PORT MEADOW, Binsey, Oxford

Report on geophysical survey, May 2004.

Introduction

During 2004 the remains of a boat were discovered in the bank of the River Thames at Port Meadow near Binsey, Oxford (Ordnance Survey NGR 449800 207540) when Bossom's Boatyard, situated on the opposite bank, was carrying out river works. The prow of the boat was exposed projecting out of the riverbank and inspection indicated that it was constructed of wood with metal nails and fittings (Figure 1). Augering indicated that the remainder of the boat was buried beneath the soils of the riverbank but neither its age nor the reason why it became embedded could be immediately ascertained. Hence, a team of specialists was assembled from English Heritage (EH), Oxford University and Oxford City Council to examine the remains and the surrounding burial environment. As part of this work Christopher Welch, the EH Inspector of Ancient Monuments for Oxfordshire, requested that the EH Geophysics Team carry out a geophysical survey over the area of riverbank in which the boat was buried to help determine its extent and character.

Figure 1: The submerged boat remains with a 1m long ranging rod (left); the riverbank the boat is embedded in with a tape measure showing its approximate length and orientation (right).

The site of the boat lies within the scheduled area of ring ditches, barrows and associated enclosures at Port Meadow (monument number 12003). It was visited for the purposes of geophysical survey on the 24th and 25th of May 2004 during a period of dry sunny weather and two surveys were conducted over an area of 0.1ha on the riverbank immediately adjacent to the find spot. The Port Meadow area is covered with alluvium overlying Oxford Clay and Kellaways Beds with soils of the Thames association (stoneless mainly calcareous clayey soils affected by groundwater) developed over the alluvium. Given the proximity of the river the local soil would be expected to have a relatively high water content and would thus be expected to exhibit a high electrical conductivity in which resistive objects will produce strong contrasts. Magnetometer surveys over Oxford Clay are generally fairly successful in detecting archaeological features although the presence of alluvial cover has lead to highly variable levels of success at nearby river terrace sites between Yarnton and Cassington (Linford 2004).

Method

Survey Location

The boat remains were located by visual inspection of the river bank, then two semi-permanent ground markers were established using a Trimble kinematic differential global positioning system (GPS) at Ordnance Survey (OS) grid references 449804.181, 207539.656 and 449772.398, 207578.239. Witness photographs showing the position of these markers relative to a local boat jetty are held in the Geophysics Team archive. The GPS was then used to establish a 30m by 30m grid (slightly truncated by the river bank) parallel to this baseline and extending inland from the river edge around the area where the remains of the boat prow were visible. The locations of the survey grid and the semi-permanent markers are depicted superimposed on the OS map of the area at 1:2500 scale in Figure 2.

Magnetometer Survey

The visible boat remains included a number of iron or steel nails some 0.25m long projecting above the water line (see Figure 6a). As ferrous material was thus expected to be found in association with the boat, an initial magnetometer survey was carried out over the survey grid to pinpoint the location of any buried remains. The survey was carried out using a Bartington Grad601B dual sensor fluxgate gradiometer with traverses separated by 0.25m and oriented approximately NE to SW. The traverses were walked in parallel fashion, always beginning at the NE end, and measurements were taken at 0.125m intervals along each.

The survey results were corrected for differences in the zero-offset of the two sensors by zeroing the median of each traverse (destriping/unbunching). Slight shifting of each traverse to maximise correlation with its neighbours was also performed to compensate for variations in the operator’s pace (destaggering). Both techniques are described by Ciminale and Loddo (2001). No removal of near-surface iron spikes was performed as localised ferrous anomalies might be expected in response to ferrous objects associated with the boat.

The magnetometer survey is depicted as a linear greyscale plot superimposed onto the OS map at 1:750 scale in Figure 3 and Figure 5 depicts the results as both trace and linear greyscale plots at 1:250 scale, note that in Figure 5a the data has been truncated to remove data outside the range +/-500nT/m to allow the profiles of the most significant anomalies to be seen clearly.

Figure 6 provides a visual comparison between the measured magnetometer survey and synthetic data created by modelling the response expected from rows of buried iron nails and an interpretation of the significant anomalies detected in the survey is provided at a scale of 1:500 in Figure 9a.

Earth Resistance Survey

As contrasts in electrical conductivity might also be expected between the soil of the river bank and the materials comprising the buried boat, an earth resistance survey was carried out over the same grid. This was achieved using a Geoscan Research RM15 earth resistance meter connected to a twin electrode array along with an MPX15 multiplexer, to allow two separate surveys, with electrode separations of 0.5m and 1.0m, to be collected simultaneously. The 0.5m electrode separation coverage was designed to detect near-surface anomalies in the upper 0.5m of the subsurface whilst the 1.0m separation survey allowed anomalies to a depth of about 1-1.25m to be detected. For the 0.5m electrode separation survey readings were taken at a density of 0.5m by 0.5m whist for the 1.0m separation survey they were taken at a density of 0.5m by 1.0m.

Extreme values caused by high contact resistance were removed from both datasets using an adaptive thresholding median filter (Scollar et al. 1990, p492) with radius 1m. The results for the near-surface 0.5m electrode separation survey are depicted as a linear greyscale plot in Figure 4 superimposed on the OS map at a scale of 1:750. Results from both datasets are shown as both trace and greyscale plots at 1:250 scale in Figure 7. Noise between adjacent readings caused by differences in contact resistance was then reduced by processing both datasets with a local neighbourhood directional smoothing algorithm and the results are depicted as linear greyscale plots in Figures 8a and b. The 1.0m electrode separation dataset was then interpolated to the same reading density as the 0.5m separation data and the resistance measurements were corrected for the difference in electrode separation. This version of the 1m separation data was then subtracted from the 0.5m separation data to accentuate near-surface anomalies as depicted in Figure 8c. Figure 8d depicts the 1m separation data processed with the Wallis statistical differencing algorithm (Wallis 1976) using a window width of 15m to accentuate more deeply buried anomalies of archaeological scale.

Results

Interpretation diagrams showing the significant anomalies detected in the magnetic and earth resistance surveys are shown at a scale of 1:500 in Figures 9a and 9b respectively. Figure 10 shows the anomalies from the two different survey techniques superimposed as well as the locations of parts of the boat structure visible in the water measured with the GPS system. Overlain on Figure 10 are the approximate location and overall dimensions of the buried boat inferred from the geophysical results and GPS measurements.

Magnetometer Survey

Inspection of the magnetic results in Figure 5 shows that whilst the background soil magnetisation is very homogenous, generating vertical magnetic gradients in the range of +/-1nT/m, the area is scattered with discrete strongly magnetised responses with diameters between 0.5-1m and peak magnitudes in the range 30-100nT/m. These have been marked with a light brown hatch in Figure 9a and are likely to be caused by ferrous objects, possibly debris associated with the boat.

