

# **A1 in Northumberland: Morpeth to Ellingham**

**Scheme Number: TR010041**

## **6.8 Environmental Statement – Appendix 8.2 Geophysical Survey Report**

### **Part B**

APFP Regulation 5(2)(a)

Planning Act 2008

Infrastructure Planning (Applications: Prescribed  
Forms and Procedure) Regulations 2009

June 2020

Infrastructure Planning

Planning Act 2008

**The Infrastructure Planning  
(Applications: Prescribed Forms and  
Procedure) Regulations 2009**

The A1 in Northumberland: Morpeth to Ellingham  
Development Consent Order 20[xx]

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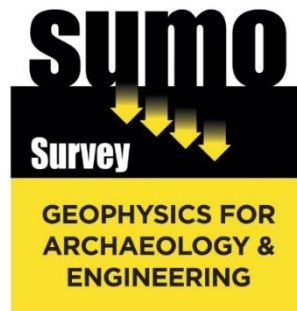
**Environmental Statement - Appendix**

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|---|--|
| <b>Regulation Reference:</b>                  | APFP Regulation 5(2)(a)  |
| <b>Planning Inspectorate Scheme Reference</b> | TR010041   |
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|----------------|-------------|--------------------------|
| Rev 0          | June 2020   | Application Issue        |





## **GEOPHYSICAL SURVEY REPORT**

**A1 in Northumberland  
Alnwick to Ellingham**

Client

**WSP**

For

**Highways England**

Survey Report

**13633**

Date

**February 2019**



## **Survey Report 13633: A1 in Northumberland - Alnwick to Ellingham**

|                           |   |
|---------------------------|---|
| <b>Survey dates</b>       | November 2018 - February 2019   |
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|-----------|---------|--|
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## 2. SURVEY TECHNIQUE

Detailed magnetic survey (magnetometry) was chosen as the most efficient and effective method of locating the type of archaeological anomalies which might be expected at this site.

Bartington Grad 601-2

Traverse Interval 1.0m

Sample Interval 0.25m

## 3. SUMMARY OF RESULTS

Magnetometer survey identified responses of possible archaeological interest adjacent or near to known heritage assets. In other areas, no 'new' monuments or settlement sites were identified, though a plethora of possible ditch-like responses has been recorded. While the latter have been classified as having an uncertain origin, simply because there are many alternative explanations, it is possible that some are associated with old field systems or divisions.

Glaciofluvial deposits are present along the route and they include gravels (with their own inherent strong magnetism) which have resulted in large areas of magnetic or ferrous-like disturbance; as a consequence, the data from some areas have been very difficult to interpret.

## 4 INTRODUCTION

4.1 **SUMO Geophysics Ltd** were commissioned to undertake a geophysical survey of an area outlined for road improvements. This survey forms part of an archaeological investigation being undertaken by **WSP** on behalf of **Highways England**. Background information contained in this report derives from the Environmental Impact Assessment (EIA) Scoping Report (WSP 2018).

### 4.2 Site details

|                       |  |
|-----------------------|--|
| NGR / Postcode        | Northern extent: NU 170 228 / NE67 5HY<br>Southern extent: NU 197 152 / NE66 2LB   |
| Location              | 66 areas along the A1 in Northumberland between Alnwick and Ellingham, extending for approximately 8 km between the single carriageway north of Denwick to the dual carriageway south of Brownieside. See Figure 01.   |
| HER                   | Northumberland Historic Environment Record   |
| Parishes              | <b>Areas 1-12:</b> Eglington CP<br><b>Areas 13-46:</b> Rennington CP<br><b>Areas 47-66:</b> Denwick CP   |
| Geology<br>(BGS 2019) | <b>Areas 1 – 19, 28 – 35 Bedrock:</b><br>Tyne Limestone Formation and Alston Formation (undifferentiated) – limestone, sandstone, siltstone and mudstone.<br><b>Areas 21 – 24 Bedrock:</b><br>Alston Formation - limestone, sandstone, siltstone and mudstone.<br><b>Areas 25 – 27, 35, 46 – 48 Bedrock:</b><br>Scremerston Coal Member - sandstone, siltstone and mudstone.<br><b>All Areas Superficial:</b> Glaciofluvial Deposits, Devensian - sand and gravel.   |
| Soils<br>(CU 2019)    | <b>Areas 1 – 24:</b> Soilscape 6: freely draining slightly acid loamy soils.<br><b>Areas 25 – 66:</b> Soilscape 17: slowly permeable seasonally wet acid loamy and clayey soils.   |
| Archaeology           | One Scheduled Monument is located within the Scheme Footprint, a pond barrow towards the north end of the project. Neolithic and Bronze Age activity is present in the form of barrows, cist burials and flint artefacts. Iron Age occupation is represented within the wider study area in the form of defended settlement sites. There are no sites of Roman or Anglo-Saxon date recorded in the inner or wider study areas. Six areas of Deserted Medieval Settlement are recorded in the study area. The largest is the Scheduled Monument North Charlton medieval village and open field system (NHLE 1018348) which extends to both the east and west side to the Scheme. A total of nine non-designated assets of post-medieval to 19th century have been identified. Just one buried archaeological asset of modern date has been noted, the Seahouses landing ground at Rennington. A cropmark of a sub-rectangular feature is potentially the remains of a ditched enclosure of unknown date and lies within the footprint (WSP 2018). |
| Survey Methods        | Magnetometer survey (fluxgate gradiometer)   |

### 4.3 Aims and Objectives

To provide more information about sites referred to in HER which lie within the study area, and to locate and characterise any anomalies of archaeological interest previously unrecorded.

## 5 RESULTS

*The survey has been divided into 66 survey areas (Areas 1-66) and specific anomalies have been given numerical labels [1] [2] which appear in the text below, as well as on the Interpretation Figures. Sites of interest identified in the EIA (WSP 2018) will be discussed first, followed by an assessment of responses under the following headings: Uncertain; Former Field Boundary; Agricultural – Ploughing / Land Drains; Natural / Geological / Pedological / Topographic; Ferrous / Magnetic Disturbance.*

### 5.1 Designated and Non-Designated Assets

#### 5.1.1 Areas 1 and 1C

**1018348 (Scheduled Monument)** *Deserted Medieval Settlement North Charlton, medieval village and open field system – adjacent to the scheme footprint.*

While there are no obvious responses which would be interpreted as being definitely associated with the medieval remains, it has to be stated that the dataset is very 'noisy'. The reason for the increased magnetic levels is difficult to ascertain; while some of the responses are almost certainly natural in origin, the very strong ferrous-like anomalies are more difficult to interpret. Given the nature of the adjacent Scheduled Monument, that is the preservation of extensive and substantial earthworks, one possible explanation for the results is that if the settlement originally extended into this field and was subsequently deliberately levelled, the magnetic anomalies could be associated with a complex of very disturbed deposits. Similar magnetic results elsewhere occur over igneous outcrops but the nearest recorded outcrops (or intrusions) are at a considerable distance from the site; erratic igneous rocks dumped following glacial retreat could account for the observed results, but this seems unlikely. When comparing the present-day topography with the fields to the north (and south) Area 1 is noticeably flatter. Whatever the cause, it is impossible to say whether archaeological features have been masked and remain unrecognised due to the sheer complexity of the results. As such, the results of the survey remain inconclusive.

#### 5.1.2 Area 1

**1018499 (Scheduled Monument)** *Prehistoric burial mound. The monument is described as a "bowl barrow", a form which dates from the Late Neolithic to the Late Bronze Age and can occur either in isolation or as a part of a group or cemetery. An excavation at the site in the late 19th century found a cist buried within the mound which contained an inhumation and a glass bead. It is believed that further burials remain intact within the monument.*

**HER 5033.** *Approximately 220 m to the north of the above Scheduled Monument, is the site of two cist burials (plus a brass spear) of probable Bronze Age date found in the early 19th century. The cists likely mark the location of a former barrow, although no trace is now visible on the ground surface.*

No magnetic responses indicative of the pond barrow are visible in the data; similarly, there are no signs of anomalies of archaeological interest in the vicinity of the recorded cist burials and no evidence for the postulated barrow. However, these results are not unexpected given the extensive magnetic disturbance referred to above (5.1.1); A pond barrow may not have an encircling ditch and cist burials are too small to produce magnetic contrasts.

Given the potential for further funerary remains in the vicinity, the very faint curving trend [1] could indicate an enclosure ring with a diameter of some 50m. However, the results are very poorly defined and given the extensive noise, they could simply be an artefact of the data processing. Without the evidence of archaeological remains in the vicinity, it is unlikely that the responses would have been given any classification; as such the uncertain origin is tentative at best.



### 5.1.3 Area 2

**HER 5043.** “Camp” which relates to an earthwork, however this site is currently undated.



The results of the magnetic survey indicate anomalies [2] which coincide with the earthworks visible on the OS 1892-1914 25-inch map and on Google imagery (red rings). The responses may be a direct effect of the topography, as well as being cut (pit-like) features, though it is difficult to be more specific about their interpretation. The magnetic results also indicate parallel striped responses which reflect the ridge and furrow ploughing in the field.

### 5.1.4 Area 4

**1006500 (Scheduled Monument)** Camp at West Linkhall. Iron Age occupation defended settlement site abuts the Scheme Footprint to the east of this area.

There is a cluster of magnetic anomalies [3] similar to those located in Area 4; that is, some of the responses are associated with extant earthworks and depressions, whilst others are possibly pits or similar archaeological features. Ridge and furrow cultivation effects are also visible in the northern third of the survey area (red survey corridor below). Without the evidence of the standing earthworks, it is uncertain how much weight would have been given to the magnetic results features, but the suggestion is that the site extends beyond the outline shown in the earthworks plan.



*The red lines show the survey corridor.*

#### 5.1.5 **Areas 10, 11, 12, 16, 17, 18 and 19**

**HER 5062.** *Findspot of worked flint (Neolithic or Early Bronze Age) from Charlton Mires could indicate the presence of further buried archaeological assets.*

**HER 5045.** *A cropmark of a ring ditch (barrow) is recorded a short distance to the west of the Scheme boundary (Areas 16 and 18) near Charlton Mires.*

**HER 504.** *Chester Hill Camp possible Iron Age settlement site but unsubstantiated (west of Area 18).*

There are several anomalies [4] which could indicate the presence of ring ditches of possible archaeological interest in Area 18 and the existence of HER entry 5045 adds weight to this interpretation. However, the results are confused by the naturally magnetic geology which could be the cause of the rings or they might even be agricultural. The same interpretation applies to a number of linear and curvilinear trends in the results which have been categorised as having an uncertain origin; some could be archaeological but other explanations are equally as likely.

#### 5.1.6 **East of Areas 51 and 53**

**HER 4437.** *Lime kiln.*

A few isolated discrete anomalies, plus several linear trends have been noted in the data but there is nothing in the data to suggest the presence of kilns.

#### 5.1.7 **Areas 55 and 56**

**HER 4440.** *Cropmark sub-rectangular ditched enclosure of unknown date.*

The results from these survey areas are largely inconclusive with regard to providing more information about the reported enclosure. Although there are a few linear responses of uncertain origin, there is nothing in the data which equates to such a feature.

### 5.2 **Probable / Possible Archaeology**

- 5.2.1 Elsewhere along the route, no magnetic responses have been recorded that could be interpreted as being of probable archaeological interest. While some could have potential, none are of a form which indicate specific monument types or are indicative of settlement activity. Given the general lack of supporting evidence, all such responses have been classed as having an uncertain origin.

### 5.3 **Uncertain**

- 5.3.1 There are many linear and curvilinear magnetic anomalies and trends throughout the entire length of the survey which suggest possible ditch-like features. These could be associated with former field systems or land divisions, but they may be of a relatively modern date, rather than of any great antiquity. Numerous examples may be land drains or simply a result of trenches dug for agricultural purposes. Many of the responses could be due to localised soil or geological conditions, some will be caused by topographic variations; the nature of these factors has made interpretation more subjective than might normally be expected. Therefore, it is inevitable on a project of this size, that a lot of magnetic responses do not fall easily into specific interpretation categories, hence they are assigned an uncertain origin.



#### 5.4 **Former Field Boundary**

- 5.4.1 Linear anomalies, trends or narrow bands of enhanced magnetic response have been checked against historic maps and Google imagery, and where there is supporting evidence they have been marked as former field boundaries (corroborated). In the absence of such evidence, but where the aligned clearly suggests a former division existed, they are marked as conjectural.

#### 5.5 **Agricultural – Ploughing / Land Drains**

- 5.5.1 Both ridge and furrow cultivation patterns and more recent ploughing effects have been mapped in many of the fields.

#### 5.6 **Natural / Geological / Pedological / Topographic**

- 5.6.1 Throughout the length of the area investigated, anomalies associated with these effects dominate the results. The glaciofluvial deposits have given rise to elevated levels of magnetic 'noise' which in places will have masked the responses from smaller features. The glacial deposits will include extraneous igneous rocks and gravels which have their own inherent magnetism. The result is that in certain areas the rocks have the same effect as ferrous materials.

#### 5.7 **Ferrous / Magnetic Disturbance**

- 5.7.1 Ferrous responses close to boundaries are due to adjacent fences and gates. Smaller scale ferrous anomalies ("iron spikes") are present throughout the data and are characteristic of small pieces of ferrous debris (or brick / tile / igneous rocks) in the topsoil; they are commonly assigned a modern origin. Only the most prominent of these are highlighted on the interpretation diagram.

