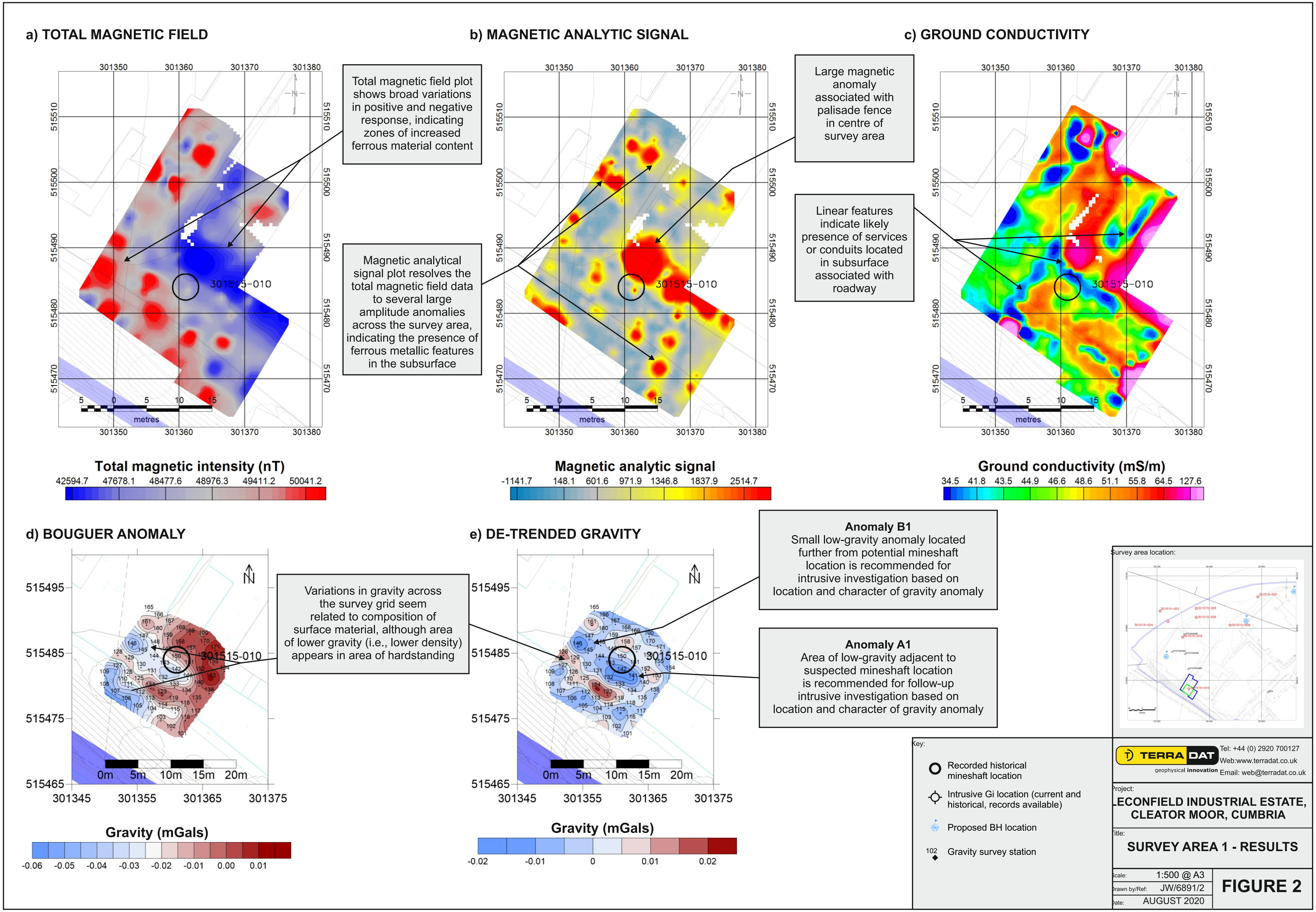
a) TOTAL MAGNETIC FIELD
b) MAGNETIC ANALYTIC SIGNAL
c) GROUND CONDUCTIVITY
Total magnetic field plot shows broad variations in positive and negative response, indicating zones of increased ferrous material content
Magnetic analytical signal plot resolves the total magnetic field data to several large amplitude anomalies across the survey area, indicating the presence of ferrous metallic features in the subsurface
Large magnetic anomaly associated with palisade fence in centre of survey area
Linear features indicate likely presence of services or conduits located in subsurface associated with roadway
301515-010
301350 301360 301370 301380
515510 515500 515490 515480 515470
5 0 5 10 15
metres
Total magnetic intensity (nT)
42594.7 47678.1 48477.6 48976.3 49411.2 50041.2
Magnetic analytic signal
-1141.7 148.1 601.6 971.9 1346.8 1837.9 2514.7
Ground conductivity (mS/m)
34.5 41.8 43.5 44.9 46.6 48.6 51.1 55.8 64.5 127.6
d) BOUGUER ANOMALY
e) DE-TRENDED GRAVITY
