'dipole' anomaly), similar to the positive/negative nature of a bar magnet. To better delineate dipolar anomalies, likely to be caused by discrete ferrous bodies, an analytical signal routine has been applied to the total field data. This 'analytic signal routine' converts dipolar anomalies into positive values based on the gradient between the two poles. Typically, the result of applying this filter is an isolated positive anomaly centred on the location of the source producing the response.

4.1.2 Electromagnetic survey

The results of the electromagnetic survey are presented as colour contoured plots of ground conductivity (Figures 2c – 5c). The ground conductivity data indicates the relative changes in bulk ground conductivity across the area surveyed. Increased ground conductivity normally indicates an increase in the clay/moisture content of the subsurface; however, fill materials such as ash or waste materials such as clinker can also cause an increase in ground conductivity.

The electromagnetic technique can aid the identification of a buried shaft/structure either by revealing an anomaly directly associated with differential material (capping structure/backfill) or secondary effects of excavation such as preferential water drainage or the presence of subsidiary structures.

4.1.3 Microgravity survey

The results of the microgravity survey are presented as colour-contour plots of height and terrain corrected gravity measurements known as the Bouguer anomaly (Figures 2d – 5d). This plot has then had regional gravitational effects calculated and removed by a de-trending process, producing what can be considered as the final microgravity colour-contoured data (Figures 2e – 5e).

Gravity plots may be considered crudely as a map of the variation in density targeting to a maximum of 10m below ground level, depending on feature size and station spacing. For a given gravity feature or anomaly, its interpretation is based on observing its shape, amplitude, and wavelength. For example, a localised decrease in the gravitational field indicates a zone of mass deficiency, which could either represent void space, poorly compacted backfill material, or an increase in the thickness of the superficial deposits.

4.2 Results

4.2.1 Survey area 1

Figure 2 presents the results of the magnetic, ground conductivity, and gravity surveys carried out at survey area 1. Survey area 1 is located in the south of the site, to the east of the former ‘zip fastener factory’ and close to an existing industrial building. The survey was acquired across a range of different ground surfaces, including hardstanding and grass. A metal palisade fence was located in the centre of the survey area, which will have acted to obscure the presence of any underlying features.

The total magnetic field plot (Figure 2a) shows broad areas of positive and negative values, indicating the presence of buried and surface, ferrous material across the survey area. In the analytic signal plot (Figure 2b), these features resolve to form several isolated increases in magnetic response, suggesting localised zones of increased metal content in the near-surface. The significant anomaly in the centre of the plot is associated with the presence of the steel palisade fence and gate.

The ground conductivity plot (Figure 2c) shows a similar distribution of extreme values as the total magnetic field data; some areas of increased response in the ground conductivity plot are co-located with strongly negative values in the magnetic data, particularly where associated with the palisade fence and existing building. To the northwest and south, areas of increased ground conductivity response are co-located with strongly positive values in the magnetic survey. Given that the total magnetic field plot indicates areas of high ferrous material content as both positives and negatives, this suggests the presence of ferrous material in these areas of high ground conductivity. Linear features in the ground conductivity are likely related to the presence of services and drains present beneath the road in the survey area.

Both the magnetic and ground conductivity surveys are likely to be acutely affected by the significant thickness of ferrous-bearing made ground that exists across the site. Current maps and historic boreholes from the BGS, as well as the Client’s recent intrusive investigations, indicate the presence of >6m of made ground in the west of the site, underlying the survey areas. This made ground, comprised of material likely recovered from historic waste piles of the ironworks, will have a significant influence on the magnetic and ground conductivity data, and anomalies detected by these surveys where extensive amounts of made ground exist are likely to derive from within the made ground rather than beneath it.

The Bouguer anomaly, derived from the gravity survey (Figure 2d) and the de-trended gravity plot (Figure 2e) indicate some areas of lower density ground relative to the surrounding area. The broad trend in gravity across the survey area reflects variations in the composition of the sub-surface across the survey grid. In particular, the de-trended gravity plot shows a strong low-density anomaly located in the road, adjacent to the location of the suspected mineshaft. While this is unlikely to be directly related to the shaft, given the suspected amount of made ground in the survey area, this low-density area may be related to crowning of a void upwards through the made ground. This anomaly, labelled **A1,** is recommended for intrusive follow-up investigation based on the anomaly's character and proximity to the suspected shaft location. A smaller gravity anomaly located further to the west of the potential mineshaft location (**B1**) is also recommended for intrusive investigation.

