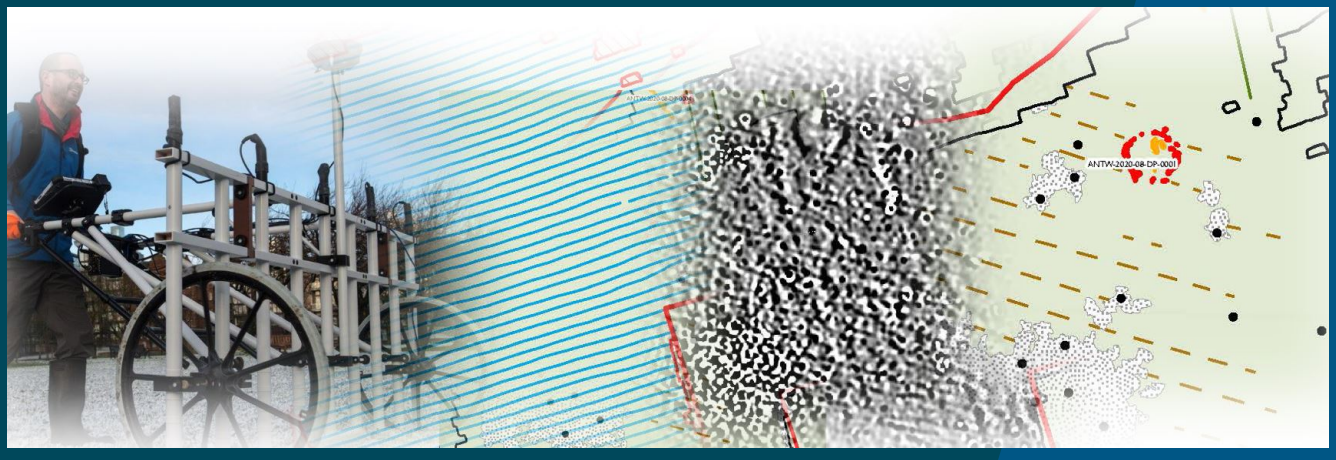
HISTORIC ENVIRONMENT SCOTLAND | ÀRAINNEACHD EACHDRAIDHEIL ALBA

# ANTONINE WALL DOUGLAS PARK

## GEOPHYSICAL SURVEY REPORT




HES PROJECT NUMBER: ANTW2020DP
NGR: NS 99758 81113
DATE: MARCH 2021
AUTHOR: DR NICK HANNON

## EXECUTIVE SUMMARY

Historic Environment Scotland, Survey and Recording, undertook gradiometer survey of 3.43ha at Douglas Park, Bo'ness, Falkirk, Scotland, EH51 9BB to investigate the extent and significance of potential for sub-surface archaeological features.

The survey was conducted on 10 December 2020 and forms part of a wider Antonine Wall Geophysical Survey project. The geophysical survey produced good quality results which give a high level of confidence that the methodology and survey strategy was appropriate to assess the archaeological potential of the survey area.

The survey produced the following results:

- No trace of the Antonine Wall has been identified within the survey area.
- The southern half of the survey area has seen a significant amount of disturbance during landscaping associated with two football pitches and their associated drainage. No features of archaeological, possible archaeological or historical origin have been identified in this area.
- The sites of two probable prehistoric round barrows have been identified occupying similar topographical positions to cists and a tumulus discovered in the 19th century around 1,000m to the east of the park (NRHE ID: 49532 & 49543). The identification of the barrows adds to the scattered evidence for prehistoric activity in the area.
- What may be a small agricultural enclosure, perhaps a sheepfold, of unknown date, has been identified in the northeast of the survey area.
- In the north of the survey area a portion of rig aligned north to south has been identified, some of which was evident on the ground as slight earthworks on the date of survey.

This survey has led to the creation of three new entries in the National Record of the Historic Environment.

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## LIST OF FIGURES



| This document has been prepared in accordance with HES' Terrestrial Geophysical Survey Standard Operating Procedures v1.0 | | | |
|---|---|---|---|
| Version: | ANTW2020DP-Report-v1.4 | | |
| Author: | Dr Nick Hannon | Date: | 23/03/2021 |
| Quality Checked by: | | Date: | |

## 1.0 - INTRODUCTION

Historic Environment Scotland (HES) undertook gradiometer survey at Douglas Park, Bo'ness, Falkirk, Scotland, EH51 9BB to investigate the extent and significance of potential sub-surface archaeological features within the survey area. The survey was conducted on 10 December 2020 and forms part of the Antonine Wall Geophysical Survey project, which aims to answer a range of management and research questions relating to the Antonine Wall.

## 2.0 – PROJECT BACKGROUND & AIMS

Survey at Douglas Park was undertaken to address research questions highlighted in the Scottish Archaeological Research Framework (ScARF) and the Antonine Wall Management plans (HES 2007 & 2014), within the framework of HES' geophysical survey programme (HES 2020a). Douglas Park is an area of parkland immediately north of the currently recorded line of the Antonine Wall. The survey forms part of a larger programme of geophysical survey within the World Heritage Site. This survey report is intended to be read alongside the survey campaign's project proposal document (HES 2020a).

Geophysical survey of Douglas Park had two aims to support enhanced understanding of the area's archaeological resource. Firstly, to identify any previously unknown archaeological, or potentially archaeological, anomalies, and secondly to gain further information about previously identified archaeological features. Beyond these general aims, the survey intended to address the following specific questions:

- Can the park be ruled out as the possible position for the line of the Antonine Wall?
- Are there any anomalies in the park which relate to the Roman occupation of the area?

The survey results could lead to the creation of new entries, or the amendment of existing entries in the National Record of the Historic Environment, and/or could inform future review of the designated area under the 1979 Ancient Monuments and Archaeological Areas Act.

## 3.0 – SITE LOCATION & DESCRIPTION

The planned survey area (centred on NS 99758 81113) covered a total of 4ha in Douglas Park, a small municipal park containing a playground, two football pitches, dispersed patches of trees and areas of grassed parkland. The park lies 500m south of the centre of Bo'ness, Falkirk, Scotland (Figure 1).

Douglas Park occupies a north facing slope dropping from 63m AOD in the south to 54m AOD in the north. At the centre of the park is a small knoll which reaches 66m AOD and is topped by a flagpole (Image 2). The survey area is bound to the north by housing, the south by Dean Road, the east by Cadzow Lane and the west by Linlithgow Road.

The solid geology (Figure 3) is recorded as Limestone Coal Formation, with a band of Bathgate Hills Volcanic Formation at the east of the park. This is overlain with superficial deposits of Till, Devensian – Diamicton (BGS 2021). The site's soil type is recorded as Built-up land (Scotland's Soils 2021).

The survey area comprised of a single land parcel, referred to hereafter as DP01. The land is owned by Falkirk Council who granted access for the survey with no constraints. It does

not contain any scheduled monuments and is outside the Antonine Wall World Heritage Site.

