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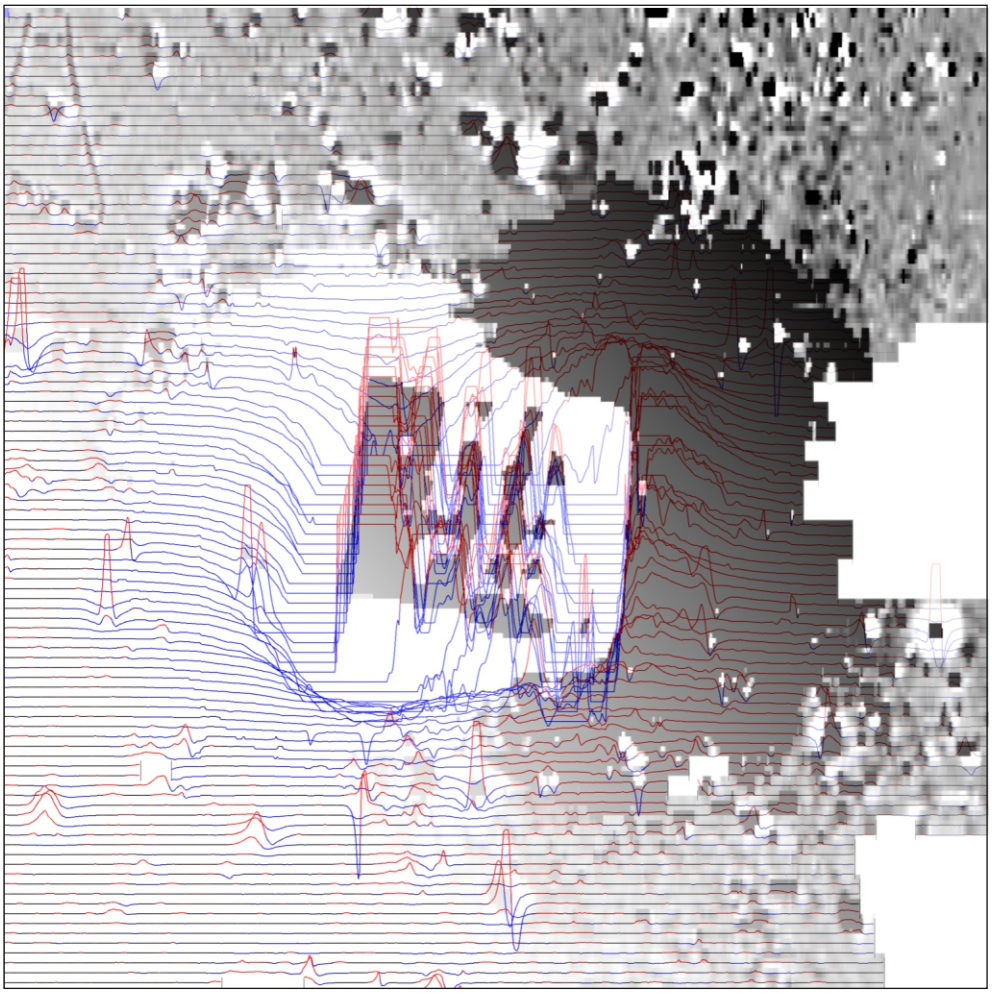
Battle Headquarters Bunkers
New Forest, Hampshire

Geophysical Survey Report



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geoservices

Battle Headquarters Bunkers
New Forest, Hampshire

Geophysical Survey Report

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Summary

A geophysical survey was conducted over land within the New Forest, Hampshire over three known or suspected battle headquarters bunker sites associated with three former airfields. The project was commissioned by the New Forest National Park Authority with the aim of establishing the extent, structure, character and state of preservation of these three sites. This survey forms part of the New Forest National Park Authority's project named "New Forest Remembers: Untold Stories of WW2" that aims to identify WW2 remains in the area and make them accessible and understandable to the public.

The sites comprise areas of rough pasture within the New Forest National Park; located at Stoney Cross Airfield near Fritham, Beaulieu Heath Airfield 3.3km WSW of Beaulieu and at Holmsley South Airfield 2.5km northeast of Bransgore. The Stoney Cross and Beaulieu Heath sites had been partially cleared of the densest vegetation prior to the survey although the Holmsley South site was overgrown at the time of the survey.

Two geophysical survey techniques were used on the sites at Stoney Cross and Beaulieu Heath, including gradiometer and Ground Penetrating Radar (GPR), with gradiometer survey conducted at Holmsley South. The surveys had mixed successes, with the gradiometer data proving the most reliable in detecting some structural features.

It is not possible to link the geophysical anomalies detected to any standard features of a battle headquarters bunker. This may be due in part to the regional variation in their design coupled with the possibility that some of these suspected headquarters were actually related to some other service related to the running of the airfield.

The geophysical survey was undertaken from 20th February to 22nd March 2014 with a further survey conducted on the 22nd October.

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The detailed gradiometer survey was commissioned by the New Forest National Park Authority. The assistance of James Brown is gratefully acknowledged in this regard. The advice of Neil Linford of English Heritage is also greatly appreciated.

The fieldwork was directed by Rachel Chester and Laura Andrews, assisted by Alistair Black, Clara Dickinson, Richard Payne, Jennifer Smith and Rachel Williams. Ross Lefort and Ben Urmston processed and interpreted the geophysical data. This report was written by Ross Lefort. The geophysical work was quality controlled by Dr. Paul Baggaley and Ben Urmston. Illustrations were prepared by Ross Lefort and Karen Nichols. The project was managed on behalf of Wessex Archaeology by Dr. Paul Baggaley.

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Geophysical Survey Report

1 INTRODUCTION

1.1 Project background

1.1.1 Wessex Archaeology was commissioned by the New Forest National Park Authority to carry out a geophysical survey of three confirmed or suspected battle headquarters bunkers located within the New Forest National Park, Hampshire (**Figure 1**). The survey forms part of an ongoing programme of archaeological works being undertaken to assess the condition of Second World War structures within the national park.

1.1.2 The three bunker sites surveyed are all associated with nearby former Second World War airfields with one close to Stoney Cross Airfield (NGR 424440, 113810), another near Beaulieu Heath Airfield (NGR 435510, 101360) and another near Holmsley South Airfield (NGR 420710, 099570).

1.1.3 The aim of the geophysical survey was to establish the extent and character of the three bunker complexes as well as seeing if internal divisions could be detected through geophysical survey. This survey forms part of the New Forest National Park Authority's project named "New Forest Remembers: Untold Stories of WW2" that aims to identify all WW2 remains in the area and make them accessible and understandable to the public.

1.1.4 This report presents a brief description of the methodology followed, the detailed survey results and the archaeological interpretation of the geophysical data.

1.2 Site Location and Topography

1.2.1 The possible bunker located NNW of Stoney Cross Airfield is located within an area of pasture with some dense patches of shrub scattered across the field. The site is located on the southeast side of the village of Fritham with Fordingbridge located 7.75km east of Fordingbridge and 11km west of the centre of Totton. The site itself is set within a scheduled Bronze Age round barrow. Stoney Cross Airfield and the surveyed possible bunker sit on a flat NNW-SSE aligned ridge with the bunker set at a height of around 115m above Ordnance Datum (aOD) and the airfield at around 110m aOD. A number of small unnamed streams are recorded running away from the site in all directions.

1.2.2 The second bunker site is located northeast of Beaulieu Heath Airfield within an area of rough pasture. The site is located 3.3km WSW of Beaulieu village with Brockenhurst located 5.6km to the WNW. The airfield and the bunker are set on fairly flat ground around 40m aOD with the bunker located at the head of a valley leading to a pond further east. There are a number of streams running from the higher ground at the heath with the River Beaulieu and the River Lymington located to the east and west of the site respectively.

1.2.3 The third bunker site is located on the northern edge of Holmsley South Airfield within an area of rough pasture named Pigsty Hill. The site is located 0.75km ESE of the village of

Thorney Hill with Bransgore located 2.5km to the southwest. The airfield is set on fairly flat ground between 60m and 65m aOD and the bunker is located on higher ground around 70m aOD. There are numerous unnamed watercourses running in all directions away from the site.

1.3 Soils and Geology

1.3.1 The bedrock geology under the Stoney Cross bunker site is recorded as Palaeogene sedimentary deposits of Barton clay formation with Selsey sand formation (sand silt and clay) recorded on lower ground close by (BGS). The superficial deposits recorded under this site date to the Quaternary period and include river terrace deposits (sand and gravel) with head deposits recorded in the lower river valleys close to the site (BGS).

1.3.2 The soils underlying the Stoney Cross bunker site are likely to be stagnogley-podzols of the 643c (Bolderwood) association. Typical stagnogley soils of the 711h (Wickham 4) association are recorded close to the site (SSEW 1983). Soils derived from such geological parent material have been shown to produce magnetic contrasts acceptable for the detection of archaeological remains through magnetometer survey.

1.3.3 The bedrock geology under the Beaulieu Heath bunker site is recorded as Palaeogene sedimentary deposits of Headon beds and Osborne beds (clay, silt and sand) (BGS). The superficial deposits recorded under this site date to the Quaternary period and include river terrace deposits (sand and gravel) (BGS).

1.3.4 The soils underlying the Beaulieu Heath bunker site are likely to be stagnogley-podzols of the 643c (Bolderwood) association. Typical argillic gley soils of the 841b (Hurst) association are recorded on the lower lying land a short distance from the site (SSEW 1983). Soils derived from such geological parent material have been shown to produce magnetic contrasts acceptable for the detection of archaeological remains through magnetometer survey.

1.3.5 The bedrock geology under the Holmsley South bunker site is recorded as Palaeogene sedimentary deposits of Headon formation (clay, silt and sand) with Lyndhurst member (sand, silt and clay) recorded close by (BGS). The superficial deposits recorded under this site date to the Quaternary period and include river terrace deposits (sand and gravel) with alluvial deposits recorded in the lower stream valleys close to the site (BGS).

1.3.6 The soils underlying the Holmsley South bunker site are likely to be typical stagnogley soils of the 711g (Wickham 3) association. A number of other soil types are recoded very close to the site including stagnogley-podzols of the 643c (Bolderwood) association, humo-ferric podzols of the 631c (Shirrell Heath 1) association and typical argillic gley soils of the 841d (Shabbington) association (SSEW 1983). Soils derived from such geological parent material have been shown to produce magnetic contrasts acceptable for the detection of archaeological remains through magnetometer survey.

1.4 Archaeological and Historical Background

1.4.1 The following information is summarized from the Heritage Gateway website (www.heritagegateway.org.uk). A search was performed for all heritage assets within 1km of the three sites.

1.4.2 The three site investigated in this project are known or suspected battle headquarters bunkers. These structures can be found on many airfields and served the purpose of giving the defence officer a secure location from which the defence of the airfield can be coordinated in the event of an invasion. The form of these structures can vary

considerably and earlier examples were located above ground. The basic plan consists of an underground box measuring 28ft x 9ft with an extra room to one side measuring 8ft x 6ft, all made from brick and concrete. A room for messengers and runners, a room for telephone equipment, a room for the defence officer and an observation room were standard features of these complexes. The observation room had thicker walls and was equipped with a concrete observation dome (cupola) (Tucknott and Taylor 2013).

1.4.3 Stoney Cross Airfield was opened in 1942 but was not fully functional until 1943. The airfield was equipped with three concrete runways, turning areas, Type T2 hangars, Blister hangars, dispersal pens and a water tower that still stands. It was initially used on a temporary basis by bombers and was also used for army cooperation and paratrooper training. The United States Army Air Force (USAAF) 397, 393 and 394 squadrons used the airfield in 1944 for training in preparation for D-Day. After the D-Day operations the airfield returned to the Royal Air Force (RAF) for use for glider training before being relegated to care and maintenance status in 1946. The airfield was derequisitioned in 1948 and part of the site is now occupied by a campsite and only some parts of the three runways survive (EH1430215).

1.4.4 The suspected battle headquarters bunker is located to the north of the airfield close to the village of Fritham. The possible bunker is set within a Bronze Age round barrow and close to another that appears to have been flattened out. These barrows are classed as a Scheduled Ancient Monument and one is recorded as showing signs of a structure made of brick and concrete of probable military origin (EH222876).

1.4.5 The airfield at Beaulieu Heath was opened in 1942 and was located further west from the First World War airfield that was located at East Boldre. By 1944 the airfield was equipped with three large runways, 50 concrete hard standings, two Type 2 hangars and one Blister hangar in addition to temporary accommodation for over 2000 personnel. The airfield was initially used by RAF coastal command and the Royal Canadian Air Force (RCAF). In 1944 the airfield was used as a forward base for 11 group fighter command that were joined by the USAAF, flying in support of the D-Day landings. The site was used by the Airborne Forces Experimental Establishment in the post-war era before its closure in 1950 (EH1158277).

1.4.6 The suspected bunker is located at the head of a stream valley to the northeast of the three runways. A rectangular structure is visible at the surface although little can be found relating to the site in local records. The battle HQ website has very little information but lists it as a type 11747/41 bunker (Tucknott and Taylor 2013).

1.4.7 Holmsley South Airfield was opened in 1942 and was equipped with three tarmac runways, five Type T2 hangars and temporary accommodation for nearly 3000 people. The airfield was used by the RAF, the USAAF and the RCAF with the airfield used to support D-Day operations. The airfield was assigned to the RAF transport command in 1944 before its closure in 1946 (EH1397754).

