

Appendix A.13.12

Geophysical Survey Report

A.13.12 Geophysical Survey Report

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Issue Document Verification with Document

Lands at Bushypark, Ballagh, Galway
as part of the
N6 Galway City Transport Project

Archaeological Consultancy Services Contract (2016)
Stage (i)i Geophysical Survey

Detection Licence No. 16R0190

Survey undertaken for

IAC

on behalf of

Galway County Council / TII

H. Gimson BA (Hons) MSc MIAI

C. Hogan BSc (Hons) MIAI

EAG 321

1 December 2016



Prospect House, Drumagh, Claremorris, County Mayo, Ireland

www.earthsound.ie

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Summary of Results

Between the 17th and 18th November 2016, a series of geophysical surveys were undertaken for IAC on behalf of Galway County Council / TIII on land at Bushypark, Ballagh, Galway. The surveys were undertaken as part of the N6 Galway City Transport Project, on lands predefined by Galway County Council, using magnetometer and resistance surveys at a sampling resolution of 0.5m x 0.25m.

The survey was conducted upon a bedrock geology consisting of Errisbeg Townland Granite, beneath tills. The majority of the survey area was covered in short grass with areas of high thistles present, with some outcropping bedrock.

The survey has identified geophysical anomalies of possible archaeological origin within the specified survey areas. These have been accurately located and their provenance has been described in tabular and map form. Further work in the form of test trench excavations has been recommended where required.

A number of possible ditches were detected across the survey area. Many of these are linear in formation and are likely to form boundary features. The resistance survey indicates that some of these may have a bank or wall feature associated with them. A series of relict field boundaries were also detected.

Possible archaeological evidence includes a number of possible burning or industrial sites, a sub-rectangular ditch and ditches. Further anomalies are likely to be associated with soil or geological conditions on site and / or near surface geological outcrops.



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.

Direct investigations are recommended to confirm the findings of this report.

Verification can only be provided via intrusive means, such as Test Trench excavations.

1 Introduction

Earthsound Archaeological Geophysics were commissioned by IAC on behalf of Galway County Council to carry out a geophysical survey along a preselected area as part of the N6 Galway City Transport Project, County Galway.

1.1 Aims of the Survey

Galway County Council required an archaeological geophysical survey of the preselected area at Bushypark, Ballagh (Galway NRDO). The survey was carried out in accordance with the brief supplied by Galway County Council, using a combination of Magnetometer and EM Apparent Electrical Resistance surveys. The aims of the Stage (i) i Geophysical Survey Services were to:

- identify any geophysical anomalies of possible archaeological origin within the specified survey areas.
- accurately locate these anomalies and present the findings in map form.
- describe the anomalies and discuss their likely provenance in a written report.
- recommend any further work (including other forms of geophysical survey if appropriate) likely to contribute to the mitigation of the impacts of the road scheme on these features.
- incorporate all of the above in a report to Galway County Council.

1.2 Description of the Survey Area

The survey area consisted of three pasture fields. The majority of the survey area was covered in short grass with areas of high thistles present, with some outcropping bedrock.

The survey was conducted upon a bedrock geology consisting of Errisbeg Townland Granite, beneath tills. This can be a highly magnetic geology which may mask weakly magnetic possible archaeological features. The use of resistance surveys mitigates against any geological influence on the gradiometer surveys.

The climatic conditions were cold and dry. The weather is unlikely to have had an impact on the results obtained.

1.3 Archaeological Background and Statutory Protections

No archaeological remains are known within the survey areas. The National Monuments Acts (1930-2004) prohibit the unauthorised use of detecting devices on archaeological sites as well as unauthorised searches for archaeological objects using such devices. All elements of the survey were approved by the Archaeological Licensing Section of the National Monuments Service. A Consent to use a Detection Device under Section 2 (2) of the National Monuments (Amendment) Act, 1987, was issued by the Minister for Arts, Heritage, Regional, Rural and Gaeltacht Affairs: Consent No. 16R0190, issued to Cian Hogan.

A children's burial ground (GA082-039----) is located *c.* 250m to the east (Gosling 1993).

2 Methodology

Fieldwork Dates	17/11/2016 - 18/11/2016
Survey Area	1.89 ha
Method / Area	Magnetometry: 1.89 ha EMI Apparent Electrical Resistivity (ER _a): 1.89 ha

2.1 Magnetometer Survey

Instrument	Eastern Atlas LEA MAX ¹⁵⁰⁵ System
Components	LEA D2, 10-channel digitiser
Data Resolution	0.5m x 0.1m
Sensors	8 x Förster FEREX [®] 4.032 CON650 fluxgate gradiometers
Platform	LEA MAX ¹⁵⁰⁵ System cart
Data Acquisition Method	Gridless, using a Trimble RTK GPS VRS Now system to an accuracy of 5cm
Sensitivity	<0.2 nT
Data Logger	Panasonic Toughbook CF-H2 Field computer
Calibration	According to manufacturers guidelines (Pilz & Goossens 2015)
Data Processing	Ealdec: Profile decoding Ealmat.m: Normalisation, drift correction Surfer 8: Data Gridding (0.5m x 0.25m), using the Kriging Gridding Method
Graphical Display	Greyscale -5nT (white) to 5nT (black)

