Community Archaeology Geophysics Group

Geophysical surveys at Puddles, Durobrivae, Cambridgeshire, 2024

CAGG Report 2024/5

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on behalf of the
Community Archaeology Geophysics Group

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1 Background to the survey

The Roman "small town" of Durobrivae (Water Newton) lies just to the west of the city of Peterborough in the UK. It is one of the larger "small towns" with 21ha lying within the town walls, and extensive extramural settlements. The town straddles Ermine Street, a major Roman road which was built on a raised agger in this area. The town was built on a sand and gravel terrace on the south side of the River Nene. Durobrivae was first noted in the literature in Henry of Huntingdon's *Historia Anglorum* of 1154 (translation published by Greenway 2012) which Camden referred to in his *Brittania* of 1607. The town name has also been found on two mortaria in Peterborough museum that provide evidence of the name and status of Durobrivae. One locally produced mortarium has the inscription 'Sennianus (the potter) of Durobrivae fired this' (Upex 2008).

Most of what we know about the town within the walls is derived from early 18th and 19th century excavations or from aerial photography. The first systematic excavations took place in the 1820s, led by Edmund Tyrell Artis, an antiquarian who was also the house steward to Earl Fitzwilliam. Having access to the Earl's land, he carried out archaeological investigations throughout his working life. Artis recorded in detailed drawings the excavations he undertook and published a book of the drawings and maps in 1828, *The Durobrivae of Antoninus*. Subsequent excavations, largely outside the town walls, were carried out between 1956–8 by Ernest Greenfeld ahead of widening the A1 and in 1957–8 by the newly set up Water Newton Research Committee prior to work on the Water Newton and Sibson bypass. The best understanding of the town however comes from 20th century aerial photographs from which much of the town plan was drawn up (Upex 2008).

The *Community Archaeology Geophysics Group* (CAGG) first became involved in the site in October 2016 when it was asked to assess which of the main geophysical survey techniques used in archaeology would give good results at Durobrivae. The answer was all of them (Lockyear & Halliwell 2017)! In 2017 we did a little more work, extending all three surveys and in particular surveying the 'mound' in the town. CAGG's surveys were followed up by a comprehensive magnetometry survey of the inside of the town by Archaeological Services Durham University in 2018 (ASDU 2018) and excavation in 2019 (Guest *et al.* 2019).

In 2022 the group tested out its new Sensys magnetometer by surveying Boat Field which lies just outside the SE gate of the town,[1] and in early 2023 we surveyed three transects in fields to the south of the A1 at the request of Historic England.[2]

Ever since we started working at Durobrivae, our eyes have been drawn to the field to the south of the town which is entertainingly called Puddles. It contains evidence not only of the Roman extramural suburb, but also of a series of prehistoric features (Figs. 1–3). In 2024 we were able to gain permission from the landowner and Historic England to survey this field. Over the week 16th–21st September 2024 we undertook magnetometry, magnetic susceptibility and Earth Resistance surveys.

The site lies on superficial deposits of 'River Terrace Sand and Gravel 1'[3] which overlies mudstones of the Rutland formation.[4] The topography of Puddles is essentially flat (Fig. 4). The land rises to the south where there is excellent preservation of ridge-and-furrow (Fig. 5).

[1] `https://hertsgeosurvey.wordpress.com/2022/12/02/messing-about-in-boats/`
[2] `https://hertsgeosurvey.wordpress.com/2023/03/08/cherry-glebe-and-sands/`
[3] `https://webapps.bgs.ac.uk/lexicon/lexicon.cfm?pub=RTD1`
[4] `https://webapps.bgs.ac.uk/lexicon/lexicon.cfm?pub=RLD`

Figure 1: Aerial photograph of Puddles. Image © Stephen Upex, reproduced with permission.

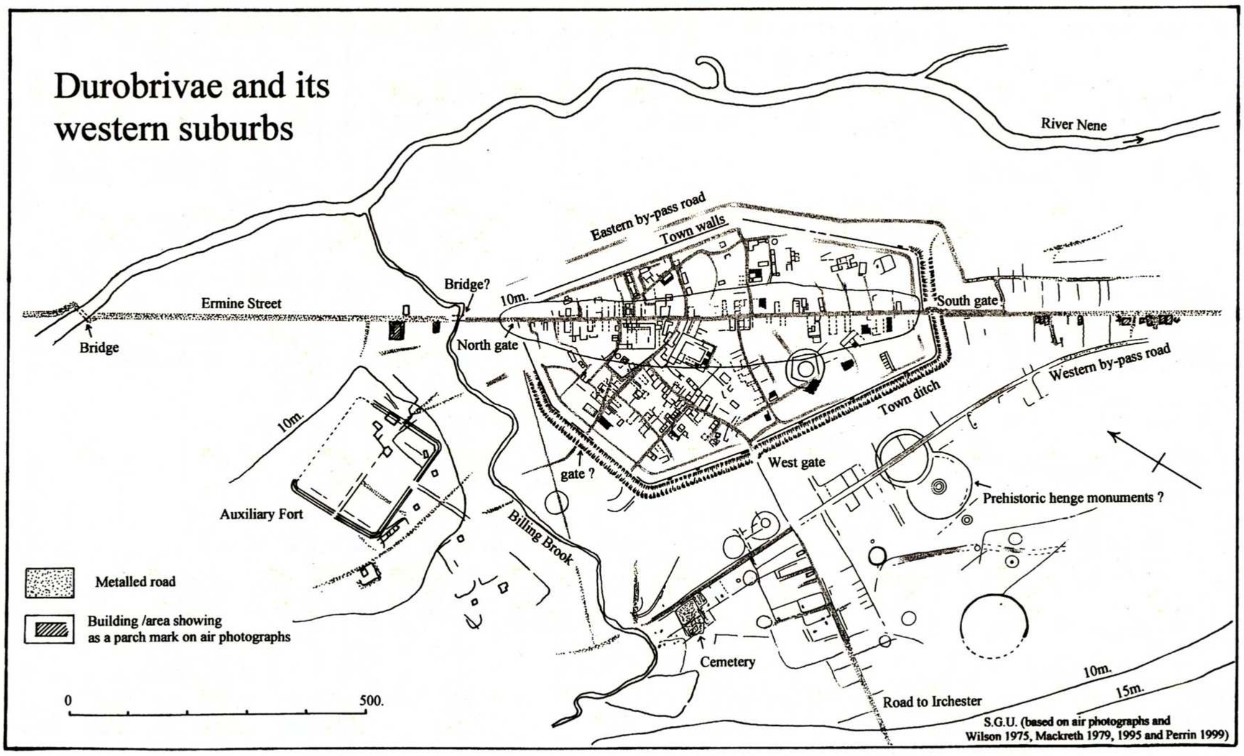

Figure 2: Plan or the archaeology around Durobrivae. Figure © Stephen Upex, reproduced with permission.

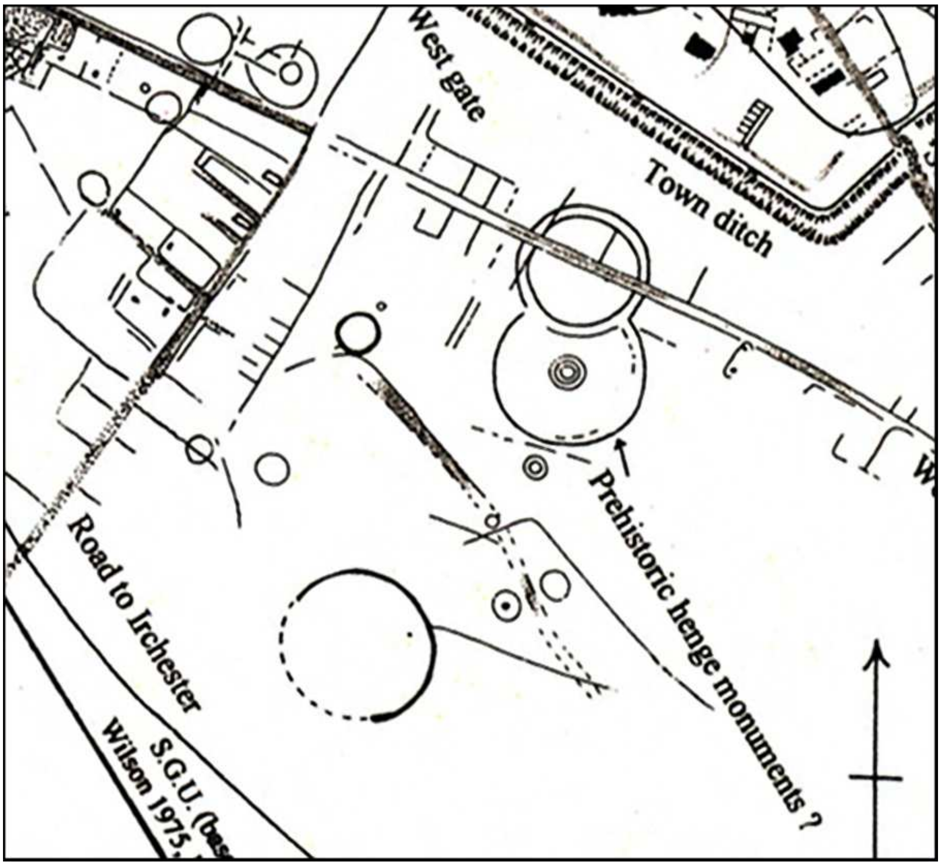

Figure 3: Detail from the plan or the archaeology around Durobrivae showing the area around Puddles. Figure © Stephen Upex, reproduced with permission.

2 Magnetometry

2.1 Notes on magnetic gradiometry survey and data interpretation

Readers familiar with magnetometry survey may wish to skip this section.

Magnetometers come in two main varieties: gradiometers and total field magnetometers. All surveys undertaken by CAGG used a gradiometer[5] and for the purposes of our reports, the terms 'gradiometer' and 'magnetometer' are treated as synonyms. A 'sensor' (or probe) in a gradiometer system consists of two magnetic sensors, often in a tube fixed vertically, one at either end. The lower sensor measures the planet's magnetic field plus the local field, and the upper sensor measures the planet's field. By subtracting the latter from the former, variations in the Earth's magnetic field are largely eliminated leaving the variation due to the local field to be recorded and analysed.

There are three main types of magnetism which are detected during a magnetometer survey: ferromagnetism which can be subdivided into that due to iron artefacts and that due to thermoremanent magnetism and magnetic susceptibility. Either during the survey, or in post processing, the average background value is set to zero. In the plots presented here, zero is set to a mid-grey value.[6] Magnetic features will have both a positive and a negative value either side of zero which are plotted here as darker and lighter tones of grey respectively. As some features are very strongly magnetic, for example ferrous items, it is necessary to clip the image in order to be able to clearly see the other features. Any value above the clipping limit is plotted black, and anything below it is plotted white.

[5]Bartington Grad 601-2, Foerster Ferex, or Sensys MXPDA.

[6]It is possible to use any colour scheme but in general a simple gray scale is preferred.

