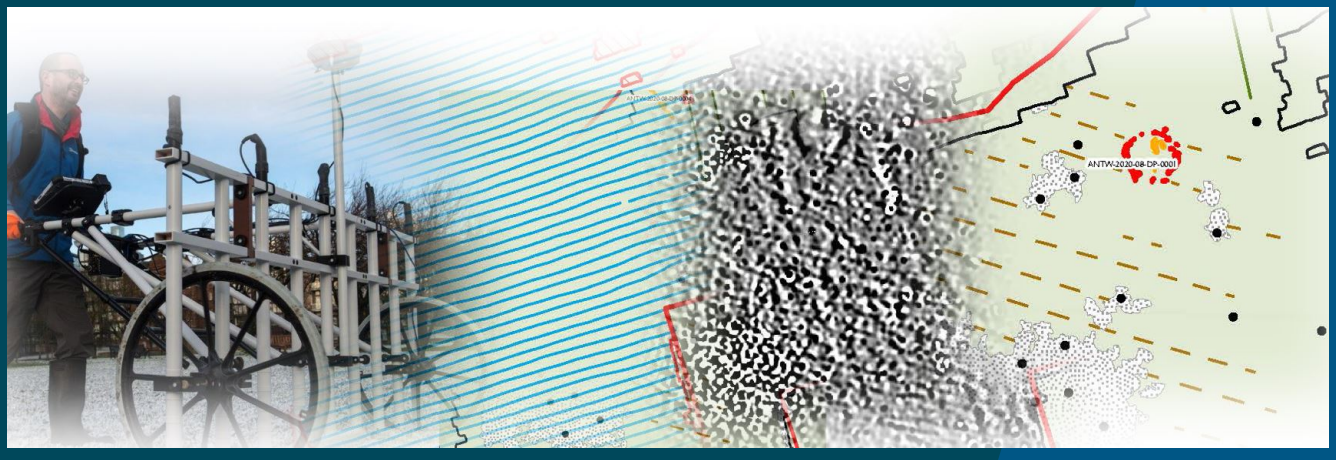
HISTORIC ENVIRONMENT SCOTLAND | ÀRAINNEACHD EACHDRAIDHEIL ALBA

ANTONINE WALL
KINNEIL HOUSE

GEOPHYSICAL SURVEY REPORT



HES PROJECT NUMBER: ANTW2020KH
NGR: NS 97889 80453
DATE: OCTOBER 2021
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EXECUTIVE SUMMARY

Historic Environment Scotland (HES), *Archaeological Survey Team*, undertook geophysical (gradiometer & electro-magnetic) survey at Kinneil House, Bo'ness, Falkirk, Scotland, EH51 0PR. The survey forms part of a wider Antonine Wall Geophysical Survey project. This aims to address management and research questions relating to the Antonine frontier by investigating the extent and significance of sub-surface archaeological remains at various locations within the World Heritage Site.

The fieldwork was conducted between 10 May 2021 and 18 May 2021. In total 8.35 ha were surveyed with a Sensys MXPDA gradiometer, and 0.45ha were surveyed using a CMD Mini Explorer electro-magnetic device. The geophysical survey has produced good quality gradiometer results which have successfully contributed to the aims of the survey. The electro-magnetic survey has provided moderate quality results which have in part supported the gradiometer results and therefore provided a moderate contribution to the survey's aims. There is a high level of confidence that the chosen mixed methodology and survey strategy were appropriate to assess the archaeological potential of the survey area.

The survey has successfully confirmed the course of the Antonine Wall Ditch which in most places corresponds well with its previously mapped line. It has also confirmed the survival of the Antonine Rampart base in some parts of the survey area. A break in the Ditch has been identified to the east of Kinneil House and may be a causeway relating to a previously unidentified installation at this location. This could be connected to the 'missing' Kinneil fort, however it may equally represent deliberate backfilling of the ditch. A previously unidentified 10m square enclosure has been identified abutting the southern side of the Rampart. This is similar to the 'Minor Enclosures' identified at Wilderness plantation and may therefore be the fourth example of this class of Roman installation.

The location of a boundary around Kinneil Kirk has been confirmed and the results suggest this may be a double ditched in places. Anomalies believed to relate to Kinneil village have been identified in the area known as 'The Meadows'. The village appears to have been partly constrained by the course of the Outer Mound before extending in a south-easterly direction. The diffuse and amorphous nature of these anomalies suggests they may relate to the clearance of the village.

An area of later prehistoric activity has been identified to the north-east of Kinneil House, comprising a small promontory fort or settlement and roundhouses. Possible droveways, land boundaries and enclosures have also been identified in this area. Some of these features may be connected to the later prehistoric activity, though a later date is equally possible.

Responses relating to Kinneil House's landscaped gardens have been identified in various location throughout the survey area.

The location of a road or trackway, defined by a pair of parallel ditches, has been identified crossing, and so postdating, the Antonine Wall.

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

This document has been prepared in accordance with HES' Terrestrial Geophysical Survey Standard Operating Procedures v1.0			
Version:	ANTW2020KH-Report-v1.4		
Author:	Dr Nick Hannon	Date:	26/10/2021
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1.0 - INTRODUCTION

Historic Environment Scotland (HES), Archaeological Survey Team, undertook geophysical (gradiometer and electro-magnetic) survey at Kinneil House, Bo'ness, Falkirk, Scotland, EH51 0PR to investigate the extent and significance of potential sub-surface archaeological features within the survey area. The survey was conducted between 10 May 2021 and 18 May 2021, 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 Kinneil House 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). Kinneil House is an area of parkland straddling the recorded line of the Antonine Wall. It also contains the remains of Kinneil fortlet and Kinneil village. 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 Kinneil House 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 exact course of the Ditch and Rampart be confirmed in the area around Kinneil House? (ScARF research question b).
- Can the course of the Military Way be established around Kinneil House, and can any branches connecting it to installations be identified? (ScARF research question b).
- Can any further details be established about Kinneil fortlet including any internal structures and its blocked northern gateway?
- Can any traces of a causeway relating to the fortlet be identified in the survey data?
- Can any trace of a Roman fort be identified in the area around Kinneil House?
- Can the relationship between Kinneil village and the Antonine Wall be established?
- Can any previously unidentified Roman installations be identified within the survey area?
- Can any previously unidentified features associated with Kinneil House be identified within the survey data?

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

Kinneil House is set in an area of the parkland, located 1.5km south-west of the centre of Bo'ness, Falkirk, Scotland (Figure 1).

The survey area (centred upon NS 97889 80453) covers a total of 14.6 ha and occupies a plateau of land at around 37m AOD. Almost immediately to the north a steep slope leads down to Kinneil Kerse, and to the south the ground gradually rises to around 100m AOD. The site affords extensive views to the north and north-west over Grangemouth and the Firth of Forth, while views to the south are restricted by the topography. The area is dissected by Deil's Burn and Gill Burn which both flow from south to north. Kinneil fortlet is positioned on a prominent knoll at 40m AOD, located to the west of Kinneil House and to the north of Kinneil Wood.

The solid geology (Figure 3) is recorded as Upper Limestone Formation, with bands of Orchard Limestone and Calmy Limestone. This is overlain with superficial deposits (Figure 4) of, Raised Devensian Marine Deposits – Clay, Silt, Sand and Gravel, and a small area of Devensian Till – Diamicton (BGS 2021). The site's soil type is recorded as Brown Earth (Scotland's Soils 2021).

The survey area is comprised of five discontinuous land parcels (Figure 2), these are:

- KH01 – A 2.5ha field containing Kinneil fortlet and a stretch of the Antonine Wall (Figures 6 & 7); this land parcel is under pasture and bounded to the north by a steep wooded slope, to the south by Kinneil Wood, to the east by Deil's Burn and to the west by a small lake. This land parcel is in the ownership of Falkirk Council and in the care of Falkirk Community Trust. It contains part of scheduled monument SM2210 and the Antonine Wall World Heritage Site (Figure 5).
- KH02 – The 6.1ha field containing the remains of Kinneil village, Kinneil Kirk, and a stretch of the Antonine Wall (Figures 13 & 14). This land parcel is under pasture and bounded to the north by a steep wooded slope, to the south by Kinneil Wood, to the east by Gill Burn and to the west by Deil's Burn. This area is known locally as 'The Meadows' and contains a modern steel sculpture towards its north. This land parcel is in the ownership of Falkirk Council and in the care of Falkirk Community Trust. It contains part of scheduled monuments SM2210 and SM4970 and the Antonine Wall World Heritage Site (Figure 5).
- KH03 – The 2.8ha field to the north of Kinneil House's drive (Figures 20 & 21). This land parcel is under grass and bounded to the north by a steep wooded slope, to the south by the drive, to the east by Dean Burn, and to the west by a residential property. This land parcel is in the ownership of Falkirk Council, and in the care of Falkirk Community Trust. It contains part of scheduled monument SM2210, and the Antonine Wall World Heritage Site (Figure 5).
- KH04 – The 1.4ha field to the south of Kinneil House's drive (Figures 20 & 21). This land parcel is under grass and bounded to the north by the drive, to the south Provost Road, to the east by Dean Burn, and to the west by a stone wall. This land parcel is in the ownership of Falkirk Council and in the care of Falkirk Community Trust. It contains part of scheduled monument SM2210 and the Antonine Wall World Heritage Site (Figure 5).
- KH05 – The 1ha area immediately to the east of Kinneil House (Figures 20 & 21). This land parcel is under short grass and bounded to the north and south by garden walls, to the west by Kinneil House and is open to the east. The land parcel is in the ownership of Falkirk Council and in the care of Falkirk Community Trust. It contains part of scheduled monument SM2210, the Antonine Wall World Heritage Site, and Historic Environment Scotland's Property in Care PIC152 (Figure 5).

Prior to conducting the survey, permissions to access the land were obtained from both Falkirk Council as owner, and Falkirk Community Trust as lessee. Land parcel KH05 also partly encompassed an Historic Environment Scotland Property in Care. Permission to

access the land and to survey was obtained from HES' Cultural Resources Team prior to commencing fieldwork.

As the survey area contains part of two Scheduled Monuments, as per The Scheduled Monument Consent Procedure (Scotland) Regulations 2015, Metal and Mineral Detecting Applications were obtained from Historic Environment Scotland's Planning, Consents and Advice Team prior to survey being conducted.

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 around it, showed no sightings of flora or fauna which required 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 there was a period of persistent heavy rain on 13th May 2021.

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

4.0 – ARCHAEOLOGICAL BACKGROUND

Kinneil fortlet (NRHE ID: 48135) was discovered in 1978 through excavation prompted by the discovery of quantities of Roman pottery in the area (Keppie & Walker 1981: 150). The area around Kinneil House has long been suspected as the site of a Roman fort based on the distance between Carriden and Inveravon forts, though no remains have ever been found (NRHE ID: 48207). William Maitland (1757: 171) believed that the Antonine Wall's eastern terminus lay at an installation positioned at the top of Cowbank (the slope to the north of Kinneil fortlet), but may have been referring to the fortlet rather than a missing fort (Keppie & Walker 1981: 152). Sibbald also mentioned the remains of a fort close to Kinneil House. This may also be Kinneil fortlet (Sibbald 1707: 30) but he could also have been referring to an additional fort believed to lie further east (Bailey & Cannel 1996; Macdonald 1911: 147).

Excavations in 1978 confirmed the existence of a fortlet with turf-cheeked ramparts set upon a stone base 3m across, although this had been badly damaged by ploughing (Keppie & Walker 1981: 151). Double ditches, separated from the ramparts by a 9m berm, surrounded the fortlet. The inner ditch measured 1.6m across and 0.7m deep and the outer 1.6m by 0.3m (ibid: 151-152). A further campaign of excavation, undertaken in 1980-1981, discovered two internal timber buildings and established that the fortlet was of one build with the Rampart of the Antonine Wall (Bailey & Cannel 1996: 307). When examining the Antonine Wall Ditch only the southern edge of the ditch was located and no causeway was identified (ibid, 310). The excavators noted the berm widened slightly in front of the fortlet and from this concluded that a causeway may have been removed (ibid, 337), a view they suggest is supported by evidence that the northern gateway was blocked during the life of the fortlet (ibid, 314). However, as the northern edge of the Ditch was not identified there is no direct evidence for a causeway at Kinneil fortlet. Following the 1981 excavation the site was consolidated and presented to the public. In 2011, small-scale excavation examined the projected course of the road heading south from the fortlet's southern gateway (DES 2011: 82). This found no Roman remains, showing that all traces had been removed by 18th century landscaping.

The site of Kinneil village (NRHE ID: 48130) lies to the west of Kinneil House and straddles the line of the Antonine Wall (Hunter 1967: 189). The foundation date of the village is unknown. However in 1661, 559 'communicable persons' were recorded as residing there

(Salmon 1913: 48). Excavations in 1998 and 2000 combined with small-scale geophysical survey revealed some traces of structures and roadways (Glendinning 2000: 521). The village was cleared in 1691 as part of a wider programme of landscaping.

The remains Kinneil Kirk (NRHE ID: 48184) lies to the north-east of the village site. It dates to at least the mid-12th century and was in use until 1670. The building was destroyed by a fire in 1745 and now only the western gable survives (MacGibbon & Ross 1896: 578). A curving section of ditch recorded as cropmarks on aerial photographs to the south-east of the church may represent the remains of an earlier church enclosure (HES 2017).

Kinneil House (NRHE ID: 48195) started life as a tower-house, a structure which is now incorporated into the building's west range. The Earl of Arran added the north range in 1553 and may have largely rebuilt the main tower at this date (HES 2017). Between 1564 and 1569 the Earl was exiled, and the west range partially destroyed by the Earl of Morton. The house assumed its present form in the 1670s when Anne, Duchess of Hamilton and her husband Duke William began reconstruction of what was then a derelict property. They altered the tower as a five storey rectangular block, to which pavilions were added. A southern range was considered but never built, possibly as the area lay over the Antonine Wall ditch. In the early part of the 20th century the building was again abandoned. During demolition in 1941 an important series of murals and ceiling paintings were discovered which led to the building being saved and taken into state care (Stevenson 1995: 55). The wall paintings were repaired and restored and the building opened to visitors.

5.0 – SURVEY METHODOLOGY

The survey was conducted between 10 May 2021 and 18 May 2021.

Gradiometer survey was undertaken in all survey areas; targeted electro-magnetic survey was undertaken in areas KH01, KH03, and KH04 only.

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 (GF Instruments 2019; 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 positions for each land parcel shown in Figures 8, 15 and 22.

The survey was conducted by walking parallel traverses in a zig-zag pattern, with traverses aligned east-west and positioned 2.5m apart for all land parcels. 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 Figures 8, 15 and 22. 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 v3.0.37.0 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 were expected to exhibit low levels of background magnetism and therefore provide a good response to this methodology (EH 2008: 15).

A total of 8.35 ha of data were collected employing this methodology.

5.2 – ELECTRO-MAGNETIC SURVEY

The electro-magnetic survey was conducted using a hand-held GF Instruments CMD Mini Explorer. This system employed a single transmitter coil and three receiver coils spaced at 0.32m, 0.71m and 1.18m from the transmitter. The system was set in Low (Vertical Coplanar) configuration in areas KH01, and KH04, providing an estimated effective depth penetration of 0.25m, 0.5m, and 0.9m It was set in High (Horizontal Coplanar) configuration in area KH03, providing an estimated effective depth penetration of 0.50m, 1.0m, and 1.8m. The system was carried at approximately 0.05m from the surface to the left-hand side of the operator.

The survey was conducted by walking a series of parallel traverses these were spaced 0.5m apart walked in a zig-zag pattern. Traverses were aligned north-south in areas KH01a, KH01c, and KH04, and east-west in areas KH01b and KH03. Navigation was provided by the system's on-board software which displays position and the areas of previously collected data, ensuring that each traverse was evenly spaced. Data points were recorded every 0.2 seconds along each traverse, with positional accuracy provided by a Leica GS16 mounted on a survey backpack at an antenna height of 1.8m. 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.

Both quadrature (conductivity) and in-phase (magnetic susceptibility) readings were measured, and recorded on the integral datalogger, this resulted in six readings being recorded at each position. This data was later transferred from the system in .bin format. The files were then processed and visualised following the process described in Appendices 4, 5 and 6. Interpretations of this data were then generated using ESRI ArcGIS Pro v2.5.1.

A total of 0.455ha of data were collected employing this methodology.

6.0 – SURVEY RESULTS & INTERPRETATION INTRODUCTION

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 presented by area and anomaly class.

The figures relating to these results and interpretations can be found in Section 12.

6.1 – SURVEY RESULTS & INTERPRETATION AREA KH01

Of the 2.72ha planned for gradiometer survey, a total of 2.09ha was surveyable (Figure 8). The 0.63ha discrepancy is accounted for by trees within the survey area (physical obstacles) and the tree canopy around the perimeter of the survey area which blocked the GNSS signal and prevented survey in these areas.

Following an initial examination of the gradiometer data for area KH01, it was decided that an additional 0.27ha of targeted electro-magnetic survey would be conducted within the survey area. This consisted of three separate but abutting survey areas with grids orientated north-north-west to south-south-east. Area KH01a measured 30m by 30m and was positioned to target anomaly ANTW2020KH-0008. Area KH01b measured 60m by 20m and was positioned to obtain a representative cross-section of the Antonine frontier. Area KH01c measured 30m by 20m and was positioned to target the fortlet's western defensive ditch.

The gradiometer results for KH01 have been visualised as greyscale plots with minimally processed data plotted at -50/50nT (Figure 9) and fully processed data displayed at -22/22nT (Figure 10, & 27). XY trace plots have been produced (Figure 11), along with an unannotated graphical interpretation of the data (Figure 12), and an annotated graphical interpretation of the data (Figure 28). Numbered anomalies are listed in Appendix 3 and described in Appendix 4.

The electro-magnetic (conductivity) results for KH01 have been visualised as greyscale plots with fully processed data displayed at -1.43/30.08mS/m for 'depth one' of approximately 0.25m (Figure 41), at -0.07/13.49mS/m for 'depth two' of approximately 0.50m (Figure 42), and at -0.09/10.63mS/m for 'depth three' of approximately 0.90m (Figure 43), along with a single graphical interpretation of the data (Figure 44).

The electro-magnetic (magnetic susceptibility) results for KH01 have been visualised as greyscale plots with fully processed data displayed at -0.03/2.88ppt for 'depth one' of approximately 0.25m (Figure 45), at -1.43/2.71ppt for 'depth two' of approximately 0.50m (Figure 46), and at -2.3/2.71ppt for 'depth three' of approximately 0.90m (Figure 47), along with a single graphical interpretation of the data (Figure 48).

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

6.1.1 – AREA KH01 GRADIOMETER SURVEY – ARCHAEOLOGICAL FEATURES

In area KH01 several anomalies of probable archaeological origin have been identified in the gradiometer data.

The first and most obviously anomaly (ANTW2020KH-0001) lies in the north of the survey area and is orientated east-north-east to west-south-west. This represents the course of the Antonine Ditch. It corresponds well with the mapping submitted as part of the World Heritage Site application (HES 2006), although the eastern end appears to turn in a north-easterly direction slightly to the west of and at a sharper angle than the previous mapping

depicts. It may also deviate slightly to the north in front of the fortlet. The Ditch is characterised as a broad band of high magnitude negative responses bounded by a narrow band of positive readings to its north, a phenomenon observed during gradiometer survey elsewhere on the frontier. The southern edge of the Ditch appears irregular, possibly because of disturbance caused by ploughing activity.

Running to the south of and parallel with ANTW2020KH-0001 is a second, high magnitude linear anomaly characterised by a line of strong dipolar responses (ANTW2020KH-0002). This runs between the northern gateway of the fortlet and Deil's Burn. It represents the stone base of the Antonine Rampart and demonstrates the subsurface survival of the rampart to the east of the fortlet. To the west of the fortlet the Rampart's stone base is only visible as a line of extremely fragmented positive responses, each possibly representing an individual in-situ stone. This pattern continues to the extreme west of the survey area where a coherent section of the rampart base is visible (ANTW2020KH-0003). Again, the responses observed correspond well with the mapping submitted for the World Heritage Site application.

To the south of ANTW2020KH-002, the position of the fortlet's ditch system has been recorded as a series of negative curvilinear responses. The single eastern ditch of the fortlet (ANTW2020KH-0004) is positioned approximately 10m from the fortlet's rampart. It can be seen curving to the south-west, terminating opposite the fortlet's southern gateway. Mirroring this is the first of the two western ditches of the fortlet (ANTW2020KH-0005). This is again positioned approximately 10m outside the fortlet's rampart and terminates at a position opposite the southern gateway. The fortlet's second western ditch (ANTW2020KH-0006) lies 8m west of ANTW2020KH-0005. It appears to terminate at or close to the south-west corner of ANTW2020KH-0005, not opposite the southern gateway. This response is of a lower magnitude than ANTW2020KH-0004 and ANTW2020KH-0005.

Within ANTW2020KH-0004 and ANTW2020KH-0005 the line of the fortlet's rampart can be seen as a series of both positive and dipolar anomalies. The dipolar responses probably relate to surviving sections of the rampart base, a significant portion of which can be seen in the north-west corner of the fortlet. The positive responses, however, are probably related to a line of modern bricks set into the turf to show the position of the rampart to visitors.

A curvilinear negative anomaly (ANTW2020KH-0007) can be seen running between the Wall's Rampart and that of the fortlet. This corresponds with the location of a small ditch identified during the excavation of the fortlet (Bailey & Cannel 1996: 316).

At the eastern end of ANTW2020KH-0002 is a sub-rectangular enclosure with a ditch enclosing an area measuring approximately 10m square (ANTW2020KH-0008). This anomaly abuts the southern side of the Antonine Rampart and is on a similar alignment to the frontier, suggesting a contemporary date. However a post-Roman date cannot be discounted. The form and dimensions of this anomaly are similar to those of the three minor enclosures (NHRE: 45261, 44483, & 44486) recorded as cropmarks to the east and west of Wilderness Plantation fortlet (NRHE: 44475). One of these enclosures was excavated in 1980 (Hanson & Maxwell 1983). If this anomaly is contemporary with the frontier it may perform a similar function to those identified at Wilderness Plantation, although at only 85m from the fortlet's northern gateway, it is considerably closer to its fortlet than those at Wilderness Plantation.

Finally, there are a series of five parallel linear anomalies orientated west-south-west to east-north-east in the west and south of the survey area (ANTW2020KH-0009). These correspond with the location of curling ponds, depicted on historic mapping (Ordnance Survey: 1898) and visible in the LiDAR data for the area (Figure 6). A combination of the geophysical survey data and LiDAR data suggests the curling pond area is more extensive then depicted on the mapping.

6.1.2 – AREA KH01 GRADIOMETER SURVEY – POSSIBLE ARCHAEOLOGICAL FEATURES

In area KH01 several anomalies of possible archaeological origin have been identified in the gradiometer data.

Anomaly ANTW2020KH-0010 is a linear feature located towards the centre of KH01 and oriented west-south-west to east-north-east. It is characterised by a high magnitude positive linear response with a break towards its centre. At the western end of the eastern section of the feature there is a marked change in direction, creating an angle deviating 20 degrees from straight and leaving a 3m break between the sections. The western section continues into the area containing the curling ponds ANTW2020KH-009, making it difficult to establish if it continues further to the west. This anomaly can only be considered of possible archaeological origin as a geological, fluvial or agricultural origin cannot be ruled out. However, if it is archaeological and contemporary with the Roman frontier, it may represent an additional defensive circuit for the fortlet, with the angle forming a *claviculae* style entrance.

A sub-circular negative feature, measuring around 3m in diameter, is visible at the eastern side of the survey area (ANTW2020KH-0011). This may represent the location of a large pit or similar feature. To the south-west of the possible pit is a series of sub-circular positive anomalies (ANTW2020KH-0012) measuring between 0.8m and 1.2m across. They form a roughly rectangular arrangement measuring 13m by 5m and may represent a series of postholes, possibly indicating the location of a building of unknown date and origin.

Within the forlet defences are numerous positive sub-circular and linear anomalies of varying sizes, possibly representing small pits, postholes, and drainage gullies associated with the fortlet's occupation. However, due to the extensive excavation this area has undergone, it is difficult to establish if this group of anomalies represents archaeological remains or are an artefact of the excavation process.

To the south-west of the fortlet and within the northern two curling ponds is an area containing numerous anomalies. These can be divided into three groups. The first is a series of linear and right-angle shaped anomalies (ANTW2020KH-0013), all sharing a similar north-east/south-west orientation suggesting they are related. However they form no coherent pattern. The second is a group of sub-circular positive anomalies, possibly representing a series of pits. The final group is a series of irregular shaped negative anomalies (ANTW2020KH-0014) that when examined in the XY trace plots appear to represent areas of burning. Individually this group of anomalies forms no coherent pattern. However, taken in conjunction this area may represent the location of settlement or industrial activity of indeterminate date. Alternatively, they may have been caused by disturbance created during the construction of the curling ponds.

A further anomaly (ANTW2020KH-0015) is located towards the centre of the southern curling pond in a magnetically quiet area. It is characterised by a 2m diameter circular response, with a 7m long linear response orientated north-west to south-east immediately to its east. The function or date of this are unknown.

Three, low magnitude negative rectilinear features lie in the area between the Antonine Rampart (ANTW2020KH-0002). These are the fortlet's eastern defensive ditch (ANTW2020KH-0004), an enclosure (ANTW2020KH-0008), and the possible defensive ditch (ANTW2020KH-0010). The first rectilinear feature (ANTW2020KH-0016) is located immediately south of the Antonine Rampart on an east-west orientation and measures around 20m by 6.5m with an 8m by 3.5m extension to its south, forming an L-shaped feature. The second is a similar but weaker anomaly (ANTW2020KH-0017). It is located to the south of the first, oriented north to south and measures 11m by 8m. The third anomaly (ANTW2020KH-0018) is located to the south-west. It is orientated roughly east-west and measures 11m by 5m. The extremely low magnitude nature of these responses makes it

difficult to establish their origin, but if they are of archaeological origin they may represent the footprints of buildings. However, as their orientation is different from that of the other Roman features in the area it is not possible to assign a Roman date.

6.1.3 – AREA KH01 GRADIOMETER SURVEY – HISTORICAL AGRICULTURE FEATURES

In area KH01 no anomalies of historical agricultural origins have been identified in the gradiometer data.

6.1.4 – AREA KH01 GRADIOMETER SURVEY – MODERN AGRICULTURAL FEATURES

In area KH01 no anomalies of modern agricultural origins have been identified in the gradiometer data.

6.1.5 – AREA KH01 GRADIOMETER SURVEY – GEOLOGICAL & FLUVIAL FEATURES

In area KH01 six anomalies of geological or fluvial origins have been identified in the gradiometer data. These fall into two groups. The first is a series of five broadly parallel curvilinear anomalies orientated north-east to south-west, most likely representing a series of raised beach deposits known to lie within the area (BGS 2021). The second is represented by a single linear anomaly oriented east-north-east to west-south-west on ground gently sloping towards Deil's Burn. This represents a relic tributary of Deil's burn and is cut by the Antonine Rampart (ANTW2020KH-0002) at its western extreme.

6.1.6 – AREA KH01 GRADIOMETER SURVEY – MODERN FEATURES

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

The first anomaly is a 90m long linear trend in the south of the survey area. It is orientated from east to west and represents a section of modern drainage. This interpretation is supported by the presence of pipe discharging into Deil's Burn at the anomaly's eastern end. A similar anomaly can be seen immediately north of this, orientated north-west to south-east. This again likely represents modern drainage, and its north-west end is located in an area that was waterlogged at the time of the survey. A third anomaly in the south-east corner of the survey area also probably represents a section of drainage pipe discharging into Deil's Burn, although the eastern end of this drain was not observed during the survey.

Within the interior of the fort are a series of ferrous spikes arranged in three discrete rectangular patterns, surrounded by rectangular areas of magnetic disturbance. These responses are caused by the series of timber posts used to depict the location of postholes representing the fortlet's interior buildings which were excavated in 1980 and 1981 (Bailey & Cannel 1996). The posts appear to be set in modern concrete.

Within the Antonine ditch there are indications of a linear feature which is may be a field drain.

To the north of the Antonine ditch are two small areas of magnetic disturbance, caused by two park benches located at the north of KH01. A similar area of magnetic disturbance occurs within the south-east corner of the fortlet ditches, caused by an interpretation board. A small area of magnetic disturbance also occurs at the eastern edge of the survey area and is most likely caused by modern material within the hedge.

6.1.7 – AREA KH01 GRADIOMETER SURVEY – FEATURES OF UNCERTAIN ORIGINS

In area KH01 no anomalies of unknown or uncertain origins have been identified in the gradiometer data.

6.1.8 – AREA KH01 ELECTRO-MAGNETIC SURVEY (CONDUCTIVITY)

Using the shortest coil separation representing a depth penetration of about 0.25m, the data for 'depth one' only contains a single response of interest. In the north-west corner of KH01c is a distinct area with a low conductivity value. This runs along the northern boundary of the survey area for 17m and coincides with the southern edge of Antonine Wall Rampart base and a line of curb stones visible through the turf at the time of the survey. The remaining responses represent variation in the topsoil.

Using the middle coil separation representing a depth penetration of about 0.50m, the data for 'depth two' contains more useful information. In the north-east corner of area KH01a is an area of low conductivity measuring about 12m square. This corresponds with the position of gradiometer anomaly ANTW2020KH-0008 and probably represents a compacted surface. Towards the south-west of all three grids, areas with high conductivity readings can be observed. These correspond with areas of slightly lower and wetter ground. Again, the position of the Rampart base curb stones can be observed in the north-west corner of KH01c.

Using the greatest coil separation representing a depth penetration of about 0.90m, the data for 'depth three' again contains useful information. Like 'depth two', in the north-east corner of KH01a is an area of low conductivity readings and in the south-west of all three grids are areas with high conductivity, corresponding with wetter ground. Again, the position of the curb stones is visible. In additional to this, the position of the Antonine Ditch can be seen in KH01b as an area of slightly raised conductivity, running parallel with and to the north of an area of low conductivity corresponding with the position of the frontier's outer mound. A further area of low conductivity occurs in the north-east corner of KH01c and crosses the line of the Antonine Wall's rampart. This probably represents a spread of the Rampart's base material.

No trace of the fortlet's eastern defence ditch can be identified in the conductivity data.

6.1.9 – AREA KH01 ELECTRO-MAGNETIC SURVEY (MAGNETIC SUSCEPTIBILITY)

Using the shortest coil separation representing a depth penetration of about 0.25m, the data for 'depth one' displays several features of probable archaeological origin. In the north-east corner of area KH01a is an irregular shaped area of low magnetic susceptibility, measuring around 12m by 10m. This corresponds with the position of gradiometer anomaly ANTW2020KH-0008 and probably represents a compacted surface. To the north of area KH01b is a distinct area of low magnetic susceptibility, corresponding with the position of the frontier's outer mound. A second area with a slight lowering of susceptibility values occurs towards the centre of KH01b, corresponding with the position of the Antonine Wall Rampart. Along the north of KH01c is a further area of low magnetic susceptibility which matches the position of the extant section of Antonine Wall base. To the south of this, a linear area of lower susceptibility measuring 3m in length and 0.80m across corresponds with the position of gradiometer anomaly ANTW2020KH-0004, the fortlet's eastern ditch. Slightly further west a similar sized linear area of low susceptibility can be seen, corresponding to the location of a small ditch identified during excavation (Bailey & Cannel 1996: 316).

Using the middle coil separation representing a depth penetration of about 0.50m, the data for 'depth two' contains similar responses to those observed at 'depth one', albeit with slightly more definition. There is also an additional area of raised magnetic susceptibility corresponding with the line of the fortlet's eastern defensive ditch.

When using the greatest coil separation representing a depth penetration of about 0.90m the survey data for 'depth three' provides similar results to both 'depth one' and 'depth two'. Again, the increased depth penetration has improved the definition of the anomalies in all three areas.

6.2 – SURVEY RESULTS & INTERPRETATION AREA KH02

Of the 6.18ha planned for gradiometer survey, a total of 5.09ha was accessible for survey (Figure 15). The 1.09ha discrepancy is accounted for by trees (physical obstacles) and the tree canopy around the perimeter of the survey area which blocked the GNSS signal and prevented survey in this area. There were also areas of thick undergrowth which prevented survey, a significant portion of which formed a triangular area in the south-west.

The gradiometer results for KH02 have been visualised as greyscale plots with minimally processed data plotted at -50/50nT (Figure 16) and fully processed data displayed at -22/22nT (Figure 17, 29, & 33). XY trace plots have been produced (Figure 18), along with an unannotated graphical interpretation of the data (Figure 19), and annotated graphical interpretations of the data (Figures 30, 32, & 34). 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.

6.2.1 – AREA KH02 GRADIOMETER SURVEY – ARCHAEOLOGICAL FEATURES

In area KH02 there are four anomalies which can be defined as of probable archaeological origin.

The first is a curving linear feature (ANTW2020KH-0019) which surrounds the site of Kinneil Kirk (NHRE: 48184). This is visible as a 4.5m wide high magnitude negative anomaly representing the location of a ditch. Inside and concentric with this is a curving positive anomaly representing the position of an upcast bank. Together this indicates the presence of an enclosure likely pre-dating the modern church enclosure and possibly connected to an earlier medieval foundation (HES 2017, 3). The southern portion of this ditch is visible in aerial photographs and the northern part can be seen in the LiDAR data (Figure 13). The ditch was uncovered during recent excavations (Bailey 2020). A second curving negative linear anomaly (ANTW2020KH-0020) is visible within ANTW2020KH-0019 and likely represents a second ditch. Again there is a curving positive linear trend on the inside of and concentric with the ditch, probably representing an internal bank. This feature does not continue to curve to the south and east, so either terminates within the trees or turns east within the line of trees, deviating from the course of the outer ditch. No break in ANTW2020KH-0019 or ANTW2020KH-0020 can be identified in the data to indicate the position of an entrance.

The line of the Antonine Wall Ditch can be seen as a high magnitude negative linear feature (ANTW2020KH-0021) running across the centre of the survey area from west-south-west to east-south-east. Visibility is lost towards the centre of the survey area within the highly magnetic response of ANTW2020KH-0024, discussed in section 6.2.2. On the west, the line of the Ditch diverges from the mapping used for the World Heritage Site nomination and is slightly to the south of the line depicted, but it converges with the

line of the mapping to the east (HES 2006). It is also slightly narrower than the mapped line, although the true position of the northern edge of this feature may be masked by the highly magnetic nature of ANTW2020KH-0023, discussed in section 6.2.2.

Running to the south of and parallel with ANTW2020KH-0021 is the line of the Antonine Wall Rampart (ANTW2020KH-0022). For most of its length this can be seen as a low magnitude positive linear anomaly, although a more coherent line of positive anomalies is visible on the west. Again, at the west it is slightly to the south of the position shown on the mapping used for the World Heritage Site nomination, but converges with the line depicted on the mapping to the east.

6.2.2 – AREA KH02 GRADIOMETER SURVEY – POSSIBLE ARCHAEOLOGICAL FEATURES

In area KH02 several anomalies of possible archaeological origin have been identified.

The first group of anomalies (ANTW2020KH-0023) runs parallel with, and to the north of the Antonine Wall Ditch ANTW2020KH-0021, along the expected position of the outer mound. It is characterised by an area of high magnitude positive and negative responses interspersed with ferrous spikes over an area 120m long and 7m wide. Due to the highly magnetic nature of this feature it is difficult to discern any detail. However the responses appear to be broadly aligned L-shapes and may represent remains relating to the demolished Kinneil Village or its main street (NRHE: 48130). This group of anomalies may also overlie the northern edge of the Antonine Wall Ditch, making it difficult to ascertain the true width of the Ditch.

A further area displaying similar magnetic properties (ANTW2020KH-0024) can be seen to the south-east of ANTW2020KH-0023, orientated north-west to south-east. Excavations conducted in 1998 identified the footings of a stone building in this area (Glendinning 2000: 519 & 514, Illus 3, Trench 4). Thus, although the highly magnetic nature of the anomalies create difficulties in interpretation, this area possibly represents structures relating to Kinneil Village. ANTW2020KH-0024 also runs along the north-eastern edge of the 'Visto', a pathway forming part of the landscaped garden, which is visible in the LiDAR data (figure 13). It is believed that this was constructed as part of the landscaping of the park following the clearance of the village, but a hollow observed beneath the 'Visto' during excavation was interpreted as possibly representing an earlier path relating to the village (*ibid* 518). The orientation of ANTW2020KH-0024 supports the view that the course of the 'Visto' respected a pre-existing route.

A group of weak rectilinear responses (ANTW2020KH-0025) to the north of ANTW2020KH-0023 form three rectangular enclosures measuring 16m by 14m, 20m by 10m and 20m by 8m. The western-most enclosure contains two smaller rectangular responses measuring 7m by 3m and 3m by 3m. This group of anomalies are aligned with both the Antonine Wall Ditch ANTW2020KH-0021 and ANTW2020KH-0023 and may represent enclosures and structures relating to Kinneil village or a garden feature from the later formal garden.

To the east of ANTW2020KH-0025 and close to the curving ditch surrounding Kinneil Kirk is a further pair of rectilinear anomalies (ANTW2020KH-0026). These are formed from a combination of positive and negative linear trends and discrete positive posthole like anomalies. The first is orientated north-east to south-west and measures 12m by 4m, the second is orientated north-north-east to south-south-west and measures 4m by 4m. These anomalies may either represent a further section of Kinneil village or structures related to Kinneil Kirk.

At the north of area KH02 and to the south-west of the steel structure, is a low magnitude circular anomaly measuring 24m in diameter (ANTW2020KH-0027). This most likely represents a parkland landscaping feature constructed following the clearance of Kinneil village. A weak linear anomaly (ANTW2020KH-0028), measuring at least 71m in length and orientated east-north-east to west-south-west, cuts through the circular anomaly. This may also relate to the landscaping of the parkland.

Towards the east of the survey area and south of Antonine Wall Ditch ANTW2020KH0021 is a weak linear anomaly forming three sides of a rectangle (ANTW2020KH-0029). This measures 25m by 14m and shares a similar orientation with the 'Visto' and the possible village remains ANTW2020KH-0024. This may either represent an enclosure relating to the village or a remnant of the post-village landscaping.

In the south-east corner of the survey area a group of low magnitude positive linear anomalies form a rectangular feature orientated north-west to south-east and measuring 47m by 40m (ANTW2020KH-0030). A smaller rectangular anomaly measuring 20m by 15m and sharing the same orientation lies within the larger enclosure, as do several magnetically positive pit-like features. A linear trend projects from the south-east corner of the large enclosure, curving gently to the south for at least 25m before reaching the southern perimeter of the survey area. These anomalies appear to form an enclosure and associated activity of undetermined date. The shape of the larger enclosure as well the proximity to the Antonine frontier may suggest they represent an Antonine period construction camp, though it would be relatively small for such an interpretation. A Roman date, however, cannot be entirely discounted. Immediately northeast of this enclosure is circular anomaly characterised by a weak positive linear trend (ANTW2020KH-0031). This feature measures 6m in diameter and is of unknown date and function.

To the west of ANTW2020KH-0030, at the southern perimeter of the survey area but perhaps extending beyond it, is an L-shaped linear anomaly characterised by a low magnitude positive response (ANTW2020KH-0032). As only 10m of the anomaly is within the survey area it is impossible to establish its full dimensions and therefore a date and function cannot be determined.

A small positive rectilinear trend forming three sides of a rectangle measuring 4.5m by 3m (ANTW2020KH-0033) is located close to the centre of the south of the survey area, within an area of rig (described below). The size of this feature, and its location some distance from the anomalies interpreted as the remains of Kinneil village, suggest that it may be a small agricultural enclosure, although its exact function is difficult to determine.

Within a magnetically relatively quiet area in the west of the survey area is a group of anomalies (ANTW2020KH-0034) formed by a defuse negative rectilinear response measuring 12m by 10m and oriented roughly north to south. This feature contains numerous positive pit-like anomalies and dipolar ferrous spikes. This group of anomalies can be interpreted as a small enclosure, possibly containing evidence of occupation or small-scale industrial activity.

At the south-western corner of the survey area there is a strong positive linear anomaly (ANTW2020KH-0035), orientated east to west. It is around 1.5m wide and extends for 13m before reaching the edge of the survey area. This anomaly appears to represent a ditch of unknown date or function.

Immediately north-west of this ditch is a highly magnetic anomaly of irregular shape which covers an area measuring approximately 14m by 12m (ANTW2020KH-0036). The magnitude of this response indicates an area of intense burning or possibly the location of a lightning strike, a phenomenon observed elsewhere in gradiometer data (Bates et al 2019: 10 fig 6). If this is the effect of burning, it is uncertain if it is modern or of greater antiquity.

There is another area of burning to the east (ANTW2020KH-0037). This anomaly measures 9m by 6m and is located in a magnetically quiet area. Again, this may represent the location of a modern bonfire or an earlier feature.

A further area of burning is located just to the south of the 'Visto' at the east of the survey area (ANTW2020KH-0038). This is irregular in shape measuring up to 25m by 12m. This could also represent a modern burning event. However, its proximity to the possible village remains ANTW2020KH-0024 may suggest the burning occurred during the demolition of the village, ahead of the landscaping of the area.

Immediately east of this area of burning is a small rectangular anomaly (ANTW2020KH-0039). This is characterised by a rectangular negative linear anomaly measuring 9m by 5m and on a similar orientation to the 'Visto' and the possible village remains ANTW2020KH-0024. Its orientation suggests this may represent either a small enclosure relating to the village or a later garden feature.

Finally, towards the western edge of the survey area and north of the Antonine Ditch ANTW2020KH-0021, is a rectilinear feature formed of a low magnitude positive linear anomaly measuring 17m by 9m and orientated north-east to south-west (ANTW2020KH-0040). Within the rectangular area are numerous small pit-like positive anomalies and a dipolar spike. This feature may be a small agricultural enclosure of unknown date.

