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Known problems with this report

There are no known archive issues with this report

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GEOPHYSICAL SURVEY
REPORT 2004/70

CARLOW OUTER RELIEF ROAD
Carlow

Duchas Licence No.
04R114

Client:

Carlow County Council

NRA
National Roads Authority

SURVEY RESULTS

2004 / 70 Carlow Relief Road

1. Survey Area

1.1 A total of 5.5ha of gradiometer survey was carried out at two sites along the route of the proposed road corridor, Area AS3 and Area AR4. Additionally, two areas of resistance survey totalling 0.84ha were investigated at AS3, Areas AS3(A) and AS3(B). Figures 1 and 2 show the location of the survey areas at a scale of 1:2500.

1.2 The survey grid was set out by **GSB Prospection Ltd** and tied in to existing boundaries using an EDM system. Detailed tie-in information has been lodged with the client

2. Display

2.1 The results are displayed as greyscale images and XY trace plots. These display formats are discussed in the *Technical Information* section, at the end of the text.

2.2 Figures 3 to 8 are summary greyscale images and interpretations of the survey results at the two sites produced at a scale of 1:1500. Figures 9 to 31 are data plots and interpretations of the data produced at a scale of 1:500, except for Figures 21 and 24 produced at 1:625, which show the results of the resistance survey in Area AS3. Figure 32 shows a summary greyscale image of the results from areas AS2 and AS3 at 1:2500

2.3 Numbers and letters in parentheses in the text of the report refer to anomalies highlighted in the relevant interpretation diagram.

3. General Considerations - Complicating Factors

3.1 The survey area at AS3 comprises parts of two fields, one of which was under short pasture and ideal for geophysical survey. The other had been cleared of a bean crop and the resulting corrugated surface of the stubble field has introduced a series of north-south linear responses into both magnetic and resistance datasets. At the northwestern corner of the same field farm machinery, bonfires, gates, fences and adjacent buildings have produced an extensive area of the magnetic interference.

3.2 The eastern part of Area AR4 is occupied by part of a drain that accounts for a gap in the survey area. The field is overgrown in this area and there is surface evidence to indicate that material has been dumped, possibly to improve drainage. The remainder of the field was under short pasture that was suitable for survey.

3.3 The soils are of a type that would be expected to provide a good magnetic contrast, particularly where remains associated with settlement activity, *fulacht fiadh* and/or industrial processes have occurred. In addition, features relating to activities that are more remote from occupation areas, such as field systems might also be recorded.

3.4 Igneous intrusions in the geology and the presence of boulders and cobbles of granite in the soil may complicate interpretation of the data. Anomalies produced by such sources can be similar

to those produced by archaeological features. With the addition of small-scale ferrous anomalies produced by iron debris in the topsoil 'noisy' datasets can occur that can be difficult to interpret, particularly if responses from archaeological features are insubstantial.

3.5 Broad high and low regions or resistance regions reflect natural moisture levels changes, topographic influences and variations in the underlying geology. Such responses are encountered in the data from most sites and major variations can complicate interpretation of the data as anomalies produced by archaeological features can be hidden or obscured.

3.6 All areas of gradiometer survey contain small-scale anomalies produced by ferrous debris in the topsoil. They are not likely to be of archaeological significance.

4. Results of Survey

AS3 comprises two survey areas separated by 3m and a post and wire fence.

Gradiometer Survey - Areas AS3(1), AS3(2) & AS3(3)

4.1 At the centre of the survey area is a well-defined oval enclosure (1) with a diameter varying from 40 to 50m. It coincides with a cropmark recorded on aerial photographs. In the northern part of the enclosure several responses hint at occupation activity including a possible hut circle (2) of around 5m in diameter that appears to be appended to the enclosure ditch. There is also the suggestion of a small square enclosure (3). However, this feature could be a consequence of linear responses relating to features continuing outside, thus suggesting a different phase of activity and ploughing disturbance.

4.2 The enclosure is itself enclosed by a ditch anomaly (4) and the intervening space varies in width from 10 to 20m. The strength (4) is much less than (1) and could indicate a less substantial feature. However, it could indicate a reduced level of occupation activity in this locality compared to the interior of the enclosure. The anomaly is magnetically weak and ill-defined, particularly in the west where significant plough damage may have occurred

4.3 In the northeast a large pit type anomaly (5) is evident in the plot. It appears to overlie the outer enclosure ditch but it is not possible to determine the chronology of these features with any certainty with geophysical methods alone. The magnetic strength of the response is not great, which suggests that it is not associated with industrial activity. The response is more characteristic of a scoop in the ground such as a sunken floor. However, a deeply buried igneous boulder or modern disturbance could account for this anomaly.

4.4 Appended to the northern side of enclosure ditch (4) is a third enclosure ditch (6). Contained within are a number of possible pit anomalies and ditch features that suggest possible occupation activity rather than an enclosed field or garden. However, given the lack of a clear pattern, the interpretation is cautious; it is possible that these responses reflect igneous cobbles and/or bonfires. Several of the latter were evident in this area at the time of the survey and it is likely that others have been ploughed into the soil.

4.5 In the northern part of the survey area a series of substantial ditch type responses have been recorded that indicate further settlement remains. The lack of a clear pattern may be a result of various phases, including more recent field boundaries and ploughing disturbance to archaeological deposits. Some ferrous interference (7) has been detected from the remains of a boundary that once ran from the nearby farm to the eastern boundary; it is shown on the OS map. It should be noted that some of these features could be natural in origin, a deep hollow in the field to the east of the survey area could be a glacial outwash feature and the possibility that

palaeochannels are present cannot be discounted.

4.6 Immediately to the south of the main enclosure part of a rectilinear enclosure (8) extends southward from (4). There are indications of internal divisions and it is likely that these anomalies represent part of a field system associated with the settlement.

4.7 Some stronger anomalies and clusters of pit responses (9) and several linear anomalies indicative of smaller enclosures (10) may reflect further features associated with occupation remains.

4.8 Numerous linear trends are indicated on the interpretation diagram that could be of archaeological interest. Most are poorly defined and very likely to be due to disturbance caused by ploughing.

4.9 Several broad regions of magnetic response are evident in the data that are thought to be natural in origin; reflecting localised soil 'noise'. Anomaly (11) could represent a build up of magnetically enhanced soils from archaeological features that have accumulated at the base of a hill.

Gradiometer Survey - Areas AS3(4) and AS3(5)

4.10 To the southwest, in the pasture field, broad variations in response and pit type responses have been found that are thought, given the context, to be of archaeological interest. The most promising group (12) lies in the northern part of the survey area, occupying a noticeable rise in ground level. However, there is no clear pattern and it is likely that some, if not all, of these responses could be due to natural pedological/geological variations.

Resistance Survey - Area AS3(A)

4.11 This area was positioned to investigate the interior of the enclosure identified from aerial photographs and to determine whether or not the remains of an embankment or wall survives.

4.12 The enclosure is evident as a low resistance oval anomaly (A). The ditch appears to be around 3m wide but of unknown depth.

4.13 In the southeast (A) is accompanied by a high resistance anomaly (B) that could relate to the remains of a bank or wall or the collapsed remains of such a structure. It lies outside the ditch, which would suggest that the enclosure is not defensive. However, another ditch anomaly (C) runs immediately to the south and it is probable that (B) is a natural consequence of moisture drainage between neighbouring ditches.

4.14 Regions of high resistance values within the enclosure could indicate the remains of collapsed stone structures though no clear building plans are apparent in the data. Anomaly (D) coincides with a linear in the magnetic data but there is no other correlation between the two data sets.

4.15 Other linear anomalies outside the enclosure coincide with magnetic ditch type responses but no additional anomalies of archaeological interest have been detected.

Resistance Survey - Area AS3(B)

4.16 The southern area investigated the site of a possible castle or tower house recorded in documentary evidence. Although the documentary evidence is non-specific, a 20m x 20m square cropmark has been identified in this hilltop location.

4.17 Two pairs of high and low resistance linear anomalies (E) and (F) are present at right angles to each other. They appear to coincide with magnetic responses that are thought to relate to boundary features.

4.18 In the centre of the survey area is an anomalous region of high and low resistance readings and a series of trends. There is the slight suggestion of a square (G), measuring about 12m x 12m, that shares the alignment of anomalies (E) and (F) and it is remotely possible that this anomaly represents the footprint of a tower house.

4.19 Despite the documentary evidence suggesting that the castle may have been totally removed, it is thought that something more substantial than these barely discernible geophysical anomalies would have survived. An irregular region of high resistance in the southeastern part of the survey area could represent a spread of building debris over the side of the hill. However such remains were visible during a field visit or at the time of the survey and no magnetic response has been recorded. This anomaly is more likely to be natural or topographic in origin. In addition, the remains of such a structure would be expected to leave a spread of magnetic debris but no significant anomalies have been recorded.

4.20 When the OS maps are studied it becomes apparent that there is a group of trees at this location that have been planted as part of the formal arrangement of a park. This implies that the anomaly and the cropmark indicate the remains of a small, enclosed plantation of trees.

4.21 Anomaly (H) lies at the centre of the survey area and represents a slightly curving linear feature that is visible as both high and low resistance elements. This feature could be of archaeological interest, though there is no corresponding magnetic anomaly. There is the possibility that a collapsed souterrain is present, though this is highly speculative. It is thought more likely to represent something that is natural in origin, possibly a fissure in the underlying bedrock.

Gradiometer Survey - Area AR4(1) & Area AR4(2)

4.22 In the east the data are dominated by widespread and strong ferrous disturbance. Some of this interference is due to the course of a boundary and/or drain shown on OS maps but no longer visible on the ground. Modern building debris, iron and cabling are present and this part of the site is overgrown. A linear response (13) lies on the edge of the disturbed area but the interpretation of this anomaly is tentative.

4.23 In the centre of the survey area the level of magnetic response is generally low, though there are some linear trends that are thought to be due to ploughing and drainage features. There are some slight trends but the archaeological potential of these is low.

4.24 There is a marked increase in the level of magnetic response to the west of a linear anomaly (14) running approximate north-south that probably relates to a former boundary, though none are shown on the OS map. The increase in response also coincides with a rise in topography but probably is associated with different land uses either side of the postulated boundary.

4.25 A group of broad anomalies (15) have been detected in the northwestern part of the survey area. It is possible that they represent part of a settlement complex that lies to the north of the road line. There is no clear pattern and it is possible that these responses represent natural soil variations. The area is low lying and could contain palaeochannels.

4.26 In addition, a number of linear responses and trends and pit type responses have been identified in the western part of the survey area but the archaeological significance of these is uncertain. Again, natural soil variations and magnetic cobbles or boulders could account for the pit anomalies, while the linears may have been produced by agricultural/building disturbance.

5. Conclusions

5.1 A complex of archaeological remains that include a ring fort, other possible settlement enclosures and field systems has been recorded at AS3 that can be seen to extend throughout the survey area. The features are extensive and the results suggest that remains of more than one phase of occupation are likely to be present. There is strong evidence in the results to suggest that significant plough damage has occurred; their hilltop location makes them particularly vulnerable. There are no convincing indications in either the magnetic or resistance data that would suggest that the remains of a tower house or castle have survived.

5.2 Survey at AR4 shows variations in magnetic responses that are thought to be due to a combination of agricultural activity, building debris and localised changes in the soils and geology. Several responses of archaeological interest have been encountered that may be part of a settlement complex that lies to the north of the proposed road line. However, no clear pattern is evident in the data that would support this interpretation.

Project Co-ordinator: D Shiel
Project Assistants: B Urmston

Date of Survey: 29th September to 5th October 2004
Date of Report: 22nd October 2004

References

GSB 2003 Report on the Geophysical Survey at *Carlow Relief Road. Report No. 03/102* GSB Prospection 2001. Unpublished report.

GSB 2004 Report on the Geophysical Survey at *Carlow Relief Road. Report No. 04/52*. GSB Prospection 2001. Unpublished report.

SITE SUMMARY SHEET

2004 / 70 Carlow Relief Road

NGR: AS3: 274950 176990
AR4: 272609 174787

Location, topography and geology

Site AS3 lies approximately 2km from the centre of Carlow, Co. Carlow, immediately to the south of the R726, in the townland of Chaplestown. Site AR4 lies in the townland of Quinagh, to the south of a minor road that runs east from the N9 road, south of Carlow and the River Barrow. AS3 occupies undulating arable land while AR4 is in a low-lying area under pasture. The geology comprises limestone that is overlain by varying depths of fluvial-glacial drift. Additionally, there are igneous boulders and cobbles contained within the soils. Some areas are subject to seasonal waterlogging.

Archaeology

At AS3 a circular cropmark with an estimated diameter of 50m has been identified that is thought to indicate the remains of a ring fort. At approximately 140m to the south a square cropmark of 20m x 20m has been observed on aerial photographs. A map of 1656 shows Cargan Castle and some houses in the vicinity but their precise position is not known. No surface indications of either site were visible at the time of a walkover survey. AR4 is low lying land adjacent to a small stream that is a potential location for *fulacht fiadh*. Again, no surface indications of possible archaeology were observed during a site visit.

Aims of Survey

The aims of this survey were to locate and identify the nature and extent of archaeological remains that may be present within areas that might be affected by a proposed road scheme. The work forms part of an archaeological assessment being undertaken by the **National Roads Authority (NRA)** and **Carlow County Council** and was carried out under licence from the **Department of Environment Heritage and Local Government.** This work comprised the third phase of geophysical survey along the route of the Carlow Relief Road (GSB 2003 & GSB 2004).

Summary of Results *

An extensive pattern of settlement enclosures and field systems has been recorded at AS3. The results suggest that remains of more than one phase of occupation have been identified. The are no indications in the data that would suggest that a tower house or castle are present.

Several responses of archaeological interest have been encountered at AR4, though no recognisable archaeological pattern is present in the data. The majority of the anomalies indicate variations in magnetic responses thought to have been produced by agricultural disturbance, modern debris and pedological/geology changes.

*** It is essential that this summary be read in conjunction with the detailed results of the survey.**

List of Figures

Appendix Archive - Technical Information, all techniques

*The following is a description of the equipment and display formats used in **GSB Prospection Ltd (GSB)** reports. It should be emphasised that whilst many display options are regularly used, the diagrams produced in the final reports are the most suitable to illustrate the data from each site. The choice of diagrams results from the experience and knowledge of the staff at **GSB.***

All survey reports are prepared and submitted on the understanding that whilst they are based on a thorough survey of the site, no responsibility is accepted for any errors or omissions.

Instrumentation

(a) Fluxgate Gradiometer – Geoscan FM256 and Bartington *Grad*601-2

Both the Geoscan and Bartington instruments comprises two fluxgate sensors mounted vertically apart; the distance between the sensors on the former is 500mm, while the latter maintains a distance of 1000mm. The gradiometers are carried by hand, with the bottom sensor approximately 100-300mm from the ground surface. At each survey station, the difference in the magnetic field between the two fluxgates is measured in nanoTesla (nT). The fluxgate gradiometer suppresses any diurnal or regional effects. Generally features up to one metre deep may be detected by this method. Readings are logged at 0.25m intervals along traverses 1.0m apart, unless stated otherwise in the report. Having two gradiometer units mounted laterally with a separation of 1000mm, the Bartington instrument can collect two lines of data per traverse.

The magnetic data have been pre-processed by removing baseline shifts due to zig-zag data collection. Where appropriate, traverses have been corrected for minor misalignments; these are due to variations in walking speed, which are usually a result of ground conditions or topography. Unless stated in the report it should be assumed that no filtering has been undertaken on the datasets collected in this project. In some greyscale images the data have been interpolated, which reduces pixelation in the visualisation.

(b) Resistance Meter - Geoscan RM15

This technique measures the electrical resistance of the earth, using a system of four electrodes (two current and two potential.) Depending on the arrangement of these electrodes an exact measurement of a specific volume of earth may be acquired; in this project the 'Twin-Probe' was used. The Twin Probe arrangement involves the paring of electrodes (one current and one potential) with one pair remaining in a fixed position, whilst the other measures the resistance variations across a grid. The latter pair is often termed 'mobile', while the fixed are called 'remote' or 'stationary'. The resistance is measured in ohms and, when calculated, resistivity is in ohm-metres. The resistance method as used for standard area survey employs a probe separation of 0.5m, which samples to a depth of approximately 0.75m. The nature of the overburden and underlying geology will cause variations in this generality. In area survey, readings are logged at 1.0m x 1.0m intervals.