However, most striking are the two parallel linear anomalies, running almost N-S, that have been indicated using solid brown colouration in Figure 9a, along with a parallel line of four discrete anomalies. These all have peak magnetic gradients around 100nT/m and the two parallel linear anomalies meet the river bank at the points where the two sides of the prow visible in the water emerge. It is thus highly likely that these anomalies are caused by ferrous material associated with the buried boat and perhaps still structurally intact.

Overlying these linear anomalies are several amorphous areas of very steep magnetic gradients alternating rapidly between positive and negative polarity and with peak magnitudes up to 1000nT/m. These have been marked with a black stipple in Figure 9a and such anomalies are characteristic of near-surface ferrous material. Given their position they are likely to be caused by scatters of ferrous debris in the upper 0.2m of the subsurface, associated with the buried boat remains.

The two linear anomalies described above are likely to be directly associated with intact remains of the boat, so further consideration of their cause is warranted. Both anomalies are continuous, so it is tempting to suggest two continuous steel sheets as the causative features. However, focussing on just the longer of the two anomalies, its dimensions are ~17m long by about 1-1.5m wide. Shape-dependent demagnetizing factors (see for instance Evans and Heller 2003, p12) dictate that a sheet of magnetised material with these dimensions will tend to become magnetised in a direction approximately parallel to its long axis to minimise magnetostatic energy. As depicted in Figure 6c, a sheet magnetised in this way would produce a bipolar anomaly with one pole at either end (i.e. separated by 17m) rather than the continuous linear high magnitude anomaly actually observed.

Inspection of the remains visible in the water (Figure 6a) suggest a more likely cause as a two lines of ~0.25m long nails oriented roughly vertically with about 0.20m separating each nail from its neighbours on the line. GPS measurements indicated that, if continued into the river bank, the centres of each nail would be approximately 1m below the position of the bottom magnetometer sensor. With this burial depth the anomalies caused by individual nails would overlap, producing the appearance of a continuous magnetic anomaly at the surface. On the assumption that the two lines of nails mark the two sides of the boat, magnetic models were generated based on the dimensions noted above but with a range of different distances separating the two lines from each other. Three such models are depicted in Figures 6d-f. Each model was compared with the observed survey data using linear correlation with the method described by Linford (2005) and the best match was found to be with a line separation of 2.0m. The magnetometer survey thus suggests that the boat remains extend at least 17m into the river bank along an axis about 13.5° E of grid north and that the boat appears to be about 2.0m wide.

Earth Resistance Survey

As would be expected adjacent to a river bank, typical background earth resistance measurements are low reflecting relatively high soil moisture content; 0.5m electrode separation readings being in the range between 5-7 ohms and 1.0m separation readings between 4-5 ohms. Measurements were lowest in the N corner of the survey probably due to drainage patterns induced by local topography. However, at the S corner readings up to 28 ohms have been recorded in a region about 10m across which has been marked with a red hatch in Figure 9b. Given its sharply defined edges and high electrical contrast with the surrounding area, this almost certainly represents an artificial intervention, perhaps material introduced to try to strengthen the river bank. Running approximately NW from the NE edge of this feature, a boundary can be discerned in both earth resistance surveys (marked as a dashed blue line in Figure 9a) separating a region of higher earth resistance anomalies in the vicinity of the buried boat remains from lower values further inland. It is likely that this represents the extent of compacted soil fill surrounding the sunken boat, possibly suggesting it was deliberately buried as further strengthening of the river bank.

In the same area that the magnetometer survey detected ferrous anomalies associated with the buried boat, the near-surface data of Figure 7c suggests the presence of a high resistance anomaly (marked with a red crosshatch in Figure 9b) and a low resistance anomaly (blue stipple). It is likely that these both represent material from the superstructure of the boat buried relatively near to the surface.

Turning to the survey of Figure 7d, which reflects more deeply buried (~1m) anomalies, it can be seen that beneath the high resistance anomaly are two linear low resistance anomalies running NNW from the river bank for about 17m before apparently converging. These have been shown in solid blue in Figure 9b and it can be seen in Figure 10 that they correlate almost exactly with the linear magnetic anomalies interpreted as lines of nails. It is highly likely that this pair of anomalies represents the two sides of the hull of the boat although it is not possible to determine whether the material causing the increased electrical conductivity is metal or waterlogged wood. The electrical anomalies extend about 2m further at their NNW end than the longer of the two corresponding magnetic anomalies extending the estimate of the length of the buried part of the boat to 19m. The transverse distance between the centres of these two linear conductive anomalies at a position near the river bank is ~2.1m, very slightly greater than the distance estimated between the two linear magnetic anomalies but in good overall agreement with the former estimate.

Conclusions

Both the magnetometer and earth resistance surveys have detected anomalies associated with the buried boat and the information provided by each is complementary.

The magnetometer survey has identified large amounts of ferrous material in the vicinity including two parallel linear anomalies likely to be caused by lines of 0.25m long nails of the same type as those visible in the exposed submerged remains. The extensive use of metal in the boat’s construction tends to suggest that it dates from the relatively recent past, probably within the last 200 years.

The earth resistance survey has detected evidence of resistive compacted material adjacent to the river bank suggesting efforts to shore it against erosion. This perhaps indicates the reason why the boat was buried: having come to the end of its useful life it was deliberately sunk and incorporated into the river bank as additional strengthening material.

Both surveys have detected anomalies that can be directly associated with the structure of the buried boat and Figure 10 demonstrates that the two sets of anomalies correspond in position and correlate with locations where exposed submerged remains have been measured in with the GPS system. Taking all the geophysical evidence together with the GPS measurements of exposed remains, it is possible to suggest approximate overall dimensions for the buried boat and these have been overlain on Figure 10. It appears that it is about 21.5m (70') in length with a beam of about 2.0-2.1m (6'6" to 6'10"). It is interesting to note that these measurements correspond closely with the maximum dimensions for navigation of the Oxford Canal which are length 70' and beam 6'10" (Shead 2006). It is thus quite likely that the vessel was originally designed to traverse this waterway and the most obvious interpretation is that it was a narrow boat. However, some elements of its design deduced from the submerged part visible in the water are inconsistent with conventional narrow boat design, suggesting a more complex explanation (B Durham *pers. comm.*).

Surveyed by:	P Linford A Payne	Date of survey:	24-25/05/2004
Reported by:	P Linford	Date of report:	30/06/2006

Geophysics Team,
English Heritage

List of enclosed figures

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Figure 2) Port Meadow, Binsey, Oxford: Location of geophysical survey, May 2004.