Variations in gravity across the survey grid seem related to composition of surface material, although area of lower gravity (i.e., lower density) appears in area of hardstanding
Anomaly B1
Small low-gravity anomaly located further from potential mineshaft location is recommended for intrusive investigation based on location and character of gravity anomaly
Anomaly A1
Area of low-gravity adjacent to suspected mineshaft location is recommended for follow-up intrusive investigation based on location and character of gravity anomaly
515495 515485 515475 515465
301345 301355 301365 301375
0m 5m 10m 15m 20m
Gravity (mGals)
-0.06 -0.05 -0.04 -0.03 -0.02 -0.01 0.00 0.01
Gravity (mGals)
-0.02 -0.01 0 0.01 0.02
Survey area location:
Key:
Recorded historical mineshaft location
Intrusive Gi location (current and historical, records available)
Proposed BH location
102 Gravity survey station
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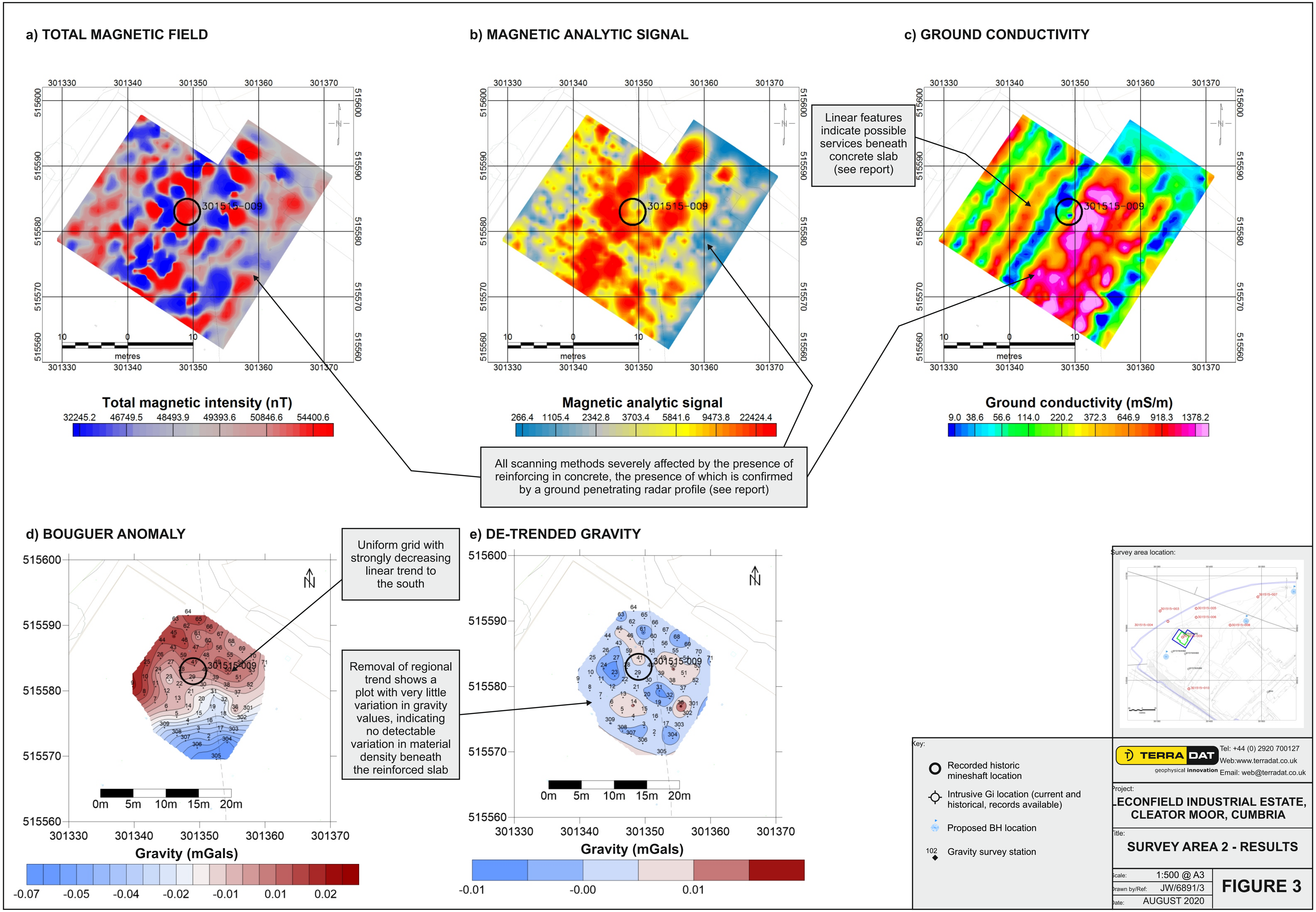
Project:
LECONFIELD INDUSTRIAL ESTATE, CLEATOR MOOR, CUMBRIA
Title:
SURVEY AREA 1 - RESULTS
Scale: 1:500 @ A3
Drawn by/Ref: JW/6891/2
Date: AUGUST 2020
FIGURE 2