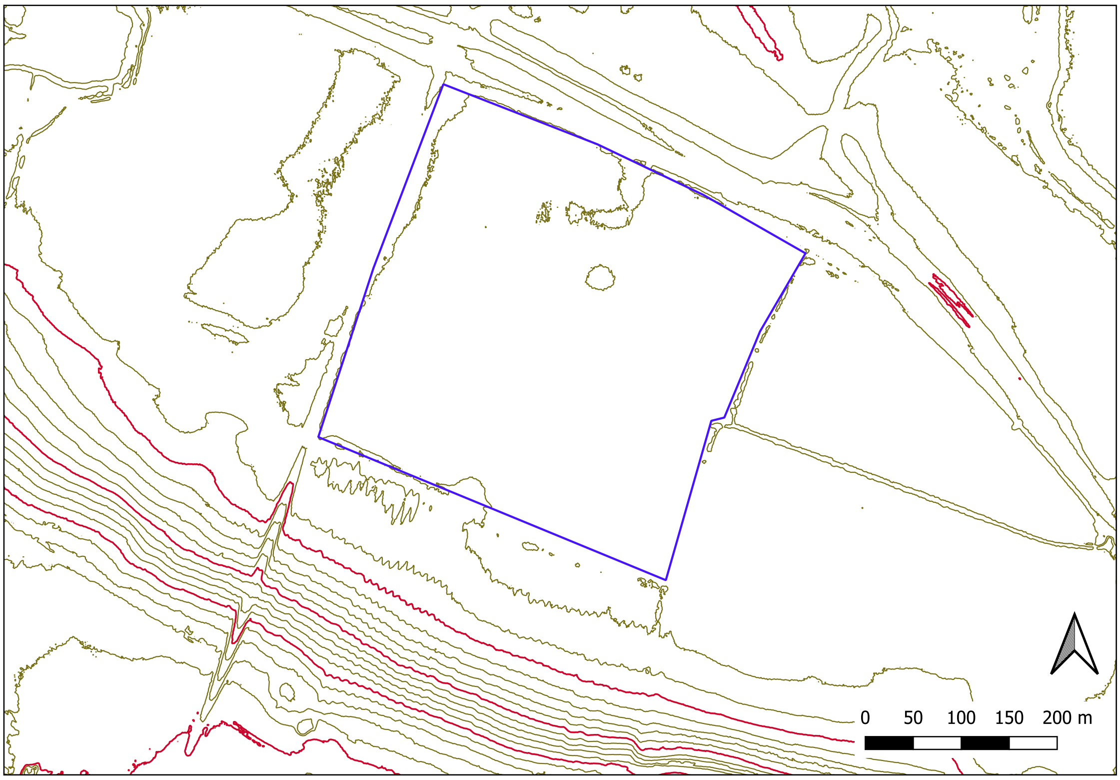

Figure 4: Contour map derived from the lidar data. Contours are at 1m intervals. The blue outline marks the extent of Puddles.

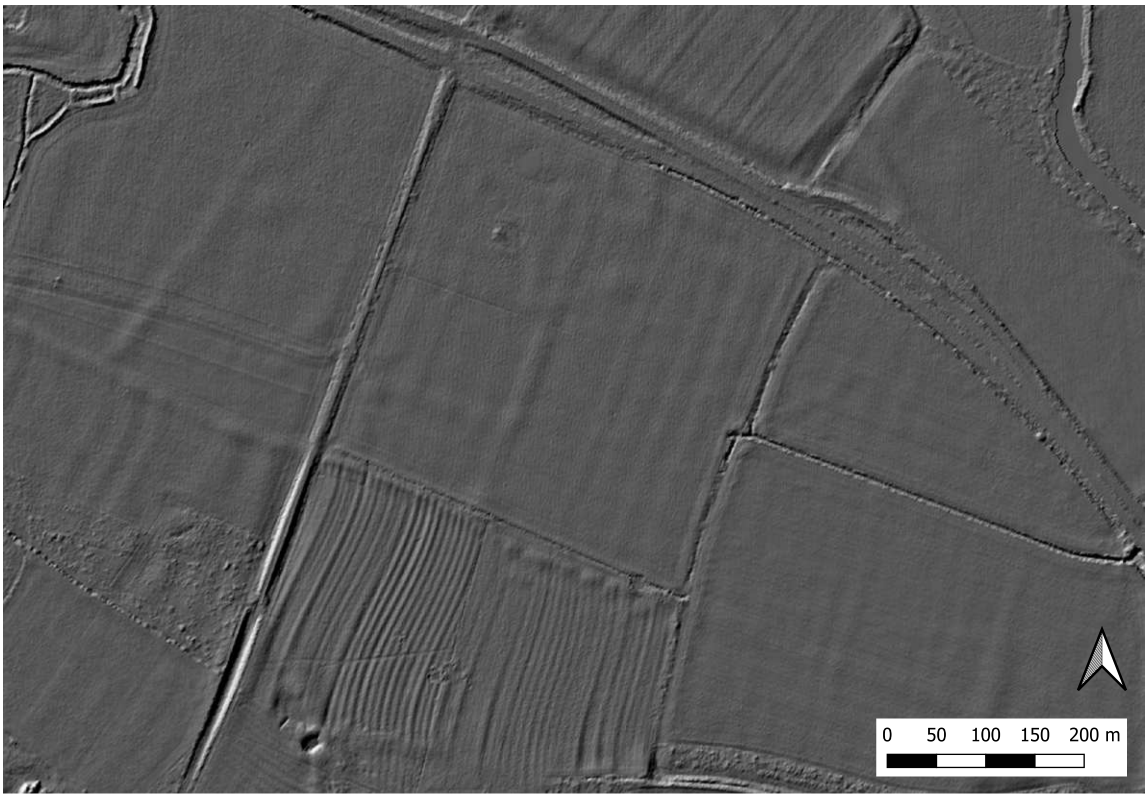

Figure 5: Local relief map from the lidar data. Note the ridge-and-furrow to the south of Puddles, and the small mound in the upper half of the field.

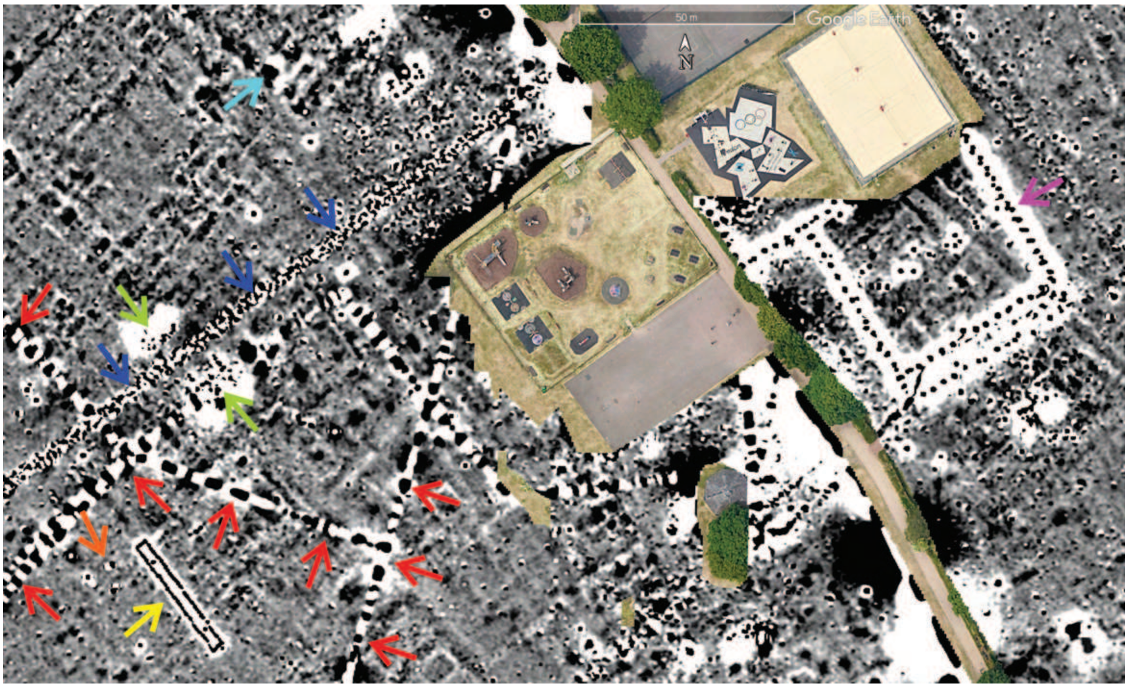

Figure 6: Various ferrous and/or strongly magnetic features in Verulamium Park. Red arrows: ferrous services; blue arrows: asphalt path; green arrows: goal mouths; yellow arrow: steel-reinforced concrete cricket pitch; pink arrow: iron railings cut off at ground level; light blue arrow: large ferrous object (a bin); orange arrow: small ferrous object. NB: not all ferrous features are indicated.

Interpreting magnetic features requires one to consider the following:

1. strength;
2. geometry;
3. clarity;
4. direction.

Ferrous items, such a tractor bolts, old horse shoes and ferrous services have a strong magnetic signature, usually above/below the clipping limits and are thus plotted as black and white features. Normally they have clear, sharp edges, and the negative portion of the magnetic signature can be in any direction, or if the item is vertical (*e.g.,* a ferrous fence post) may surround the positive part. A selection of these types of features are given in Figure 6. A single ferrous object will create a single magnetic feature with a positive and negative element (*e.g.,* Fig. 6, light blue and orange arrows). Groups of ferrous features arranged in lines or other regular patterns may indicate fence lines (*e.g.,* Fig. 6, pink arrow), or even buildings. Linear features such as old services will show as a line with alternating black and white segments (*e.g.,* Fig. 6, red arrows). A larger more complex feature will present as a chaotic mixture of positive and negative readings. These can be, for example, historic period sites or dumps of modern rubbish.

Thermoremanent magnetism occurs when something containing iron oxides — usually in archaeology sediment such as the clay lining to a kiln, or the site of a hearth — is heated-up beyond the Curie point (Gaffney & Gator 2003, p. 37). As the oxides pass the Curie point they loose their magnetic property. On cooling, this is regained and if the oxides are in the presence of a strong magnetic field, they will aline with that field. The actual value of the Curie point depends on the iron oxide involved, for example for haematite it is 675°C. In archaeology the ‘strong magnetic

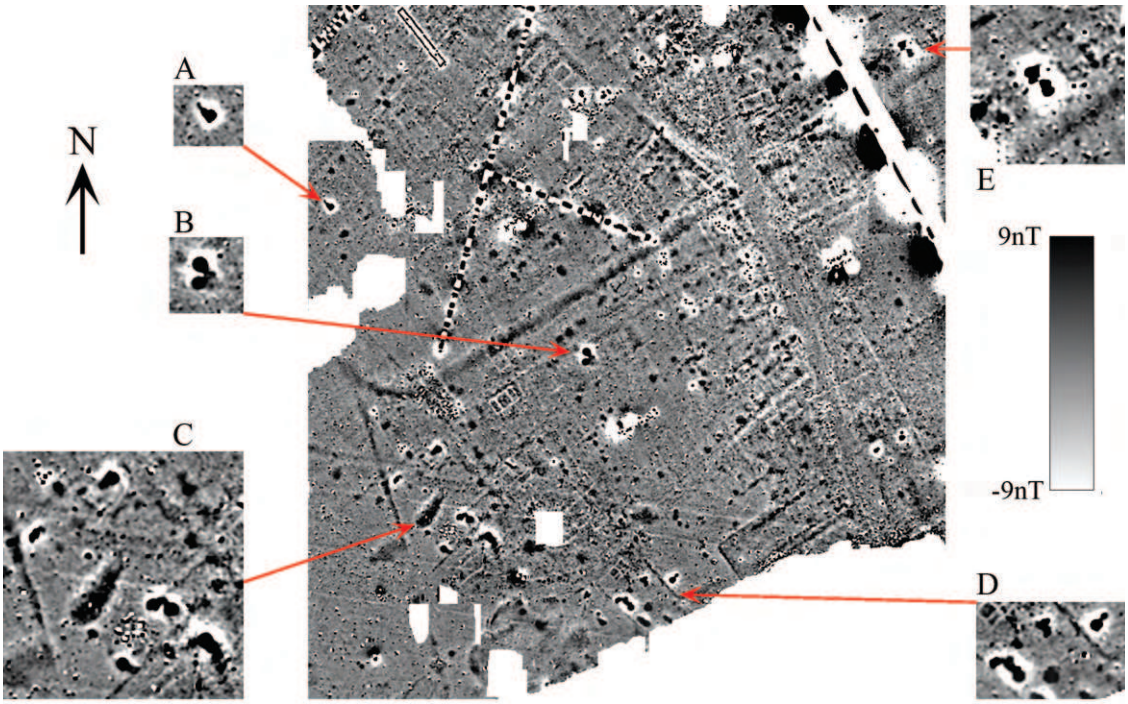

Figure 7: Roman pottery kilns at Verulamium. Features in areas A–D proved to be kilns but that in E had a range of −66nT to +306nT and is almost certainly something ferrous.

field' is that of the Earth. If the fired sediment remains *in situ* it can be used for archaeomagnetic dating. Even if it does not remain *in situ* it can be detected by magnetometry survey. Sediments which have been enhanced by this material can help with the detection of ditches and pits.

