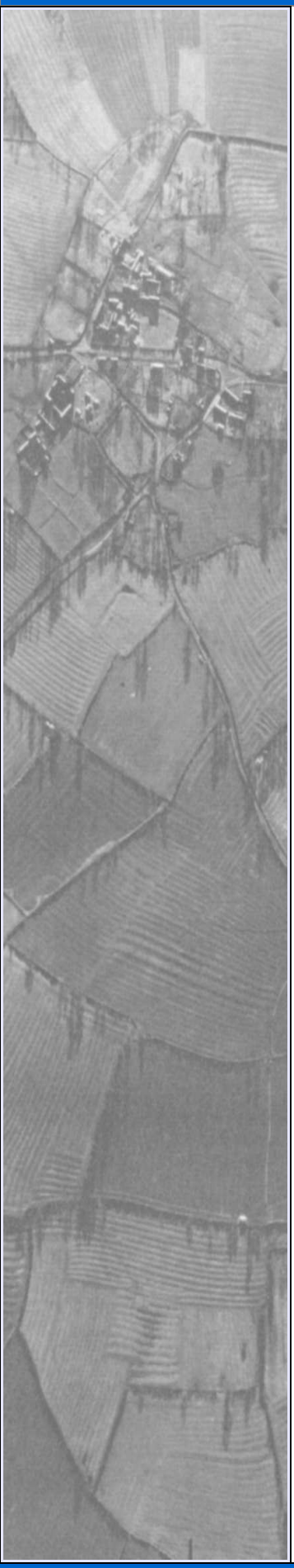

St John the Baptist Church
Cemetery Extension
Brokenborough
Wiltshire

MAGNETOMETER & EARTH RESISTANCE SURVEY REPORT

for

St John the Baptist Church PCC

Kerry Donaldson & David Sabin

June 2018

Ref. no. J756

ARCHAEOLOGICAL SURVEYS LTD

St John the Baptist Church
Cemetery Extension
Brokenborough
Wiltshire

Magnetometer & Earth Resistance Survey Report

for

St John the Baptist Church PCC

Fieldwork by David Sabin BSc (Hons) MCIfA
Report by Kerry Donaldson BSc (Hons)
Report checked by David Sabin
Primary archive location - Archaeological Surveys Ltd, Yatesbury, Wiltshire

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Archaeological Surveys Ltd
1 West Nolands, Nolands Road, Yatesbury, Calne, Wiltshire, SN11 8YD
Tel: 01249 814231 Fax: 0871 661 8804
Email: info@archaeological-surveys.co.uk
Web: www.archaeological-surveys.co.uk

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SUMMARY

A geophysical survey was carried out by Archaeological Surveys Ltd as part of an archaeological assessment of land outlined for a proposed extension to the St John the Baptist Church cemetery at Brokenborough in Wiltshire. The new extension is outlined to be approximately 53m by 15m in the north western part of a pasture field; however, this field contains earthworks relating to the shrunken medieval settlement at Brokenborough. Detailed magnetometery was, therefore, undertaken over a wider area surrounding the proposed cemetery extension in order to aid the interpretation of any anomalies located within it.

The results indicate a regular series of linear and rectilinear ditches or holloways defining platforms with some evidence of structural remains. Anomalies within the proposed cemetery extension relate to an extant ditch surrounding a platform with evidence for a former structure just to the south. An additional earth resistance survey was also carried out within the area outlined for the cemetery extension in order to gain a fuller understanding of the potential structural remains. High resistance anomalies were located, possibly indicating structural remains may extend into the cemetery extension. Several further high resistance anomalies that did not have a corresponding magnetic response were also located beyond the cemetery extension area. LiDAR data has also been analysed in order to assist the interpretation of the geophysical anomalies. The LiDAR imagery clearly shows the earthworks in the wider vicinity relating to the shrunken medieval village.

1 INTRODUCTION

1.1 Survey background

1.1.1 Archaeological Surveys Ltd was commissioned by St John the Baptist Church PCC to undertake a geophysical survey of an area of land outlined for a proposed new extension to the cemetery of St John the Baptist Church in Brokenborough, Wiltshire.

1.1.2 The main survey was carried out using magnetometry over a wider area than the 53m by 15m proposed cemetery extension in order to gain as much information as possible about any anomalies that may be recorded. The field in which the proposed extension is located contains earthworks relating to ditches and platforms associated with the shrunken medieval village at Brokenborough. An earth resistance trial was also conducted across the proposed cemetery extension using both a Geoscan RM85 earth resistance meter in twin probe array configuration and with the MSP25 Mobile Sensor Platform in order to ascertain which configuration was most suitable. The twin probe array produced the best response and the survey was completed using that configuration.

1.2 Survey objectives and techniques

1.2.1 The objective of the survey was to use magnetometry to locate geophysical anomalies that may be archaeological in origin so that they may be assessed prior to the development of the cemetery extension. An additional earth resistance survey (resistivity) survey was carried out in order to achieve a complimentary data set as the site contains earthwork evidence for a shrunken medieval village. Resistivity is effective at revealing structural remains as often these do not have sufficient magnetic contrast to be visible within the magnetometry data. The methodology is considered an efficient and effective approach to archaeological prospection.

1.2.2 Geophysical survey can provide useful information on the archaeological potential of a site; however, the outcome of any survey relies on a number of factors and as a consequence results can vary. The success in meeting the aims and objectives of a survey is, therefore, often impossible to predetermine.

1.3 Standards, guidance and recommendations for the use of this report

1.3.1 The survey and report generally follow the recommendations set out by: English Heritage (2008) *Geophysical survey in archaeological field evaluation;* European Archaeological Council (2015) *Guidelines for the Use of Geophysics in Archaeology;* Institute for Archaeologists (2002) *The use of Geophysical Techniques in Archaeological Evaluations*. The work has been carried out to the Chartered Institute for Archaeologists (2014) *Standard and Guidance for Archaeological Geophysical Survey.*

1.3.2 Archaeological Surveys Ltd provide a detailed geophysical survey report and it is recommended that where possible the contents should be considered in full. The Summary provides a brief overview of the results with more detail available in the Discussion and/or Conclusion. The *List of anomalies* within the Results provides a detailed assessment of the anomalies within separate categories which can be useful in inferring a level of confidence to the interpretation. Quality and factors influencing the interpretation of anomalies is also set out within the results.

1.3.3 It is recommended that the full report should always be considered when using data and interpretation plots; where this is not possible, in the field for example, the abstraction and interpretation plots should retain their colour coding and be used with a corresponding legend.

1.3.4 Where targeting of anomalies by excavation is to be carried out, care should be taken to place trenches over solid lines or features visible on the abstraction and interpretation plots. Archaeological Surveys abstraction and interpretation avoids the use of dashed or dotted lines; broken or fragmented anomalies may well correspond closely with subsurface truncation.

1.4 Site location, description and survey conditions

1.4.1 The site is located at Brokenborough in north Wiltshire. The proposed cemetery extension measures 53m by 15m and is centred on Ordnance Survey National Grid Reference (OS NGR) ST 91805 89270, see Figs 01 and 02. It is bounded to the north by the current church cemetery, to the west by the road through the village known as The Causeway and agricultural land to the east and south.

1.4.2 The magnetometry survey was carried out over approximately 1ha, covering the majority of the pasture field in which the proposed cemetery extension is located. A small area within the pasture field to the east of the current cemetery was also surveyed. The earth resistance survey focused on the proposed cemetery extension, but covered 60m by 30m in total. Environment Agency LiDAR data has also been assessed in order to gain a greater understanding of the earthwork features within the wider vicinity.

1.4.3 The ground conditions across the site were generally considered to be favourable for the collection of geophysical data. Weather conditions during the survey were fine although periods of very wet weather had occurred a few days before the resistance survey.

Plate 1: Proposed cemetery extension location

1.5 Site history and archaeological potential

1.5.1 The field in which the proposed cemetery extension is sited, along with the field to the north and also the field to the south east, contain former medieval settlement earthworks. These include extant linear ditches and also house platforms. The Wiltshire Historic Environment Record lists these earthworks

(MWI5378) along with a record for an archaeological evaluation in 2004 (MWI5364) within the field immediately to the north and covered by the magnetometry survey. The hand excavated trench revealed evidence for occupation from the 13th to 16th centuries and included an outer stone wall of a probable building, paving, a holloway, pottery and animal bone. LiDAR imagery (Fig 06) shows a regular network of linear and rectilinear ditches and evidence for platforms and possible structures. The 1841 tithe map shows two land parcels in the western part of the site (167 & 168), with only the more southern triangular parcel (168) then recorded between 1886 and 1970, but removed by 1980.

1.5.2 The surface conditions within the site were not suitable for the observation of cultural material during the course of the survey. However, earthworks are located across much of the surveyed area but appear to extend only into the eastern part of the proposed cemetery extension.

1.6 Geology and soils

1.6.1 The underlying geology is mudstone from the Kellaways Clay Member (BGS, 2018). Some surface stone was observed, but this is likely to relate to former structures known to have been located within the survey area.

1.6.2 The overlying soil across the site is from the Wickham 3 association and is a typical stagnogley soil. It consists of a slowly permeable, seasonally waterlogged, fine loamy over clayey soil (Soil Survey of England and Wales, 1983).

1.6.3 Magnetometry carried out over similar geology and soil has produced variable results. The underlying geology and soils are frequently associated with low magnetic contrast and low levels of magnetic susceptibility. However, cut features of archaeological potential may be located where human activity has altered the magnetic characteristics of the soil sufficiently. The underlying geology and soils are, therefore, considered acceptable for magnetic survey.

1.6.4 Damp clayey soils tend to produce very poor conditions for the location of former cut features using earth resistance survey; however, former structural remains may produce strongly contrasting features particularly after prolonged dry spells.

