University of Reading

Geophysical Survey Report
Electrical Resistivity Tomography (ERT) Survey

CASTLE MOTTE 3
HAMSTEAD MARSHALL
WEST BERKSHIRE

24th June 2016

Dr. Robert Fry
Geophysicist and GIS Technician

Dr. Phil Stastney
Research Assistant

SAGES Geophysics
The University of Reading
OASIS ID: theunive1-253446

Summary

Two Electrical Resistivity Tomography (hereafter ERT) survey transects were undertaken over a castle motte at land at Hamstead Marshall, West Berkshire. The surveys were conducted to meet specific research questions concerning the structure of the mound following a geotechnical investigation which appeared to locate a large void within (Stastney *et al.* 2016). The surveys were conducted in single lines across the mound, at approximate right angles. Traverse 1 measured 121m in length as a NNW orientation. Traverse 2 measured 105m, at a WNW orientation. Both traverses began from outside the mound and associated ditch, continued over the entirety of the mound, and finished off of the mound and ditch at the opposite side.

The geophysical survey appears to correlate well with the geotechnical investigation, and both ERT traverses show large areas of high resistivity which may represent the possible void.

Version Control

VERSION	AUTHOR	CHECKED	DATE
Interim			
Draft	R Fry	P Stastney	20/06/2016
Revision	P Stastney/R Fry	R Fry	24/06/2016
Final			24/06/2016

Contents

1. INTRODUCTION

Between the 4th and 5th April 2016, a geophysical survey was conducted over Motte 3, Hamstead Marshall, West Berkshire, to answer a specific research question relating to the internal structure of the mound (Scheduled Monument List No. 1007924). The work is associated with the Research Project 'Extending Histories: from Medieval Mottes to Prehistoric Round Mounds' at the University of Reading, Directed by Dr. Jim Leary. The main aim of the geophysical investigation was to try and delimit the size and depth of the possible void, discovered during geotechnical work in 2015. Two ERT surveys were conducted in total, crossing the motte at approximate right angles over the area of investigation.

1.1 Location

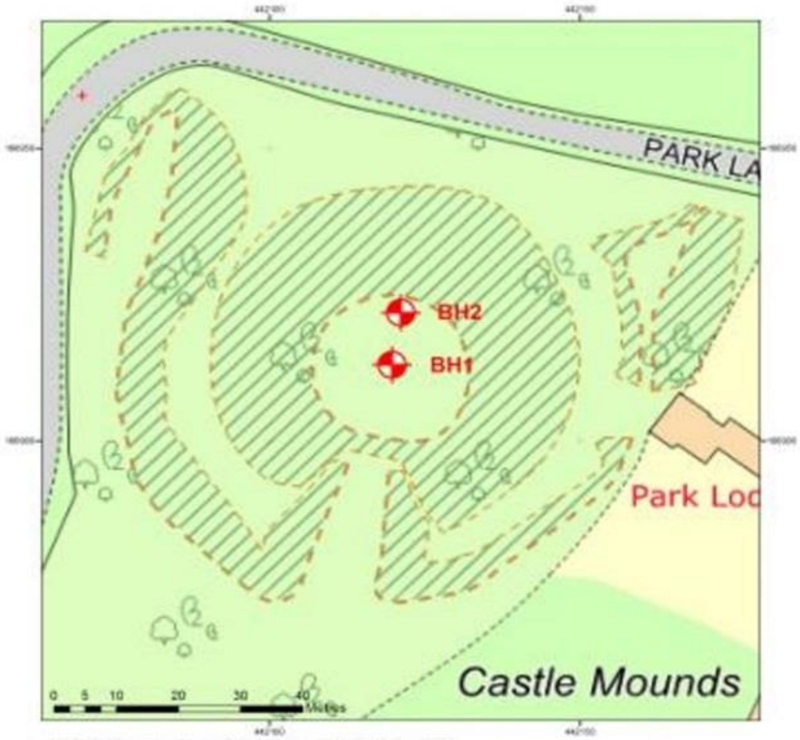
PROJECT NAME	MOTTE 3, HAMSTEAD MARSHALL, WEST BERKSHIRE
Country	England
County	West Berkshire
Nearest Settlement	Hamstead Marshall
Central Co-ordinates	442160,166860

2. CONTEXT

2.1 Archaeology and previous investigations

Extending Histories: from Medieval Mottes to Prehistoric Round Mounds is a three year research project, led by the University of Reading and funded by The Leverhulme Trust, In September 2015, as part of this project, geoarchaeological boreholes were drilled through the westernmost of three castle mottes at the site of Hampstead Marshall, West Berkshire – ('Castle 3' Myres 1932). Both boreholes were drilled from the flattened top of the mound, BH1 was positioned in the centre of the mound, BH2 was position 10m to the north (see image below). This work, combined with analytical earthwork survey, aimed to conclusively date and understand the sequence and development of 'Castle 3'.

