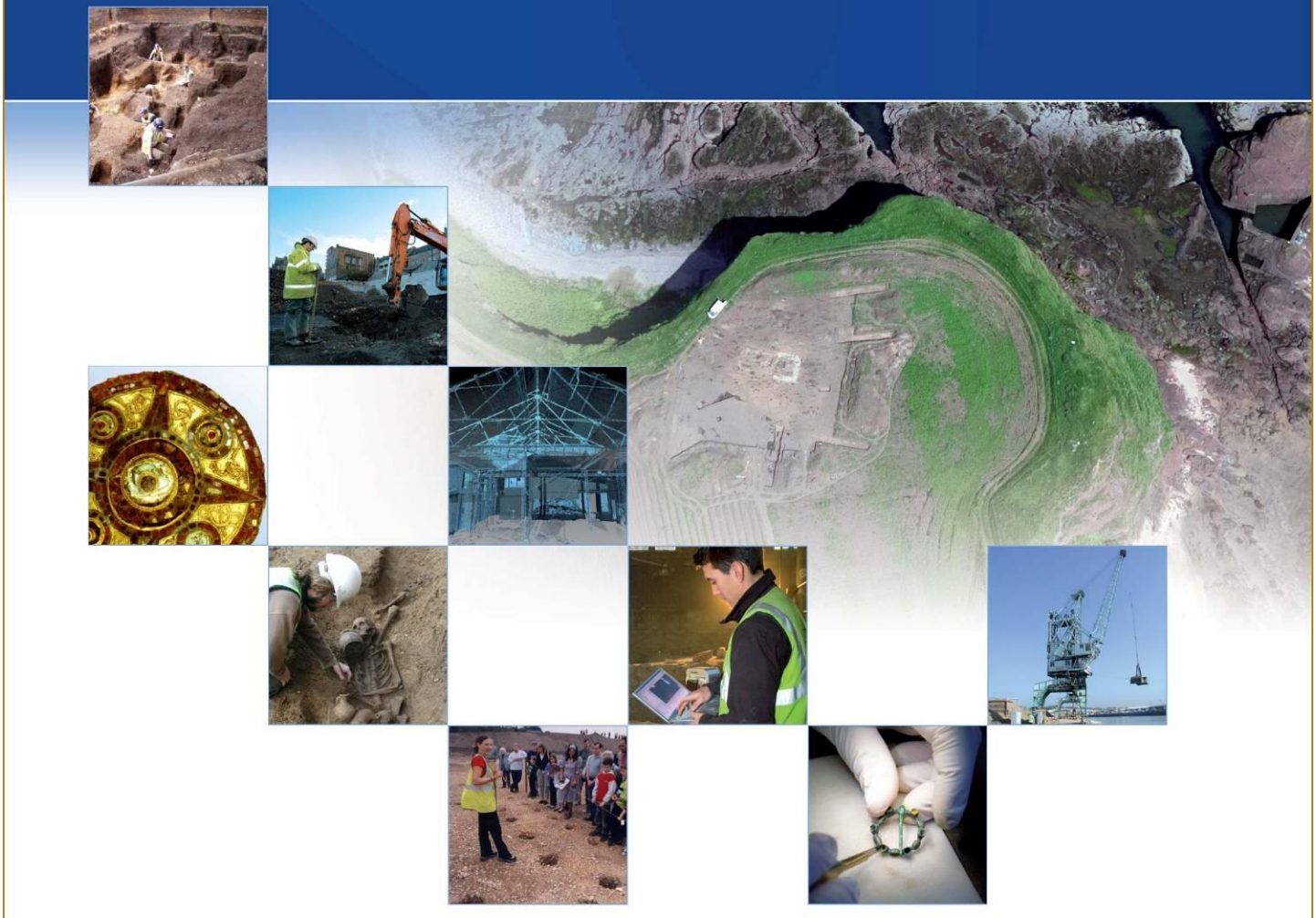
Howpark Solar Farm, Scottish Borders

Archaeological Geophysical Survey

National Grid Reference: NT 83820 66531
AOC Project No: 40525
Date: 11 August 2023



AOC Archaeology Group

ARCHAEOLOGY | HERITAGE | CONSERVATION

Howpark Solar Farm, Scottish Borders

Archaeological Geophysical Survey

On Behalf of:	**SLR Consulting Limited** **Floor 2** **4/5 Lochside View** **Edinburgh Park** **Edinburgh** **EH12 9DH**
National Grid Reference (NGR):	**NT 83820 66531 (centre)**
AOC Project No:	**40525**
OASIS ID	**aocarcha1-514575**
Prepared by:	**Susan Ovenden**
Illustrations by:	**Susan Ovenden**
Date of survey:	**28th March – 6th April 2023**
Surveyors:	**Kinnie Wade, Henry Conran, Marguerite Hall, Reed Haywood**

This document has been prepared in accordance with AOC standard operating procedures.

Author: Susan Ovenden	**Date: 11 August 2023**
Quality Checked by: Chris Sykes	**Date: 11 August 2023**
Report Stage: Final Report	**Date: 11 August 2023**

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Contents

List of Plates

List of Figures

Non-Technical Summary

AOC Archaeology Group was commissioned by SLR Consulting Limited to undertake an archaeological geophysical survey, using the magnetic gradiometry method, to investigate the potential for buried archaeological remains prior to a proposed development at Howpark, Scottish Borders, centred at NT 83820 66531 centre.

The survey area covers four pasture and arable fields up to 46ha. An area of approximately 32.3ha was surveyed with approximately 13.7ha being unsuitable for survey due to woods, boggy ground conditions associated with the stream which runs through the Site, and a modern track.

The gradiometer data has a relatively high level of background response. This is thought to be due to a combination of the underlying geology, agricultural activity to improve drainage, wire fencing, and modern land use.

In the southwest of the Site a strong linear response has been recorded. The response does not correspond with any features recorded on past mapping. While the anomaly may indicate an undocumented former field boundary associated with the extant woodland, it has been noted as having a possible archaeological origin as the response is consistent with a brick structure and it could be associated with RAF Dronehill. Linear responses on an associated alignment have been detected to the west which may indicate associated former field divisions. However, they have been noted as having an unclear origin as they could have a natural origin.

Across the Site several sinuous trends have been detected which have been categorised as having unclear origins. Given their branch-like form a natural origin is most likely, but the responses are not conclusively natural. It is possible that the responses are a combination of natural features infilled with modern material to improve drainage.

Additional trends of an unclear origin have been noted across the Site which are most likely associated with agricultural activity or natural variations, but an archaeological origin for all of them cannot be wholly dismissed. Numerous discrete areas of enhanced magnetism have been noted within across the Site. These are not particularly coherent and do not form a clear pattern. It is most likely that they are due to localised natural variations and more deeply buried modern fired or ferrous material.

Several well-defined areas of enhanced magnetism have been detected throughout the Site which have a natural origin. These tend to take three forms; broad areas of elevated response, better defined linear anomalies, and weaker trends.

Linear trends characteristic of modern field drains, forming distinctive herring-bone patterns, have been detected within the Site.

Small zones of magnetic disturbance along the limits of the field are due to ferrous material in and adjacent to the field boundary. Linear zones of magnetic disturbance within the survey area are due to wire fences and modern features. A moderate to high level of isolated dipolar anomalies (ferrous / iron spikes) is visible throughout the dataset which are likely to be modern in origin.

1 Introduction

1.1 AOC Archaeology Group was commissioned by SLR Consulting Limited to undertake an archaeological geophysical survey using magnetic gradiometry of an area of land at Howpark, Scottish Borders. The survey was commenced on the 28th March 2023 and completed on 6th April 2023 as part of a wider scheme of archaeological assessment in advance of the proposed development of the Site. The planned survey area was 46ha, of which 32.3ha was completed. Approximately 4.5ha could not be surveyed due to wooded areas, while a further 9.2ha was unsuitable for survey due to boggy ground conditions associated with the stream which runs through the Site and a modern track.

1.2 Archaeological geophysical survey uses non-intrusive and non-destructive techniques to determine the presence or absence of anomalies likely to be caused by archaeological features, structures, or deposits, as far as is reasonably possible (CIfA, 2014). It is therefore a common component of the process of evaluating the impact of development on the historic environment. It is also a key tool in archaeological research as it is non-destructive and able to cover large areas, to allow below ground interventions to be appropriately targeted.

1.3 This survey was carried out to provide information on the presence, character, and extent of potential buried archaeological remains within the proposed development Site. The significance of any such remains can only be determined with reference to further information; as such this report may form part of an assessment of significance but cannot stand alone as such.

2 Survey Area Location and Description

2.1 The proposed development Site (hereafter the Site) is located on land to the west of High View Caravan Park, approximately 2.5km east of Granthouse (NGR NT 83820 66531). The survey area is situated on land in use as pasture and arable (see Figure 1).

2.2 The survey area covers approximately 46ha across four of fields bounded to the north and east by wooded areas and to the south and west by field boundaries (Figure 2). The area is undulating with a stream running through the area from southeast to northwest. The survey area ranges from approximately 197m to 226m above Ordnance Datum (aOD), generally sloping down to the northwest.

2.3 The recorded solid geology underlying the survey area consists of greywackes and shale of the Wacke Group. This is overlain by superficial deposits of Devensian Till in some areas (BGS, 2023). The soils within the survey area consist of Brown Earths of the Ettrick association (Scotland's Soils, 2023).

2.4 This sedimentary bedrock is suited to gradiometer survey but can give mixed results (David et. al. 2008, 15). In this instance, the soil and geological environment of the survey area do not contraindicate the use of the planned method.

3 Archaeological Background

3.1 The archaeological background below is summarised from the Environmental Impact Assessment Screening Report prepared by SLR for their client in February 2023, which summarises a draft Desk Based Assessment (DBA) carried out by SLR in 2022, the report for which is still in preparation

3.2 A Site walkover survey was undertaken on 2nd August 2022 to inform and support the findings of the DBA of heritage conditions of the Site, and the immediate surrounds.

3.3 Ten archaeological assets were identified within the Site, seven of which were identified during the walkover. The heritage DBA initially identified some potential for unknown post-medieval and modern archaeological remains within the Site. These are proposed to comprise post-medieval agricultural remains such as field boundaries or potential remains associated with the Second World War RAF Dronehill to the east of the Site. A high potential for unknown modern heritage assets to be present within the Site has been identified, due to the Site's connection to RAF Dronehill, Chain Home Radar Station (105960) to the immediate east. Whilst it is also unlikely that there are any unknown buried remains of structures associated with this period, due to the Site being well documented through accounts, contemporary aerial photographs, and later mapping, there is still the potential for remains associated with training.

3.4 No Scheduled Monuments are identified within the Site boundary, the closest comprising the remains of an enclosed settlement at Atton (SM12504) which is visible as a cropmark located approximately 570m west of the Site, demonstrating a wider domestic use of the area. No Listed Buildings are identified within the Site. Howpark Farmhouse, a 19th Century Grade C Listed Building with an associated garden wall (LB46642) is located approximately 700m to the west.

4 Aims

4.1 The aim of the geophysical survey was to identify anomalies that suggest the presence of archaeological remains, in order to enhance the current understanding of the historical environment within the survey area.