2 METHODOLOGY

2.1 Technical synopsis

2.1.1 Magnetometry survey records localised magnetic fields that can be associated with features formed by human activity. Magnetic susceptibility and magnetic thermoremnance are factors associated with the formation of localised fields. Additional details are set out below and within Appendix A.

2.1.2 Iron minerals within the soil may become altered by burning and the break down of biological material; effectively the magnetic susceptibility of the soil is increased, and the iron minerals become magnetic in the presence of the Earth's magnetic field. Accumulations of magnetically enhanced soils within features, such as pits and ditches, may produce magnetic anomalies that can be mapped by magnetic prospection.

2.1.3 Magnetic thermoremnance can occur when ferrous minerals have been heated to high temperatures such as in a kiln, hearth, oven etc. On cooling, a permanent magnetisation may be acquired due to the presence of the Earth's magnetic field. Certain natural processes associated with the formation of some igneous and metamorphic rock may also result in magnetic thermoremnance.

2.1.4 The localised variations in magnetism are measured as sub-units of the Tesla, which is a SI unit of magnetic flux density. These sub-units are nano Teslas (nT), which are equivalent to 10^{-9} Tesla (T).

2.1.5 The electrical resistance or resistivity of the soil depends upon the moisture content and distribution within the soil. Buried features such as walls can affect the moisture distribution and are usually more moisture resistant than other features such as the infill of a ditch. A stone wall will generally give a high resistance response and the moisture retentive content of a ditch can give a low resistance response. Localised variations in resistance are measured in ohms (Ω) which is the SI unit for electrical impedance or resistance. Additional details are set out below and within Appendix B.

2.2 Equipment configuration, data collection and survey detail

2.2.1 The detailed magnetic survey was carried out using a SENSYS MAGNETO®MXPDA 5 channel cart-based system. The instrument has 5 fluxgate gradiometers (FGM650) spaced 0.5m apart with readings recorded at 20 Hz. The cart is pushed at walking speed and not towed. Each sensor is not zeroed in the field as the vertical axis alignment is precisely fixed leaving sensor offsets that are removed during data processing. The fixing of the vertical alignment ensures the sensors are not unduly influenced by localised magnetic fields and that the vertical component of a magnetic anomaly is measured. The gradiometers have a range of recording data between ±0.1nT and ±10,000nT. They are linked to a Leica GS10 RTK GPS with data recorded by SENSYS MAGNETO®MXPDA software on a rugged PDA computer system.

2.2.2 Due to the fixed offsets within the fluxgate sensors, as a result of the manufacturing and tensioning process, the survey data do not provide a visually useful dataset until a zero median traverse algorithm is applied. It is recognised that this has the potential to affect some anomalies detrimentally by removing linear features orientated parallel to survey transects. However, this has not been noted as a particular problem with the system due to the high resolution data collection, generally long length of traverses and variability within the magnetic characteristics of a linear anomaly.

2.2.3 Data are collected along a series of parallel survey transects to achieve 100% coverage of the surveyable land. The length of each transect is variable and relates to the size of the survey area and other factors including ground conditions. A visual display allows accurate placing of transects and helps maintain the correct separation between adjacent traverses. Data are not collected within fixed grids and data points are considered to be random even though the data are collected in a systematic manner covering all accessible areas (Aspinall, Gaffney and Schmidt, 2009).

2.2.4 Fluxgate sensors are highly sensitive to temperature change and this is manifest as drift during the course of a survey. This can be particularly noticeable during the morning as temperatures rise and the equipment warms or cools. Sensor drift within the course of a traverse will appear as a line trending from negative to positive after processing with a zero median traverse algorithm. To remove the potential for temperature drift data were collected after a 20 minute stabilisation period and traverses were limited to a time of generally <100s.

2.2.5 The earth resistance survey was carried out using Geoscan Research Ltd RM85 resistance meter using a mobile parallel twin probe array with a 0.5m electrode separation. Data were recorded at 1m intervals along traverses separated by 1m within 30m grids with a zig-zag progression. The instrument was set to filter stray earth currents which can cause errors within the resistance measurements.

2.2.6 The earth resistance survey grids were set out to the Ordnance Survey OSGB36 datum using a Leica GS10 RTK GPS. The GPS is used in conjunction with Leica's SmartNet service, where positional corrections are sent via a mobile telephone link. Positional accuracy of around 10 – 20mm is possible using the system. The instrument is regularly checked against the ETRS89 reference framework using Ordnance Survey ground marker C1ST7784 (Horton).

2.3 Data processing and presentation

2.3.1 Magnetic data collected by the MAGNETO®MXPDA cart-based system are initially prepared using SENSYS MAGNETO®DLMGPS software. The software effectively allocates a geographic position for each data point and can compensate for fixed offsets present within the FGM650 sensors. The offsets are positive or negative values present on all fluxgate gradiometer sensors. Some systems use manual or electronic balancing to effectively zero the sensors; however, this is a short term measure that is prone to drift through temperature changes and vibration and can easily be incorrectly set due to localised magnetic fields. The FGM650 sensors are very accurately aligned to the vertical magnetic gradient and are highly stable showing negligible drift on long traverses. The offset values are removed using TerraSurveyor software.

2.3.2 Survey tracks are analysed and georeferenced raw data (UTM Z30N) are then

exported in ASCII format for further analysis and display within TerraSurveyor. The removal of offset values (compensation) of the sensors is also carried out in TerraSurveyor using a zero median traverse function. Data are then considered to be minimally processed. Note: without the zero median traverse function it is not possible to create a meaningful data plot as all sensors have a different offset value. Although a zero median traverse algorithm can remove anomalies aligned with the survey tracks, in practice this rarely occurs due to the use of long traverses, high resolution measurement and variability within the magnetic susceptibility of long linear features.

2.3.3 Appendix D contains metadata concerning the survey and data attributes and is derived directly from TerraSurveyor. Reference should be made to Appendix C for further information on processing.

2.3.4 A TIF file is produced by TerraSurveyor software along with an associated world file (.TFW) that allows automatic georeferencing (OSGB36 datum) when using GIS or CAD software. The main form of data display used in the report is the minimally processed greyscale plot. With regard to the Sensys MXPDA, minimally processed data is considered by the manufacturer to be data that is compensated by SENSYS MAGNETO DLMGPS software, see 2.3.1 and 2.3.2. Note: traceplots are not considered to be appropriate as they do not provide an accurate or useful assessment of the magnetic anomalies due to very high density of data collection.

2.3.5 Data logged by the resistance meter are downloaded and processed within TerraSurveyor and Geoplot 4 software. Raw data are analysed and displayed within the report as well as processed data. Appendix C outlines the processing sequence with further information on processing set out within Appendix B. TIF files are prepared in TerraSurveyor for the earth resistance data. The main form of resistivity data display used in the report is the minimally processed greyscale plot. A filtered image is also displayed where a high pass filter is used to enhance relatively narrow features, such as linear ditches. The processing applied within each survey area is outlined in Appendix D.

2.3.6 The raster images are combined with base mapping using ProgeCAD Professional 2016 creating DWG (2010) file formats. All images are externally referenced to the CAD drawing in order to maintain good graphical quality. The CAD plots are effectively georeferenced facilitating relocation of features using GPS, resection method, etc.

2.3.7 An abstraction and interpretation is also drawn and plotted for all geophysical anomalies located by the survey. Anomalies are abstracted using colour coded points, lines and polygons. All plots are scaled to landscape A3 for paper printing.

2.3.8 A brief summary of each anomaly, with an appropriate reference number, is set out in list form within the results (Section 3) to allow a rapid and objective assessment of features within each survey area. Where further interpretation

is possible, or where a number of possible origins should be considered, more subjective discussion is set out in Section 4.

2.3.9 The abstraction and interpretation procedure has been supported by analysis of a digital terrain model derived from the Environment Agency's Light Detection and Ranging (LiDAR) data. LiDAR is an airborne mapping technique carried out by the Environment Agency which accurately measures the height of the terrain and surface objects on the ground through the use of a scanning laser that measures the distance between the aircraft and the ground. Shaded relief plots are created using Surfer 10 with a vertical exaggeration of 5 times.

2.3.10 A digital archive is produced with this report, see Appendix E below. The main archive is held at the offices of Archaeological Surveys Ltd.

3 RESULTS

3.1 Data interpretation

3.1.1 The list of sub-headings below attempts to define a number of separate categories that reflect the range and type of features located during the survey. A basic explanation of the characteristics of the magnetic anomalies is set out for each category in order to justify interpretation, see Table 1.

Interpretation category	Description and origin of anomalies
Anomalies with archaeological origin	Anomalies have the characteristics (mainly morphological) of a range of archaeological features such as pits, ring ditches, enclosures, etc. The category is used where there is a high level of confidence which may be due to additional supporting information where morphology is unclear or uncharacteristic.
Anomalies associated with magnetic debris	Magnetic debris often appears as areas containing many small dipolar anomalies that may range from weak to very strong in magnitude. They often occur where there has been dumping or ground make-up and are related to magnetically thermoremnant materials such as brick or tile or other small fragments of ferrous material. This type of response is occasionally associated with kilns, furnace structures, hearths and nail spreads from former wooden structures or rooves and may, therefore, be archaeologically significant. Strong discrete dipolar anomalies are responses to ferrous objects within the topsoil.
Anomalies with a modern origin	The magnetic response is often strong and dipolar indicative of ferrous material and may be associated with extant above surface features such as wire fencing, cables, pylons etc. Often a significant area around these features has a strong magnetic flux which may create magnetic disturbance; such disturbance can effectively obscure low magnitude anomalies if they are present. Fluxgate sensors may respond erratically adjacent to strong magnetic sources. Resistivity anomalies may be high or low and are clearly associated with extant modern features.

