highways england

European Union
European Regional Development Fund

A30 Chiverton to Carland Cross
Environmental Statement

Volume 6 Document Ref 6.4 ES Appendix 6.3 Geophysical Report

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August 2018

Planning Act 2008
Infrastructure Planning (Applications: Prescribed Forms and Procedure) Regulations 2009 (as amended)
APFP Regulation 5(2)(a)

GEOPHYSICAL SURVEY REPORT

GEOPHYSICS FOR ARCHAEOLOGY & ENGINEERING

A30 Carland to Chiverton, Cornwall

Client
WSP Parsons Brinckerhoff
For
Cornwall Council

Survey Report
11198

Date
June 2017

Incorporating

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and

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GEOPHYSICAL SURVEY REPORT

Project name:
A30 Carland to Chiverton, Cornwall

SUMO Job reference:
11198

Client:
WSP Parsons Brinckerhoff
For:
Cornwall Council

Survey date:
25 April – 24 May 2017

Report date:
29 June 2017

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DIGITAL CONTENT (Archive Data)

- Minimally Processed Greyscale Images and XY Trace Plots in DWG format
- DWG Viewer
- Digital Copies of Report Text and Figures (both PDF and native formats)

LIST OF FIGURES

1 SUMMARY OF RESULTS

The survey identified numerous anomalies of probable and possible archaeological interest, scattered along the length of the survey corridor but with concentrations around Areas 8-10, 14-15, 23-24 and 26-32. By far the most common features identified were ditches, some appearing to form parts of enclosures or field systems. Possible ring ditches were also detected. Elsewhere, occasional lengths of ditch and isolated pit-like anomalies were recorded but an archaeological interpretation is less confident. Pipes and anomalies of natural origin were identified and past agriculture is visible throughout the datasets.

2 INTRODUCTION

2.1 Background synopsis

SUMO Services Ltd were commissioned to undertake a geophysical survey of an area outlined for highway improvements. This survey forms part of an archaeological investigation being undertaken by **WSP Parsons Brinckerhoff** on behalf of **Cornwall Council**.

2.2 Site details

NGR / Postcode	North-east: SW 851 543 / TR8 5JB South-west: SW 747 469 / TR4 8HS
Location	The linear survey areas of variable width are adjacent to the A30 from Carland Cross, 9km north of Truro, to Chiverton / Three Burrows, 8km west-north-west of Truro.
HER/SMR	Cornwall and Scilly
Parish	Area 1- St. Newlyn East; Areas 3-10- St. Erme; Areas 11-24- St. Allen; Areas 25- 69- Perranzabuloe
Topography	Varied, flat moderate slopes
Current Land Use	Pasture, low crop
Weather	Varied
Geology	Solid Areas 1, 2 - Trendrean Mudstone - mudstone and siltstone; Areas 3-24 - Grampound Formation- siltstone and mudstone; Areas 25-69 - Porthtowan Formation- mudstone and sandstone No recorded superficial deposits throughout the site (BGS 2017).
Soils	Areas 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 49, 50, 51, 52, 53, 54, 55, 56, 57, 58, 59, 60, 61, 62, 63 - Denbigh 2 Association (541k)- Palaeozoic slaty- well drained fine loamy soils over slate and slate rubble. Areas 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 64, 65, 66, 67, 68, 69 - Sportsmans Association (713b) - Palaeozoic sandstone, slate and mudstone - slowly permeable seasonally waterlogged fine loamy soils (SSEW 1983).
Archaeology	Numerous barrows are recorded adjacent to the survey corridor.
Survey Methods	Magnetometer survey (fluxgate gradiometer)
Study Area	*c.*106ha

2.3 Aims and Objectives

To locate and characterise any anomalies of possible archaeological interest within the study area.

3 METHODS, PROCESSING & PRESENTATION

3.1 Standards & Guidance

This report and all fieldwork have been conducted in accordance with the latest guidance documents issued by Historic England (EH 2008) (then English Heritage), the Chartered Institute for Archaeologists (CIfA 2014) and the European Archaeological Council (EAC 2016).

3.2 Survey methods

Detailed magnetic survey was chosen as an efficient and effective method of locating archaeological anomalies.

Technique	Instrument	Traverse Interval	Sample Interval
Magnetometer	Bartington Grad 601-2	1.0m	0.25m

More information regarding this technique is included in Appendix A.

3.3 Data Processing

The following basic processing steps have been carried out on the data used in this report:

De-stripe; de-stagger; interpolate

3.4 Presentation of results and interpretation

. The presentation of the results for each site involves a grey-scale plot of processed data. Magnetic anomalies are identified, interpreted and plotted onto the 'Interpretation' drawings. The minimally processed data are provided as a greyscale image in the Archive Data Folder with an XY trace plot in CAD format. A CAD viewer is also provided.

When interpreting the results, several factors are taken into consideration, including the nature of archaeological features being investigated and the local conditions at the site (geology, pedology, topography etc.). Anomalies are categorised by their potential origin. Where responses can be related to other existing evidence, the anomalies will be given specific categories, such as: *Abbey Wall* or *Roman Road*. Where the interpretation is based largely on the geophysical data, levels of confidence are implied, for example: *Probable*, or *Possible Archaeology*. The former is used for a confident interpretation, based on anomaly definition and/or other corroborative data such as cropmarks. Poor anomaly definition, a lack of clear patterns to the responses and an absence of other supporting data reduces confidence, hence the classification *Possible*.

4 RESULTS

This report covers the results from the first phase of investigation of a number of areas earmarked for survey (Areas 1-69). It should be noted at the outset when examining the data from a relatively narrow corridor it is often difficult to accurately interpret linear single responses which cross the corridor or zones of variable magnetic response. It is particularly difficult to gauge whether the latter are simply a result of localised variations in the soils and geology.

Responses considered to have archaeological potential are discussed by Area, starting in the east and moving west. Thereafter, a brief summary is provided for all of the survey area where non-archaeological responses will be described.

4.1 ***Probable / Possible Archaeology***

4.1.1 Area 1 Figures 02 and 03

A strong linear ditch-like anomaly may be of archaeological interest, perhaps part of an enclosure, or it may just possibly be an old field boundary. There are a few pit-like anomalies in the data, but these could easily be natural. A second less well-defined linear response is visible in the western half of the survey area; there is also a scatter of short linear trends / anomalies and, although possibly archaeological, they seem more characteristic of natural geological responses. They are therefore classified as *Uncertain Origin*.

4.1.2 Area 3 Figures 04 and 05

The results from this area are dominated by a large pipe which runs through the middle of the survey block and further hinders the interpretation of the responses. Two linear anomalies north of the pipe could be of archaeological interest; there is the suggestion of a small double ditch linking the two together. To the south of the pipe is a slightly curvilinear response, which is a ditch of probable archaeological interest; the pair of linear anomalies in the separate survey block probably indicate a historic boundary.

4.1.3 Area 4 Figures 04 and 05

Two linear responses, one aligned east-west and the other north-south, could indicate former boundaries or archaeological ditches. The data are much quieter in the west compared to the results in the east; this could be a geological effect.

4.1.4 Area 6 Figures 04 and 05

When viewed with the results from Area 7 (below), the results could indicate the presence of plough damaged ditches, perhaps originally forming enclosures.

4.1.5 Area 7 Figures 06 and 07

Linear responses close to Area 6 (above) are classified as being of possible archaeological interest because they are stronger and more clearly defined than the c.200m stretch to the west. This 200m contains several potential linear and curvilinear responses, though many are poorly defined, suggesting possible plough damage. However, they could simply be agricultural effects or even natural responses, though given the context (archaeology nearby) they could be of interest, and they are therefore classified as *Uncertain Origin*.

The western 250-300m of Area 7 contains numerous linear anomalies which cross the survey corridor south of an east-west aligned pipe. Some are probably old boundaries but others could be earlier in date. Close to the western end adjacent to a copse of trees / bushes are curving anomalies and a complex of other responses which look archaeological and it is tempting to interpret the responses as continuing under the copse and forming a Round, that is an Iron Age / Romano-British settlement feature. However, historic mapping shows an old shaft in this location which could account for the area of magnetic disturbance and possibly some of the other anomalies. Unfortunately a pipe masks the results along the northern edge of the survey block.

4.1.6 Area 8 Figures 08 and 09

It is unfortunate that the pipe seen in Area 7 continues right through this area as it obscures many magnetic responses which are clearly of archaeological interest. Apart from two clear "Cornish" boundaries, there is a plethora of linear ditches presumably associated with the other archaeological features. There is a clearly defined oval ditch which appears to sit between two of the aforementioned ditches. A ring or penannular feature which might be a barrow or tumulus, or perhaps a "round house", is visible close to the southern boundary. Several potential pits were also detected.

4.1.7 Area 9 Figures 08 and 09

Several ditch-like anomalies form possible enclosures. Less well-defined anomalies to the east are within an area of increased magnetic response – these responses could be anthropogenic or geological, hence the *Uncertain Origin* classification.

4.1.8 Area 10 Figures 08 and 09

An oval feature appears to have ditches running into it and may represent a barrow. Several other linear anomalies appear to be plough damaged but are classed as *Possible Archaeology* given the context. A possible second oval feature similar to that in Area 8 is partially obscured and is aligned north-south rather than east-west. Other linear responses are categorised as *Uncertain Origin* as they are very straight and could be of relatively modern origin

4.1.9 Areas 11 and 13 Figures 10 and 11

Ditch-like anomalies are visible in the extreme north of Area 11 and in Area 13. A number of pit-like anomalies (within a zone of increased magnetic response in Area 11) may be of archaeological interest, but they could be also be geological, former woodland or relatively modern; therefore they have been classed as *Uncertain Origin*.

4.1.10 Areas 14 and 15 Figures 10 and 11

Numerous ditch-like anomalies have archaeological potential and appear to form an enclosure complex, including a number of possible pits; there may be a trackway on the southern side of the system. Most of the features are in Area 15 and at the western extremity there is a single ditch with a D-shaped enclosure appended to it. The complex is traversed by former "Cornish" field boundaries.

4.1.11 Areas 17, 18 and 19 Figure 12

A number of linear anomalies are of possible archaeological provenance, but the relatively small survey hinders interpretation. Field systems are a possible explanation; some coincide with former boundaries visible on old mapping, so these are easier to interpret. .

4.1.12 Areas 23 and 24 Figure 13

Several ditch-like anomalies are visible in the results, though the presence of former boundaries and drains makes interpretation difficult. The ditches might be parts of enclosures or simply former field systems.

4.1.13 Areas 25 - 28 Figure 14

Linear anomalies, along with a few pit-like responses, are interpreted as being of possible archaeological interest. The ditches are broadly orientated south-west to north-east, but in view of the relatively narrow survey strip they are difficult to interpret - former trackways or droveways is one possible explanation.

4.1.14 Areas 29 – 35 Figure 15

A pipe crosses Areas 29 – 34 obscuring any possible magnetic responses beneath. Several somewhat fragmented linear anomalies in Area 29 may be archaeological, but they are on the line of the modern ploughing. A ditch in Area 32 is also classed as *Possible Archaeology* but is parallel to existing and recorded former boundaries, and may therefore be medieval or post-medieval.

4.1.15 Area 36 Figures 16 and 17

Plough-damaged ditch-like anomalies can be seen in Area 36; they are magnetically weak and shown as *Possible Archaeology - trends*.

4.1.16 Areas 46 and 47

There is a line of isolated responses in Area 46, which could continue into Area 47. At first glance they appear ferrous-like, but a closer examination of the shape and form of the anomalies raises the possibility that they could be large pits or perhaps large igneous boulders. While such an interpretation is tentative, a possible pit or stone alignment cannot be ignored in the wider context of the results. A possible archaeological interpretation, albeit uncertain, is proposed.

4.1.17 Area 50 Figure 20

A ring ditch has been detected at the southern boundary of Area 50. It is magnetically weak but correlates with a “tumulus” depicted on the OS base mapping.

4.1.18 Area 61 Figure 23

A sinuous, linear anomaly is visible in the north-west of Area 61 and whilst it is isolated and fragmented it could be of archaeological interest.

4.1.19 Area 65 Figure 25

A curious pit-like anomaly has a short length of ditch leading to it, and there is a short length of ditch to the south. However, they are isolated and lack context, and confidence is therefore low and they are classed as *Possible Archaeology*.

4.2 *Uncertain / Natural / Geological / Pedological*

4.2.1 As explained above in the introductory section to the results, it is inevitable that a number of anomalies and trends, plus zones of increased magnetic response are going to be difficult to interpret with a high degree of confidence. Linear anomalies can result from old boundaries (not always marked on maps), ploughing, headlands, land drains and some service trenches (with cables or plastic as opposed to ferrous pipes); usually the data have characteristic responses but not always. Changes in geology, the topsoils, alluvial areas or made ground can all result in differing magnetic responses; but a relatively narrow corridor can only give a narrow window through the results when a much wider area is usually required to interpret the responses. Therefore, whilst an archaeological provenance cannot be entirely dismissed, weak “trends” are equally if not more likely to be due to boundaries, agrictural, natural or modern effects.

4.3 *Former Field Boundary*

4.3.1 Single linear anomalies are often associated with former field boundaries and analysis of old maps can help verify the interpretation. In Cornwall, historic field boundaries often result in positive-negative-positive linear magnetic anomalies – which in essence equate with a ditch-bank or wall-ditch arrangement. Former field boundaries are shown in the interpretation diagrams as “Corroborated” (i.e. shown on historic mapping) or “Conjectural”.

