

# **Archaeological geophysical survey on the site of Warden Abbey Old Warden, Bedfordshire March to April 2017**

Report No: 17/62

Author: John Walford

Illustrator: John Walford





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**OASIS REPORT**

PROJECT DETAILS		Oasis No. molanort1-286561	
Project name	Archaeological geophysical survey on the site of Warden Abbey, Old Warden, Bedfordshire		
Short description	MOLA (Museum of London Archaeology) was commissioned to undertake magnetometer and earth resistance surveys across the site of Warden Abbey, a medieval Cistercian abbey located near Old Warden in Bedfordshire. The survey mapped the ground plan of the claustral complex, including the church, cloisters, inner court and other buildings. Some features more probably associated with the post-medieval Gostwick Mansion were also detected. A separate area, lying c 400m to the east, was also surveyed. This was suspected to be an industrial area associated with the abbey, and the detection of probable tile kilns and other possible structures in this area strongly supports this interpretation.		
Project type	Geophysical survey		
Site status	Scheduled Monument		
Previous work	Excavations		
Current land use	Mixed arable and pasture		
Future work	None planned		
Monument type/ period	Medieval Cistercian monastery Medieval tile kiln Post-medieval mansion		
Significant finds	None		
PROJECT LOCATION			
County	Bedfordshire		
Site address	Abbey Farm, Warden Street		
Study area	c 12ha		
OS Easting & Northing	TL 119 439		
Height OD	c 53m - 66m aOD		
PROJECT CREATORS			
Organisation	MOLA		
Project brief originator	Christine Hill and Margaret Roberts, Old Warden History and Heritage Society		
Project design originator	MOLA		
Director/Supervisor	Adam Meadows		
Project Manager	John Walford		
Sponsor or funding body	Old Warden History and Heritage Society		
PROJECT DATE			
Start date	24th March 2017		
End date	17th April 2017		
ARCHIVES	Location	Content	
Physical	N/A		
Paper	MOLA Northampton	Site survey records	
Digital		Geophysical survey & GIS data	
BIBLIOGRAPHY	Journal/monograph, published or forthcoming, or unpublished client report		
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# Archaeological geophysical survey on the site of Warden Abbey, Old Warden, Bedfordshire March to April 2017

## ABSTRACT

*MOLA (Museum of London Archaeology) was commissioned to undertake magnetometer and earth resistance surveys across the site of Warden Abbey, a medieval Cistercian abbey located near Old Warden in Bedfordshire. The survey mapped the ground plan of the claustral complex, including the church, cloister, inner court and other buildings. Other features, more probably associated with the post-medieval Gostwick Mansion, were also detected. A separate area, lying c 400m to the east, was also surveyed. This was suspected to be an industrial area associated with the abbey, and the detection of probable tile kilns and other possible structures in this area strongly supports this interpretation.*

## 1 INTRODUCTION

MOLA (Museum of London Archaeology) was commissioned by the Old Warden History and Heritage Society (OWHHS) to conduct a programme of archaeological geophysical survey on the site of Warden Abbey, a medieval Cistercian abbey located near Old Warden in Bedfordshire. The survey was to form part of the Heritage Lottery funded 'Greensand Country Landscape Partnership' project, and had the aims of enabling volunteer participation and training in geophysical survey techniques whilst shedding light on the layout of an important but poorly known medieval site.

The survey fieldwork was conducted from 24th March to 17th April 2017, and comprised both earth resistance and magnetometer surveys. It was led by MOLA staff, aided by a pool of volunteers co-ordinated by committee members from OWHHS.

As Warden Abbey and its precinct is a Scheduled Monument (Monument No. 1002936) the survey was conducted under a 'Section 42' licence from Historic England (ref. SL00151728). A copy of this survey report will be lodged with Historic England and another with the Central Bedfordshire Historic Environment Record (HER), as required under the terms of this licence.

## 2 BACKGROUND

### 2.1 Topography and geology

The site of Warden Abbey lies roughly a mile south-west of the parish church at Old Warden, on the southern side of Bedford Road leading to Cardington. The foundations of the abbey's claustral buildings lie under the modern Abbey Farm and the surrounding gardens and fields, whilst to the south of the farm there is a complex of medieval water channels and fish ponds. Approximately 400m to the east there is a group of old clay pits which are thought to denote an industrial area contemporary with the abbey.

Three areas were investigated by the survey (Fig 1). The main area comprised the garden of Abbey Farm together with the pasture fields lying immediately around it to the east, south and west. A second area, comprising a large mixed use (arable and fallow) field on the eastern side of Rowney Lane, was separated from the main survey area by



the disused line of the Bedford to Hitchin railway. The third area was the outlying 'industrial area' referred to in the preceding paragraph. All these areas are in the ownership of the Southill Estate, who kindly granted access for the survey.

All three survey areas lie on the gentle, south-westerly-facing dip-slope of the 'Greensand Ridge' at between 53m and 66m above Ordnance Datum. Several streams rise in the vicinity, converging into a single stream valley which leads south-eastwards from below the site of the abbey.

The solid geology of the survey areas comprises Oxford Clay, but this is largely concealed beneath recent drift geology. Oadby diamicton is present on some of the higher ground to the north and west, and broad swathes of head have accumulated along the main lines of drainage (BGS 2017).

## **2.2 Historical and archaeological background**

*The following section is based on notes and other materials made available by Margaret Roberts of OWHHS, who is currently researching the history of Warden Abbey.*

Warden Abbey was a Cistercian abbey, founded in 1135 by Walter Espec, Lord of the Manor of Warden. It was, at its inception, a relatively small site with timber buildings and was initially populated by an abbot and 12 monks transferred from Rievaulx Abbey in Yorkshire. It grew substantially over the following decades, so that by the late 12th to early 13th century it had around 65 monks and 190 lay brothers and owned many landholdings, including 23 granges. The abbey church had been re-built in stone by the late 12th century and was significantly extended in the late 13th century or shortly thereafter.

The fortunes of the abbey declined following famine, then plague, in the first half of the 14th century and the abbey struggled further with various financial difficulties and the loss of estates throughout the 14th and 15th centuries. Despite this, the abbey remained as one of the more prominent and wealthy houses of the Cistercian order, having a net income of £389 16s 6¼d in 1535 (Caley 1821, 193-4). It was dissolved in 1537, the first of the greater monasteries to voluntarily surrender to the crown in the Dissolution, and the greater part of the Abbey buildings were pulled down in the following two decades.

Following the Dissolution, the abbey came into the tenancy of Robert Gostwick, who built a mansion on the site, and according to Rudd & West (1964), incorporated some surviving elements of the abbey buildings into an otherwise new structure. An engraving published by S. and N. Buck in 1730 records the mansion as it appeared at that date, and an estate map dated circa 1750 also provides information about its ground plan (Fig 2). Only a small part survives today, as a Grade I Listed Building (List No. 1222165), the remainder having been pulled down in the late 18th century.

In addition to the Gostwick Mansion, the 1750 map depicts a pair of 16th-century barns<sup>1</sup> which still stand today, to the north of Abbey Farm, and other buildings to the south-west on the site of the now-demolished Rook Tree Farm. Various other landscape features, including ponds and field boundaries, are also depicted. However Abbey Farm itself is not depicted and evidently post-dates 1750. It was referred to as a 'good modern farmhouse in 1815 (Walter 1815), which would fit with a late 18th- or early 19th-century construction date.

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<sup>1</sup> These are Grade II\* Listed Buildings (List No.1274805),

Only scant remains of the abbey are visible above ground today but piecemeal antiquarian and archaeological works on the site have allowed for some buried elements of the claustral buildings to be traced. A plan drawn up by Bradford Rudge, based on his excavations in the 1830s, shows parts of the cloister and church in relation to the garden wall of Abbey Farm. This plan was used by members of the Bedfordshire Archaeological Society to guide their own excavations, in 1960-61, which uncovered the eastern end of the abbey church together with burials, a decorative tiled floor and other features (Rudd and West 1964). The same floor, which may have lain at the foot of the night stair, was re-exposed in an excavation led by Evelyn Baker in 1974.