1.4.8 The bunker associated with this airfield is located to the north of the runways and is located in an area of dense vegetation. A concrete structure is visible at the surface and is recorded in detail on the battle HQ website. The bunker is recorded in poor condition with the cupola removed along with the main entrance. Two rooms are visible along with the emergency exit but these have been backfilled with concrete. The only visible feature is part of the emergency exit ladder (Tucknott and Taylor 2013).

2 METHODOLOGY

2.1 Introduction

2.1.1 The detailed magnetometer survey was conducted using a Bartington Grad601-2 dual fluxgate gradiometer system and the GPR survey was carried out using the Radarteam Cobra system. The two surveys were conducted in accordance with English Heritage guidelines (2008).

2.1.2 The geophysical survey was undertaken by Wessex Archaeology's in-house geophysics team in two main phases from the 20th to the 26th February 2014 with a third phase on the 22nd October 2014. Field conditions at the time of the survey were variable, the Stoney Cross and Beaulieu Heath sites had been cleared prior to the survey but the Holmsley South site was overgrown which reduced the area that could be surveyed.

2.2 Method

2.2.1 Individual survey grid nodes were established at 30m x 30m intervals using a Leica Viva RTK GNSS instrument, which is precise to approximately 0.02m and therefore exceeds English Heritage recommendations (2008).

2.2.2 The magnetometer survey was conducted using a Bartington Grad601-2 fluxgate gradiometer instrument, which has a vertical separation of 1m between sensors. Data were collected at 0.25m intervals along transects spaced 1m apart with an effective sensitivity of 0.03nT, in accordance with EH guidelines (2008). Data were collected in the zigzag method using the 100nT and 1000nT ranges.

2.2.3 Data from the gradiometer survey were subject to minimal data correction processes. These comprise a Zero Mean Traverse (ZMT) function (±25nT thresholds) applied to correct for any variation between the two Bartington sensors used, the deslope function to account for flaws in the ZMT function and a de-step function to account for variations in traverse position due to varying ground cover and topography. These three steps were applied to all survey areas, with no interpolation applied.

2.2.4 The Ground Penetrating Radar (GPR) survey was conducted using a Radarteam Cobra instrument with dual central frequencies of 300MHz and 500MHz. Data were collected at 0.0125m intervals along profiles spaced 0.5 m apart. The data interpreted and presented in this report were from the 300MHz channel.

2.2.5 Data from the GPR survey were subject to standard processing, including gain and wobble correction, before being sliced and regridded to produce 3D timeslices of the dataset. These are effectively horizontal groupings of data of equal depth, as determined by the two way travel time and the effective velocity of the radar pulse through the ground.

2.2.6 The approximate depth conversion is shown in Table 2 below, assuming the velocity of the GPR pulse through the ground is c. 0.07m/ns. It is possible to determine more precisely the average velocity of the GPR pulse through the ground if excavated features at a known depth can be identified in the data. Radargrams were analysed for suitable hyperbolic reflections, which can be used to determine the velocity of the GPR pulse through the sub-surface deposits; few such hyperbolae were observed and a typical value of 0.07m/ns was used.

2.2.7 The Relative Dielectric Permittivity (RDP) of the bulk structure can be calculated using $K = \left(\frac{V_c}{V_r}\right)^2$, where K is the RDP, V_c speed of light in a vacuum and V_r the GPR pulse velocity.

Timeslice	From (ns)	To (ns)	From (m)	To (m)
1	0.00	9.44	0.00	0.33
2	4.64	14.08	0.16	0.49
3	9.27	18.72	0.32	0.66
4	13.91	23.35	0.49	0.82
5	18.55	27.99	0.65	0.98
6	23.18	32.63	0.81	1.14
7	27.82	37.27	0.97	1.30
8	32.46	41.90	1.14	1.47
9	37.10	46.54	1.30	1.63
10	41.73	51.18	1.46	1.79
11	46.37	55.81	1.62	1.95
12	51.01	60.45	1.79	2.12
13	55.64	65.09	1.95	2.28
14	60.28	69.72	2.11	2.44
15	64.92	74.36	2.27	2.60
16	69.55	79.00	2.43	2.76
17	74.19	83.64	2.60	2.93
18	78.83	88.27	2.76	3.09
19	83.47	92.91	2.92	3.25
20	88.10	97.55	3.08	3.41
21	92.74	102.18	3.25	3.58
22	97.38	106.82	3.41	3.74
23	102.01	111.46	3.57	3.90
24	106.65	116.09	3.73	4.06
25	111.29	120.73	3.89	4.23
26	116.88	126.40	4.09	4.42
27	121.55	131.07	4.25	4.59
28	126.23	135.75	4.42	4.75
29	130.90	140.42	4.58	4.91
30	135.58	145.10	4.74	5.08
31	140.25	149.77	4.91	5.24
32	144.93	154.45	5.07	5.41
33	149.60	159.12	5.24	5.57
34	154.28	163.80	5.40	5.73
35	158.95	168.47	5.56	5.90
36	163.63	177.82	5.73	6.06
37	168.30	177.82	5.89	6.22
38	172.98	182.50	6.05	6.39
39	177.65	187.00	6.22	6.54
40	182.33	187.00	6.38	6.54

Table 1: GPR timeslice information, assuming v=0.007m/ns

2.2.8 Further details of the geophysical and survey equipment, methods and processing are described in **Appendices 1** to **3**.

3 GEOPHYSICAL SURVEY RESULTS AND INTERPRETATION

3.1 Introduction

3.1.1 The geophysical survey has had mixed success in identifying internal features relating to three headquarters bunkers with the clearest results obtained at Beaulieu Heath Airfield. Results are presented as a series of greyscale, colour scale and XY plots along with archaeological interpretations, at a scale of 1:1000 (**Figures 2** to **6**).

3.1.2 The gradiometer data are displayed at a range of -2nT (white) to +3nT (black) (**Figures 2-5**) and ±30nT (**Figure 6**) for the greyscale images and a range of ±25nT at 25nT per cm for the XY trace plots. A second series of greyscales was produced in order to provide more clarity over the highly magnetic features of the WWII structures.

3.1.3 GPR results are presented as a series of timeslices, profiles and archaeological interpretations at a scale of 1:500 (**Figures 7** to **13**). Data are displayed as Low Amplitude (white or blue) to High Amplitude (black or red).

3.1.4 The interpretation of the datasets highlights the presence of potential archaeological anomalies, modern features and weak linear trends. Full definitions of the interpretation terms used in this report are provided in **Appendix 3**.

3.1.5 Numerous ferrous anomalies are visible throughout the gradiometer survey dataset. Some are presumed to be modern in provenance but most of them are likely to relate to this areas use during the Second World War.

3.2 Gradiometer Survey Results and Interpretation: Stoney Cross Airfield

3.2.1 The main anomaly visible within the barrow mound is a broad spread of ferrous responses; within this are a few strong bipolar anomalies (black and white) at **4000** and **4001**. These responses could be indicative of large brick or reinforced concrete structures although a clear regular layout cannot be discerned from these responses. These three strongest bipolar responses have been interpreted as possible archaeology.

3.2.2 The remaining anomalies in the quieter regions of the survey area include small positive anomalies of possible archaeological interest and weak linear trends of uncertain origin. The small positive anomalies may represent cut archaeological features but could equally be created by geological processes or may represent unusual ferrous responses.

3.3 Gradiometer Survey Results and Interpretation: Stoney Cross Airfield Additional Survey

3.3.1 The increased area covered in this additional survey at Stoney Cross has revealed further detail and context to the initial small area survey.

3.3.2 The anomalies **4002** and **4003** are largely comparative to those detected in the first survey (**4000** and **4001**) and are indicative of large brick or reinforced concrete structures. Within the ±30nT images it is possible to discern two strongly magnetic features that appear central within the mound. It is probable that these anomalies are archaeological however no clear shape can be discerned.

3.3.3 South east of the mound at **4004** are a series of weak linear trends of uncertain origin but may be associated with the mound.

3.3.4 To the south of the modern service **4005** denotes several strong anomalies in a linear alignment. It is unclear what these may relate to and it is possible that they are associated with the modern service.

3.3.5 Across the rest of the survey area there are several small positive anomalies and further weak linear trends of uncertain origin.

3.4 Gradiometer Survey Results and Interpretation: Beaulieu Heath Airfield

3.4.1 This survey area contains the most promising anomalies with a square ferrous anomaly detected at **4006** that corresponds to the position of the exposed concrete visible at the surface. The anomaly measures approximately 10.5m x 10.5m and has some hint of variation of values within in the form of a positive projection that may be indicative of internal structure. This anomaly has been interpreted as archaeology.

3.4.2 Close to this square ferrous response is a regular elongated ferrous response at **4007** that is set on the same northwest to southeast alignment as **4006**. This anomaly is considered to be related and may be indicative of structural remains. This feature has been interpreted as probable archaeology. There are other smaller variations within this large spread of ferrous responses although none appear to be as regular in form as the two discussed at **4006** and **4007**.

3.4.3 There is a sub-oval pit-like anomaly on the edge of the ferrous spread at **4008**; this anomaly has positive values over +3nT and measures around 5m in length. It is unclear whether this feature is related to the suspected bunker complex although it has been classed as probable archaeology.

3.4.4 The remaining anomalies are small positive anomalies of possible archaeological interest and weak linear trends of uncertain origin. A spread of increased magnetic response on the southeast side of the large central ferrous response may represent a concentration of debris relating to this complex or its partial demolition.

3.5 Gradiometer Survey Results and Interpretation: Holmsley South Airfield

3.5.1 The survey area at Holmsley South was reduced by dense vegetation and the surveyed area is dominated by ferrous responses. There are bipolar anomalies present around **4009** that may relate to structural features of the bunker. Few other anomalies are visible.

3.6 GPR Survey Results and Interpretation: Stoney Cross Airfield

3.6.1 Within Timeslice 3, a number of high amplitude anomalies can be seen. At the eastern extent of the survey, sub-annular anomaly **5000** is consistent with an archaeological feature, given its shape in plan. Strong anomalies **5001** at the centre of the survey area are likely to be associated with the visible WWII structures seen at the surface, although it is possible that these responses represent ringing within the dataset. Further anomalies **5002** and **5003** along the southern extents are rectilinear in plan, and are therefore possibly associated with buried structures, although their responses are somewhat fragmentary.

3.6.2 Within Timeslice 6, rectilinear anomalies **5004** and **5005** are consistent with the remnants of buried structures, taking on the form of a rectangular enclosure some 15m E-W by 10m N-S; the variable response of these anomalies weakens confidence in their interpretation, although the presence of a low amplitude response at **5004** is perhaps consistent with a void. Further linear trends can be seen within the timeslice, e.g. **5006**, although these are only weakly defined.

3.6.3 Within Timeslice 8, curvilinear response **5007** can be seen within the northern portion of the dataset; although it is not entirely clear what this anomaly relates to, it is considered to be of possible archaeological interest. Further linear and curvilinear trends **5008** and **5009** are on similar orientations and may be associated with the clearer anomalies to the north.

3.6.4 The dataset from Timeslice 14 shows a fragmentary curvilinear anomaly across the northern and western portions of the site, at **5010** and **5011**. It is possible that this represents a continuous feature, which would be of possible archaeological interest. High amplitude responses can be seen around the periphery of the dataset, e.g. **5012**, although it is unclear to what these may relate and it is possible that they are associated with the natural geology below the mound and WWII structures.

3.7 GPR Survey Results and Interpretation: Beaulieu Heath Airfield

3.7.1 Within Timeslice 4, several strong anomalies are visible in the near surface data; amorphous anomalies **5013** and **5014** are sufficiently well defined to be associated with the WWII bunker structure, although this cannot be demonstrated conclusively. Isolated anomalies of increased response **5015** can be seen to the southwest, which may be associated with debris or intact structures; a linear anomaly near the northeastern extent of the data is less coherent but may also relate to a former feature, given its orientation.

3.7.2 The dataset from Timeslice 9 is rather variable, with few coherent patterns visible within the data. Some rectilinearity can be seen at **5016**, although no clear anomalies can be discerned. Similarly, higher amplitude responses are visible further east at **5017**; the northern portions of the dataset are somewhat quieter, although localised variability is still evident throughout.

3.7.3 The dataset from Timeslice 12 is similar in character to those above and below, with few coherent anomalies visible. Responses at **5018** represent the longest continuous group of anomalies, although they are not clearly associated with an archaeological feature.

3.7.4 The data from Timeslice 16 are largely consistent with geological sources, with few coherent anomalies visible. Strong responses can be seen at the southwestern and southeastern extents, with a region of markedly weaker response towards the centre of the survey area at **5019**.

3.8 GPR Survey Results and Interpretation: Holmsley South Airfield

3.8.1 The size of the survey area at Holmsley during the third phase of field survey on the 22nd October 2014 was still greatly reduced by dense vegetation. The area is dominated by high amplitude anomalies, of which some may relate to structural features of the bunker.

3.8.2 Within Timeslice 3 a number of high amplitude anomalies can be seen. In the northern part of the survey area a series of sub-rectilinear anomalies **5020** can be seen. The radargrams from this part of the survey area show high amplitude reflectors at approximately 45ns depth (**Figure 13**). In particular Profile 38 and 39 show a horizon between 30 and 45ns depth (approximately 1.5m depth *c.f.* **Table 1**), within the first two meters of the profile. Profile 36 shows a region of low amplitude in the centre of the transect and a high amplitude reflector consistent with profiles 38 and 39. The location of these is consistent with the bunker and there are likely to be associated with the WWII structure that can be seen on the surface. Low Amplitude responses around **5020** are consistent with a void to be expected with a buried bunker. Strong high amplitude anomalies **5021** are located on the eastern extent of the survey area and are of uncertain origin.

