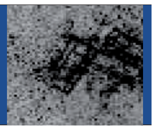

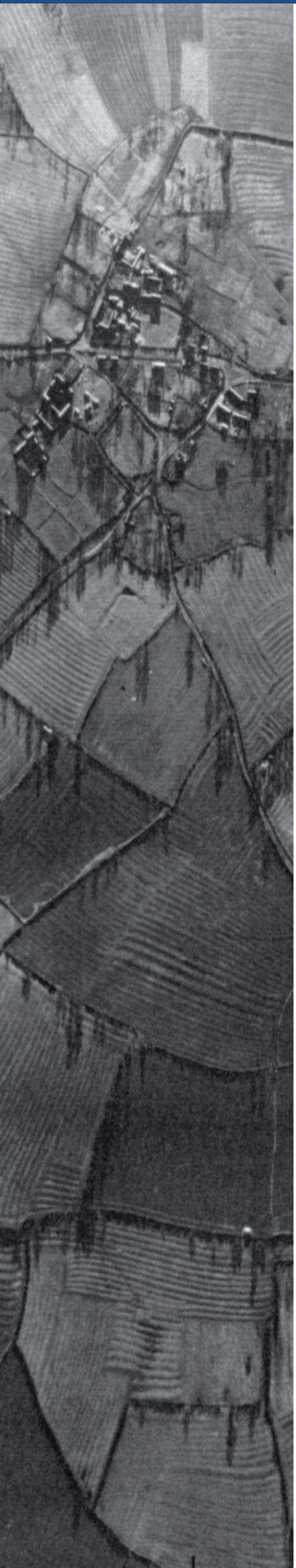

Lugbury Long Barrow, Nettleton, Wiltshire

MAGNETOMETRY, RESISTIVITY, GROUND PENETRATING RADAR SURVEY AND LIDAR ANALYSIS

for

Wiltshire Council Archaeology Service

David Sabin and Kerry Donaldson

February/March 2010

Ref. no. 314

ARCHAEOLOGICAL SURVEYS LTD

Lugbury Long Barrow, Nettleton, Wiltshire

Magnetometry, Resistivity, Ground Penetrating Radar Survey
and LiDAR analysis

for

Wiltshire Council Archaeology Service

Fieldwork by David Sabin, Kerry Donaldson and Jack Cousins
Report by David Sabin BSc (Hons) MIFA and Kerry Donaldson BSc (Hons)

Survey date - **from February to April 2010**
Ordnance Survey Grid Reference – **ST 832 735**

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SUMMARY

Archaeological Surveys Ltd was commissioned by Wiltshire Council Archaeology Service to undertake a geophysical survey of Lugbury Long Barrow near Nettleton, Wiltshire. The survey was requested due to the continued impact of ploughing on the barrow which is designated a Scheduled Monument (SM 12290). The work has been carried out under the Monument Management Scheme funded by English Heritage.

Survey techniques included magnetometry, resistivity and ground penetrating radar. Topographic survey using survey grade GPS and LiDAR analysis was used in support of the geophysical data. Magnetometry survey was carried out across the barrow and within the field in which the barrow resides whilst resistivity and ground penetrating radar were targeted on the barrow mound within the scheduled area.

Magnetometry clearly revealed flanking quarry ditches/pits to the north and south of the barrow. The magnetic anomalies suggest a series of interconnecting pits forming elongated ditches with occasional discontinuities giving the appearance of more discrete pit-like features.

The data from all of the geophysical techniques revealed variable response across the barrow mound with little coherence. No clear evidence for internal structure was obtained and this may support the historical evidence for complete excavation in the mid 19th century. However, it is possible the presence of jumbled limestone at very shallow depth has effectively obscured deeper features.

Geophysical data combined with topographic survey data and LiDAR data have clearly demonstrated the encroachment of ploughing in recent years and support field observations over the last decade. The current plough limit clearly encroaches onto the barrow 'structure' as visible in the magnetometry and resistivity data.

Magnetometry also revealed a number of other features of agricultural and natural origin and possible areas of quarrying. No evidence for a round barrow to the east of the long barrow was visible in the data. The round barrow had been recorded by John Aubrey as being ploughed away in 1630. A linear anomaly to the east of the long barrow appears to relate to a former track of medieval date. A linear anomaly in the north eastern part of the field may indicate a former route to the Fosse Way that may also be visible in LiDAR data.

1 INTRODUCTION

1.1 Survey background

1.1.1 Archaeological Surveys Ltd was commissioned by Wiltshire Council Archaeology Service to undertake a geophysical survey of Lugbury Long Barrow near Nettleton, Wiltshire. The survey was requested due to the continued impact of ploughing on the barrow which is designated a Scheduled Monument (SM 12290). The work has been carried out under the Monument Management Scheme funded by English Heritage.

1.1.2 A licence, under Section 42 of the 1979 Ancient Monuments and Archaeological Areas Act (as amended by the National Heritage Act 1983), was granted by English Heritage prior to commencing the fieldwork. The survey aims to provide information on the archaeological remains within the Scheduled area, helping to evaluate the impact of agricultural activity on the monument. The survey was carried out in accordance with a Method Statement produced by Archaeological Surveys (2010) and approved by English Heritage.

1.1.3 Lugbury Long Barrow (SM 12290), is located to the north of Nettleton in Wiltshire, and some 300m to the west of the Fosse Way Roman road. It comprises a mound approximately 60m by 20m and 0.5m high with three upright orthostats at the eastern end. 19th century excavations revealed one internal chamber and four lateral chambers in the south side.

1.2 Survey objectives and techniques

1.2.1 The objective of the survey was to use magnetometry, resistivity and ground penetrating radar (GPR) survey to locate geophysical anomalies that may be archaeological in origin. Specific aims included defining the limits of the long barrow, locating known or unknown burial chambers and locating the position of the flanking quarry ditches. In addition, the survey was also considered an effective means of assessing the state of preservation of archaeological features and the impact of agricultural activity.

1.2.2 The identification of previously unknown features, and the potential quality of any associated archaeological record, was considered an important objective that may influence future management of the site. More widespread magnetometry survey was considered an effective approach to assessing the archaeological potential of the land surrounding the monument but outside of the scheduled area.

1.2.3 LiDAR data were also available for analysis of the area surrounding the barrow. Analysis of interpolated digital elevation models derived from the LiDAR data was considered an effective means of supporting the interpretation of the geophysics. Additionally, the LiDAR data provide a record of surface features caused by modern cultivation at the time of data capture.

1.2.4 Magnetometry is a highly effective and efficient means of archaeological prospection recommended for survey over large areas. Resistivity survey and GPR are relatively slow techniques compared to magnetometry; however, where structural remains are suspected, the techniques can produce superior results. The survey and report generally follow the recommendations set out by: English Heritage, 2008, *Geophysical survey in archaeological field evaluation;* Institute for Archaeologists, 2002, *The use of Geophysical Techniques in Archaeological Evaluations*.