At c 144 acres, the precinct of Warden Abbey was almost certainly the largest monastic precinct in Britain. It would have seen a range of land uses including pasture, vineyards, fishponds and various industrial activities. Traces of the precinct boundary survive in places as earthworks, for instance on its western side where a substantial bank runs alongside Rowney Lane. There are also surviving fishponds within the precinct and in the east, to the north of the modern Warden Abbey Vineyard, there are irregular flooded hollows which have been interpreted as clay pits associated with medieval tile production.

### **3 METHODOLOGY**

Two complimentary survey techniques were deployed at Warden Abbey. Approximately 4.6ha of ground around the claustral complex was covered by an earth resistance survey, and c 12.2ha of ground, including the claustral complex, the industrial area and the field by Rowney Lane, were covered by a magnetometer survey. The choice of which technique or techniques to apply in any given area were based on advice given to OWWHS by Paul Linford of Historic England (correspondence dated 11th March 2016), as well as the appropriateness of the techniques to the expected nature of the archaeology, and practical considerations such as access arrangements and the likelihood of magnetic interference from modern structures and deposits.

#### **3.1 Magnetometer survey**

This survey technique was conducted with the MOLA magnetometer cart, which is a two-wheeled, lightweight structure designed to be pushed by hand. It incorporates a bank of six vertically-mounted Bartington Grad601 magnetic sensor tubes, spaced at half-meter intervals along a bar aligned crossways to the direction of travel, and also incorporates a Leica Geosystems Viva GPS antenna mounted on the central axis, 0.5m astern of the sensors. The magnetic sensors each output data at a rate of six readings per second and the GPS antenna outputs NMEA format data (GGA messages) at a rate of one position every second. These data streams are fed into a laptop computer where they are compiled into a single raw data file by MultiGrad601 logging software specifically designed for that purpose.

The cart was propelled along straight and parallel traverses across the survey area, with data logging being manually toggled on and off at the start and end of each traverse to avoid the collection of spurious data whilst turning. Traverse ends were marked with ranging poles to aid even coverage, and the evenness of coverage was further checked by monitoring the positional trace plotted in real time by the MultiGrad601 logging software. The average speed of coverage was c 1.5m/s and the effective data resolution thus approximated to 0.25m x 0.50m.

The raw survey data was initially processed with MLGrad601 software, which calculated an actual UTM co-ordinate for each data point by interpolating the GPS readings and applying offset corrections based on the array geometry and calculated heading

direction. This produced an output file in XYZ format which could be imported into TerraSurveyor software for data visualisation and further processing.

The raw XYZ data exhibited striping caused by slight mismatches in the calibration of the individual magnetic sensors. This was removed in TerraSurveyor by applying the median de-stripe function to runs of data from each sensor.

### **3.2 Earth resistance survey**

The earth resistance survey was conducted with a Geoscan Research RM15 resistance meter. This was deployed in twin probe configuration with a mobile probe spacing of 0.5m and the remote probes being spaced a similar distance apart. Measurements of earth resistance were recorded to a precision of  $0.1\Omega$  at 1m intervals across networks of contiguous 20m survey grids. The locations of key grid points were logged to c 1cm position with a Leica Geosystems Viva GPS.

The weather and ground conditions were favourable for the earth resistance survey, being neither excessively wet nor dry. They were also consistent enough throughout the three week duration of the survey that there were no significant mis-matches between adjacent grids of data collected on different days.

The earth resistance data was visualised and processed using Geoplot 3.00v software. Biases in the mean value of adjacent grids, arising from the re-locating of the remote probes, were balanced out using the "Edge Match" function. Following this a targeted "Despike" function was used in order to remove a small number of bad readings (those with values greater than three standard deviations above or below the local mean) caused by poor electrical contact between the probes and the ground.

### **3.3 Data presentation**

The processed data is presented in this report as greyscale raster images which have been rotated and scaled to fit against Ordnance Survey base-mapping. The display ranges of the resistance data have been individually chosen to reflect the range of readings in each data set (Fig 3). A consistent display range of  $\pm 20\text{nT}$  was chosen for the magnetometer data (Figs 5, 7 & 9), as this was judged to provide the best compromise between muting areas of high intensity noise and retaining the visibility of weak anomalies.

Interpretive overlays for each data set are presented in Figures 4, 6, 8 and 10 and Figure 11 provides a synthetic overview of the interpretations. The synthesis has been produced by combining the resistance and magnetometer interpretation layers, stripping out features judged to be of little archaeological significance and redrawing a 'best fit' interpretation where the magnetic and resistance anomalies from a particular dataset did not perfectly correlate. Annotations have been made to cross-reference key features on this figure with their descriptions in the written account of the results (below).

The raw survey data is presented in Figures 12 to 14 in this report. All the resistance data is presented at a range of  $10\Omega$  to  $70\Omega$  to allow for comparison across the survey areas. The magnetometer data is likewise presented at a consistent range of  $\pm 20\text{nT}$ .

## 4 SURVEY RESULTS

### 4.1 The main survey area (Figs 3-6)

The earth resistance survey has identified sufficient elements of the claustral complex for a reasonably accurate plan of its remains to be determined (Figs 3 & 11). In particular the church, the western half of the cloister, and the buildings ranged to the south of the cloister are all clearly apparent. Furthermore, the resistance and magnetometer data both indicate that a large, detached range of buildings, interpreted as the 'inner court' and possibly including guest accommodation, once stood c 50m to the west of the church (Figs 3, 5 & 11). There is also evidence for structural remains to the east, some of which can be attributed to the post-medieval Gostwick Mansion.

#### ***The claustral complex***

The abbey church has been detected in its anticipated location, with its remains running directly beneath Abbey Farm and continuing under the field to the east. The overall length of the church is just short of 100m and its width, although not absolutely clear, averages roughly 20m. The orientation is close to east-west, as is usual for churches. There is a subtle misalignment between the east and west ends of the building, and it might be suspected that this reflects a small error in positioning the survey data. However, Rudge's plan shows a comparable misalignment between the east end of the church and the cloister, which suggests that the fallibility of the medieval builders, rather than of the modern surveyors, is most likely to blame.

Although the position of the church has been firmly established, not all details of its ground plan can be resolved. The west end is obvious in the survey data, as is an arcade of column bases running down the southern side of the choir and nave. The east end and northern arcade are also tolerably clear. However much of the southern and northern walls of the church are ill-defined, and part of the latter remains unsurveyed as it lies beneath a modern driveway. There are suggestions of projecting structures (possibly side-chapels) north and south of the chancel, and part of a northern transept may also have been detected.

The western side of the cloister is defined by two parallel high resistance anomalies, spaced c 4m apart, which run south for c 40m from near the west end of the church. The southern side of the cloister has also been detected, albeit as a more nebulous set of anomalies. One other high resistance anomaly may define a part of the eastern side but it would appear that much of this side of the cloister lies under the edge of Abbey Farm's garden, where the ground was not suitable for survey. Based on the detected anomalies, the internal dimensions of the cloister would seem to be somewhere around 28m east to west by 32m north to south.

To the immediate south and south-east of the cloister there is a complex of high resistance anomalies relating to the monk's living quarters (dormitory, refectory, reredorter, etc). The layout of these buildings can be discerned in broad outline, and clearly follows an orderly rectilinear plan, although some details are indistinct. The strength of the anomalies is striking, particularly in the south of the complex, and this would suggest that some substantial masses of stonework survive below ground.

To the south-west of the living quarters, there is a shallow, north-south aligned linear depression in the field surface (*pers obs*), over which a negative magnetic anomaly and a low resistance anomaly have been detected. The likely interpretation of this is a drain or conduit leading water from the abbey buildings towards the ponds to the south.

On the western side of the cloister, where the lay brothers' facilities would occur in a typical Cistercian abbey, only a little structural detail can be recognised. Two parallel high resistance anomalies running south from the west end of the church may indicate part of a narrow range of buildings, and the 8m wide space between this and the cloister would be consistent with the 'lane' often found in this location on Cistercian sites.