3.8.3 Data from Timeslice 6 are largely consistent with those above and detail more clearly a rectilinear formation of high amplitude anomalies **5022**. Future linear trends **5023** are visible in the central area of the survey region however it is unclear the significance of these however it is unlikely they are related to the WWII structures due to their varied response.

3.8.4 Within Timeslice 14 high amplitude responses remain present in the north part of the survey area and are consistent with buried structures however their shape has lost coherency. Linear trends **5024** in the central and southern parts of the survey area have variable responses and alignments; it is not entirely clear what these relate to.

3.8.5 The dataset from Timeslice 25 shows varied responses with anomalies in the south largely consistent with geological sources with few coherent anomalies. Strong responses in the north area are perhaps still related to the buried structures. Low amplitude **5025** is perhaps associated with a void and is probably associated with the bunker.

3.9 Geophysical Survey Results and Interpretation: Modern Services

3.9.1 No clear modern services could be identified from any of the geophysical data sets. It should be noted that geophysical survey may not detect all services present on Site. This report and accompanying illustrations should not be used as the sole source for service locations and appropriate equipment (e.g. CAT and Genny) should be used to confirm the location of buried services before any trenches are opened on Site.

4 CONCLUSION

4.1.1 The geophysical surveys have had mixed successes with the gradiometer data revealing some details of the structure at Beaulieu Heath and some possible structure at Stoney Cross but revealed very little at Holmsley South. The GPR surveys did not elucidate the interpretation particularly, although some anomalies of possible archaeological interest were identified at both sites.

4.1.2 The clearest gradiometer results were obtained from the Beaulieu Heath site where a clear structure could be discerned. The anomalies detected at Stoney Cross and Holmsley South are less clear in terms of forming a clear layout but this could be partly the result of post-war demolition and is also partly the product of the reduced size of the survey areas here.

4.1.3 The GPR results were inconclusive and this is considered likely to be the result of a number of factors. The Stoney Cross site comprises WWII structures intruding into a Bronze Age mound, with partial demolition evident at the surface. The presence of standing water in the ditch surrounding the monument also indicates that the GPR signal would attenuate rapidly through the waterlogged ground.

4.1.4 GPR survey was also hampered at Beaulieu Heath by the presence of woody scrub across the entire survey area, with varying densities of heather, gorse and other undergrowth preventing cart-based survey entirely. Combined with the uneven ground, the nature of the ground cover made collection of a good quality dataset challenging, evidence of which can be seen in the numerous partial lines and the noise within the dataset. It is difficult to recommend cart-based GPR survey on similar terrain and that a physically larger, sledge-based antenna would be more practicable.

4.1.5 The GPR survey at Holmsley South airfield produced results that were indicative of the WWII bunker, in particular in the northern part of the survey area where the anomalies

were consistent with the location of surface remains. This survey was hampered due to the presence of wood scrub across the entire survey area and high density of gorse and other undergrowth which made the collection of good quality data challenging as can be seen by the shape of the survey area.

4.1.6 Although a clear structure was identified at Beaulieu heath the dimensions appear to differ to the standard plan outlined by Tucknott and Taylor (2013). The reasons for this could relate to the bunker being built to an earlier or non-standard plan but could also indicate that these sites may not be the battle headquarters but some other defensive or service structure related to these airfields. More invasive investigation may help to further identify these structures.

4.1.7 It should be noted that some features may produce responses that are below the detection threshold of the survey equipment used. It may therefore be the case that more archaeological features may be encountered than have been identified through geophysical survey.

5 REFERENCES

5.1 Bibliography

British Geological Survey (BGS) http://mapapps.bgs.ac.uk/geologyofbritain/home.html

English Heritage, 2008. Geophysical Survey in Archaeological Field Evaluation. Research and Professional Service Guideline No 1, 2nd edition.

Soil Survey of England and Wales, 1983. Sheet 6, Soils of South East England. Ordnance Survey, Southampton.

Tucknott, M. and Taylor, I. 2013. *WWII Airfield Battle Headquarters* [Online]. Available at: http://www.battlehq.info/ [Accessed: 27/05/2014].

5.2 English Heritage PastScape Records

EH222876 – The Butt

EH1158277 – Beaulieu Heath Airfield

EH1397754 – Holmsley South Airfield

EH1430215 – Stoney Cross Airfield

APPENDIX 1: GRADIOMETER SURVEY EQUIPMENT AND DATA PROCESSING

Survey Methods and Equipment

The magnetic data for this project was acquired using a Bartington 601-2 dual magnetic gradiometer system. This instrument has two sensor assemblies fixed horizontally 1m apart allowing two traverses to be recorded simultaneously. Each sensor contains two fluxgate magnetometers arranged vertically with a 1m separation, and measures the difference between the vertical components of the total magnetic field within each sensor array. This arrangement of magnetometers suppresses any diurnal or low frequency effects.

The gradiometers have an effective resolution of 0.03nT over a ±100nT range, and measurements from each sensor are logged at intervals of 0.25m. All of the data are stored on an integrated data logger for subsequent post-processing and analysis.

Wessex Archaeology undertakes two types of magnetic surveys: scanning and detail. Both types depend upon the establishment of an accurate 20m or 30m site grid, which is achieved using a Leica Viva RTK GNSS instrument and then extended using tapes. The Leica Viva system receives corrections from a network of reference stations operated by the Ordnance Survey and Leica Geosystems, allowing positions to be determined with a precision of 0.02m in real-time and therefore exceed the level of accuracy recommended by English Heritage (2008) for geophysical surveys.

Scanning surveys consist of recording data at 0.25m intervals along transects spaced 10m apart, acquiring a minimum of 80 data points per transect. Due to the relatively coarse transect interval, scanning surveys should only be expected to detect extended regions of archaeological anomalies, when there is a greater likelihood of distinguishing such responses from the background magnetic field.

The detailed surveys consist of 20m x 20m or 30m x 30m grids, and data are collected at 0.25m intervals along traverses spaced 1m apart. These strategies give 1600 or 3600 measurements per 20m or 30m grid respectively, and are the recommended methodologies for archaeological surveys of this type (EH, 2008).

Data may be collected with a higher sample density where complex archaeological anomalies are encountered, to aid the detection and characterisation of small and ephemeral features. Data may be collected at up to 0.125m intervals along traverses spaced up to 0.25m apart, resulting in a maximum of 28800 readings per 30m grid, exceeding that recommended by English Heritage (2008) for characterisation surveys.

Post-Processing

The magnetic data collected during the detail survey are downloaded from the Bartington system for processing and analysis using both commercial and in-house software. This software allows for both the data and the images to be processed in order to enhance the results for analysis; however, it should be noted that minimal data processing is conducted so as not to distort the anomalies.

As the scanning data are not as closely distributed as with detailed survey, they are georeferenced using the GPS information and interpolated to highlight similar anomalies in adjacent transects. Directional trends may be removed before interpolation to produce more easily understood images.

Typical data and image processing steps may include:

- Destripe – Applying a zero mean traverse in order to remove differences caused by directional effects inherent in the magnetometer;
- Destagger – Shifting each traverse longitudinally by a number of readings. This corrects for operator errors and is used to enhance linear features;
- Despike – Filtering isolated data points that exceed the mean by a specified amount to reduce the appearance of dominant anomalous readings (generally only used for earth resistance data).

Typical displays of the data used during processing and analysis:

- XY Plot – Presents the data as a trace or graph line for each traverse. Each traverse is displaced down the image to produce a stacked profile effect. This type of image is useful as it shows the full range of individual anomalies;
- Greyscale – Presents the data in plan view using a greyscale to indicate the relative strength of the signal at each measurement point. These plots can be produced in colour to highlight certain features but generally greyscale plots are used during analysis of the data.

APPENDIX 2: GPR SURVEY EQUIPMENT AND DATA PROCESSING

Survey Methods and Equipment

The ground penetrating radar (GPR) data were collected using a cart-based dual-frequency GPR system (Radarteam Cobra); this system can collect frequencies ranging from 100MHz to 900MHz. This configuration consists of the antenna sat in between the four wheels of the cart, one of which has an odometer attached to measure distance travelled. The combined viewer and data logger unit is affixed to the top of the handle.

The depth of penetration of GPR systems is determined by the central frequency of the antenna and the relative dielectric permittivity (RDP) of the material through which the GPR signal passes. In general, soils in floodplain settings may have a wide range of RDPs, although around 8 may be considered average, resulting in a maximum depth of penetration c. 2.5m with the GPR signal having a velocity of approximately 0.1m/ns.

The GPR beam is conical in shape and whilst most of the energy is concentrated in the centre of the cone, the GPR signal illuminates a horizontal footprint which becomes wider with increasing depth. At the maximum depth of the antenna, it becomes impossible to resolve any feature smaller than the horizontal footprint for the corresponding depth. The size of the footprint is dependent upon central frequency, and its size increases as the central frequency decreases.

The vertical resolution is similarly dependent upon the central frequency; for the 300MHz antenna, features of the order of 0.05m may be resolved vertically. Antennae with lower frequencies can therefore penetrate more deeply but are less resolute in both horizontal and vertical directions. Choice of antenna frequency is guided largely by the anticipated depth to the target and the required resolution.

GPR data for detailed surveys are collected along traverses of varying length separated by 0.5m with cross lines collected running perpendicular to these traverses at wider separations. The data sampling resolution is governed by the data logger and a minimum separation of 0.05m between traces is collected for all surveys.

Post-Processing

The radar data collected during the detail survey are downloaded from the GPR system for processing and analysis using commercial software (GPR Slice). This software allows for both the data and the images to be processed in order to enhance the results for analysis; however, it should be noted that minimal data processing is conducted so as not to distort the anomalies.

Typical data and image processing steps may include:

- Gain – Amplifies GPR data based upon its position in the profile, which boosts the contrast between anomalies and background. A wobble correction is also applied during this step;
- Bandpass – Removes GPR data lying outside a specified range, which removes high- and low-frequency noise.

Typical displays of the data used during processing and analysis:

- Timeslice – Presents the data as a series of successive plan views of the variation of reflector energy from the surface to the deepest recorded response. The variation in amplitude is represented using a colour scale with red indicating high amplitude and blue indicating low amplitude responses;
- Radargram – Presents each radar profile in a vertical view with distance along the profile expressed along the x axis and depth along the y axis. The amplitude variation is expressed using a greyscale.

APPENDIX 3: GEOPHYSICAL INTERPRETATION

The methodology used by Wessex Archaeology separates the anomalies into four main groups of interpretation categories: archaeological, modern, agricultural and uncertain origin/geological.

The archaeological category is used for features when the form, nature and pattern of the anomaly are indicative of archaeological material. Further sources of information such as aerial photographs and early mapping may also have been incorporated in providing the final interpretation. This category is further sub-divided into three groups, implying a decreasing level of confidence:

- Archaeology – used when there is a clear geophysical response and anthropogenic pattern;
- Probable archaeology – used for features which give a clear response but which form incomplete patterns;
- Possible archaeology – used for features which give a response but which form no discernible pattern or trend.

The modern category is used for anomalies that are presumed to be relatively recent in date:

- Ferrous – used for responses caused by ferrous material. These anomalies are likely to be of modern origin;
- Modern service – used for responses considered relating to cables and pipes; most are composed of ferrous/ceramic material although services made from non-magnetic material can sometimes be observed.

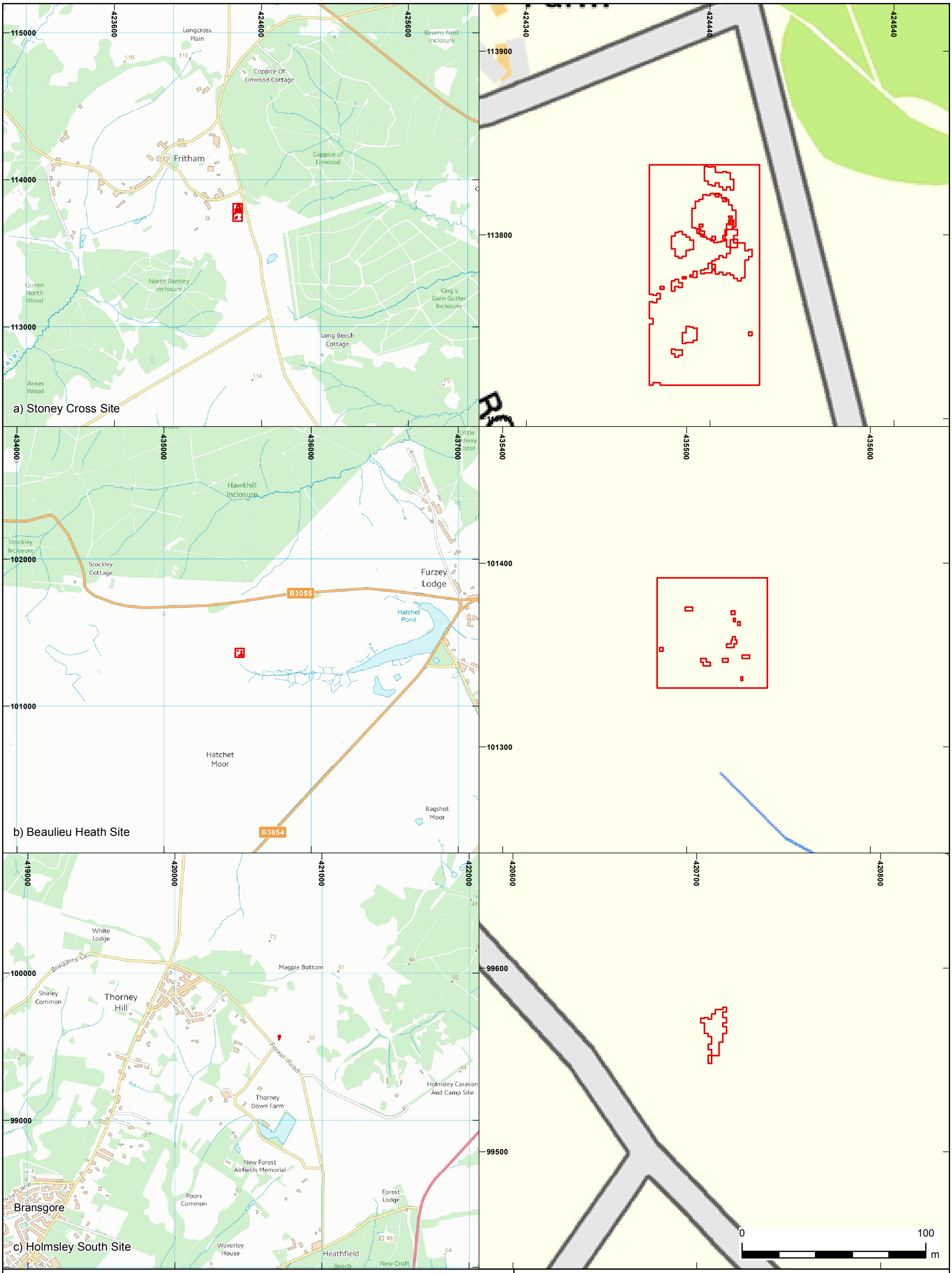
The agricultural category is for clear features that are likely to relate to recent farming activity:

- Former field boundaries – used for ditch sections that correspond to the position of boundaries marked on earlier mapping;
- Agricultural ditches – used for ditch sections that are aligned parallel to existing boundaries and former field boundaries that are not considered to be of archaeological significance;
- Ridge and furrow – used for broad and diffuse linear anomalies that are considered to indicate areas of former ridge and furrow;
- Ploughing – used for well-defined narrow linear responses, usually aligned parallel to existing field boundaries;
- Drainage – used to define the course of ceramic field drains that are visible in the data as a series of repeating bipolar (black and white) responses. These drains can also be defined as ditches where a clear herringbone pattern can be discerned.

The uncertain origin/geological category is used for features when the form, nature and pattern of the anomaly are not sufficient to warrant a classification as an archaeological feature. This category is further sub-divided into:

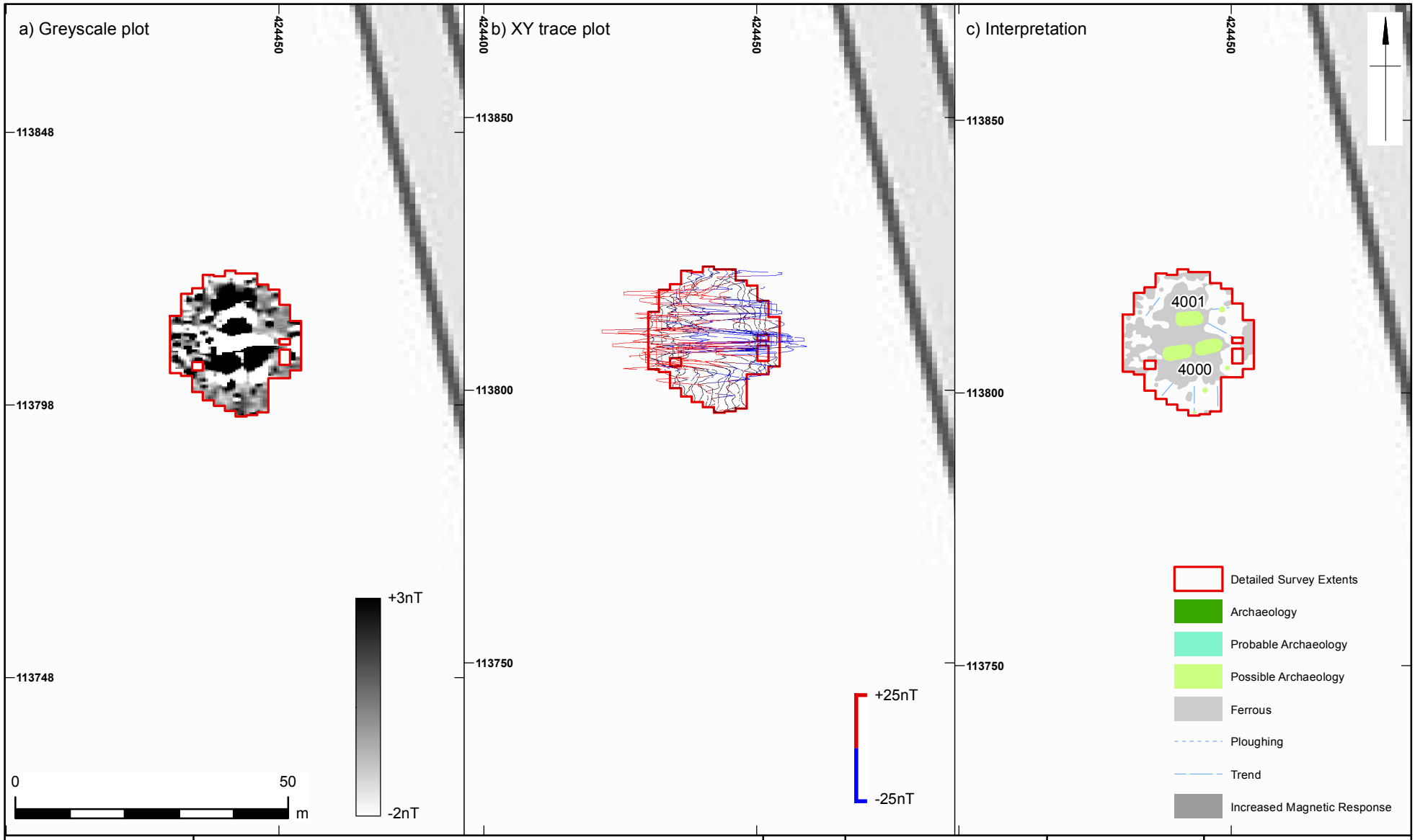
- Increased magnetic response – used for areas dominated by indistinct anomalies which may have some archaeological potential;
- Trend – used for low amplitude or indistinct linear anomalies;
- Superficial geology – used for diffuse edged spreads considered to relate to shallow geological deposits. They can be distinguished as areas of broad irregular shaped anomalies.

Apart from the categories particular to gradiometer data (Ferrous and Increased magnetic response) all categories listed above are utilised where relevant for the interpretation of earth resistance and Ground Penetrating Radar (GPR) data. Uncertain categories such as high or low amplitude response and high or low resistance anomaly may be added but these are purely geophysical interpretations describing the anomaly, they make no comment on their archaeological significance.



Site location and detailed survey extents

Figure 1



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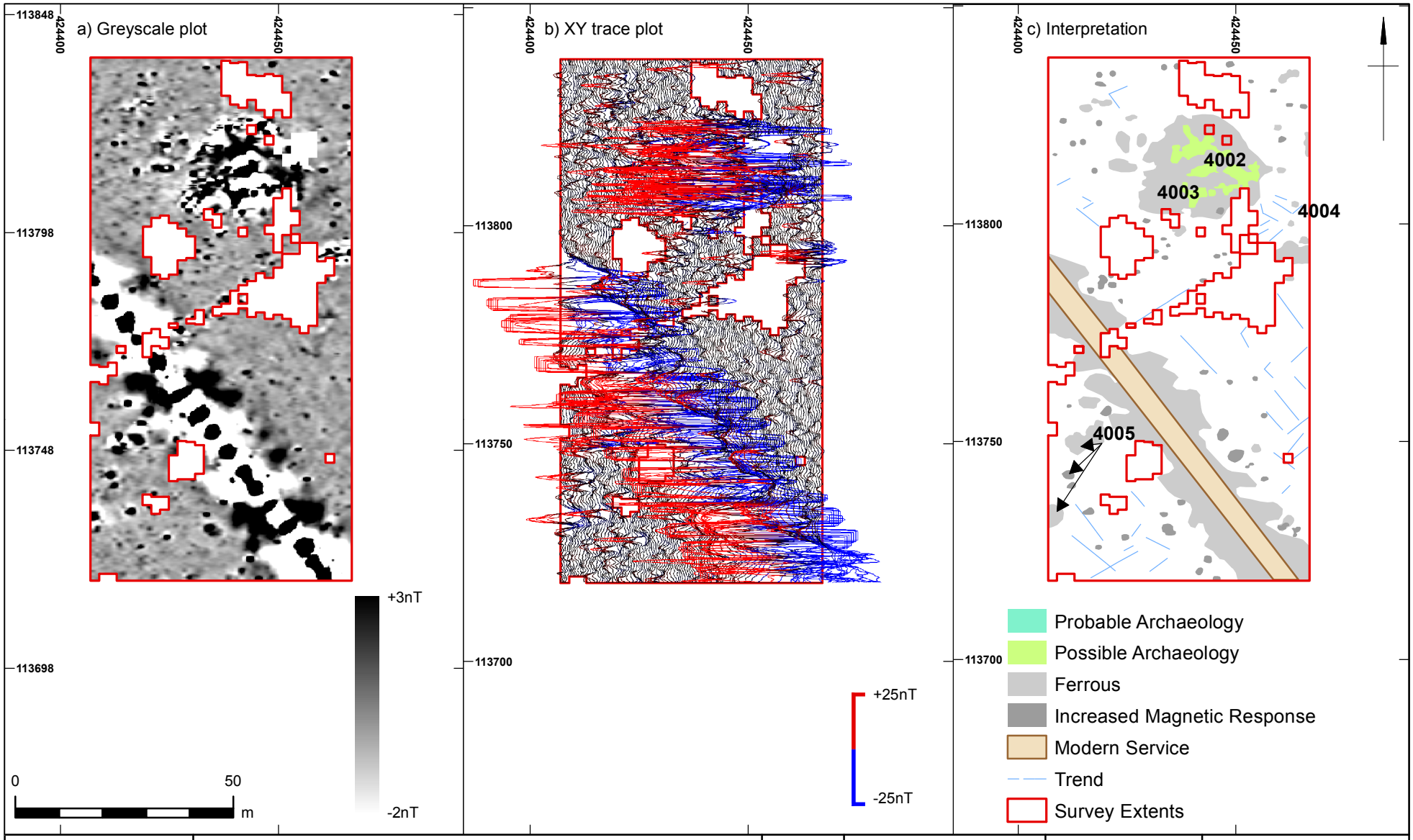
Stoney Cross: Greyscale plot, XY trace plot and interpretation

Figure 2



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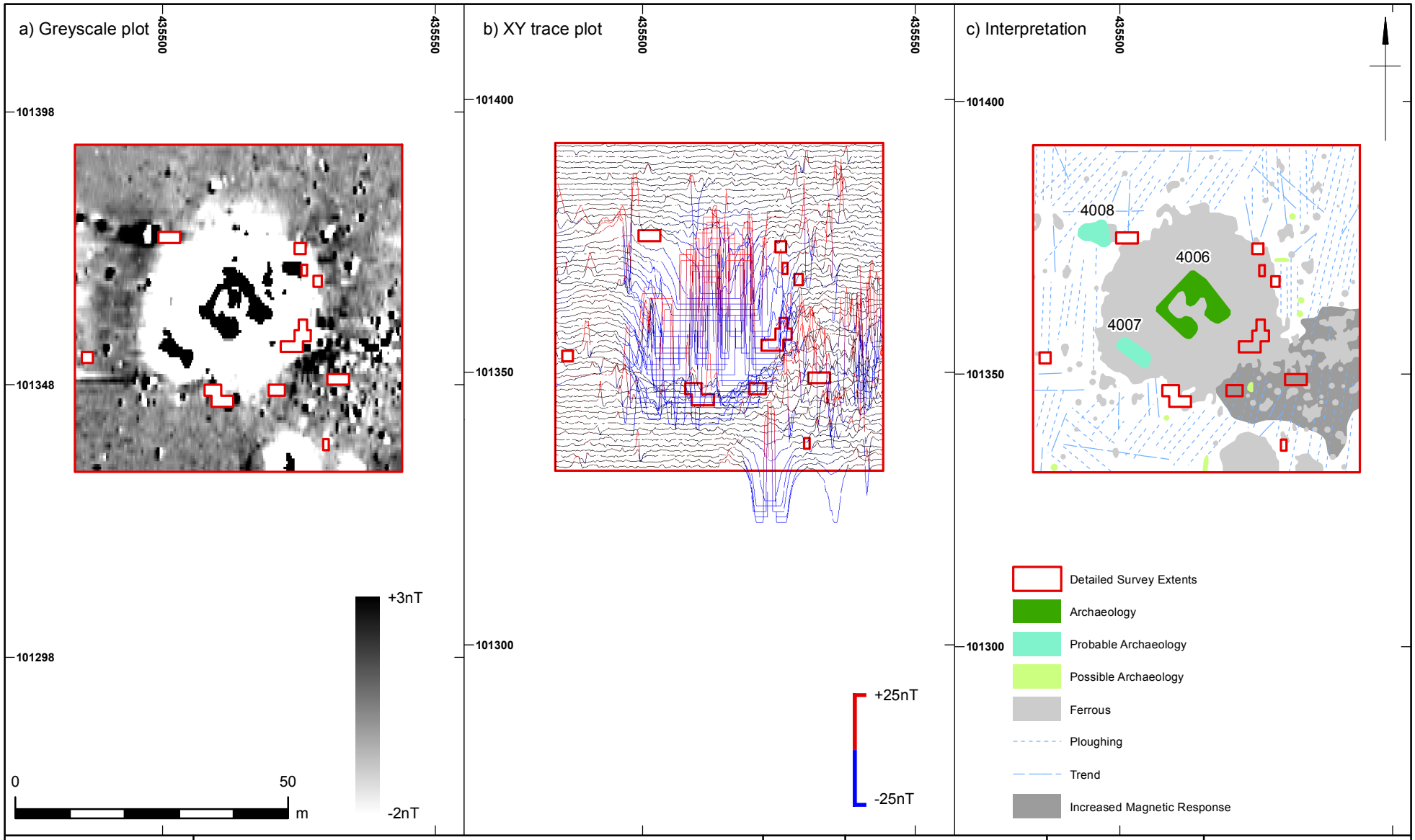
Stoney Cross: Greyscale plot, XY trace plot and interpretation