a) TOTAL MAGNETIC FIELD
b) MAGNETIC ANALYTIC SIGNAL
c) GROUND CONDUCTIVITY
301330
301340
301350
301360
301370
515600
515590
515580
515570
515560
301515-009
metres
Total magnetic intensity (nT)
32245.2 46749.5 48493.9 49393.6 50846.6 54400.6
Magnetic analytic signal
266.4 1105.4 2342.8 3703.4 5841.6 9473.8 22424.4
Ground conductivity (mS/m)
9.0 38.6 56.6 114.0 220.2 372.3 646.9 918.3 1378.2
Linear features indicate possible services beneath concrete slab (see report)
All scanning methods severely affected by the presence of reinforcing in concrete, the presence of which is confirmed by a ground penetrating radar profile (see report)
d) BOUGUER ANOMALY
e) DE-TRENDED GRAVITY
Uniform grid with strongly decreasing linear trend to the south
Removal of regional trend shows a plot with very little variation in gravity values, indicating no detectable variation in material density beneath the reinforced slab
0m 5m 10m 15m 20m
Gravity (mGals)
-0.07 -0.05 -0.04 -0.02 -0.01 0.01 0.02
Gravity (mGals)
-0.01 -0.00 0.01
Survey area location:
Key:
Recorded historic mineshaft location
Intrusive GI location (current and historical, records available)
Proposed BH location
102 Gravity survey station
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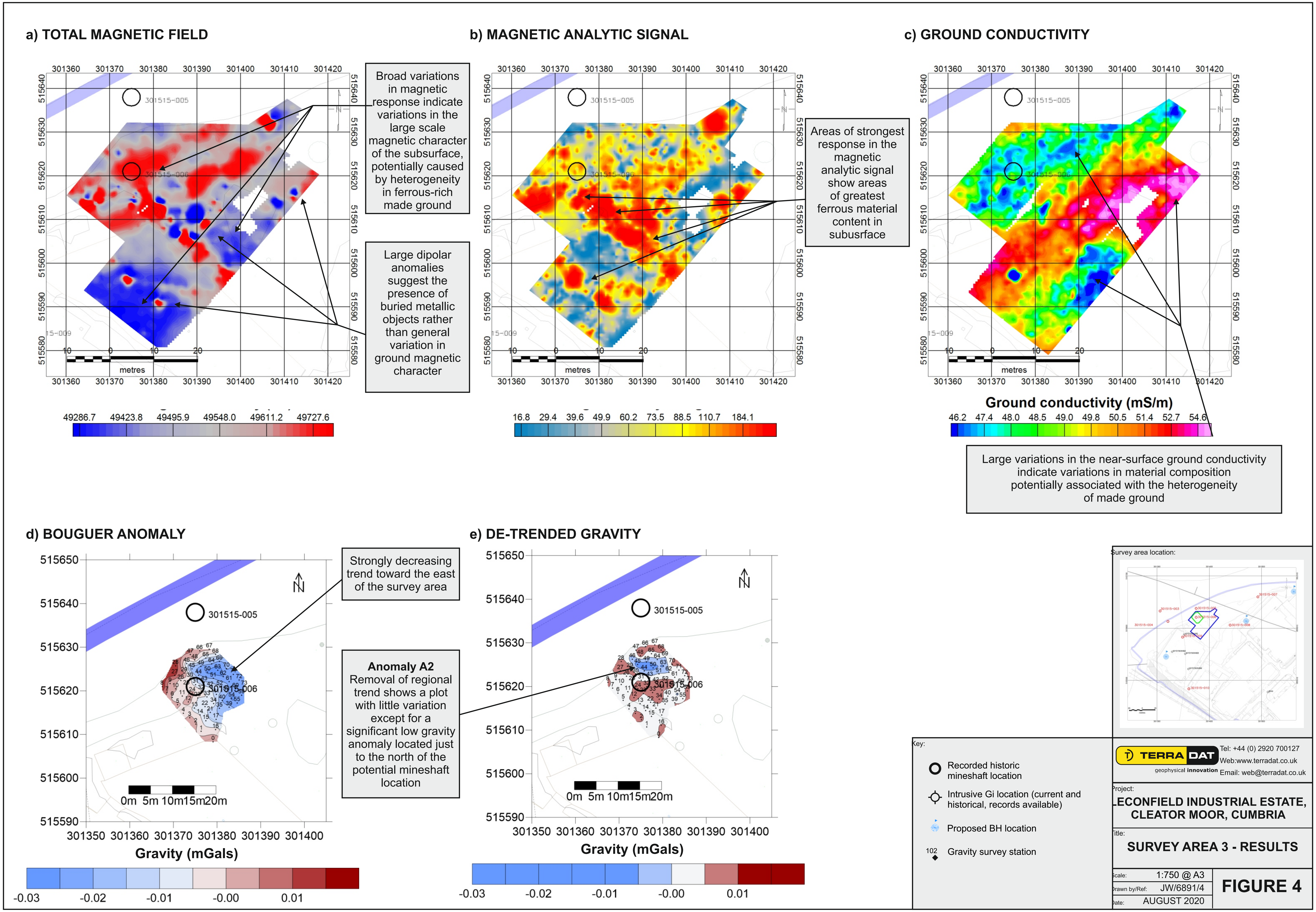
Project:
LECONFIELD INDUSTRIAL ESTATE, CLEATOR MOOR, CUMBRIA
Title:
SURVEY AREA 2 - RESULTS
Scale: 1:500 @ A3
Drawn by/Ref: JW/6891/3
Date: AUGUST 2020
FIGURE 3