The survey area does not include any land designated as either a Site of Special Scientific Interest or a Special Area of Conservation. It is not protected under the Ramsar Convention, does not lie within a National or Regional Park and it is not a nature reserve (NatureScot 2021). Reference to the National Biodiversity Network's Atlas (NBN 2021) for the survey area, and a 200m buffer surrounding it, showed no sightings of flora or fauna which require the granting of a licence for the survey to be conducted, therefore NatureScot were not consulted.

During the survey the weather conditions were generally dry and sunny although a period of persistent heavy rain in the days before the survey had caused waterlogging in isolated areas.

A photographic record showing the survey area and ground conditions can be found in Section 11.

## 4.0 – ARCHAEOLOGICAL BACKGROUND

Douglas Park lies to the north of the current mapped line of the Antonine frontier and is a pocket of land which has escaped the development seen in the surrounding areas. The area of the park is of interest because of the depiction of the Wall on the 2nd edition 6-inch OS map (Linlithgowshire, 1895). The course of the Wall is depicted by hachures 500m to the east of the park and is shown running along the 200-foot (60.96m ) contour, the same elevation as the park. This is 65m to the north of Grahamsdyke Road which is the frontier's currently recorded position. Therefore, if the frontier maintained the same elevation it would pass through the park as it continued towards Kinneil House. However, this northerly alignment was discounted by Macdonald in the 2nd edition of his *The Roman Wall in Scotland* in preference for a route following Grahamsdyke Road and Dean Road (Macdonald 1934: 102-4). Small-scale excavation 250m south-west of the survey area and immediately to the west of St. Mary of the Assumption Roman Catholic Church identified the southern edge of a negative feature. The excavators (Keppie *et al* 1995: 606-610) believed this to be the Ditch of the Antonine frontier, supporting the line published by Macdonald. Nevertheless, the geophysical investigation of Douglas Park was deemed worthwhile to establish whether any vestiges of the Wall ran through it.

Prehistoric activity in the area is represented by the discovery of cists in the 19th century. These lay some 1,000m to the east and close to the position of "Deacon's Stone", a standing stone which once stood at the summit of a tumulus and is depicted on early OS mapping (NRHE IDs: 49532 & 49543).

## 5.0 – SURVEY METHODOLOGY

The survey was conducted on 10 December 2020.

All survey was carried out in accordance with the Chartered Institute for Archaeologists, *Standard and Guidance for archaeological geophysical survey* (CIfA 2016), the *EAC Guideline for the Use of Geophysics in Archaeology* (Schmidt *et al.* 2016), and the Historic Environment Scotland, *Geophysical Survey, Standard Operating Procedures* (HES 2020b).

Survey methods were selected to best deliver the aims detailed in Section 2, in accordance with the recommendations outlined in the EAC guidelines, and in accordance with the manufacturer's guidelines (Sensys 2019). All sensors had valid in-date calibration certificates which are included in Appendix 2.

## 5.1 – GRADIOMETER SURVEY

The gradiometer survey was conducted using a hand propelled Sensys MXPDA system mounted on a Sensys F-type non-magnetic cart, with standard profile wheels. This system utilised five Sensys FGM650/3 sensors operating at 100hz, mounted at a 0.5m sensor separation with bases positioned 0.05m from the surface. The system was balanced prior to the commencement of the survey, with the calibration position shown in Figure 2.

The survey was conducted by walking parallel traverses in a zig-zag pattern, with traverses aligned east-west and positioned 2.5m apart. Navigation was provided by MONMX, the system's on-board software which displays position and the areas of previously collected data, ensuring that each traverse was evenly spaced. The position of the traverses is shown as a "breadcrumb" trail in Figure 2. Data points were recorded every 0.125m along each traverse, with positional accuracy provided by a Leica GS16 GNSS antenna mounted directly on the frame of the cart at a height of 1.5m. This provided a constant stream of data in NMEA format allowing each reading to be accurately georeferenced without the need for a pre-determined grid system.

Data was logged using the system's MONMX v.5.01-03/00 software package on a Panasonic FZ-G1 tablet computer in .prm format. Following the completion of the survey the data was then exported from the system in both .asc and .uxo formats. The .uxo file was processed and visualised using DW Consulting's Terrasurveyor v3.0.36.10 and the .asc file retained for archiving purposes. Interpretations of this data were then generated using ESRI ArcGIS Pro v2.5.1.

Data quality was maintained by avoiding ferrous objects within the survey such as fences, gates and inspection covers where possible.

Gradiometer survey can be affected by the site's underlying geology. High levels of background magnetism are often experienced in locations with igneous or metamorphic geologies. This can mask the subtle changes in the magnetic field associated with archaeological remains, making them difficult to detect. The sedimentary bedrock formations recorded at the site are expected to exhibit low levels of background magnetism and therefore provide a good response to this methodology, however data quality over the band of igneous geology may be poor (EH 2008: 15).

## 6.0 – SURVEY RESULTS & INTERPRETATION

The following section presents the results obtained using the data collection methodology detailed in Section 5 and the data processing methodologies in Appendices 5, 6, and 7. The results are dealt with by area and anomaly class.

A total of 3.43ha of the planned 4ha for survey were surveyable (Figure 2). The 0.57ha discrepancy is accounted for by areas of tarmac path (which were avoided due to their highly magnetic nature), the flagpole at the summit of the knoll (a physical obstacle), the chain-link fence in the southeast corner of the survey area (a highly magnetic physical obstacle), trees within the survey area (physical obstacles) and the tree canopy around the perimeter of the northern part of the survey area which blocked the GNSS signal and prevented survey in this area.

The figures relating to these results and interpretations can be found in Section 12. The gradiometer results have been visualised as greyscale plots with minimally processed data plotted at -50/50nT (Figure 4) and fully processed data displayed at -12/12nT (Figure 5). XY trace plots have been produced (Figure 6), along with a graphical interpretation of the data (Figure 7). Numbered anomalies are listed in Appendix 3 and described in Appendix 4.

In general, only anomalies of archaeological or possible archaeological origins have been assigned an anomaly number.

## 6.1 – AREA DP01 GRADIOMETER SURVEY – ARCHAEOLOGICAL FEATURES

In area DP01 two anomalies of probable archaeological origin have been identified in the gradiometer data.

The first anomaly (ANTW2020DP-0001) lies in the north-west of the survey area and comprises a circular band of raised magnetic response. This is interpreted as a ditched feature, forming a discontinuous ring-ditch with an overall external diameter of 10m. The form, dimensions, and topographic position of this feature suggest that it is probably a prehistoric round barrow. Anomalies, interpreted as possible pits, are evident in the interior of the ring-ditch. This has been added to the NRHE ID: 367880.