1.3 Site location, description and survey conditions

1.3.1 The site lies approximately 1km to the north-east of the village of Nettleton in Wiltshire, see Figure 01, central OS Grid Reference ST 832 785. The scheduled area (0.3ha) lies within the south western corner of a 7.3ha field, see Figure 02.

1.3.2 The field boundaries consist of dilapidated drystone walls within hedgerows. The Fosse Way Roman road lies immediately to the east and Three Stones Plantation to the south. The north eastern corner of the field contains a small quarry pit with mature trees and a small clump of mature trees is located a short distance to the west of the barrow in the south west corner of the site. A very small quarry pit can be observed at the far western end of Three Stones Plantation just to the south of the barrow. Bridleways cross the field immediately adjacent to the southern and western boundaries.

1.3.3 The ground cover across most of the field consisted of maize stubble with some patchy new grass. The barrow is covered by rough grass with areas of briar and elder, see Plate 1. Decaying branches and twigs, related to occasional scrub clearance, and large pieces of limestone were also visible on the barrow surface. Oolitic limestone fragments, with occasional pieces up to approximately 400mm across, were visible within the area of cultivation immediately surrounding the barrow and on the barrow surface itself; the latter are disturbed stones that have been thrown onto the barrow from the cultivated zone and originate from the barrow structure.

Plate 1: Central part of the barrow mound looking towards the east – taken March 2010

Plate 2: Lugbury long barrow looking towards the north east - taken May 2010

1.3.4 Ground conditions were generally considered to be favourable for magnetometry although long maize stubble resulted in difficult conditions for setting out and traversing. Zones of wet clayey soil also produced less than optimum conditions in some areas. Frozen ground and the high density of limestone fragments within the soil produced difficult conditions for resistivity. Uneven surfaces produced less than optimum conditions for GPR survey.

1.4 Site history and archaeological potential

1.4.1 Lugbury is an example of a Neolithic long barrow, or megalithic chambered tomb, of the Cotswold Severn region. There are at least 220 of this type of chambered tomb within south east Wales, Gloucestershire, Somerset, Oxfordshire, Berkshire and Wiltshire (Corcoran, 1969, Darvill, 2004). These monuments are believed to have been constructed and used between 4000 and 3000BC; however, recent radiocarbon dating from five barrows across the region have identified that within four of them construction began around 3800BC and that burial ended around 3625BC (Bayliss et al, 2007). These barrows were, therefore, only used for a few generations although many of them have several phases of construction and use.

1.4.2 The barrow measures today approximately 50m by 15m and is 0.5m high. At the eastern end, three upright orthostats are visible, these have been known as a cromlech since antiquity, see Plate 3. John Aubrey recorded the barrow with its orthostats during the 17th century and also noted that “near to this stone was a little round barrow, before it was ploughed away since AD 1630” (Jackson, 1862).

Plate 3: Lugbury long barrow orthostats looking towards the west - taken May 2010

1.4.3 There have been two previous recorded investigations of the barrow, both taking place within the 19th century. In 1821 Sir Richard Colt Hoare conducted an excavation along a 150ft (45m) length of the barrow. He found that charcoal had been mixed in with the natural ground surface at around 6ft deep, and that the floor and sides of the barrow had been constructed with a layer of loose stones. A wall was uncovered by the cromlech, with a second wall oriented north-south discovered approximately 60ft (18.3m) to the west. Between these two walls, some 30ft (9.14m) to the west of the cromlech, was discovered the inhumation of a young adult male, lying in a stone lined cist some 2ft (0.6m) deep, over which a "rude arch" had been constructed and orientated east-west (although Colt Hoare seems to have queried that it may have been north-south (Crawford, 1925)), with the knees drawn up level with the hips and a sharpened piece of flint lay close to his head. Colt Hoare's original manuscript shows that the dimensions of the mound were 219ft by 78ft (66.75m by 23.77m).

1.4.4 Colt Hoare believed that the primary burial lay at the eastern end under the cromlech but he did not want to disturb the stones for fear of them falling. In 1854 and 1855, landowner George Poulett Scrope, excavated around these stones, finding that they were buried upwards of 4ft (1.22m) below the natural ground surface. No human burials were located in the vicinity, only some fragments of Roman pottery, a foot or two from the surface, and a few fragments of boar bones, teeth and tusks and flint flakes (Thurnham, 1857).

1.4.5 The 1854 excavation was necessitated when ploughing revealed a stone cist on the south side, near the centre of the barrow, containing several skeletons. The subsequent investigations by Scrope, revealed a total of four stone chambers or cists on the southern side, containing seven, zero, nine and ten skeletons respectively. There was evidence of some distinction between age and gender to the relative cists they were placed in. Thurnham (1857) notes that, *"the whole barrow has latterly been excavated by Mr. Scrope, but without discovering any further interments, nor anything worthy of note except two or three more flint-flakes of irregular form. The bulk of the stones having been carted away, the barrow is now consequently much reduced in elevation".*

1.4.6 Although ploughing, excavation and subsequent removal of material have greatly reduced the extent of the barrow, it is possible that the geophysical survey will locate anomalies that may relate to the remnants of internal features as well as external features such as the quarry ditches. It was reported by Thurnham (1868) that the southern ditch was visible as a depression in the field. The ditches have not been subject to recording or excavation as far as is known.

1.5 Geology and soils

1.5.1 The underlying bedrock across the site is Forest Marble (BGS, 1965). The overlying soil across the survey area is from the Sherborne association which is a brown rendzina. This consists of shallow, well drained, brashy soil over limestone, associated with slowly permeable calcareous clayey soils (Soil

Survey of England and Wales, 1983).

1.5.2 The geological and pedological conditions are generally considered favourable for GPR, magnetometry and earth resistance survey. Natural anomalies such as cracking associated with cambering and shallow irregularities within the soil/rock interface may produce significant magnetic anomalies; it is known that significant magnetic enhancement can occur in the area due to natural chemical processes. Earth resistance may also show a response to natural features especially where solid geology is shallow. GPR and earth resistance surveys will be affected by waterlogged soils.

2 METHODOLOGY

2.1 Technical synopsis - magnetometry

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).

2.2 Technical synopsis - resistivity

2.2.1 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.

2.2.2 The Twin Probe configuration used in this survey is favoured for archaeological prospection and can give a response to features up to 1m in depth with a mobile probe separation of 0.5m.

2.3 Technical synopsis - ground penetrating radar

2.3.1 Ground penetrating radar systems transmit an electromagnetic wave into the ground and record the time delay and amplitude of reflections from buried features. Reflections occur from changes in conductivity or dielectric permittivity.