During the drilling of the borehole (BH1) in the centre of the mound however, an apparent air-filled void was encountered at 10m below the ground surface; due to the presence of this void, *in-situ* geological strata were not reached. No voids were encountered in the second borehole (BH2) drilled at the site (ca. 10m north of the centre of the mound). The void beneath the centre of the mound was an unexpected feature and at the time of survey, the most likely explanation is that the void may represent a dissolution-hollow; a number of such features are locally known to occur at sites with similar geologies: at the edge of the outcrop of Palaeogene bedrock overlying Chalk (Dr Clive Edwards, Peter Brett Associates LLP – *pers. comm.*). (Stastney *et al.* 2016)



Borehole locations, Castle 3. (After Stastney *et al.* 2016)

The analysis of the borehole data appears to indicate that the mound was constructed by redeposited Reading Formation Lambeth Group strata, likely to have come from the creation of the surrounding ditch. Within the base of BH1, a peat horizon was encountered; containing remains of plants, and may represent a former ground surface. The material encountered in BH2 indicated however that such reworked material directly overlies the bedrock, and did not contain evidence of such ground surface. This finding lends itself to a hypothesis that the ground was levelled prior to the construction of the mound, with peat forming into a hollow situated above a dissolution feature (Stastney *et al.* 2016). Directly above the peat horizon, a 'trample layer' may directly relate to the mound's construction. See Stastney *et al.* for further information.

2.2 Environment

Soil Classification (UKSO)	Freely draining slightly acid loamy soil (6)
Superficial 1:50000 (BGS)	None mapped
Bedrock 1:50000 (BGS)	Lambeth Group (Clay Silt and Sand) / Seaford Chalk Formation (Chalk)
Current Land Use	Back garden
Historic Land Use	Castle: Motte and Bailey
Vegetation Cover	Grass, Trees, Shrubs
Sources of Interference	None

2.2.1 Comments

The motte is positioned on the north-facing slope of a an area of raised ground approximately 80m south of the River Kennet / Kennet and Avon Canal at an elevation of approximately 100m OD. A number of small springs, some apparently seasonal, rise just below the crest of the hill at *c.*120m OD, and drain northwards into the River Kennet.

The site lies on bedrock of the Lambeth Group (predominantly clays, sands and silts), although the underlying Seaford Chalk Formation is mapped as outcropping less than 50m to the north. Although no superficial deposits are mapped immediately beneath the site, river terrace deposits of the Beenham Grange Gravel Member overlain in turn by Peat and Tufa are mapped c.100m north of the site (BGS 2015; Aldiss et al. 2010).

The higher ground to the south of the site is capped by deposits of the Hamstead Marshall Gravel over bedrock of the London Clay Formation that in turn overlies the Lambeth Group bedrock beneath the site. This situation, where a permeable deposit (i.e. gravel) overlies impermeable strata (London Clay Fm and Lambeth Group), gives rise to the large number of springs and small seasonal watercourses which occur in the vicinity of the site.

The site currently forms part of the gardens of a residential property, Park Lodge. The principal dwelling is situated *c.*40m east of the centre of Castle 3 mound and *c.*70m north of the centre of Castle 2 mound. Stables and a garden shed are located immediately north and east of Castle 3 mound, respectively. Both mounds are maintained as parkland with a vegetation cover comprising open mixed-deciduous woodland interspersed with small patches of scrub and areas of improved grassland.

The geology and soils to which the site is based is likely to favour the geophysical techniques adopted for this survey. The response to the ERT technique is however dependant on the overburden to archaeology and how well the archaeological deposits contrast in their physical characteristics (in this case, largely governed by moisture content) to the natural or deposited soils around.

The mound of the motte was relatively steep, and contained various trees and shrubs to navigate the survey around, however the vast majority of the probes were able to be positioned in a straight line. On the rare occasion where a tree obscured the exact point at which a probe should be placed, the nearest possible placement was instead used.

3. METHODOLOGY

3.1 Survey

Electrical Resistivity Tomography (ERT) survey measures the electrical resistance of the ground by injecting a small electrical current into the soil, and measuring generated equipotential readings at the surface. The electrical resistance measurement is therefore bulk resistance measurement and requires further processing in the form of inversion to produce a 'true' (or best estimated) resistivity profile of the data. The following section will outline the instruments used, and the field method and data processing employed.

3.2 Electrical Resistivity Tomography (ERT) Survey

3.2.1 Technical Equipment

Instrument	Allied Associates TIGRE system (96 probes)
Measured variable	Electrical Resistance (Ohms)
Configuration	Wenner Array
QA Procedure	Continuous observation of measurements. Electrode checks prior to survey to check for good contact with the ground.
Spatial Resolution	2m along line interval

3.2.2 Data Processing

Data processing is generally kept to a minimum, to reduce any significant alteration of the measured data and prevent artefacts within the data being falsely created. Processing of the dataset therefore is designed to remove and reduce aspects of noise, or positional or heading errors. Data was collected using ImagerPro2006 (supplied with the TIGRE), and the data was processed using Res2DInv inversion software, considered to be the industry standard for such surveys.

