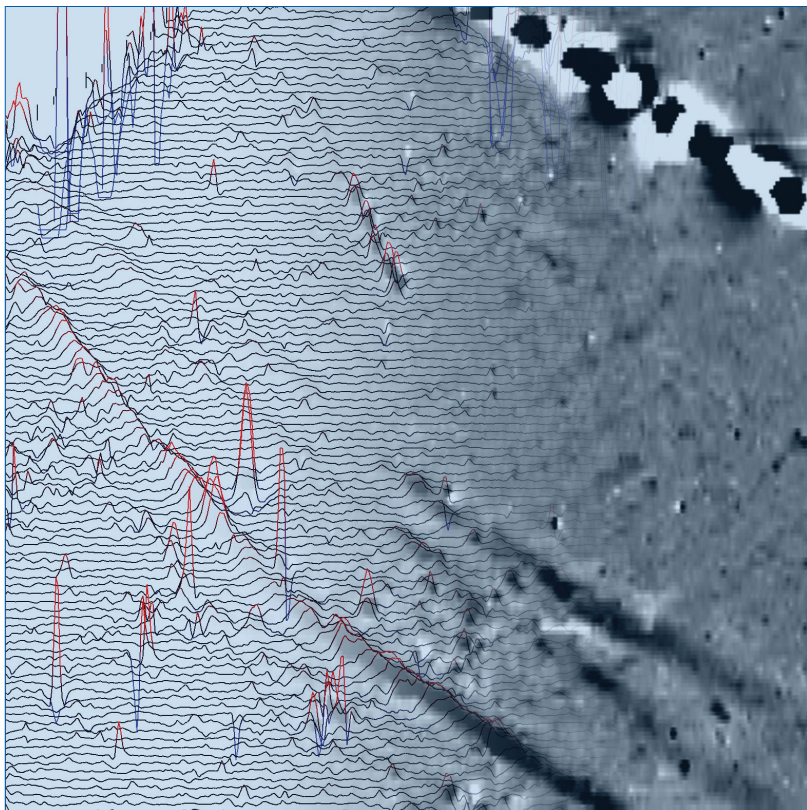




Swinford Wind Farm Leicestershire

Detailed Gradiometer Survey Report



**SWINFORD WIND FARM
LEICESTERSHIRE**

Detailed Gradiometer Survey Report

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Detailed Gradiometer Survey Report

Summary

A detailed gradiometer survey was conducted across targeted areas of a proposed wind farm near Swinford, Leicestershire, approximately centred upon OS NGR 457662 821214. The survey was successful in detecting a number of anomalies of possible archaeological potential within the study area. In general, the site was magnetically quiet with a consistent background level across all the areas surveyed.

The main anomalies identified of potential archaeological interest are numbers **4009** (turbine 4), a pair of roughly linear features with an associated area of magnetic disturbance, **4019** (turbine 9) a sinuous linear feature with associated spur and **4022** (turbine 10), a trio of linear and curvilinear anomalies. All these identified anomalies are thought to be backfilled negative linear features that represent either former boundaries or hollow-ways.

In addition, the survey has confirmed the presence of former ridge and furrow ploughing systems across most of the site, enhancing the known extent of these systems beyond that previously thought.

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Acknowledgements

The detailed gradiometer survey was commissioned by CgMs Consulting. The assistance of Rob Bourn is gratefully acknowledged in this respect.

The fieldwork was directed by Ben Urmston and Nathan Thomas, assisted by Hannah Spieler and Piotr Brozyna. Nathan Thomas and Ben Urmston processed and interpreted the geophysical data and Nathan Thomas wrote this report. The geophysical work was managed and quality controlled by Paul Baggaley. Illustrations were prepared by Linda Coleman. The project was managed on behalf of Wessex Archaeology by Paul Baggaley.

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Detailed Gradiometer Survey Report

1 INTRODUCTION

1.1 Project background

1.1.1 Wessex Archaeology was commissioned by CgMs Consulting on behalf of Nuon to carry out a program of geophysical survey at the proposed site of the Swinford Wind Farm (**Figure 1**), hereafter 'the Site'. The Site is approximately centred upon OS NGR 457662 821214, and comprises eleven areas designated for the construction of turbines and an additional site compound at Swinford Corner.

1.1.2 The aim of the project was to establish the presence/absence, extent and character of detectable archaeological remains within the survey areas.

1.1.3 This report presents a brief description of the methodology followed, the detailed survey results and the archaeological interpretation of the geophysical data.

1.2 Survey areas

1.2.1 The Site falls within an overall planning area of 350 ha, located 1km to the north-east of the village of Swinford and 4km to the south-east of the town of Lutterworth in the county of Leicestershire (**Figure 1**). The landscape of the area is characterised by small to medium sized arable and pasture fields enclosed by hedgerows, with ponds and small streams common across the landscape (Entec 2008, 6-24).

1.2.2 The topography of the study area consists of a gently rising plateau that runs on a south-west to north-east alignment, with a maximum elevation of 154m AOD, falling to approximately 117m at the southern boundary of the Site (Entec 2008, 6-24).

1.2.3 The proposed Wind Farm entails the construction of eleven turbines with associated infrastructure, tracks and a site compound at Swinford Corner. For each turbine location, a one hectare footprint was surveyed as recommended by the guidelines issued by English Heritage *Geophysical Survey in Archaeological Field Evaluation* (2008, 18). This methodology accounts for both the actual physical foundation of the turbine and its future magnetic footprint that may preclude subsequent magnetic survey within the localised area.

1.2.4 Numbering for the turbine survey areas follows the system presented in the environmental statement (Entec 2008) and Wind Farm proposal that are available online (Nuon 2009).