Figure 3



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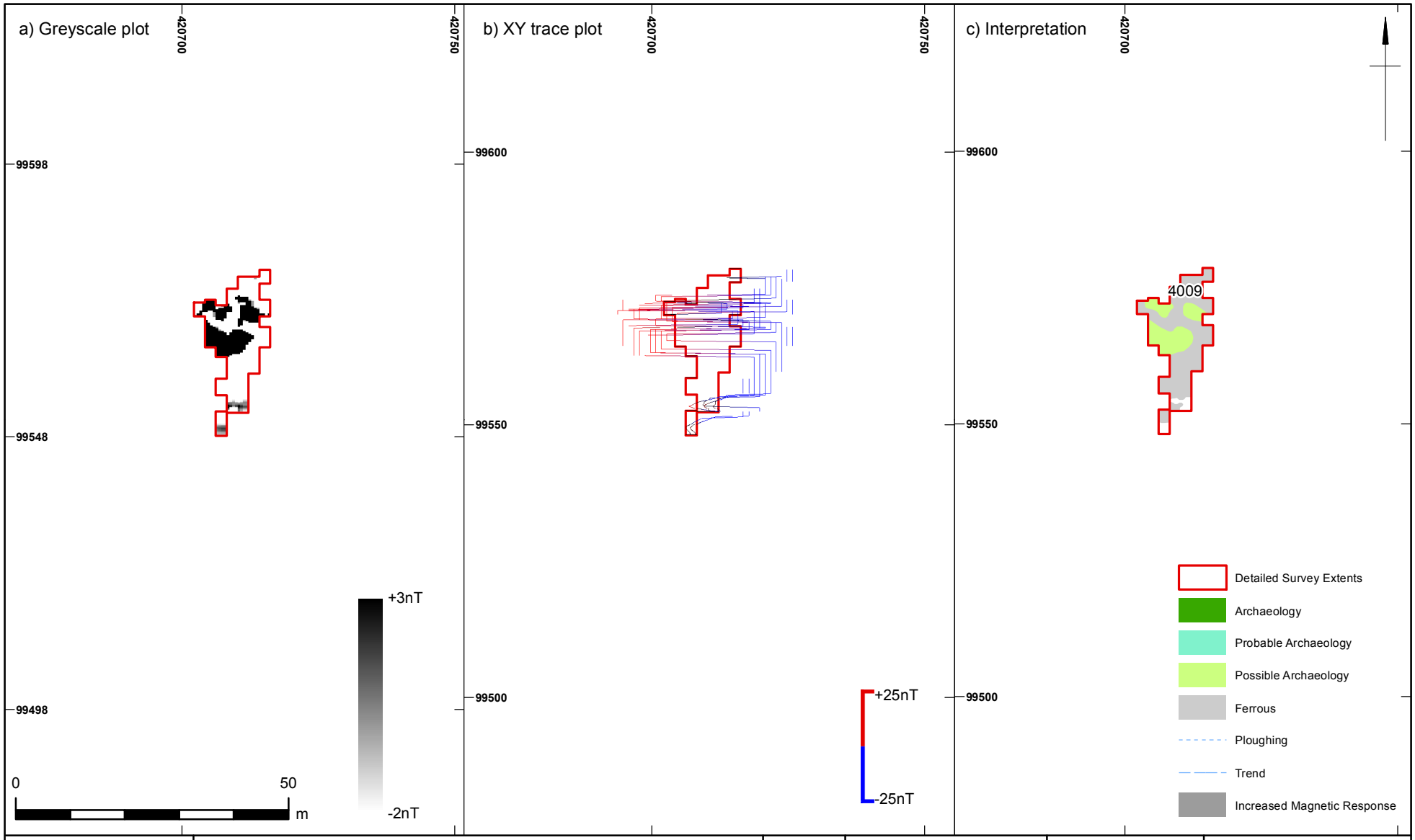
Beaulieu Heath: Greyscale plot, XY trace plot and interpretation

Figure 4



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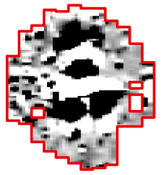
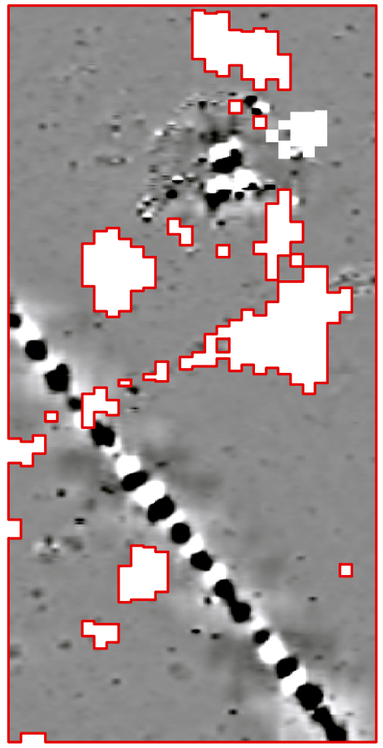
Holmsley South: Greyscale plot, XY trace plot and interpretation

Figure 5



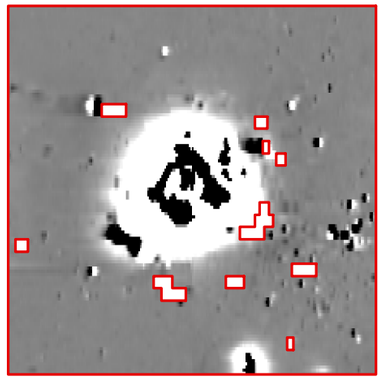
Stoney Cross



Detailed Survey Extents

30nT

- 30nT



Holmsley South

0 100 Metres

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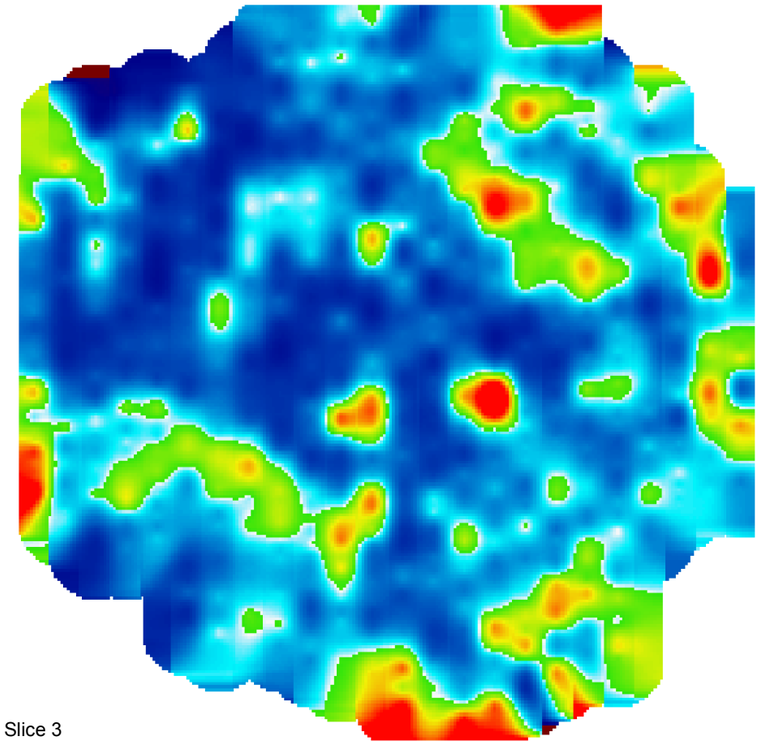
Detailed Gradiometer Results - ± 30 nT

Figure 6



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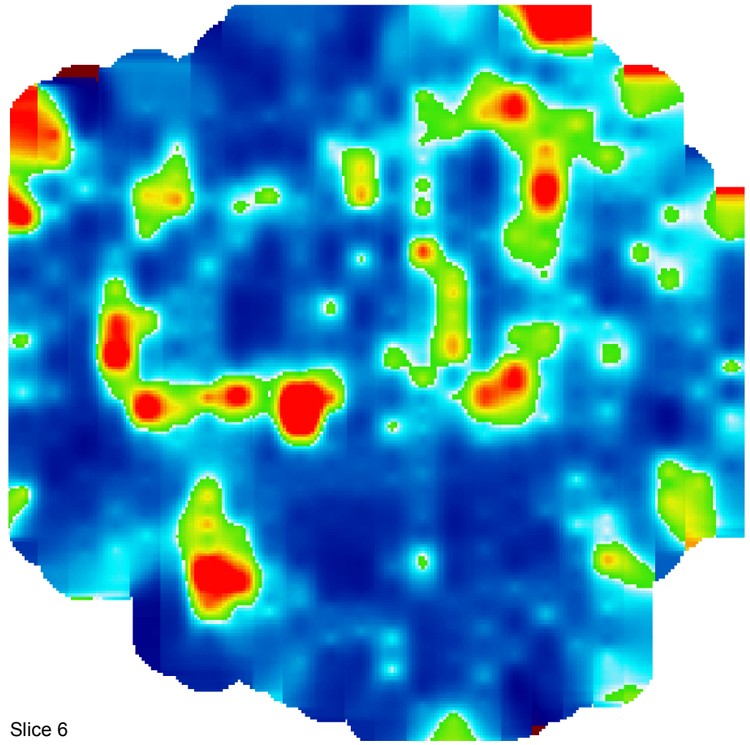

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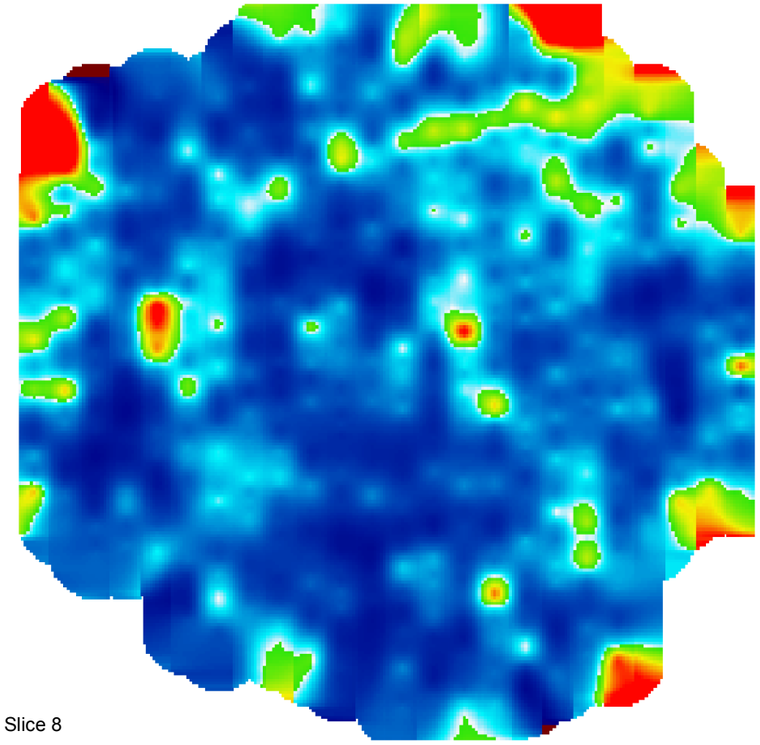

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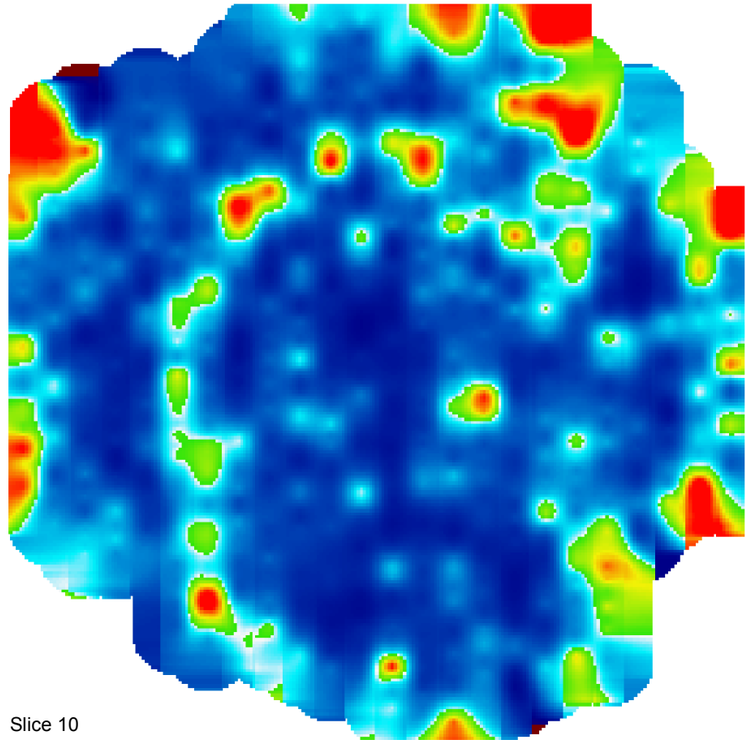