### ***The 'inner court' buildings and their vicinity***

A large detached group of buildings has been detected c 50m to the west of the church and cloister, with both the resistance data and magnetometer data revealing elements of its plan. These probably lay within the 'inner court' of the abbey. A long, curving high resistance anomaly runs in between these buildings and the claustral complex, and the most likely cause of this would be the remains of a boundary wall.

Although neither dataset provides a complete plan of the buildings in this area, and the two sometimes conflict in small details, a reasonably consistent overview can be achieved by considering both datasets together (Fig 11). A north-south aligned wing (or possibly several discrete buildings on a common axis), measures nearly 60m long and forms the core of the group, whilst to the north a smaller wing or group of buildings lies crossways, paralleling the line of the track to the north. To the south-west there is another small building on an east-west axis. This seemingly overlaps a corner of the north-south aligned wing, which it may therefore postdate. There are also some negative magnetic anomalies that could indicate further rooms or buildings south of the main wing but, given the absence of any corroborating resistance anomalies, the interpretation of these is tentative.

The magnetometer data includes a string of positive magnetic anomalies which are regularly positioned through the centre of the north south-wing and similar anomalies, oriented perpendicularly, in the northern buildings. Their intensities are typically in the range 30nT to 70nT. The most plausible interpretation would be that they represent fireplaces; possibly tiled hearths set into the floors of rooms.

A small area of earth resistance data was collected to the north of the track to see whether there was any evidence for the buildings continuing into this area. Some amorphous high resistance anomalies were detected but none are convincingly structural and, given the abundant presence of bonfire debris on the ground surface (*pers obs*), it is possible they relate to very recent ground disturbance.

The curving, high resistance anomaly that runs around the eastern side of the buildings seems to represent a boundary wall dividing them from the claustral buildings to the east. The northern end of this anomaly merges into the anomalies relating to the northern wing of the inner court buildings, and its southern end butts against an anomaly that may represent an east-west aligned boundary (see below). There are at least four small gaps in its southern half, including one where it is crossed by a low resistance linear anomaly leading south from a pond and one where it is crossed by a weak meandering linear anomaly running south-east from the range. The former feature appears to represent a drainage channel from the pond (possibly equivalent to a boundary depicted on the 1750 map) and the latter, although less easy to interpret, may represent something like a metallised path surface. Two other resistance anomalies, lying parallel to each other on the east side of the boundary, are of obscure significance.

The magnetometer data includes a broad positive anomaly which follows the same course as the southern half of the curving boundary. Anomalies of this type are typically natural in origin, and it is probable that this one represents a band of hillwash or alluvium accumulated along a natural line of drainage. Interestingly, the gap in the data alongside

this anomaly reflects where the survey area was obstructed by two mature willow trees (*pers obs*), a species which tends to favour damp soils near watercourses.

Both the resistance data and the magnetometer data suggest the presence of linear features (possibly a ditch with a wall or bank) enclosing a sub-rectangular plot of land to the west of the inner court buildings. The magnetometer data also indicates two parallel features, possibly ditches or the edges of a building, that extend westwards from this boundary before disappearing under the modern hedgeline.

The function of the inner court buildings cannot be firmly established on geophysical evidence alone, but their position and size are broadly comparable to a set of buildings at Kirkstall Abbey (W. Yorks) which have been interpreted as a guest accommodation (Youngs *et al* 1983, 211-14). It has also been suggested (M. Roberts *pers com*) that the northern part of the range may form a part of the abbey gatehouse given its location alongside a trackway.

### **Buildings lying south-east of the inner court buildings**

South-east of the inner court buildings, both the resistance survey and magnetic survey have detected the remains of an elongated, east-west aligned building that is depicted on the 1750 map. Unusually, it is the magnetometer data which most fully and clearly reveals its plan. A possible explanation for this could be that the soil surrounding the walls has been magnetically enhanced (eg through burning), which would result in a strong contrast between the magnetic soil and a relatively unmagnetic building material such as limestone.

To the east of the elongated building, the resistance survey has detected a small rectangular feature which corresponds to another building depicted on the 1750 map. This lies alongside the possible conduit or drain noted in the previous section of this report.

The northern edges of these two buildings lie on or close to a persistent linear trend aligned east to west through the resistance data. West of the building it takes the form a high resistance anomaly, possibly representing a wall or bank, whereas to the east it is simply an abrupt transition from the high resistance of the claustral complex to much lower resistance on the south. The western anomaly has a couple of short northerly projections, which possibly represent part of a small adjoining structure.

South of the elongated building, the magnetic data contains two parallel but widely separated linear anomalies, one positive and one negative. These probably represent boundaries (possibly a ditch and a wall) and may be related to the rectilinear set of boundaries detected in the western survey area, on the opposite side of the disused railway (see below).

### ***The Gostwick Mansion and its vicinity***

Two parallel high resistance anomalies extend westwards from the standing part of the Gostwick mansion. These correspond to wall foundations noted in the 1960-1 excavations (Rudd and West 1964) and presumably represent the remains of the narrow western wing of the mansion depicted on the 1750 map. On the other side of the standing building there is a sub-rectangular area of low resistance, aligned north to south, which correlates with the eastern wing shown on the same map. The reason for the low resistance response is uncertain, but one possibility would be the presence of cellars backfilled with relatively moist sediment.

Immediately north-east of the eastern wing there is a slightly smaller rectangular anomaly of similarly low resistance, measuring c 15m long by 6m wide. This, and a subtle rectangular magnetic anomaly detected in the same location, presumably represent a building not recorded on the 1750 map. Another unmapped building is indicated by resistance anomalies immediately south of the eastern wing. This is a rectangular structure, oriented on the same axis as the wing, which may have a smaller square structure appended to its western side. It measures c 20m long by 10m wide, with the possible annex also being c 10m across. There is no evidence as to whether either of these buildings was related to the medieval abbey complex or was purely post-medieval in date.

Various linear anomalies in both datasets correspond to a pattern of earthworks lying north and south of the mansion site. These earthworks are variable in character but typically comprise low banks and terraces, at least some of which may relate to the former gardens of the mansion. In the magnetic data it is possible to distinguish two types of anomaly; normal linear anomalies and those composed of linear scatters of magnetic noise. The latter indicate accumulations of magnetic debris (ferrous material, brick rubble), such as might occur in a backfilled ditch or ha-ha.

East of the mansion, at the corner of two of the possible garden boundaries, there is a square patch of magnetic 'noise' measuring c 10m across. This corresponds with a square feature (possibly a building) marked on the 1750 map, and may indicate a spread of demolition rubble.

Approximately 80m north-east of the mansion, also at the corner of an earthwork, the magnetic data contains an intense anomaly of circular form with a negative halo. When viewed closely (Fig 5 inset), this can be seen to comprise an outer anomaly, c 60nT to 90nT, curving around a less magnetic core. The strength and shape of this would be consistent with the response from a pottery kiln or an oven, the strongest response coming from the wall of the structure and the slightly weaker response from the firing chamber. West and east of this there are weaker positive magnetic anomalies of uncertain archaeological significance.

### **Miscellaneous features**

In the northernmost part of the survey area there is an east-west aligned linear magnetic anomaly with another linear anomaly abutting it perpendicularly from the north. Both these anomalies are associated with linear spreads of dipoles, indicative of ferrous debris, and their overall appearance is typical of the magnetic response from backfilled field boundary ditches. Their orientation square to the modern landscape would also be consistent with this interpretation.

Many other small dipolar anomalies of ferrous origin are present throughout the magnetic data. Most of these will relate to insignificant pieces of debris (eg horse shoes) in the topsoil. Two larger examples north of the mansion lie in the area of the 1960s excavations and possibly represent larger pieces of rubbish buried in the backfilled trenches.

Three anomalies in the resistance data can be firmly attributed to modern causes. An elongated patch of exceptionally high resistance just outside the eastern garden wall of Abbey Farm corresponds to a patch of hardcore around a cattle trough and, further north along this wall, a nebulous area of moderately high resistance corresponds to a patch of soft ground heavily riddled with rabbit holes (*pers obs*), thought to be the backfill of the 1974 excavation trench. The third modern anomaly is a vague, meandering linear trend that runs north-west from the standing part of the Gostwick mansion, following the line of

a modern footpath. Additionally, there is a conspicuous string of high resistance readings running in from the northern edge of the resistance survey area which is strongly suspected to be a data flaw rather than a real anomaly.