Table 1: List and description of interpretation categories

3.2 General assessment of survey results - magnetometry

3.2.1 The detailed magnetic survey was carried out over approximately 1ha. The additional area of survey has proved useful in determining the origin of anomalies that may extend into, or are in close proximity to, the proposed extension.

3.2.2 Magnetic anomalies located can be generally classified as positive and negative anomalies of archaeological origin, areas of magnetic debris and disturbance and strong discrete dipolar anomalies relating to ferrous objects. Anomalies located within the survey area have been numbered and are described in 3.4 below with subsequent discussion in Section 4.

3.3 Data quality and factors influencing the interpretation of anomalies- magnetometry

3.3.1 Data are considered representative of the magnetic anomalies present within the site. There are no significant defects within the dataset.

3.3.2 Within the proposed area of the cemetery extension there is some magnetic disturbance adjacent to the northern field boundary and close to the north western corner of the field. It is unlikely that this has obscured weaker anomalies of archaeological potential. In the southern part of the survey area highly magnetic debris may obscure features of archaeological potential; however, these lie well beyond the southern limit of the extension.

3.3.3 The magnetic characteristics of features associated with earthworks is frequently less than optimum and separating enhancement associated with the fill of cut features from that produced by soil accumulated in earthworks and thick area deposits can be problematic.

3.4 List of anomalies – magnetometry

Area centred on OS NGR 391852 189271, see Fig 03.

Anomalies with an archaeological origin

(1-3) - A number of positive and negative responses have been located within the survey area. They correspond to small earthwork features visible on the LiDAR imagery (Figs 05 & 06) and are associated with former structures. While negative linear anomalies may be a response to former walling, the positive responses may relate to magnetic enhancement derived from human occupation and burnt material. Anomalies (1) are situated on a platform, defined by anomaly (4), and are located approximately 16-19m south east of the northern edge of the survey area, just beyond the indicated 15m wide proposed cemetery extension.

(4) - A broad, weakly positive linear response with an adjacent negative linear response to the east relates to an extant linear ditch. This corresponds to the

position of a former land boundary to plot 167 indicated on the 1841 tithe map.

(5) - The survey area contains a number of discrete positive responses which may relate to pits or areas of burning. There appears to be at least two such responses within the 15m wide proposed cemetery extension.

(6) - The eastern and northern parts of the survey area contain a number of rectilinear anomalies relating mainly to extant linear ditches/holloways, which extend beyond the limits of the survey area. These define rectangular plots or platforms associated with the medieval village.

(7) - In the northern part of the survey area are a complex array of positive and negative responses. Many relate to earthwork features, such as linear ditches and possible walling; however, the complexity and strength of the anomalies indicates a long period of occupation and development as anomalies are not well defined. This area was subject to evaluation in 2004 with occupation dating to the 13th to 16th centuries revealed.

(8) - Negative and positive linear and curvilinear responses are situated at the south eastern corner of the survey area and relate to further earthwork features, with a more irregular appearance than anomalies (4 & 6).

(9) - A triangular area of magnetic debris (10) is bounded by a negative linear anomaly which relates to walling surrounding the land plot which is mapped in 1841 as plot 168 and which is still in existence in 1975, but gone by 1980. Inside this area are other negative linear anomalies, which although are not clearly defined are likely to relate to other archaeological features or buildings within the land plot.

Anomalies associated with magnetic debris

(10) - Very strongly magnetic debris within a triangular formation relates to demolished material associated with a former dwelling recorded from at least 1886 to 1975. Although no building is indicated on the 1841 tithe map, the triangular land parcel no 168 relates to this area of magnetic debris. The strength of the response indicates that ferrous material is included within the demolition material and although the building was demolished in the 20th century it may be that the land parcel contained earlier dwellings associated with the medieval village.

(11) - A circular patch of strongly magnetic debris is located 25m east of anomaly (10) and close to anomalies (11). There is no obvious corresponding feature visible within the LiDAR imagery and the strength indicates some ferrous content, it is not possible to determine if it relates to a relatively modern bonfire or if it is associated with archaeological features.

(12) - Strong, discrete, dipolar anomalies relate to ferrous and other magnetically thermoremnant objects within the topsoil. While such objects may be relatively modern, many are likely to be associated with the occupation of the site.

3.5 General assessment of survey results – resistivity

3.5.1 The earth resistance survey was carried out over approximately 0.18ha and extends approximately 15m further south than the proposed cemetery extension.

3.5.2 Anomalies located can be generally classified as high and low resistance anomalies of archaeological origin, they have been numbered and will be outlined in 3.7 below with subsequent discussion in Section 4.

3.6 Data quality and factors influencing the interpretation of anomalies - resistivity

3.6.1 Data are considered representative of the resistive anomalies present within the site. There are no significant defects within the dataset.

3.6.2 The recorded data fall within a very narrow range of low resistance values that can be typical of clayey water retentive or poorly drained soil. However, the damp ground conditions at the time of survey aided good electrical contact and background 'noise' within the data was considered very low aiding the extraction of useful information from the dataset. The Geoscan RM85 system in twin probe configuration has previously been found to be very effective in conditions that are less than optimum for resistance survey.

3.6.3 Data were subject to a high resistance filter and interpolation in order to further enhance the resistive contrast. Both filtered and unfiltered data are analysed to ensure no significant artefacts have been created by the processing algorithm.

3.6.4 Although the survey was carried out after a relatively dry period, very wet conditions had prevailed through much of the early Spring and late Winter and ground moisture was considered likely to be higher than normal for the time of year, effectively suppressing resistive contrast. Heavy rainfall just prior to the survey is considered unlikely to have detrimentally affected the survey and may have aided good electrical contact.

3.7 List of anomalies – resistivity

Area centred on OS NGR 391815 189267, see Fig 04.

Anomalies of archaeological origin

(13) - A group of high resistance responses that relate in part to magnetic anomalies (1). However, the high resistance response also appears to extend northwards into the area earmarked for the new cemetery extension and could relate to further structural remains.

(14) - High resistance anomaly that corresponds to the northern edge of magnetic

anomalies (3) and relate to further structural remains.

(15) - A rectangular high resistance block does not have any corresponding magnetic response; however, the rectangular shape and high resistance indicates that this is likely to relate to a former structure.

(16) - Low resistance linear responses relate to extant, linear ditches and correspond to negative linear anomalies seen within the magnetic data.

(17) - High resistance responses extending from and along the edge of the north western part of the survey area, which has been outlined for the new cemetery. Although not clearly defined, the likelihood of them relating to archaeological features should be considered.

(18) - Areas of high resistance do not relate to to any magnetic anomalies or features seen within LiDAR imagery. However the responses may relate to further structural remains.

4 DISCUSSION

4.1.1 The detailed magnetometry was carried out over a wider area than the proposed cemetery extension in order to gain a fuller understanding of the archaeological remains in the vicinity and place any of those located within the proposed cemetery in context. The results correspond well with the visible earthwork remains of linear and rectilinear ditches, defining plots and platforms with some associated dwellings also located.

4.1.2 The additional earth resistance survey was carried out to support the magnetometry and also try to define any structural remains within and immediately adjacent to the cemetery extension. The results demonstrate that there is a linear ditch extending through the eastern part of the cemetery extension that defines a platform to the west. Situated within this platform are the remains of a former structure indicated in the magnetometry data, but the earth resistance data indicates that this may extend northwards into the area outlined for the cemetery and also indicates a potential further structure 10m to the east. Other high resistance anomalies can also be seen within this part of the site, and although not well defined, may relate to further archaeological features.

5 CONCLUSION

5.1.1 The geophysical survey comprised magnetometry with additional earth resistance survey also carried out within the site. Although only a small area in the the north western corner of the site has been outlined for the proposed cemetery extension, the field in which it is located contains earthworks relating to the shrunken medieval settlement at Brokenborough. Magnetometry was, therefore, undertaken over a wider area in order to aid the interpretation of anomalies within or immediately adjacent to the area of the proposed extension.

5.1.2 The magnetometry results have revealed a number of positive and negative linear and rectilinear anomalies that relate to a formally arranged series of ditches and holloways defining rectangular platforms. These platforms are associated with former structural remains. The high resistance anomalies partially correspond to magnetic anomalies relating to the structural remains; however, there appear to be more high resistance anomalies that may also relate to further structures that do not have any magnetic response. The majority of the archaeological features lie beyond the area outlined for the cemetery extension; however, possible structural remains may just extend into it.

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Appendix A – basic principles of magnetic survey

Iron minerals are always present to some degree within the topsoil and enhancement associated with human activity is related to increases in the level of magnetic susceptibility and thermoremnant material. Magnetic susceptibility is an induced magnetism within a material when it is in the presence of a magnetic field. This can be thought of as effectively permanent due to the presence of the Earth's magnetic field. Thermoremnant magnetism occurs when ferrous material is heated beyond a specific temperature known as the Curie Point. Demagnetisation occurs at this temperature with re-magnetisation by the Earth's magnetic field upon cooling.

Enhancement of magnetic susceptibility can occur in areas subject to burning and complex fermentation processes on biological material; these are frequently associated with human settlement. Thermoremnant features include ovens, hearths, and kilns. In addition thermoremnant material such as tile and brick may also be associated with human activity and settlement.

Silting and deliberate infilling of ditches and pits with magnetically enhanced soil can create an area of enhancement compared with surrounding soils and subsoils into which the feature is cut. Mapping enhanced areas will produce linear and discrete anomalies allowing an assessment and characterisation of hidden subsurface features.

It should be noted that areas of negative enhancement can be produced from material having lower magnetic properties compared to the topsoil. This is common for many sedimentary bedrocks and subsoils which were often used in the construction of banks and walls etc. Mapping these 'negative' anomalies may also reveal archaeological features.