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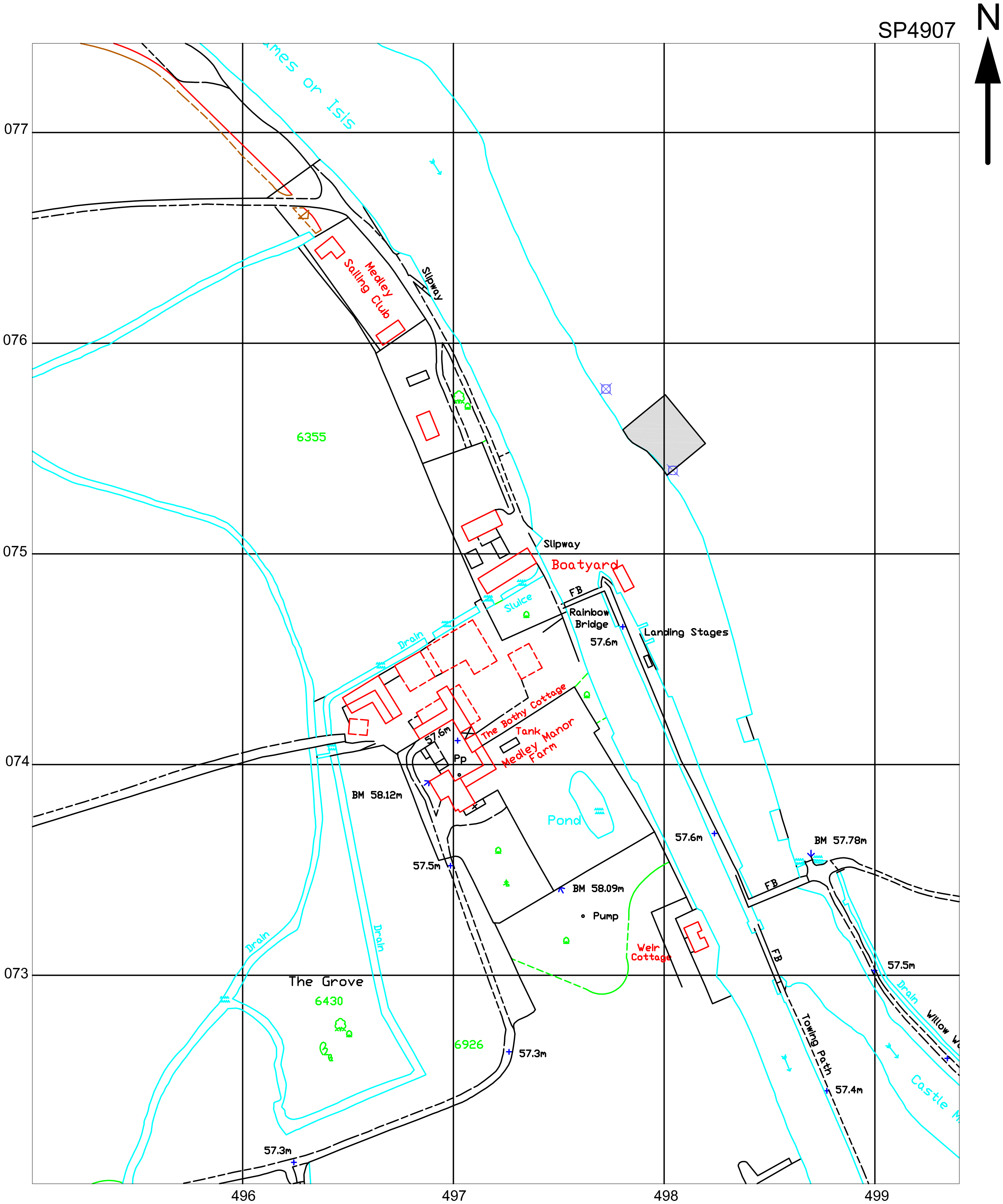

1 : 2500

0 50 150m

Geophysical survey area

Semi-permanent ground markers

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Figure 3) Port Meadow, Binsey, Oxford: Greyscale plot of magnetometer survey on base map, May 2004.

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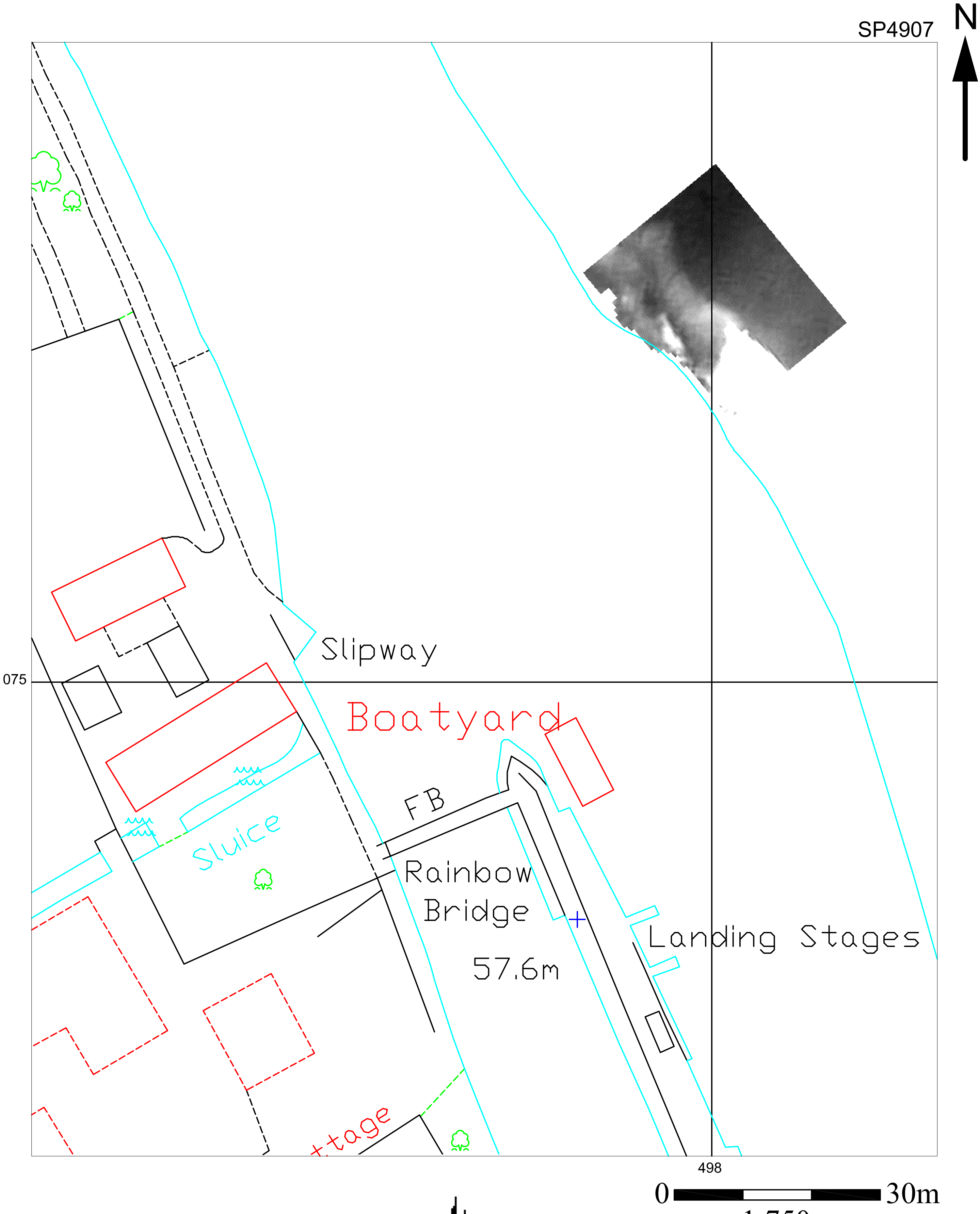
Figure 4) Port Meadow, Binsey, Oxford: Greyscale plot of earth resistance survey on base map, May 2004.



