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# Archaeological Geophysical Survey Database 2001-2010: Archive Report

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| Survey Event No. | **156** |
| Survey Name | **Derrinsallagh 3, M7 Portlaoise-Castletown / M8 Portlaoise-Cullahill** |

## This Geophysical Report should be Referenced or Acknowledged as:

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Survey carried out for Laois County Council

Survey funded by the National Roads Authority

**Known problems with this report**

There are no known archive issues with this report

| | |
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| Depositor | James Bonsall, NRA Fellowship Programme |
| Primary Archive held by | Naas NRDO |
| Secondary Archive held by | Earthsound Archaeological Geophysics |

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# Derrinsallagh/Doon 3, M7 Portlaoise-Castletown / M8 Portlaoise-Cullahill, Contract 2, Coolfin To Townparks And Derrinsallagh

Archaeological Geophysical Survey

Direction No. A015
Registration No. R43
(Testing Area 12 A015/039)

Survey undertaken on behalf of

***Archaeological Consultancy Services Ltd.***

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EAG 95

18 December 2006

EARTHSOUND archaeological geophysics
PROSPECT HOUSE, DRUMAGH, CLAREMORRIS, COUNTY MAYO, IRELAND
WWW.EARTHSOUND.NET

# Table of Contents

## Summary of Results

*On the 20th November 2006, a geophysical survey funded by* Archaeological Consultancy Services Ltd., *was conducted outside the compulsory purchase order boundary of the proposed M7 Portlaoise to Castletown / M8 Portlaoise to Cullahill Road Scheme, County Laois. The areas were investigated using a fluxgate gradiometer at a sampling resolution of 1 x 0.25 m*

*The survey was conducted upon a bedrock geology consisting of Ballysteen Formation Fossiliferous dark-grey muddy Limestone shale. The survey areas were covered in short grass that was amenable for geophysical surveys.*

*A number of isolated ferrous responses were detected within the survey area. These could represent the location of kilns or pits containing burnt debris similar to those revealed during excavation. A large number of possible pits were also detected throughout the survey area. These appear to have no discernable pattern or boundary associated with them and could present a continuation of the kilns, pits, postholes and cremation pots found during excavation.*

*A number of linear and curvilinear features were detected within the geophysical data. These were often diffuse in nature and difficult to positively classify, but appear to match the type of features also revealed during the archaeological excavation.*

## Statement of Indemnity

*A geophysical survey is a scientific procedure that produces observations of results which are influenced by specific variables. The results and subsequent interpretation of the geophysical survey presented here should not be treated as an absolute representation of the underlying archaeological features, but as a hypothesis that must be proved or disproved. It is normally only possible to provide verification via intrusive means, such as Test Trench excavations.*

# 1. Introduction

*Earthsound Archaeological Geophysics* were commissioned by Ms. D. Murphy of *Archaeological Consultancy Services Ltd.*, to execute a geophysical survey adjacent to a defined archaeological site within the proposed M7 Portlaoise to Castletown / M8 Portlaoise to Cullahill Road Scheme, County Laois.

Permissions to undertake the survey were obtained from the *Department of the Environment, Heritage and Local Government* (Licence Number 0A015/168-R43). There are no Recorded Monuments present and the site is not the subject of any legal instruments under the National Monuments Act (1930-94).

The geophysical survey was requested to determine the presence/absence of unknown archaeological features located beyond the Motorway corridor.

## 1.1 Geography, Topography, Geology & Climate

Located on the edge of townlands Derrinsallagh and Doon, the northwest corner of the site (Figure 1) lies at *Ordnance Survey of Ireland* Irish National Grid (ING) Reference E225451 N185901.

The site is located near a railway line and on the eastern side of the R435 Regional Road which runs between Borris-in-Ossory and Rathdowney. The site is 1000 m south of Borris-in-Ossory and is located in west County Laois. The survey area encompassed the southern half of a field which is bounded by a trackway. The northern and western extent of the site was marked by the CPO boundary. The field was covered in short grass which proved amenable for the survey and the topography of the site was flat.

The bedrock geology is comprised of Ballysteen Formation of fossiliferous dark-grey muddy limestone shale. This type of geology is magnetically quiet and is unlikely to have caused problems for the magnetic surveys.

In the week preceding the geophysical survey, the climatic conditions were mild and wet and this continued during fieldwork. The weather is unlikely to have affected the geophysical survey.

