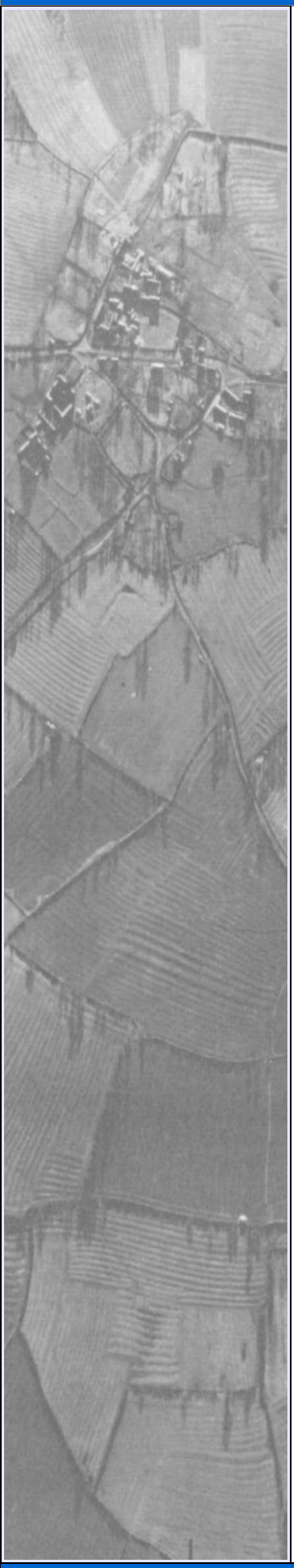

The Recreation Ground
Bath
Bath & North East Somerset

MAGNETOMETER SURVEY REPORT

for

Arena 1865

Kerry Donaldson & David Sabin

October 2018

Ref. no. J767

ARCHAEOLOGICAL SURVEYS LTD

The Recreation Ground
Bath
Bath & North East Somerset

Magnetometer Survey Report

for

Arena 1865

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

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Ordnance Survey Grid Reference – **ST 75450 64905**

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SUMMARY

Detailed magnetometry was carried out by Archaeological Surveys Ltd, for Arena 1865, at the Recreation Ground in Bath. The survey area comprised the pitch within the Bath Rugby Stadium as well as the Recreation Ground and croquet lawns to the east. The results indicate the presence of a large number of former boundary ditches, many of which relate to larger, sub-divided plots of land utilised as kitchen gardens during the late 18th and early 19th centuries and also several later 19th century land boundaries. The results also indicate that the larger land plots were bounded by trackways, with several parallel linear anomalies relating to flanking trackway ditches.

The site of the 18th century formal Spring Gardens was located in the north western part of the site, the south western corner of which was later utilised as a timber and stone yard and subsequent Victoria Iron and Brass mill in the 1880s. Geophysical anomalies have been located within this part of the site, with several relating to formerly mapped boundary features, but others could relate to features such as beds and paths associated with the former Spring Gardens.

In the eastern part of the site, within the Recreation Ground and croquet lawns, there are a number of positive linear and rectilinear anomalies that are not parallel with the mapped boundary features and also appear to have been truncated by them, indicating that they may relate to earlier cut features.

1 INTRODUCTION

1.1 Survey background

1.1.1 Archaeological Surveys Ltd was commissioned by J4 Projects, on behalf of Arena 1865, to undertake a magnetometer survey at The Recreation Ground in Bath. The site has been outlined for a proposed development of a new rugby stadium and the survey forms part of an archaeological assessment. The geophysical survey was carried out in accordance with a Written Scheme of Investigation (WSI) produced by Archaeological Surveys (2018) and issued to the client prior to commencing the fieldwork.

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 development of the site. 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: 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.* Note: currently Historic England (2018) no longer support the guidelines set out in English Heritage (2008) *Geophysical survey in archaeological field evaluation* and there are currently no plans to update the document. As a consequence other sources of written guidance referring to this document may be out of date and/or contain unsupported information (e.g. Chartered Institute for Archaeologists, 2014).

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 within the Recreation Ground, Bath and is centred on Ordnance Survey National Grid Reference (OS NGR) ST 75450 64905, see Figs 01 and 02.

1.4.2 The geophysical survey covers approximately 3ha and includes the open playing field of the Recreation Ground and croquet lawns in the eastern part of the site and rugby pitch within the stadium to the west.