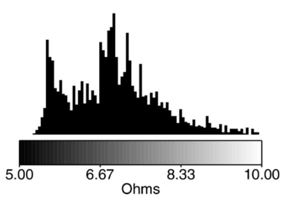


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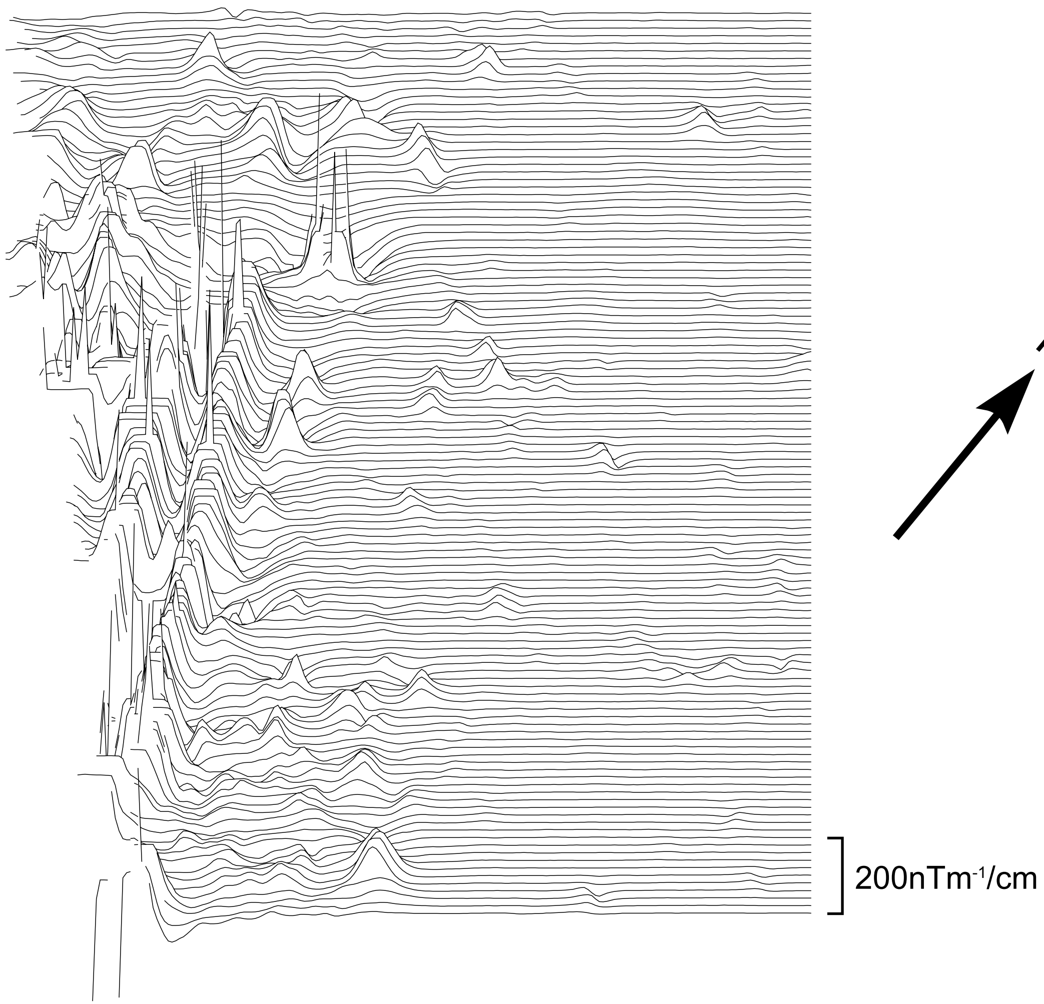
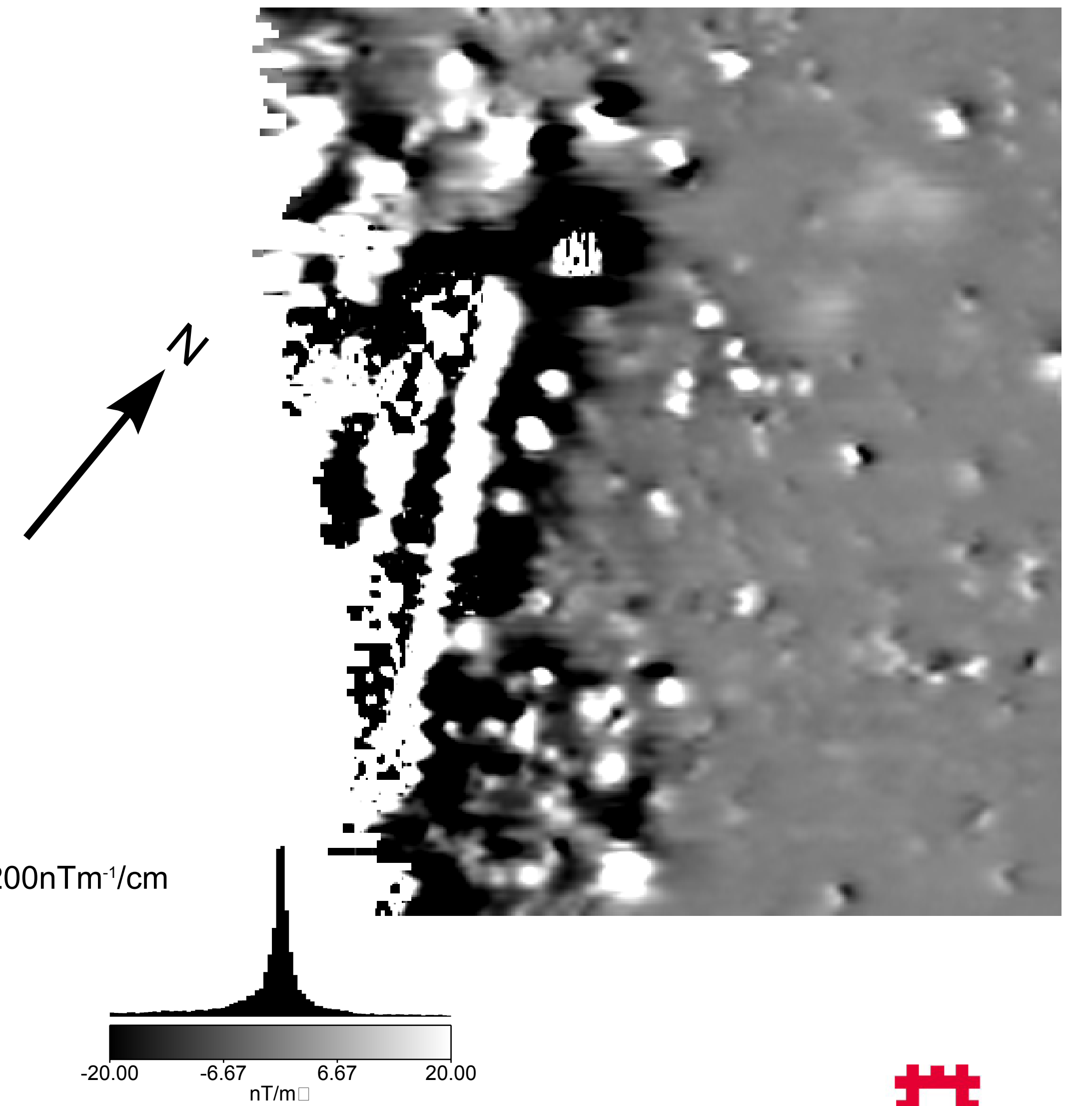
Figure 5) Port Meadow, Binsey, Oxford: Fluxgate gradiometer survey over buried boat, 24-25/05/2004.