4.4 *Agricultural – Ploughing, Land Drains*

4.4.1 As a general rule, broadly spaced parallel anomalies are indicative of ridge and furrow cultivation, while more closely spaced parallel anomalies / trends reflect more modern ploughing. Ploughing is in evidence in all areas and is therefore not discussed below. Land drains are easy to interpret when they form herringbone patterns and when they result in characteristic chains of small dipole anomalies.

4.5 *Ferrous / Magnetic Disturbance*

4.5.1 Where ferrous responses are at the survey edges they are often the result of adjacent fences and gates. Ferrous pipes result in a variety of strong magnetic responses which are usually easily distinguishable from other buried features. Smaller scale ferrous anomalies ("iron spikes") are present throughout the data and their form is best illustrated in the XY trace plots. These responses are characteristic of small pieces of ferrous debris (or brick / tile / igneous rocks) in the topsoil and are commonly assigned a modern origin. Only the most prominent of these are highlighted on the interpretation diagram

Figure	*Area*	*Summary of results*
02 / 03	1	See above for archaeology. Several weak trends are of uncertain origin, and broadly align with the responses from modern ploughing. Areas of magnetic disturbance are likely to be of modern origin, perhaps spreads of consolidation material or former woodland.
04 / 05	3 - 6	See above for archaeology. A pipe crosses Area 3, and magnetic disturbance is probably modern as described above. Parallel linear anomalies in the southern part of Area 3 probably represent a former boundary in the "Cornish" tradition; similar former boundaries have already been mentioned in Area 4 (see 4.1.3 above); linear trends parallel to the latter could be ploughing. The data in the west are much quieter than the results to the east and this could be a geological effect
06 / 07	7	See above for archaeology. Serval ditch-like anomalies cross the survey corridor, and could be archaeological or former boundaries, hence the *Uncertain Origin* classification. Very straight trends are likely to be modern. A pipe is visible adjacent to the northern boundary.
08 / 09	8 - 10	See above for archaeology. The pipe visible in Area 7 continues through Area 8. A number of weak trends are visible in the dataset. Whilst possibly natural, these may result from past agricultural activity. Two corroborated "Cornish" field boundaries cross Area 8, whilst conjectural examples can be seen in Areas 9 and 10. An area of amorphous anomalies in the west of Area 10 is probably of natural origin.
10 / 11	11 - 15	See above for archaeology and anomalies of uncertain origin. Possible former boundaries were detected in Areas 11, 12, 14 and 15 with a corroborated example in Area 13. Several pit-like anomalies can be seen but being isolated and possibly natural they are classed as *Uncertain Origin*.
12	17 - 20	See above for archaeology. Former field boundaries, both conjectural and corresponding to divisions shown on historic mapping, cross the survey areas. A positive response in Area 19 may be two pits, or a truncated length of ditch; as it may also be of natural origin, it is classified as *Uncertain Origin*. Trends are generally likely to be agricultural or natural, and a group in the north of Area 19 may be modern as they are very straight – possibly drains.
13	21 - 24	See above for archaeology. Several former field boundaries in the Cornish tradition are visible and are depicted on First Edition OS mapping. In the north of Area 23, a dramatic change in the magnetic character of the responses is due to natural causes and extension of the area of bog / marsh shown on the base mapping to the east. Field drains were detected in Areas 23 and 24. A number of trends could be agricultural, natural or former boundaries.
14	25 -28	There is evidence of recent ploughing and a headland in the data and a small area of magnetic disturbance in the south-western limits of Area 28 may be a track.

15	29 - 35	See above for archaeology. Pairs of parallel linear anomalies in Areas 31 and 32 suggest “Cornish” field boundaries. A second pair runs just south of those in Area 32, and could be a former (or later) alignment, archaeological in origin, or they maybe ploughing headlands. A pipe traverses Areas 29 – 34. Responses due to natural causes were recorded in Area 35 and weak trends may be agricultural, natural or modern in origin.
16 /17	36 - 42	See above for archaeology. Former field boundaries were identified in Areas 37, 39, 40 and 41. A small pipe or drain crosses Area 41, and a larger pipe follows the western boundary of Area 42. The ferrous responses in the west of Area 39 are due to the adjacent buildings; ploughing and “uncertain” trends were also detected.
18	43 - 45	Although no definite archaeological responses were detected, see the discussion in 4.1.16 (above). A linear response crossing Area 45 is parallel to the existing boundary, and therefore may be a former field division. The pipe mentioned in Area 42 continues along the western boundary of Area 43, and magnetic disturbance at the southern limit of Area 45 is likely to be associated with the adjacent road.
19	46 - 49	No anomalies of clear archaeological interest were detected. Pipes or drains were recorded in Area 49 along with possible ploughing. A few trends of uncertain origin were detected.
20	50 - 53	See above for archaeology. Ploughing, a headland and weak trends were also recorded.
21 / 22	54 - 60	No anomalies of clear archaeological interest were detected. A “T” junction of field boundaries (conjectural) was detected in the west of Area 60. In the same area, a short length of pipe terminates at a ferrous response, and is likely to represent the service to a water trough or similar. Ploughing, a headland and trends were recorded.
23	61 - 63	See above for archaeology. A former field boundary was identified crossing Area 63. There are a few trends of uncertain origin; they form no recognisable patterns and are not thought to be significant.
24	64	No anomalies of clear archaeological interest were detected. Several former field boundaries traverse the area perpendicular to the A30, and a pair of magnetically weak anomalies may represent an east-west example towards the south; confidence in this interpretation is low, however.
25	65 - 67	See above for archaeology. The series of former “Cornish” field boundaries crossing the areas continues. Two pipes were identified in Areas 65 and 66, the former continuing in Area 67 south of the modern roads. Trends are parallel with the ploughing and are thus likely to be agricultural.
26	68 - 69	No anomalies of clear archaeological interest were detected. Former boundaries in the Cornish tradition were detected in both areas. Parallel anomalies in Area 68 are truncated by the survey limits and are difficult to interpret.

5 DATA APPRAISAL & CONFIDENCE ASSESSMENT

5.1 Historic England guidelines (EH 2008) Table 4 states that the average magnetic response on mudstone is poor. Relatively high levels of background magnetic variation were recorded, hence the presentation of the greyscale plots at a range of -3nT to +5nT. However, the detection of numerous anomalies of archaeological interest indicates that the technique has been successful.

6 CONCLUSION

6.1 The survey has succeeded in meeting the main aims of the project. It has identified and mapped, as far as is possible within a relatively narrow corridor, features of definite archaeological interest. Most were detected in Areas 8-10, 14-15, 23-24, 26-27 and 29-32. The majority are ditches, some forming enclosures or field systems, whilst others are more isolated. Possible ring diches were identified in Areas 8 and 10, and a known barrow was pinpointed in Area 50. Elsewhere, occasional lengths of ditch and isolated pit-like anomalies were recorded but an archaeological interpretation remains tentative.

6.2 Numerous former field boundaries were recorded, many in the Cornish tradition. Anomalies of a natural origin were detected, as were several pipes. Past agricultural practices were evident in all areas.

7 REFERENCES

BGS 2017 British Geological Survey, Geology of Britain viewer [accessed 15/06/2017] *website*: (http://www.bgs.ac.uk/opengeoscience/home.html?Accordion1=1#maps)

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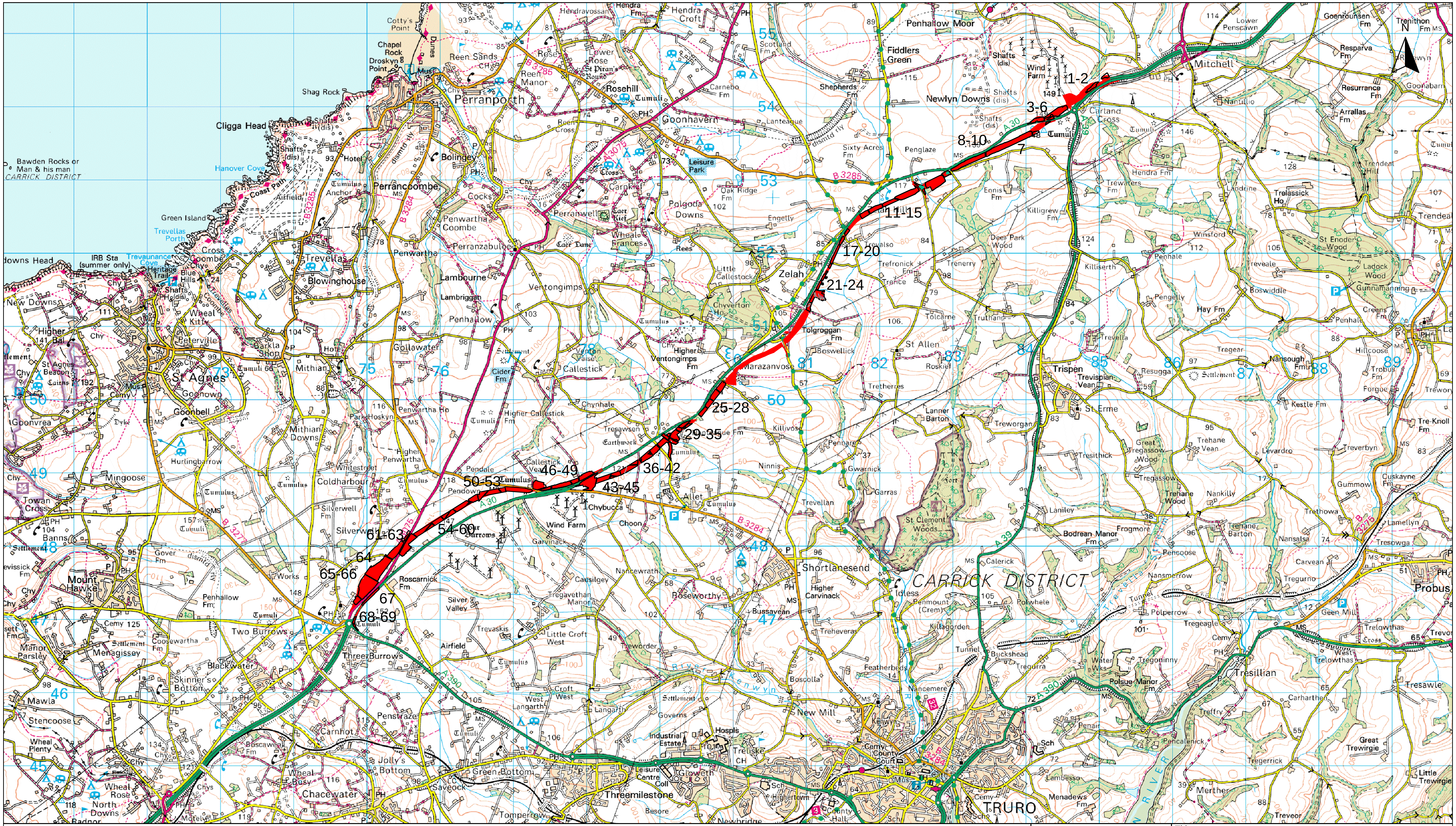
SSEW 1983 *Soils of England and Wales. Sheet 5, South West England*. Soil Survey of England and Wales, Harpenden.