2.2 Electromagnetic Apparent Electrical Resistance (ER_a) Survey

EMI Measurement	Quadrature – referred to as apparent electrical conductivity (EC _a)
Instrument	GF Instruments CMD-MiniExplorer (Bonsall <i>et al.</i> 2013)
Data Resolution	0.5m x 0.2s
Coil Configuration / Effective depth range	Vertical Coplanar Coil configuration (VPC) or ‘half-depth’, effective depth range: 0.25m, 0.5m, 0.9m
Platform	SparrowHawk-1000 cart system, sensor positioned 10cm above the ground
Data Acquisition Method	Continuous mode, Gridless, using a Trimble RTK GPS VRS Now system to an accuracy of 5cm
Measuring Range	EC _a : 1000mS/m, resolution 0.1mS/m
Data Logger	CMD Control Unit
Calibration	According to manufacturers guidelines (GF Instruments 2010)
Data Processing	Drift correction using a moving filter, Despiking, High Pass Gaussian Filter, Interpolation
Graphical Display	Greyscale ± 1.5 Standard Deviation

2.3 Reporting, Mapping & Archiving

The geophysical survey and report follow the recommendations outlined by relevant best practice guidance documents as a minimum standard (Bonsall *et al.* 2014b; David *et al.* 2008; Gaffney *et al.* 2002, Schmidt *et al.* 2015).

Ordnance Survey of Ireland mapping was supplied by Galway County Council.

Geophysical data, the figures presented here and the text have been archived following the recommendations of the Archaeology Data Service (Schmidt & Ernenwein 2011).

3 Results

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 highlighted in the interpretation diagrams and are described and interpreted within the text.

3.1 Magnetometer Anomalies

No.	Form of Anomaly	NGR (E,N)	Possible Source(s) of Anomaly	Recommendation
1	Multiple areas of soil or geological interference	Across the whole survey area	Geological Bedrock	None
2	Linear interlinking positive anomalies cut by cultivation furrows	527207.03, 727585.69	Possible Ditch	Test Excavation
3	Two parallel linear positive anomalies	527191.91, 727600.48	Possible Ditch	Test Excavation
4	Linear positive anomaly	527164.11, 727625.68	Possible Ditch	Test Excavation
5	Rectilinear trend	527164.72, 727642.45	Possible Geological interference or an archaeological feature	Test Excavation
6	Isolated highly magnetic anomaly	527220.91, 727605.73	Possible burning or industrial activity	Test Excavation
7	Two areas of modern disturbance	527209.62, 727653.77	Electricity Pylons	None
8	Linear positive anomaly	527193.17, 727649.32	Possible Ditch	Test Excavation

No.	Form of Anomaly	NGR (E,N)	Possible Source(s) of Anomaly	Recommendation
9	Rectilinear trend	527214.47, 727662.87	Possible Geological interference or archaeological feature	Test Excavation
10	Interlinking positive linear anomalies	527204.46, 727682.86	Relict field boundary	None
11	Linear positive anomaly	527238.03, 727719.62	Probable extension to relict field boundary	Test Excavation
12	Linear / Curvilinear interlinking positive anomalies	527218.03, 727687.56	Possible Ditches	Test Excavation
13	Linear positive anomaly	527259.65, 727666.42	Possible Ditch	Test Excavation
14	Four highly magnetic anomalies	527242.54, 727693.18	Possible burning or industrial activity	Test Excavation

3.2 Resistance Anomalies

No.	Form of Anomaly	NGR (E,N)	Possible Source(s) of Anomaly	Recommendation
2	Linear area of high resistance	527226.38, 727563.47	Possible bank or wall	Test Excavation
3	Linear area of high resistance surrounded by cultivation furrows	527187.15, 727594.88	Possible bank or wall	Test Excavation
10	Interlinking linear low resistance anomalies	527204.46, 727682.86	Relict field boundary	None
11	Linear low resistance anomaly	527238.03, 727719.62	Probable extension to relict field boundary	Test Excavation
15	Interlinking linear low resistance anomalies	527190.11, 727672.48	Probable extension to relict field boundary	Test Excavation
16	Rectilinear high resistance anomaly	527251.47, 727694.52	Possible bank or wall	Test Excavation
17	Isolated high resistance anomalies	Across the eastern edge of the survey area	Possible near surface geology or archaeological remains	Test Excavation
18	Rectilinear high resistance anomaly	527200.93, 727699.46	Possible bank or wall	Test Excavation
19	Linear high resistance anomaly running parallel to 18	527185.37, 727683.58	Possible bank or wall	Test Excavation
20	Linear high resistance anomaly	527180.43, 727695.58	Possible bank or wall	Test Excavation
21	Curvilinear low resistance anomaly	527220.72, 727645.10	Possible ditch or geological activity	Test Excavation
22	Linear high resistance anomaly	527279.74, 727685.70	Possible bank or wall	Test Excavation
23	Linear low resistance anomaly	527240.39, 727586.53	Possible ditch	Test Excavation

4 Conclusion

4.1 Summary of Results

The survey has identified geophysical anomalies of possible archaeological origin within the specified survey areas. These have been accurately located and their provenance has been described in tabular and map form. Further work in the form of test trench excavations has been recommended where required.

The survey revealed a number of possible ditches across the survey area. Many of these are linear in formation and are likely to form boundary features. The resistance survey suggests that some may have a bank or wall feature associated with them. A series of relict field boundaries were also detected.

Possible archaeological evidence includes a number of possible burning or industrial sites, a sub-rectangular ditch and ditches. Further anomalies are likely to be associated with soil or geological conditions on site and / or near surface geological outcrops.

4.2 Recommendations

Test trenching should occur at locations recommended in Sections 3.1 and 3.2, above. Many of these will be to determine the presence/absence of geology/archaeology interpreted from weakly magnetic trends.