Features due to thermoremanent magnetism will have a relatively strong positive and negative value, although the negative value will often be somewhat less than the positive. For example, pottery kilns at Verulamium had negative values > -28nT and maximum positive values in the range 98–107nT (Fig. 7; Lockyear & Shlasko 2017, pp. 30–1).

For a variety of reasons, topsoil is generally slightly more magnetic than subsoil, partly due to soil formation processes which convert less magnetic iron oxides into slightly more magnetic oxides. Human occupation resulting in dumping of organic materials and burning, will also enhance the soils. These weakly magnetic materials are detectable when in the presence of a strong magnetic field. This is known as magnetic susceptibility (Gaffney & Gator 2003, p. 38–9). Again, the Earth provides such a field. Where a cut feature such as a pit or a ditch is filled with such material, it will be subtly more magnetic than the surrounding area. In these circumstances the negative 'pole' can be so weak as to be almost non-existent. Where it can be seen, the negative portion of the magnetic feature will lie to magnetic north. Depending on the nature of the soils and the size of the feature, the nanotesla values may be no more than ± 1nT compared to the background.

Interpreting these features depends on their geometry and clarity. Linear features are likely to be ditches, for example. Well-defined sub-circular features are likely to be pits or even large post holes. Features with less clarity could be something like a tree throw, especially if one edge has greater clarity than the other. Large, more amorphous features could be the result of quarrying. A good working knowledge of likely archaeological features in the area being surveyed can help with the interpretation.

To illustrate the interpretation of magnetometry data we can examine the results for part of the survey undertaken at Kelshall in north Hertfordshire. Figure 8 shows a larger area of the survey after processing and Figure 9 shows a detail with the image clipped at different levels. The feature indicated with a red arrow in Figure 8 can be clearly seen even in the image clipped at ± 20nT.

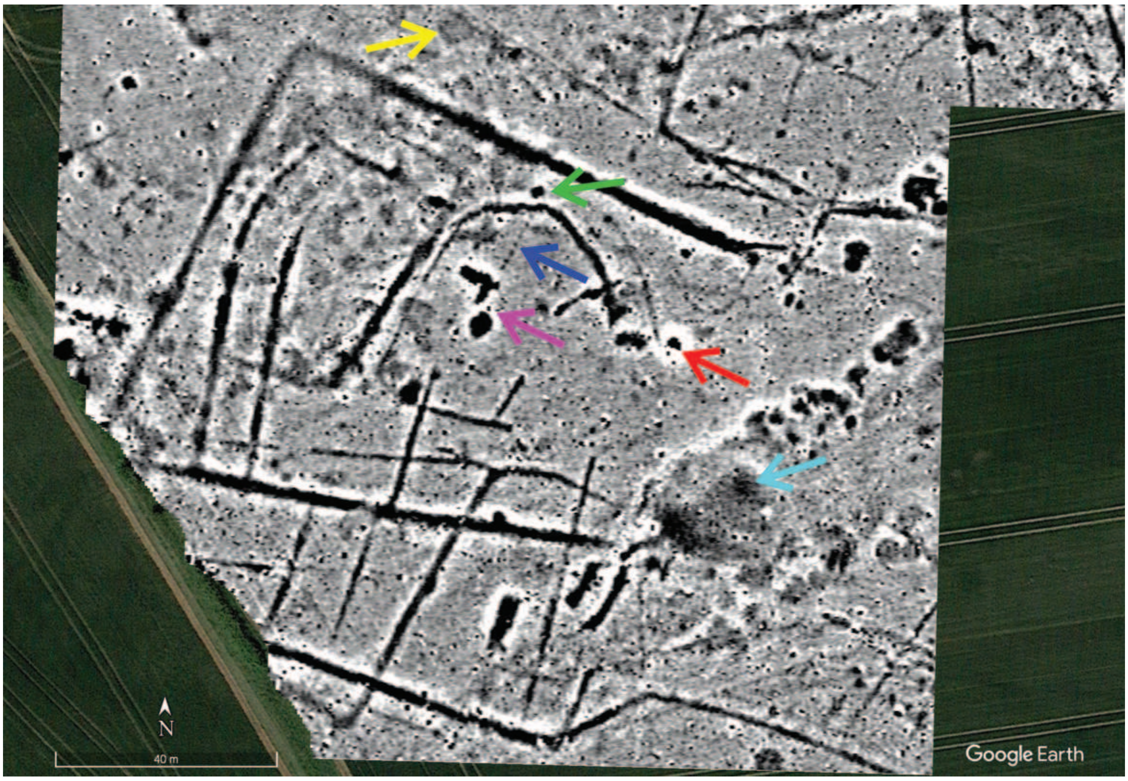

Figure 8: Survey results from Kelshall. Red arrow: large ferrous feature; pink arrow: small ferrous feature; green arrow: probable pit; blue arrow: line of post holes; yellow arrow: possible tree-throw; cyan arrow: probable quarrying.

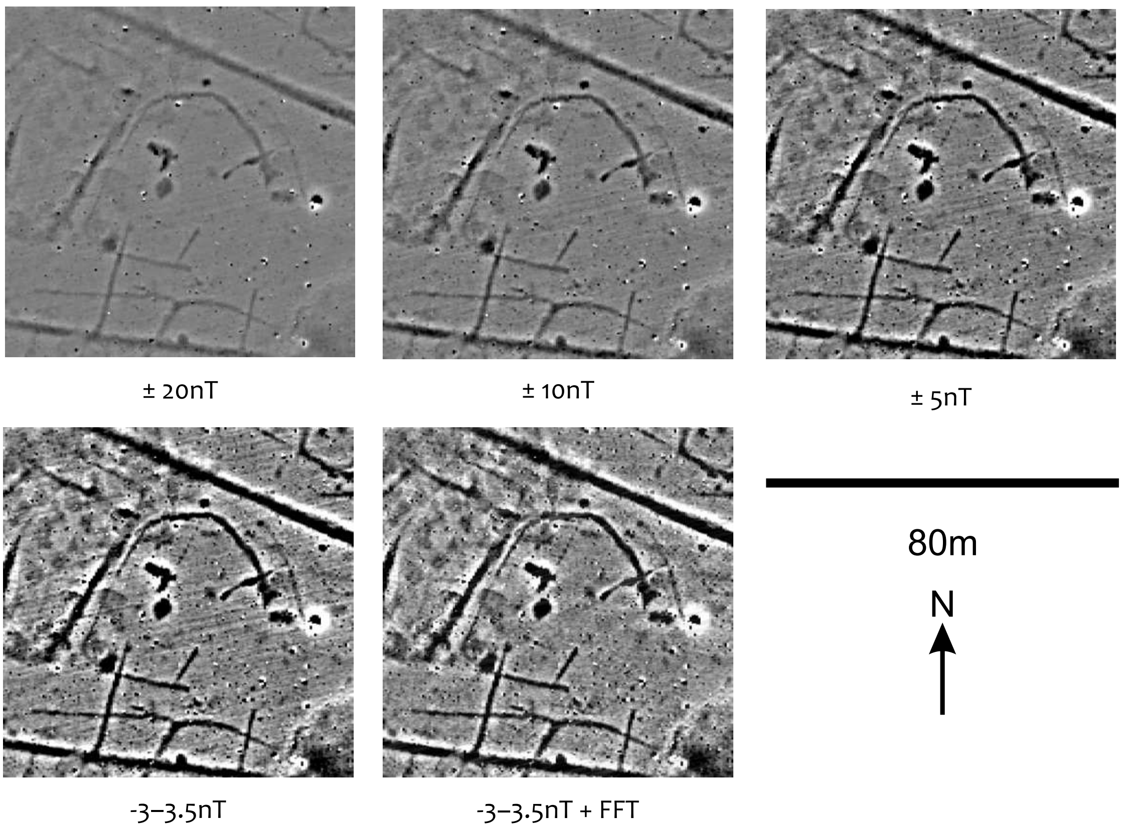

Figure 9: Detail from the survey at Kelshall. Clipping of the image as shown. The FFT helps remove striping caused by cultivation.

Notice that in the ±20nT image the negative portion is to the south of the positive. This is almost certainly something ferrous. The feature indicated by the pink arrow in Figure 8 looks at first like part of the larger features either side. Looking at Figure 9, however, shows that it is much more magnetic than those features and is likely to be something ferrous.

In contrast, the feature that is indicated with green arrow, although visible in the clipped data, has a very weak negative reading. The values go from −5.3nT to +20.7nT suggesting that this is a pit, and probably one that contains some burnt material. The line of 'dots' indicated by the blue arrow are weakly magnetic, not exceeding +3.5nT are probably post holes. In this case, it is the geometry, *i.e.,* the fact they lie in a line, that suggests the interpretation. This illustrates one of the difficulties in interpreting magnetic data: if there was a single post hole, or if they did not form an easily recognisable pattern, it would be very difficult to spot and interpret.

The features indicated by the yellow and cyan arrows illustrate definition. Both are poorly defined although clearly exist in the data. The smaller feature indicated with the yellow arrow maybe a tree throw, the larger indicated by the cyan arrow appears to be part of an area of quarrying.

The interpretation of geophysical data has to acknowledge the problem of equifinality. This simply means that two very different subsurface features may create similar geophysical signatures. All interpretations of geophysical surveys rely on the experience of the analyst, but confirmation of the interpretation can only be obtained by other means such as excavation or coring. It is important to note that such 'ground truthing' is testing the *interpretation*, not the data itself. Stories of mis-interpreted geophysical data are not hard to come by — it is in the nature of the task — but there have been occasions when excavation has missed features detected by survey (Lockyear *et al.* 2018). Not all features are visible to the naked eye.

2.2 CAGG survey methodology

The Sensys MXPDA cart-based gradiometer system consists of five probes. These are typically at 0.5m separation, although 0.25m is an alternative when the targets are small but this drastically reduces the area which can be covered in a day. For this survey, a 0.5m transect spacing was used. Location is recorded via a Carlson dGPS system with a typical accuracy of 0.01m in ideal conditions. The system is controlled by a rugged PC fitted to the handles and the area surveyed is shown on screen.

In order to ensure even coverage two 66m long strings are employed with marks at 2.5m intervals. These are placed on the ground to form two approximately parallel lines usually about 50m apart. Two members of the CAGG team then hold targets, consisting of 2m white plastic pipes with brightly coloured bands of duct tape at one end, on the marks. The person operating the cart positions themselves on one mark and using the GPS pole as a guide, walks to towards the target in as straight a line as possible (Fig. 10). On an open site, the aim is to cover the area evenly minimising overlaps between lines of data.

The Sensys system collects data at 200hz. This is far in excess of what is needed representing about 80 data points per meter at a moderate walking pace. CAGG typically, therefore, downsamples the data to 50hz when exporting the data to a UXO file which can be input to TerraSurveyor.

The Sensys system also does not require the sensors to be zeroed at the start of a survey unlike most other systems. Application of a moving median filter at export to the UXO file negates the need for zeroing. The length of the moving filter, however, can be varied and depends on each individual survey. It will typically be set at somewhere between 10 and 30m. As a result, very short survey lines are generally to be avoided especially when near ferrous items such as fences.

Figure 10: The Sensys magnetometer in use. The target for the return leg can be seen in the background.

3 Earth Resistance survey

3.1 Earth Resistance survey theory

Readers familiar with Earth Resistance survey may wish to skip this section.

Soil will transmit an electric current provided it contains both water and salt. In lateral surveys — the most common use in archaeology —- by measuring the resistance to the flow of the electric current through the soil on a regular grid and then plotting those values, one can detect subsurface features. Commonly, compact, solid features which have low water content will register as high resistance and features which may pool or hold water will register as low resistance. Therefore, features such as roads or walls will normally show as high resistance and features such as ditches will show as low resistance.

In order to take accurate and consistent readings, four probes (electrodes) are required: two are passing the electric current and creating a circuit (the current electrodes), and the other two use a volt meter to take readings (the potential electrodes). The readings are converted to resistance in ohms (Ω). In general, archaeologists are less concerned with the absolute values, as the plotting of values to reveal patterns is the primary aim. In other disciplines the resistance may be converted to resistivity (expressed in Ω/m) as this can provide information regarding the materials.