a) Trace plot of magnetometer survey after destriping and truncation of data outside the range +/-500nT/m.



b) Linear greyscale plot of the magnetometer data from a).



0 15m

1:250

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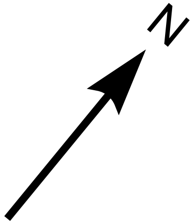
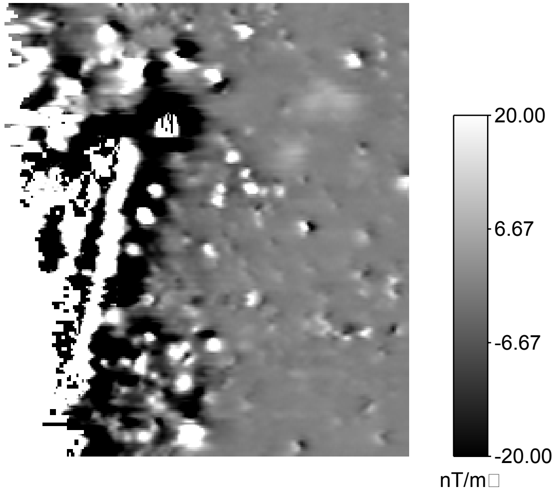
Figure 6) Port Meadow, Binsey, Oxford: Magnetic models compared with the boat's magnetic anomaly.

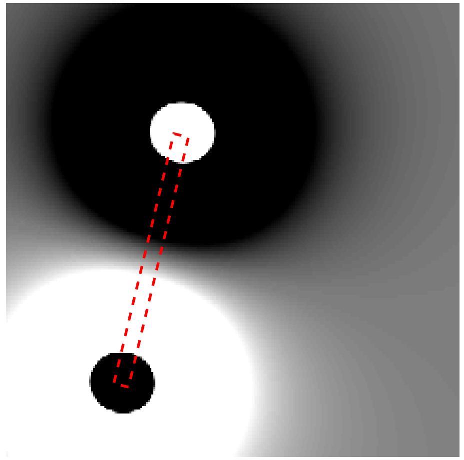
a) Nails visible in the exposed part of the boat. The ranging rod is 1m long.



b) Linear greyscale plot of magnetic survey for comparison.



c) Magnetic anomaly due to a continuous sheet (red dashed outline) magnetised along its length.



Magnetic model of two rows of 0.25m long vertical nails, spaced 0.2m apart and at a depth of 1m beneath the magnetometer's bottom sensor. The two rows are separated by a distance of:

d) 1.85m (~6 feet).

e) 2.00m (~6 feet, 6 inches), the best match.

f) 2.15m (~7 feet).

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Figure 7) Port Meadow, Binsey, Oxford: Earth resistance survey over buried boat, 24-25/05/2004.