4.3 Dissemination

The results of this survey were submitted to Galway County Council. Earthsound will ensure that copies will be forwarded to the Department of the Arts, Heritage, Regional, Rural and Gaeltacht Affairs and the National Museum of Ireland in compliance with the Licence agreement.

5 Acknowledgements

Fieldwork:	Dr. James Bonsall MIAI Hannah Brown BA (Hons) MA MSc Darren Regan BSc (Hons) MA Cian Hogan BSc (Hons) MIAI
Report:	Heather Gimson BA (Hons) MSc MIAI Cian Hogan BSc (Hons) MIAI
Graphics:	Heather Gimson

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7 Figures

- Figure 1: Location map
- Figure 2: Detailed location map
- Figure 3: Magnetometer data
- Figure 4: Magnetometer interpretation
- Figure 5: Resistance data
- Figure 6: Resistance interpretation

Technical Appendix

Appendix 1: Anomaly Classifications

Magnetometry

Positive Magnetic Anomalies

Burnt features, particularly kilns, but also hearths, furnaces and burnt (specifically ‘burnt’, not ‘heated’) mounds of stone will create a strongly magnetic anomaly due to thermoremanence. Cut features, such as pits, ditches or wooden postholes will create anomalies that will vary in shape and magnetic intensity depending on which material they were backfilled by (Fassbinder 2015). For cut features backfilled (or ‘refilled’) by

- magnetically enhanced topsoil – the refill will generate a positive magnetic anomaly
- homogeneous topsoil – the refill will generate an anomaly proportional to the size and volume of the archaeological feature.

The magnetic anomaly shape and intensity will also be determined by concentrations of pottery, ash or burned material, solid rocks or other material.

Negative Magnetic Anomalies

Negative magnetic anomalies have a number of causes (Fassbinder 2015):

- The material remains of the archaeological feature may have a lower magnetic susceptibility (MS) than the adjacent topsoil. In some cases the MS of a ditch may appear as both a positive and negative anomaly, reflecting the variable MS of the refill material. Some stone foundations can also appear as weakly magnetic or negative magnetic anomalies.
- If a cut feature is immediately refilled by the same material e.g. a grave cut excavated before a funeral is (almost) immediately refilled by the human body and the same (unaltered) sediment that was excavated before.
- Geochemical processes (see Fassbinder 2015) can alter the magnetic response, e.g. an archaeological feature identified by a positive anomaly can convert to a negative anomaly due to the combination of stagnant moisture and a changing groundwater table. This is particularly true in Ireland (Bonsall et al. 2014a) for circular ring-ditch features located in areas of poor drainage, which can result in the removal of a measurable magnetic response for such features.

Dipolar Anomalies

A dipolar anomaly or 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 (iron agricultural implements, rubbish), they can be indicative of archaeological material.

Absence of Anomalies

It is also possible that archaeological features exist that exhibit no magnetic contrast and hence cannot be identified by magnetometer survey.

Anomaly classification used to interpret Magnetometry data

After Gaffney & Gater (2003) and Gaffney *et al.* (2000).

A known archaeological feature type e.g. Ditch / Wall / Structure etc: An anomaly with a magnetic gradient that contrasts strongly with the surrounding sub-soil, where the presence of a type of archaeological feature is known from supporting evidence.

Archaeology: A linear, curvilinear or isolated anomaly with a magnetic gradient that contrasts strongly with the surrounding sub-soil, without any supporting evidence from another source.

- **Ditch / Wall:** A linear, curvilinear, annular or penannular anomaly with a magnetic gradient that contrasts strongly with the surrounding sub-soil. A positive polarity suggests a ditch; a negative polarity suggests a stone-filled ditch or wall.
- **Burnt Mound / Spread:** A horseshoe or ovoid shaped anomaly with a positive magnetic gradient that contrasts strongly with the surrounding sub-soil. An associated trough may be observed as a positive/negative anomaly, a hearth may also be expected nearby. Isolated responses in the vicinity could represent spreads of (or ploughed out) heat shattered stones.
- **Hearth:** A small isolated area (<2m diameter) of higher magnetic gradient than the surrounding sub-soil (typically >6nT).
- **Pit:** A small isolated area (>1-2m diameter) of moderate to high magnetic gradient, judged to be caused by a pit-type feature with a fill more magnetic than the surrounding soil.

Industrial: An isolated anomaly with a strong positive gradient (>30nT), judged not to be surface iron. This type of anomaly is typically caused by the remains of kilns or furnaces.

Magnetic Enhancement: A broad area of moderate positive magnetic gradient that contrasts with the surrounding sub-soil. May represent cultural noise associated with occupation or soil disturbance, judged to be of archaeological origin.

Ferrous: Dipolar anomalies indicating ferrous responses, judged to be in the near-surface.

Cultivation: Parallel linear responses of positive or negative polarity. Strong responses may indicate added magnetic material (e.g. burnt deposits) as fertiliser. Lower magnetic gradient anomalies 'beneath' the furrow overprint may be obscured. Higher magnetic gradient anomalies may be visualised *in situ* or ploughed out 'beneath' the furrow overprint.

?Archaeology: A linear, curvilinear or isolated anomaly with a magnetic gradient that contrasts weakly with the surrounding sub-soil, without any supporting evidence from another source. Such categories may represent possible archaeological or geological sources.

Modern Disturbance: Area where the ground has been disturbed in the recent past. Characterised by very large magnetic gradients and a high level of noise often accompanied by concentrations of dipolar, near-surface ferrous responses. This category also represents anomalies whose source may lie beyond the survey area, such as fencelines, vehicles or modern buildings.