Location of Survey Areas
With Area Numbers

Title:
Site Location Diagram

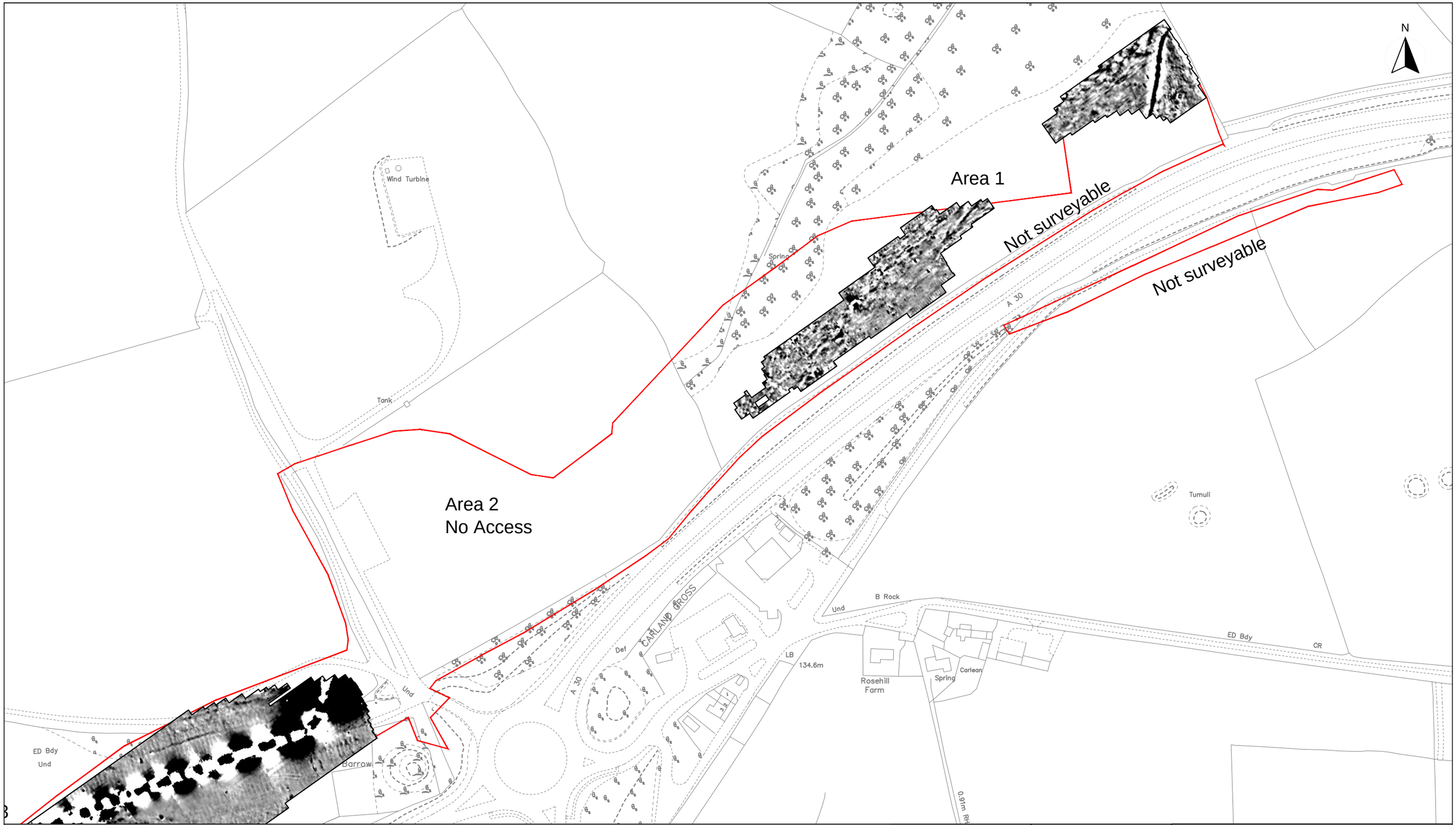
Client:
WSP Parsons Brinckerhoff

Project:
11198 A30 Carland to Chiverton, Cornwall

Scale: 0 metres 2000
1:50000 @ A3

Fig No:
01

sumo Survey
GEOPHYSICS FOR ARCHAEOLOGY & ENGINEERING



sumo Survey
GEOPHYSICS FOR ARCHAEOLOGY & ENGINEERING

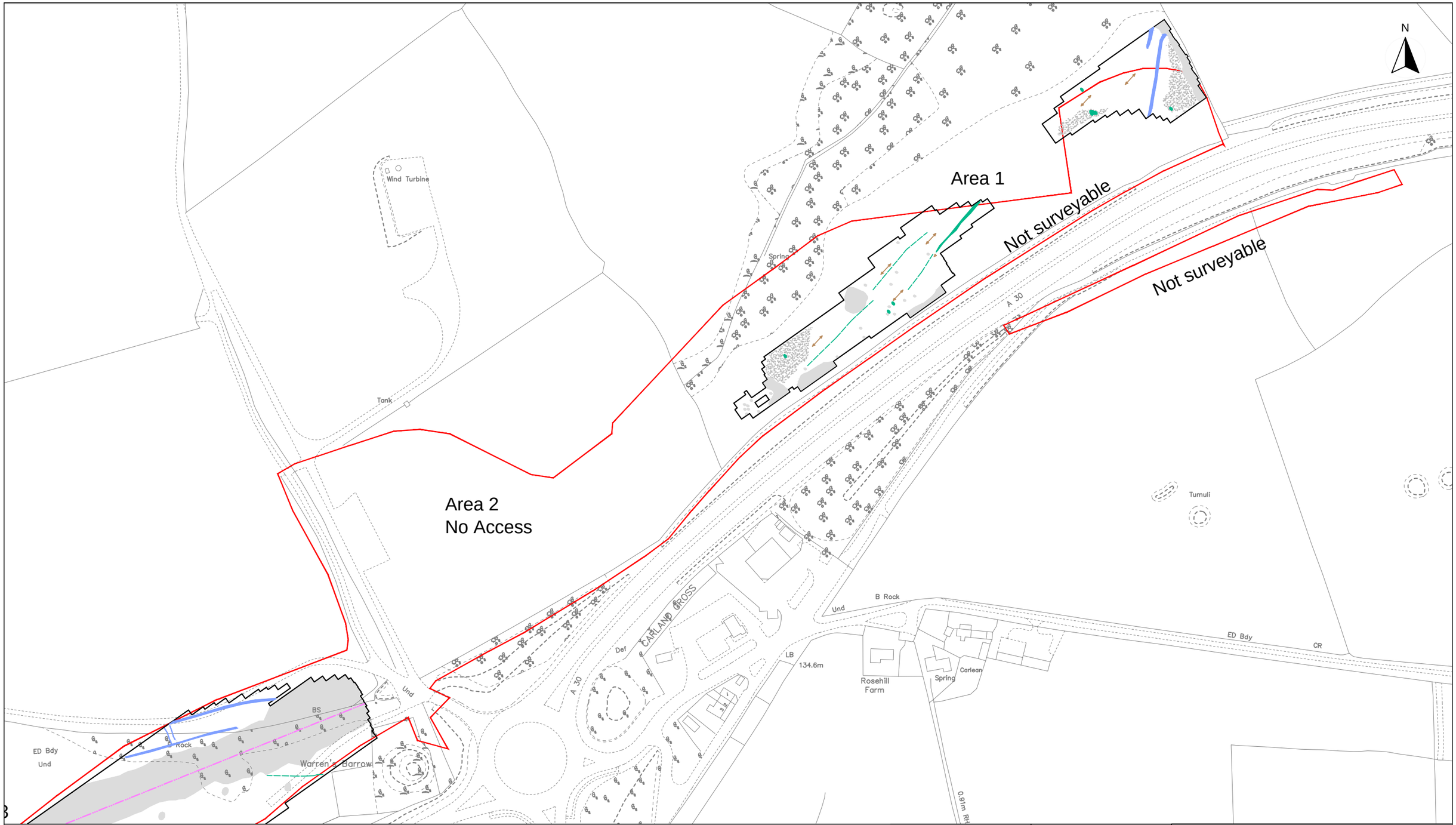
Title:
Magnetometer Survey [Areas 1- 2]
Greyscale Plots

Client:
WSP Parsons Brinckerhoff

Project:
11198 A30 Carland to Chiverton, Cornwall

Scale: 0 metres 100
1:2500 @ A3

Fig No:
02



Possible Archaeology

Magnetic Disturbance

Uncertain Origin
(discrete anomaly / trend)

Ferrous

Agriculture
(Ridge and Furrow / Ploughing)

sumo Survey
GEOPHYSICS FOR ARCHAEOLOGY & ENGINEERING

Title:
Magnetometer Survey [Areas 1- 2]
Interpretation

Client:
WSP Parsons Brinckerhoff

Project:
11198 A30 Carland to Chiverton, Cornwall

Scale: 0 metres 100
1:2500 @ A3

Fig No:
03

Area 3
Newlyn Downs

Area 4

Area 5

Area 6

Wind Turbine
Spring
ED Bdy
Und
Barrow
MS
A 30
A 39
Def
CARLAND CROSS
146.9m
141.8m
Tumulus
(site of)
Loy-by
Tumulus
Quarry
(disused)
Pond
142.2m
Tumulus
Tumulus
137.0m
Tumuli
Pond
140.1m
MS
138.3m
N

5
nT
-3

sumo Survey
GEOPHYSICS FOR ARCHAEOLOGY & ENGINEERING

Title:
Magnetometer Survey [Areas 3 - 6]
Greyscale Plots

Client:
WSP Parsons Brinckerhoff

Project:
11198 A30 Carland to Chiverton, Cornwall

Scale: 0 metres 100
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Fig No:
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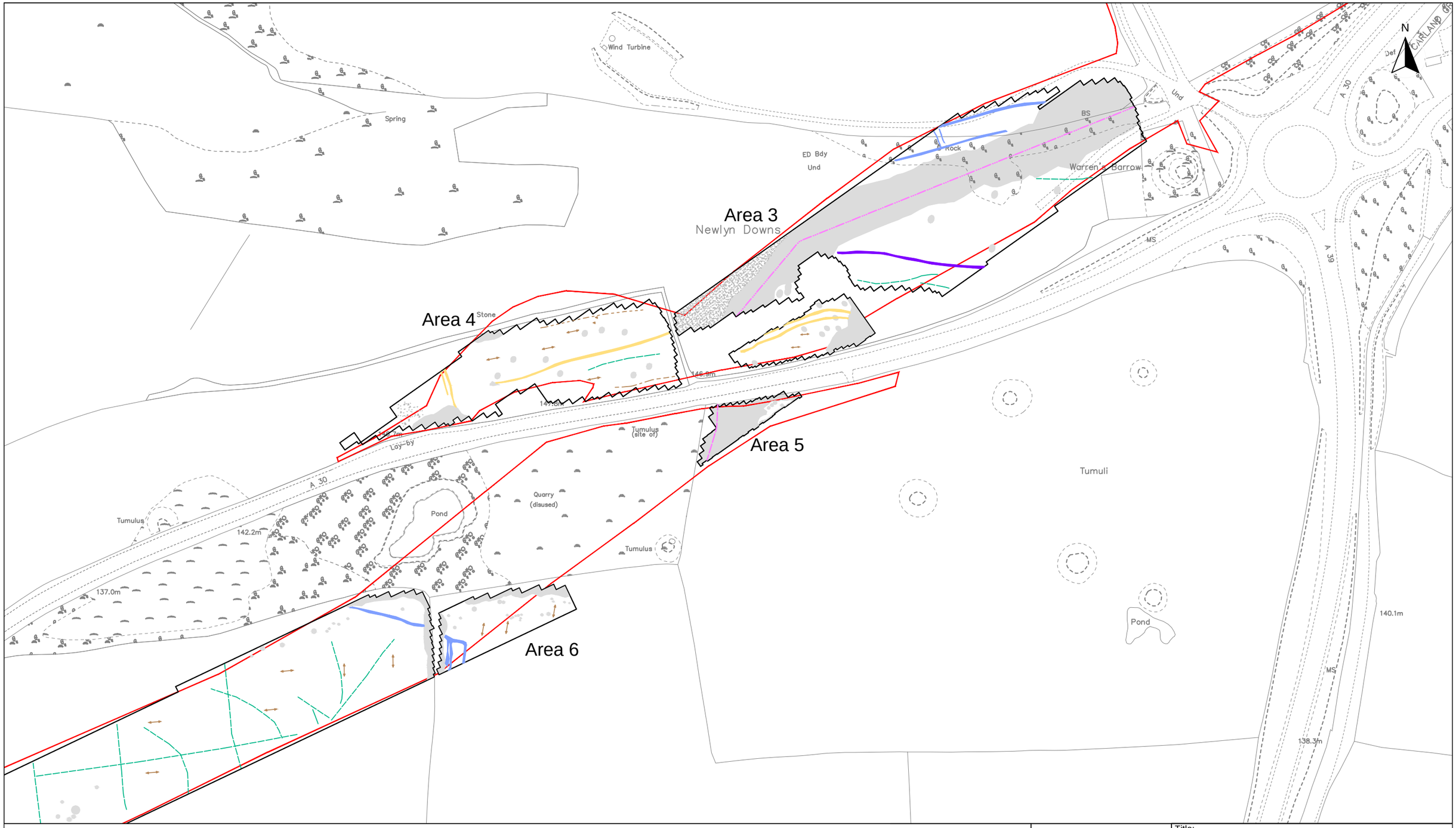

Probable Archaeology

Possible Archaeology
(discrete anomaly / trend)

Uncertain Origin
(discrete anomaly / trend)

Former Field Boundary
(Conjectural)

Agriculture
(Ridge and Furrow / Ploughing)

Ploughing (headland)