4.2.2 Survey area 2

Figure 3 presents the results of the magnetic, ground conductivity, and gravity surveys carried out in survey area 2. Survey area 2 is located at the northern end of the footprint of the former 'zip fastener factory', and the survey surface comprises the reinforced pad of the former structure.

***Plate 8** – Concrete slab at survey area 2*

The total magnetic field (Figure 3a), magnetic analytic signal (Figure 3b), and ground conductivity plots (Figure 3c) all show significant interference from near-surface metal. The magnetic datasets indicate the presence of a considerable amount of ferrous material within the slab. The ground conductivity survey has resolved a series of individual, linear, metallic elements within the slab construction. Consequently, anomalies identified in this survey grid are unlikely to derive from features beneath the slab. A ground penetrating radar (GPR) was used to confirm the presence of reinforcing, the GPR survey has identified a series of shallow, repeated parabolic responses as the radar pulses are reflected from individual reinforcing bars (Plate 9). The GPR cross-section in Plate 9 indicates areas of differential reinforcement between the individual slabs, as well as the presence of structural features beneath them; However, the GPR does not penetrate deep enough to identify features likely to be associated with the mineshaft, particularly given that BGS boreholes in this area show a significant thickness of made ground.

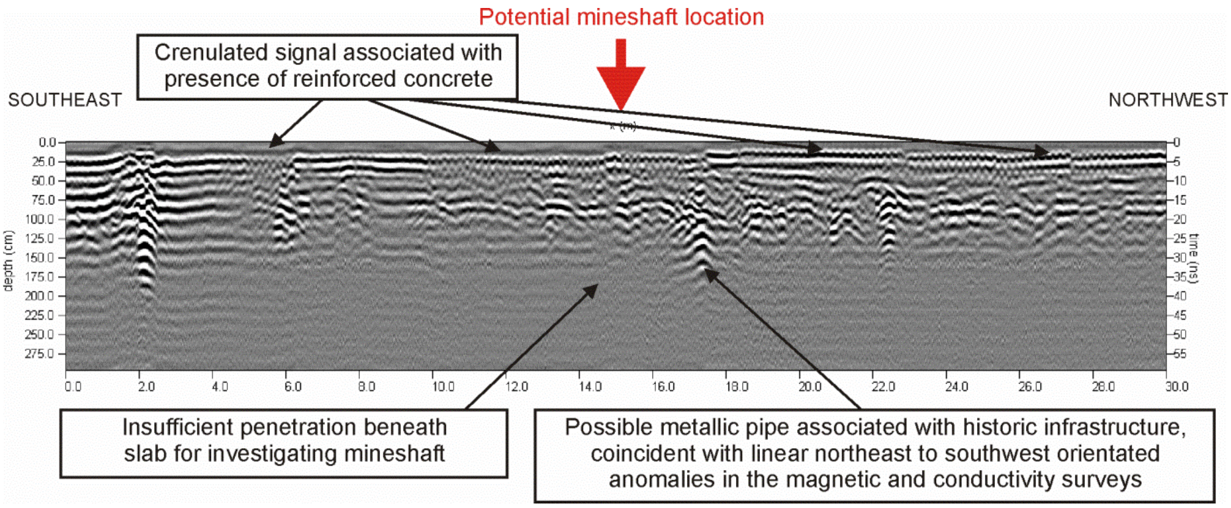


***Plate 9** – A GPR profile from survey area 2, confirming the presence of a reinforced concrete pad, the metallic content of which introduces significant interference to the magnetic and ground conductivity survey data.*

The Bouguer anomaly plot (Figure 3d) shows relatively uniform values across the survey area with a trend decreasing to the south. Removal of this trend (Figure 3e) leaves residual gravity values that exhibit a very small range of values (±0.001 mGals), which suggests no significant variation in material density exists beneath the area surveyed.

4.2.3 Survey area 3

Figure 4 presents the results of the magnetic, ground conductivity, and gravity surveys undertaken in survey area 3. The survey data was initially acquired in this area around several areas of dense vegetation, this was cleared, and the survey was subsequently repeated to gain better coverage. The south of the survey area comprised an area of hardstanding, and the remainder was rough and water-logged ground (Plate 10).