Where necessary the resistance data have been pre-processed to correct for grid-mismatch errors resulting from surveying on different days – this is not a correction due to geological or topographical variation between sample areas. De-spiking has been undertaken to reduce minor errors from contact with the ground surface. This is carried out prior to interpolation, which is often employed to reduce pixelation in greyscale visualisation. Filtering is commonly used on resistance data to suppress, for example, a geological background and where used this will be noted on the relevant diagrams.

(c) Ground Penetrating Radar – Sensors & Software Smartcart (250 MHz)

The Ground Penetrating Radar (GPR) method utilises the absorption and reflection of electromagnetic waves at contrasting interfaces. The transmitter induces electromagnetic pulses into the ground and reflection of these pulses occurs when there are abrupt changes in the dielectric properties of the propagating medium. GPR systems record detailed vertical time sections that can provide a wealth of stratigraphic information and clearly define any discontinuities (Conyers and Goodman 1997; Conyers 2004). The primary advantage of GPR is that it can provide an estimation of the depth of a target.

The 'Sensors & Software Noggin Plus Smart Cart' includes an onboard digital video logger (DVL III), an odometer wheel, and battery. It is, therefore, a fully integrated system. The built-in software uses the integrated odometer to provide an accurate distance measurement to the response. The data are recorded in digital format and can be processed to produce depth slice maps, 2D sections or 3D cubes. In this project single traverses were collected and corrected for topographic variation.

The time window of data collection per trace (normally in the order of tens of nanoseconds) is user controlled and is displayed on the time axis of the GPR profiles. The time axis denotes the length of time required for a pulse to be emitted from the transmitter, travel down to a reflector and back up to the receiver. This is called 'two-way-time'. The GPR traces are plotted side by side in their correct relative lateral positions and the records, called *radargrams*, are displayed with their 'two-way-time' axes arranged vertically. The nature of archaeological deposits can present a complicated image when viewed as individual radargrams and it can be difficult to relate associated features from one profile to another.

The complex nature of archaeological deposits can present a complicated image when viewed as individual radargrams and it can be difficult to relate associated features from one profile to another. However, by collecting data along a series of closely spaced parallel traverses, one can combine the data to form a series of *time-slice maps*; horizontal slices through the ground at different time/depth intervals, enabling a 3D image of the survey area to be built up. This type of data collection and processing enables more subtle features, and the relationship between features, to be analysed more easily.

(d) Magnetic Susceptibility

Variations in the magnetic susceptibility of subsoils and topsoils occur naturally, but greater enhanced susceptibility can also be a product of increased human/anthropogenic activity. This phenomenon of susceptibility enhancement can therefore be used to provide information about the "level of archaeological activity" associated with a site. It can also be used in a predictive manner to ascertain the suitability of a site for a magnetic survey. Sampling intervals vary widely but are often within the 5- 20m range. The instrument employed for measuring this phenomenon is either a field coil or a laboratory based susceptibility bridge. The field coil measures the susceptibility of a volume of soil. The laboratory procedure determines the susceptibility of a specific mass of soil. For the latter 50g soil samples are collected in the field. These are then air-dried, ground down and sieved to exclude the coarse earth (>2mm) fraction. Readings are made using an AC-coil and susceptibility bridge, with results being expressed either as SI/kg x 10^{-8} or m^3/kg.

(e) Electrical Imaging - Iris (Syscal)

This resistivity technique is used to provide a vertical section / slice through the ground, particularly to estimate depth to features or to investigate stratigraphic sequences (Aspinall and Crummett 1997). Field procedure involves a straight line of electrodes, 24 in number, spaced at a set interval. The electrodes are connected to a portable computer via a multi-core cable. Software is used to switch between each measurement position and the variation in apparent resistivity in both vertical and horizontal directions is mapped. The data can then be analysed using the RES2DINV inversion program to provide an image that is closer to the real variation in resistivity. This model produces a 'true' depth (Loke and Barker 1995).

For this survey the 'Syscal Junior, IRIS' instrument was used. The electrode spacing was 2m for a total length of 96m (2 strings of 24 electrodes). The system has an internal 100W power source; the output voltage is automatically adjusted. Standard electrode arrays can be selected with the option to customise the array and define the depth, dependent on the length of the string. Resistivity accuracy is given at 0.5% typical; Induced Polarisation is 1% of the measured value for input voltage higher than 10 mV.

For both sites the survey line was based on the previous magnetometer and resistance survey. Once the electrodes were in position each array was selected and the data was collected before the electrodes were moved and the process repeated. For continuity the electrodes were overlapped hence the total line length for Area 3 was 186m (-10m to 176m) and 182 m (0m-182m) for Area 4.

The manufacturer's software (Electre II) was used to pre-define the electrode array. Tests were carried out using standard arrays to establish the best combination. The data were viewed using 'Prosys II' software, and processing was limited to merging files to create a continuous line and filtering out erroneous readings.

(f) Seismic Refraction – Geometrics Geode

The seismic investigation was carried out using a 'Geometrics Geode 24-channel seismic recorder'. High spatial resolution was achieved by using 24 single geophones at 2m spacing with shot spacing at 1 and 11m (i.e. 10m between shot points) from each end of the geophone line. The energy source was a hammer and plate with an automatic trigger system. The plate was struck repeatedly to improve the detection of the arrivals by 'stacking' which increases the signal-to-noise ratio.

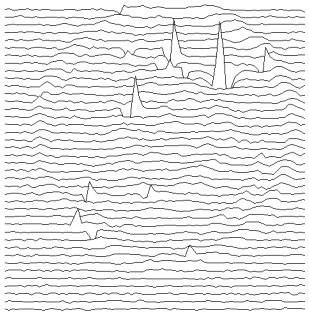
Energy from the source propagates through the ground and is refracted at interfaces, resulting in the ray running along the boundary, whilst sending rays (*headwaves*) back to the surface. Subsurface features manifest themselves as variations in the time difference between source-shot and the arrival of the headwaves, recorded along the line of geophones. The technique is particularly useful when the stratigraphic changes are close to horizontal (Mussett and Khan 2000).

Data collection was conducted via a laptop supporting software provided by the manufacturer. Detailed notes were made of the geophone and shot positions for each profile. Two seismograms were recorded for each shot point to assess the consistency of results, and thus give an indication of the data quality.

Processing initially involves picking headwave *first arrival* times at the geophones which was achieved using 'Interpex IXSeg2SegY' software. Mathematical and graphical analyses (Goulty et al 1990, Milsom 2003) allow for calculation of the seismic wave velocity and thus correction of the obvious time difference induced by an increasing offset between shot point and geophone along the survey line. This allows the depth to a subsurface feature below each geophone to be calculated and plotted against distance, with a topographic correction if necessary. This final analysis can be done in any spreadsheet program, in this case Microsoft Excel.

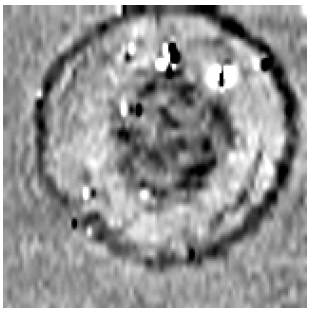
Display Options

The following is a description of the display options used. Unless specifically mentioned in the text, it may be assumed that no filtering or smoothing has been used to enhance the data. For any particular report a limited number of display modes may be used. See Gaffney and Gater 2003 for more details on display options.



(a) XY Plot

This involves a line representation of the data. Each successive row of data is equally incremented in the Y axis, to produce a stacked profile effect. This display may incorporate a hidden-line removal algorithm, which blocks out lines behind the major peaks and can aid interpretation. The advantages of this type of display are that it allows the full range of the data to be viewed and shows the shape of the individual anomalies. The display may also be changed by altering the horizontal viewing angle and the angle above the plane. The output may be either colour or black and white.

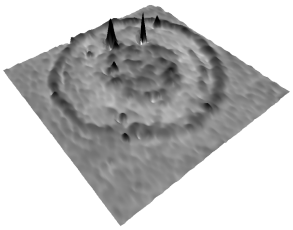


(b) Greyscale

This format divides a given range of readings into a set number of classes. These classes have a predefined arrangement of dots or shade of grey, the intensity increasing with value. This gives an appearance of a toned or grey-scale. 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. While colour plots can look impressive and can be used to highlight certain anomalies, greyscales tend to be more informative.

(c) Relief Plot

Relief Plots / Shaded Relief Maps use colors or greys to map the surface relative to a user-defined light source. The analogy of the sun illuminating a topographic surface is a good way to envisage this form of display. Those parts of the surface that are in the shadow of the light source are darker than those in full view. The display can be varied by changing the height and direction of the light source. In this way, broad changes in the data can be reduced, and subtle changes enhanced.



(d) 3D Surface Plot

All detailed survey data can be used to create 3D plots which involve the creation of a smoothed surface from the original data. The height of the surface corresponds to value of the data and the surface variation can also be enhanced via a colour or greyscale.

Terms commonly used in the graphical interpretation of gradiometer data

Ditch / Pit
This category is used only when other evidence is available that supports a clear archaeological interpretation e.g. cropmarks or excavation.

Archaeology
This term is used when the form, nature and pattern of the response are clearly or very probably archaeological but where no supporting evidence exists. These anomalies, whilst considered anthropogenic, could be of any age. If a more precise archaeological interpretation is possible then it will be indicated in the accompanying text.

? Archaeology
The interpretation of such anomalies is often tentative, with the anomalies exhibiting either weak signal strength or forming incomplete archaeological patterns. They may be the result of variable soil depth, plough damage or even aliasing as a result of data collection orientation.

Areas of Increased Magnetic Response
These responses show no visual indications on the ground surface and are considered to have some archaeological potential.

Industrial
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.

Natural
These responses form clear patterns in geographical zones where natural variations are known to produce significant magnetic distortions e.g. palaeochannels or magnetic gravels.

? Natural
These are anomalies that are likely to be natural in origin i.e geological or pedological.

Ridge and Furrow
These are regular and broad linear anomalies that are presumed to be the result of ancient cultivation. In some cases the response may be the result of modern activity.

Ploughing Trend
These are isolated or grouped linear responses. They are normally narrow and are presumed modern when aligned to current field boundaries or following present ploughing.

Trend
This is usually an ill-defined, weak, isolated or obscured linear anomaly of unknown cause or date.

Areas of Magnetic Disturbance
These responses are commonly found in places where modern ferrous or fired materials are present e.g. brick rubble. They are presumed to be modern.

Ferrous Response
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.

NB This is by no means an exhaustive list and other categories may be used as necessary.

Terms commonly used in the graphical interpretation of GPR data

HIGH AMPLITUDE ANOMALIES:

Wall / Foundation / Vault / Culvert etc.
This definitive categorisation is used only when other evidence is available that supports a clear archaeological interpretation e.g. aerial photographs, documentary sources or excavation.

Archaeology
This relates to anomalies whose form, nature and pattern are clearly, or very probably, archaeological but where little or no supporting evidence exists. These anomalies, whilst considered anthropogenic, could be of any age. If a more precise archaeological interpretation is possible, for example the responses appear to respect known local archaeology, then this will be indicated in the accompanying text.

? Archaeology
The interpretation of such anomalies is often tentative, with the anomalies exhibiting either little contrast or forming incomplete archaeological patterns. They may be the result of rubble spreads or variations in soil depth.

High Amplitude Response
Discrete high amplitude anomalies that cannot be categorised as archaeological and yet may still hold some importance will fall into this category.

Area of Increased Response
A data set may contain areas in which the response levels are very slightly elevated with respect to the 'background'. Where no obvious surface features or documentary evidence can explain this spread of increased reflectivity it is assumed to denote some kind of disturbance, though the origins could be of any age and either anthropogenic or natural.

LOW AMPLITUDE ANOMALIES:

Archaeology
This term is used when the form, nature and pattern of the response is clearly archaeological (i.e. robbed foundations, wet ditches and pits) and usually some form of supporting evidence exists. These anomalies, whilst considered anthropogenic, could however be of any age. As low amplitude responses are less obvious features, in both time-slices and radargrams, it is unlikely that they would ever have a definitive categorisation but if a more precise archaeological interpretation is possible then it will be indicated in the accompanying text.

? Archaeology
This category is used when the attenuation of the signal could be archaeologically significant, given the discrete nature of the anomaly, but where the distribution of the responses is not clearly archaeological.

Low Amplitude Zone
Responses in this category tend to be anomalous zones of weak response rather than discrete anomalies. They may be the effect of ground water 'ponding' where drainage is impaired, perhaps by archaeological or modern deposits. These zones may also relate to variations in the subsurface composition, when it is unlikely to be natural (for example urban environments).

Terms commonly used in the graphical interpretation of GPR data (cont.)

OTHER CATEGORIES:

Natural
Anomalies in this category can be high and/or low amplitude and will relate to natural sub-surface features as indicated by documentary sources, local knowledge or evidence on the surface.

?Natural
These responses (again high and/or low amplitude) form patterns which may be due to subsoil/geological variations either attenuating or reflecting greater amounts of energy. An archaeological origin such as rubble spreads (high amplitude) or robbed out remains (low amplitude) cannot be dismissed.

Trend
This is usually an ill defined, weak or isolated linear anomaly of unknown cause or date and can be a high or low amplitude response.

Historic
These responses show clear correlation with earlier map evidence and may be high or low amplitude or a combination of both.

?Historic
This category indicates responses that may relate to features not directly recorded on earlier maps but which certainly appear to respect features that are. They may form patterns suggestive of formal gardens, landscaping or footpaths for example.

Modern
This category is used for reflections that indicate features such as services, rebar or modern cellars that correlate with available evidence (maps, communications with the client, alignment of drain covers etc.).

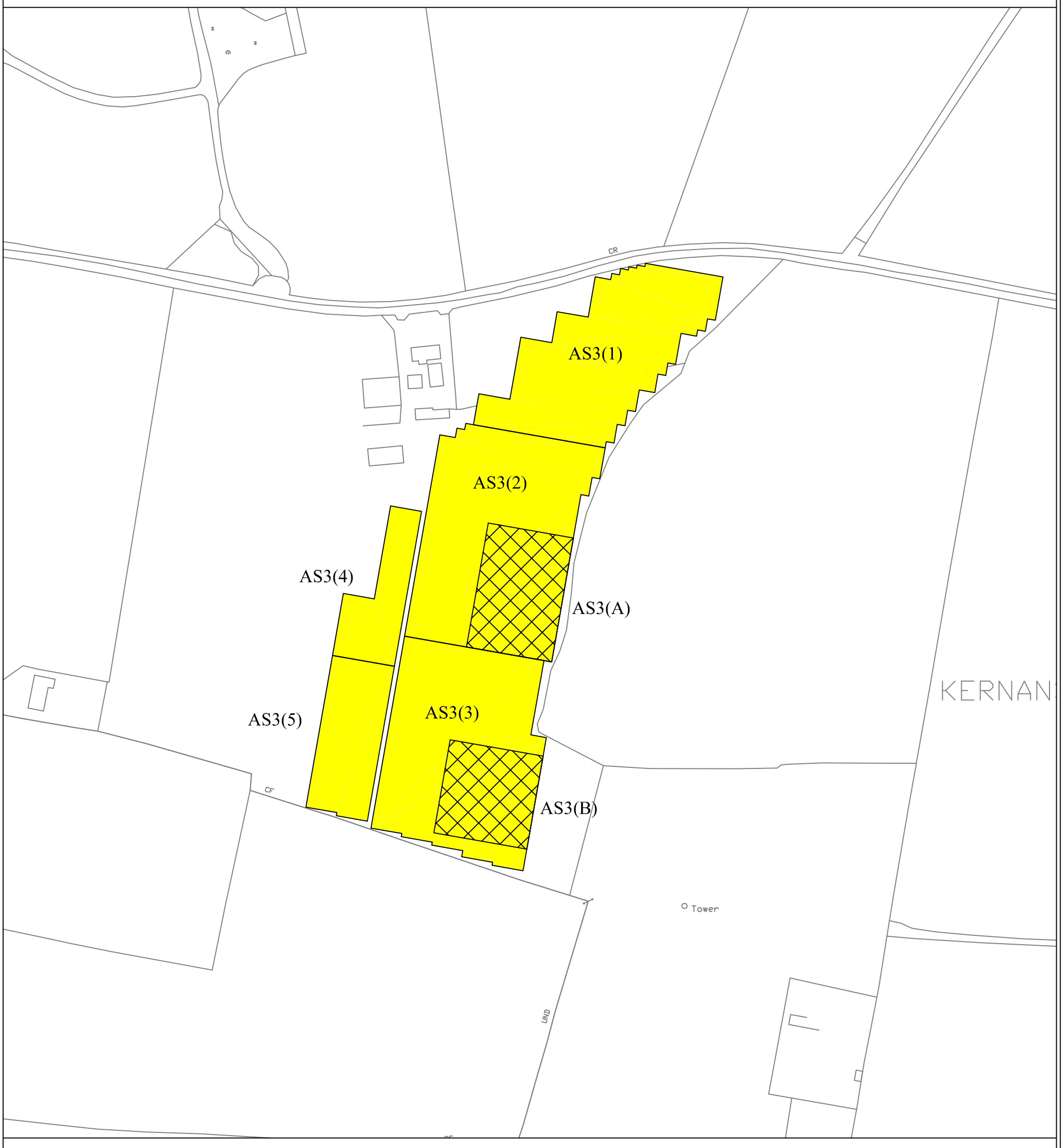
?Modern
This category is used for reflections which appear to indicate buried services but for which there is no supporting evidence. It is also used for responses which form patterns, or are at a depth which suggests a modern origin. However, an archaeological source cannot be dismissed.