2.3.2 Electromagnetic waves are increasingly attenuated as frequency increases and, therefore, lower frequencies provide greater penetration into the subsurface. However, the longer wavelengths associated with lower frequencies reduce the resolution of buried features. Typical frequencies chosen for archaeological prospection are around 500 and 200 MHz.

2.4 Technical synopsis - LiDAR

2.4.1 Light Detection and Ranging (LiDAR) is a remote sensing technique that measures range using a laser. Data are collected using scanning equipment mounted on aircraft and positional information is added using GPS and/or inertial measurement. Range measurements are effectively converted to terrain heights (ODN) that are associated with Ordnance Survey eastings and northings.

2.4.2 Height data are converted to digital terrain models with relief shading in order to highlight subtle surface features such as low banks and ditches that may not be visible from the ground. Filtering and processing of LiDAR data can effectively remove surface features such as trees and building. The technique has proved very effective at locating unknown archaeological features in wooded areas.

2.4.3 LiDAR data used in this report are derived from surveys carried out by the Environment Agency's Geomatics Group. The data have a resolution of 1m with a quoted vertical accuracy of ±15cm and are available in 1km tiles. Data used in this report were collected in 2005.

2.5 Equipment configuration, operation and resolution - magnetometry

2.5.1 The detailed magnetic survey was carried out using Bartington Grad601-2 gradiometers. This instruments effectively measure a magnetic gradient between two fluxgate sensors mounted vertically 1m apart. Two sets of sensors are mounted on a single frame 1m apart horizontally.

2.5.2 The instruments are extremely sensitive and are able to measure magnetic variation to 0.01nanoTesla (nT) with an effective resolution of 0.03 nT. The data are limited to ±100nT when surveying with the highest sensitivity. All readings are saved to an integral data logger for analysis and presentation

2.5.3 The instruments are operated according to the manufacturer's instructions with consideration given to the local conditions. An adjustment procedure is required, prior to collection of data, in order to balance the sensors and remove the effects of the Earth's magnetic field; further adjustment is required during the survey due to instrument drift often associated with temperature change.

2.5.4 It may be very difficult to obtain optimum balance for the sensors due to localised magnetic vectors that can be associated with large ferrous objects, geological/pedological features, 'magnetic' debris within the topsoil and natural temperature fluctuations. Imperfect balance results in a heading error often visible as striping within the data; this can be effectively removed by software processing and generally has little effect on the data unless extreme. Archaeological Surveys use a non-magnetic tripod, with an additional supporting structure, to raise the instrument during the set-up procedure; this has been found to improve the sensor balance.

2.5.5 The Bartington gradiometers undergo regular servicing and calibration by the manufacturer. A current assessment of the instruments is shown in Table 1 below.

Date of calibration/service	16th May 2009
Sensor type	Bartington Grad - 01 – 1000 Nos. 084, 085, 242 and 396
Bandwidth	12Hz (100nT range) both sensors
Noise	<100pT peak to peak
Adjustable errors	<2nT

Table 1: Bartington fluxgate gradiometer sensor calibration results

The instruments were considered to be in good working order prior to the survey with no known faults or defects.

2.5.6 Data were collected at 0.25m centres along traverses 1m apart. The survey area was separated into 30m by 30m grids (900m²) giving 3600 recorded measurements per grid. This sampling interval is very effective at locating archaeological features and is the recommended methodology for archaeological prospection (English Heritage, 2008).

2.6 Equipment configuration, operation and resolution - resistivity

2.6.1 The earth resistance survey was carried out using a TR Systems Ltd Resistance Meter TRCIA 1.31 with a mobile Twin Probe array. The standard mobile frame for the TRCIA instrument has a 0.5m electrode separation and readings were recorded at 0.5m intervals along 0.5m traverses across the barrow earthwork. The instrument was set to filter stray earth currents which can cause errors within the resistance measurements.

2.7 Equipment configuration, operation and resolution - GPR

2.7.1 Ground penetrating radar data were acquired using an Utsi Electronics Groundvue 3A system running with a 400MHz shielded antenna. Scans were recorded at 0.0295m along traverses separated by 0.25m. A dielectric constant of 10 was used in the field to set up the instrument and view data.

2.8 Mapping and data collection strategy

2.8.1 Base mapping has been provided by Wiltshire County Council Archaeology Service and is based on Ordnance Survey vector maps with the addition of archaeological sites and monuments. Ground survey of the barrow orthostats, by Archaeological Surveys using RTK GPS, suggests a potential error in the base mapping of 4m in the vicinity of the barrow. The corrected position of the orthostats and an unsurveyable patch of vegetation have been plotted in the figures attached to this report.

2.8.2 The survey grids were set out to the Ordnance Survey OSGB36 datum using a Penmap RTK GPS. The GPS is used in conjunction with Topcon TopNet service where positional corrections are sent via a mobile telephone link. Positional accuracy of around 10 – 20mm is possible using the system.

2.8.3 The fixed orientation of survey grids based on the OSGB36 datum was considered appropriate given that the orientation of land boundaries was variable and consequently partial survey grids were unavoidable. In addition there is an optimum north – south traverse direction for magnetic survey (English Heritage, 2008). Survey in this direction can produce anomalies with a higher contrast when compared to other orientations; this is a function of their presence within the Earth's magnetic field. A fixed grid across the site also simplifies its relocation should that be required.

2.9 Data processing - magnetometry

2.9.1 Magnetometry data downloaded from the Grad 601-2 data logger are analysed and processed using specialist software known as ArcheoSurveyor. The software allows greyscale and trace plots to be produced for presentation and display. Survey grids are assembled to form an overall composite of data (composite file) creating a dataset of the complete survey area. Appendix C contains specific information concerning the survey and data attributes and is derived directly from ArcheoSurveyor; this should be used in conjunction with information provided by Figure 02.

2.9.2 Only minimal processing is carried out in order to enhance the results of the magnetometry. Raw data are always analysed as processing can modify anomalies. The following schedule sets out the data and image processing used in this survey:

- clipping of the raw data at ±30nT to improve greyscale resolution,
- clipping of processed data at ±5nT to enhance low magnitude anomalies,
- de-stagger is used to enhance linear anomalies,
- zero median/mean traverse is applied in order to balance readings along each traverse.

Reference should be made to Appendix B for further information on the specific processes carried out on the data. Appendix C metadata includes details on the processing sequence used for the survey area.