4.2 Specifically, the aims of the gradiometer survey were;

- To locate, record and characterise any potential surviving sub-surface archaeological remains within the survey area, as part of a broader archaeological evaluation
- To produce a comprehensive Site archive (Appendix 1) and report

5 Methodology

5.1 The geophysical survey was undertaken between 28th March and 6th April 2023.

5.2 All geophysical survey work was carried out in accordance with recommended good practice specified in the EAC guideline documents published by Historic England (Schmidt et al. 2016) and the Chartered Institute for Archaeologists Standard and Guidance for archaeological geophysical survey (2014).

5.3 Parameters and survey methods were selected that were suitable for the prospective aims of the survey and in accordance with recommended professional good practice (Schmidt et al. 2016).

5.4 Digital photographs of every survey parcel were taken before, during and after geophysical survey to show any changes to field conditions following the programme of works. The photos were downloaded and stored off Site, and relevant examples are included as Plates 1 to 4 in this report.

5.5 The gradiometer survey was carried out using a cart system which utilised upto six gradiometer sensors mounted a set distance apart upon a carbon fibre frame, along with data logging equipment and batteries (see Appendix 2). Before each session of use, the cart system was balanced around a single set up point within the Site specifically chosen for being magnetically quiet. Balancing the machine around this point produces a more uniform dataset throughout and allows all data to be plotted with ease on the same palette.

5.6 Data was collected using zig-zag traverses alongside a constant stream of GPS data collected through a Trimble R10 GPS, enabling the collected data to be spatially georeferenced without the need for a pre-determined grid system. The data was logged on a laptop mounted to the cart using bespoke software.

5.7 A total of 32.3ha were surveyed using a gradiometer cart.

5.8 Care was also taken to attempt to avoid metal obstacles present within the survey area, such as metal objects within and adjacent to the survey area as gradiometer survey is affected by ‘above-ground ferrous disturbance’ and avoiding these improves the overall data quality and results obtained.

5.9 The data was downloaded from MLGrad601 and converted into a .xyz file in Geomar MultiGrad601 before being processed along with the GPS data in TerraSurveyor v3.0.34.10. The details of these processes can be found in Appendices 2 and 3.

5.10 Interpretations of the data were created in ArcGIS Pro and the technical terminology used to describe the identified features can be found in Appendix 4.

6 Results and Interpretation

6.1 The gradiometer survey results have been visualised as greyscale plots and XY traces. An overview greyscale image of the processed gradiometer data is provided in Figure 3 at a scale of 1:3500, with an accompanying summary interpretation provided in Figure 4. The processed data is plotted at -2nT to 3nT at a scale of 1:1250 in Figures 5.1 – 5.5. Interpretations of the data can be seen in Figures 6.1 – 6.5. The minimally processed data is displayed as XY traces plotted at 40nT per cm in Figures 7.1 – 7.5.

6.2 Appendix 4 contains a guide to the interpretation categories employed and the logic used to assign anomalies to specific classes, as well as a short discussion of how past human activity results in these anomalies, however some important points are noted below:

6.3 The classes have three sub-types (generally); anomalies (typically indicated by a solid colour polygon), spreads (a stippled polygon) and trends (a line with a colour matching the polygon colour). *Anomalies* refer to distinct changes in the survey data which suggest an abrupt boundary between materials below ground, such as a cut feature with a magnetically contrasting fill. *Spreads* of enhanced material refer to diffuse areas of altered magnetic contrast which suggest a localised spread of material with a magnetic contrast within the topsoil or ploughzone. Linear *trends* are less distinct and are typically visible as linear patterning in the overall texture of the data. A common example of these is the striping effect caused by recent ploughing.

6.4 Anomalies placed in the 'uncertain' class may have an archaeological origin, but other explanations are equally likely. Where any interpretation is *more* likely than others, the anomaly is assigned to that class.

6.5 The definite 'Archaeology' class is only used for anomalies with no other possible explanation, either due to their diagnostic characteristics or because they are corroborated by other sources such as previous interventions within the survey area. Anomalies with magnetic characteristics or morphologies that suggest an archaeological origin with generally be assigned to the 'Possible Archaeology' class.

6.6 The anomaly type 'ferrous spike' is assigned to strong dipolar anomalies which cover a small spatial area and have a characteristic appearance in the XY traces of the survey data. These are strongly likely to be of recent origin in the form of magnetic or ferrous debris within the topsoil; 'spikes' of other origin will be assigned to their appropriate classification.

6.7 A distinction is made between modern *disturbance* from strongly ferrous materials within or adjacent to the survey area, such as the strong dipolar 'halos' produced by services like gas mains, and spreads of material within the topsoil causing noise which is assumed to have a recent origin. Generally speaking, '*modern disturbance'* occurs at a distance from magnetic source, whereas *modern magnetic spreads/debris* are related to material directly at that location.

6.8 Generally, only anomalies (or groups thereof) of a likely archaeological or historical origin have been assigned an anomaly letter on the interpretation figures. However, anomalies interpreted as resulting from other processes that are integral to the discussion of the results have also been assigned anomaly letter. The anomaly letter is prefixed with the filed number.

6.9 The results show a generally elevated level of background response due to geological variations and agricultural activity.

Field 1 (Figures 5.1-5.2, 6.1-6.2, 7.1-7.2)

Archaeology

6.10 No anomalies indicative of definite archaeological remains have been detected within this field.

Possible Archaeology

6.11 No anomalies suggestive of possible archaeology have been detected within this field.

Unclear Origins

6.12 Two linear trends [**1A**] have been detected within this survey area. The origin of these is unclear. It is most likely that they are associated with natural variations or agricultural activity, although an archaeological origin can not be wholly dismissed.

6.13 Several discrete areas of enhanced magnetism [**1B**] have been noted throughout this survey area. These are not particularly coherent and do not form a coherent pattern. It is most likely that they are due to localised natural variations and more deeply buried modern fired or ferrous material.

6.14 Ephemeral curving trends [**1C**] are just discernible in the centre of the data set. It is most likely that these are natural in origin given the high density of natural responses observed within the survey area, but an archaeological origin cannot be excluded.

Historical Features

6.15 The negative trend [**1D**] crossing the southern half of the survey area appears to correspond with a former field boundary depicted on the 1st Edition Ordnance Survey (OS) map of 1888 (NLS, 2023)

Agricultural

6.16 The parallel trends in the southwest of the survey area are characteristic of modern field drains.

Non – Archaeology

6.17 Several well-defined areas of enhanced magnetism have been detected throughout this field which have a natural origin. These tend to take two forms; broad areas of elevated response and better defined linear trends. The latter probably indicate palaeochannels from migration of the stream which forms the southern limit of this Field.

6.18 Small zones of magnetic disturbance along the limits of the field are due to ferrous material in and adjacent to the field boundary. Linear zones of magnetic disturbance within the survey area are due to wire fences dividing the field into quarters.

6.19 A moderate level of isolated dipolar anomalies (ferrous / iron spikes) is visible throughout the dataset which are likely to be modern in origin.

Field 2 (Figures 5.2-5.4, 6.2-6.4, 7.2-7.4)

Archaeology

6.20 No anomalies indicating the presence of definite archaeology have been detected within this field.

Possible Archaeology

6.21 No anomalies suggestive of possible archaeology have been detected within this field.

Unclear Origins

6.22 A linear zone of slightly elevated response [**2A**] has been detected in the northeast of this survey area. This appears to correspond with a slight topographic change, but it is not known if this has a natural origin, or a more recent agricultural origin.

6.23 Similarly, the sinuous zone of magnetic enhancement [**2B**] is most likely natural in origin, but it could have a more recent anthropogenic origin such as a former field boundary or track, hence its categorisation as having an unclear origin.

6.24 Two trends of negative magnetism [**2C**] have been noted in the southwest of the survey area. It is most likely that these trends indicate modern field drains, or possibly natural variations.

6.25 Several discrete areas of enhanced magnetism [**2D**] have been noted within this survey area. As with Field 1 to the east, these are not particularly coherent and do not form a clear pattern. It is most likely that they are due to localised natural variations and more deeply buried modern fired or ferrous material.

Historical Features

6.26 No features indicated on historic mapping have been detected by the survey.

Agricultural

6.27 The parallel trends in the southwest of the survey area are characteristic of modern field drains and form a distinctive herring-bone pattern.

Non – Archaeology

6.28 The well-defined linear zone of magnetic enhancement is associated with the stream which runs through the survey area.

6.29 Zones of magnetic disturbance along the limits of the field are due to ferrous material in and adjacent to the field boundary.

6.30 Within the survey area, isolated anomalies of magnetic disturbance, are due to a modern track, feeding stations etc.

6.31 A high level of isolated dipolar anomalies (ferrous / iron spikes) is visible throughout the dataset which are likely to be modern in origin.

Field 3 (Figures 5.3-5.4, 6.3-6.4, 7.3-7.4)

Archaeology

6.32 No anomalies indicative of definite archaeology have been detected within this field.

Possible Archaeology

6.33 No anomalies suggestive of possible archaeology have been detected within this field.

Unclear Origins

6.34 In the south of the survey area several sinuous trends [**3A**] have been detected which have been categories as having unclear origins. Given the branch-like form of these responses a natural origin is most likely, but the responses are not conclusively natural.

6.35 The linear trends [**3B**] on generally east-west alignments have a slightly different form. These may indicate undocumented field divisions, but natural origins are also possible.

6.36 The discrete areas of enhance magnetism [**3C**] appear to coincide with slight hollows on the surface and may indicate former quarries which are recorded in the wider landscape. However, they could be associated with military activity.

6.37 A cluster of well-defined pit-type anomalies [**3D**] has been detected in the northeast of the survey area. The origin of these is unclear. They could have a modern or natural origin, but an archaeological origin cannot be wholly excluded.

Historical Features

6.38 No features indicated on historic mapping have been detected by the survey.

Agricultural

6.39 No clearly defined agricultural responses are apparent within this data set.

Non – Archaeology

6.40 The data are dominated by subtle variations in the background level of response caused by natural geological and topographic changes.

6.41 Zones of magnetic disturbance along the limits of the field are due to ferrous material in and adjacent to the field boundary. In addition, areas of magnetic disturbance within the survey parcel are due to additional fence and modern debris.

6.42 A high level of isolated dipolar anomalies (ferrous / iron spikes) is visible throughout the dataset which are likely to be modern in origin.

Field 4 (Figures 5.5, 6.5, 7.5)

Archaeology

6.43 No anomalies indicative of definite archaeological features have been detected within this field.

Possible Archaeology

6.44 In the southwest of the survey area, a strong magnetically enhanced linear response, [**4A**] has been recorded. The geometry and strength of the anomaly does not suggest a field drain, and the response does not correspond with any features recorded on past mapping. While the anomaly may indicate an undocumented former field boundary associated with the extant woodland, it has been noted as having a possible archaeological origin as the response is consistent with an unidentifiable brick structure and could be associated with RAF Dronehill. The orientation of [4A] runs perpendicular to unclear linear responses [2B] and [3B] recorded to the west which might suggest that they are all contemporary, but this is conjecture.

Unclear Origins

6.45 Ephemeral trends on NW-SE [**4B**] and SW-NE [**4C**] have been recorded in the centre of this survey area. The origin of these is unclear, but drainage features seem most plausible.

6.46 As with elsewhere within the Site, discrete areas of enhanced magnetism [**4D**] have been noted within this survey area. These are not particularly coherent and do not form a clear pattern. It is most likely that they are due to localised natural variations and more deeply buried modern fired or ferrous material.

