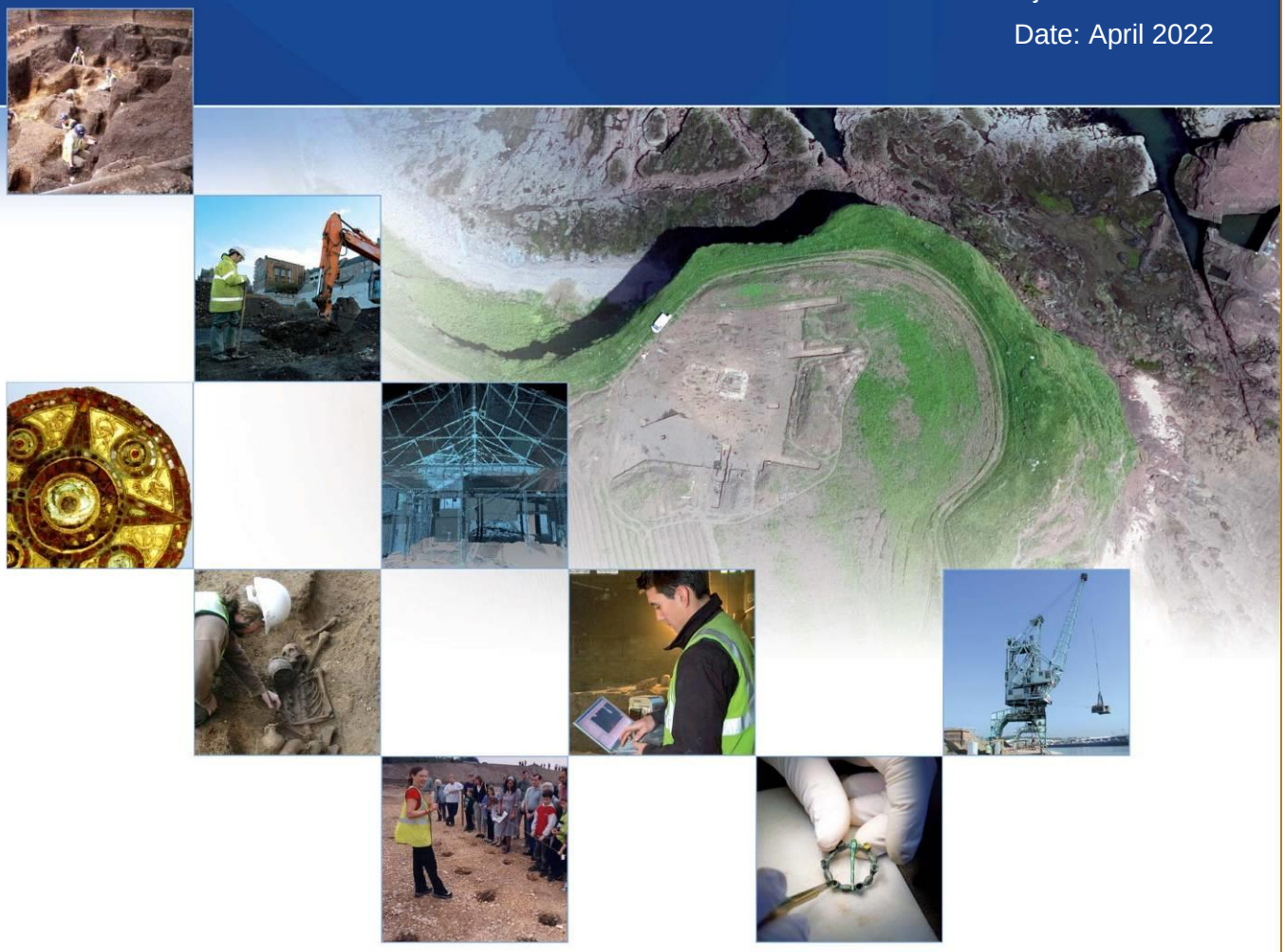
Nairn Academy, Highland

Archaeological Geophysical Survey

National Grid Reference: **NH 87247 55559**

AOC Project No: 40323

Date: April 2022



AOC Archaeology Group

ARCHAEOLOGY | HERITAGE | CONSERVATION

Nairn Academy, Highland

Archaeological Geophysical Survey

On Behalf of:	**Balfour Beatty** **UK Construction Services - Scotland** **Mindmull Business Park** **Tumulus Way, Kintore** **Aberdeenshire** **AB51 0TG**
National Grid Reference (NGR):	**NH 87247 55559**
AOC Project No:	**40323**
Prepared by:	**Kayt Armstrong**
Illustrations by:	**Kayt Armstrong**
Date of survey:	**15th & 16th February 2022**
Surveyors:	**K Armstrong & G Hudson**

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

Author: Kayt Armstrong	**Date: 12th April 2022**
Quality Checked by: Susan Ovenden	**Date: 12th April 2022**
Report Stage: Final Version 1	**Date: 12th April 2022**

Enquiries to: AOC Archaeology Group
The Lodge
Unit 8, Mortec Park
York Road
Leeds
LS15 4TA

Tel. 01138 232 853
e-mail. leeds@aocarchaeology.com

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Non-Technical Summary

AOC Archaeology Group was commissioned by Balfour Beatty to undertake an archaeological geophysical gradiometer survey on 15th and 16th February 2022 to investigate the potential for buried archaeological remains ahead of a proposed development on playing fields at Nairn Academy, Highland, Scotland (centred at NH 87247 55559).

A total of 4 hectares were surveyed and the results of the survey have identified the following:

There is a concentration of anomalies of possible archaeological interest in the eastern part of the survey area, adjacent to extant buildings and the artificial pitches. These have been tentatively interpreted an enclosure and associated trackways and internal features, potentially of prehistoric date, on the basis of their overall shape and the presence of prehistoric material in a cut feature which is also visible as a positive geophysical anomaly. Their interpretation is complicated by the presence of positive and negative areas of magnetic enhancement, which are either natural in origin (related to periglacial processes) or caused by human activity, whether that be archaeological or more recent (i.e. agriculture or management of the sports pitches).

The western part of the survey area contains more of the curved enhanced bands, but rather fewer anomalies of archaeological interest, except for four oval clusters of discrete positive and dipolar anomalies tentatively interpreted as pits or postholes. There are other possible pits in their close vicinity.

Along the southern boundary of the survey area on a slight rise and adjacent to rough ground, there are two unusual dipoles of uncertain origin surrounded by a u-shaped area of magnetic enhancement. These have been highlighted because the dipolar anomalies are not characteristic of ferrous material, but bear similarities to anomalies shown to be caused by small, buried stone-lined structures in other datasets from comparable geologies.

A drain or utility running along the route of a depression that also marks a historic ward boundary and right of way has been identified bisecting the survey area.