a) TOTAL MAGNETIC FIELD
b) MAGNETIC ANALYTIC SIGNAL
c) GROUND CONDUCTIVITY
301515-005
301515-006
metres
Broad variations in magnetic response indicate variations in the large scale magnetic character of the subsurface, potentially caused by heterogeneity in ferrous-rich made ground
Large dipolar anomalies suggest the presence of buried metallic objects rather than general variation in ground magnetic character
Areas of strongest response in the magnetic analytic signal show areas of greatest ferrous material content in subusrface
49286.7 49423.8 49495.9 49548.0 49611.2 49727.6
16.8 29.4 39.6 49.9 60.2 73.5 88.5 110.7 184.1
Ground conductivity (mS/m)
46.2 47.4 48.0 48.5 49.0 49.8 50.5 51.4 52.7 54.6
Large variations in the near-surface ground conductivity indicate variations in material composition potentially associated with the heterogeneity of made ground
d) BOUGUER ANOMALY
e) DE-TRENDED GRAVITY
Strongly decreasing trend toward the east of the survey area
Anomaly A2
Removal of regional trend shows a plot with little variation except for a significant low gravity anomaly located just to the north of the potential mineshaft location
0m 5m 10m15m20m
Gravity (mGals)
-0.03 -0.02 -0.01 -0.00 0.01
Survey area location:
Key:
Recorded historic mineshaft location
Intrusive Gi location (current and historical, records available)
Proposed BH location
Gravity survey station
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Project:
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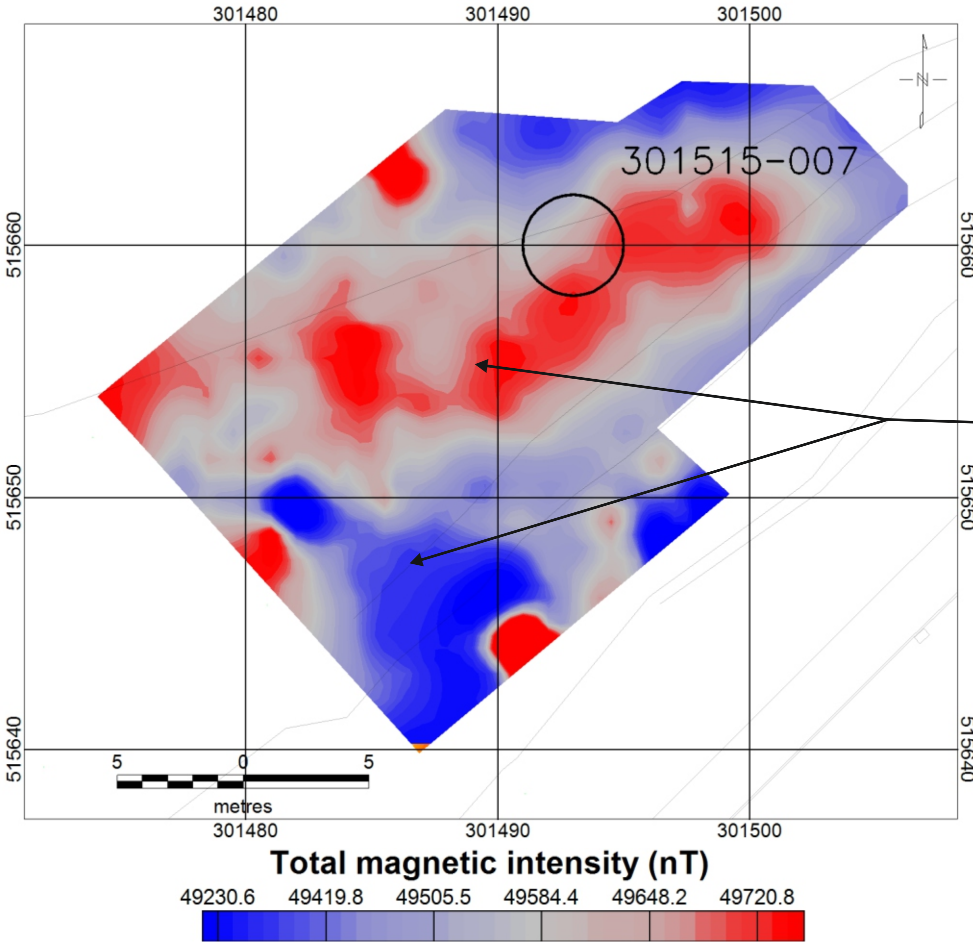
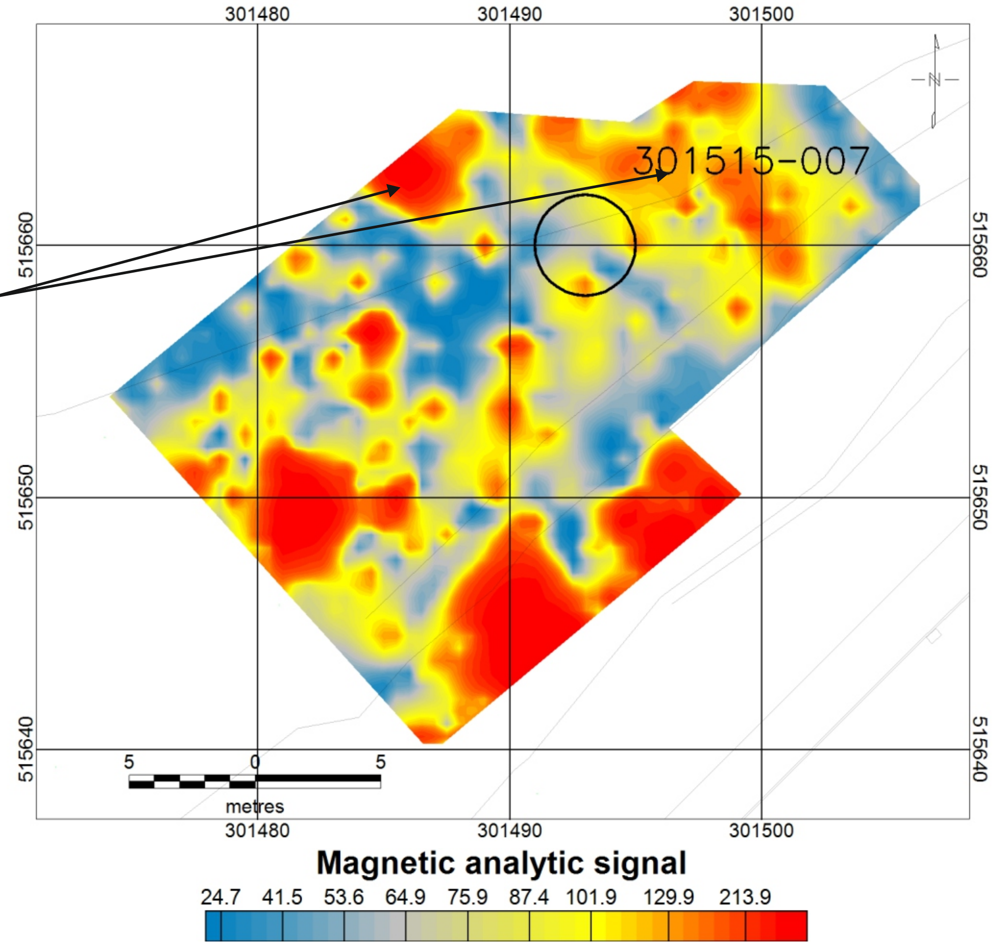
Title:
SURVEY AREA 3 - RESULTS
Scale: 1:750 @ A3
Drawn by/Ref: JW/6891/4
Date: AUGUST 2020
FIGURE 4