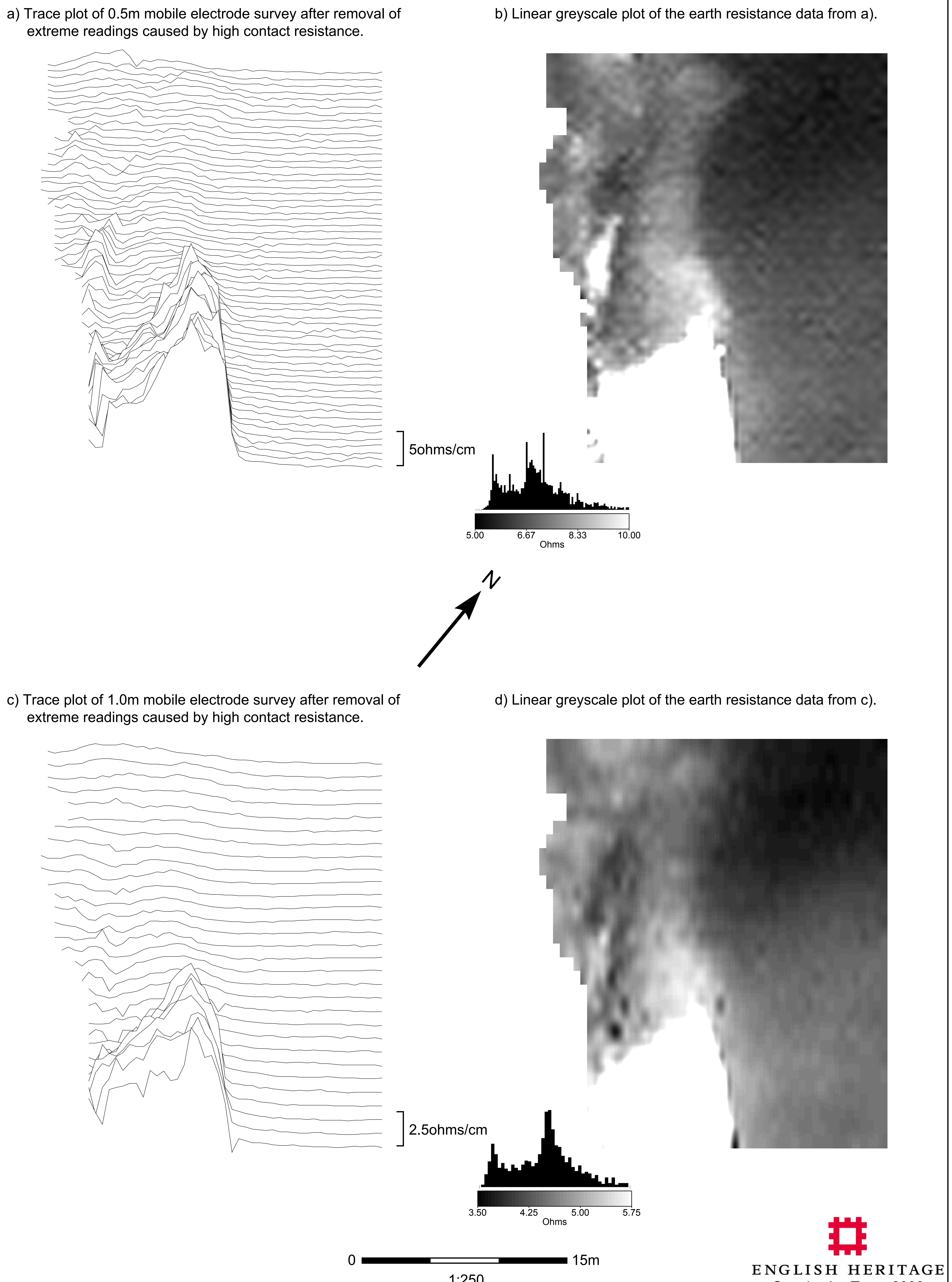

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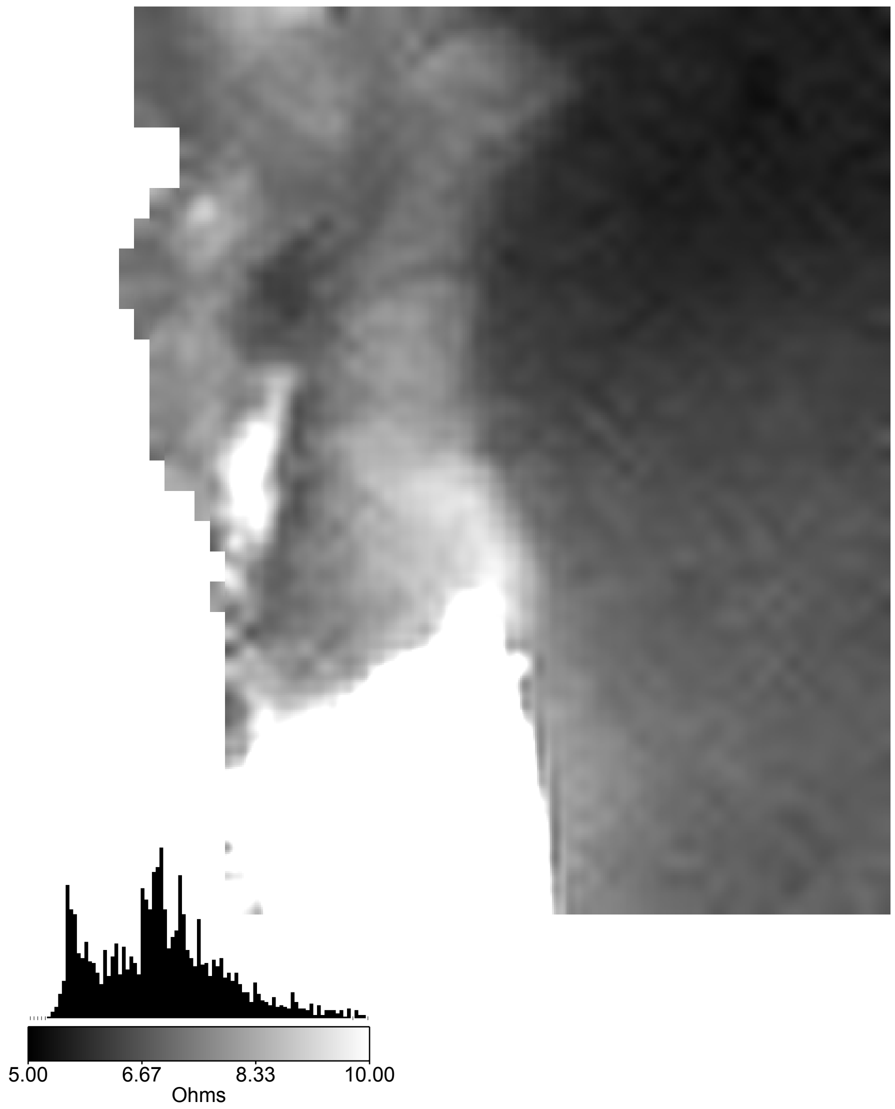
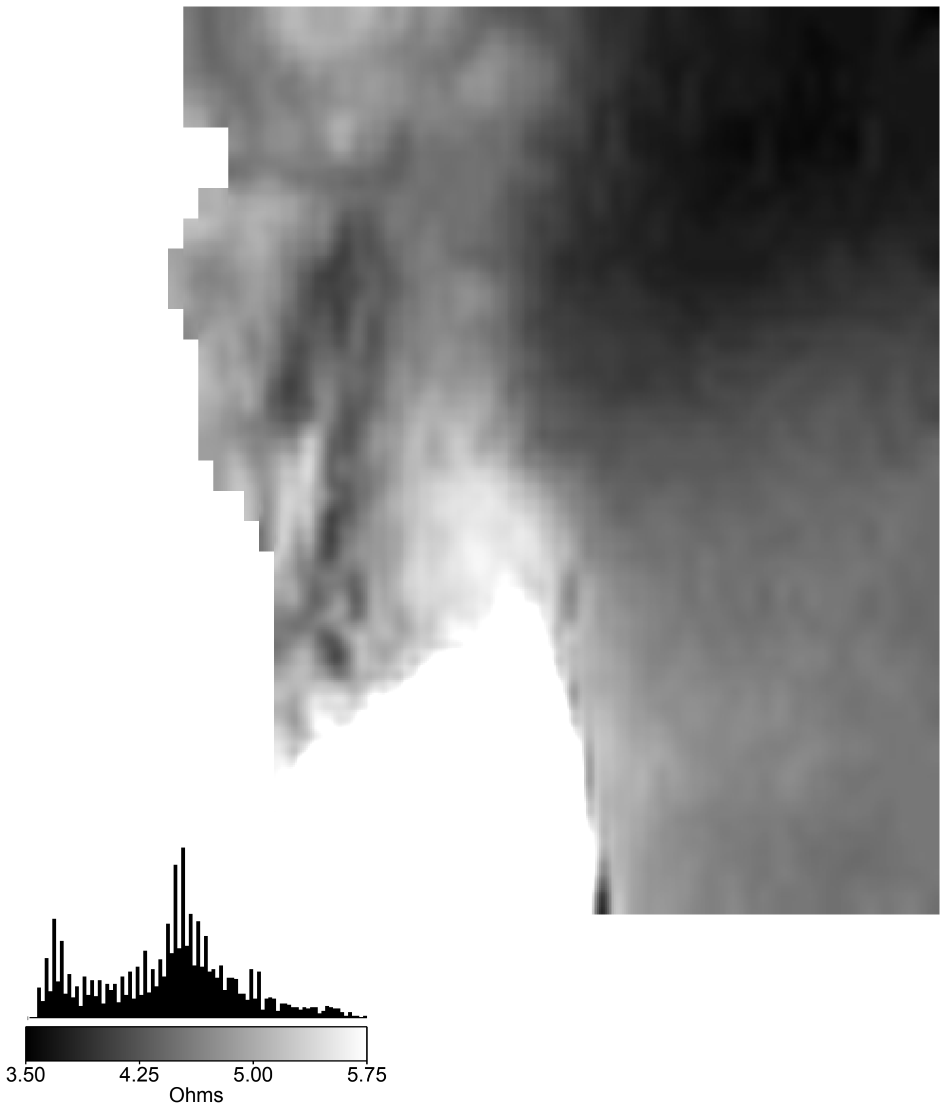
Figure 8) Port Meadow, Binsey, Oxford: Processed earth resistance data sets.