Process	**Software**	**Parameters**
Collect and save data in the field	ImagerPro 2006	Data saved as .DAT file
Download data from instrument	N/A	Data saved onto USB stick and transferred to office network.
Topography Correction	Res2DInv	Uniform distorted FEM
Inversion Parameters	Res2DInv	See Appendix 1
Inversion	Res2DInv	Least-squares Inversion
Data export	Res2DInv	Export to Surfer file
Data Presentation	Surfer	Grid data (Natural Neighbour)

3.3 Standards and Guidance

All work was conducted in accordance with the following standards and guidance:

- David *et al*, 2008. Geophysical Survey in Archaeological Field Evaluation. English Heritage.
- Institute for Archaeologists (IFA), 2008. Standard and Guidance for Archaeological Field Evaluation.

All personnel involved with the survey are experienced surveyors trained to use the equipment in accordance with the manufacturer's expectations. All fieldwork was supervised by an experienced and fully qualified geophysicist.

4. INTERPRETATION

4.1 Introduction

The following section describes the results of the geophysical survey with interpretations provided to explain the geophysical data. The nature of geophysical anomalies is complicated and often varied. Interpretations which are made are therefore considered the probable case and are never certainties.

The discussion below should be followed with the associated interpretation figures.

- Figure 2: Line 1 Data
- Figure 3: Line 2 Data
- Figure 4: Line 1 Interpretation
- Figure 5: Line 2 Interpretation

4.2 Principal Results

4.2.1 ERT Results

The ERT survey was able to successfully penetrate through the motte mound and provide good quality data approximately 15m into the subsurface. The interpretation of the data is aided by the additional information provided by the borehole data which provide further information regarding the stratigraphy of the mound. The ERT transects were positioned so that they would both intersect the location of Borehole 1 (BH1), which discovered the possible void space (Figure 1).

4.2.1.1 Line 1

At the near-surface, the data is characterised by very high resistivity zones over the top of the mound and over the NNW facing slope [1]. Across the SSE half of the transect, the higher resistivity zone exists at the surface, however on this side, they are thinner, and zones of lower resistivity are detected beneath [2]. This difference may indicate a change in the physical makeup over the sides of the mound, and/or possibly a more compacted surface on the top and on one side of the mound. However, such a change in resistivity may also indicate the more exposed side of the mound, and as such, more affected by recent rainfall events. Unlike the NNW facing slope, the topography of the SSE facing slope retains a ditch and outer bank, which would collect a higher proportion of rainwater. Off of the slope, at the NNW extent, the ERT traverse was located on a flat hard-cored road surface (indicated by a high resistivity zone), allowing surface water to run off the mound [3].

The interfaces of soil material within BH1 appear to match relatively well with the ERT dataset. The low resistivity area is likely to relate to correlate to the 'upcast bedrock' clay and silts [4]. A thin lens of 'trample' between the upcast bedrock, and peat/void contexts thought in the borehole survey, to indicate a buried surface has been highlighted on the interpretation figure. This interface matches well with the ERT data, as the resistivity increases below this point delineating the change in soil [5].

Between 69 – 88m along the traverse, at a depth of approx. 10m below ground surface, a large high resistivity anomaly has been identified [6]. The anomaly itself measures approximately 19m across by 8m in height and appears to correlate with the potential void seen in BH1. The high resistivity readings from this area are also be suggestive of the air-filled void.

The large high and low resistivity readings from the bottom of the dataset [7] & [8] are thought unlikely to represent any significant features, and probable instead represent 'edge effects' from the inversion process.

4.2.1.2 Line 2

As with the SSE facing side of Line 1, the surface of the transect of Line 2 contains a thin high resistivity area which continues over both slopes, and over the top of the mound [9]. This is likely due to surface compaction and appears to be more uniform across the mound than in Line 1. Due to the existence of outer banks at either end of the traverse, zones of low resistivity are indicated at [10] & [11] which, as with [2], are likely to represent areas of water infiltration from decreased surface water run-off, and likely indicate therefore, areas where the soils hold more moisture. The outer banks of the mound, either side of the survey line show as high resistivity areas, indicating that they are, as the mound itself, made of relatively compacted soils [12] & [13].

Within the centre of Line 2, there are only small changes in resistivity which do not appear to correlate as clearly with the stratigraphy within BH1 as Line 1 did. A small change in resistivity is tentatively indicated at [14] and may indicate a similar horizon between the up cast bedrock and the peat.