Figure 11 shows part of the Earth Resistance survey at Verulamium, principally Insula XXXVII. The corridor building, Insula XXXVII building 1 shows very clearly as do sections of other buildings. The two blue arrows indicate the line of Watling Street. This shows as an area of low resistance bounded by two lines of high resistance, most probably due to robbing of the flint. The red arrow indicates the line of Street 26 (Niblett & Thompson 2005) which has not been robbed. The '1955' ditch, which runs parallel to Street 26 approximately 12m to the NW, does not show at all. It is not unusual for cut features to not show clearly in Earth Resistance surveys whereas more 'solid' features like roads and building show more clearly.

Figure 12 shows, however, an exception to this. The ditches show very clearly as low resistance features, the results in agreement with a magnetometer survey. The circular feature in the SE corner is from a medieval post windmill, and the fainter circle just below the middle of the survey

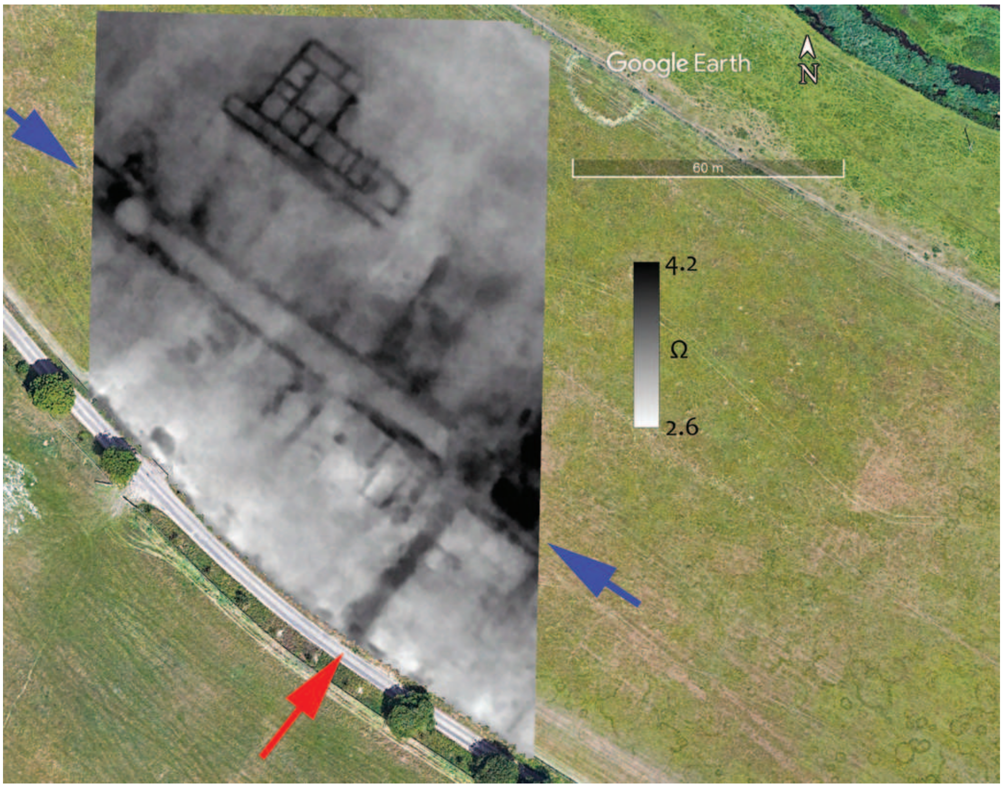

Figure 11: Earth Resistance survey of part of Insula XXXVII at Verulamium.

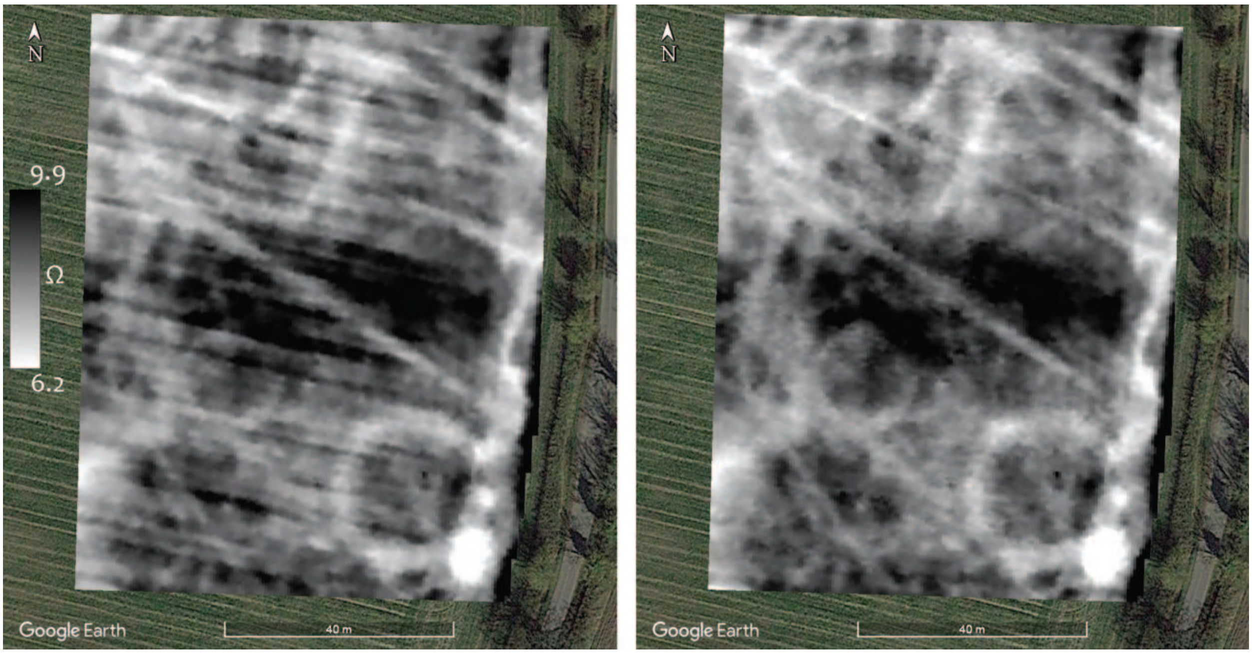

Figure 12: Earth Resistance survey near Little Hadham, Hertfordshire. The image on the left is the processed data before the application of a 2D Fast Fourier Transform. The image on the right has had a 2DFFT filter applied to remove the plough scars.

Figure 13: Earth Resistance survey near Baldock, Hertfordshire.

is possibly a ploughed-out Bronze Age round barrow. The large area of high resistance is a deposit of flint, not uncommon on hilltops in Hertfordshire and the result of glaciation. The strips running roughly NW to SE are plough scars. These have been removed in the right-hand plot using a 2D fast fourier transform in TerraSurveyor. This filter has to be used with care as it can remove archaeology as well as plough scars!

The final example is a site near Baldock in Hertfordshire (Figure 13). A number of linear high resistance features can be seen which match the crop marks seen in the Google Earth background and a magnetometry survey undertaken professionally. This is one of the very rare occasions where ditches — as confirmed by evaluation trenches excavated by MoLA — show has high rather than low resistance features. In this case the chalk subsoil must have retained more moisture than the more clayey fills.

There are a wide variety of possible probe configurations (Gaffney & Gator 2003, pp. 28–34), some of which maintain a fixed spacing between the probes such as the Wenner array, or a square array. If, however, sufficient distance is introduced between each pair of probes, one set can be moved around as the survey progresses while the second set remains fixed at a remote location without impacting the readings. CAGG employs the 'pole-pole' configuration to minimise problems with grid matching caused by the need to move the remote probes (see below for a description).

As Earth Resistance is massively impacted by the moisture content of the soil, the results of a survey will vary according to the recent weather conditions. All geophysical survey methods rely on contrast between the features of interest and the background. In the case of Earth Resistance survey this contrast can vary greatly depending on the ground conditions. A waterlogged site will have no contrast, and is unlikely to detect anything whereas a survey undertaken during a drought will not only be hard to actually undertake, it is also unlikely to give the best results.

3.2 CAGG survey methodology

The set-up is as follows:

1. A 20m grid is laid out using a Leica dGPS. Tapes are laid at the top and bottom of the grid squares, and marked strings between the tapes.

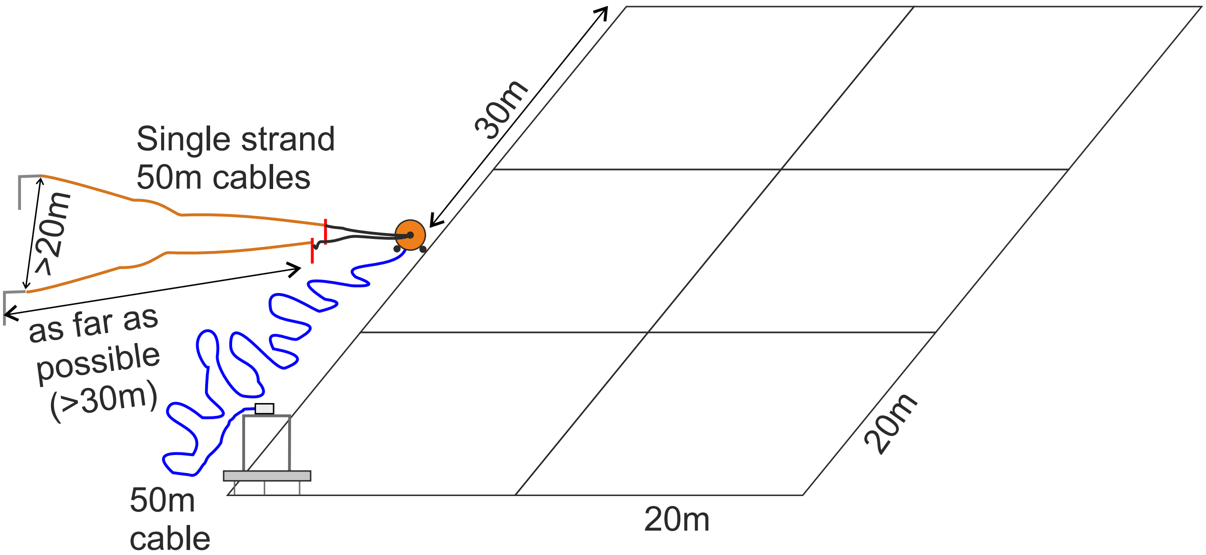

Figure 14: The method for laying out the Earth Resistance surveys undertaken by CAGG.

Figure 15: The Earth Resistance survey underway.

2. A Geoscan RM85 meter is used with a 1m long beam on the frame fitted with 3 probes (Fig. 15). The 1 + 2 program is used which takes three readings at each insertion of the probes. The first uses the outer two probes at 1m separation, and the second and third use the middle probe and one of the outer probes in turn, giving two side-by-side readings with a probe separation of 0.5m. This results in two surveys, the first using the 1m probe spacing at a data density of 0.5m along the transects but 1m between them. The second uses the 0.5m probe spacing with 0.5m along the transects and 0.5m between them. The former is measuring at a depth of approximately 1m, the second at a depth of approximately 0.5m.

3. The meter is attached to the remote probes via a 50m multistrand cable on a reel, and two 50m long single strand cables. By placing the reel in the middle of one side of a block of six grid squares (see Figure 14) there is just sufficient cable to survey the six squares without moving the remote probes. The two single strand cables, also 50m long, are then placed away from the grid so that the remote probes are at least 30m away and 20m apart (in practice the distance is usually nearer 40m away).

4. The strings are stretched between the tapes on the 1m, 3m, 5m... marks and data is collected by going up the left-hand-side of the string and back down the right-hand-side.

5. Incomplete grids, or areas within a grid where it is not possible to take readings (*e.g.,* on a path) use 'dummy' readings to fill the gaps.

6. The data are downloaded each evening to TerraSurveyor for processing.

4 Magnetic Susceptibility

4.1 Background and aims

Readers familiar with magnetic susceptibility survey may want to skip this section.