A similar but slightly weaker anomaly (ANTW2020DP-0002) lies in the east of the survey area. It, too, is a roughly circular band of raised magnetic response, with an overall external diameter of 9m, and is also interpreted as probably a prehistoric round barrow. Anomalies, interpreted as possible pits, are evident in the interior of the ring-ditch. This has been added to the NRHE ID: 367881.

## 6.2 – AREA DP01 GRADIOMETER SURVEY – POSSIBLE ARCHAEOLOGICAL FEATURES

In area DP01 several anomalies of possible archaeological origin have been identified in the gradiometer data.

The first anomaly (ANTW2020DP-0003) is located towards the northeast of the survey area on a north-facing slope. It is a band of raised magnetism that defines what may be a rectangular enclosure measuring 7m from north-east to south-west by 6m. A linear trend extends from it in a northwesterly direction. This may be a small agricultural enclosure of unknown date, such as a sheepfold. However, a modern origin for this anomaly cannot be ruled out. This has been added to the NRHE ID: 367885.

The second anomaly (ANTW2020DP-0004) lies in the north-west of the survey area on a steep north-facing slope. It is a 14m long linear trend orientated from north-west to south-east. The magnitude of the response and its different alignment separates it from the neighbouring area of medieval cultivation (ANTW2020DP-0005) and indicates it may be of archaeological origin, albeit of unknown function and date. However, a non-archaeological origin cannot be ruled out.

## 6.3 – AREA DP01 GRADIOMETER SURVEY – HISTORICAL AGRICULTURE & FEATURES

There is an area of parallel linear trends set some 7m apart and orientated from north to south located on the relatively steep slope in the north of the survey area (ANTW2020DP-0005). These are interpreted as furrows of rig cultivation and cover an area of 0.5ha.

## 6.4 – AREA DP01 GRADIOMETER SURVEY – MODERN AGRICULTURAL FEATURES

No anomalies of modern agricultural origins have been identified in the gradiometer data.

## 6.5 – AREA DP01 GRADIOMETER SURVEY – GEOLOGICAL & FLUVIAL FEATURES

In area DP01 no anomalies of geological or fluvial origins have been identified in the gradiometer data. The band of igneous geology identified within the park (Figure 3) is not apparent in the data and has therefore not affected its quality.

## 6.6 – AREA DP01 GRADIOMETER SURVEY – MODERN FEATURES

Numerous anomalies of modern origin have been identified in the gradiometer data.

The first anomaly is a 19m long linear trend in the north-east of the survey area. It is orientated from north-east to south-west and probably represents a section of modern drainage. This interpretation is supported by a series of drain covers visible along the adjacent pathway.

At the summit of the knoll there is an area of enhanced magnetism associated with the position of the flagpole (Image 2) and the series of steel guy lines used to secure it. Within this area of disturbance, a ring of 15 ferrous spikes form a circular arrangement around the flagpole. They may represent the former position of a fence around the flagpole or anchor points previously used to stabilise the flagpole.

A series of parallel linear anomalies orientated from north-west to south-east lie beneath the western football pitch. A second series of similar anomalies orientated from north-east to south-west can be identified beneath the eastern football pitch. These represent land drains installed during the landscaping associated with the football pitches.

A large irregular area of magnetic disturbance measuring 45m east-west by 32m north-south covers the central section of the western football pitch. Similar smaller areas of magnetic disturbance are located around both of the goalposts. These are interpreted as areas where modern material of an enhanced magnetic nature (such as brick or concrete) have been dumped, either as part of the levelling of the area ahead of the construction of the football pitches or in an attempt to improve drainage.

Areas of magnetic disturbance occur at the edges of the surveyed area, including around the playground at the centre of the park, along the edges of the paths, parallel with the chain-link fence in the south-west of the park (Figure 3) and along the park's northern edge. These responses are caused by the ferrous nature of the fencing enclosing the playground, the magnetic material used to construct the path and the magnetic nature of the boundary between the park and the residential properties at the north.

## 6.7 – AREA DP01 GRADIOMETER SURVEY – FEATURES OF UNCERTAIN ORIGINS

No anomalies of unknown or uncertain origins have been identified in the gradiometer data.

## 7.0 – CONCLUSIONS

The geophysical survey has produced good quality gradiometer results which have successfully contributed to the aims detailed in Section 2. There is a high level of confidence that the chosen methodology and survey strategy was appropriate to assess the archaeological potential of the survey area.

No trace of the Antonine Wall has been identified within the survey area.

The southern half of the survey area has seen a significant amount of disturbance during the landscaping associated with two football pitches and their associated drainage. No features of archaeological, possible archaeological or historical origin have been identified in this area. This is not surprising given the modern landscaping activities, however if the course of the Ditch associated with the Antonine Wall did run through this area it should still be identifiable due to its anticipated depth and width.

The sites of two probable prehistoric round barrows have been identified occupying similar topographical positions to cists and a tumulus discovered in the 19th century around 1,000m to the east of the park (CANMORE NRHE ID: 49532 & 49543). The identification of the barrows adds to the scattered evidence for prehistoric activity in the area.

What may be a small agricultural enclosure, such as a sheepfold, of unknown date, has been identified in the northeast of the survey area. A modern origin, however, cannot be ruled out for this feature.

In the north of the survey area a block of rig aligned north to south has been identified, some of which was still evident on the ground as slight earthworks on the date of survey.

In assessing these results against the specific aims listed in Section 2.

- They have confirmed that no element of the Antonine Wall is contained within Douglas Park.
- They have not identified any anomalies likely to be contemporary with the occupation of the Antonine Wall within Douglas Park.

In summary the survey has confirmed that the course of the Antonine Wall does not pass through Douglas Park.

## 8.0 – CAVEATS

Geophysical survey relies upon the detection of anomalous values and patterns in the physical properties of the ground and uses these as a proxy for anthropogenic activity; it does not directly detect archaeological features. Therefore, the results from this method of survey will not be a direct indicator of the absence or presence of archaeological features.

The ability of geophysical survey to identify the potential for archaeological remains is impacted by several interconnecting factors, including geological and fluvial processes, weather conditions, ground conditions, and the taphonomic processes involved in the archaeological site's formation. Therefore, the survey results may not provide a complete plan of the site's archaeology.

Nonetheless Historic Environment Scotland have endeavoured to produce interpretations of the data as accurately as possible. However, it should be noted that these interpretations and the conclusions contained within this report are a subjective assessment of the data.

## 9.0 – ARCHIVE DEPOSITION

A digital copy of this report has been supplied to both Historic Environment Scotland and the local Historic Environment Record for archive purposes. An event record has been generated for the National Record of the Historic Environment (NRHE) summarising the methodology and results of the project. As the interpretation of the results has led to the identification of new sites, new NRHE site records have been created. A list of these can be found in Appendix 9. No existing site records have been amended.