#### **4.2 The western survey area (Figs 3-4 & 7-8)**

The resistance survey across the northern part of this area has detected a small, amorphous zone of high resistance alongside the railway line. This corresponds in part to the mapped location of Rook Tree Farm and may represent some surviving foundations of the farmhouse. A linear anomaly of slightly enhanced resistance which runs north from location, parallel with the railway, is of obscure significance. A series of narrow, weak, linear resistance anomalies further to the north-west are similarly enigmatic: whilst it is conceivable that they represent more buildings remains they are not strong enough for this suggestion to be fully convincing.

West from the site of the farm there is a long trapezoidal zone of moderately high resistance which corresponds with a pond depicted on the 1750 map. The same feature is apparent, though less well defined, in the magnetometer data and both datasets show a linear feature extending south from its south-eastern corner. The magnetometer data shows that other linear features extend east and west from this, and the overall impression is of a series of boundaries (probably ditches) defining rectangular plots of land. The eastern plot corresponds to an area where medieval tile sherds are abundantly present on the field surface (*pers obs*) and the data in this area exhibits weak background patterning which would be consistent with a dense scatter of such material.

The resistance data from the northernmost part of this survey area is difficult to interpret because it is dominated by broad-scale features that lack sufficient context to show whether they are real anomalies or simply changes in the background resistance level. It is possible that there is another backfilled pond crossing this area, as one anomaly is comparable to the definite pond anomaly further south and correlates with a set of diffuse positive magnetic anomalies suggestive of gleyed sediment. However, this should be regarded as no more than a tentative suggestion.

Slightly beyond the southern extent of the rectilinear plot boundaries there is a positive anomaly, c 4m across, with a weak negative halo. On close inspection this can be seen to comprise a ring of magnetic enhancement, c 15nT to 38nT in intensity, around a less magnetic core (Fig 7, inset). It is interpreted as representing a possible kiln, analogous to that previously noted beyond the east end of the abbey church.

South from the possible kiln, and more or less coinciding with the 436 northing line (Fig 7), an east-west aligned grouping of dipolar anomalies and large but weaker positive anomalies extends across the width of the survey area. A cluster of large, intense dipolar anomalies occurs at the eastern end of this feature, three of them lying so close together that, at the data display range, they seem to merge into one irregularly shaped anomaly. The overall line of these anomalies corresponds to that of a field boundary depicted on the 1750 map, the eastern end of which still survives as a water-filled ditch on the opposite side of the former railway.

The magnetometer data from the southern half of this survey area includes no anomalies of obvious archaeological interest. The three very weak linear anomalies of alternating polarity which cross the field from east to west are characteristic of recent field drains, and some weak, amorphous magnetic patterning at the southern end of the field probably arises from a band of gleyed alluvial sediments alongside the stream on the southern field boundary.



### 4.3 The 'industrial area'

The magnetometer survey has detected a complex set of intense magnetic anomalies covering the northern end of the presumed industrial area. Considered as a whole, this type of response would be entirely consistent with a heavily disturbed piece of ground containing substantial concentrations of fired clay and similarly magnetic industrial by-products. Two particular anomalies stand out as being very likely to represent medieval tile kilns and others, though less conclusive, also suggest the presence of structural features. However, much of the magnetic response is 'noise' which, although exhibiting enough patterning to suggest a planned and coherent site layout, cannot be securely interpreted in terms of individual features such as ditches, banks and trackways.

The two likely tile kilns are represented by magnetically intense anomalies (up to 90nT) of rectangular form, each composed of three more or less parallel linear elements with traces of other elements running perpendicularly across them. The shape of these anomalies is very consistent with the typical form of a tile kiln, in which two outer walls and a central dividing wall define two parallel flues running beneath a firing chamber (eg, see Green 2005, fig 9). Both kilns are similarly sized, measuring c 4m wide by c 8-9m long.

Close to the kiln anomalies there is a more homogenous, irregular anomaly of similar size and magnetic intensity, surrounded by a negative magnetic halo. This quite probably represents another kiln; its different character could be explained by a different form or a different state of preservation. Just west of this there is a smaller more complex anomaly of similar intensity which probably represents the partial remains of a fourth kiln.

In the north-west of the industrial area are a group of large amorphous positive anomalies, somewhat less intense than the probable kiln anomalies. A possible interpretation for these would be dumps of kiln wasters or other magnetic debris.

Two rectangular zones in the north of this area are partly bounded by irregular positive anomalies and stand out as being remarkably 'quiet' compared with the complex magnetic noise that surrounds them. They are comparable in size, one measuring c 9m by 24m and the other c 12m by 24m. A plausible interpretation would be that they represent the footprints of buildings which, being enclosed spaces, may have been fairly free of the industrial detritus which would have spread across the ground outdoors.

The southern boundary of the industrial 'noise' is clearly defined and corresponds in part with a steep earthwork cut into the slope of the field surface (*pers obs*). The eastern extent of the noise is also quite clear, scarcely extending into the adjacent fields. However, the western and northern edges have not been fully traced by this survey.

To the south of the zone of industrial noise, the data is mainly bland, with only a few linear anomalies suggestive of ditches and a few amorphous anomalies of obscure significance.

The data from the small north-eastern field show little of note, except at the south-western corner where there is a thin scatter of small magnetic dipoles indicative of ferrous debris. The location of this corresponds to the location of some small buildings shown on the first edition of the 6" Ordnance Survey map (1883), suggesting that the debris may be related to these. The data from the third field in this survey area is similarly bland, with only minimal evidence for industrial remains.

## 5 CONCLUSION

The survey results provide new and useful archaeological information about the former site of Warden Abbey. Much of the ground plan of the claustral complex has been detected, confirming the general accuracy of previous site plans whilst adding new information such as the location of the west end of the abbey church. A group of inner court buildings, possibly guest accommodation, has been identified for the first time, and some elements of the post-Dissolution Gostwick Mansion have also been mapped. Furthermore, the survey of land to the east of the claustral complex, has confirmed the view that this was a zone of industrial activity. Two probable tile kilns have been detected together with possible structures and spreads of industrial debris occurring in close association with a group of clay pits.