6.2.3 – AREA KH02 GRADIOMETER SURVEY – HISTORICAL AGRICULTURE FEATURES

In area KH02 three areas of historical agricultural activity are apparent. On a gentle north-facing slope at the north of the survey area is an area of rig, orientated north-west to south-east, with each furrow set around 10m apart.

A further small area of rig is located towards the centre of the southern edge of the survey area. It is orientated roughly north to south, with the furrows set around 8m apart.

Finally, a linear anomaly characterised by two parallel negative linear trends extends north-north-west to south-south-east across the east of the survey area. This represents the position of a former field boundary depicted on a 1748 plan of Kinneil Park (Bailey 2015: 11, Illus 12).

6.2.4 – AREA KH02 GRADIOMETER SURVEY – MODERN AGRICULTURAL FEATURES

In area KH02 no anomalies of modern agricultural origins have been identified in the gradiometer data.

6.2.5 – AREA KH02 GRADIOMETER SURVEY – GEOLOGICAL & FLUVIAL FEATURES

In area KH02 several anomalies of geological or fluvial origins have been identified in the gradiometer data. A sinuous positive curvilinear trend in the north of the survey area most likely represents the alignment of one of the series of raised Mesolithic beach deposits known to lie within the area (BGS 2021). Two parallel curving positive linear trends in the west likely also represent raised beach deposits, as do four concentric curving positive linear trends close to the centre of the southern boundary of the survey area.

In addition, the positions of two relic stream channels can be identified. One previously flowed from the west of KH02 in a north-easterly direction and can be traced until it reaches the Antonine Wall Ditch (ANTW2020KH-0021). The second emanates from the south-eastern corner of the survey and extends in a roughly north-westerly direction.

6.2.6 – AREA KH02 GRADIOMETER SURVEY – MODERN FEATURES

In the north of the survey area there is a sub-circular area of magnetic disturbance around an unsurveyable area. The disturbance covers an area of around 20m in diameter and is caused by the large steel sculpture installed at this location.

In the south-east corner a large area of magnetic disturbance bordering the southern edge of the survey area is caused by the highly magnetic nature of the metalled track immediately south of the survey area.

A sinuous negative linear trend running between the line of the Antonine Ditch and the north-east corner of KH02 denotes the position of a modern desire path.

6.2.7 – AREA KH02 GRADIOMETER SURVEY – FEATURES OF UNCERTAIN ORIGINS

In area KH02 no anomalies of unknown or uncertain origins have been identified in the gradiometer data

6.3 – SURVEY RESULTS & INTERPRETATION AREA KH03

Of the 2.79ha planned for gradiometer survey, a total of 2.34ha was available for survey (Figure 22). The 0.45ha discrepancy is accounted for by trees within the survey area (physical obstacles) and the tree canopy around the perimeter of the survey area which blocked the GNSS signal and prevented survey. An area of waterlogged ground in the west of the area also reduced the area available for survey.

Following an initial examination of the gradiometer data for area KH03, it was decided that an additional 0.1ha of targeted electro-magnetic survey would be conducted within the survey area. This comprised an area of 50m by 20m with the grid orientated north-north-west to south-south-east. This aimed to further investigate linear anomaly ANTW2020KH-0047.

The gradiometer results for KH03 have been visualised as greyscale plots with minimally processed data plotted at -50/50nT (Figure 23) and fully processed data displayed at -22/22nT (Figure 24, & 35). XY trace plots have been produced (Figure 25), along with an unannotated graphical interpretation of the data (Figure 26), and an annotated graphical interpretation of the data (Figure 36). Numbered anomalies are listed in Appendix 3 and described in Appendix 4.

The electro-magnetic (conductivity)results for KH03 have been visualised as greyscale plots with fully processed data displayed at -1.25/25.92mS/m for ‘depth one’ at approximately 0.50m (Figure 49), at -7.62/8.16mS/m for ‘depth two’ at approximately 1.00m (Figure 50), and at -1.54/9.95mS/m for ‘depth three’ at approximately 1.80m (Figure 51), along with a single graphical interpretation of the data (Figure 52).

The electro-magnetic (magnetic susceptibility) results for KH03 have been visualised as greyscale plots with fully processed data displayed at -0.02/2.58ppt for ‘depth one’ approximately 0.50m (Figure 53), at -0.08/5.23ppt for ‘depth two’ approximately 1.00m (Figure 54), and at -0.04/5.93ppt for ‘depth three’ at approximately 1.80m (Figure 55), along with a single graphical interpretation of the data (Figure 56).

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

6.3.1 – AREA KH03 GRADIOMETER SURVEY – ARCHAEOLOGICAL FEATURES

In area KH03 numerous features of probable archaeological origin have been identified.

In the north a positive linear anomaly, oriented north-west to south-east and measuring 72m in length and 2-3m across (ANTW2020KH-0041), probably represents a ditch. Running parallel and 11m to the north-east is a positive linear trend which may mark the location of an upcast bank. Together, these two features probably represent the ditch and rampart of a prehistoric promontory fort or settlement. Occupying what was originally a promontory overlooking the Firth of Forth this fort or settlement is defined by a steep sea cliff to the north, the steep sides of Gil Burn to the east and with the ditch and bank situated across the promontory's neck to the south-west, together this encloses an area of around 0.25ha; it occupies a similar topographic position to the promontory fort at Stacks, 5km to the east (NRHE: 49536).

There are two circular positive anomalies within the area enclosed by ANTW2020KH-0041, both probably representing the location of roundhouses. The first (ANTW2020KH-0042) measures 11m in diameter and the second (ANTW2020KH-0043) 10m.

About 40m to the south-west of ANTW2020KH-0041 is a further potentially circular feature (ANTW2020KH-0044), though as only part of this anomaly lies within the survey area its true extent cannot be established. It consists of two broadly concentric rings measuring 16m and 9m across and formed of discrete positive responses. The responses probably represent the locations of a posthole. It is not possible to establish the relationship between the two rings through geophysical survey alone, but this response may represent the inner and outer rings of roof supports for a single roundhouse or, alternatively, the site of two roundhouses of differing sizes and dates.

Two further responses consistent with probable roundhouse locations are visible in the data. The first (ANTW2020KH-0045) is in the north-west corner of the survey area and is characterised by a positive ring of anomalies measuring 9m in diameter. There are two dipolar ferrous spikes within this ring. The second (ANTW2020KH-0046) lies toward the centre of the southern edge of the survey area and is only partially within the survey area. It is characterised by a positive ring of anomalies measuring 11m diameter.

6.3.2 – AREA KH03 GRADIOMETER SURVEY – POSSIBLE ARCHAEOLOGICAL FEATURES

In area KH03 numerous features of possible archaeological origin have been identified.

Two parallel, slightly curving, anomalies (ANTW2020KH-0047) set around 3.5m apart extend from east-north-east to west-south-west across the centre of the survey area. Their location corresponds with a linear feature identified during analysis of the LiDAR data for the area (Figure 20) (Hannon 2018: 262, figure 5.1) and they probably represent ditches either side of a trackway of unknown date. Crossing and appearing to cut this feature are a second pair of broadly parallel, linear anomalies. These are on a slightly different orientation and gently curve towards the north-east at their eastern end. These are characterised by two rows of small discrete positive anomalies possibly representing rows of pits or post holes. The similarity in alignment between these two features may suggest they represent two phases of development.

At the eastern end of ANTW2020KH-0047 is a 15m sub-square feature, characterised by a defuse negative linear anomaly (ANTW2020KH-0048). This probably represents a small enclosure. It corresponds with a feature identified in the LiDAR data which appears as a slightly raised sub-square feature (Figure 20) (Hannon 2018: 262, figure 5.1). Interpreted

together, ANTW2020KH-0047 and ANTW2020KH-0048 may represent a droveway and stock enclosure.

To the north of the eastern end of ANTW2020KH-0047 is another linear anomaly. It is characterised as a strong negative linear anomaly oriented north-north-west to south/south-east and measuring 45m in length. At the northern end of this anomaly and extending from north-east to south-west is a further linear feature (ANTW2020KH-0050). This negative linear anomaly extends for 26m in length before reaching the edge of the survey area. If all these linear anomalies are related, they may represent a system of droveways and land boundaries. Dating is uncertain, but some may be contemporary with the promontory settlement. Alternatively they may be associated with activity connected to nearby Kinneil village.

At the western side of the survey area is a curvilinear feature (ANTW2020KH-0051), comprising a curving negative linear anomaly measuring about 25m in length. As only part of this feature lies within the survey area its full dimensions are unknown and it is not possible to assign a function or date.

A negative linear anomaly measuring 20m in length and orientated north-north-west to south-south-east lies in the south-west corner of the survey area (ANT2020KH-0052). It lies at a right-angle to the line of the Antonine frontier and may be related to a feature observed in area KH04, discussed in Section 6.4.1. It appears to be cut by the area of rig (See section 6.3.3) and so probably predates it.

6.3.3 – AREA KH03 GRADIOMETER SURVEY – HISTORICAL AGRICULTURE FEATURES

In the south of area KH03 an area of rig has been identified. The rig is orientated north-west to south-east with the furrows set around 6.5m apart. It is restricted to the slightly higher ground in the south of KH03, avoiding the lower lying waterlogged areas to the north around Lady Well Spring.

6.3.4 – AREA KH03 GRADIOMETER SURVEY – MODERN AGRICULTURAL FEATURES

Towards the south of KH03 is an area of closely set positive linear anomalies orientated east-north-east to west-south-west. These anomalies have a separation of around 1.5m which suggests a modern agricultural origin. As with the earlier agricultural activity these anomalies are restricted to the slightly higher ground in the south of KH03, avoiding the lower lying waterlogged areas in the north. Records show that parts of the parkland surrounding Kinneil House were ploughed for crops of potatoes during the Second World War (Bailey 2015: 22) and this group of anomalies may represent this activity.

6.3.5 – AREA KH03 GRADIOMETER SURVEY – GEOLOGICAL & FLUVIAL FEATURES

In area KH03 no anomalies of geological or fluvial origins have been identified in the gradiometer data.

6.3.6 – AREA KH03 GRADIOMETER SURVEY – MODERN FEATURES

At the western end of area KH03, immediately east of Duchess Anne Cottages, is an area of rectilinear responses sharing the same orientation as Kinneil House's main drive. These are characterised as a series of positive linear anomalies combined with number dipolar ferrous spikes and sharing the same orientation. During the survey some of these

responses were seen to coincide with pathways constructed from paving slabs, but others had no visible cause. This group of anomalies is most likely to relate to a children's petting zoo built in the 1980's, and removed in the 1990's (Bailey 2015: 23).

In the north-west of KH03 a small area of modern field drains can be observed arranged in a herringbone pattern. This appears to be an attempt to drain the waterlogged area around Lady Well Spring, which made it unsurveyable at the time of survey.

In the south-east corner of the survey area there is a concentration of dipolar ferrous spikes and an area of magnetic disturbance. During the survey it was observed that this area was used as overflow parking by dog-walkers visiting the park, so the disturbance may be caused by this.

Crossing the south-west corner of the survey area is a response caused by the line of a modern service running between the driveway and Duchess Anne Cottages.

Running along the western, southern and eastern edges of the survey are areas of magnetic disturbance, caused by ferrous material.

6.3.7 – AREA KH03 GRADIOMETER SURVEY – FEATURES OF UNCERTAIN ORIGINS

In area KH03 no anomalies of unknown or uncertain origins have been identified in the gradiometer data.

6.3.8 – AREA KH03 ELECTRO-MAGNETIC SURVEY (CONDUCTIVITY)

Using the shortest coil separation and representing a depth penetration of around 0.50m, the data for 'depth one' clearly shows the concrete slabbed path as an area of very low conductivity. A further narrow band of very low conductivity can be seen in the north of the survey area, broadly following the line of gradiometer anomaly ANTW2020KH-0047. Immediately north of the position at which the pathway changes direction is an area of high conductivity. The cause of this is uncertain but may relate to the root action of the neighbouring tree.

Using the middle coil separation and representing a depth penetration of about 1m, the data for 'depth two' also displays the pathway location. This is visible as a weak negative signal and not a positive value as seen at depth one; it is not uncommon for electro-magnetic data to demonstrate a polarity inversion when examining depths of over a metre. Again, the position of gradiometer anomaly ANTW2020KH-0047 can be seen as narrow parallel bands of high and low conductivity.

Using the greatest coil separation and representing a depth penetration of about 1.80m, the data for 'depth three' provides very similar results to those for depth two and provides no additional information.

While the conductivity survey confirmed the presence of linear anomaly ANTW2020KH-0047, it has added no additional information.

6.3.9 – AREA KH03 ELECTRO-MAGNETIC SURVEY (MAGNETIC SUSCEPTIBILITY)

Using the shortest coil separation and representing a depth penetration of about 0.50m, the data for 'depth one' clearly shows the position of the concrete slabbed path as an area of low magnetic susceptibility values. This corresponds with the response in the

gradiometer data. Gradiometer anomaly ANTW2020KH-0047 can be seen in the north of the survey area as an area of raised values running parallel to a band of low values.

Using the middle coil separation and representing a depth penetration of about 1m, the data for 'depth two' also displays the pathway location. Tt also exhibits reversed polarity and can be seen as high susceptibility values. The location of anomaly ANTW2020KH-0047 is also visible as two parallel lines of slightly elevated susceptibility values.

Using the greatest coil separation and representing a depth penetration of about 1.80m, the survey data for 'depth three' also shows the location of the pathway as high susceptibility values. The location of gradiometer anomaly ANTW2020KH-0047 is visible at the north of the survey area, this time as two parallel bands with the northern as low values and the southern as high values. The area of rig can be seen as a series of parallel linear trends with low magnetic susceptibility values, orientated north-west to south-east.

While the magnetic susceptibility survey confirmed the presence of linear anomaly ANTW2020KH-0047, it has added no additional information.

6.4 – SURVEY RESULTS & INTERPRETATION AREA KH04

Of the 1.41ha planned for gradiometer survey, a total of 1.27ha was surveyable (Figure 22). The 0.63ha discrepancy is accounted for by trees within the survey area (physical obstacles) and the tree canopy around the perimeter of the survey area which blocked the GNSS signal and prevented survey in this area.

Following an initial examination of the of the gradiometer data for area KH04, it was decided that an additional 0.085ha of targeted electro-magnetic survey would be conducted within the survey area. This consisted an area measuring 40m by 20m, orientated north-north-west to south-south-east, and aimed to further investigating the break in linear anomaly ANTW2020KH-0053.

The gradiometer results for KH04 have been visualised as greyscale plots with minimally processed data plotted at -50/50nT (Figure 23) and fully processed data displayed at -22/22nT (Figure 24, & 37). XY trace plots have been produced (Figure 25), along with an unannotated graphical interpretation of the data (Figure 26), and an annotated graphical interpretation of the data (Figure 38). Numbered anomalies are listed in Appendix 3 and described in Appendix 4.

The electro-magnetic (conductivity) results for KH04 have been visualised as greyscale plots with fully processed data displayed at -25.75/20.54mS/m for 'depth one' at approximately 0.25m (Figure 49), at -3.06/9.7mS/m for 'depth two' at approximately 0.50m (Figure 50), and at 4.19/12.89mS/m for 'depth three' at approximately 0.90m (Figure 51), along with a single graphical interpretation of the data (Figure 52).

The electro-magnetic (magnetic susceptibility) results for KH04 have been visualised as greyscale plots with fully processed data displayed at 0.00/2.73ppt for 'depth one' at approximately 0.25m (Figure 53), at 0.00/3.23ppt for 'depth two' at approximately 0.50m (Figure 54), and at -2.56/4.86ppt for 'depth three' at approximately 0.90m (Figure 55), along with a single graphical interpretation of the data (Figure 56).

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

6.4.1 – AREA KH04 GRADIOMETER SURVEY – ARCHAEOLOGICAL FEATURES

In area KH04 three features of probable archaeological origin have been identified in the gradiometer data.

The first and most obvious feature is the location of the Antonine Wall Ditch (ANTW2020KH-0053). This is characterised by a high magnitude negative linear response measuring 5m in width and bordered by a pair of narrow positive responses (a phenomenon seen elsewhere on the Antonine frontier). It runs through the length of the survey area and accords well with the mapping used for the World Heritage Site Nomination. Notably, 50m from the western edge of the survey area there appears to be a 7.5m break in the Antonine Ditch. The magnitude of the Ditch's negative response is at its greatest either side of this break and decreases in magnitude to the east. Towards the eastern edge of the survey area, the Ditch is cut by two modern services (See Section 6.4.6) and feature ANTW2020KH-0055 (discussed below). These all appear to be chronologically later than the Antonine Ditch.

The break in the Antonine ditch has not been noted before. There are two plausible explanations for this break. Either the ditch was never dug at this point and it is an original causeway across the frontier, or the Ditch was fully excavated by the Roman engineers and backfilled at a later date with material with very similar magnetic properties to the surrounding area.

The first of these possibilities is interesting, as it raises the question of why a causeway would be deliberately left at this location. Causeways normally occur opposite the northern gateway of a fort or fortlet, allowing controlled passage across the frontier. Thus the presence of a causeway could suggest that either a causeway was left in anticipation of the construction of a fort or fortlet, or that one already existed at this location. As noted in Section 4.0 the area around Kinneil House, mid-way between the fort at Carriden (NRE: 49589) and the fort at Inveravon (NRHE: 47799), has long been suspected to be the location of an undiscovered Roman fort. The break, therefore, may support this suspicion. It should be noted that the break coincides with anomaly ANTW2020KH-0052 in area KH03, which is perpendicular to the Antonine Ditch and could represent a feature connected to the causeway. However, no other evidence of a Roman fort has been identified within survey area KH04 or any other survey area, and at present this interpretation remains unproven and a post-roman explanation is equally likely.

If the ditch was later infilled, this could imply that a post Antonine period route crossed the line of the Antonine Wall, leading towards the sea cliffs to the north.

A further linear feature has been recorded 5m to the south of, and running parallel with, the Antonine Ditch (ANTW2020KH-0054). It is visible as a discontinuous series of positive linear anomalies extending for 37m. The position of this linear feature suggests it is the remnants of the base of the Antonine Wall Rampart and this agrees with the findings of small-scale excavations in the area (Steer 1960).

Finally, orientated east-north-east to west-south-west are a pair of parallel negative linear anomalies set 11m apart (ANTW2020KH-0055 and ANTW2020KH-0056) and overlying the Antonine ditch at their north-west end They may represent ditches running either side of a trackway, postdating the Antonine frontier.

6.4.2 – AREA KH04 GRADIOMETER SURVEY – POSSIBLE ARCHAEOLOGICAL FEATURES

In area KH04 two features of possible archaeological origins have been identified in the gradiometer data.

The first is an oval negative anomaly bordered by a narrow positive response (ANTW2020KH-0057), measuring around 30m by 10m. It lies immediately to the south of ANTW2020KH-0056, which is interpreted as a trackway. This anomaly may represent a small quarry, possibly for the metalling of a road or trackway.

The second feature lies about half way along the southern edge of the survey area and comprises a positive low magnitude feature (ANTW2020KH-0058). It is orientated east-north-east to south-south-west and is visible as a curved L-shape, measuring 30m by 10m. As only part of this feature lies within the survey area, its full extent cannot be established and its date and function are unknown.

6.4.3 – AREA KH04 GRADIOMETER SURVEY – HISTORICAL AGRICULTURE FEATURES

In area KH04 no anomalies of historical agricultural origins have been identified in the gradiometer data.

6.4.4 – AREA KH04 GRADIOMETER SURVEY – MODERN AGRICULTURAL FEATURES

In area KH04 no anomalies of modern agricultural origins have been identified in the gradiometer data.

6.4.5 – AREA KH04 GRADIOMETER SURVEY – GEOLOGICAL & FLUVIAL FEATURES

In area KH04 a single anomaly of geological or fluvial origin has been identified in the gradiometer data. This is a weak negative linear anomaly orientated east-north-east to west-south-west. This probably represents the alignment of one of the series of raised Mesolithic beach deposits known to lie within the area (BGS 2021).

6.4.6 – AREA KH04 GRADIOMETER SURVEY – MODERN FEATURES

In area KH04 several features of modern origins have been identified in the gradiometer data.

A strong dipolar linear response, representing the line of a modern service, cuts through the north-west corner of the survey area and extends towards the cottages to the west. Two further modern services are apparent in the east of the survey area. The first is orientated north-north-east to south-south-west and is a strong dipolar linear anomaly. It is orientated with drain covers observed on Provost Road and Kinneil House's driveway and so represents the course of a modern drain. The second is orientated north-north-west to south-south-east and crosses the first drain at the north-east corner of the survey area. It is characterised as a weak linear anomaly alternating between positive and negative responses.

In the north-east corner of the survey area is an area of magnetic disturbance, coinciding with an area used as an overflow parking by dog walkers. Some 30m east-south-east of this is a second area of magnetic disturbance caused by a set of football goal posts set against the wall bordering the north of the survey area.

Towards the centre of the southern boundary of the survey area is a sub-circular area of magnetic disturbance around 8m diameter, caused by a pair of football goalposts.

Some 50m west of these goalposts is a large semi-circular area of magnetic disturbance, caused by the steel railings surrounding the children's play park.

6.4.7 – AREA KH04 GRADIOMETER SURVEY – FEATURES OF UNCERTAIN ORIGINS

In area KH04 no anomalies of unknown or uncertain origins have been identified in the gradiometer data.

6.4.8 – AREA KH04 ELECTRO-MAGNETIC SURVEY (CONDUCTIVITY)

Using the shortest coil separation and representing a depth penetration of about 0.25m, very little of the Antonine Wall can be discerned in the data for 'depth one'. A sub-circular area with high conductivity values is positioned just to the north of the possible causeway observed in the gradiometer data.

Using the middle coil separation and representing a depth penetration of about 0.50m, the data for 'depth two' is more informative. The area with high conductivity values observed at depth one extends through the location of the possible causeway from the north to the south of the survey area as a 5m wide band. The location of the Antonine Ditch is visible as two areas with low conductivity values, corresponding with the location of the ditch observed in the gradiometer data. The location of the Outer Mound is also visible as areas of low conductivity values.

Using the greatest coil separation and representing a depth penetration of about 0.90m, the data for 'depth three' shows that the area of high conductivity values has expanded to around 12m in width. Again the location of the Antonine Ditch and Outer Mound are apparent as areas of low value readings.

The conductivity survey has identified similar anomalies to those observed in the gradiometer data, supporting the interpretation of a causeway across the Antonine Ditch at this location.

6.4.9 – AREA KH04 ELECTRO-MAGNETIC SURVEY (MAGNETIC SUSCEPTIBILITY)

Using the shortest coil separation and representing a depth penetration of about 0.25m, the data for 'depth one' shows a band with raised magnetic susceptibility values running through the location of the possible causeway. The locations of both the Antonine Ditch and Outer Mound can also be detected as areas of low magnetic susceptibility values.

Using the middle coil separation and representing a depth penetration of about 0.50m, the data for 'depth two' shows similar responses for the locations for the Ditch and Outer Mound. An area displaying elevated magnetic susceptibility values run between these low value responses and extends into the area between the apparent 'butt ends'.

The greatest coil separation representing a depth penetration of about 0.90m for 'depth three' shows very similar responses to 'depth two', displaying the Outer Mound and Ditch as low value anomalies and a band of high values on the boundary between the Ditch and the Mound.

The magnetic susceptibility survey has produced results supporting the interpretation of a causeway across the Antonine Ditch. The high value reading passing through this possible causeway could suggest the presence of a compacted surface.

6.5 – SURVEY RESULTS & INTERPRETATION AREA KH05

Of the 1.01ha planned for gradiometer survey, a total of 0.56ha was surveyable (Figure 22). The 0.45ha discrepancy is accounted for by trees at the east of the survey area

(physical obstacles) and the tree canopy along the southern perimeter of the survey area which blocked the GNSS signal and prevented survey in this area. The area known as 'The Orchard' was excluded from the survey due to the highly ferrous protective cages which have been installed to protect the newly planted saplings. An additional 0.038ha of targeted electro-magnetic survey was conducted.

The gradiometer results for KH05 have been visualised as greyscale plots with minimally processed data plotted at -50/50nT (Figure 23) and fully processed data displayed at -22/22nT (Figure 24, & 39). XY trace plots have been produced (Figure 25), along with an unannotated graphical interpretation of the data (Figure 26), and an annotated graphical interpretation of the data (Figure 40). 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.

6.5.1 – AREA KH05 GRADIOMETER SURVEY – ARCHAEOLOGICAL FEATURES

In area KH05 two features of probable archaeological origins have been identified.

At the southern edge of the survey area is a negative linear anomaly measuring 28m in length. It is bordered by a narrow positive linear anomaly along its northern edge (ANTW2020KH-0059). This has very similar magnetic properties to anomaly ANTW2020KH-0053, the section of the Antonine Ditch identified in KH04, and is on an identical alignment. The eastern end of ANTW2020KH-0059 is obscured by an area of magnetic disturbance, but at its western end the magnitude of the response decreases until the anomaly appears to fade out. This coincides with an area where the northern side of the walled garden can be seen to be sitting directly on top of the bedrock, showing the proximity of the bedrock to the surface. The nature of this response could suggest that the ditch does not continue westwards to Gill Burn, with the bedrock preventing the Roman engineers from digging the ditch here in a similar manner to that suggested for the section of uncut ditch at Croy Hill (Gordon 1726: 56).

The second anomaly is a high magnitude positive linear anomaly orientated north-north-west to south-south-east (ANTW2020KH-0060). This runs perpendicular to the line of the path and aligns with the extant gate piers. A photograph of the house taken around 1910 shows a dwarf wall running either side of the gate piers (Bailey 2015: 18, Illus 18), so this anomaly relates to traces of the wall's foundation.

6.5.2 – AREA KH05 GRADIOMETER SURVEY – POSSIBLE ARCHAEOLOGICAL FEATURES

In area KH05 several anomalies of probable archaeological origin have been identified, all of which appear to either run parallel with or perpendicular to the path approaching the main entrance of Kinneil House. They likely all represent traces of a formal garden.

Anomaly ANTW2020KH-0061 is a linear feature containing a mix of low magnitude positive and negative responses and possibly represents a former pathway. Anomalies ANTW2020KH-0062, ANTW2020KH-0063, ANTW2020KH-0064, and ANTW2020KH-0065 are all negative low magnitude linear anomalies, probably representing traces of a formal garden.

Immediately east of the front of the house is a rectangular anomaly measuring 17m by 4.5m and formed of a mixture of both positive and negative responses. This may represent an area of metaled ground now covered with turf and is possibly part of a pathway.

6.5.3 – AREA KH05 GRADIOMETER SURVEY – HISTORICAL AGRICULTURE FEATURES

In area KH05 no anomalies of unknown or historical agricultural origins have been identified in the gradiometer data.

6.5.4 – AREA KH05 GRADIOMETER SURVEY – MODERN AGRICULTURAL FEATURES

In area KH05 no anomalies of unknown or modern agricultural origins have been identified in the gradiometer data.

6.5.5 – AREA KH05 GRADIOMETER SURVEY – GEOLOGICAL & FLUVIAL FEATURES

In area KH05 no anomalies of geological or fluvial origins have been identified in the gradiometer data.

6.5.6 – AREA KH05 GRADIOMETER SURVEY – MODERN FEATURES

In area KH05 several anomalies of modern origins have been identified in the gradiometer data.

Five high magnitude dipole linear anomalies in the east of the survey area, orientated north to south and east to west, represent modern services for the museum building and the cottages.

Immediately south of the museum building is a rectangular area of magnetic disturbance caused by the museum building itself.

Along the southern boundary of the survey area are several areas of magnetic disturbance caused by metal fasteners on a wooden barrier in front of the garden wall to protect visitors from falling masonry.

In the south east corner of the survey area an irregular area of magnetic disturbance is caused by an interpretation board.

6.5.7 – AREA KH05 GRADIOMETER SURVEY – FEATURES OF UNCERTAIN ORIGINS

In area KH05 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 of the survey detailed in Section 2. The electro-magnetic survey has provided moderate quality results which have in part supported the gradiometer results and therefore provided a moderate contribution to the aims detailed in Section 2. There is a high level of confidence that the chosen mixed methodology and survey strategy were appropriate to assess the archaeological potential of the survey area.

The survey has successfully confirmed the course of the Antonine Wall Ditch, which in most places corresponds well with its previously mapped line. It has also confirmed the survival of the Antonine Rampart base in some parts of the survey area. A break in the Ditch has been identified to the east of Kinneil House which could be interpreted as a causeway and may relate to a previously unidentified installation at this location. This may be connected to the 'missing' Kinneil fort, however it may equally represent deliberate backfilling of the ditch.

A previously unidentified 10m square enclosure has been identified abutting the southern side of the Rampart. It is like the 'Minor Enclosures' identified at Wilderness plantation and may therefore be the fourth example of this class of installation.

The location of the circular ditch surrounding Kinneil Kirk has been confirmed and the results suggest this may be a double ditch in places.

Anomalies believed to relate to Kinneil village have been identified in the area known as 'The Meadows'. The village appears to have followed the course of the Outer Mound in part before extending in a south-easterly direction. The nature of these anomalies suggest they relate to a period of destruction connected to the village's clearance.

An area of later prehistoric activity has been identified to the north-east of Kinneil House, comprising a small promontory fort or settlement and roundhouses. Possible droveways, land boundaries and enclosures have also been identified in this area and may be related to this prehistoric activity, although a later date is equally possible.

Responses relating to Kinneil House's landscaped gardens have been identified in various location throughout the survey area.

The location of a road or trackway, defined by a pair of parallel ditches, has been identified crossing and so postdating the Antonine Wall.

In assessing these results against the specific aims listed in Section 2, the following observations can be made.

- The exact course of the Ditch has been confirmed throughout the grounds of Kinneil House. The location of small sections of Rampart base have been confirmed in the area around Kinneil House. This contributes towards ScARF research question b.
- The survey was unsuccessful at identifying the course of the Military Way around Kinneil House, and unable to identify any branches connecting it to installations.
- The survey was able to confirm details of the fortlet's defensive ditches and ramparts, established though excavation. Details of internal structures were obscured by the magnetic disturbance caused by the excavation within the interior. No additional information was obtained about the fortlet's blocked northern gateway.
- No trace of a causeway relating to the fortlet was identified in the survey data.

- No traces of a Roman fort have been identified in the area around Kinneil House. However, a break in the Ditch to the east of Kinneil House could suggest this was the intended location of the fort with the break representing a causeway.
- Some details regarding the relationship between Kinneil village and the Antonine Wall have been established.
- A previously unidentified installation of possible Antonine date has been identified within the survey area.
- Possible features associated with Kinneil House have been identified within the survey data.

In summary the survey has confirmed the course of the Antonine Wall and provided new information about Kinneil village and Kirk as well as the later formal gardens of Kinneil House. The survey has also identified anomalies which appear to relate to later prehistoric settlement immediately north of the Antonine frontier.

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 archived with Historic Environment Scotland and supplied to the local Historic Environment Record. 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 .txt files.
- Processed survey data supplied as .tif files.
- 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

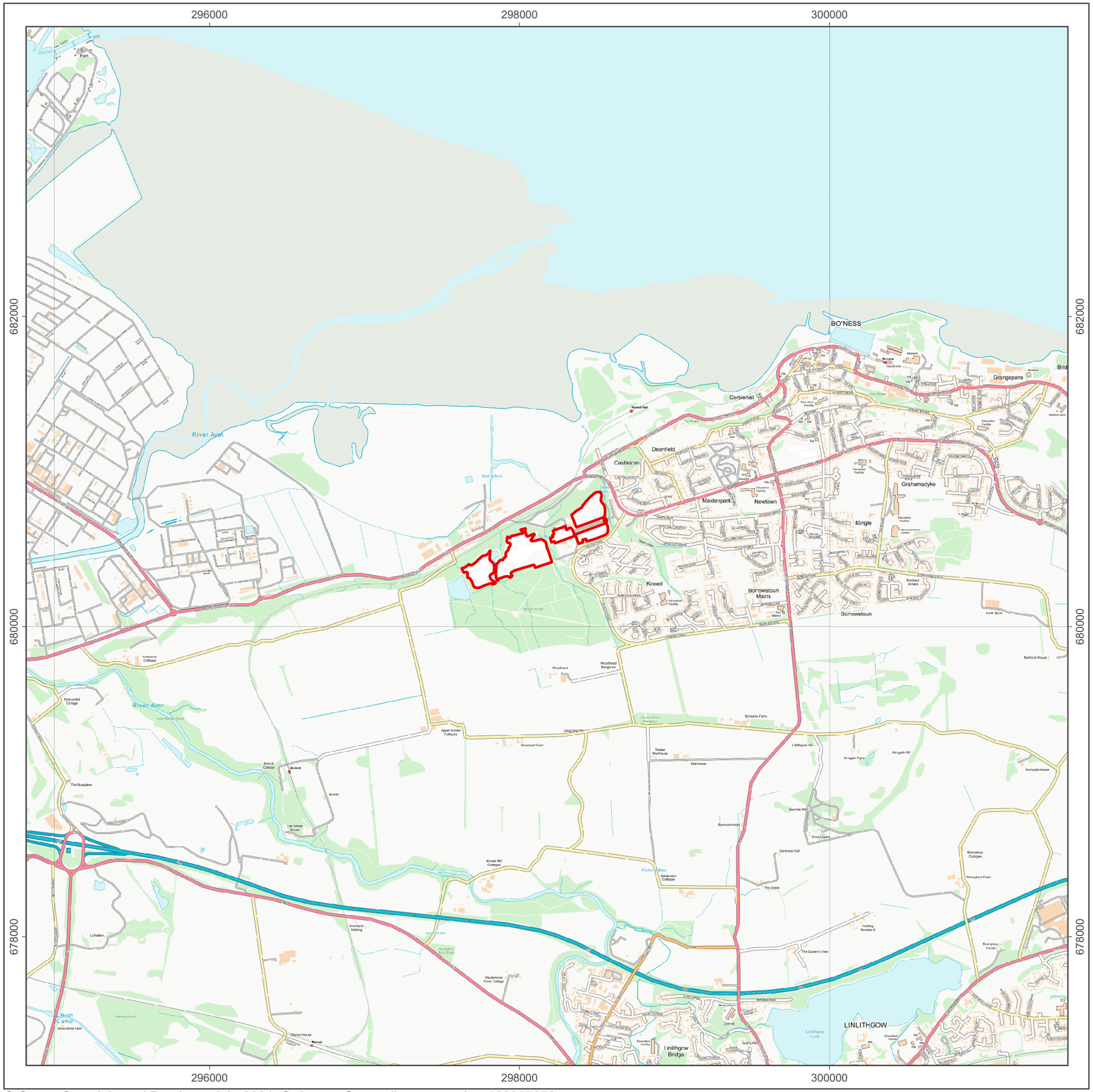
Image 1 – Survey area KH01, looking south-west showing the location of Kinneil fortlet and the concrete set wooden posts (DP375241)

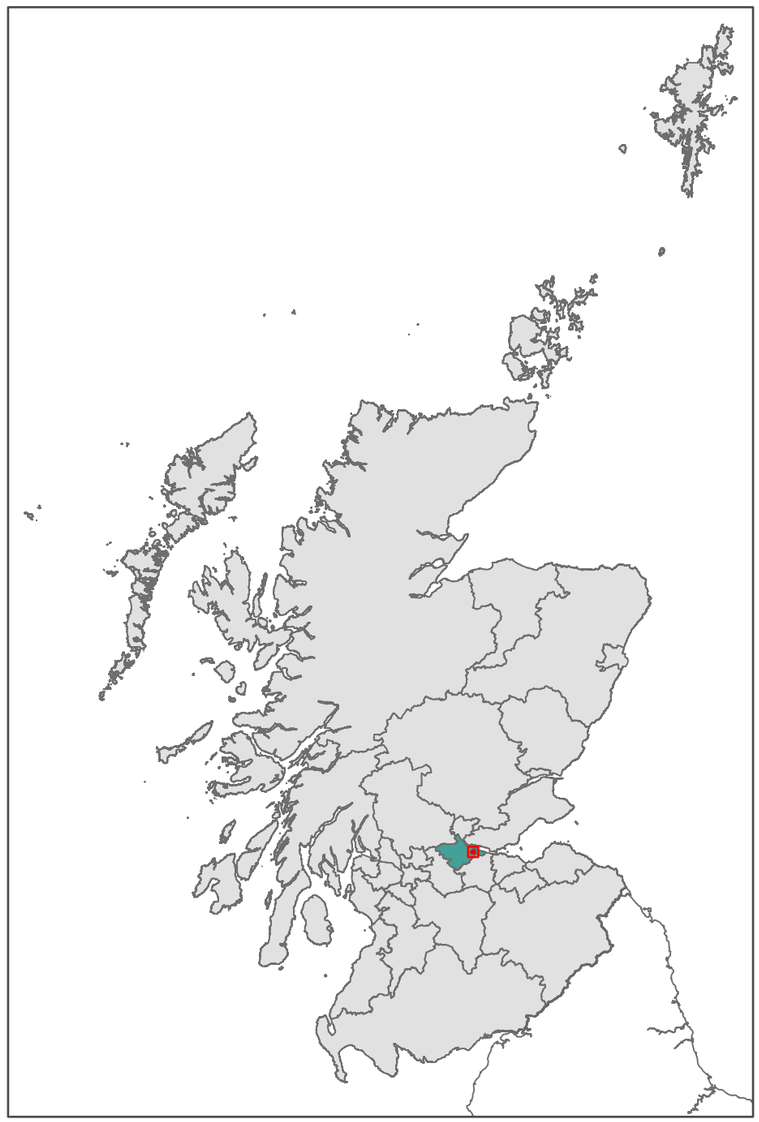
Image 2 – Survey area KH03 looking south-east (DP375240)

12.0 – FIGURES

Project Name	Kinneil House
Project Code	ANTW2020KH
Prepared By	Nick Hannon
Prepared On	26/10/2021
Figure 01	Survey Location

HISTORIC ENVIRONMENT SCOTLAND | ÀRAINNEACHD EACHDRAIDHEIL ALBA





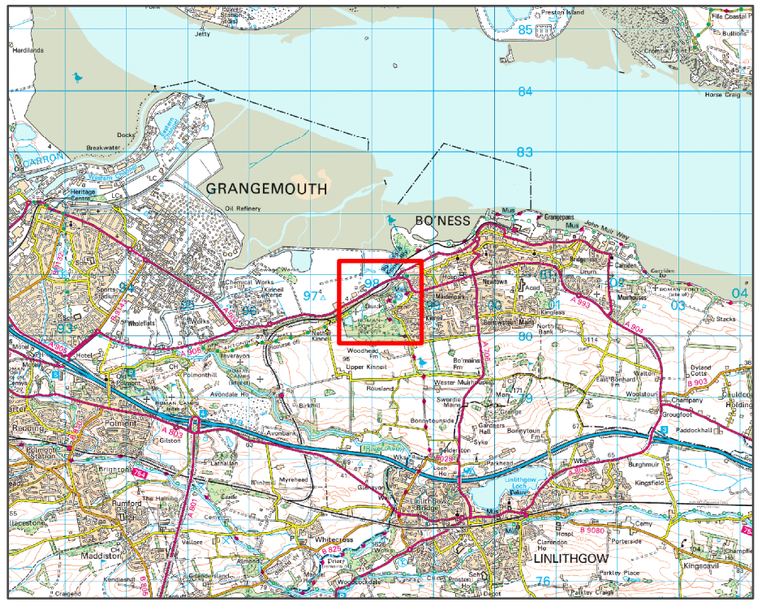
Survey Location
Falkirk

North	Scale: 1:25,000 @ A3	Datum: OSGB 1936

Meters
0 500 1,000 1,500 2,000

Project Name	Kinneil House
Project Code	ANTW2020KH
Prepared By	Nick Hannon
Prepared On	26/10/2021
Figure 02	Survey Area Showing Photograph Positions

HISTORIC ENVIRONMENT SCOTLAND | ÀRAINNEACHD EACHDRAIDHEIL ALBA



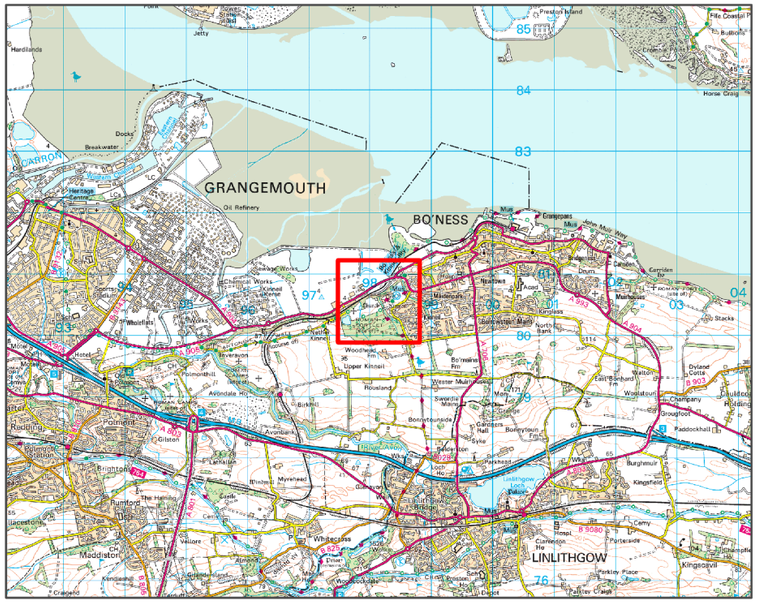
GEOPHYSICAL SURVEY
- Survey Area
- Photograph Position