Modern Pipe: Straight, linear anomaly with very large magnetic gradients alternating regularly between positive and negative polarity.

Previous Excavation?: Area of uniform magnetic signal contained within a well-defined boundary in regions otherwise densely covered with archaeological anomalies.

Geology: Anomalies of possible geomorphological origin.

Apparent Electrical Resistance

The resistivity property has been calculated from the Apparent Electrical Conductivity response of an electromagnetic induction (EMI) instrument. The EMI instrument transmits an alternating current which induces a primary and subsequently a secondary electromagnetic field. The electromagnetic fields interact with the underlying soils and one of the subsequent responses is measured as Apparent Electrical Conductivity, which are subsequently calculated via automated software to Apparent Electrical Resistance (ER_a).

Anomaly classification used to interpret ER_a data

After Gaffney & Gater (2003) and Gaffney *et al.* (2000).

A known archaeological feature type e.g. Ditch / Wall / Structure etc: An anomaly with a ER_a that contrasts strongly with the surrounding sub-soil, where the presence of a type of archaeological feature is known from supporting evidence.

Archaeology: A linear, curvilinear or isolated anomaly with an ER_a that contrasts strongly with the surrounding sub-soil, without any supporting evidence from another source.

- **Ditch / Wall:** A discrete linear, curvilinear, annular or penannular anomaly with an ER_a that contrasts strongly with the surrounding sub-soil. A low ER_a suggests a ditch; a high ER_a suggests a stone-filled ditch or wall.
- **Mound of Stones:** A discrete horseshoe or ovoid shaped anomaly with a higher ER_a than the surrounding sub-soil.
- **Pit:** A small isolated area (>1-2m diameter) of ER_a that contrasts with the surrounding sub-soil, judged to be caused by a pit-type feature.
- **Cultivation:** Parallel linear responses of high or low ER_a .
- **Disturbed Soil:** A broad area of moderate ER_a change that contrasts with the surrounding sub-soil. May represent cultural noise associated with soil disturbance, judged to be of archaeological origin.

High ER_a Anomalies

Soils comprised of materials of a higher ER_a than the surrounding soil will exhibit anomalies of 'higher resistivity'. These are likely to include stone walls, masonry, rubble, cobbled or gravel surfaces, as well as near surface geology.

Low ER_a Anomalies

Soils that are comprised of materials of a lower ER_a than the surrounding soil will exhibit anomalies of 'lower resistivity'. These are likely to include ditches, drainage ditches and pits, as well as badly palaeochannels, drained soils, a high water table, deep topsoil, springs, boggy areas, areas adjacent to rivers and clay soils.

Modern Disturbance: Area where the ground has been disturbed in the recent past. Characterised by very large ER_a gradients and a high level of noise.

Modern Pipe: Straight, linear anomaly with a ER_a contrast.