### 6 **DATA APPRAISAL & CONFIDENCE ASSESSMENT**

- 6.1 Historic England guidelines (EH 2008) Table 4 states that the average magnetic response on the local geology varies from poor to good; the glaciofluvial deposits, especially the magnetic gravels, have had a detrimental effect on the results. Despite this fact, numerous anomalies have been recorded; therefore, there is no reason why settlement features or major monument types would not have been detected, if present.

### 7 **CONCLUSION**

- 7.1 Sixty-six survey areas were surveyed along the length of proposed improvements to the A1 road between Alnwick and Ellingham.

The results have identified possible features of archaeological interest in the vicinity of known Scheduled Monuments or near to sites previously recorded in the HER. These include:

**Area 1 1018499 (Scheduled Monument) Prehistoric burial mound. HER 5033. two cist burials** -a very faint curving trend [1] which could indicate an enclosure ring ditch with potential diameter of some 50m. There is no evidence in the geophysics for the mound. The results suggest that upstanding features may have been levelled.

**Area 2** HER 5043 Iron age “Camp”: anomalies [2] which coincide with the earthworks visible on the OS 1892-1914 25-inch map and on Google imagery.

**Area 4** 1006500 (Scheduled Monument) Iron Age Camp. a cluster of magnetic anomalies [3], some associated with extant earthworks and depressions, whilst others are possibly pits. Ridge and furrow cultivation has also been recorded.

**Area 18** HER 5045 cropmark of a ring ditch (barrow) to the west of the Scheme boundary: several anomalies [4] which could indicate the presence of ring ditches of possible archaeological interest.

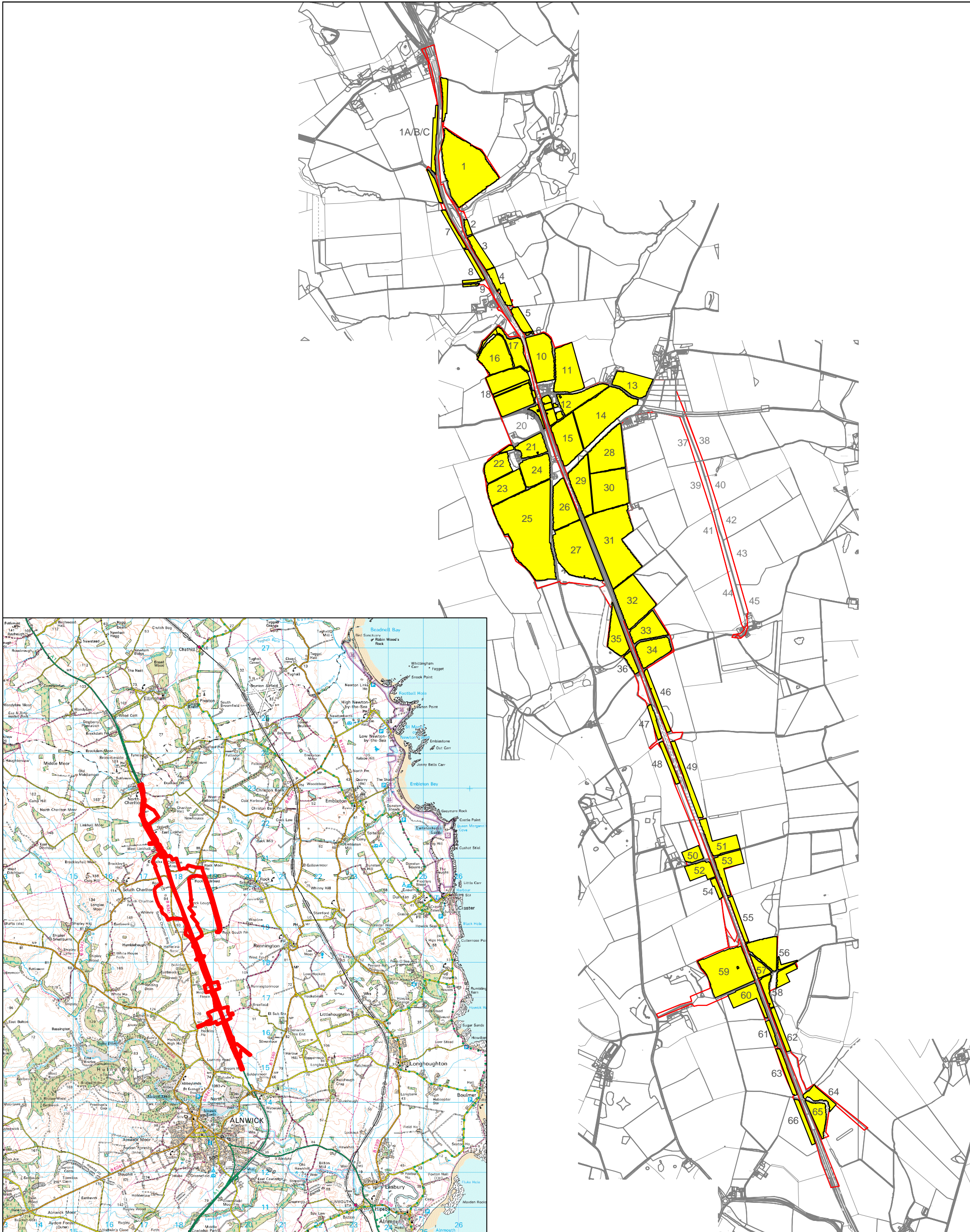
Elsewhere, no ‘new’ archaeological monuments or settlement sites have been recorded though there are numerous uncertain responses, some of which may equate to old field systems or divisions.



Geological and pedological deposits have resulted in elevated magnetic levels which in places may have masked some features.

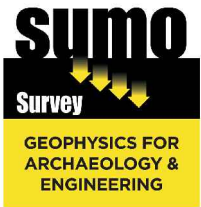
## 8 REFERENCES

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[http://www.archaeologists.net/sites/default/files/ClfAS%26GGeophysics\\_2.pdf](http://www.archaeologists.net/sites/default/files/ClfAS%26GGeophysics_2.pdf)
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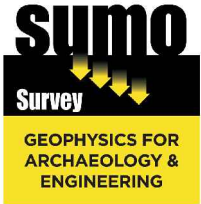
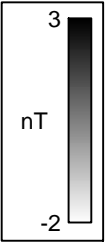
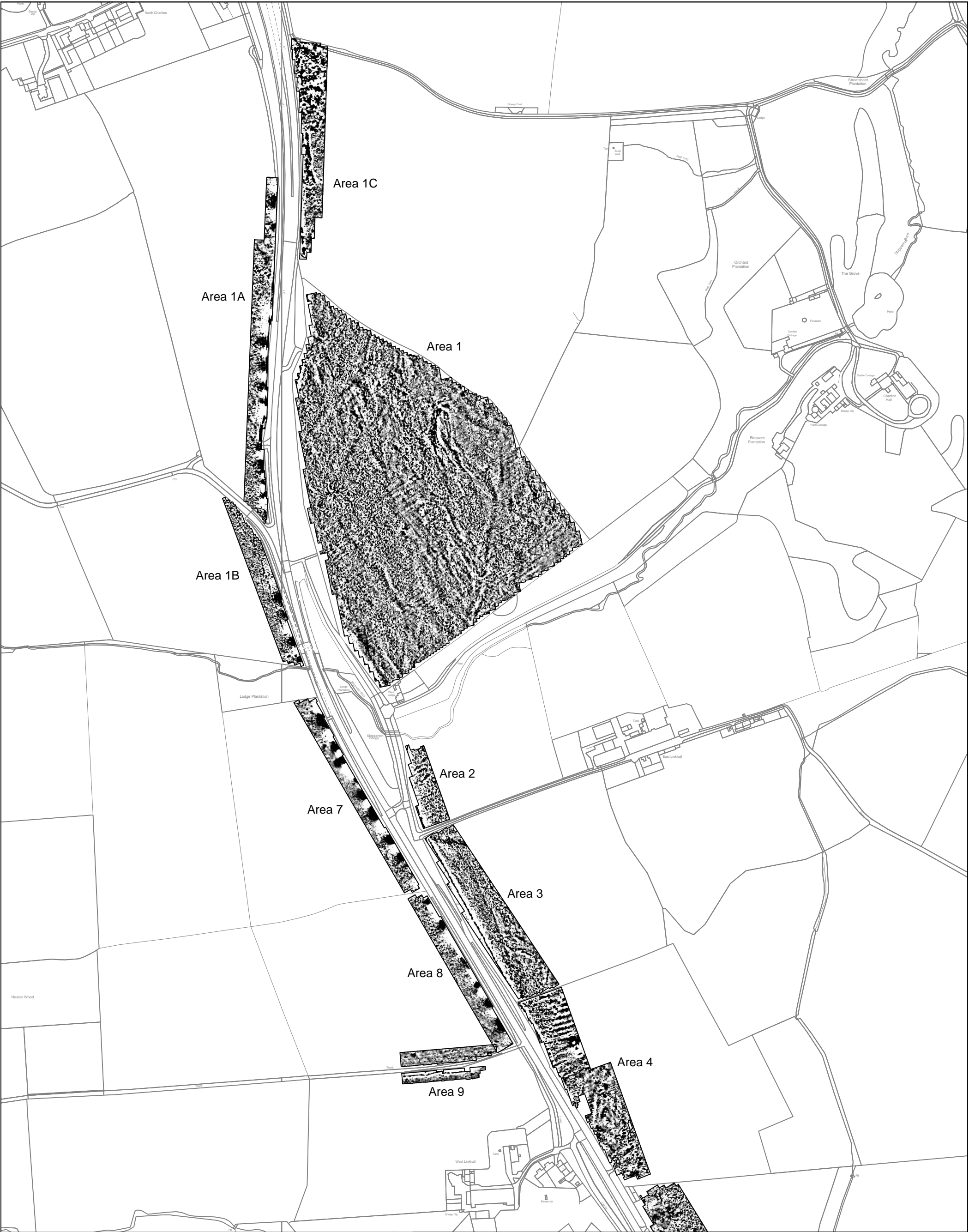


|   |                          |
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|  | Magnetometer Survey Area |
|  |                          |



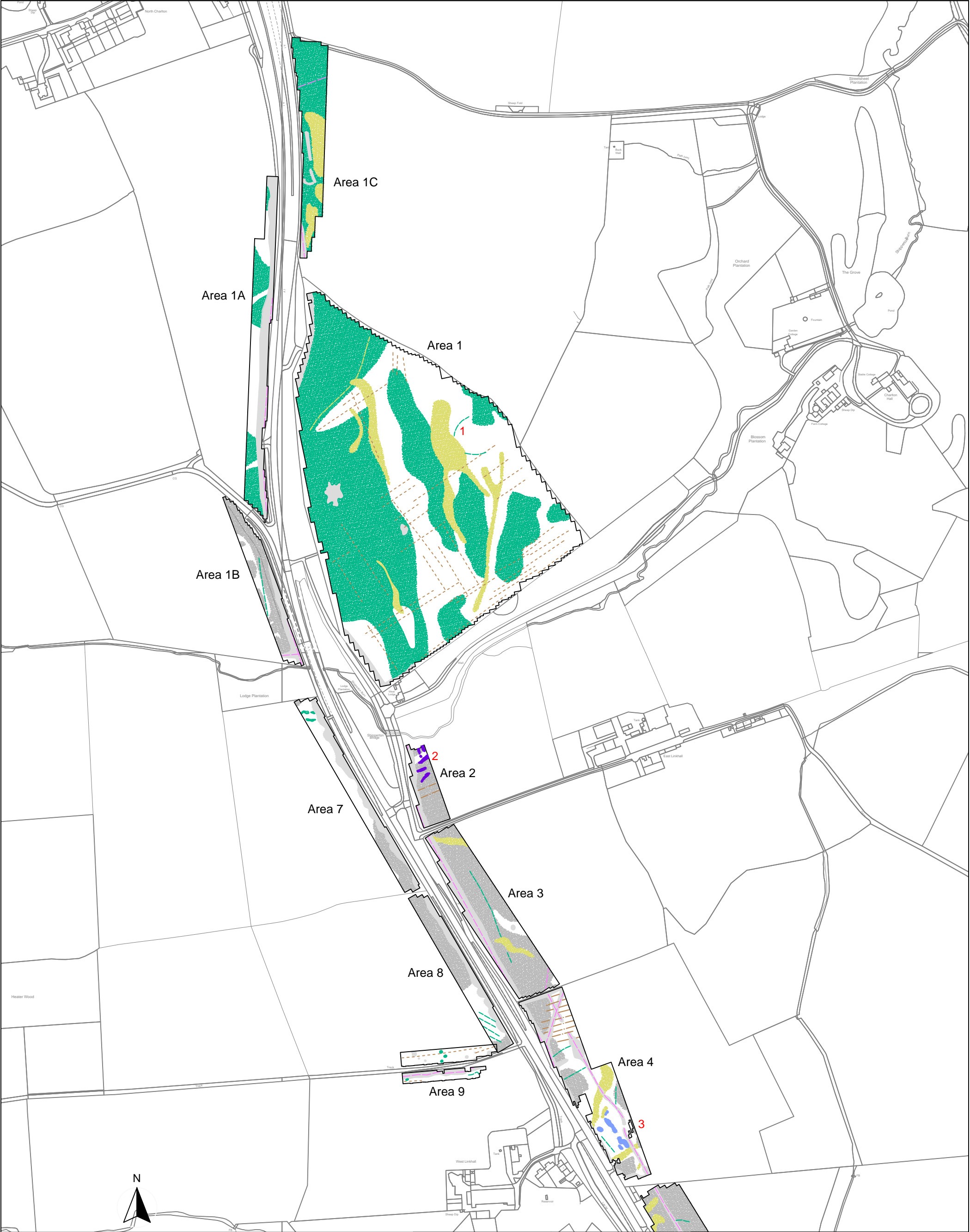
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| Client:<br>WSP   |               |
| Project:<br>13633 A1 in Northumberland<br>Alnwick to Ellingham |               |
| Scale:<br>0 metres 1250<br>1:25000 @ A3                        | Fig No:<br>01 |





|   |               |
|---|---------------|
| Title:<br>Magnetometer Survey [Areas 1-4, 7-9]<br>Greyscale Plots |               |
| Client:<br>WSP  |               |
| Project:<br>13633 A1 in Northumberland<br>Alnwick to Ellingham    |               |
| Scale:<br>0 metres 250<br>1:5000 @ A3                             | Fig No:<br>02 |