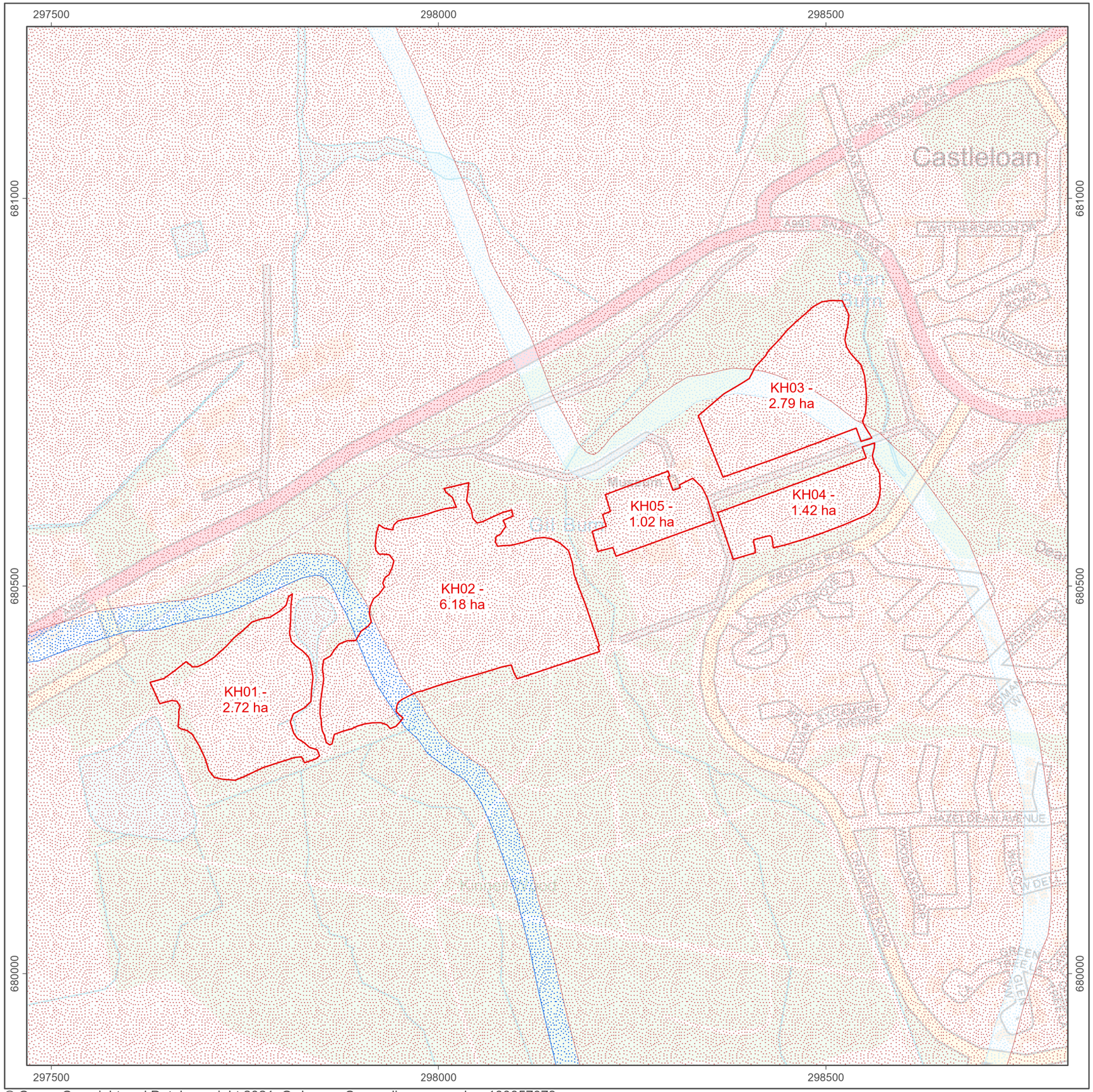
North	Scale: 1:5,000 @ A3	Datum: OSGB 1936

Metres
0 100 200 300 400

Project Name	Kinneil House
Project Code	ANTW2020KH
Prepared By	Nick Hannon
Prepared On	10/11/2021
Figure 03	Geology Solid (BGS 2021)

HISTORIC ENVIRONMENT SCOTLAND | ÀRAINNEACHD EACHDRAIDHEIL ALBA





GEOPHYSICAL SURVEY
- Survey Area

GEOLOGY - SOLID
- Calmy Limestone
- Orchard Limestone
- Upper Limestone Formation

North

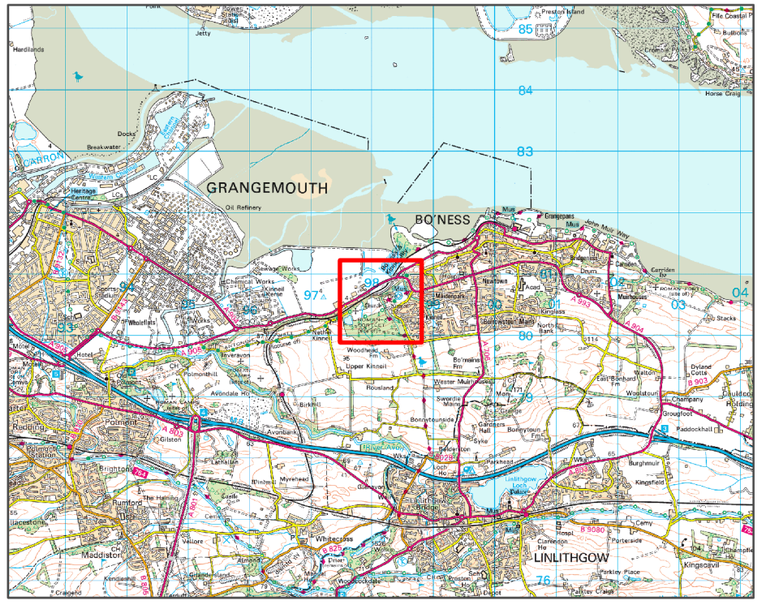
Scale: 1:5,000 @ A3

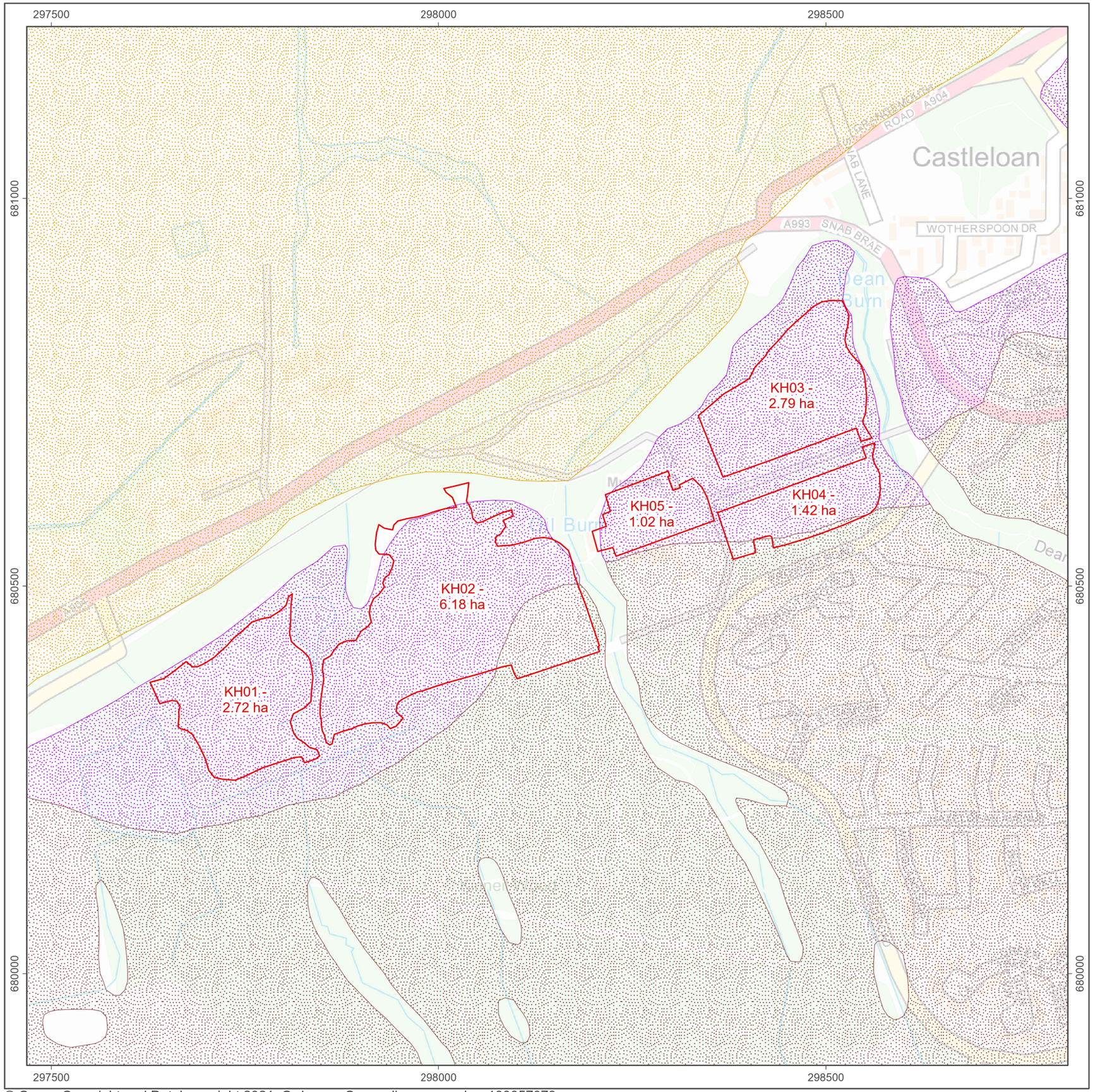
Datum: OSGB 1936

Metres
0 100 200 300 400

Project Name	Kinneil House
Project Code	ANTW2020KH
Prepared By	Nick Hannon
Prepared On	10/11/2021
Figure 04	Geology Drift (BGS 2021)

HISTORIC ENVIRONMENT SCOTLAND | ÀRAINNEACHD EACHDRAIDHEIL ALBA





GEOPHYSICAL SURVEY

- Survey Area

GEOLOGY - DRIFT

- Raised Marine Deposits, Clay, Silt, Sand, & Gravel - Devensian
- Raised Tidal Flat Deposits - Holocene
- Till, Diamicton - Devensian

North

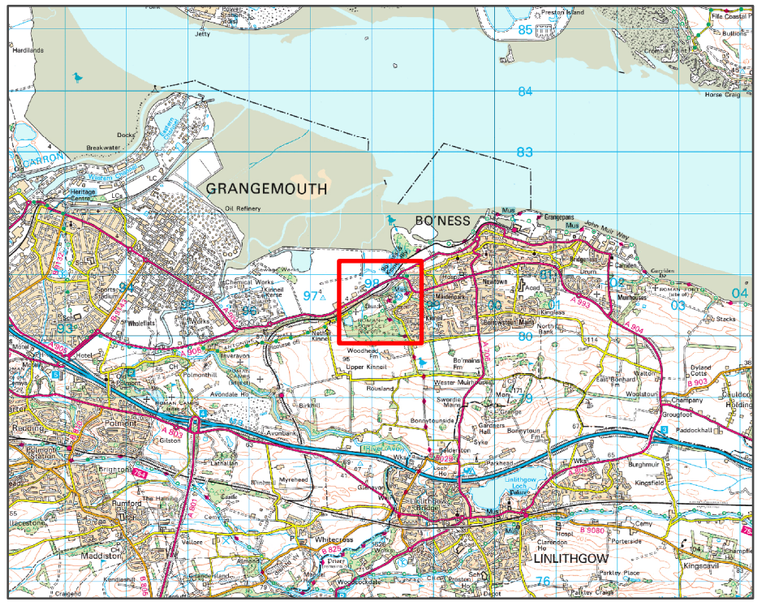
Scale: 1:5,000 @ A3

Datum: OSGB 1936

Metres 0 100 200 300 400

Project Name	Kinneil House
Project Code	ANTW2020KH
Prepared By	Nick Hannon
Prepared On	26/10/2021
Figure 05	Historic Environment

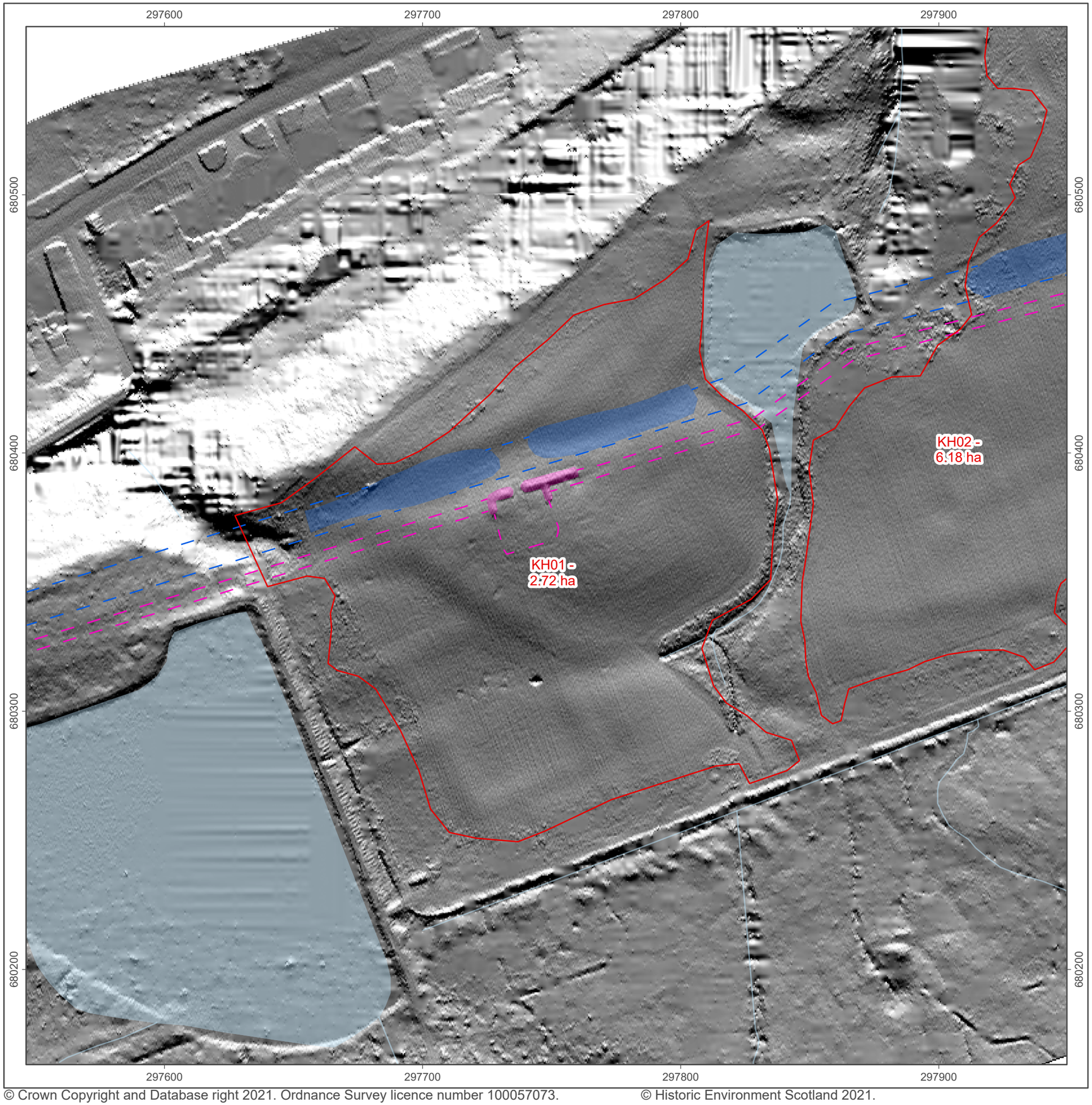
HISTORIC ENVIRONMENT SCOTLAND | ÀRAINNEACHD EACHDRAIDHEIL ALBA



HISTORIC ENVIRONMENT
- Scheduled Monument
- Property In Care
- Antonine Wall World Heritage Site

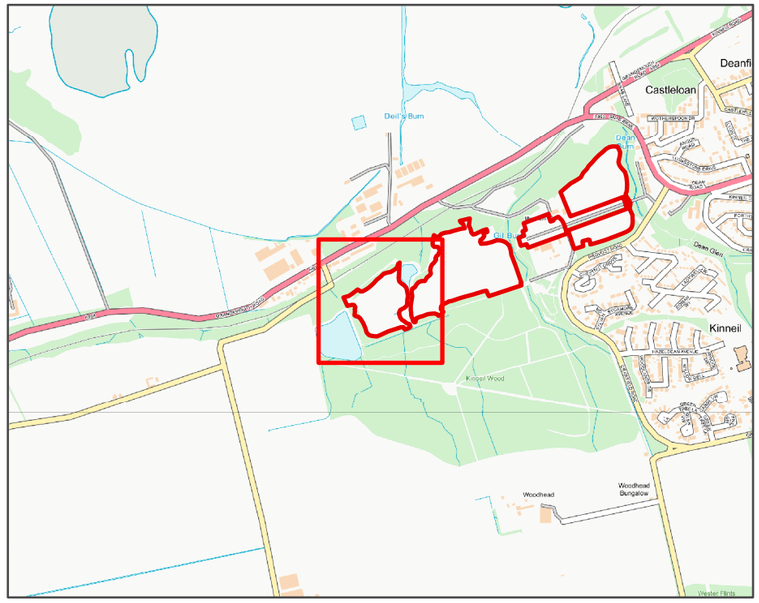
North	Scale: 1:5,000 @ A3	Datum: OSGB 1936

Metres
0 100 200 300 400



Project Name	Kinneil House
Project Code	ANTW2020KH
Prepared By	Nick Hannon
Prepared On	26/10/2021
Figure 06	Historic Environment Scotland Commissioned LiDAR Data - KH01

HISTORIC ENVIRONMENT SCOTLAND | ÀRAINNEACHD EACHDRAIDHEIL ALBA



GEOPHYSICAL SURVEY
- Survey Area

THE ANTONINE WALL
- Rampart
- Ditch
- Rampart - projected
- Ditch - projected

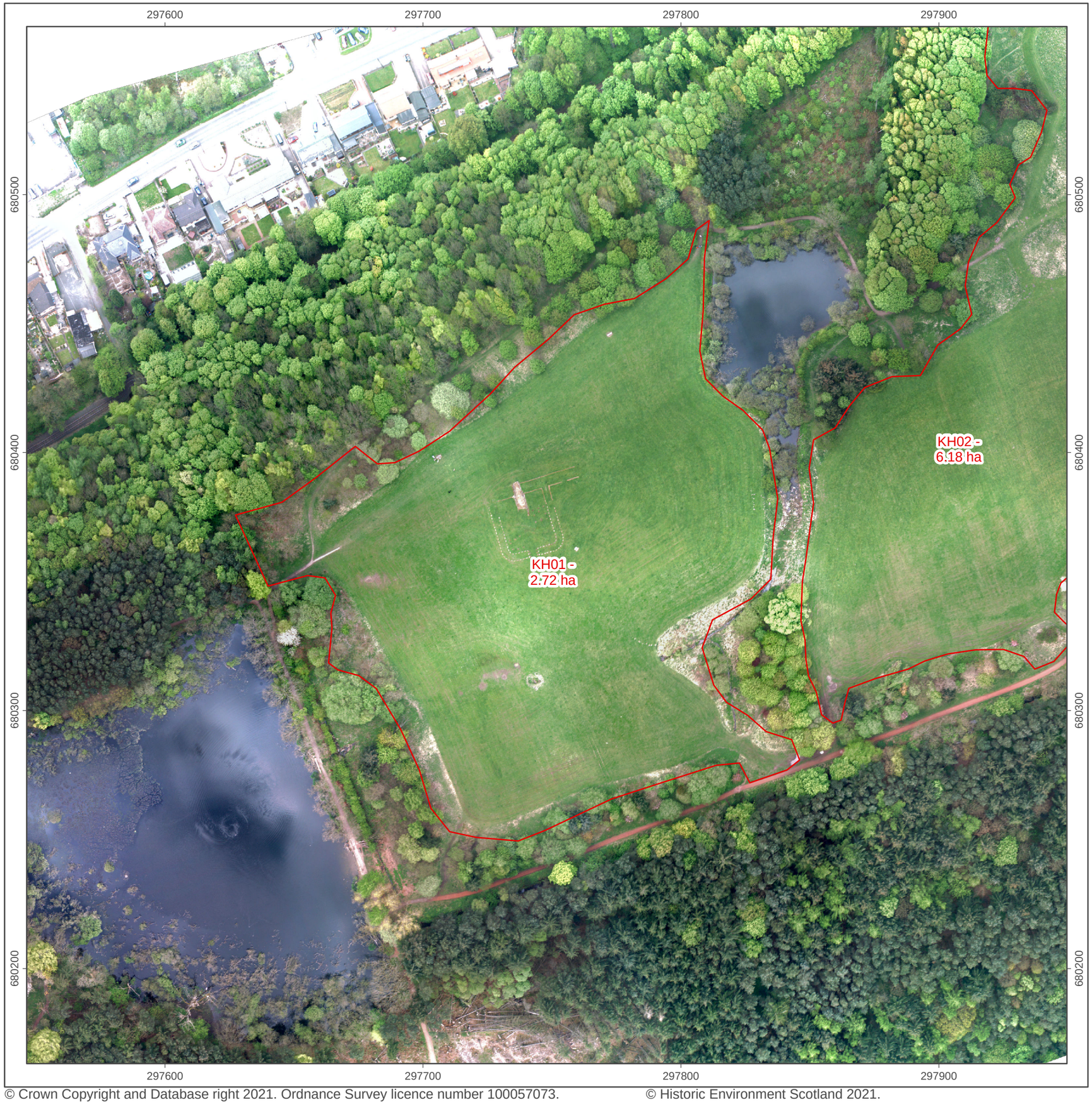
Resolution (metres)	0.50
Visualisation	Multi Direction Hillshade
Directions	64
Altitude (degrees)	35
Azimuth (degrees)	N/A
Stretch	Standard Deviation
Standard Deviations	2
Gamma	1
Z-Factor	1

North

Scale: 1:1,500 @ A3

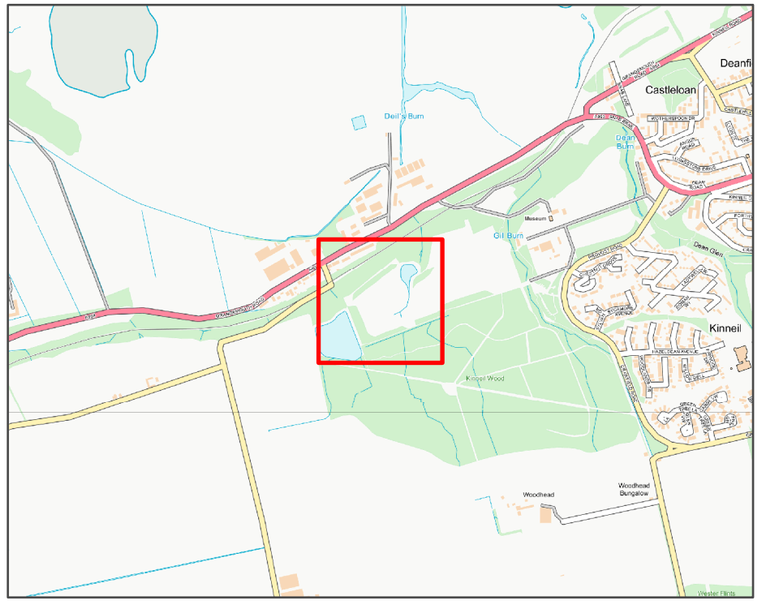
Datum: OSGB 1936

Metres
0 25 50 75 100



Project Name	Kinneil House
Project Code	ANTW2020KH
Prepared By	Nick Hannon
Prepared On	10/11/2021
Figure 07	Historic Environment Scotland Commissioned Orthographic Photograph - KH01

HISTORIC ENVIRONMENT SCOTLAND | ÀRAINNEACHD EACHDRAIDHEIL ALBA



GEOPHYSICAL SURVEY

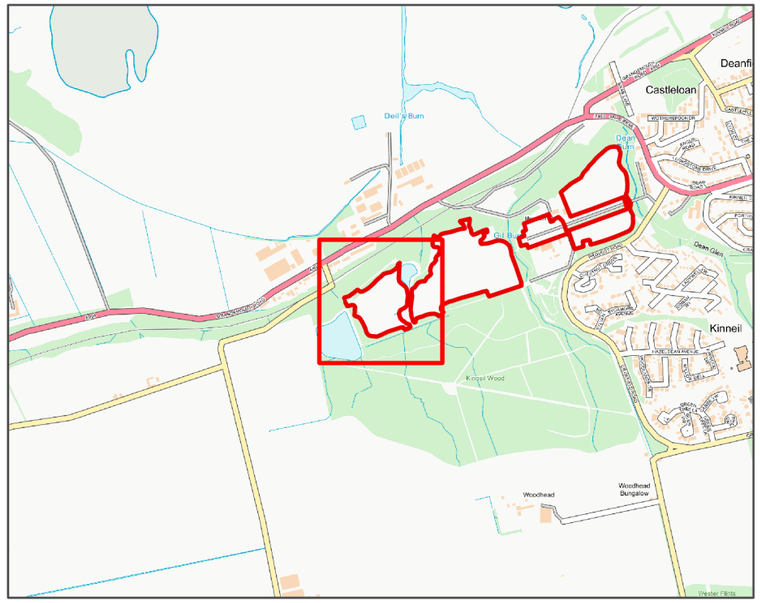
Survey Area

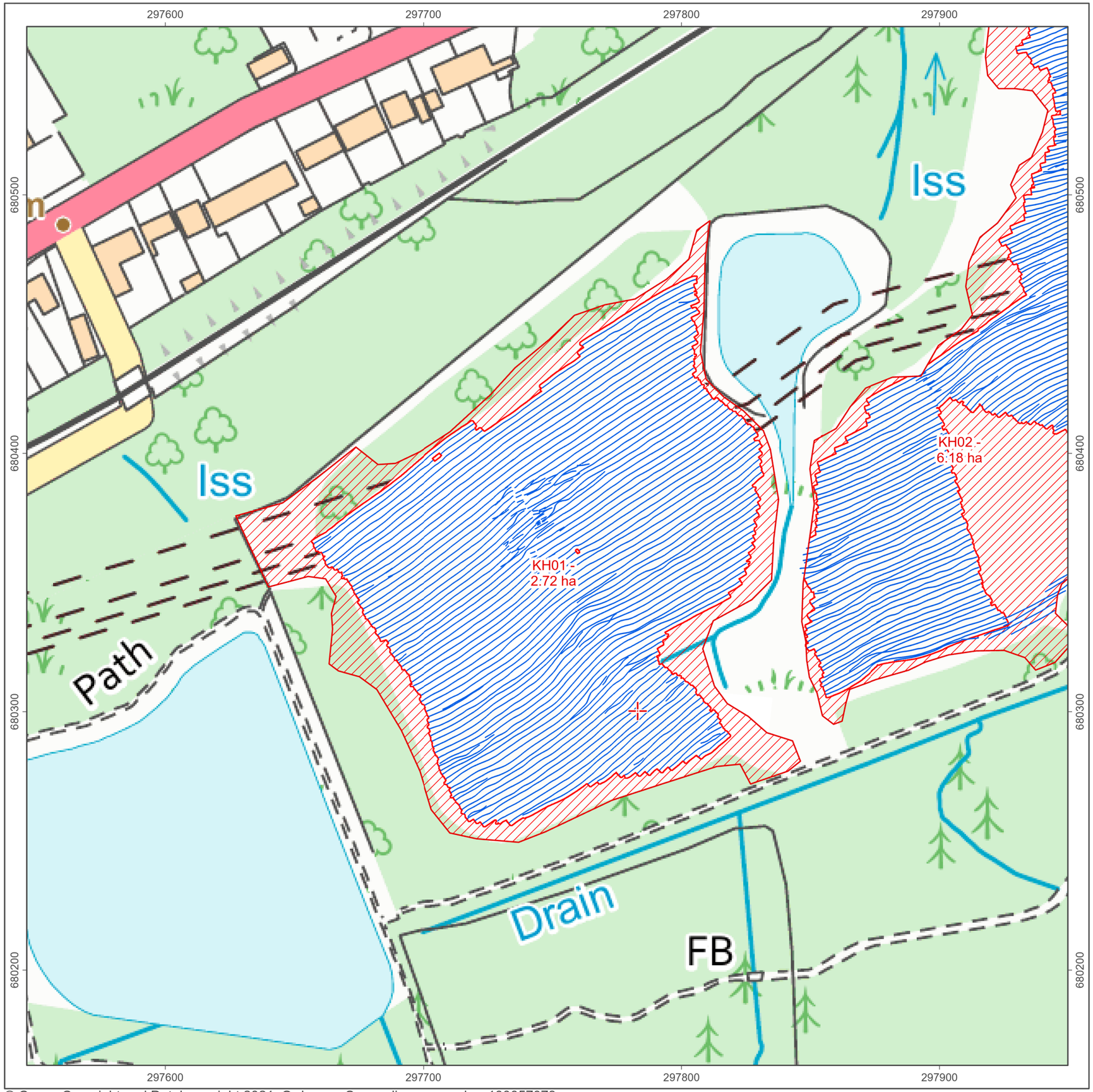
North	Scale: 1:1,500 @ A3	Datum: OSGB 1936

Metres
0 25 50 75 100

Project Name	Kinneil House
Project Code	ANTW2020KH
Prepared By	Nick Hannon
Prepared On	10/11/2021
Figure 08	Gradiometer Survey GNSS Swaths & Calibration Position - KH01

HISTORIC ENVIRONMENT SCOTLAND | ÀRAINNEACHD EACHDRAIDHEIL ALBA





GEOPHYSICAL SURVEY

Survey Metadata

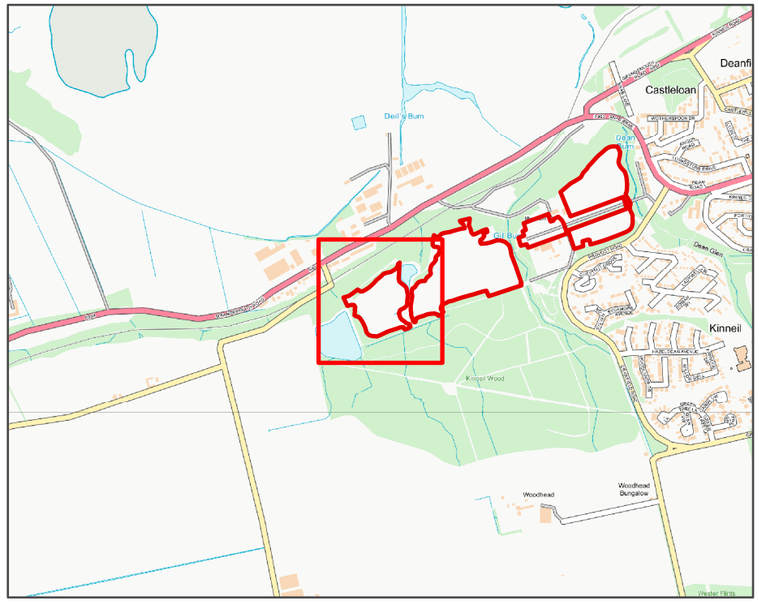
- Calibration Position
- GNSS Breadcrumb
- Survey Area
- Unsurveyable

North	Scale: 1:1,500 @ A3	Datum: OSGB 1936

Metres: 0 25 50 75 100

Project Name	Kinneil House
Project Code	ANTW2020KH
Prepared By	Nick Hannon
Prepared On	27/10/2021
Figure 09	Minimally Processed Gradiometer Data - Greyscale Plot - KH01

HISTORIC ENVIRONMENT SCOTLAND | ÀRAINNEACHD EACHDRAIDHEIL ALBA



GREYSCALE PLOT

Value

50

-50

Cell size (m)	0.12
Stretch	Standard Deviation
Standard Deviations	2
Gamma	1

North

Scale: 1:1,500 @ A3

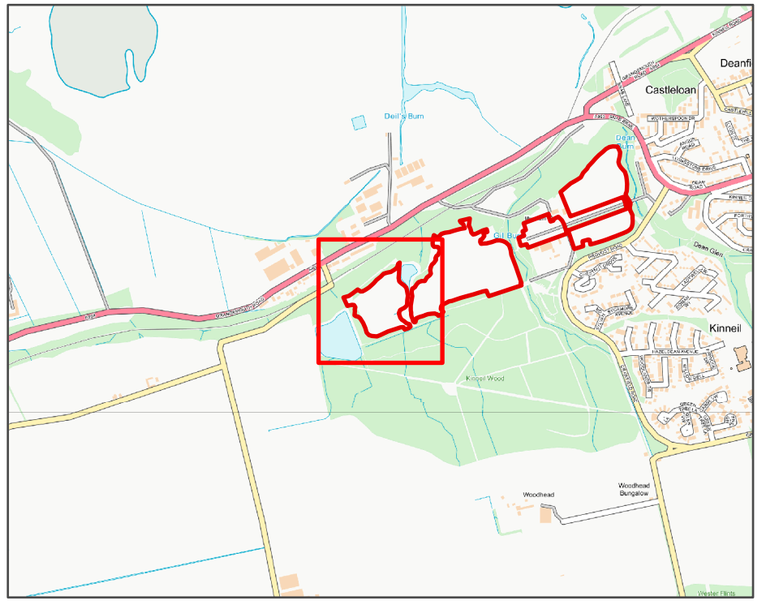
Datum: OSGB 1936

Metres

0 25 50 75 100

Project Name	Kinneil House
Project Code	ANTW2020KH
Prepared By	Nick Hannon
Prepared On	27/10/2021
Figure 10	Processed Gradiometer Data - Greyscale Plot - KH01

HISTORIC ENVIRONMENT SCOTLAND | ÀRAINNEACHD EACHDRAIDHEIL ALBA



GREYSCALE PLOT

Value

22

-22

Cell size (m)	0.12
Stretch	Standard Deviation
Standard Deviations	2
Gamma	1

North

Scale: 1:1,500 @ A3

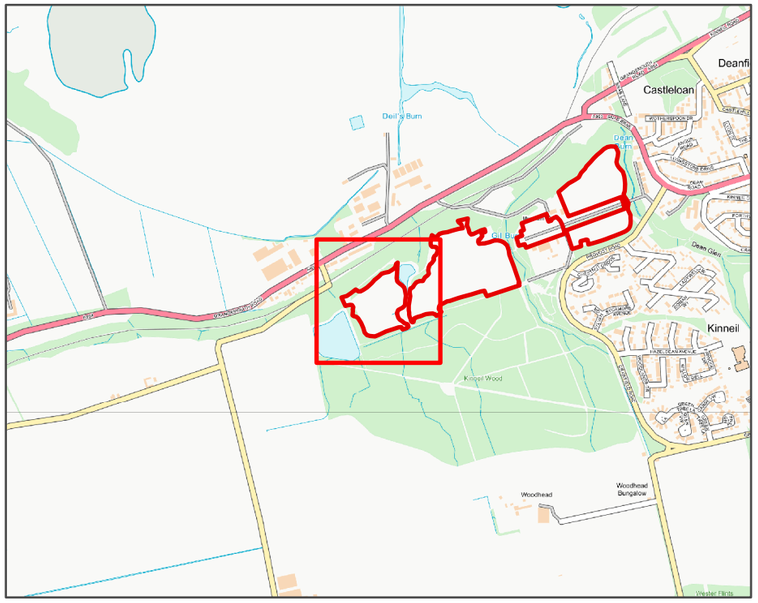
Datum: OSGB 1936

Metres

0 25 50 75 100

Project Name	Kinneil House
Project Code	ANTW2020KH
Prepared By	Nick Hannon
Prepared On	27/10/2021
Figure 11	XY Trace Plot of Gradiometer Data - KH01

HISTORIC ENVIRONMENT SCOTLAND | ÀRAINNEACHD EACHDRAIDHEIL ALBA



GEOPHYSICAL SURVEY

XY Trace Plot

100 nT

50 nT

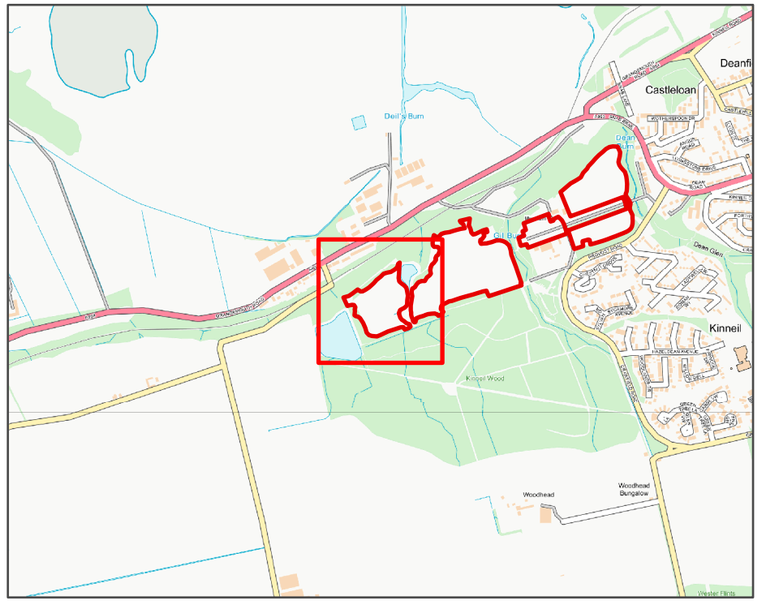
0 nT

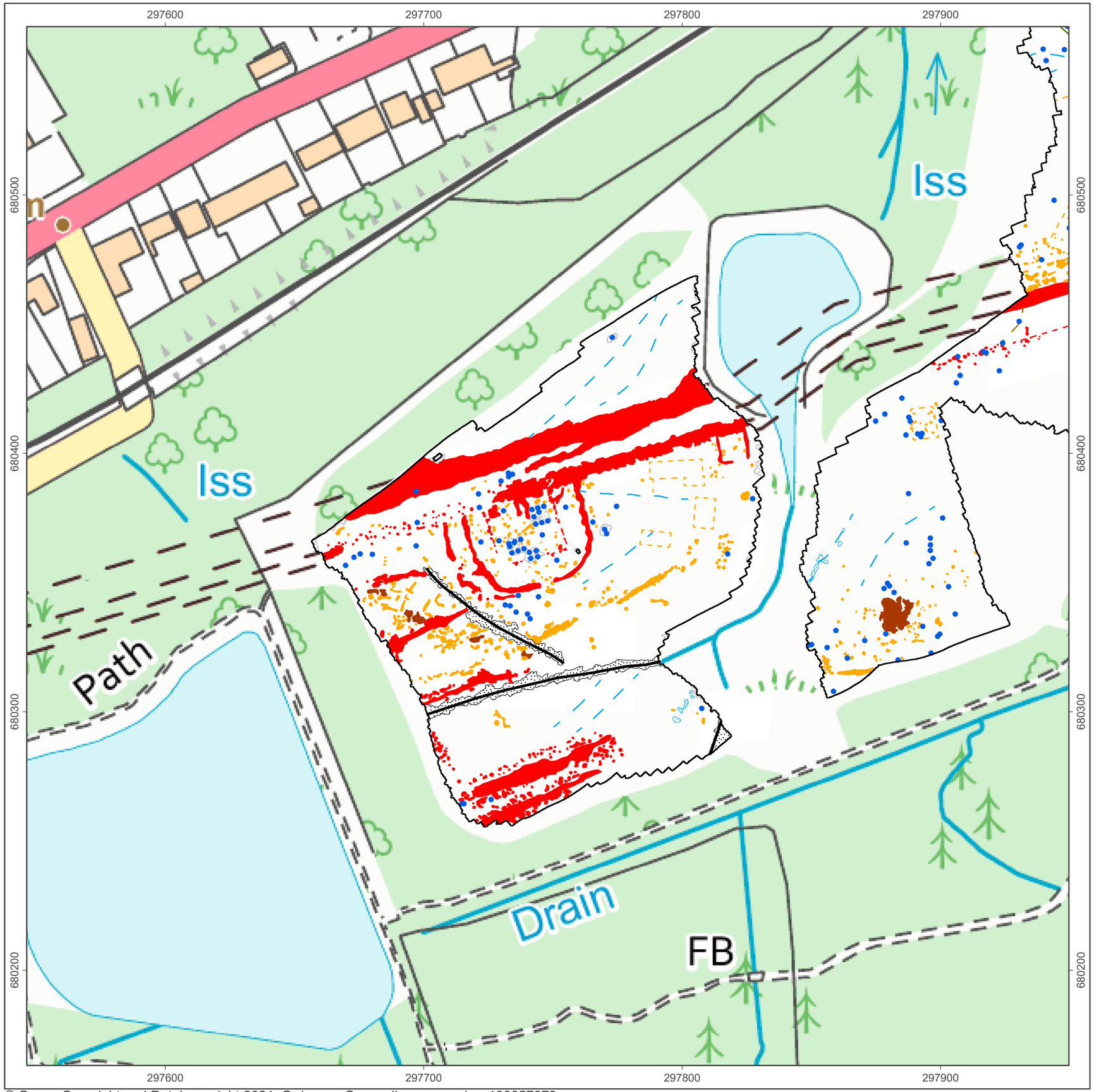
North	Scale: 1:1,500 @ A3	Datum: OSGB 1936

Metres 0 25 50 75 100

Project Name	Kinneil House
Project Code	ANTW2020KH
Prepared By	Nick Hannon
Prepared On	27/10/2021
Figure 12	Interpretation of Gradiometer Data - KH01