a) TOTAL MAGNETIC FIELD



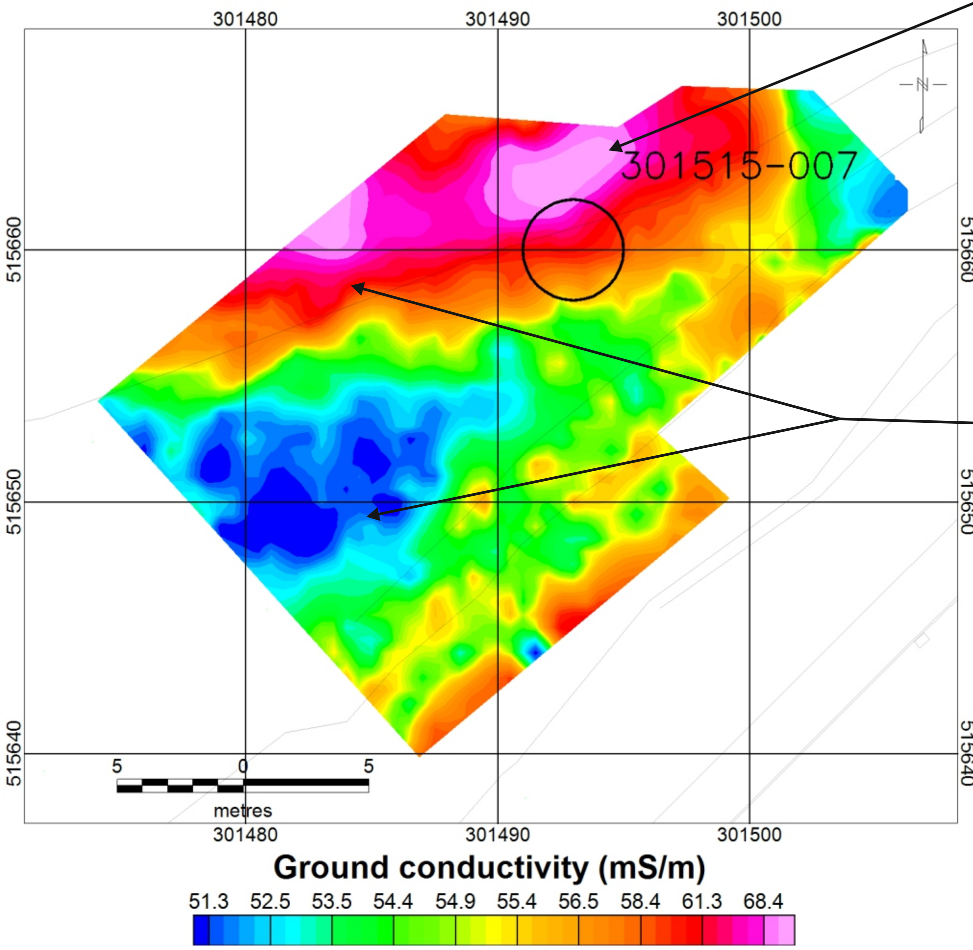
Large variation in magnetic response across the survey area indicates variation in composition of subsurface fill

b) MAGNETIC ANALYTIC SIGNAL



Anomaly B2
Collection of magnetic anomalies near to location of potential mineshaft

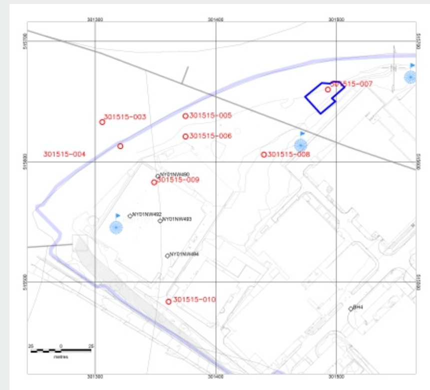
c) GROUND CONDUCTIVITY



Anomaly B3
Broad zone of elevated ground conductivity within area of potential mineshaft may be related to ground heterogeneity associated with historical mining activity

Large variation in ground conductivity values across the survey area indicates variation in composition of subsurface fill

Survey area location:



Key:

- Recorded historical mineshaft location
- Intrusive Gi location (current and historical, records available)
- Proposed BH location

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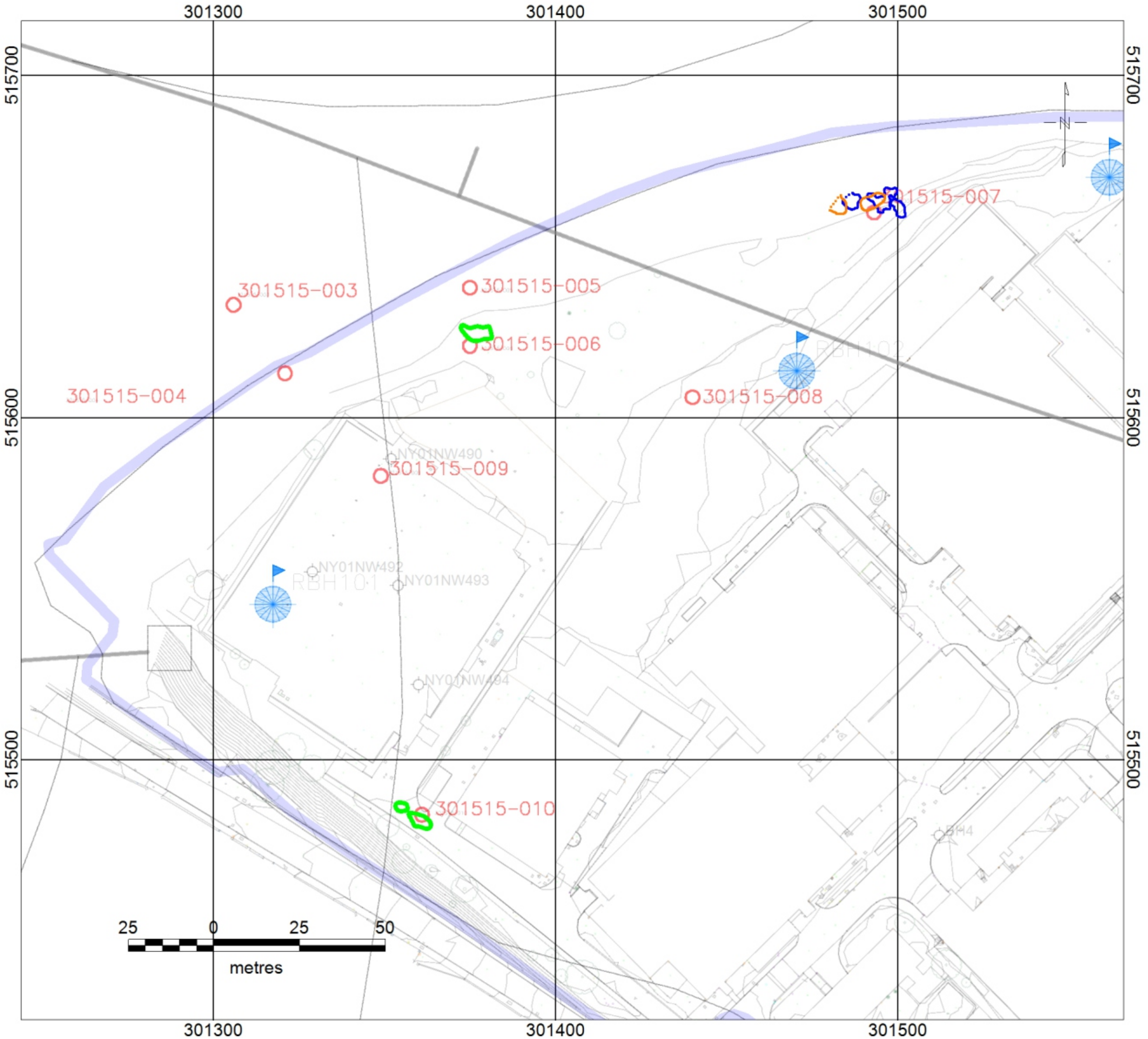
Title: SURVEY AREA 4 - RESULTS

