Ancient Monuments Laboratory
Report 31/2000

ETAL CASTLE, ETAL, NORTHUMBERLAND, REPORT ON GEOPHYSICAL SURVEY, 1998

P K Linford

Opinions expressed in AML reports are those of the author and are not necessarily those of English Heritage (Historic Buildings and Monuments Commission for England).

Ancient Monuments Laboratory Report 31/2000

ETAL CASTLE, ETAL, NORTHUMBERLAND, REPORT ON GEOPHYSICAL SURVEY, 1998

P K Linford

Summary

A geophysical survey was carried out at Etal Castle in Northumberland in an attempt to locate remains of a putative fourth tower suggested by the topography of the site. An excavation in the 1970's had previously been attempted in the most likely position but had found no traces of wall footings for such a tower. The geophysical survey results did not produce unequivocal evidence for a fourth tower but did detect another possible location for it along the north east boundary of the castle site, as well as finding the probable location of the excavation.

Author's address :-

Mr P K Linford
ENGLISH HERITAGE
Centre For Archaeology Fort Cumberland
Fort Cumberland Road Eastney
Portsmouth
HANTS
UK
PO4 9LD

© Historic Buildings and Monuments Commission for England

ETAL CASTLE, ETAL, NORTHUMBERLAND

Report on Geophysical Survey, October 1988.

Introduction

The site of Etal Castle in Northumberland (NT 9239 3939) consists of the great tower to the north west, a gate tower to the south east and a smaller third tower to the south west. A length of the original curtain wall survives connecting the latter two. The layout of the surviving ruins and the topography of the ground surface suggest that a fourth tower may originally have existed of which no trace now remains. An excavation was carried out in the 1970s to attempt to locate this fourth tower but no traces were uncovered.

Geologically the site is situated on Tournaisian and Viséan carboniferous limestone (Institute of Geological Sciences, 1979), overlain with boulder clay (Geological Survey of Great Britain 1979). The soil association, SALOP (711m, Soil Survey of England and Wales, 1983) states that the soil is "slowly permeable seasonally waterlogged reddish fine loam over clayey, fine loamy and clayey soils associated with fine loamy over clayey soils with slowly permeable subsoils and slight seasonal waterlogging". Hence, whilst resistive anomalies might be expected to be well defined in the conductive soil, the heterogeneous nature of the boulder clay and localised waterlogging might lead to a confusing background response from which archaeological anomalies may be difficult to distinguish.

Method

Field Procedure

A grid of two 30 metre squares [1 and 4] was established in the area between the keep and the gatehouse and three smaller partial squares [2, 3 and 5] were adjoined to these to cover as much of the site as the boundaries and topography would allow (north of square 5 the ground sloped away steeply and it was not possible to survey that area). The location of this grid was determined by tape measurement to the adjacent keep and gatehouse and it is depicted in Figure 1.

Squares 1 and 4 in Figure 1 were surveyed with a Geoscan FM36 fluxgate gradiometer according to the standard technique outlined in Annex 1, note 2. All the squares were then surveyed using a Geoscan RM4 earth resistance meter with a mobile electrode separation of 0.5m. This was done according to the technique described in Annex 1. Finally the earth resistance survey in squares 3-5 was repeated with the reading stations offset 0.5m to the north. When combined with the first earth resistance measurements for these squares, this provided a higher 0.5x1m resolution resistivity survey for the northern half of the site.

Data Processing and Presentation

The magnetometer results were corrected for instrument heading errors by subtracting the median value of each traverse from all measurements on the traverse ("unbunching" or "destepping"). These results are depicted as a trace plot at 1:500 scale in Figure 2a. The results were then additionally processed with an adaptive thresholding median filter to replace measurements of extreme magnitude with a local median calculated over a 2m by 2m rectangular window ("despiking"). Such values are usually caused by modern, near surface, ferrous material and, if not removed, can skew the statistical distribution of the data set. The results after this second processing step are depicted as a linear greyscale plot at 1:500 scale in Figure 3.

The unprocessed 1m by 1m resistivity measurements are depicted as a trace plot in Figure 2b at 1:500 scale. This data set was then also treated with an adaptive thresholding median filter to replace measurements of extreme magnitude, caused by poor electrode contact, with a local median calculated over a 2m by 2m rectangular window. The results after this operation are depicted as a 1:500 scale greyscale plot in Figure 4.

The unprocessed 0.5m by 1m resistivity survey of the northern part of the site is depicted as a trace plot at 1:500 scale in Figure 5a. Figure 5b depicts the same data, again as a trace plot, after processing with a 1m by 1m adaptive thresholding median filter to remove extreme values. The data in this figure has been further processed using a 3x1 reading gaussian low pass convolution mask with weights [1, 3, 1] to reduce discontinuities between the original and offset datasets which make up this survey. These discontinuities were caused by changes in soil moisture due to precipitation between the times of the original and offset surveys. The data from Figure 5b is presented as a linear greyscale plot at 1:500 scale in Figure 6.

Results

The anomalies described in this section are all indicated on the interpretation plan in Figure 7, further discussion of this figure is provided in the conclusions below.