2.10 Data processing - resistivity

2.10.1 Data logged by the resistance meter is downloaded and processed within ArcheoSurveyor software. Raw data is analysed and displayed within the report as well as processed data. The following processing has been carried out on data in this survey:

- raw earth resistance data have been shown with absolute readings of between 46.49Ω and 332.92Ω,
- processed data have been clipped between -12.86Ω and11.42Ω to enhance any possible archaeological anomalies (negative values are a function of the mathematical operation carried out across the data during processing),
- data have been “despiked” in order to remove spurious high contact responses,
- data are passed through a high pass filter in order to enhance archaeological features,
- the image has been interpolated to smooth data for presentation.

Reference should be made to Appendix B for further information on the specific processes carried out on the data. Appendix C metadata includes details on the processing sequence used for the survey area.

2.11 Data processing - GPR

2.11.1 The GPR data were analysed using REFLEX software. Each traverse was analysed as an individual profile to allow a manual abstraction of buried features. In addition, profiles across the whole survey area were combined and processed in order to create time slices showing the variation in reflector amplitude at various depths.

2.11.2 The following processing has been carried out on the radar profiles:

- fix profile length has been used to remove small positional errors resulting from surface irregularities,
- X flip profile has been used on every odd file number (1, 3, 5 etc.) to fix the order of data captured by zig-zag survey,
- background removal 2D filtering has been carried out in order to 'clean' the appearance of the data,
- gain function has been used to provide increasing signal gain on later weaker reflections,
- a bandpass Butterworth filter has been used to remove 'noise' beyond a bandwidth of 200 – 600 Mhz.

2.11.3 Attempts were made to assess the velocity of the radar wave through the ground by hyperbola matching. An accurate measurement of velocity, which can be used to derive depth information, can be achieved by analysing hyperbolas within the radar profile. No satisfactory matching was achieved and a figure of 0.1m/ns was considered a satisfactory compromise.

2.11.4 Time slices were produced from the set of radar profiles allowing a useful plan view of the subsurface to be analysed. Time slices were plotted from the envelope of the radar wave which is proportional to the square root of the total energy of the reflection at any instant.

2.12 Data processing - LiDAR

2.12.1 The LiDAR data were imported and interpolated using Surfer. A digital surface relief map was created using a kriging algorithm. Georeferenced TIF images were exported from Surfer and attached to the base mapping using ProgeCAD.

2.13 Data presentation

2.13.1 An abstraction and interpretation is offered for all geophysical anomalies located by the survey. 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 assessment of features within the survey area. Where further interpretation is possible, or where a number of possible origins should be considered, more detailed discussion is set out in Section 4.

2.13.2 The main form of data display for magnetometry and resistivity used in this report is the greyscale plot. Both 'raw' and 'processed' data have been shown followed by an abstraction and interpretation plot.

2.13.3 GPR data are displayed as 4 separate time slices using an appropriate colour scale to indicate the relative strength of reflections. A GPR abstraction and interpretation plot with a depth estimate is also included.

2.13.4 Geophysical anomalies are abstracted as colour coded points, lines and polygons using CAD software. All CAD plots are scaled to landscape A3 for paper printing.

2.13.5 Graphic raster images in bitmap format (.BMP) are initially prepared in ArcheoSurveyor. Regardless of survey orientation, data captured along each traverse are displayed and processed by ArcheoSurveyor and Reflex from left to right. This corresponds to a direction of south to north in the field for the survey. Prior to displaying against base mapping, raster graphics require a rotation of 90° anticlockwise to restore north to the top. Graphics are rotated by AutoCAD.

2.13.6 The raster images are combined with base mapping using ProgeCAD Professional 2010 and AutoCAD LT 2007, creating DWG file formats. All images are externally referenced to the CAD drawing in order to maintain good graphical quality. Quality can be compromised by rotation of graphics in order to allow the data to be orientated with respect to grid north; this is considered acceptable as the survey results are effectively georeferenced allowing relocation of features using GPS, resection method etc.. A digital archive, including raster images, is produced with this report allowing separate analysis if necessary, see Appendix D below.

3 RESULTS

3.1 General overview - magnetometry

3.1.1 The detailed magnetic survey was carried out over a total of 7ha. Geophysical anomalies located can be generally classified as positive linear and discrete positive responses of archaeological origin, variable response associated with the barrow, positive linear and discrete anomalies of an uncertain origin, linear anomalies of an agricultural origin, areas of magnetic debris and strong discrete dipolar anomalies relating to ferrous objects. Anomalies located within each survey area have been numbered and will be outlined below with subsequent discussion in Section 4.

3.1.2 Magnetic data were considered representative of the site and of useful contrast. Modern cultivation has caused a degree of 'noise' although is unlikely to have seriously degraded the data.

3.1.3 The listing of sub-headings below attempts to define a number of separate categories that reflect the range and type of features located during the magnetometry survey. A basic explanation of the characteristics of the magnetic anomalies is set out for each category in order to justify interpretation, a basic key is indicated to allow cross reference to the abstraction and interpretation plot. Sub-headings are then used to group anomalies with similar characteristics together.

Report sub-heading CAD layer names and plot colour	Description and origin of anomalies
Anomalies with archaeological potential AS-ABST MAG POS LINEAR ARCHAEOLOGY AS-ABST MAG DIPOLAR ARCHAEOLOGY	Anomalies have the characteristics (mainly morphological) of a range of archaeological features such as pits, ring ditches, enclosures, etc..
Anomalies with an uncertain origin AS-ABST MAG POS LINEAR UNCERTAIN AS-ABST MAG POS DISCRETE UNCERTAIN AS-ABST MAG POS AREA UNCERTAIN	The category applies to a range of anomalies where <u>there is not enough evidence to confidently suggest an origin</u>. Anomalies in this category <u>may well be related to archaeologically significant features, but equally relatively modern features, geological/pedological features and agricultural features should be considered</u>. Positive anomalies are indicative of magnetically enhanced soils that may form the fill of 'cut' features or may be produced by accumulation within layers or 'earthwork' features; soils subject to burning may also produce positive anomalies. Negative anomalies are produced by material of comparatively low magnetic susceptibility such as stone and subsoil.
Anomalies with an agricultural origin AS-ABST MAG AGRICULTURAL AS-ABST MAG RIDGE AND FURROW	The anomalies are often linear and form a series of parallel responses or are parallel to extant land boundaries. Where the response is broad, former ridge and furrow is likely; narrow response is often related to modern ploughing.
Anomalies associated with magnetic debris AS-ABST MAG DEBRIS AS-ABST MAG STRONG DIPOLAR	Magnetic debris often appears as areas containing many small dipolar anomalies that may range from weak to very strong in magnitude. It often occurs where there has been dumping or ground make-up and is 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, or hearths and <u>may therefore be archaeologically significant</u>. It is also possible that the response may be caused by natural material such as certain gravels and fragments of igneous or metamorphic rock. Strong discrete dipolar anomalies are responses to ferrous objects within the topsoil.