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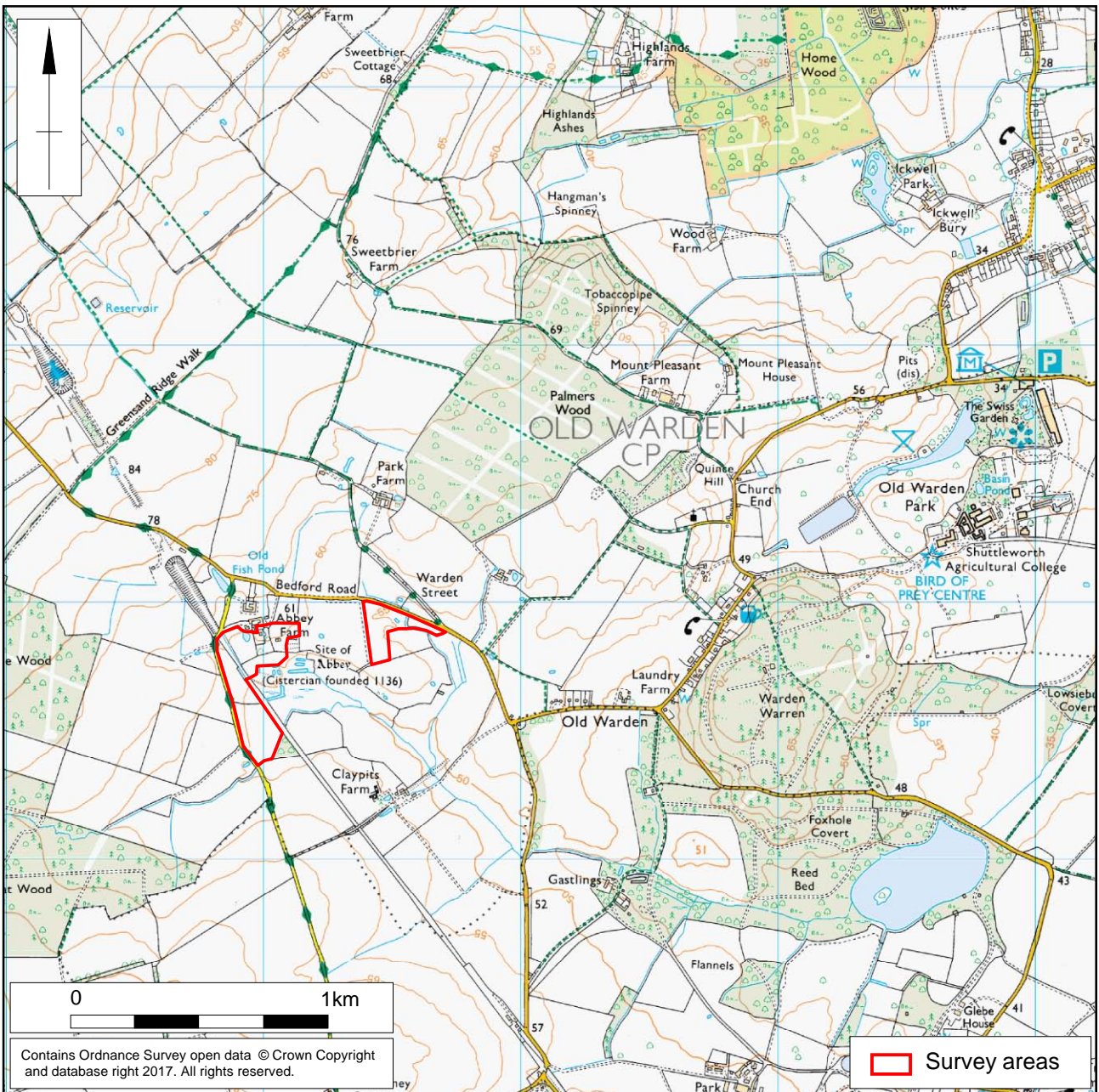
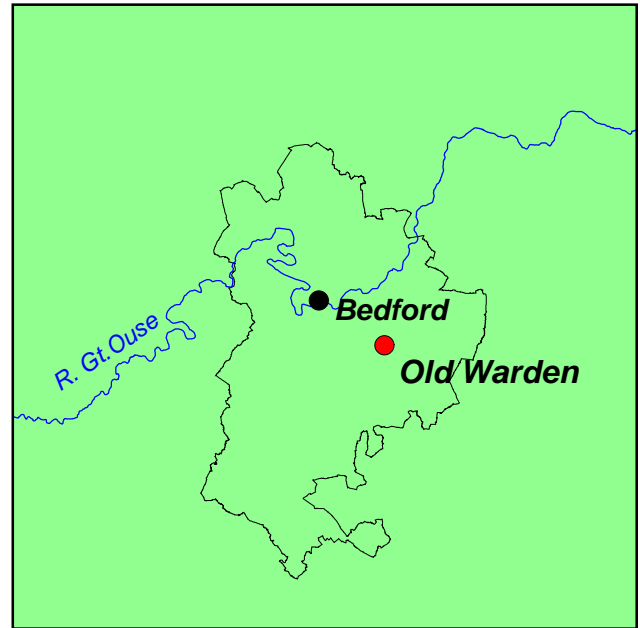
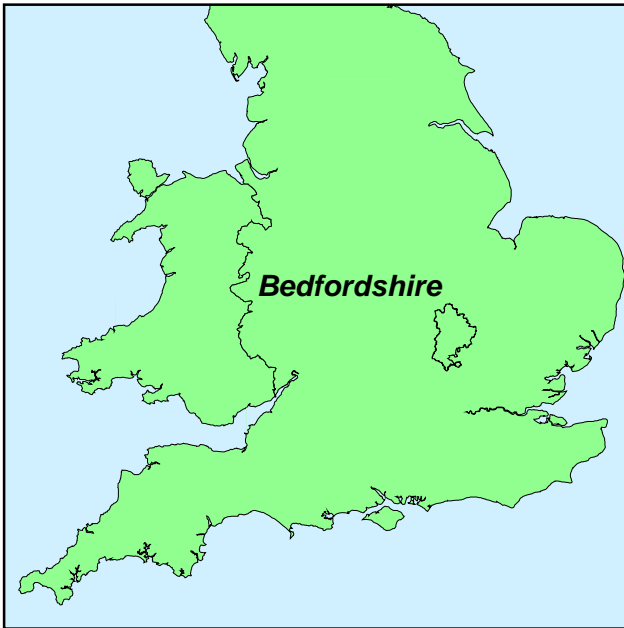
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Scale 1:25,000

Site location Fig 1



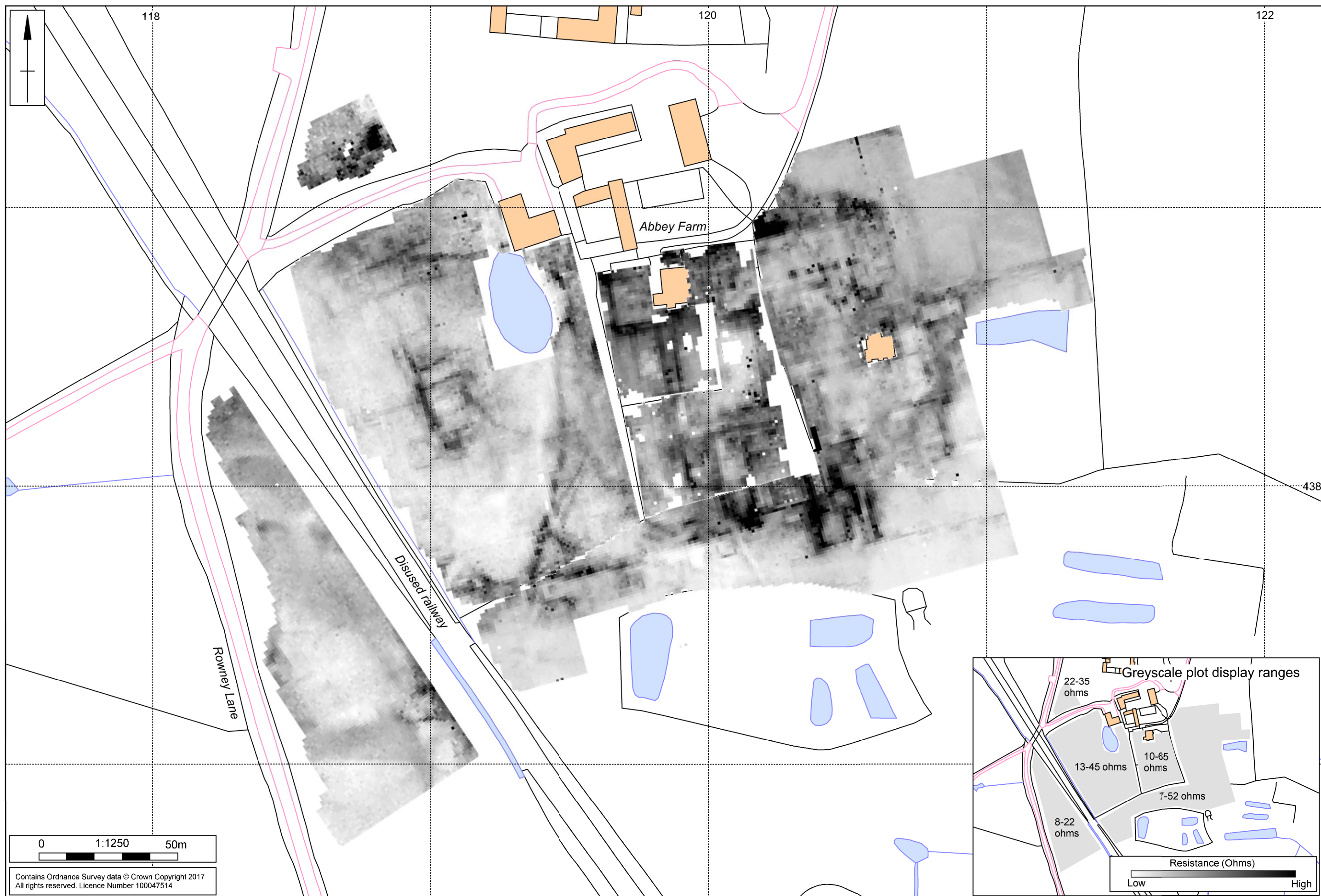


Scale 1:2500 (A4)