The magnetometer survey

It is clear from Figure 2a that most of the anomalies detected in the magnetometer survey are of extremely high magnitude and are likely to represent relatively modern intervention at the site. A linear anomaly of alternating high and low magnetisation can be seen following the line of the old trackway marked on the plan of the castle. This is likely to represent a modern pipeline running along the side of this route.

To the south of this, in square 1, is a sub rectangular area of high magnetisation measuring some 15m north-south by 10m east-west. If one were to project lines out perpendicular to the faces of the keep and gatehouse, this is where they would meet, and this is a likely location for a possible fourth tower. However the magnitude of the magnetic disturbance suggests that this is a modern intervention and it is possible that the anomaly marks the position of the excavation trench which set out to locate the fourth tower. A resistivity anomaly occurs within this magnetic anomaly and this is discussed below.

The earth resistance survey

Just to the northeast of the keep in square 2 the resistivity survey has detected a number of high resistance anomalies which suggest by their position and alignment that they represent the remains of a structure once associated with it.

About 30m to the northeast of these in square 1, within the rectangular magnetic anomaly described above, another high resistance anomaly has been detected which is approximately square with sides about 5m long. As discussed above this is in the position where one might assume a fourth tower would be located. However, it is rather small in area compared to both the keep and the gatehouse. Furthermore, it is known that excavations in this area found no trace of wall footings, so it is perhaps more likely that this anomaly was caused by backfilling the excavation trench.

Further to the northeast at the eastern edge of the survey area and straddling squares 1 and 4 is a large high resistance anomaly some 18m long by 6m wide. This is close to the present site boundary and may represent modern activity but its position and size does make it a likely candidate to represent buried rubble remains of a fourth tower.

At the southern end of the survey in square 1, some less intense high resistance anomalies have been indicated, in association with a discrete low resistance anomaly which might have archaeological significance.

Some further anomalies have also been indicated in square 4 to the north of the old trackway. However, it should be borne in mind that these could be caused by trees in this area altering the natural soil moisture levels of the surrounding ground.

The 0.5m by 1m earth resistance survey

Knowing that no trace of a fourth tower had been discovered in the most probable position, it was decided to carry out a higher resolution survey over the northern part of the site in case the tower had been offset in this direction and its surviving remains were slight. However, it is clear from comparison of Figures 4 and 6 that the additional measurements have revealed little information not discernable in the initial survey.

Conclusions

The geophysical survey has not been able to identify unequivocal evidence for the existence of a fourth tower at Etal Castle. Nevertheless, rectangular anomalies have been detected by both the magnetometer and the earth resistance meter in the most likely location of such a tower. However, the strength of the magnetic response in particular suggests that these probably represent modern intervention, perhaps the excavation carried out in the 1970s attempting to locate the tower.

Some 10m to the south east of these anomalies, against the south east boundary of the castle site, the resistance survey has detected another amorphous high resistance anomaly likely to represent a rubble spread. This is a possible candidate location for a putative fourth tower, although no evidence of curtain wall footings connecting it to any of the other towers is apparent in the survey.

Some other anomalies of possible archaeological significance have also been identified, the most prominent being the line of an old hollow trackway.

Surveyed by: A. Payne, P. Linford — Dates: 18th-20th October 1988

Report by: P. Linford — Date: 6th June 2000

References

Geological Survey of Great Britain, 1979,
1:50,000 Drift Edition, Sheet 3, Ford.

Institute of Geological Sciences, 1979
1:625,000 Geological Map of the UK, North, 3rd Edition, Solid.

Soil Survey of England and Wales, 1983,
Legend for the 1:250,000 Soil Map of England and Wales.

Enclosed Figures and plans

Annex 1: Notes on standard procedures

1) **Resistivity Survey:** Each 30 metre square is surveyed by making repeated parallel traverses across it, all aligned parallel to one pair of the square's edges, and each separated by a distance of 1 metre from the last; the first and last traverses being 0.5 metres from the nearest parallel square edge. Readings are taken along each traverse at 1 metre intervals, the first and last readings being 0.5 metres from the nearest square edge.

   Unless otherwise stated the measurements are made with a Geoscan RM15 earth resistance meter incorporating a built-in data logger, using the twin electrode configuration with a 0.5 metre mobile electrode separation. As it is usually only relative changes in resistivity that are of interest in archaeological prospecting, no attempt is made to correct these measurements for the geometry of the twin electrode array to produce an estimate of the true apparent resistivity. Thus, the readings presented in plots will be the actual values of earth resistance recorded by the meter, measured in Ohms (Ω). Where correction to apparent resistivity has been made, for comparison with other electrical prospecting techniques, the results are quoted in the units of apparent resistivity, Ohm-m (Ωm).

   Measurements are recorded digitally by the RM15 meter and subsequently transferred to a portable laptop computer for permanent storage and preliminary processing. Additional processing is performed on return to the Ancient Monuments Laboratory using desktop workstations.