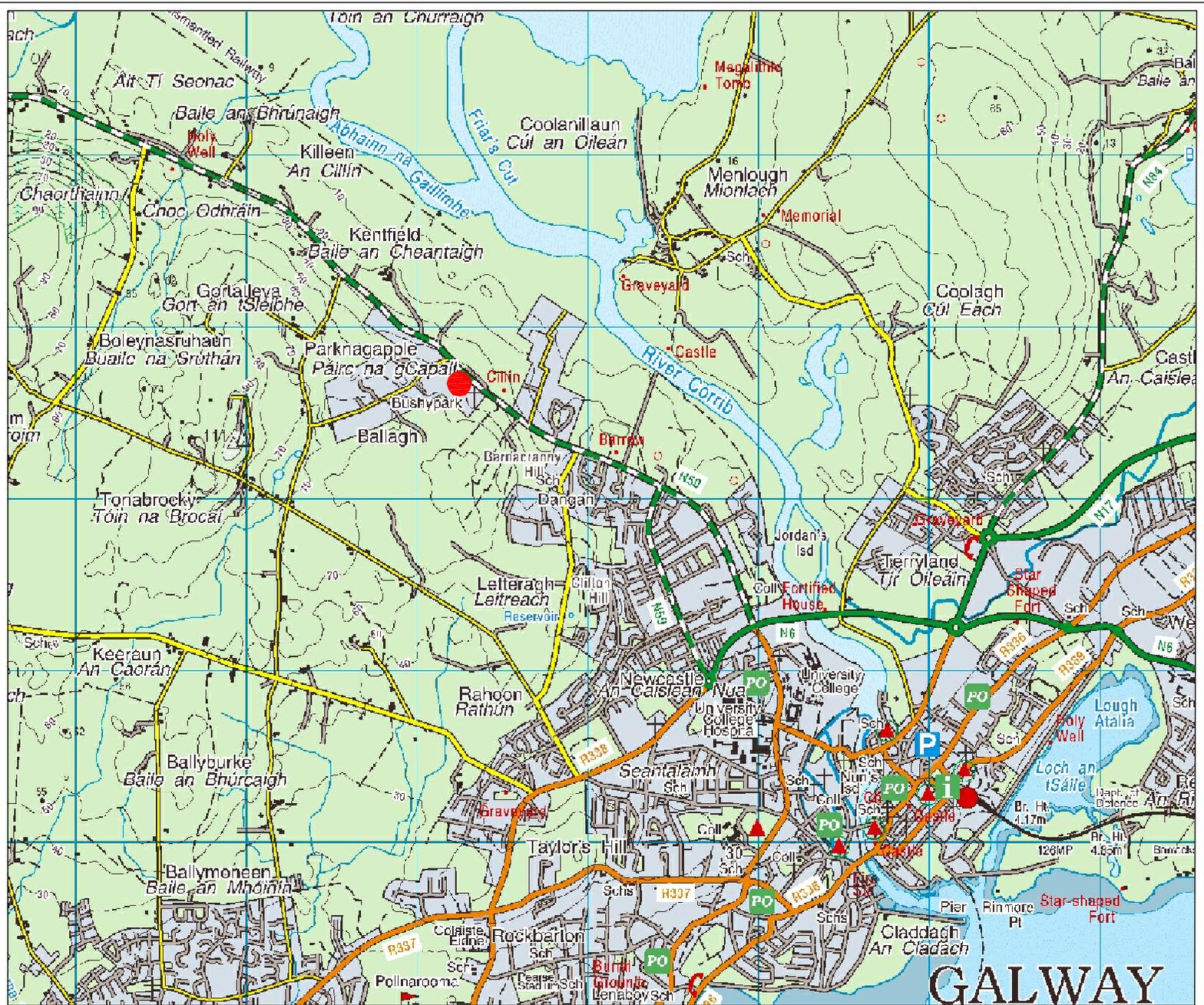
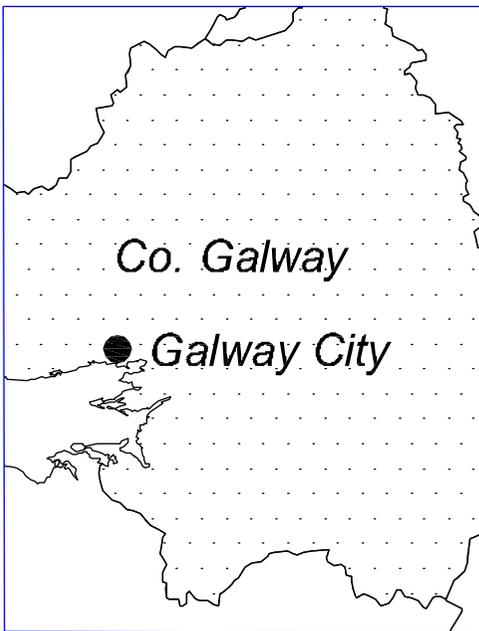
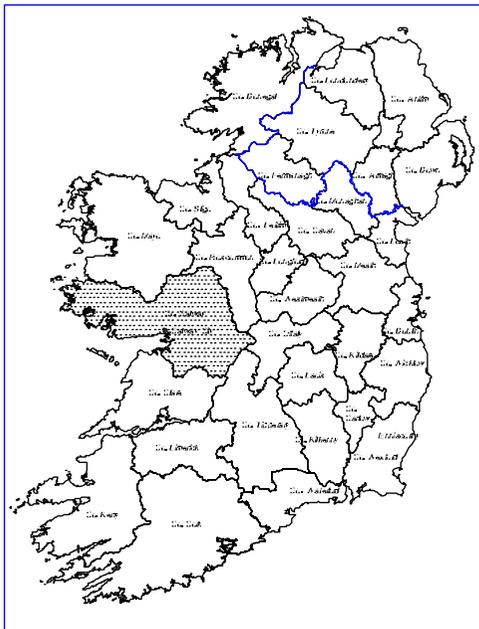
Geology: Anomalies of possible geomorphological origin.

Absence of Anomalies

It is also possible that archaeological features exist that exhibit no resistivity contrast and hence cannot be identified by Apparent Electrical Resistivity survey.

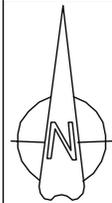
Appendix 2: Geophysical Archive

- Two soft and hard copies of the archive are held by Earthsound Archaeological Geophysics, at separate locations to ensure preservation against accidental damage or theft.
- The Client, IAC, holds further hard and soft copies of the archive.
- A hard copy and a soft copy will be deposited with the Archaeological Licensing Section, National Monuments Service, Department of Arts, Heritage, Regional, Rural and Gaeltacht Affairs, Room G50, Custom House, Dublin 1.
- A hard copy will be deposited with the National Museum of Ireland, Kildare Street, Dublin 2.