Pipe

Magnetic Disturbance

Ferrous

sumo Survey
GEOPHYSICS FOR ARCHAEOLOGY & ENGINEERING

Title:
Magnetometer Survey [Areas 3 - 6]
Interpretation

Client:
WSP Parsons Brinckerhoff

Project:
11198 A30 Carland to Chiverton, Cornwall

Scale: 0 metres 100
1:2500 @ A3

Fig No:
05

5
nT
-3

sumo Survey
GEOPHYSICS FOR ARCHAEOLOGY & ENGINEERING

Title:
Magnetometer Survey [Area 7]
Greyscale Plot

Client:
WSP Parsons Brinckerhoff

Project:
11198 A30 Carland to Chiverton, Cornwall

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Fig No:
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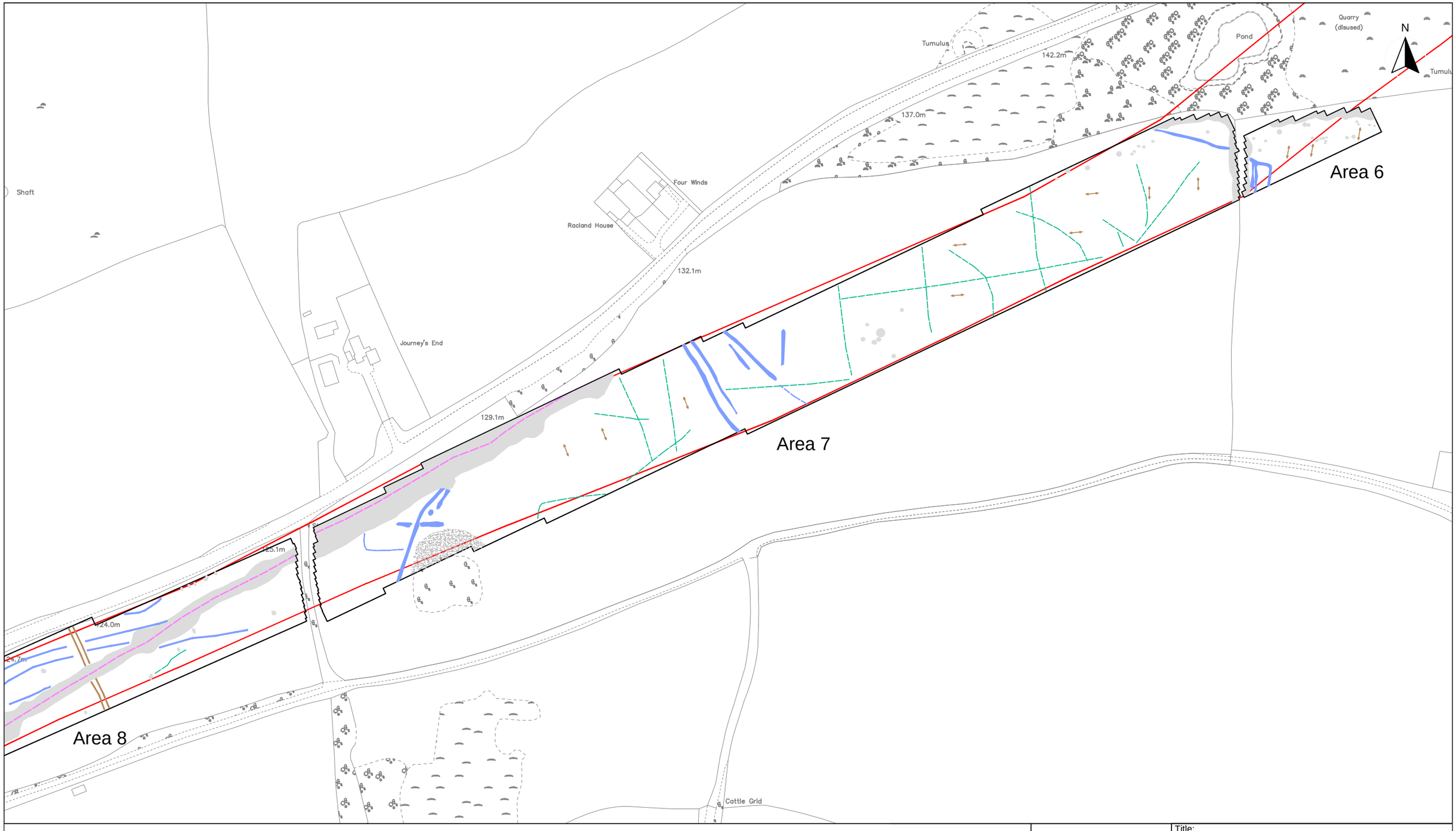


Possible Archaeology
(discrete anomaly / trend)

Uncertain Origin (trend)

Agriculture
(Ridge and Furrow / Ploughing)

Pipe

Magnetic Disturbance

Ferrous

sumo Survey
GEOPHYSICS FOR ARCHAEOLOGY & ENGINEERING

Title:
Magnetometer Survey [Area 7]
Interpretation

Client:
WSP Parsons Brinckerhoff

Project:
11198 A30 Carland to Chiverton, Cornwall

Scale: 0 metres 100
1:2500 @ A3

Fig No:
07

sumo Survey
GEOPHYSICS FOR ARCHAEOLOGY & ENGINEERING

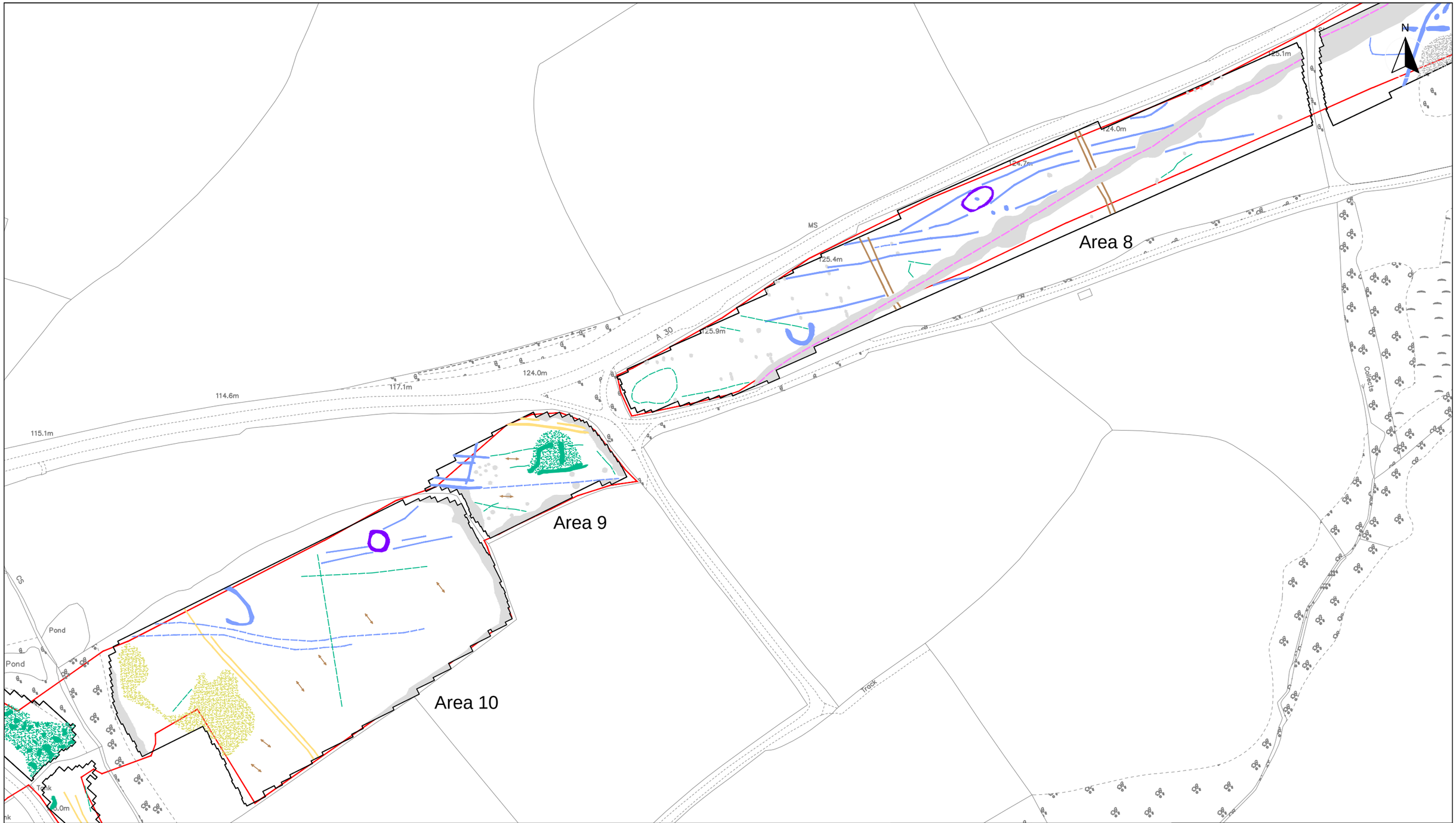
Title:
Magnetometer Survey [Areas 8 - 10]
Greyscale Plots

Client:
WSP Parsons Brinckerhoff

Project:
11198 A30 Carland to Chiverton, Cornwall

Scale: 0 metres 100
1:2500 @ A3

Fig No:
08



Probable Archaeology

Possible Archaeology (discrete anomaly / trend)

Uncertain Origin (discrete anomaly / trend)

Uncertain Origin (increased response)

Former Field Boundary (corroborated / conjectural)

?Natural

Agriculture (Ridge and Furrow / Ploughing)

Pipe

Magnetic Disturbance

Ferrous

sumo Survey
GEOPHYSICS FOR ARCHAEOLOGY & ENGINEERING

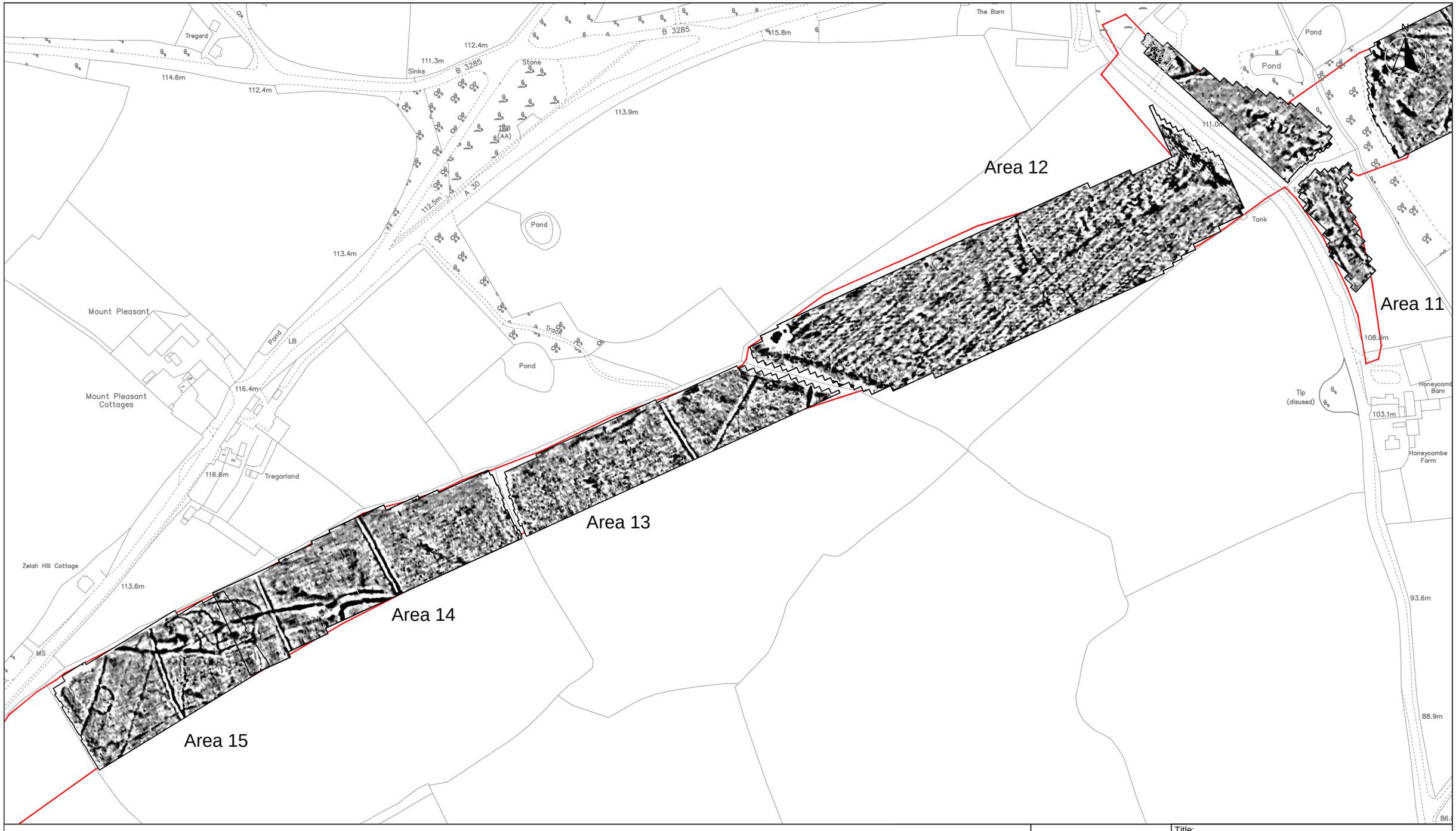
Title: Magnetometer Survey [Areas 8 - 10] Interpretation