2) **Magnetometer Survey:** Each 30 metre square is surveyed by making repeated parallel traverses across it, all parallel to that pair of square edges most closely aligned with the direction of magnetic North. Each traverse is separated by a distance of 1 metre from the last; the first and last traverses being 0.5 metre from the nearest parallel square edge. Readings are taken along each traverse at 0.25 metre intervals, the first and last readings being 0.125 metre from the nearest square edge.

   These traverses are walked in so called 'zig-zag' fashion, in which the direction of travel alternates between adjacent traverses to maximise survey speed. However, the magnetometer is always kept facing in the same direction, regardless of the direction of travel, to minimise heading error.

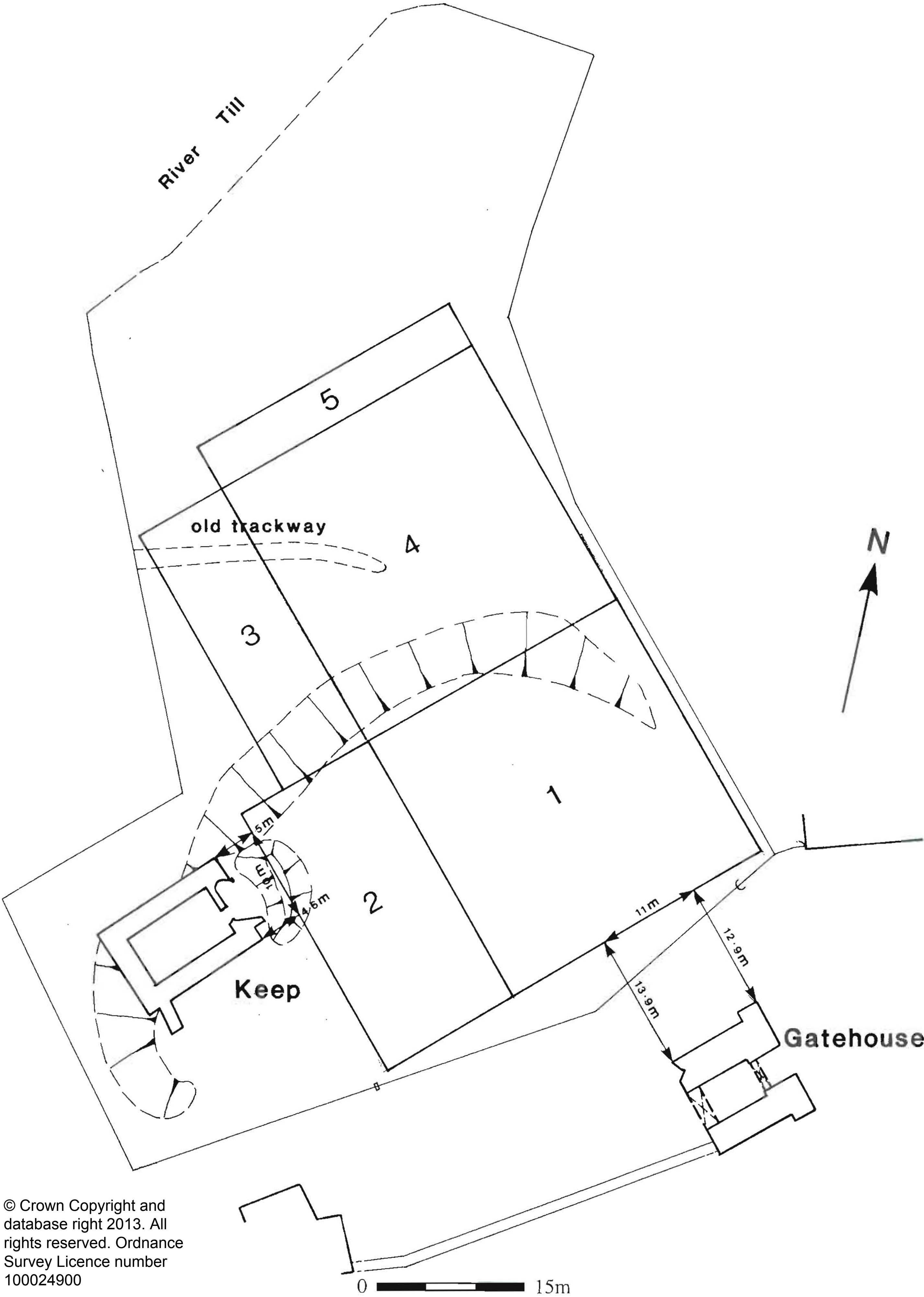
   Unless otherwise stated the measurements are made with a Geoscan FM36 fluxgate gradiometer which incorporates two vertically aligned fluxgates, one situated 0.5 metres above the other; the bottom fluxgate is carried at a height of approximately 0.2 metres above the ground surface. The FM36 incorporates a built-in data logger that records measurements digitally; these are subsequently transferred to a portable laptop computer for permanent storage and preliminary processing. Additional processing is performed on return to the Ancient Monuments Laboratory using desktop workstations.