a) Greyscale plot of 0.5m mobile electrode data after filtering with local neighbourhood directional smoothing algorithm.



b) Greyscale plot of 1.0m mobile electrode data after filtering with local neighbourhood directional smoothing algorithm.



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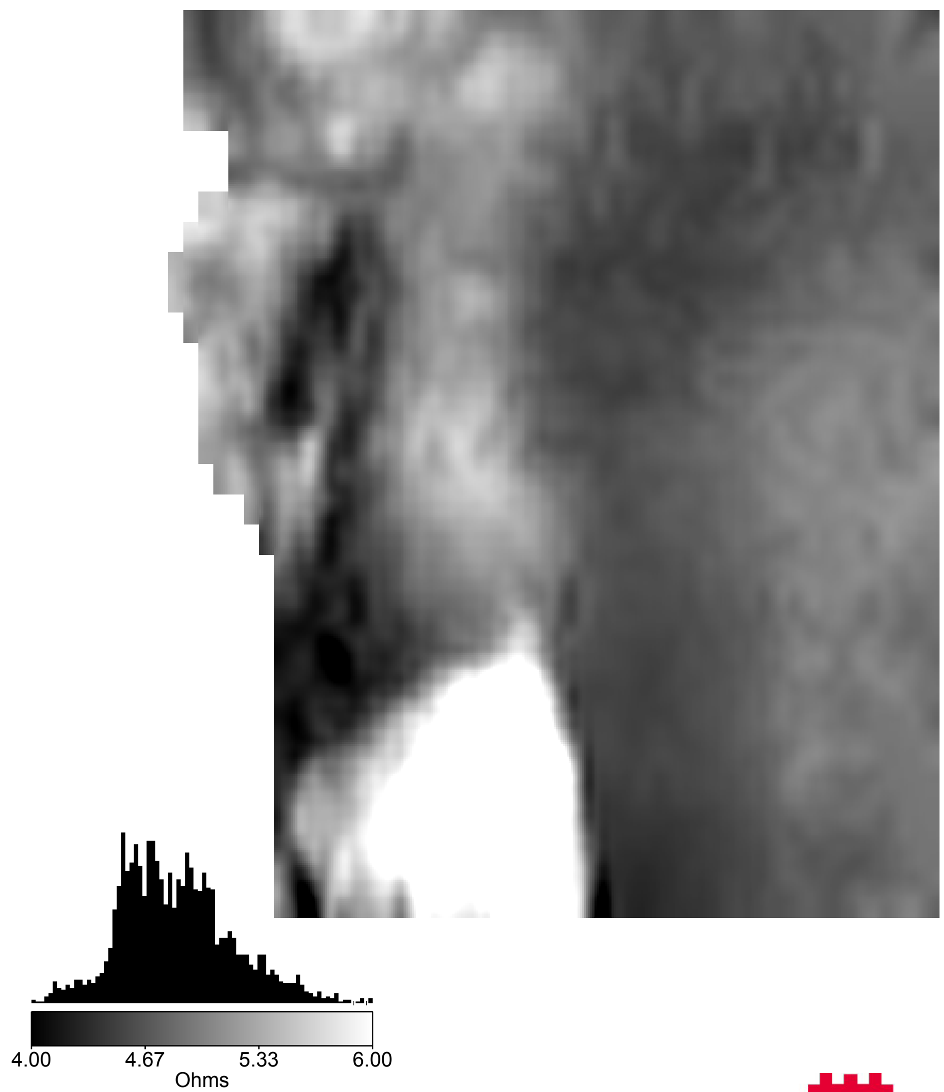
c) 0.5m electrode separation data from a) after subtraction of corresponding reading from 1.0m separation data from b). The latter was first corrected for the difference in mobile electrode separation. The result accentuates near surface anomalies.

d) 1m separation data from b) after processing with the Wallis contrast enhancement algorithm using a window size of 15m. The result shows more deeply buried anomalies without the obscuring effects of large-scale trends.



0 15m

1:250

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Figure 9) Port Meadow, Binsey, Oxford: Interpretation of geophysical anomalies, May 2004.