Scale:	1:300 @ A3
Drawn by/Ref:	JW/6891/5
Date:	AUGUST 2020

FIGURE 5



Anomaly outlines provided in digital format in file 'TD-6891-RESULTS.dxf'

Key:

- Gravity anomaly
- Magnetic anomaly
- Ground conductivity anomaly
- Recorded historic mineshaft location
- Intrusive ground investigation location (current and historic, records available)
- Proposed ground investigation location (no records available)

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Project:

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Title:

SUMMARY ANOMALY MAP

Scale:	1:2000 @ A4
Drawn by/Ref:	JW/6891/6
Date:	AUGUST 2020

FIGURE 6

APPENDICES

Appendix - Magnetic Survey

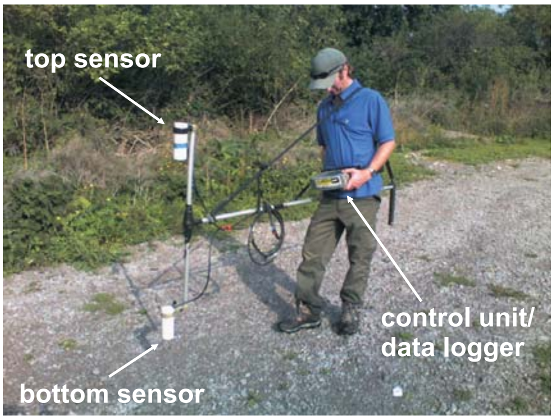
The magnetic survey technique is based on mapping localised variations in the Earth's magnetic field caused sub-surface magnetic materials, which range from naturally occurring magnetic minerals to man-made ferrous objects. This leads to a wide range of applications from small-scale archeology and engineering surveys to detect buried metallic objects, to large-scale surveys carried out to investigate regional geological trends or mineralisation.

Magnetic surveys are carried out using a man-portable instrument with readings taken on a regular grid or along selected traverse lines. The equipment functions by measuring the Earth's magnetic field to a very high precision at each survey station. Ferrous materials in the subsurface have an induced magnetic field that is superimposed on the Earth's field at that location creating a magnetic anomaly. The spacing of survey stations depends on the width of the expected anomaly, which broadens with the size, and depth of burial of the targeted feature. Continuous profiling methods may be used for a high-resolution dataset.

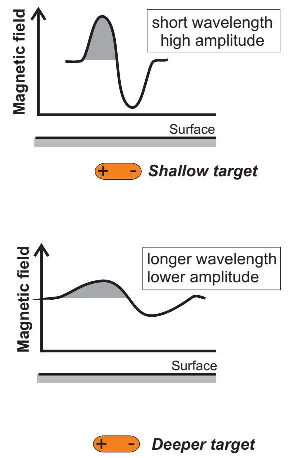
Magnetometer data are stored digitally by the survey instrument and down loaded to a field computer at the end of each day. The magnetic data are then processed to enhance any identifiable anomalies and presented on colour-contoured plots overlain with site maps (when available).

The results of the magnetic survey are usually presented as total field and analytical signal plots . The total field data may be used to observe the general character of the magnetic field across the survey area while the peak values (pink) displayed on the analytical signal plot indicate the source positions for dipole type magnetic anomalies. In general terms, the interpretation of a magnetic anomaly is based on observing the type (pole/dipole), amplitude and wavelength of the anomalous features.

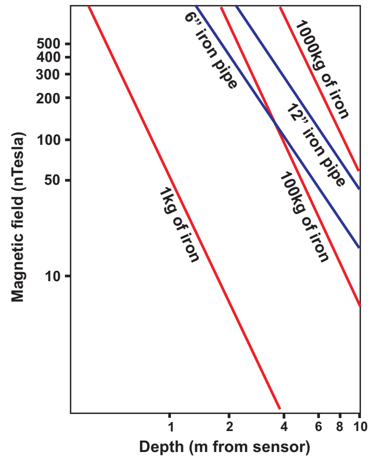
Gradiometer survey



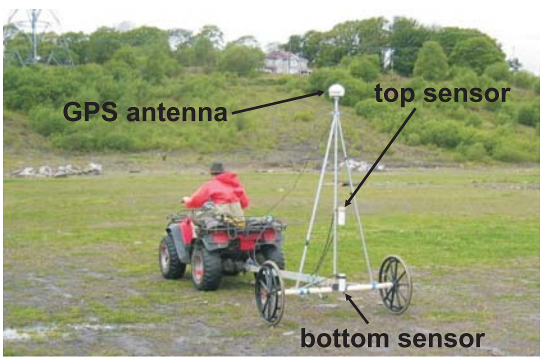
Magnetic anomalies



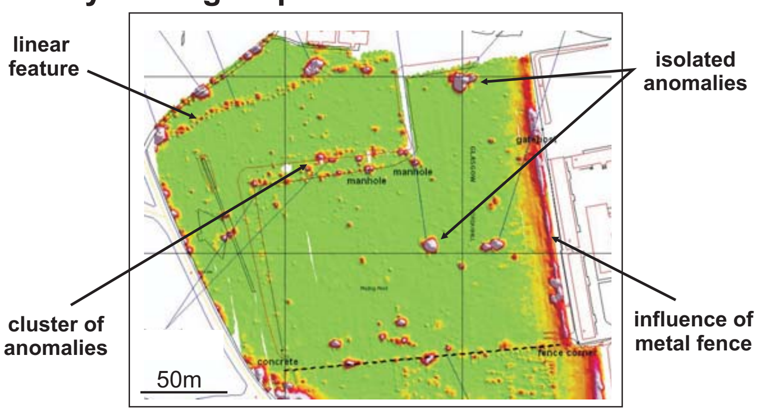
Guide to anomaly size



Towed gradiometer with dGPS



Analytical signal plot



Constraints

Metal objects or structures close to the survey area (fences, vehicles, debris etc.) produce a strong signal that can overshadow more subtle effects of sub-surface anomalies.