It is the opinion of the manufacturer of the Geoscan instrument that two sensors placed 0.5 metres apart cannot produce a true estimate of vertical magnetic gradient unless the bottom sensor is far removed from the ground surface. Hence, when results are presented, the difference between the field intensity measured by the top and bottom sensors is quoted in units of nano-Tesla (nT) rather than in the units of magnetic gradient, nano-Tesla per metre (nT/m).

3) **Resistivity Profiling:** This technique measures the electrical resistivity of the subsurface in a similar manner to the standard resistivity mapping method outlined in note 1. However, instead of mapping changes in the near surface resistivity over an area, it produces a vertical section, illustrating how resistivity varies with increasing depth. This is possible because the resistivity meter becomes sensitive to more deeply buried anomalies as the separation between the measurement electrodes is increased. Hence, instead of using a single, fixed electrode separation as in resistivity mapping, readings are repeated over the same point with increasing separations to investigate the resistivity at greater depths. It should be noted that the relationship between electrode separation and depth sensitivity is complex so the vertical scale quoted for the section is only approximate. Furthermore, as depth of investigation increases the size of the smallest anomaly that can be resolved also increases.

Typically a line of 25 electrodes is laid out separated by 1 or 0.5 metre intervals. The resistivity of a vertical section is measured by selecting successive four electrode subsets at increasing separations and making a resistivity measurement with each. Several different schemes may be employed to determine which electrode subsets to use, of which the Wenner and Dipole-Dipole are typical examples. A Campus Geopulse earth resistance meter, with built in multiplexer, is used to make the measurements and the Campus Imager software is used to automate reading collection and construct a resistivity section from the results.

Figure1) ETAL CASTLE, NORTHUMBERLAND: Location of geophysical survey grid superimposed on estate plan, 1988.

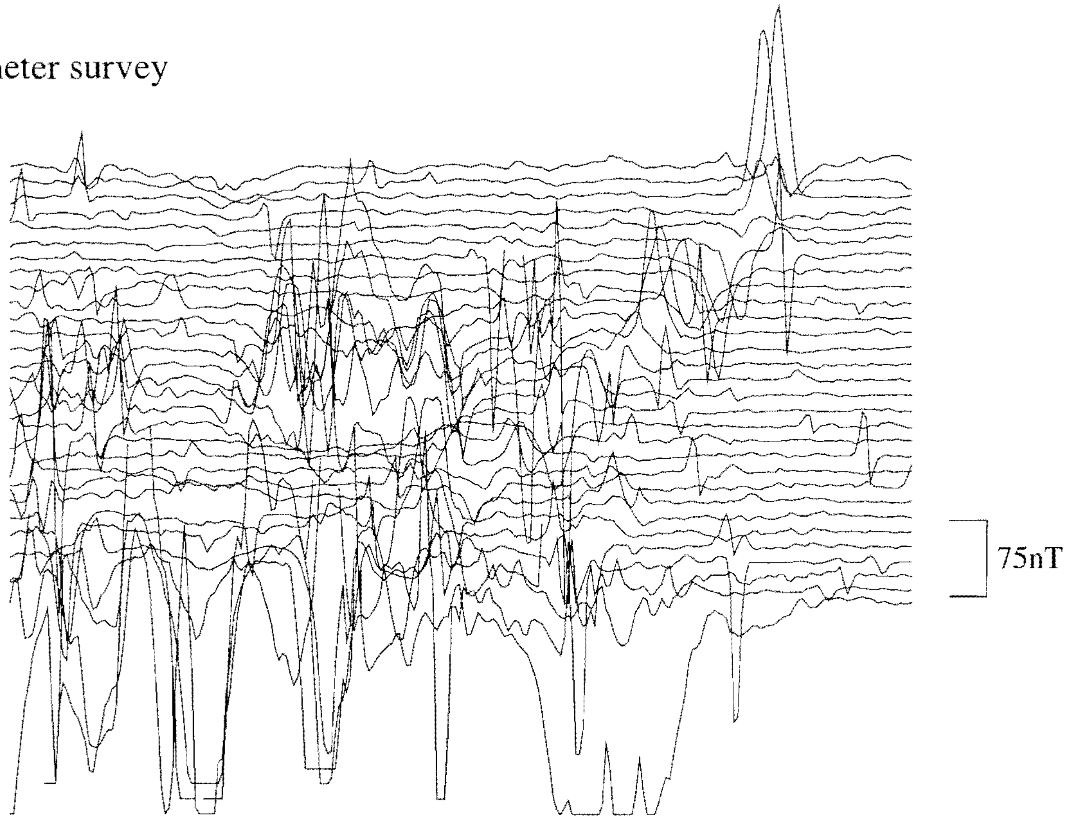


© Crown Copyright and database right 2013. All rights reserved. Ordnance Survey Licence number 100024900