Magnetic survey or magnetometry can be carried out using a fluxgate gradiometer and may be referred to as gradiometry. The SENSYS gradiometer is a passive instrument consisting of two fluxgate sensors mounted vertically 65cm apart. The instrument is carried about 10-20cm above the ground surface and the upper sensor measures the Earth's magnetic field as does the lower sensor but this is influenced to a greater degree by any localised buried magnetic field. The difference between the two sensors will relate to the strength of the magnetic field created by the buried feature.

There are a number of factors that may affect the magnetic survey and these include soil type, local geology and previous human activity. Situations arise where magnetic disturbance associated with modern services, metal fencing, dumped waste material etc., obscures low magnitude fields associated with archaeological features.

Appendix B – basic principles of earth resistance survey (resistivity)

Earth resistance survey, commonly known as resistivity, relies on the variability of conduction of current through soil and the subsurface matrix. The variability relates to the distribution of moisture within different materials so that non-porous features, such as foundations, produce a relatively high resistance response and more moisture retentive soil, such as found within the fill of a former ditch, produces a low resistance measurement. The technique is, therefore, influenced by climatic factors although the success of a survey can be difficult to predict based on these alone. Soil type, ground use, vegetative cover and the nature of buried features and subsoil are all factors that will influence the outcome of a survey.

The technique involves inputting a small electrical current into the ground and measuring subtle variations to the current at regular intervals across an area. The current input and measurement requires a series of probes to be inserted into the ground and the configuration of these can influence the resolution of resistive anomalies and the depth of response. Research has demonstrated that the twin electrode configuration is one of the most useful for archaeological prospection. It requires a mobile frame with two electrodes separated usually by 0.5m and a pair of remote probes linked to the logging instrument using a long cable.

Cart-based systems are also regularly used in archaeological prospection, and generally these require four spiked wheels to inject current into the ground and take measurements. The four wheels act as a square array which can be electronically switched to change the orientation of measurement and current input. Two or three readings are rapidly logged at each recording station and these are referred to as alpha, beta and

gamma. The gamma is often not recorded as this represents the difference between the alpha and beta configurations and can be derived during data processing. The alpha and beta datasets often demonstrate subtle differences that relate to the orientation of subsurface features and both are analysed as part of the abstraction and interpretation process. Advantages of cart systems are speed and resolution and they do not require a trailing cable; however, ground conditions are more critical and problems can be encountered with ground cover and in areas that are excessively damp or dry.

When using the twin probe configuration a useful reading interval for archaeological prospection across an area is 1m. Data are logged at 1m centres along traverses separated by 1m. Where areas contain known archaeological features 0.5m x 0.5m or 1m x 0.5 readings are considered more informative. Data collected by cart-based systems are typically at 0.25m centres along traverses separated by 1m.

Appendix C – data processing notes

Clipping

Minimum and maximum values are set and replace data outside of the range with those values. Extreme values are removed improving colour or greyscale contrast associated with data values that may be archaeologically significant. Different ranges are applied to data in order to determine the most suitable for anomaly abstraction and display.

Edge Match

Calculates the mean of the 2 lines (rows or columns) of data either side of the edge to match. It then subtracts the difference between the means from all datapoints in the selected area.

High Pass Filter

Removes low frequency anomalies within the data that are not considered to be archaeologically significant and may be natural in origin. A window passes over the data, the mean of all the data within the window is subtracted from the centre value. The size of the window is adjusted as is the weighting which may be uniform or Gaussian.

Zero Median/Mean Traverse

The median (or mean) of each traverse is calculated ignoring data outside a threshold value, the median (or mean) is then subtracted from the traverse. The process is used to equalise slight differences between the set-up and stability of gradiometer sensors and can remove striping. The process can remove archaeological features that run along a traverse so data analysis is also carried out prior its application.

Despike

Removal of data points that exceed the mean/median/threshold by selecting a window size of data points and replace by mean/median/threshold

Appendix D – survey and data information

Minimally processed magnetometer data clipped at ±3nT

Filename: J756-mag-proc.xcp
Description: Imported as Composite from: J756-mag.asc
Instrument Type: Sensys DLMGPS
Units: nT
UTM Zone: 30U
Survey corner coordinates (X/Y): OSGB36
Northwest corner: 391779.67, 189341.85 m
Southeast corner: 391916.77, 189201.75 m
Collection Method: Randomised
Sensors: 5
Dummy Value: 32702
Source GPS Points: 314500
Dimensions
Composite Size (readings): 914 x 934
Survey Size (meters): 137 m x 140 m
Grid Size: 137 m x 140 m
X Interval: 0.15 m
Y Interval: 0.15 m
Stats
Max: 3.32
Min: -3.30
Std Dev: 1.33
Mean: -0.01
Median: 0.01
Composite Area: 1.9208 ha
Surveyed Area: 1.0552 ha
PROGRAM
Name: TerraSurveyor
Version: 3.0.23.0
GPS based Proce4
1 Base Layer.
2 Unit Conversion Layer (Lat/Long to OSGB36).
3 DeStripe Median Traverse:
4 Clip from -3.00 to 3.00 nT

Minimally processed magnetometer data clipped at ±8nT

Stats
Max: 8.84
Min: -8.80
Std Dev: 2.55
Mean: -0.06
Median: 0.01
GPS based Proce4
1 Base Layer.
2 Unit Conversion Layer (Lat/Long to OSGB36).
3 DeStripe Median Traverse:
4 Clip from -8.00 to 8.00 nT

Minimally processed magnetometer data clipped at ±50nT

Stats
Max: 55.25
Min: -55.00
Std Dev: 7.68
Mean: -0.14
Median: 0.02
GPS based Proce4
1 Base Layer.
2 Unit Conversion Layer (Lat/Long to OSGB36).
3 DeStripe Median Traverse:
4 Clip from -50.00 to 50.00 nT

Raw earth resistance data

Filename: Res-raw.xcp
Description: Imported as Composite from GeoPlot : Res-raw
Instrument Type: Resist. (RM85)
Collection Method: Zig zag
Sensors: 4
Dummy Value: 2047.5
Dimensions
Composite Size (readings): 60 x 30
Survey Size (meters): 60 m x 30 m
Grid Size: 30 m x 30 m
X Interval: 1 m
Y Interval: 1 m
Stats
Max: 6.14
Min: 3.38
Std Dev: 0.60
Mean: 4.74
Median: 4.62
Composite Area: 0.18 ha
Surveyed Area: 0.18 ha
Processes: 2
1 Base Layer
2 Clip at 2.00 SD

Processed earth resistance data

Filename: Res-proc.xcp
Stats
Max: 1.12
Min: -1.00
Std Dev: 0.37
Mean: -0.01
Median: -0.06
Processes: 4
1 Despike X=1 Y=1Thr=3 Repl=Mean
2 HPF X=10 Y=10 Wt=U Applications=1
3 Interpolate Y, Expand - SinX/X, x2 Interpolate X, Expand - SinX/X, x2
4 Clip at 3.00 SD

Appendix E – digital archive

Archaeological Surveys Ltd hold the primary digital archive at their offices in Wiltshire. Data are backed-up onto an on-site data storage drive and at the earliest opportunity data are copied to CD ROM for storage on-site and off-site.

A printed copy of the report and a PDF copy will be supplied to the Wiltshire Historic Environment Record. The report will also be uploaded to the Online AccesS to the Index of archaeological investigationS (OASIS).

File type	Naming scheme	Description
Data	J756-mag.asc J756-mag.xcp J756-mag-proc.xcp J756-res-raw.xcp J756-res-proc.xcp	Raw data as ASCII CSV TerraSurveyor raw data TerraSurveyor minimally processed data TerraSurveyor raw data TerraSurveyor minimally processed data
Graphics	J756-mag-proc-3nt.tif J756-mag-proc-8nt.tif J756-mag-proc-50nt.tif J756-res-raw.tif J756-res-proc.tif	Image in TIF format
Drawing	J756-[version 1].dwg	CAD file in 2010 dwg format
Report	J756 report.odt	Report text in Open Office odt format

Table 2: Archive metadata

Appendix F – CAD layers for abstraction and interpretation plots

The table below sets out Archaeological Surveys Ltd CAD layer names with associated colours and graphical content. Where CAD files are available layers may be extracted for further CAD/GIS use. Note: hatched polygon boundaries are contained within layers with the RGB colour code 254, 255, 255 (near white) in order to prevent their visibility.