KEY

|  |  |  |                                  |
|--|--|--|----------------------------------|
|  | Probable Archaeology                                     |  | Agricultural (Ploughing / Drain) |
|  | Possible Archaeology                                     |  | Natural (zone / trend)           |
|  | Uncertain Origin (discrete / trend / increased response) |  | Pipe or Service                  |
|  | ?Ridge & Furrow  |  | Ferrous / Magnetic Disturbance   |

**GEOPHYSICS FOR  
ARCHAEOLOGY &  
ENGINEERING**

Title: Magnetometer Survey [Areas 1-4, 7-9] Interpretation

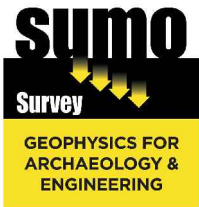
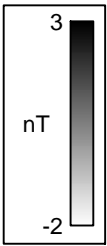
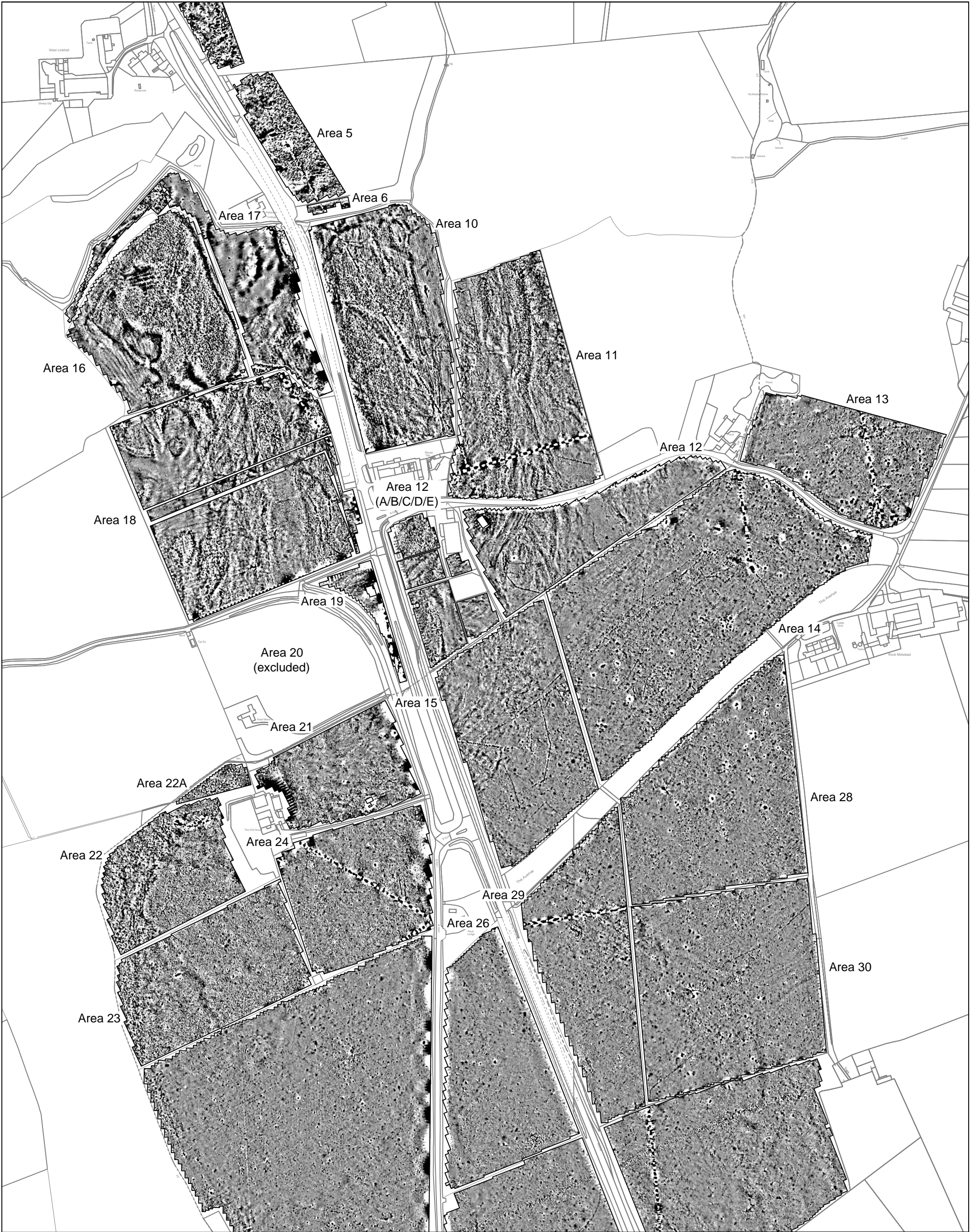
Client: WSP

Project: 13633 A1 in Northumberland Alnwick to Ellingham

Scale: 0 metres 250 1:5000 @ A3

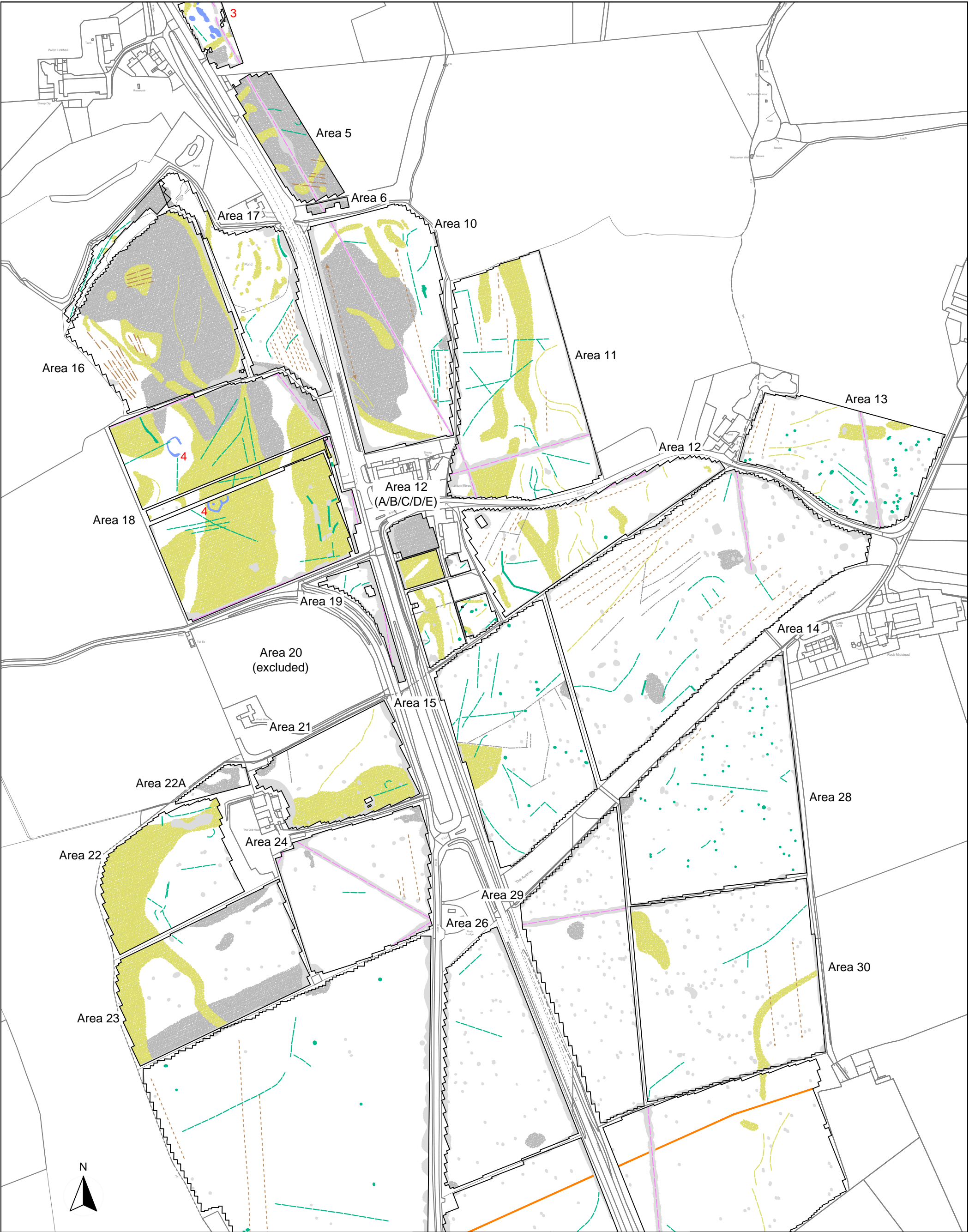
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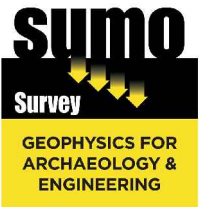


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| Title:<br>Magnetometer Survey [Areas 5, 6 10-19,<br>21-24, 26, 28-30] Greyscale Plots |               |
| Client:<br>WSP  |               |
| Project:<br>13633 A1 in Northumberland<br>Alnwick to Ellingham                        |               |
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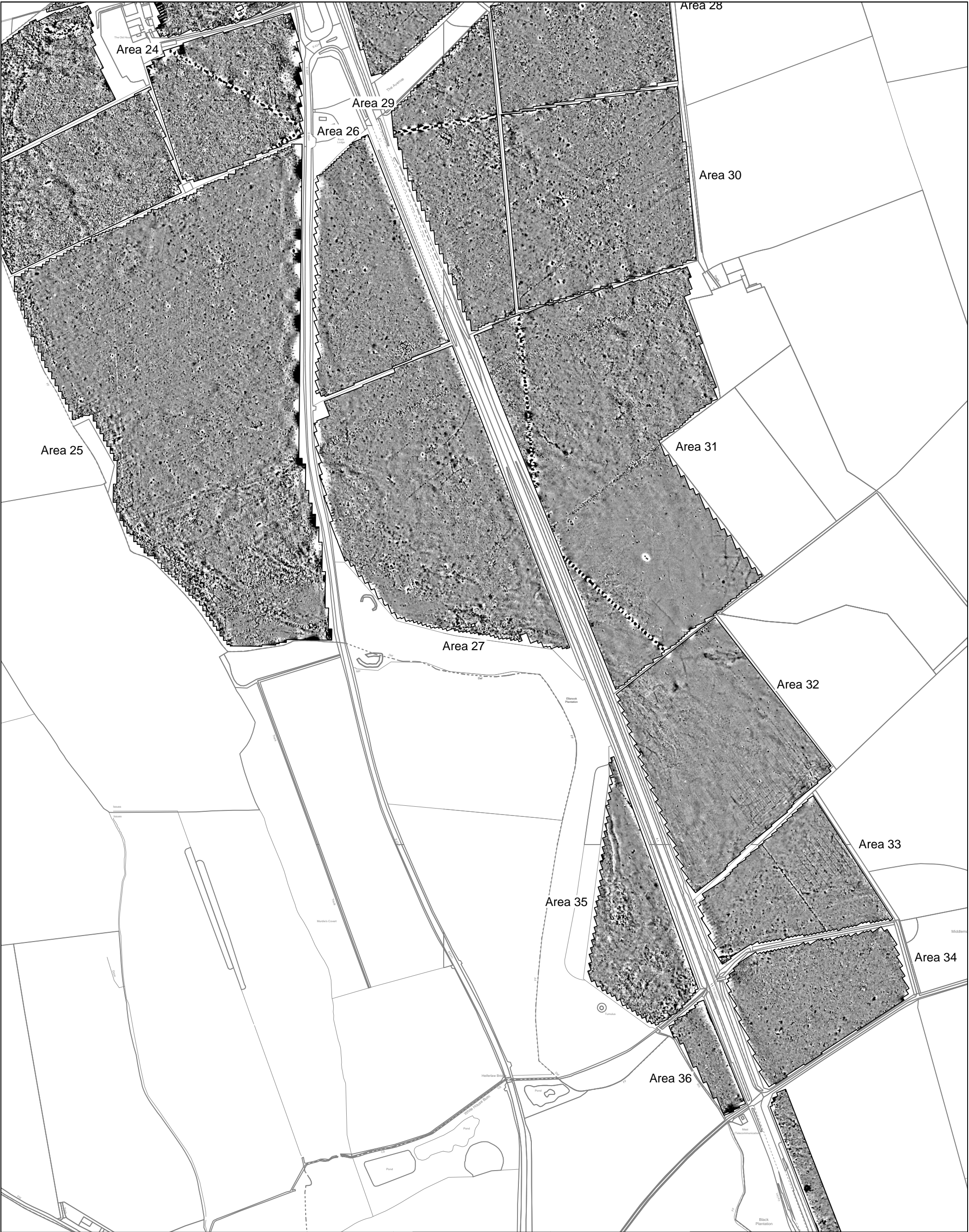