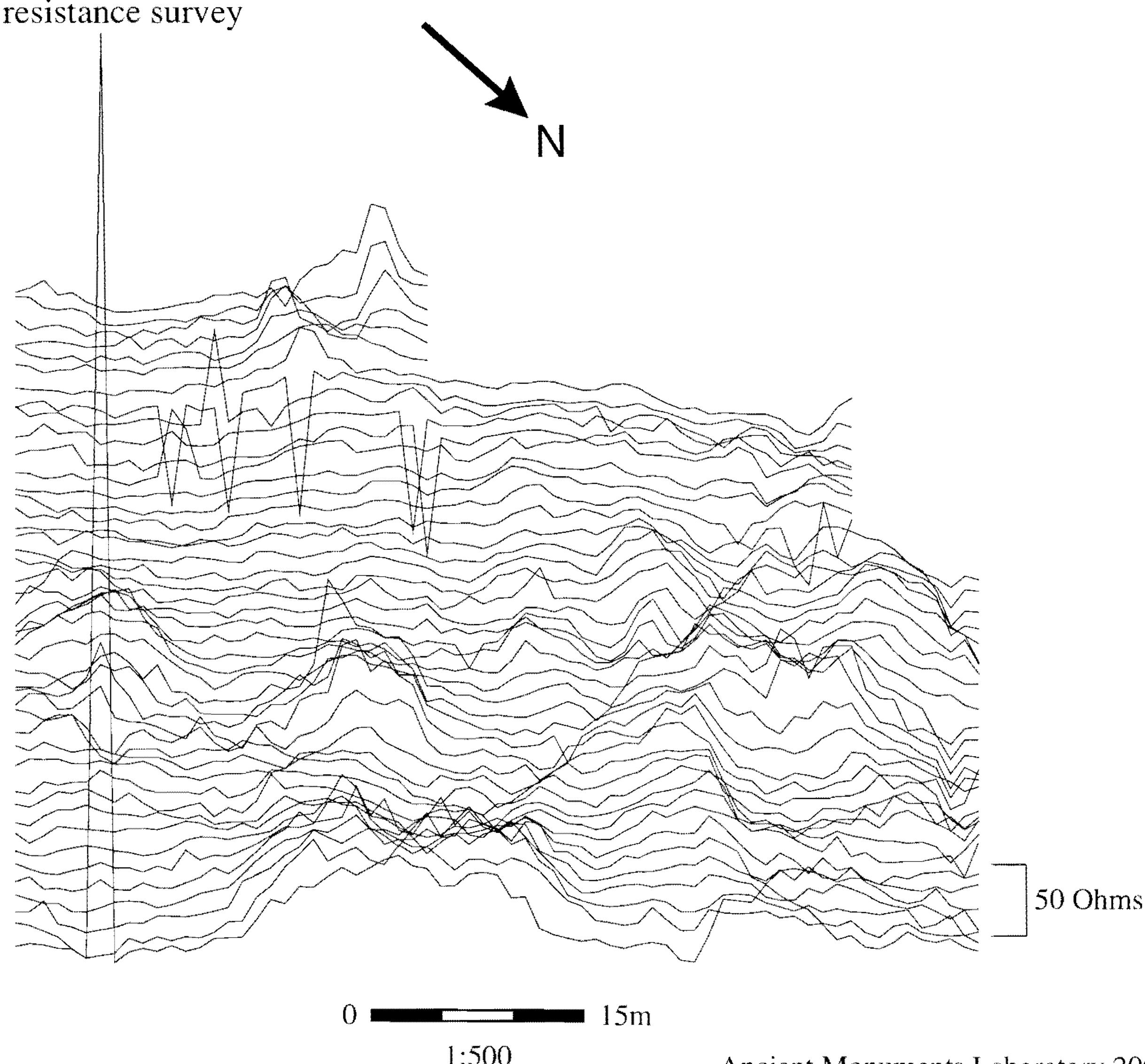
Ancient Monuments Laboratory 2000

Figure 2) ETAL CASTLE, NORTHUMBERLAND: Trace plots of unprocessed magnetometer and 1x1m earth resistance measurements, 1988.