In accordance with standard industry practice an Online Access to the Index of Archaeological Investigations (OASIS) record has been generated and submitted to the Historic Environment Record (HER) and the Archaeological Data Service (ADS).

As the survey was conducted in Scotland an entry has been generated for inclusion in "Discovery and Excavation in Scotland". This text can be found in Appendix 8.

The digital elements of the project have been supplied to the NRHE for archive in the following formats.

- Unprocessed survey data supplied as a .txt file.
- Processed survey data supplied as a .tif file.
- A .zip containing the following .shp files.
    - Polygons showing the survey area extents and containing the survey's metadata.
    - Interpretation polygons.
    - Interpretation polylines.
    - Interpretation points.

## 10.0 – BIBLIOGRAPHY

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## 11.0 – IMAGES

Image 1 – Douglas Park, from the east end looking north-west, with the survey underway (DP350696)

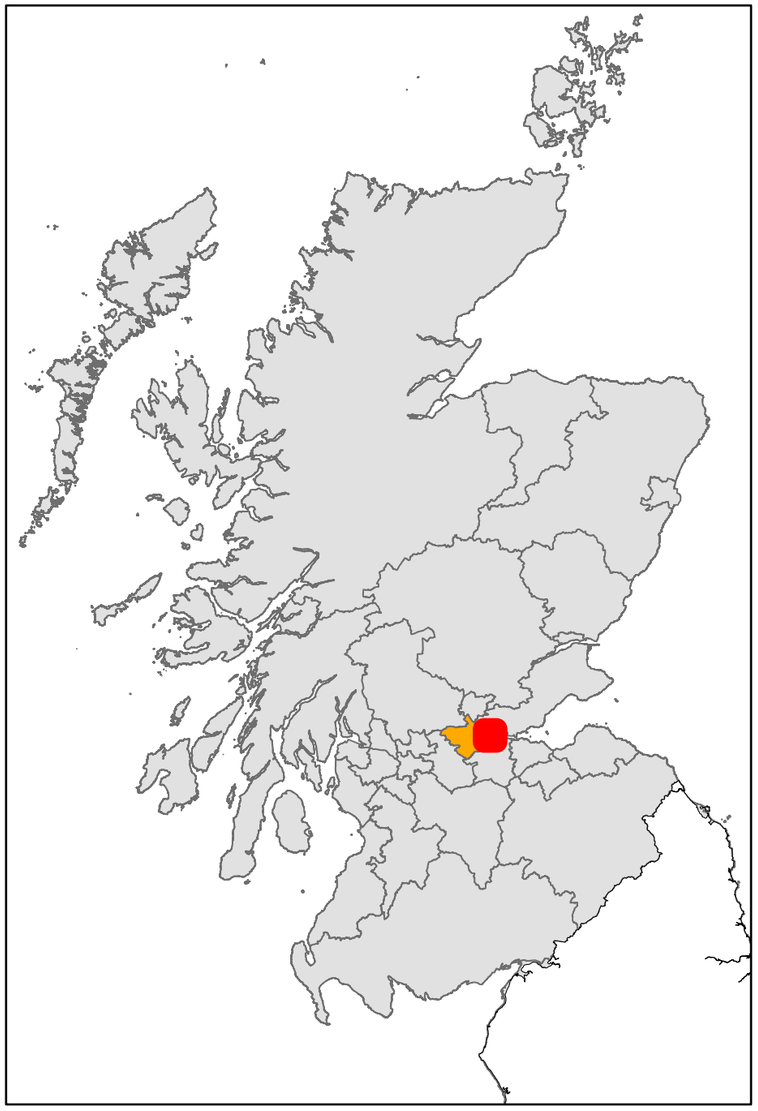
Image 2 – Douglas Park, from the west end looking east (DP350697)

Image 3 – Douglas Park, from the west end looking south-east (DP350698)

## 12.0 – FIGURES

| | |
|---|---|
| Project Name | Antonine Wall, Douglas Park |
| Project Code | ANTW2020DP |
| Prepared By | Nick Hannon |
| Prepared On | 17/03/2021 |

HISTORIC ENVIRONMENT SCOTLAND | ÀRAINNEACHD EACHDRAIDHEIL ALBA



THE ANTONINE WALL
- Rampart
- Ditch

OVERVIEW MAP
- Falkirk Council
- Survey Location

North

Scale: 1:25,000 @ A3

Datum: OSGB 1936

Metres
0 400 800 1,200 1,600 2,000

Figure 1 Survey area location

| | |
|---|---|
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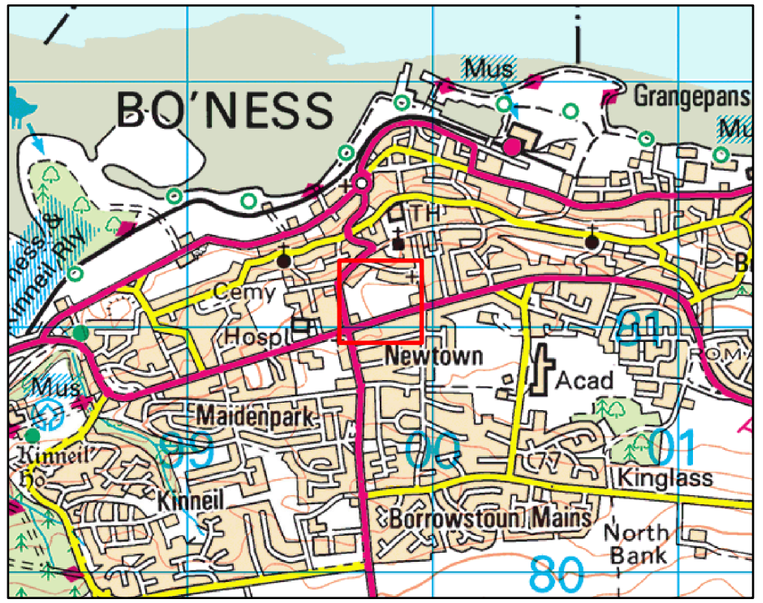