Client: WSP Parsons Brinckerhoff

Project: 11198 A30 Carland to Chiverton, Cornwall

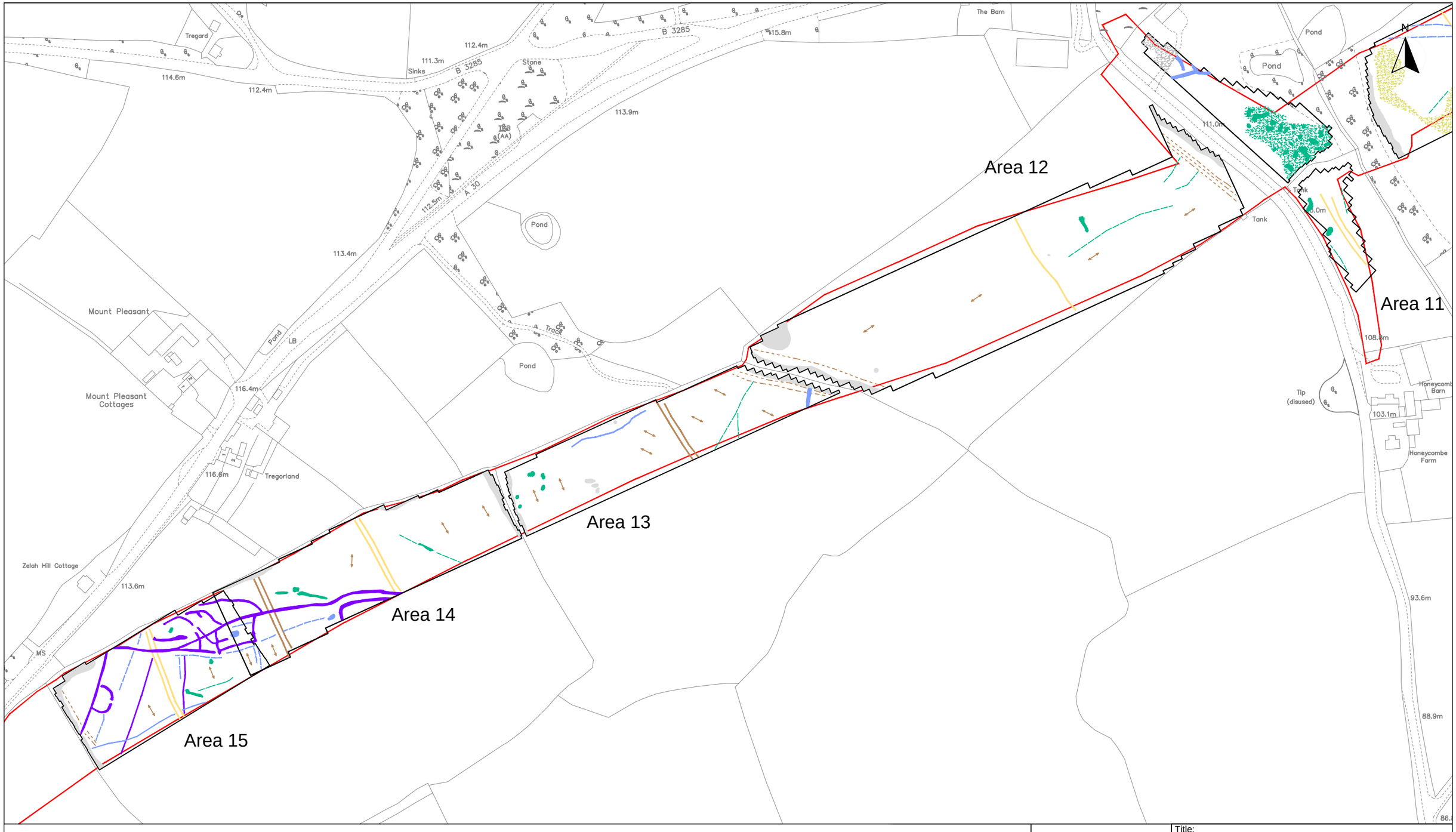
Scale: 0 metres 100
1:2500 @ A3

Fig No: 09



Title:	Magnetometer Survey [Areas 11 - 15] Greyscale Plots
Client:	WSP Parsons Brinckerhoff
Project:	11198 A30 Carland to Chiverton, Cornwall
Scale:	0 metres 100 — 1:2500 @ A3
Fig No:	10

sumo Survey
GEOPHYSICS FOR ARCHAEOLOGY & ENGINEERING



Probable Archaeology	Former Field Boundary (corroborated / conjectural)
Possible Archaeology (discrete anomaly / trend)	Agricultural (Ridge and Furrow / Ploughing)
Uncertain Origin (discrete anomaly / trend)	Ploughing (headland)
Uncertain Origin (increased response)	Ferrous

sumo Survey
GEOPHYSICS FOR ARCHAEOLOGY & ENGINEERING

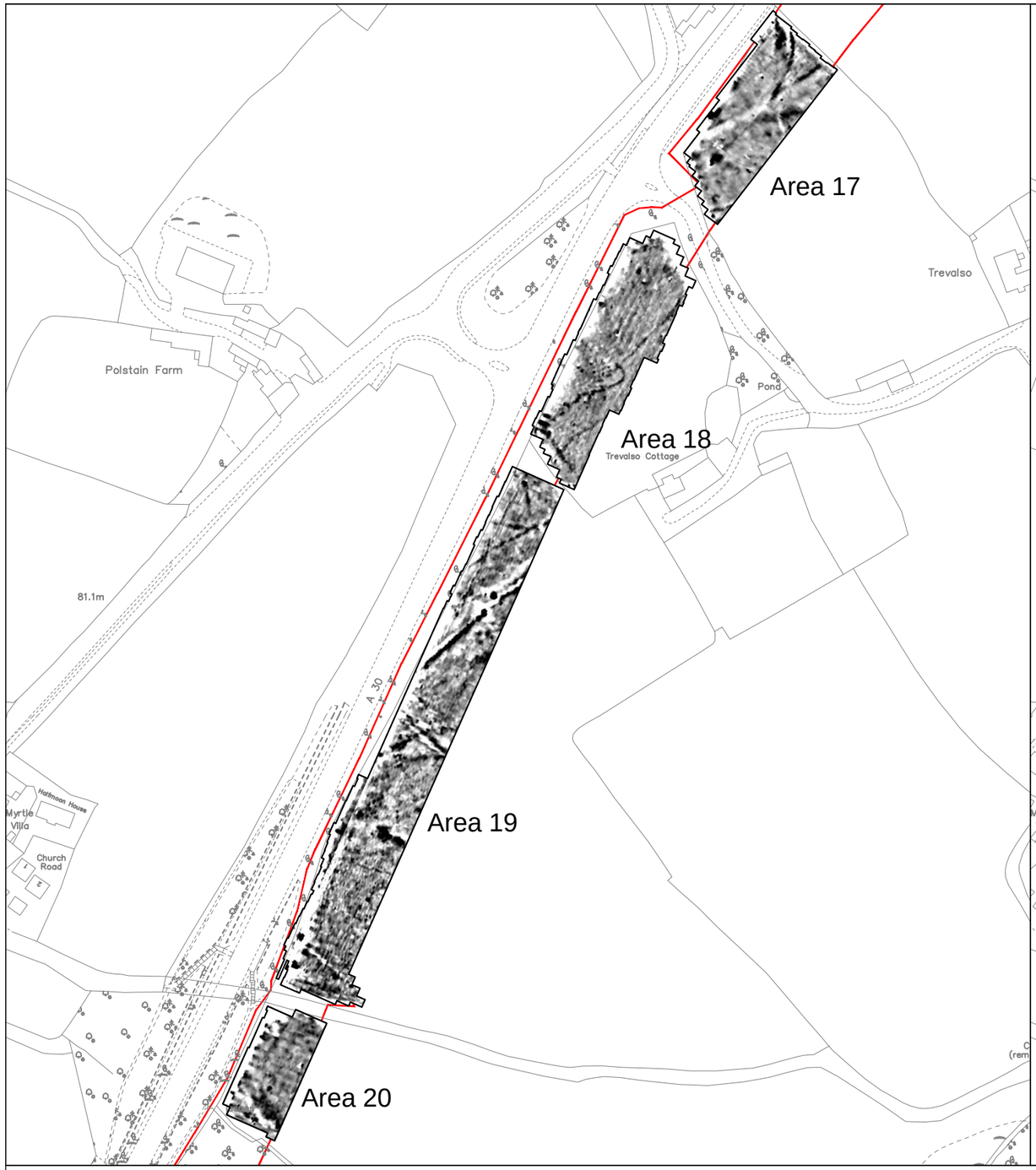
Title: Magnetometer Survey [Areas 11 - 15] Interpretation

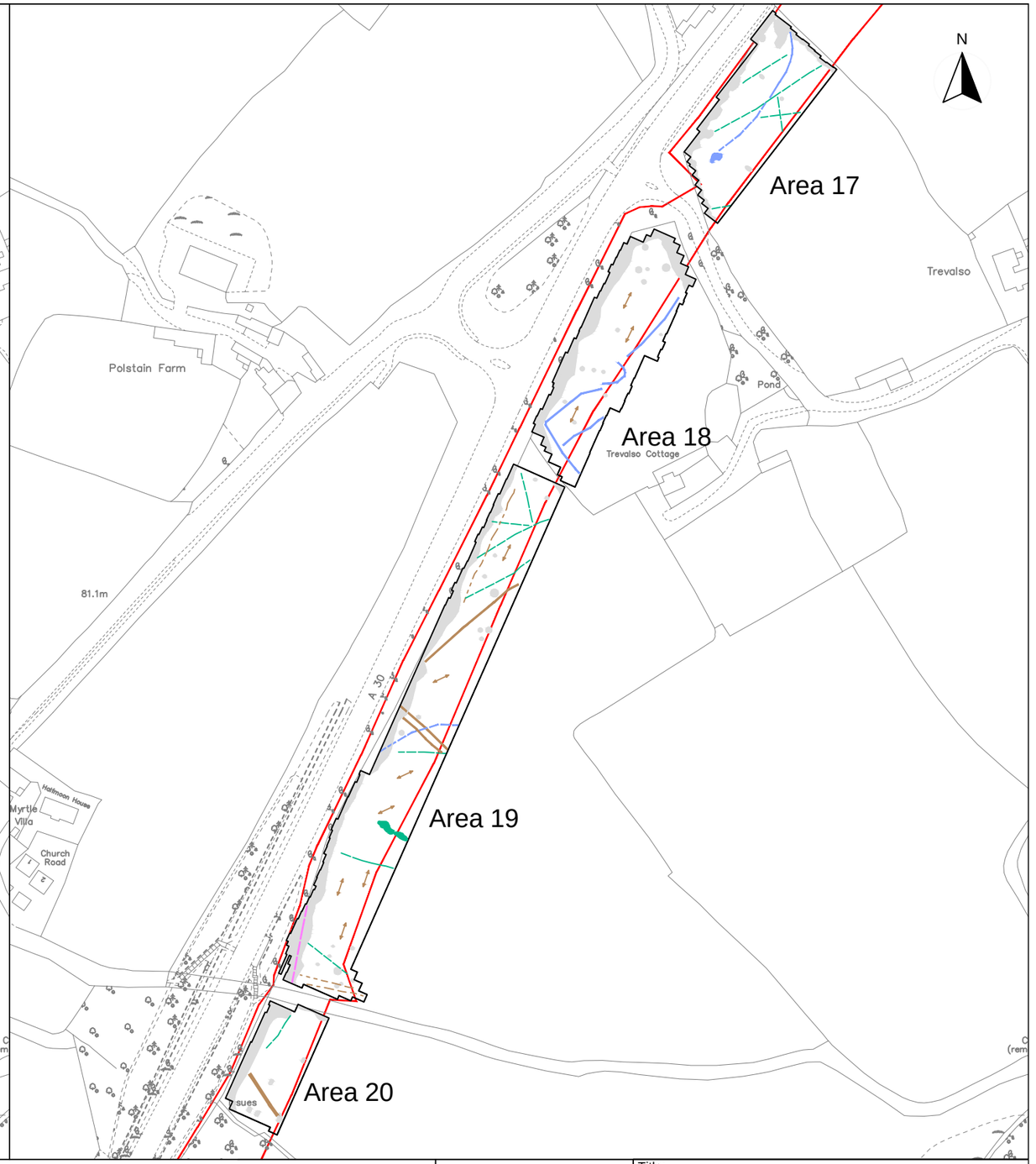
Client: WSP Parsons Brinckerhoff

Project: 11198 A30 Carland to Chiverton, Cornwall

Scale: 0 metres 100
1:2500 @ A3

Fig No: 11





5
nT
-3

Possible Archaeology
(discrete anomaly / trend)

Uncertain Origin
(discrete anomaly / trend)

Former Field Boundary
(corroborated)

Agricultural
(Ridge and Furrow / Ploughing)

Ploughing (headland)