a) Magnetometer survey

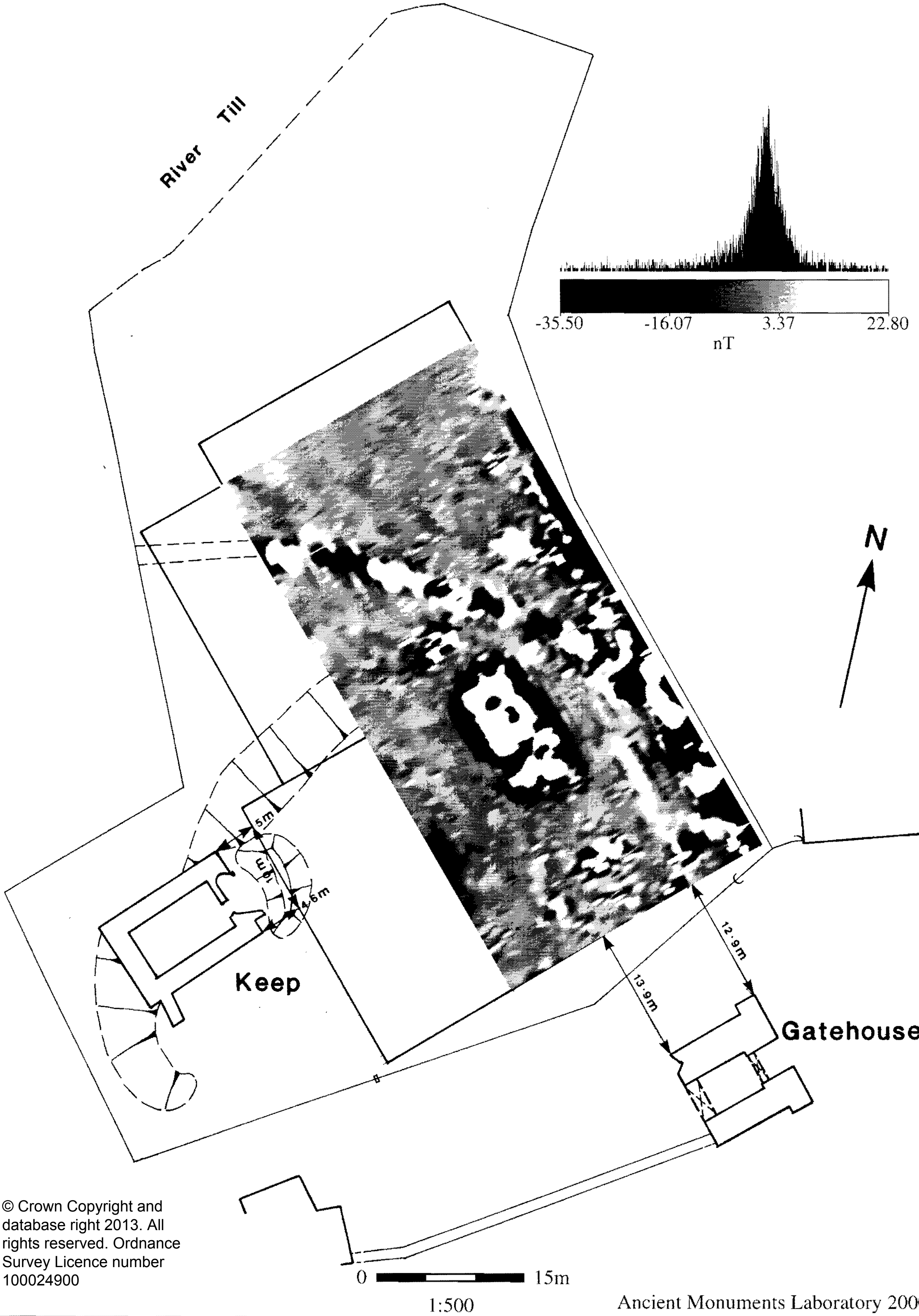


b) Earth resistance survey



Ancient Monuments Laboratory 200

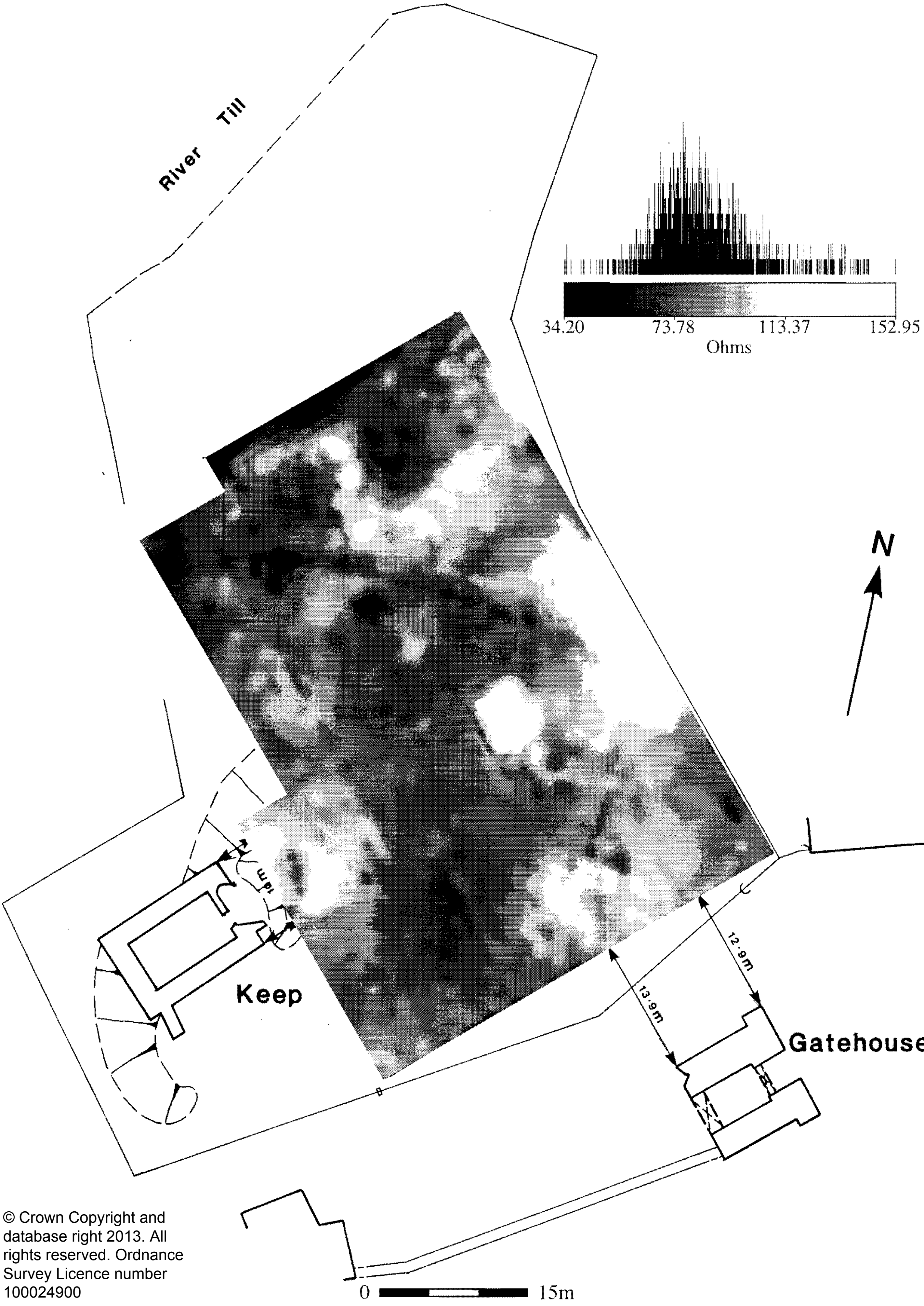
Figure 3) ETAL CASTLE, NORTHUMBERLAND: Greyscale plot of magnetometer results superimposed on estate plan, 1988.