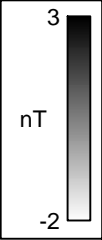
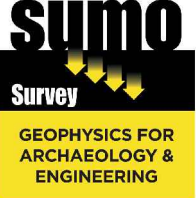
| KEY |                                     |  |                                  |
|-----|-------------------------------------|--|----------------------------------|
|     | Possible Archaeology (discrete)     |  | Agricultural (Ploughing / Drain) |
|     | Uncertain Origin (discrete / trend) |  | Natural (zone / trend)           |
|     | ?Ridge & Furrow                     |  | Pipe or Service                  |
|     |                                     |  | Ferrous / Magnetic Disturbance   |



|   |               |
|---|---------------|
| Title:<br>Magnetometer Survey [Areas 5, 6 10-19, 21-24, 26, 28-30] Interpretation |               |
| Client:<br>WSP  |               |
| Project:<br>13633 A1 in Northumberland<br>Alnwick to Ellingham                    |               |
| Scale:<br>0 metres 250<br>1:5000 @ A3   | Fig No:<br>05 |





|   |  |   |  |            |
|---|--|---|--|------------|
|  |  |  | Title: Magnetometer Survey [Areas 25-27, 31-36]<br>Greyscale Plots |            |
|   |  |   | Client: WSP  |            |
|   |  |   | Project: 13633 A1 in Northumberland<br>Alnwick to Ellingham        |            |
|   |  |   | Scale: 0 metres 250<br>1:5000 @ A3                                 | Fig No: 06 |





KEY

|  |   |  |                                     |
|--|---|--|-------------------------------------|
|  | Possible Archaeology<br>(discrete / trend)            |  | Agricultural<br>(Ploughing / Drain) |
|  | Uncertain Origin<br>(discrete / trend)                |  | Natural<br>(zone / trend)           |
|  | Former Field Boundary<br>(corroborated / conjectural) |  | Pipe or Service                     |
|  |   |  | Ferrous / Magnetic Disturbance      |

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Survey  
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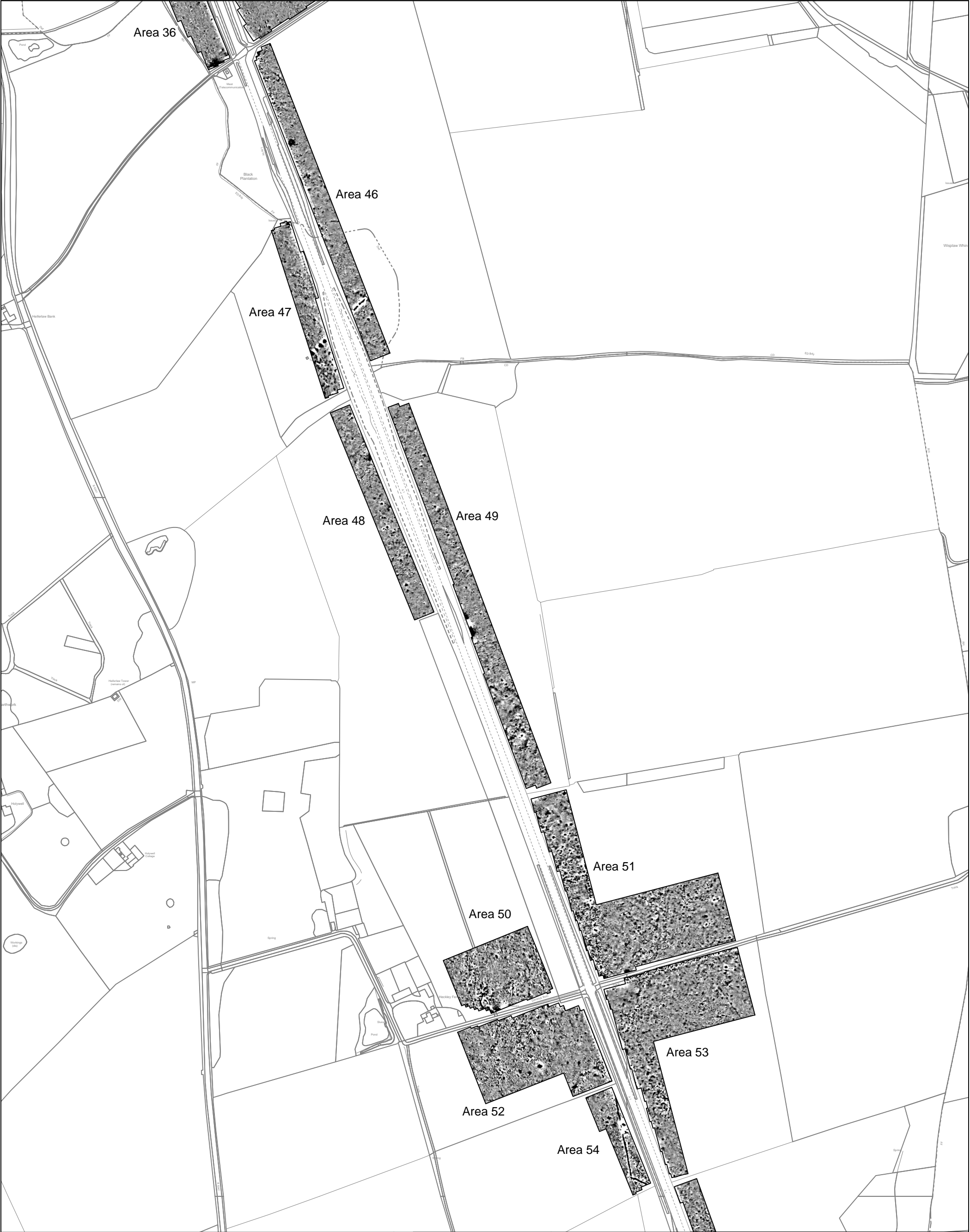
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Magnetometer Survey [Areas 25-27, 31-36]  
Interpretation

Client:  
WSP

Project:  
13633 A1 in Northumberland  
Alnwick to Ellingham

Scale:  
0 metres 250  
1:5000 @ A3

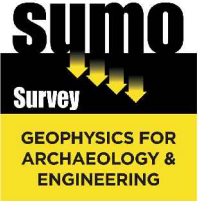







Fig No:  
07

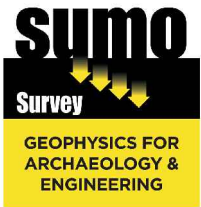
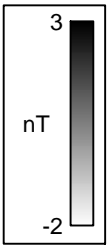


|  |  |  |   |            |
|--|--|--|---|------------|
|  |  |  | Title: Magnetometer Survey [Areas 46-54]<br>Greyscale Plots |            |
|  |  |  | Client: WSP   |            |
|  |  |  | Project: 13633 A1 in Northumberland<br>Alnwick to Ellingham |            |
|  |  |  | Scale: 0 metres 250<br>1:5000 @ A3                          | Fig No: 08 |



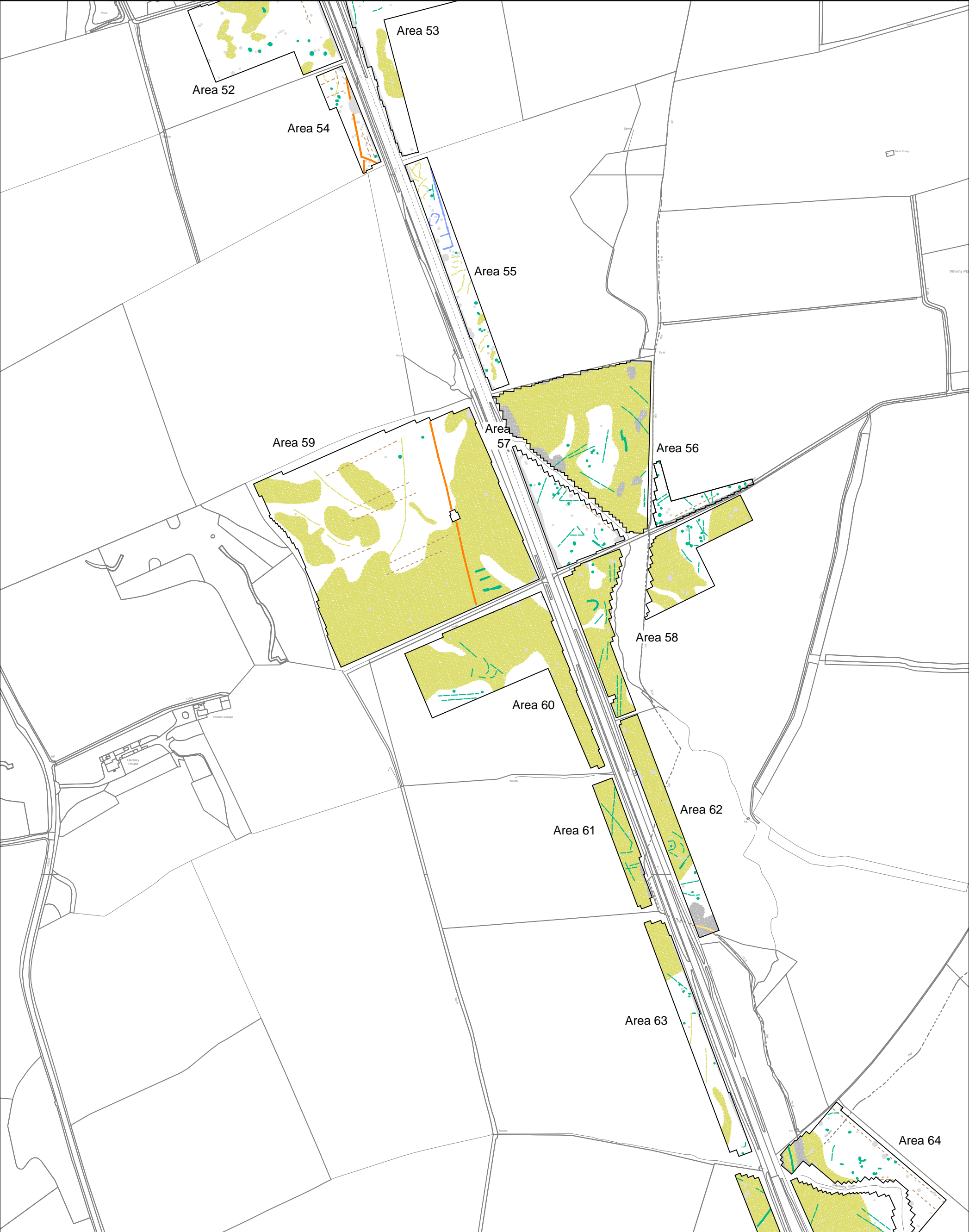


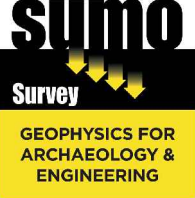







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|---|--|--|--|---|--|--|
| <h3>KEY</h3>  |  |  |  |  | Title: Magnetometer Survey [Areas 46-54] Interpretation  |  |
|  Uncertain Origin (discrete / trend)  |  |  Agricultural (Ploughing) |  |   | Client: WSP  |  |
|  Former Field Boundary (corroborated) |  |  Natural (zone / trend)   |  |   | Project: 13633 A1 in Northumberland Alnwick to Ellingham |  |
|                                      |  |  Pipe or Service          |  |   | Scale: 0 metres 250<br>1:5000 @ A3                       |  |
|   |  |  Ferrous                  |  |   |  |  |
|   |  |  |  | Fig No: 09  |  |  |



|  |               |
|--|---------------|
| Title:<br>Magnetometer Survey [Areas 55-63]<br>Greyscale Plots |               |
| Client:<br>WSP   |               |
| Project:<br>13633 A1 in Northumberland<br>Alnwick to Ellingham |               |
| Scale:<br>0 metres 250<br>1:5000 @ A3                          | Fig No:<br>10 |



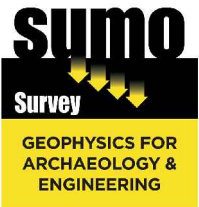
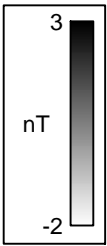


|   |  |   |  |   |  |  |
|---|--|---|--|---|--|--|
| <b>KEY</b>  |  |   |  | <br>GEOPHYSICS FOR<br>ARCHAEOLOGY &<br>ENGINEERING | Title:<br>Magnetometer Survey [Areas 55-63]<br>Interpretation  |  |
|  Possible Archaeology<br>(discrete / trend) |  |  Former Field Boundary<br>(corroborated / conjectural) |  |   | Client:<br>WSP   |  |
|  Uncertain Origin<br>(discrete / trend)     |  |  Agricultural<br>(Ploughing)                           |  |   | Project:<br>13633 A1 in Northumberland<br>Alnwick to Ellingham |  |
|    |  |  Natural<br>(zone / trend)                             |  |   | Scale:<br>0 metres 250<br>1:5000 @ A3                          |  |
|   |  |  Ferrous / Magnetic Disturbance                        |  |   |  |  |
|   |  |   |  | Fig No:<br>11   |  |  |