GEOPHYSICAL SURVEY

- Survey Area
- Calibration Position
- Photograph Position
- Unsurveyable
- GNSS Breadcrumbs

| | | |
|---|---|---|
| North | Scale: 1:1,250 @ A3 | Datum: OSGB 1936 |
| | Metres 0 25 50 75 100 | |
| Figure 2 | Survey area showing GNSS survey swaths | |

| | |
|---|---|
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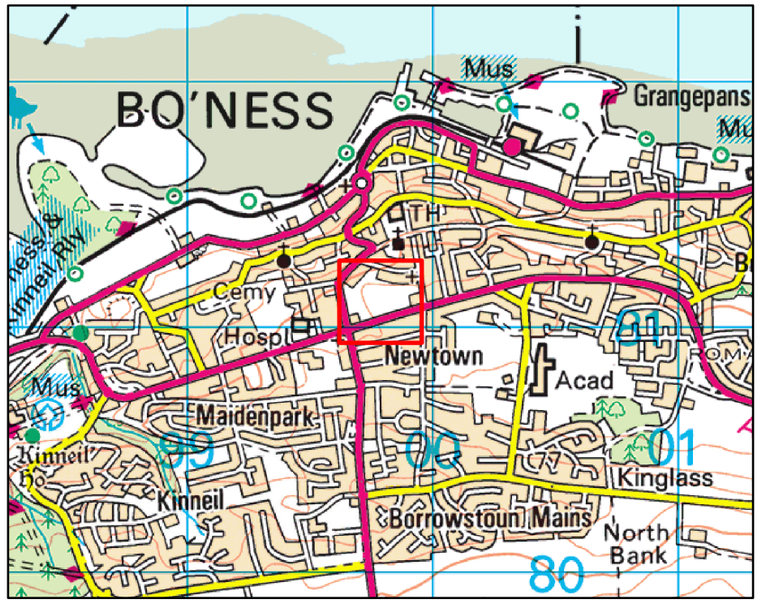


GEOLOGY

- Survey Area
- Bathgate Hills Volcanic Formation - Basalt
- Limestone Coal Formation

| North | Scale: 1:1,250 @ A3 | Datum: OSGB 1936 |
|---|---|---|
| | Metres 0 25 50 75 100 | |
| Figure 3 | Survey area geology | |

| | |
|---|---|
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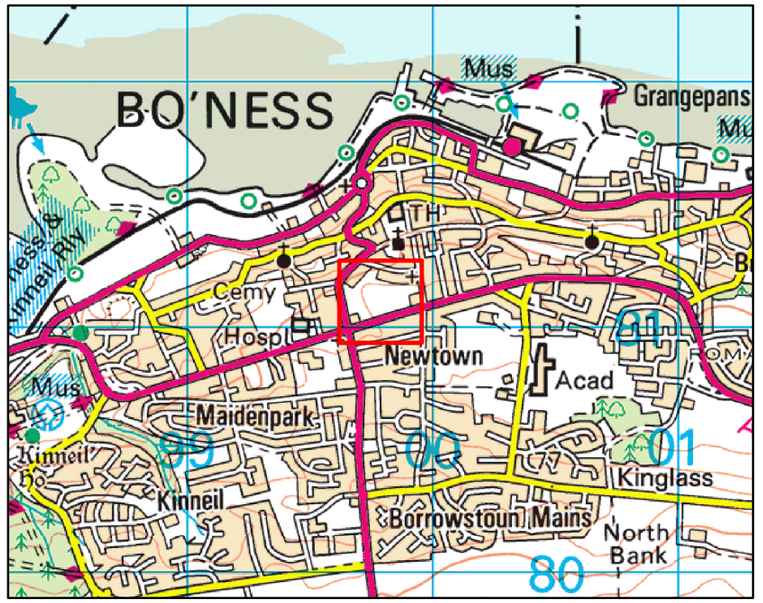


GRADIOMETER DATA

50 nT

-50 nT



| | | |
|---|---|---|
| North | Scale: 1:1,250 @ A3 | Datum: OSGB 1936 |
| | Metres 0 25 50 75 100 | |
| Figure 4 | Minimally processed greyscale magnetometer data | |

| | |
|---|---|
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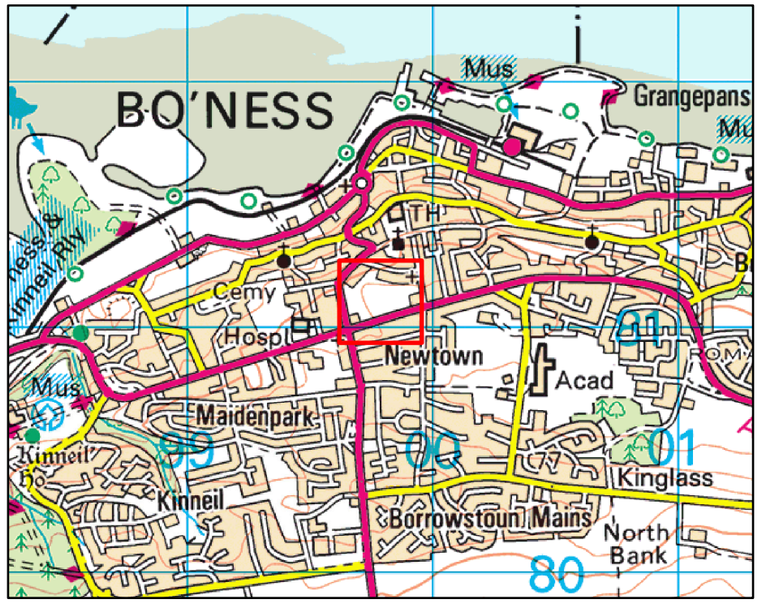


GRADIOMETER DATA

12 nT

-12 nT

| | | |
|---|---|---|
| North | Scale: 1:1,250 @ A3 | Datum: OSGB 1936 |
| | Metres 0 25 50 75 100 | |
| Figure 5 | Processed greyscale magnetometer data | |

| | |
|---|---|
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| Prepared On | 16/03/2021 |

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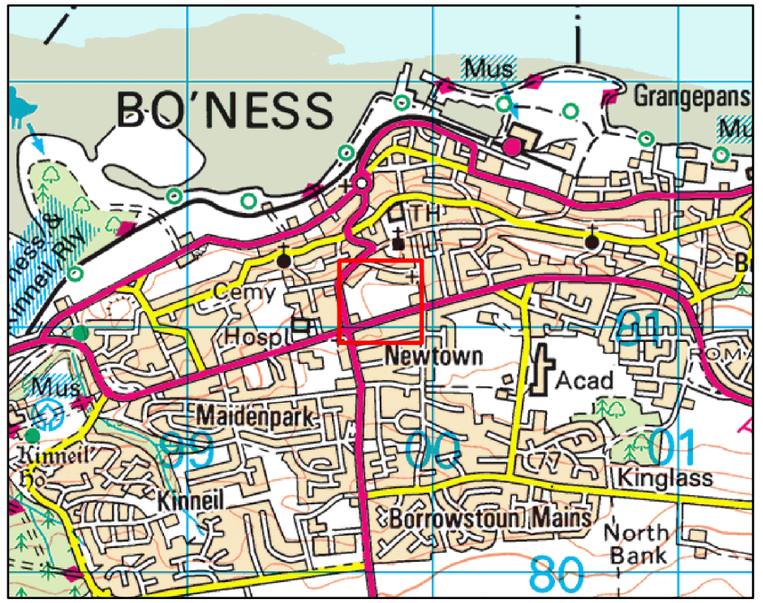