## 1.2 Archaeological Background

Archaeological excavations at Derrinsallgh/Doon 3 were completed in November 2005 (1st phase) and June 2006 (2nd phase), by *Archaeological Consultancy Services Ltd* (under Licence E2179). These excavations revealed that Derrinsallagh 3 consisted of the remains of a circular enclosure with associated external kilns. To the east of this a number of ancillary features were exposed. These consisted of kilns, pits and postholes, linear and curvilinear features, cremation pits and stone lined slot trenches, indicating that the function of this site was varied and possibly multi-phased.

## 1.3 Aims & Objectives

The aim of the geophysical survey was to determine the extent of the archaeological resource beyond the Motorway corridor. Specific objectives were to:

- Determine the presence or absence of suspected archaeology
- Assessment of the spatial extent of any archaeological features

# 2. Methodology

The fieldwork was carried out on the 20th November 2006 by J. Bonsall and I. Murin of *Earthsound Archaeological Geophysics*.

The geophysical survey was carried out using two *Geoscan Research* FM256 fluxgate gradiometers.

The survey area covered a total of 0.52 hectares. A rectangular grid was laid out using a *Trimble* Pro-XRS Differential Global Positioning System (see Technical Appendix 2), and divided in to 40 × 40 m sub-grids for the gradiometer survey.

## 2.1 Magnetic Gradiometer Survey

The survey was undertaken along lines parallel to the sub-grid edges, walking approximately west to east, starting in the northwest corner of each grid. Subsequent lines were surveyed in alternate directions ('zigzag').

Data were recorded using an FM256 at a spatial resolution of 1 m intervals between traverses and 0.25 m intervals along those lines. The instrument was positioned facing north, parallel to the Earth's magnetic field, to allow increased geo-magnetic resolution.

The instrument was set to a recording sensitivity of 0.1 nT. Prior to the beginning of the survey and after the completion of every two sub-grids, the electronic and mechanical set-up of the instrument were examined and calibrated as necessary over a common reference point. The magnetic drift from zero was not logged.

Data were collected automatically using an internal sample trigger while the operator walked at a constant pace along the traverse. The data were stored in an internal data logger and downloaded to a field computer using the *Geoscan Research* Geoplot v.3.00a software.

### 2.1.1 *Data Processing*

#### 2.1.1.1 Preliminary Data Treatment

The data were pre-processed in Geoplot 3.00.

Spurious high intensity anomalies, commonly statistical outliers, are referred to as geophysical 'spikes'. In magnetic data, an 'iron spike' is a response to a buried ferrous object, often in the topsoil. Iron spikes are generally not removed in geophysical data; although often modern in origin, they can be indicative of archaeological material.

The raw data contained some poorly matched sub-grids, caused by the internal drift of the fluxgate gradiometer and the gradual misalignment of the fluxgate sensors between calibration episodes. To compensate for this, a zero mean traverse (ZMT) function was employed. The use of ZMT alters data to adjust the mean of each traverse to zero by increasing or decreasing data as necessary. This alters the statistical properties of the data to give a uniformly bipolar background, centred around zero. Post-ZMT plots were compared with raw data to analyse the potential removal of geophysical anomalies along the line of a traverse.

#### 2.1.1.2 Further Processing

No further processing functions were applied due to the high quality of the data collection.

A low pass Gaussian filter was applied, reducing the variability of the data whilst improving the visibility of weak archaeological features. This also had a smoothing effect on the data.

A sine wave interpolation function was applied to provide a smooth, aesthetically pleasing image for presentation. For a given point *x*, the contribution of adjacent readings to the interpolated point is given by the function sinc $(x) = \sin \pi x / \pi x$ (Scollar 1990). This function is used as a sliding window along each transect, resulting in an interpolated image, expanding the resolution of the data from 1 m x 0.25 m to 0.5 m x 0.125 m. This function was chosen as giving a clearer interpolated image than linear interpolation (which assumes a direct linear change between each point) or bicubic interpolation (taking the surrounding sixteen values into account).

### 2.1.2 *Graphical Display*

Pre-processed data are displayed in XY traceplot format in Figure 2. An XY traceplot presents the data logged on each traverse as a single line with each successive traverse incremented on the Y-axis to produce a stacked plot. The data have been clipped at –3 and +3 nT. The main advantage of this display option is that the full range of data can be viewed, dependent on the clip, so that the ‘shape’ of individual anomalies can be discerned and potentially archaeological anomalies differentiated from iron ‘spikes’.