Table 2: List and description of interpretation categories

3.2 General overview – earth resistance survey

3.2.1 The earth resistance survey was carried out over a total area of 0.3ha. Geophysical anomalies located can be generally classified as high, moderate and low resistance anomalies associated with barrow remains and low resistance anomalies associated with barrow ditches. Anomalies located have been numbered and will be outlined below with subsequent discussion in Section 4.

3.2.2 Data were recorded with difficulty due to deeply frozen ground and dense areas of oolitic limestone within the topsoil. However, data quality appears good with few erratic readings that can be caused by high contact resistance in poor ground conditions.

3.2.3 The listing of sub-headings below attempts to define a number of separate categories that reflect the range and type of features located during the earth resistance survey. A basic explanation of the characteristics of the anomalies is set out for each category in order to justify interpretation, a basic key is indicated to allow cross reference to the abstraction and interpretation plot. Sub-headings are then used to group anomalies with similar characteristics.

Report sub-heading **CAD layer names and plot colour**	**Description and origin of anomalies**
Anomalies with archaeological potential AS-ABST RES HIGH AREA ARCHAEOLOGY AS-ABST RES LOW AREA ARCHAEOLOGY AS-ABST RES LOW LINEAR ARCHAEOLOGY	Anomalies have the characteristics (mainly morphological) of a range of archaeological features such as enclosures, structures, ring ditches, etc.. High resistance may indicate structural material (e.g. stone); low resistance may relate to the moisture retentive fill of cut features.
Anomalies with an agricultural origin AS-ABST RES AGRICULTURAL	The anomalies are often linear and form a series of parallel responses or are parallel to extant land boundaries. Where the response is broad, former ridge and furrow is likely; narrow response is often related to modern ploughing. Anomalies associated with land drainage often form distinctive patterns.

Table 3: List and description of resistivity interpretation categories

3.3 General overview – ground penetrating radar

3.3.1 The ground penetrating radar survey was carried out over a total of 0.25ha. Anomalies located by the survey can be generally classified as linear features of uncertain and agricultural origins. Complex and variable reflections were located across much of the barrow earthwork and are likely to represent a highly jumbled limestone matrix.

3.3.2 Ground coupling of the radar antenna was often poor and very variable due to the uneven ground surface. The variability in ground coupling has produced strong surface reflections and an increase in the general 'noise' level. Velocity appears to change markedly with depth which may be as a result of increasing water content within air spaces between limestone fragments. A confident assessment of the velocity was not possible although an approximation of depth is suggested in Figure 12. Useful reflections appear to diminish at approximately 50ns which may equate to a depth of 2m.

3.3.3 The listing of sub-headings below attempts to define a number of separate categories that reflect the range and type of features located during the GPR survey. A basic explanation of the characteristics of the anomalies is set out for each category in order to justify interpretation, a basic key is indicated to allow cross reference to the abstraction and interpretation plot. Sub-headings are then used to group anomalies with similar characteristics.

Report sub-heading CAD layer names and plot colour	Description and origin of anomalies
Anomalies with an uncertain origin AS-ABST GPR LINEAR UNCERTAIN	The category applies to a range of anomalies where there is not enough evidence to confidently suggest an origin. Anomalies in this category may well be related to archaeologically significant features, but equally relatively modern features, geological/pedological features and agricultural features should be considered.
Anomalies with an agricultural origin AS-ABST GPR AGRICULTURAL	The anomalies are often linear and form a series of parallel responses or are parallel to extant land boundaries.

Table 4: List and description of GPR interpretation categories

3.4 General overview – LiDAR data

3.4.1 LiDAR data reveal a number of low earthworks and hollows and it is likely that most are associated with former land boundaries although some may indicate former tracks. An abstraction and interpretation plot, Figure 14, has been included with the report in order to highlight features within the wider area surrounding the barrow. It is possible that some of the abstracted linear features relate to very early land division although none could be confidently associated with the barrow. Further discussion is set out in Section 4.

3.5 List of anomalies – magnetometry

Area centred on Ordnance Survey National Grid Reference 383240 178610, see Figures 03 – 06.

Anomalies with archaeological potential

(1) – Area of variable response caused by considerable variability in the magnetic susceptibility of the barrow make-up. This response displays little coherence suggesting that the mound is formed by a mix of soil and limestone with no evidence for survival of the original features.

(2 & 3) – Positive anomalies up to 20nT in magnitude, indicate the location of the

flanking quarry ditches. They appear as irregularly shaped discontinuous cut features or elongated pits which extend along the northern and southern sides of the barrow at a distance of 4 -12m. They converge slightly towards the western tail end of the barrow and extend beyond the eastern end by approximately 35m. The strength of the anomalies suggests magnetically enhanced material that may be of considerable archaeological potential.

(4) – Two positive linear anomalies located at the western tail end of the mound may indicate cut features associated with the barrow ditches.

Anomalies with an uncertain origin

(5) – Positive response, located between the barrow and the southern ditch. It is possible that this anomaly is associated with the quarry ditches.

(6) – A positive linear anomaly located close to the southern quarry ditch. It is possible that it relates to a cut feature.

(7) – A positive linear anomaly located close to the southern edge of the survey area. This anomaly has a magnetic response of up to 30nT suggesting that it has a large quantity of magnetically enhanced material incorporated into it. The anomaly may relate to a former track or boundary feature.

(8) – Positive pit-like anomalies appear to be directly associated with or form part of anomaly (7).

(9) – Discrete positive anomalies appear to form pit-like features although they may relate to features with a natural origin.

(10) – A weak positive linear anomaly to the south of anomaly (8) may relate to agricultural activity.

(11) – A positive linear anomaly, located close to and parallel with the eastern field boundary, may relate to agricultural activity. It should be noted that the Fosse Way Roman road lies directly east of the field boundary, and the anomaly may indicate an associated ditch, see section 4.4.6.

(12) – Discrete positive anomalies located close to and possibly associated with anomaly (11).

(13) – Weak positive response that may relate to former quarrying. The response is much weaker than those associated with the barrow quarry ditches.

(14 & 15) – Weak, broadly linear positive anomaly (14) appears to extend north westwards from anomaly (13). Similar anomalies (15) are oriented north-east to south-west. It is not possible to directly ascertain the origin of these anomalies, it is likely that they have a similar origin to anomalies (16).

(16) – Weakly positive linear anomalies oriented north-east to south-west and north-

west to south-east appear as ditch-like features; however, they may relate to soil filled cracks within the underlying geology and therefore a natural origin should be considered.

(17) – Discrete positive response with a magnitude of up to 60nT suggests a feature with highly magnetic content which may indicated burnt material.

(18) – Two weak positive linear anomalies located in the eastern part of the survey area may relate to a discontinuous linear ditch-like feature.