Plate 1: Rugby pitch looking south west

Plate 2: The Recreation Ground looking east

1.4.3 The ground conditions across the site were generally considered to be favourable for the collection of magnetometry data. However, numerous above ground steel objects were noted as sources of magnetic disturbance. Weather conditions during the survey fine.

1.5 Site history and archaeological potential

1.5.1 An Archaeological Desk-Based Assessment has been carried out for the site (Watkins, 2018). This document outlines that there are no entries on the Bath and North East Somerset (BANES) Historic Environment Record (HER) for prehistoric activity within the site, although there are several entries for mesolithic activity within a 250m radius. The site lies 300m from the Roman town of *Aquae Sulis* which is a designated Scheduled Ancient Monument. The main focus for Roman activity was on the western side of the River Avon, but there is evidence for a Roman cemetery with the presumed edge situated 60m north east of the site. There is little medieval activity recorded in the near vicinity, but the site of Bathwick Mill lies just to the north west of the site.

1.5.2 Early mapping indicates that until 1790 the majority of the recreation ground was a large meadow known as West Mead, with a number of smaller strip fields to the south. The north western part of the site became part of a pleasure grounds known as Spring Gardens in the 1730s, which closed in 1798. During the late 18th century much of the surrounding area was developed, with the recreation ground being split into small parcels and used as kitchen gardens during the early 19th century. The north west corner also contained a timber and stone yard, which was then used as an iron and brass works until the late 19th century. The land has been used as a Recreation Ground since 1894, this included groundworks to make the site suitable for the playing of sports such as rugby and cricket. The West Stand of the rugby stadium was built in 1933 but was bomb damaged in 1942. An archaeological evaluation in 1993, carried out prior to construction of the new south stand, did not locate any archaeological features.

1.6 Geology and soils

1.6.1 The underlying solid geology across the site is from the Charmouth Mudstone Formation with overlying alluvial deposits of clay, silt, sand and gravel (BGS, 2017).

1.6.2 The overlying soil across the survey area is unmapped due to the urban location (Soil Survey of England and Wales, 1983).

1.6.3 Magnetometry survey carried out across similar soils has produced variable results as alluvial soils can have poor magnetic contrast and archaeology can be deeply buried. However, archaeology that is not masked by the overlying alluvium, and where long term occupation or industrial activity has taken place, may be associated with good magnetic contrast. Modern landscaping and ground make-up can also obscure weaker anomalies. The underlying geology and soils are, therefore, considered acceptable for magnetic survey.

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).

2.2 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 manifests 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.

2.3 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 The minimally processed data are collected between limits of ±10000nT and clipped for display at ±20nT (Fig 02), ±50nT (Fig 03) and ±100nT with values over 85nT highlighted in red and below -85nT highlighted in blue (Fig 04). Data are interpolated to a resolution of effectively 0.5m between tracks and

0.15m along each survey track.

2.3.4 Additional data processing has been carried out in the form of high pass filtering (Fig 05). This effectively removes low frequency variation along a traverse that has been caused by large magnetic bodies or rapid temperature change. Data treated to additional processing has been compared to unprocessed data to ensure that no significant anomalies have been removed.

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

2.3.6 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 are considered by the manufacturer to be data that are 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 the very high density of data collection.

2.3.7 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.

2.3.8 An abstraction and interpretation is 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. Appendix E sets out CAD layer names with colour and graphic content for each interpretation category, see 3.3.

2.3.9 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.

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

3 RESULTS

3.1 General assessment of survey results

3.1.1 The detailed magnetic survey was carried out over a total of six separate land parcels covering approximately 3ha and comprising of the rugby pitch in the

west and the Recreation Ground and three croquet lawns in the east, together with a fourth lawn or court, just to the south.

3.1.2 Magnetic anomalies located can be generally classified as positive and negative anomalies of an uncertain origin, anomalies associated with land management, areas of magnetic disturbance and strong discrete dipolar anomalies relating to ferrous objects.

3.1.3 Anomalies located within each survey area have been numbered and are described in 3.4 below.

3.2 Statement of data quality and factors influencing the interpretation of anomalies

3.2.1 Data are considered representative of the magnetic anomalies present within the site. Severe magnetic disturbance is associated with large above ground steel objects and has the potential to obscure or confuse other weaker anomalies. The disturbance is most severe over the south eastern part of the rugby pitch. High pass filtering was carried in order to suppress the effects of the magnetic disturbance and clarify weaker anomalies. Both processed and unprocessed data are analysed to ensure no significant anomalies have been removed or altered.