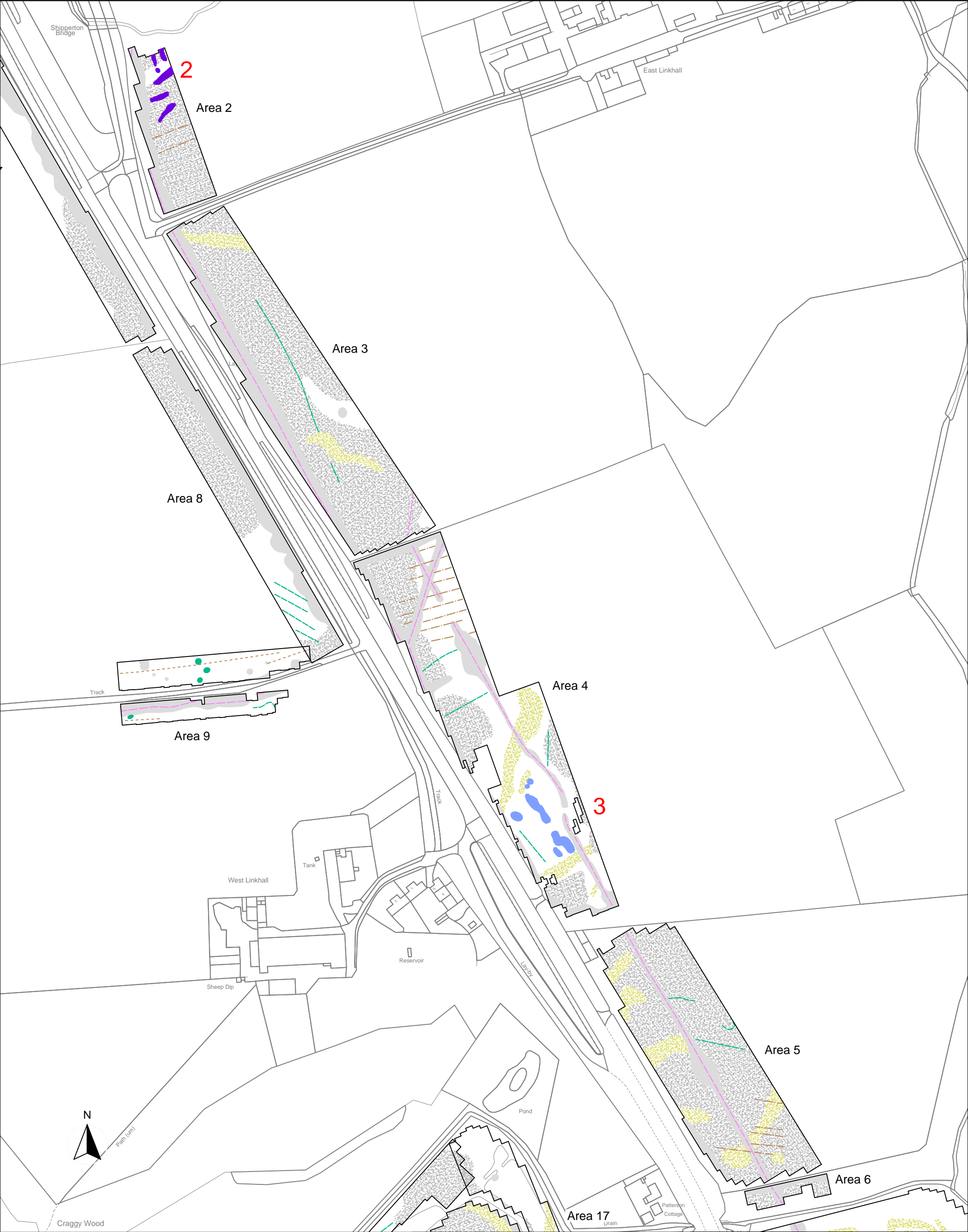
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|--|------------|--|--|--|--|--|
|  | <b>KEY</b> |  |  |  | Title: Magnetometer Survey [Areas 64-66]<br>Greyscale Plots & Interpretation |  |
|  |            | Uncertain Origin<br>(discrete / trend) |  |  | Client: WSP  |  |
|  |            | Agricultural<br>(Ploughing)            |  |  | Project: 13633 A1 in Northumberland<br>Alnwick to Ellingham                  |  |
|  |            | Natural<br>(zone / trend)              |  |  | Scale: 0 metres 250<br>1:5000 @ A3   |  |
|  |            | Ferrous / Magnetic Disturbance         |  |  | Fig No: 12   |  |





|  |               |
|--|---------------|
| Title:<br>Magnetometer Survey [Areas 2 - 4]<br>Greyscale Plots (Possible Archaeology - Detail) |               |
| Client:<br>WSP   |               |
| Project:<br>13633 A1 in Northumberland<br>Alnwick to Ellingham                                 |               |
| Scale:<br>0 metres 125<br>1:2500 @ A3  | Fig No:<br>13 |





KEY

|  |  |  |                                  |
|--|--|--|----------------------------------|
|  | Probable Archaeology                                     |  | Agricultural (Ploughing / Drain) |
|  | Possible Archaeology                                     |  | Natural (zone / trend)           |
|  | Uncertain Origin (discrete / trend / increased response) |  | Pipe or Service                  |
|  | ?Ridge & Furrow  |  | Ferrous / Magnetic Disturbance   |

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ENGINEERING

Title:

Magnetometer Survey [Areas 2 - 4]  
Interpretation (Possible Archaeology - Detail)

Client:

WSP

Project:

13633 A1 in Northumberland  
Alnwick to Ellingham

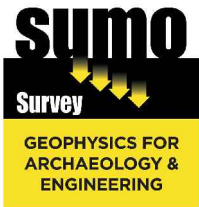
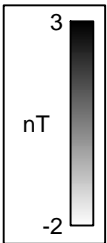
Scale:

0 metres 125  
1:2500 @ A3

Fig No:

14

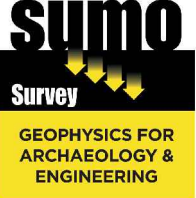











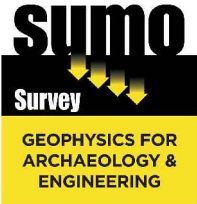
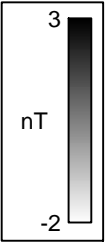
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|--|---------------|
| Title:<br>Magnetometer Survey [Areas 10, 11 & 18]<br>Greyscale Plots (Possible Archaeology - Detail) |               |
| Client:<br>WSP   |               |
| Project:<br>13633 A1 in Northumberland<br>Alnwick to Ellingham                                       |               |
| Scale:<br>0 metres 125<br>1:2500 @ A3  | Fig No:<br>15 |





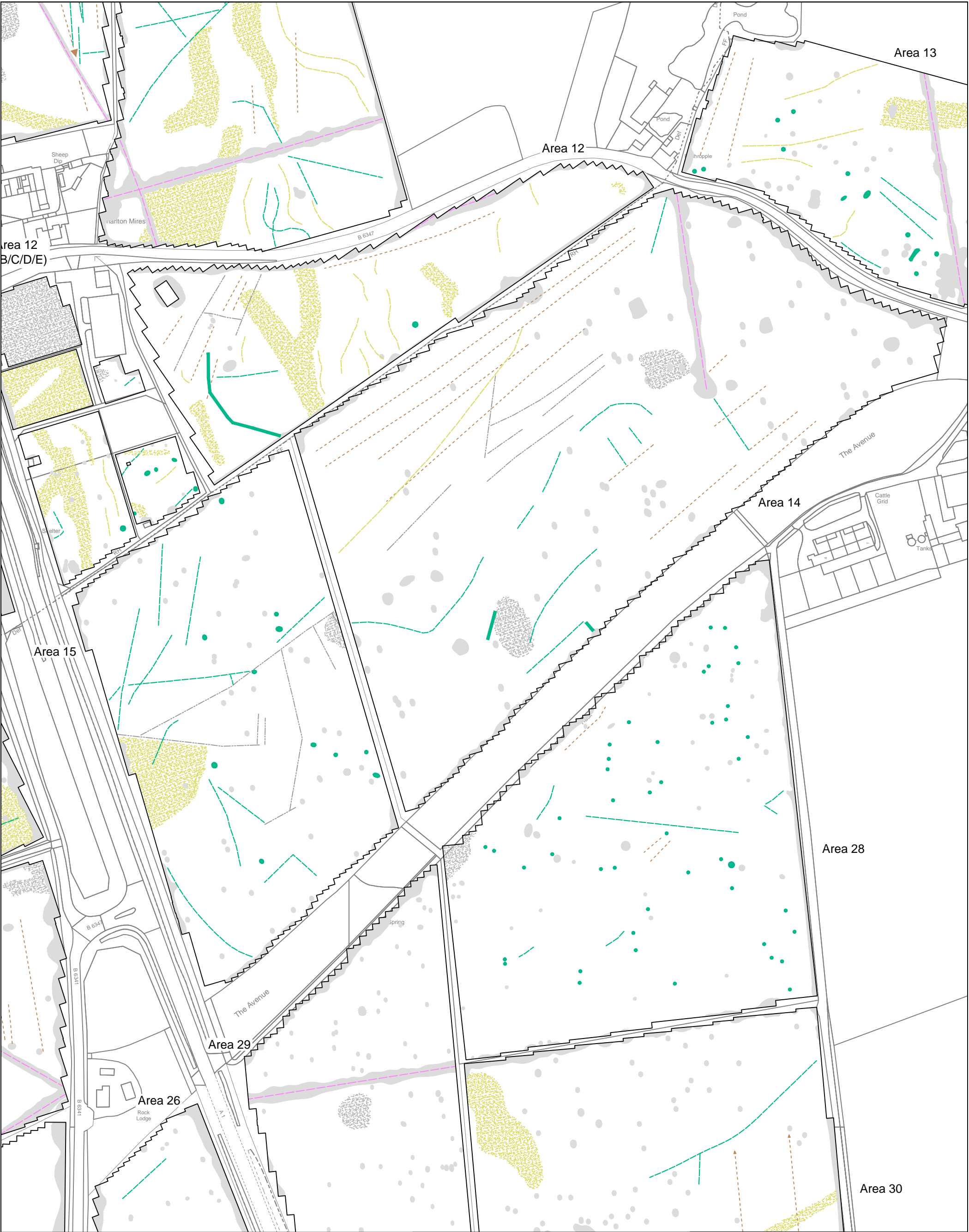
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|---|--|---|--|--|--|--|
| <h3>KEY</h3>  |  |   |  |  <p><b>sumo</b><br/>Survey<br/>GEOPHYSICS FOR<br/>ARCHAEOLOGY &amp;<br/>ENGINEERING</p> | <b>Title:</b><br>Magnetometer Survey [Areas 10, 11 & 18]<br>Interpretation (Possible Archaeology - Detail) |  |
|  Possible Archaeology<br>(discrete / trend) |  |  Agricultural<br>(Ploughing / Drain) |  |  | <b>Client:</b><br>WSP  |  |
|  Uncertain Origin<br>(discrete / trend)     |  |  Natural<br>(zone / trend)           |  |  | <b>Project:</b><br>13633 A1 in Northumberland<br>Alnwick to Ellingham                                      |  |
|    |  |  Pipe or Service                     |  |  | <b>Scale:</b><br>0 metres 125<br>1:2500 @ A3   |  |
|   |  |  Ferrous / Magnetic Disturbance      |  |  |  |  |
|   |  |   |  | <b>Fig No:</b><br>16   |  |  |