The survey has also identified below ground elements of infrastructure associated with the sports pitches, including goal-post holders, field drains and buried electrical cables for floodlights.

1 Introduction

1.1 AOC Archaeology Group was commissioned by Balfour Beatty to undertake an archaeological geophysical gradiometer survey of a site at Nairn Academy, Highland, Scotland. The survey was conducted on the 15th and 16th February 2022 as part of a wider scheme of archaeological assessment in advance of the proposed development of the site.

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).

1.3 The survey was carried out to provide information on the extent and significance of potential buried archaeological remains within the proposed development site.

2 Site Location and Description

2.1 The proposed development site (hereafter 'the Site') is located on the playing fields of the Academy site sandwiched between the Aberdeen- Inverness Railway and housing off Moss Side Road which is located to the south of the A96. The western end of the survey area is bounded by a metal fence leading to a grassed recreation area, and the eastern end is bounded by an Astro-turf sports pitch, metal fencing and outbuildings associated with the Academy (see Figure 1).

2.2 The Site totals approximately 8.8 ha and consists of one playing field, school buildings and car-parking. Of these the playing field (4.25 ha) is the only part suitable for magnetic gradiometer survey. The ground level within the site is flat and level, situated at around 20m above Ordnance Datum (aOD).

2.3 The site is located on the Sandstones from the Upper and Middle Old Red groups; specifically the northern and eastern part of the site is underlain by the Nairn member, with the southern and western portion underlain by sandstone from the Inverness group (BGS, 2022). These are sedimentary rocks of fluvial origin in the Devonian period (383 – 388 m years ago), and fine to coarse grained. These are overlain by superficial Quaternary deposits of glaciogenic sands and gravels of the Alturlie formation (BGS, 2022).

2.4 No soil information is recorded for the northern and eastern part of the site. The soils within the southern and western part of the site (where survey was undertaken) are listed as Podzols; specifically hummus – iron (Fe) podzols with a high sand content and high organic content. These pose no contraindications for magnetic survey, though concentrations in Fe might cause anomalies related to the pedology and local hydrology of the survey area of the same or greater strength than those related to sub surface anthropogenic features (if any are present) (Scotland's Soils, 2022).

2.5 The geotechnical pits excavated shortly after the survey (on 10/03/2022) confirmed the soil type and established that the depth of soil varies over the survey area from 0.25m to 0.5m, with evidence just outside the survey area of made ground of up to 1.2m depth (Murray, 2022).

2.6 Gradiometer survey is suggested to provide a variable response over sedimentary rocks; in this instance the higher Fe content of the parent material and the resulting Podzols should allow for reasonable enhancement of any anthropogenic deposits on the site. However, it is also possible that this higher iron content will also give a strongly contrasted natural magnetic background which might make distinguishing weaker anthropogenic anomalies a challenge (David *et al.* 2008, 15).

3 Archaeological Background

3.1 The archaeological background is summarised from the WSI for the watching brief proposed by AOC and produced by AOC Archaeology in 2022 (AOC, 2022). All references to HER numbers and the like are drawn from this document.

3.2 No Scheduled Monuments are located on the Site.

3.3 The Site lies within an area of rich archaeological heritage. It lies on the outskirts of what would have been Nairn Royal Burgh, which was probably founded in the late 12th century by Alexander II. No known archaeological sites are present within the development area, but cropmarks within the fields adjacent to the site have indicated the presence of a complex of huts, a large defended enclosure, and several barrows of likely prehistoric date (Highland Historic Environment Records (HHER): MHG6922, MHG40178, MHG40179).

4 Aims

4.1 The aim of the geophysical survey was to identify any potential archaeological anomalies that would enhance the current understanding of the archaeological resource within the proposed survey area.

4.2 Specifically, the aims of the gradiometer survey were;

- To locate, record and characterise any surviving sub-surface archaeological remains within the survey area,
- To provide an assessment of the potential significance of any identified archaeological remains in a local, regional and (if relevant) national context,
- To produce a comprehensive site archive (Appendix 2) and report
- To engage with the community at Nairn Academy to teach them about geophysics and archaeology

5 Methodology

5.1 The geophysical survey was undertaken between 15th and 16th February 2022.

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.

5.5 The survey was carried out using a Sensys MAGNETO® MXPDA push-cart magnetometer system. The cart utilises four FGM650/3 fluxgate gradiometer sensors mounted at 0.5m spacing upon a frame along with data logging equipment and batteries (see Appendix 3).

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 and measured tracks were collected through the data acquisition unit MXPDA and visualised through a tablet PC mounted to the cart.

5.7 A total of 4ha were surveyed using the Sensys cart.

5.8 Care was taken to attempt to avoid metal obstacles present within the survey area, such as metal fencing around hedge boundaries as gradiometer survey is affected by 'above-ground noise' and avoiding these improves the overall data quality and results obtained.

5.9 The data was downloaded via USB and converted using DLMGPS and Geoserver before being processed (compensated) using MAGNETO® 3.0 software. The details of these processes can be found in Appendices 3 and 4.

5.10 Interpretations of the data were created as layers in ArcGIS Pro using multiple plotting ranges to characterise the anomalies: the technical terminology used to describe the identified features can be found in Appendix 5.

6 Results and Interpretation

6.1 The gradiometer survey results have been visualised as greyscale plots, with the minimally processed data plotted as a greyscale of -5nTto +5nT in Figure 3. A wider plot is shown in Figure 5, at -10nT to +10nT. An interpretation of the data can be seen in Figure 4 and a characterisation of the identified groups of anomalies can be seen in Figure 5. Figure 6 shows the 10/03/22 geotechnical pits within the survey area alongside the interpretation of the geophysical survey results.

Archaeology

6.2 Though the geotechnical test-pits identified possible prehistoric cut-features in pits 2 and 7, no anomalies within the geophysical results have been definitively classified as archaeological in origin. This is because the strength and morphology of the anomalies are not categorically classifiable as archaeology; there remain other potential explanations for their appearance such as natural soil variations or more recent human activity such as agriculture or management of the sports pitches.

6.3 Figure 4 shows the interpretation of the survey results, classified into categories (for more information about the classification, see Appendix 5). Figure 5 shows the survey results as a greyscale of the gradiometer data, with broad zones indicated and labelled with letters. These 'zones' are groups of anomalies that have been identified within the results which seem to be related or associated (on the basis of both their character and their morphology). These anomalies groups will be discussed below, and Figures 4 and 5 should be consulted alongside this discussion.

Possible Archaeology

6.4 While no definitive archaeology has been identified in the results, there are a high number of anomalies considered as having possible archaeological origins, especially given the finds of prehistorical material and cut features within two of the geotechnical pits (Murray, 2022). These are largely concentrated in the eastern part of the site closer to the existing school buildings and artificial pitches, though there is a second group along the southern boundary in the western part of the survey area.