3.2.2 Parts of the site are likely to have been subject to some degree of landscaping which has the potential to truncate or bury features. Those areas identified with some degree of landscaping are the croquet lawns in the eastern part of the site and possibly the northern side of the recreation ground; however, other parts of the site may also have been subject to alteration.

3.2.3 The results demonstrate numerous anomalies probably relating to different phases of activity across the site. It may not be possible to separate anomalies of more ancient origin from those that are comparatively recent. Magnetic contrast is generally good and soil magnetic susceptibility may have been enhanced by the close proximity of the site to the city, due to the spreading of waste material to assist horticultural activity.

3.3 Data interpretation

3.3.1 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 an uncertain origin	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. Morphology may be unclear or

	uncharacteristic and there may be a lack of additional supporting information. 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 relating to land management	Anomalies are mainly linear and may be indicative of the magnetically enhanced fill of cut features (i.e. ditches). The anomalies may be long and/or form rectilinear elements and they may relate to topographic features or be visible on early mapping. Associated agricultural anomalies (e.g. headlands, plough marks and former ridge and furrow) may support the interpretation. Land drains can appear in a classic herringbone pattern of interconnected multiple dipolar linear anomalies, or as parallel linear anomalies.
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. 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. Buried services may produce characteristic multiple dipolar anomalies dependant upon their construction.

Table 1: List and description of interpretation categories

3.4 List of anomalies - rugby pitch

Area centred on OS NGR 375370 164855, see Figs 03 – 06.

Anomalies with an uncertain origin

(1) - Positive rectilinear anomalies that do not appear to relate to mapped boundary features but which do appear to be directly associated with anomalies (6). The response to the anomaly is very strong, peaking at over 130nT in the western part, with the smaller, eastern rectilinear anomaly having a lower, but still moderately enhanced response of c30nT. The strength of the western anomaly indicates that it is associated with intense burning. The location of the former Victorian Iron and Brass works just to the west may indicate that associated highly magnetic waste material has been incorporated into the features.

(2) - Just to the east of anomalies (1) are a number of irregularly shaped and curvilinear positive responses. It is not clear if they are associated with anomalies (1), and although their origin is uncertain, it is possible that they relate to features associated with the former Spring Gardens (1730s-1798), the southern edge of which extended into this part of the site.

(3) - A positive response, surrounded by negative linear anomalies could relate to a former structure. Early mapping does not indicate a structure within this position, although such a structure, possibly relating to a cricket pavilion, with similar 3-4m dimensions is mapped in 1886, 9m to the south west. It is possible that the anomaly is associated with the former kitchen gardens that existed across much of the site in the late 18th and early 19th centuries.

(4) - The survey area contains a small number of positive linear anomalies with no coherent form or pattern. They do not appear to relate to former boundary features or kitchen garden plots due to their orientation, and it is possible that some may relate to land drainage.

(5) - A positive linear anomaly extends across the entire length of the survey area. It is not clear if it relates to a former boundary feature as one is not mapped in this position, or if it is associated with land drainage as other linear anomalies appear to extend towards it forming a possible herringbone pattern.

Anomalies associated with land management

(6) - Two parallel positive linear anomalies are located in the north western corner of the survey area and relate to formerly mapped boundary features. These once bounded the plot of land associated with the former timber/stone yard and Victoria Iron and Brass Works that were located at the south western corner of the former Spring Gardens site during the 1880s.

(7) - A positive linear anomaly that can also be seen to continue into the Recreation Ground to the east (28) may relate to the former southern boundary of the Spring Gardens complex.

(8) - Two parallel linear anomalies appear to flank a former trackway. The southernmost linear is mapped from 1818 until at least the late 1880s, and the northernmost one also appears in J. Barrett's New and Correct Plan of the City of Bath in 1818, which shows a number of kitchen plots divided by linear tracks.

(9) - A number of negative linear anomalies oriented parallel with the width of the rugby pitch are likely to be associated with land drainage. Another appears to cross them, but may also be associated with land drainage.

Anomalies with a modern origin

(10) - Magnetic disturbance at the margins of the survey area is a response to steel within the nearby stands and goal posts.