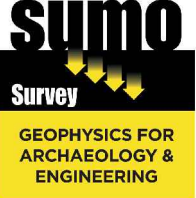










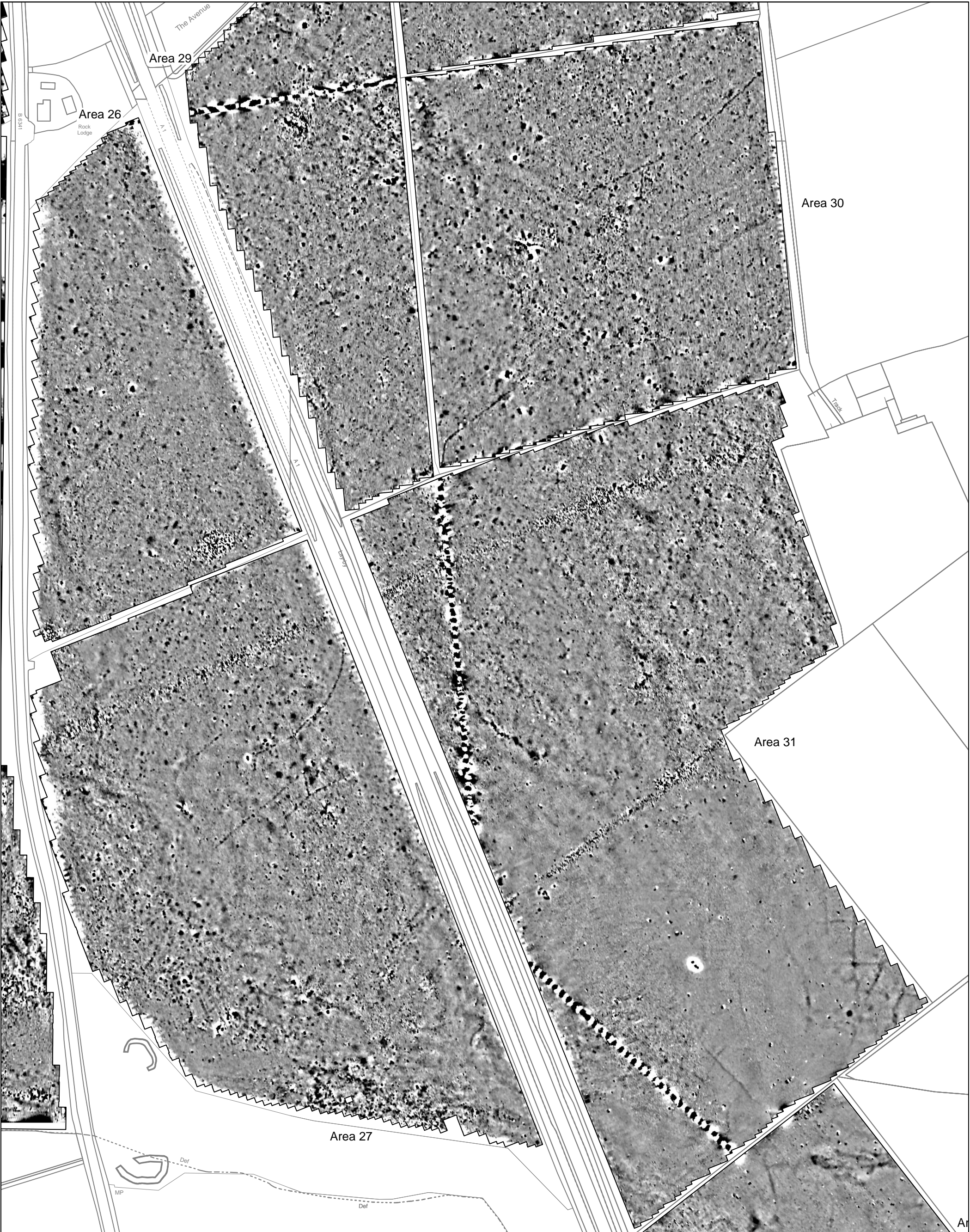
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|--|---------------|
| Title:<br>Magnetometer Survey [Areas 14 & 15]<br>Greyscale Plots (Possible Archaeology - Detail) |               |
| Client:<br>WSP   |               |
| Project:<br>13633 A1 in Northumberland<br>Alnwick to Ellingham                                   |               |
| Scale:<br>0 metres 125<br>1:2500 @ A3  | Fig No:<br>17 |





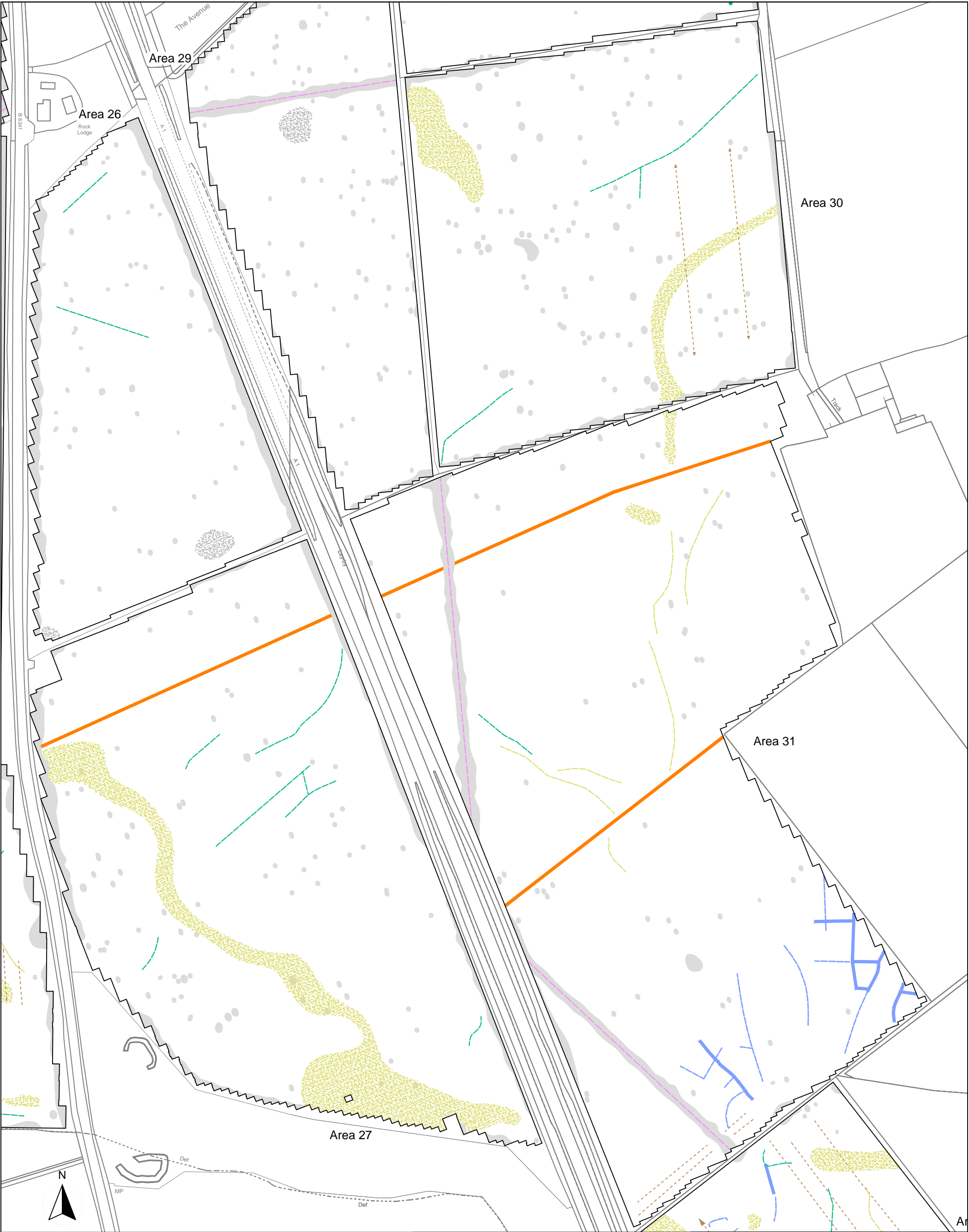
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|---|--|--|---|--|
| <b>KEY</b>  |  | <br><b>GEOPHYSICS FOR<br/>ARCHAEOLOGY &amp;<br/>ENGINEERING</b> | <b>Title:</b> Magnetometer Survey [Areas 14 & 15]<br>Interpretation (Possible Archaeology - Detail) |  |
|  Possible Archaeology<br>(discrete / trend) |  |  | <b>Client:</b> WSP  |  |
|  Uncertain Origin<br>(discrete / trend)     |  |  | <b>Project:</b> 13633 A1 in Northumberland<br>Alnwick to Ellingham                                  |  |
|  Agricultural<br>(Ploughing / Drain)       |  |  | <b>Scale:</b> 0 metres 125<br>1:2500 @ A3   |  |
|  Natural<br>(zone / trend)                 |  |  | <b>Fig No:</b> 18   |  |
|  Pipe or Service                           |  |  |   |  |
|  Ferrous / Magnetic Disturbance            |  |  |   |  |

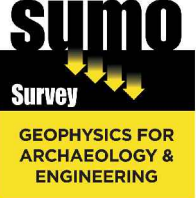











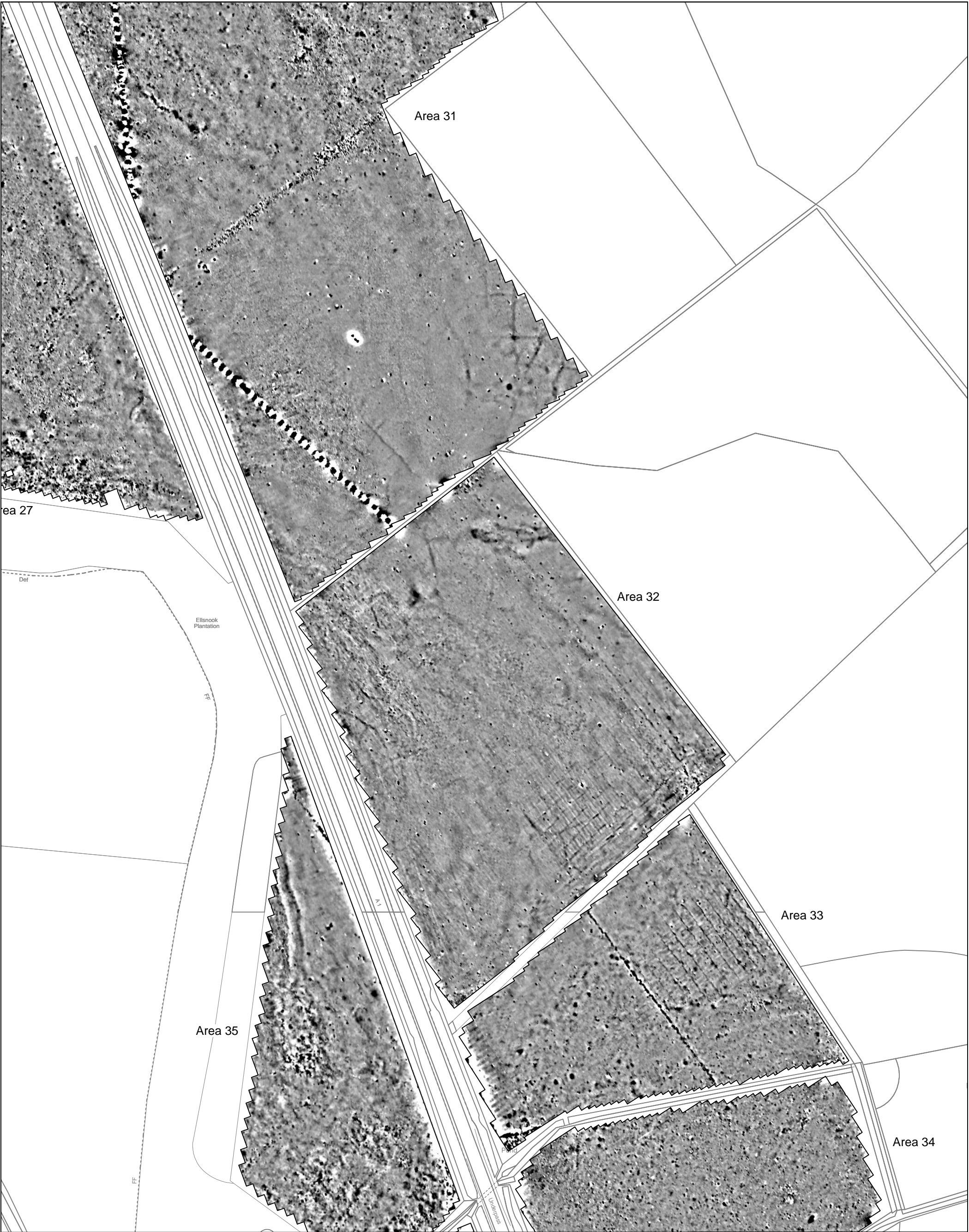
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|--|--|--|--|---------------|
|  |  |  | Title:<br>Magnetometer Survey [Areas 27, 30 & 31]<br>Greyscale Plots (Possible Archaeology - Detail) |               |
|  |  |  | Client:<br>WSP   |               |
|  |  |  | Project:<br>13633 A1 in Northumberland<br>Alnwick to Ellingham                                       |               |
|  |  |  | Scale:<br>0                      metres                      125<br><br>1:2500 @ A3                  | Fig No:<br>19 |