6.5 The anomalies marked in Figure 5 as group A are a series of discontinuous linear positive anomalies with relatively sharply defined edges, particularly those aligned north-south along the edge of the survey area that borders the artificial pitches. They appear to turn to run east-west and to continue beneath the disturbance from modern infrastructure and the north-eastern boundary of the survey area. In places there are indications of two parallel features. These anomalies are interpreted as one corner of a rectilinear enclosure, as discrete positive linear anomalies like these are likely to be caused by the enriched fills of cut features such as ditches. These anomalies appear to enclose or otherwise constrain responses of possible archaeological interest (see C below), and also apparently relate to two sets of paired linear anomalies that diagonally cross the survey area (see B below). This is a dense concentration of possible human activity, and it has not been possible to distinguish phases or clear

chronological relationships between the groups of anomalies, but there is likely to be more than one phase of activity present.

6.6 Two similar, but less magnetic linear anomaly groups have been identified, marked B on Figure 5. These are possibly better visualised in Figure 3, using the tighter plotting range. Similar in character to the anomalies making up group A, these are discrete discontinuous linear positive anomalies indicative of cut features with enhanced fills. Their paired parallel arrangement suggests these relate to two distinct trackways; one intersecting with the corner and north-western edge of the enclosure formed by anomaly group A, and one crossing into the centre of the enclosed area further north and east. Both possible trackways are partially obscured by magnetic interference from modern structures present within the survey area and appear to continue beyond the survey area to the north and west. However, it is also possible these are co-incidental alignments of naturally occurring variations in the soils or geology underlying the survey area that is banded due to the deposition processes involved in their formation. This is why a 'possible' rather than definitive classification has been used.

6.7 There are also concentrations of positive anomalies in association with the linear features interpreted from anomaly groups A & B. Marked C on Figure 5, these groups of anomalies are characterised by discrete positive anomalies of varying size, frequently indicative of cut features with enhanced fills such as pits and post-holes. One of these groups lies within the possible enclosure, and also has curved elements which might relate to ring-ditches, if the anomalies are of archaeological origin. This is corroborated by the find from geotechnical pit 2, and the presence of a cut (possible ditch) feature noted during the watching brief. This group of anomalies also involves a series of negative patches of magnetic response, which have been interpreted as 'natural/geology' as the most likely explanation is that these are caused by variations in the geology underlying the area related to glacio-fluvial processes such as ice wedges. However, it is also possible that negative anomalies like these can be caused by spreads of stone, which may be of archaeological interest (for example, from collapsed structures, or from cobble floors). The second group of discrete anomalies lies along the north western border of the survey area, in close spatial association with one of the possible trackways. There are two large (up to 20m across) discrete anomalies which are tentatively interpreted as pits, perhaps for quarrying, which appear to have fills with magnetically variable characteristics. These features are relatively sharply defined, and so have been interpreted as possible archaeology, though there could also be a natural explanation for them, such as variations in the soil depth or in the superficial geology.

6.8 The southern and western half of the survey is comparatively quiet, in terms of strong distinct anomalies. There are discrete anomalies which have however been highlighted for discussion. The first of these is a pair of uncertain strong dipolar anomalies, marked D, on the southern boundary of the survey area, where rough ground and a slight rise in the topography prevented survey right up to the railway boundary. This pair of dipolar anomalies appear to be enclosed by a band of negative magnetic response in a horseshoe-shape. The characteristics of the dipolar anomalies are not consistent with those caused by modern ferrous material elsewhere within the results, and resembles anomalies encountered in similar landscape settings which were shown to be caused by small buried stone-lined structures. The material causing the surrounding negative anomaly could be a spread of stone with an anthropogenic origin. As such, though these anomalies have an 'uncertain' classification, they are highlighted as being of possible archaeological interest, and so mentioned here rather than below.

6.9 There are also four oval groups of discrete positive or dipolar anomalies within the eastern half of the survey area. These have tentatively been given a possible archaeology classification on the basis of both their magnetic characteristics and their spatial arrangement, which might reflect postholes or pits related to ephemeral structures. There are other groups and isolated instances of discrete positive

anomalies in this general area, which might relate to pits or postholes, as their appearance is characteristic of cut features with magnetically enhanced fills.

Unclear Origins

6.10 Throughout the survey area, positive and negative anomalies of varying shapes, strengths and dimensions have been assigned an uncertain origin. This is because it is unclear whether they relate to natural variations in the soil and geology, to changes associated with the playing fields or former agricultural practices or to archaeological features; there is no clear evidence in favour of a particular interpretation. Geotechnical pit 7 occurs in close association with a group of discrete positive anomalies classified as uncertain (see Figure 6). Unlike the anomalies in close association with the prehistoric find and feature in pit 2 (see above), these anomalies have not been identified as potential archaeology because the association between the features seen in the trench and the geophysical anomalies is less clear. The test pit also contained 'features' interpreted as animal burrows, along with a potential pit with prehistoric pottery in association with it. Thus the discrete anomalies may relate to anthropogenic features, but they may equally be related to animal activity or other natural processes.

6.11 Bands of curving weakly positive enhanced magnetism seen throughout the data could relate to variations in the geology or soils, as is the case with the negative anomalies identified in the western part of the survey, but these anomalies have potential recent (sports-pitches) or archaeological explanations as well, and no clear determination could be made as to their likely origin.

Agricultural

6.12 There are no anomalies or trends characteristic of arable agricultural practice (such as ridge and furrow or modern ploughing 'tramlines') visible within the survey area.

Non - Archaeology

6.13 The area of the site forming the westernmost corner of the survey area has a series of strong negative linear anomalies arranged in a pattern characteristic of drains, leading to a strong ferrous dipole in the corner of the survey which matches with a metal inspection cover noted during the survey.

6.14 Two further drains or other utilities cross the site on a similar alignment, one almost following the southwestern edge of the survey area, and one bisecting the survey area roughly east-west between the corner of the housing on the western border and the railway line. Historic maps show that this drain or service lies along a former boundary that is marked variously as a ward boundary and a footpath or a cart track leading to a level crossing (after the railway was built). This explains the slightly a-typical anomaly, which is a little jumbled compared to the other drains and services seen within the survey result. There was a visible linear depression co-occurring with this anomaly.

6.15 Curved bands of both positive and negative magnetic enhancement exist throughout the survey results. The negative instances have been interpreted as most likely being of natural origin, and related to periglacial processes such as ice wedges, creating variations in the composition of the subsurface materials. The other positive examples have been interpreted as 'uncertain' as they also have anthropogenic explanations, as well as natural (soil, glacial or fluvial) processes being involved in their creation.