3.5 List of anomalies - Recreation Ground and croquet lawns

Area centred on OS NGR 375496 164908, see Figs 03 – 06.

Anomalies with an uncertain origin

(11) - A positive linear anomaly extends through much of the Recreation Ground from south to north. It is not parallel with the predominate north west to south east trend of the former boundary features (25); however, it does appear in the position of and at the same orientation as a planned new road boundary feature, indicated on proposed plans for the layout of the city from 1777 to 1818. However, there has never been an indication that any of the proposed new road layout was ever carried out. The anomaly also corresponds with a linear depression in the ground surface. This could indicate that it relates to a more modern feature, such as a service. However, there does seem to be an association with anomalies (12) to (14) and they all appear to have been truncated by the 18th and 19th century land boundaries which would indicate that this pre-dates those boundaries.

(12 - 14) - Positive linear anomaly (12) appears to join anomaly (11) at an acute angle. This type of response could indicate former land management in the form of water meadows, but there is no record of this taking place within the site. Anomaly (13) relates to rectilinear anomalies extending eastwards from the northern extent of anomaly (12) and anomaly (14) extends to the north west. These anomalies appear to have been truncated by linear boundary ditches dating to the late 18th and early 19th centuries.

(15) - Located in the south eastern corner of the site are a number of positive anomalies. They are not generally parallel with the main trend of the later boundary features, although they may be associated with anomalies (12) and (13). They appear to have been truncated by parallel anomalies (25) and this indicates that they may relate to cut features that pre-date the late 18th century. Prior to this the site was mapped as a single open field.

(16) - The northernmost croquet lawn contains a small number of short positive linear anomalies. They may be associated with the late 18th century kitchen plots.

(17) - Several positive linear and discrete anomalies are located in the northern part of the survey area. They may be associated with the late 18th century kitchen plots.

(18) - A number of parallel, positive linear anomalies can be seen towards the northern part of the survey area. They could relate to the former kitchen gardens, although this type of response is often associated with former ridge and furrow.

(19) - Positive linear and curvilinear anomalies located in the south western part of the Recreation Ground. They may relate to cut features, although modern ground disturbance is also possible.

(20 & 21) - Two groups of positive and negative anomalies are located in the

southern part of the Recreation Ground. They appear as a series of 3m wide alternating positive and negative anomalies with one series oriented south west to north east (20) and with overall dimensions of 16.5m by 17.5m and another north west to south east (21), with overall dimensions of 19.5m by 14m. They may be associated with the former kitchen plots, but a more recent origin is also possible.

(22) - A group of positive and negative anomalies that are located on a low square mound at the western edge of the Recreation Ground. This area also contains a number of parch marks on recent aerial photographs (Google Earth, 2018). Several small discrete dipolar anomalies similar to those caused by steel tent pegs are also present. It seems likely that this is a relatively modern feature, associated with the sports ground. It is adjacent to, parallel with and has similar dimensions to the existing cricket square located 12.5m to the east and although at the western edge of the current Recreation Ground, it is centrally placed in terms of the whole site.

(23) – A broad, negative, rectilinear anomaly that appears to bound anomalies (22) and may be associated.

(24) - A broad, negative linear anomaly extends across the north western part of the Recreation Ground and appears to continue into the rugby pitch area. It has truncated a number of earlier boundary features and kitchen plot features. Along its length are a series of large, strong, discrete, dipolar anomalies which could relate to steel/iron joints or collars or buried inspection chambers associated with a sewer pipe.

Anomalies associated with land management

(25) - Parallel, positive linear anomalies relating to boundary features flanking a trackway that extends south eastwards. In the north, another former trackway leads south westwards from it, with the features bounding large parcels of land in which the late 18th century kitchen garden plots were located.

(26) - A number of positive linear anomalies demonstrate some complexity that relates to various phases of boundary features. They continue westwards as anomaly (8) within the rugby pitch.

(27) - The northern part of the survey area contains a number of positive linear anomalies that relate to smaller boundary features associated with the late 18th century kitchen garden plots.

(28) - An inverted T shaped feature is a continuation of anomaly (7) within the rugby pitch and may relate to the south eastern corner of the former 18th century Spring Gardens, with a continuation to the east.

(29) - Situated in the south eastern part of the survey area are a number of positive linear anomalies that relate to phases of boundary features dating to the late 18th and 19th centuries.