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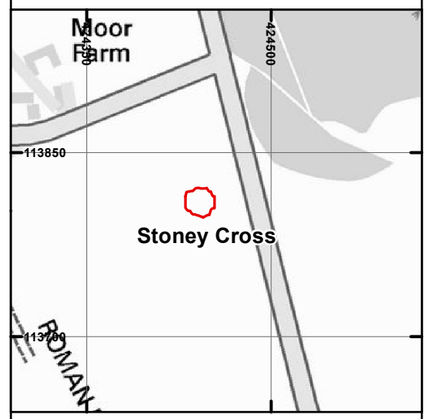

High amplitude

Low amplitude

0 10 m

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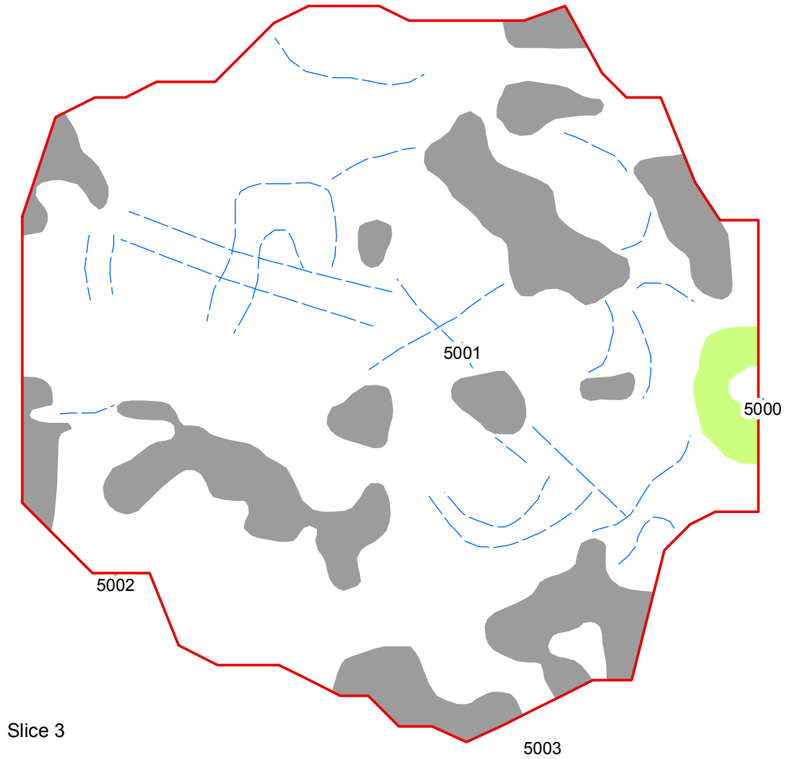
Stoney Cross: GPR Timeslices (Slice 3, Slice 6, Slice 8, Slice 14)

Figure 7



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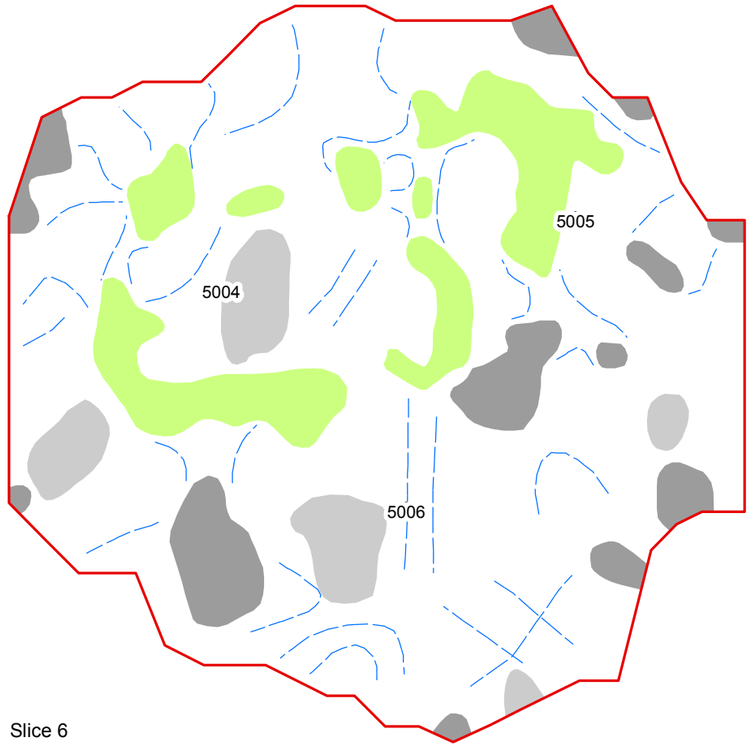

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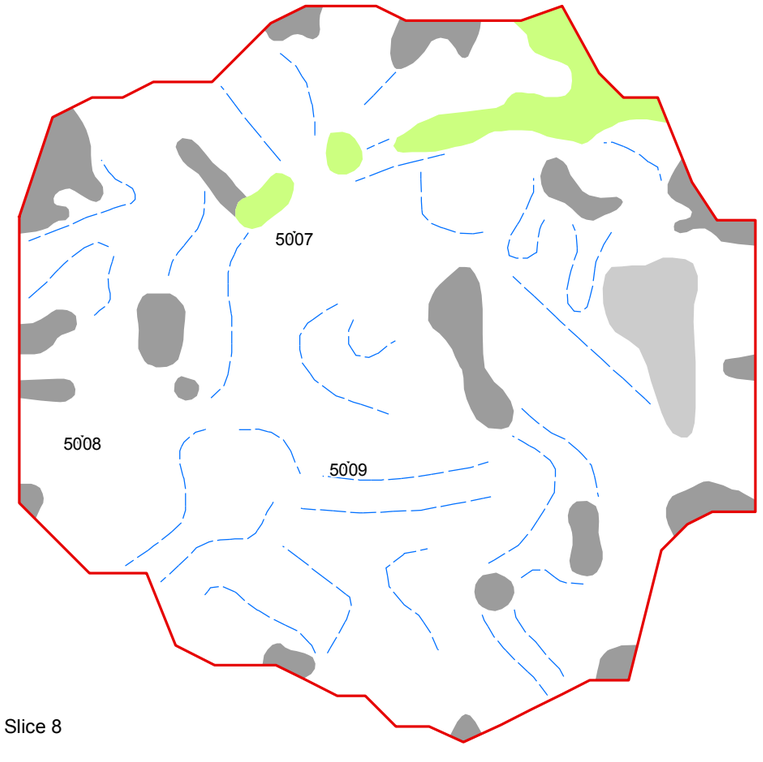

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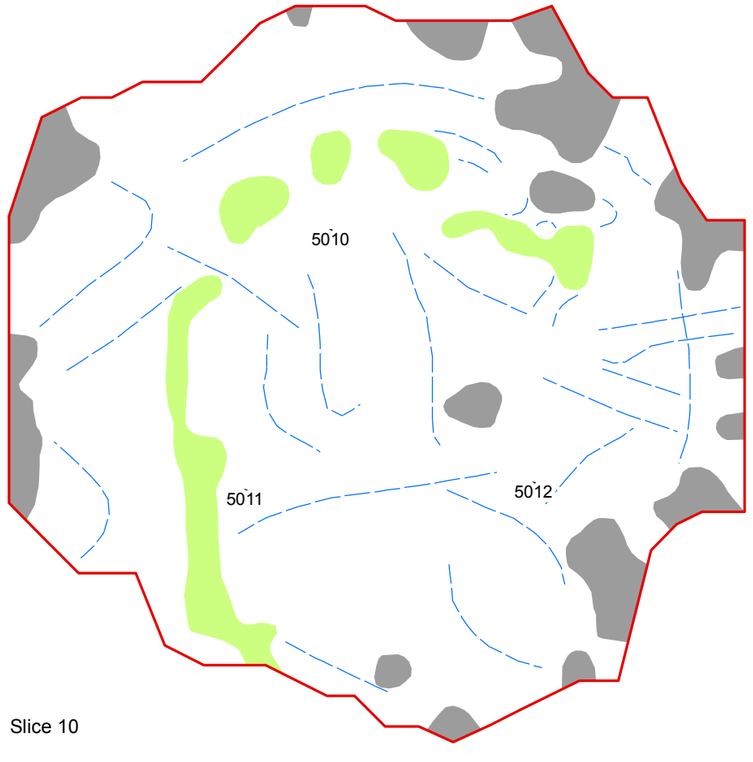

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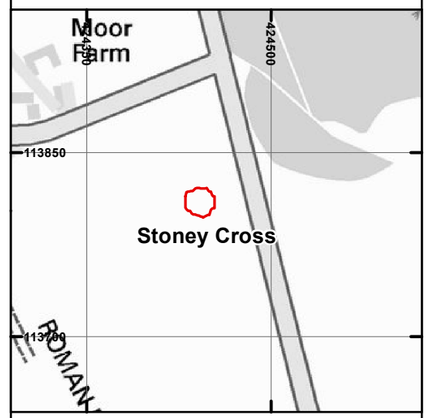

GPR Survey Extents

Possible Archaeology

Trend

High Amplitude Response

Low Amplitude Response

0 10 m

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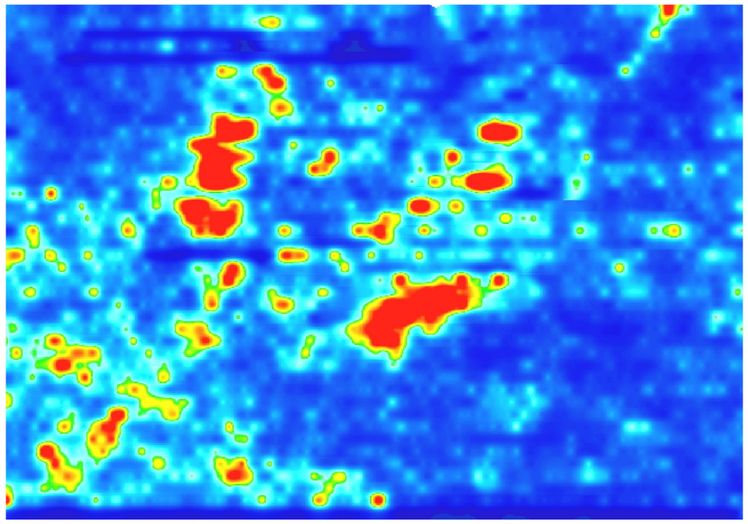
Stoney Cross: GPR interpretation

Figure 8



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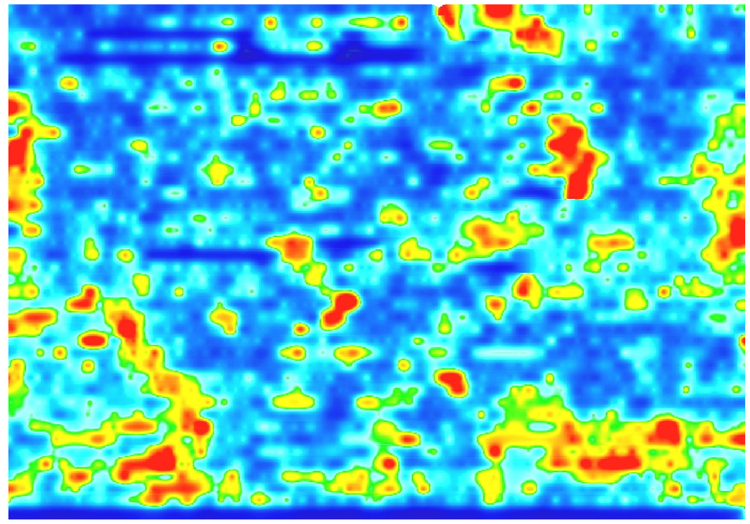

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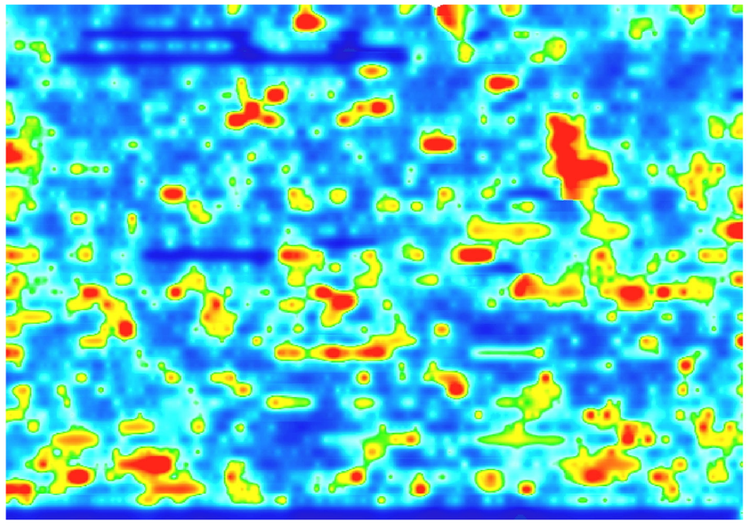