Surface
These are responses clearly due to surface discontinuities, the effects of which may be seen to 'ring' down through radargrams and thus also appear in the deeper time-slices.

NB This is by no means an exhaustive list and other categories may be used as necessary.

GSB PROSPECTION Ltd.
PROJECT: 2004/70 Carlow Outer Relief Road
TITLE: Location of Area AS3
Based on a plan provided by the client

0 metres 100



Gradiometer Survey

Resistance Survey

Figure 1

GSB PROSPECTION Ltd.
PROJECT: 2004/70 Carlow Outer Relief Road
TITLE: Location of Area AR4
Based on a plan provided by the client

0 metres 100

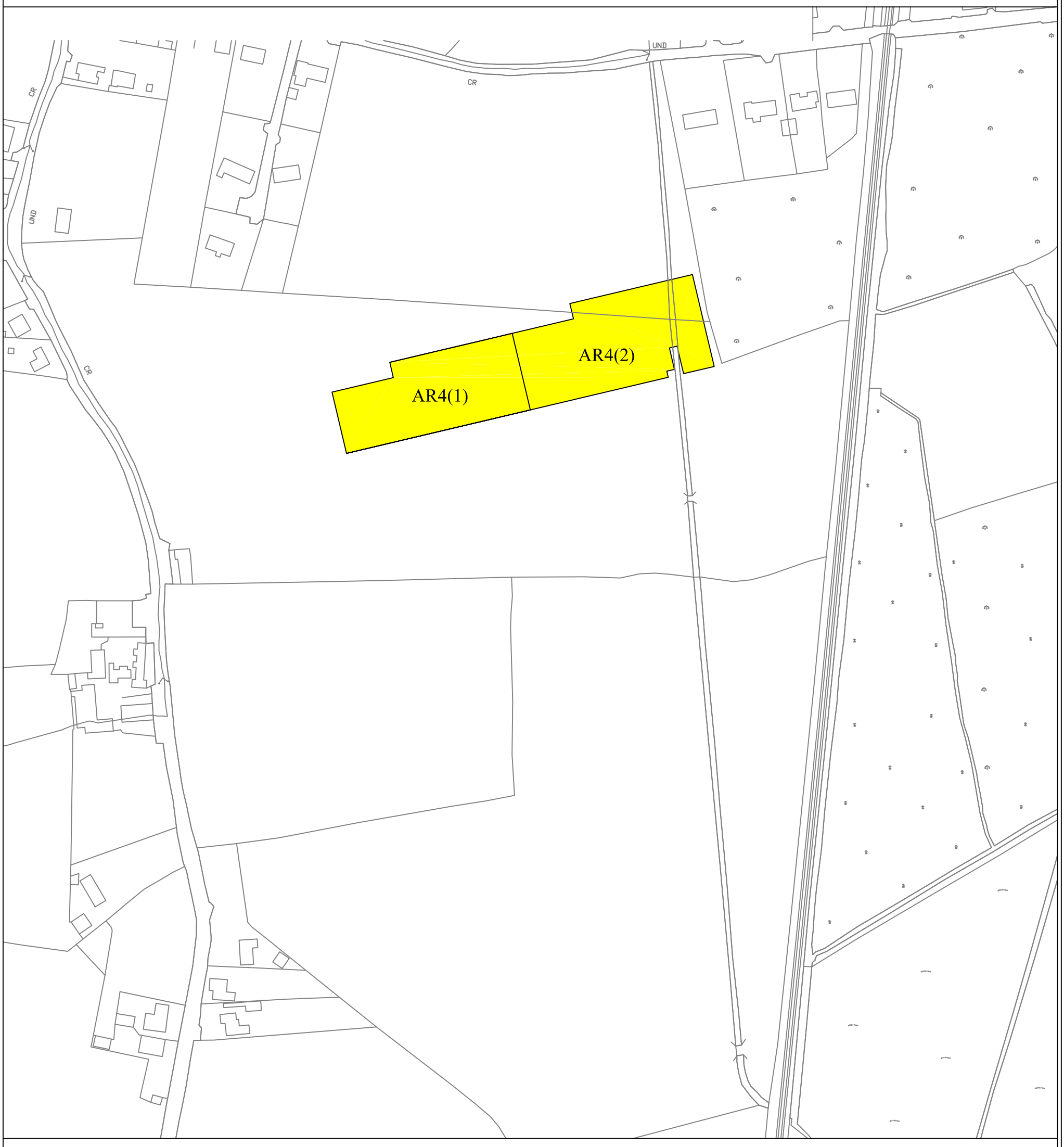


Figure 2

GSB PROSPECTION Ltd.
PROJECT: 2004/70 Carlow Outer Relief Road
TITLE: Summary Greyscales (Gradiometer) - Area AS3
Based on a plan provided by the client

0 metres 60

Figure 3

GSB PROSPECTION Ltd.

PROJECT: 2004/70 Carlow Outer Relief Road

TITLE: Summary Interpretation (Gradiometer) - Area AS3

Based on a plan provided by the client

0 metres 60

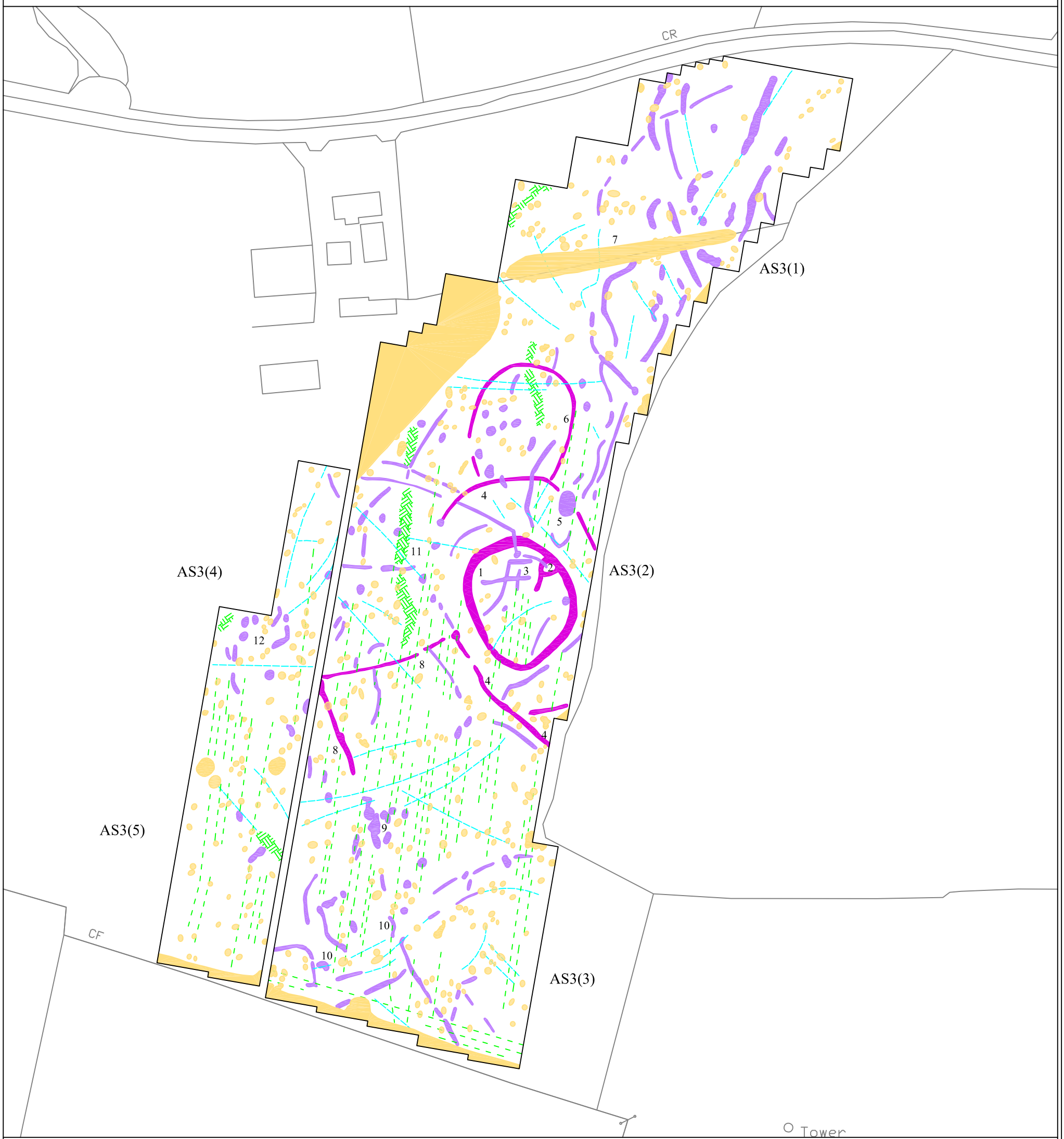
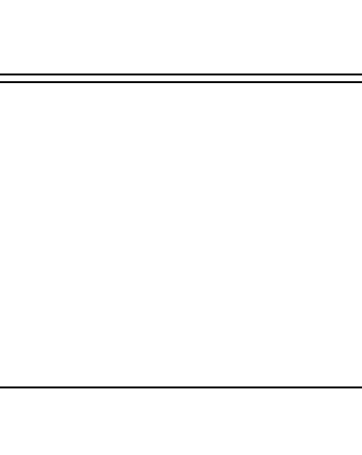


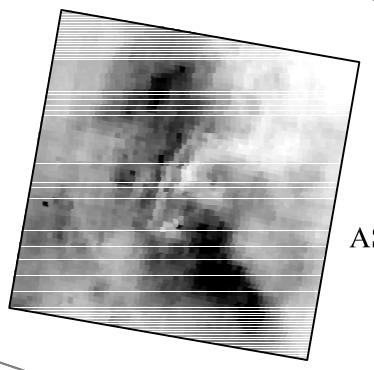
Figure 4

GSB PROSPECTION Ltd.
PROJECT: 2004/70 Carlow Outer Relief Road
TITLE: Summary Greyscales (Resistance) - Area AS3
Based on a plan provided by the client

0 metres 60



AS3(A)



AS3(B)

CF

Tower

120 ohms 60

Area AS3(A)

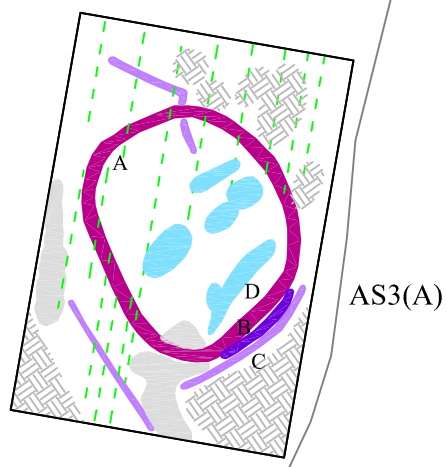
60 ohms 30

Area AS3(B)

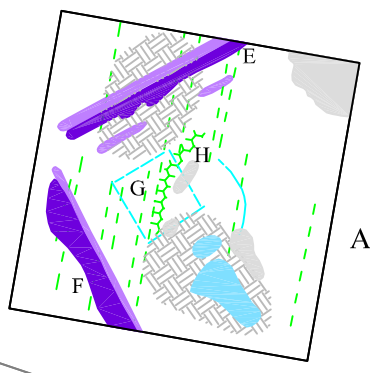
Figure 5

GSB PROSPECTION Ltd.
PROJECT: 2004/70 Carlow Outer Relief Road
TITLE: Summary Interpretation (Resistance) - Area AS3
Based on a plan provided by the client

0 metres 60



AS3(A)



AS3(B)

CF

Tower

ND

Low Resistance

High Resistance

Enclosure Ditch

Ditch

?Natural

?Natural/Geological

Bank/Wall Remains

?Building Debris

?Natural

Trend

Ploughing

Figure 6

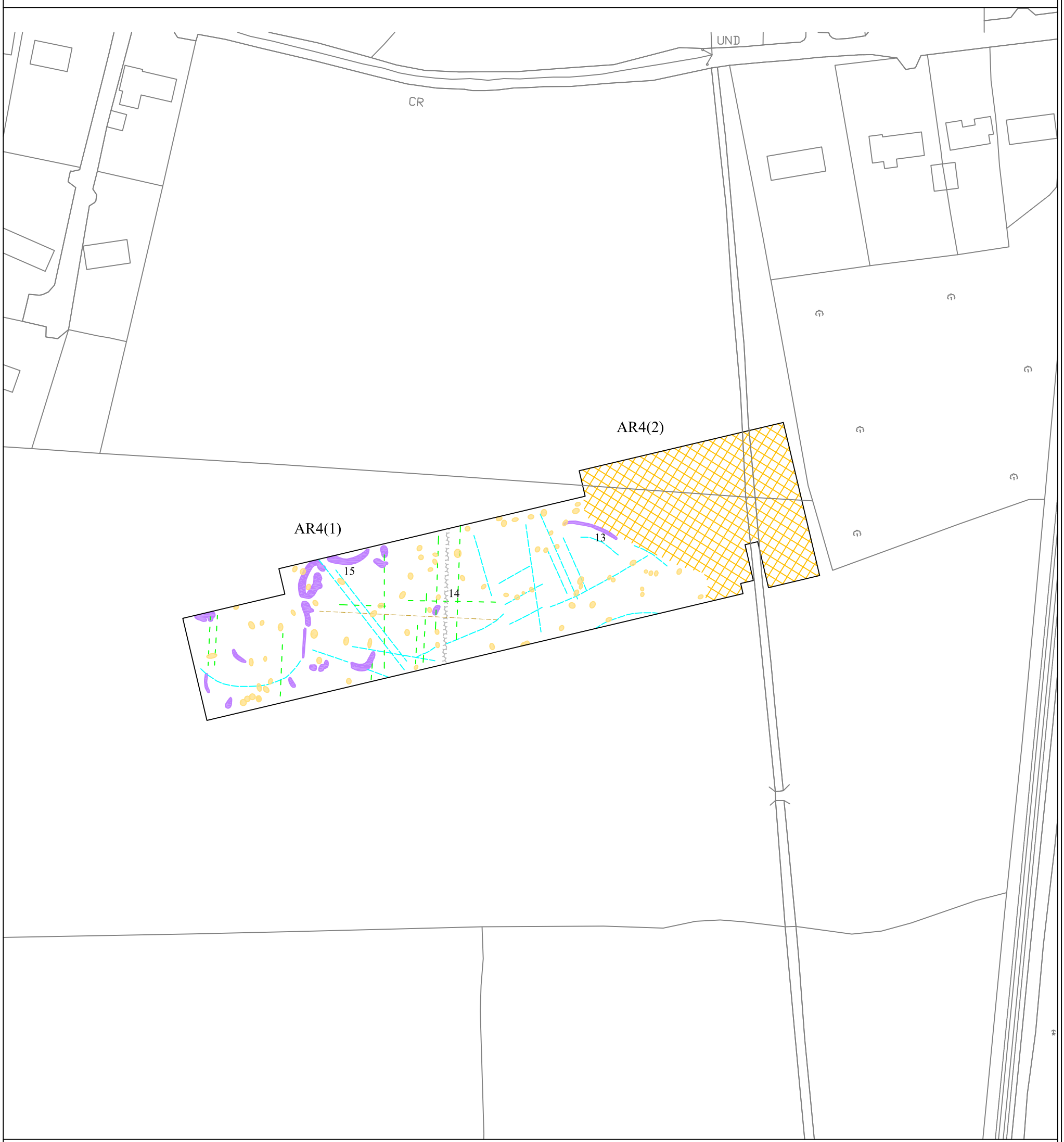
GSB PROSPECTION Ltd.
PROJECT: 2004/70 Carlow Outer Relief Road
TITLE: Summary Greyscales (Gradiometer) - Area AR4
Based on a plan provided by the client