Between around 65-80m along Line 2, a large zone of high resistivity within the centre of the mound is apparent [15]. This is likely to represent the same feature as seen by [6] in Line 1. In this Line however, the borehole location for the void does not perfectly fit with the geophysical data, and may suggest that on the ENE-WSW axis, the borehole was positioned at the western limit of the void. The depths for both the ERT and borehole data do however approximately match. The size of the high resistivity anomaly is similar to the void in Line 1.

4.3 Conclusions

The ERT surveys have both successfully located within the castle motte, a large, high resistivity anomaly that matches the location of the suspected void discovered by geotechnical investigation in 2015. It is assumed this high resistivity feature is therefore representative of such void space, filled with air hence creating a high resistivity medium for electrical current to pass through.

5. PROJECT METADATA

PROJECT NAME	MOTTE 3, HAMSTEAD MARSHALL, WEST BERKSHIRE
Project Code	Hamstead Marshall ERT Survey
Client	Dr. Phil Stastney
Fieldwork Dates	5th – 6th April 2016
Field Personnel	Dr. Robert Fry, Dr. Phil Stastney
Data Processing Personnel	Dr. Robert Fry
Report Personnel	Dr. Robert Fry, Dr. Phil Stastney
Interim Report Date	
Draft Report Date	10th June 2016
Final Report Date	24th June 2016

6. REFERENCES

Aldiss, D.T., Newell, A.J., Marks, R.J., Hopson, P.M., Farrant, A.R., Royse, K.R., Aspden, J.A., Evans, D.J., Smith, N.J.P., Woods, M.A. and Wilkinson, I.P. (2010). *Geology of the Newbury district and part of the Abingdon district*. Sheet description of the British

Myres, J.N.L. (1932). Three unrecognised castle mounds at Hamstead Marshall. *Transactions of the Newbury District Field Club* VI, 114-126.

Stastney, P., Jamieson, E., Dunbar, E. (2016). *Extending Histories: from Medieval Mottes to Prehistoric Round Mounds. Hamstead Marshall motte and bailey castles, West Berkshire. Interim Report.* Unpublished. The University of Reading.

7. APPENDIX 1

Inversion Parameters

Inversion settings
Initial damping factor (0.01 to 1.00) = 0.1600
Minimum damping factor (0.001 to 0.75) =0.0150
Line search option (0=Never, 1=Sometimes, 2=Always) = 2
Convergence limit for relative change in RMS error in percent (0.1 to 20) = 5.0000
Minimum change in RMS error for line search in percent (0.5 to 100) = 0.4000
Number of iterations (1 to 30) = 5
Vertical to horizontal flatness filter ratio (0.25 to 4.0) = 1.0000
Model for increase in thickness of layers(0=default 10, 1=default 25, 2=user defined) = 2
Number of nodes between adjacent electrodes (2 or 4) = 4
Flatness filter type, Include smoothing of model resistivity (0=model changes only,1=directly on model) = 0
Reduce number of topographical datum points? (0=No,1=Yes. Recommend leave at 0) = 0
Carry out topography modeling? (0=No,1=Yes) = 1
Type of topography trend removal (0=Average,1=Least-squares,2=End to end) = 1
Type of Jacobian matrix calculation (0=Quasi-Newton, 1=Gauss-Newton, 2=Mixed) = 1
Increase of damping factor with depth (1.0 to 2.0) =1.0500
Type of topographical modeling (0=None, 1=No longer supported so do not use, 2=uniform distorted FEM, 3=underwater, 4=damped FEM, 5=FEM with inverse Swartz-Christoffel) = 2
Robust data constrain? (0=No, 1=Yes) = 0
Cutoff factor for data constrain (0.0001 to 0.1)) = 0.0500
Robust model constrain? (0=No, 1=Yes) = 0
Cutoff factor for model constrain (0.0001 to 1.0) = 0.0050
Allow number of model parameters to exceed datum points? (0=No, 1=Yes) = 1
Use extended model? (0=No, 1=Yes) = 0
Reduce effect of side blocks? (0=No, 1=Slight, 2=Severe, 3=Very Severe) = 0
Type of mesh (0=Normal,1=Fine,2=Finest) = 0
Optimise damping factor? (0=No, 1=Yes) = 0
Time-lapse inversion constrain (0=None,1=Least-squares,2=Smooth,3=Robust) = 0
Type of time-lapse inversion method (0=Simultaneous,1=Sequential) = 1
Thickness of first layer (0.25 to 1.0) = 0.5000
Factor to increase thickness layer with depth (1.0 to 1.25) = 1.1000
USE FINITE ELEMENT METHOD (YES=1,NO=0) = 1
WIDTH OF BLOCKS (1=NORMAL WIDTH, 2=DOUBLE, 3=TRIPLE, 4=QUADRAPLE, 5=QUINTIPLE) =1
MAKE SURE BLOCKS HAVE THE SAME WIDTH (YES=1,NO=0) = 1
RMS CONVERGENCE LIMIT (IN PERCENT) =1.000
USE LOGARITHM OF APPARENT RESISTIVITY (0=USE LOG OF APPARENT RESISTIVITY, 1=USE RESISTANCE VALUES, 2=USE APPARENT RESISTIVITY) = 0
TYPE OF IP INVERSION METHOD (0=CONCURRENT,1=SEQUENTIAL) = 0
PROCEED AUTOMATICALLY FOR SEQUENTIAL METHOD (1=YES,0=NO) = 0
IP DAMPING FACTOR (0.01 to 1.0) = 0.100
USE AUTOMATIC IP DAMPING FACTOR (YES=1,NO=0) = 0
CUTOFF FACTOR FOR BOREHOLE DATA (0.0005 to 0.02) = 0.00300
TYPE OF CROSS-BOREHOLE MODEL (0=normal,1=halfsize) =0
LIMIT RESISTIVITY VALUES(0=No,1=Yes) = 0
Upper limit factor (10-50) = 50.000
Lower limit factor (0.02 to 0.1) = 0.020
Type of reference resistivity (0=average,1=first iteration) = 0
Model refinement (1.0=Normal,0.5=Half-width cells) = 1.00