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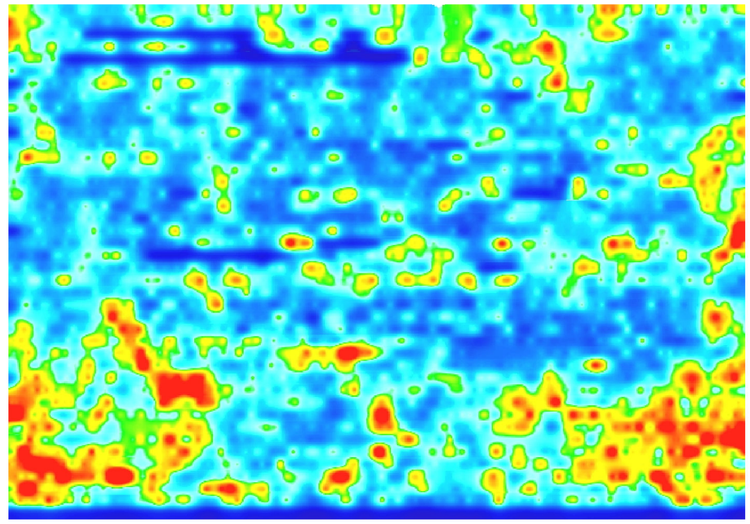

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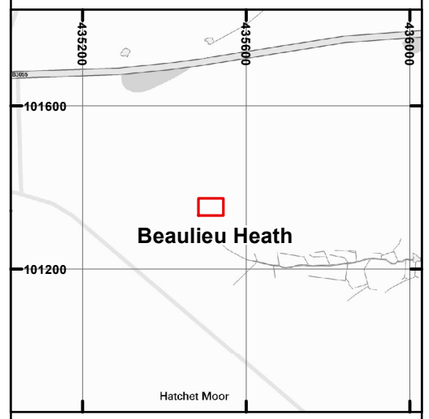

High amplitude

Low amplitude

0 25 m

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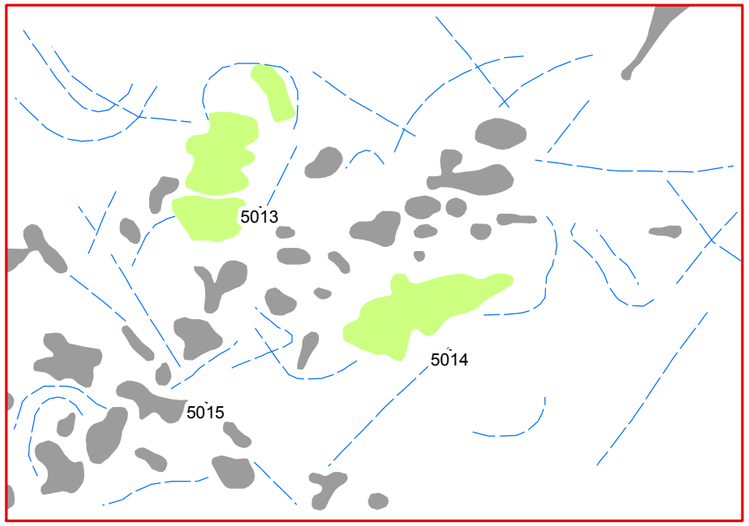
Beaulieu Heath: GPR Timeslices (Slice 4, Slice 9, Slice 12, Slice 16)

Figure 9



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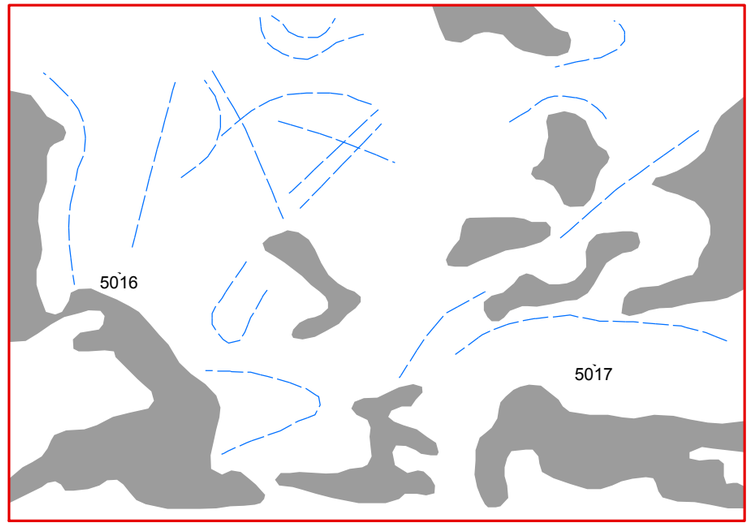

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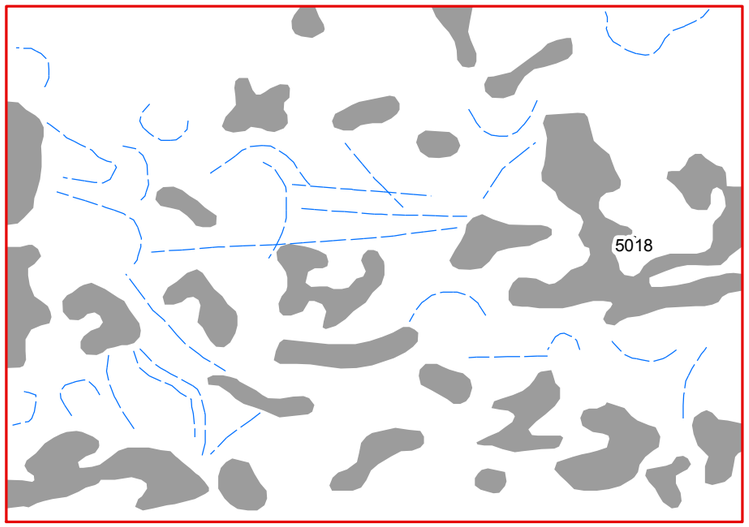

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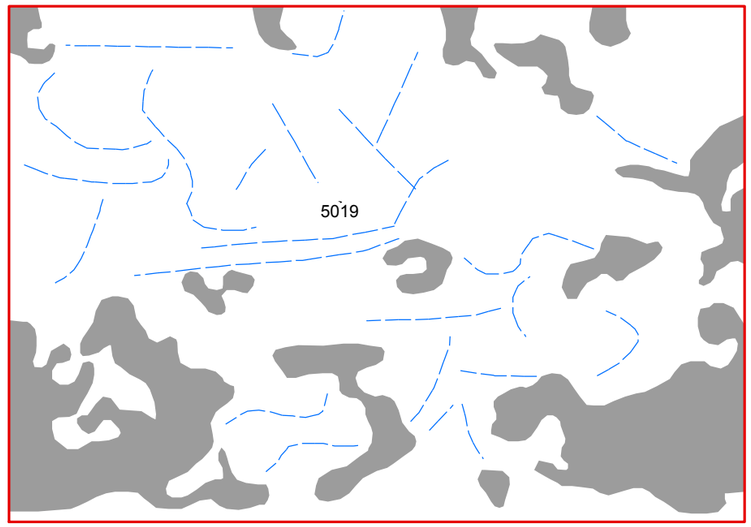

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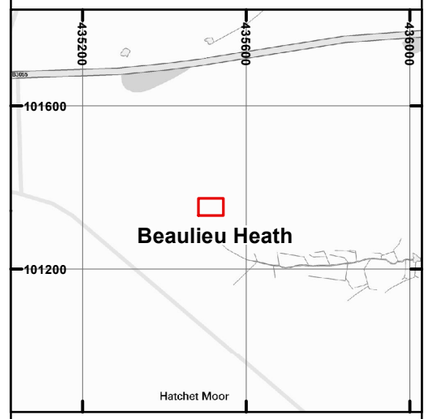

GPR Survey Extents

Slice4 Possible Archaeology

Slice4 Trend

Slice4 High Amplitude Response

0 25 m

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Revision Number:	0
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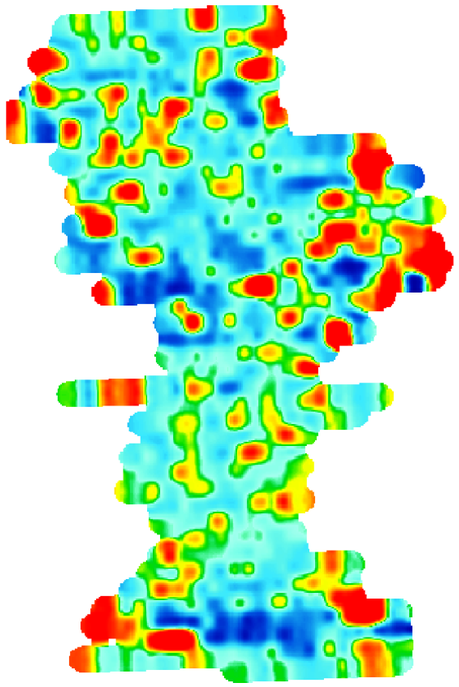
Beaulieu Heath: GPR interpretation

Figure 10



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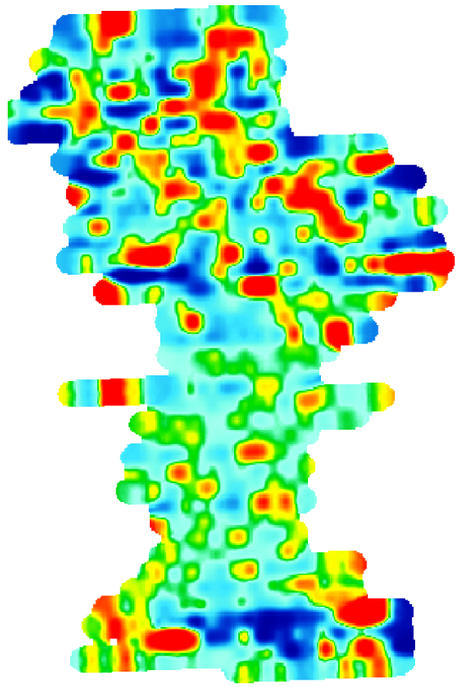

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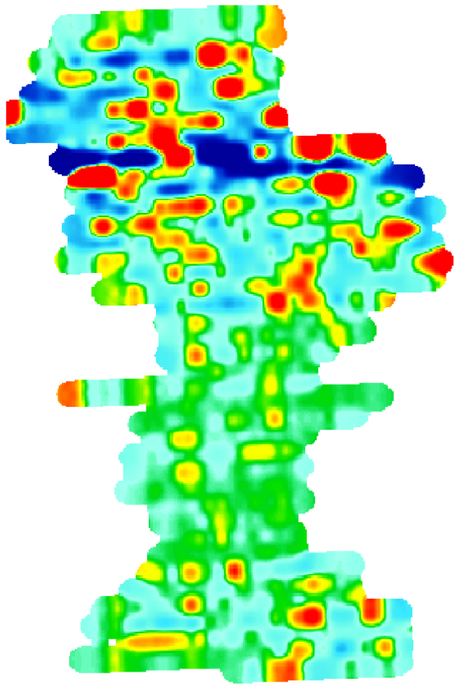

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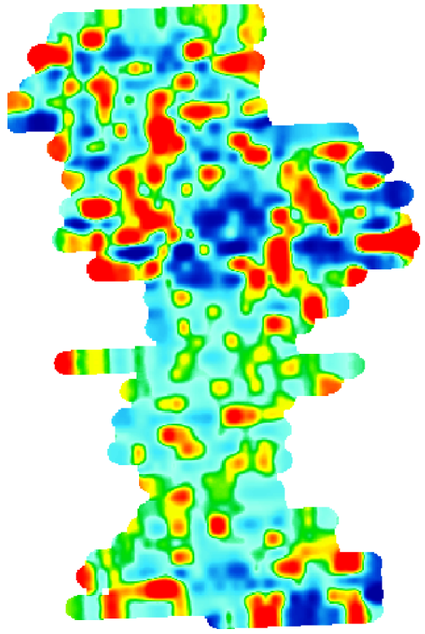
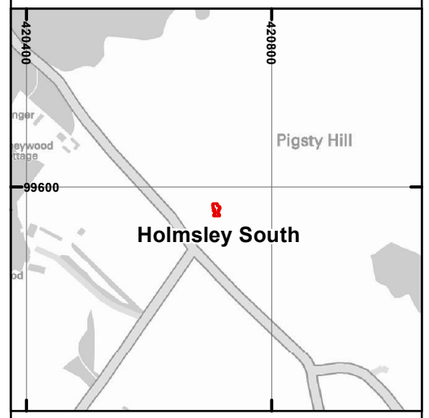