Anomalies with an agricultural origin

(19 & 20) – A series of parallel linear anomalies, oriented west-south-west to east-north-east and located in the central eastern part of the survey area, are likely to indicate former ridge and furrow. A second series oriented west-north-west to east-south-east, close to the north eastern corner of the field, also indicate former ridge and furrow.

(21) – Widespread linear anomalies, parallel with the northern field boundary, relate to the recent cultivation trend.

Anomalies associated with magnetic debris

(22) – A patch of magnetic debris located in the field entrance relates to magnetically thermoremnant material (brick/tile/slag etc.) that has been used to consolidate the ground. A patch of magnetic debris is also evident on the barrow and probably indicates recent bonfires or dumped material of modern origin.

(23) – Strong discrete dipolar anomalies relate to ferrous/magnetically thermoremnant objects within the topsoil.

3.6 List of anomalies – earth resistance survey

Area centred on Ordnance Survey National Grid Reference 383075 178555, see Figures 07 – 09.

Anomalies with archaeological potential

(24) – High resistance anomalies associated with remains of the barrow.

(25) – Low resistance anomalies associated with the barrow. The anomalies may indicate zones of more moisture retentive soil and broadly define the shape of the barrow.

(26) – Low resistance anomalies caused by quarry ditches surround the barrow on northern, western and southern sides.

Anomalies with an agricultural origin

(27) – High resistance linear anomalies are associated with a distinct change in the profile of the barrow caused by modern ploughing.

3.7 List of anomalies – ground penetrating radar survey

Area centred on Ordnance Survey National Grid Reference 383075 178555, see Figures 10 – 12.

Anomalies with an uncertain origin

(28) – Several poorly defined linear features appear within GPR data from the central and eastern parts of the barrow. Depths are variable and range from near surface to approximately 0.75m. It is uncertain as to whether the anomalies are associated with 19th century investigations or more recent disturbance.

Anomalies with an agricultural origin

(29) – High energy reflections have been caused by poor coupling of the GPR antenna at a distinct step relating to the limit of modern ploughing.

(30) – Linear anomalies that may relate to the former limit of ploughing.

4 DISCUSSION

4.1 Quarry ditches/pits

4.1.1 Low resistance anomalies surrounding the barrow on the northern, western and southern sides correlate with positive magnetic anomalies and are indicative of quarry ditches. Darvill (2004) defines two distinct types: regular quarry ditches and irregular quarry pits. Thurnham (1868) noted that the Lugbury long barrow had a visible ditch on the southern side; however, Crawford (1925) suggests that this is “a most unusual feature for a barrow in Oolitic country”. It has since become known as the most northerly reported quarry ditch for this type of monument.

4.1.2 Generally, long barrows constructed from chalk, such as West Kennet (English Heritage, 2001), have regular flanking ditches, whilst those on the Cotswold oolitic limestone, such as Hazleton North (Saville, 1990), have much more irregularly shaped ditches. Thurnham's comment has been taken in its literal sense, probably without any real field investigation of the ditches. It appears from the geophysical survey that the morphology of the features located at Lugbury perhaps reveal a possible combination of the two as they appear as irregular, discontinuous quarry ditches.

4.2 Agricultural erosion

4.2.1 The results of both the earth resistance and ground penetrating radar surveys clearly define the current limit of ploughing. Ground observations suggest encroachment onto the barrow by ploughing in recent years. Figure 13 demonstrates the relationship between the current limit of ploughing, as mapped by RTK GPS, and both the magnetic and resistive responses. In addition the Ordnance Survey mapping for the top and bottom of the barrow mound is shown. It is clear that the current ploughing limit lies within magnetic and resistive anomalies that define the 'structure' of the barrow mound. The ploughing limit also lies well within the extent of the barrow as defined by the Ordnance Survey mapping; however, the base mapping has been demonstrated to contain some considerable positional errors in the vicinity of the orthostats that may well be apparent within the earthwork boundaries also.

4.2.2 The LiDAR data provide evidence of a former limit of agricultural cultivation to the south of the barrow. A distinct 'step' or edge is visible that appears to be approximately 5m south of the current ploughing edge along the southern side of the barrow. LiDAR data were collected in 2005 although it should be considered that the feature may be the remnants of a much earlier ploughing limit. The interpretation is further supported by linear features abstracted from the GPR data, Figure 12 anomalies (30). The linear features appear to correlate very closely with the LiDAR 'edge', they are very shallow and provide additional evidence for a well formed previous limit to ploughing.

4.3 Structural preservation and survival

4.3.1 Although the earth resistance survey shows high resistance anomalies along the southern edge of the barrow, in the vicinity of the chambers excavated in the 19th century, it is not possible to conclude that the anomalies are associated with structural remains. The evidence from the GPR survey indicates little coherence to the make-up of the barrow with no indication of structures in the area where the chambers were discovered.

4.3.2 The general lack of coherence associated with anomalies revealed by all of the geophysical techniques would support the documentary evidence for complete excavation in 1854 and suggests that no structures were left undisturbed. It is possible that the low resistance anomalies, predominantly in the eastern half of the mound, indicate that much structural material has been removed from this area during excavation. Low resistance in the central part of the barrow could possibly be associated with the excavation of 1821.

4.3.3 The surface of the barrow mound is littered with freshly disturbed oolitic limestones up to approximately 400mm across and these represent stones that have been disturbed by recent encroachment of ploughing onto the mound. Although the material may have been redeposited after the 19th century excavations, it is possible that there are parts of the original structure still in-situ that have not been revealed by the geophysics due to the nature of the overburden.

4.3.4 During the survey work, a number of visitors viewed the monument as an accessible example of a Cotswold Severn Long Barrow. Preservation of the barrow mound is, therefore, an important objective of site management regardless of whether or not the mound has been completely disturbed and re-modelled in the 19th century. Further erosion of soil in the vicinity of the orthostats may result in their eventual destabilisation, especially considering that previous excavation works may have lowered the mechanical strength of the soil matrix keeping them up. The orthostats are also vulnerable to accidental damage by agricultural implements.

4.4 LiDAR analysis

4.4.1 A shaded relief image of LiDAR data is plotted in Figure 14. The plot also contains a number of abstracted boundaries and/or tracks visible as earthwork features. Features mapped as part of the Wiltshire Sites and Monuments Record are also included. The data have been included in the report in order to assess the wider landscape in which the barrow and anomalies located by magnetometry lie.

4.4.2 A number of removed field boundaries are evident as surface features and an earlier pattern of smaller fields has been revealed by highlighting former boundaries. A number of fields to the south and south-west of the barrow have evidence of medieval ridge and furrow. The pattern generally shows little regard to the line of the Fosse Way, perhaps indicating more important boundary or topographic features in the landscape.