Extract of 1750 estate map with modern Ordnance Survey overlaid

Fig 2

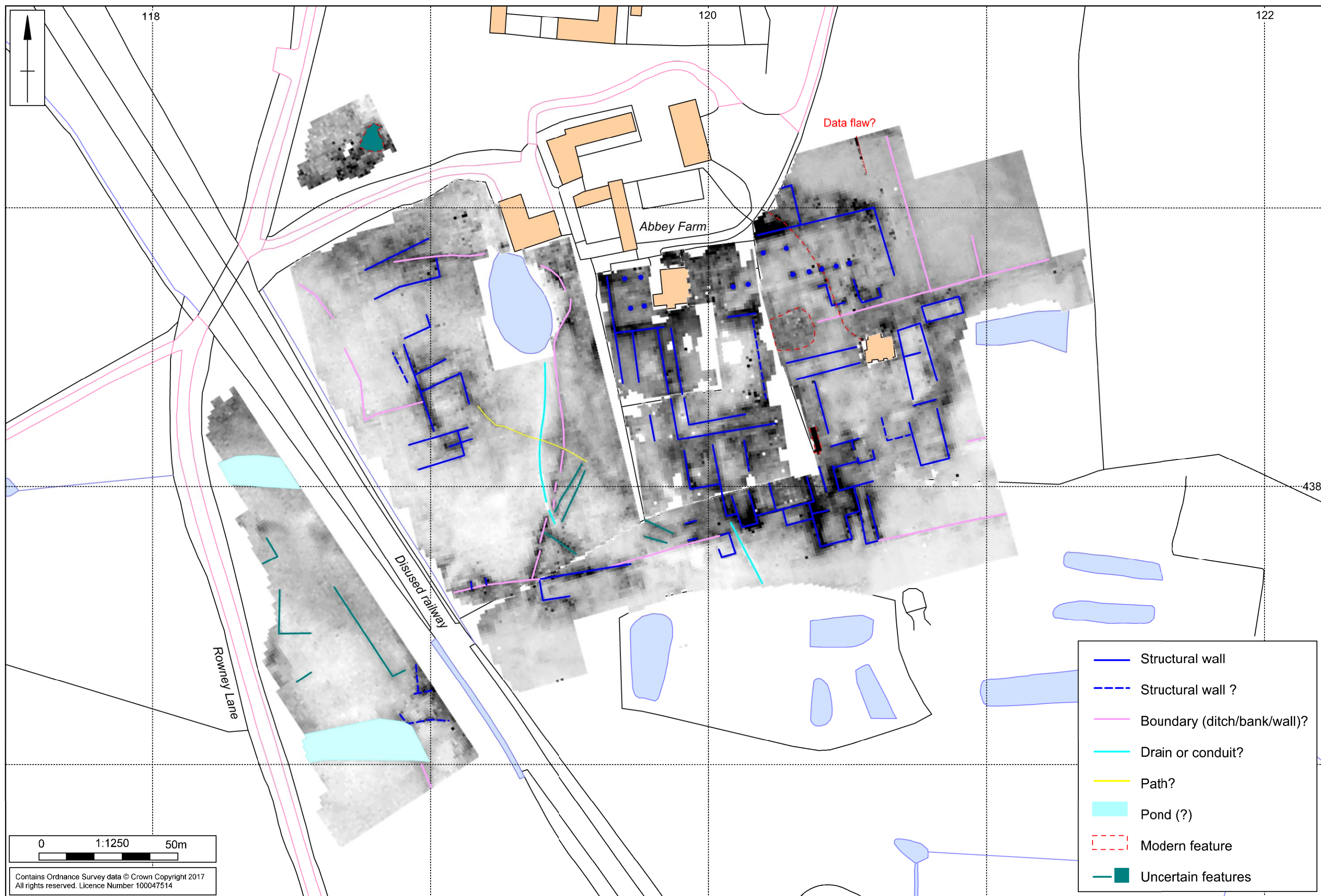




Scale 1:1250 (A3)

Earth resistance survey results Fig 3









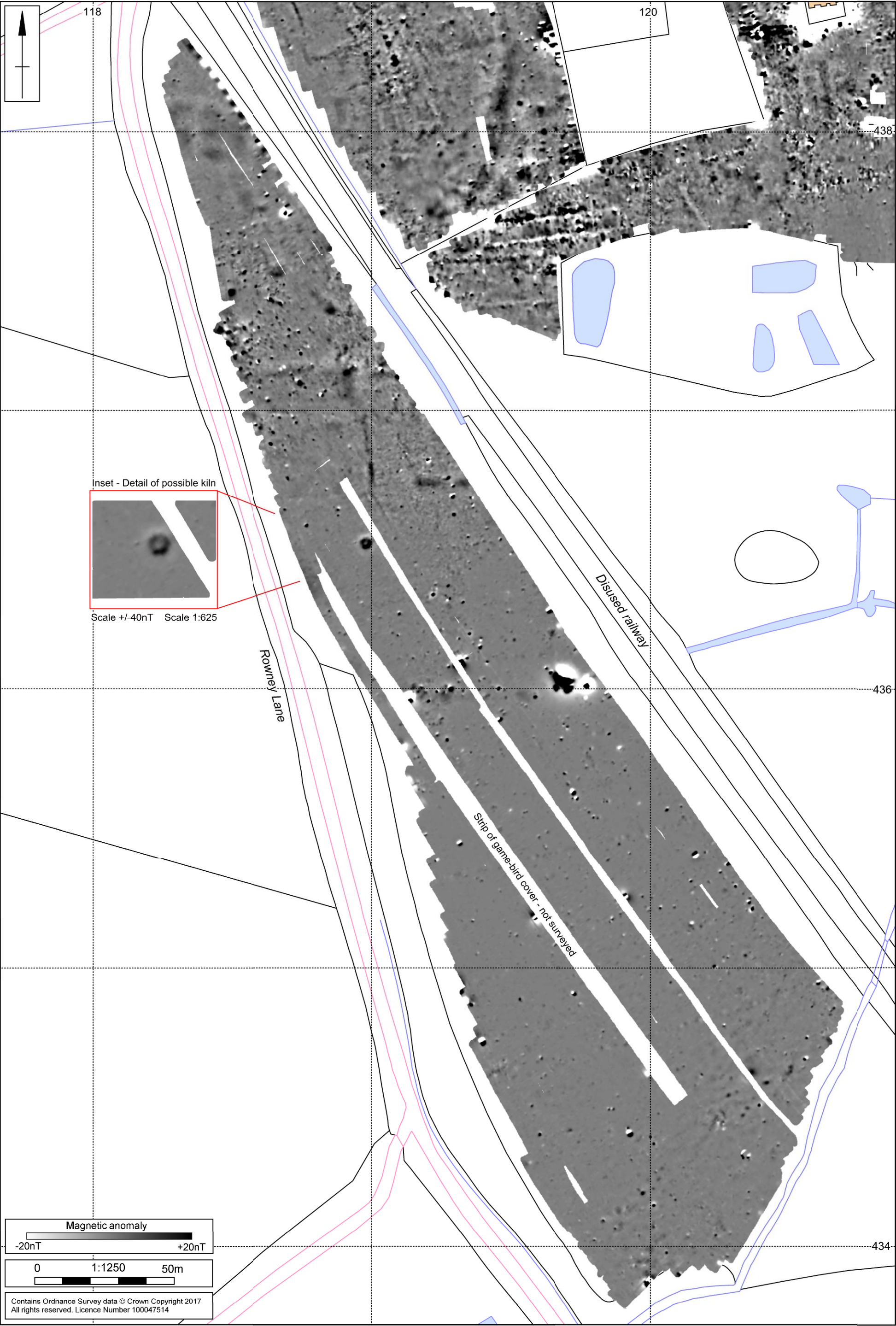
Scale 1:1250 (A3)