- 1.2.5 At the time of survey, the areas around Turbines 1, 2 and 4 -10 were under a short (ankle length) cereal crop. Turbine 3 and the site compound at Swinford Corner were covered by short to medium length grass, (up to knee high). The proposed area for turbine 11 was unsuitable for survey due to a waist high crop of rape. In total detailed gradiometer survey of 10.6 hectares was conducted at the Site (**Figure 1**).
- 1.2.6 The soils underlying the Site are predominantly poorly drained, seasonally waterlogged, surface water gleys. These overly a drift geology of glacial till across the majority of the Site. The solid geology consists of undifferentiated Blue Lias and Charmouth laminated clay and mudstone (BGS Sheet 170, Entec 2008, 12.3.16). Soils in such geological settings have been shown to produce magnetic contrasts suitable for the detection of archaeological remains through survey with the Bartington Grad 601-2 gradiometer.

2 METHODOLOGY

2.1 Introduction

- 2.1.1 A geophysical specification was prepared by Wessex Archaeology to investigate the Site. The methodology consisted of detailed gradiometer survey conducted using Bartington Grad 601-2 dual gradiometer systems. The survey was conducted in accordance with English Heritage guidelines *Geophysical Survey in Archaeological Field Evaluation* (2008).
- 2.1.2 The geophysical survey was conducted by Wessex Archaeology's in-house geophysics team from 5th to 8th May 2009. For the period of the survey, the prevailing weather was cloudy with sunny intervals.
- 2.1.3 Individual survey grid nodes were established at 20m x 20m intervals using a Leica 1200 RTK GPS system, which is precise to within 0.05m and therefore exceeds English Heritage recommendations.
- 2.1.4 The detailed gradiometer survey was conducted using Bartington Grad 601-2 gradiometer systems over 20m x 20m grids with a sample interval of 0.25m along transects spaced 1m apart. Data were collected in the zig-zag manner.
- 2.1.5 Data from the survey was subject to limited data correction processes. This included a zero mean traverse function (+/- 5 nT thresholds) applied to correct for any variation between the two Bartington sensors used, and also a de-step function to account for variations in traverse position due to the zig-zag data collection method. These two steps were applied to all survey areas, with no further data filtering or interpolation.
- 2.1.6 Further details of the geophysical and survey equipment, methods and processing are described in **Appendix 1**.

3 RESULTS AND INTERPRETATION

3.1 Introduction

- 3.1.1 The geophysical survey identified a number of anomalies of possible archaeological origin. Results are presented as a series of greyscale, XY trace plots and interpretation diagrams over the Site at a scale of 1:1500 (**Figures 2 to 23**).
- 3.1.2 The interpretation of the datasets highlights the presence of potential archaeological anomalies, ploughing trends, ferrous/burnt or fired objects, areas of general increased magnetic response and modern services. Full definitions of the interpretation terms used in this report are provided in **Appendix 2**.
- 3.1.3 Numerous ferrous anomalies are visible throughout the detailed survey dataset. These are presumed to be modern in provenance and are not referred to, unless considered relevant to the archaeological interpretation.

3.2 Detailed survey results and interpretation

- 3.2.1 At the **Swinford Corner Compound**, anomaly **4001** consists of a series of irregular shaped anomalies to the north-west of the survey area that appear to be part of a curvilinear trend of magnetic aberrations. The morphology and alignments of these anomalies do not appear to form any coherent patterns that would suggest an anthropogenic origin, and it is therefore probable that these anomalies represent variations in the underlying geology, with similar irregular shaped anomalies noted elsewhere in the study area, (see below, turbine 5).
- 3.2.2 Anomalies **4002** and **4003** represent two large areas of strong magnetic responses. The nature of the anomalies would indicate the presence of strongly magnetic deposits such as ferrous or fired material. At the time of survey, nettles were noted across the areas of both these anomalies, possibly indicating disturbed ground. It is feasible that both these anomalies represent dumps of material, for example demolition/building material, although it is impossible to know from the geophysical data alone whether they represent *in-situ* demolition debris or more recent episodes of fly tipping. It is also interesting to note that one of these anomalies is coincident with a pond like feature marked on the first edition OS map (Entec 2008, vol. 3), suggesting this may have been backfilled with debris.
- 3.2.3 **Turbine 1** can be seen to be dominated by a series of linear anomalies (**4004**) running on a roughly north-east to south-west orientation. The responses comprise a series of strong discrete anomalies and are likely to represent a drainage system, constructed/backfilled with strongly magnetic materials. In addition, a further series of weaker and roughly parallel magnetic trends can be observed (**4005**). The more subtle nature of these anomalies suggests an earlier ridge and furrow ploughing regime across the survey block.

- 3.2.4 **Turbine 2** is relatively sterile in terms of any significant anomalies of interest. However, anomalies **4006** and **4007** indicate the location of further relic ploughing trends. **4006** highlights a series of east-west magnetic trends, and **4007** trends running roughly north-south. A number of small discrete anomalies marked as possible archaeology have also been indicated which may represent negative features such as pits. However, the lack of any clear patterning may suggest a natural origin to these anomalies, for example, tree throws.
- 3.2.5 **Turbine 3** was identified in the environmental statement (Entec 2008, fig. 11.1) to be an area of extant ridge and furrow. At the time of survey, the field was covered in long grass which made the identification of these earthworks difficult. The magnetic data however, indicates a regular patterning of sinuous magnetic trends on an east-west alignment that probably represents the course of former ridge and furrow.
- 3.2.6 **Turbine 4** contains a number of anomalies of possible archaeological interest. Anomaly **4008** is a large ferrous like response at the north-east corner of the survey area. It is likely that this response derives from a large piece of iron/steel, however; the possibility that the anomaly derives from former industrial/pyrotechnical activities should not be ruled out. Anomaly **4009** is a series of broken linear responses, running from the eastern edge of the survey area westwards with a small parallel linear anomaly to the south. In addition to these linear anomalies there is a broad area of increased magnetic background further to the south-east. These linear anomalies may indicate backfilled former boundaries or drains. The area of increased magnetic background may indicate intensified human activity, for example, former occupation areas. The area of magnetic disturbance may indicate archaeological features that have been truncated by ploughing, with the only evidence for their existence remaining in the disturbed magnetic signal of the plough soil. Further linear trends, indicative of ridge and furrow ploughing, are also present within the dataset (anomaly **4010**).
- 3.2.7 **Turbine 5** again falls within an area previously identified from aerial photographs as containing evidence for ridge and furrow ploughing. This is clearly visible as long sinuous weakly magnetic trends running across the survey area from north-east to south-west. A number of irregular anomalies (**4011**) of similar character to those identified above within the Swinford Corner compound have also been highlighted. The irregular alignment and forms of these anomalies is again suggested to indicate a natural origin.
- 3.2.8 **Turbine 6** presents a similar picture to turbine 5. A series of weak magnetic trends, running aligned east-west, are evident across most of the dataset, (anomalies **4012** and **4014**), with further north-south trends at the western fringe of the survey area. Anomaly **4013** highlights an area not surveyed due to an extant pond. A cluster of strong ferrous responses dispersed around this feature are probably associated with former fencing or agricultural activities. A short linear anomaly seen emanating from the south-east of this feature probably represents a pipe or drain.