© Crown Copyright and database right 2013. All rights reserved. Ordnance Survey Licence number 100024900

Ancient Monuments Laboratory 200

Figure 4) ETAL CASTLE, NORTHUMBERLAND: Greyscale plot of 1x1m earth resistance results superimposed on estate plan, 1988.

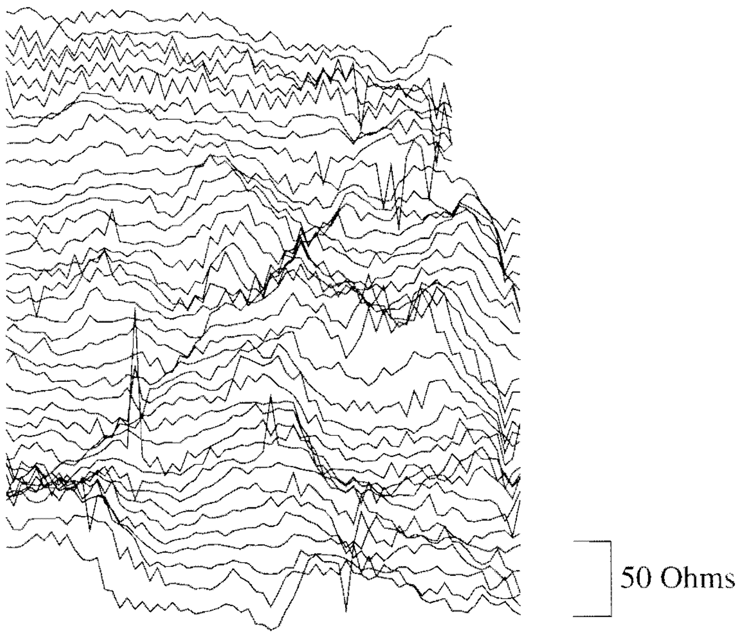


© Crown Copyright and database right 2013. All rights reserved. Ordnance Survey Licence number 100024900

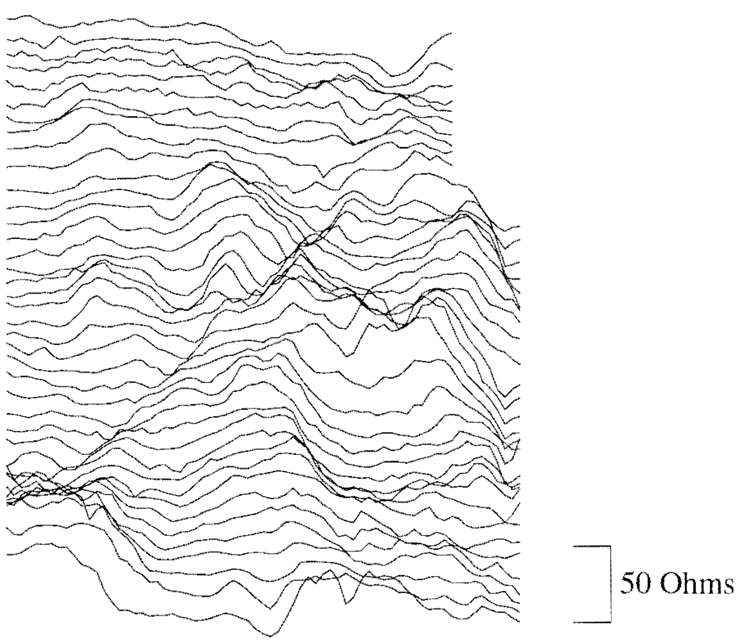
Ancient Monuments Laboratory 200

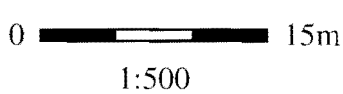
Figure 5) ETAL CASTLE, NORTHUMBERLAND: Trace plots of 0.5x1m earth resistance measurements before and after processing, 1988.