Slice 25



High amplitude

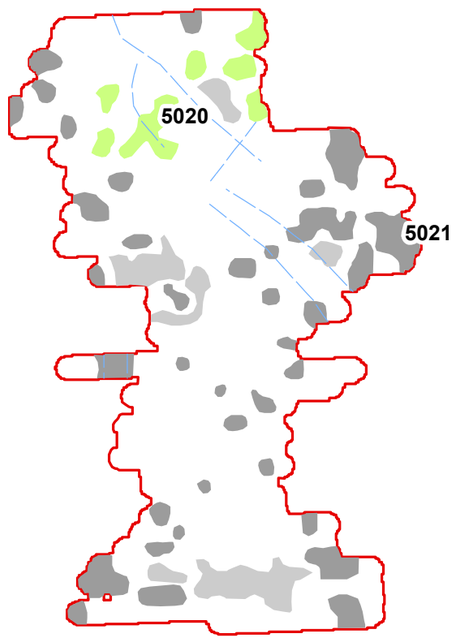
Low amplitude

0 7.5 m

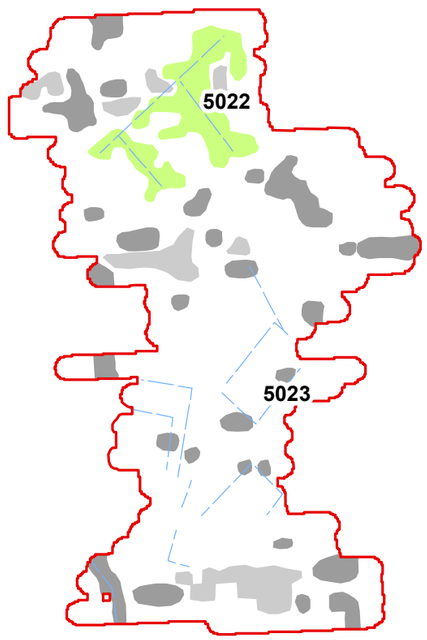
Date:	11/11/14
Revision Number:	0
Scale:	Slice 1:200 at A3
Illustrator:	ECR
Path:	X:\PROJ\101960\Geophysics
	\Additional Sites\GIS\Figs MXD\Fig11.mxd

Holmsley South GPR Timeslices (Slice 3, Slice 6, Slice 14, Slice 25)

Figure 11



Slice 3



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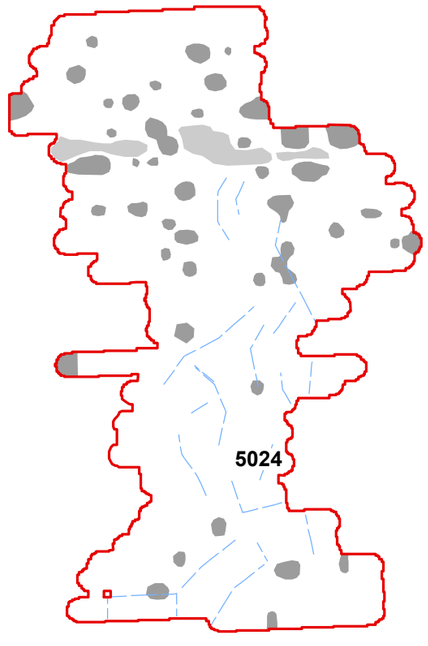
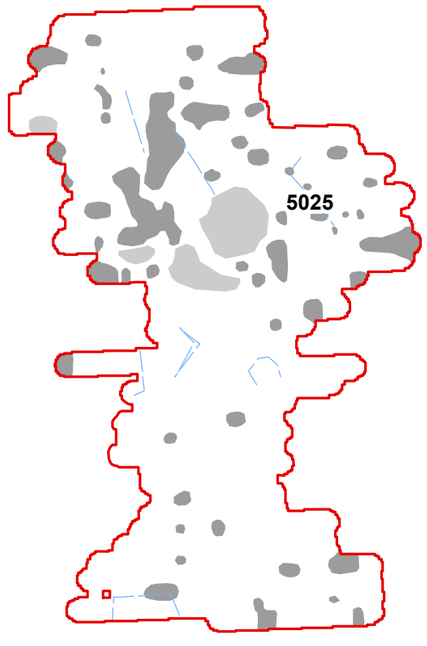
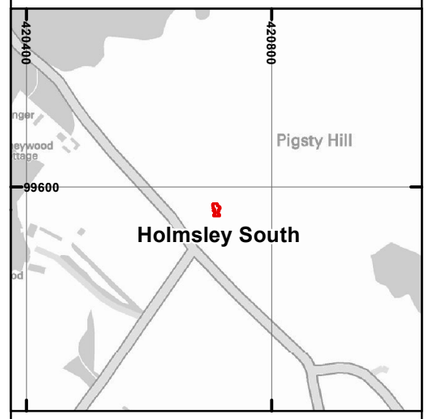


Slice 12



Slice 16



Key

- Possible Archaeology
- High Amplitude
- Low Amplitude
- Trend
- Survey Extents

0 10 m

Date:	12/11/2014
Revision Number:	0
Scale:	Slice 1:200 at A3
Illustrator:	ECR
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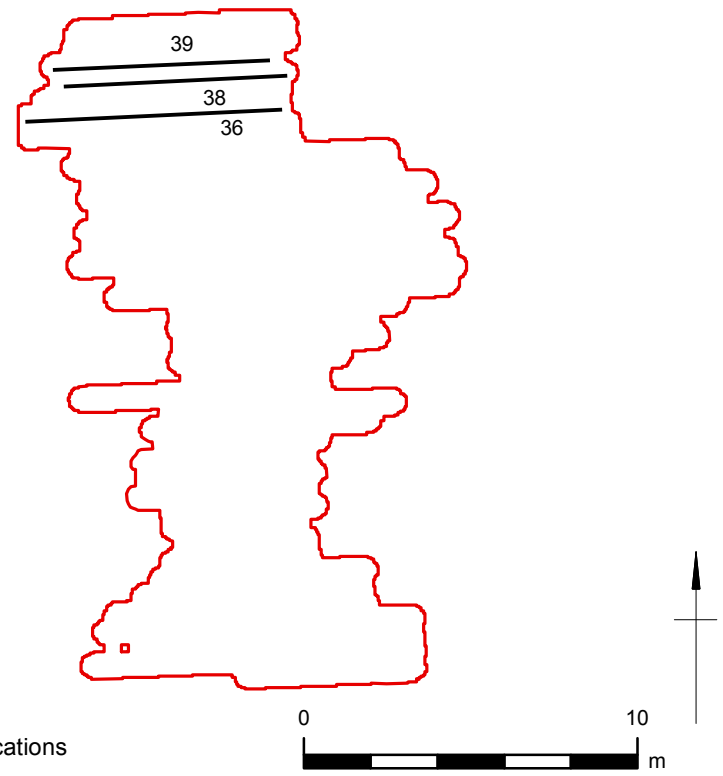
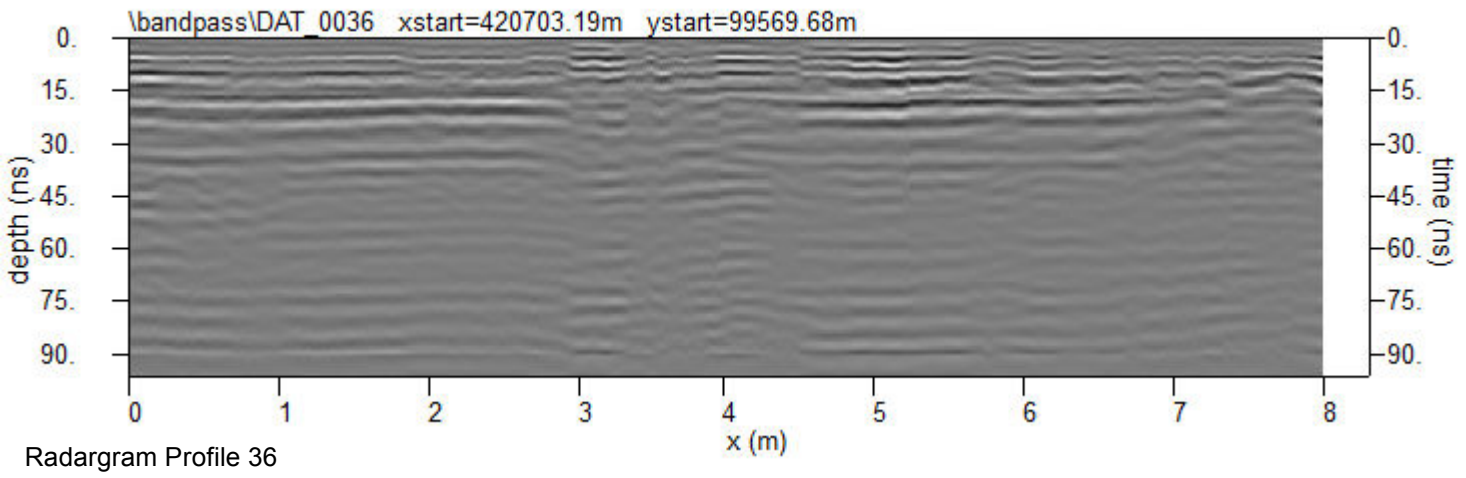
Holmsley South: GPR interpretation

Figure 12



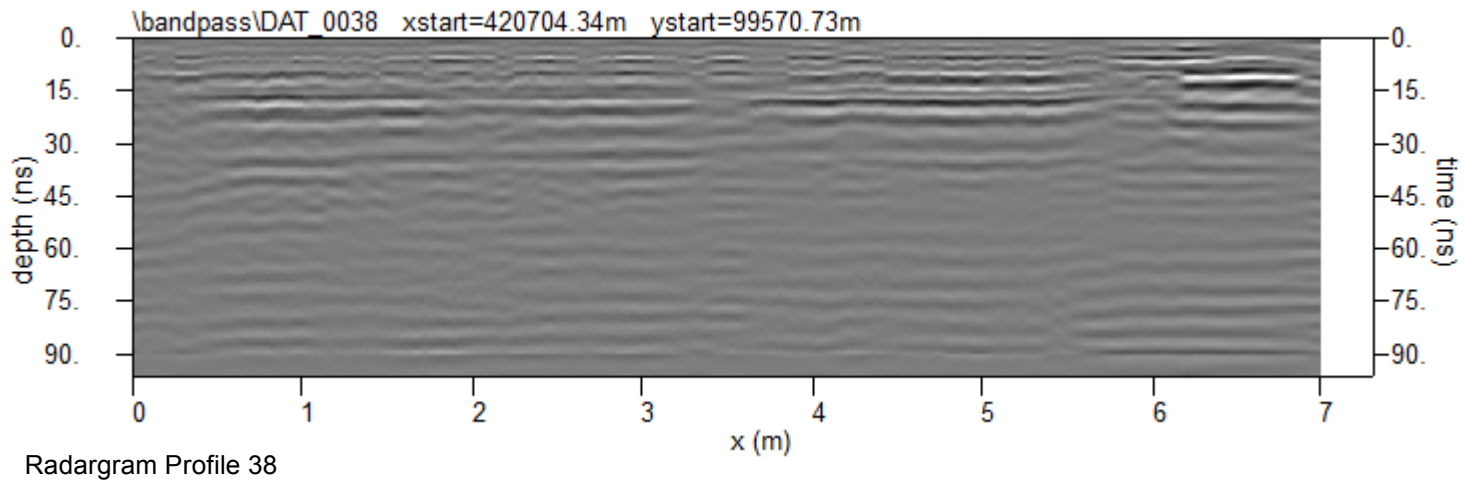
Radargram profile locations

East West



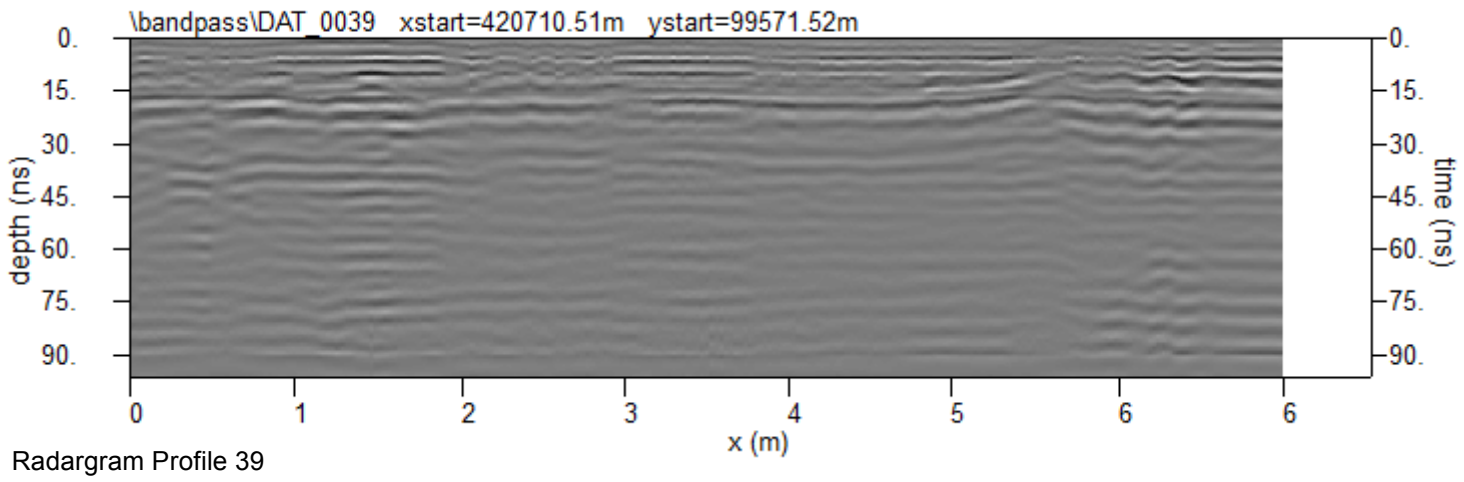
Radargram Profile 36

East West



Radargram Profile 38

West East



Radargram Profile 39

Radargram Profile

Survey Extents

Date:	19/12/2014	Revision Number:	1
Scale:	1:250 at A3	Illustrator:	ECR
Path:	X:\PROJECTS\101960\Geophysics\Additional Sites\GIS\Figs PDF\Fig13		

Holmsley South - Selected Radargarms

Figure 13

wessex archaeology

salisbury rochester sheffield edinburgh

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