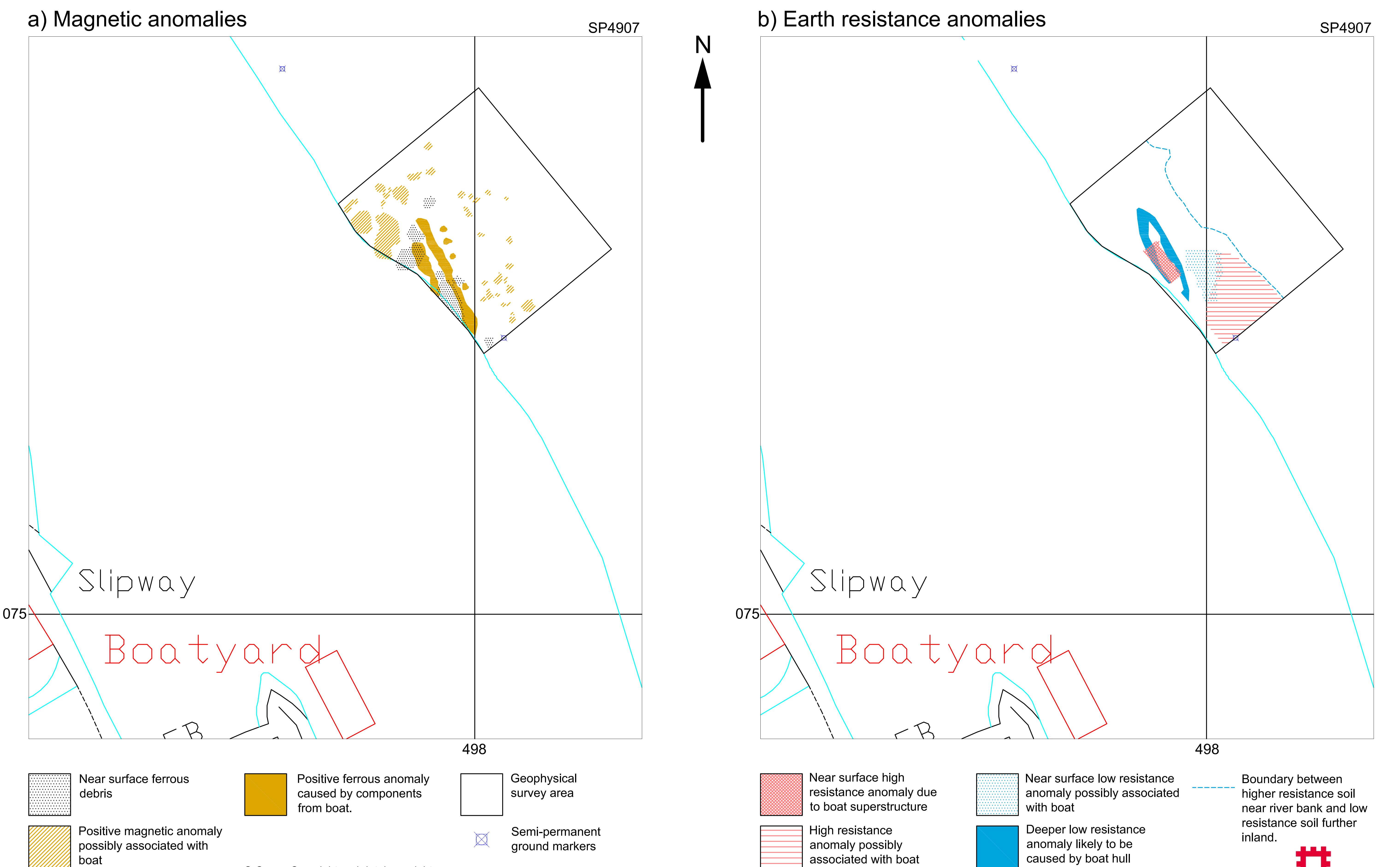

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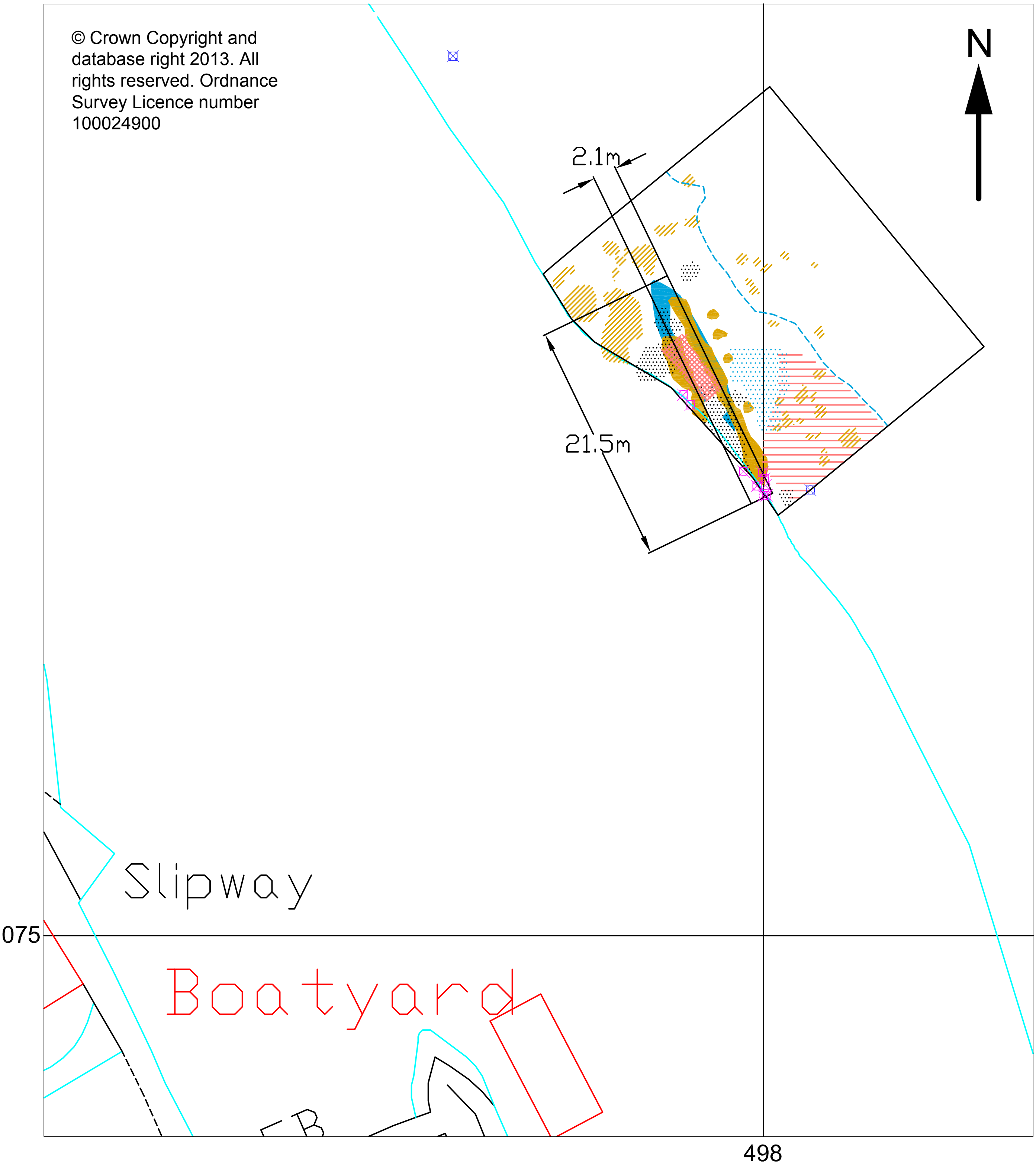
Figure 10) Port Meadow, Binsey, Oxford: Superposition of magnetic and earth resistance interpretations showing inferred boat dimensions, May 2004.



Semi-permanent ground markers

Measured position of part of exposed boat structure

Anomaly key as in Figure 9

0 30m
1:500

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