Historical Features

6.47 No features indicated on historic mapping have been detected by the survey.

Agricultural

6.48 Weak parallel trends aligned WSW-ENE reflect modern agricultural activity.

Non – Archaeology

6.49 The data contains subtle variations in the background level of response caused by natural and topographic changes.

6.50 Zones of magnetic disturbance along the limits of the field are due to ferrous material in and adjacent to the field boundary.

6.51 A moderate level of isolated dipolar anomalies (ferrous / iron spikes) is visible throughout the dataset which are likely to be modern in origin.

7 Conclusion

7.1 The gradiometer survey has recorded a wide variety of responses across the survey area. A relatively high level of background response is evident which is thought to be due to a combination of the underlying geology, agricultural activity to improve drainage, wire fencing, and modern land use.

7.2 No anomalies indicating definite archaeological remains have been detected within the Site.

7.3 In the southwest of the Site a strong linear response has been recorded. The response does not correspond with any features recorded on past mapping. While the anomaly may indicate an undocumented former field boundary associated with the extant woodland, it has been noted as having a possible archaeological origin as the response is consistent with a brick structure and it could be associated with RAF Dronehill. Linear responses on an associated alignment have been detected to the west which may indicate associated former field divisions. However, they have been noted as having an unclear origin as they could have a natural origin.

7.4 Across the Site several sinuous trends have been detected which have been categorised as having unclear origins. Given their branch-like form a natural origin is most likely, but the responses are not conclusively natural. It is possible that the responses are a combination of natural features infilled with modern material to improve drainage.

7.5 Additional trends of an unclear origin have been noted across the Site which are most likely associated with agricultural activity or natural variations, but an archaeological origin for all of them cannot be wholly dismissed. Numerous discrete areas of enhanced magnetism have been noted within across the Site. These are not particularly coherent and do not form a clear pattern. It is most likely that they are due to localised natural variations and more deeply buried modern fired or ferrous material.

7.6 Several well-defined areas of enhanced magnetism have been detected throughout the Site which have a natural origin. These tend to take three forms; broad areas of elevated response, better defined linear anomalies, and weaker trends.

7.7 Linear trends characteristic of modern field drains, forming distinctive herring-bone patterns, have been detected within the Site.

7.8 Small zones of magnetic disturbance along the limits of the field are due to ferrous material in and adjacent to the field boundary. Linear zones of magnetic disturbance within the survey area are due to wire fences dividing the field into quarters. A moderate to high level of isolated dipolar anomalies (ferrous / iron spikes) is visible throughout the dataset which are likely to be modern in origin.

7.9 In assessing the results of the geophysical survey against the specific aims set out in Section 4;

- The survey has succeeded in locating, recording, and characterising surviving sub-surface remains within the Site;
- The survey will help in determining the next stage of works as it has provided evidence that remains of an uncertain origin are most likely present on Site, and has provided a number of targets for further investigation;
- The survey has resulted in a comprehensive report and archive.

8 Statement of Indemnity

8.1 Although the results and interpretation detailed in this report have been produced as accurately as possible, it should be noted that the conclusions offered are a subjective assessment of collected data sets.

8.2 The success of a geophysical survey in identifying archaeological remains can be heavily influenced by several factors, including geology, seasonality, field conditions and the properties of the features being detected. Therefore, the geophysical interpretation may only reveal certain archaeological features and not produce a complete plan of all the archaeological remains within a survey area.

9 Archive Deposition

9.1 In accordance with professional standard practice an 'Online Access to the Index of archaeological investigations' ('OASIS') record will be completed for submission to the HER and Archaeological Data Service (ADS) (Appendix 2).

9.2 A 'Discovery and Excavation in Scotland' ('DES') text will be created and added as an appendix to the report, for submission to Archaeology Scotland.

9.3 One digital and hard copy of the report and data will be submitted to the relevant Historic Environment Record (HER) at the Client's discretion.

9.4 A digital copy of the report and data will also be submitted to the ADS at the Client's discretion.

10 Bibliography

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SLR, 2023 *Howpark Solar PV EIA Screening Report*

*denotes a reference that occurs in Appendix 2 rather than the main body of this report.

11 Plates

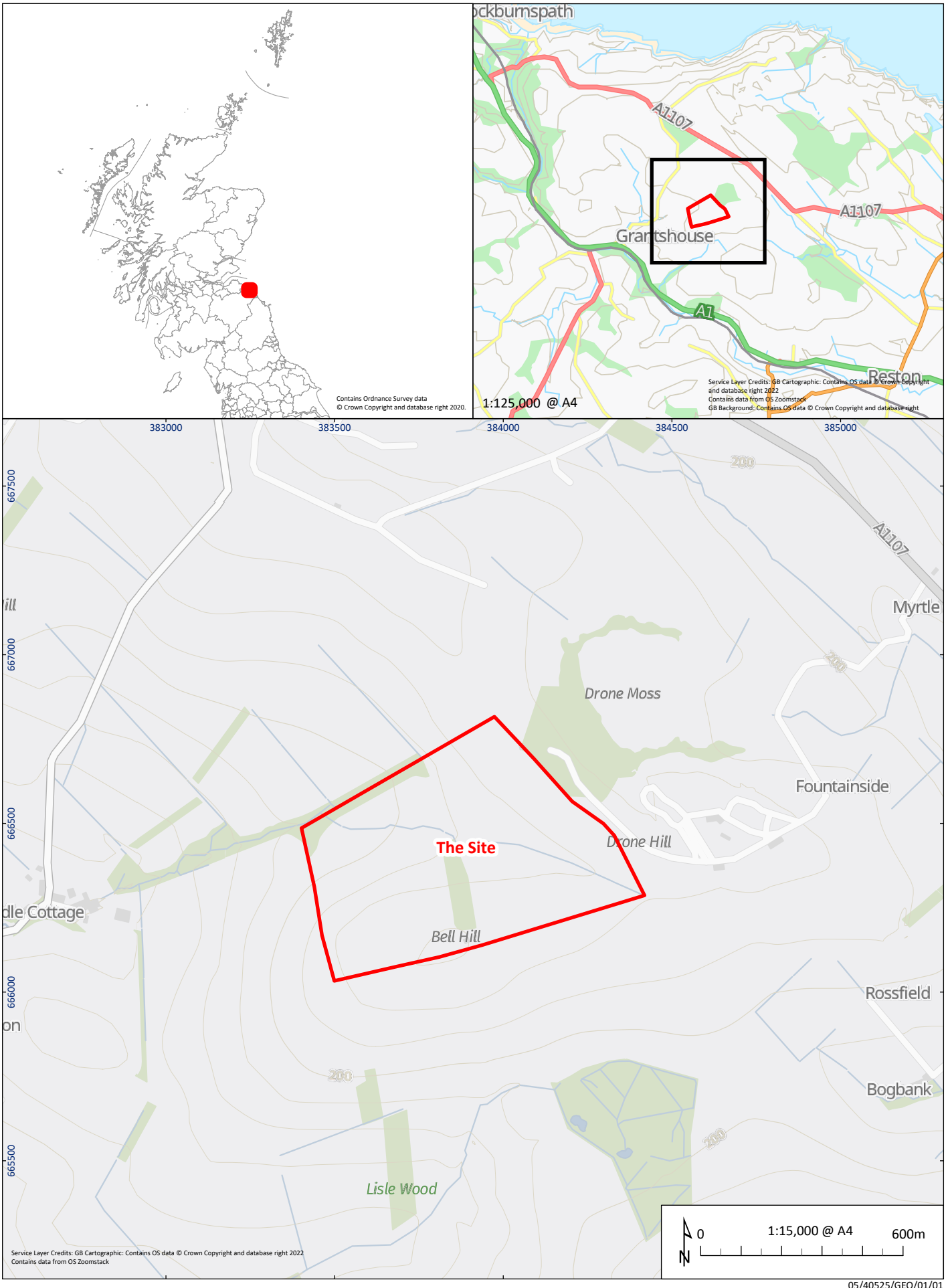
Plate 1: Field 1 looking west

Plate 2: Field 2 looking east

Plate 3: Field 3 looking west

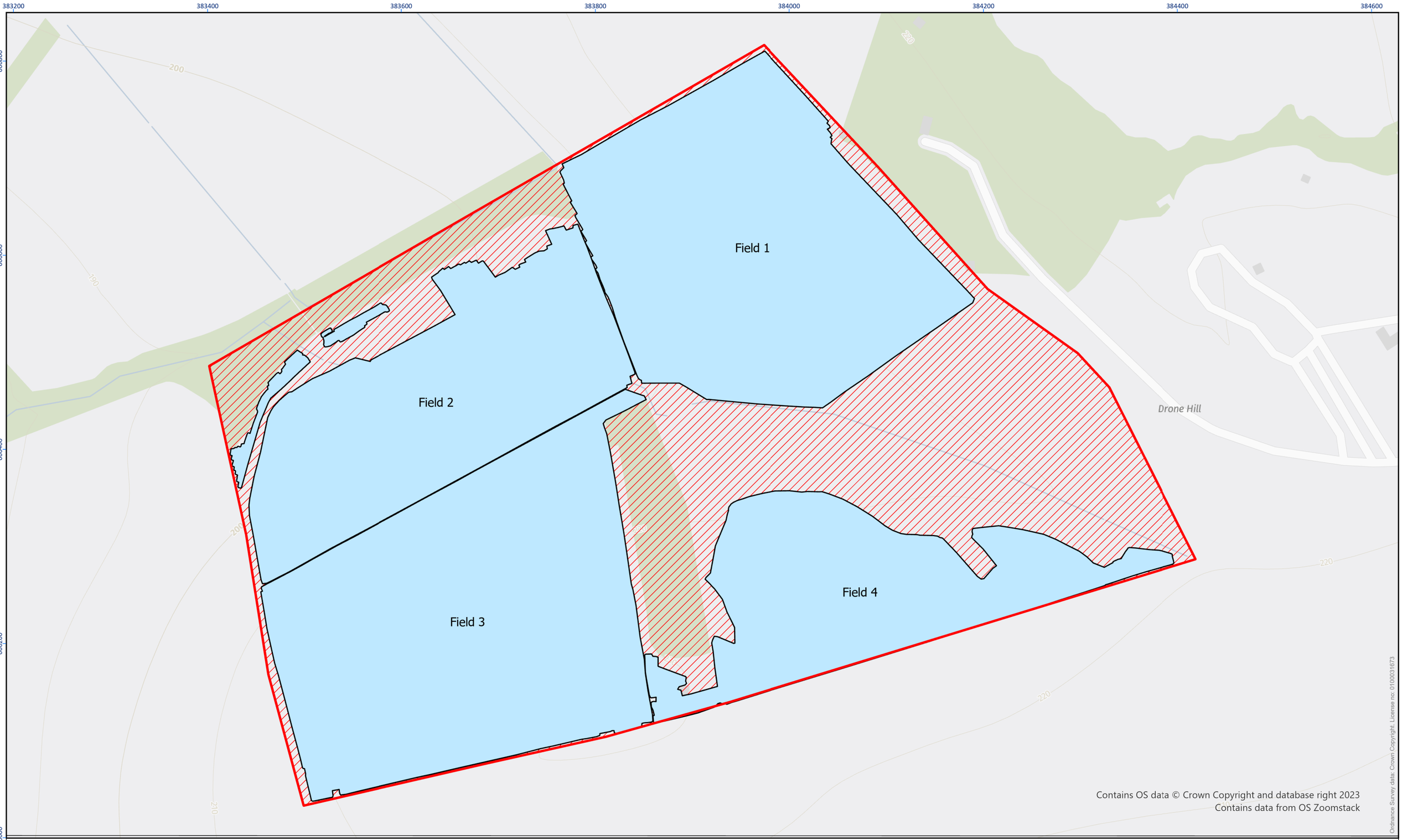
Plate 4: Field 4 showing boggy ground

12 Figures



05/40525/GEO/01/01

Figure 1: Site Location



Survey Areas

Figure 2

- Site Boundary
- Gradiometer Survey
- Unsuitable for Survey

N

0 60m

Scale: 1:3,500 @ A3

Drawing Number: 05/40525/GEO/02/01	
Created by: SO	Date: 11/08/2023
Checked by: CS	Date: 11/08/2023
Approved by: JL	Date: 11/08/2023