HISTORIC ENVIRONMENT SCOTLAND | ÀRAINNEACHD EACHDRAIDHEIL ALBA





ARCHAEOLOGICAL INTERPRETATION

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

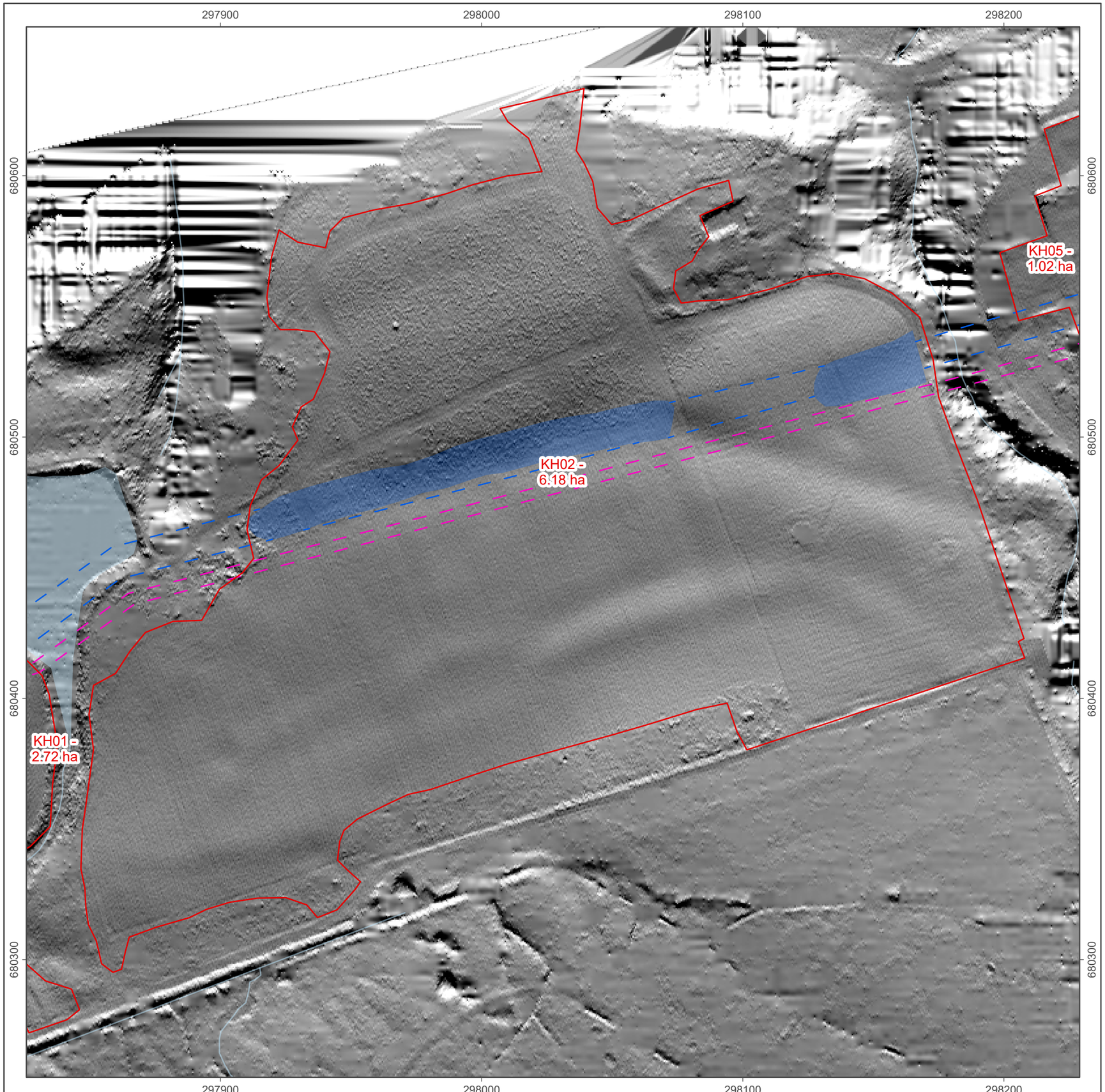
North	Scale: 1:1,500 @ A3	Datum: OSGB 1936

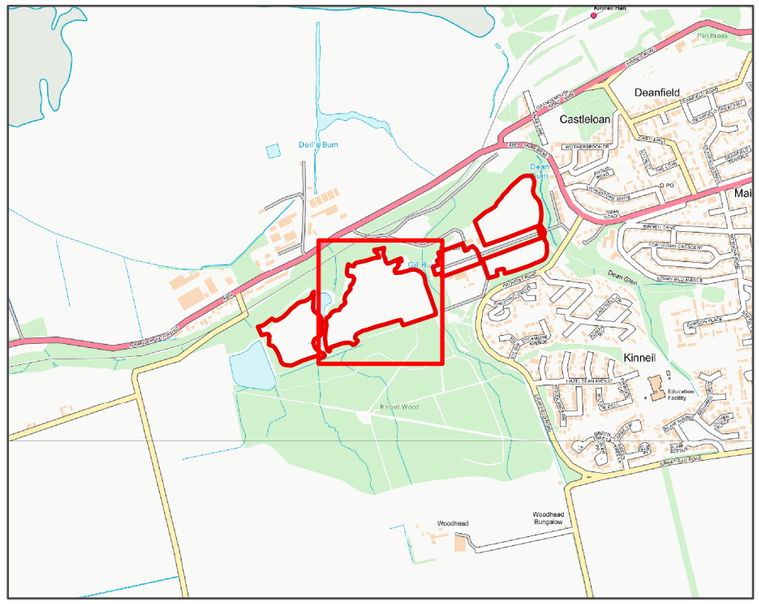
Metres
0 25 50 75 100

Project Name	Kinneil House
Project Code	ANTW2020KH
Prepared By	Nick Hannon
Prepared On	27/10/2021

HISTORIC ENVIRONMENT SCOTLAND | ÀRAINNEACHD EACHDRAIDHEIL ALBA

Figure 13 Historic Environment Scotland Commissioned LiDAR Data - KH02





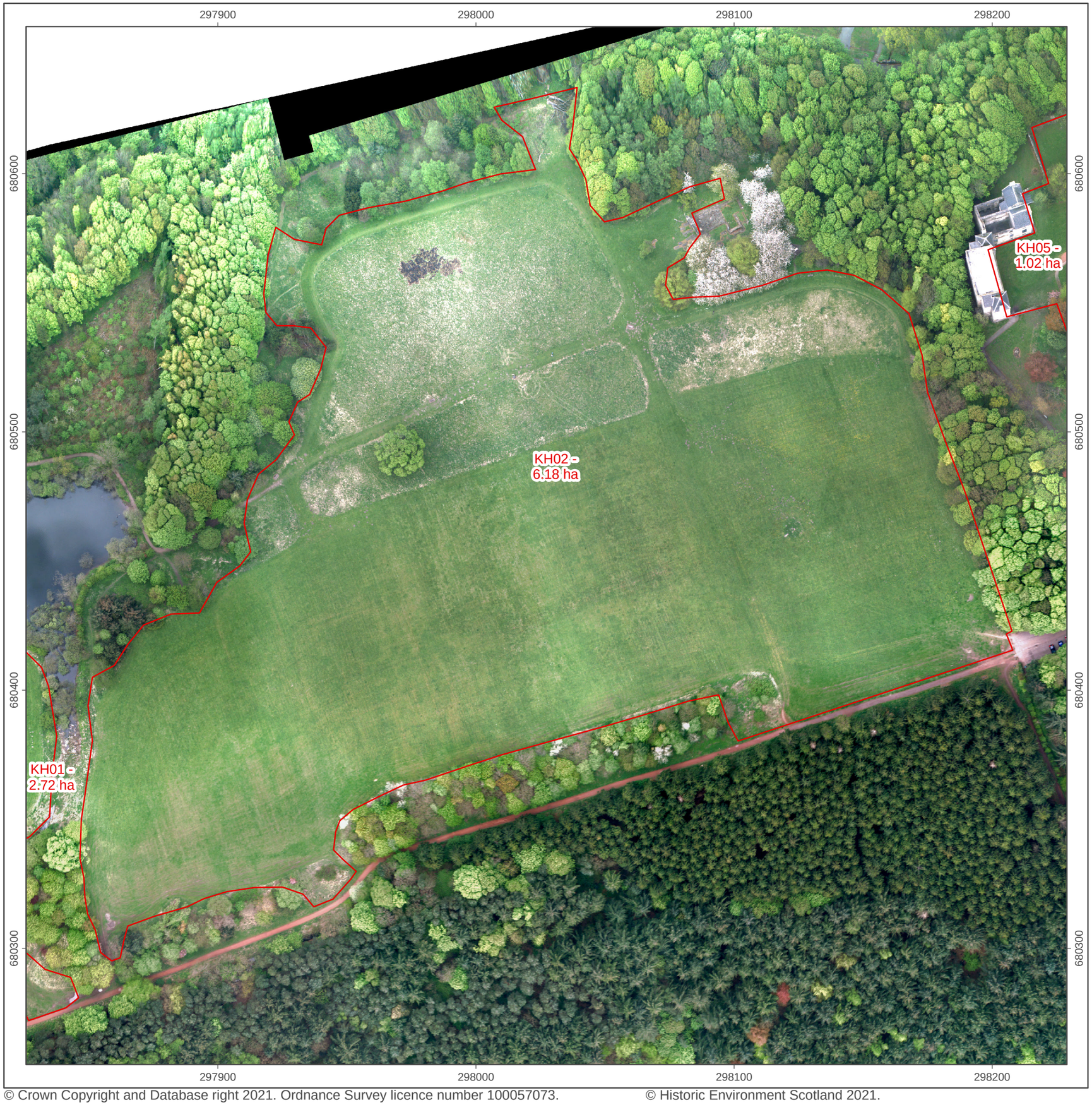
GEOPHYSICAL SURVEY
- Survey Area

THE ANTONINE WALL
- Ditch
- Rampart - projected
- Ditch - projected

Resolution (metres)	0.50
Visualisation	Multi Direction Hillshade
Directions	64
Altitude (degrees)	35
Azimuth (degrees)	N/A
Stretch	Standard Deviation
Standard Deviations	2
Gamma	1
Z-Factor	1

North | Scale: 1:1,500 @ A3 | Datum: OSGB 1936

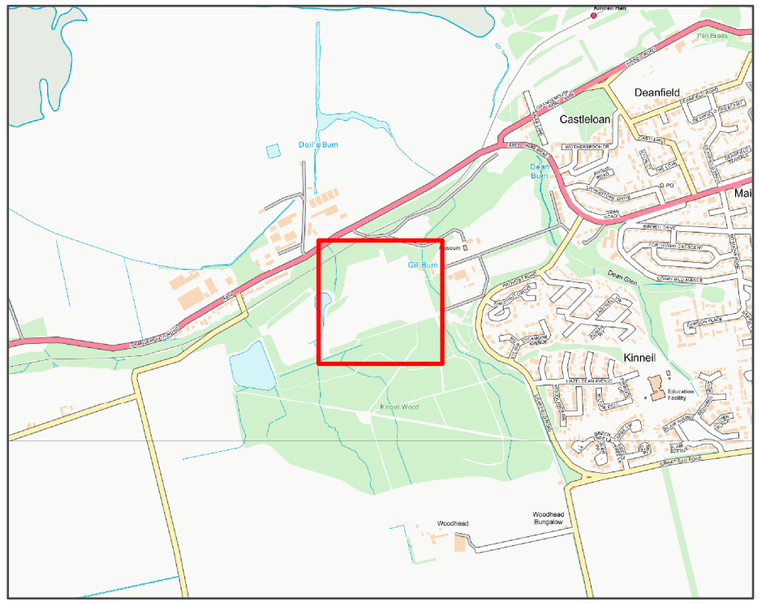
Metres
0 25 50 75 100



Project Name	Kinneil House
Project Code	ANTW2020KH
Prepared By	Nick Hannon
Prepared On	10/11/2021

HISTORIC ENVIRONMENT SCOTLAND | ÀRAINNEACHD EACHDRAIDHEIL ALBA

Figure 14 Historic Environment Scotland Commissioned Orthographic Photograph - KH02



GEOPHYSICAL SURVEY

Survey Area

North

Scale: 1:1,500 @ A3

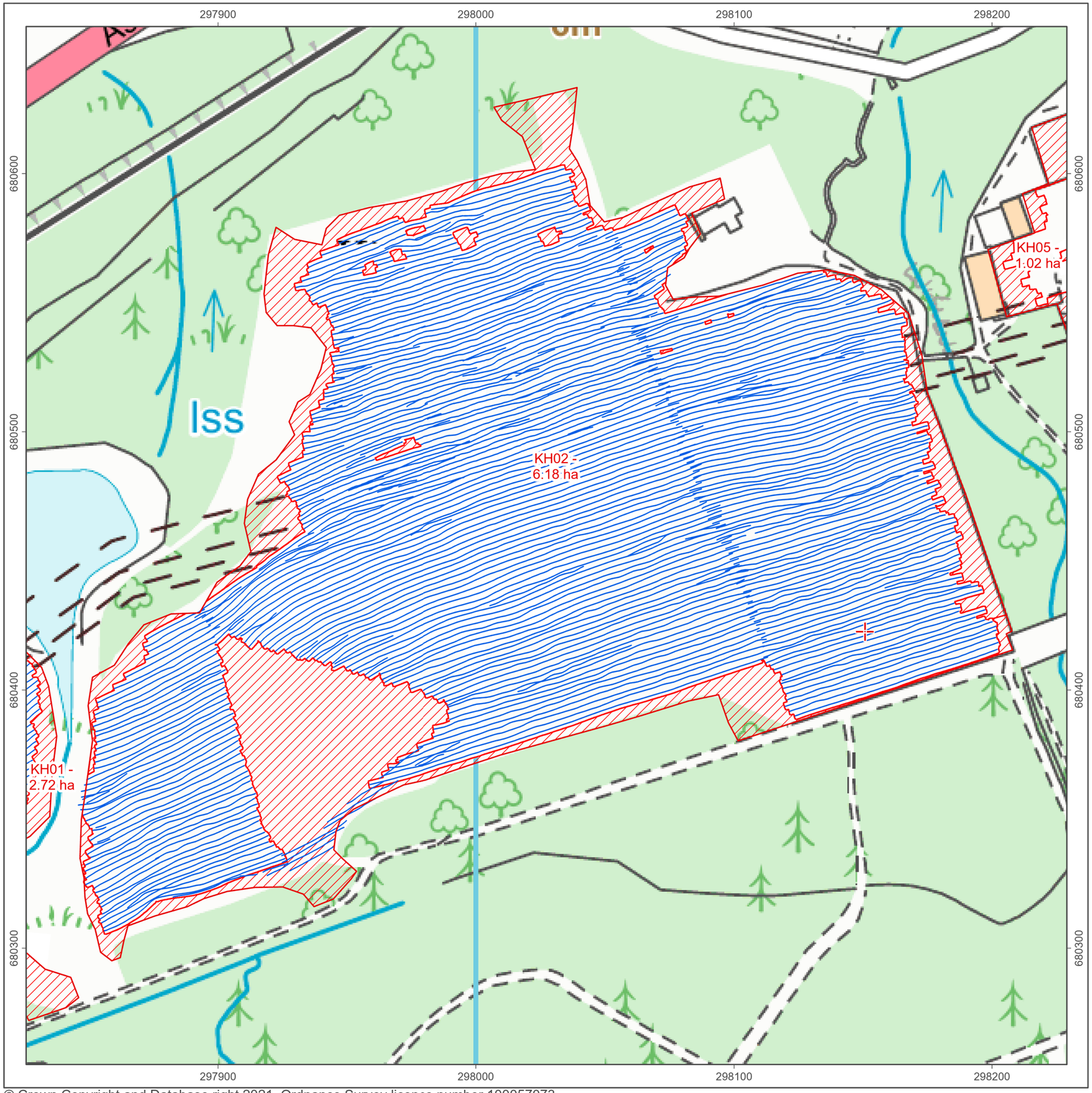
Datum: OSGB 1936

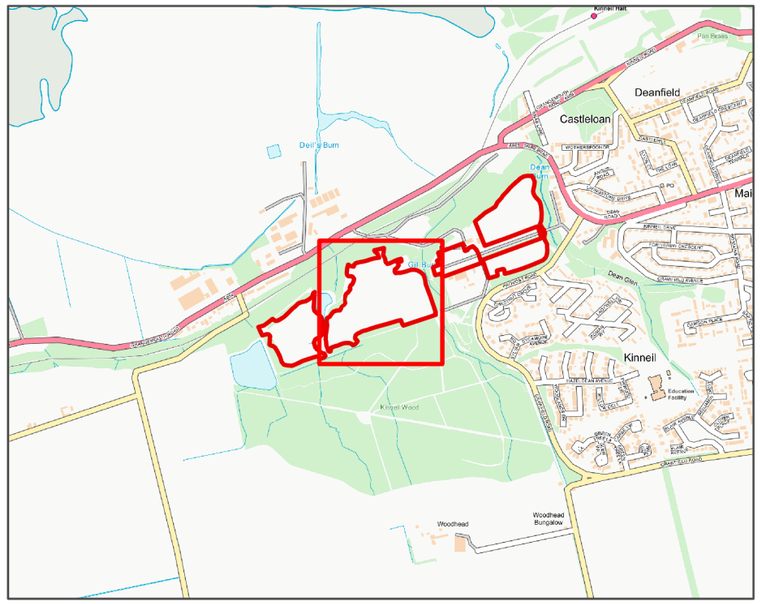
Metres

0 25 50 75 100

Project Name	Kinneil House
Project Code	ANTW2020KH
Prepared By	Nick Hannon
Prepared On	10/11/2021
Figure 15	Gradiometer Survey GNSS Swaths & Calibration Position - KH02

HISTORIC ENVIRONMENT SCOTLAND | ÀRAINNEACHD EACHDRAIDHEIL ALBA





GEOPHYSICAL SURVEY

Survey Metadata

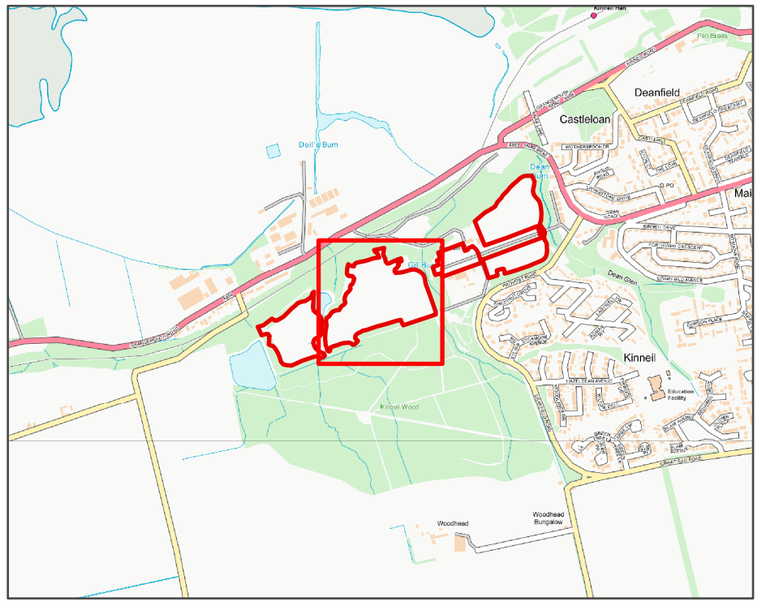
- Calibration Position
- GNSS Breadcrumb
- Survey Area
- Unsurveyable

North	Scale: 1:1,500 @ A3	Datum: OSGB 1936

Metres: 0 25 50 75 100

Project Name	Kinneil House
Project Code	ANTW2020KH
Prepared By	Nick Hannon
Prepared On	27/10/2021
Figure 16	Minimally Processed Gradiometer Data - Greyscale Plot - KH02

HISTORIC ENVIRONMENT SCOTLAND | ÀRAINNEACHD EACHDRAIDHEIL ALBA



GREYSCALE PLOT

Value

50

-50

Cell size (m)	0.12
Stretch	Standard Deviation
Standard Deviations	2
Gamma	1

North

Scale: 1:1,500 @ A3

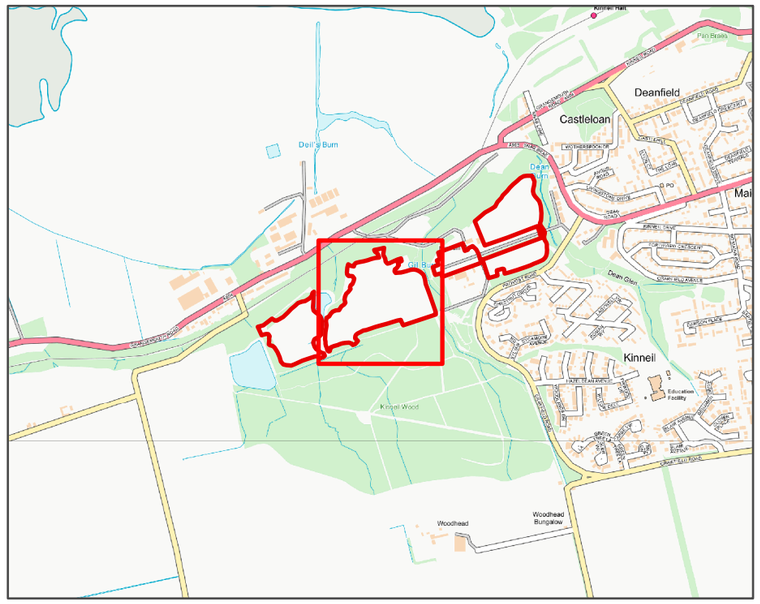
Datum: OSGB 1936

Metres

0 25 50 75 100

Project Name	Kinneil House
Project Code	ANTW2020KH
Prepared By	Nick Hannon
Prepared On	28/10/2021
Figure 17	Processed Gradiometer Data - Greyscale Plot - KH02

HISTORIC ENVIRONMENT SCOTLAND | ÀRAINNEACHD EACHDRAIDHEIL ALBA



GREYSCALE PLOT

Value

22

-22

Cell size (m)	0.12
Stretch	Standard Deviation
Standard Deviations	2
Gamma	1

North

Scale: 1:1,500 @ A3

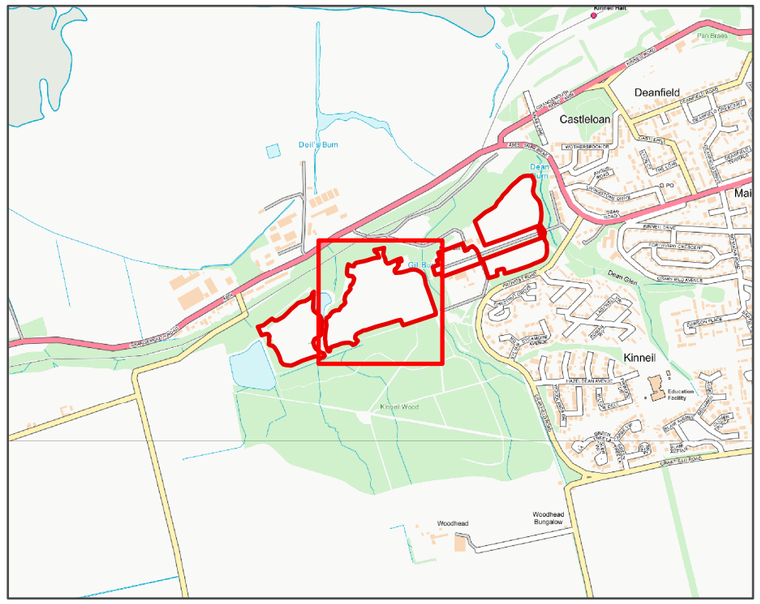
Datum: OSGB 1936

Metres

0 25 50 75 100

Project Name	Kinneil House
Project Code	ANTW2020KH
Prepared By	Nick Hannon
Prepared On	28/10/2021
Figure 18	XY Trace Plot of Gradiometer Data - KH02

HISTORIC ENVIRONMENT SCOTLAND | ÀRAINNEACHD EACHDRAIDHEIL ALBA



GEOPHYSICAL SURVEY

XY Trace Plot

100 nT

50 nT

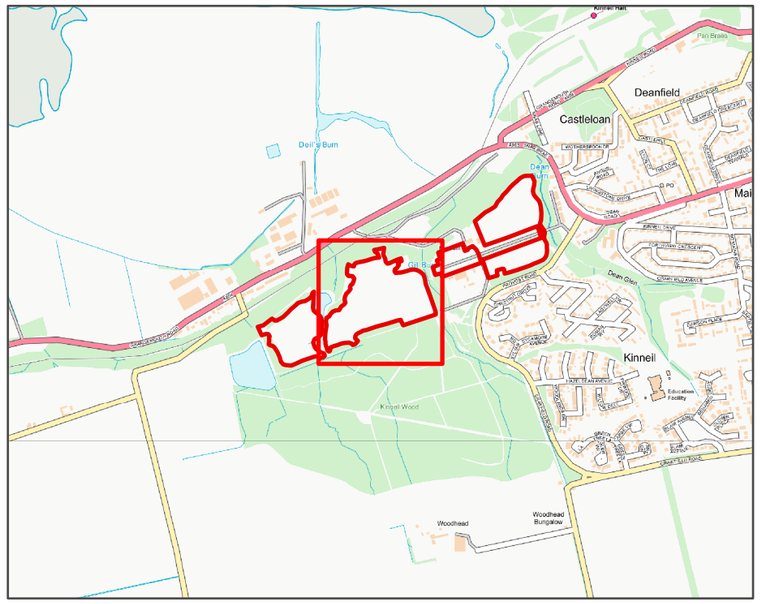
0 nT

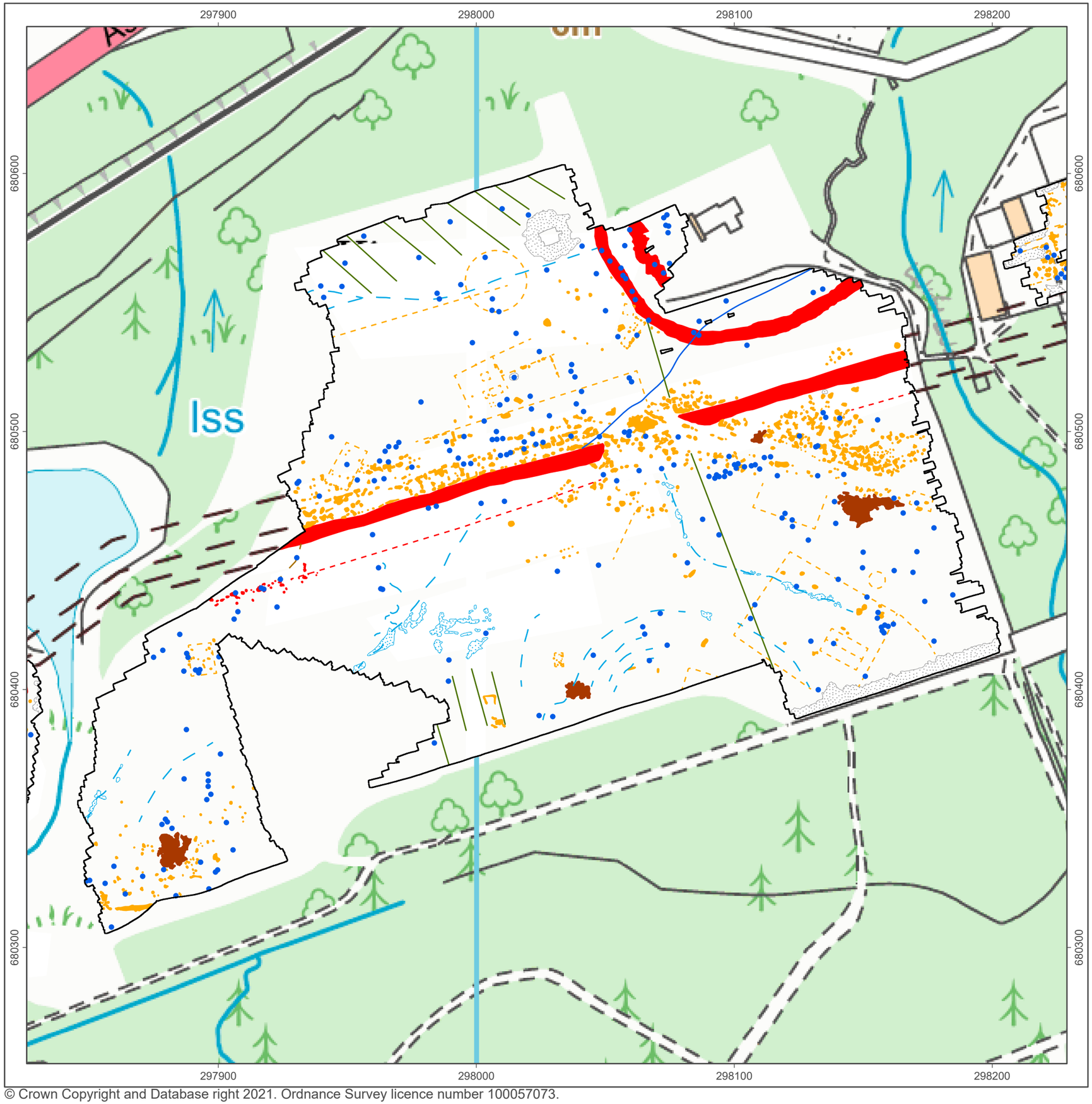
North	Scale: 1:1,500 @ A3	Datum: OSGB 1936

Metres 0 25 50 75 100

Project Name	Kinneil House
Project Code	ANTW2020KH
Prepared By	Nick Hannon
Prepared On	28/10/2021
Figure 19	Interpretation of Gradiometer Data - KH02

HISTORIC ENVIRONMENT SCOTLAND | ÀRAINNEACHD EACHDRAIDHEIL ALBA





ARCHAEOLOGICAL INTERPRETATION

- Ferrous Spike
- Geology/Fluvial
- Linear Trend (Archaeology
- Linear Trend (Possible Archaeology)
- Linear Trend (Historic Feature)
- Linear Trend (Historic Agriculture)
- Linear Trend (Drainage)
- Area of Disturbance (Modern)
- Geology/Fluvial
- Enhanced Magnetism (Archaeology)
- Enhanced Magnetism (Possible Archaeology)
- Enhanced Magnetism (Area of Burning)

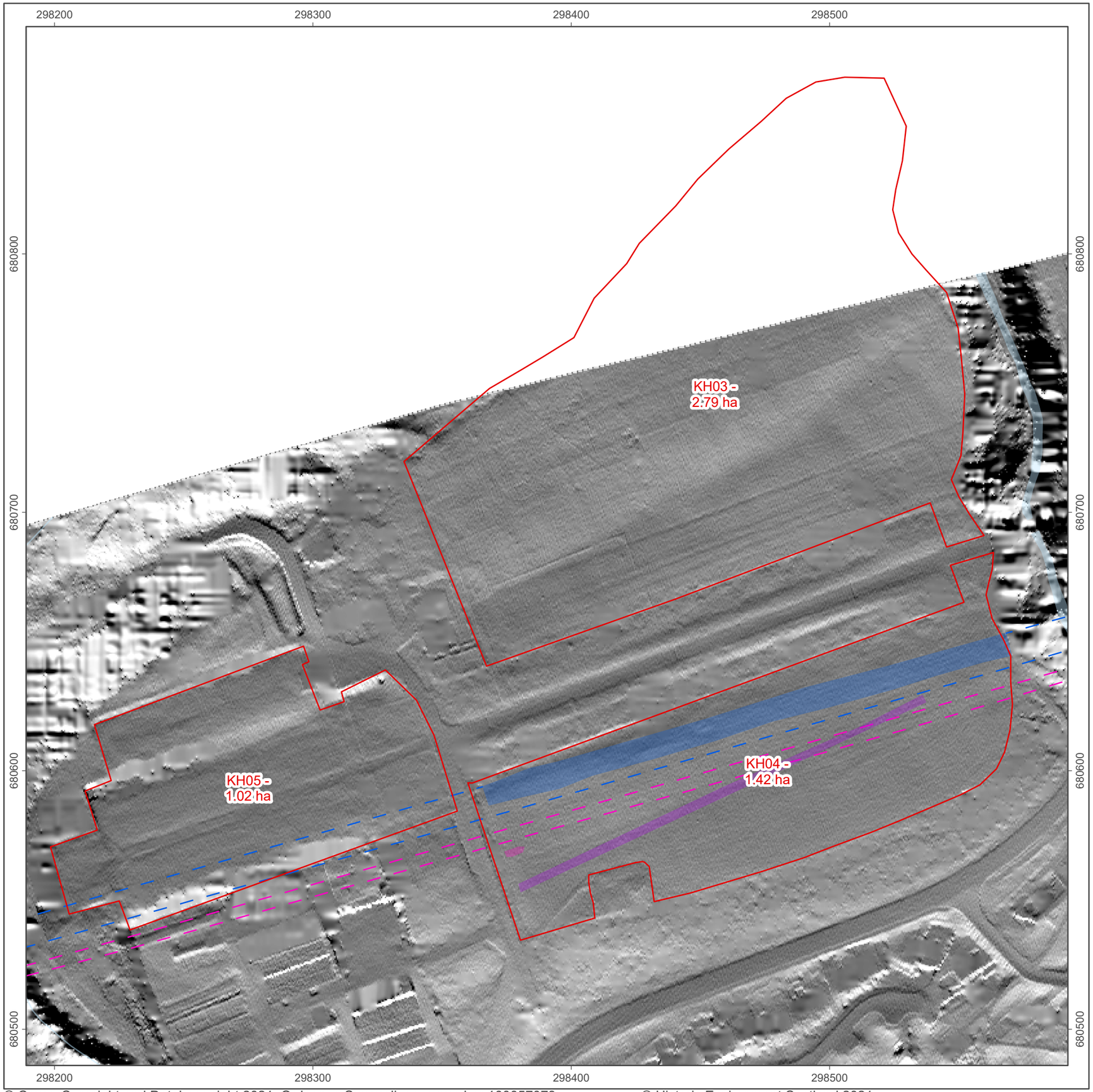
North	Scale: 1:1,500 @ A3	Datum: OSGB 1936

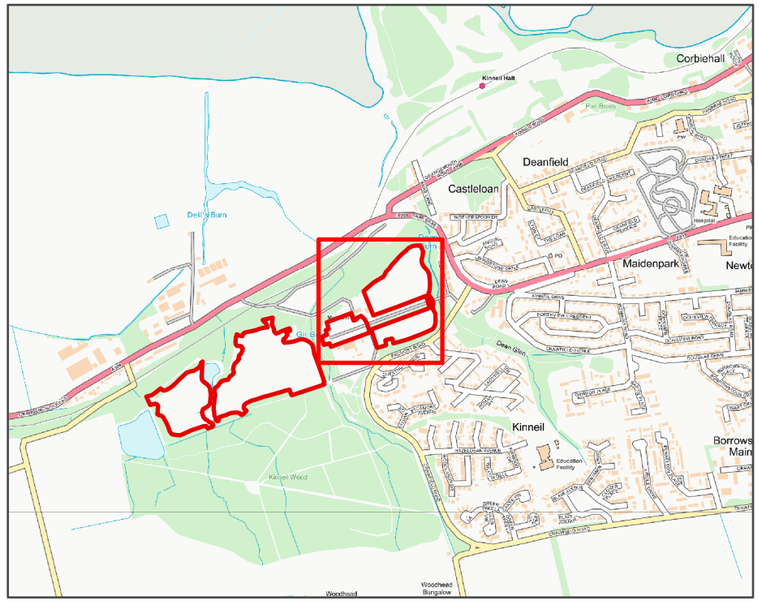
Metres
0 25 50 75 100

Project Name	Kinneil House
Project Code	ANTW2020KH
Prepared By	Nick Hannon
Prepared On	27/10/2021

HISTORIC ENVIRONMENT SCOTLAND | ÀRAINNEACHD EACHDRAIDHEIL ALBA

Figure 20 Historic Environment Scotland Commissioned LiDAR Data - KH03, KH04, & KH05





GEOPHYSICAL SURVEY
- Survey Area

THE ANTONINE WALL
- Rampart
- Military Way
- Ditch
- Rampart - projected
- Ditch - projected

Resolution (metres)	0.50
Visualisation	Multi Direction Hillshade
Directions	64
Altitude (degrees)	35
Azimuth (degrees)	N/A
Stretch	Standard Deviation
Standard Deviations	2
Gamma	1
Z-Factor	1

North

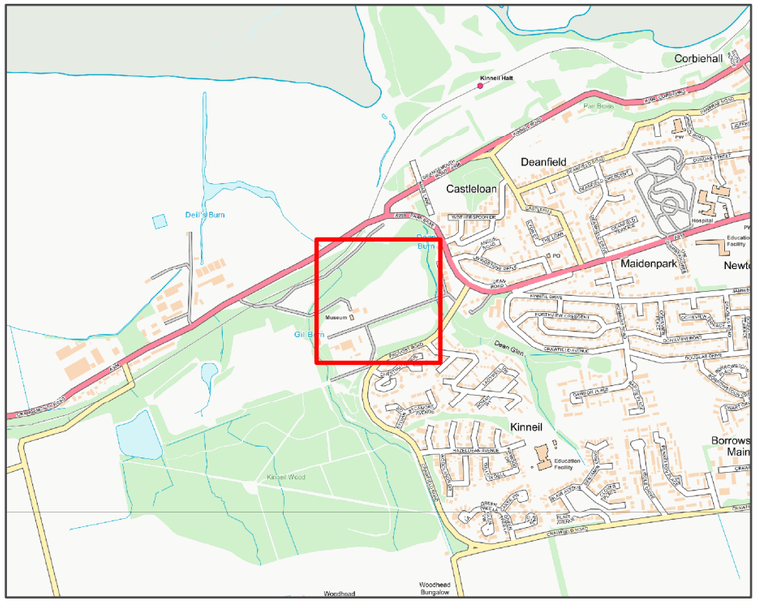
Scale: 1:1,500 @ A3

Datum: OSGB 1936

Metres
0 25 50 75 100

Project Name	Kinneil House
Project Code	ANTW2020KH
Prepared By	Nick Hannon
Prepared On	10/11/2021
Figure 21	Historic Environment Scotland Commissioned Orthographic Photograph - KH03, KH04, & KH05

HISTORIC ENVIRONMENT SCOTLAND | ÀRAINNEACHD EACHDRAIDHEIL ALBA



GEOPHYSICAL SURVEY

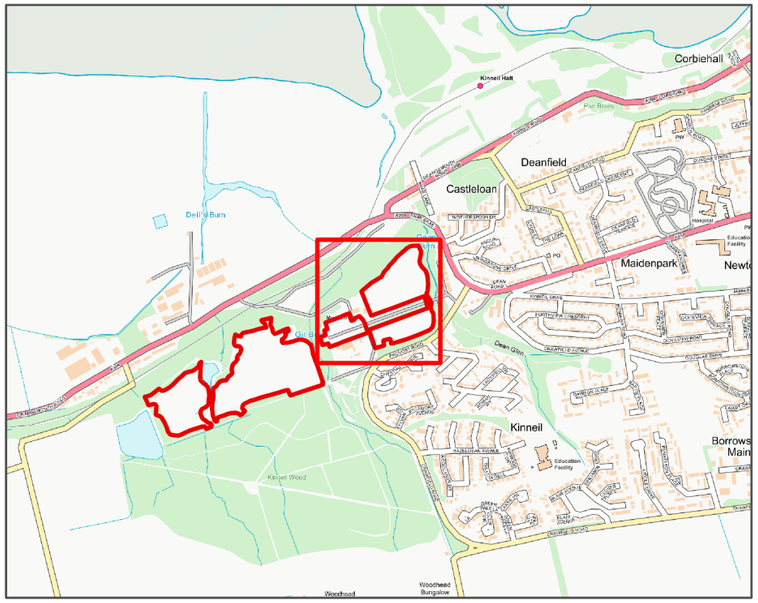
Survey Area

North	Scale: 1:1,500 @ A3	Datum: OSGB 1936
	Metres 0 25 50 75 100	

Project Name	Kinneil House
Project Code	ANTW2020KH
Prepared By	Nick Hannon
Prepared On	10/11/2021

HISTORIC ENVIRONMENT SCOTLAND | ÀRAINNEACHD EACHDRAIDHEIL ALBA

Figure 22 Gradiometer Survey GNSS Swaths & Calibration Position - KH03, KH04, & KH05