0 metres 60

Figure 7

GSB PROSPECTION Ltd.
PROJECT: 2004/70 Carlow Outer Relief Road
TITLE: Summary Interpretation (Gradiometer) - Area AR4
Based on a plan provided by the client

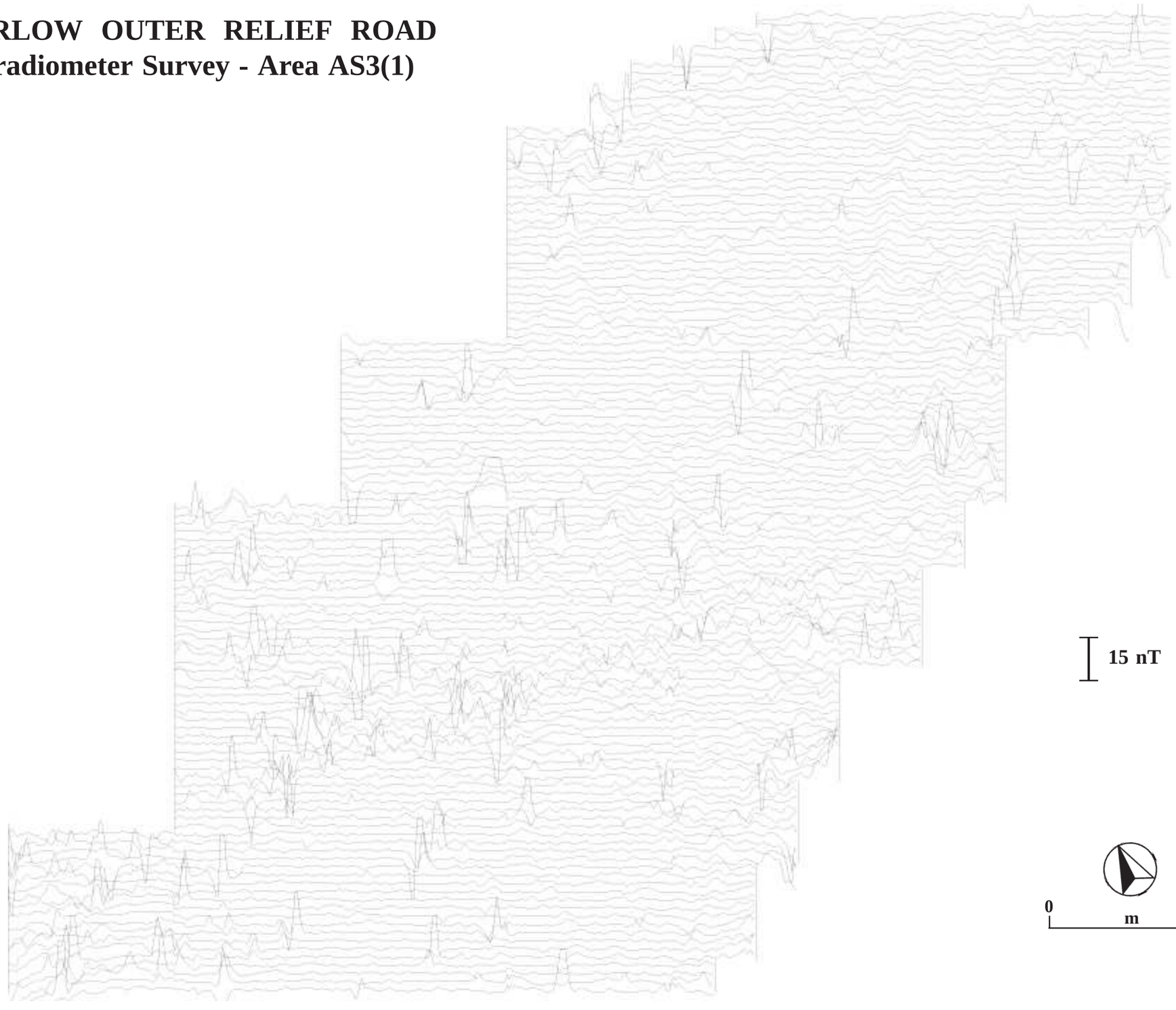
0 metres 60



?Archaeology
?Drain
Trend
Ploughing
Ferrous
Old Field Boundary
Magnetic Disturbance

Figure 8

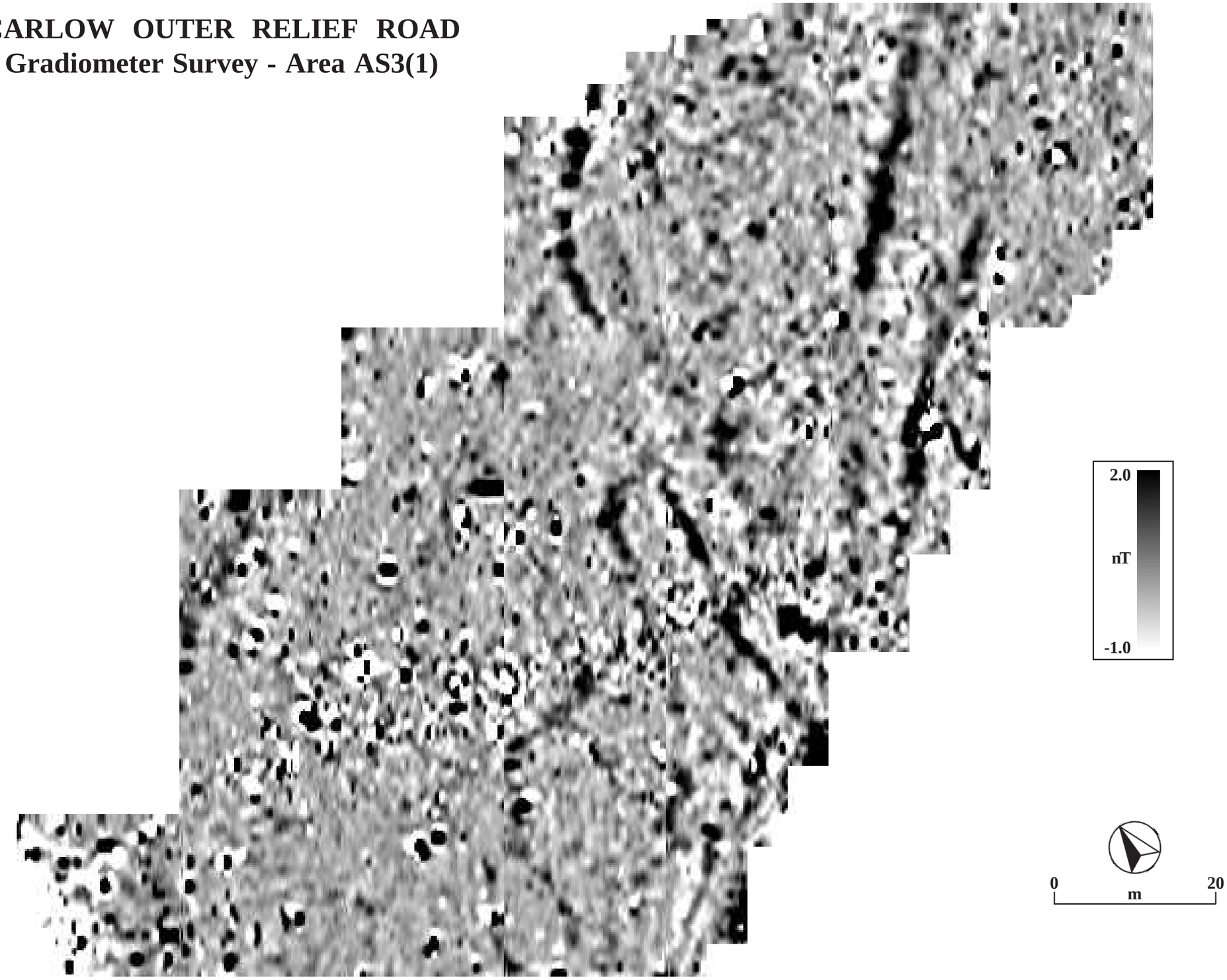
CARLOW OUTER RELIEF ROAD
Gradiometer Survey - Area AS3(1)



GSB Prospection Ltd. 2004/70

Figure 9

CARLOW OUTER RELIEF ROAD
Gradiometer Survey - Area AS3(1)



GSB Prospection Ltd. 2004/70

Figure 10

CARLOW OUTER RELIEF ROAD
Gradiometer Survey - AS3(1)

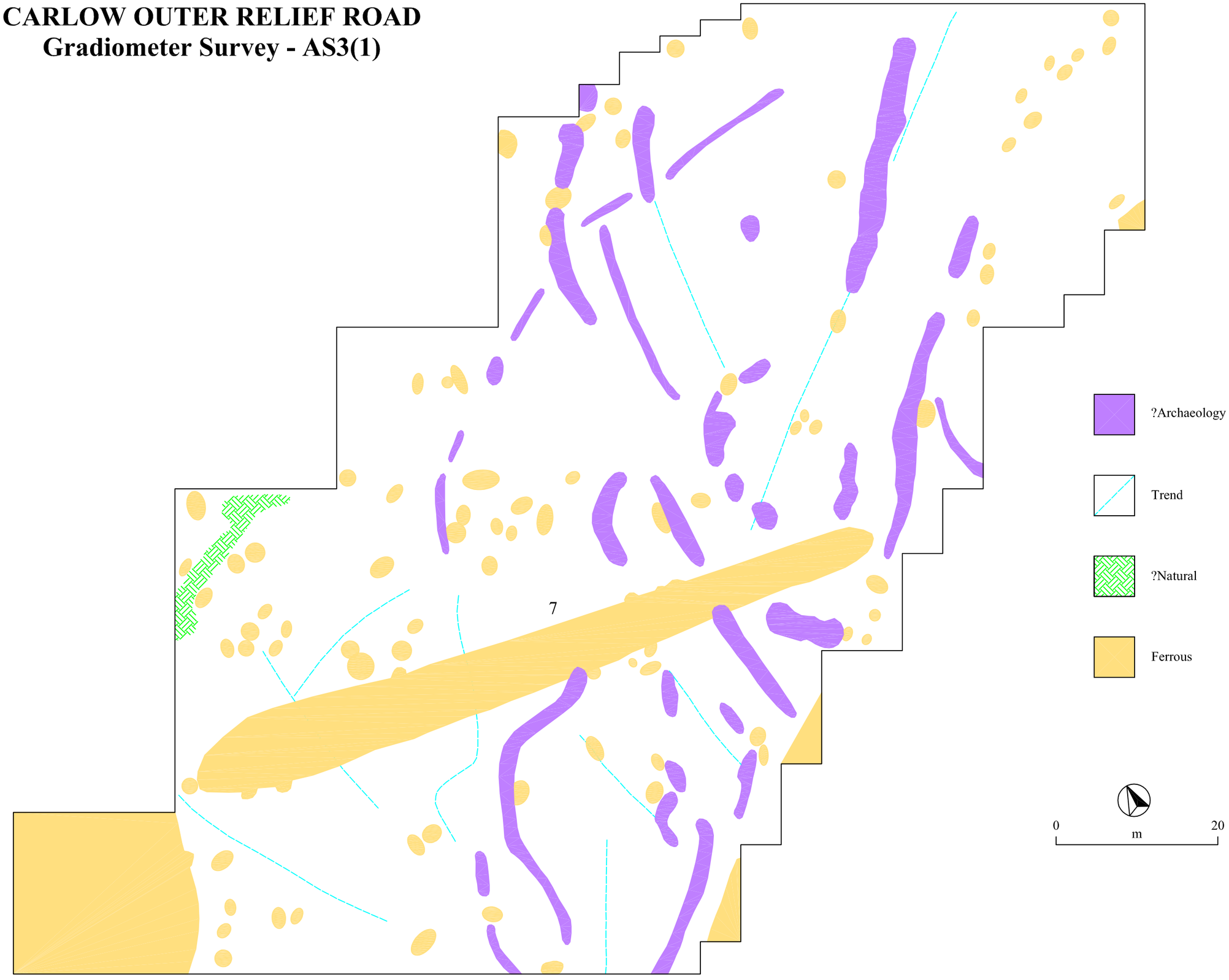


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Figure 11

CARLOW OUTER RELIEF ROAD
Gradiometer Survey - Area AS3(2)

GSB Prospection Ltd. 2004/70

Figure 12

CARLOW OUTER RELIEF ROAD
Gradiometer Survey - Area AS3(2)

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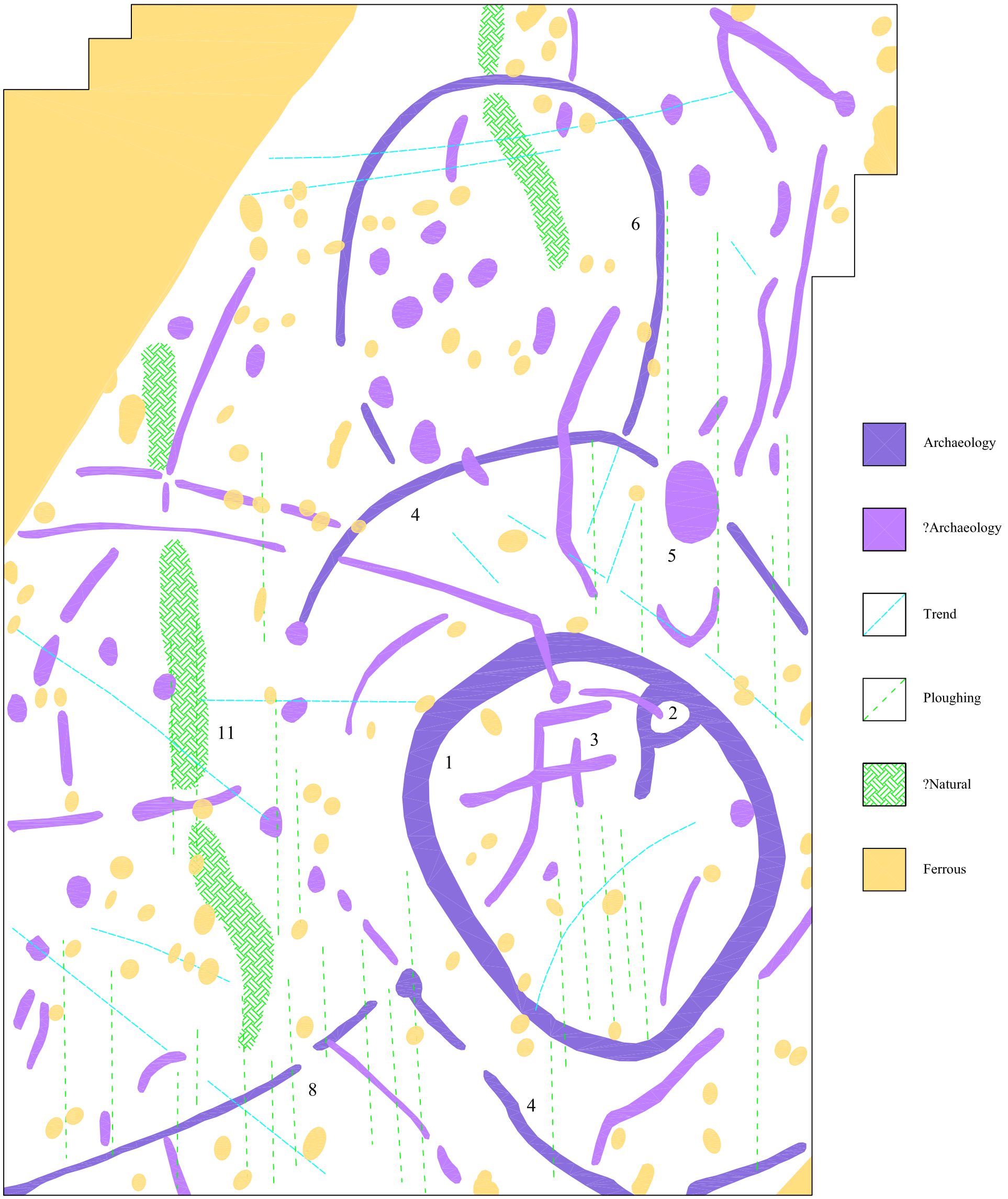
Figure 13