Legend

— Site Location



Site Location: Lands at Bushypark, Ballagh, County Galway

Client: IAC / Galway County Council

Drawing Courtesy of: OSI

Date: 23/1/16

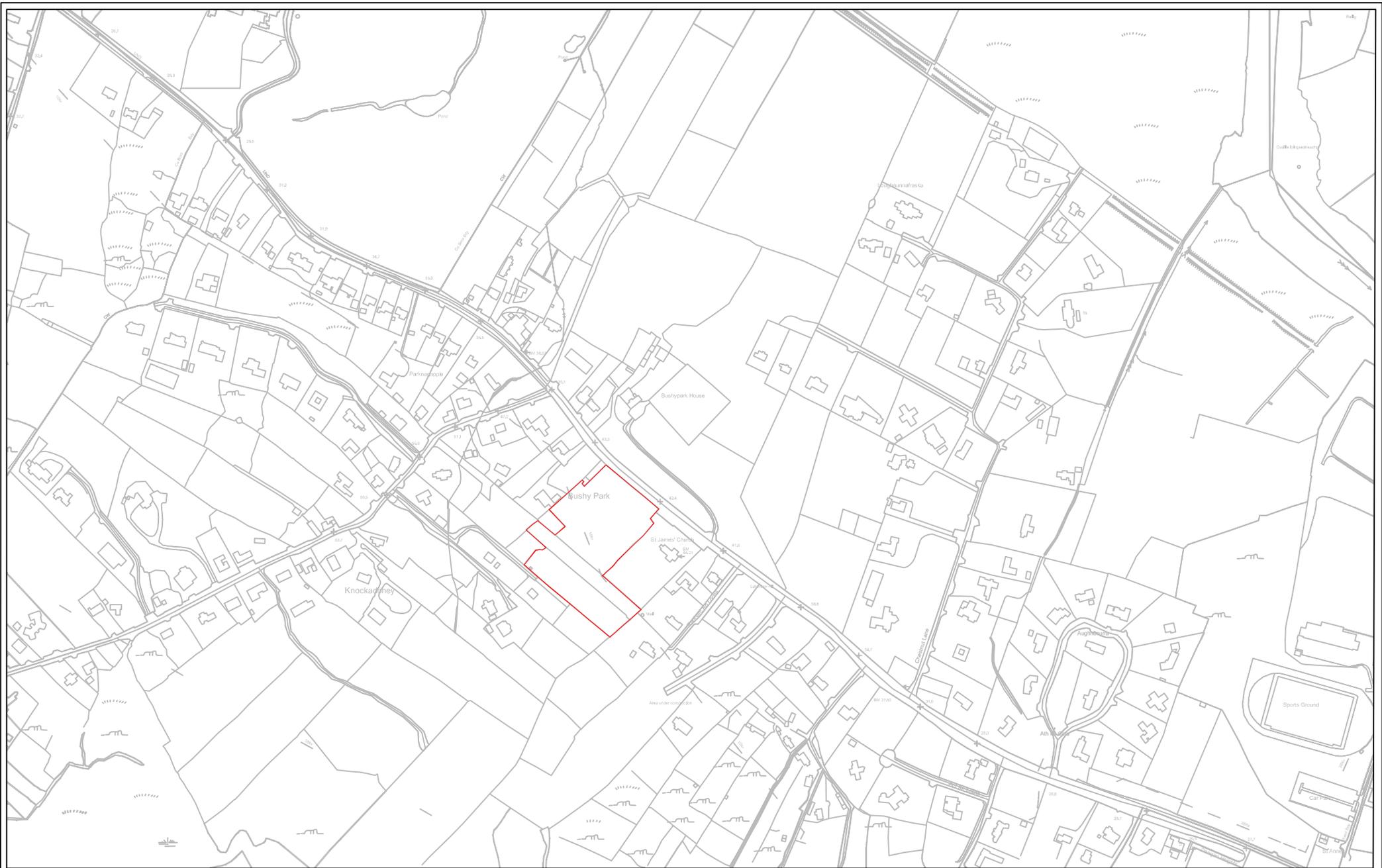
Drawing No.: 16-07201

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Figure No. 1 Location map





Legend

- Basemap
- Site Location



Site Location: Lands at Bushypark, Ballagh, County Galway

Client: IAC / Galway County Council

Drawing Courtesy of: Galway Coco

Date 29/11/16

Drawing No.: 16-072/02

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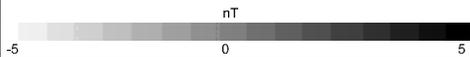
Figure No. 2 Detailed location map