XY TRACE PLOT

- Survey Area
- XY Trace Plot
- 100 nT
- 50 nT
- 0 nT

| | | |
|---|---|---|
| North | Scale: 1:1,250 @ A3 | Datum: OSGB 1936 |
| | Metres 0 25 50 75 100 | |
| Figure 6 | XY plot of minimally processed magnetometer data | |

| | |
|---|---|
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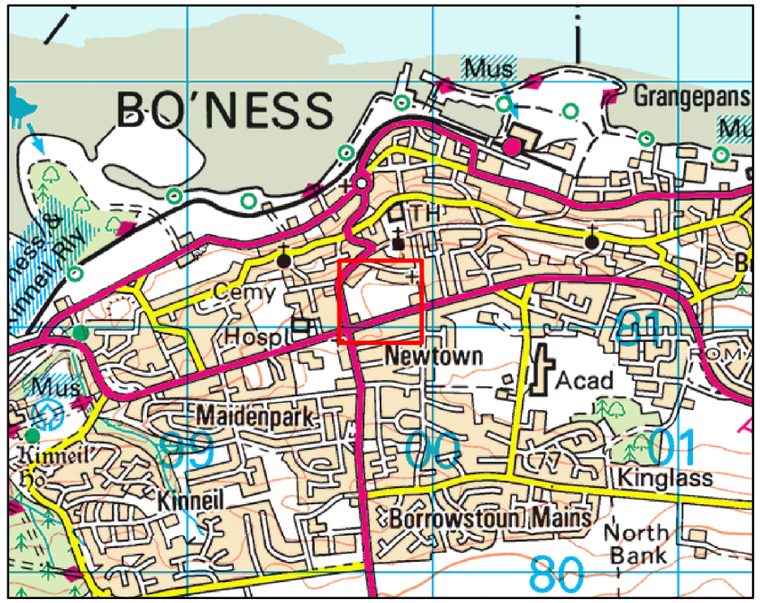


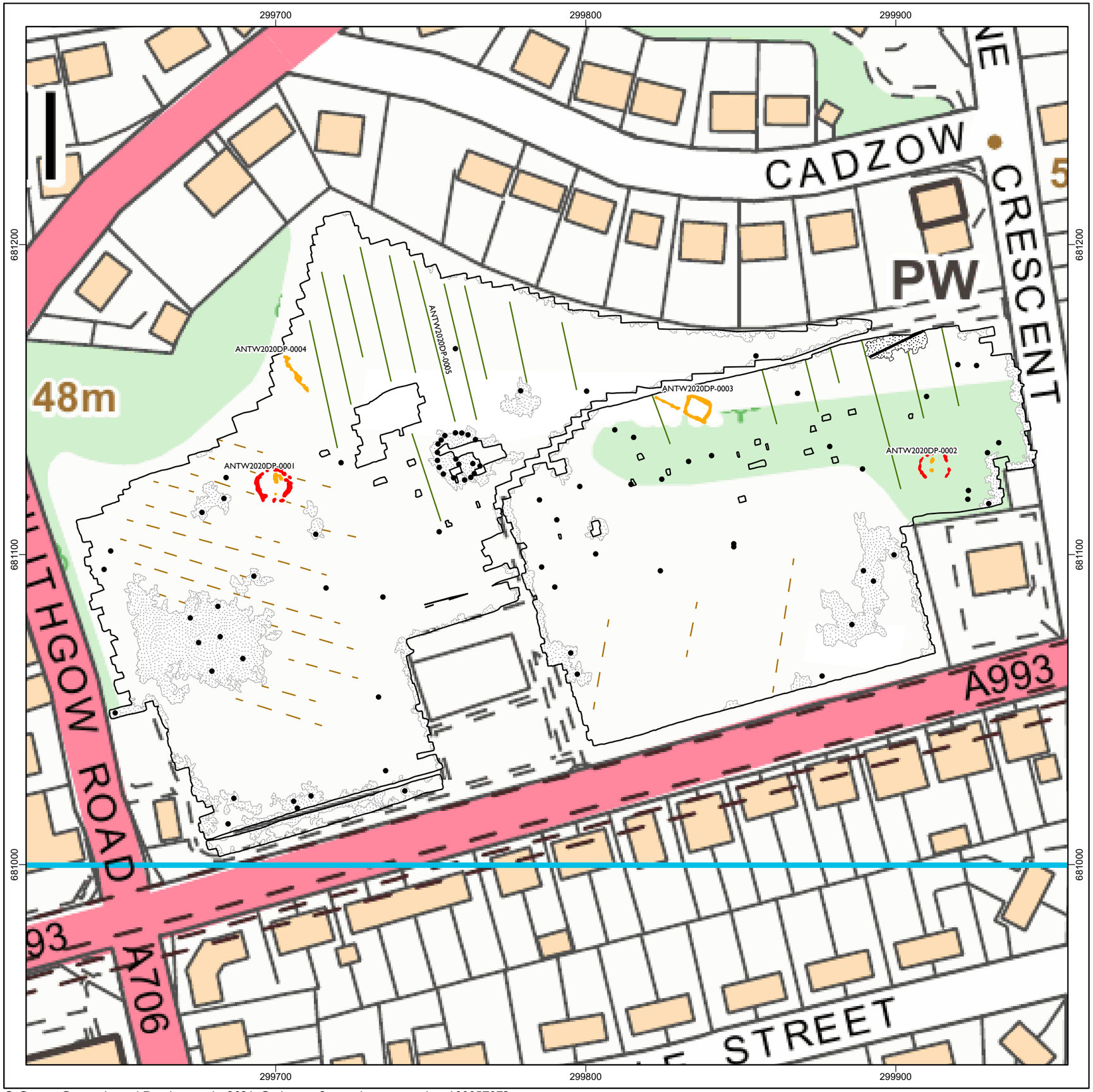


GEOPHYSICAL SURVEY INTERPRETATION

- Ferrous Spike
- Linear Trend (Historic Agriculture)
- Linear Trend (Drainage)
- Linear Trend (Utility)
- Area of Disturbance (Modern)
- Enhanced Magnetism (Archaeology)
- Enhanced Magnetism (Possible Archaeology)
- Enhanced Magnetism (Utility)

| North | Scale: 1:1,250 @ A3 | Datum: OSGB 1936 |
|---|---|---|
| | Metres 0 25 50 75 100 | |
| Figure 7 | Interpretation of magnetometer data | |

## APPENDIX 1 – SURVEY METADATA

The following table details the survey's metadata.