(30 & 31) - Negative linear anomalies extending across the Recreation Ground

have truncated earlier features and relate to land drainage. A number of similar anomalies can be seen within the croquet lawns.

Anomalies with a modern origin

(32) - The Recreation Ground and rugby pitch both contain numerous strong, discrete, dipolar responses. They are widespread, but also occur in distinct zones and clusters within the Recreation Ground, such as within the confines of anomalies (22) & (23). They are likely to be associated with activities related to the uses within the sports field, such as former events with marquees etc.

(33) - Two lines of strong, discrete, dipolar responses are located within the northern part of the Recreation Ground. They are parallel, with each anomaly approximately 5m apart and the two lines of anomalies 32m. Although this type of response can relate to former fence posts, such features have not been mapped. It is possible that they relate to some event or activity associated with the sports field.

4 CONCLUSION

4.1.1 The geophysical survey has located numerous positive linear and rectilinear anomalies relating to former land boundaries. Many are associated with small land parcels used as kitchen gardens in the late 18th and early 19th centuries. There are a number of parallel linear anomalies that bound former trackways associated with this period of use. Several of the boundary features demonstrate evidence for phases of re-cuts, and several were mapped until the late 19th century. In the north western part of the rugby pitch are a number of positive linear and curvilinear anomalies that could relate to former features associated with the 18th century Spring Gardens.

4.1.2 A number of other positive linear, rectilinear and curvilinear anomalies have also been located within the site, and these do not conform to the general north west to south east and south west to north east orientation of the formerly mapped boundary features. They do appear ditch-like and also they appear to have been truncated by the 18th and 19th century boundary features, indicating that they are likely to pre-date them.

4.1.3 Evidence for modern land use, in the form of land drainage and numerous discrete buried ferrous objects, has also been located.

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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 – 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. It has been found that clipping data to ranges between ±5nT and ±3nT often improves the appearance of features associated with archaeology. Different ranges are applied to data in order to determine the most suitable for anomaly abstraction and display.

Zero (destripe) 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 differences between the baseline value of gradiometer sensors.

High Pass Filtering

A mathematical process used to remove low frequency anomalies relating to survey tracks, modern agricultural features and other large magnetic bodies within or adjacent to survey areas.

Low Pass Filtering

A mathematical process used to remove high frequency anomalies relating to uneven ground, vibration, etc.

Appendix C – survey and data information

Filename: J767-mag-proc.xcp
Description: Imported as Composite from: J767-mag.asc
Instrument Type: Sensys DLMGPS
Units: nT
UTM Zone: 30U
Survey corner coordinates (X/Y):OSGB36
Northwest corner: 375312.896460179, 164991.383230424 m
Southeast corner: 375569.996460179, 164793.683230424 m
Collection Method: Randomised
Sensors: 5
Dummy Value: 32702
Source GPS Points: 732600
Dimensions
Composite Size (readings): 1714 x 1318
Survey Size (meters): 257 m x 198 m
Grid Size: 257 m x 198 m
X Interval: 0.15 m
Y Interval: 0.15 m

Clipped at ±100nT
Stats
Max: 110.50
Min: -110.00
Std Dev: 24.46
Mean: 0.33
Median: 0.01
Composite Area: 5.0829 ha
Surveyed Area: 2.8996 ha
GPS based Proce4
1 Base Layer.
2 Unit Conversion Layer (Lat/Long to OSGB36).
3 DeStripe Median Traverse:
4 Clip from -100.00 to 100.00 nT

Clipped at ±50nT

Stats
Max: 55.25
Min: -55.00
Std Dev: 18.20
Mean: 0.12
Median: 0.13
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

Clipped at ±200nT
Stats
Max: 22.10
Min: -22.00
Std Dev: 11.26
Mean: -0.03
Median: 0.17
GPS based Proce4
1 Base Layer.
2 Unit Conversion Layer (Lat/Long to OSGB36).
3 DeStripe Median Traverse:
4 Clip from -20.00 to 20.00 nT

High pass filtered

Stats
Max: 55.25
Min: -55.00
Std Dev: 17.11
Mean: 0.23
Median: 0.06
GPS based Proce6
1 Base Layer.
2 Unit Conversion Layer (Lat/Long to OSGB36).
3 DeStripe Median Traverse:
4 Clip from -100.00 to 100.00 nT
5 High pass Uniform (median) filter: Window dia: 300
6 Clip from -50.00 to 50.00 nT

Appendix D – 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 PDF copy will be supplied to the B&NES Historic Environment Record. The report will also be uploaded to the Online AccesS to the Index of archaeological investigationS (OASIS).