AOC Archaeology Group

383200 383400 383600 383800 384000 384200 384400 384600

666800 666600 666400 666200 666000

200 190 210 220 Drone Hill

Summary Greyscale Image

Figure 3

3nT
-2nT

Site Boundary
Unsuitable for Survey

N
0 60m
Scale: 1:3,500 @ A3

Drawing Number: 05/40525/GEO/03/01	
Created by: SO	Date: 11/08/2023
Checked by: CS	Date: 11/08/2023
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AOC Archaeology Group

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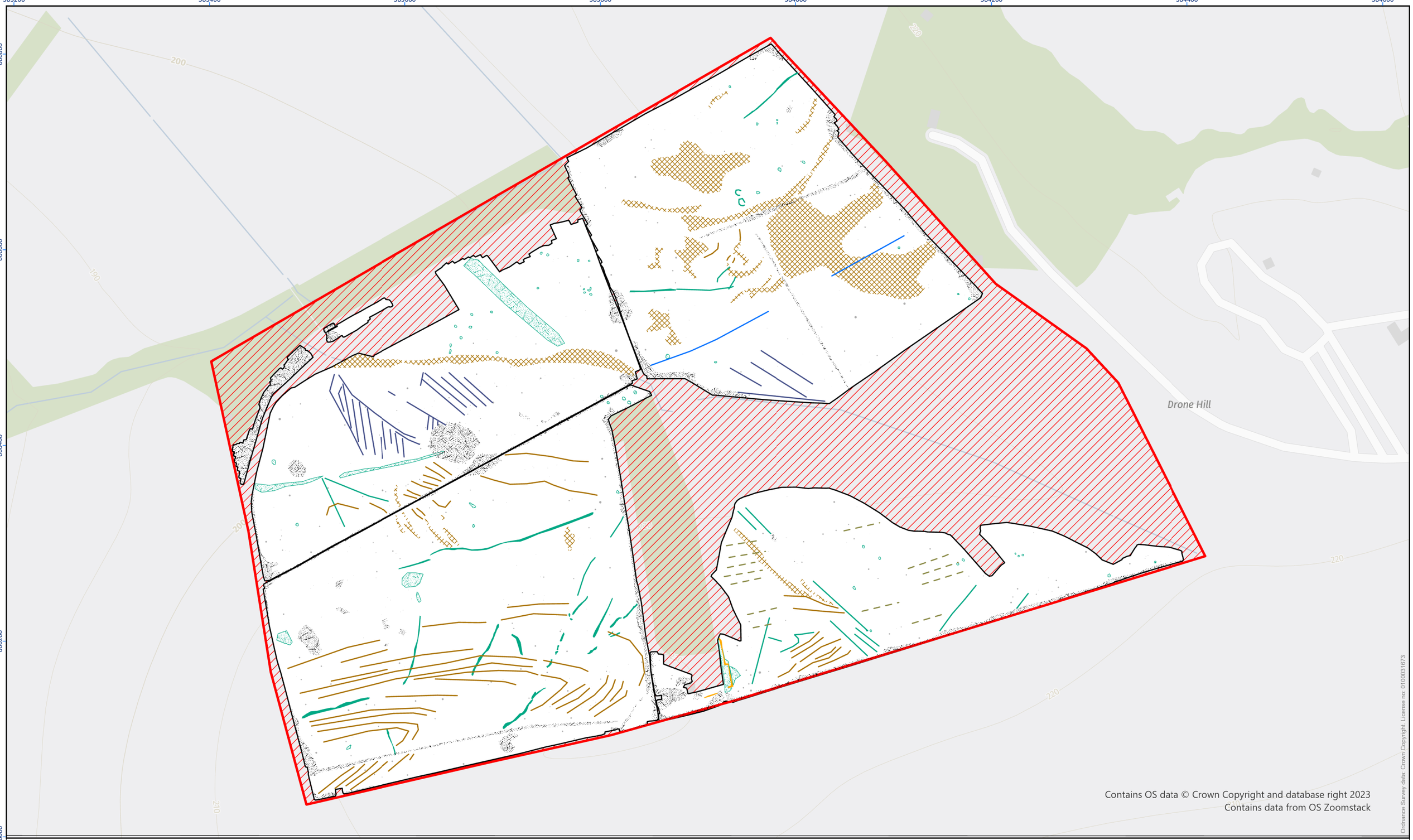

Summary Interpretation

Figure 4

- Site Boundary
- Unsuitable for Survey
- Anomaly (Possible Archaeology)
- Anomaly (Unclear Origin)
- Spread (Unclear Origin)
- Spread (Geology/Natural)
- Spread (Magnetic Disturbance)
- Anomaly (Ferrous/Iron Spike)
- Linear Trend (Historic Feature)
- Linear Trend (Unclear Origin)
- Linear Trend (Agricultural, Ploughing)
- Linear Trend (Drainage)
- Linear Trend (Geology/Natural)

N

0 60m

Scale: 1:3,500 @ A3

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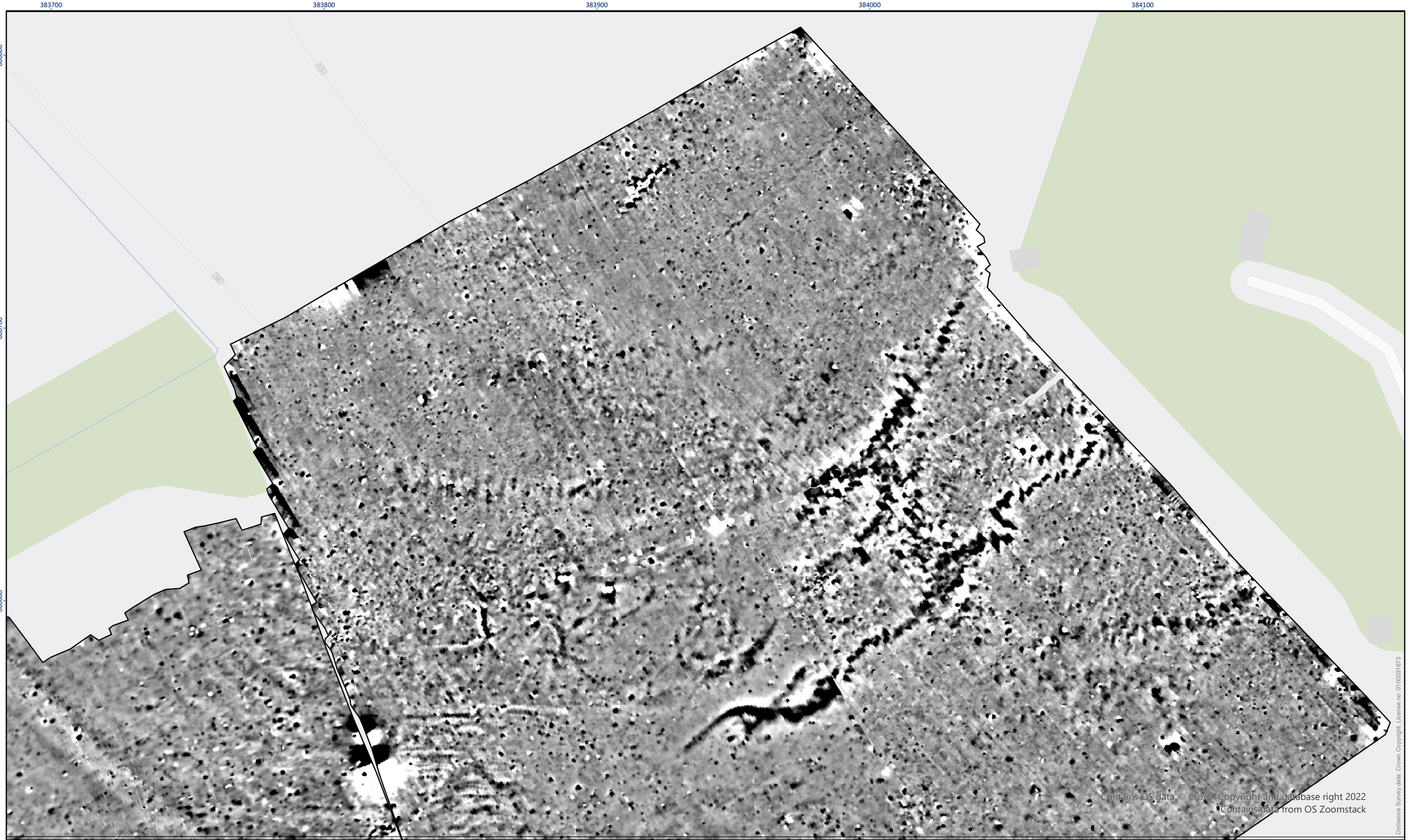
Checked by: CS	Date: 11/08/2023
Approved by: JL	Date: 11/08/2023

AOC Archaeology Group



Processed Gradiometer Data - Greyscale Image

Figure 5.1

3nT
-2nT

N

0 30m

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Checked by: CS	Date: 24/04/2023
Approved by: JL	Date: 24/04/2023

AOC Archaeology Group

383700 383800 383900 384000 384100

666600 666500 666400

Processed Gradiometer Data - Greyscale Image

Figure 5.2

3nT
-2nT

N

0 30m

Scale: 1:1,250 @ A3

Drawing Number: 05/40525/GEO/5.2/01	
Created by: SO	Date: 24/04/2023
Checked by: CS	Date: 24/04/2023
Approved by: JL	Date: 24/04/2023

AOC Archaeology Group

383400 383500 383600 383700 383800

666600 666500 666400

Processed Gradiometer Data - Greyscale Image

Figure 5.3

3nT
-2nT

N

0 30m

Scale: 1:1,250 @ A3

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Created by: SO	Date: 24/04/2023
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Approved by: JL	Date: 24/04/2023