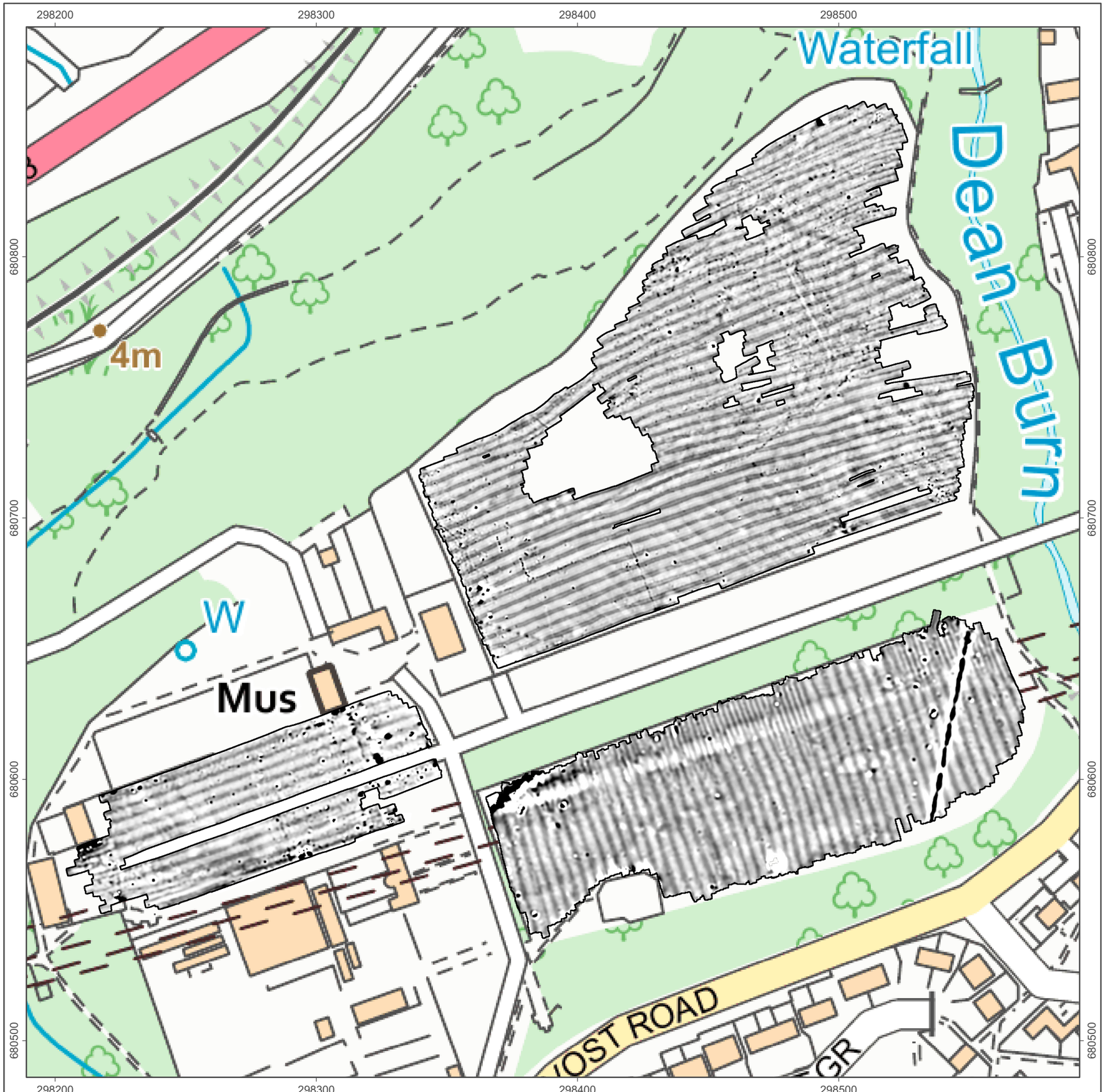
GEOPHYSICAL SURVEY

Survey Metadata

- Calibration Position
- GNSS Breadcrumb
- Survey Area
- Unsurveyable

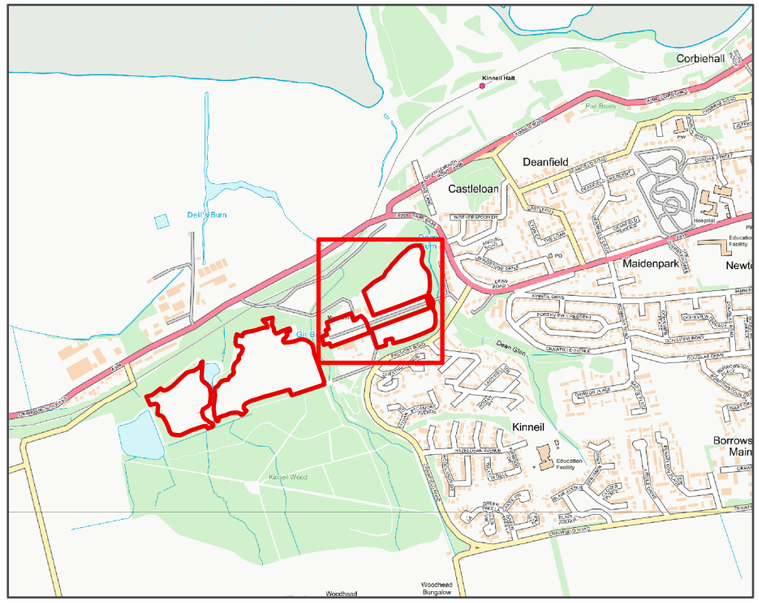
North	Scale: 1:1,500 @ A3	Datum: OSGB 1936

Metres 0 25 50 75 100



Project Name	Kinneil House
Project Code	ANTW2020KH
Prepared By	Nick Hannon
Prepared On	27/10/2021
Figure 23	Minimally Processed Gradiometer Data - Greyscale Plot - KH03, KH04, & KH05

HISTORIC ENVIRONMENT SCOTLAND | ÀRAINNEACHD EACHDRAIDHEIL ALBA



GREYSCALE PLOT

Value

50

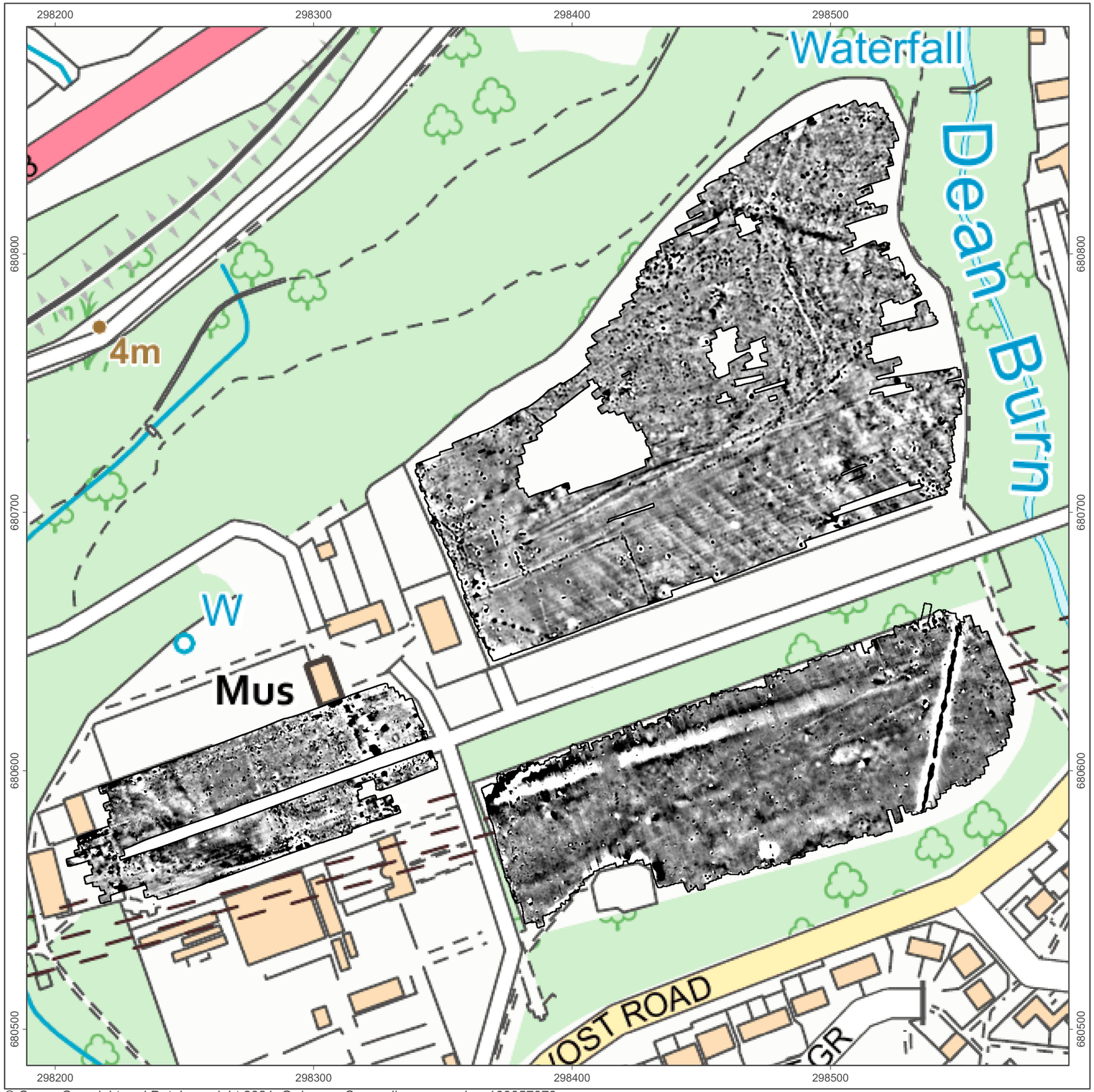
-50

Cell size (m)	0.12
Stretch	Standard Deviation
Standard Deviations	2
Gamma	1

North	Scale: 1:1,500 @ A3	Datum: OSGB 1936

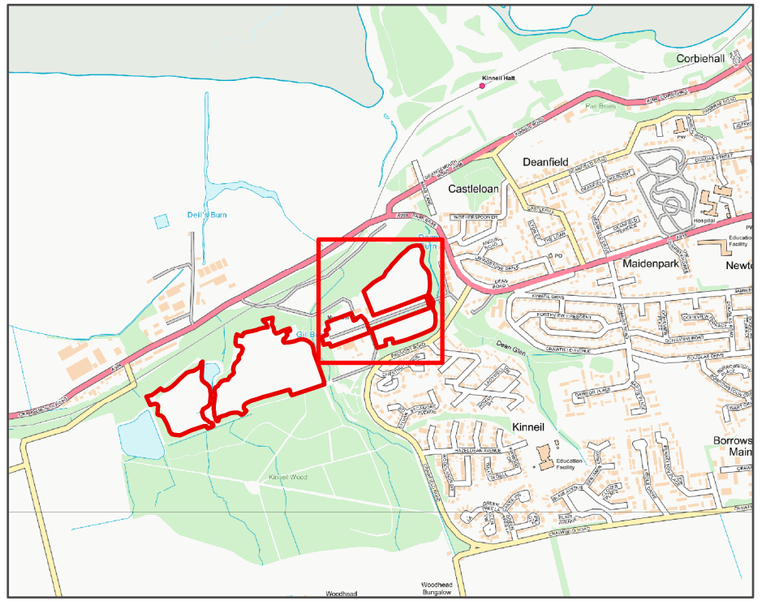
Metres

0 25 50 75 100



Project Name	Kinneil House
Project Code	ANTW2020KH
Prepared By	Nick Hannon
Prepared On	28/10/2021
Figure 24	Processed Gradiometer Data - Greyscale Plot - KH03, KH04, & KH05

HISTORIC ENVIRONMENT SCOTLAND | ÀRAINNEACHD EACHDRAIDHEIL ALBA



GREYSCALE PLOT

Value

22

-22

Cell size (m)	0.12
Stretch	Standard Deviation
Standard Deviations	2
Gamma	1

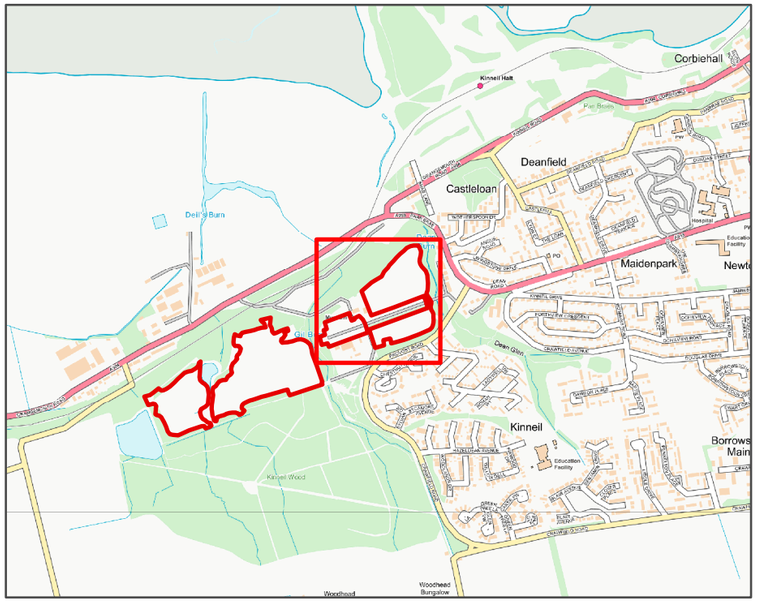
North	Scale: 1:1,500 @ A3	Datum: OSGB 1936

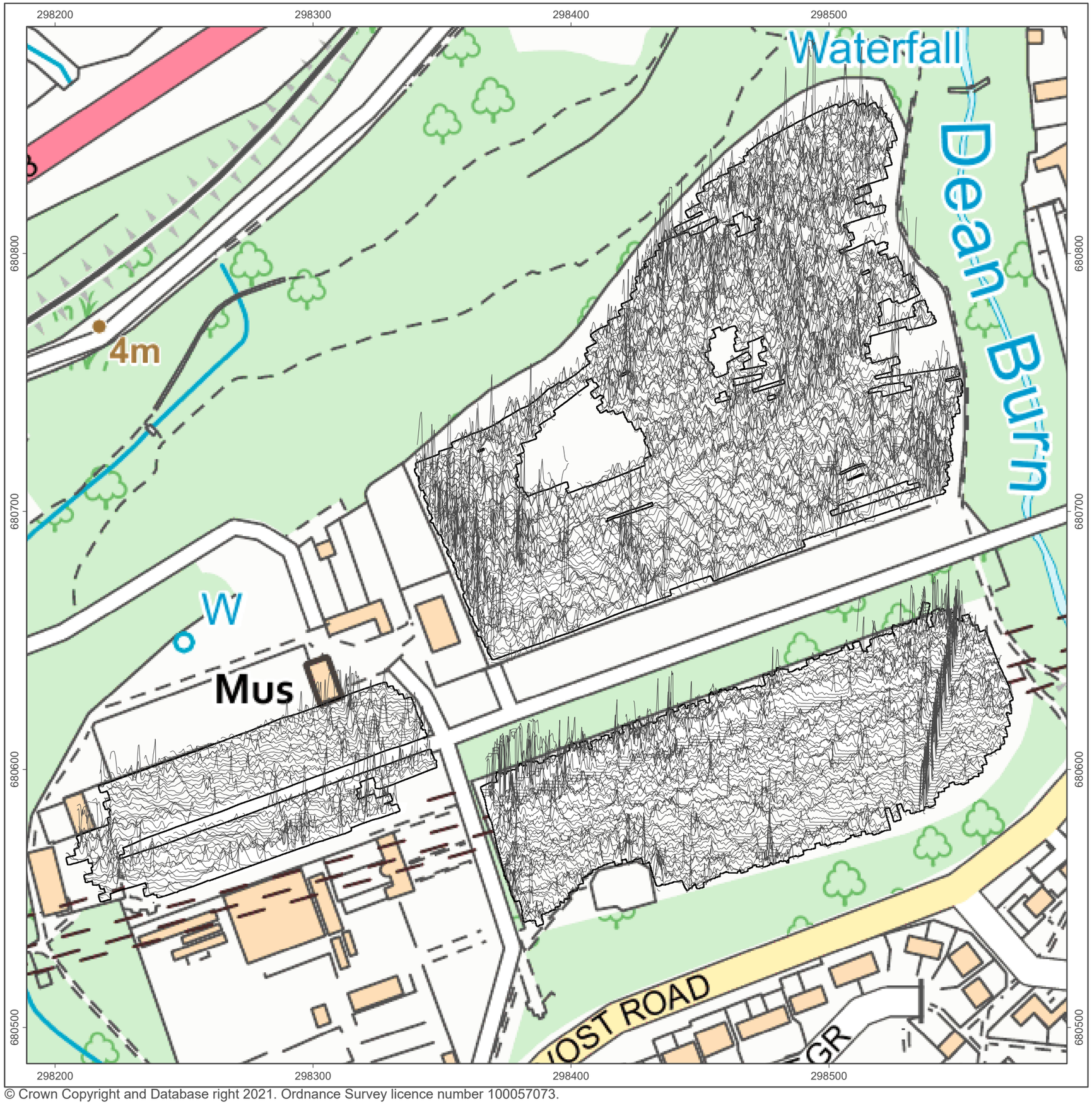
Metres

0 25 50 75 100

Project Name	Kinneil House
Project Code	ANTW2020KH
Prepared By	Nick Hannon
Prepared On	28/10/2021
Figure 25	XY Trace Plot of Gradiometer Data - KH03, KH04, & KH05

HISTORIC ENVIRONMENT SCOTLAND | ÀRAINNEACHD EACHDRAIDHEIL ALBA





GEOPHYSICAL SURVEY

XY Trace Plot

100 nT

50 nT

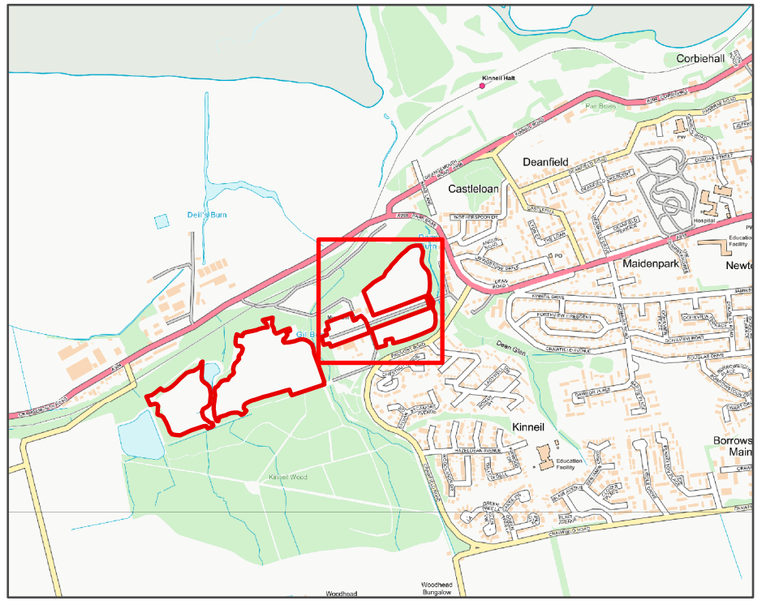
0 nT

North	Scale: 1:1,500 @ A3	Datum: OSGB 1936

Metres 0 25 50 75 100

Project Name	Kinneil House
Project Code	ANTW2020KH
Prepared By	Nick Hannon
Prepared On	28/10/2021
Figure 26	Interpretation of Gradiometer Data - KH03, KH04, & KH05

HISTORIC ENVIRONMENT SCOTLAND | ÀRAINNEACHD EACHDRAIDHEIL ALBA

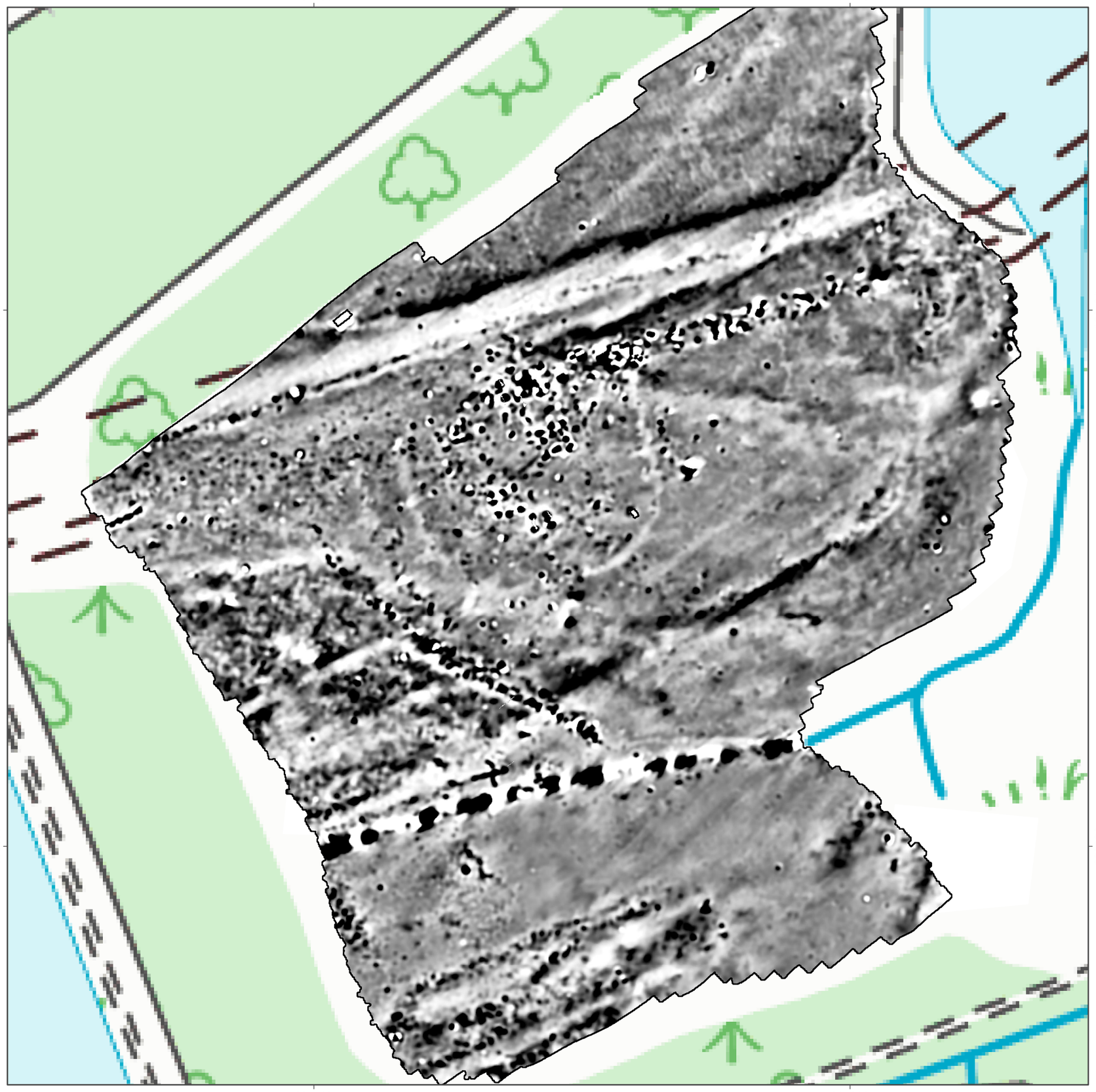


ARCHAEOLOGICAL INTERPRETATION

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

North	Scale: 1:1,500 @ A3	Datum: OSGB 1936

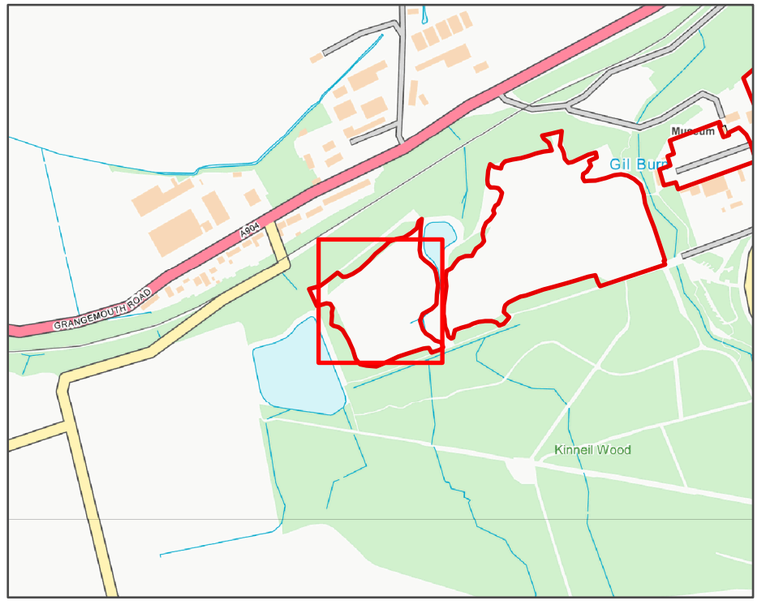
Metres 0 25 50 75 100



Project Name	Kinneil House
Project Code	ANTW2020KH
Prepared By	Nick Hannon
Prepared On	28/10/2021

HISTORIC ENVIRONMENT SCOTLAND | ÀRAINNEACHD EACHDRAIDHEIL ALBA

Figure 27 Processed Gradiometer Data - Greyscale Plot - KH01



GREYSCALE PLOT

Value

22

-22

Cell size (m)	0.12
Stretch	Standard Deviation
Standard Deviations	2
Gamma	1

North

Scale: 1:750 @ A3

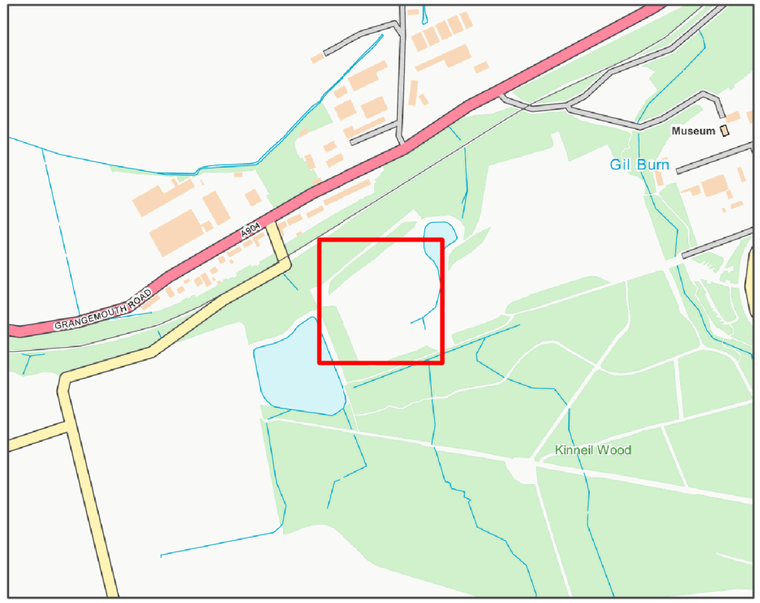
Datum: OSGB 1936

Metres

0 10 20 30 40

Project Name	Kinneil House
Project Code	ANTW2020KH
Prepared By	Nick Hannon
Prepared On	25/02/2022
Figure28	Interpretation of Gradiometer Data - KH01

HISTORIC ENVIRONMENT SCOTLAND | ÀRAINNEACHD EACHDRAIDHEIL ALBA

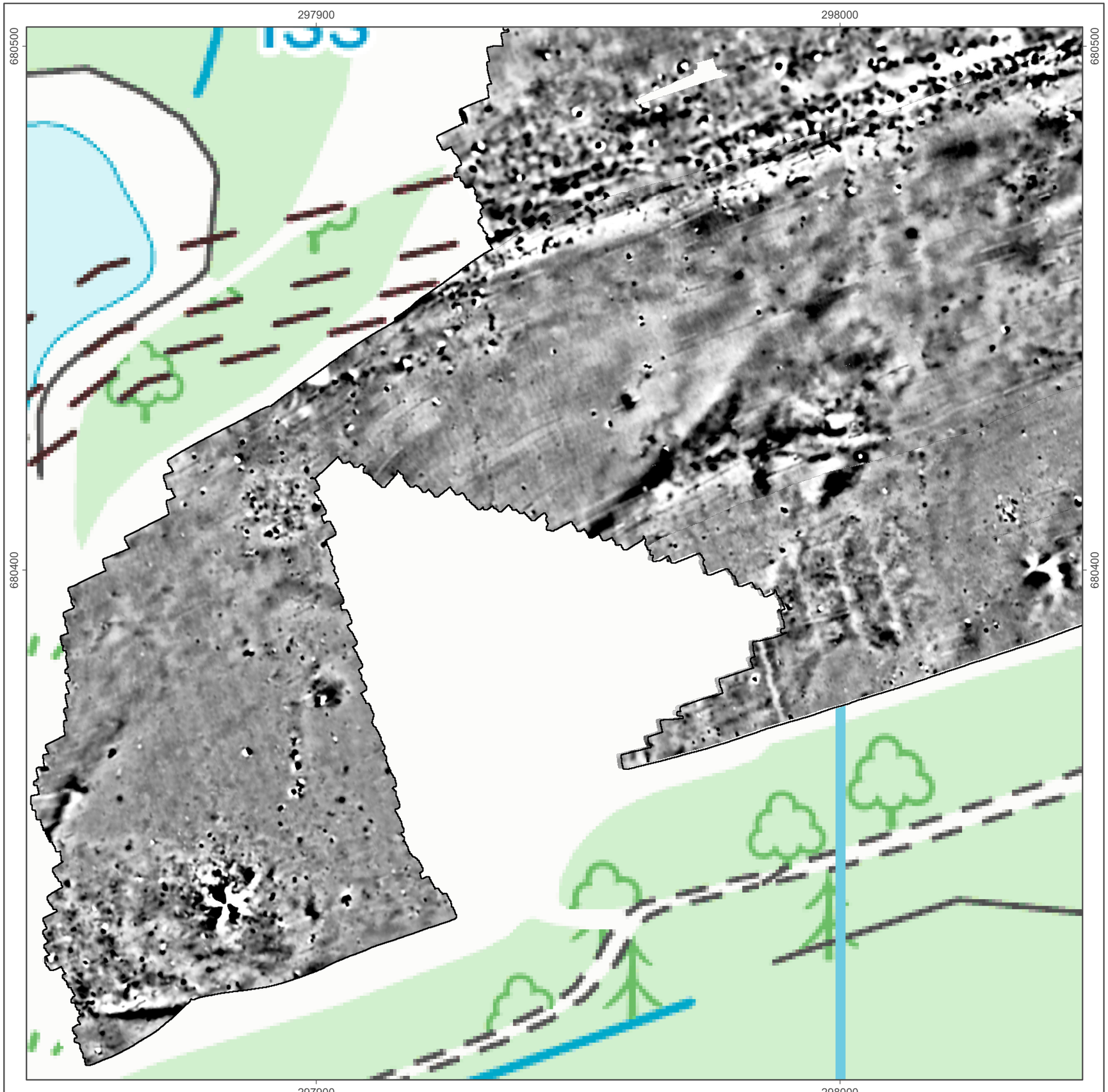


ARCHAEOLOGICAL INTERPRETATION

- Ferrous Spike
- Geology/Fluvial
- Linear Trend (Archaeology
- Linear Trend (Possible Archaeology)
- Linear Trend (Drainage)
- Linear Trend (Utility)
- Area of Disturbance (Modern)
- Geology/Fluvial
- Enhanced Magnetism (Archaeology)
- Enhanced Magnetism (Possible Archaeology)
- Enhanced Magnetism (Area of Burning)
- Enhanced Magnetism (Utility)

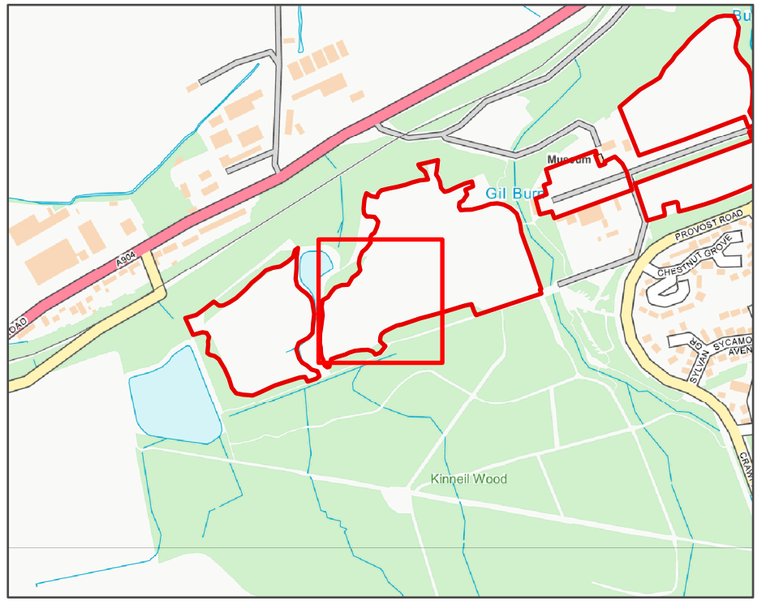
North	Scale: 1:750 @ A3	Datum: OSGB 1936

Metres 0 10 20 30 40



Project Name	Kinneil House
Project Code	ANTW2020KH
Prepared By	Nick Hannon
Prepared On	28/10/2021
Figure 29	Processed Gradiometer Data - Greyscale Plot - KH02 - West

HISTORIC ENVIRONMENT SCOTLAND | ÀRAINNEACHD EACHDRAIDHEIL ALBA



GREYSCALE PLOT

Value

22

-22

Cell size (m)	0.12
Stretch	Standard Deviation
Standard Deviations	2
Gamma	1

North

Scale: 1:750 @ A3

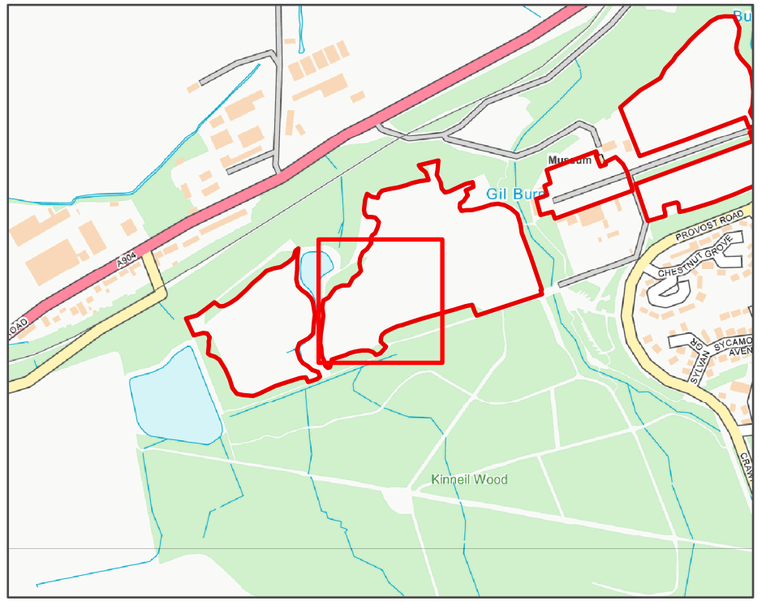
Datum: OSGB 1936

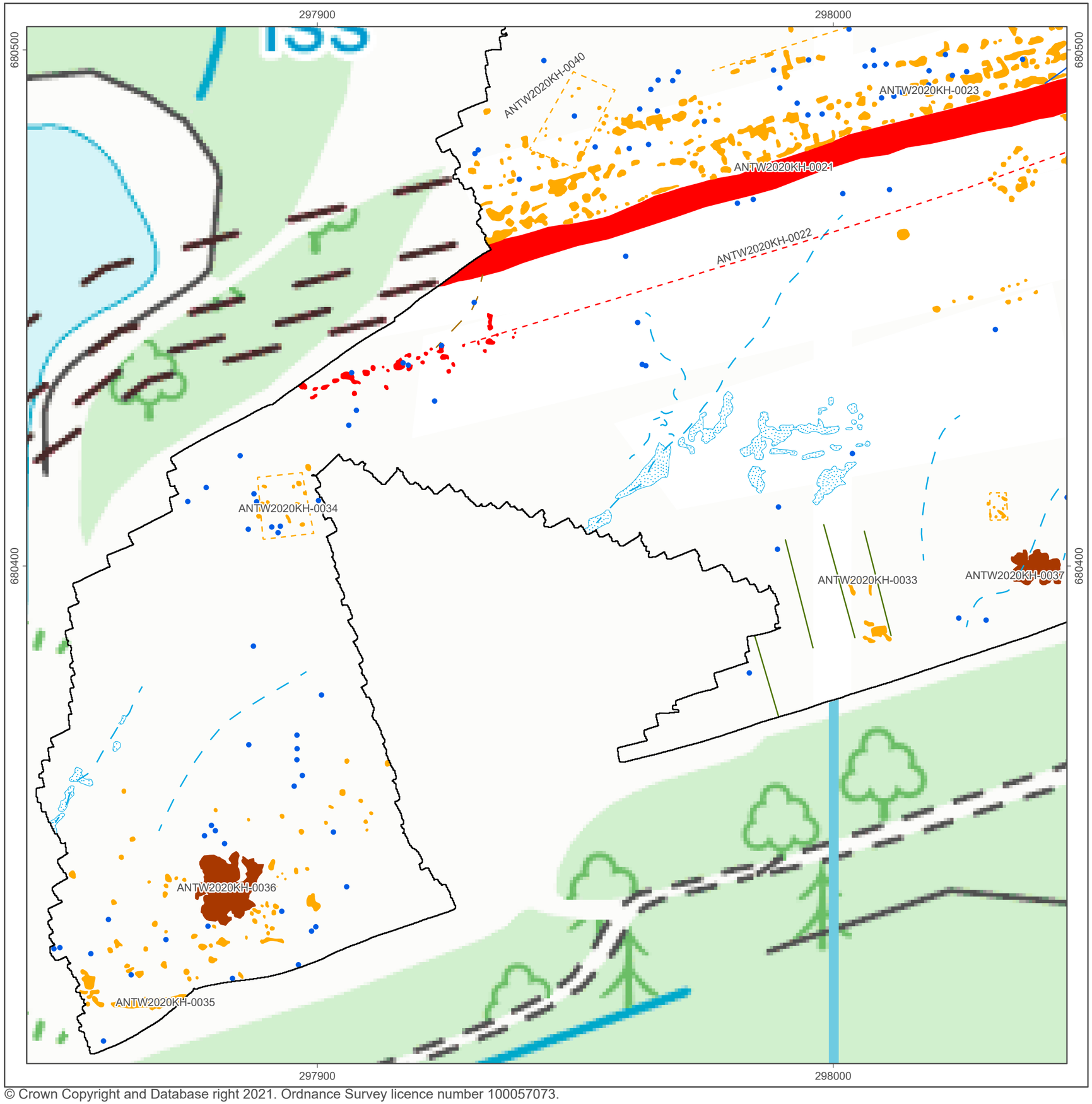
Metres

0 10 20 30 40

Project Name	Kinneil House
Project Code	ANTW2020KH
Prepared By	Nick Hannon
Prepared On	09/11/2021
Figure 30	Interpretation of Gradiometer Data - KH02 - West

HISTORIC ENVIRONMENT SCOTLAND | ÀRAINNEACHD EACHDRAIDHEIL ALBA





ARCHAEOLOGICAL INTERPRETATION

- Ferrous Spike
- Geology/Fluvial
- Linear Trend (Archaeology
- Linear Trend (Possible Archaeology)
- Linear Trend (Historic Feature)
- Linear Trend (Historic Agriculture)
- Linear Trend (Drainage)
- Geology/Fluvial
- Enhanced Magnetism (Archaeology)
- Enhanced Magnetism (Possible Archaeology)
- Enhanced Magnetism (Area of Burning)

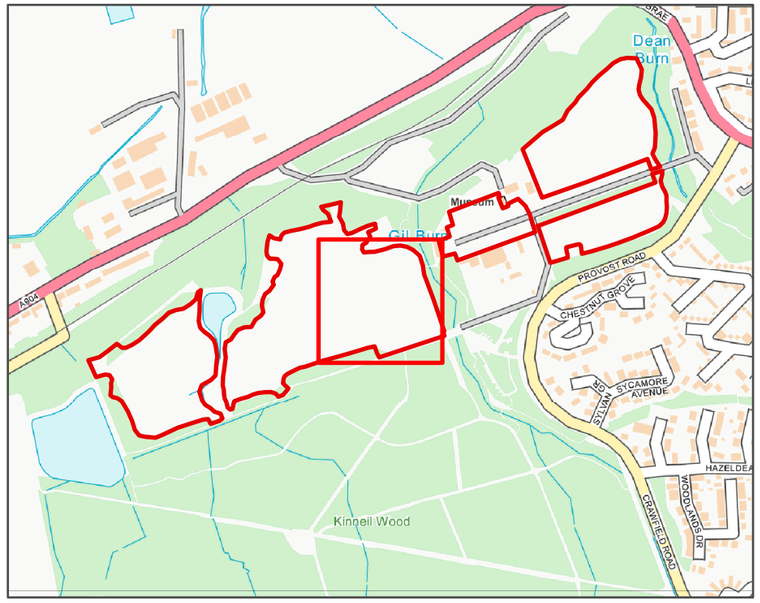
North	Scale: 1:750 @ A3	Datum: OSGB 1936

Metres 0 10 20 30 40

Project Name	Kinneil House
Project Code	ANTW2020KH
Prepared By	Nick Hannon
Prepared On	28/10/2021

HISTORIC ENVIRONMENT SCOTLAND | ÀRAINNEACHD EACHDRAIDHEIL ALBA

Figure 31 Processed Gradiometer Data - Greyscale Plot - KH02 - East



GREYSCALE PLOT

Value

22

-22

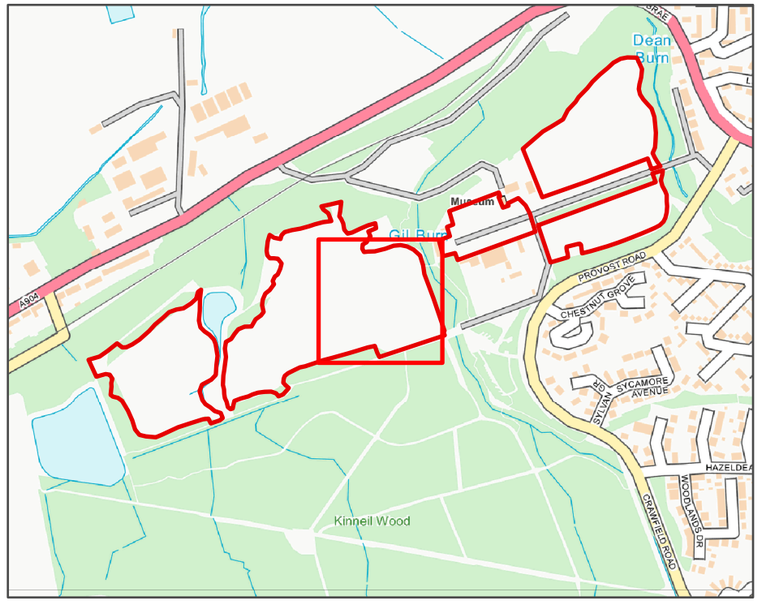
Cell size (m)	0.12
Stretch	Standard Deviation
Standard Deviations	2
Gamma	1