Plate 10 *- Survey area 3, viewed from the southwest.*

The total magnetic field plot (Figure 4a) shows a broad area of elevated response in the northwest of the survey area and a generally lower response in the south of the survey area. The area of high-amplitude response broadly correlates with the historical location of railway tracks. The southern zone of low response is likely to be an effect of the reinforced slab, located to the southwest of survey area 3. In the centre of the plot are several large dipolar anomalies. These anomalies are more apparent in the analytic signal plot (Figure 4b) and are likely to derive from shallow buried ferrous debris. A broad scattering of buried and part-buried waste was observed in this area. Additional high-amplitude magnetic anomalies are located within the southern area of low response, and these are associated with drain covers. Further anomalies are located in the north and east of the plot, and these indicate the presence of buried ferrous material.

A central zone of increased conductivity dominates the ground conductivity survey (Figure 4c), and this area correlates with the presence of significantly water-logged ground. There is also a subtle correlation between the more conductive values and the historical location of the reservoir, though this may be coincidental. Several extreme ground conductivity responses are present across the plot, and many of these correlate with buried ferrous material identified by the magnetic survey and indicate the presence of shallow ferrous material.

Both the magnetic and ground conductivity surveys are likely to be acutely affected by the significant thickness of ferrous-bearing made ground that exists across the site. The Client's recent intrusive investigations indicate the presence of 8.9 m of made ground in this area. This made ground, comprised of material likely recovered from historic waste piles of the ironworks, will have a significant influence on the magnetic and ground conductivity data, and the anomalies detected here are likely to derive from within the made ground rather than beneath it.

The Bouguer anomaly plot (Figure 4d) displays smooth values with a decreasing trend to the east. With this trend removed (Figure 4e), a large low gravity anomaly is identified to the north of the potential mineshaft location in survey area 3. The remainder of the gravity survey area shows very little variation, making the contrast of this anomaly striking. Given the suspected amount of made ground in the survey area, this is unlikely to relate directly to a shaft; However, this low-density feature may relate to the upward crowning of a void. This anomaly, labelled **A2**, is therefore recommended for intrusive follow-up investigation based on the anomaly character and proximity to the suspected shaft location.

4.2.4 Survey area 4

Figure 5 presents the results of the magnetic and ground conductivity surveys undertaken in survey area 4. The survey area is located close to the northern boundary of the site, at the time of surveying the ground was too wet and soft to conduct a gravity survey reliably.

The total magnetic field plot (Figure 5a) shows a broad area of elevated magnetic readings in the central zone of the survey area and broad areas of low values at the fringes of the grid. Some large-amplitude dipolar anomalies are identified in the south of the survey area indicating the presence of buried ferrous material, one of which is located to the north to the west of the historical mineshaft location. These dipolar anomalies are defined better by the analytic signal plot (Figure 5b).

The ground conductivity plot (Figure 5c) shows significant variations in values, with low conductivity values in the southwest of the survey grid, and the highest values in the north. The highest conductivity values are located adjacent to the historical mineshaft location.

Both the magnetic and ground conductivity surveys are likely to be acutely affected by the significant thickness of ferrous-bearing made ground that exists across the site. The Client's recent intrusive investigations indicate the presence of 5.9 - 9 m of made ground in this area.

This made ground, comprised of material likely recovered from historic waste piles of the ironworks, will have a significant influence on the magnetic and ground conductivity data, and the anomalies detected are likely to derive from within the made ground rather than beneath it.

Two anomalies in the magnetic (anomaly **B2**) and conductivity surveys (**B3**) have been identified for intrusive follow-up. No metallic material/debris was observed at the surface; therefore, all the magnetic anomalies identified indicate the presence of buried ferrous material within the made ground

Following cross-correlation with intrusive observations in this survey area, it may be that the priority of these anomalies can be upgraded or downgraded as appropriate. If significant amounts of made ground underlie this survey area, then it is unlikely that these anomalies are indicative of historic mine features, and instead are more likely to reflect the heterogeneous subsurface fill conditions.

4.3 Summary

The main anomalies identified in the geophysical survey are summarised in Table 1 below. Anomalies have been ascribed a letter, indicating whether they are significant (A) or less significant (B), based on their size, character, and the existence of supporting intrusive information. Anomalies can be reclassified in the light of any additional intrusive information.