AOC Archaeology Group

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666300 666200 666100

Processed Gradiometer Data - Greyscale Image

Figure 5.4

3nT
-2nT

N

0 30m

Scale: 1:1,250 @ A3

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AOC Archaeology Group

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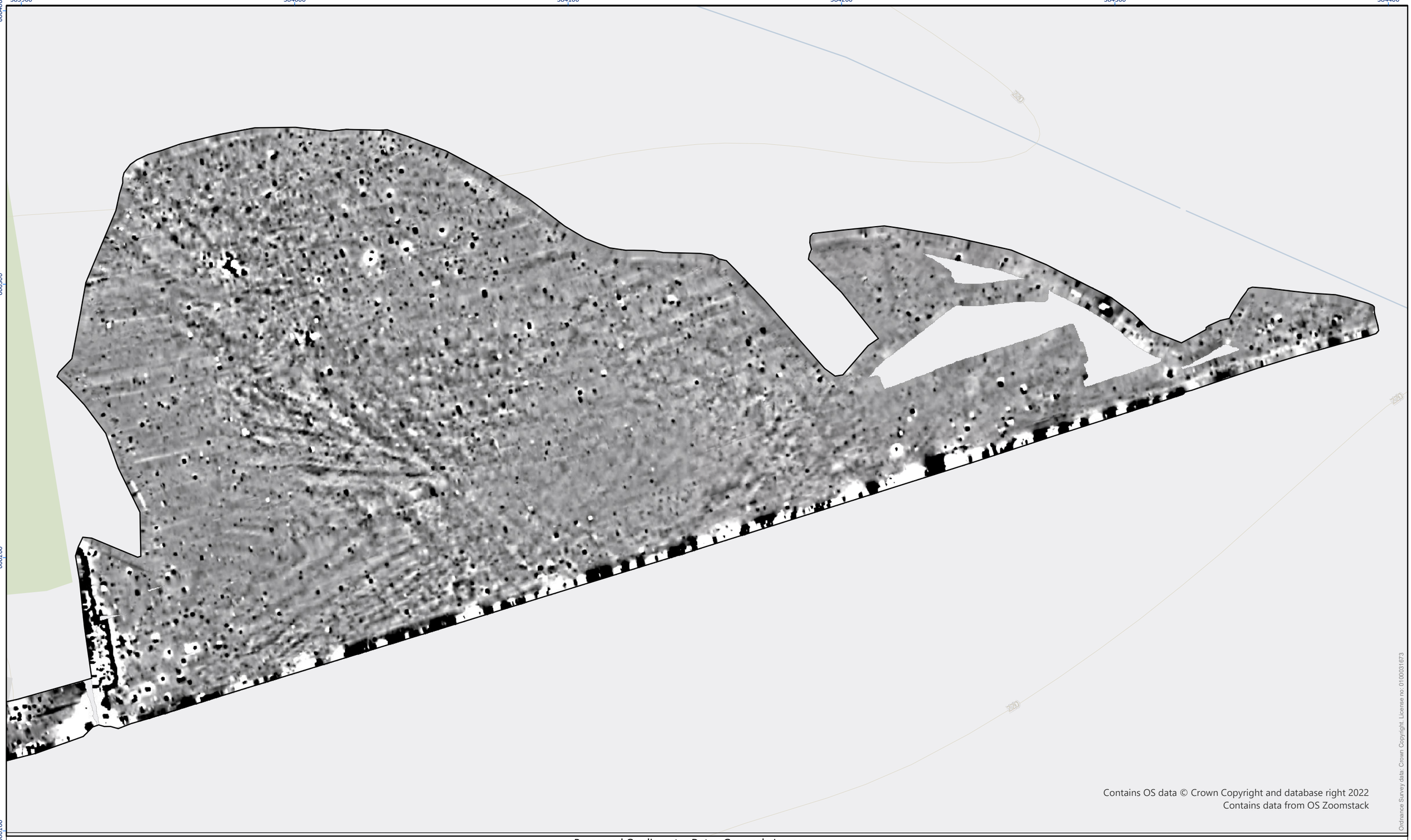
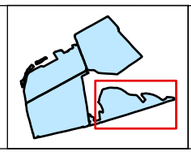
666400 666300 666200 666100



Processed Gradiometer Data - Greyscale Image

Figure 5.5

3nT
-2nT



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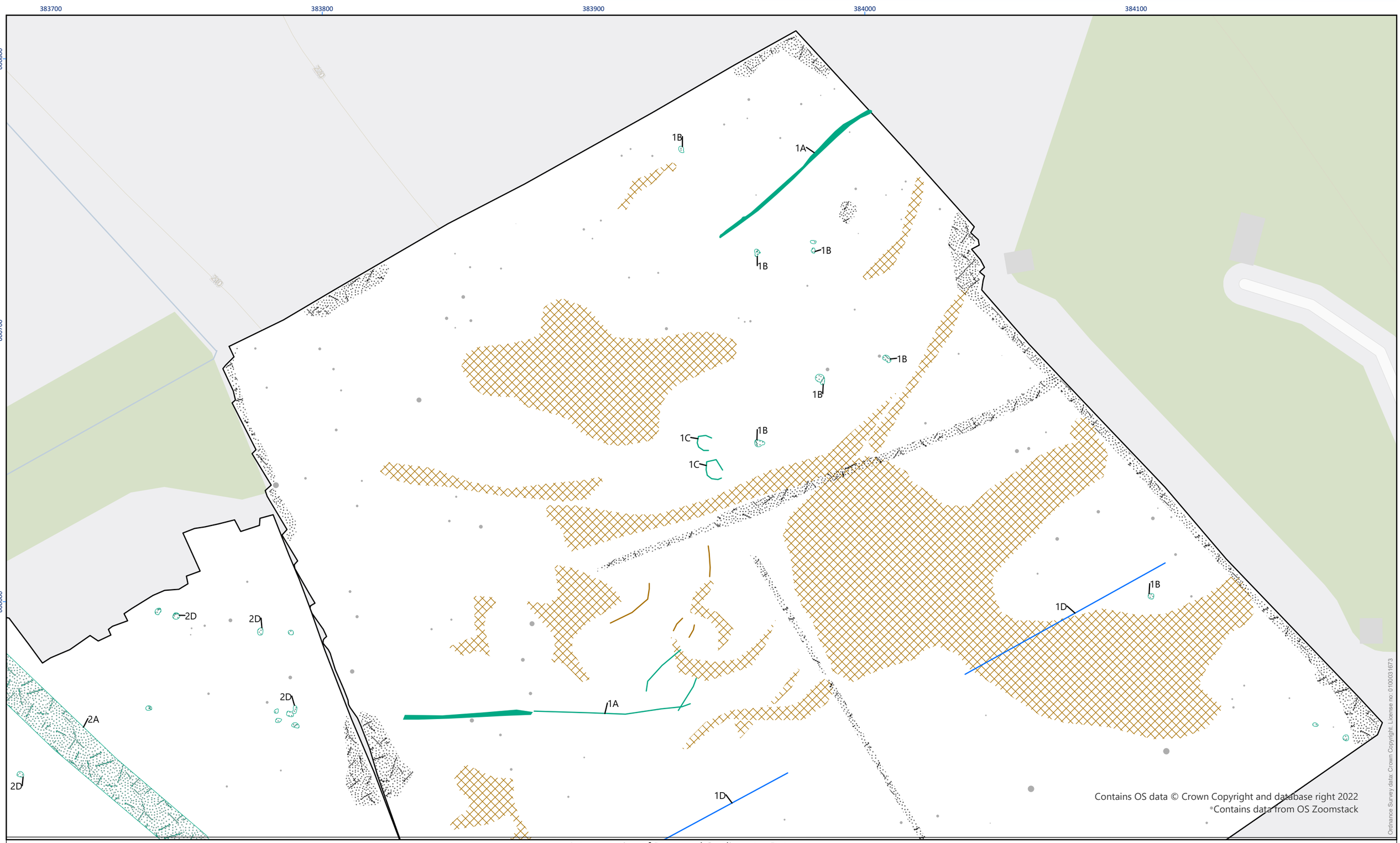
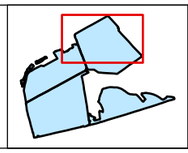


Interpretation of Processed Gradiometer Data

Figure 6.1

- Anomaly (Unclear Origin)
- Spread (Unclear Origin)
- Spread (Geology/Natural)
- Spread (Magnetic Disturbance)
- Anomaly (Ferrous/Iron Spike)
- Linear Trend (Historic Feature)
- Linear Trend (Unclear Origin)
- Linear Trend (Geology/Natural)



N

0 30m

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Created by: SO	Date: 25/04/2023
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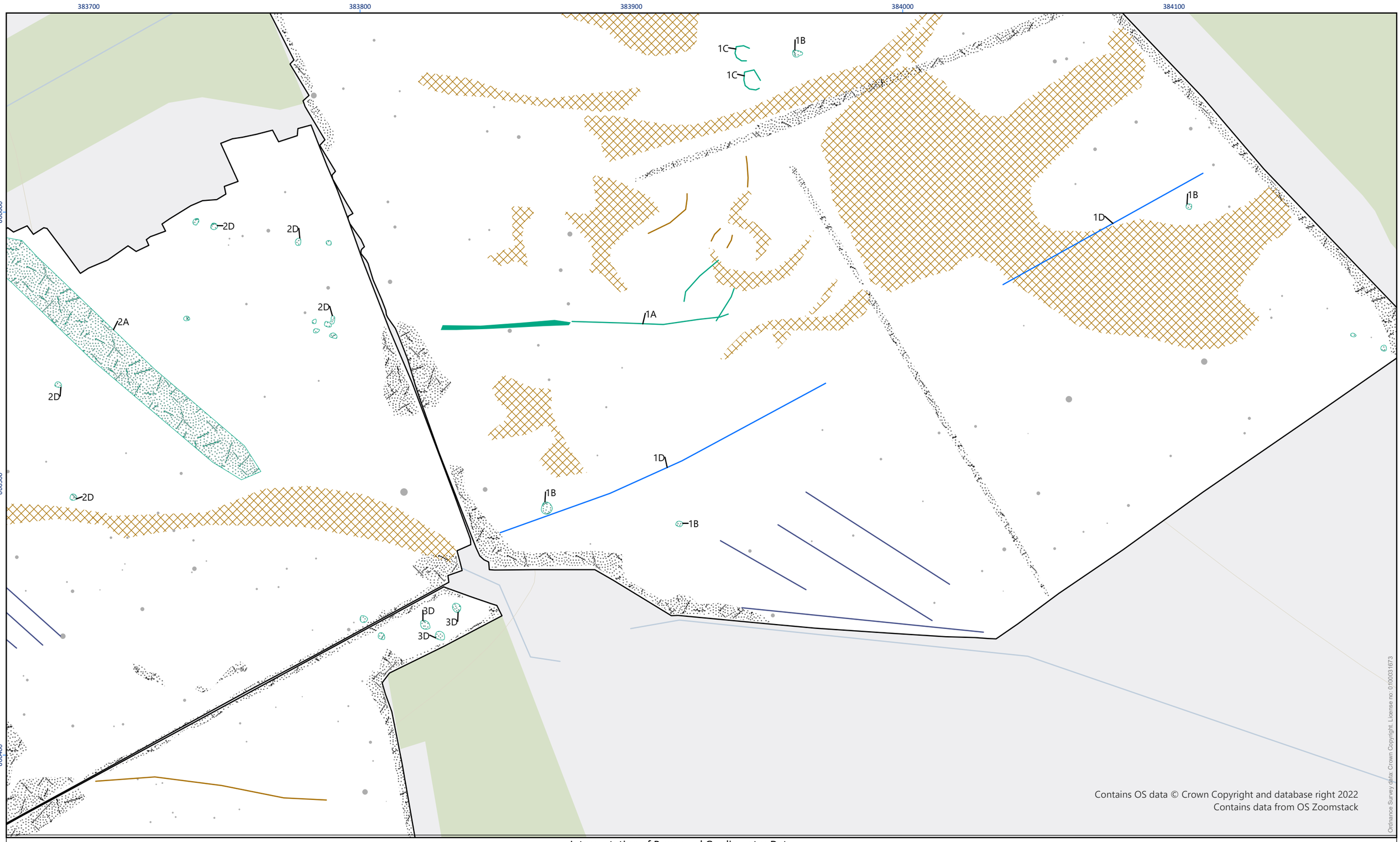
Approved by: JL	Date: 25/04/2023