North	Scale: 1:750 @ A3	Datum: OSGB 1936

Metres 0 10 20 30 40

Project Name	Kinneil House
Project Code	ANTW2020KH
Prepared By	Nick Hannon
Prepared On	09/11/2021
Figure 32	Interpretation of Gradiometer Data - KH02 - East

HISTORIC ENVIRONMENT SCOTLAND | ÀRAINNEACHD EACHDRAIDHEIL ALBA

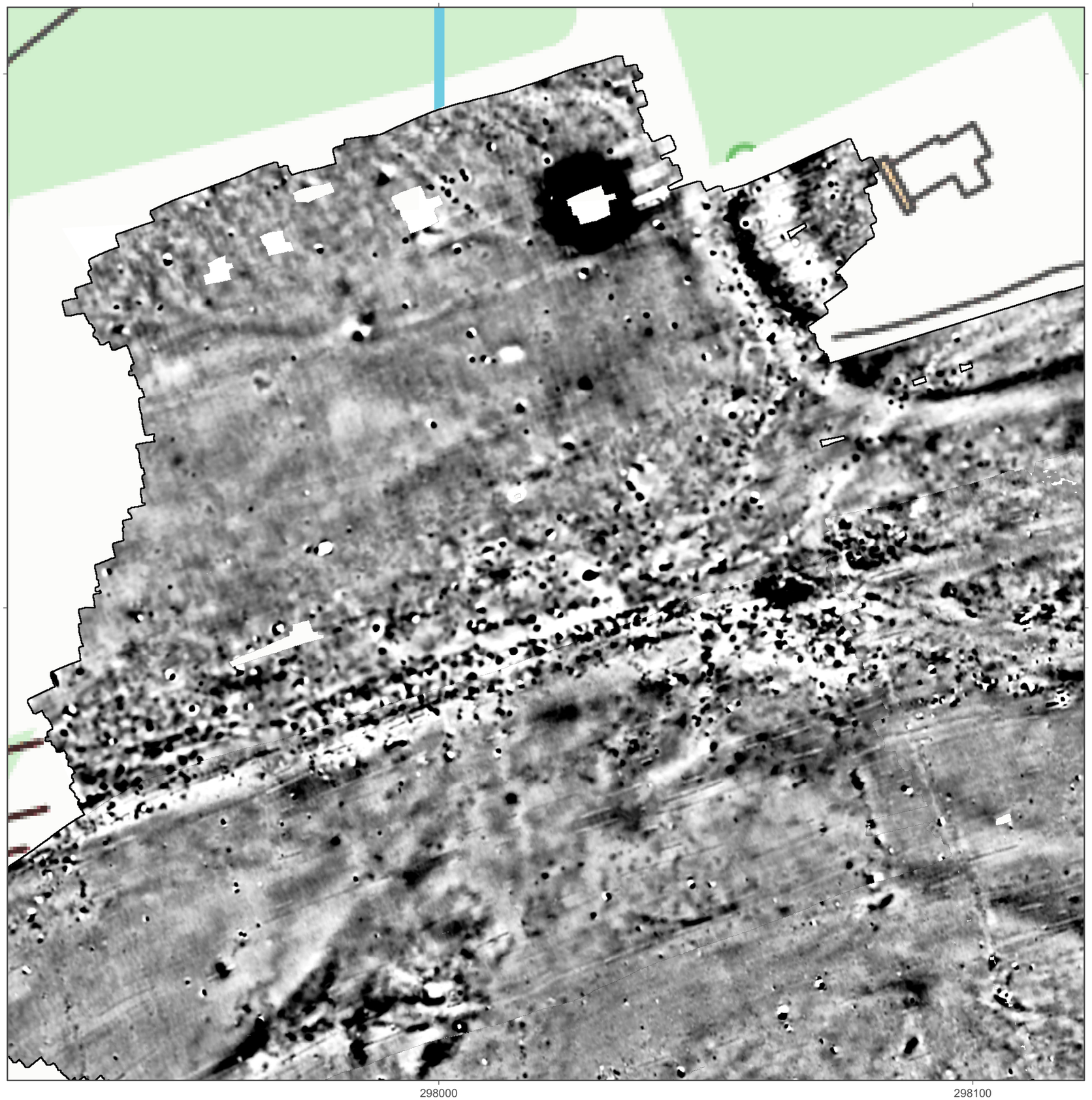


ARCHAEOLOGICAL INTERPRETATION

- Ferrous Spike
- Geology/Fluvial
- Linear Trend (Archaeology
- Linear Trend (Possible Archaeology)
- Linear Trend (Historic Feature)
- Linear Trend (Historic Agriculture)
- Area of Disturbance (Modern)
- Geology/Fluvial
- Enhanced Magnetism (Archaeology)
- Enhanced Magnetism (Possible Archaeology)
- Enhanced Magnetism (Area of Burning)

North	Scale: 1:750 @ A3	Datum: OSGB 1936

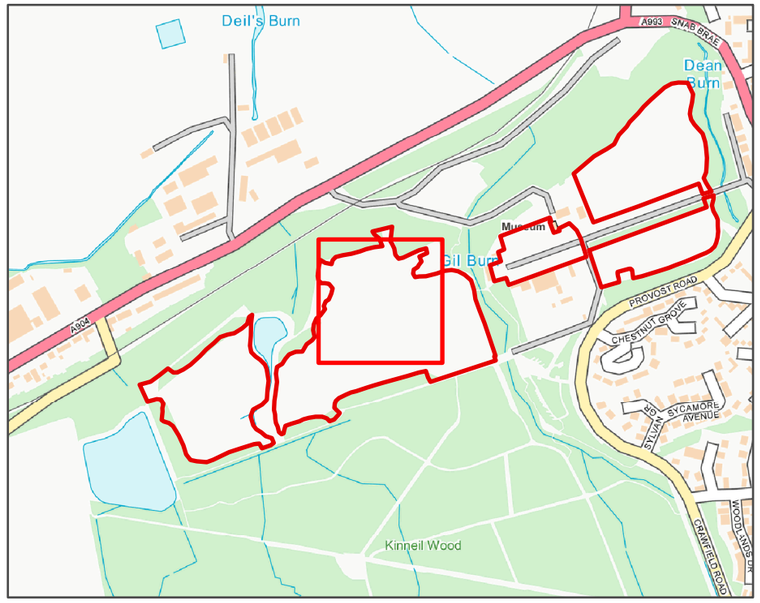
Metres 0 10 20 30 40



Project Name	Kinneil House
Project Code	ANTW2020KH
Prepared By	Nick Hannon
Prepared On	28/10/2021

HISTORIC ENVIRONMENT SCOTLAND | ÀRAINNEACHD EACHDRAIDHEIL ALBA

Figure 33 Processed Gradiometer Data - Greyscale Plot - KH02 - North



GREYSCALE PLOT

Value

22

-22

Cell size (m)	0.12
Stretch	Standard Deviation
Standard Deviations	2
Gamma	1

North

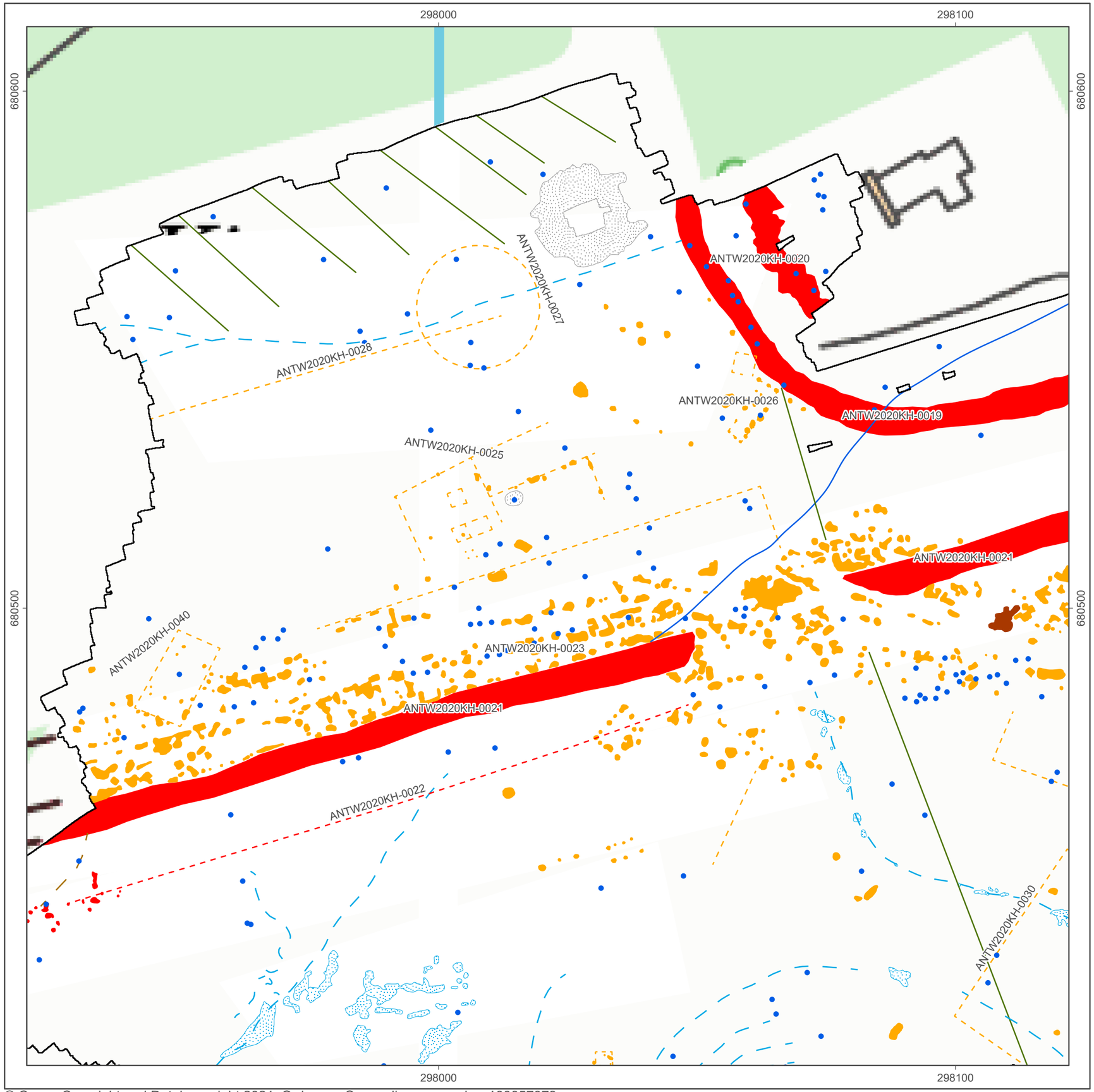
Scale: 1:750 @ A3

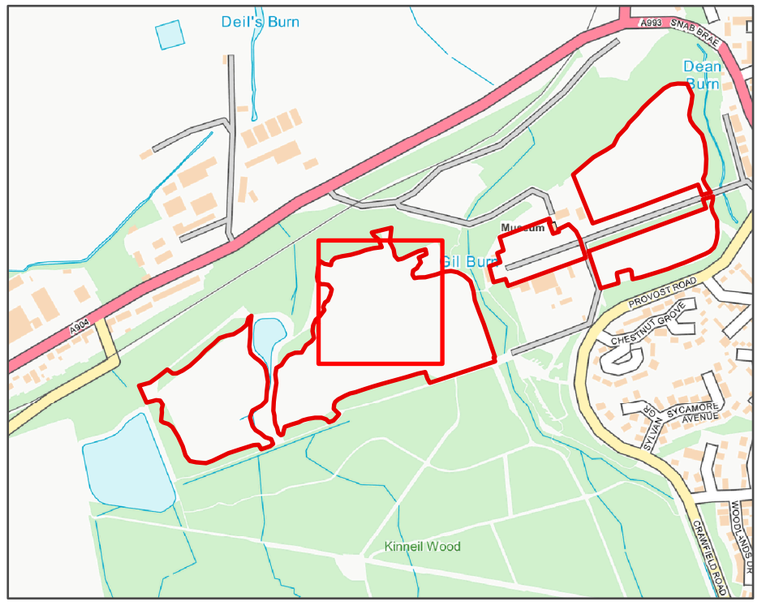
Datum: OSGB 1936

Metres 0 10 20 30 40

Project Name	Kinneil House
Project Code	ANTW2020KH
Prepared By	Nick Hannon
Prepared On	09/11/2021
Figure 34	Interpretation of Gradiometer Data - KH02 - North

HISTORIC ENVIRONMENT SCOTLAND | ÀRAINNEACHD EACHDRAIDHEIL ALBA





ARCHAEOLOGICAL INTERPRETATION

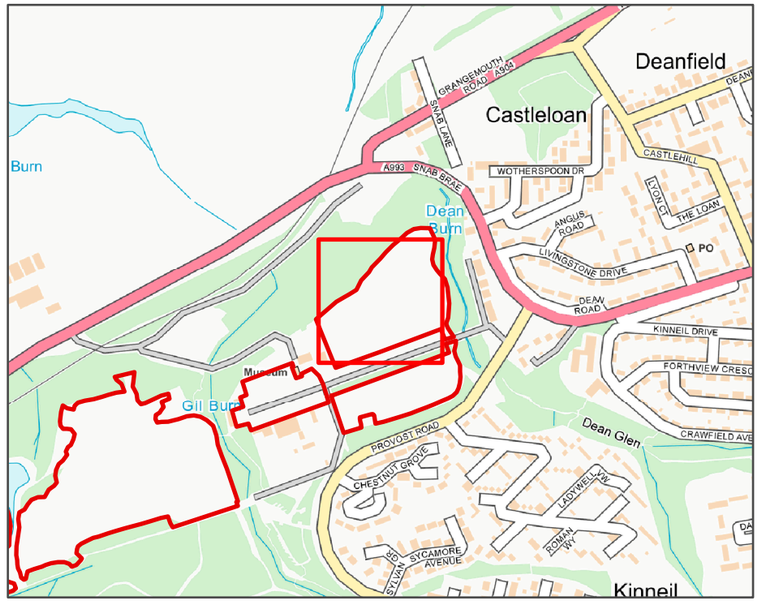
- Ferrous Spike
- Geology/Fluvial
- Linear Trend (Archaeology
- Linear Trend (Possible Archaeology)
- Linear Trend (Historic Feature)
- Linear Trend (Historic Agriculture)
- Linear Trend (Drainage)
- Area of Disturbance (Modern)
- Geology/Fluvial
- Enhanced Magnetism (Archaeology)
- Enhanced Magnetism (Possible Archaeology)
- Enhanced Magnetism (Area of Burning)

North	Scale: 1:750 @ A3	Datum: OSGB 1936

Metres 0 10 20 30 40

Project Name	Kinneil House
Project Code	ANTW2020KH
Prepared By	Nick Hannon
Prepared On	28/10/2021
Figure 35	Processed Gradiometer Data - Greyscale Plot - KH03

HISTORIC ENVIRONMENT SCOTLAND | ÀRAINNEACHD EACHDRAIDHEIL ALBA



GREYSCALE PLOT

Value

22

-22

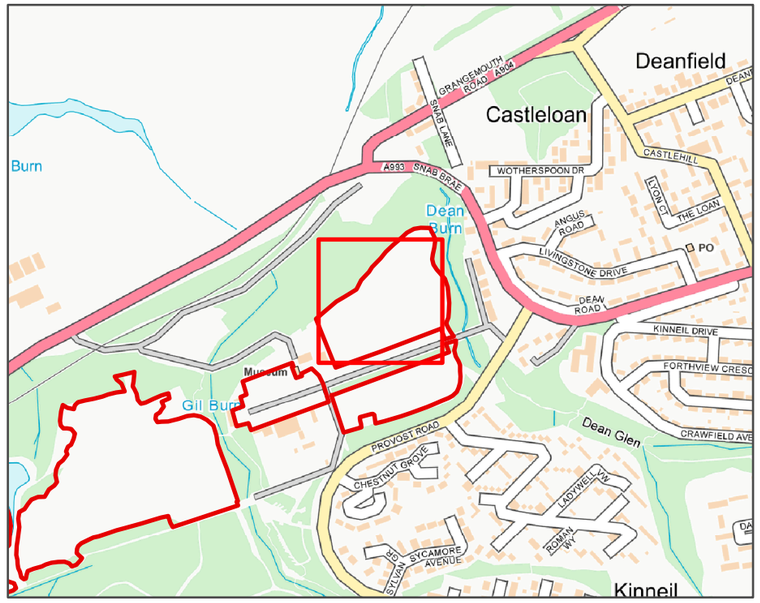
Cell size (m)	0.12
Stretch	Standard Deviation
Standard Deviations	2
Gamma	1

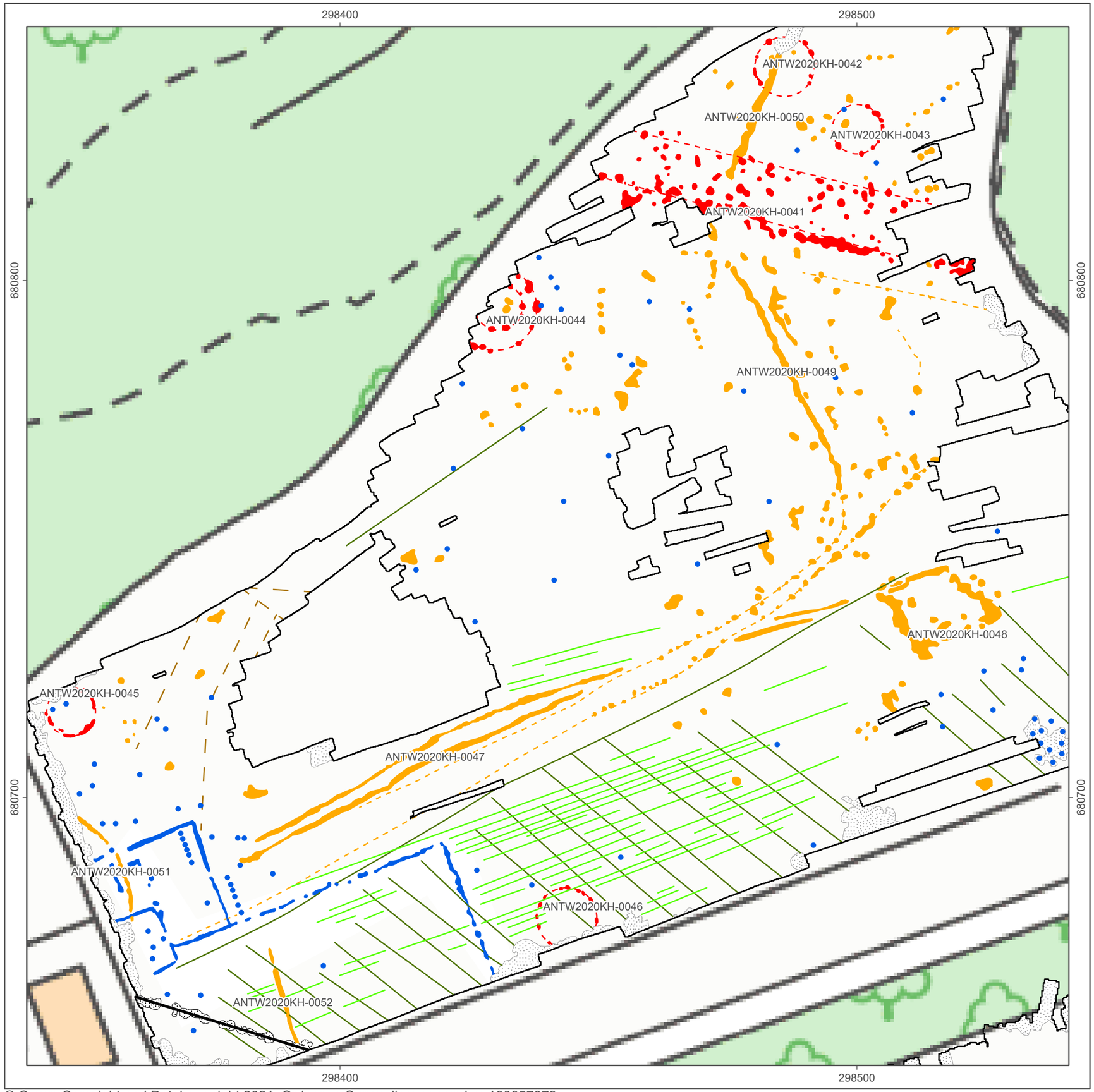
North	Scale: 1:750 @ A3	Datum: OSGB 1936

Metres 0 10 20 30 40

Project Name	Kinneil House
Project Code	ANTW2020KH
Prepared By	Nick Hannon
Prepared On	09/11/2021
Figure 36	Interpretation of Gradiometer Data - KH03

HISTORIC ENVIRONMENT SCOTLAND | ÀRAINNEACHD EACHDRAIDHEIL ALBA





ARCHAEOLOGICAL INTERPRETATION

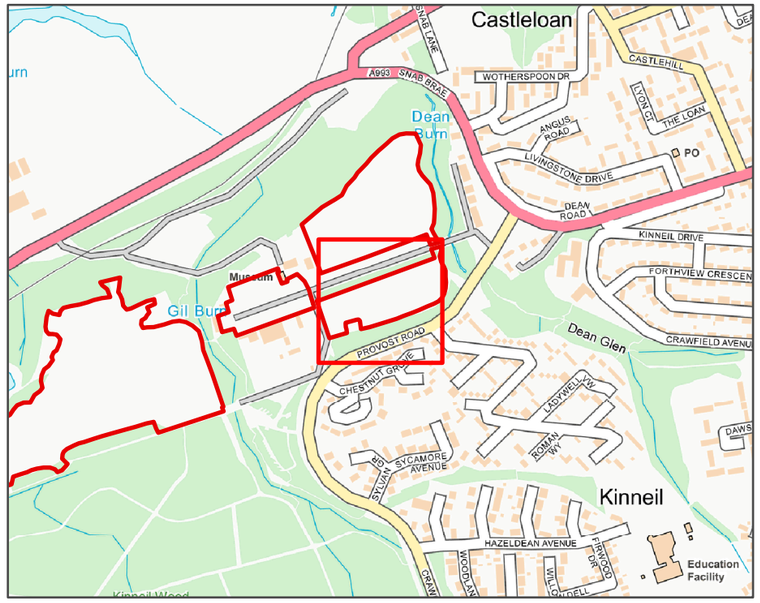
- Ferrous Spike
- Linear Trend (Archaeology)
- Linear Trend (Possible Archaeology)
- Linear Trend (Historic Agriculture)
- Linear Trend (Modern Agriculture)
- Linear Trend (Drainage)
- Linear Trend (Utility)
- Area of Disturbance (Modern)
- Enhanced Magnetism (Archaeology)
- Enhanced Magnetism (Possible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

North	Scale: 1:750 @ A3	Datum: OSGB 1936

Metres 0 10 20 30 40

Project Name	Kinneil House
Project Code	ANTW2020KH
Prepared By	Nick Hannon
Prepared On	28/10/2021
Figure 37	Processed Gradiometer Data - Greyscale Plot - KH04

HISTORIC ENVIRONMENT SCOTLAND | ÀRAINNEACHD EACHDRAIDHEIL ALBA



GREYSCALE PLOT

Value

22

-22

Cell size (m)	0.12
Stretch	Standard Deviation
Standard Deviations	2
Gamma	1

North

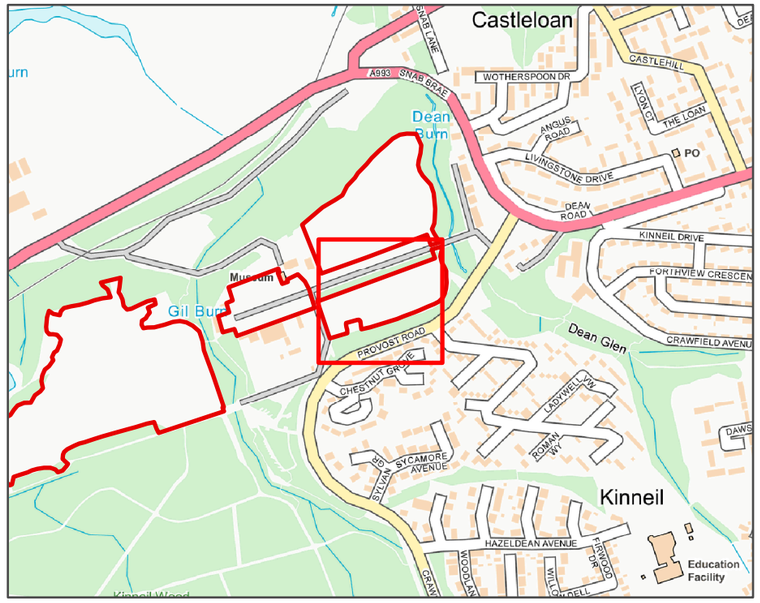
Scale: 1:750 @ A3

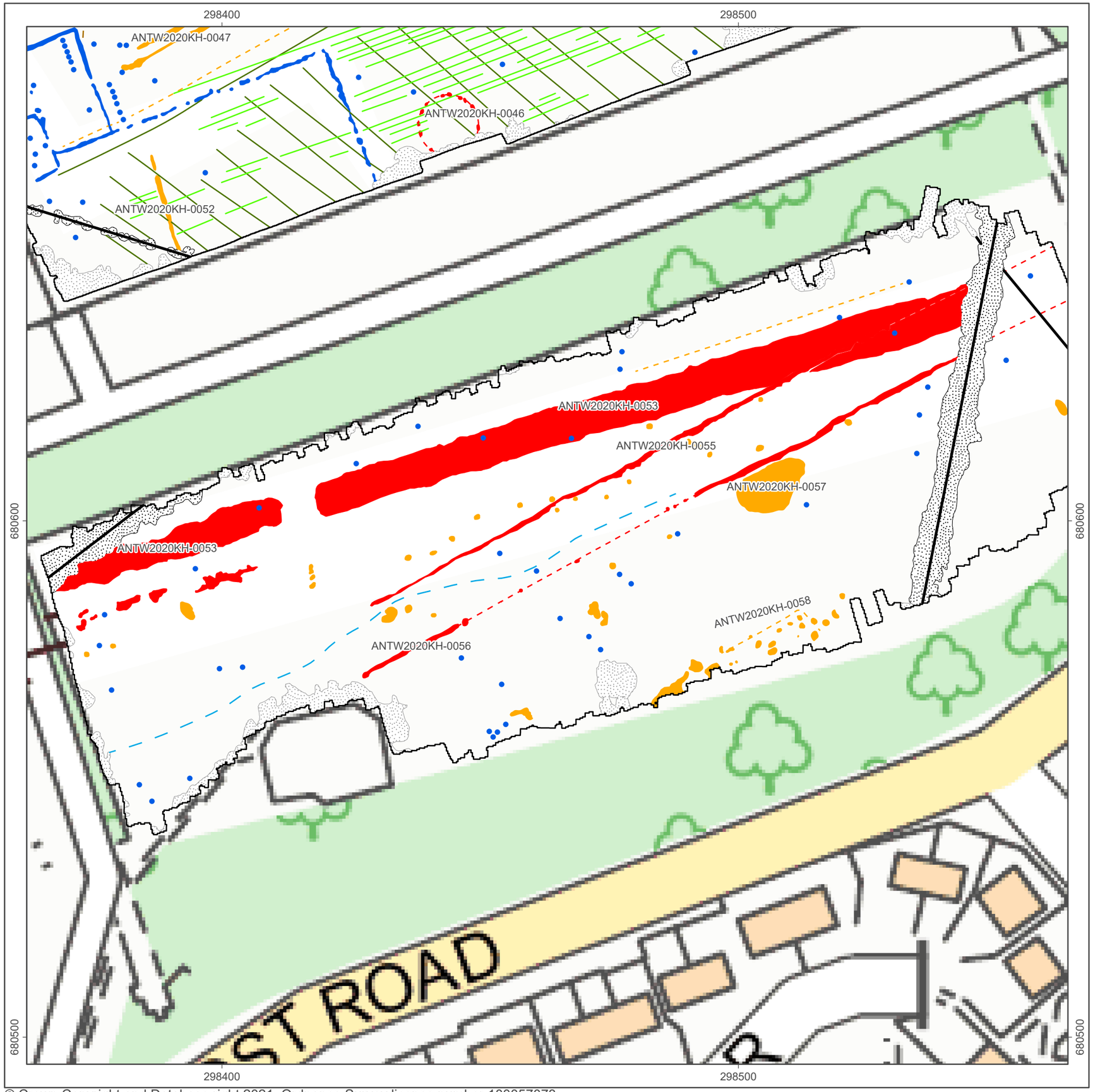
Datum: OSGB 1936

Metres 0 10 20 30 40

Project Name	Kinneil House
Project Code	ANTW2020KH
Prepared By	Nick Hannon
Prepared On	09/11/2021
Figure 38	Interpretation of Gradiometer Data - KH04

HISTORIC ENVIRONMENT SCOTLAND | ÀRAINNEACHD EACHDRAIDHEIL ALBA



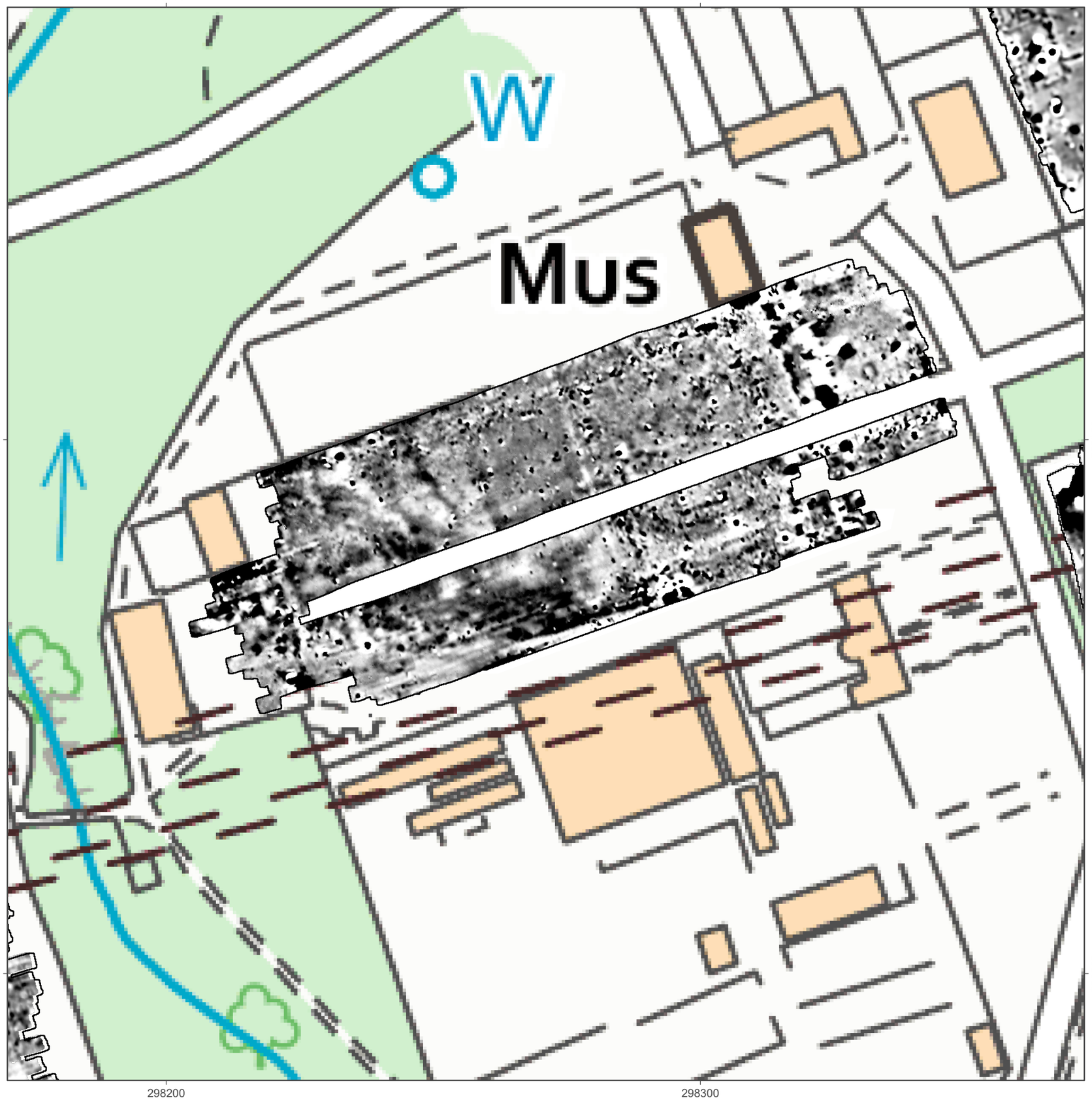


ARCHAEOLOGICAL INTERPRETATION

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

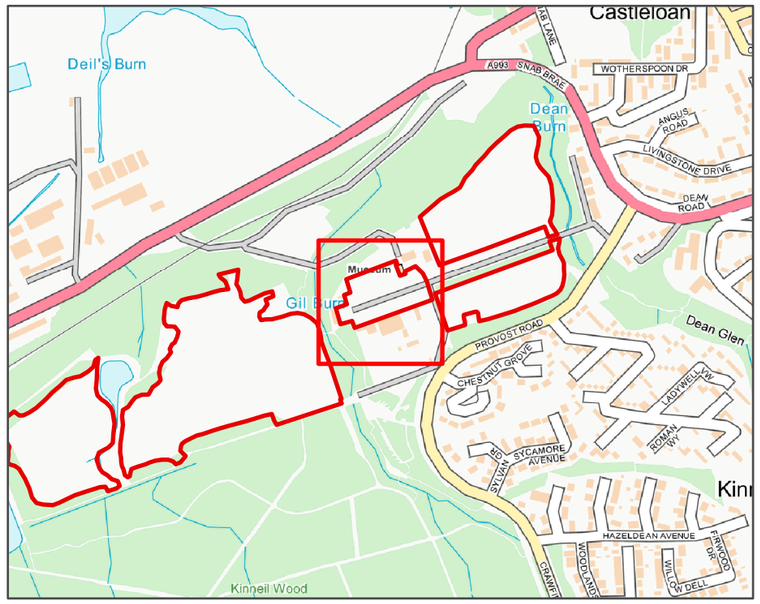
North	Scale: 1:750 @ A3	Datum: OSGB 1936

Metres 0 10 20 30 40



Project Name	Kinneil House
Project Code	ANTW2020KH
Prepared By	Nick Hannon
Prepared On	28/10/2021
Figure 39	Processed Gradiometer Data - Greyscale Plot - KH05

HISTORIC ENVIRONMENT SCOTLAND | ÀRAINNEACHD EACHDRAIDHEIL ALBA



GREYSCALE PLOT

Value

22

-22

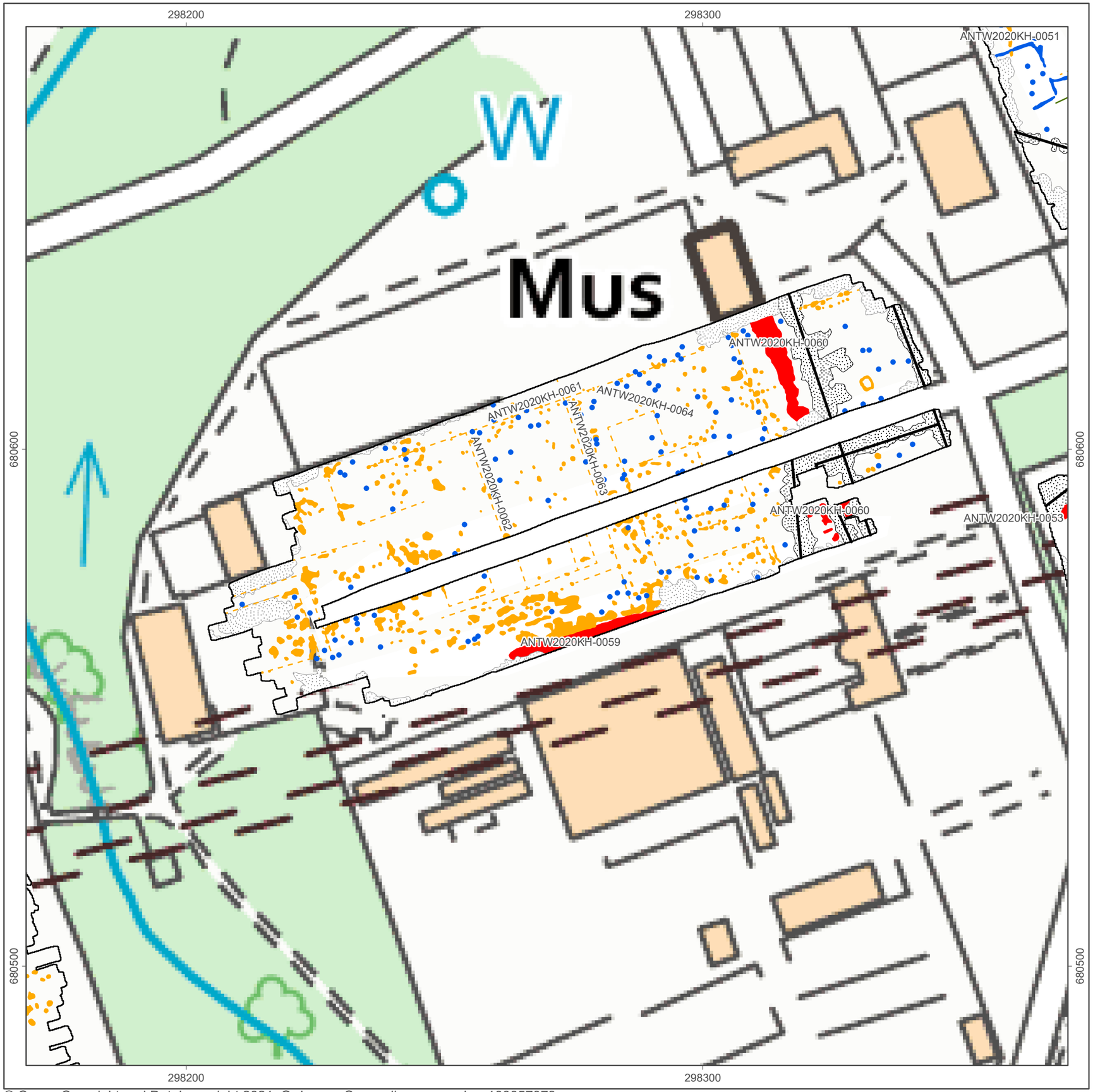
Cell size (m)	0.12
Stretch	Standard Deviation
Standard Deviations	2
Gamma	1

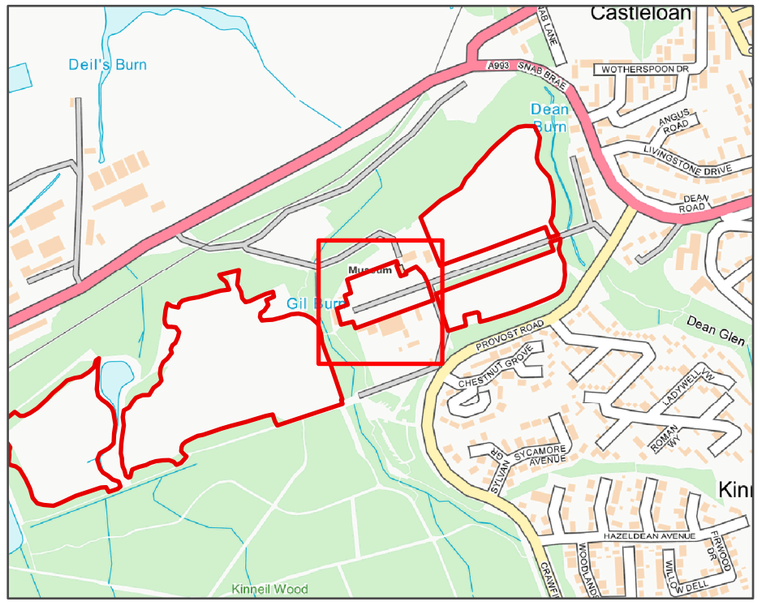
North	Scale: 1:750 @ A3	Datum: OSGB 1936

Metres 0 10 20 30 40

Project Name	Kinneil House
Project Code	ANTW2020KH
Prepared By	Nick Hannon
Prepared On	09/11/2021
Figure 40	Interpretation of Gradiometer Data - KH05

HISTORIC ENVIRONMENT SCOTLAND | ÀRAINNEACHD EACHDRAIDHEIL ALBA





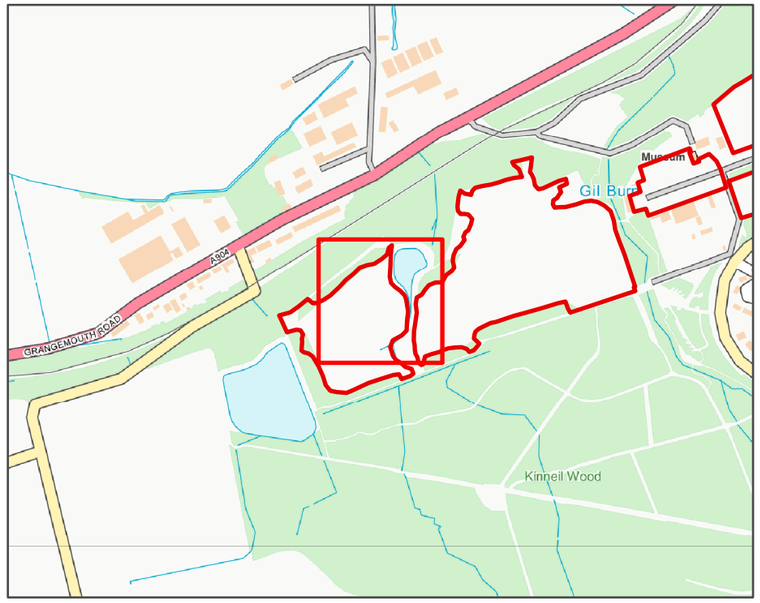
ARCHAEOLOGICAL INTERPRETATION

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

North	Scale: 1:750 @ A3	Datum: OSGB 1936
	Metres 0 10 20 30 40	

Project Name	Kinneil House
Project Code	ANTW2020KH
Prepared By	Nick Hannon
Prepared On	09/11/2021
Figure 41	Processed Conductivity Data - Greyscale Plot - KH01 - Depth 1