Anomaly ID	Easting	Northing	Magnetic	Ground Conductivity	Microgravity	Description
A1	301360.2	515482.4			✓	Significant, broad, low gravity anomaly located adjacent to potential mineshaft location
A2	301376.9	515624.8			✓	Significant, broad, low gravity anomaly located adjacent to potential mineshaft location
B1	301354.9	515486.3			✓	Significant, smaller, low gravity anomaly located close to potential mineshaft location, although further away than **A1**
B2	301486	515663.2	✓			Small, isolated magnetic anomaly located in the vicinity of potential mineshaft location
B3	301488.8	515662.9		✓		A broad area of increased ground conductivity in the area of potential mineshaft location

Table 1 – *Summary of main anomalies identified across the survey areas. Significant anomalies ('A' anomalies) are the highest priority for follow-up intrusive investigation. Less significant anomalies ('B' anomalies) may require reclassification after further intrusive information becomes available.*

5 CONCLUSIONS

- The geophysical surveys have provided a rapid means of surveying the site for anomalous features that may indicate the presence of mine shafts.

- Several anomalies have been identified, digitised and tabulated in the results. It is recommended that these are investigated with follow-up intrusive works.

- Historical boreholes, along with the results of the August 2020 intrusive investigation, indicate that the survey areas are all likely to be underlain by approximately 6 – 9 m of made ground. The made ground is derived from re-worked ironworks waste and is likely to have a very high ferrous content. The presence of this material is expected to mask any features located beneath it, and therefore, features identified by this survey are likely to derive from within the made ground.

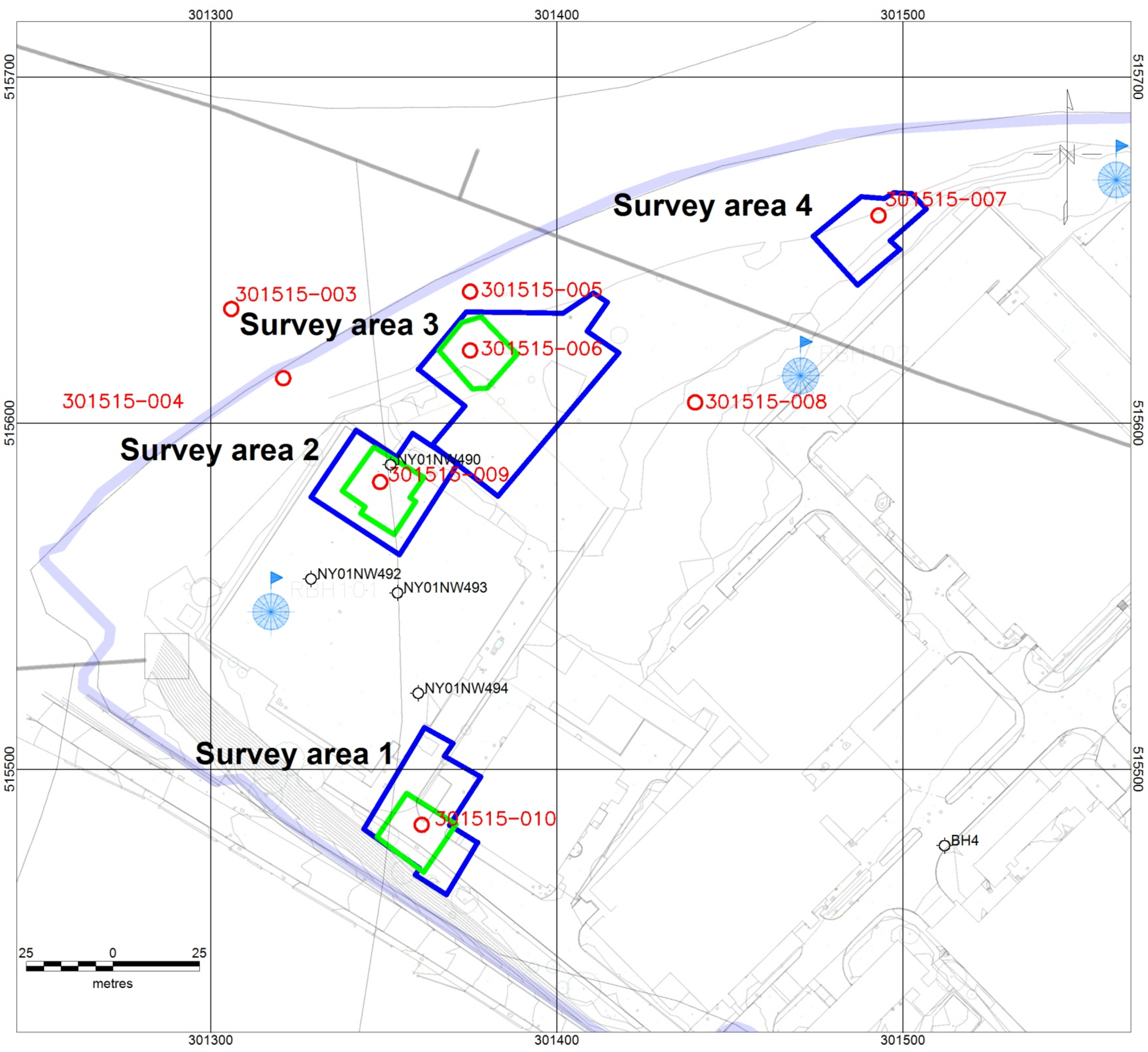
- Anomaly locations should be relocated using a suitably accurate GPS system using the OSGB36 coordinate system.