Ferrous

sumo Survey
GEOPHYSICS FOR ARCHAEOLOGY & ENGINEERING

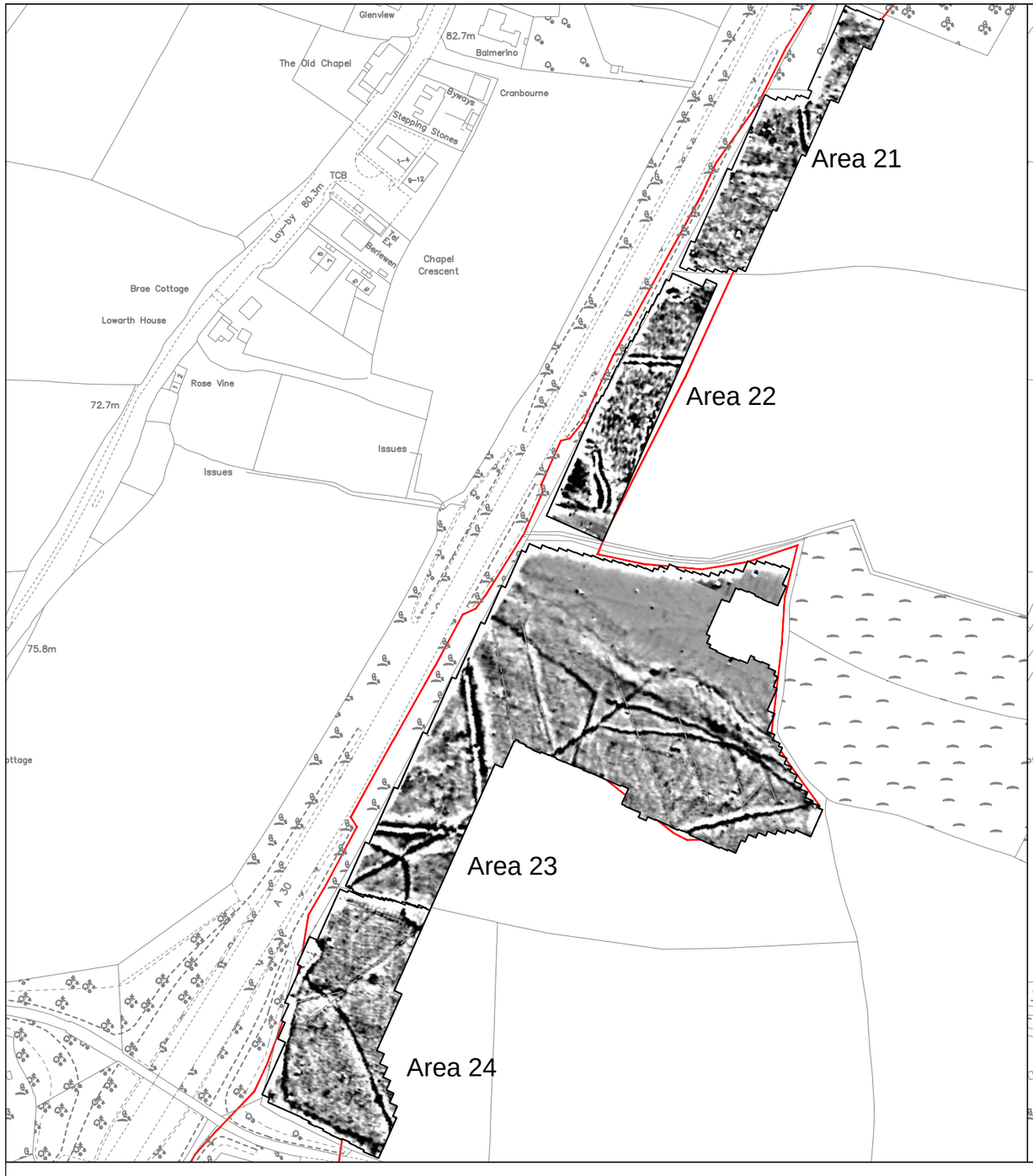
Title:
Magnetometer Survey [Areas 17 - 20]
Greyscale Plots and Interpretation

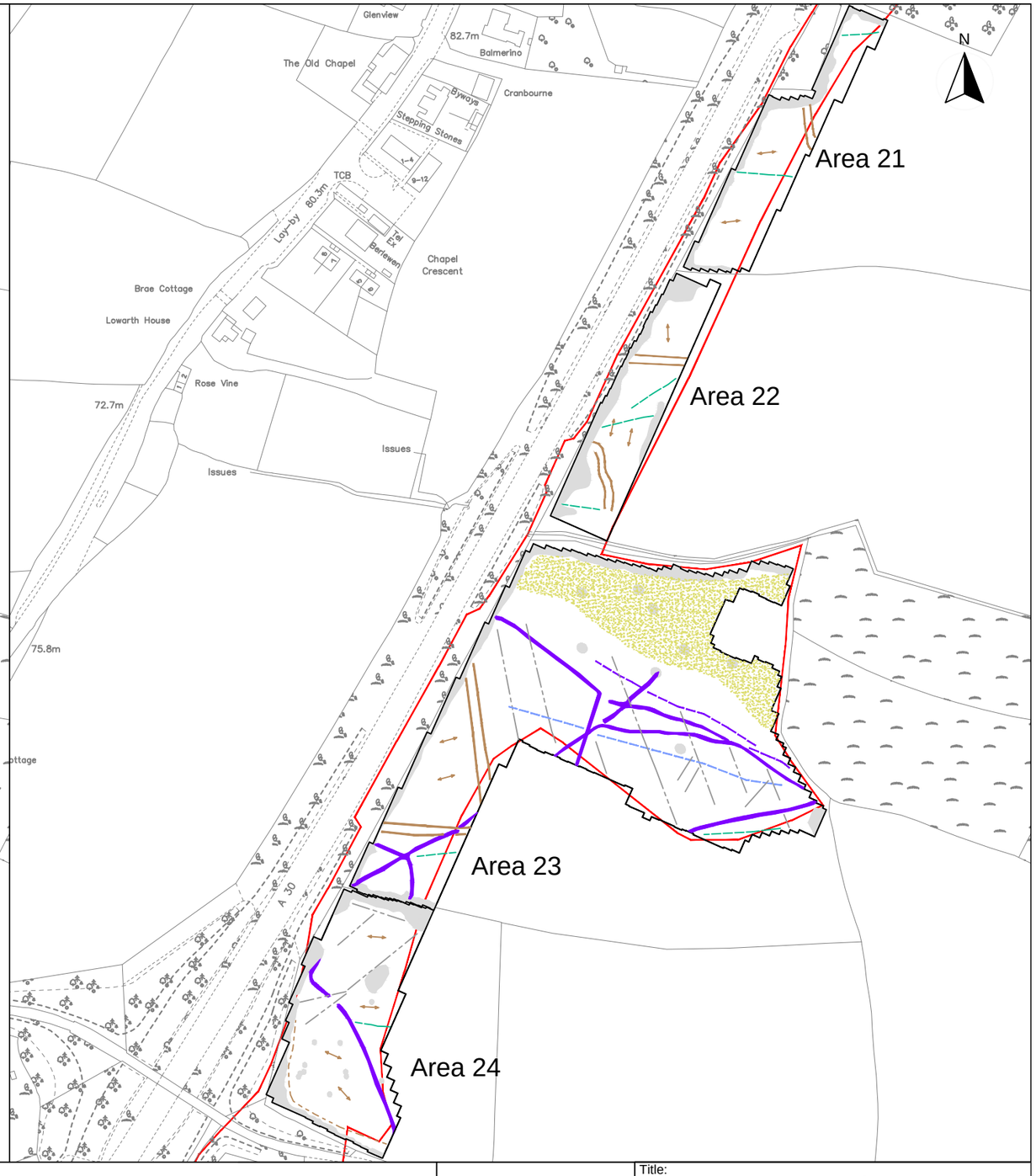
Client:
WSP Parsons Brinckerhoff

Project:
11198 A30 Carland to Chiverton, Cornwall

Scale: 0 metres 100
1:2500 @ A3

Fig No:
12





5
nT
-3

Probable Archaeology (discrete anomaly / trend)

Possible Archaeology (trend)

Uncertain Origin (discrete anomaly / trend)

?Natural

Former Field Boundary (corroborated)

Agricultural (Ridge and Furrow / Ploughing)

Ploughing (headland)

Drain

Ferrous

sumo Survey
GEOPHYSICS FOR ARCHAEOLOGY & ENGINEERING

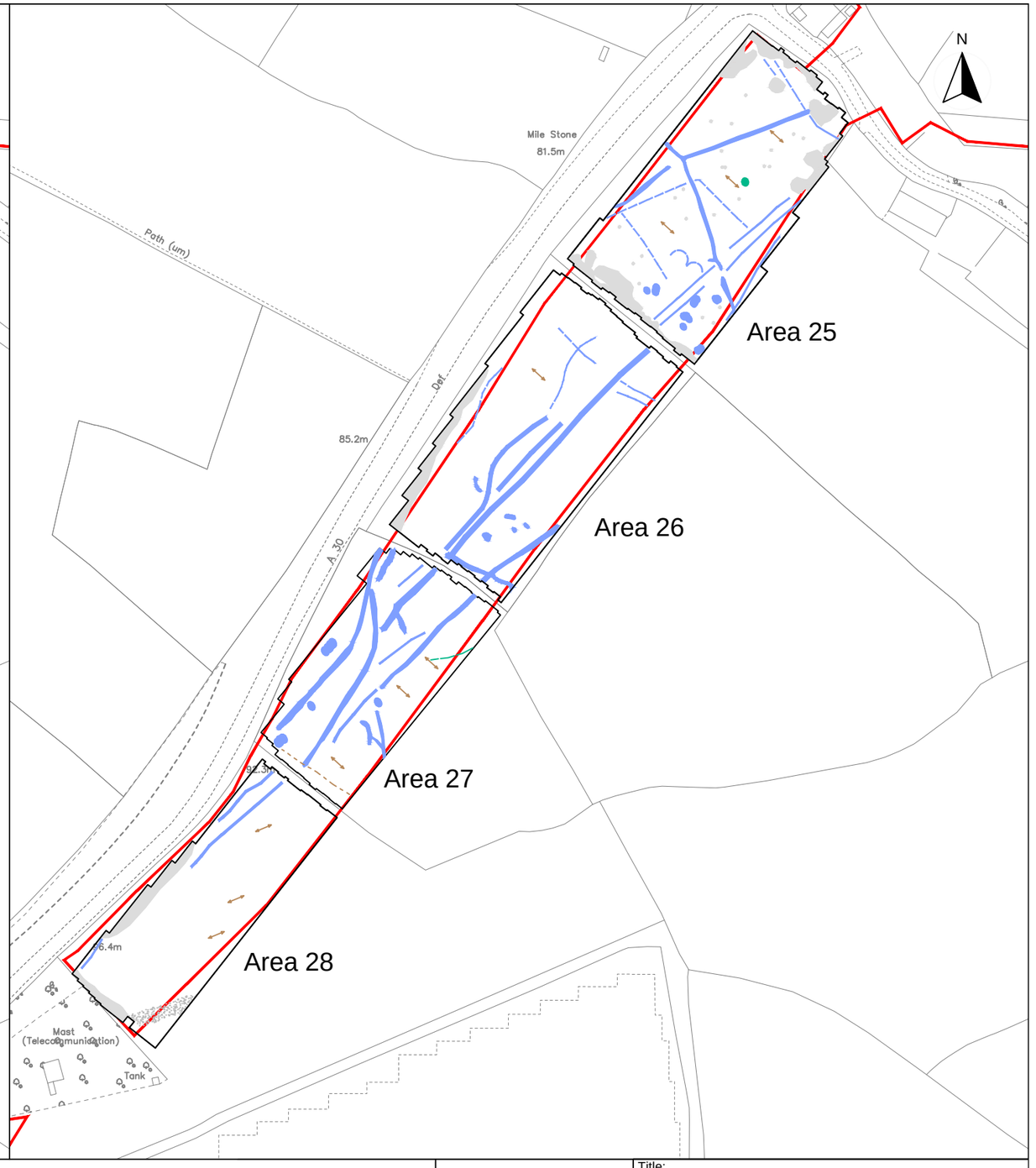
Title:
Magnetometer Survey [Areas 21 - 24]
Greyscale Plots and Interpretation

Client:
WSP Parsons Brinckerhoff

Project:
11198 A30 Carland to Chiverton, Cornwall

Scale: 0 metres 100
1:2500 @ A3

Fig No:
13



5
nT
-3

- Possible Archaeology (discrete anomaly / trend)
- Uncertain Origin (discrete anomaly / trend)
- Agricultural (Ridge and Furrow / Ploughing)
- Ploughing (headland)
- Magnetic Disturbance
- Ferrous

sumo Survey
GEOPHYSICS FOR ARCHAEOLOGY & ENGINEERING

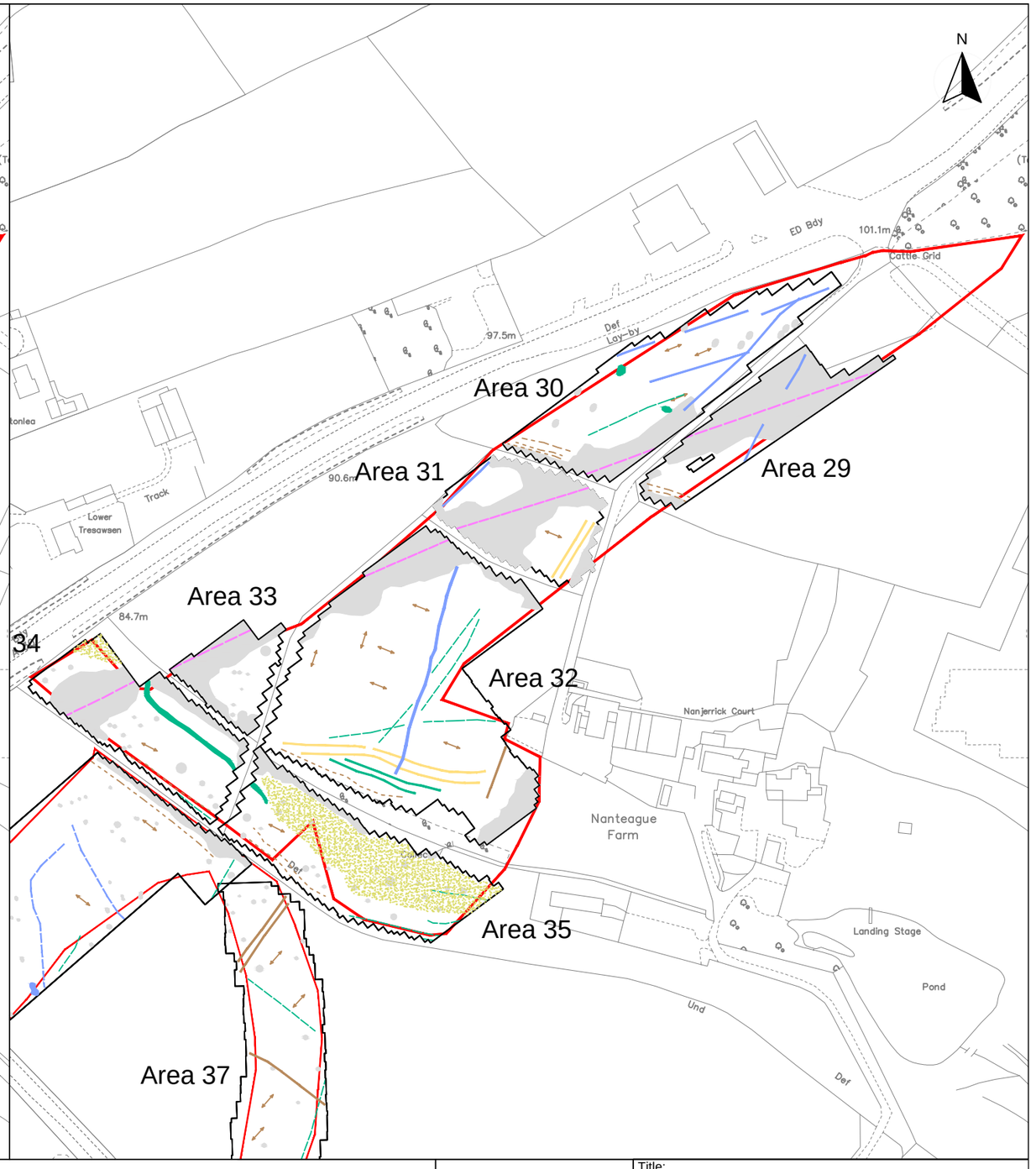
Title: Magnetometer Survey [Areas 25 - 28]
Greyscale Plots and Interpretation