HISTORIC ENVIRONMENT SCOTLAND | ÀRAINNEACHD EACHDRAIDHEIL ALBA



GREYSCALE PLOT

Value

30.08

-1.43

Cell size (m)	0.12
Stretch	Standard Deviation
Standard Deviations	1.2
Gamma	1

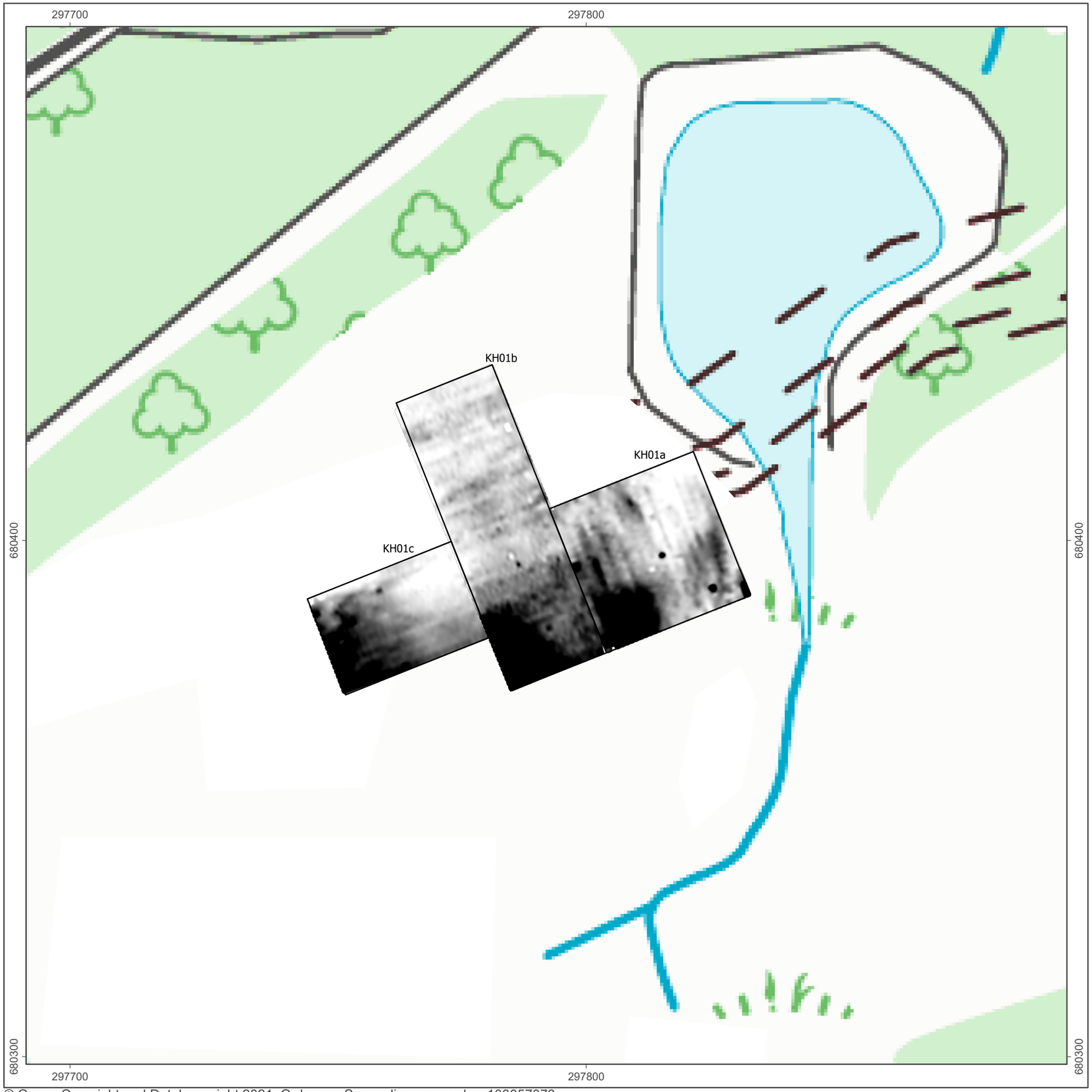
North	Scale: 1:750 @ A3	Datum: OSGB 1936

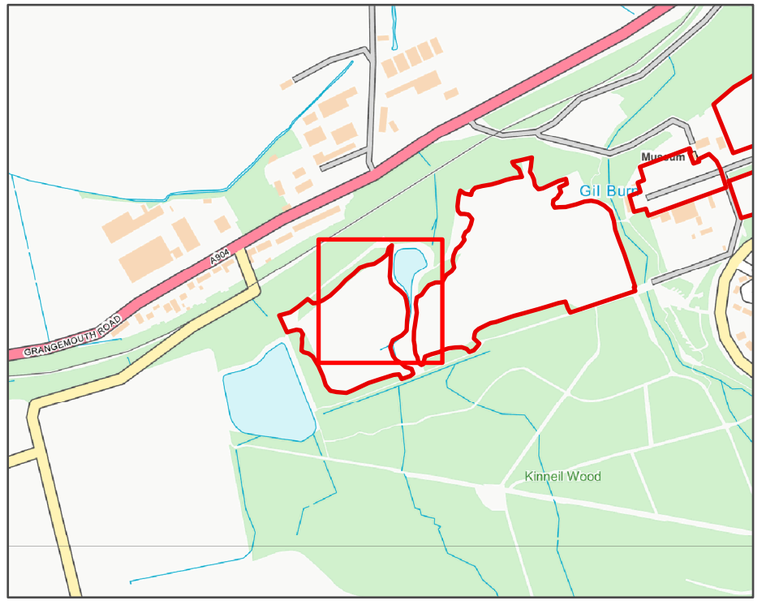
Metres 0 10 20 30 40

Project Name	Kinneil House
Project Code	ANTW2020KH
Prepared By	Nick Hannon
Prepared On	09/11/2021

HISTORIC ENVIRONMENT SCOTLAND | ÀRAINNEACHD EACHDRAIDHEIL ALBA

Figure 42 Processed Conductivity Data - Greyscale Plot - KH01 - Depth 2





GREYSCALE PLOT

Value

13.49

-0.07

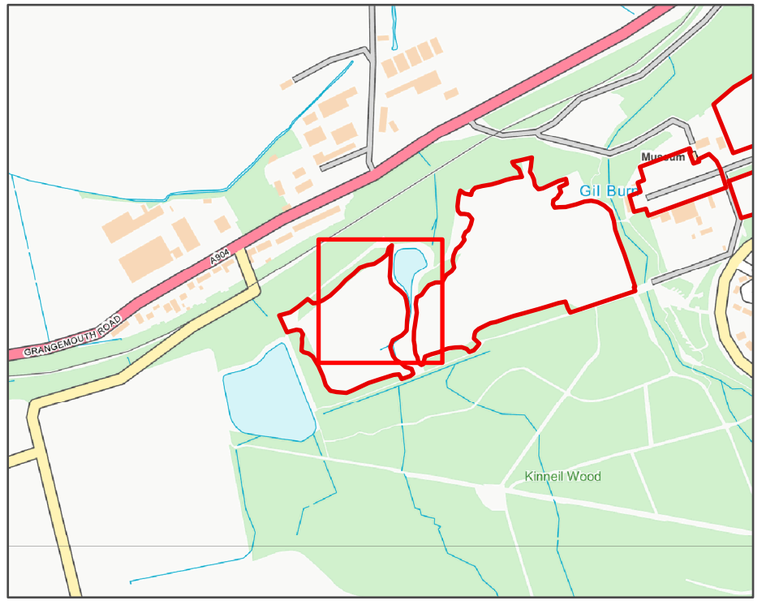
Cell size (m)	0.12
Stretch	Standard Deviation
Standard Deviations	1.2
Gamma	1

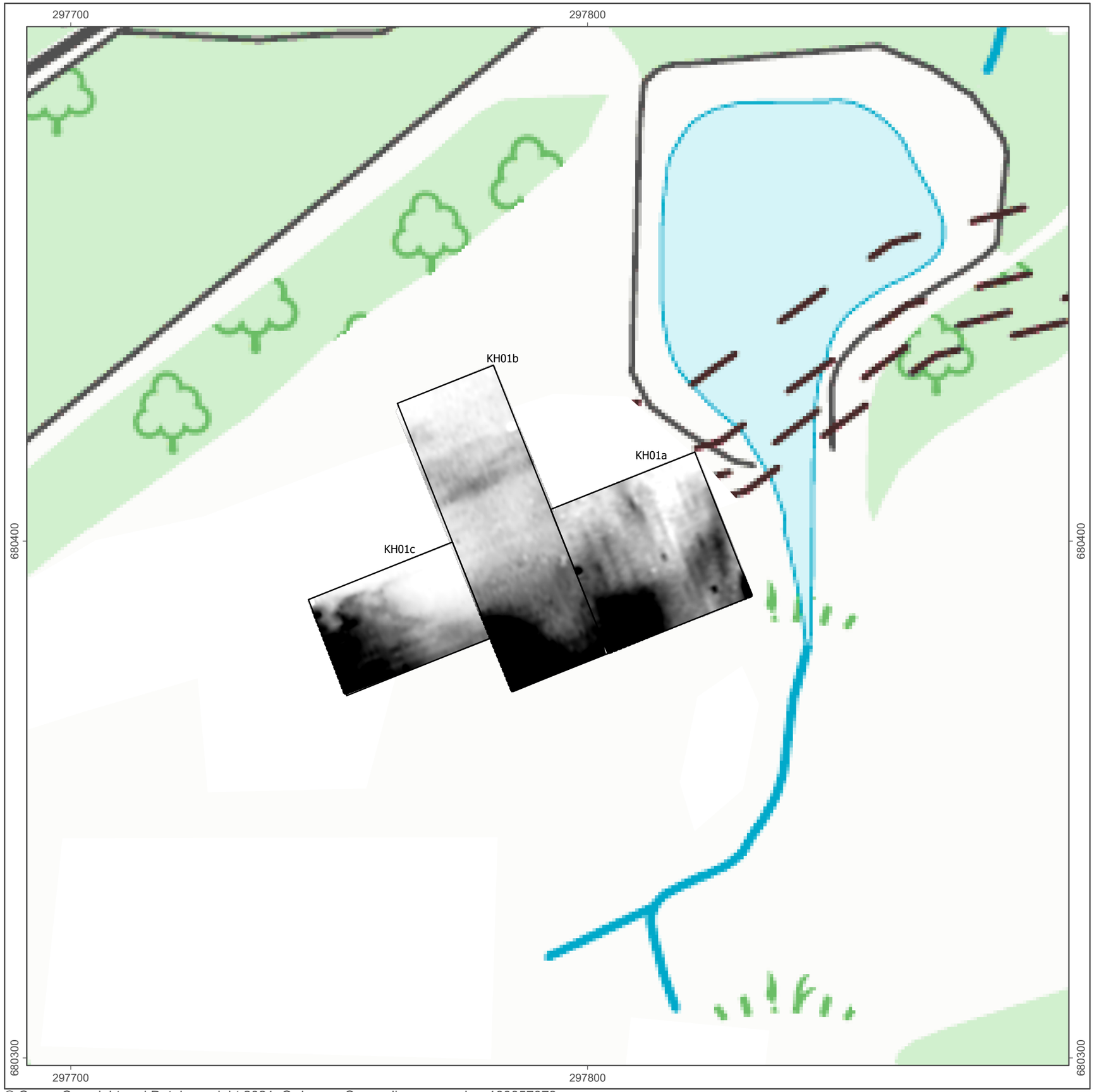
North	Scale: 1:750 @ A3	Datum: OSGB 1936

Metres 0 10 20 30 40

Project Name	Kinneil House
Project Code	ANTW2020KH
Prepared By	Nick Hannon
Prepared On	09/11/2021
Figure 43	Processed Conductivity Data - Greyscale Plot - KH01 - Depth 3

HISTORIC ENVIRONMENT SCOTLAND | ÀRAINNEACHD EACHDRAIDHEIL ALBA





GREYSCALE PLOT

Value

10.63

-0.09

Cell size (m)	0.12
Stretch	Standard Deviation
Standard Deviations	1.2
Gamma	1

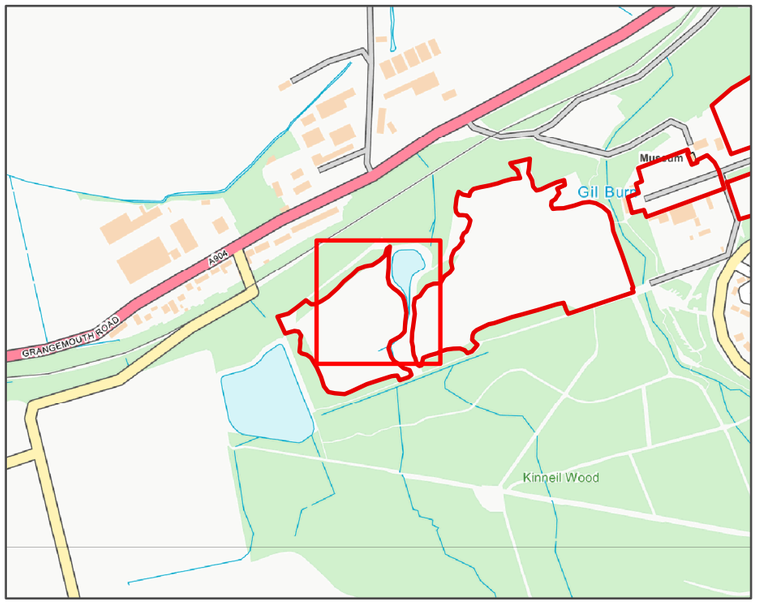
North	Scale: 1:750 @ A3	Datum: OSGB 1936

Metres 0 10 20 30 40

Project Name	Kinneil House
Project Code	ANTW2020KH
Prepared By	Nick Hannon
Prepared On	09/11/2021

HISTORIC ENVIRONMENT SCOTLAND | ÀRAINNEACHD EACHDRAIDHEIL ALBA

Figure 44 Interpretation of Conductivity Data - KH01



ARCHAEOLOGICAL INTERPRETATION

- High Conductivity
- Low Conductivity
- Very Low Conductivity

North

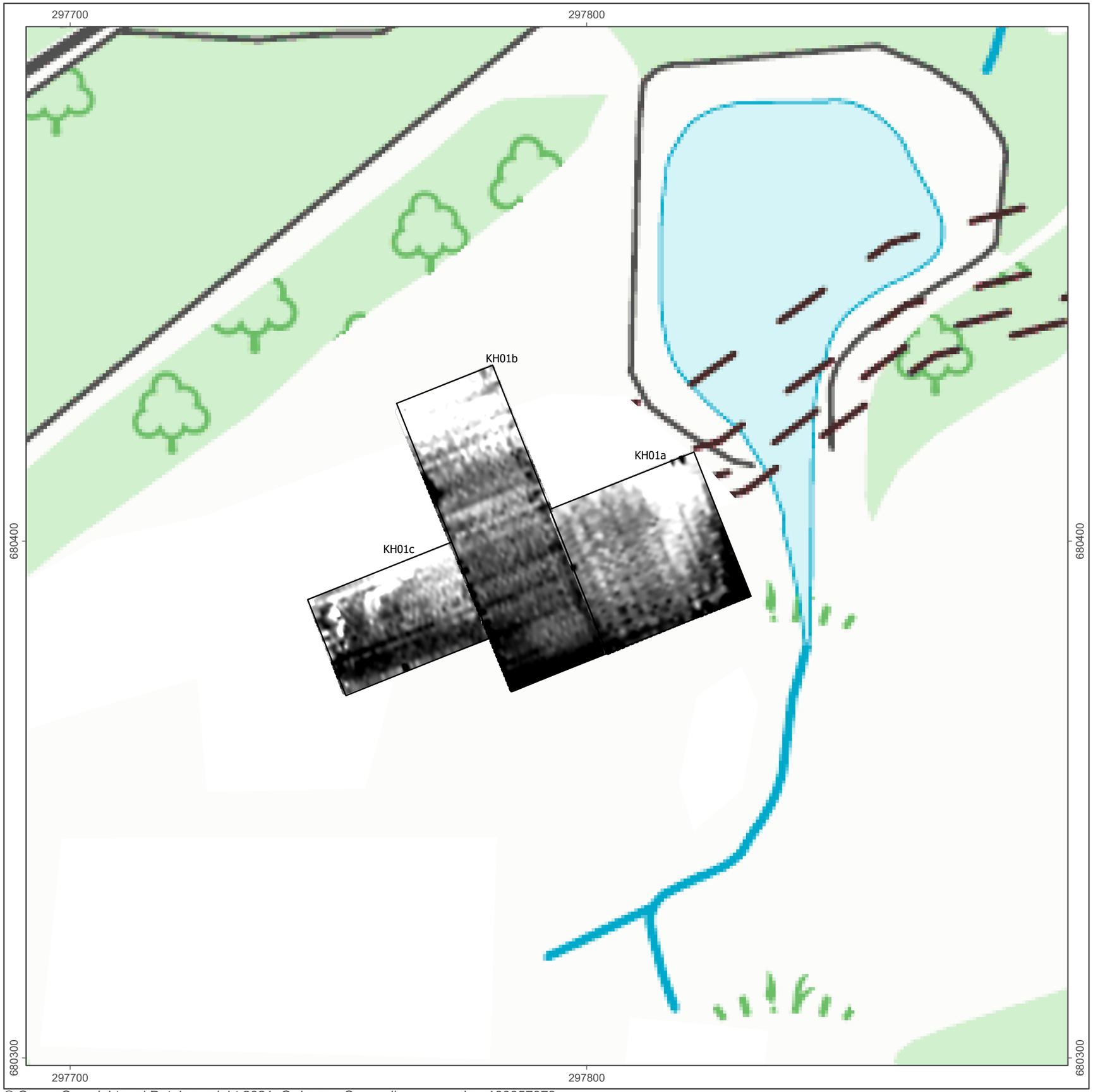
Scale: 1:750 @ A3

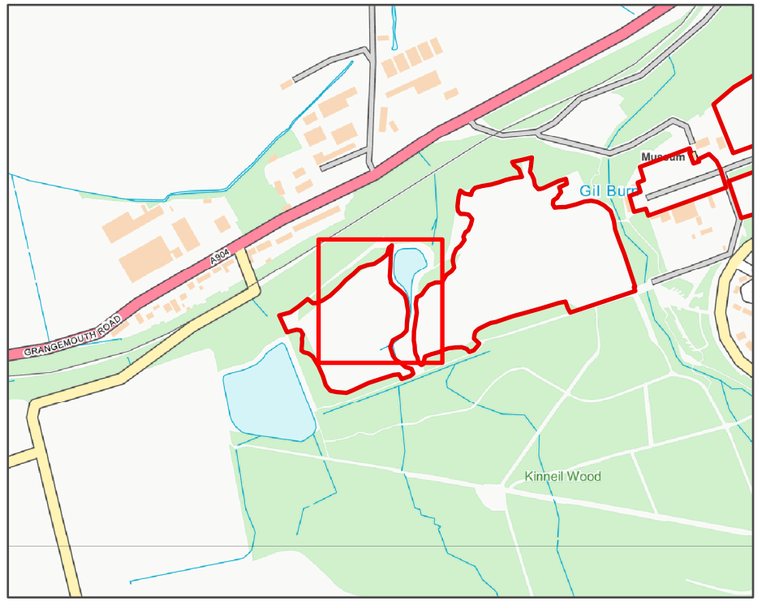
Datum: OSGB 1936

Metres 0 10 20 30 40

Project Name	Kinneil House
Project Code	ANTW2020KH
Prepared By	Nick Hannon
Prepared On	09/11/2021
Figure 45	Processed Magnetic Susceptibility Data - Greyscale Plot - KH01 - Depth 1

HISTORIC ENVIRONMENT SCOTLAND | ÀRAINNEACHD EACHDRAIDHEIL ALBA





GREYSCALE PLOT

Value

2.88

-0.03

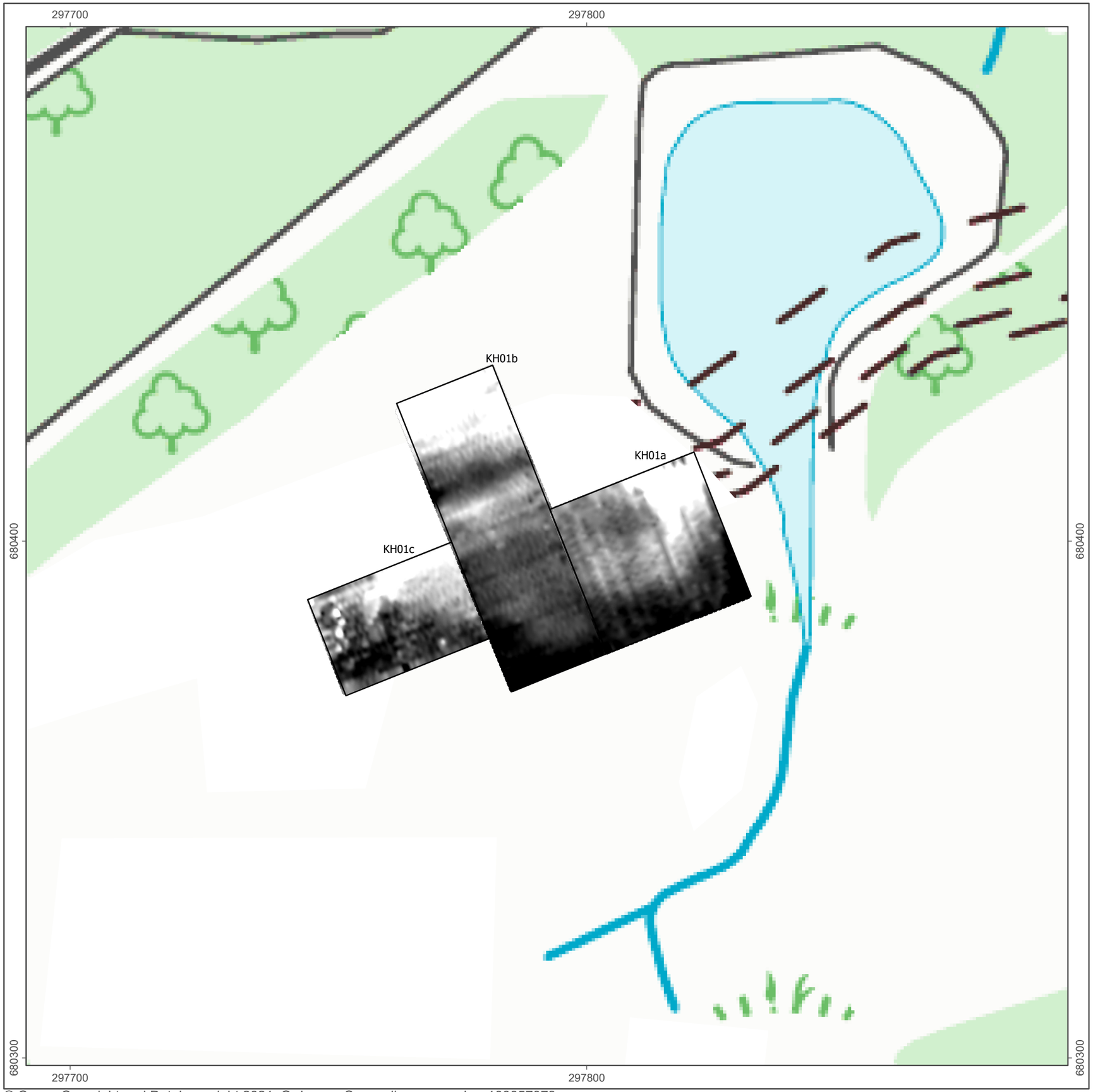
Cell size (m)	0.12
Stretch	Standard Deviation
Standard Deviations	1.2
Gamma	1

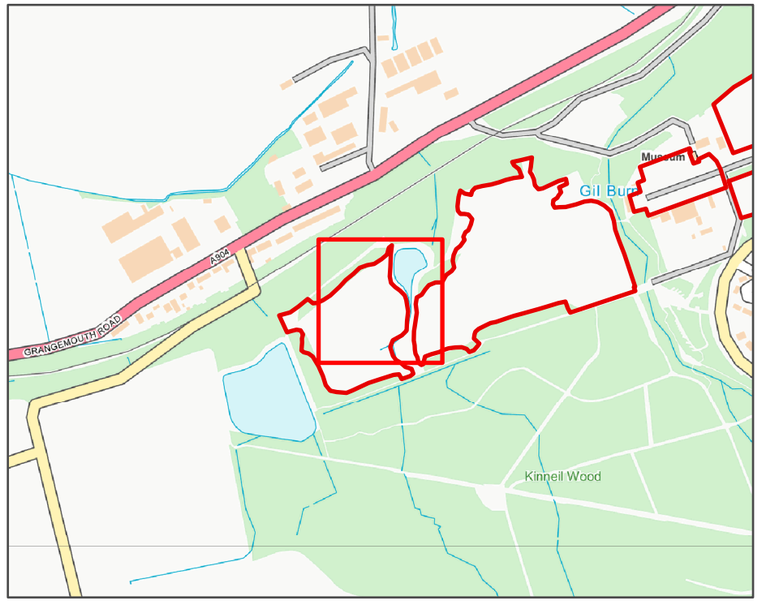
North	Scale: 1:750 @ A3	Datum: OSGB 1936

Metres 0 10 20 30 40

Project Name	Kinneil House
Project Code	ANTW2020KH
Prepared By	Nick Hannon
Prepared On	09/11/2021
Figure 46	Processed Magnetic Susceptibility Data - Greyscale Plot - KH01 - Depth 2

HISTORIC ENVIRONMENT SCOTLAND | ÀRAINNEACHD EACHDRAIDHEIL ALBA





GREYSCALE PLOT

Value

2.71

-1.43

Cell size (m)	0.12
Stretch	Standard Deviation
Standard Deviations	1.2
Gamma	1

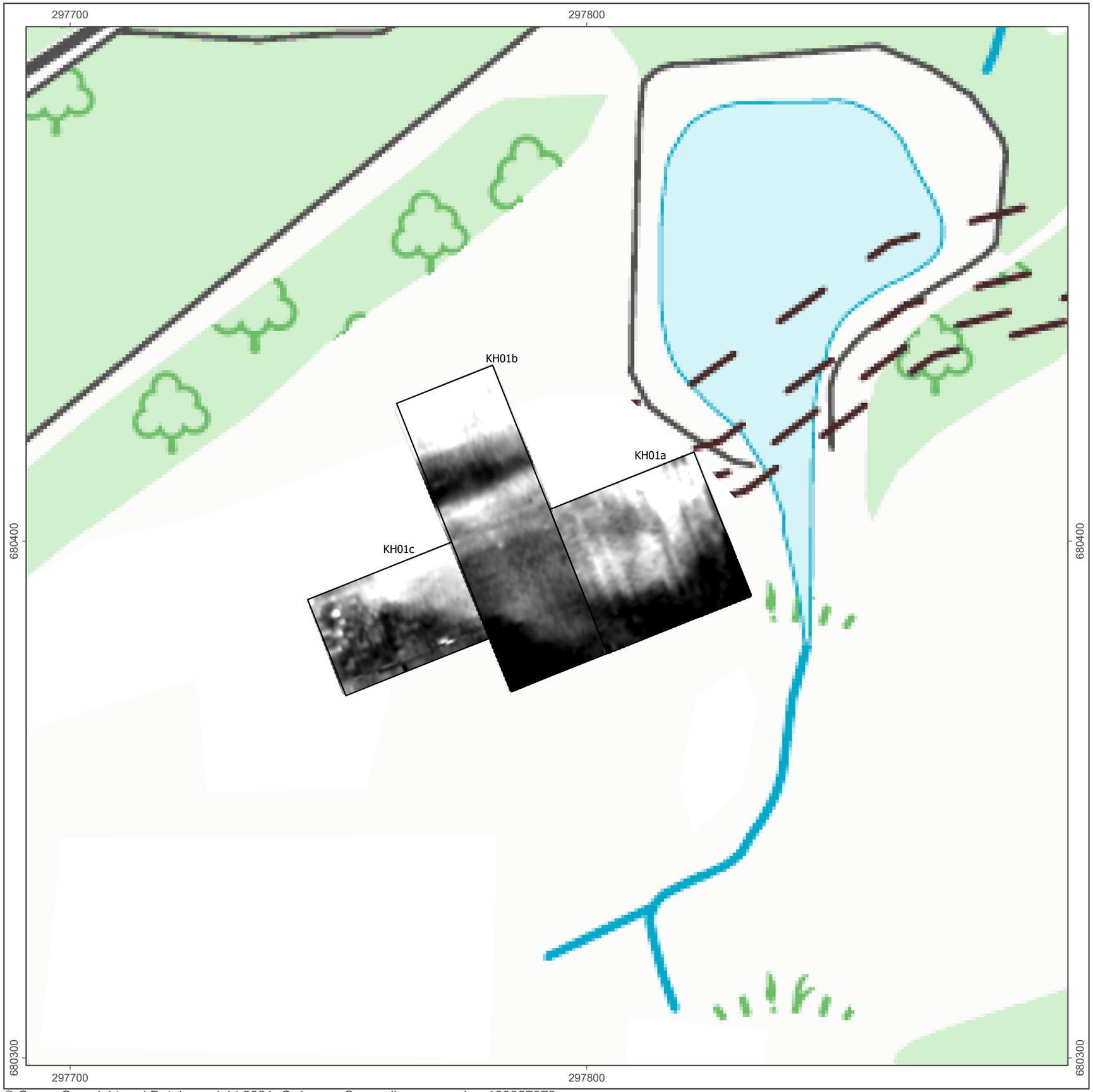
North	Scale: 1:750 @ A3	Datum: OSGB 1936

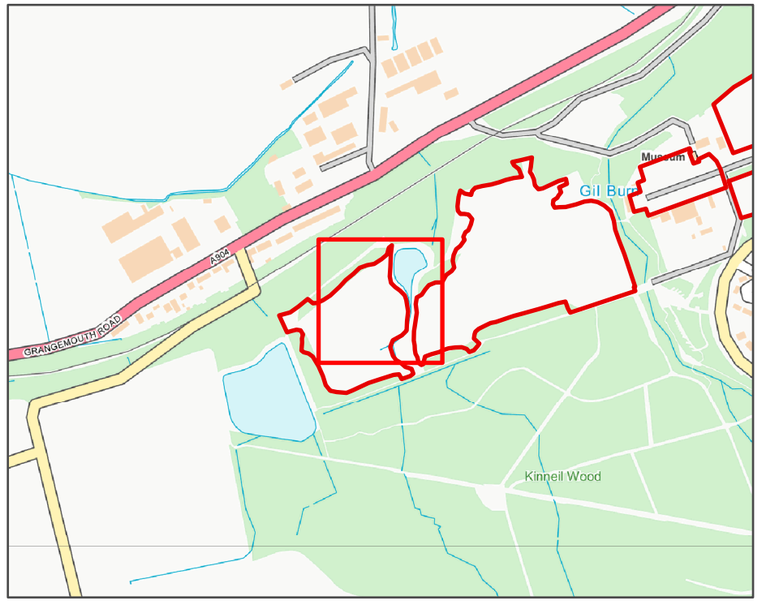
Metres 0 10 20 30 40

Project Name	Kinneil House
Project Code	ANTW2020KH
Prepared By	Nick Hannon
Prepared On	09/11/2021

HISTORIC ENVIRONMENT SCOTLAND | ÀRAINNEACHD EACHDRAIDHEIL ALBA

Figure 47 Processed Magnetic Susceptibility Data - Greyscale Plot - KH01 - Depth 3





GREYSCALE PLOT

Value

2.71

-2.3

Cell size (m)	0.12
Stretch	Standard Deviation
Standard Deviations	1.2
Gamma	1

North

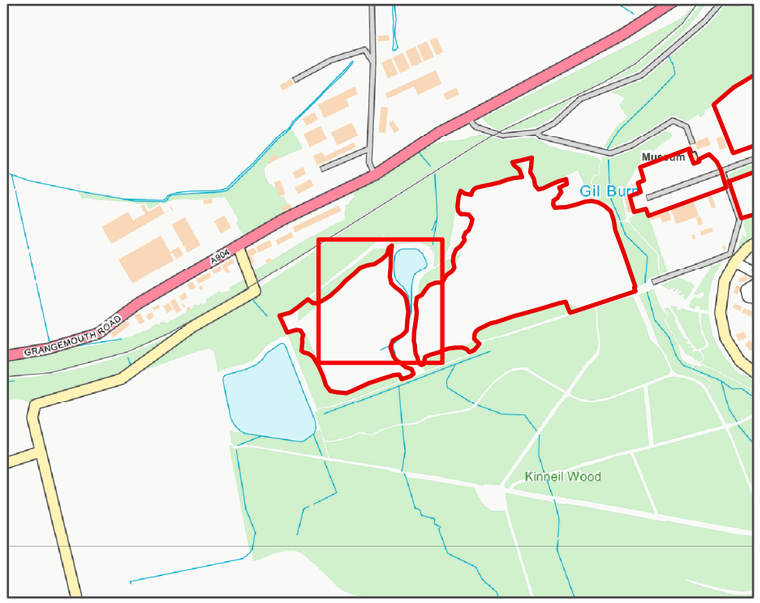
Scale: 1:750 @ A3

Datum: OSGB 1936

Metres 0 10 20 30 40

Project Name	Kinneil House
Project Code	ANTW2020KH
Prepared By	Nick Hannon
Prepared On	09/11/2021
Figure 48	Interpretation of Magnetic Susceptibility Data - KH01

HISTORIC ENVIRONMENT SCOTLAND | ÀRAINNEACHD EACHDRAIDHEIL ALBA



297700 297800

680400

680300

KH01b

KH01a

KH01c

ARCHAEOLOGICAL INTERPRETATION

- High Magnetism
- Low Magnetism

North

Scale: 1:750 @ A3

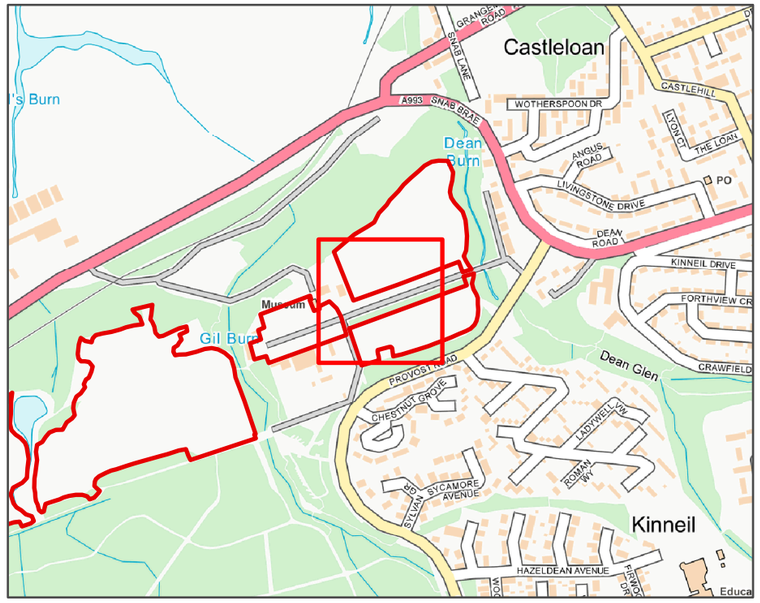
Datum: OSGB 1936

Metres 0 10 20 30 40

Project Name	Kinneil House
Project Code	ANTW2020KH
Prepared By	Nick Hannon
Prepared On	09/11/2021

HISTORIC ENVIRONMENT SCOTLAND | ÀRAINNEACHD EACHDRAIDHEIL ALBA

Figure 49 Processed Conductivity Data - Greyscale Plot - KH03 & KH04 - Depth 1



GREYSCALE PLOT

Value

25.92

-1.25

Cell size (m)	0.12
Stretch	Standard Deviation
Standard Deviations	1.2
Gamma	1

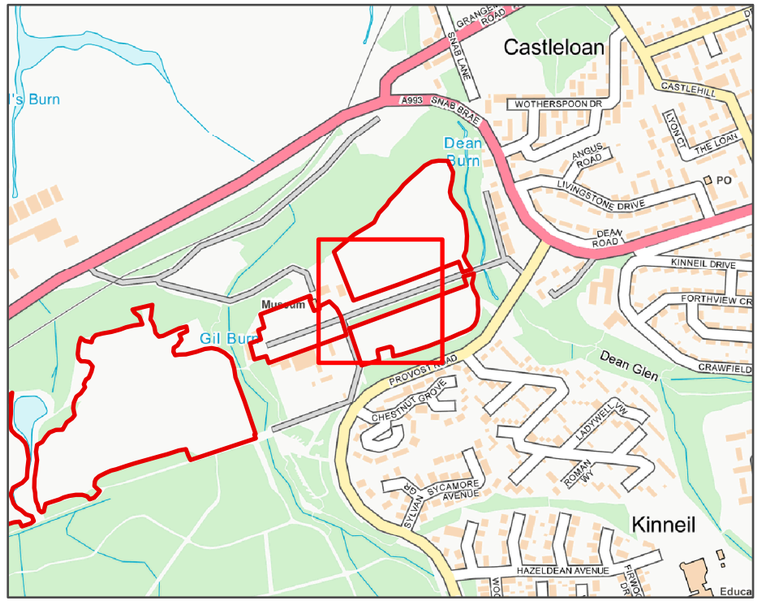
North	Scale: 1:750 @ A3	Datum: OSGB 1936

Metres 0 10 20 30 40

Project Name	Kinneil House
Project Code	ANTW2020KH
Prepared By	Nick Hannon
Prepared On	09/11/2021

HISTORIC ENVIRONMENT SCOTLAND | ÀRAINNEACHD EACHDRAIDHEIL ALBA

Figure 50 Processed Conductivity Data - Greyscale Plot - KH03 & KH04 - Depth 2



GREYSCALE PLOT

Value

8.16

-7.62

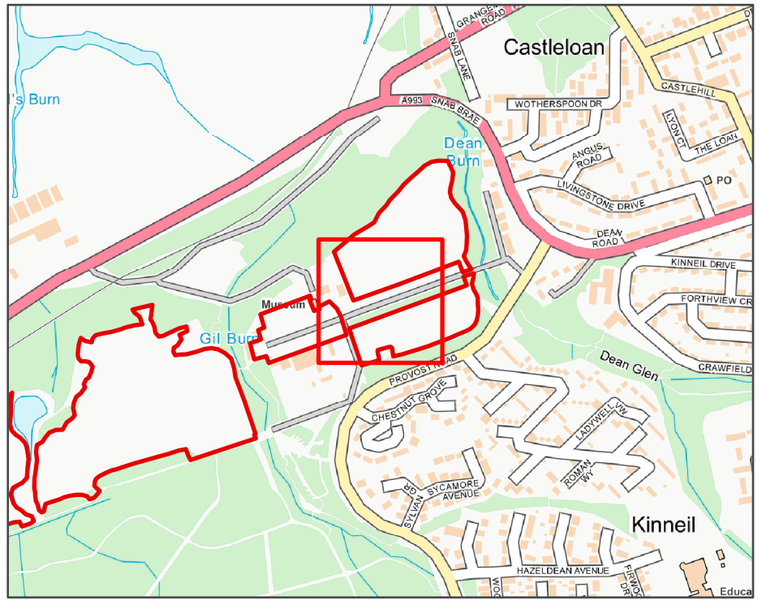
Cell size (m)	0.12
Stretch	Standard Deviation
Standard Deviations	1.2
Gamma	1

North	Scale: 1:750 @ A3	Datum: OSGB 1936

Metres 0 10 20 30 40

Project Name	Kinneil House
Project Code	ANTW2020KH
Prepared By	Nick Hannon
Prepared On	09/11/2021
Figure 51	Processed Conductivity Data - Greyscale Plot - KH03 & KH04 - Depth 3

HISTORIC ENVIRONMENT SCOTLAND | ÀRAINNEACHD EACHDRAIDHEIL ALBA



GREYSCALE PLOT

Value

9.95

-1.54

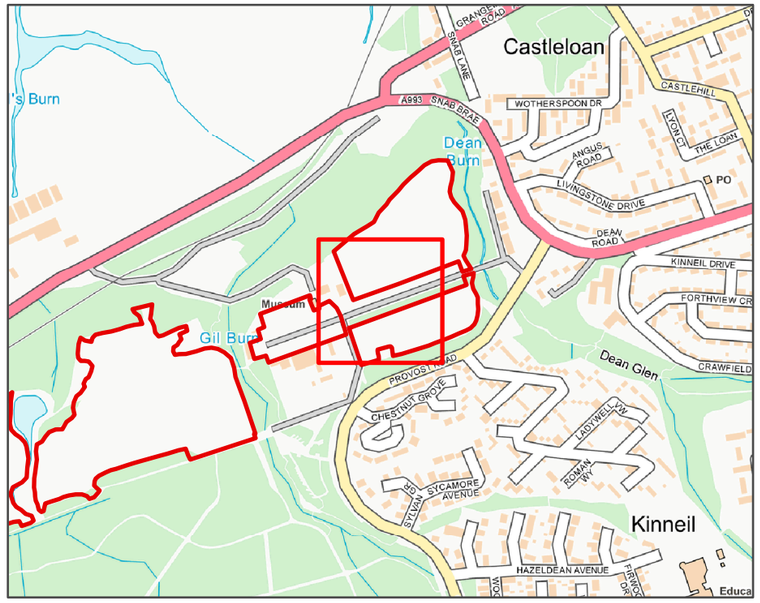
Cell size (m)	0.12
Stretch	Standard Deviation
Standard Deviations	1.2
Gamma	1