Legend

— Basemap



Site Location: Lands at Bushypark, Ballagh, County Galway

Client: IAC / Galway County Council

Drawing Courtesy of: Galway Coco

Date: 29/11/16

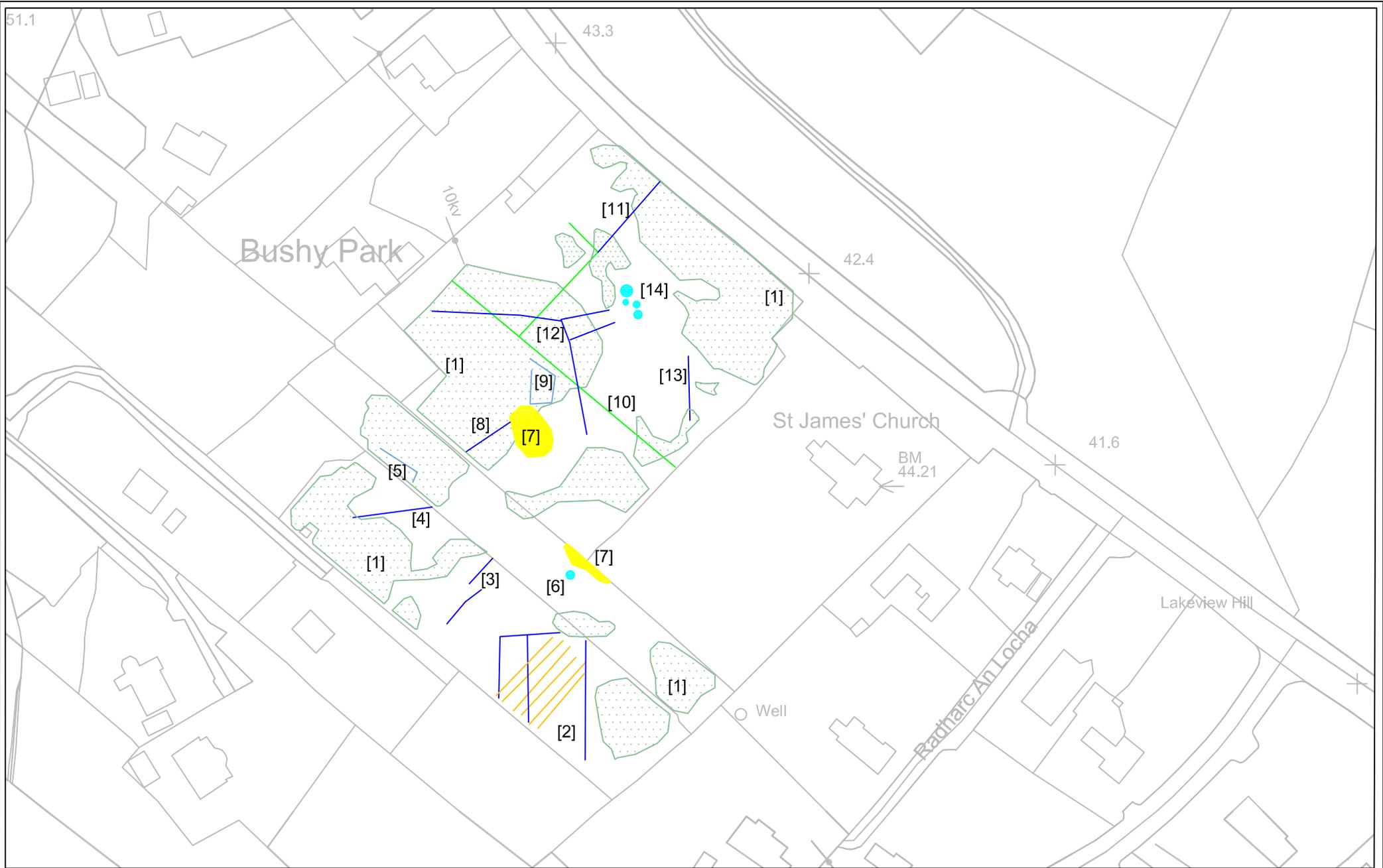
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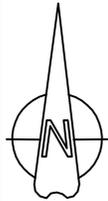
Figure No. 3 Magnetometer data





Legend

- Basemap
- Historic Mapping Features
- ? Archaeology
- ? Industrial
- Trend
- Cultivation
- Geology / Soil
- Modern Disturbance



Site Location: Lands at Bushypark, Ballagh, County Galway

Client: IAC / Galway County Council

Drawing Courtesy of: Galway Coco

Date: 29/11/16

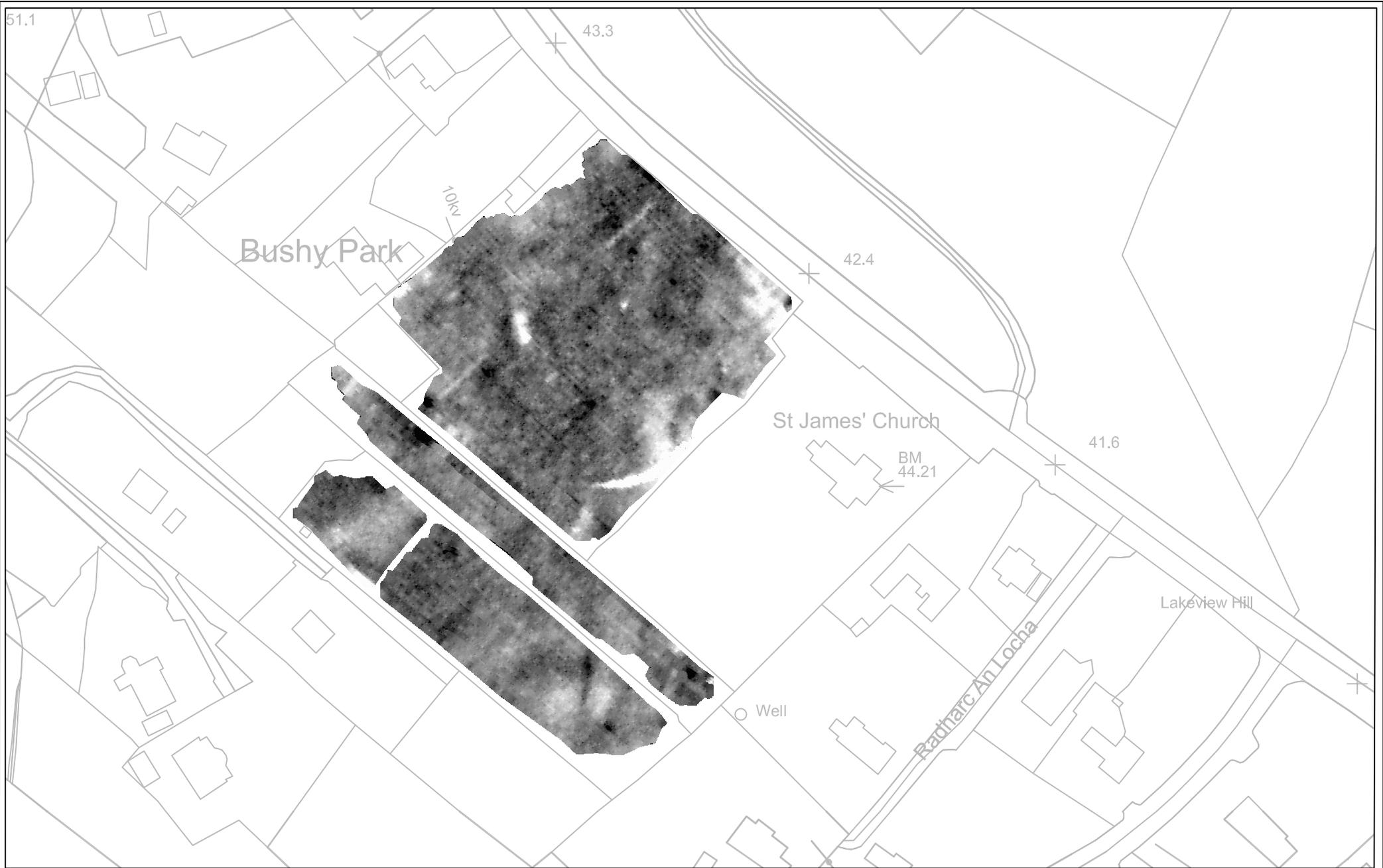
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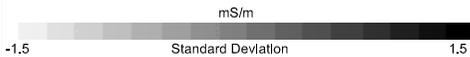
Figure No. 4 Magnetometer interpretation