Report sub-heading and associated CAD layer names	Colour with RGB index		Layer content
Anomalies with archaeological potential			
AS-ABST MAG POS DISCRETE ARCHAEOLOGY		Red 255,0,0	Solid donut, point or polygon (solid)
AS-ABST MAG POS ARCHAEOLOGY		Red 255,0,0	Polygon (cross hatched ANSI37)
AS-ABST MAG POS STRUCTURAL ARCHAEOLOGY		255,0,127	Line, polyline or polygon (solid)
AS-ABST MAG NEG STRUCTURAL ARCHAEOLOGY		0,78,36	Line, polyline or polygon (solid)
AS-ABST MAG NEG LINEAR ARCHAEOLOGY		127,0,255	Line, polyline or polygon (solid)
AS-ABST RES HIGH LINEAR ARCHAEOLOGY		153,0,0	Line, polyline or polygon (solid)
AS-ABST RES HIGH AREA ARCHAEOLOGY		153,0,0	Polygon (net)
AS-ABST RES HIGH STRUCTURAL ARCHAEOLOGY		127,0,31	Line, polyline or polygon (solid)
AS-ABST RES LOW LINEAR ARCHAEOLOGY		191, 127, 255	Line, polyline or polygon (solid)
AS-ABST RES LOW AREA ARCHAEOLOGY		191, 127, 255	Polygon (net)
Anomalies associated with magnetic debris			
AS-ABST MAG DEBRIS		132, 132, 132	Polygon (cross hatched ANSI37)
AS-ABST MAG STRONG DIPOLAR		132, 132, 132	Solid donut, point or polygon (solid)
Anomalies with a modern origin			
AS-ABST MAG DISTURBANCE		132, 132, 132	Polygon (hatched ANSI31)

Table 3: CAD layering conventions

Appendix G – copyright and intellectual property

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Archaeological Surveys Ltd

Geophyisical Survey
St John the Baptist Church Cemetery Extension
Brokenborough
Wiltshire

Map of survey area

● Survey location

Site centred on OS NGR
ST 91805 89270

SCALE 1:25 000

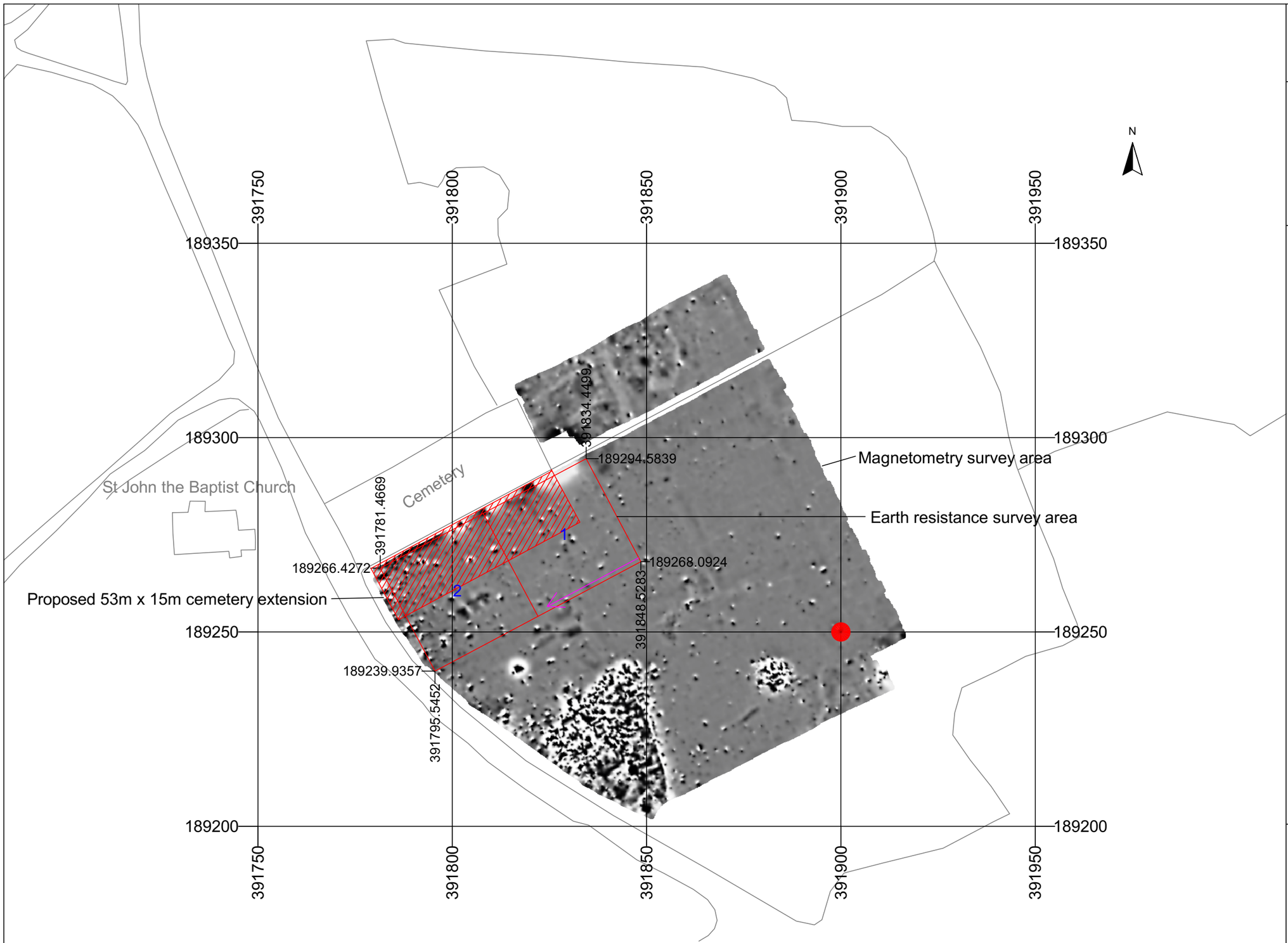
0m 500m 1000m

SCALE TRUE AT A3

FIG 01

Archaeological Surveys Ltd

Geophyisical Survey
St John the Baptist Church
Cemetery Extension
Brokenborough
Wiltshire



Referencing information

Referencing grid to OSGB36 datum at 50m intervals for detailed magnetometry

Data collected at 20Hz and georeferenced to ETRS89 zone 30 with conversion to OSGB36 using OSTN02

● 391900 189250

Earth resistance grid coordinates based on Ordnance Survey OSGB36 datum

Grids set out using RTK GPS with Leica SmartNet correction data RTCMv2 format OSTN02 transformation