- 3.2.9 **Turbine 7** is a magnetically quiet area, again with few anomalies of any archaeological interest. Further former ploughing trends are evident; anomaly **4015** indicates trends on a north-south orientation within the north-east of the survey block. **4016** highlights an area of ploughing that run perpendicular to each other in the south-west corner of the survey block.
- 3.2.10 **Turbine 8** provides further evidence for the continuation of ridge and furrow cultivation across most of the Site. Within this survey block, three fragments of separate strip fields can be seen with different orientations. **4017** highlights furrows running on a north-south orientation, while **4018** represents a series of sinuous linear trends running east-west.
- 3.2.11 **Turbine 9** contains a curvilinear anomaly **4019** that crosses the dataset from south to north with a possible spur running off to the west. This anomaly may represent a backfilled negative feature, such as a former field boundary or hollow-way. Considering the proximity of turbine 9 to the SAM (17085) of Stormsworth deserted medieval village, it is tempting to suggest this anomaly may be associated with the former village. Again, further evidence for ridge and furrow ploughing is evident across the survey block, in this instance mostly following an east-west orientation.
- 3.2.12 **Turbine 10** presents the most cogent evidence for archaeological features. Towards the north-western extent of the survey block, anomaly **4020** is characteristic of a modern service pipe. This anomaly is located to the south of the high pressure gas pipeline indicated in the constraints map (figure 4.4 Entec 2008, vol.2), and it is possible that this anomaly is associated with such a service. Anomaly **4021** is a short linear cluster of anomalies on a north-east to south-west alignment. It is possible that this anomaly represents a negative feature, such as a ditch or series of pits that may be of anthropogenic origin. Running across the survey block, on a north-east to south-west alignment, anomaly **4022** is a series of linear and curvilinear anomalies. Displaying the greatest magnetic contrast and consistency the south-eastern most anomaly may indicate the route of a former field boundary or hollow-way. The presence of two further linear anomalies running on approximately the same course may support the suggestion of a former route-way that has seen repeated phases of usage. Similarly, it is possible that the two apparently straighter linear anomalies are respecting an existing boundary, as represented by the curvilinear anomaly.
- 3.2.13 Numerous linear and curvilinear trends are visible throughout the datasets. It is possible that some of these may indicate weakly magnetic features, although their lack of contrast with the general magnetic background makes interpretation uncertain.
- 3.2.14 Similarly, numerous discrete pit like anomalies have been identified across the survey areas as possible archaeology. As these features do not display any distinct patterning it is difficult to determine any firm conclusions regarding their origin. It is possible they represent variations in the local geology or potential cultural material, such as ferrous material, that is buried to a greater depth than the distinctly ferrous responses identified.

4 CONCLUSION

4.1 Introduction

4.1.1 The detailed gradiometer survey has been successful in detecting a number of anomalies of probable and possible archaeological potential within the study area and can therefore be considered to have successfully fulfilled the aims of the survey.

4.2 Conclusions

4.2.1 In general, the Site was relatively magnetically quiet with a consistent background level across all the areas surveyed.

4.2.2 The main anomalies identified that can be considered of potential archaeological interest are numbers **4009** (turbine 4), **4019** (turbine 9) and **4022** (turbine 10). All these identified anomalies are thought to be backfilled negative features that represent either former boundaries or hollow-ways.

4.2.3 In addition, the survey has confirmed the presence of former ridge and furrow ploughing systems across most of the Site, enhancing the known extent of these systems beyond that previously thought.

4.2.4 The extent of this former ploughing, combined with modern arable agriculture could also be considered to have had a significant impact on any earlier (i.e. prehistoric) remains that may have been extant in the study area.

4.3 Statement of indemnity

4.3.1 The results and subsequent interpretation of geophysical surveys should not be treated as an absolute representation of the underlying features. It is normally only possible to prove the nature of anomalies through intrusive means, such as trial excavations.

5 REFERENCES

Entec, 2008, *Swinford Wind Farm Environmental Statement*. Volumes 1, 2 and 3. Available online; <http://www.harborough.gov.uk> accessed 12 May 2009

English Heritage, 2008. *Geophysical Survey in Archaeological Field Evaluation*. Research and Professional Service Guideline No 1, 2nd edition.

Nuon, 2009, *Swinford Wind Farm Project*. Available online; <http://www.nuonrenewables.com/newsite/projects/LUTH1/info.aspx>, accessed 12 May 2009

APPENDIX 1: SURVEY EQUIPMENT AND DATA PROCESSING

Survey Methods and Equipment

The magnetic data for this project was acquired using a Bartington 601-2 dual magnetic gradiometer system. This instrument has two sensor assemblies fixed horizontally 1m apart allowing two traverses to be recorded simultaneously. Each sensor contains two fluxgate magnetometers arranged vertically with a 1m separation, and measures the difference between the vertical components of the total magnetic field within each sensor array. This arrangement of magnetometers suppresses any diurnal or low frequency effects.

The gradiometers have a resolution of 0.1nT over a ± 3000 nT range, and measurements from each sensor are logged at intervals of 0.25m. All of the data are stored on an integrated data logger for subsequent post-processing and analysis.