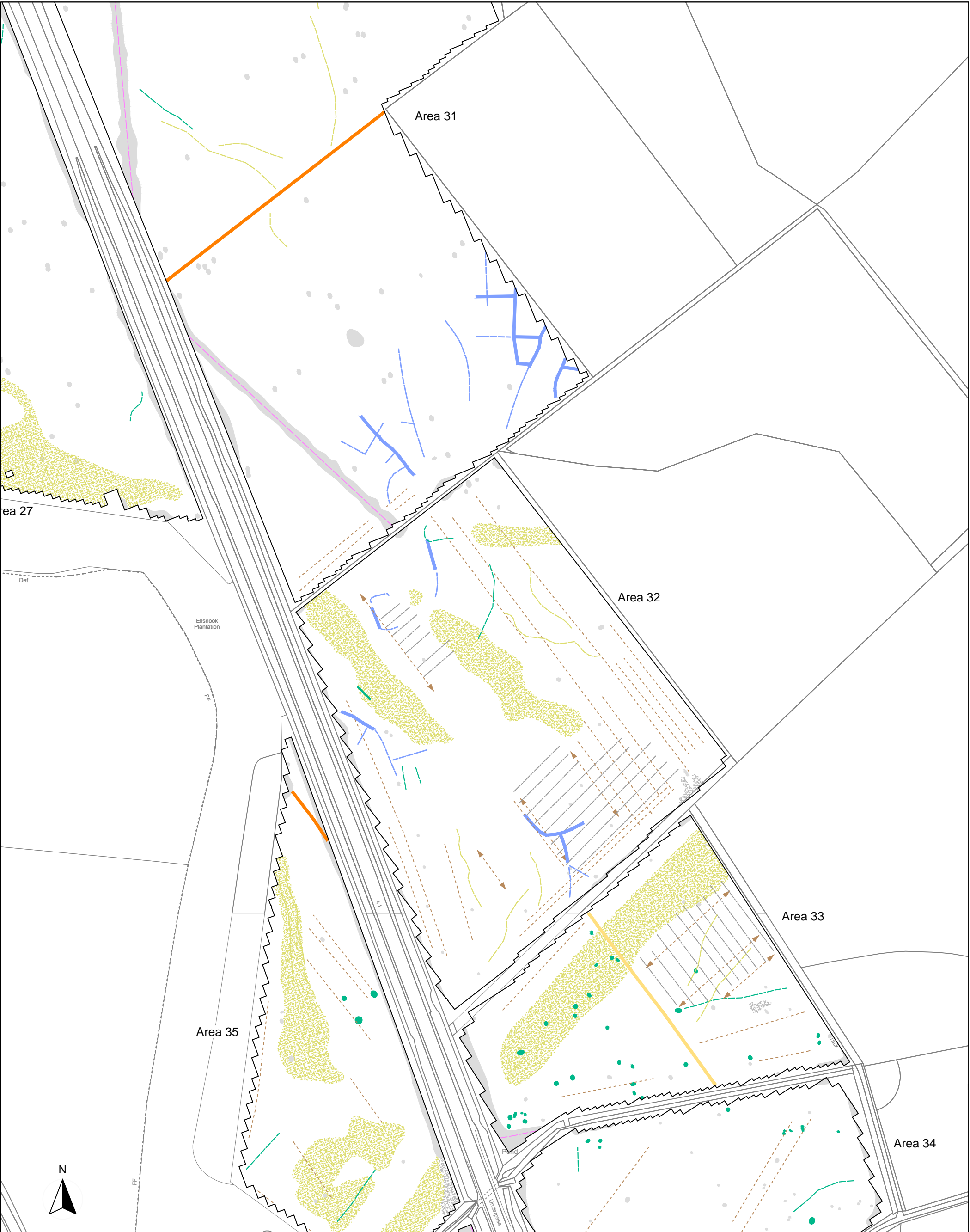
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| <h3>KEY</h3>  |  |  |  |  <p><b>sumo</b><br/>Survey<br/>GEOPHYSICS FOR<br/>ARCHAEOLOGY &amp;<br/>ENGINEERING</p> | Title:<br>Magnetometer Survey [Areas 27, 30 & 31]<br>Interpretation (Possible Archaeology - Detail) |  |
|  Possible Archaeology<br>(discrete / trend) |  |  Agricultural<br>(Ploughing)    |  |  | Client:<br>WSP  |  |
|  Uncertain Origin<br>(trend)                |  |  Natural<br>(zone / trend)      |  |  | Project:<br>13633 A1 in Northumberland<br>Alnwick to Ellingham                                      |  |
|  Former Field Boundary<br>(corroborated)    |  |  Pipe or Service                |  |  | Scale:<br>0 metres 125<br>1:2500 @ A3   |  |
|   |  |  Ferrous / Magnetic Disturbance |  |  | Fig No:<br>20   |  |





|  |  |  |   |            |
|--|--|--|---|------------|
|  |  |  | Title: Magnetometer Survey [Areas 31 & 32]<br>Greyscale Plots (Possible Archaeology - Detail) |            |
|  |  |  | Client: WSP   |            |
|  |  |  | Project: 13633 A1 in Northumberland<br>Alnwick to Ellingham                                   |            |
|  |  |  | Scale: 0 metres 125<br>1:2500 @ A3  | Fig No: 21 |





KEY

|  |   |  |                                     |
|--|---|--|-------------------------------------|
|  | Possible Archaeology<br>(discrete / trend)            |  | Agricultural<br>(Ploughing / Drain) |
|  | Uncertain Origin<br>(discrete / trend)                |  | Natural<br>(zone / trend)           |
|  | Former Field Boundary<br>(corroborated / conjectural) |  | Pipe or Service                     |
|  |   |  | Ferrous                             |

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ENGINEERING

Title:  
Magnetometer Survey [Areas 31 & 32]  
Interpretation (Possible Archaeology - Detail)

Client:  
WSP

Project:  
13633 A1 in Northumberland  
Alnwick to Ellingham

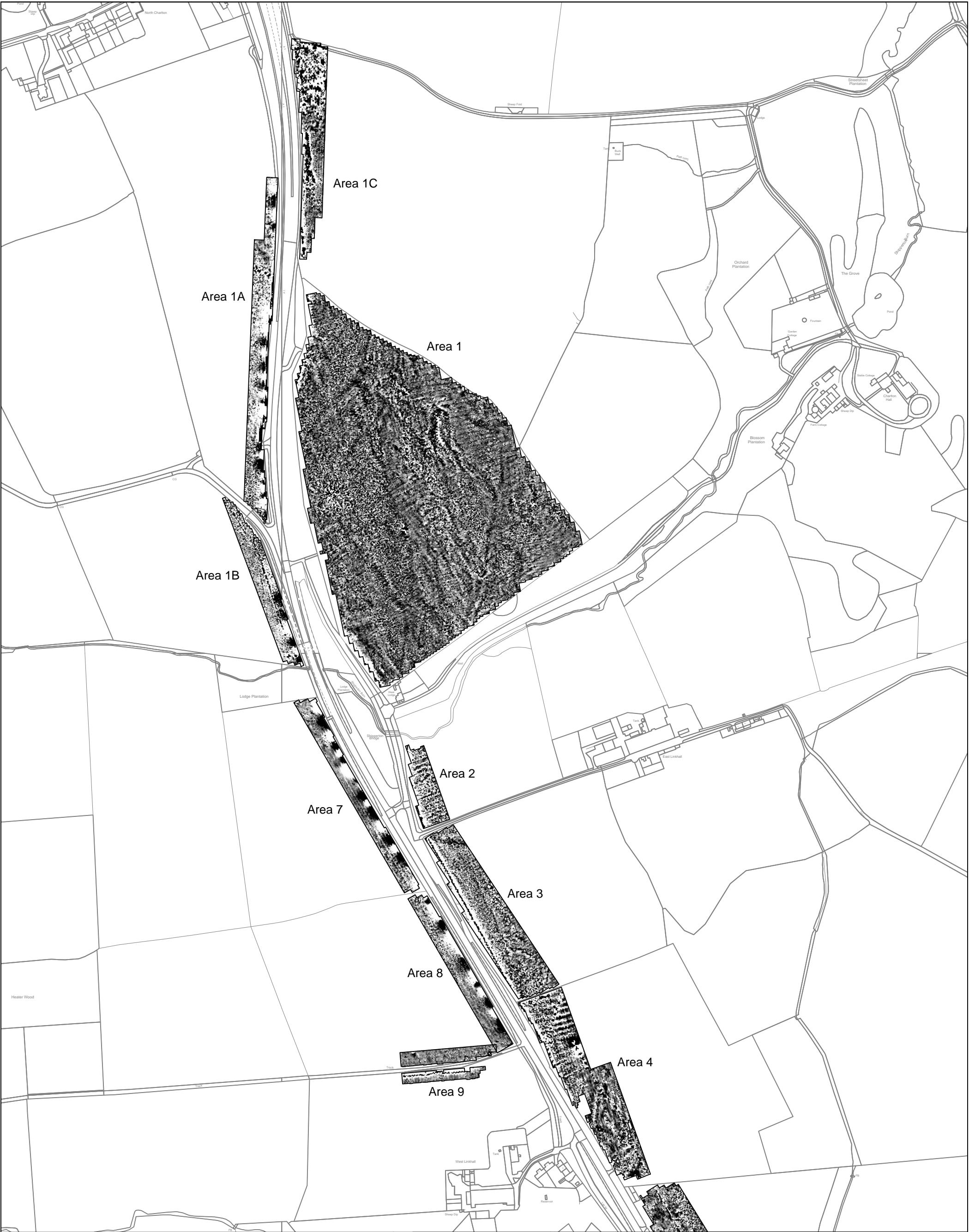
Scale:  
0 metres 125  
1:2500 @ A3

Fig No:  
22



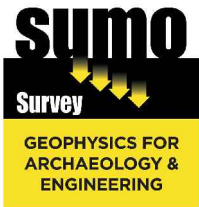
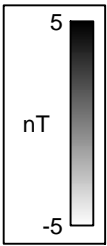
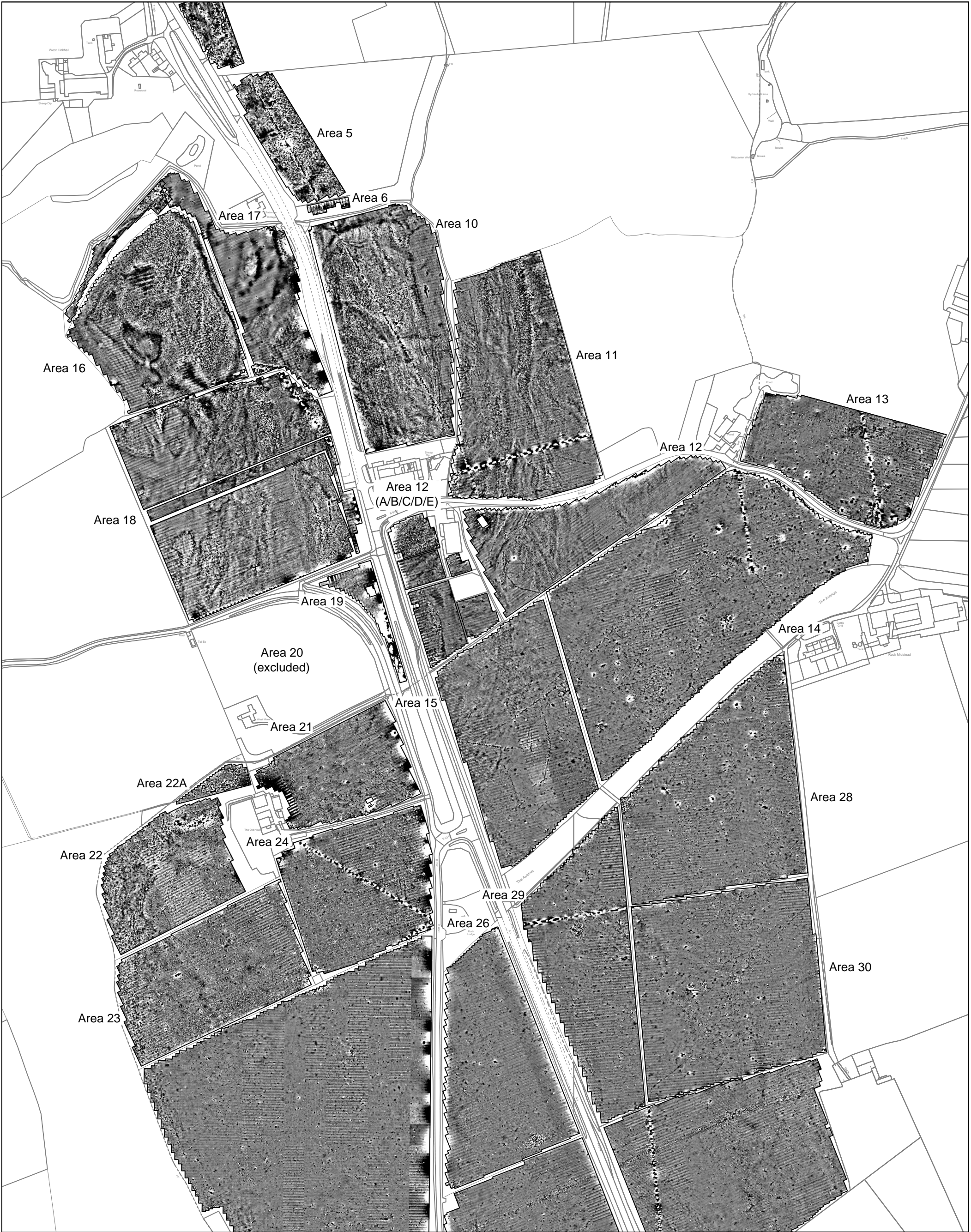


|  |            |   |  |  |  |  |
|--|------------|---|--|--|--|--|
|  | <b>KEY</b> |   |  |  | Title:<br>Magnetometer Survey [Area 55] Greyscale Plots & Interpretation (Possible Archaeology - Detail) |  |
|  |            | Possible Archaeology (discrete / trend) |  |  | Client:<br>WSP   |  |
|  |            | Uncertain Origin (discrete / trend)     |  |  | Project:<br>13633 A1 in Northumberland<br>Alnwick to Ellingham   |  |
|  |            | Natural (zone / trend)                  |  |  | Scale:<br>0                      metres                      250<br>1:5000 @ A3                          |  |
|  |            | Ferrous                                 |  |  | Fig No:<br>23  |  |



|  |  |            |   |  |
|--|--|------------|---|--|
|  |  |            | Title: Magnetometer Survey [Areas 1-4, 7-9]<br>Greyscale Plots (Minimally Processed Data) |  |
|  |  |            | Client: WSP   |  |
|  |  |            | Project: 13633 A1 in Northumberland<br>Alnwick to Ellingham                               |  |
|  |  |            | Scale: 0 250 metres<br>1:5000 @ A3  |  |
|  |  | Fig No: 24 |   |  |