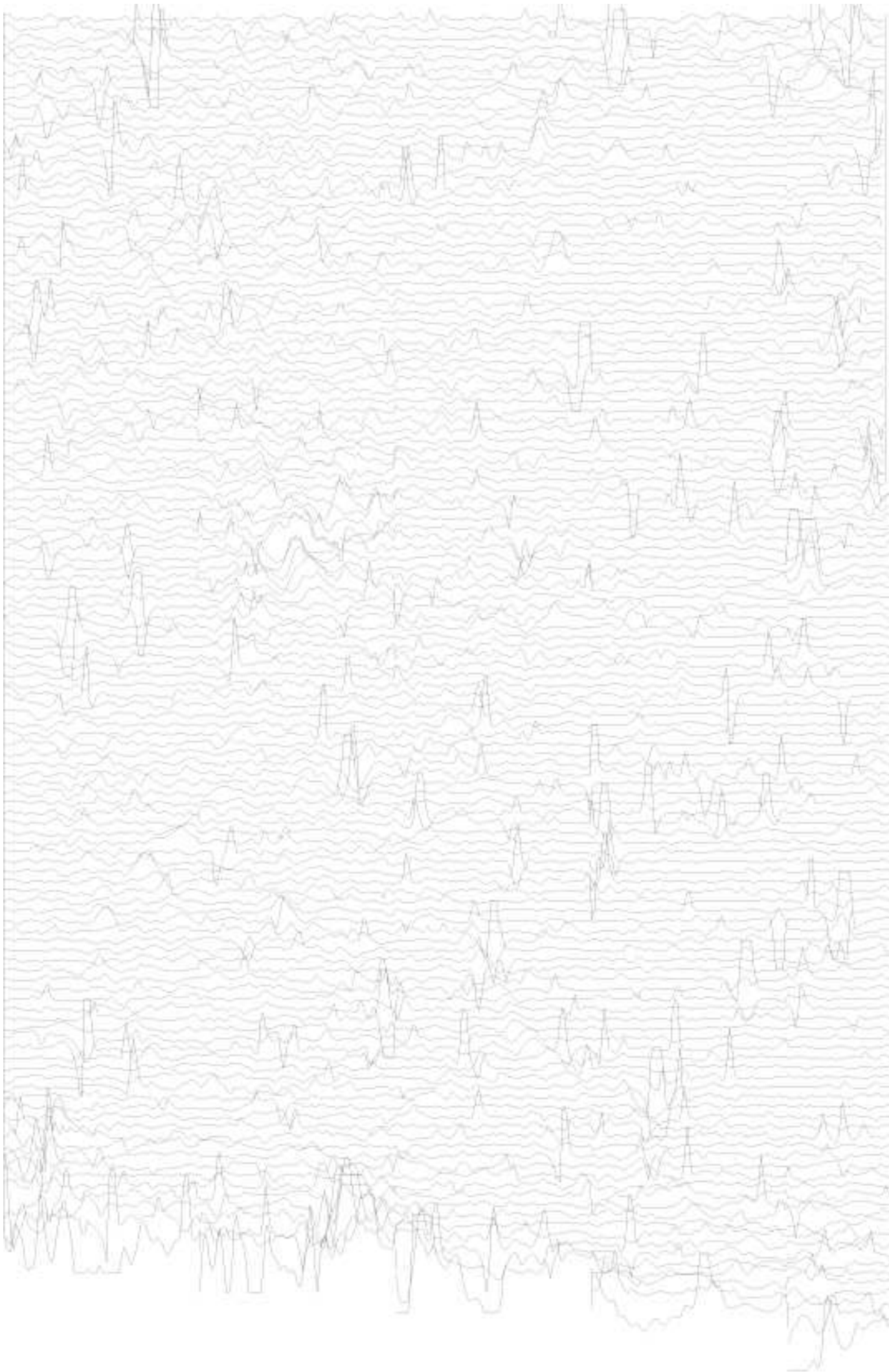
CARLOW OUTER RELIEF ROAD
Gradiometer Survey - AS3(2)



GSB Prospection Ltd. 2004/70

Figure 14

CARLOW OUTER RELIEF ROAD
Gradiometer Survey - Area AS3(3)



GSB Prospection Ltd. 2004/70

Figure 15

CARLOW OUTER RELIEF ROAD
Gradiometer Survey - Area AS3(3)

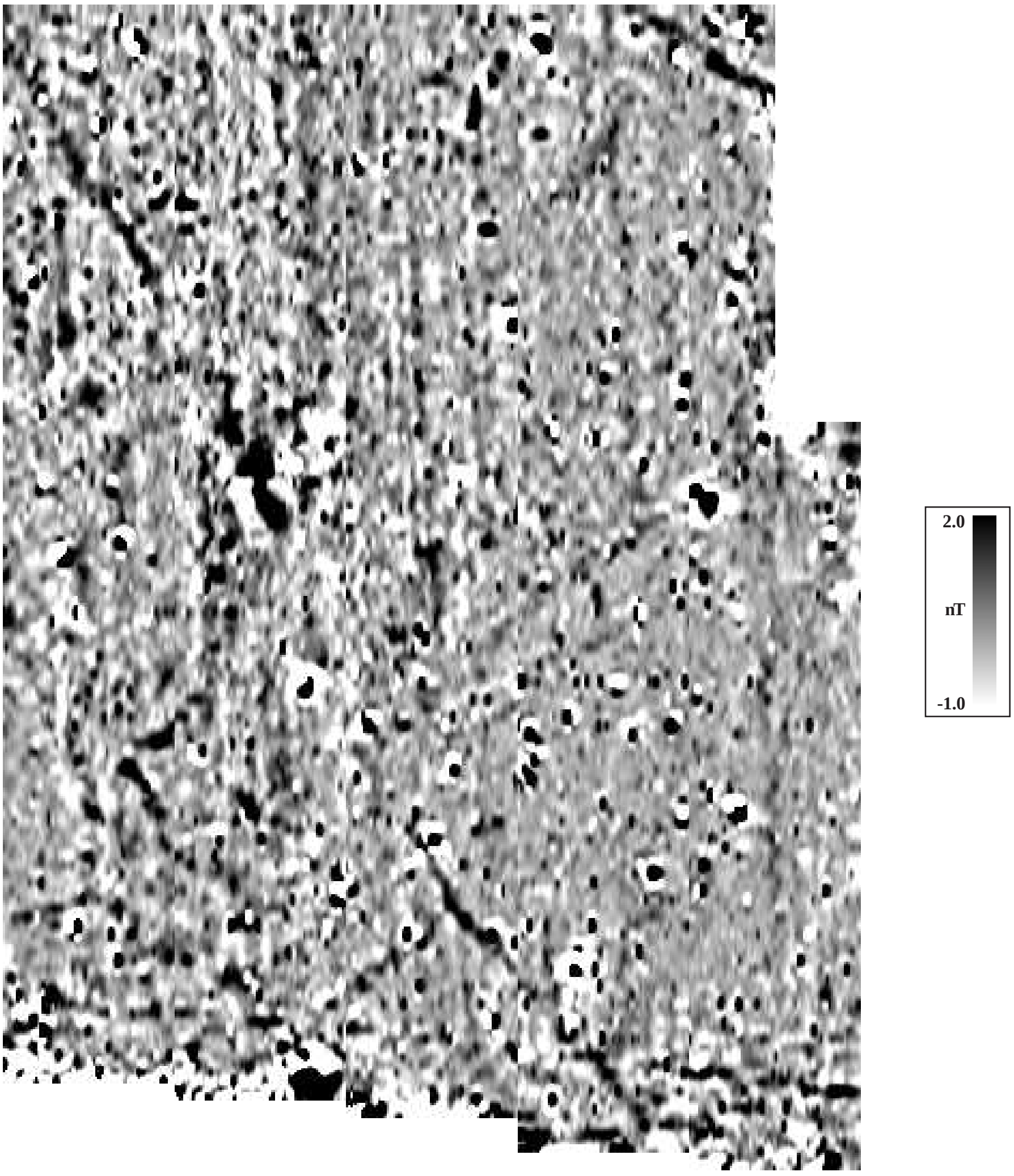


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Figure 16

CARLOW OUTER RELIEF ROAD
Gradiometer Survey - AS3(3)

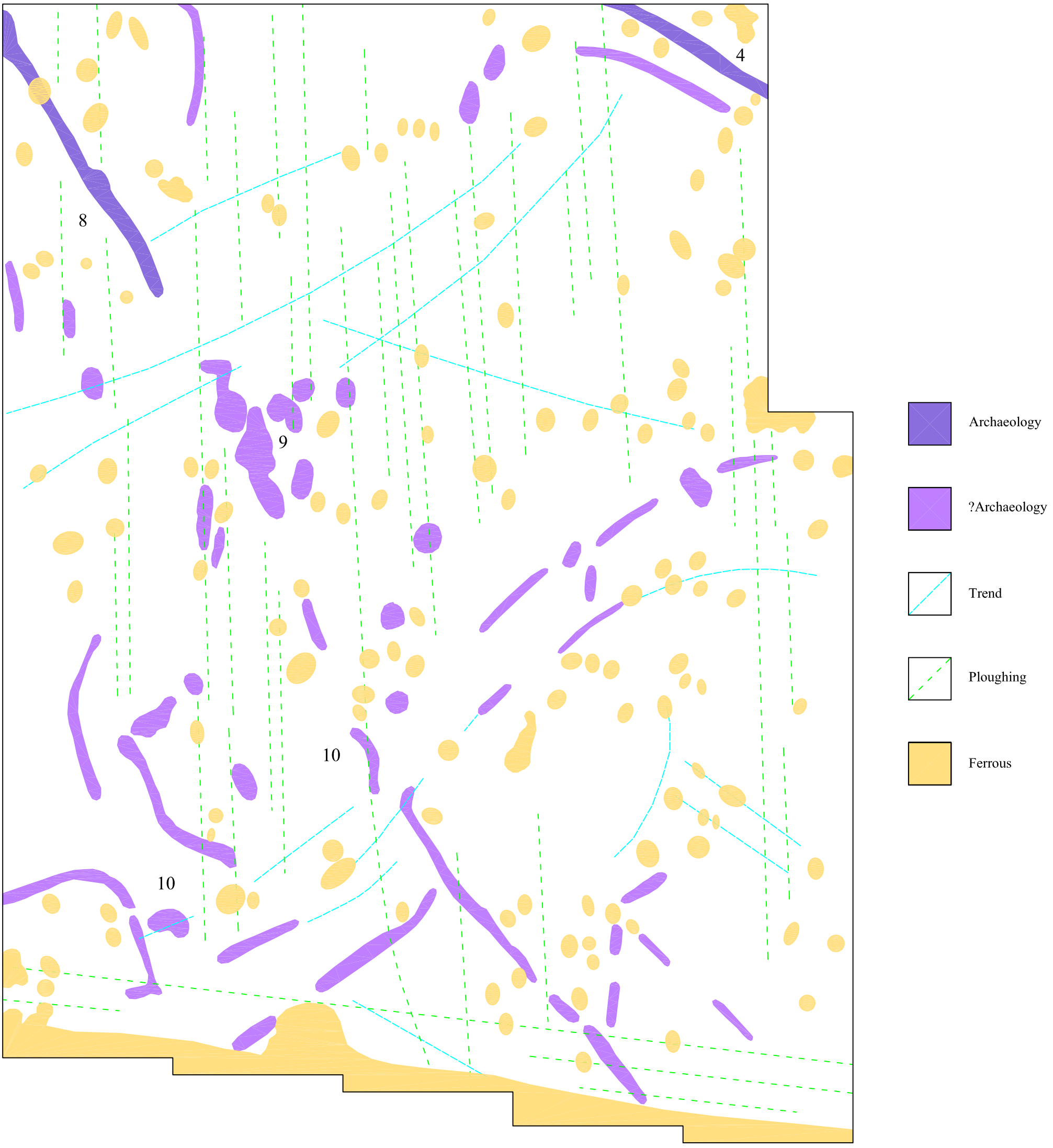

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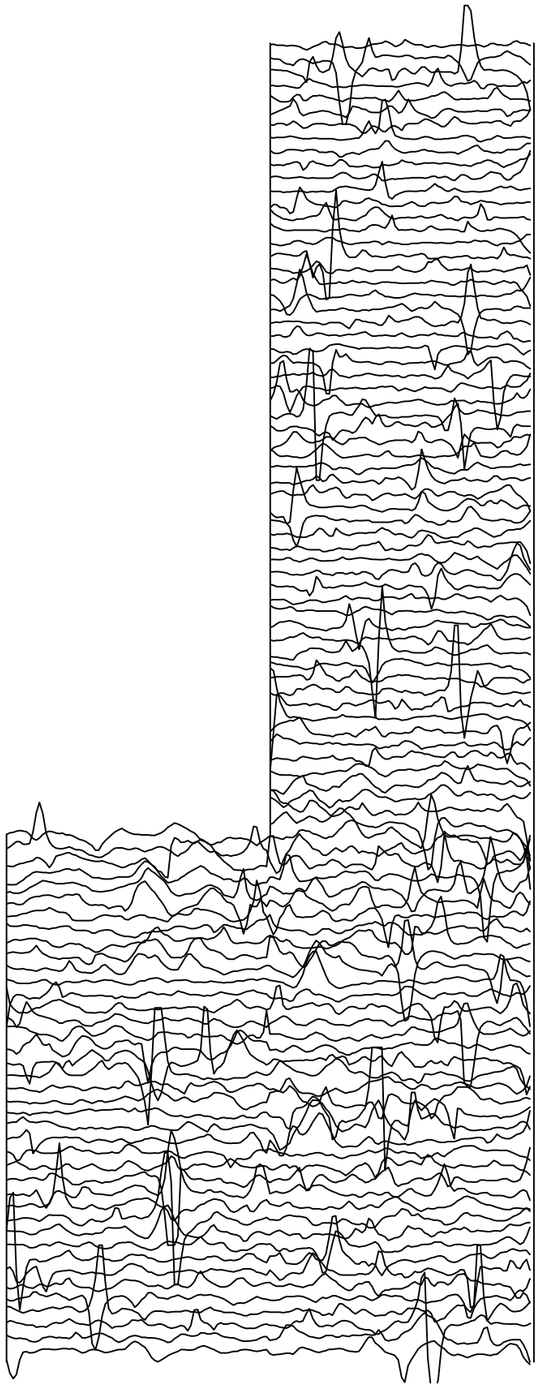
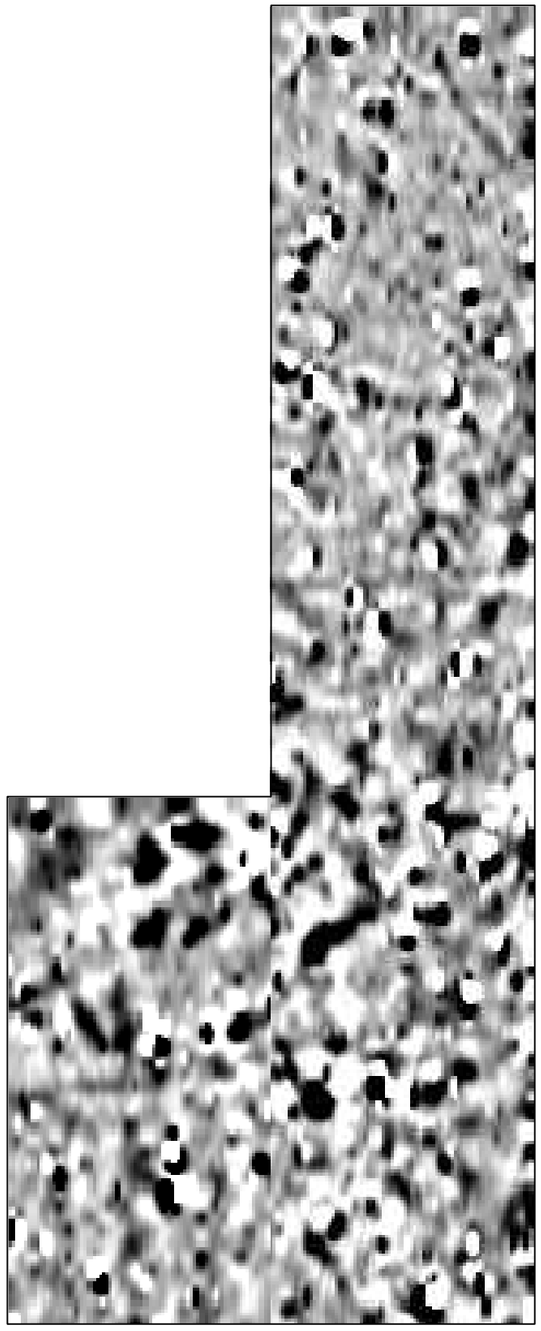
Figure 17