Gradiometry survey — the most common form of magnetic survey in archaeology — is a purely passive technique. It measures the magnetic field *as is.* Due to factors such as differences between the sensors, drift during the survey due to temperature changes, and so on, some form of 'destriping' is applied, usually a zero mean or zero median traverse. This makes the mean or median value of a traverse zero. The aim is for the archaeological features to show as deviations from the mean/median. Magnetic susceptibility meters, however, create a magnetic field within a loop. Any potentially magnetic material within that field is magnetised. Therefore, whereas gradiometry provides relative values against an average, magnetic susceptibility survey provides an absolute measure of magnetism. Dalan (2006) provides a useful overview of the technique.

The magnetic susceptibility of the soil depends on a variety of factors of which geology and human impact are two important ones. The underlying geology of a site impacts soil formation and different types of soil have different values for magnetic susceptibility. Human impact, through burning, the deposition of organic waste and other factors also enhance the magnetic susceptibility of soils. Detailed study of soils and sediments through magnetic studies can contribute to a detailed understanding of soil and sediment formation although this type of detailed study is rare.

The size of the sample measured depends on the size of the loop being used. The Bartington MS2-D 'field' loop has a diameter of 185mm and measures to a depth of about 100mm, the MS2-K is only 25mm in diameter and measures to about 10mm. For the latter, the readings need to be taken from bare earth such as an excavated surface or section. For the former, bare earth would be ideal but in practice it is mostly used through thin vegetation. The spacing between readings depends on the aims of the survey. At Vulci where it was hoped that the survey would help reveal a feature seen in the gradiometry survey, readings were taken using the MS2-K at 100mm intervals in a grid over the surface in an excavated trench. The readings were repeated after each spit was

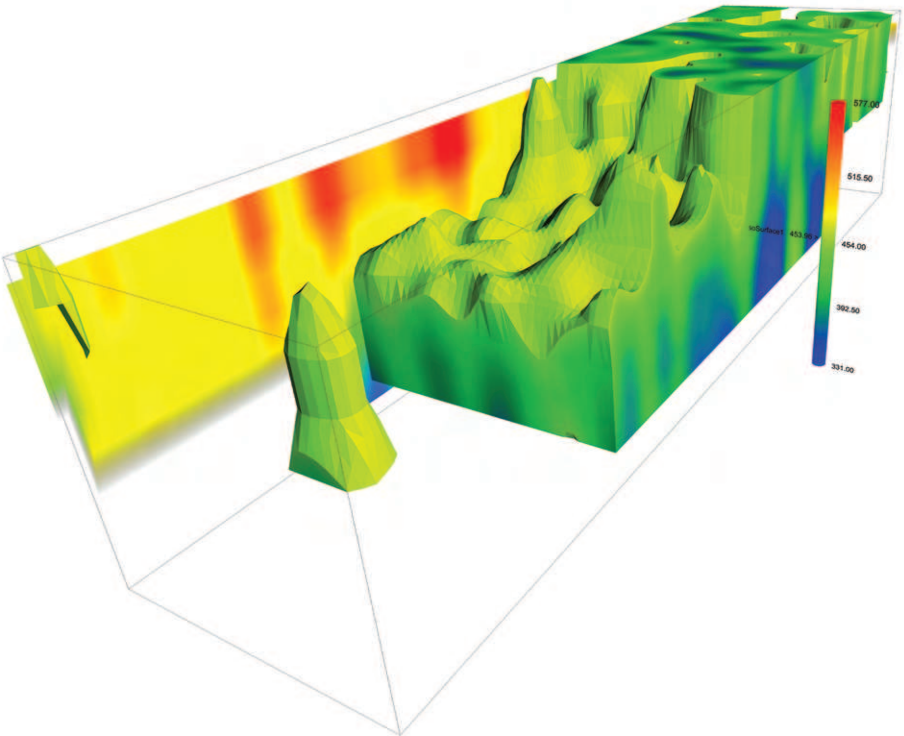

Figure 16: 3D representation of magnetic susceptibility readings in an excavated trench at Vulci. The readings clearly show the 'invisible' feature.

excavated leading to a 100mm × 100mm × 100mm block of readings which were then processed to show the presence of the unseen feature (see Fig. 16; Lockyear *et al.* 2018). For large scale lateral surveys the spacing can vary greatly. CAGG has used anything from 5m to 25m depending on the area to be covered and the time available.

In the case of surveys undertaken by CAGG the aim is to provide extra information to aid the interpretation of the other survey data as well as to provide information in its own right. At Bygrave, for example, readings taken at 10m intervals helped show the differences in susceptibility on either side of a grubbed-out hedge line which in turn helped with the interpretation of the gradiometry results (see Fig. 17; Lockyear 2023). For the three transects south of the A1 at Durobrivae, the readings were taken at 25m intervals along the transects (Fig. 18). These helped show how the underlying geology influenced the magnetic susceptibility of the topsoils which in turn impacted on the visibility of features in the gradiometer survey.

A longer term aim for CAGG is to develop an understanding of how local geologies influence the 'success' of magnetometer surveys. We are, therefore, aiming to collect magnetic susceptibility data whenever we undertake a gradiometer survey.

4.2 CAGG survey methodology

CAGG uses a Bartington MS2 magnetic susceptibility meter with a MS2-D field loop (Fig. 19). The MS2 has no data logger and so the readings are recorded in a 'Rite in the Rain' notebook for later data entry. The spacing between readings varies according to the aim of the survey and the time / personnel available. Relatively detailed survey at *c.* 2m intervals was undertaken over a possible structure at Pirton whereas at Durobrivae the survey aimed to compliment the magnetometry survey and time dictated a survey density of one reading every 25m.

Working in teams of three, one person paces out the approximate spacing and picks a flat spot to take the reading. A reading is taken by first zeroing the meter with the coil in the air, and then

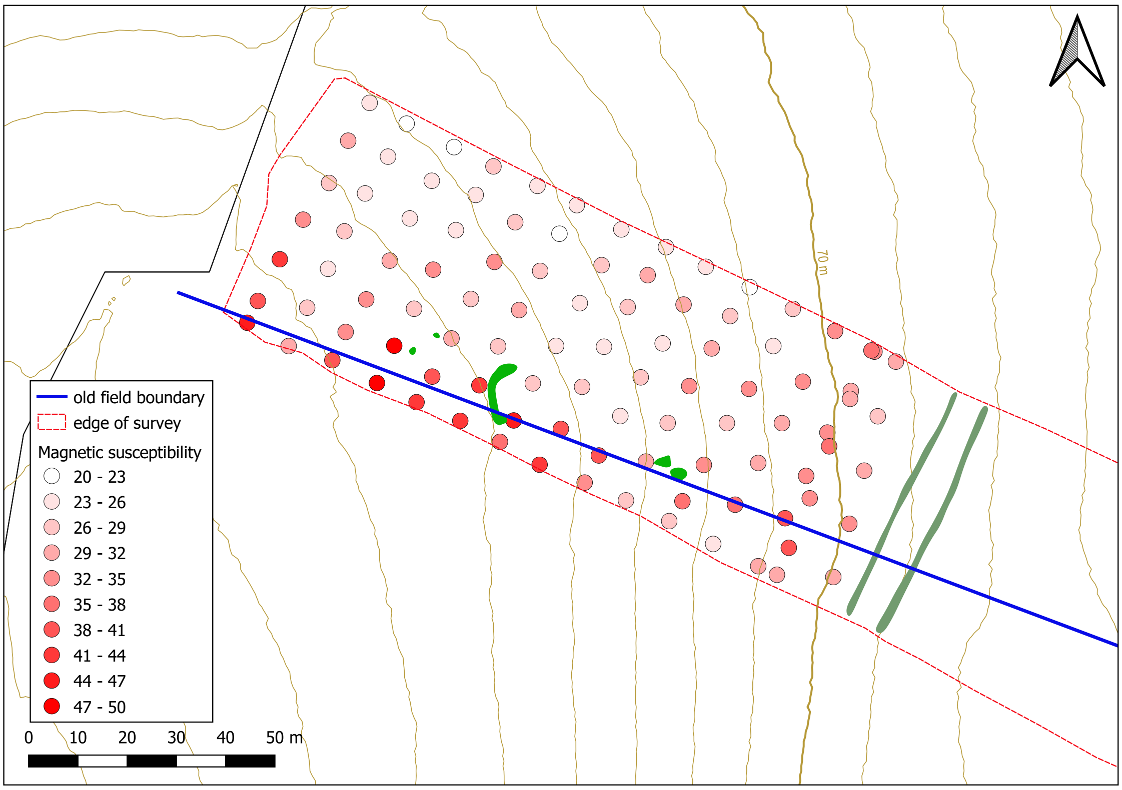

Figure 17: Magnetic susceptibility readings either side of an old hedge line at Bygrave. Background map © Crown Copyright and Database Right 2025. Ordnance Survey (Digimap Licence).

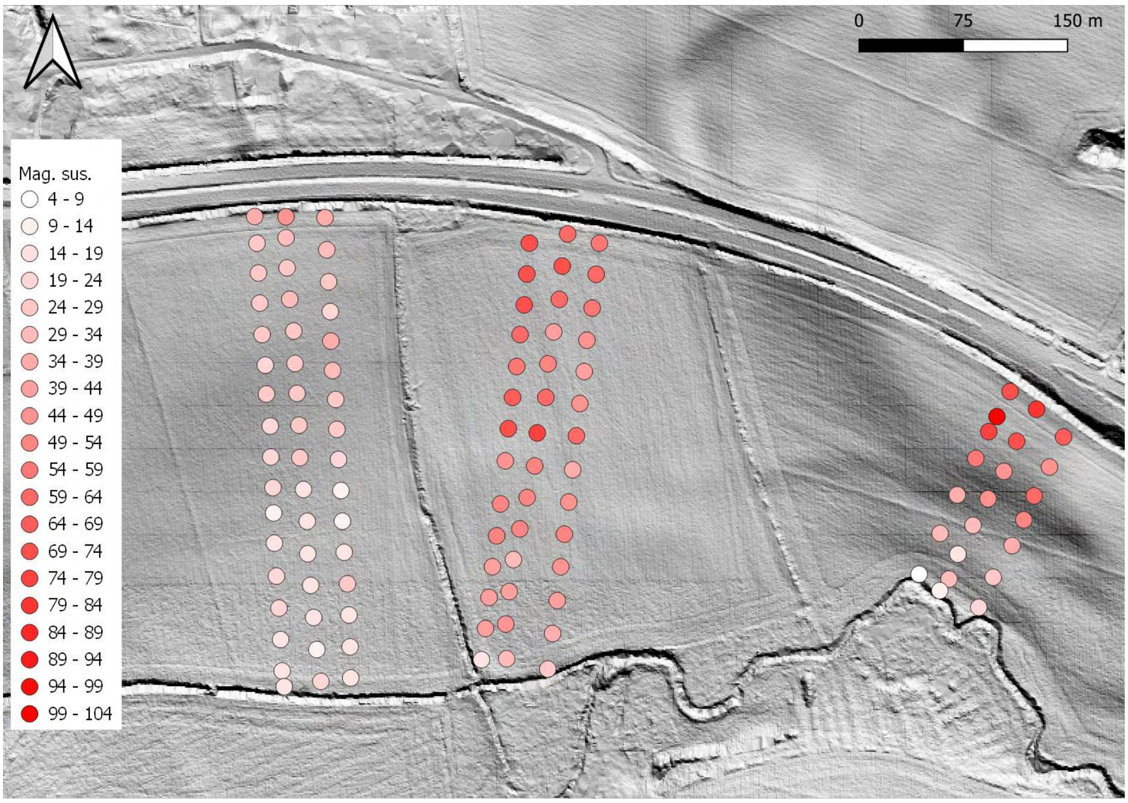

Figure 18: Magnetic susceptibility readings along the three transects south of the A1 at Durobrivae. Background map © Crown Copyright and Database Right 2025. Ordnance Survey (Digimap Licence).

Figure 19: The Bartington MS2 in action.

placing it as flat as possible on the ground picking a spot with as little vegetation as possible. Once the reading is recorded in the notebook, a third person uses the Leica dGPS to record the location. This is decidedly more accurate than required but simply using a phone or suchlike would be too inaccurate. Transects are created by simply using two ranging rods as targets at either end of the area to be surveyed.

Data processing consists of downloading the coordinates from the dGPS into a spreadsheet then manually entering the susceptibility values. Once completed the data can be imported into a GIS package — in our case QGIS — as a CSV file and then the individual data points can be represented by coloured circles as in Figures 17–18, or can be interpolated into a continuous surface.