a) Unprocessed 0.5x1m earth resistance survey



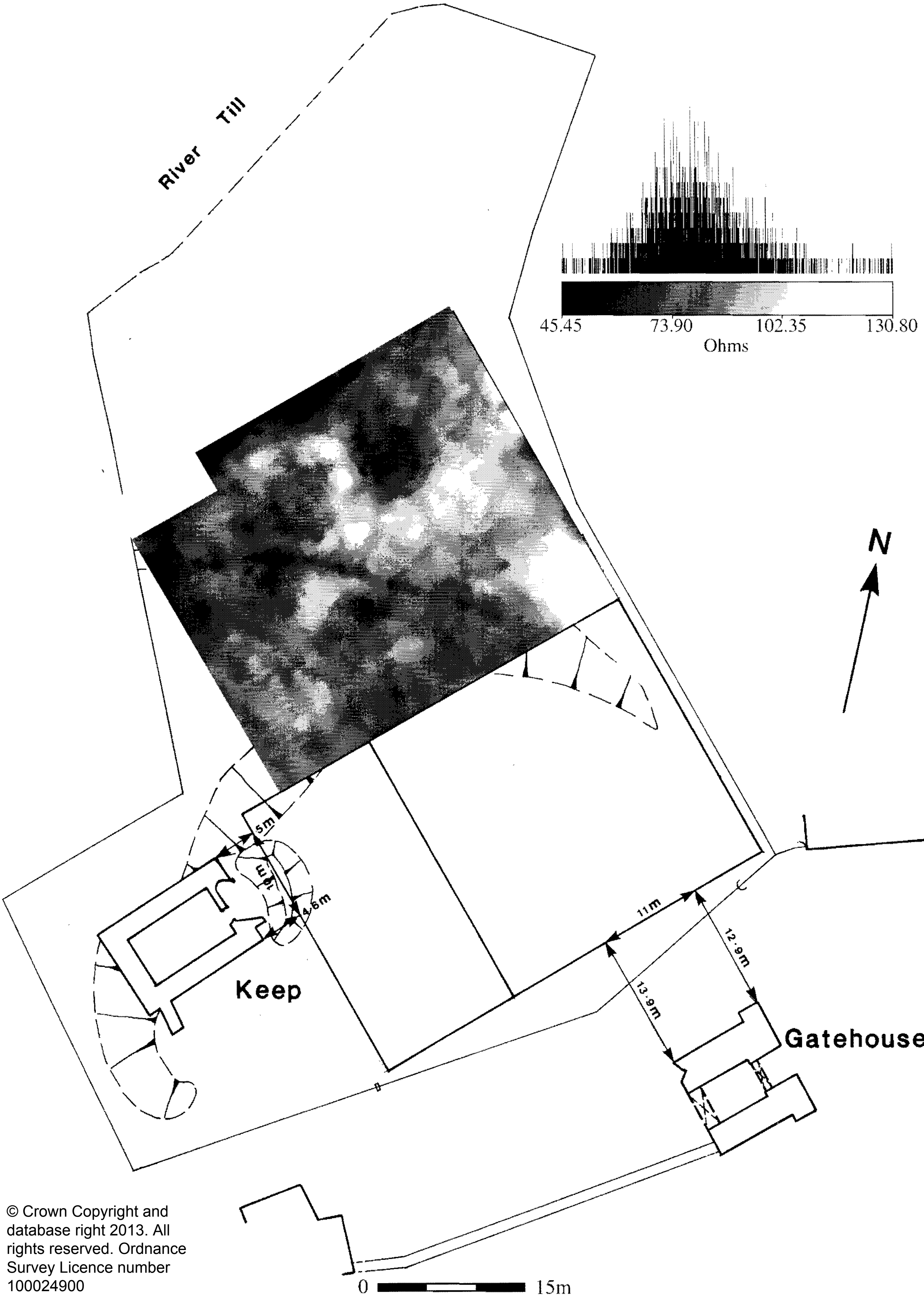
b) 0.5x1m earth resistance survey after processing to remove spikes and smoothing with 3x1 convolution mask.





Ancient Monuments Laboratory 2000

Figure 6) ETAL CASTLE, NORTHUMBERLAND: Greyscale plot of 0.5x1m earth resistance results superimposed on estate plan, 1988.



© Crown Copyright and database right 2013. All rights reserved. Ordnance Survey Licence number 100024900

Ancient Monuments Laboratory 200

Figure 7) ETAL CASTLE, NORTHUMBERLAND: Interpretation plan of geophysical survey results superimposed on estate plan, 1988.

© Crown Copyright and database right 2013. All rights reserved. Ordnance Survey Licence number 100024900