4.4.3 The field in which the barrow resides contains a former field boundary with an almost north south orientation. Although the feature was not visible in the magnetometry data, there are differences in the orientation of former ridge and furrow that indicate the boundary was probably extant in the medieval period. The boundary is not visible on late 19th century Ordnance Survey mapping.

4.4.4 A second linear feature within the barrow field appears as a very shallow depression that correlates with magnetic anomaly (7). The feature continues to the east of the Fosse Way where it forms a deeply incised holloway. To the west of the barrow, the feature appears as a linear earthwork that may continue and eventually turn into part of a lane to the north-west of Manor

Farm at Nettleton Green. The feature is likely to represent the former course of a track linking medieval settlement at Nettleton Green to medieval Gatcombe Mill adjacent to the Bybrook. The former track may define a long established land boundary passing immediately south of Lugbury long barrow.

4.4.5 Approximately 200m west of the barrow, a low earthwork may represent a rectilinear feature. Its morphology and size of the are similar to a rectilinear cropmark some 150m south of the barrow, SMR no. ST87NW612.

4.4.6 Immediately north of the north eastern corner of the barrow field, a linear earthwork extends to the north and it is tentatively suggested that this may be evidence for a former course to the Fosse Way. Positive linear anomaly (11) could represent a road side ditch and support this interpretation.

5 CONCLUSION

5.1.1 Magnetometry, resistivity and ground penetrating radar surveys have provided useful geophysical data with regard to the preservation and structure of Lugbury long barrow and the archaeological potential of the surrounding environment. LiDAR data have been useful in supporting the interpretation of a number of geophysical anomalies and assessing the archaeological potential of the wider environment beyond the area of geophysical survey. The geophysical techniques, supported by LiDAR and topographic survey, have allowed an assessment of erosion caused by encroachment of agricultural cultivation onto the monument.

5.1.2 Magnetometry data have effectively revealed the position of flanking quarry ditches or pits that form an important archaeological resource. The magnetic anomalies suggest a series of irregular ditches, that may be formed by a series of interconnecting pits, although there is some evidence of discontinuity within both the northern and southern ditches and the construction of more discrete pit-like features.

5.1.3 The current limit of ploughing around the barrow was clearly defined by linear anomalies in both resistivity and ground penetrating radar data. The anomalies correlate with the limit as mapped by GPS survey. It is clear from the results of the geophysics that the current limit to ploughing encroaches onto the actual 'structure' of the barrow itself. Ground penetrating radar anomalies and LiDAR data suggest a former ploughing limit some 5m further away from the barrow along the southern side and give weight to ground observations of encroachment over the last decade.

5.1.4 Geophysical data from the barrow tend to lack coherence and indicate a great deal of variability within the barrow 'structure'. No clear evidence for the survival of burial chambers was visible in the data. The geophysics does tend to support the historical references of Thurnham (1857) that indicate the whole barrow was excavated with “the bulk of the stones being carted away”. The present barrow 'structure' may, therefore, be formed of a matrix of soil and oolitic limestone fragments of variable size; effectively it is the spoil of the 19th century excavations. However, the fragmented limestone just below the ground surface may effectively be obscuring more coherent features at depth.

5.1.5 Magnetometry survey within the field in which the barrow resides revealed a number of agricultural and natural anomalies and possible evidence of quarrying. A linear anomaly, visible in data to the east of the barrow, is considered likely to relate to a track dating to the medieval period at the latest and linking Nettleton Green, to the west, with Gatcombe Mill to the east of the Fosse Way. Much of the route is visible as surface features within LiDAR data. A linear anomaly within the north eastern part of the field may relate to a former route of the Fosse Way of which there is also some supporting evidence from the LiDAR data. No evidence of a round barrow, recorded as being ploughed away in 1630 by John Aubrey, to the east of Lugbury long barrow was visible in the geophysical data.

6 REFERENCES

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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 gradiometer is a passive instrument consisting of two fluxgate sensors mounted vertically 1m apart. The instrument is carried about 30cm 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 field. The difference between the two sensors will relate to the strength the magnetic field created by the buried feature. If no enhanced feature is present the field measured by both sensors will be similar and the difference close to zero.

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 – 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.

Zero Median/Mean Traverse (magnetometry only)

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.

De-stagger (magnetometry only)

Compensates for small positional errors within data collection by shifting the position of the readings along each traverse by a specified amount. Data lost at the end of each traverse are extrapolated from adjacent value in the same row.

Deslope (magnetometry only)

Corrects for striping and distortion caused by metal objects/services etc.. The process calculates a curve based on a polynomial best fit mathematical function for each traverse. This curve is then subtracted from the actual data.

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.

Appendix C – survey and data information

Raw magnetometry data

Filename: J314-mag-raw.xcp
Instrument Type: Bartington (Gradiometer)
Units: nT
Surveyed by: on 22/02/2010
Assembled by: on 22/02/2010
Direction of 1st Traverse: 0 deg
Collection Method: ZigZag
Sensors: 2 @ 1.00 m spacing.
Dummy Value: 32702
Origin: Zero

Dimensions
Composite Size (readings): 960 x 510
Survey Size (meters): 240 m x 510 m
Grid Size: 30 m x 30 m
X Interval: 0.25 m
Y Interval: 1 m

Stats
Max: 30.00
Min: -30.00
Std Dev: 2.36
Mean: -0.02
Median: -0.11
Composite Area: 12.24 ha
Surveyed Area: 6.9467 ha