5 The survey results

5.1 Magnetometry

The survey covered 15.3ha and was completed over eight days. Figure 20 shows the overall results in context with some of the other surveys conducted by CAGG. The field was divided into six paddocks which resulted in the linear gaps in the survey. There were also a number of strongly magnetic water troughs.

The magnetic contrasts in Puddles varied considerably. The prehistoric features were detectable, but with a low contrast to the background. In contrast, the Roman features were more strongly magnetic and, on the whole, showed quite clearly. As a result, images using different image clips were used to investigate and interpret the data.

The data processing steps were:

1. The data was exported from the Sensys software as a UXO file. As part of this process the data was down-sampled to 50hz and a 30m moving median filter was applied.

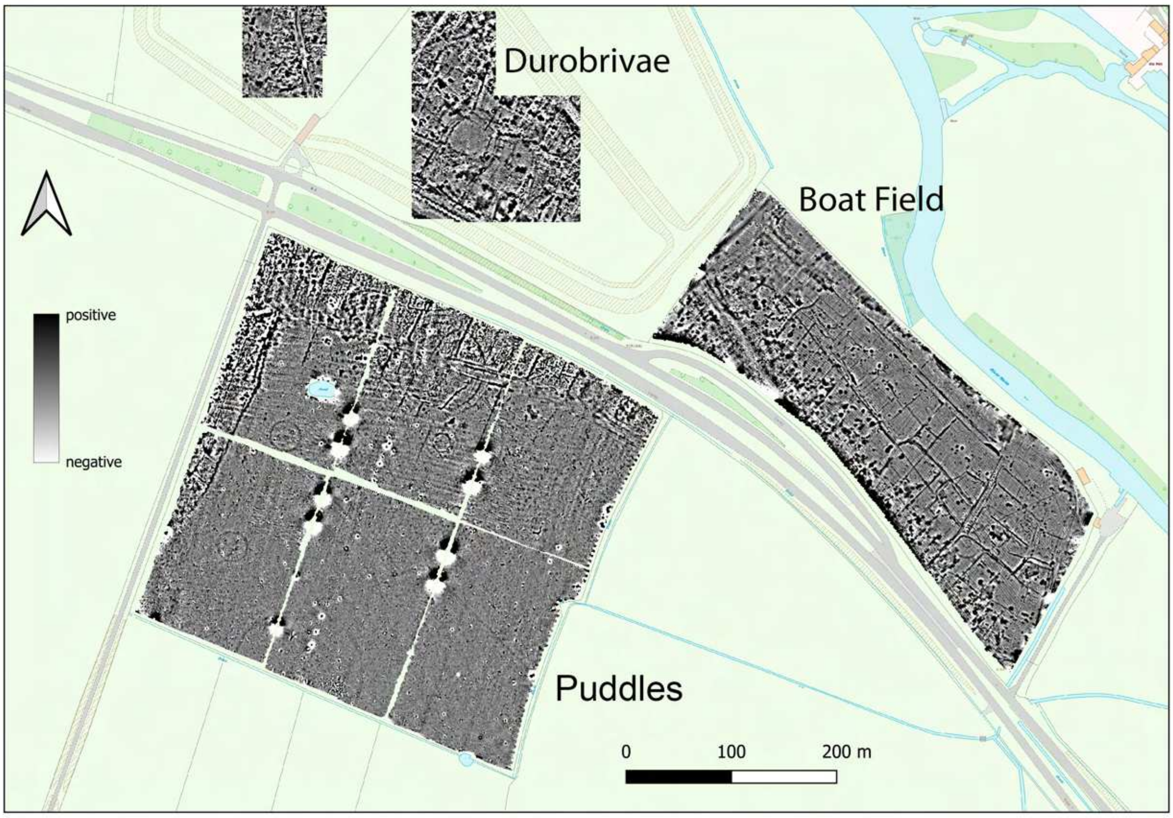

Figure 20: Magnetometry results in context with the Boat Field to the north-east, and Durobrivae to the north. Background map © Crown Copyright and Database Right 2025. Ordnance Survey (Digimap Licence).

2. The UXO file was imported to TerraSurveyor64. It was interpolated to a 0.1m raster using a 0.75m interpolation radius. The 'trim to tracks' option was used to minimise edge effects.
3. Images of each survey block were exported in three forms:
   (a) normal palette, +/- 4nT image clip;
   (b) normal palette, +/- 2nT image clip;
   (c) custom two-tone palette, +/- 6nT image clip.
4. The images were imported to QGIS for examination and interpretation for this report. They were imported to Google Earth Pro to create images for the blog post.[7]

The custom palette in step 3c allows one to highlight strongly magnetic, mainly modern ferrous, features in the data.

For this discussion, I have divided the field into two: the southern three paddocks (Fig. 21) and the northern three (Figs. 22–23). A simplified interpretation map is provided in Figure 27.

There are a number of obvious prehistoric features in the southern half of the field. The ring ditch (Fig. 21, light green arrow; Fig. 27, A) is the most obvious and is 30m in diameter. This is probably a ploughed out Bronze Age barrow. Running out of the field to the south is a larger linear feature, probably the ditch to an enclosure of which half lies in the next field (Fig. 21, light blue arrows; Fig. 27, B). This is probably prehistoric but of unknown age. Upex shows at least three other barrows in this part of the field (Fig. 3). One is just about visible in the magnetic data

[7] `https://hertsgeosurvey.wordpress.com/2025/08/01/no-more-puddles/`

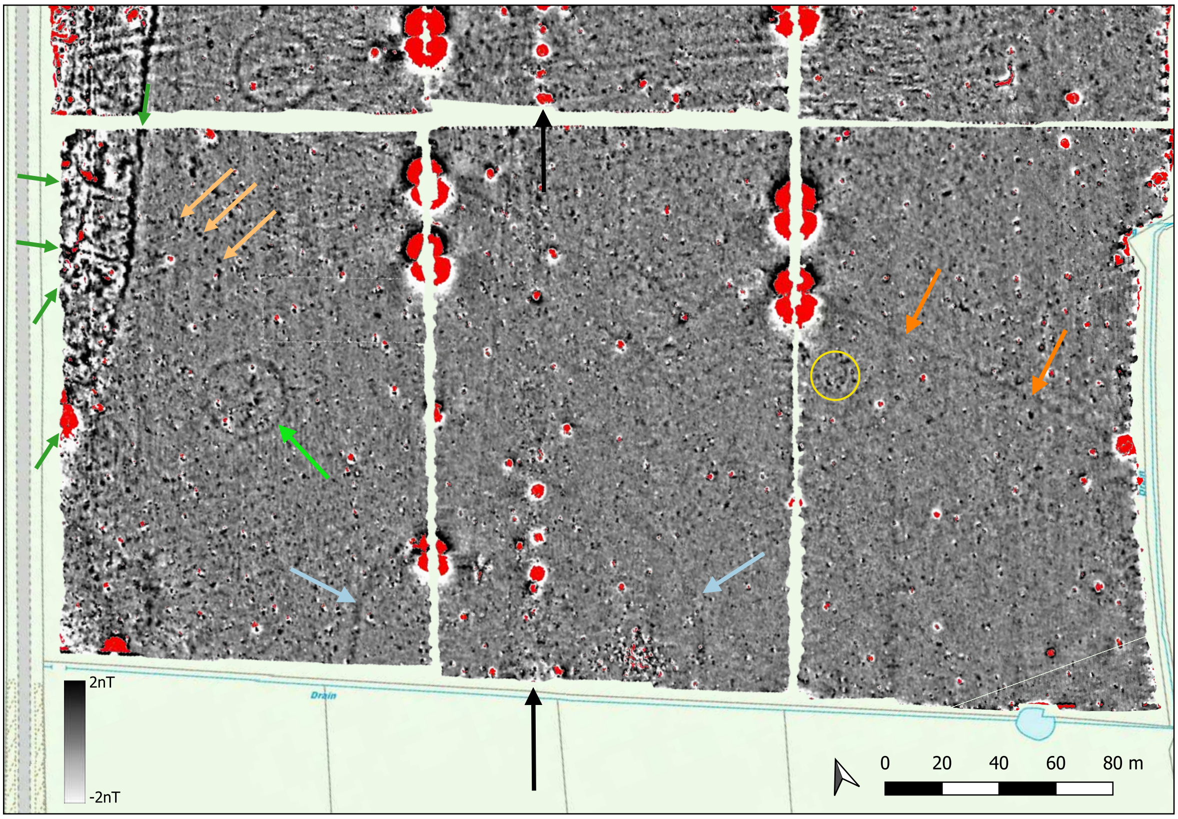

Figure 21: Magnetometry results from the southern half of Puddles. For the arrows, see text. Red coloured areas are strongly magnetic. Background map © Crown Copyright and Database Right 2025. Ordnance Survey (Digimap Licence).

and is circled in yellow in Figure 21 (Fig. 27, C). The second is shown close to this one on Upex's map but is not visible and the third is masked by the strong magnetic responses along the western edge of the field associated with the Roman settlement.

The linear feature indicated with darker orange arrows in Figure 21 is probably a non-ferrous pipeline associated with the water troughs (Fig. 27, D). The black arrows indicate the line of strong magnetic features, many coloured red indicating a strength outside the +/-5nT range, which is probably an old fence line (Fig. 27, E).

There are a number of small discrete magnetic features which may be posts or pits. One group, indicated with the light orange arrows in Figure 21 form a curve and could be part of a post circle (Fig. 27, F).

The complex of strong linear magnetic anomalies along the western edge of the field is associated with the Roman extramural settlement which lies along the road to Irchester (Fig. 21, dark green arrows; Fig 27, G). The majority of this settlement lies in the field to the west. There are large numbers of discrete magnetic features associated with this area some of which may be pits or burnt features but the proximity to the edge of the field and the track which runs along the field edge makes disentangling them extremely difficult. In Figure 27 features which are obviously ferrous have been omitted but there is a high probability that some of the others may well be ferrous.

In the northern half of the field the strong magnetic values, largely due to the Roman suburban settlement, dominate the plot. Two plots are presented: one clipped at +/-2nT with the high values outside the range of +/-5nT indicated in red (Fig. 22). The second plot is clipped at a more modest +/-4nT (Fig. 23). It should be noted that even +/-4nT is quite a strong clip compared to other Roman sites where clipping in the range of +/-7 to +/-9nT is not uncommon.

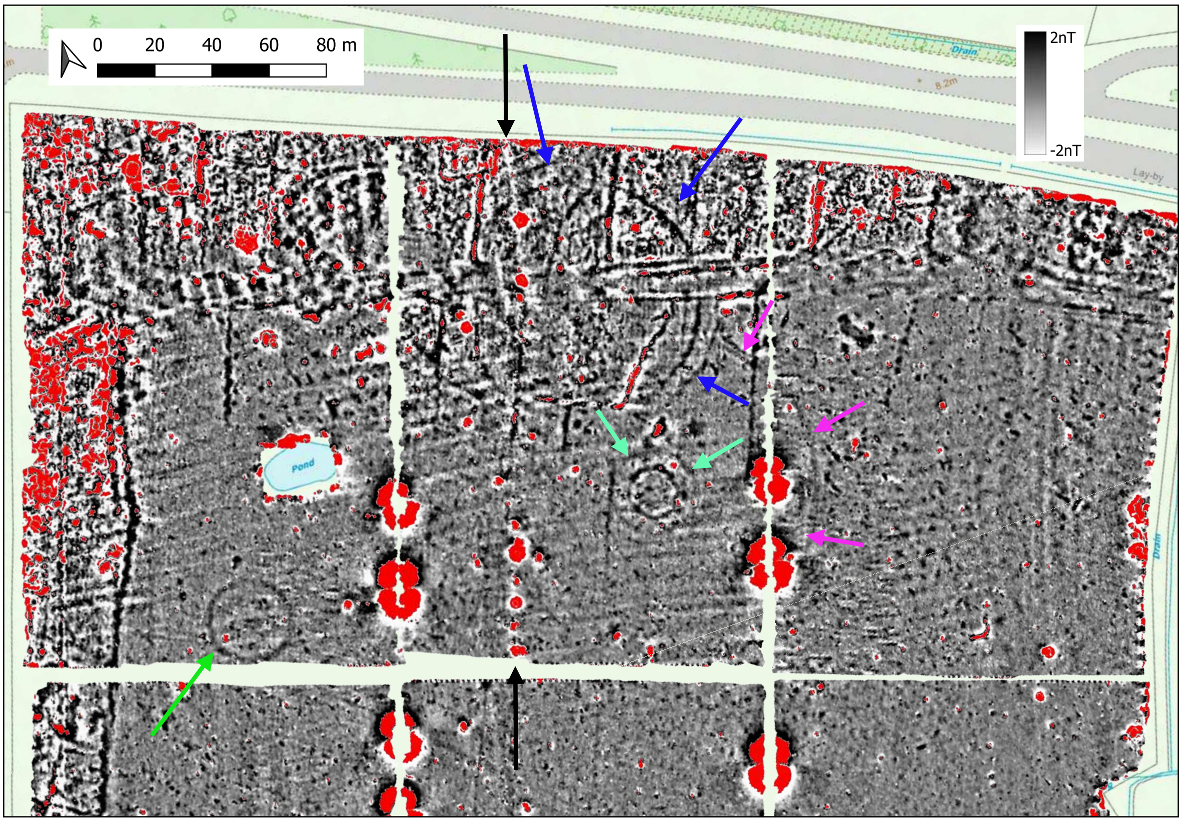

Figure 22: Magnetometry results from the northern half of Puddles clipped at +/- 2nT. For the arrows, see text. Red coloured areas are strongly magnetic. Background map © Crown Copyright and Database Right 2025. Ordnance Survey (Digimap Licence).