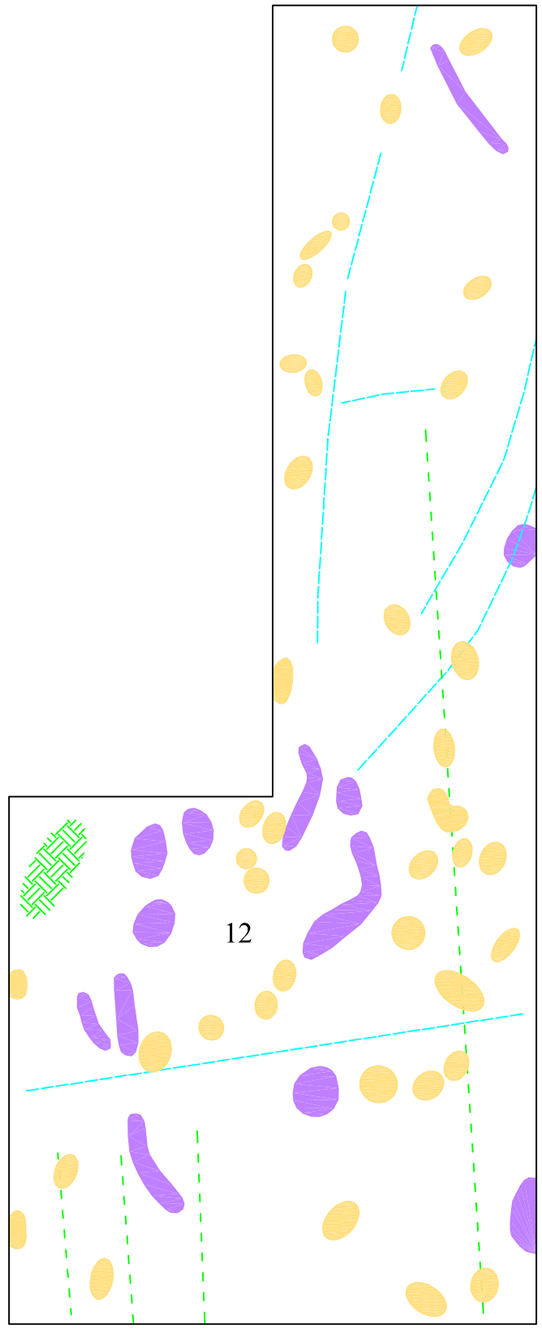
CARLOW RELIEF ROAD
Gradiometer Survey - AS3(4)



15 nT



2
nT
-1



?Archaeology

Trend

Ploughing

?Natural

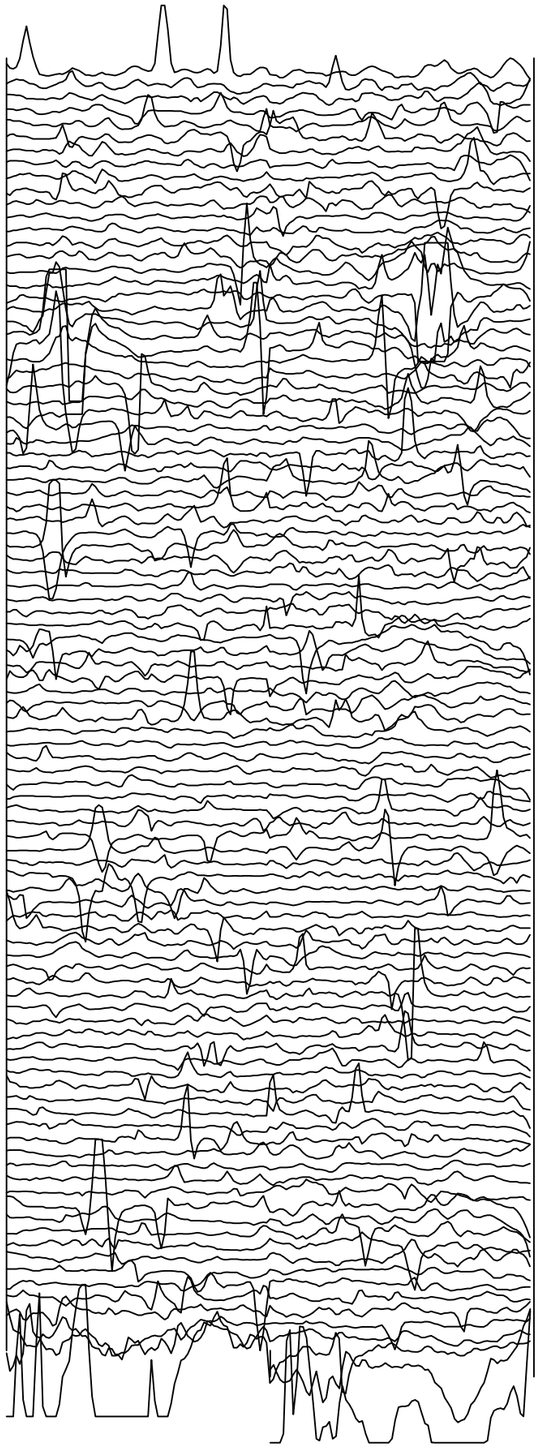
Ferrous

0 m 20

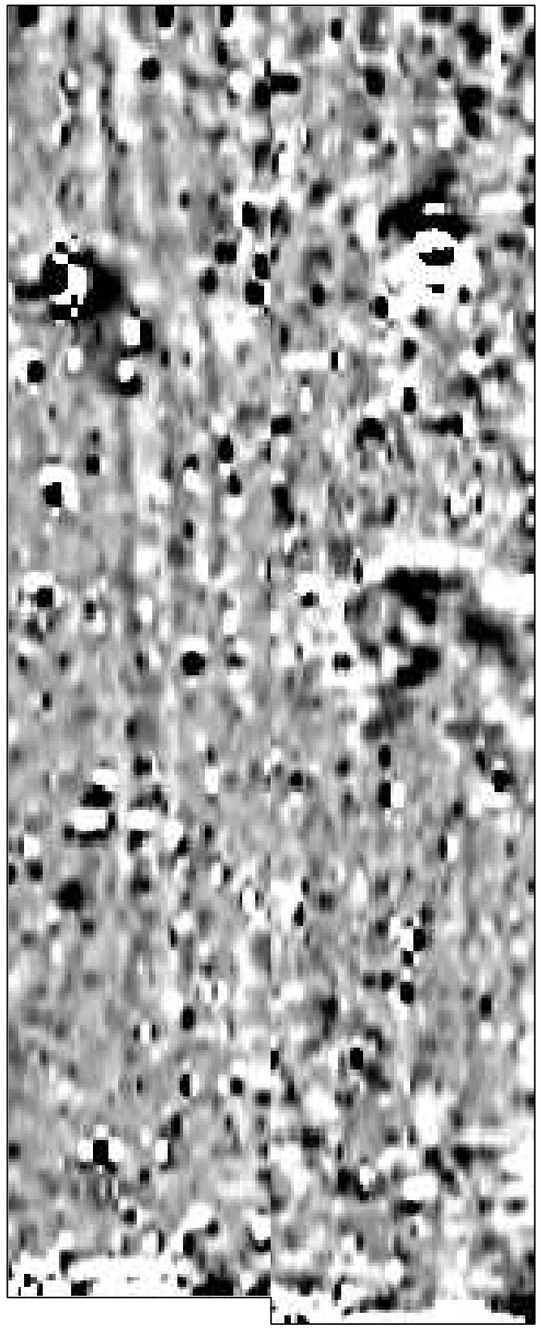
GSB Prospection Ltd. 2004/70

Figure 18

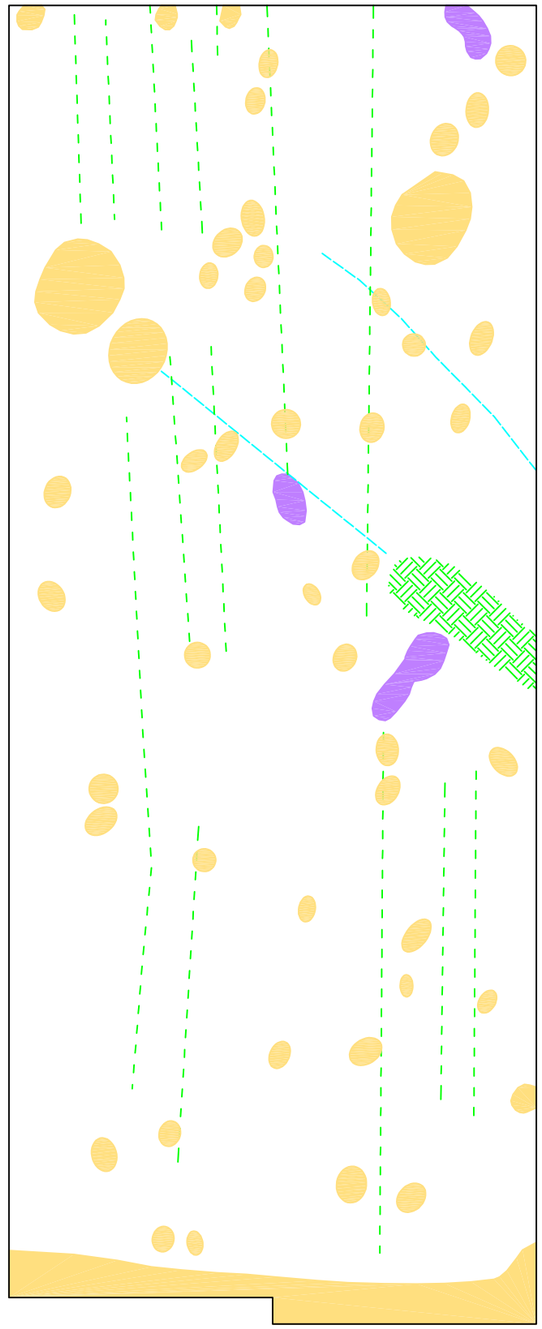
CARLOW RELIEF ROAD
Gradiometer Survey - AS3(5)



15 nT



2
nT
-1



?Archaeology

Trend

Ploughing

?Natural

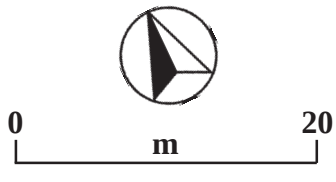
Ferrous

0 m 20

GSB Prospection Ltd. 2004/70

Figure 19

CARLOW RELIEF ROAD
Resistance Survey - Area AS3(A)



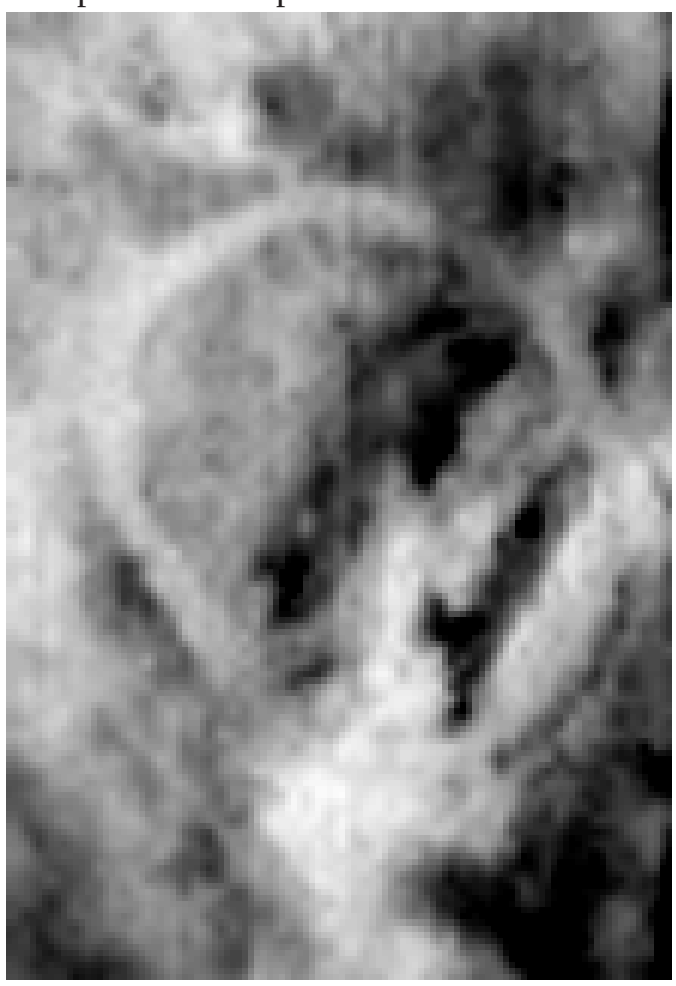
GSB Prospection Ltd. 2004/70

Figure 20

CARLOW RELIEF ROAD
Resistance Survey - Area AS3(A)