Wessex Archaeology undertakes two types of magnetic surveys: scanning and detail. Both types depend upon the establishment of an accurate 20m or 30m site grid, which is achieved using a Leica 1200 RTK GPS system and then extended using tapes. The Leica 1200 RTK GPS system receives corrections from a network of reference stations operated by the Ordnance Survey and Leica Geosystems, allowing positions to be determined to an accuracy of 1-2cm in real-time and therefore exceed the level of accuracy recommended by English Heritage (2008) for geophysical surveys.

Scanning surveys consist of recording data at 0.25m intervals along transects spaced 10m apart, acquiring a minimum of 80 data points per transect. Due to the relatively coarse transect interval, scanning surveys should only be expected to detect extended regions of archaeological anomalies, when there is a greater likelihood of distinguishing such responses from the background magnetic field.

The detail surveys consist of 20m x 20m or 30m x 30m grids, and data are collected at 0.25m intervals along traverses spaced 1m apart. These strategies give 1600 or 3600 measurements per 20m or 30m grid respectively, and are the recommended methodologies for archaeological surveys of this type (English Heritage, 2008).

Post-Processing

The magnetic data collected during the detail survey are downloaded from the Bartington system for processing and analysis using both commercial and in-house software. This software allows for both the data and the images to be processed in order to enhance the results for analysis; however, it should be noted that minimal data processing is conducted so as not to distort the anomalies.

As the scanning data are not as closely distributed as with detailed survey, they are georeferenced using the GPS information and interpolated to highlight similar anomalies in adjacent transects. Directional trends may be removed before interpolation to produce more easily understood images.

Typical data and image processing steps may include:

- Destripe – Applying a zero mean traverse in order to remove differences caused by directional effects inherent in the magnetometer;
- Destagger – Shifting each traverse forward or backward by a number of readings. This corrects for operator errors and is used to enhance linear features;
- Despike – Filtering isolated data points that exceed the mean by a specified amount to reduce the appearance of dominant anomalous readings (generally only used for earth resistance data)

Typical displays of the data used during processing and analysis:

- XY Plot – Presents the data as a trace or graph line for each traverse. Each traverse is displaced down the image to produce a stacked profile effect. This image can include a hidden line algorithm to remove certain lines and enhance the image. This type of image is useful as it shows the full range and shape of individual anomalies.
- Greyscale – Presents the data in plan view using a greyscale to indicate the relative strength of the signal at each measurement point. These plots can be produced in colour to highlight certain features but generally greyscale plots are used during analysis of the data.

APPENDIX 2: GEOPHYSICAL INTERPRETATION

The interpretation methodology used by Wessex Archaeology separates the anomalies into two main categories: archaeological and unidentified responses.

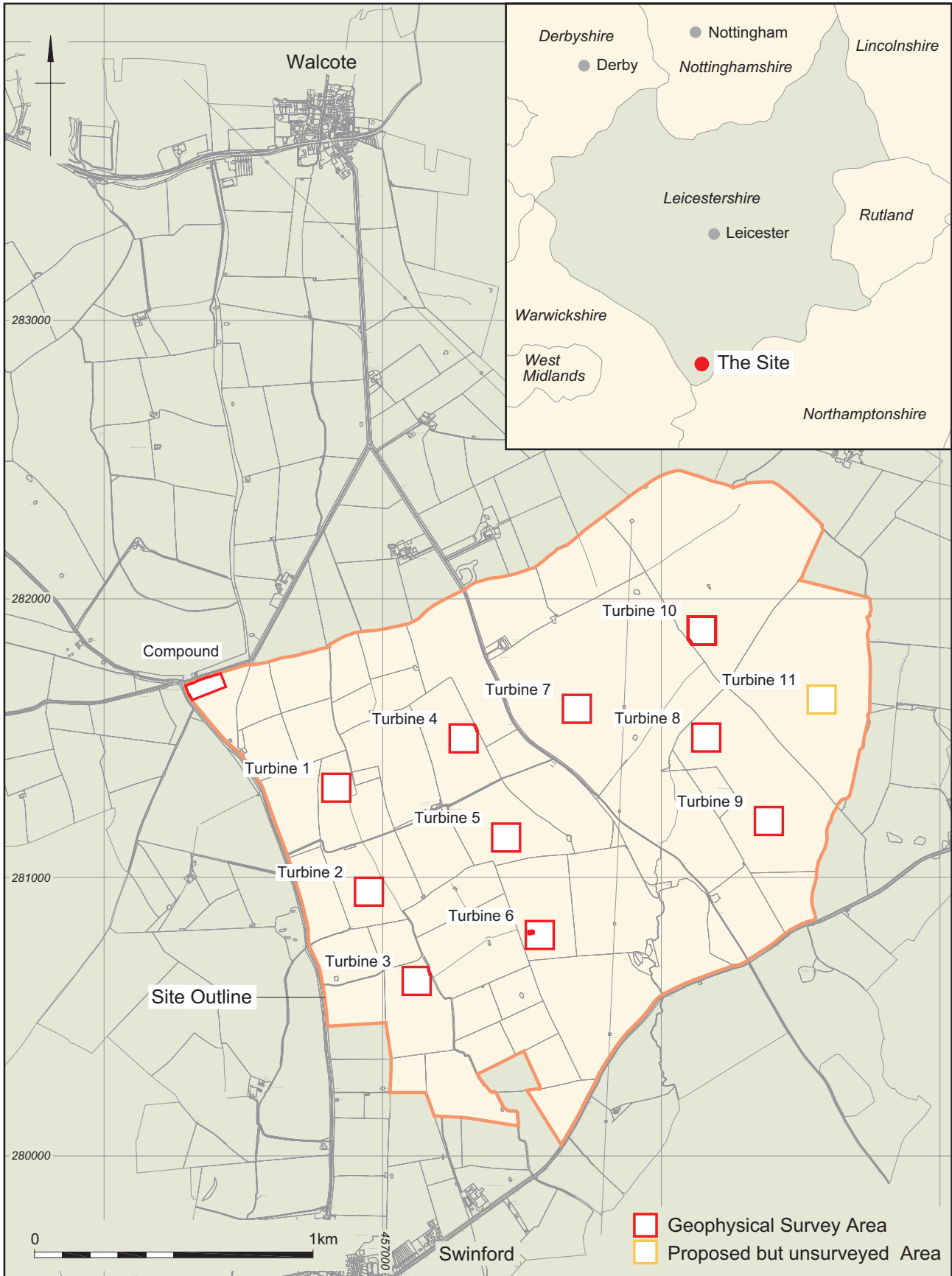
The archaeological category is used for features when the form, nature and pattern of the anomaly are indicative of archaeological material. Further sources of information such as aerial photographs may also have been incorporated in providing the final interpretation. This category is further sub-divided into three groups, implying a decreasing level of confidence:

- Archaeology – used when there is a clear geophysical response and anthropogenic pattern.
- Probable archaeology – used for features which give a clear response but which form incomplete patterns.
- Possible archaeology – used for features which give a response but which form no discernable pattern or trend.

The unidentified category is used for features when the form, nature and pattern of the anomaly are not sufficient to warrant a classification as an archaeological feature. This category is further sub-divided into:

- Increased magnetic response – used for areas dominated by indistinct anomalies which may have some archaeological potential.
- Trend – used for low amplitude or indistinct linear anomalies.
- Ferrous – used for responses caused by ferrous material. These anomalies are likely to be of modern origin.

Finally, services such as water pipes are marked where they have been identified.



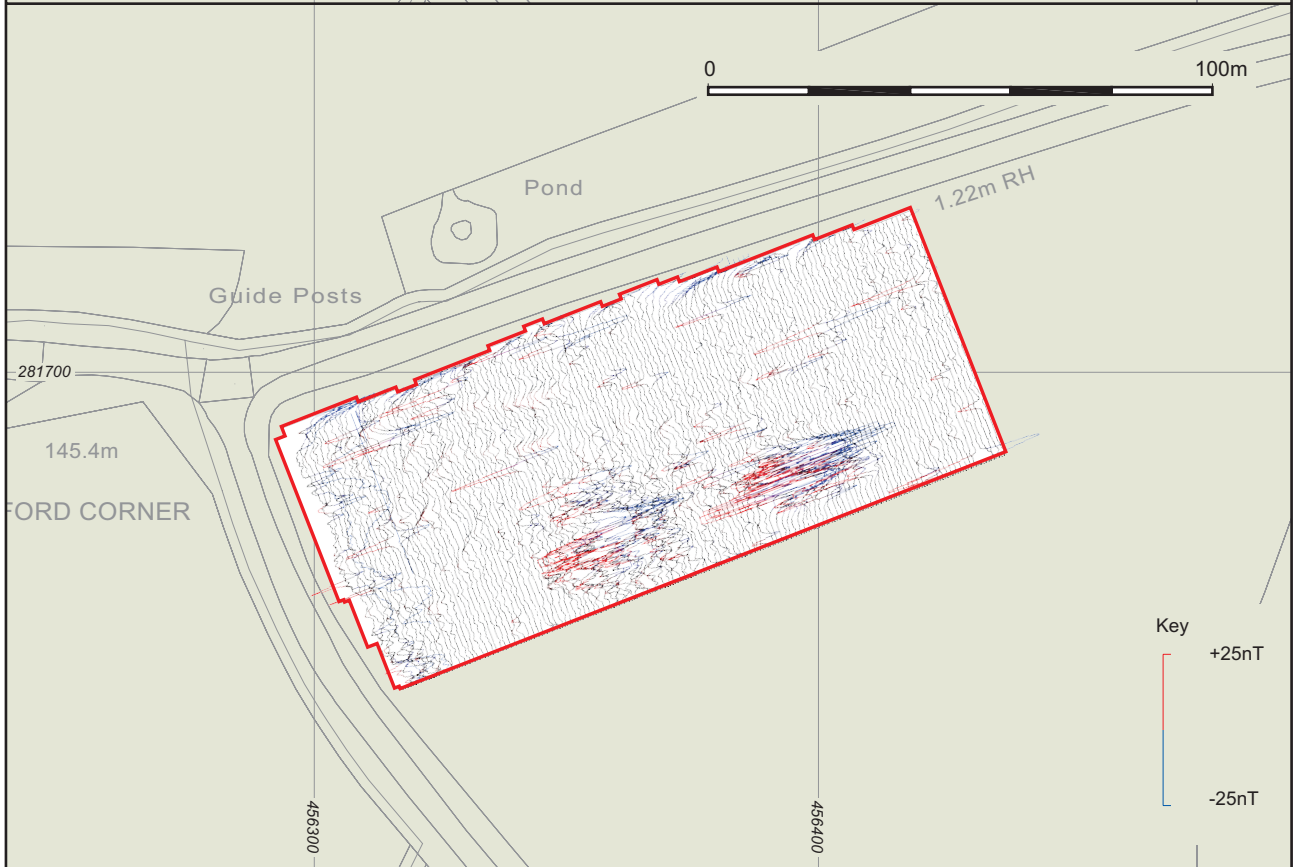
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Site location and surveyed areas