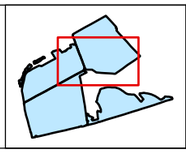
AOC Archaeology Group



Interpretation of Processed Gradiometer Data

Figure 6.2

- Anomaly (Unclear Origin)
- Spread (Unclear Origin)
- Spread (Geology/Natural)
- Spread (Magnetic Disturbance)
- Anomaly (Ferrous/Iron Spike)
- Linear Trend (Historic Feature)
- Linear Trend (Unclear Origin)
- Linear Trend (Drainage)
- Linear Trend (Geology/Natural)



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Drawing Number: 05/40525/GEO/6.2/01	
Created by: SO	Date: 25/04/2023
Checked by: CS	Date: 25/04/2023
Approved by: JL	Date: 25/04/2023

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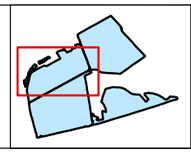
Interpretation of Processed Gradiometer Data

Figure 6.3

- Anomaly (Unclear Origin)
- Spread (Unclear Origin)
- Spread (Geology/Natural)
- Spread (Magnetic Disturbance)
- Anomaly (Ferrous/Iron Spike)
- Linear Trend (Historic Feature)
- Linear Trend (Unclear Origin)
- Linear Trend (Drainage)
- Linear Trend (Geology/Natural)



N

0 30m

Scale: 1:1,250 @ A3

Drawing Number: 05/40525/GEO/6.3/01	
Created by: SO	Date: 25/04/2023
Checked by: CS	Date: 25/04/2023
Approved by: JL	Date: 25/04/2023

AOC Archaeology Group

383500 383600 383700 383800 383900

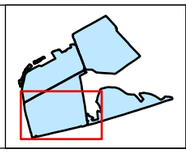
666300 666200 666100

2C 3B 3C 3G 3A 3A 3A 3A 3A 3A 3A 3A 3A 3B 4A 4A

Interpretation of Processed Gradiometer Data

Figure 6.4

- Anomaly (Possible Archaeology)
- Anomaly (Unclear Origin)
- Spread (Unclear Origin)
- Spread (Geology/Natural)
- Spread (Magnetic Disturbance)
- Anomaly (Ferrous/Iron Spike)
- Linear Trend (Unclear Origin)
- Linear Trend (Agricultural, Ploughing)
- Linear Trend (Geology/Natural)



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Scale: 1:1,250 @ A3

Drawing Number: 05/40525/GEO/6.4/01	
Created by: SO	Date: 25/04/2023
Checked by: CS	Date: 25/04/2023
Approved by: JL	Date: 25/04/2023

AOC Archaeology Group

383900 384000 384100 384200 384300 384400

666400 666300 666200 666100

4B 4B 4D 4D 4D 4D 4B 4C 4B 4C 4A 4A

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Interpretation of Processed Gradiometer Data

Figure 6.5

- Anomaly (Possible Archaeology)
- Spread (Unclear Origin)
- Spread (Geology/Natural)
- Spread (Magnetic Disturbance)
- Anomaly (Ferrous/Iron Spike)
- Linear Trend (Unclear Origin)
- Linear Trend (Agricultural, Ploughing)
- Linear Trend (Geology/Natural)

N

0 30m

Scale: 1:1,250 @ A3

Drawing Number: 05/40525/GEO/6.5/01	
Created by: SO	Date: 25/04/2023
Checked by: CS	Date: 25/04/2023
Approved by: JL	Date: 25/04/2023

AOC Archaeology Group

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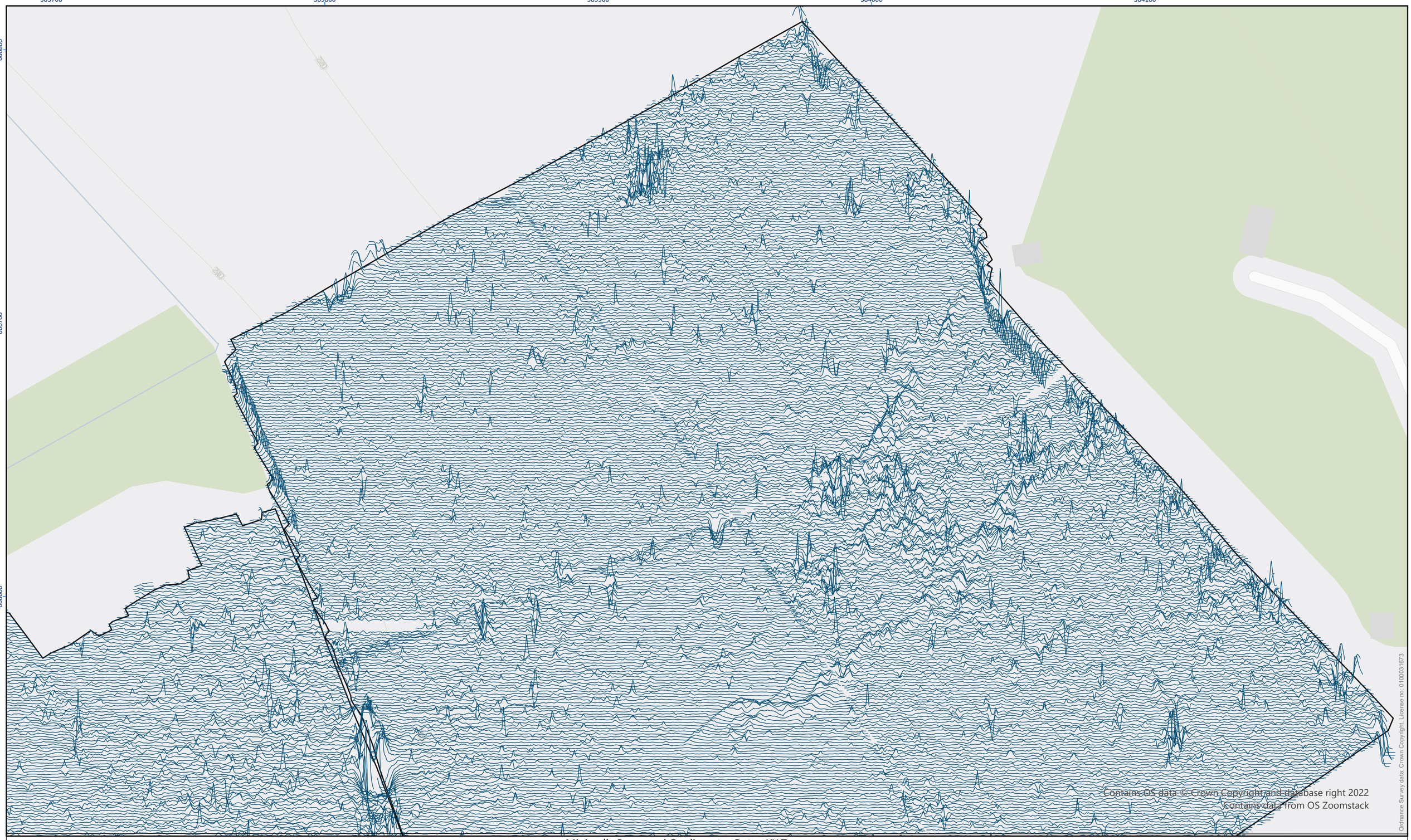
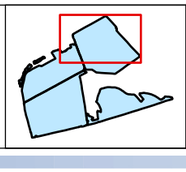
666800 666700 666600



Minimally Processed Gradiometer Data - XY Trace

Figure 7.1

40nT
-40nT



N

0 30m

Scale: 1:1,250 @ A3

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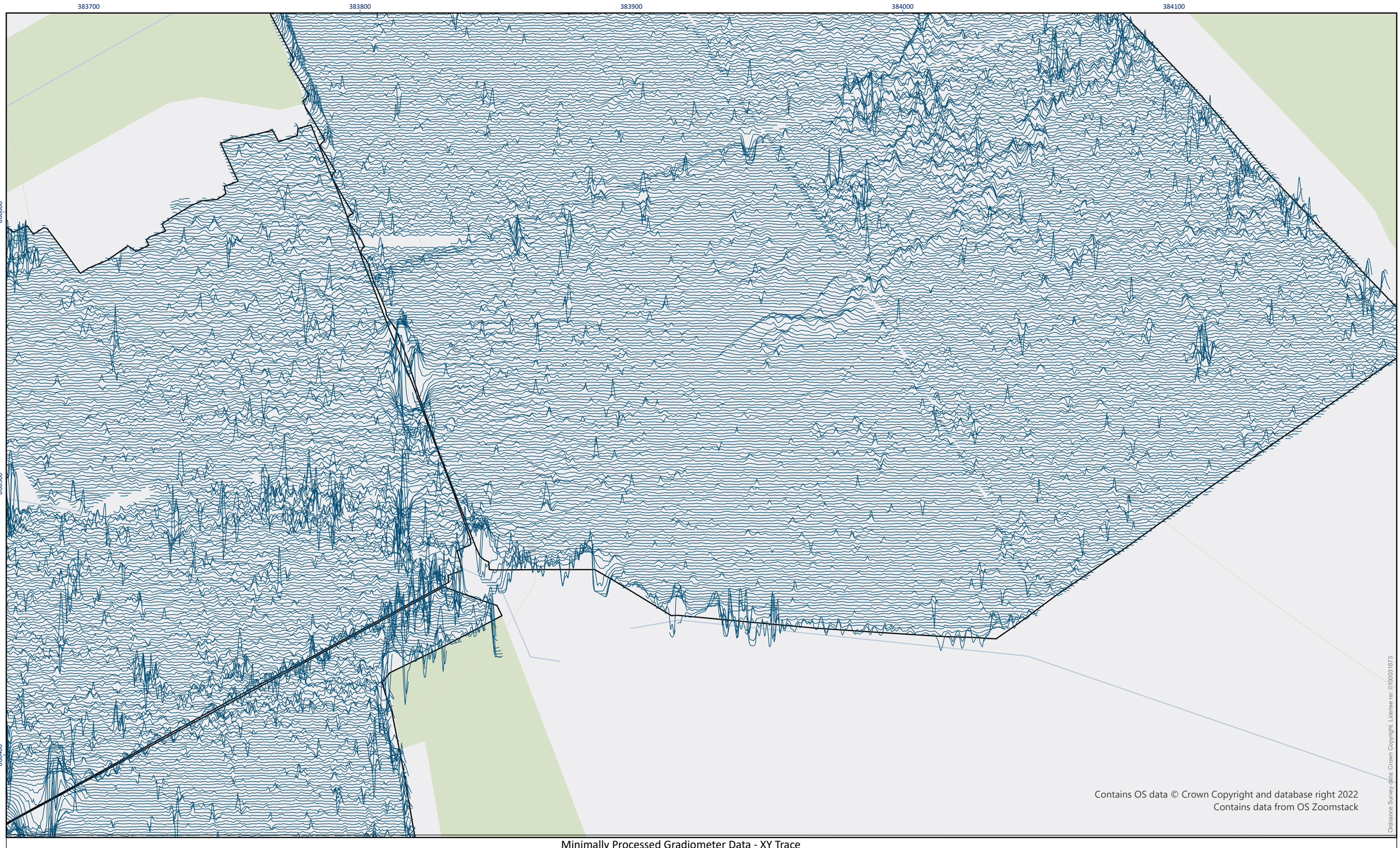
Created by: SO	Date: 24/04/2023
Checked by: CS	Date: 24/04/2023
Approved by: JL	Date: 24/04/2023