Earth resistance survey grid size = 30m

→ Survey start and traverse direction

1 Grid reference number and filename

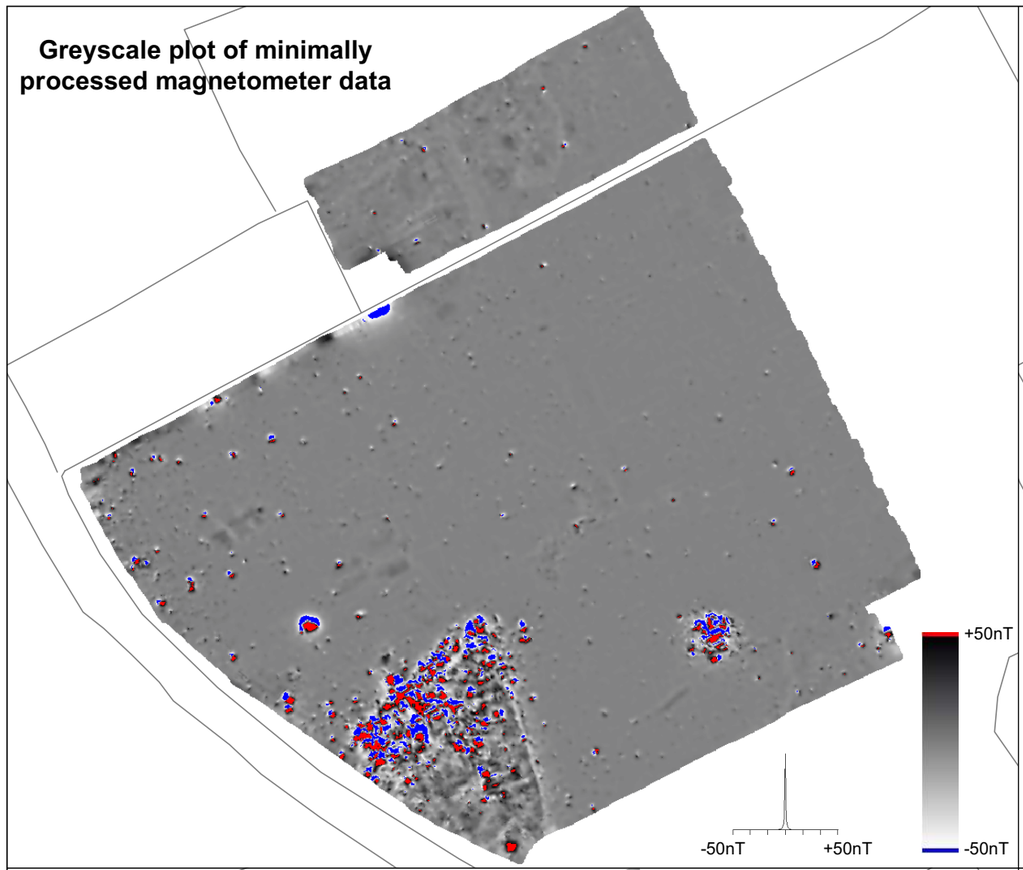
SCALE 1:1000

0m 10 20 30 40 50m

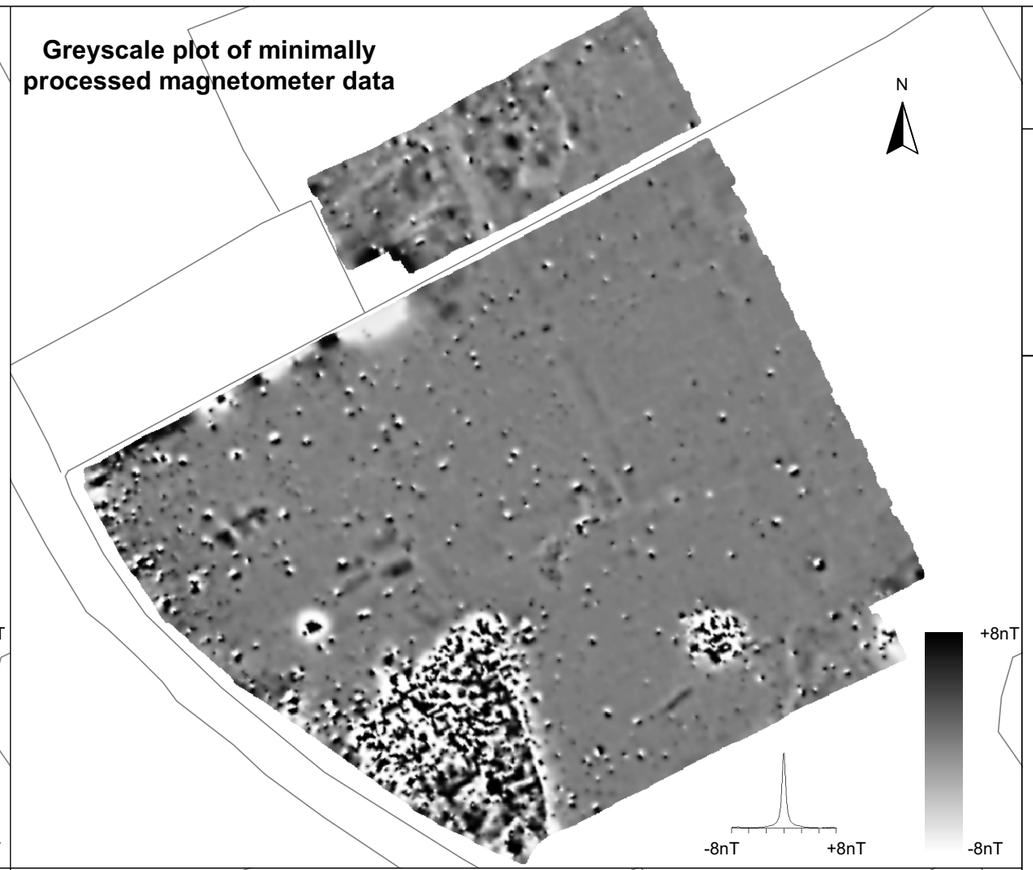
SCALE TRUE AT A3

FIG 02

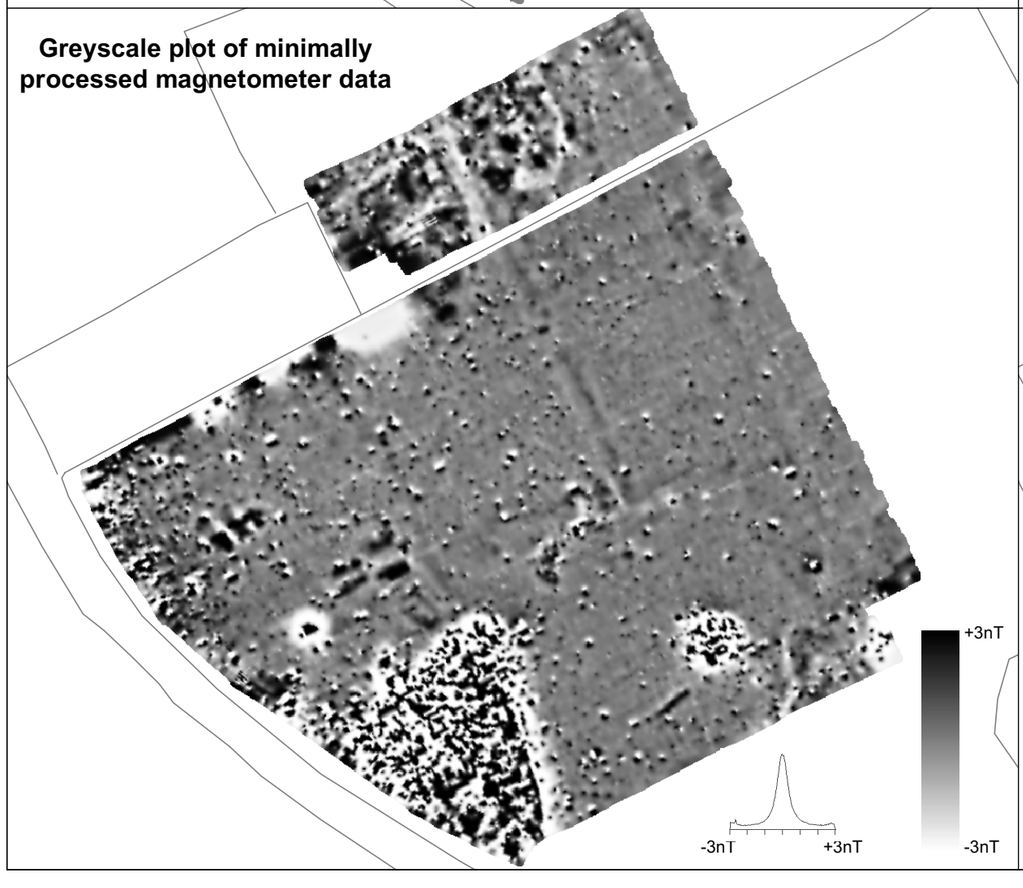
Greyscale plot of minimally processed magnetometer data



Greyscale plot of minimally processed magnetometer data



Greyscale plot of minimally processed magnetometer data



Abstraction and interpretation of magnetic anomalies

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St John the Baptist Church Cemetery Extension
Brokenborough
Wiltshire

Greyscale plots of minimally processed magnetometer data & abstraction & interpretation of magnetic anomalies

- Positive linear anomaly - of archaeological origin
- Negative linear anomaly - of archaeological origin
- Negative linear anomaly - associated with structural remains
- Positive response - magnetic enhancement associated with structural remains
- Discrete positive response - pit/magnetic enhancement of archaeological origin
- Negative anomaly - of archeological origin
- Positive anomaly - magnetic enhancement of archaeological origin
- Magnetic debris - spread of magnetically thermoremnant/ferrous material
- Magnetic disturbance from ferrous material
- Strong dipolar anomaly - ferrous object

SCALE 1:1000

0m 10 20 30 40 50m

SCALE TRUE AT A3

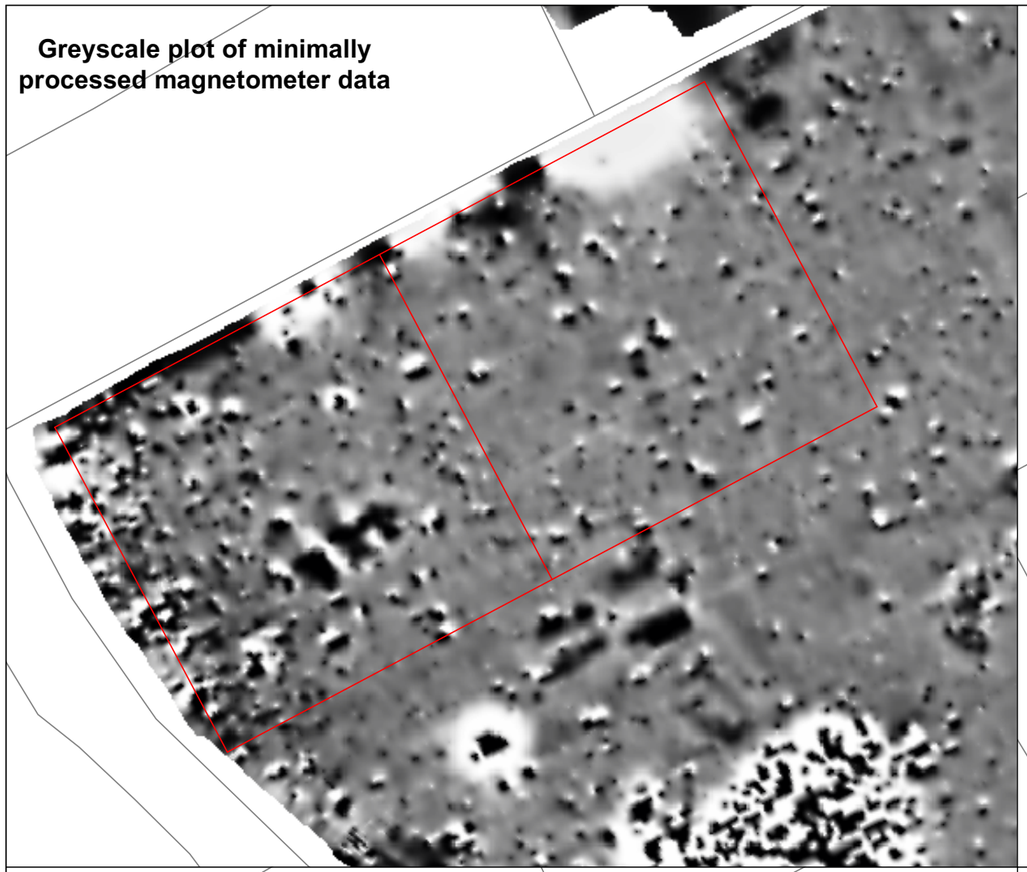
FIG 03

Archaeological Surveys Ltd

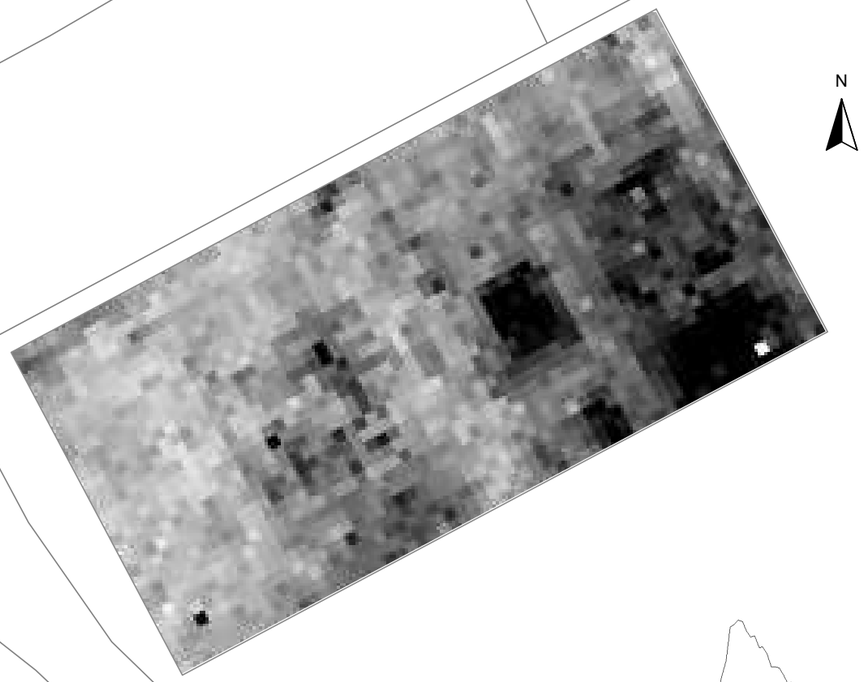
Geophyisical Survey
St John the Baptist Church Cemetery Extension
Brokenborough
Wiltshire