Combined Combined Marquardt and Occam inversion (0=Not used,1=used) = 0
Type of optimisation method (0=Gauss-Newton,2=Incomplete GN) = 0
Convergence limit for Incomplete Gauss-Newton method (0.005 to 0.05) = 0.010
Use data compression with Incomplete Gauss-Newton (0=No,1=Yes) = 0
Use reference model in inversion (0=No,1=Yes) = 0
Damping factor for reference model (0.0 to 0.3) = 0.01000
Use fast method to calculate Jacobian matrix. (0=No,1=Yes) = 1
Use higher damping for first layer? (0=No,1=Yes) = 0
Extra damping factor for first layer (1.0 to 100.0) = 2.50000
Type of finite-element method (0=Triangular,1=Trapezoidal elements) = 1
Factor to increase model depth range (1.0 to 5.0) = 1.000
Reduce model variations near borehole (0=No, 1=Yes) = 0
Factor to control the degree variations near the boreholes are reduced (2 to 100) = 5.0
Factor to control variation of borehole damping factor with distance (0.5 to 5.0) = 1.0
Floating electrodes survey inversion method (0=use fixed water layer, 1=Incorporate water layer into the model) = 0
Resistivity variation within water layer (0=allow resistivity to vary freely,1=minimise variation) = 1
Use sparse inversion method for very long survey lines (0=No, 1=Yes) = 0
Optimize Jacobian matrix calculation (0=No, 1=Yes) = 0
Automatically switch electrodes for negative geometric factor (0=No, 1=Yes) = 1
Force resistance value to be consistant with the geometric factor (0=No, 1=Yes) = 0
Shift the electrodes to round up positions of electrodes (0=No, 1=Yes) = 0
Use difference of measurements in time-lapse inversion (0=No,1=Yes) = 1
Use active constraint balancing (0=No,1=Yes) = 0
Type of active constraints (0=Normal,1=Reverse) = 0
Lower damping factor limit for active constraints = 0.4000
Upper damping factor limit for active constraints = 2.5000
Water resistivity variation damping factor = 4.0000

Inversion Iterations

Line 1

Iteration	Time for this iteration	Total Time	RMS Error
1	3.01	3.01	11.773
2	1.48	4.49	8.507
3	1.45	5.94	7.153
4	1.45	7.40	6.497
5	1.44	8.83	6.216

Line 2

Iteration	Time for this iteration	Total Time	RMS Error
1	1.97	1.97	16.461
2	1.09	3.06	11.598
3	1.09	4.15	9.892
4	1.15	5.30	8.870
5	1.08	6.38	8.229

Historic England

Historic England Geophysical Survey Summary Questionnaire

Survey Details

Name of Site: Castle Motte 3, Hamstead Marshall

County: West Berkshire

NGR Grid Reference (Centre of survey to nearest 100m): SU4216066860

Start Date: 5th April 2016 **End Date: 6th April 2016**

Geology at site (Drift and Solid):

Drift: None Mapped
Solid: Lambeth Group / Seaford Chalk Formation

Known archaeological Sites/Monuments covered by the survey

(Scheduled Monument No. or National Archaeological Record No. if known)

Scheduled Monument List No. 1007924

Archaeological Sites/Monument types detected by survey

(Type and Period if known. "?" where any doubt).

Castle Motte

Surveyor (Organisation, if applicable, otherwise individual responsible for the survey):

Dr. Robert Fry, Dr. Phil Stastney, The University of Reading

Name of Client, if any:

None (research)

Purpose of Survey:

To investigate possible location and form of suspected void within castle motte.