Appendix - Ground conductivity (EM) survey

A ground conductivity or electromagnetic (EM) survey involves the generation of an EM field at the surface and subsequent measuring of the response as it propagates through the subsurface. The main components of the instrument are a transmitter coil (to generate the primary EM field) and receiver coil (to measure the induced secondary EM field). The amplitude and phase-shift of the secondary field are recorded and are then converted into values for ground conductivity and in-phase component (metal indicator).

The ground conductivity (EM) instruments are either hand carried or mounted/towed behind a quad bike. Readings are usually taken on a regular grid or along selected traverse lines and positional control can be provided by dGPS if there is sufficient satellite coverage.

The selection of the particular EM instrument (EM-38/EM-31/GEM-2) is primarily based on the required penetration depth of the survey. However for most conductivity surveys the GEM-2 has replaced the more conventional EM-31 instrument due to its ability to simultaneously acquire data at different frequencies (i.e. different depth levels) and a greater depth of penetration. At the end of each survey, the survey data is downloaded to a field computer and corrected for instrument, diurnal and positional shifts. Additional editing may be carried out to remove any 'noisy' data values/positions.

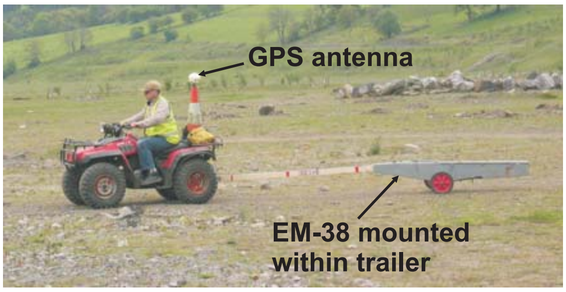
The results from the EM survey can be presented as colour contoured plots of conductivity and inphase (metal response) data. In general terms, a relative increase in conductivity values usually indicates a local increase in clay content or water saturation. However, if there is a corresponding increase in the inphase response, the influence of some artificial source is likely (i.e. metal).

EM-38
Single frequency
Exploration depth ~1.5m

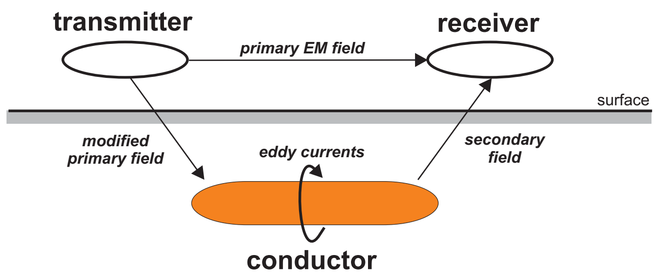
EM-31
Single frequency
Exploration depth ~3 to 5m

GEM-2
Multi-frequency
Exploration depth up to 10m

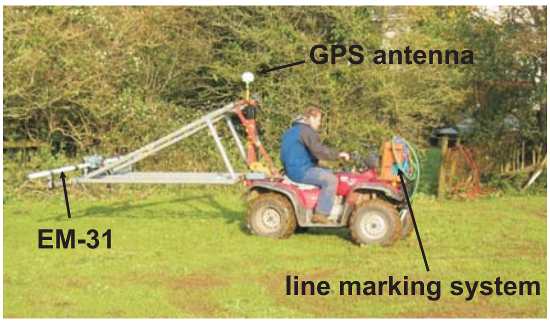
Towed EM-38 with dGPS



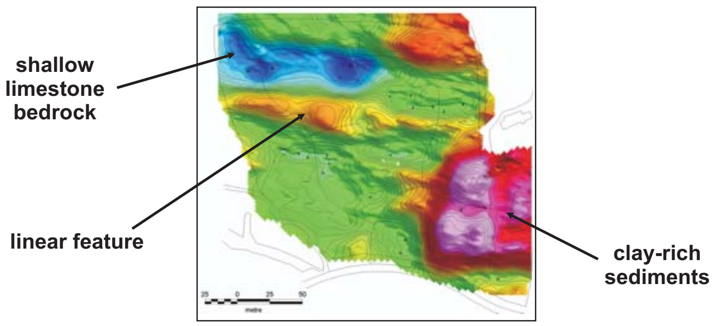
General principle of EM surveying



Mounted EM-31 with dGPS



Ground conductivity data plot



Constraints

Power lines, buildings, metal structures (fences, rebar, vehicles, debris etc.) and buried services can interfere with the electro-magnetic measurements.

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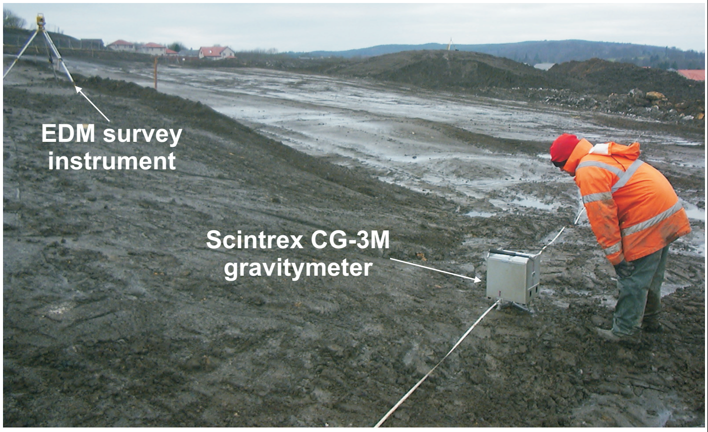
Appendix - Microgravity Survey

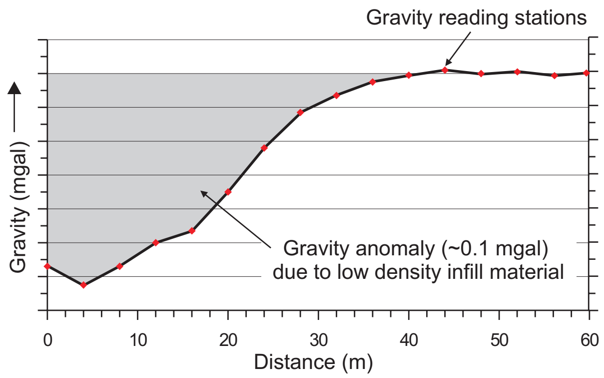
The gravity technique is based on measuring localised variations in the Earth's gravitational field which are caused by materials of different densities. The presence of an anomalously high (or low) density body in the subsurface causes a localised high (or low) anomaly in the measured gravitational field. The gravity effects described are extremely small, however, modern instrumentation and exhaustive data processing techniques enable detection of both geological and artificial structures or voids.