6.16 Magnetic disturbance is visible around the periphery of the Site and relates to modern metallic boundary fencing, adjacent housing and infrastructure, and fixtures associated with the sports pitches such as flood lights (in the eastern half) and goal posts (or below-ground ferrous fixtures for them).

7 Conclusion

7.1 The gradiometer has identified a concentration of anomalies of possible archaeological interest, in the eastern part of the survey area, where an enclosure with internal features and two possibly related trackways have been cautiously interpreted from the results. The discovery of prehistoric ceramics and a cut feature (probably a ditch) in geotechnical pit 2 lend weight to this interpretation, and further suggests that some of the possible features are prehistoric in date.

7.2 In the western half of the survey area, the evidence for possible archaeological features is less clear, and largely relates to groups of discrete positive anomalies arranged in oval forms, which have been tentatively interpreted as pits or postholes related to ephemeral structures. Despite the identification of a possible pit and prehistoric ceramic material in geotechnical pit 7, no clear features of archaeological origin have been identified in the survey results in association with the trench.

7.3 Throughout the survey area weakly positive and negative curving linear bands of magnetic enhancement have been identified. These have largely been classified as being of uncertain origin, and so archaeological explanations of them cannot be ruled out.

7.4 Though a high proportion of the anomalies have been classified as being of possible archaeological interest, no definite archaeological features have been interpreted from the survey results. This is because there are possible alternative explanations for all of the anomalies identified within the survey area. Those judged more likely to be archaeological in origin than otherwise have been specified. This distinction has been made due to differences in the shape, strength, and magnetic character of the anomalies, but also on the basis of material or features noted during the watching brief carried out alongside geotechnical test pitting on 10/03/2022.

7.5 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 possible surviving sub-surface remains within the Site, though more remains may be present that are not suitable for detection through magnetometry;
- The survey will help in determining the next stage of works as it has provided evidence that remains of a possible archaeological and an uncertain origin are most likely present on site, and has provided a number of targets for further investigation;
- It is not possible to provide an assessment of the potential significance of the identified remains in a local, regional or national context as it has not been possible to definitively characterise the nature of the anomalies identified through survey alone;
- The survey has resulted in a comprehensive report and archive;
- Community engagement objectives were met with a visit to the survey area by the Higher Geography students and their teacher and the deputy head of the school. They had a short talk about geophysics and its use in archaeology, the ‘polluter pays’ principle in planning legislation, and careers that make use of geography as a subject, before taking part in data collection under the supervision of staff from the Academy, and staff from AOC Archaeology. The school celebrated the event with a twitter post (see Plate 8). The Communities officer from the client, Balfour Beatty was also on site during this visit, and will be working with the Consultancy team at AOC Archaeology to further engage the community during planned further work.

7.6 The geophysical survey has produced good quality gradiometer results which have successfully helped to clarify whether archaeological or uncertain remains are present across the Site. There is a high confidence level that the methodology and survey strategy chosen were appropriate to assess the archaeological potential across the Site.

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 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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11 Plates

Plate 1. Site from southwestern boundary looking north-east (prior to survey)

Plate 2. Site from midway along southern boundary, looking north towards adjacent housing, post survey

Plate 3. Goal posts in centre of survey area (looking east towards Astro-turf pitch and Academy buildings)

Plate 4. Infrastructure at eastern limit of survey area – looking south

Plate 5 - Infrastructure at eastern limit of survey area – looking north

Plate 6- In northern edge of survey area at widest part – survey underway, showing topographic change

Plate 7 Southern boundary, looking south-west, showing rough ground (unsurveyable)

Plate 8: Screen capture of tweet from Nairn Academy, celebrating Higher Geography students helping collect data

12 Figures

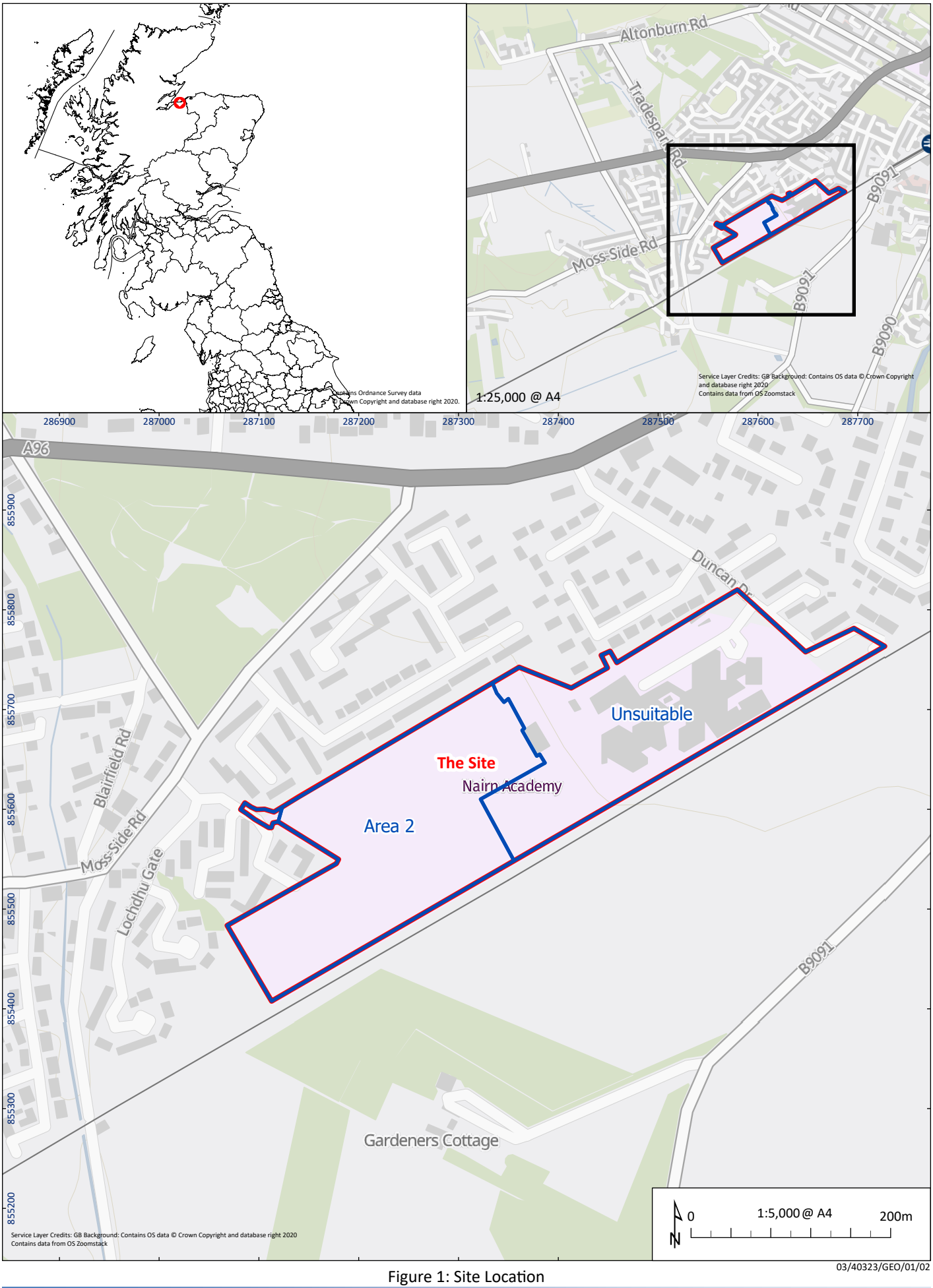

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Figure 1: Site Location

Survey Areas

Figure 2

Red Line Boundary
Surveyed
Unsuitable

N

0 60m

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Created by: KA	Date: 08/04/2022
Checked by: JL	Date: 08/04/2022
Approved by: JL	Date: 08/04/2022