Archive contents:

File type	Naming scheme	Description
Data	J767-mag-**[area number/name]**.asc J767-mag-**[area number/name]**.xcp J767-mag-**[area number/name]**-proc.xcp	Raw data as ASCII CSV TerraSurveyor raw data TerraSurveyor minimally processed data
Graphics	J767-mag-**[area number/name]**-proc.tif	Image in TIF format
Drawing	J767-**[version number]**.dwg	CAD file in 2010 dwg format
Report	J767 report.odt	Report text in Open Office odt format

Table 2: Archive metadata

Appendix E – 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 an uncertain origin			
AS-ABST MAG POS LINEAR UNCERTAIN		255,127,0	Line, polyline or polygon (solid)
AS-ABST MAG NEG LINEAR UNCERTAIN		Blue 0,0,255	Line, polyline or polygon (solid)
AS-ABST MAG POS DISCRETE UNCERTAIN		255,127,0	Solid donut, point or polygon (solid)
AS-ABST MAG POS UNCERTAIN		255,127,0	Polygon (cross hatched ANSI37)
AS-ABST MAG NEG UNCERTAIN		Blue 0,0,255	Polygon (cross hatched ANSI37)
Anomalies relating to land management			
AS-ABST MAG BOUNDARY		127,0,0	Line, polyline or polygon (solid or cross hatched ANSI37)
AS-ABST MAG LAND DRAIN		Cyan 0,255,255	Line or polyline
Anomalies associated with magnetic debris			
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