Processed data are shown in Greyscale format in Figure 3. The greyscale plot presents data as pixels on a linear grey shaded scale, increasing or decreasing dependent on the values of the maximum and minimum clip. The geophysical data in Figure 3 have been clipped at –2 (white) and +2 nT (black). Data values beyond the clip limits are shown as ‘pure’ black or white. The main advantage of this display option is that the data can be viewed as a base map.

An interpretation plot is presented in Figure 4.

Figure 5 combines the geophysical interpretation with the archaeological excavation results.

## 2.2 Reporting, Mapping and Archiving

The geophysical survey and report follow the recommendations outlined in the *English Heritage Guidelines* (David 1995) and *IFA Paper No. 6* (Gaffney *et al.* 2002) as a minimum standard.

Geophysical data, figures and text are archived following the recommendations of the *Archaeology Data Service* (Schmidt 2001).

Field boundaries were mapped and drawn based upon data gathered by the DGPS. All figures reproduced from *Ordnance Survey Ireland* mapping are done so with permission from *OSI* copyright (Licence No. AR 0047306).

Technical information on the equipment used, data processing and methodology are given in Appendix 1. Appendix 2 details the survey geo-referencing information and Appendix 3 describes the composition and location of the archive.

# 3. Results & Discussion

*The interpretation figures should not be looked at in isolation but in conjunction with the relevant discussion section and with the information contained in the Appendices. Features are numbered in Figure 4 and are described and interpreted within the text.*

## 3.1 Magnetic Gradiometer Survey

Figure 3 – Magnetic Gradiometer Data

Figure 4 – Magnetic Gradiometer Interpretation

In magnetic data, a dipolar anomaly or 'iron spike' is a response to buried ferrous objects, often in the topsoil. Iron spikes generally are not removed in geophysical data, although often modern in origin, they can be indicative of archaeological material such as kilns, post holes and cremation pots revealed during archaeological excavations.

A large number of possible pit features were detected across the survey area. These have a slightly raised magnetism associated with them suggesting that burnt or fired debris may be contained within them. The archaeological excavation revealed the presence of kilns, pits, postholes and cremation pots. The pits could represent cremation burials.

Anomaly **[1]** is a curvilinear possible ditch feature which runs in a northwest direction. To the southeast, this anomaly appears to bend onto a southerly orientation. The anomaly with a detected length of 63 m does not appear to act as a boundary feature to the other archaeology and is very diffuse in nature.

Anomaly **[2]** is a linear possible ditch which extends in a northerly direction from the centre of anomaly 1. Detected for a length of 13 m this anomaly appears to terminate within the survey area. The two features combined may represent internal partitions within the habitation area or may be relict field boundaries.

Anomaly **[3]** is a weak linear area of magnetic enhancement that runs through the middle of a series of possible pits. Its limited geophysical signature suggests that it might be archaeological or geological in nature. It appears to terminate against anomaly 1 and may be associated with anomaly 5, which suggests that it is more likely to be archaeological, possibly a ditch or gully.

Anomaly **[4]** is a linear area of magnetic enhancement which runs in a northwest direction across the eastern half of the survey area. Detected for a length of 51 m it is possible that this represents a relict field boundary.

Anomaly **[5]** is a linear possible ditch which terminates at its western edge against anomaly 3. Measuring 42 m in length this anomaly has unknown archaeological significance.

Anomaly **[6]** comprises a curvilinear area of magnetic enhancement that is roughly 'L-shaped'. Measuring 53 m in length it is possibly archaeological or geological in origin. The southern branch of the anomaly is on the same alignment as anomaly 3 and may suggest that the two features are related, although no direct relationship can be seen within the geophysical data.

# 4. Conclusions

## 4.1 Achievement of Objectives

The geophysical survey has allowed further possible archaeological anomalies to be detected outside the CPO boundary which will aid the interpretation of the excavated features. Direct correlation can be seen between the type of features found in the excavation and the geophysical anomalies.

## 4.2 Summary of Results

A number of isolated ferrous responses were detected within the survey area. These could represent the location of possible cremation pits, similar to those revealed during excavation. A large number of possible pits were also detected throughout the survey area. These appear to have no discernable pattern or boundary associated with them and could present a continuation of the kilns, pits, postholes and cremation pots found during excavation.

A number of linear and curvilinear features were detected within the geophysical data. These were often diffuse in nature and difficult to positively classify, but appear to match the type of features also revealed during the archaeological excavation.