AOC Archaeology Group

287000

855400

287200

Albyn Court

Nairn Academy

Minimally Processed Greyscale

Figure 3

+5nT

-5nT

Surveyed

Unsuitable

0 60m

Scale: 1:1,000 @ A3

Drawing Number: 05/40323/GEO/03/01	
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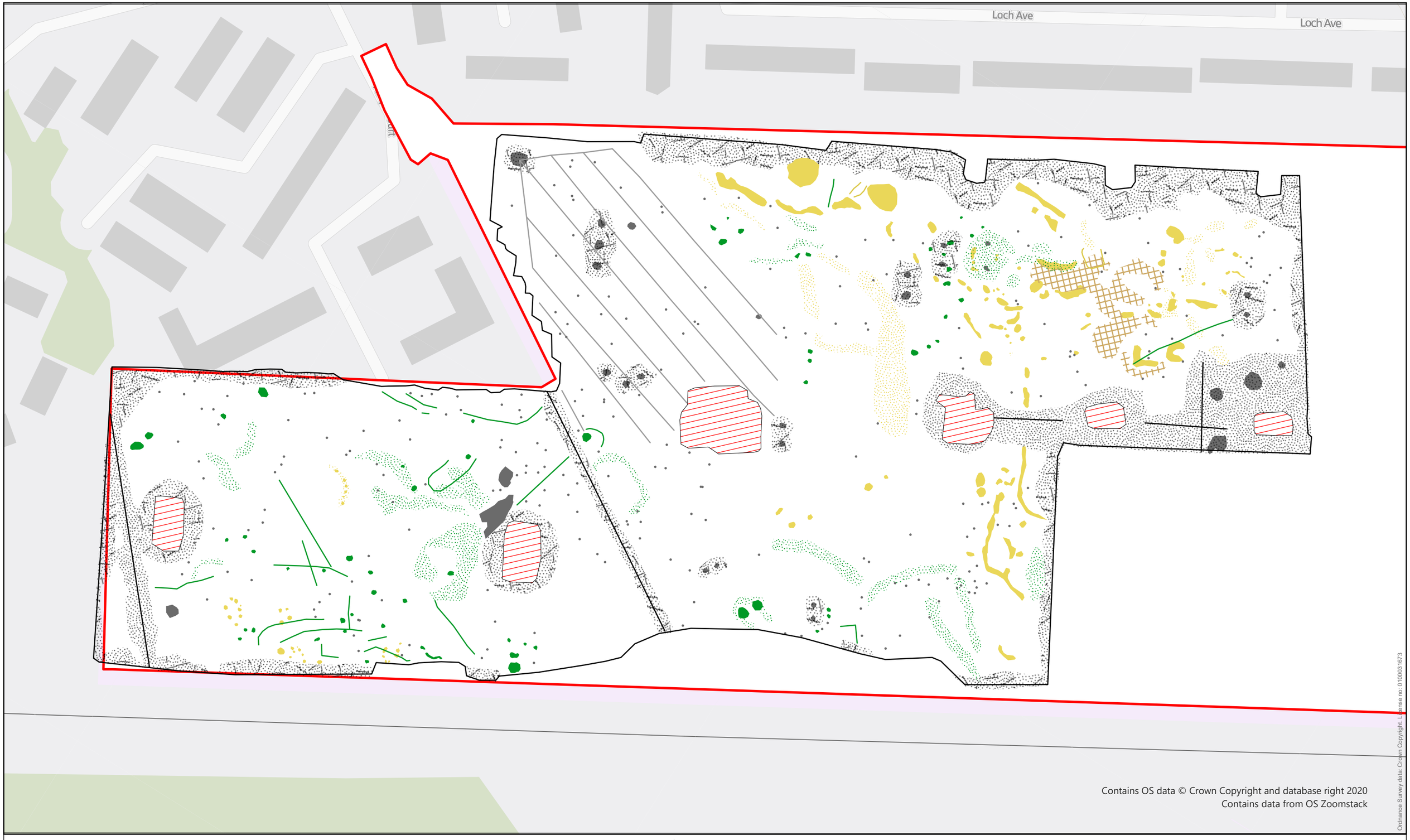

Interpretation of Gradiometer Survey

Figure 4

- Surveyed
- Unsuitable
- Possible Archaeology
- Enhanced Magnetism (Possible Archaeology)
- Ferrous/Iron Spike
- Geology/Natural
- Unclear Origin
- Enhanced Magnetism (Unclear Origin)
- Enhanced Magnetism (Historic Feature)
- Enhanced Magnetism (Modern)
- Enhanced Magnetism (Utility)
- Linear Trend (Drainage)
- Trend (Possible Archaeology)
- Linear Trend (Utility)
- Trend (Unclear Origin)

0 60m

Scale: 1:1,000 @ A3

Drawing Number: 05//GEO/04/01	
Created by: KA	Date: 08/04/2022
Checked by: JL	Date: 08/04/2022
Approved by: JL	Date: 08/04/2022