Appendix F – copyright and intellectual property

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Archaeological Surveys Ltd

Geophysical Survey
The Recreation Ground
Bath
Bath & North East Somerset

Map of survey area

● Survey location

Site centred on OS NGR
ST 75450 64905

SCALE 1:25 000

0m 500m 1000m

SCALE TRUE AT A3

DRAWN BY	CHECKED BY	
KTD	DJS	FIG 01

Archaeological Surveys Ltd

Geophysical Survey
The Recreation Ground
Bath
Bath & North East Somerset

Referencing information

Referencing grid to OSGB36 datum at 50m intervals

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

● 375350 164850

SCALE 1:1250

0m 10 20 30 40 50m

SCALE TRUE AT A3

DRAWN BY	CHECKED BY	
KTD	DJS	FIG 02

Recreation ground

Croquet lawns

Rugby pitch

Goalposts

Goalposts

N

Archaeological Surveys Ltd

Geophysical Survey
The Recreation Ground
Bath
Bath & North East Somerset

Greyscale plot of minimally processed magnetometer data clipped at ±50nT

+50nT

-50nT +50nT

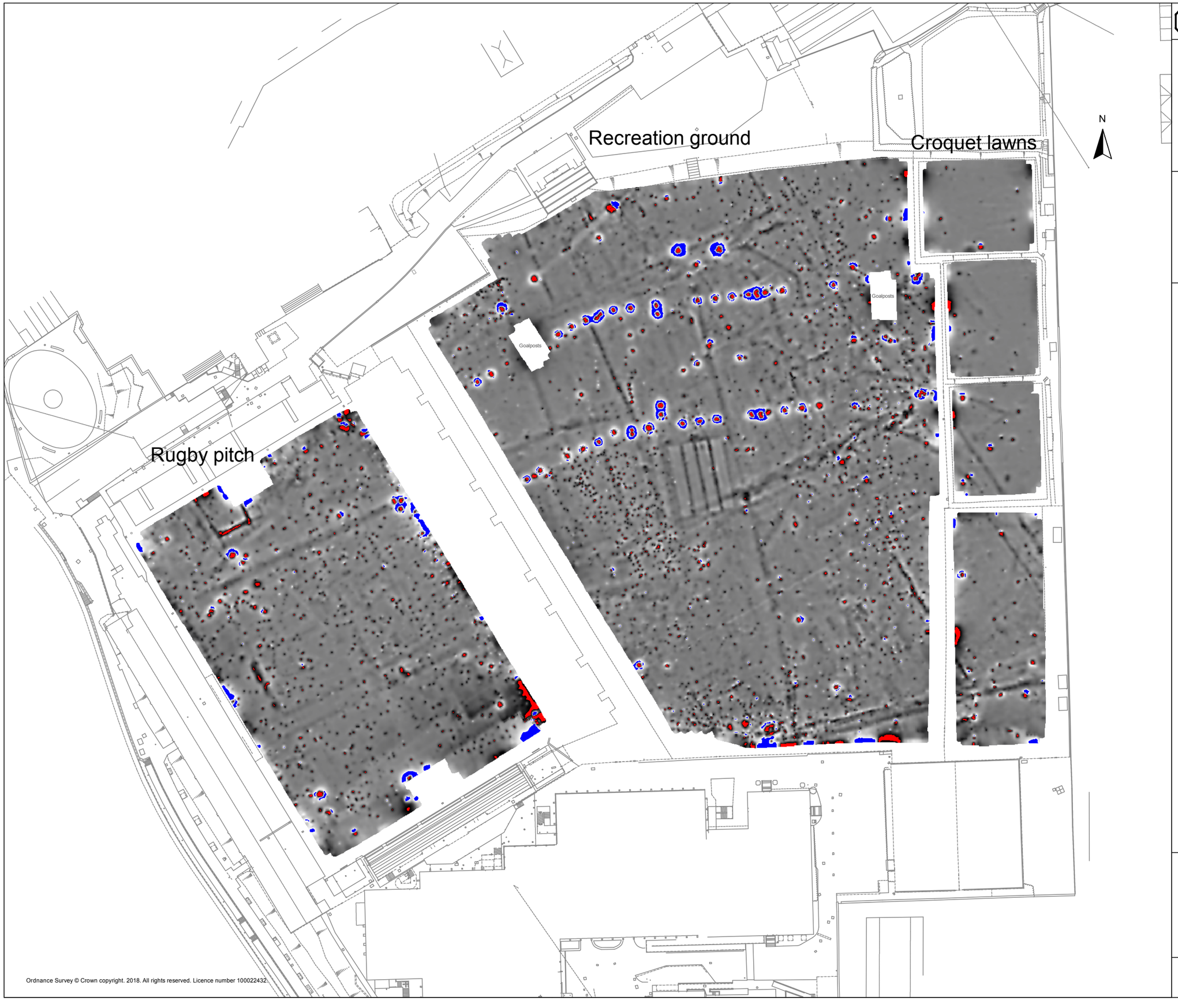
-50nT

SCALE 1:1000

0m 10 20 30 40 50m

SCALE TRUE AT A3

DRAWN BY	CHECKED BY	
KTD	DJS	FIG 03



Archaeological Surveys Ltd

Geophysical Survey
The Recreation Ground
Bath
Bath & North East Somerset

Greyscale plot of minimally processed magnetometer data clipped at ±100nT

-100nT +100nT

+100nT

-100nT

SCALE 1:1000

0m 10 20 30 40 50m

SCALE TRUE AT A3

DRAWN BY	CHECKED BY	
KTD	DJS	FIG 04

Recreation ground

Croquet lawns

Rugby pitch

Goalposts

Goalposts

N

Archaeological Surveys Ltd

Geophysical Survey
The Recreation Ground
Bath
Bath & North East Somerset

Greyscale plot of high pass filtered magnetometer data

+50nT

-50nT +50nT -50nT

SCALE 1:1000

0m 10 20 30 40 50m

SCALE TRUE AT A3

DRAWN BY	CHECKED BY	
KTD	DJS	FIG 05

Archaeological Surveys Ltd

Geophysical Survey
The Recreation Ground
Bath
Bath & North East Somerset

Abstraction and interpretation of magnetic anomalies

Recreation ground

Croquet lawns

Rugby pitch

Goalposts

Goalposts

N

- Positive linear anomaly - possible ditch-like feature
- Negative linear anomaly - material of low magnetic susceptibility
- Positive linear anomaly - former boundary feature
- Linear anomaly - land drain / service
- Linear anomaly - associated with cricket pitch
- Discrete positive response - possible pit-like feature
- Positive anomaly - magnetically enhanced material
- Negative anomaly - material of low magnetic susceptibility
- Magnetic disturbance from ferrous material
- Strong dipolar anomaly - ferrous object

SCALE 1:1000

0m 10 20 30 40 50m

SCALE TRUE AT A3

DRAWN BY	CHECKED BY	
KTD	DJS	FIG 06