Processes: 2
1 Base Layer
2 Clip from -30.00 to 30.00 nT

Source Grids: 99
1 Col:0 Row:7 43.xgd
2 Col:0 Row:8 44.xgd
3 Col:0 Row:9 45.xgd
4 Col:0 Row:10 46.xgd
5 Col:0 Row:11 47.xgd
6 Col:0 Row:12 95.xgd
7 Col:0 Row:13 96.xgd
8 Col:1 Row:0 12.xgd
9 Col:1 Row:1 13.xgd
10 Col:1 Row:2 14.xgd
11 Col:1 Row:3 15.xgd
12 Col:1 Row:4 39.xgd
13 Col:1 Row:5 40.xgd
14 Col:1 Row:6 41.xgd
15 Col:1 Row:7 42.xgd
16 Col:1 Row:8 48.xgd
17 Col:1 Row:9 49.xgd
18 Col:1 Row:10 50.xgd
19 Col:1 Row:11 51.xgd
20 Col:1 Row:12 92.xgd
21 Col:1 Row:13 93.xgd
22 Col:1 Row:14 94.xgd
23 Col:2 Row:0 08.xgd
24 Col:2 Row:1 09.xgd
25 Col:2 Row:2 10.xgd
26 Col:2 Row:3 11.xgd
27 Col:2 Row:4 35.xgd
28 Col:2 Row:5 36.xgd
29 Col:2 Row:6 37.xgd
30 Col:2 Row:7 38.xgd
31 Col:2 Row:8 52.xgd
32 Col:2 Row:9 53.xgd
33 Col:2 Row:10 54.xgd
34 Col:2 Row:11 55.xgd
35 Col:2 Row:12 88.xgd
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37 Col:2 Row:14 90.xgd
38 Col:2 Row:15 91.xgd
39 Col:3 Row:1 05.xgd
40 Col:3 Row:2 06.xgd
41 Col:3 Row:3 07.xgd
42 Col:3 Row:4 31.xgd
43 Col:3 Row:5 32.xgd
44 Col:3 Row:6 33.xgd
45 Col:3 Row:7 34.xgd
46 Col:3 Row:8 56.xgd
47 Col:3 Row:9 57.xgd
48 Col:3 Row:10 58.xgd
49 Col:3 Row:11 59.xgd
50 Col:3 Row:12 84.xgd
51 Col:3 Row:13 85.xgd
52 Col:3 Row:14 86.xgd
53 Col:3 Row:15 87.xgd
54 Col:3 Row:16 99.xgd
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57 Col:4 Row:4 27.xgd
58 Col:4 Row:5 28.xgd
59 Col:4 Row:6 29.xgd
60 Col:4 Row:7 30.xgd
61 Col:4 Row:8 60.xgd
62 Col:4 Row:9 61.xgd
63 Col:4 Row:10 62.xgd
64 Col:4 Row:11 63.xgd
65 Col:4 Row:12 80.xgd
66 Col:4 Row:13 81.xgd
67 Col:4 Row:14 82.xgd
68 Col:4 Row:15 83.xgd
69 Col:4 Row:16 98.xgd
70 Col:5 Row:3 02.xgd
71 Col:5 Row:4 23.xgd
72 Col:5 Row:5 24.xgd
73 Col:5 Row:6 25.xgd
74 Col:5 Row:7 26.xgd
75 Col:5 Row:8 64.xgd
76 Col:5 Row:9 65.xgd
77 Col:5 Row:10 66.xgd
78 Col:5 Row:11 67.xgd
79 Col:5 Row:12 76.xgd
80 Col:5 Row:13 77.xgd
81 Col:5 Row:14 78.xgd
82 Col:5 Row:15 79.xgd
83 Col:5 Row:16 97.xgd
84 Col:6 Row:3 01.xgd
85 Col:6 Row:4 19.xgd
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87 Col:6 Row:6 21.xgd
88 Col:6 Row:7 22.xgd
89 Col:6 Row:8 68.xgd
90 Col:6 Row:9 69.xgd
91 Col:6 Row:10 70.xgd
92 Col:6 Row:11 71.xgd
93 Col:6 Row:12 72.xgd
94 Col:6 Row:13 73.xgd
95 Col:6 Row:14 74.xgd
96 Col:6 Row:15 75.xgd
97 Col:7 Row:4 16.xgd
98 Col:7 Row:5 17.xgd
99 Col:7 Row:6 18.xgd

Magnetometry processing

Filename: J314-mag-proc.xcp

Processes: 5
1 Base Layer
2 Clip from -30.00 to 30.00 nT
3 DeStripe Median Traverse: Grids: All
4 Clip from -5.00 to 5.00 nT
5 De Stagger: Grids: 50.xgd Mode: Outbound By: 1 intervals

Raw resistivity data

Filename: J314-res-raw.xcp
Instrument Type: TRCIA (Resistance)
Units: Ohm
Surveyed by: on 09/03/2010
Assembled by: on 24/03/2010
Direction of 1st Traverse: 0 deg
Collection Method: ZigZag
Sensors: 0 @ 0.00 m spacing.
Dummy Value: 32702
Origin: Zero

Dimensions
Composite Size (readings): 120 x 180
Survey Size (meters): 60 m x 90 m

Grid Size: 30 m x 30 m
X Interval: 0.5 m
Y Interval: 0.5 m

Stats
Max: 332.92
Min: 46.49
Std Dev: 34.03
Mean: 86.25
Median: 78.56
Composite Area: 0.54 ha
Surveyed Area: 0.28335 ha

Processes: 1
1 Base Layer

Source Grids: 6

1 Col:0 Row:0 grids\04.xgd
2 Col:0 Row:1 grids\05.xgd
3 Col:0 Row:2 grids\06.xgd
4 Col:1 Row:0 grids\01.xgd
5 Col:1 Row:1 grids\02.xgd
6 Col:1 Row:2 grids\03.xgd

Resistivity processing

Processes: 5
1 Base Layer
2 Despike Threshold: 1 Window size: 3x3
3 High pass Gaussian filter: Window: 21 x 21
4 Clip at 1.00 SD
5 Interpolate: X & Y Doubled.

Appendix D – digital archive

Archaeological Surveys Ltd hold the primary digital archive at Castle Combe, Wiltshire (see inside cover for address). 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. Digital data are also supplied to the client on CD ROM, see below.

Surveys are reported on in hardcopy (recycled paper) using A4 for text and A3 for plots (all plots are scaled for A3). The distribution of both hardcopy report and digital data is considered the responsibility of the Client unless explicitly stated in the survey Brief, Written Scheme of Investigation or other contractual agreement.

This report has been prepared using the following software on a Windows XP platform:

- ArcheoSurveyor version 2.5.3.2 (geophysical data analysis),
- ProgeCAD Professional 2009 (report graphics),
- AutoCAD LT 2007 (report figures),
- OpenOffice.org 3.0.1 Writer (document text),
- PDF Creator version 0.9 (PDF archive).

Digital data are supplied on CD ROM which includes the following files:

- ArcheoSurveyor grid and composite files for magnetometry and resistivity data,
- CSV files for raw and processed composites,
- geophysical composite file graphics as Bitmap images,
- AutoCAD DWG files in 2000 and 2007 versions,
- report text as OpenOffice.org ODT file,
- report text as Word 2000 doc file,
- report text as rich text format (RTF),
- report text as PDF,
- PDFs of all figures,
- photographic record in JPEG format.

The CD ROM structure is formed from a tree of directories under the title J314 Lugbury – CD. Directory titles include Data, Documentation, CAD, PDFs and Photos. Multiple directories exist under Data and hold Grid, Composite and Graphic files with CSV composite data held in Export.

The CAD file contains externally referenced graphics that are rotated with separate A3 size layouts for each figure. Layouts are fixed using frozen layers and named views allowing straightforward plotting or analysis on screen. (Note – CAD files are prepared using AutoCAD's e Transmit function to produce a directory containing the digital drawing along with any externally referenced graphics which may need reloading).