Through the use of a geophysical survey outside the CPO boundary further archaeological activity has been detected, suggesting that the archaeological site is bigger than that revealed during archaeological excavation. Indeed no distinct boundary feature was revealed within the geophysical survey suggesting that the exact extent of the archaeological activity has yet to be defined.

## 4.3 Dissemination

The results of this survey were submitted to *Archaeological Consultancy Services Ltd.*. *Earthsound* will ensure that copies will be forwarded to the *Department of the Environment, Heritage and Local Government* and the National Museum of Ireland in compliance with the Licence agreement.

## 5. Acknowledgements

Project Management: James Bonsall BA (Hons) MSc PIFA

Fieldwork: James Bonsall
Igor Murin MSc

Report: Heather Gimson BA (Hons) MSc MIAI
James Bonsall

Graphics: Heather Gimson

## 6. Bibliography

CLARK, A.J. 1996 *Seeing Beneath the Soil*, London, Batsford

DAVID, A. 1995 *Geophysical Survey in Archaeological Field Evaluation: Research and Professional Services Guidelines*, No. 1. English Heritage

GAFFNEY, C., GATER, J. & OVENDEN, S. 2002 *The use of Geophysical Techniques in Archaeological Evaluations*, IFA Paper No. 6, Institute of Field Archaeologists

SCHMIDT, A. 2001 *Geophysical Data in Archaeology: A Guide to Good Practice*, Archaeology Data Service, Oxford, Oxbow

SCOLLAR, I., TABBAGH, A., HESSE, A. AND HERZOG, I. 1990 *Archaeological Prospecting and Remote Sensing*, Cambridge, Cambridge University Press. Topics in Remote Sensing Vol. 2

The following texts are referenced in the Technical Appendix:

WALKER, R. 2000 *Geoplot Version 3.00 for Windows, Instruction Manual, Version 1.2*, Clayton, West Yorkshire

# 7. Figures

# Technical Appendix

# Appendix 1

## 1. Magnetic Survey: Technical Information

### 1.1 Magnetic Susceptibility and Soil Magnetism

The Earth is comprised of approximately 6% iron. Via geological and pedological processes iron is present in soils and rocks as three main minerals; haematite, magnetite and maghaemite. Haematite is a very common mineral in archaeological soils and is largely responsible for most of the red colouration in the environment. Magnetite is a common mineral found in all igneous rocks, most sedimentary rocks and nearly all soils. These minerals have a weak, measurable magnetic property.

The magnetism observed in a rock is made up of remanent and induced components. In the weak magnetic field due to the earth, the induced component is proportional to the earth's field. The constant of proportionality is called the magnetic susceptibility. The susceptibility of a rock is controlled by the amount of ferrimagnetic material contained in them, their grain size, and mode of distribution.

An enhancement of ferrimagnetic minerals is responsible for the formation of magnetic anomalies in soils at archaeological sites. Magnetic Susceptibility (MS) measures how susceptible a material is to becoming magnetized. A MS survey can identify and classify different types of iron bearing materials in a safe, fast and non-destructive manner either in a laboratory or as a fieldwork component, complementing other archaeological analyses.

Anthropogenic activities can redistribute these minerals and alter others into more magnetic forms by a process of enhancement, such as burning, industrial activity, fermentation and manuring. MS enhancement of antiferromagnetic haematite in the topsoil is caused by the Le Borgne effect of domestic fires on soils and vegetational matter:

> *The burning of organic matter and the heating of non-organic matter above 200°C, allows electrons to be gained through a process of reduction, creating ferrimagnetic magnetite. As the matter cools, or in the case of organic matter, is combusted, electrons are lost through a process of re-oxidation, creating ferrimagnetic maghaemite.*

The decay of organic material associated with areas of human occupation or settlement can be identified by measuring the MS of the topsoil and noting the degree of enhancement. If the enhanced material subsequently comes to fill features, such as ditches or pits, localised isolated and linear magnetic anomalies can result whose presence can be detected by a magnetometer (fluxgate gradiometer).

There are five different types of magnetic behaviour found in Magnetic Susceptibility surveys, dependent upon the sub-atomic properties of the samples:

Strongest

- *Ferromagnetism*
- *Ferrimagnetism*
- *Antiferromagnetism*
- *Antiferromagnetism*
- *Paramagnetism*
- *Diamagnetism*

Weakest

Magnetic susceptibility is a value defined by a combination of all of the above types of magnetic behaviour, so that weaker paramagnetism and diamagnetism will be masked if other, *stronger*, magnetic properties are present. For example, a topsoil magnetic susceptibility survey will introduce additional contributions from colluvial/alluvial covering or a disturbed Ap horizon (cultivation/pasturing disturbance *etc*.) that may mask an archaeologically derived response.