Figure 1



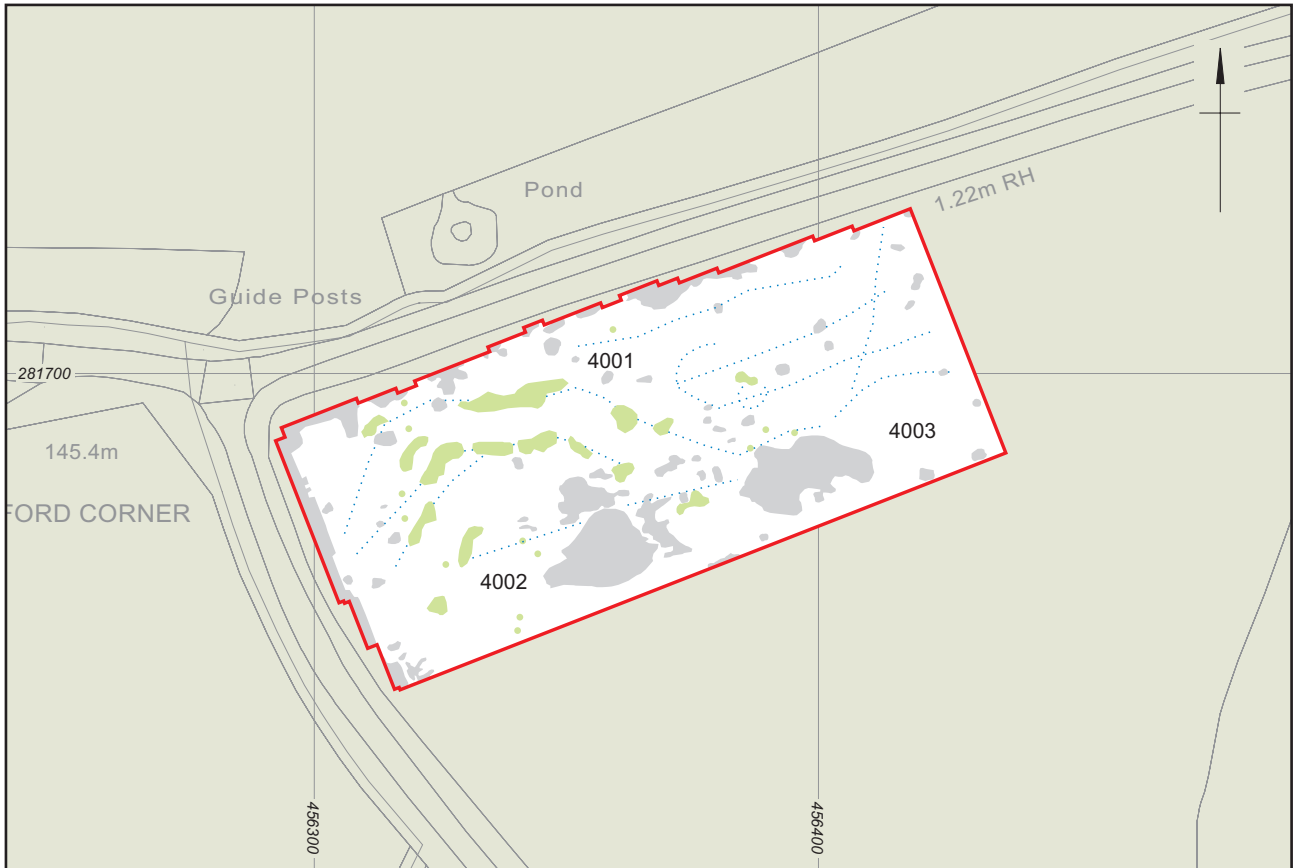
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Compound: Greyscale plot and XY trace