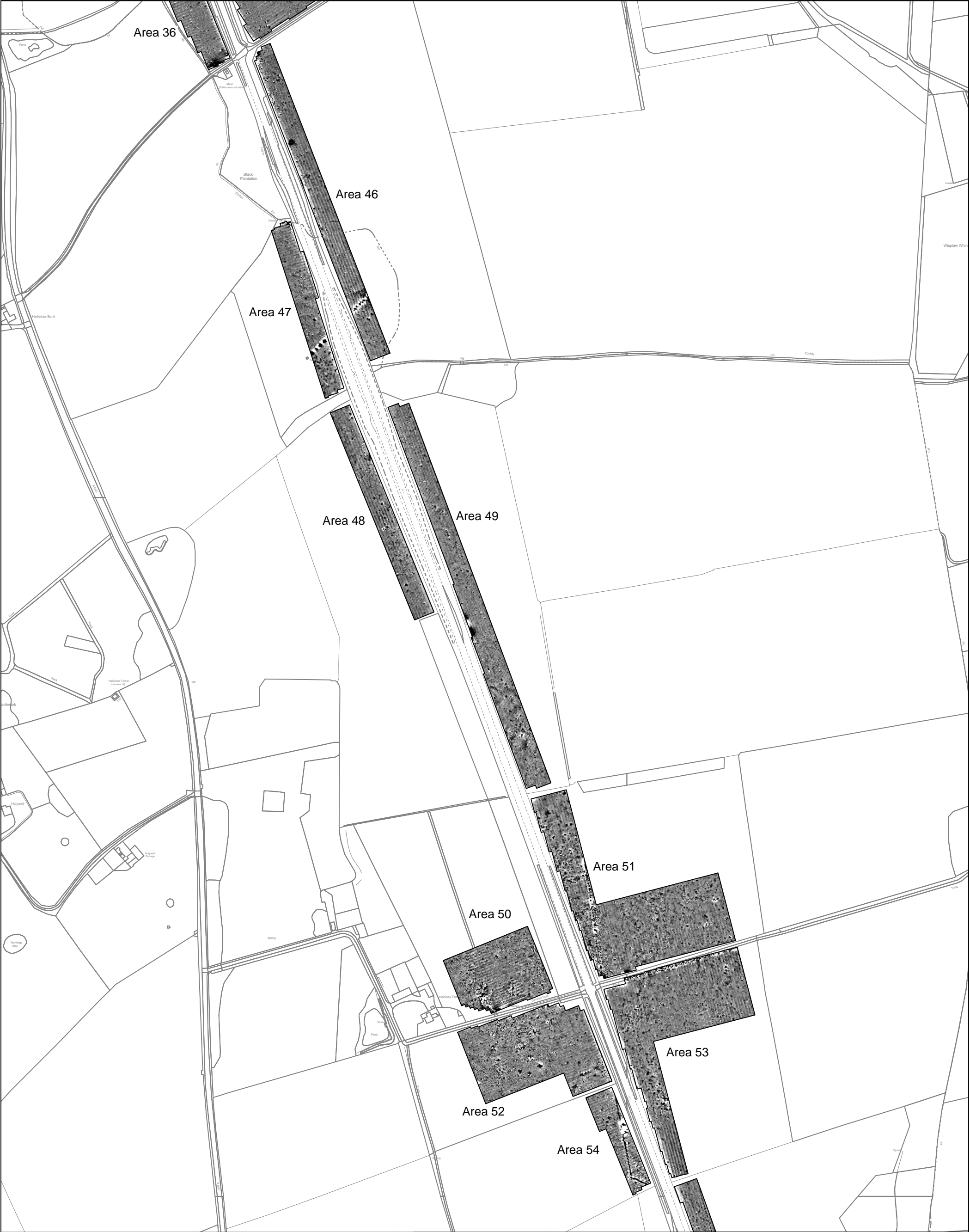


|   |               |
|---|---------------|
| Title:<br>Magnetometer Survey [Areas 5, 6 10-19, 21-24, 26, 28-30] Greyscale Plots (Minimally Processed Data) |               |
| Client:<br><br>WSP  |               |
| Project:<br><br>13633 A1 in Northumberland<br>Alnwick to Ellingham  |               |
| Scale:<br>0                      metres                      250<br>1:5000 @ A3                               | Fig No:<br>25 |



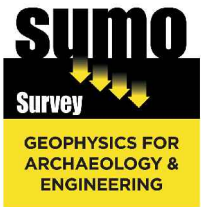
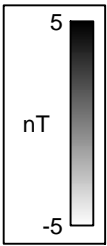






|  |  |  |  |            |
|--|--|--|--|------------|
|  |  |  | Title: Magnetometer Survey [Areas 46-54]<br>Greyscale Plots (Minimally Processed Data) |            |
|  |  |  | Client: WSP  |            |
|  |  |  | Project: 13633 A1 in Northumberland<br>Alnwick to Ellingham                            |            |
|  |  |  | Scale: 0 metres 250<br>1:5000 @ A3   | Fig No: 27 |





|   |               |
|---|---------------|
| Title:<br>Magnetometer Survey [Areas 55-66]<br>Greyscale Plots (Minimally Processed Data) |               |
| Client:<br>WSP  |               |
| Project:<br>13633 A1 in Northumberland<br>Alnwick to Ellingham                            |               |
| Scale:<br>0 metres 250<br>1:5000 @ A3   | Fig No:<br>28 |

## Appendix A - Technical Information: Magnetometer Survey Method

### Grid Positioning

For hand held gradiometers the location of the survey grids has been plotted together with the referencing information. Grids were set out using a Trimble R8 Real Time Kinematic (RTK) VRS Now GNSS GPS system.

An RTK GPS (Real-time Kinematic Global Positioning System) can locate a point on the ground to a far greater accuracy than a standard GPS unit. A standard GPS suffers from errors created by satellite orbit errors, clock errors and atmospheric interference, resulting in an accuracy of 5m-10m. An RTK system uses a single base station receiver and a number of mobile units. The base station re-broadcasts the phase of the carrier it measured, and the mobile units compare their own phase measurements with those they received from the base station. This results in an accuracy of around 0.01m.

| Technique    | Instrument            | Traverse Interval | Sample Interval |
|--------------|-----------------------|-------------------|-----------------|
| Magnetometer | Bartington Grad 601-2 | 1m                | 0.25m           |

### Instrumentation: **Bartington Grad 601-2**

Bartington instruments operate in a gradiometer configuration which comprises fluxgate sensors mounted vertically, set 1.0m apart. The fluxgate gradiometer suppresses any diurnal or regional effects. The instruments are carried, or cart mounted, with the bottom sensor approximately 0.1-0.3m from the ground surface. At each survey station, the difference in the magnetic field between the two fluxgates is measured in nanoTesla (nT). The sensitivity of the instrument can be adjusted; for most archaeological surveys the most sensitive range (0.1nT) is used. Generally, features up to 1m deep may be detected by this method, though strongly magnetic objects may be visible at greater depths. The Bartington instrument can collect two lines of data per traverse with gradiometer units mounted laterally with a separation of 1.0m. The readings are logged consecutively into the data logger which in turn is daily down-loaded into a portable computer whilst on site. At the end of each site survey, data is transferred to the office for processing and presentation.

### Data Processing

|                                 |   |
|---------------------------------|---|
| Zero Mean                       | This process sets the background mean of each traverse within each grid to zero.  |
| Traverse                        | The operation removes striping effects and edge discontinuities over the whole of the data set.   |
| Step Correction<br>(De-stagger) | When gradiometer data are collected in 'zig-zag' fashion, stepping errors can sometimes arise. These occur because of a slight difference in the speed of walking on the forward and reverse traverses. The result is a staggered effect in the data, which is particularly noticeable on linear anomalies. This process corrects these errors. |

### Display

|                                |   |
|--------------------------------|---|
| Greyscale/<br>Colourscale Plot | This format divides a given range of readings into a set number of classes. Each class is represented by a specific shade of grey, the intensity increasing with value. All values above the given range are allocated the same shade (maximum intensity); similarly, all values below the given range are represented by the minimum intensity shade. Similar plots can be produced in colour, either using a wide range of colours or by selecting two or three colours to represent positive and negative values. The assigned range (plotting levels) can be adjusted to emphasise different anomalies in the data-set. |
|--------------------------------|---|



## Interpretation Categories

In certain circumstances (usually when there is corroborative evidence from desk-based or excavation data) very specific interpretations can be assigned to magnetic anomalies (for example, *Roman Road, Wall*, etc.) and where appropriate, such interpretations will be applied. The list below outlines the generic categories commonly used in the interpretation of the results.

|  |  |
|--|--|
| <i>Archaeology / Probable Archaeology</i>              | This term is used when the form, nature and pattern of the responses are clearly or very probably archaeological and /or if corroborative evidence is available. These anomalies, whilst considered anthropogenic, could be of any age.  |
| <i>Possible Archaeology</i>                            | These anomalies exhibit either weak signal strength and / or poor definition, or form incomplete archaeological patterns, thereby reducing the level of confidence in the interpretation. Although the archaeological interpretation is favoured, they may be the result of variable soil depth, plough damage or even aliasing as a result of data collection orientation.                                  |
| <i>Industrial / Burnt-Fired</i>                        | Strong magnetic anomalies that, due to their shape and form or the context in which they are found, suggest the presence of kilns, ovens, corn dryers, metal-working areas or hearths. It should be noted that in many instances modern ferrous material can produce similar magnetic anomalies.   |
| <i>Former Field Boundary (probable &amp; possible)</i> | Anomalies that correspond to former boundaries indicated on historic mapping, or which are clearly a continuation of existing land divisions. Possible denotes less confidence where the anomaly may not be shown on historic mapping but nevertheless the anomaly displays all the characteristics of a field boundary.   |
| <i>Ridge &amp; Furrow</i>                              | Parallel linear anomalies whose broad spacing suggests ridge and furrow cultivation. In some cases, the response may be the result of more recent agricultural activity.   |
| <i>Agriculture (ploughing)</i>                         | Parallel linear anomalies or trends with a narrower spacing, sometimes aligned with existing boundaries, indicating more recent cultivation regimes.   |
| <i>Land Drain</i>                                      | Weakly magnetic linear anomalies, quite often appearing in series forming parallel and herringbone patterns. Smaller drains may lead and empty into larger diameter pipes, which in turn usually lead to local streams and ponds. These are indicative of clay fired land drains.  |
| <i>Natural</i>   | These responses form clear patterns in geographical zones where natural variations are known to produce significant magnetic distortions.  |
| <i>Magnetic Disturbance</i>                            | Broad zones of strong dipolar anomalies, commonly found in places where modern ferrous or fired materials (e.g. brick rubble) are present.   |
| <i>Service</i>   | Magnetically strong anomalies, usually forming linear features are indicative of ferrous pipes/cables. Sometimes other materials (e.g. pvc) or the fill of the trench can cause weaker magnetic responses which can be identified from their uniform linearity.  |
| <i>Ferrous</i>   | This type of response is associated with ferrous material and may result from small items in the topsoil, larger buried objects such as pipes, or above ground features such as fence lines or pylons. Ferrous responses are usually regarded as modern. Individual burnt stones, fired bricks or igneous rocks can produce responses similar to ferrous material.   |
| <i>Uncertain Origin</i>                                | Anomalies which stand out from the background magnetic variation, yet whose form and lack of patterning gives little clue as to their origin. Often the characteristics and distribution of the responses straddle the categories of <i>Possible Archaeology / Natural</i> or (in the case of linear responses) <i>Possible Archaeology / Agriculture</i> ; occasionally they are simply of an unusual form. |

Where appropriate some anomalies will be further classified according to their form (positive or negative) and relative strength and coherence (trend: weak and poorly defined).

## Appendix B - Technical Information: Magnetic Theory

Detailed magnetic survey can be used to effectively define areas of past human activity by mapping spatial variation and contrast in the magnetic properties of soil, subsoil and bedrock. Although the changes in the magnetic field resulting from differing features in the soil are usually weak, changes as small as 0.1 nanoTeslas (nT) in an overall field strength of 48,000 (nT), can be accurately detected.

Weakly magnetic iron minerals are always present within the soil and areas of enhancement relate to increases in *magnetic susceptibility* and permanently magnetised *thermoremanent* material.

Magnetic susceptibility relates to the induced magnetism of a material when in the presence of a magnetic field. This magnetism can be considered as effectively permanent as it exists within the Earth's magnetic field. Magnetic susceptibility can become enhanced due to burning and complex biological or fermentation processes.

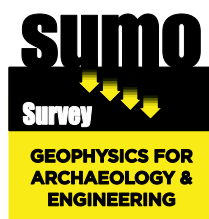
Thermoremanence is a permanent magnetism acquired by iron minerals that, after heating to a specific temperature known as the Curie Point, are effectively demagnetised followed by re-magnetisation by the Earth's magnetic field on cooling. Thermoremanent archaeological features can include hearths and kilns; material such as brick and tile may be magnetised through the same process.

Silting and deliberate infilling of ditches and pits with magnetically enhanced soil creates a relative contrast against the much lower levels of magnetism within the subsoil into which the feature is cut. Systematic mapping of magnetic anomalies will produce linear and discrete areas of enhancement allowing assessment and characterisation of subsurface features. Material such as subsoil and non-magnetic bedrock used to create former earthworks and walls may be mapped as areas of lower enhancement compared to surrounding soils.

Magnetic survey is carried out using a fluxgate gradiometer which is a passive instrument consisting of two sensors mounted vertically 1m apart. The instrument is carried about 30cm above the ground surface and the top sensor measures the Earth's magnetic field whilst the lower sensor measures the same field but is also more affected by any localised buried feature. The difference between the two sensors will relate to the strength of a magnetic field created by this feature, if no field is present the difference will be close to zero as the magnetic field measured by both sensors will be the same.

Factors affecting the magnetic survey may include soil type, local geology, previous human activity and disturbance from modern services.





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