AOC Archaeology Group

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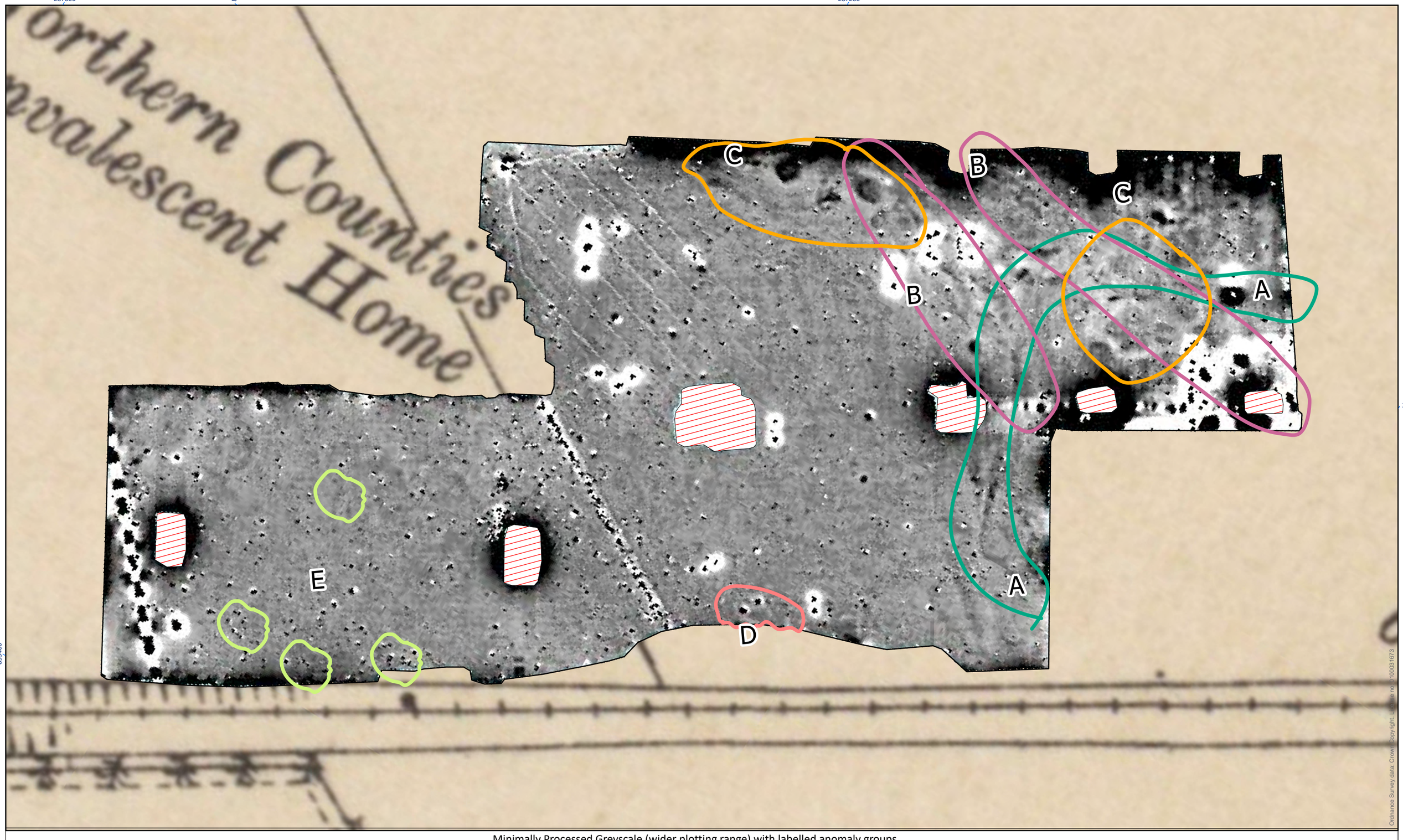

Minimally Processed Greyscale (wider plotting range) with labelled anomaly groups

Figure 5

+10

-10

0 60m

Scale: 1:1,000 @ A3

Drawing Number:	05/40323/GEO/05/01
Created by: KA	Date: 08/04/2022
Checked by: JL	Date: 08/04/2022
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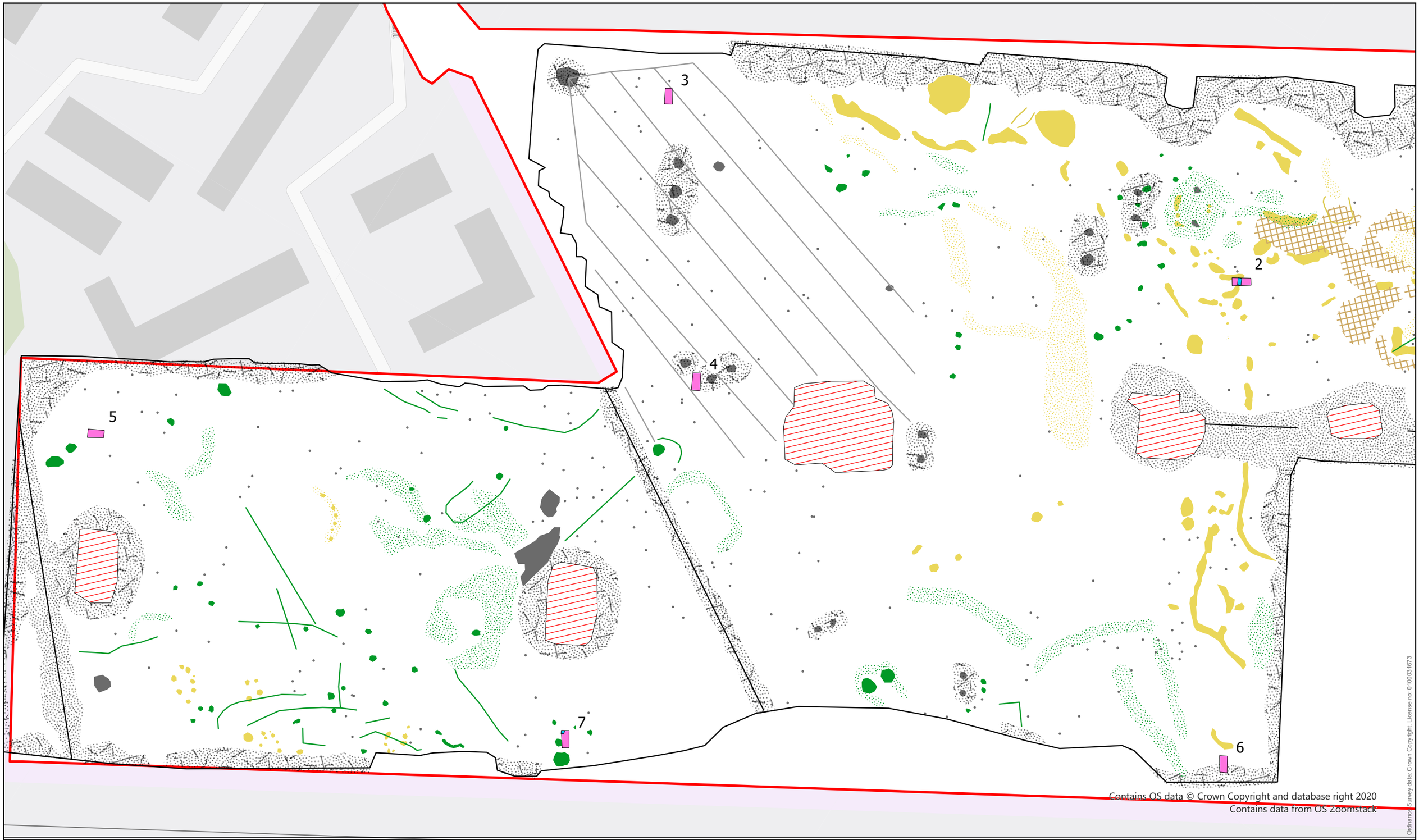