In Figure 22 the black arrows indicate the continuation of the fence line noted in the southern area (Fig. 27, E). An obvious ring ditch lies in the western paddock (Fig. 22, bright green arrow; Fig. 27, H). It is the same size as the ring ditch in the south-west paddock being c.30m in diameter. The complex of circular features noted by Upex (Figs. 2–3) and suggested to be a Neolithic henge is hard to see in the data. The northern double ring is indicated with dark blue arrows in Figure 22 and is most obvious where the more-magnetic Roman material is likely to have accumulated in the upper fills (Fig. 27, J). The lower single circle, indicated by the pink arrows, is even harder to see and is essentially invisible on its western side in the magnetic data (Fig. 27, K). It is clearer, however, in the Earth Resistance data discussed below. In the centre of the lower circle is a smaller double circle (Fig. 22 light green arrows; Fig. 27, L). The inner circle is quite distinct and almost certainly a ditch. The outer circle is more faint, and may represent a less prominent ditch or the edge of a bank. Some of the discrete features close to these circles are strongly magnetic and may be ferrous noise, but some are more subtle and may represent internal pits.

The more strongly magnetic features are highlighted in Figure 23. The fence line is again indicated, this time with a yellow arrow. The boundary ditch along the western side of the field seen in the south area continues and is indicated with dark green arrows (G in Fig. 27). East-west along the northern edge are parallel ditches shown by dark blue arrows which are likely to be the boundaries of a trackway (M in Fig. 27). Ditches running north-south from the edge of the map appear to join the east-west ones and are likely to be boundary ditches to house plots (M in Fig. 27). A selection of these are indicated with the black arrows in Figure 23. One of these ditches on the eastern side appear to continue as a line of post holes to the south of the trackway as shown by the pink arrows (P in Fig. 27). Finally, a rather irregular and strongly magnetic feature runs across the double-circle discussed above (Fig, 23, light blue arrow, Fig. 27, Q). This would appear

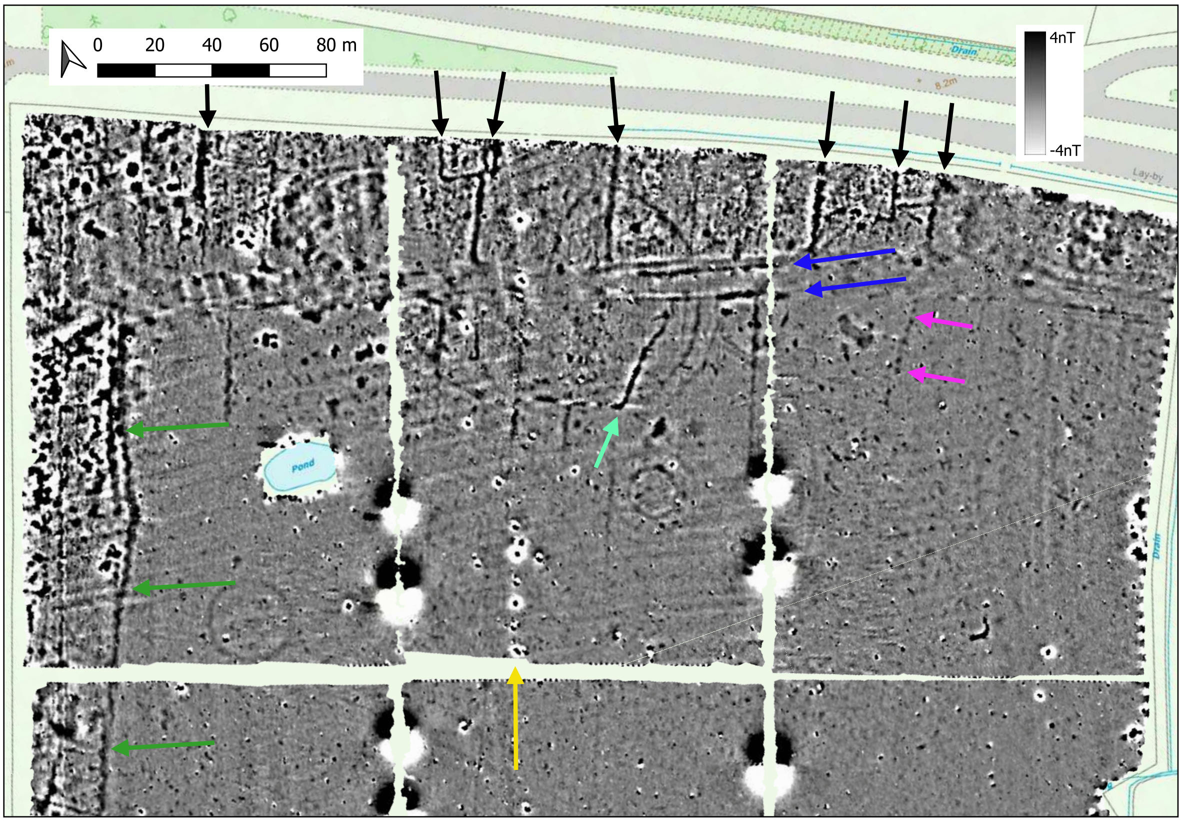

Figure 23: Magnetometry results from the northern half of Puddles clipped at +/-4nT. For the arrows, see text. Background map © Crown Copyright and Database Right 2025. Ordnance Survey (Digimap Licence).

to be a cut feature like a ditch but does not seem to be associated with either the prehistoric or Roman features and is thus of unknown date and function. Also associated with the Roman 'ladder' settlement are large numbers of discrete features (Fig. 27, R). As with those to the south, these are probably a mixture of pits, burnt features and ferrous noise. Some may be associated with the prehistoric features but this is impossible to determine from the geophysics data alone.

5.2 Earth Resistance

A 100m × 100m block of Earth Resistance data was collected in the northern half of Puddles. Unfortunately, the combination of very hard ground and a slightly defective main cable resulted in less data being collected than was hoped, and more data processing than usual to clean the images up. The result for the 0.5 mobile probe spacing was, however, extremely useful and is shown in Figure 24.

The data processing consisted of the following steps.

1. Replacement of erroneous negative and dummy readings caused by the defective cable with 500.

2. Despiking to replace high readings with the mean of the surrounding values.

3. Compression using log values reduce the skew in the data.

4. Clipping to 3.37 to 4.26 logged ohms.

5. Interpolation and low pass filtering to smooth the image.

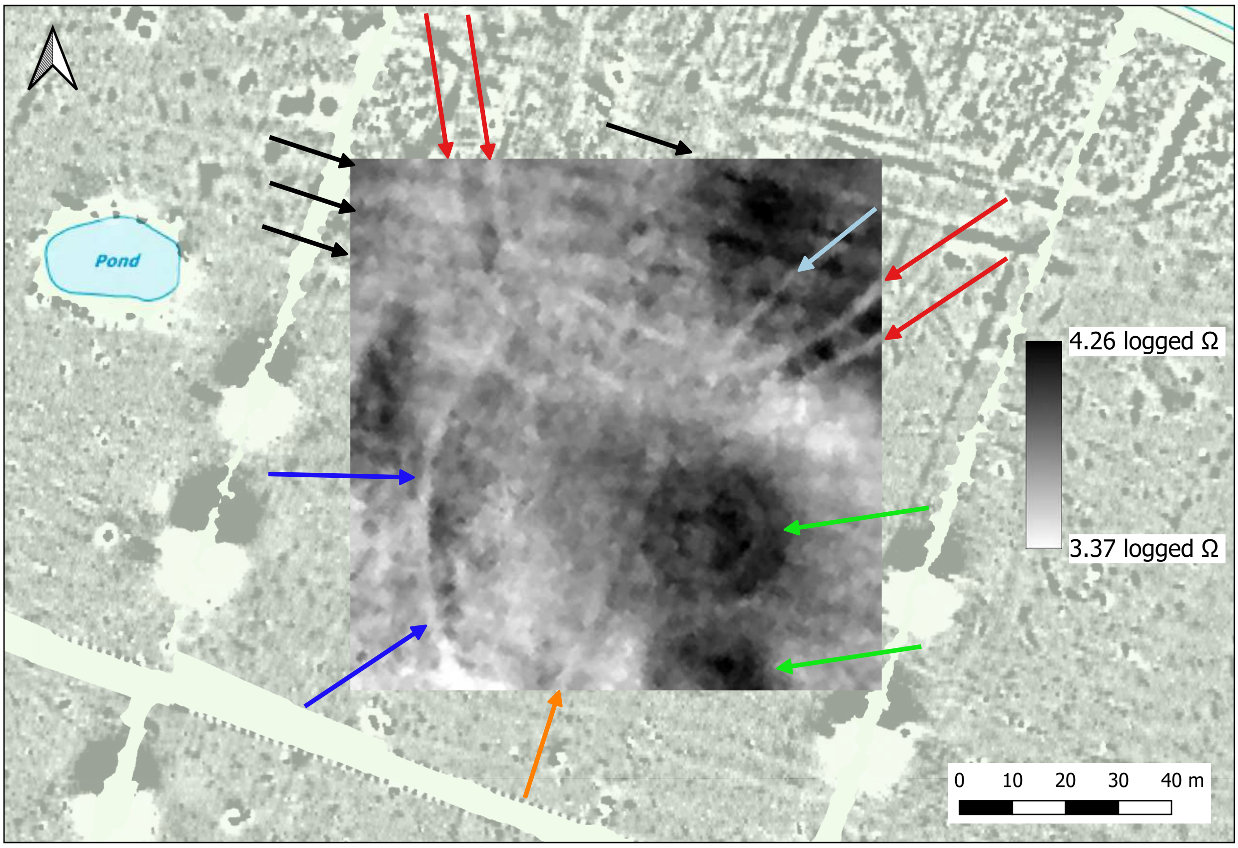

Figure 24: Earth Resistance survey results, 0.5m mobile probe separation. For explanation of the coloured arrows, see text. Background map © Crown Copyright and Database Right 2025. Ordnance Survey (Digimap Licence).

The resulting image was exported as a `.png` file and imported to QGIS for this report and Google Earth for the blog.

The results clearly show the two large interlocking circles seen in the aerial imagery (Fig. 1) and the magnetometer data discussed above (Fig. 24, lower circle blue arrows, upper double circle red arrows, Fig. 27, J and K). These features which show as positive magnetic features in the gradiometry data and low resistance features here are clearly ditches. They are most likely prehistoric, perhaps henges as suggested by Upex.