Magnetometer survey results (main area) Fig 5





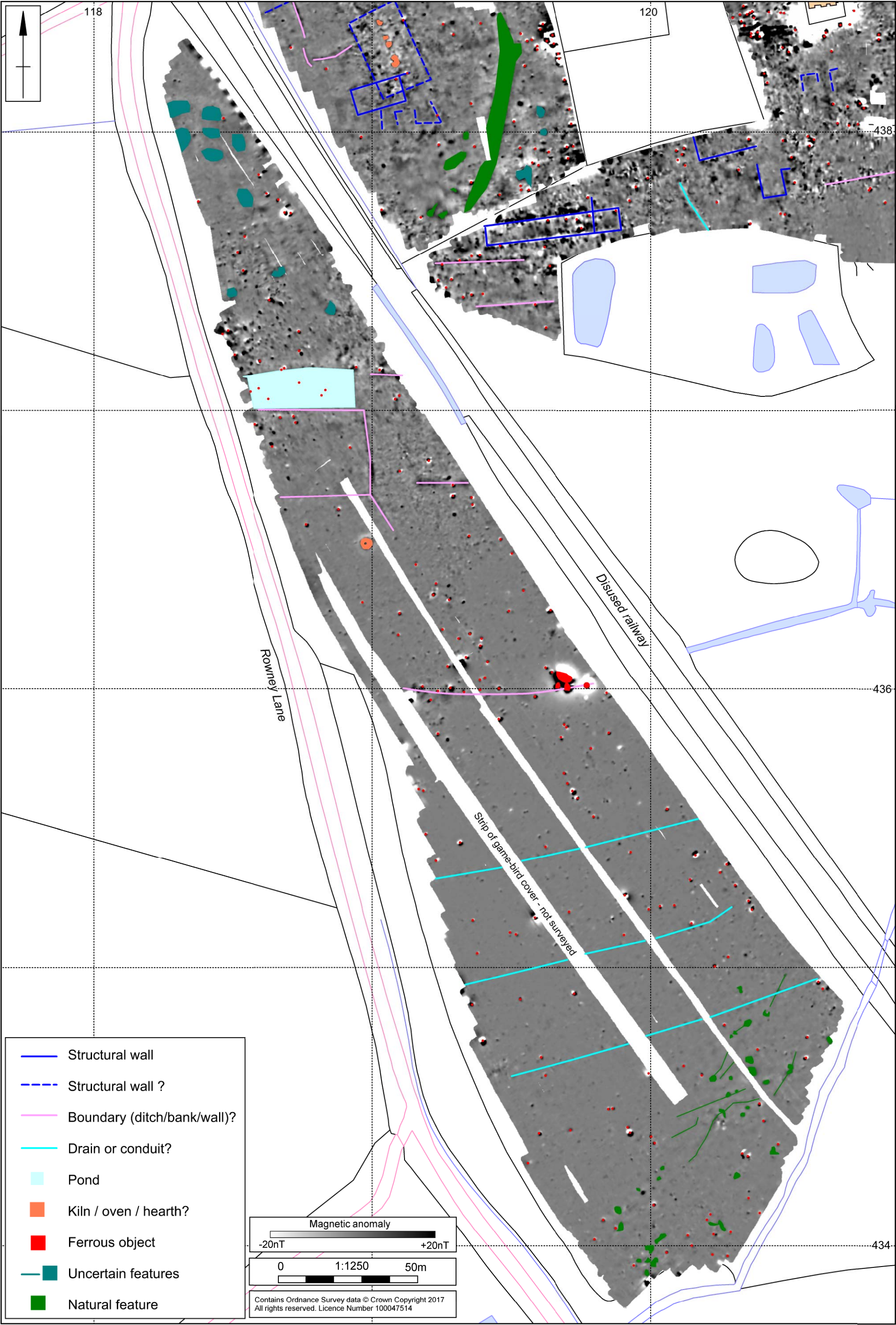




Scale 1:1250 (A3)

Magnetometer survey results (western area) Fig 7





Scale 1:1250 (A3)