| Field | Description |
|---|---|
| | |
| Data Collection Organisation | Historic Environment Scotland |
| Site Name | Antonine Wall, Douglas Park |
| Project ID | ANTW2020DP |
| OASIS ID | historic14-412624 |
| Report Title | Antonine Wall, Douglas Park, Archaeological Geophysical Survey Report |
| Report Author | Dr Nick Hannon |
| Report QC | Dr Kirsty Millican/Dave Cowley |
| National Grid Reference (centre) | NS 99758 81113 |
| Coordinate System | OSGB1936 |
| Transformation | OSTN15 |
| Geoid | OSGM15 |
| County | Falkirk |
| Scheduled Ancient Monument/s | None |
| Known Archaeology on site | None |
| Survey Personnel | Dr Nick Hannon & Dr George Geddes |
| Survey Dates | 10/12/2020 – 10/12/2020 |
| Weather Conditions | Dry & Sunny |
| Land Use | Grassed Parkland |
| Ground Conditions | Waterlogged in places |
| Solid Geology | Limestone Coal Formation with bands of Bathgate Hills Volcanic Formation (BGS 2021) |
| Drift Geology | Till, Devensian - Diamicton (BGS 2021) |
| Soil | Built-up Land (Scotland's Soils 2021) |
| | |
| Survey Type | Gradiometer |
| | |
| Gradiometer Equipment | Sensys MXPDA |
| Sensors Type | FGM650/3 |
| Sample Rate (hz) | 100 |
| Number of Sensors | 5 |
| Sensor Serial Numbers | 1519/1520/1521/1522/1523 |
| Sensor Separation (m) | 0.5 |
| Reading Interval (m) | 0.125 |
| Data Collection Software | MONMX v5.01-03/00 |
| Data Processing Software | TerraSurveyor v3.0.36.10 |
| Data Visualisation Software | ArcGIS Pro v2.5.1 |
| Area Covered (ha) | 3.43 |
| Positional Accuracy | Leica GS16 GNSS +/- 0.02m |

## APPENDIX 2 – CALIBRATION CERTIFICATES

SENSYS®
Magnetometers & Survey Solutions

SENSYS Sensorik & Systemtechnologie GmbH · Rabenfelde 5 · 15526 Bad Saarow

Technologiezentrum Rabenfelde

# Inspection and Calibration Certificate

We hereby confirm that the device below:

## MAGNETO® MXPDA 5channel system

(S/N: 000144)

## with sensor probes FGM650/3

(S/N: 1519, 1520, 1521, 1522, 1523)

has been inspected and calibrated on **17.09.2020** by SENSYS - Sensorik und Systemtechnologie GmbH according to manufacturer's instructions and according to in-house inspection requirements. All inspections and maintenance procedures are carried out according to the quality management systems ISO 9001:2015 of SENSYS GmbH. No technical defects have been detected on the device. Thus the device can be used without any restrictions.

The next inspection is due in **September 2021** if no other damages or malfunction occurs in the meantime.

Bad Saarow, 17.09.2020

Gerd Rückschloss
Head of Customer Service

SENSYS Sensorik & Systemtechnologie GmbH
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BIC: WELADED1LOS
IBAN: DE 24 1705 5050 3000 0030 60

## APPENDIX 3 – IDENTIFIED ANOMALIES

The following table lists each named anomaly identified in the survey.

| Anomaly ID | Location | Classification | Interpretation |
|---|---|---|---|
| | | | |
| ANTW2020DP-0001 | 299699 / 681122 | Enhanced Magnetism (Archaeology) | Probable round barrow |
| ANTW2020DP-0002 | 299911 / 681128 | Enhanced Magnetism (Archaeology) | Probable round barrow |
| ANTW2020DP-0003 | 299836 / 681147 | Enhanced Magnetism (Possible Archaeology) | Small rectangular enclosure |
| ANTW2020DP-0004 | 299706 / 681147 | Enhanced Magnetism (Possible Archaeology) | Linear anomaly |
| ANTW2020DP-0005 | 299744 / 681169 | Enhanced Magnetism (Historic Agriculture) | Area of rig |

## APPENDIX 4 – GLOSSARY OF ANOMALY TYPES

The following table contains a glossary of the technical terminology used for gradiometer survey anomalies within this report.

| | Anomaly Type | Description |
|---|---|---|
| | | |
| Area | Area of Disturbance (Modern) | An area of magnetic disturbance caused by modern activity such as metallic fences, gates, inspection covers, green waste, or modern refuse. |
| | Enhanced Magnetism (Area of Burning) | An anomaly with a distinct pattern in the XY trace plot which indicates burning has taken place, suggesting the location of a hearth or kiln. |
| | Enhanced Magnetism (Historic Agriculture) | An anomaly caused by historic agricultural activity such as rig & furrow, or a headland. |
| | Enhanced Magnetism (Archaeology) | An anomaly of probable archaeological origin; this interpretation will either be based on other supporting evidence or on the form of the anomaly. |
| | Enhanced Magnetism (Historic Feature) | An anomaly caused by an historic feature. This will appear on a documentary record such as an old map but the feature is no longer extant on the surface, such as a demolished building, or a former field boundary. |
| | Enhanced Magnetism (Possible Archaeology) | An anomaly of possible archaeological origin; this interpretation will have no other supporting evidence. |
| | Enhanced Magnetism (Unclear Origin) | An anomaly for which it is not possible to assign an interpretation. |
| | Enhanced Magnetism (Utility) | An area of magnetic disturbance caused by the magnetic field of a utility, such as the halo around a gas pipe. |
| | Geology/Natural | An anomaly interpreted as caused by geological or fluvial processes, such as variations in underlying bedrock, or palaeo-channels. |
| Trend | Linear Trend (Archaeology) | A linear anomaly of probable archaeological origin; this interpretation will either be based on other supporting evidence or on the form of the anomaly. |
| | Linear Trend (Drainage) | A linear anomaly caused by modern drainage such as a field drain. |
| | Linear Trend (Historic Agriculture) | A linear anomaly caused by historic agricultural activity such as rig & furrow, or a headland. |
| | Linear Trend (Historic Feature) | A linear anomaly caused by a historic feature. This will appear on a documentary record such as an old map but the feature is no longer visible on the ground, such as an old pathway. |
| | Linear Trend (Modern Agriculture) | A linear anomaly caused by modern agricultural activity such as ploughing. |
| | Linear Trend (Possible Archaeology) | A linear anomaly of possible archaeological origin; this interpretation will have no other supporting evidence. |
| | Linear Trend (Unclear Origin) | A linear anomaly for which it is not possible to assign an interpretation. |
| | Linear Trend (Utility) | A linear anomaly caused by the presence of a modern utility, such as a gas pipe. |
| | Geology/Natural | A linear anomaly interpreted as caused by geological or fluvial processes, such as variations in underlying bedrock, or palaeo-channels. |
| Point | Ferrous Spike | An anomaly caused by a ferrous object in the topsoil which causes a spike in the XY trace plot of the data. |

# APPENDIX 5 – DATA PROCESSING METHODOLOGY

The following section details the data processing methodology used for this survey; the specific process parameters used for each datafile are detailed in Appendix 6.