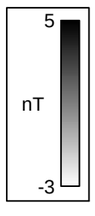
Client: WSP Parsons Brinckerhoff

Project: 11198 A30 Carland to Chiverton, Cornwall

Scale: 0 metres 100
1:2500 @ A3

Fig No: 14





- Possible Archaeology
- Uncertain Origin (discrete anomaly / trend)
- Former Field Boundary (corroborated / conjectural)
- ?Natural
- Agricultural (Ridge and Furrow / Ploughing)
- Ploughing (headland)
- Pipe
- Ferrous

sumo Survey
GEOPHYSICS FOR ARCHAEOLOGY & ENGINEERING

Title: Magnetometer Survey [Areas 29 - 35] Greyscale Plots and Interpretation

Client: WSP Parsons Brinckerhoff

Project: 11198 A30 Carland to Chiverton, Cornwall

Scale: 0 metres 100
1:2500 @ A3

Fig No: 15

5
nT
-3

sumo Survey
GEOPHYSICS FOR ARCHAEOLOGY & ENGINEERING

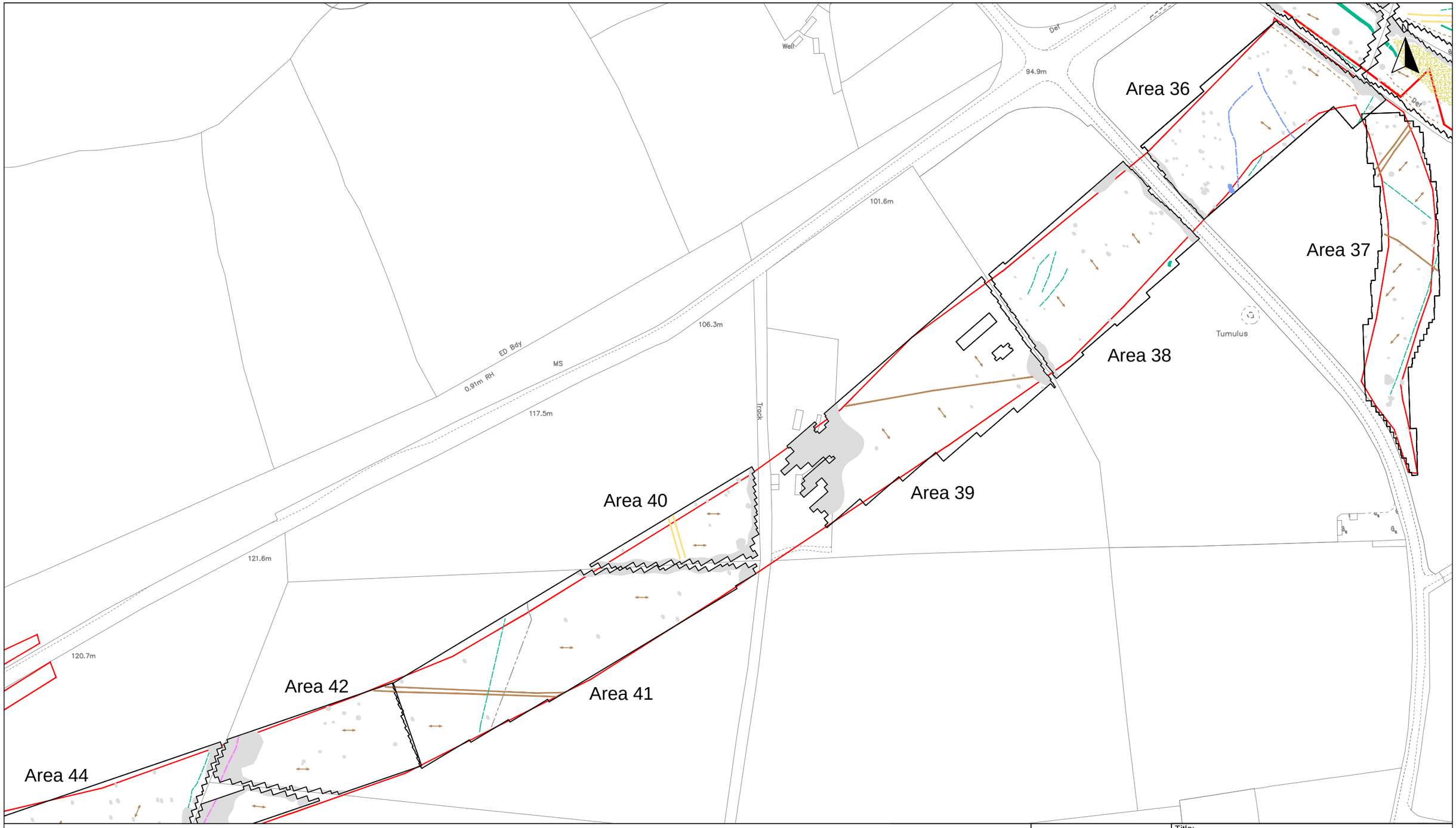
Title: Magnetometer Survey [Areas 36 - 42] Greyscale Plots

Client: WSP Parsons Brinckerhoff

Project: 11198 A30 Carland to Chiverton, Cornwall

Scale: 0 metres 100
1:2500 @ A3

Fig No: 16



Possible Archaeology (discrete anomaly / trend)

Uncertain Origin (discrete anomaly / trend)

Pipe

Drain

Former Field Boundary (corroborated / conjectural)

Agricultural (Ridge and Furrow / Ploughing)

Ploughing (headland)

Ferrous

sumo Survey

GEOPHYSICS FOR ARCHAEOLOGY & ENGINEERING

Title: Magnetometer Survey [Areas 36 - 42] Interpretation

Client: WSP Parsons Brinckerhoff

Project: 11198 A30 Carland to Chiverton, Cornwall

Scale: 0 metres 100

1:2500 @ A3

Fig No: 17

Area 46

Area 47

Area 45

Area 44

Area 43

Creegmeor Farm

A 30

110.0m

111.0m

B 3284

Cattle Grid

111.9m

116.6m

Track

Hillview Farm

N

5

nT

-3

Possible Archaeology

Uncertain Origin (trend)

Former Field Boundary (conjectural)

Pipe

Agricultural (Ridge and Furrow / Ploughing)

Magnetic Disturbance

Ferrous

sumo Survey

GEOPHYSICS FOR ARCHAEOLOGY & ENGINEERING

Title: Magnetometer Survey [Areas 43 - 45] Greyscale Plots and Interpretation

Client: WSP Parsons Brinckerhoff

Project: 11198 A30 Carland to Chiverton, Cornwall

Scale: 0 metres 100

1:2500 @ A3

Fig No: 18

Area 46

Area 47

Area 49

Area 48

Area 45

Creegmeor Farm

B 3284

110.0m

111.0m

110.3m

111.9m

116.6m

Track

A 30

N

5
nT
-3

Uncertain Origin (trend)

Pipe

Agricultural
(Ridge and Furrow / Ploughing)

Ferrous

sumo Survey
GEOPHYSICS FOR ARCHAEOLOGY & ENGINEERING

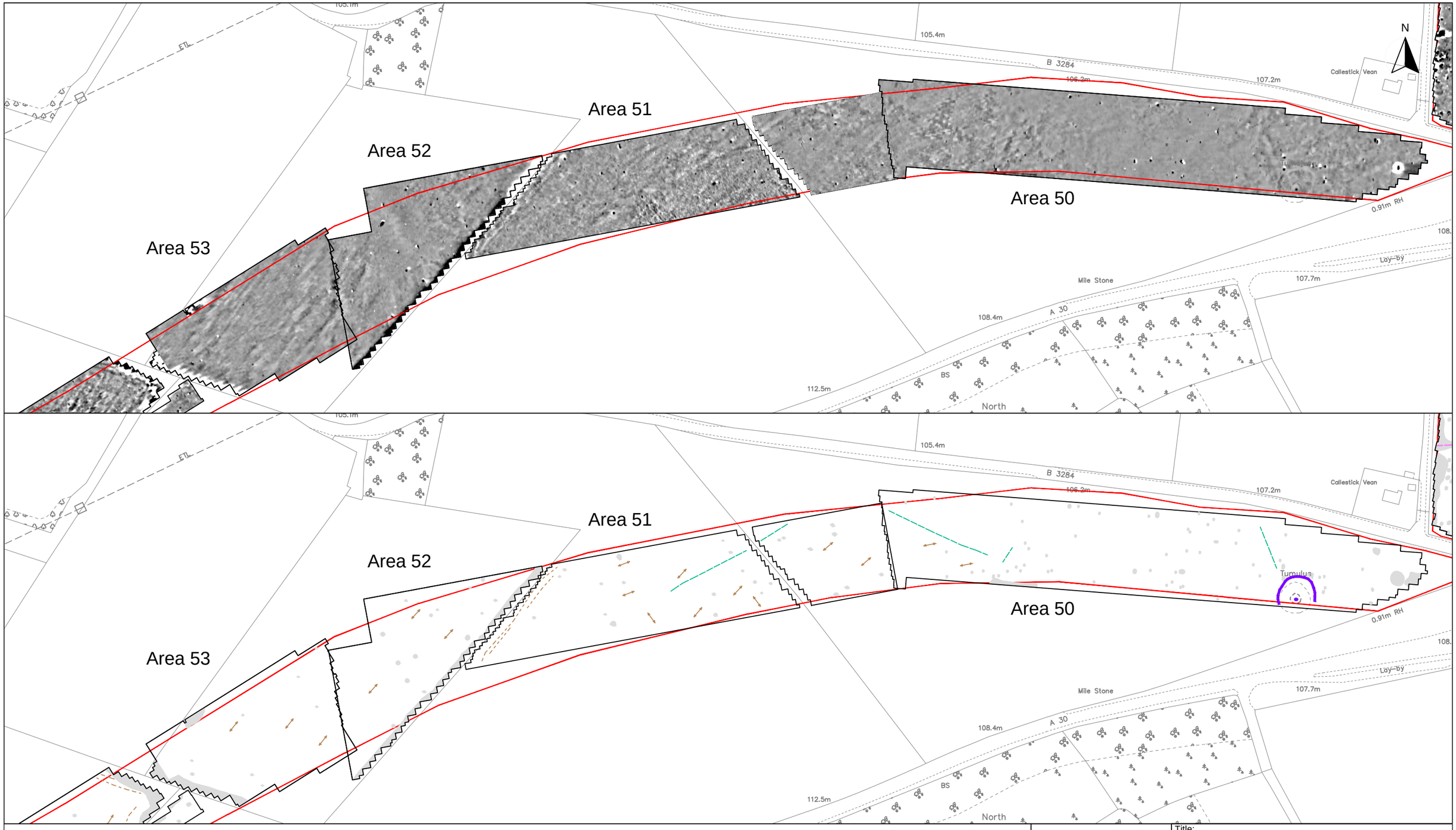
Title:
Magnetometer Survey [Areas 46 - 49]
Greyscale Plots and Interpretation