In the centre of the lower circle is another circular feature (Fig. 24, upper green arrow; Fig. 27, L). The obvious circle in the gradiometer data is matched here by a low resistance circle and is therefore most likely a ditch. The less-obvious outer circle in the gradiometer data matches the edges of the higher-resistance area outside the ditch and appears to be an outer bank to the feature. The higher resistance feature suggests an internal mound as well. The entire higher resistance feature closely matches the small mound that can be seen in the countour plot (Fig. 4) and the lidar data (Fig. 5).

The position of this feature in the centre of the lower large circle suggests that these two features are part of the same monument. If so, we have a complex feature with a circular outer ditch 115m in diameter, and a smaller inner feature about 28m across with an outer bank, an inner ditch and then an inner mound.

To the south of this central mound is another area of higher resistance (Fig. 24, lower green arrow). It is possible this is a second flattened mound which does not survive well enough to be seen in the lidar data.

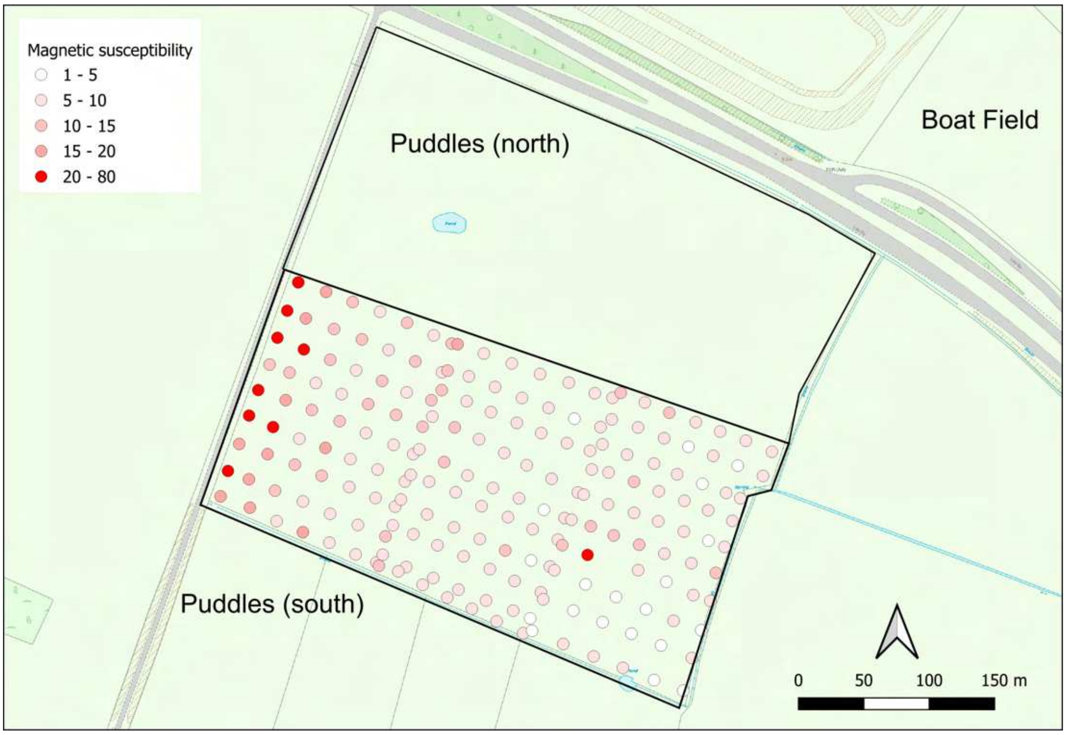

Figure 25: The magnetic susceptibility results. The area covered is the equivalent of that shown in Fig. 21. Background map © Crown Copyright and Database Right 2025. Ordnance Survey (Digimap Licence).

There are some other low resistance linear features. In Figure 24, the orange, black and light blue arrows indicate some of these. The one shown by the orange arrow follows the orientation of the fence lines and is likely a modern field boundary (S in Fig. 27). The parallel curving lines of alternating higher and lower resistance, some of which are shown by the black arrows, are most likely the remains of medieval ridge-and-furrow cultivation (not shown in Fig. 27). The remaining feature, shown by the light blue arrow is of uncertain date and function. It is shown in the gradiometer data as a very strong magnetic feature and would appear with strongly magnetic fills (Q in Fig. 27).

5.3 Magnetic susceptibility

Time constraints led to the survey only covering the southern half of the field at approximately 25m intervals (Fig. 25). The vast majority of the readings were extremely low: 145/200 were 10 or less. Only 10 readings were greater than 20 (Fig. 26). The distribution of the higher values was, with the exception of one errant point, along the western edge of the field and is associated with the Roman extramural settlement.

One caveat for these results was the extremely uneven surface of this field which may have led to slightly lower readings. It does appear, however, that the underlying geology of river sands and gravels has led to soils with a very low magnetic susceptibility. This helps explain why the prehistoric features are less clear in the gradiometry results than one would hope. Essentially, there is a very low contrast between the soil horizons and the subsoils. This is a similar result to the survey further west where the transect on the river gravel terraces 1 and 2 were lower than the other transects and as a result the archaeological features were harder to see.

The Roman settlement, however, has greatly enhanced the magnetic susceptibility of the soils through burning and rubbish disposal. As noted above, the presence of Roman deposits in the upper fills of some of the prehistoric features probably explains why they are more visible in the gradiometry results.

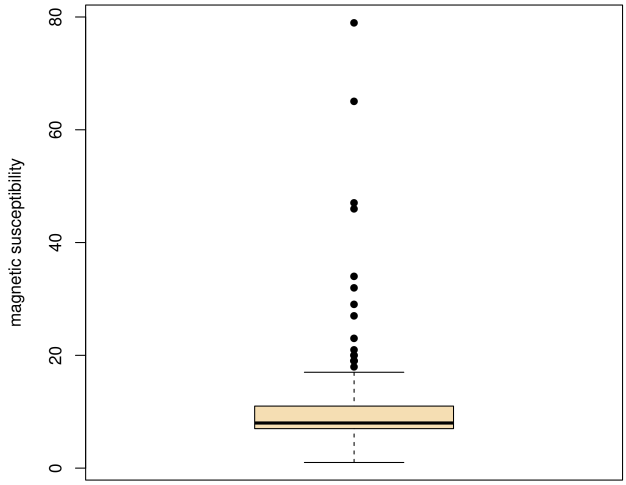

Figure 26: Box-and-whisker plot of the magnetic susceptibility values.

6 Conclusions

The survey has revealed a number of important archaeological features. The complex of prehistoric features is particularly significant. The ring ditches probably attest to a landscape of burial in this area. The barrows detected here add to the one discovered in the Boat Field and the 'mound' within the walls of Durobrivae. The latter is especially interesting as it is clear that it was not built on during the Roman period. The double-circle feature is difficult to parallel. It could be a henge monument as suggested by Upex, or perhaps a particularly large and complex barrow or barrows? The survival of a slight mound in the centre of the lower circle as seen in the lidar data that perfectly correlates with the central feature (Figs 4–5, cf. Fig. 27, L) is a surprise in a field with a long history of cultivation as shown by the ridge-and-furrow.

The Roman period settlement along the north and west sides of the field is easy to see but harder to interpret. Much must have been destroyed when the A1 was widened. The western side is overlain by the field boundary with the concomitant ferrous noise. The results do show, however, a series of small enclosures, probably house plots and a mass of probable pits.

The medieval use of the field is seen in the traces of ridge-and-furrow running across the northern part of the field in an east-west direction. It probably extended into the southern area as well but the lower magnetic enhancement of the soils in the southern part of the field makes it harder to detect.

Ideally, the Earth Resistance survey should be expanded to cover the whole of the large double ring feature in the north of the field (Fig, 27, J and K). An expanded survey may show the relationship between the two circles more clearly. It would also be helpful to expand the Earth Resistance survey over the Roman settlement area to see if any stone structures exist within the plot boundaries. Any such structures might also be visible in the Ground Penetrating Radar survey. Completing the magnetic susceptibility survey would also help confirm some of the interpretations offered here.

On a larger scale, it is clear that geophysics has much to offer for the investigation of this landscape and the extension of the surveys along the south side of the A1 would be highly beneficial.

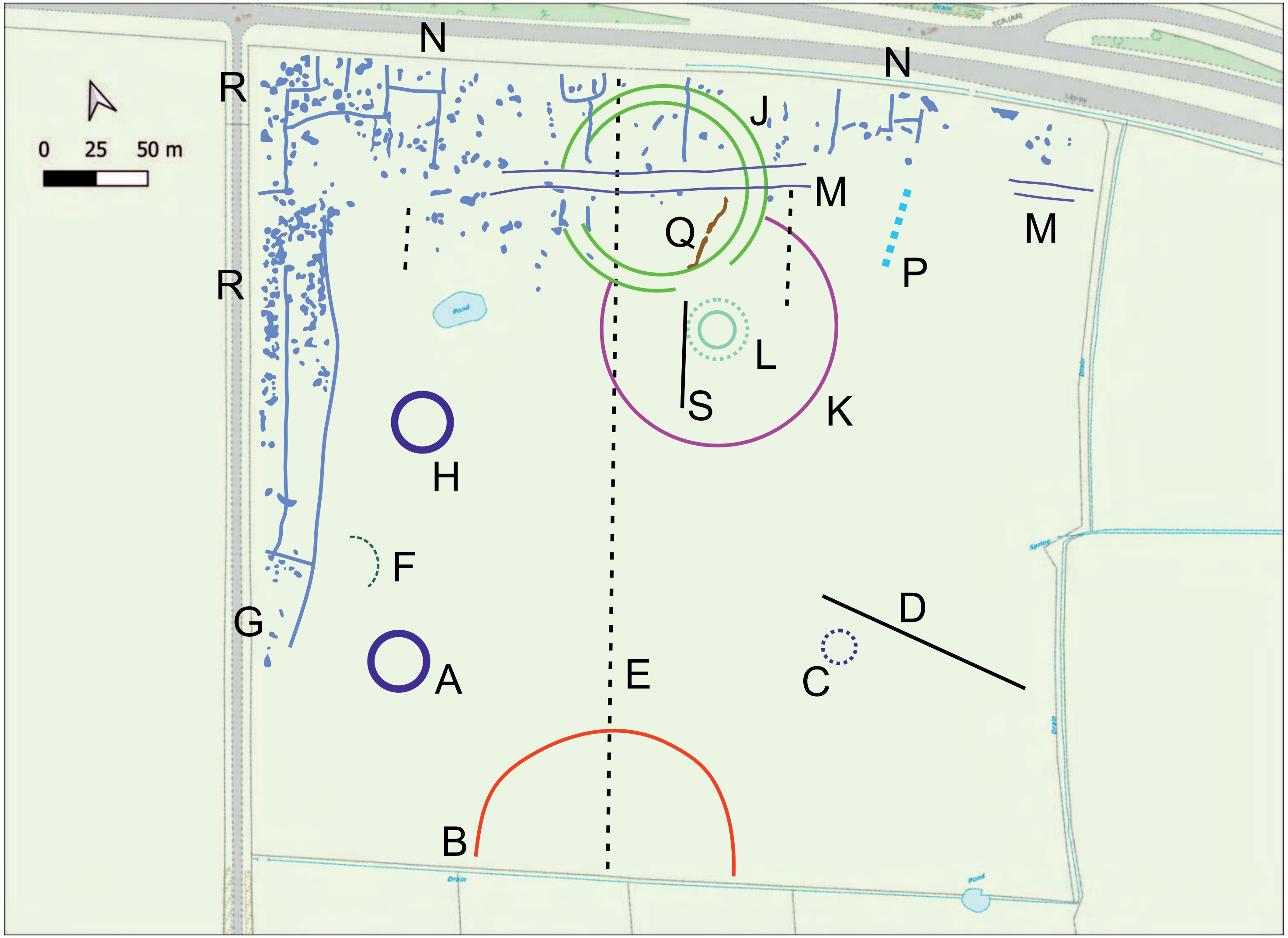

Figure 27: Interpretation map. Letters are referred to in the text. Black lines are probable modern features. Light blue features (M, N and P) are probably Roman. Other colours are likely to be prehistoric except Q which is of unknown date. Ferrous items and ridge-and-furrow have been omitted. Background map © Crown Copyright and Database Right 2025. Ordnance Survey (Digimap Licence).

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