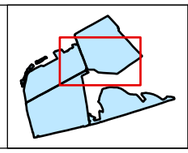
AOC Archaeology Group



Minimally Processed Gradiometer Data - XY Trace

Figure 7.2

40nT
-40nT



N

0 30m

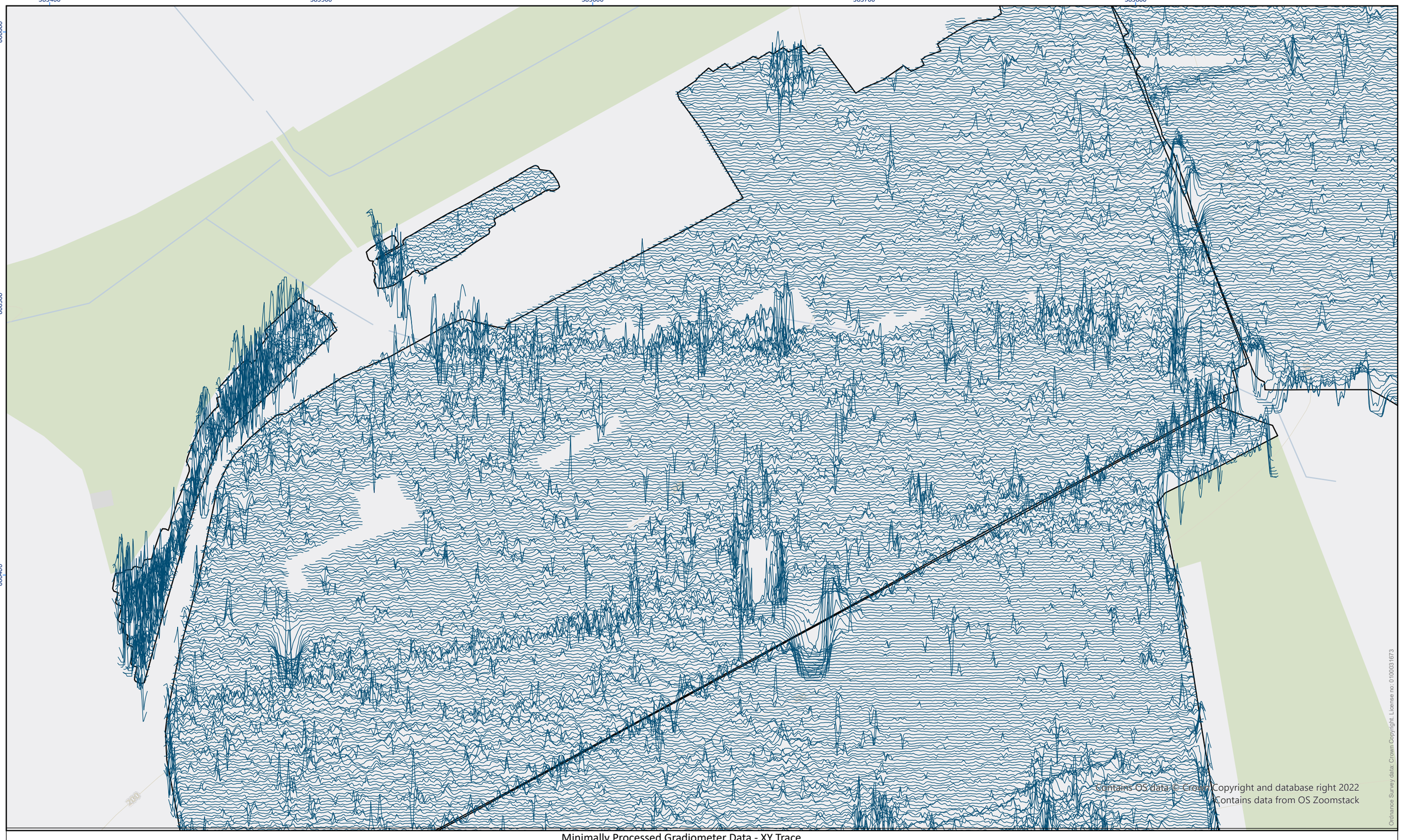
Scale: 1:1,250 @ A3

Drawing Number: 05/40525/GEO/7.2/01	
Created by: SO	Date: 24/04/2023
Checked by: CS	Date: 24/04/2023
Approved by: JL	Date: 24/04/2023

AOC Archaeology Group

383400 383500 383600 383700 383800

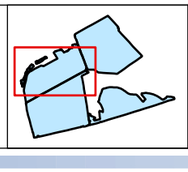
666600 666500 666400



Minimally Processed Gradiometer Data - XY Trace

Figure 7.3

40nT
-40nT



N

0 30m

Scale: 1:1,250 @ A3

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Created by: SO	Date: 24/04/2023
Checked by: CS	Date: 24/04/2023
Approved by: JL	Date: 24/04/2023

AOC Archaeology Group

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666300 666200 666100

Minimally Processed Gradiometer Data - XY Trace

Figure 7.4

40nT
-40nT

N

0 30m

Scale: 1:1,250 @ A3

Drawing Number: 05/40525/GEO/7.4/01	
Created by: SO	Date: 24/04/2023
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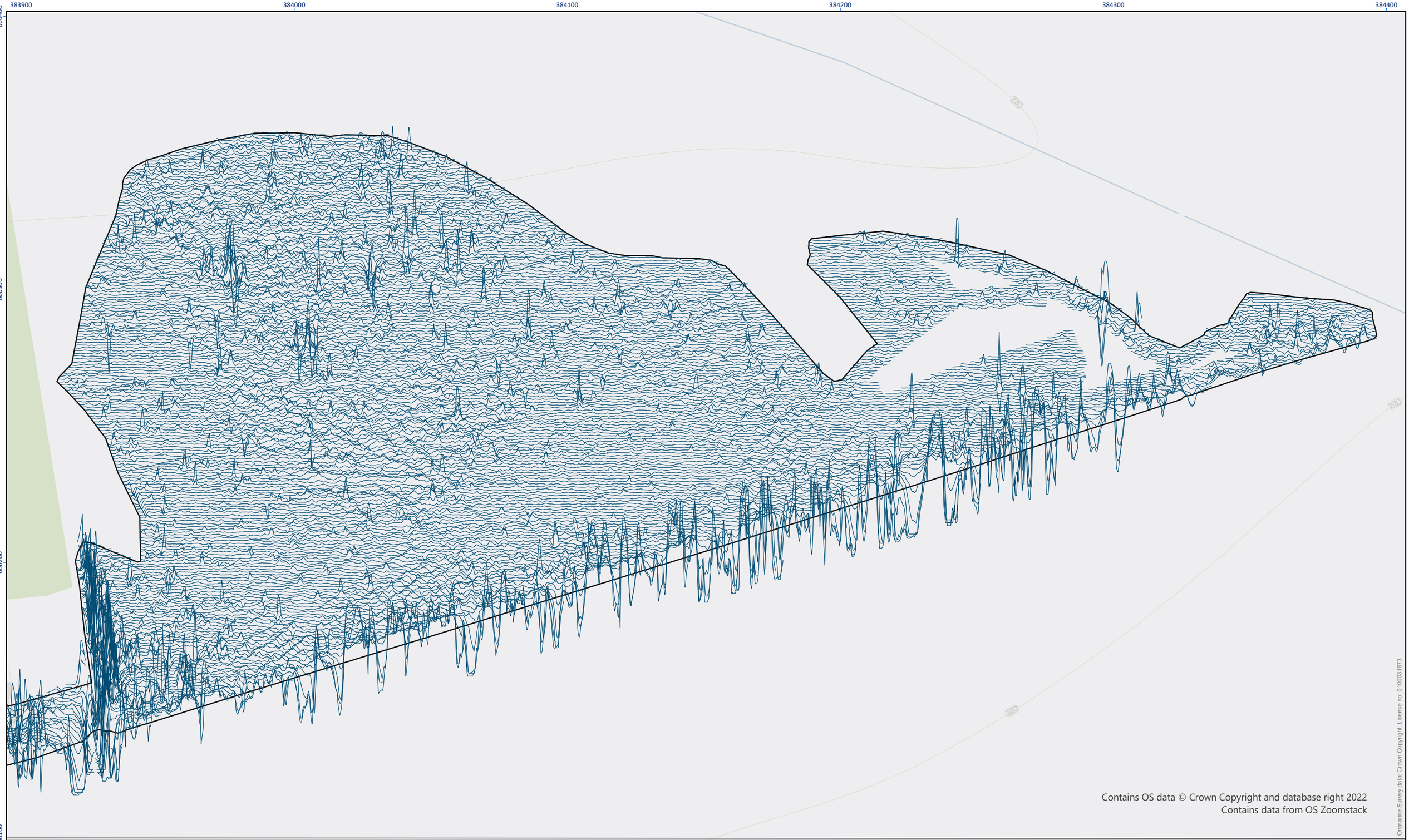
Approved by: JL	Date: 24/04/2023

AOC Archaeology Group



Minimally Processed Gradiometer Data - XY Trace

Figure 7.5

40nT
-40nT

N

0 30m

Scale: 1:1,250 @ A3

Drawing Number:	05/40525/GEO/7.5/01
Created by: SO	Date: 24/04/2023
Checked by: CS	Date: 24/04/2023
Approved by: JL	Date: 24/04/2023

AOC Archaeology Group

Appendix 1: Survey Metadata

Oasis ID: aocarcha1-514575

Field	Description
Surveying Company	AOC Archaeology Group
Data collection staff	Kinnie Wade, Henry Conran, Marguerite Hall, Reed Haywood
Client	SLR Consulting Limited
Site name	Howpark, Borders
County	Borders
NGR	NT 83820 66531 (centre)
Land use/ field condition	Pasture & Arable
Duration	28/03/2023 – 06/04/2023
Weather	Dry
Survey type	Gradiometer Survey
Instrumentation	Bartington cart survey: Bartington Non-Magnetic Cart, three Bartington Grad 601-2, Trimble R10 GNSS System, Sensys cart survey: Sensys MXPDA cart, four FGM650/3 sensors, Trimble R10 GNSS System
Area covered	32.3ha
Download software	MLGrad601
Processing software	MultiGrad601 and TerraSurveyor
Visualisation software	ArcGIS Pro
Geology	Greywackes and shale of the Wacke Group. This is overlain by superficial deposits of Devensian Till in some areas (BGS, 2023).
Soils	The soils within the survey area consist of Brown Earths of the Ettrick association (Scotland's Soils, 2023)
Scheduled Ancient Monument	No
Known archaeology on Site	None
Historical documentation/ mapping on Site	None
Report title	Howpark Solar Farm, Scottish Borders: Archaeological Geophysical Survey
Project number	40525
Report Author	Susan Ovenden
Quality Checked by	Chris Sykes

Appendix 2: Archaeological Prospection Techniques, Instrumentation and Software Utilised

Gradiometer Survey

Gradiometer surveys measure small changes in the earth's magnetic field. Archaeological materials and activity can be detected by identifying changes to the magnetic values caused by the presence of weakly magnetised iron oxides in the soil (Aspinall et al., 2008, 23; Sharma, 1997, 105). Human habitation often causes alterations to the magnetic properties of the soils and sediments present in the area (Aspinall et al, 2008, 21). There are two physical transformations that produce a significant contrast between the magnetic properties of archaeological features and the surrounding soil: the enhancement of magnetic susceptibility and thermoremnant magnetization (Aspinall et al., 2008, 21; Heron and Gaffney 1987, 72).