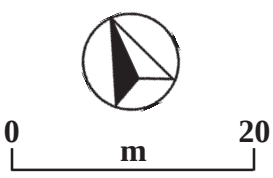
Raw Data

De-spiked & Interpolated Data



Relief Plot

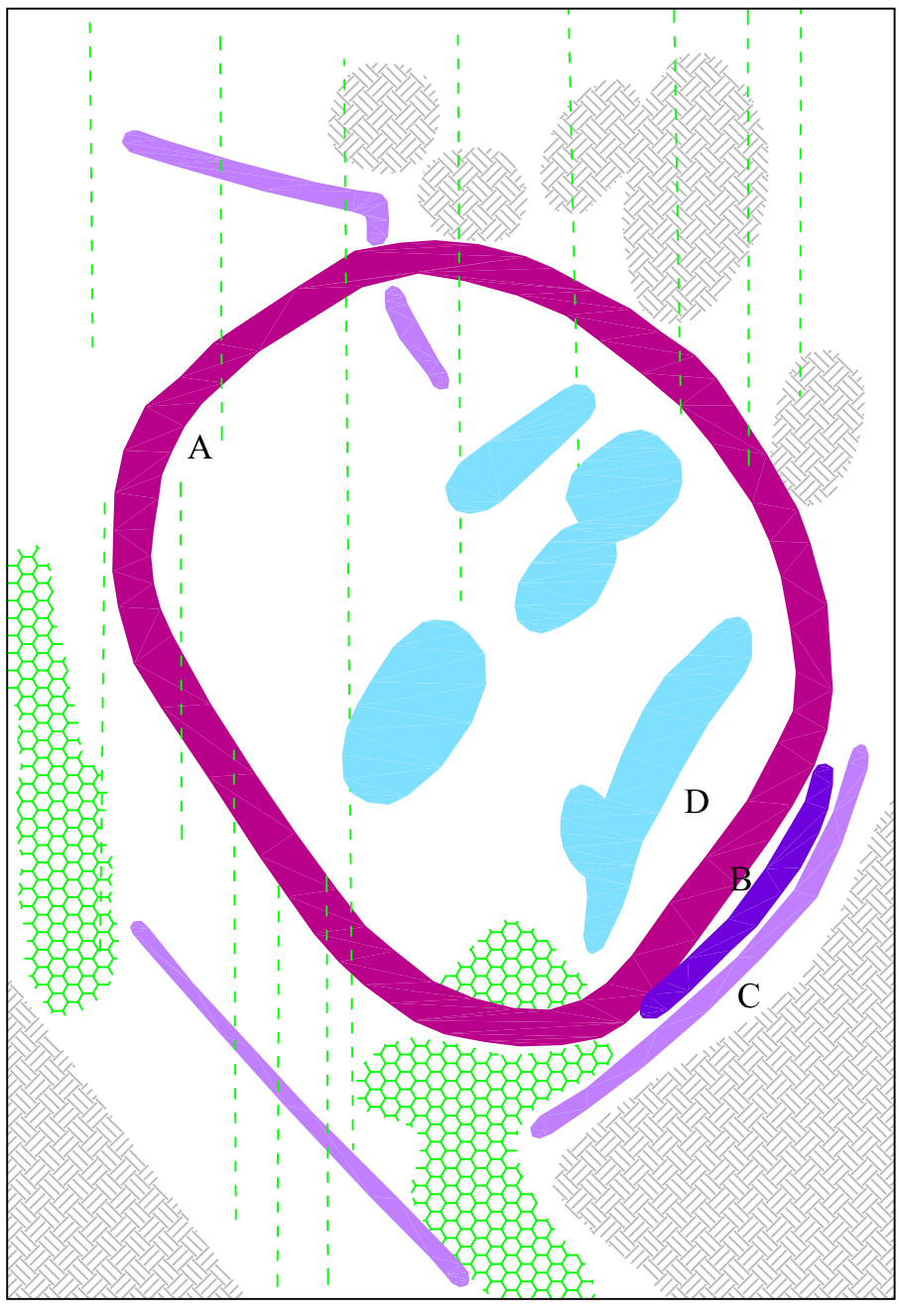
High Pass Filtered Data



GSB Prospection Ltd. 2004/70

Figure 21

CARLOW RELIEF ROAD
Resistance Survey - Area AS3(A)



Low Resistance

Enclosure Ditch

Ditch

?Natural

High Resistance

Bank/Wall Remains

?Building Debris

?Natural

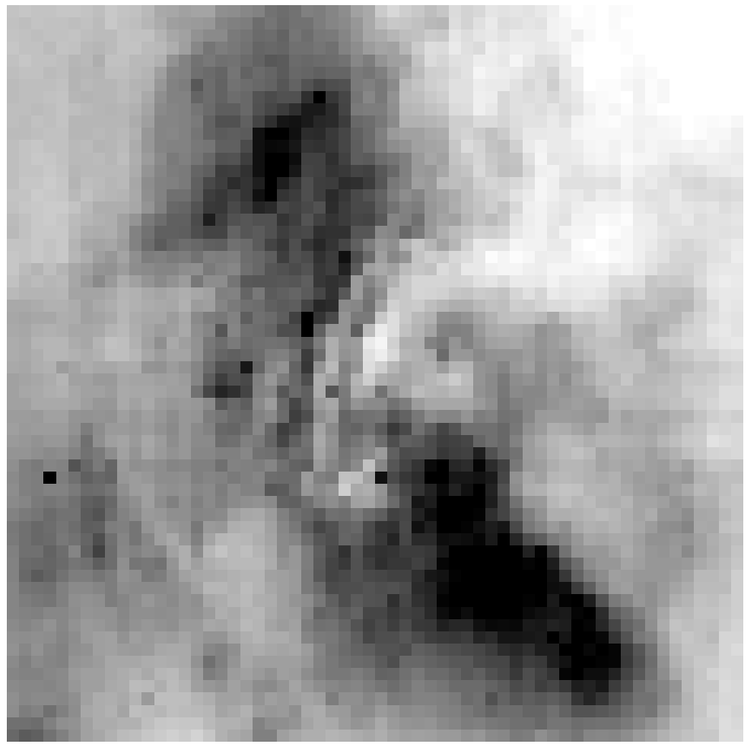
Ploughing

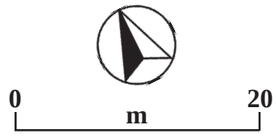
0 m 20

GSB Prospection Ltd. 2004/70

Figure 22

CARLOW RELIEF ROAD
Resistance Survey - Area AS3(B)



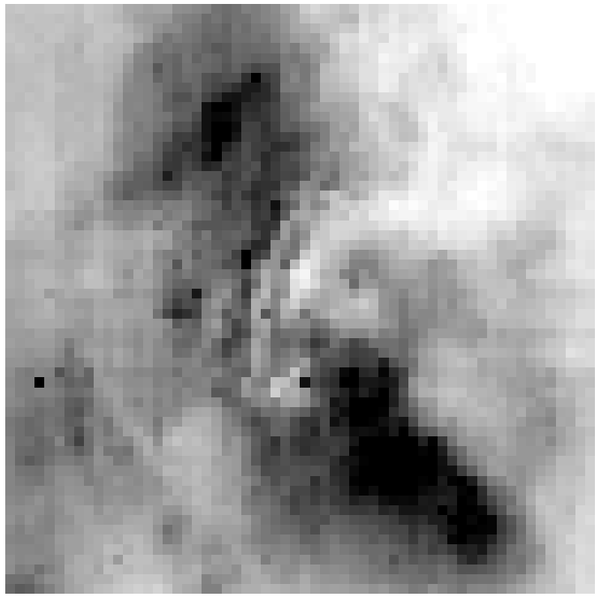


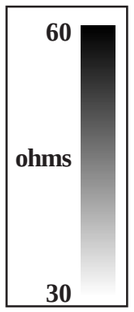
GSB Prospection Ltd. 2004/70

Figure 23

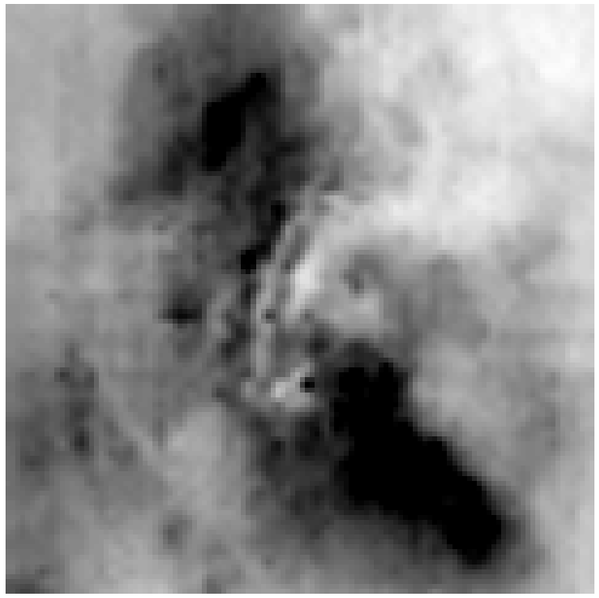
CARLOW RELIEF ROAD
Resistance Survey - Area AS3(B)

Raw Data

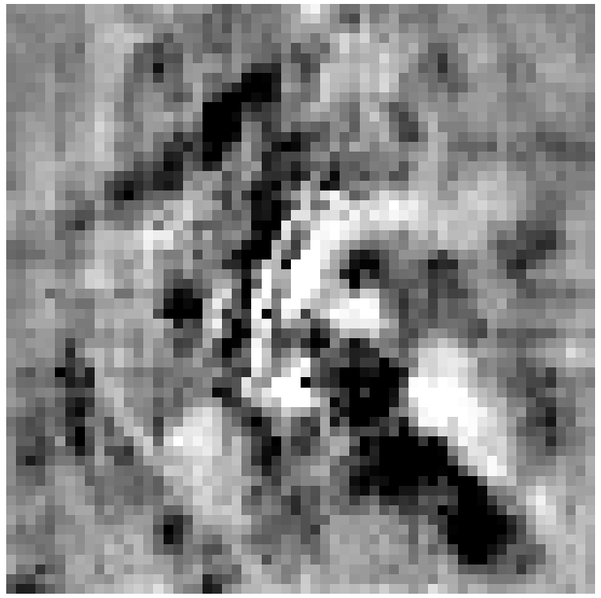




De-spiked & Interpolated Data



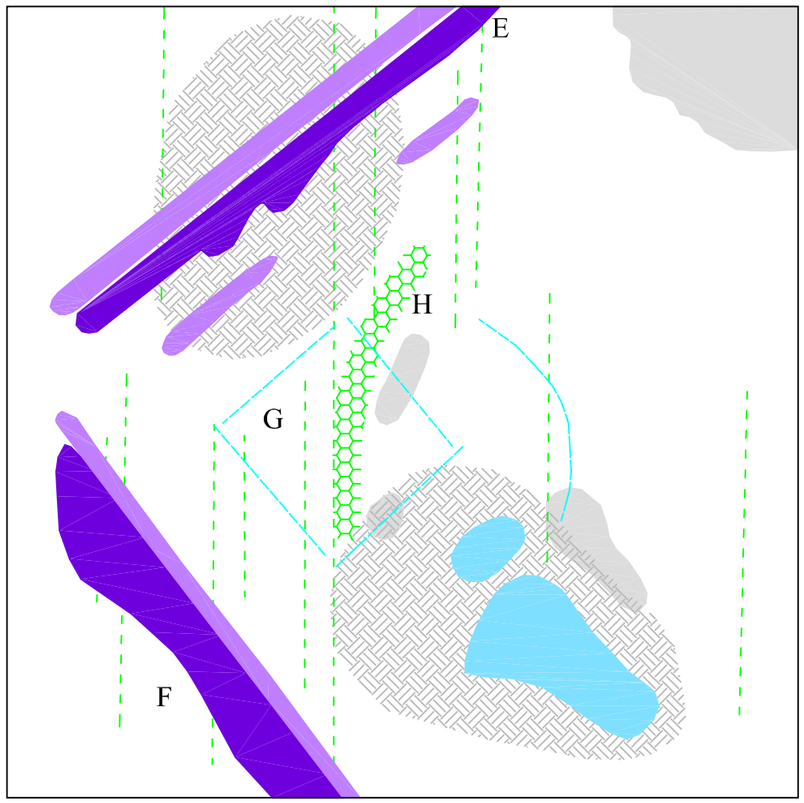
High Pass Filtered Data



GSB Prospection Ltd. 2004/70

Figure 24

CARLOW RELIEF ROAD
Resistance Survey - Area AS3(B)



Low Resistance

High Resistance

Ditch

Bank/Wall Remains

Trend

?Natural/geological

?Building Debris

Ploughing

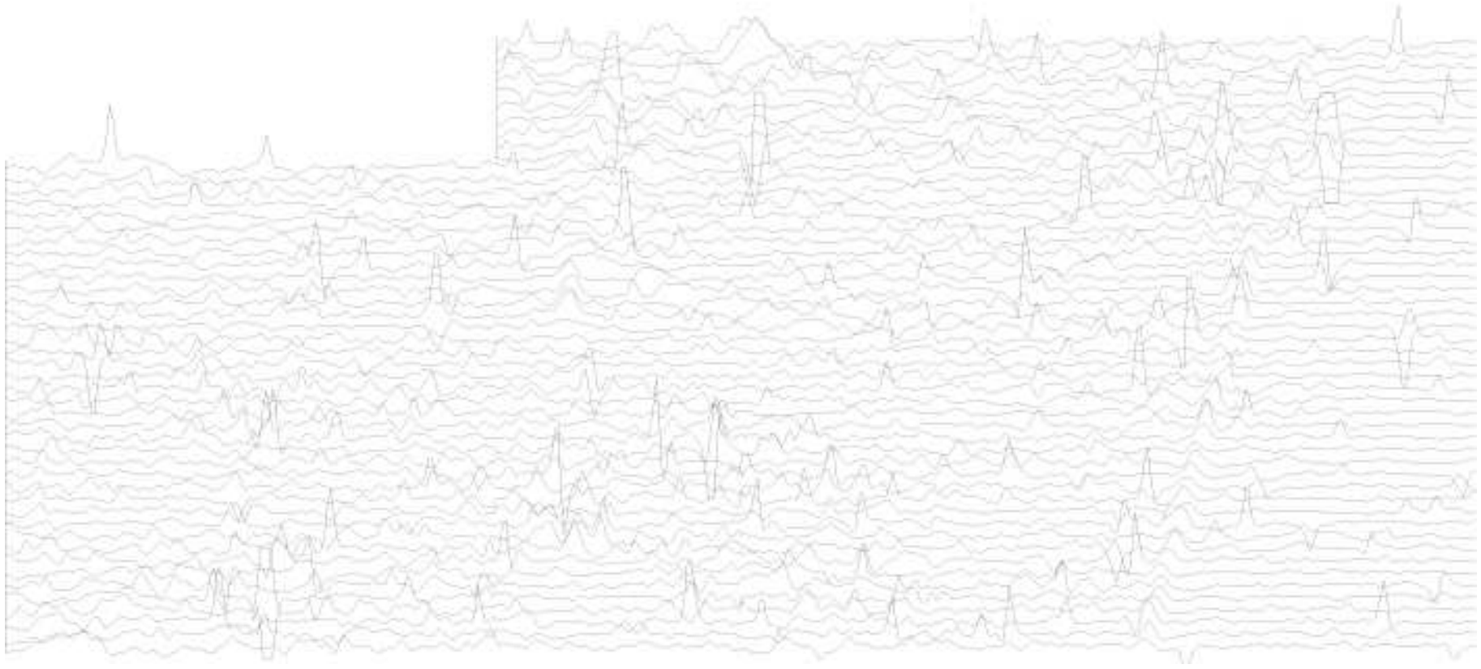
?Natural/soil

?Natural

0 m 20

Figure 25

CARLOW OUTER RELIEF ROAD
Gradiometer Survey - Area AR4(1)



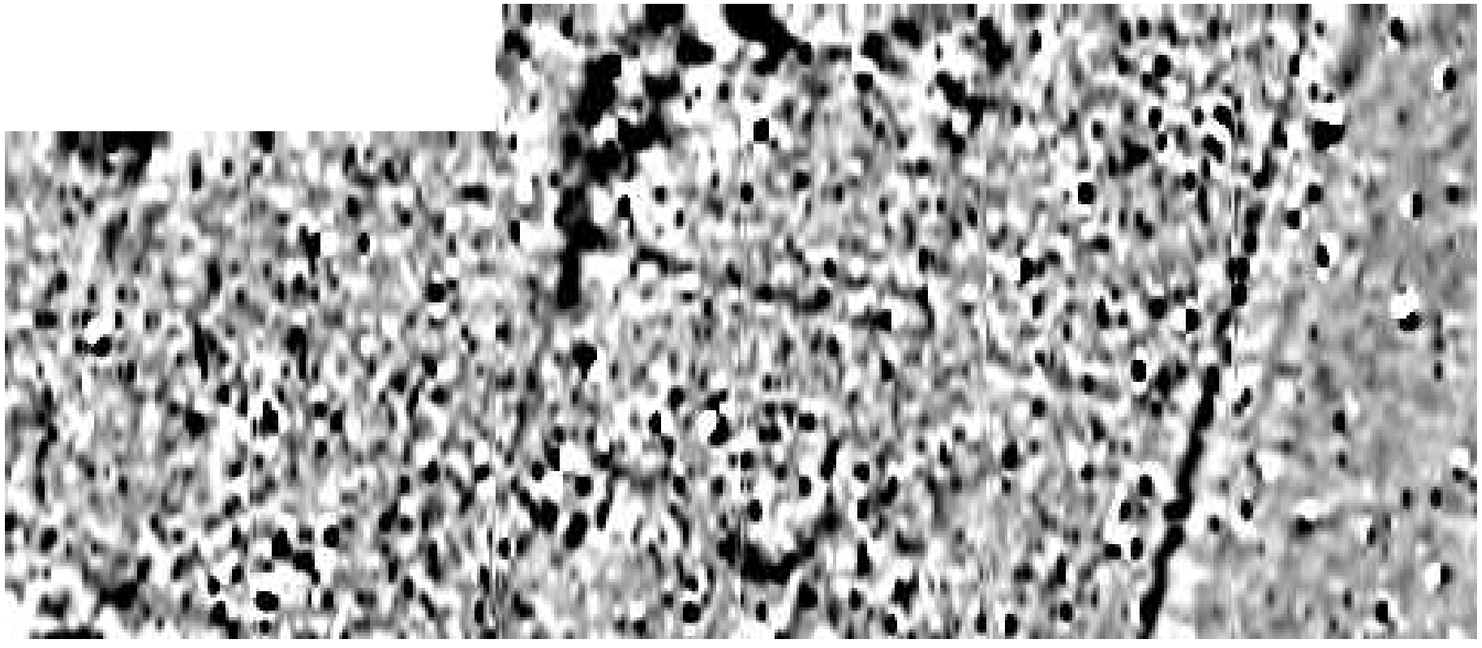
15 nT

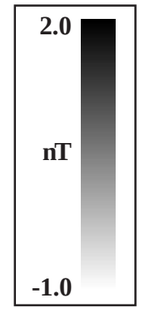
0 m 20

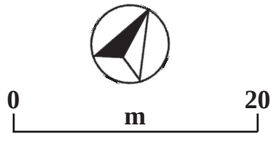
GSB Prospection Ltd. 2004/70

Figure 26

CARLOW OUTER RELIEF ROAD
Gradiometer Survey - Area AR4(1)