Figure 2



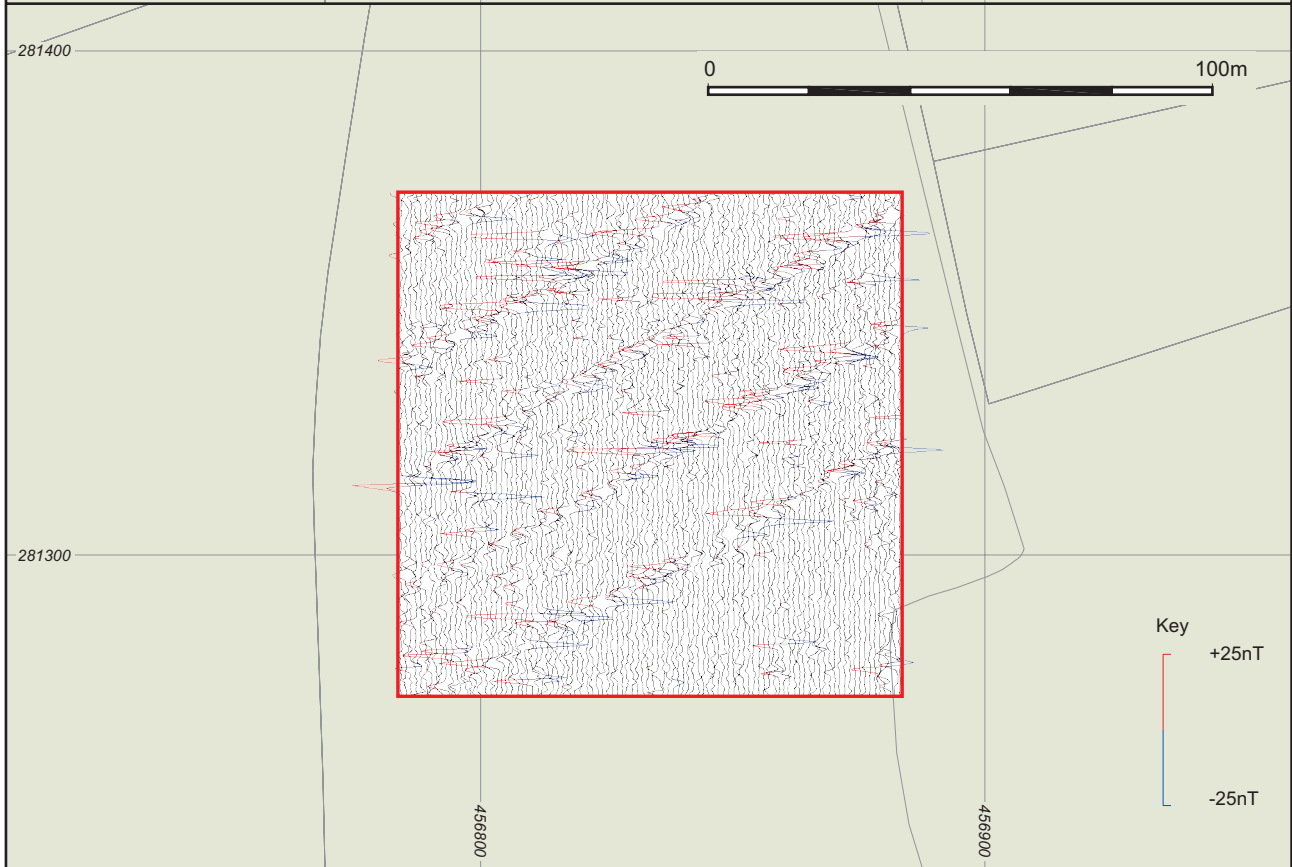
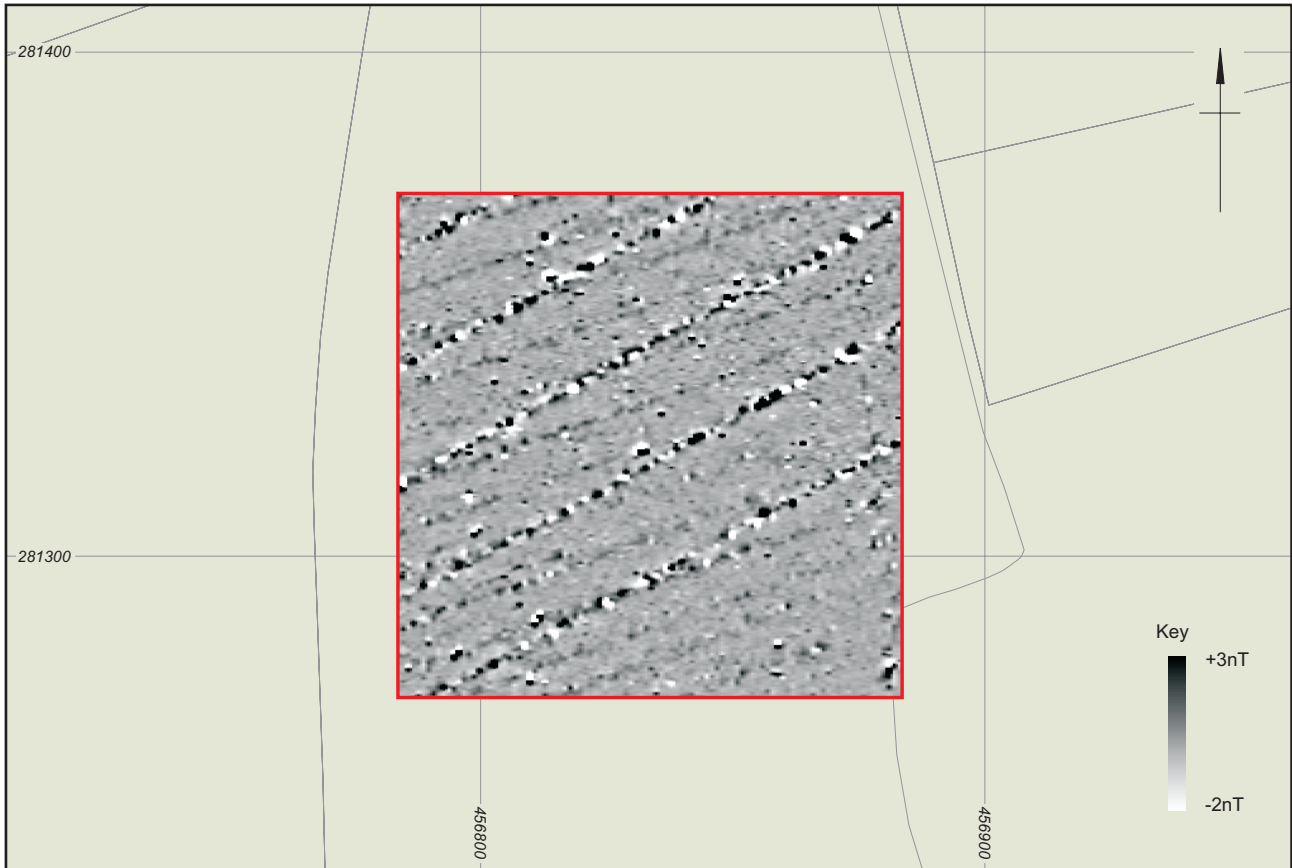
- Archaeology (probable)
- Archaeology (possible)
- Ferrous
- Increased magnetic response
- Modern services
- Trend
- Ploughing trend