## 1.2 Types of Magnetic Anomaly

Magnetic anomalies are either are termed **'negative'** or **'positive'** referring to their magnetic properties relative to the bipolar background (theoretically, 'zero').

The types of response mentioned above can be divided into five main categories which are used in the graphical interpretation of the gradiometer data:

*Areas of positive/negative enhancement*

These responses can be quite widespread, and often caused by rubble or foundations, burning, agricultural disturbance and general occupational induced enhancement.

*Linear and curvilinear anomalies*

Such anomalies have a variety of origins. They may be caused by agricultural practice (recent ploughing trends, earlier ridge and furrow regimes or land drains), natural geomorphological features such as palaeochannels or by in-filled archaeological ditches or walls.

*Isolated positive/negative anomalies*

These generally represent small areas of enhancement. They may be caused by exotic geology or by in-filled archaeological pits.

*Isolated Ferrous anomalies*

Theses are very strong magnetic responses caused by ferrous (iron) debris, often found scattered in fields. These are usually modern in origin, although may represent archaeological material such as coffin nails.

*Areas of Disturbance*

These are mostly modern in origin, causing widespread magnetic interference, often masking all other magnetic features within the vicinity. These can be caused by nearby structures, metallic fences, road traffic and metallic pipelines.

### 1.3 Methodology

#### 1.3.1. *Magnetic Susceptibility Survey*

The magnetic susceptibility meter displays the MS value of material when they are brought within the influence of the sensor, such as the field search loop. An oscillator circuit within the *Bartington* MS2 meter generates a low alternating magnetic field. Any material brought within the influence of the field (in the case of the search loop, the field of influence is between 0-18cm beneath the loop, i.e. generally the topsoil), will bring about a change in the oscillator frequency. The frequency information is returned in pulse form to the MS2, where it is converted in to a value of magnetic susceptibility, $\kappa$, in SI units.

A topsoil MS survey assumes that the sample size is infinite, as the precise mass of each sample point cannot be calculated in the field. Calibration therefore, is best expressed in units of Volume Specific susceptibility. Repeatability of the survey is dependent upon the uniformity of the surface under investigation. Volume susceptibility is expressed as $\kappa \times 10^{-5}$ SI units.

#### 1.3.2. *Fluxgate Gradiometer Survey*

A detailed survey requires a sample trigger to automatically take readings at predetermined points. These readings are stored in the memory of the instrument and are later dumped to computer for processing and interpretation. Detailed survey allows the visualisation of weaker anomalies that may not have been detected by magnetic scanning or magnetic susceptibility.

## 2. Data Processing and Presentation

### 2.1 Interpolation

Interpolation can be defined as the estimation of a value between known values. The data magnetometer data displayed in this project have been interpolated using the sin *x*/*x* function in *Geoplot* 3.0 (Walker 2000).

Gridding methods produce a regularly spaced, rectangular array of Z values from irregularly spaced XYZ data. The term "irregularly spaced" means that the points follow no particular pattern over the extent of the map, so there are many "holes" where data are missing. Gridding fills in these holes by extrapolating or interpolating Z values at those locations where no data exists.

A grid is a rectangular region comprised of evenly spaced rows and columns. The intersection of a row and column is called a grid node. Rows contain grid nodes with the same Y co-ordinate, and columns contain grid nodes with the same X co-ordinate. Gridding generates a Z value at each grid node by interpolating or extrapolating the data values. The *Kriging* gridding method produces visually appealing maps from irregularly spaced data. *Kriging* is a geostatistical gridding method that has proven useful and popular in many fields. *Kriging* attempts to express trends suggested in the data so that, for example, high points might be connected along a ridge rather than isolated by bull's-eye type contours.

# Appendix 2

## Survey Grid Re-location

1. Each survey grid was laid out using a *Trimble* Pro-XRS Differential Global Positioning System (DGPS), to an accuracy of ±50cm.
2. There was a good correlation between the geophysical survey data and the digital map base and it is estimated that the average 'best fit' error is lower than ±0.25m. It is important to note that local grid north (27/08/03) varies slightly from *Ordnance Survey* north, with an annual decrease of 0.9°3'.