Geotechnical Pits within Surveyed Area

Figure 6

- Surveyed
- Unsuitable
- Feature with prehistoric material
- Geotechnical Test Pit
- Possible Archaeology
- Enhanced Magnetism (Possible Archaeology)
- Ferrous/Iron Spike
- Geology/Natural
- Unclear Origin
- Enhanced Magnetism (Unclear Origin)
- Enhanced Magnetism (Historic Feature)
- Enhanced Magnetism (Modern)
- Enhanced Magnetism (Utility)
- Linear Trend (Drainage)
- Trend (Possible Archaeology)
- Linear Trend (Utility)
- Trend (Unclear Origin)

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Created by: KA	Date: 08/04/2022
Checked by: JL	Date: 08/04/2022
Approved by: JL	Date: 08/04/2022

AOC Archaeology Group

Appendix 1: Characterisation of Anomalies

Gradiometer survey

Anomaly Group	Type of Anomaly
A	Linear positive anomalies forming a right-angled boundary, interpreted as an enclosure.
B	Paired parallel linear positive anomalies interpreted as the bounding ditches of two trackways or paths
C	Concentration of positively magnetic discrete circular and amorphous features characteristic of pits or other cut features with enhanced fills
D	Pair of unusual dipolar anomalies which are similar in character to those detected on other sites in the highland region in association with small stone lined structures, surrounded by a weak negative anomaly with indistinct margins
E	Oval groups of small discrete positive and dipolar anomalies tentatively interpreted as post-holes or pits associated with ephemeral structures

Appendix 2: Survey Metadata

Oasis ID: aocarcha*TBC*

Field	Description
Surveying Company	AOC Archaeology
Data collection staff	Kayt Armstrong, Gemma Hudson
Client	Balfour Beatty
Site name	Nairn Academy
County	Highland
NGR	NH 87247 55559
Land use/ field condition	Actively maintained sports pitches
Duration	15/02/2022 – 16/02/2022
Weather	Strong wind and rain/sleet/hail showers
Survey type	Gradiometer Survey
Instrumentation	Sensys cart survey: Sensys MXPDA cart, four FGM650/3 sensors, Trimble R10 GNSS System
Area covered	Approx 4 ha
Download software	DLMGPS v4.01-10, Geoserver v1.00-02
Processing software	MAGNETO® and TerraSurveyor
Visualisation software	ArcGIS Pro
Geology	Sandstones from the Upper and Middle Old Red groups (BGS 2022)
Soils	Podzols; specifically hummus – iron (Fe) podzols (Scotlands' Soils, 2022)
Scheduled Ancient Monument	No
Known archaeology on site	None
Historical documentation/ mapping on site	None
Report title	Nairn Academy, Highland: Archaeological Geophysical Survey
Project number	40323
Report Author	Kayt Armstrong
Quality Checked by	Susan Ovenden

Appendix 3: 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 inhabitation often causes alterations to the magnetic properties of the ground (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 is generally suggested to have a greater magnetisation than the subsoil caused by human habitation. 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 surrounding soil will consequently have a greater magnetization, resulting in the feature in question displaying a negative signature. For example, stone materials of a structural nature that are composed of sedimentary rocks are considered non-magnetic and so will appear as negative features within the dataset.

Ferrous objects – i.e. iron and its alloys - are strongly magnetic and are typically detected as high-value peaks in gradiometer survey data, though it is not usually possible to determine whether these relate to archaeological or modern objects.

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 thick layers of alluvium or till. All magnetic geophysical surveys must therefore take the effects of background geological and geomorphological conditions into account.

Sensys MAGNETO® MXPDA Non-Magnetic Cart Instrumentation and Software

AOC Archaeology's cart-based surveys are carried out using a Sensys MAGNETO® MXPDA push-cart magnetometer system. 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 five FGM650/3 fluxgate gradiometer sensors mounted upon a frame along with data logging equipment and batteries. The sensors are normally positioned at 0.5m intervals along a horizontal bar, with the data being collected in a constant stream through the data acquisition unit MXPDA. 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. Whilst the cart is surveying, the data acquisition is visualised through a tablet PC which is mounted to the cart.

The data is downloaded via USB and converted using DLMGPS and Geoserver, before being processed (compensated) using MAGNETO® 3.0 software (see Appendix 4 for a summary of the processes used in MAGNETO® to create final data plots).