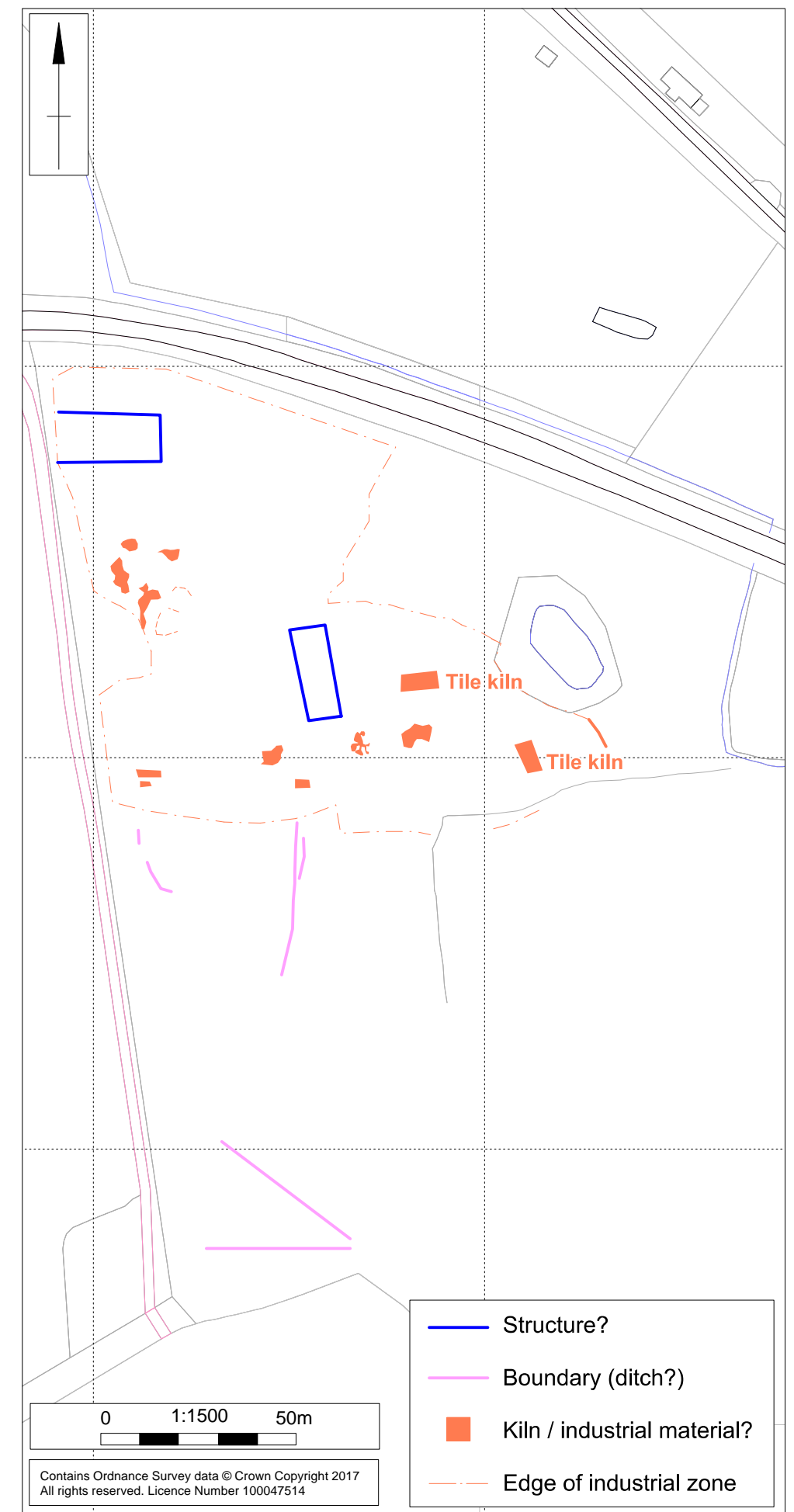
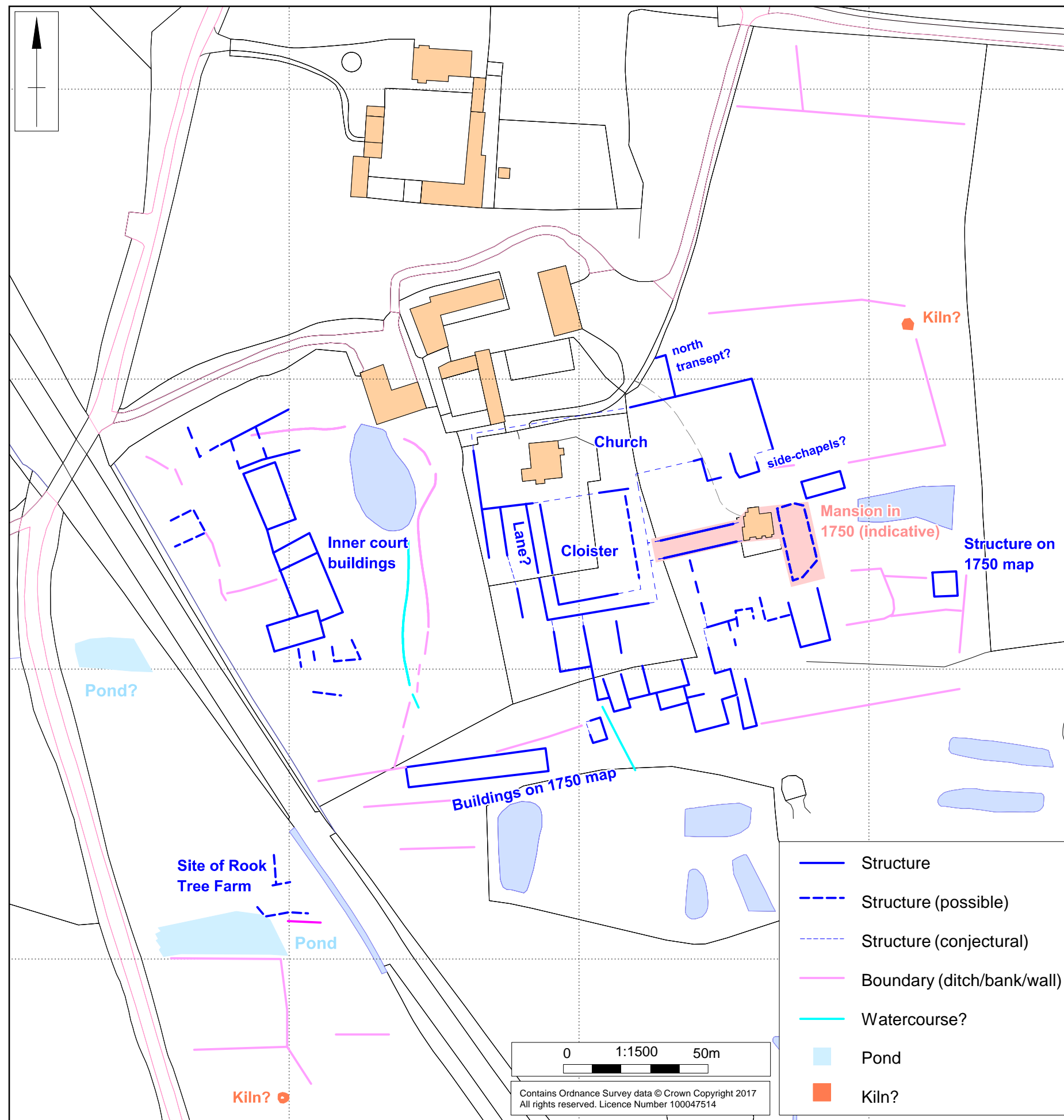
Magnetometer survey interpretation (western area) Fig 8



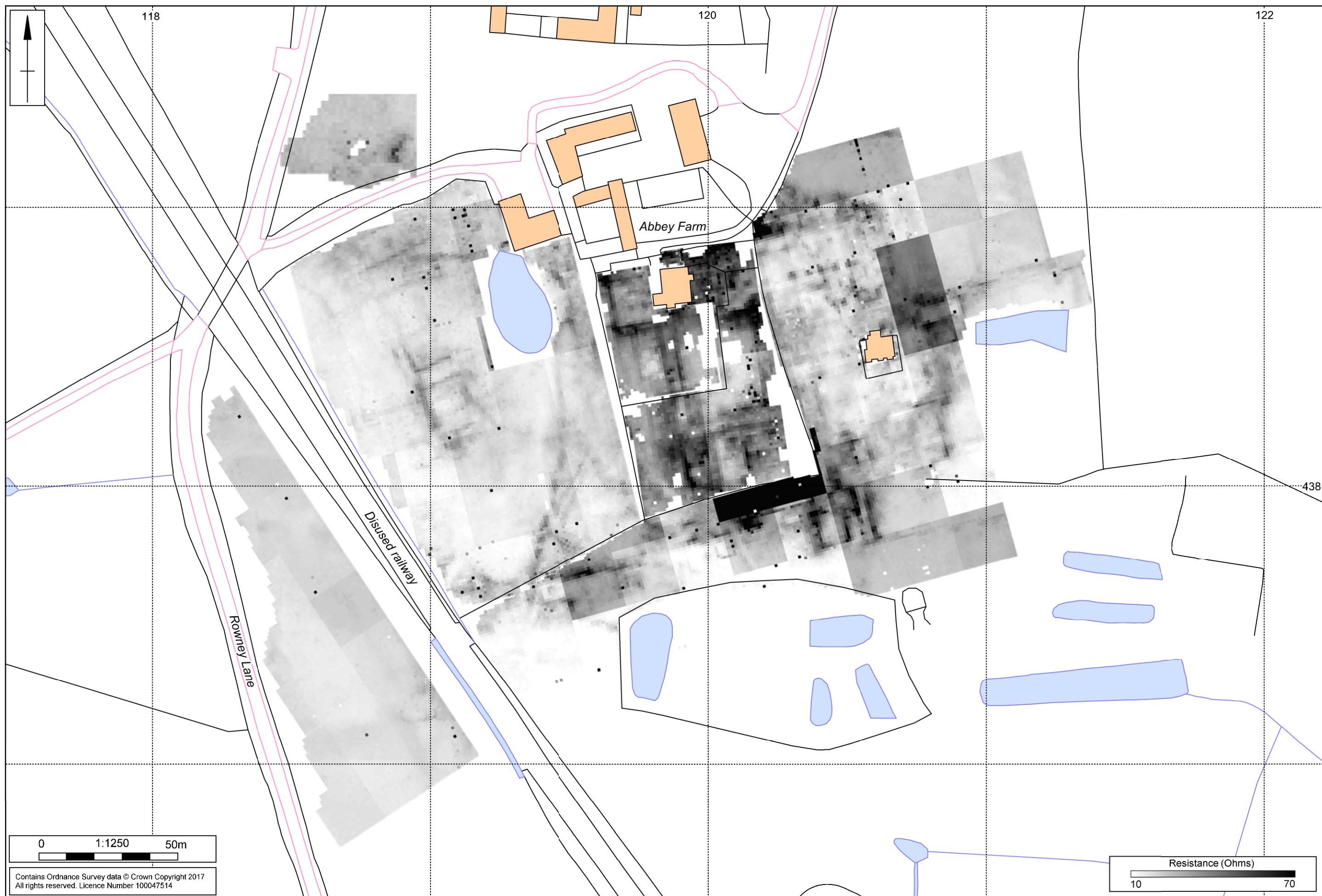








Simplified overviews of survey interpretation Fig 11







Scale 1:2000 (A3)

Unprocessed magnetometer data (main and western area) Fig 13







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