Client:
WSP Parsons Brinckerhoff

Project:
11198 A30 Carland to Chiverton, Cornwall

Scale: 0 metres 100
1:2500 @ A3

Fig No:
19



sumo Survey
GEOPHYSICS FOR ARCHAEOLOGY & ENGINEERING

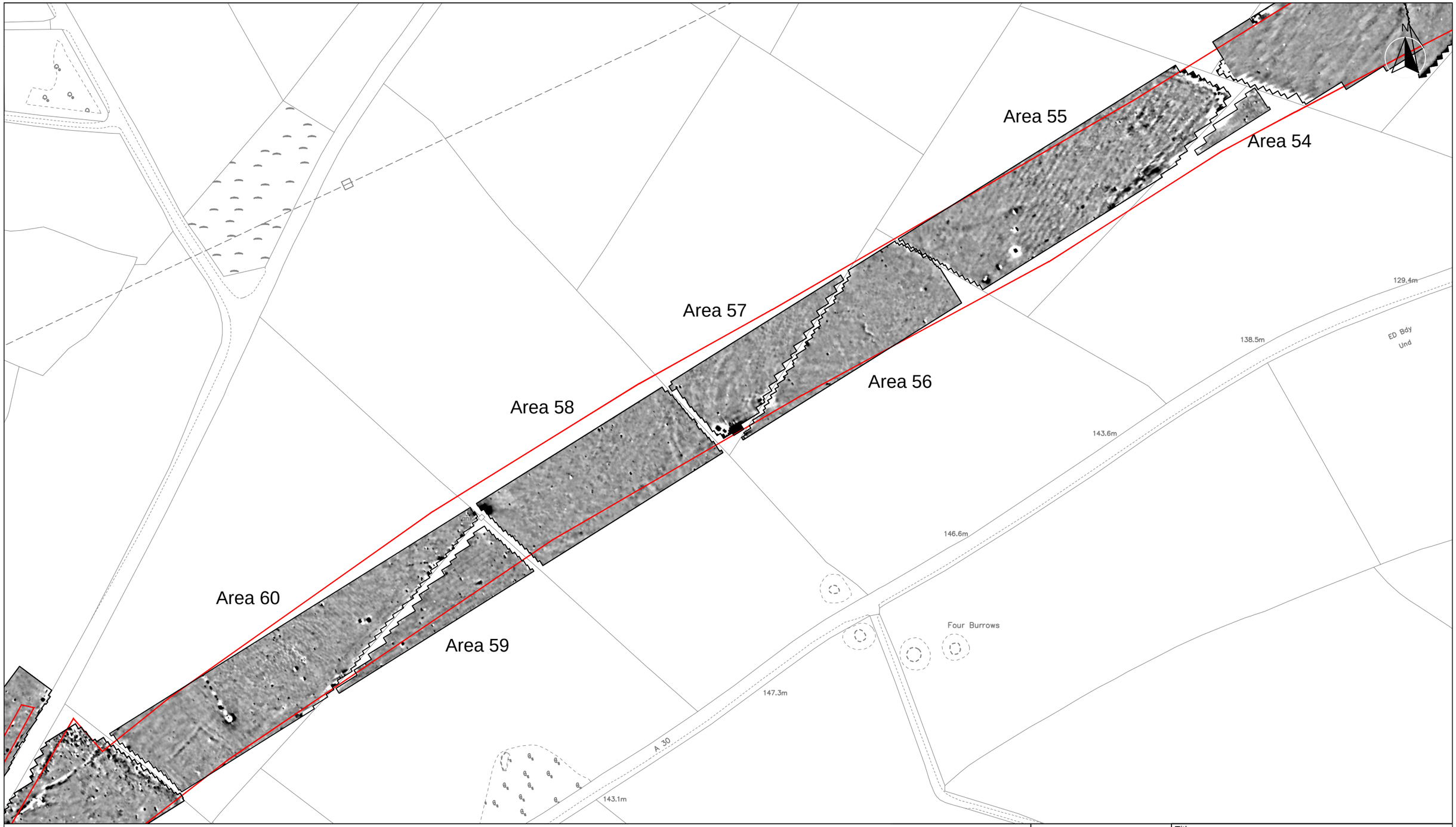
Title: Magnetometer Survey [Areas 50 - 53]
Greyscale Plots and Interpretation

Client: WSP Parsons Brinckerhoff

Project: 11198 A30 Carland to Chiverton, Cornwall

Scale: 0 metres 100
1:2500 @ A3

Fig No: 20



5
nT
-3

sumo Survey
GEOPHYSICS FOR ARCHAEOLOGY & ENGINEERING

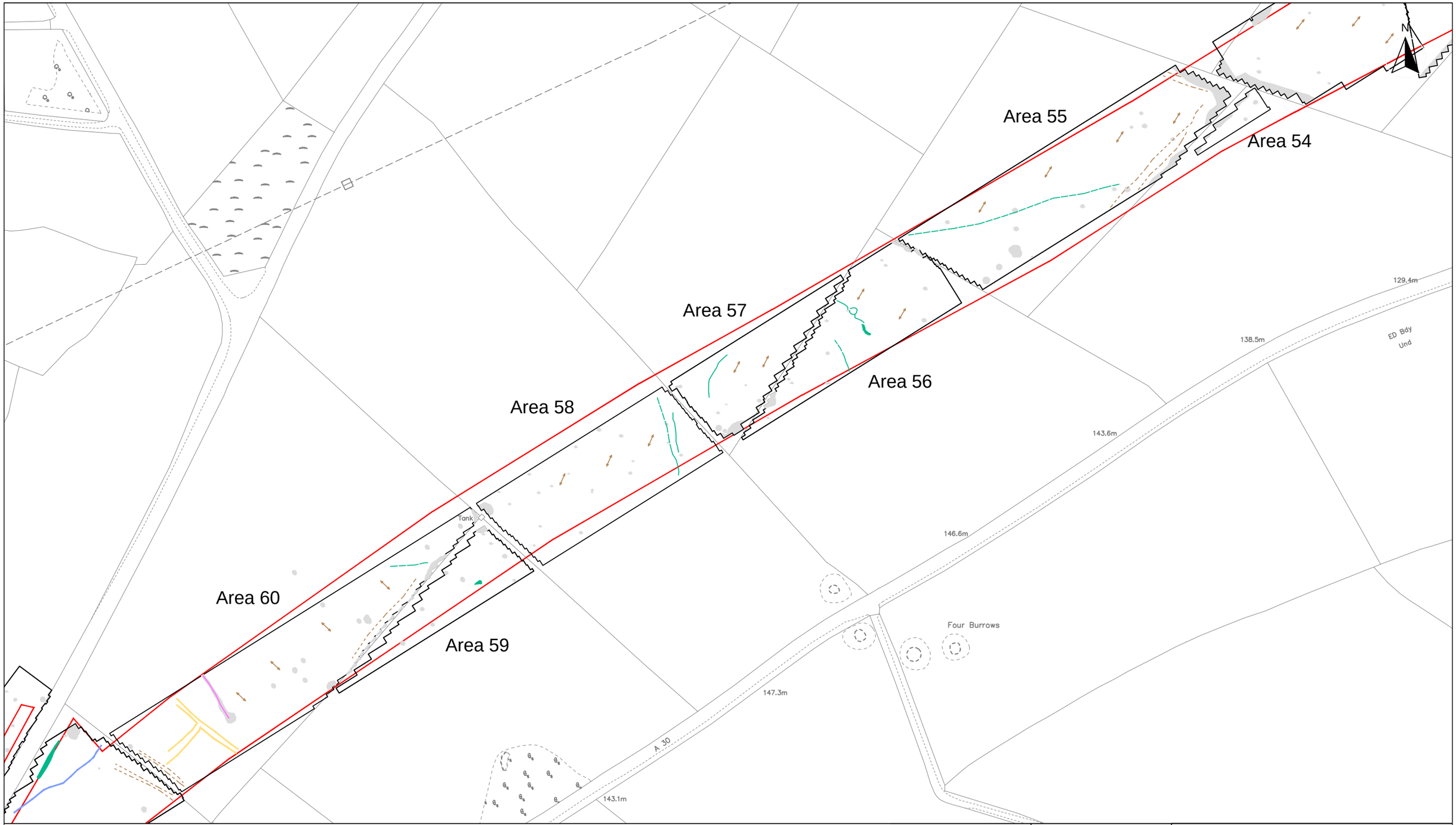
Title:
Magnetometer Survey [Areas 54 - 60]
Greyscale Plots

Client:
WSP Parsons Brinckerhoff

Project:
11198 A30 Carland to Chiverton, Cornwall

Scale: 0 metres 100
1:2500 @ A3

Fig No:
21



Uncertain Origin
(discrete anomaly / trend)

Former Field Boundary
(conjectural)

Agricultural
(Ridge and Furrow / Ploughing)

Ploughing (headland)

Pipe

Ferrous

sumo Survey
GEOPHYSICS FOR ARCHAEOLOGY & ENGINEERING

Title:
Magnetometer Survey [Areas 54 - 60]
Interpretation

Client:
WSP Parsons Brinckerhoff

Project:
11198 A30 Carland to Chiverton, Cornwall

Scale: 0 metres 100
1:2500 @ A3

Fig No:
22

Area 62

Area 61

Area 63

Cottage

Well

Poltaire

A 3075

Stone

131.1m

Wind Turbine

BS

0.91m RH

Trevissome Park

Chynoweth House

129.1m

N

5

nT

-3

Possible Archaeology

Uncertain Origin
(discrete anomaly / trend)

Former Field Boundary
(corroborated)

Agricultural
(Ridge and Furrow / Ploughing)

Ploughing (headland)

Ferrous

sumo Survey

GEOPHYSICS FOR ARCHAEOLOGY & ENGINEERING

Title:
Magnetometer Survey [Areas 61 - 63]
Greyscale Plots and Interpretation

Client:
WSP Parsons Brinckerhoff

Project:
11198 A30 Carland to Chiverton, Cornwall

Scale:
0 metres 100
1:2500 @ A3

Fig No:
23

Area 63

Area 64

Ferreira

Silverwell

Silverdene

Trevissome Park

Chynoweth House

Trevissome House

Trevissome Barn

Track

133.8m

137.8m

0.91m

BS

Def

Issues

Roscar

N

5

nT

-3

Former Field Boundary
(corroborated / conjectural)

Agricultural
(Ridge and Furrow / Ploughing)

Ferrous

sumo Survey

GEOPHYSICS FOR ARCHAEOLOGY & ENGINEERING

Title:
Magnetometer Survey [Area 64]
Greyscale Plot and Interpretation

Client:
WSP Parsons Brinckerhoff

Project:
11198 A30 Carland to Chiverton, Cornwall

Scale: 0 metres 100
1:2500 @ A3

Fig No:
24

Area 65

Area 66

Area 67

Not surveyable

Not surveyable

Spring

137.8m

BS

A 3075

A 30

Three Burrows

N

5
nT
-3

Possible Archaeology

Uncertain Origin
(discrete anomaly / trend)

Former Field Boundary
(corroborated / conjectural)

Agricultural
(Ridge and Furrow / Ploughing)

Pipe

Ferrous

sumo Survey
GEOPHYSICS FOR ARCHAEOLOGY & ENGINEERING

Title:
Magnetometer Survey [Areas 65 - 67]
Greyscale Plots and Interpretation

Client:
WSP Parsons Brinckerhoff

Project:
11198 A30 Carland to Chiverton, Cornwall

Scale: 0 metres 100
1:2500 @ A3

Fig No:
25

Not surveyable

Not surveyable

Area 68

Area 69

Chiverton House

Old Vicarage Court

Hall

The Old Vicarage

Und

Three Burrows

Tumulus

Tumuli

Def

ED Bdy

0.91m RH

A 3075

A 30

A 390

Communication Mast

Service Area

Filling Station

Highfields

Stone

Mast

Hartley Farm

Hartley House

Ruby Cottage

Acland House

144.5m

142.5m

142.0m

140.4m

N

5

nT

-3

Uncertain Origin
(discrete anomaly)

Former Field Boundary
(corroborated)

Agricultural
(Ridge and Furrow / Ploughing)

Ferrous

sumo Survey

GEOPHYSICS FOR ARCHAEOLOGY & ENGINEERING

Title:
Magnetometer Survey [Areas 68 - 69]
Greyscale Plots and Interpretation

Client:
WSP Parsons Brinckerhoff

Project:
11198 A30 Carland to Chiverton, Cornwall

Scale:
0 metres 100
1:2500 @ A3

Fig No:
26

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 Traverse	This process sets the background mean of each traverse within each grid to zero. The operation removes striping effects and edge discontinuities over the whole of the data set.
Step Correction (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/ 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.

Archaeology / Probable Archaeology	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.
Possible Archaeology	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.
Industrial / Burnt-Fired	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.
Former Field Boundary (probable & possible)	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.
Ridge & Furrow	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.
Agriculture (ploughing)	Parallel linear anomalies or trends with a narrower spacing, sometimes aligned with existing boundaries, indicating more recent cultivation regimes.
Land Drain	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.
Natural	These responses form clear patterns in geographical zones where natural variations are known to produce significant magnetic distortions.
Magnetic Disturbance	Broad zones of strong dipolar anomalies, commonly found in places where modern ferrous or fired materials (e.g. brick rubble) are present.
Service	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.
Ferrous	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.
Uncertain Origin	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 *Possible Archaeology* / *Natural* or (in the case of linear responses) *Possible Archaeology* / *Agriculture*; 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.

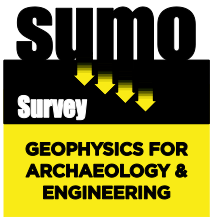
Magnetic susceptibility relates to the induced magnetism of a material when in the presence of a magnetic field. This magnetism can be considered as effectively permanent as it exists within the Earth's magnetic field. Magnetic susceptibility can become enhanced due to burning and complex biological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



- Archaeological
- Geophysical
- Laser Scanning
- Measured Building
- Topographic
- Utility Mapping

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