Location of:

a) Primary archive, i.e. raw data, electronic archive etc:

Dr. Robert Fry. The University of Reading

b) Full Report:

Dr. Robert Fry, The University of Reading

West Berkshire SMR

Technical Details

(Please fill out a separate sheet for each survey technique used)

Type of Survey (Use term from attached list or specify other):
Resistivity Profile: Electrical Resistivity Tomography (ERT) 2D Survey

Area Surveyed, if applicable (In hectares to one decimal place):
2* Transects (Approx. 100m each)

Traverse Separation, if regular:
Not Regular (at a right angle to each other)

Reading/Sample Interval:
Probe spacing 2m.

Type, Make and model of Instrumentation:
Allied Associates TIGRE ERT system

For Resistivity Survey:

Probe configuration: Wenner Array

Probe Spacing: 2m

Land use <u>at the time of the survey</u> (Use term/terms from the attached list or specify other):

Garden

Hamstead Marshall: Motte 3
Location Map

Figure No.
1

N

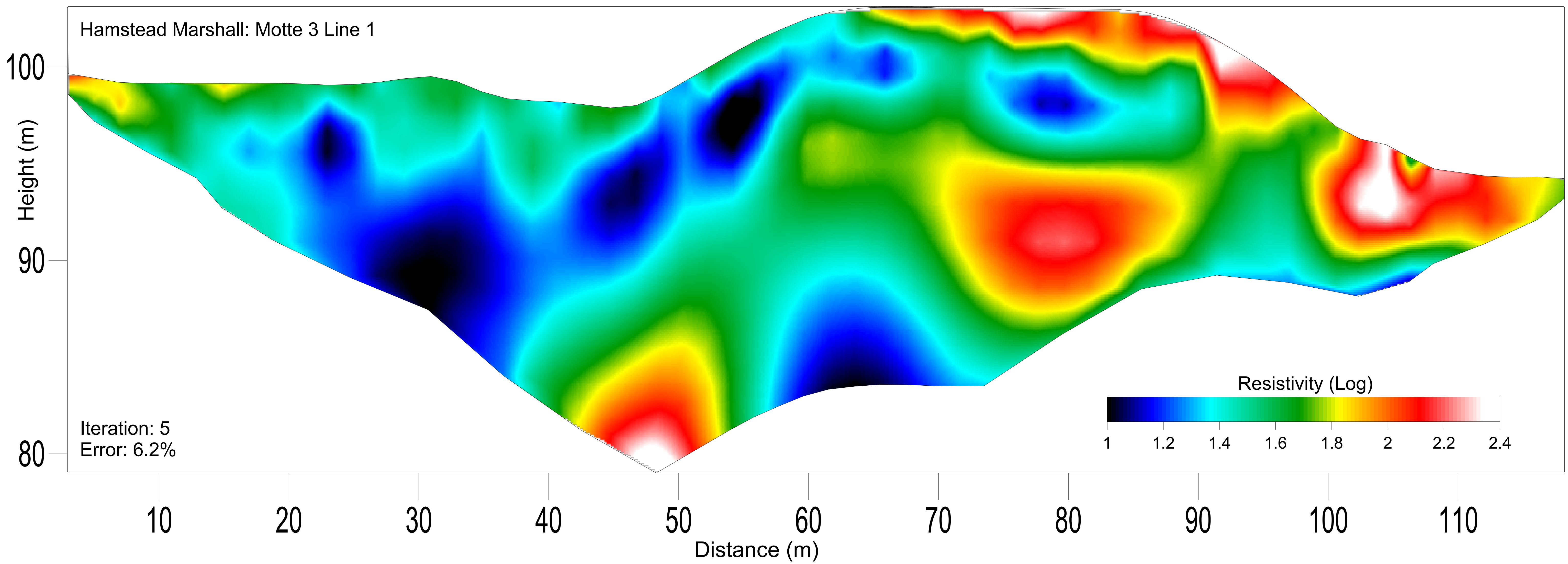
The University of Reading

Surveyed By
Robert Fry, Phil Stastney

Map Data
(C) EDINA Digimap 2016

SSE
Co-ords: 442141.98, 166841.26

NNW
Co-ords: 442110.22, 166958.17



The University of Reading

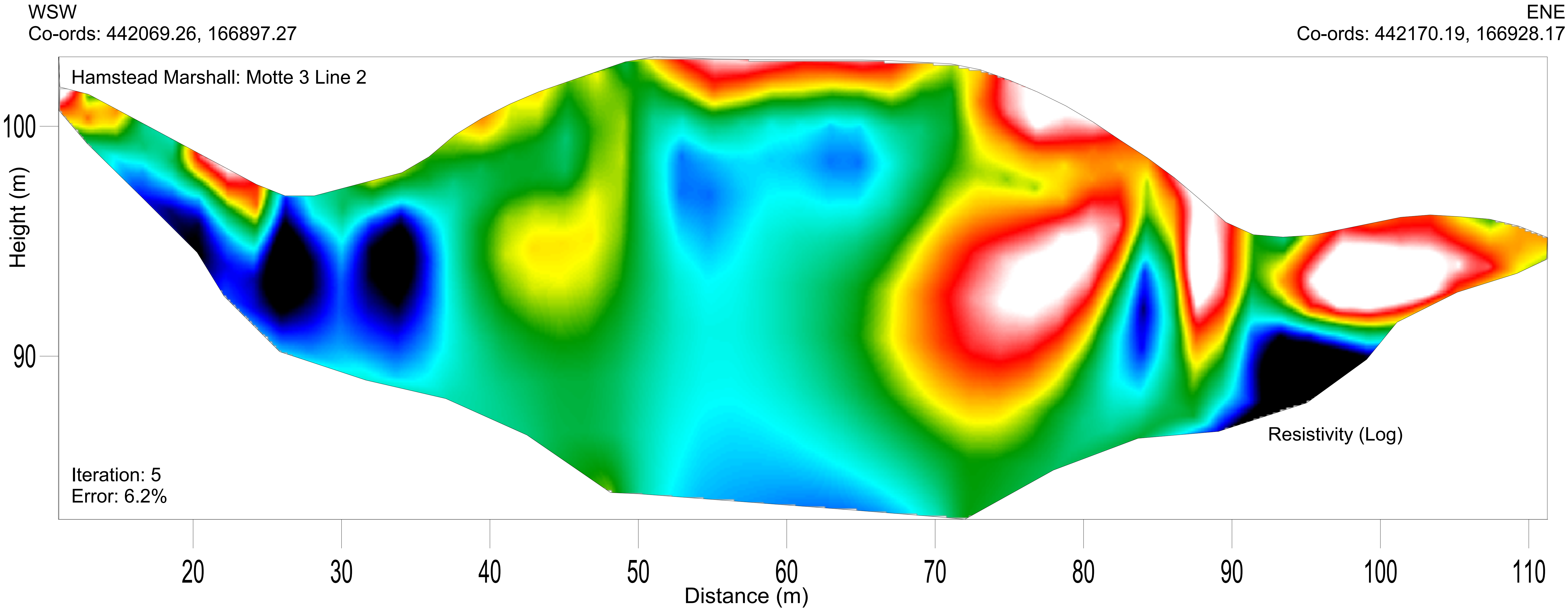
Hamstead Marshall: Motte 3

Line 1. Inversion Results

Figure No. 2

Surveyed By:
Robert Fry, Phil Stastney

Notes:
Allied Associates TIGRE ERT (2m probe seperation)