Greyscale plots of magnetometry, raw & processed earth resistance data & abstraction and interpretation of resistance anomalies

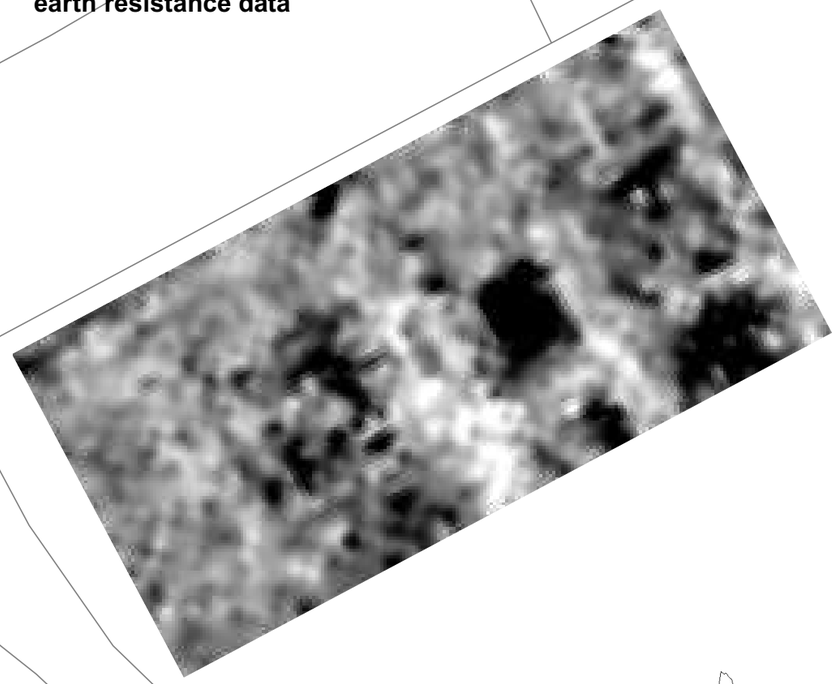
Greyscale plot of minimally processed magnetometer data



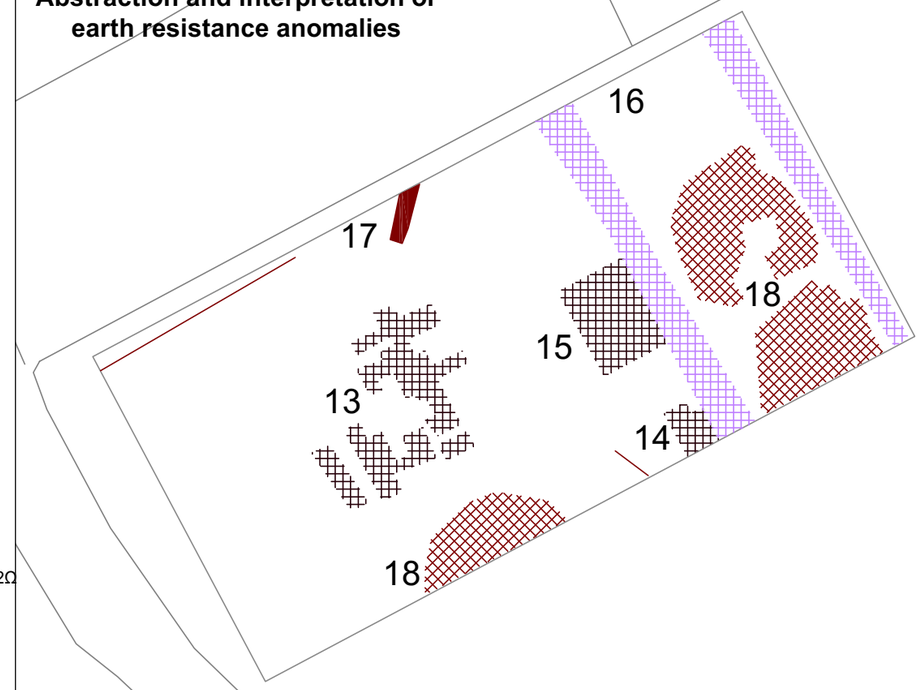
Greyscale plot of raw earth resistance data



Greyscale plot of processed earth resistance data



Abstraction and interpretation of earth resistance anomalies



- High resistance linear anomaly - of archaeological origin
- Area of high resistance - structural remains
- Area of high resistance - of archaeological origin
- Area of low resistance - linear ditch