The CG-3M gravity meter is a semi-automated system that enables statistical averaging and filtering of readings taken every second over a fixed period of time (typically 2-3 minutes). The elevation of the gravity instrument was recorded to a 1mm precision (<0.3cm error) at each survey station to facilitate accurate elevation correction. The results from the microgravity survey can be presented as a series of gravity profiles or colour contoured plot displaying the derived Bouguer Anomaly. Interpretation of the microgravity data is based on observing the shape, amplitude and wavelength of a particular anomaly and comparing it against the modelled gravity profile of a given target feature.

Typical field set-up



Gravity profile over the edge of a backfilled quarry



In order to remove (reduce) background gravitational effects i.e. those that do not originate from the target feature, the following processing steps were applied to the acquired dataset using a combination of internal CG-3M software and TerraDat proprietary software *GRED*.

Earth Tide, Temperature & Tilt Correction: Applied automatically by the gravity meter software.

Un-modelled Temporal Residual Correction: Obtained by least-squares fitting of a quadratic polynomial through the base station readings for each day. It is our normal practice to set the Bouguer anomaly at the base to zero so that the calculated values for the other stations are relative to a base station zero.

Latitude Correction: Calculated on the basis of the site latitude. Typically, due to the small latitude extent of the survey gird the correction is assumed to be linear per metre north.

Free-air Correction: Applied to the dataset based on the instrument elevations, which were recorded to a 1mm precision (<0.3cm error) using an EDM survey system.

Terrain Correction: Based on the measured ground level at each gravity reading station and selected points beyond the survey grid.

Bouguer Correction: The selection of the reduction density is based on both site and geological

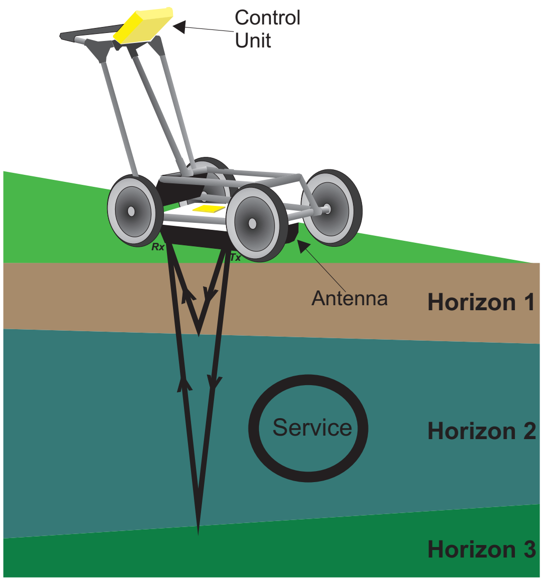
Constraints

The principal limitation on the use of gravity is the time required for careful acquisition and data processing. The detectability of a feature using the gravity methods is proportional to its size/depth ratio and its density contrast with the host material. There is a decrease in spatial resolution with increased depth of burial. In terms of site considerations, it is best to avoid sites with severe terrain or are have excessive vibrational noise.

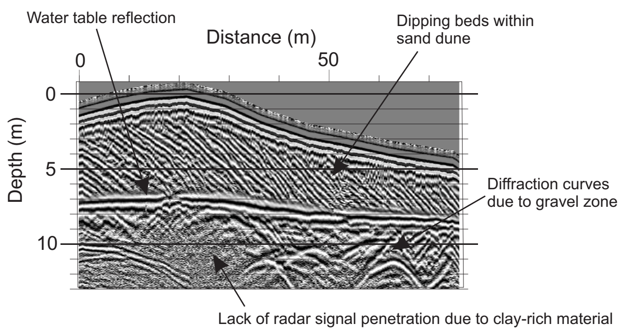
Appendix - Ground Penetrating Radar (GPR)

A Ground Penetrating Radar (GPR) survey involves one or two people either continuously towing a radar system or taking readings at very closely spaced intervals along selected traverse lines. GPR systems use a pulsed electromagnetic (radio wave) transmitted via a tuned frequency antenna that can penetrate soils, rock, concrete, and many other natural and man-made materials. Reflection events from geological or hydrological boundaries between sufficiently contrasting materials are recorded via a receiver antenna. A time-depth cross-section (radargram) of the shallow subsurface is constructed as the radar system is moved along a survey line. The radargram can be depth calibrated to enable detailed interpretation given known or measured velocities for the materials being investigated. While viewing relatively raw radar data can prove useful in the field there are numerous processing routines that can be employed to significantly improve the results. Final sections are presented showing annotated features of interest with apparent depth calibration.

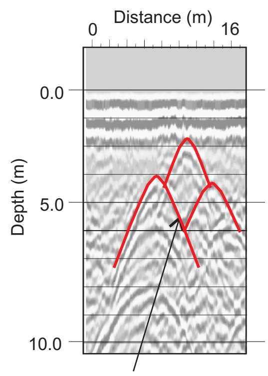
General principle of Ground Radar



GPR Survey in progress



Ground Radar profile over a parabolic sand dune (100MHz)



Observed diffraction curves over a sub-surface cavity within limestone

In order to improve the quality of the recorded radar data, a number of processing routines can be applied to the data using dedicated software (REFLEX). The final radar sections are converted to depth by applying a conversion velocity, which is usually based on an average velocity value for the local sediments. Without any additional calibration the measured depth to a particular feature is likely to be resolved within a 20% error margin depending on the local velocity structure.

Constraints:

The main limitations affecting radar surveys are the presence of conductive materials near surface (e.g., clay and water) which reduce penetration, and blocky material which scatters signal.