Legend

— Basemap



Site Location: Lands at Bushypark, Ballagh, County Galway

Client: IAC / Galway County Council

Drawing Courtesy of: Galway Coco

Date 30/11/16

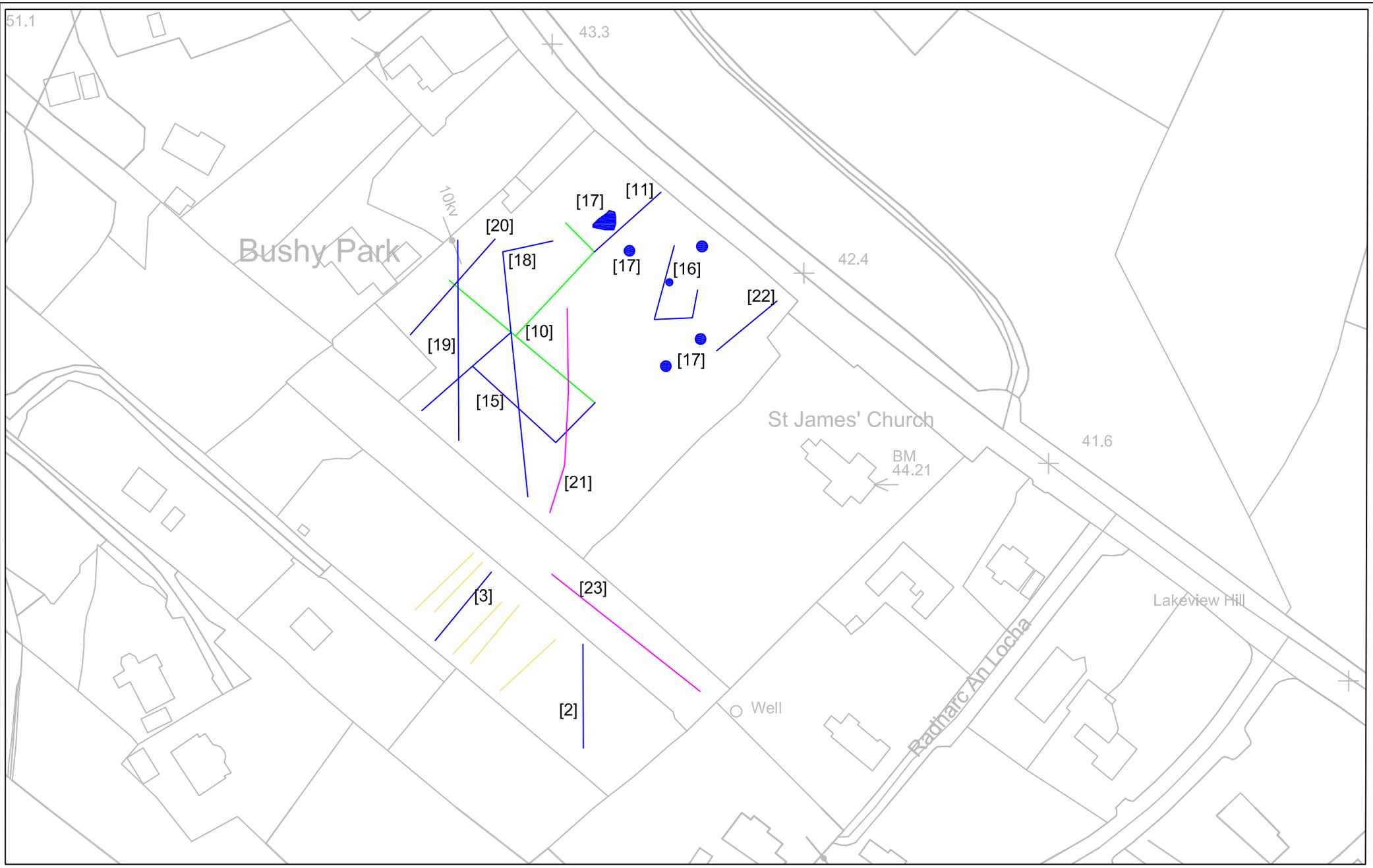
Drawing No.: 16-072/05

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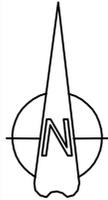
Figure No. 5 Resistance data





Legend

- Basemap
- Historic Mapping Features
- ? Archaeology
- Cultivation
- Low ER₃ Anomaly



Site Location: Lands at Bushypark, Ballagh, County Galway

Client: IAC / Galway County Council

Drawing Courtesy of: Galway Coco

Date: 01/12/16

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Figure No. 6 Resistance interpretation