North	Scale: 1:750 @ A3	Datum: OSGB 1936
	Metres 0 10 20 30 40	

Project Name	Kinneil House
Project Code	ANTW2020KH
Prepared By	Nick Hannon
Prepared On	09/11/2021

HISTORIC ENVIRONMENT SCOTLAND | ÀRAINNEACHD EACHDRAIDHEIL ALBA

Figure 52 Interpretation of Conductivity Data - KH03 & KH04



ARCHAEOLOGICAL INTERPRETATION

- High Conductivity
- Low Conductivity
- Very Low Conductivity

North

Scale: 1:750 @ A3

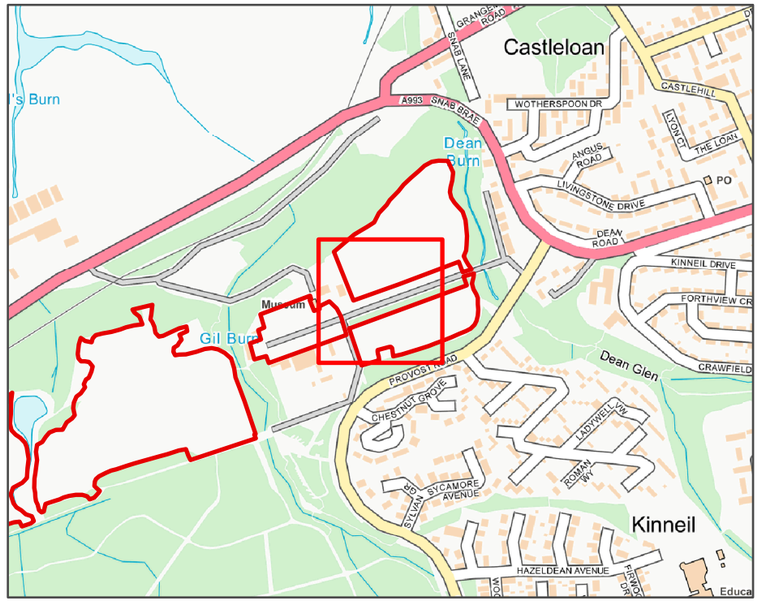
Datum: OSGB 1936

Metres 0 10 20 30 40

Project Name	Kinneil House
Project Code	ANTW2020KH
Prepared By	Nick Hannon
Prepared On	09/11/2021

HISTORIC ENVIRONMENT SCOTLAND | ÀRAINNEACHD EACHDRAIDHEIL ALBA

Figure 53 Processed Magnetic Susceptibility Data - Greyscale Plot - KH03 & KH04 - Depth 1



GREYSCALE PLOT

Value

2.58

-0.02

Cell size (m)	0.12
Stretch	Standard Deviation
Standard Deviations	1.2
Gamma	1

North

Scale: 1:750 @ A3

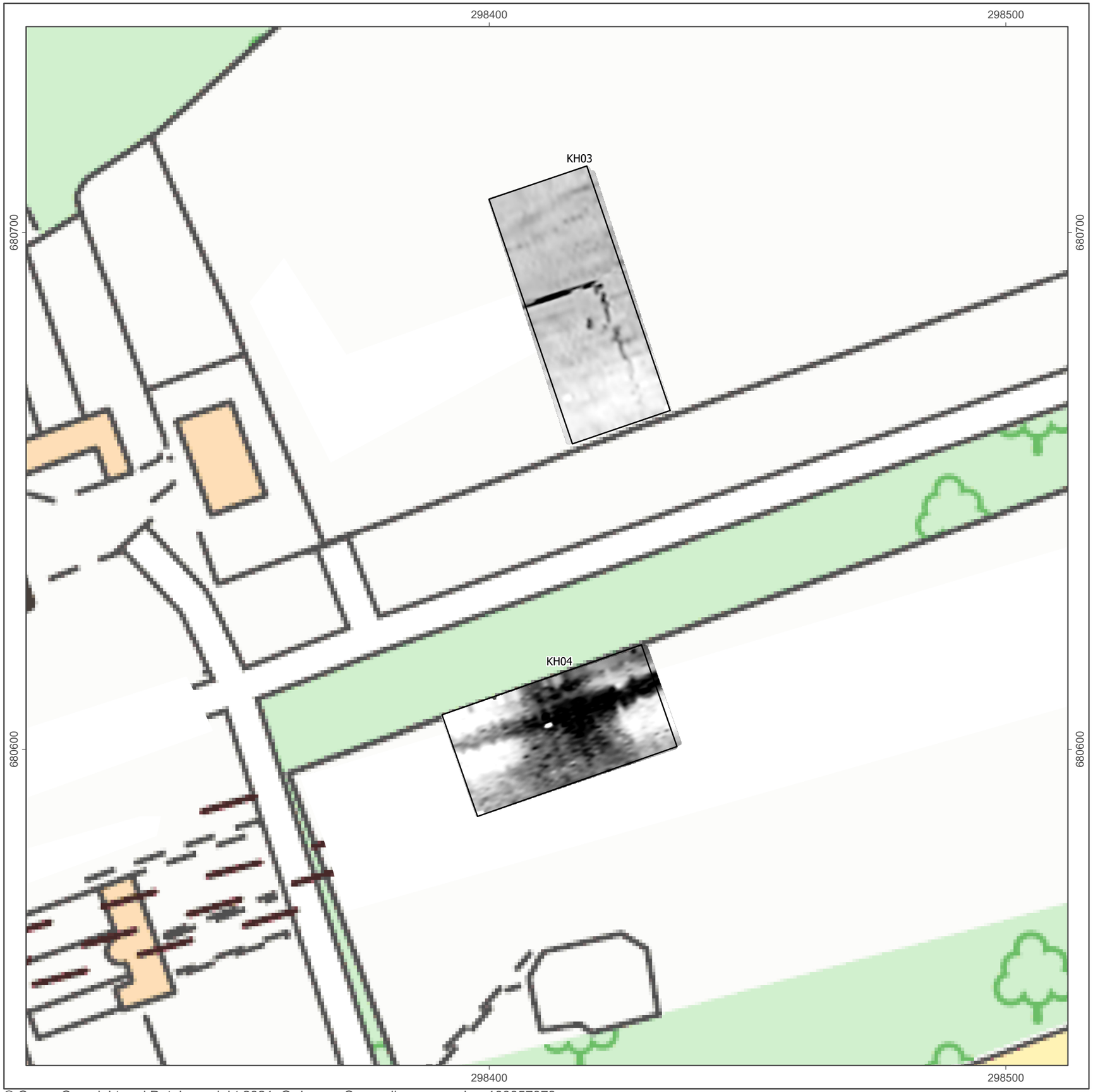
Datum: OSGB 1936

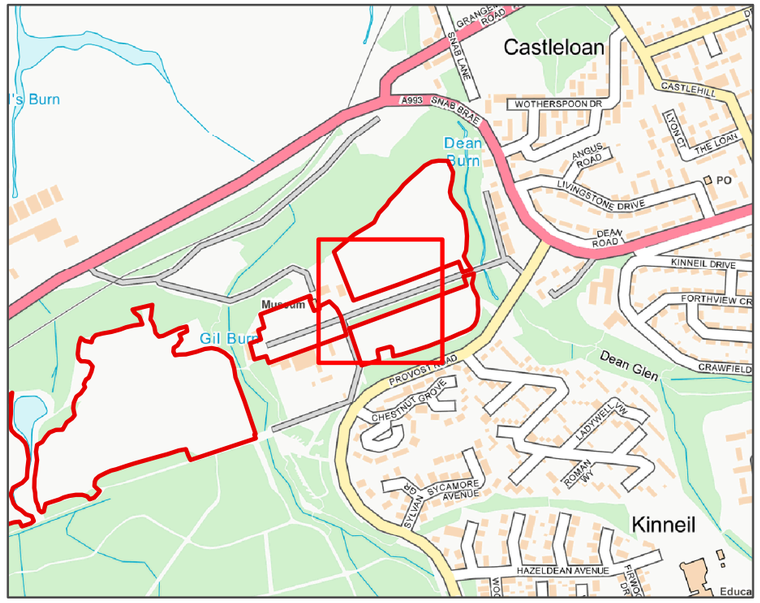
Metres

0 10 20 30 40

Project Name	Kinneil House
Project Code	ANTW2020KH
Prepared By	Nick Hannon
Prepared On	09/11/2021
Figure 54	Processed Magnetic Susceptibility Data - Greyscale Plot - KH03 & KH04 - Depth 2

HISTORIC ENVIRONMENT SCOTLAND | ÀRAINNEACHD EACHDRAIDHEIL ALBA





GREYSCALE PLOT

Value

5.23

-0.08

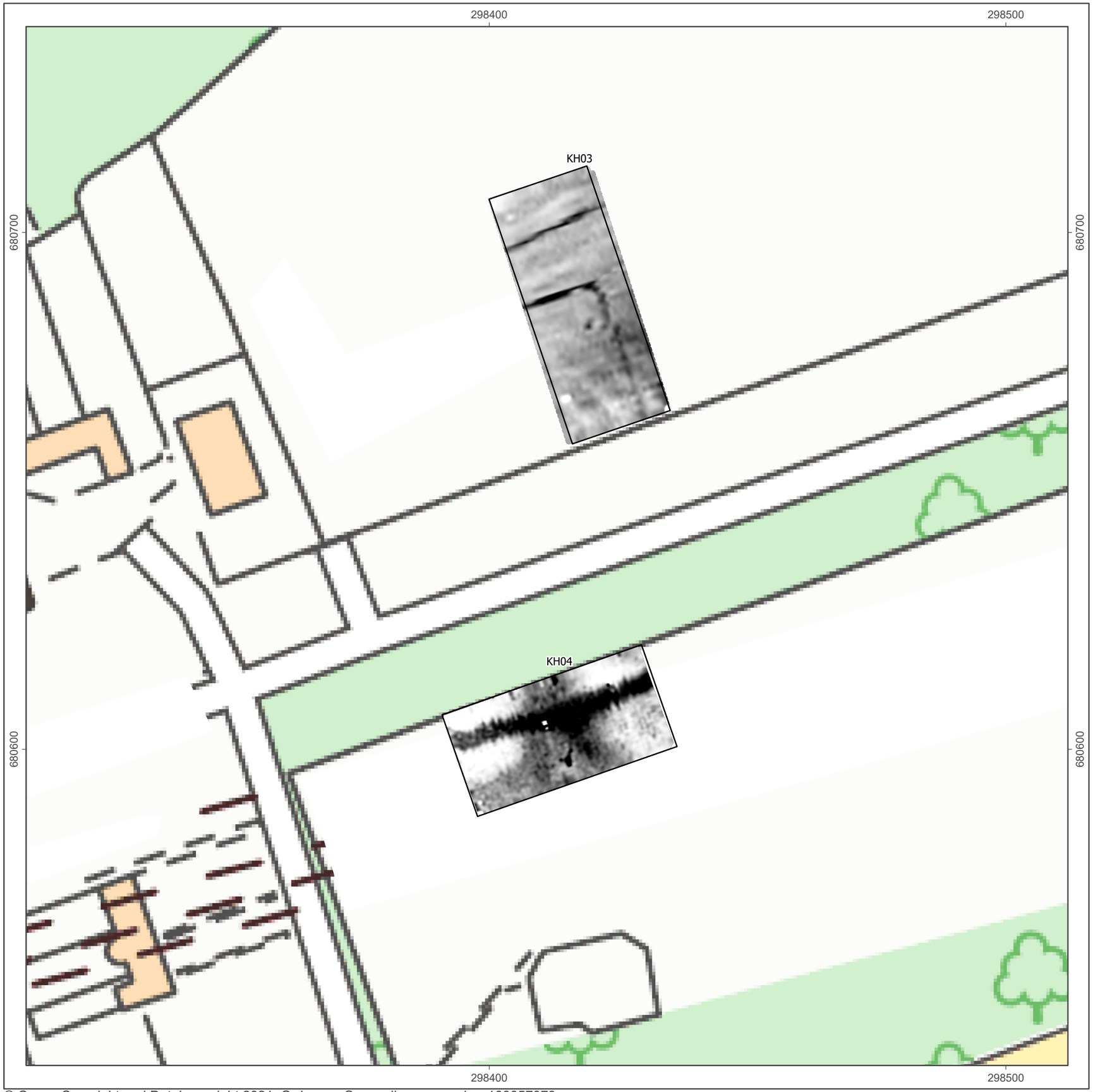
Cell size (m)	0.12
Stretch	Standard Deviation
Standard Deviations	1.2
Gamma	1

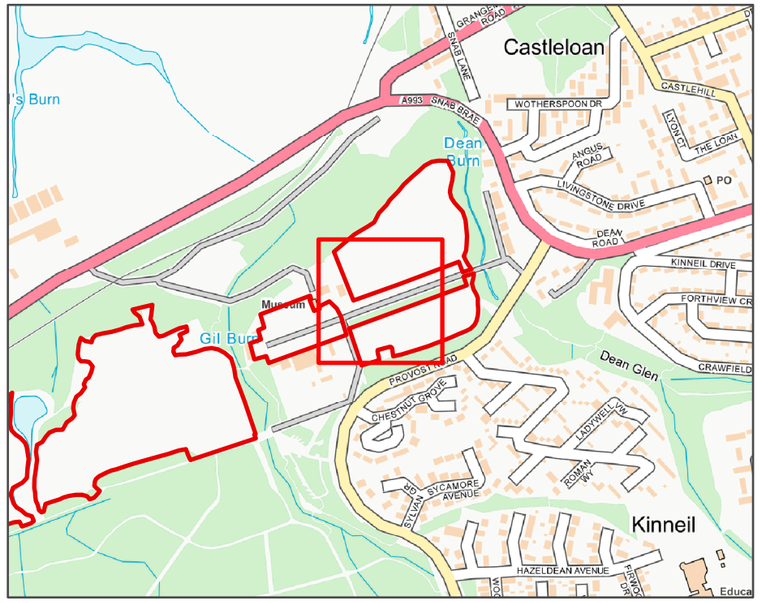
North	Scale: 1:750 @ A3	Datum: OSGB 1936
	Metres 0 10 20 30 40	

Project Name	Kinneil House
Project Code	ANTW2020KH
Prepared By	Nick Hannon
Prepared On	09/11/2021

HISTORIC ENVIRONMENT SCOTLAND | ÀRAINNEACHD EACHDRAIDHEIL ALBA

Figure 55 Processed Magnetic Susceptibility Data - Greyscale Plot - KH03 & KH04 - Depth 3





GREYSCALE PLOT

Value

5.93

-0.04

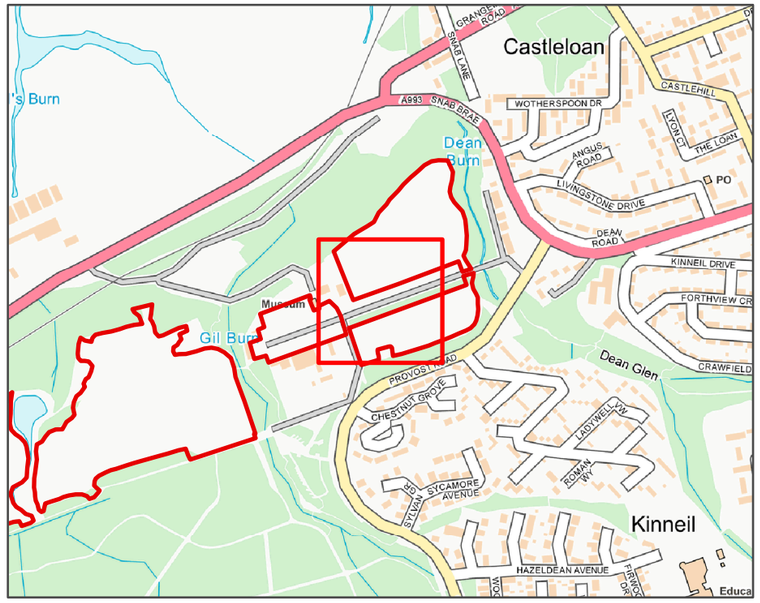
Cell size (m)	0.12
Stretch	Standard Deviation
Standard Deviations	1.2
Gamma	1

North	Scale: 1:750 @ A3	Datum: OSGB 1936

Metres 0 10 20 30 40

Project Name	Kinneil House
Project Code	ANTW2020KH
Prepared By	Nick Hannon
Prepared On	09/11/2021
Figure 56	Interpretation of Magnetic Susceptibility Data - KH03 & KH04

HISTORIC ENVIRONMENT SCOTLAND | ÀRAINNEACHD EACHDRAIDHEIL ALBA



ARCHAEOLOGICAL INTERPRETATION

- High Magnetism
- Low Magnetism

North	Scale: 1:750 @ A3	Datum: OSGB 1936

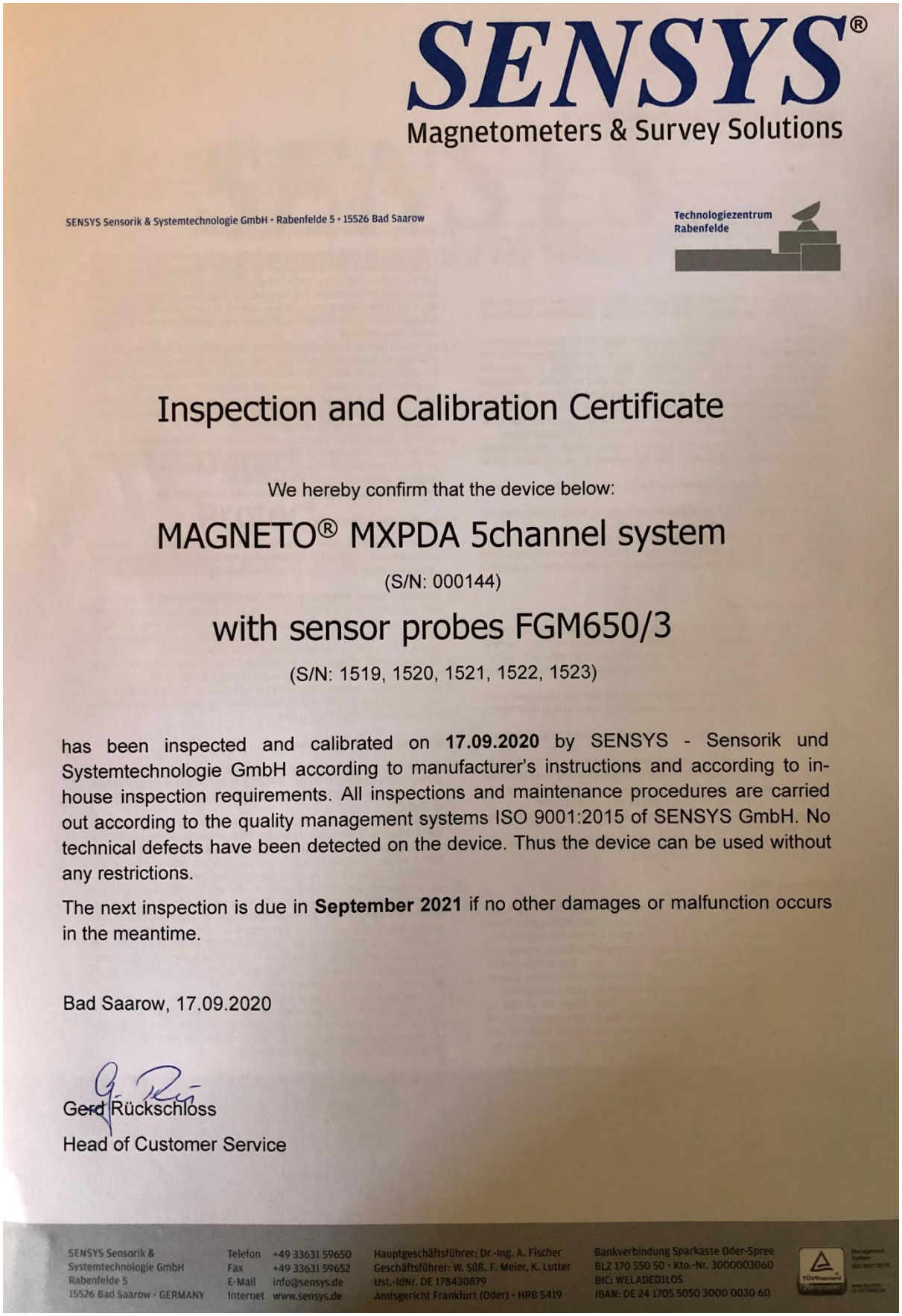
Metres 0 10 20 30 40

APPENDIX 1 – SURVEY METADATA

The following table details the survey's metadata.

Field	Description
Data Collection Organisation	Historic Environment Scotland
Site Name	Antonine Wall, Kinneil House
Project ID	ANTW2020KH
OASIS ID	historic14-412624
Report Title	Antonine Wall, Kinneil House, Archaeological Geophysical Survey Report
Report Author	Dr Nick Hannon
Report QC	Dr Kirsty Millican/Dr Dave Cowley
National Grid Reference (centre)	NS 97889 80453
Coordinate System	OSGB1936
Transformation	OSTN15
Geoid	OSGM15
County	Falkirk
Scheduled Ancient Monument/s	SM2210, & SM4970
Known Archaeology on site	48130, 48135, 48184, 353312, 365167, 144531, & 154529
Survey Personnel	Dr Nick Hannon, Georgina Brown, Alison McCaig, Angela Gannon, John Sheriff & Lukasz Banaszek
Survey Dates	10/05/2021 – 18/05/2021
Weather Conditions	Mostly dry and sunny, although torrential rain on 12/05/2021
Land Use	Grassed Parkland
Ground Conditions	Mostly dry, although waterlogged in isolated places
Solid Geology	Upper Limestone Formation, with bands of Orchard Limestone and Calmy Limestone (BGS 2021)
Drift Geology	Till, Devensian – Diamicton, and areas of Raised Marine Deposits, Devensian – Clay, Silt and Gravel (BGS 2021)
Soil	Brown Earth (Scotland's Soils 2021)
Survey Type	Gradiometer
Gradiometer Equipment	Sensys MXPDA (sn 000144)
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 v3.0.37.0
Data Visualisation Software	ArcGIS Pro v2.5.1
Area Covered (ha)	8.35
Positional Accuracy	Leica GS16 GNSS +/- 0.02m (RTK Fixed)
EMI Equipment	CMD Mini Explorer
Sensor Separation/s (m)	0.32/0.71/1.18
Sensor Configuration	Low (Vertical Coplanar) Areas KH01 & KH04. High (Horizontal Coplanar) Area KH03.
Traverse Separation (m)	0.5
Reading Interval (sec)	0.2
Data Collection Software	Data Logger Firmware
Data Processing Software	TerraSurveyor v3.0.37.0
Data Visualisation Software	ArcGIS Pro v2.5.1
Area Covered (ha)	0.45
Positional Accuracy	Leica GS16 GNSS +/- 0.02m (RTK Fixed)

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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15526 Bad Saarow · GERMANY

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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
ANTW2020KH-0001	KH01	Enhanced Magnetism (Archaeology)	Antonine Wall - Ditch
ANTW2020KH-0002	KH01	Enhanced Magnetism (Archaeology)	Antonine Wall - Rampart
ANTW2020KH-0003	KH01	Enhanced Magnetism (Archaeology)	Antonine Wall - Rampart
ANTW2020KH-0004	KH01	Enhanced Magnetism (Archaeology)	Kinneil fortlet - defensive ditch
ANTW2020KH-0005	KH01	Enhanced Magnetism (Archaeology)	Kinneil fortlet - defensive ditch
ANTW2020KH-0006	KH01	Enhanced Magnetism (Archaeology)	Kinneil fortlet - defensive ditch
ANTW2020KH-0007	KH01	Enhanced Magnetism (Archaeology)	Kinneil fortlet – small ditch ditch
ANTW2020KH-0008	KH01	Enhanced Magnetism (Archaeology)	Antonine Wall - enclosure
ANTW2020KH-0009	KH01	Enhanced Magnetism (Archaeology)	Curling Ponds
ANTW2020KH-0010	KH01	Enhanced Magnetism (Possible Archaeology)	Possible defensive ditch
ANTW2020KH-0011	KH01	Enhanced Magnetism (Possible Archaeology)	Possible pit
ANTW2020KH-0012	KH01	Enhanced Magnetism (Possible Archaeology)	Possible building
ANTW2020KH-0013	KH01	Enhanced Magnetism (Possible Archaeology)	Possible settlement
ANTW2020KH-0014	KH01	Enhanced Magnetism (Area of Burning)	Possible settlement
ANTW2020KH-0015	KH01	Enhanced Magnetism (Possible Archaeology)	Unknown
ANTW2020KH-0016	KH01	Enhanced Magnetism (Possible Archaeology)	Possible building
ANTW2020KH-0017	KH01	Enhanced Magnetism (Possible Archaeology)	Possible building
ANTW2020KH-0018	KH01	Enhanced Magnetism (Possible Archaeology)	Possible building
ANTW2020KH-0019	KH02	Enhanced Magnetism (Archaeology)	Kinneil Kirk - boundary ditch
ANTW2020KH-0020	KH02	Enhanced Magnetism (Archaeology)	Kinneil Kirk - boundary ditch
ANTW2020KH-0021	KH02	Enhanced Magnetism (Archaeology)	Antonine Wall - Ditch
ANTW2020KH-0022	KH02	Enhanced Magnetism (Archaeology)	Antonine Wall - Rampart
ANTW2020KH-0023	KH02	Enhanced Magnetism (Possible Archaeology)	Kinneil village remains
ANTW2020KH-0024	KH02	Enhanced Magnetism (Possible Archaeology)	Kinneil village remains
ANTW2020KH-0025	KH02	Enhanced Magnetism (Possible Archaeology)	Kinneil village remains
ANTW2020KH-0026	KH02	Enhanced Magnetism (Possible Archaeology)	Kinneil village remains or Kinneil House landscaping
ANTW2020KH-0027	KH02	Enhanced Magnetism (Possible Archaeology)	Kinneil House landscaping
ANTW2020KH-0028	KH02	Enhanced Magnetism (Possible Archaeology)	Kinneil House landscaping
ANTW2020KH-0029	KH02	Enhanced Magnetism (Possible Archaeology)	Kinneil village remains or Kinneil House landscaping
ANTW2020KH-0030	KH02	Enhanced Magnetism (Possible Archaeology)	Enclosure
ANTW2020KH-0031	KH02	Enhanced Magnetism (Possible Archaeology)	Unknown
ANTW2020KH-0032	KH02	Enhanced Magnetism (Possible Archaeology)	Unknown
ANTW2020KH-0033	KH02	Enhanced Magnetism (Possible Archaeology)	Small agricultural enclosure
ANTW2020KH-0034	KH02	Enhanced Magnetism (Possible Archaeology)	Small settlement or industrial enclosure
ANTW2020KH-0035	KH02	Enhanced Magnetism (Possible Archaeology)	Ditch

ANTW2020KH-0036	KH02	Enhanced Magnetism (Area of Burning)	Area of burning
ANTW2020KH-0037	KH02	Enhanced Magnetism (Area of Burning)	Area of burning
ANTW2020KH-0038	KH02	Enhanced Magnetism (Area of Burning)	Kinneil village remains
ANTW2020KH-0039	KH02	Enhanced Magnetism (Possible Archaeology)	Kinneil village remains or Kinneil House landscaping
ANTW2020KH-0040	KH02	Enhanced Magnetism (Possible Archaeology)	Small agricultural enclosure
ANTW2020KH-0041	KH03	Enhanced Magnetism (Archaeology)	Promontory fort ditch
ANTW2020KH-0042	KH03	Enhanced Magnetism (Archaeology)	Roundhouse
ANTW2020KH-0043	KH03	Enhanced Magnetism (Archaeology)	Roundhouse
ANTW2020KH-0044	KH03	Enhanced Magnetism (Archaeology)	Roundhouse
ANTW2020KH-0045	KH03	Enhanced Magnetism (Archaeology)	Roundhouse
ANTW2020KH-0046	KH03	Enhanced Magnetism (Archaeology)	Roundhouse
ANTW2020KH-0047	KH03	Enhanced Magnetism (Possible Archaeology)	Pair of parallel ditches
ANTW2020KH-0048	KH03	Enhanced Magnetism (Possible Archaeology)	Small agricultural enclosure
ANTW2020KH-0049	KH03	Enhanced Magnetism (Possible Archaeology)	Ditch
ANTW2020KH-0050	KH03	Enhanced Magnetism (Possible Archaeology)	Ditch
ANTW2020KH-0051	KH03	Enhanced Magnetism (Possible Archaeology)	Unknown
ANTW2020KH-0052	KH03	Enhanced Magnetism (Possible Archaeology)	Agricultural enclosure
ANTW2020KH-0053	KH04	Enhanced Magnetism (Archaeology)	Antonine Wall - Ditch
ANTW2020KH-0054	KH04	Enhanced Magnetism (Archaeology)	Antonine Wall - Rampart
ANTW2020KH-0055	KH04	Enhanced Magnetism (Archaeology)	Trackway ditches
ANTW2020KH-0056	KH04	Enhanced Magnetism (Possible Archaeology)	Quarry pit
ANTW2020KH-0057	KH04	Enhanced Magnetism (Possible Archaeology)	Unknown
ANTW2020KH-0059	KH05	Enhanced Magnetism (Archaeology)	Antonine Wall - Ditch
ANTW2020KH-0060	KH05	Enhanced Magnetism (Archaeology)	Wall foundation
ANTW2020KH-0061	KH05	Enhanced Magnetism (Possible Archaeology)	Kinneil House- garden features
ANTW2020KH-0061	KH05	Enhanced Magnetism (Possible Archaeology)	Kinneil House- garden features
ANTW2020KH-0061	KH05	Enhanced Magnetism (Possible Archaeology)	Kinneil House- garden features
ANTW2020KH-0061	KH05	Enhanced Magnetism (Possible Archaeology)	Kinneil House- garden features
ANTW2020KH-0061	KH05	Enhanced Magnetism (Possible Archaeology)	Kinneil House- garden features

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.

The following table contains a glossary of the technical terminology used for anomalies for electro-magnetic (Magnetic Susceptibility) survey within this report.

	Anomaly Type	Description
Area	High Magnetism	An area displaying particularly high magnetic properties, possibly of anthropogenic origins.
	Low Magnetism	An area displaying particularly low magnetic properties, possibly of anthropogenic origins.

The following table contains a glossary of the technical terminology used for anomalies for electro-magnetic (Conductivity) survey within this report.

	Anomaly Type	Description
Area	Very Low Conductivity	An area displaying very low conductivity, possibly of anthropogenic origins.
	Low Conductivity	An area displaying low conductivity, possibly of anthropogenic origins.
	High Conductivity	An area displaying low high conductivity, possibly of anthropogenic origins.

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 v3.0.37.0 (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 to .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 de-striped 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.

ELECTRO-MAGNETIC DATA PROCESSING

Following the collection of data following the methodology detailed in section 5.2, all datafiles were exported from the CMD Mini Explorer's datalogger via a USB memory stick in .bin format. These files were then transferred to the processing computer and opened with the CMD Data Transfer application; each file was then exported as an interpolated .dat file. Each data file was opened in Microsoft Excel and the trailing "W" and "N" removed from the data in columns A and B; column B also had the leading "-" removed. The data was saved in .csv format.

Data processing was conducted using Terrasurveyor (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 .csv files were imported using the pre-defined TerraSurveyor import template appropriate for the CMD Mini Explorer system, and converted to .xcp format composite. This process was repeated six times, each time changing the "Val posn" value on the "Source Settings" screen to produce a composite for each of the six sets of readings taken during survey.

The .xcp files were opened and a .grd exported to allow visualisation of the minimally processed data. The data was de-spiked, de-striped and had a high-pass filter applied. The data was interpolated to values appropriate for 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 data was clipped and an XY trace plot generated and exported as a .dxf.

The .grd's were imported to the project's ArcGIS Pro geodatabase and converted into the British National Grid coordinate system using the "Project Raster" tool, 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
ANTW2020KH01-MAG.xcp	De-stripe	Median / SD 1.5
	Clip	-100/100 nT
	Base Settings	Interval 0.121m, Track Radius 0.45m
	Remove Turns	Threshold Angle 45, Cut Length 5m
ANTW2020KH02-MAG.xcp	De-stripe	Median / SD 1.5
	Clip	-100/100 nT
	Base Settings	Interval 0.121m, Track Radius 0.45m
	Remove Turns	Threshold Angle 45, Cut Length 5m
ANTW2020KH03-MAG.xcp	De-stripe	Median / SD 1.5
	Clip	-100/100 nT
	Base Settings	Interval 0.121m, Track Radius 0.45m
	Remove Turns	Threshold Angle 45, Cut Length 5m
ANTW2020KH04-MAG.xcp	De-stripe	Median / SD 1.5
	Clip	-100/100 nT
	Base Settings	Interval 0.121m, Track Radius 0.45m
	Remove Turns	Threshold Angle 45, Cut Length 5m
ANTW2020KH05-MAG.xcp	De-stripe	Median / SD 1.5
	Clip	-100/100 nT
	Base Settings	Interval 0.121m, Track Radius 0.45m
	Remove Turns	Threshold Angle 45, Cut Length 5m
ANTW2020KH01a-EMHI-COND1xcp	Base Settings	Interval 0.20m, Track Radius 0.56m
	Remove Turns	Threshold Angle 45, Cut Length 5m
ANTW2020KH01a-EMHI-COND2xcp	Base Settings	Interval 0.20m, Track Radius 0.56m
	Remove Turns	Threshold Angle 45, Cut Length 5m
ANTW2020KH01a-EMHI-COND3xcp	Base Settings	Interval 0.20m, Track Radius 0.56m
	Remove Turns	Threshold Angle 45, Cut Length 5m
ANTW2020KH01a-EMHI-MSUS1xcp	Base Settings	Interval 0.20m, Track Radius 0.56m
	Remove Turns	Threshold Angle 45, Cut Length 5m
ANTW2020KH01a-EMHI-MSUS2xcp	Base Settings	Interval 0.20m, Track Radius 0.56m
	Remove Turns	Threshold Angle 45, Cut Length 5m
ANTW2020KH01a-EMHI-MSUS3xcp	Base Settings	Interval 0.20m, Track Radius 0.56m
	Remove Turns	Threshold Angle 45, Cut Length 5m
ANTW2020KH01b-EMHI-COND1xcp	Base Settings	Interval 0.20m, Track Radius 0.56m
	Remove Turns	Threshold Angle 45, Cut Length 5m
ANTW2020KH01b-EMHI-COND2xcp	Base Settings	Interval 0.20m, Track Radius 0.56m
	Remove Turns	Threshold Angle 45, Cut Length 5m
ANTW2020KH01b-EMHI-COND3xcp	Base Settings	Interval 0.20m, Track Radius 0.56m
	Remove Turns	Threshold Angle 45, Cut Length 5m

ANTW2020KH01b-EM HI-MSUS1xcp	Base Settings	Interval 0.20m, Track Radius 0.56m
	Remove Turns	Threshold Angle 45, Cut Length 5m
ANTW2020KH01b-EM HI-MSUS2xcp	Base Settings	Interval 0.20m, Track Radius 0.56m
	Remove Turns	Threshold Angle 45, Cut Length 5m
ANTW2020KH01b-EM HI-MSUS3xcp	Base Settings	Interval 0.20m, Track Radius 0.56m
	Remove Turns	Threshold Angle 45, Cut Length 5m
ANTW2020KH01c-EM HI-COND1xcp	Base Settings	Interval 0.20m, Track Radius 0.56m
	Remove Turns	Threshold Angle 45, Cut Length 5m
ANTW2020KH01c-EM HI-COND2xcp	Base Settings	Interval 0.20m, Track Radius 0.56m
	Remove Turns	Threshold Angle 45, Cut Length 5m
ANTW2020KH01c-EM HI-COND3xcp	Base Settings	Interval 0.20m, Track Radius 0.56m
	Remove Turns	Threshold Angle 45, Cut Length 5m
ANTW2020KH01c-EM HI-MSUS1xcp	Base Settings	Interval 0.20m, Track Radius 0.56m
	Remove Turns	Threshold Angle 45, Cut Length 5m
ANTW2020KH01c-EM HI-MSUS2xcp	Base Settings	Interval 0.20m, Track Radius 0.56m
	Remove Turns	Threshold Angle 45, Cut Length 5m
ANTW2020KH01c-EM HI-MSUS3xcp	Base Settings	Interval 0.20m, Track Radius 0.56m
	Remove Turns	Threshold Angle 45, Cut Length 5m
ANTW2020KH03-EM HI-COND1xcp	Base Settings	Interval 0.20m, Track Radius 0.56m
	Remove Turns	Threshold Angle 45, Cut Length 5m
ANTW2020KH03-EM HI-COND2xcp	Base Settings	Interval 0.20m, Track Radius 0.56m
	Remove Turns	Threshold Angle 45, Cut Length 5m
ANTW2020KH03-EM HI-COND3xcp	Base Settings	Interval 0.20m, Track Radius 0.56m
	Remove Turns	Threshold Angle 45, Cut Length 5m
ANTW2020KH03-EM HI-MSUS1xcp	Base Settings	Interval 0.20m, Track Radius 0.56m
	Remove Turns	Threshold Angle 45, Cut Length 5m
ANTW2020KH03-EM HI-MSUS2xcp	Base Settings	Interval 0.20m, Track Radius 0.56m
	Remove Turns	Threshold Angle 45, Cut Length 5m
ANTW2020KH03-EM HI-MSUS3xcp	Base Settings	Interval 0.20m, Track Radius 0.56m
	Remove Turns	Threshold Angle 45, Cut Length 5m
ANTW2020KH04-EM HI-COND1xcp	Base Settings	Interval 0.20m, Track Radius 0.56m
	Remove Turns	Threshold Angle 45, Cut Length 5m
ANTW2020KH04-EM HI-COND2xcp	Base Settings	Interval 0.20m, Track Radius 0.56m
	Remove Turns	Threshold Angle 45, Cut Length 5m
ANTW2020KH04-EM HI-COND3xcp	Base Settings	Interval 0.20m, Track Radius 0.56m
	Remove Turns	Threshold Angle 45, Cut Length 5m
ANTW2020KH04-EM HI-MSUS1xcp	Base Settings	Interval 0.20m, Track Radius 0.56m
	Remove Turns	Threshold Angle 45, Cut Length 5m
ANTW2020KH04-EM HI-MSUS2xcp	Base Settings	Interval 0.20m, Track Radius 0.56m
	Remove Turns	Threshold Angle 45, Cut Length 5m

ANTW2020KH04-EM HI-MSUS3xcp	Base Settings	Interval 0.20m, Track Radius 0.56m
	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.
Despike	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.
Dstagger	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.
Destripe	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 (HES) Archaeological Survey Team undertook geophysical (gradiometer & electro-magnetic) survey at Kinneil House, Bo'ness, Falkirk, Scotland, EH51 0PR. This forms part of a wider Antonine Wall Geophysical Survey project that aims to address management and research questions relating to the Antonine frontier by investigating the extent and significance of sub-surface archaeological remains at various locations within the World Heritage Site.

The fieldwork was conducted between 10 May 2021 and 18 May 2021. In total 8.35ha were surveyed using a Sensys MXPDA gradiometer, with 0.455ha surveyed using a CMD Mini Explorer electro-magnetic device. The geophysical survey has produced good quality gradiometer results which have successfully contributed to the aims of the survey. The electro-magnetic survey has provided moderate quality results which have in part supported the gradiometer results and therefore provided a moderate contribution to the aims of the survey. There is a high level of confidence that the chosen mixed methodology and survey strategy was appropriate to assess the archaeological potential of the survey area.

The survey has successfully confirmed the course of the Antonine Wall Ditch which in most places corresponds well with its previously mapped line. It has also confirmed the survival of the Antonine Rampart base in some parts of the survey area. A possible causeway across the Ditch has been identified to the east of Kinneil House and may relate to a previously unidentified Roman installation at this location. This may relate to the 'missing' Kinneil fort.

A previously unidentified 10m square enclosure has been identified abutting the southern side of the Rampart. It is like the Minor Enclosures identified at Wilderness plantation and may therefore be the fourth example of this class of Roman installation.

The location of the ditch surrounding Kinneil Kirk has been confirmed and the results suggest this may be a double ditch in places.

Anomalies believed to relate to Kinneil village have been identified in the area known as 'The Meadows'. The village appears to have followed the course of the Outer Mound in part before extending in a south-easterly direction. The nature of these anomalies suggest they may relate to a period of destruction as the village was cleared.

An area of later prehistoric activity has been identified to the north-east of Kinneil House, comprising a small promontory fort or settlement and roundhouses. Possible droveways, land boundaries and enclosures have also been identified in this area. Some of these features may be connected to the later prehistoric activity, though a later date is equally possible.

Responses relating to Kinneil House's landscaped gardens have been identified in various location throughout the survey area.

The location of a road or trackway, defined by a pair of parallel ditches, has been identified crossing and so postdating the Antonine Wall.

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

(Project ID: ANTW2020KH)

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
371190	ANTW2020KH-0057	Addition	Site Created
371191	ANTW2020KH-0041	Addition	Site Created
371192	ANTW2020KH-0045	Addition	Site Created
371193	ANTW2020KH-0008	Addition	Site Created
371195	ANTW2020KH-0044	Addition	Site Created
371196	ANTW2020KH-0046	Addition	Site Created
371200	ANTW2020KH-0055	Addition	Site Created
371201	ANTW2020KH-0009	Addition	Site Created

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HISTORIC ENVIRONMENT SCOTLAND | ÀRAINNEACHD EACHDRAIDHEIL ALBA

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