# Appendix 3

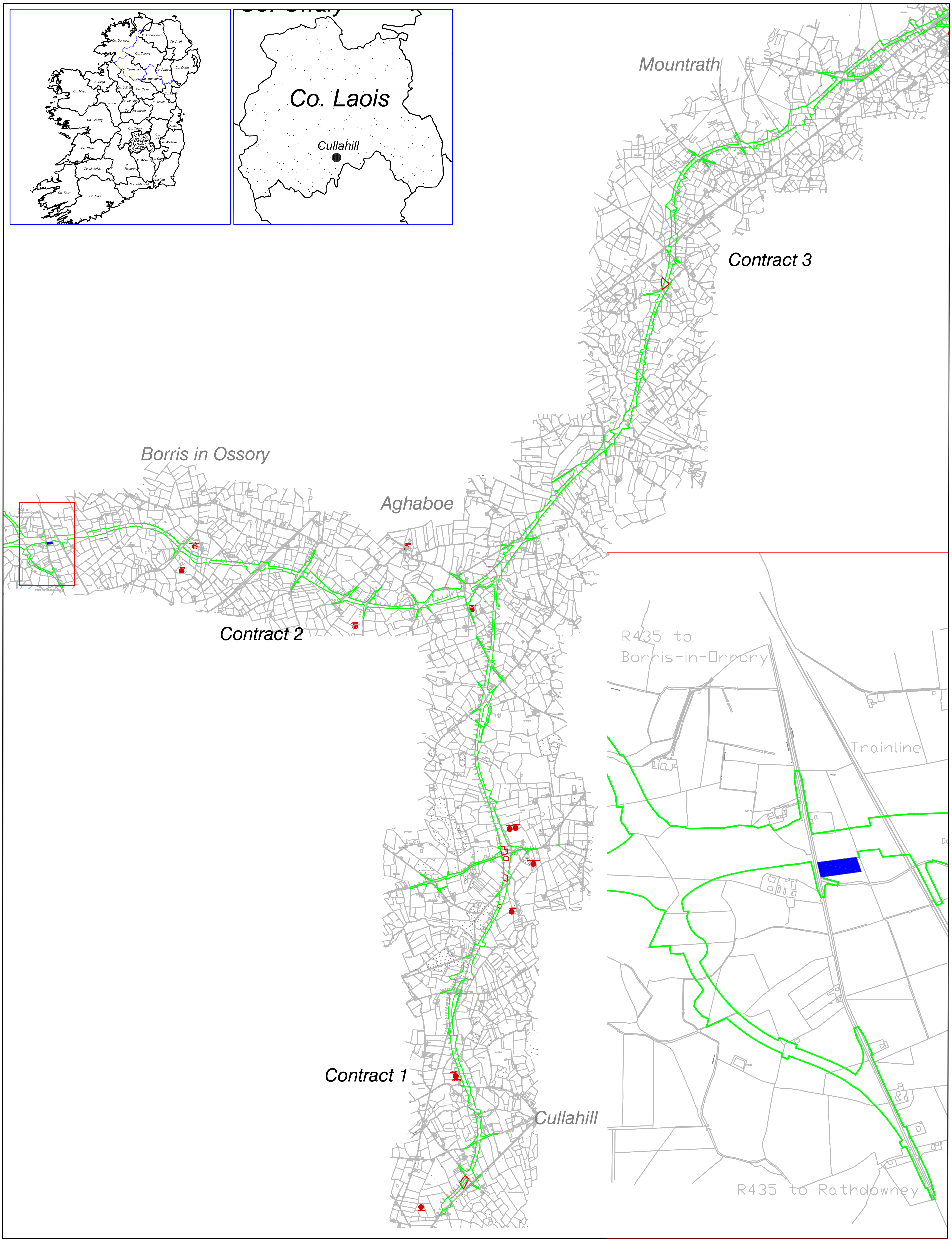
## Geophysical Archive

*Earthsound Archaeological Geophysics* takes its archiving responsibilities very seriously. Archiving is a necessary measure to maintain a complete record of past research, prevent unnecessary duplication and allow the re-use and re-interpretation of geophysical data as analytical techniques evolve.

The geophysical archive comprises:-

- an archive CD-ROM containing files of the raw data (Geoplot 3.00a, MS-Excel), report text (Word 2000 9.0), and graphics files (AutoCAD 2000).
- a hard (paper) copy of the report

At present, two copies of the archive are held by *Earthsound Archaeological Geophysics*, at separate locations to ensure preservation against accidental damage or theft. The Client, *Archaeological Consultancy Services Ltd.*, holds one further copy of the archive. Additional paper copies intended for ultimate deposition with the *Department of the Environment, Heritage and Local Government* are in the guardianship, and are the responsibility of, *Earthsound Archaeological Geophysics*.