## GRADIOMETER DATA PROCESSING

Following the collection of data using the methodology detailed in section 5.1, all datafiles were exported from the Sensys system's MONMX in .asc, and .uxo formats. These files were then transferred to the processing computer.

Data processing was conducted using TerraSurveyor v3.0.36.10 (DW Consulting: 2019). The GPS Geoid was set to "WGS-84" and the coordinate system set to "UTM Zone 30" prior to data import, to match the GNSS used during data collection. The .uxo files were imported using the pre-defined TerraSurveyor import template appropriate for the Sensys system and converted into .xcp format composites. The .asc format file was retained for archiving.

The .xcp file was opened and a .grd exported to allow visualisation of the minimally processed data. The data was destriped and clipped. The data was interpolated to values appropriate to the display requirements for the processed results. These processed results were exported in .grd format. An image boarder was generated and exported as a .dxf. The minimally processed data was clipped to -10/100 nT and an XY trace plot generated and exported as a .dxf.

The .grd and .dxf files were imported to the project's ArcGIS Pro geodatabase and converted into the British National Grid coordinate system using the "Project" and "Project Raster" tools, with the input coordinate system set as "ETRS_1989_UTM_Zone_30N", the output coordinate system as "British National Grid", using the "OSGB_1936_To_ETRS_1989_1" geographic transformation, resampled as "Nearest neighbour".

Once the reprojection was complete the data was manually interpreted.

# APPENDIX 6 – DATA PROCESSING STEPS

The following table details the processing steps each data file has undergone and the order these processes were applied before the data was transferred to the data visualisation software.

| Filename | Process | Values |
|---|---|---|
| | | |
| ANTW2020DP01-MAG.xcp | Destripe | Mean / SD 1.5 |
| | Clip | -100/100 nT |
| | Base Settings | Interval 0.121m, Track Radius 0.45m |
| | Remove Turns | Threshold Angle 45, Cut Length 5m |

## APPENDIX 7 – GLOSSARY OF DATA PROCESSING TERMS

The following table contains a glossary of the technical terminology used during sections 4 and 5 of this report.

| Process | Definition |
|---|---|
| | |
| Break on Jump | This process calculates the distance between each data point along a traverse and if this distance exceeds the set threshold the traverse will be split into individual traverses. This process is used when there is a large gap in the collected data points caused by GNSS signal drop-out. |
| Clip | This process removes values outside of the defined upper and lower limits and replaces them with the upper and lower limits. It can be applied as absolute values, or as a standard deviation. The process is used to remove the skewing effect of areas of unusually high or low values in the data. |
| De-spike | This process identifies data points which are unusually high or low compared with those around it and replaces the values with an average value based on the surrounding points. This process is used to remove the skewing effect of spikes in the data due to ferrous objects in the topsoil. |
| De-stagger | This process corrects mechanical errors which occur during data collection when a traverse is started too early or too late. It shifts the traverse backwards or forwards to compensate for the error. This process is used when data is collected on steep terrain when it is difficult to keep the cart parallel with the surface. |
| De-stripe | This process calculates the average (Mean, Mode or Median) of each individual traverse and then deducts this value from the readings along that traverse. This transforms the values into the difference from the average instead of an absolute value. This process is used to remove the striping effect caused by neighbouring traverses being surveyed in opposite directions (heading errors). This process is sometimes referred to as a 'Zero Mean Traverse'. |
| Discard Overlap | This process is used to remove data points when they have been collected too close to other data points. This process is used to remove the distorting effect caused by traverses overlapping due to operator error. |
| High Pass Filter | This process uses either a Gaussian or uniformly weighted window to remove low-frequency noise from the data to highlight the high-frequency trends. |
| Interval | This process sets the size of the cells in the greyscale image of the data and thus the level of interpolation applied to the data |
| Low Pass Filter | This process uses either a Gaussian or uniformly weighted window to remove high-frequency trends from the data resulting in a smoothing effect. |
| Reduce Points | This process uses an algorithm to reduce the number of data points passed to subsequent processing step. This process is used to reduce processing time for large data sets. |
| Remove Turns | This process is used to separate a track of data into individual traverses when data collection was not manually stopped by the surveyor at the end of each traverse. A turn is detected by a change in direction of travel and set in degrees. This is commonly used when data is collected using a mechanical towing device. |
| Straighten | This process corrects sudden changes in direction along a traverse. This process is used to correct errors caused by the GNSS changing between satellite constellations which cause a slight jump in position. |
| Track Radius | This process sets the size of area around each data point which is included in the interpolated calculation. |

## APPENDIX 8 – DISCOVERY AND EXCAVATION IN SCOTLAND TEXT

The text below was submitted for inclusion in the next Discovery and Excavation in Scotland.

*Historic Environment Scotland, Survey and Recording, undertook gradiometer survey at Douglas Park, Bo'ness, Falkirk, Scotland, EH51 9BB to investigate the extent and significance of potential for sub-surface archaeological features.*

*The survey was conducted on 10 December 2020 and formed part of a wider Antonine Wall Geophysical Survey project The geophysical survey has produced good quality gradiometer results which give a high level of confidence that the chosen methodology and survey strategy was appropriate to assess the archaeological potential of the survey area.*

*In total 3.43ha were surveyed with a Sensys MXPDA gradiometer. The results have led to the following conclusions.*

*No trace of the Antonine Wall has been identified within the survey area.*

*The southern half of the survey area has seen a significant amount of disturbance during landscaping associated with two football pitches and their associated drainage. No features of archaeological, possible archaeological or historical origin have been identified in this area.*

*The sites of two probable prehistoric barrows have been identified occupying similar topographical positions to cists and a tumulus discovered in the 19th century around 1,000m to the east of the park. The identification of the barrows adds to the scattered evidence for prehistoric activity in the area.*

*What may be a small agricultural enclosure such as a sheepfold, of unknown date, has been identified in the northeast of the survey area.*

*In the north of the survey area a block of rig aligned north-south has been identified, some of which is still evident on the ground as slight earthworks.*

*This survey has led to the creation of three new entries in the National Record of the Historic Environment.*

*(Project ID: ANTW2020DP)*

## APPENDIX 9 – NATIONAL RECORD OF THE HISTORIC ENVIRONMENT SITE RECORD CREATION OR AMENDMENT

The following table details the National Record of the Historic Environment entries which have been amended or created as a result of this survey.

| NRHE ID | Anomaly ID | Change | Notes |
|---|---|---|---|
| | | | |
| 367880 | ANTW2020DP-0001 | Creation | Probable round barrow |
| 367881 | ANTW2020DP-0002 | Creation | Probable round barrow |
| 367885 | ANTW2020DP-0003 | Creation | Possible enclosure |

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HISTORIC ENVIRONMENT SCOTLAND | ÀRAINNEACHD EACHDRAIDHEIL ALBA

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