Appendix 4: Summary of Data Processing

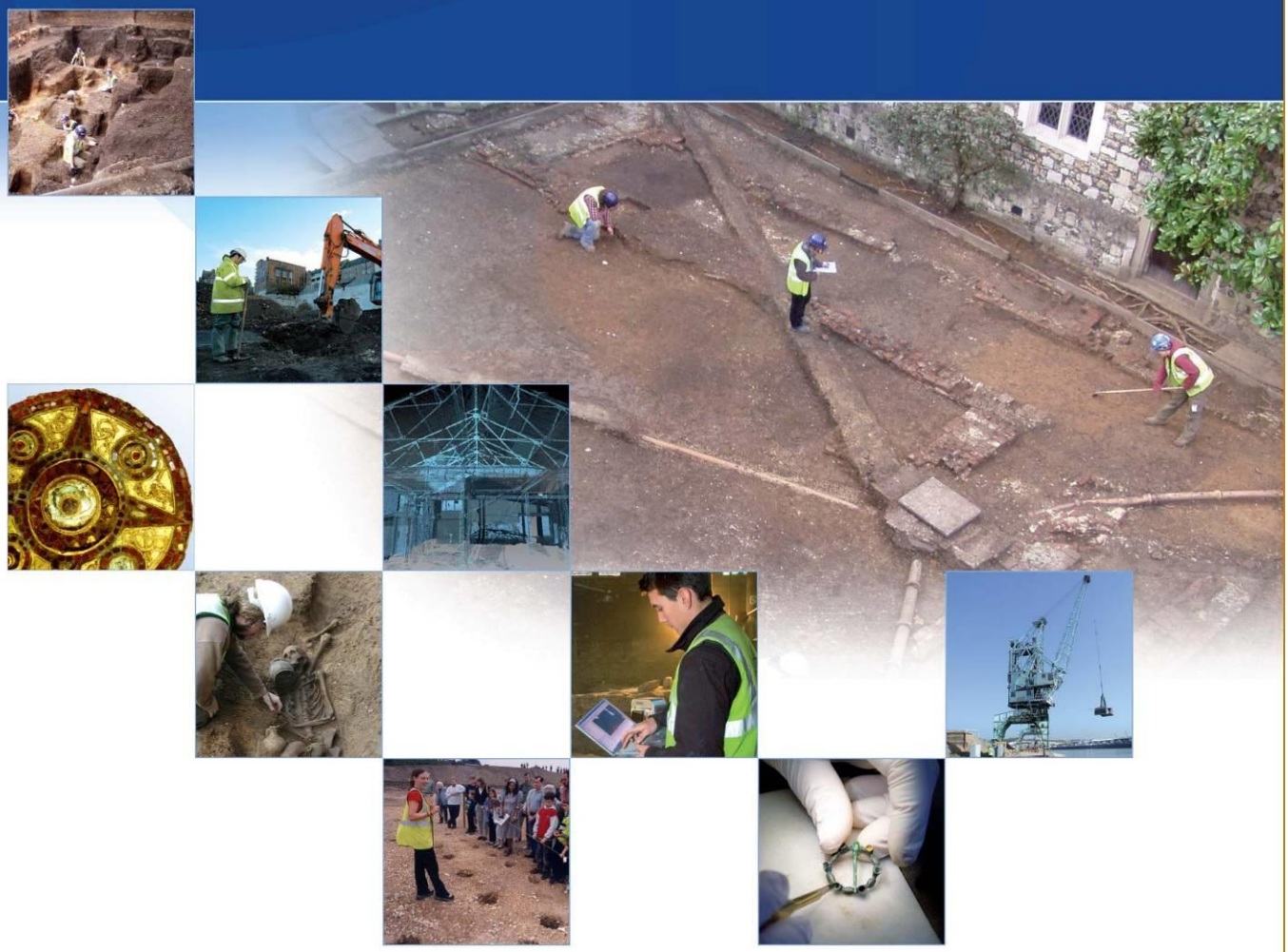
Process	Effect
Clip	Limits data values to within a specified range
De-spike	Removes exceptionally high readings in the data that can obscure the visibility of archaeological features. In resistivity survey, these can be caused by poor contact of the mobile probes with the ground. In gradiometer survey, these can be caused by highly magnetic items such as buried ferrous objects.
De-stagger	Corrects a misalignment of data when the survey is conducted in a zig-zag traverse pattern.
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 scale detail 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 scale detail, 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 plough lines.
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

Sensys Cart survey	
Process	**Extent**
Filter	Moving median with 15 metre rolling median (import with a minimum of 5 GPS points)
GPS filter	1Hz with angle correction
Clip	No compensation
Interpolate	X = 0.2 metres, Y = 0.2 metres Interpolation output = Bi-linear triangle
Palette Scale	User colour palette (256 colours) Min= -5nT Max= 5nT and Min= -10nT Max= 10nT

Appendix 5: Technical Terminology

Type of Anomaly	Description
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.*
Trend	Linear / curvilinear / rectilinear anomalies either characterised by an increase or decrease in values compared to the magnetic background.
Area of enhanced magnetism	A zone of enhanced magnetic responses over a localised area. These anomalies do not have the high dipolar response which are manifested in an 'iron spike' anomaly and likely have a relationship with nearby archaeological trends.
Pit	An anomaly composed of an increase in magnetic values with a patterning on the XY trace plot that is pit-like in appearance.
Possible Archaeology	*Trends are likely to have an archaeological origin, however without supporting evidence from known archaeological remains, HER records, LiDAR or aerial photography, they can only be classed as having a possible archaeological origin.*
Trend	Linear / curvilinear / rectilinear anomalies either characterised by an increase or decrease in values compared to the magnetic background.
Area of enhanced magnetism	A zone of enhanced magnetic responses over a localised area. These anomalies do not have the high dipolar response which are manifested in an 'iron spike' anomaly but lacks definitive records to be classed as being archaeological.
Pit-like anomaly	An anomaly composed of an increase in magnetic values with a patterning on the XY trace plot that is pit-like in appearance.
Burnt area	An anomaly with a patterning on the XY trace plot that is suggestive of industrial activity such as a kiln or hearth.
Unclear Origin	*Trends are magnetically weak, fractured or isolated and their context is difficult to ascertain. Whilst an archaeological origin is possible, an agricultural, geological or modern origin is also likely.*
Trend	Linear / curvilinear / rectilinear anomalies which are composed of a weak or different change in magnetic values. The trends do not appear to form a patterning that is suggestive of archaeological remains, such as enclosures or trackways.
Area of enhanced magnetism	A zone of enhanced magnetic responses which lack context for a conclusive interpretation. They do not appear to have a relationship with nearby trends of an archaeological origin. Can often be caused by areas of former woodland, geological variations or agricultural activity.
Agricultural	*Trends associated with agricultural activity, either historical or modern.*
Old Field Boundary	These isolated long linear anomalies, most often represented as a negative or fractured magnetic trend, relate to former field boundaries when their positioning is cross referenced with historical mapping.
Historical Features	Features observed on historical mapping that correspond with anomalies or trends in the data. Areas of enhanced magnetism could relate to former buildings, trackways, quarries or ponds.
Ridge and Furrow / Rig and Furrow	A series of regular linear or curvilinear anomalies either composed of an increased or decreased magnetic response compared to background values. The wide regular spacing between the anomalies is consistent with that of a ridge and furrow / rig and furrow ploughing regime. The anomalies often present as a positive 'ridge' trend adjacent to a negative 'furrow' trend.
Ploughing Trends	A series of regular linear anomalies 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.
Field Drainage	A series of magnetic linear anomalies of an indeterminate date, usually with a regular or herringbone patterning.
Non - Archaeology	*Trends which are likely to have derived from non-archaeological processes or activities.*
Geology / Natural	An area of enhanced magnetism that is composed of irregular weak increases or decreases in magnetic values compared with background readings. It is likely to indicate natural variations in soil composition or reflect variations in the bedrock or superficial geology.
Possible Modern Service	Anomalies of a linear form often composed of contrasting high positive and negative dipolar values. Such anomalies usually signify a feature with a high level of magnetisation and are likely to belong to modern activity such as pipes or modern services.
Magnetic Disturbance	A zone of highly magnetic disturbance that has been caused by or is a reflection of modern activity, such as metallic boundary fencing, gateways, roads, boreholes, adjacent buildings, rubbish at field edges or a spread of green waste material.
Isolated Dipolar Anomalies / Ferrous (iron spikes) and Ferrous Zones	A response caused by ferrous materials on the ground surface or within the subsoil, which causes a 'spike' in the data representing a rapid variation in the magnetic response. These generally represent modern material often re-deposited during manuring.



AOC Archaeology Group The Lodge, Unit 8, Mortec Park, Leeds, LS15 4TA
tel: **01138 232 853** | email: **leeds@aocarchaeology.com**