**Legend**

- CPO line
- Basemap
- RMP Sites
- Geophysical survey area

Site Location: Bushfield, Contract 2, M7 / M8, County Laois

Client: Archaeological Consultancy Services Ltd.

Drawing Courtesy of:LCC | Date 08/12/06 | Drawing No.: 06-35/01



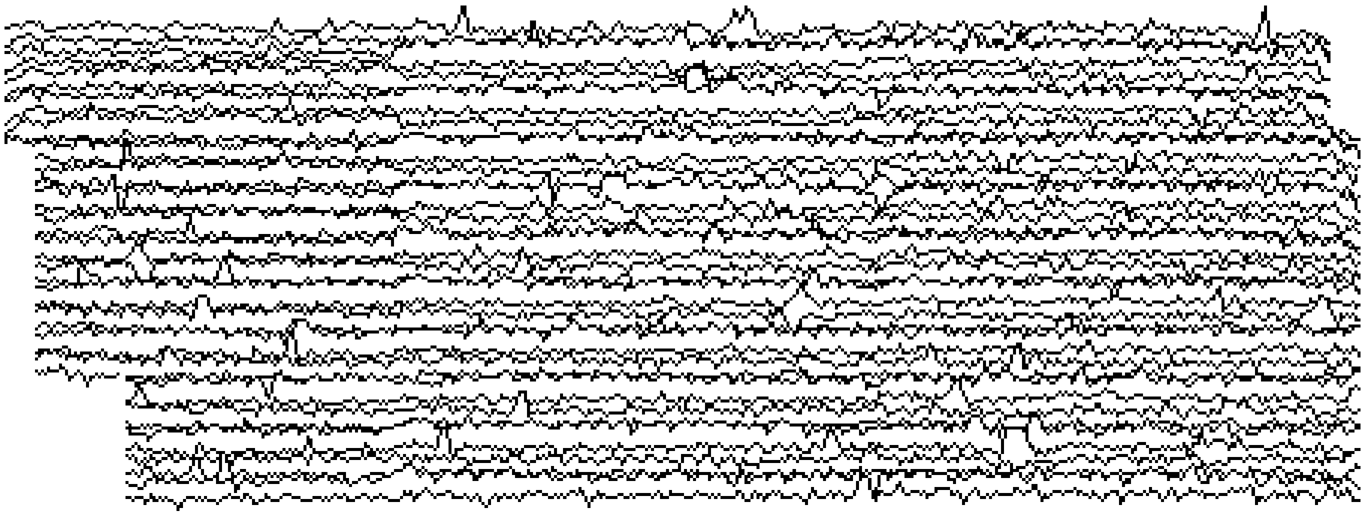
0m 2000m 4000m

**Figure No. 1 Location map**

EARTHSOUND archaeological geophysics

# Derrinsallagh 3, Contract 2, M7 / M8, County Laois

**Figure 2: Pre-processed Fluxgate Gradiometer XY Traceplot**



20.00 nT

N

0 20m

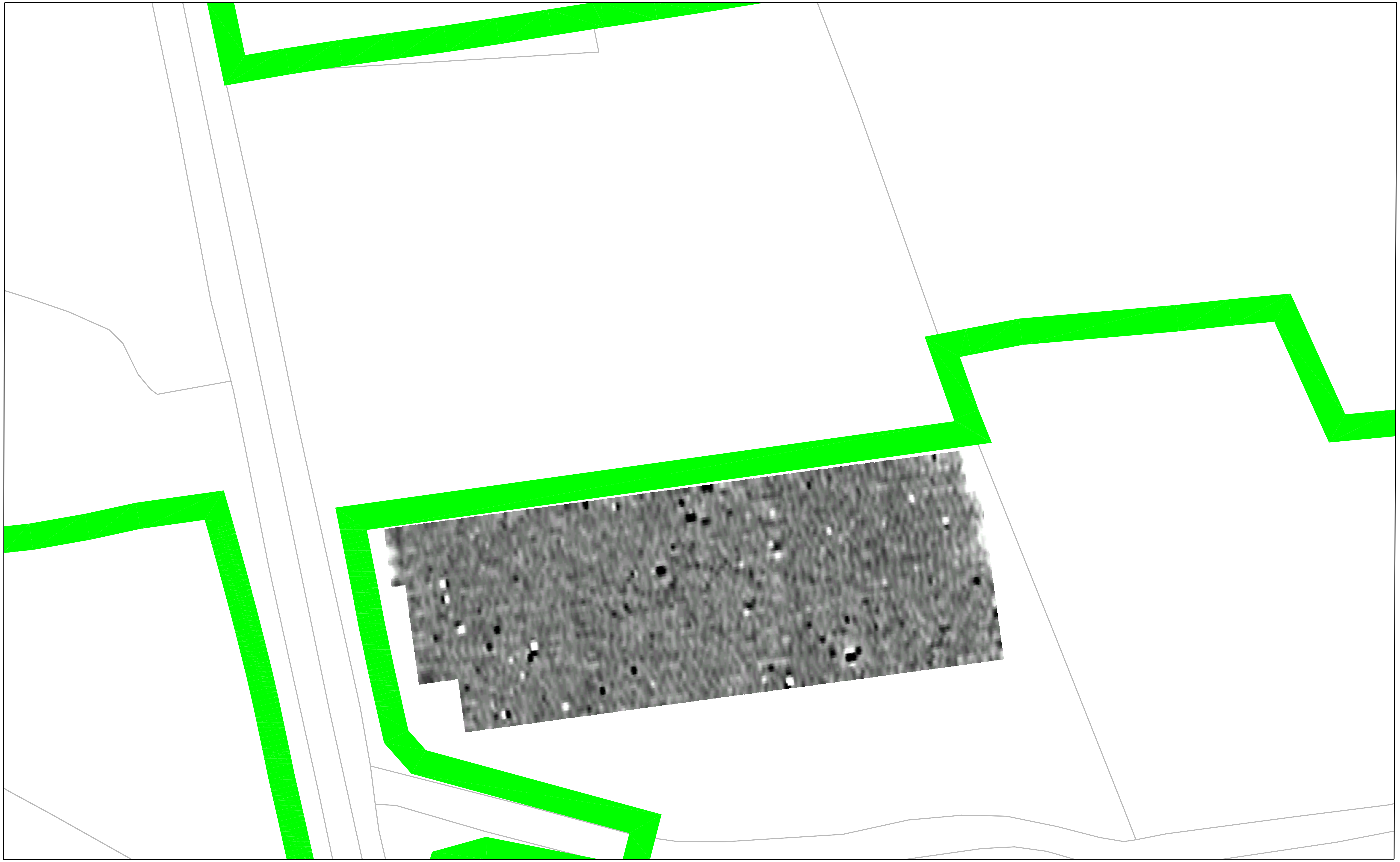
**Resolution 0.5nT,**

**Data Clipped to ± 3nT,**

**1m x 0.25m Sample Interval**

EARTHSOUND archaeological geophysics

Drawing No.: 06_35/02



***Legend***

CPO line
Basemap

nT
-2 0 2

Site Location: Derrinsallgh 3, Contract 2, M7 / M8, County Laois

Client: Archaeological Consultancy Services Ltd.

| Drawing Courtesy of:LCC | Date 13/12/06 | Drawing No.: 06-35/03 |
|---|---|---|



0m 25m 50m

**Figure No. 3 Magnetic Gradiometer data**

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***Legend***

- CPO line
- Basemap
- Survey area

- Possible pit
- Possible Ditch
- Positive Magnetic Enhancement
- Dipolar Anomaly (Possible burnt or metallic remains)

Site Location: Derrinsallgh 3, Contract 2, M7 / M8, County Laois

Client: Archaeological Consultancy Services Ltd.

| Drawing Courtesy of:LCC | Date 13/12/06 | Drawing No.: 06-35/04 |
|---|---|---|

Ordnance Survey Ireland Licence No. AR 0047306



0m 25m 50m

**Figure No. 4 Magnetic Gradiometer interpretation**

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## Legend

- CPO line
- Basemap
- Survey area
- Excavation area
- Archaeological excavation results
- Possible pit
- Possible Ditch
- Positive Magnetic Enhancement
- Dipolar Anomaly (Possible burnt or metalic remains)

N

0m 25m 50m

Site Location: Derrinsallgh 3, Contract 2, M7 / M8, County Laois

Client: Archaeological Consultancy Services Ltd.

Drawing Courtesy of:LCC | Date 13/12/06 | Drawing No.: 06-35/05



**Figure No. 5 Magnetic Gradiometer interpretation and Archaeological Excavations Results**

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