Hamstead Marshall: Motte 3

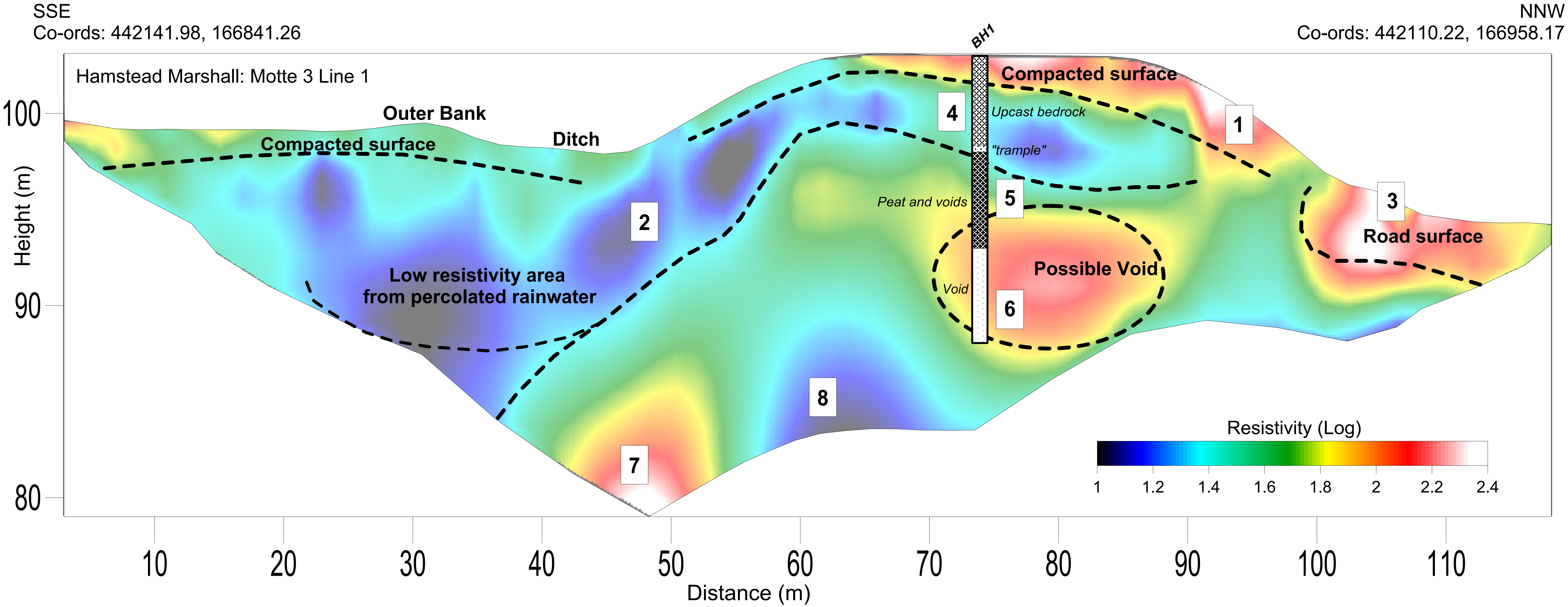
Line 2. Inversion Results

Figure No. 3

The University of Reading

Surveyed By:
Robert Fry, Phil Stastney

Notes:
Allied Associates TIGRE ERT (2m probe seperation)



Hamstead Marshall: Motte 3

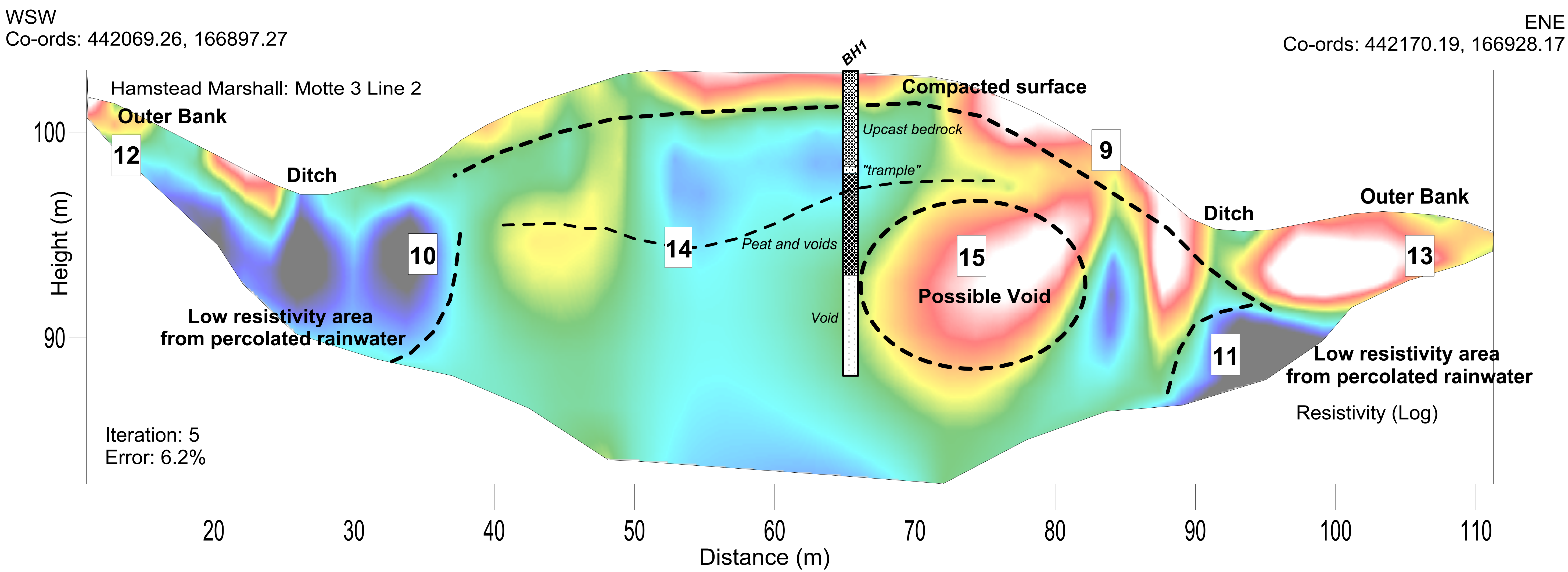
Line 1. Interpretation

Figure No. 4

The University of Reading

Surveyed By:
Robert Fry, Phil Stastney

Notes:
Allied Associates TIGRE ERT (2m probe seperation)



The University of Reading

Hamstead Marshall: Motte 3

Line 2. Interpretation

Figure No. 5

Surveyed By:
Robert Fry, Phil Stastney

Notes:
Allied Associates TIGRE ERT (2m probe seperation)