Disclaimer

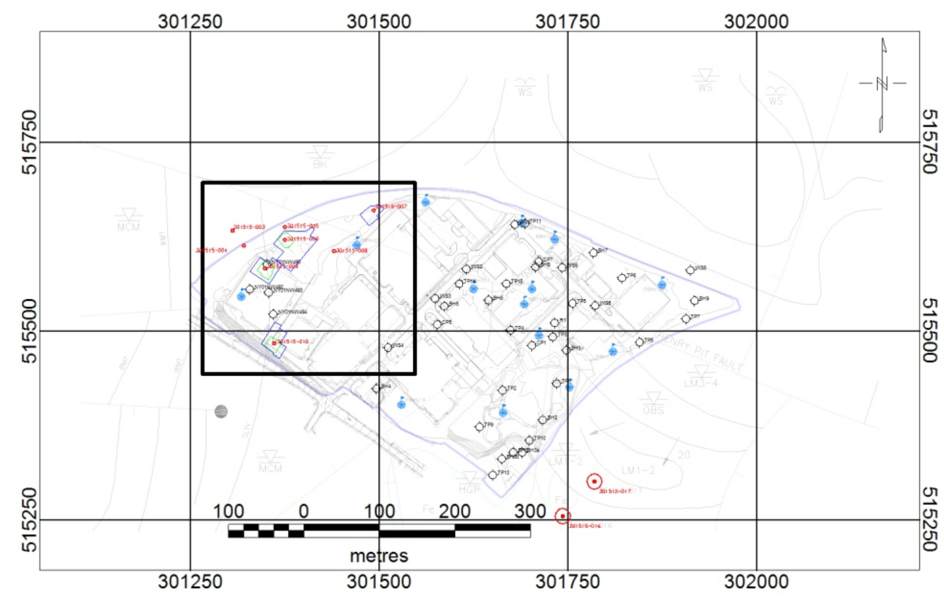
This report represents an opinionated interpretation of the geophysical data. It is intended for guidance with follow-up invasive investigation. Features that do not produce measurable geophysical anomalies or are hidden by other features may remain undetected. Geophysical surveys complement invasive/destructive methods and provide a tool for investigating the subsurface; they do not produce data that can be taken to represent all of the ground conditions found within the surveyed area. Areas that have not been surveyed due to obstructed access or any other reason are excluded from the interpretation.

FIGURES

SURVEY AREA MAP
Scale 1:1,500



SITE MAP
Scale 1:10,000
See expanded inset for survey area



Key:

- Magnetic and ground conductivity survey outline
- Gravity survey outline
- Recorded historical mineshaft location
- Intrusive GI location (current and historical, records available)
- Proposed BH Location

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Project:	LECONFIELD INDUSTRIAL ESTATE, CLEATOR MOOR, CUMBRIA
Title:	SITE AND SURVEY AREAS
Scale:	SEE FIGURES
Drawn by/Ref:	JW/6891/1
Date:	AUGUST 2020

FIGURE 1