SCALE 1:500

0m 5 10 15 20 25m

SCALE TRUE AT A3

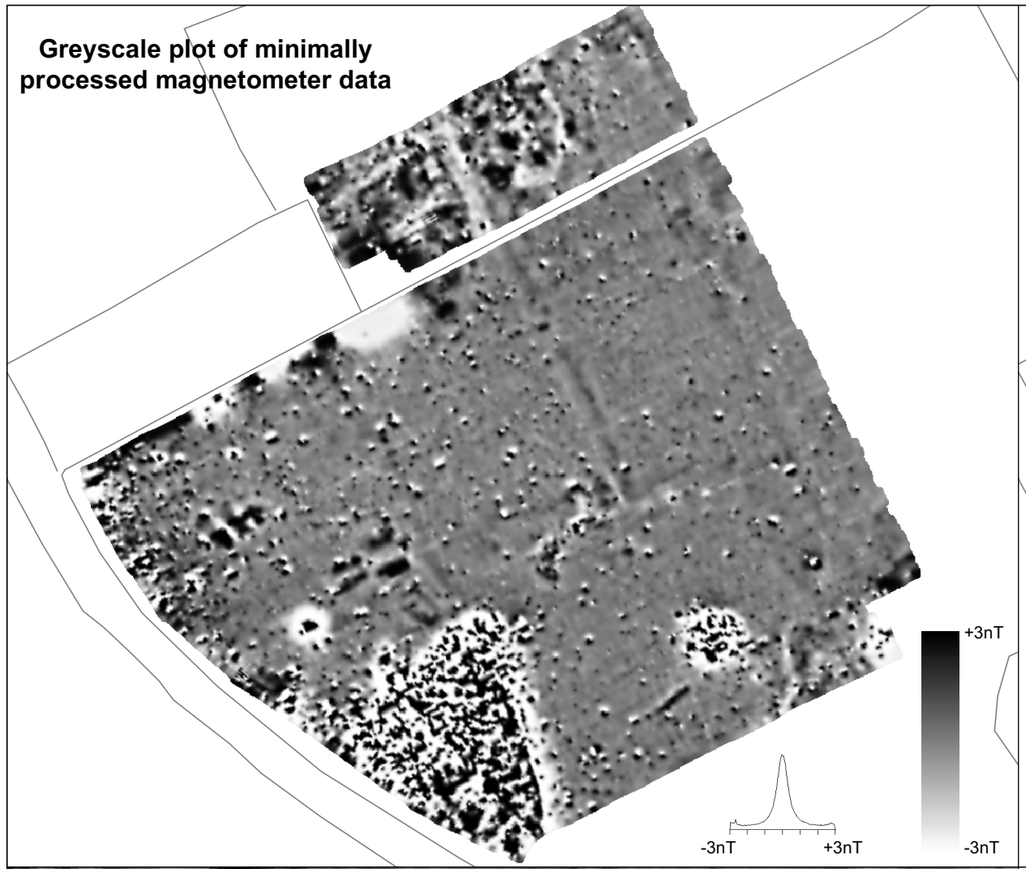
FIG 04

Archaeological Surveys Ltd

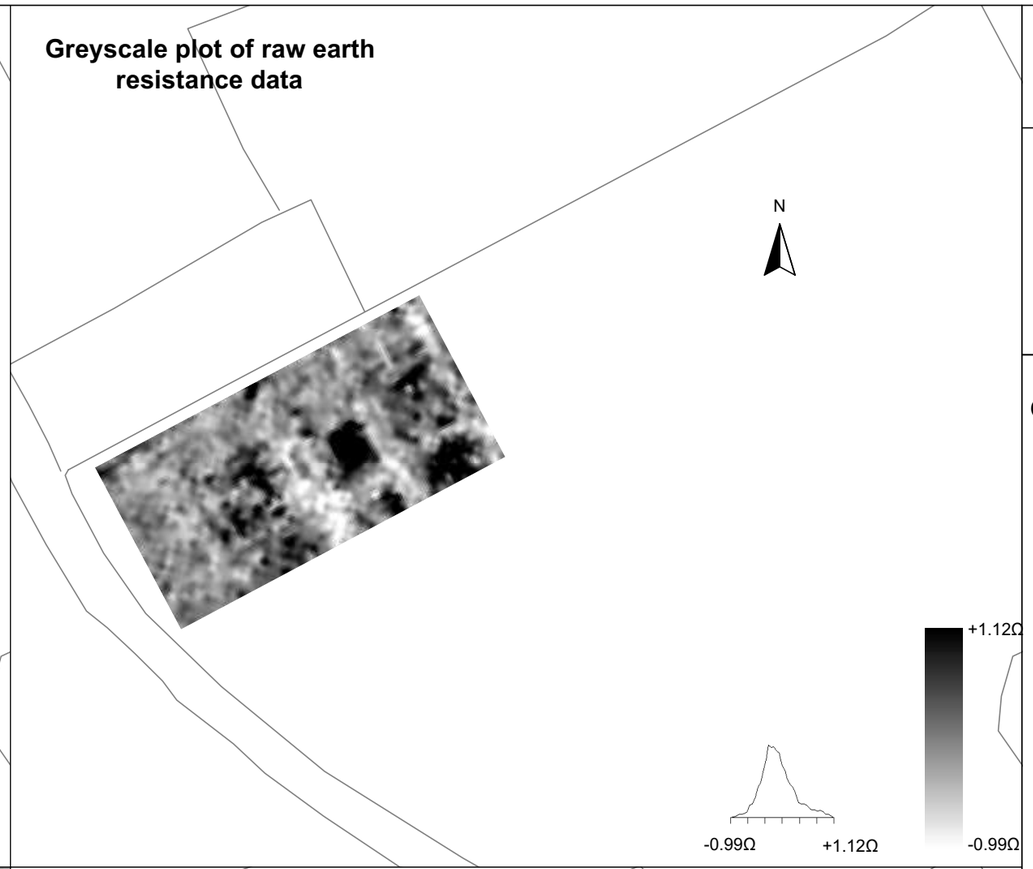
Geophyisical Survey
St John the Baptist Church Cemetery Extension
Brokenborough
Wiltshire

Greyscale plots of magnetometry, earth resistance & LiDAR data & abstraction and interpretation of geophysical anomalies

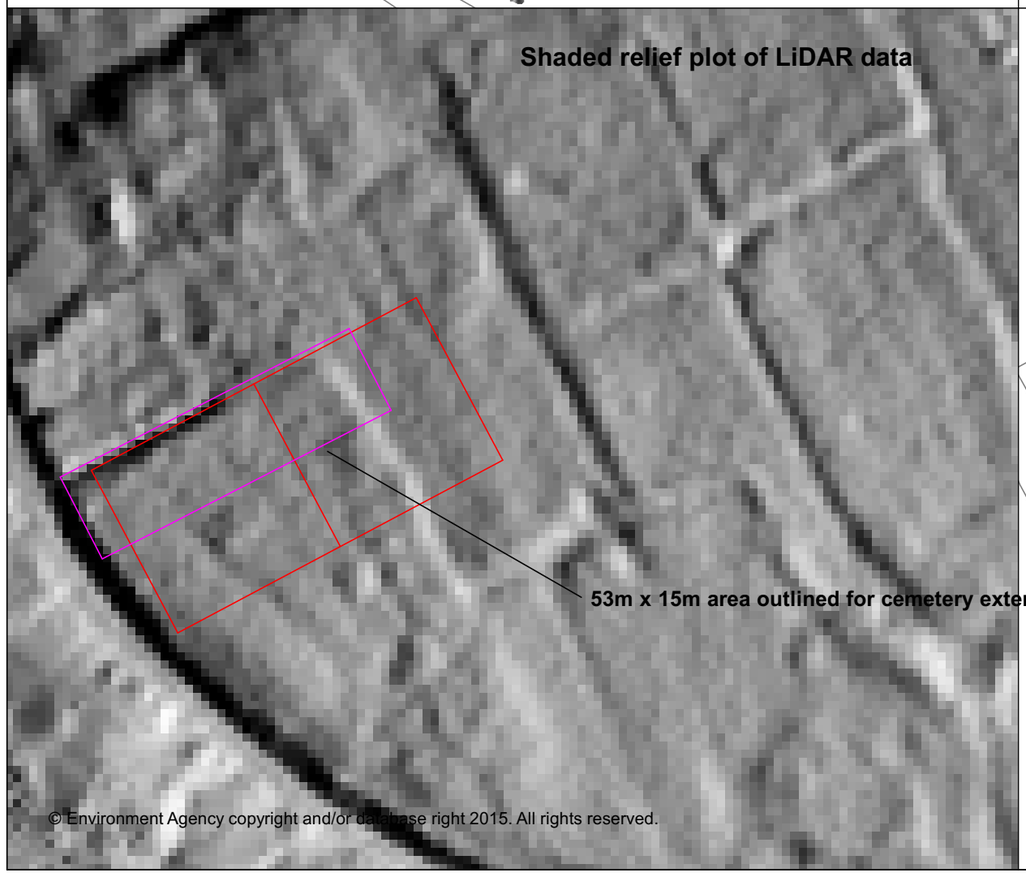
Greyscale plot of minimally processed magnetometer data



Greyscale plot of raw earth resistance data



Shaded relief plot of LiDAR data



Abstraction and interpretation of magnetic and earth resistance anomalies

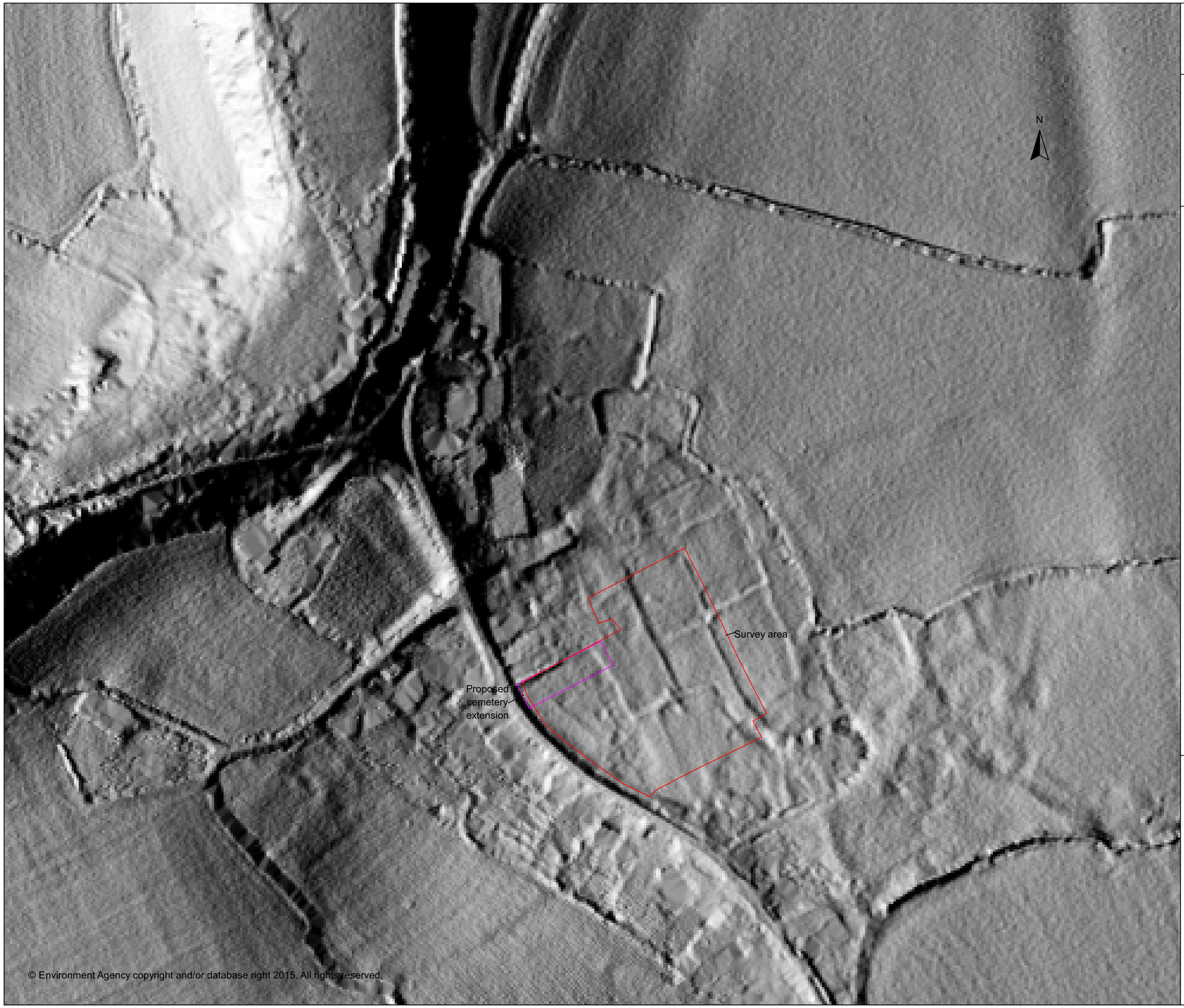
- Positive linear anomaly - of archaeological origin
- Negative linear anomaly - of archaeological origin
- Negative linear anomaly - associated with structural remains
- Positive response - magnetic enhancement associated with structural remains
- Discrete positive response - pit/magnetic enhancement of archaeological origin
- Negative anomaly - of archeological origin
- Positive anomaly - magnetic enhancement of archaeological origin
- Magnetic debris - spread of magnetically thermoremnant/ferrous material
- Magnetic disturbance from ferrous material
- Strong dipolar anomaly - ferrous object
- High resistance linear anomaly - of archaeological origin
- Area of high resistance - structural remains
- Area of high resistance - of archaeological origin
- Area of low resistance - linear ditch

SCALE 1:1000

0m 10 20 30 40 50m

SCALE TRUE AT A3

FIG 05



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Wiltshire

Shaded relief plot of Digital Terrain Model

Derived from Environment Agency's LiDAR data 1m resolution 5x vertical exaggeration

SCALE 1:2000

0m 20 40 60 80 100m

SCALE TRUE AT A3

FIG 06