Ditches and pits can be easily detected through gradiometer survey as the topsoil within and around settlements generally has a greater magnetisation than the subsoil; caused by human activity. This enhanced material accumulates in cut features such as ditches and pits. Areas of burning or materials which have been subjected to heat commonly also have high magnetic signatures, such as hearths, kilns, fired clay and mudbricks (Clark 1996, 65; Lowe and Fogel 2010, 24).

It should be noted that negative anomalies can also be useful for characterising archaeological features. If the buried remains are composed of a material with a lower magnetisation compared to the surrounding soil, the feature in question displaying a negative signature. For example, stone- built structures that are composed of sedimentary rocks are frequently non-magnetic and so will appear as negative features within the dataset if the local soils and sediments are at all magnetised.

Ferrous objects – i.e. iron and its alloys - are strongly magnetic and are typically detected as high-value peaks in gradiometer survey data; small (in spatial terms) spikes are generally assumed to derive from ferrous material of recent origin (e.g. stray bits of farm equipment) in the topsoil, though archaeological sources cannot be ruled out. Broader dipolar anomalies and those with diagnostic characteristics of form will be assigned to other classifications based on their character, which might include archaeology, burning, modern ferrous or uncertain.

Although gradiometer surveys have been successfully carried out in all areas of the United Kingdom, the effectiveness of the technique is lessened in areas with complex geology, particularly where igneous and metamorphic bedrock is present or there are layers of alluvium or till between the surface and the layers of interest. All magnetic geophysical surveys must therefore take the effects of background geological and geomorphological conditions into account.

AOC Archaeology's cart-based surveys are carried out using a Bartington Non-Magnetic Cart. The cart enables multiple traverses of data to be collected at the same time, increasing the speed at which surveys may be carried out and offers the benefits of reduced random measurement noise and rapid area coverage (Schmidt et al 2015, 60-62, David et al. 2008, 21).

The cart uses a configuration of four Grad-01-1000L sensors mounted upon a carbon fibre frame along with two DL601 dataloggers and one BC601 battery cassette. The sensors are normally positioned at 1m intervals on a horizontal bar, with the datalogger taking readings every 12.5cm along each traverse, though this can be altered to increase / reduce resolution if required. The data is georeferenced via a Trimble R10 Real Time Kinematic (RTK) VRS Now GNSS GPS which streams data throughout survey and allows the data to be recorded relative to a WGS1984 UTM coordinate system.

The gradiometer data is collected through Geomar MLGrad601 software on a laptop in real-time during the survey. The data is downloaded and converted into a .xyz file in Geomar MultiGrad601 before being processed along with the GPS data in TerraSurveyor v3.0.34.10 (see Appendix 3 for a summary of the processes used in Geoplot to create final data plots).

Appendix 3: Summary of Data Processing

Process	Effect
Clip	Limits data values to within a specified range
De-spike	Removes small spatial scale exceptionally high readings in the data. In resistivity survey, these can be caused by poor contact of the mobile probes with the ground. In gradiometer survey, these can be caused by highly magnetic items such as buried modern ferrous objects.
De-stagger	Corrects a misalignment of data when the survey is conducted in a zig-zag traverse pattern.
Discard Overlap (TerraSurveyor)	Removes datapoints which occur too closely together and can cause digital artefacts in the data which are caused by the overlapping of parallel traverses.
Edge Match	Counteracts edge effects in grid composites by subtracting the difference between mean values in the two lines either side of the grid edge from one of the grids.
Filter (MAGNETO)	Much like a zero mean traverse, it resets the median value of each point to zero, in order to address the effect of striping in the data and counteract edge effects. In MAGNETO the individual values take into account the value of all uncorrected points within a certain distance to create its own median.
GPS Filter (MAGNETO)	Used to either remove or reduce the appearance of constant and reoccurring features that are not consistent with the GPS signal in use by the cart system.
High pass filter	Removes low-frequency, large spatial scale variance in order to remove background trends in the data, such as variations in geology.
Interpolate	Increases the resolution of a survey by interpolating new values between surveyed data points, creating a smoother overall effect.
Low Pass filter	Uses a Gaussian filter to remove high-frequency, small spatial scale variance, typically for smoothing the data.
Periodic Filter	Used to either remove or reduce the appearance of constant and reoccurring features that distort other anomalies, such as recent plough lines.
Remove Turns (TerraSurveyor)	Uses analysis of the direction of travel derived from the GNSS data to break continuous streams of data into individual traverses.
Zero Mean Grid	Resets the mean value of each grid to zero, in order to counteract grid edge discontinuities in composite assemblies.
Zero Mean Traverse	Resets the mean value of each traverse to zero, in order to address the effect of striping in the data and counteract edge effects.

Processing Steps

Cart survey	
Process	**Extent**
Base Settings	Interval 0.121m, Track Radius 1.06m
Remove Turns	Threshold Angle 90°, Cut Length 5m
Discard Overlap	Threshold Distance 0.4m, Minimum Track 5, Newest
Despike	Mean Diameter 3 Threshold 12
Destripe	Mean Traverse SD 1.5
High Pass Filter	Uniform (Median) 12
Clip	-30/30nT

Appendix 4: Technical Terminology

Type of Anomaly	Description of Type/Class and rationale for interpretation
Anomaly	Usually linear / curvilinear / rectilinear / discrete anomalies characterised by a sharp-edged increase or decrease in values compared to the magnetic background. Some interpretation classes may have more gradual transitions in magnetic character- this is used as part of the classification process.
Spread	Spreads of enhanced material refer to diffuse areas of altered magnetic character, which suggest a localised spread of material with a magnetic contrast within the topsoil or ploughzone or a generalised enhancement of the magnetic properties over a specific area.. These anomalies do not have the high dipolar response characteristic of ferrous material anomaly unless specifically classified as a spread of ferrous debris.
Linear Trend	Linear trends are less distinct and are typically visible as linear patterning in the overall texture of the data. A common example of these is the striping effect caused by recent ploughing.

Class of Anomaly	Description
Probable Archaeology	Interpretation is supported by the presence of known archaeological remains or by other forms of evidence such as HER records, LiDAR data or cropmarks identified through aerial photography. OR the data contains diagnostic anomalies in terms of character or morphology which allow a secure interpretation. Anomalies typically have well defined edges with abrupt transitions indicative of cut features with magnetically enhanced fills, such as ditches. Discrete anomalies will be checked on XY traces for their magnetic character; discrete anomalies in this class likely to be cut features such as pits; anomalies indicating high temperature processes will alternatively classified as 'burned area' - see below. Ferrous material creates distinct 'spikes' and is classified as such.
Possible Archaeology	Anomalies are interpreted as likely to have an archaeological origin, though other explanations are also possible, but less likely. Anomalies typically have well defined edges with abrupt transitions indicative of cut features with magnetically enhanced fills, such as ditches. Discrete anomalies checked on XY traces; discrete anomalies in this class likely to be cut features such as pits; anomalies indicating high temperature processes classified as 'burned area' - see below.
Burned Area	An anomaly with a form on the XY trace plot that is characteristic of high temperature activity such as a kiln or hearth. Should be considered as possible archaeology and should be assigned an anomaly number if a more specific interpretation is possible based on the anomaly characteristics (for example, a clear kiln) so that this can be discussed in text.
Historical Features	Features observed on historical mapping that correspond with anomalies in the data. Linear anomalies caused by removed field boundaries often exhibit distinct characteristics related to the removal process. Areas of enhanced magnetism in this class could relate to former buildings, trackways, quarries or ponds and their nature should be clarified with the use of anomaly numbers and discussion in the results section.
Unclear Origin	These anomalies are (often) magnetically weak and discontinuous or isolated making their context difficult to ascertain. OR they are indistinct for other reasons such as magnetic disturbance in their vicinity. Anomalies in this category have no more likely explanation than another, so whilst an archaeological origin is possible, an agricultural, geological, or modern origin is also equally likely.
Agricultural	Anomalies associated with agricultural activity, either historical (unless shown on a map, then classed as a historical feature) or modern. Usually, this interpretation is arrived at due to on the ground observations of (for example) ploughing, access tracks and the like, or from observation of recent aerial images of the survey area. Recent ploughing is shown as a dashed line and Ridge and Furrow ploughing is shown as a solid line.
Ridge and Furrow / Rig and Furrow	A series of regular linear or slightly curvilinear anomalies which are broad and usually have diffuse edges, either composed of an increased or decreased magnetic response compared to background values. Wide regular spacing between the anomalies is consistent with that of a ridge and furrow / rig and furrow ploughing regime, and the regime may also have a degree of sinuosity characteristic of certain types of ridge and furrow cultivation. Often, multiple directions will be present, with distinct headlands in between. The pattern might follow the general landscape organisation, or it may radically differ from it, depending on the local sequence of inclosure. The anomalies often present as a positive 'ridge' anomaly adjacent to a negative 'furrow' anomaly.
Ploughing Trends	A series of regular linear anomalies or changes in the texture of the survey data, either composed of an increased or decreased magnetic response compared to background values. Anomalies seen parallel to field edges are representative of headlands caused by ploughing.
Drains	A series of magnetic linear anomalies (often with a characteristic alternating positive-negative pattern, which indicates a ceramic drain) of an indeterminate date, usually with a regular dendritic or herringbone patterning which reflects the topography of the survey area.
Geology / Natural	An area of enhanced magnetism that is composed of irregular (usually) weak increases or decreases in magnetic values, frequently with gradual transitions in character, compared with background readings. These are likely to indicate natural variations in soil composition or reflect variations in the bedrock or superficial geology. In areas where former water courses were present, paleochannels may present as distinct curving and banded or braided linear anomalies.
Service	Strong linear anomalies often composed of contrasting high positive and negative dipolar values, with a halo of magnetic disturbance extending from the causative body. Such anomalies are characteristic of below-ground services.
Magnetic Disturbance	A zone of strong magnetic response (usually alternating between positive and negative with abrupt transitions) that has been caused by modern infrastructure or ferrous material within or adjacent to the survey area, such as metallic boundary fencing, gateways. The magnetic haloes around services and changes in the background texture of the data resulting from overhead power lines also fall into this class. These haloes are strong enough to obscure other anomalies (including those of possible archaeological interest) in the area they affect.
Ferrous Anomalies / Ferrous (iron spikes) and ferrous or debris spreads	A response caused by ferrous materials on the ground surface or within the subsoil, which causes a strong but localised dipolar response in the data. These generally represent modern material often re-deposited during manuring, rubbish at field edges and spreads of debris or building material used to surface tracks or left behind following demolition. Distinct from magnetic disturbance, these anomalies relate to material at their spatial location, rather than an effect occurring at a distance from the material responsible.
Free Category for custom use	A category which may be employed to denote specifically identified anomalies related to known past activity within the area, for example those definitely associated with a former airfield, or mapped former mineral extraction.









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