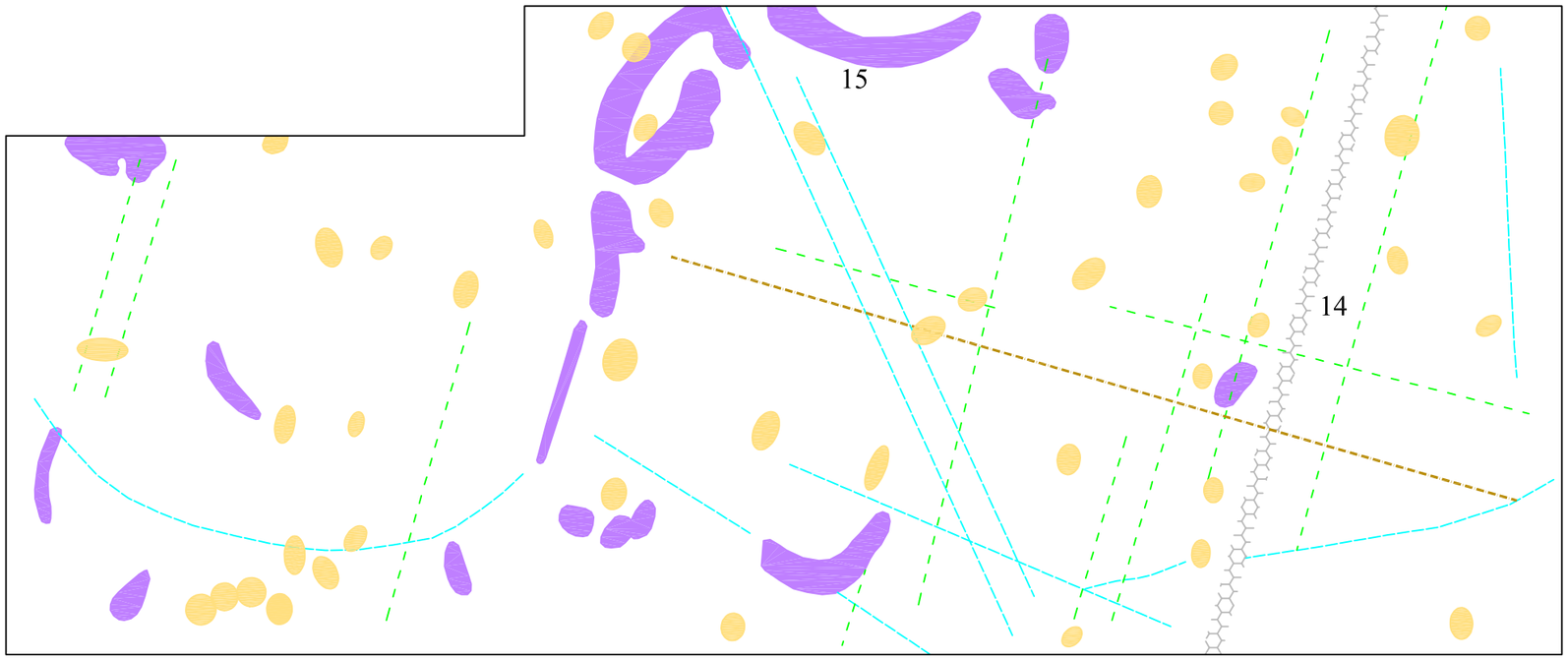




GSB Prospection Ltd. 2004/70

Figure 27

CARLOW OUTER RELIEF ROAD
Gradiometer Survey - Area AR4(1)



?Archaeology

Trend

Old Field Boundary

?Drain

Ploughing

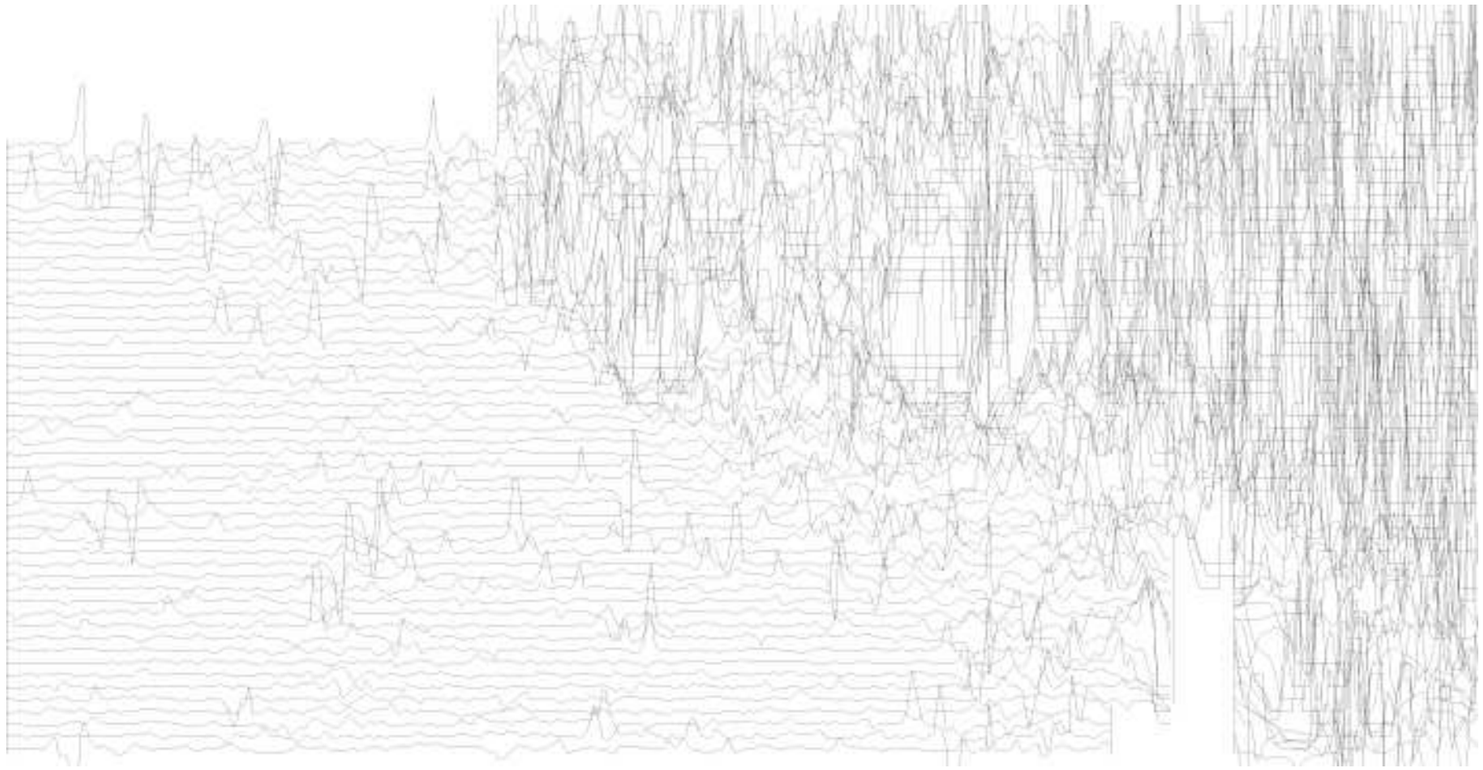
Ferrous

0 m 20

GSB Prospection Ltd. 2004/70

Figure 28

CARLOW OUTER RELIEF ROAD
Gradiometer Survey - Area AR4(2)



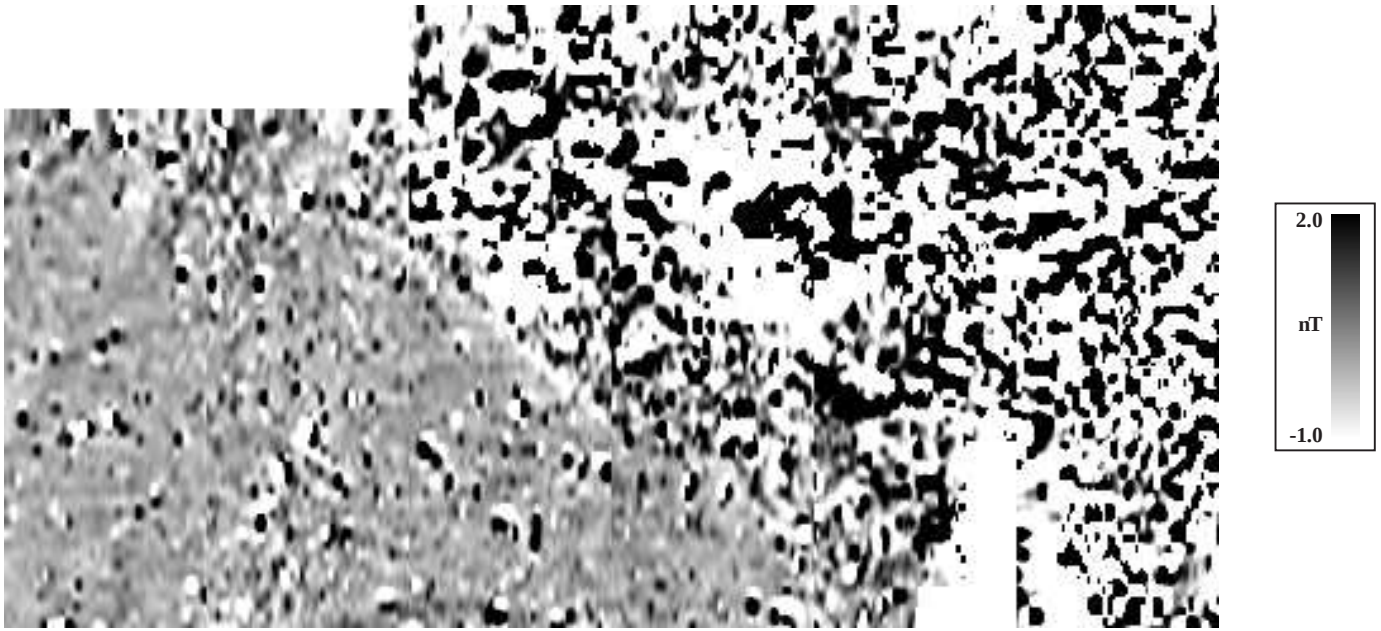
15 nT

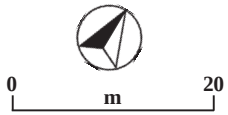
0 m 20

GSB Prospection Ltd. 2004/70

Figure 29

CARLOW OUTER RELIEF ROAD
Gradiometer Survey - Area AR4(2)

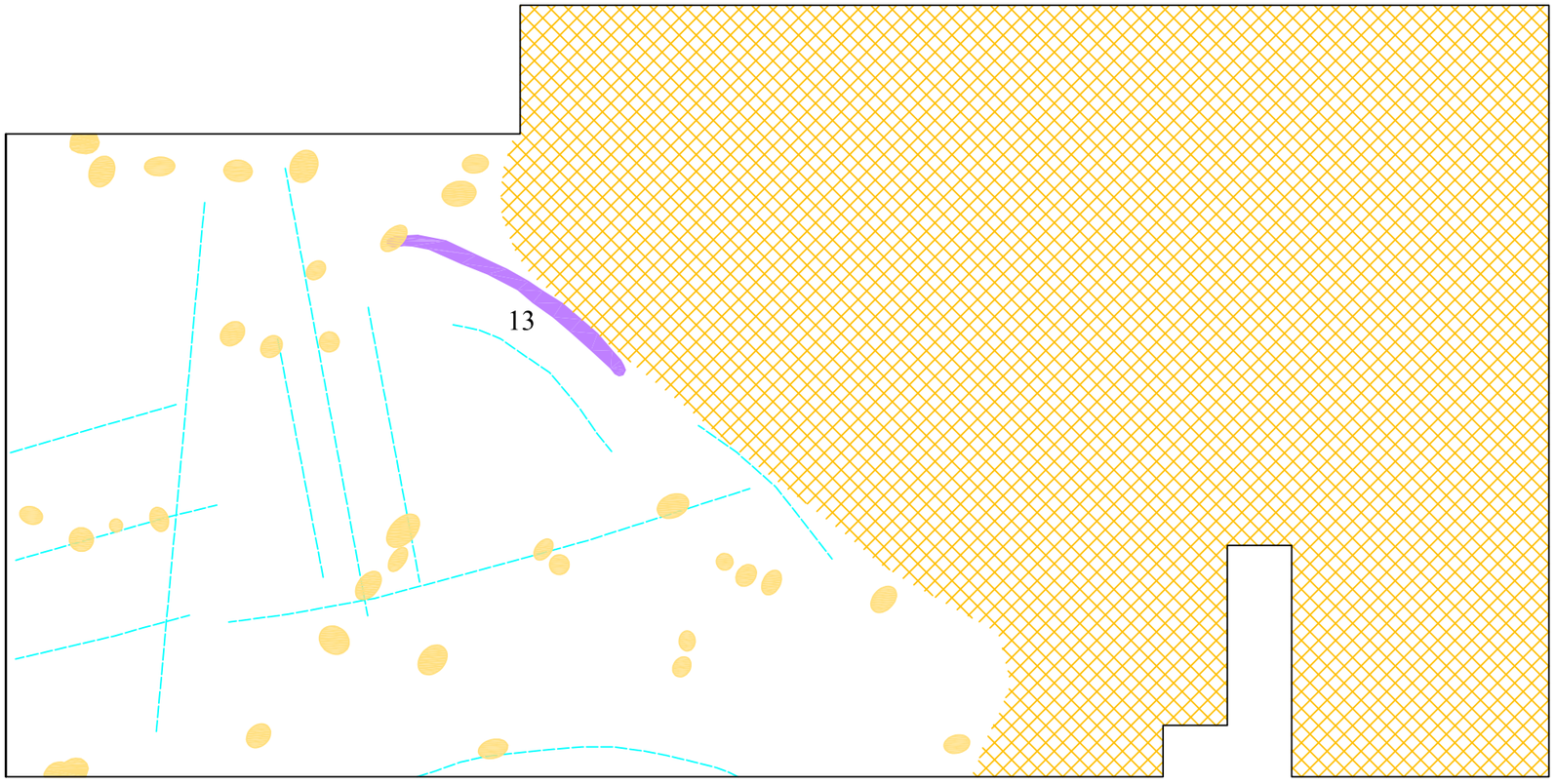




GSB Prospection Ltd. 2004/70

Figure 30

CARLOW OUTER RELIEF ROAD
Gradiometer Survey - Area AR4(2)



?Archaeology

Trend

Old Field Boundary

Ferrous

0 m 20

GSB Prospection Ltd. 2004/70

Figure 31

0 metres 100

2
nT
-1

GSB PROSPECTION Ltd.

PROJECT: 2004/70 Carlow Outer Relief Road

TITLE: Summary Greyscales - Areas AS2 + AS3

Based on a plan provided by the client

Figure 32