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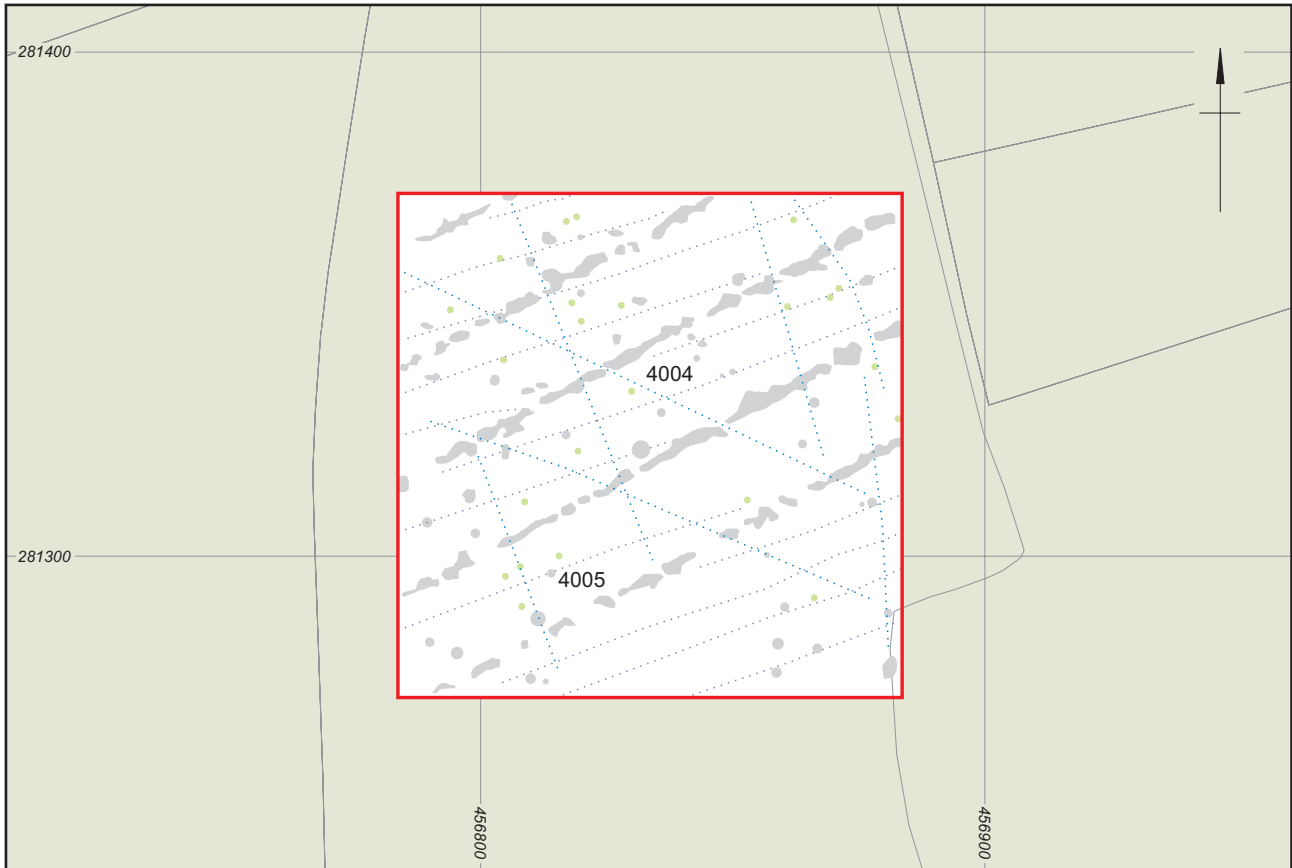
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Turbine 1: Greyscale plot and XY trace

Figure 4



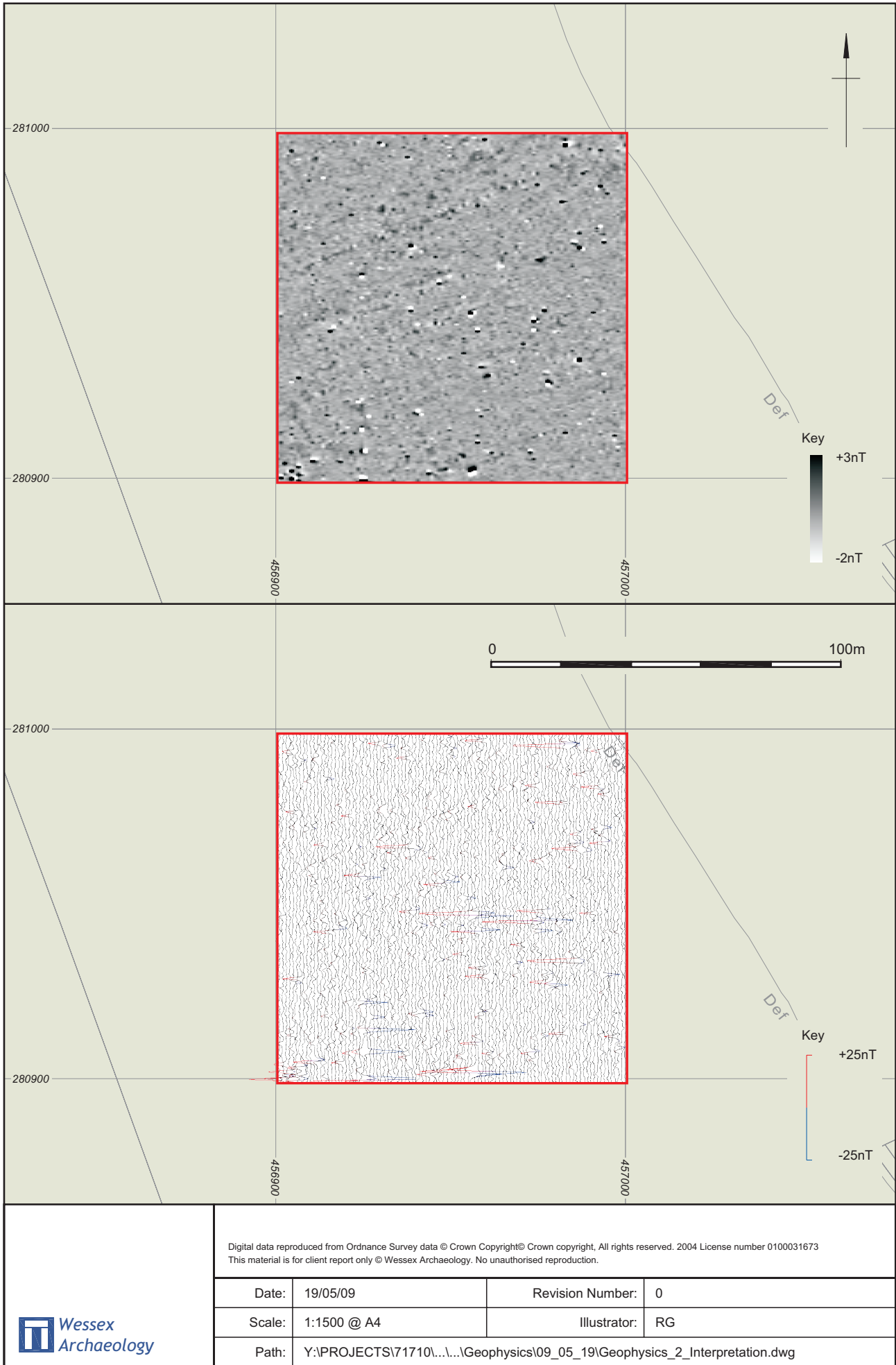
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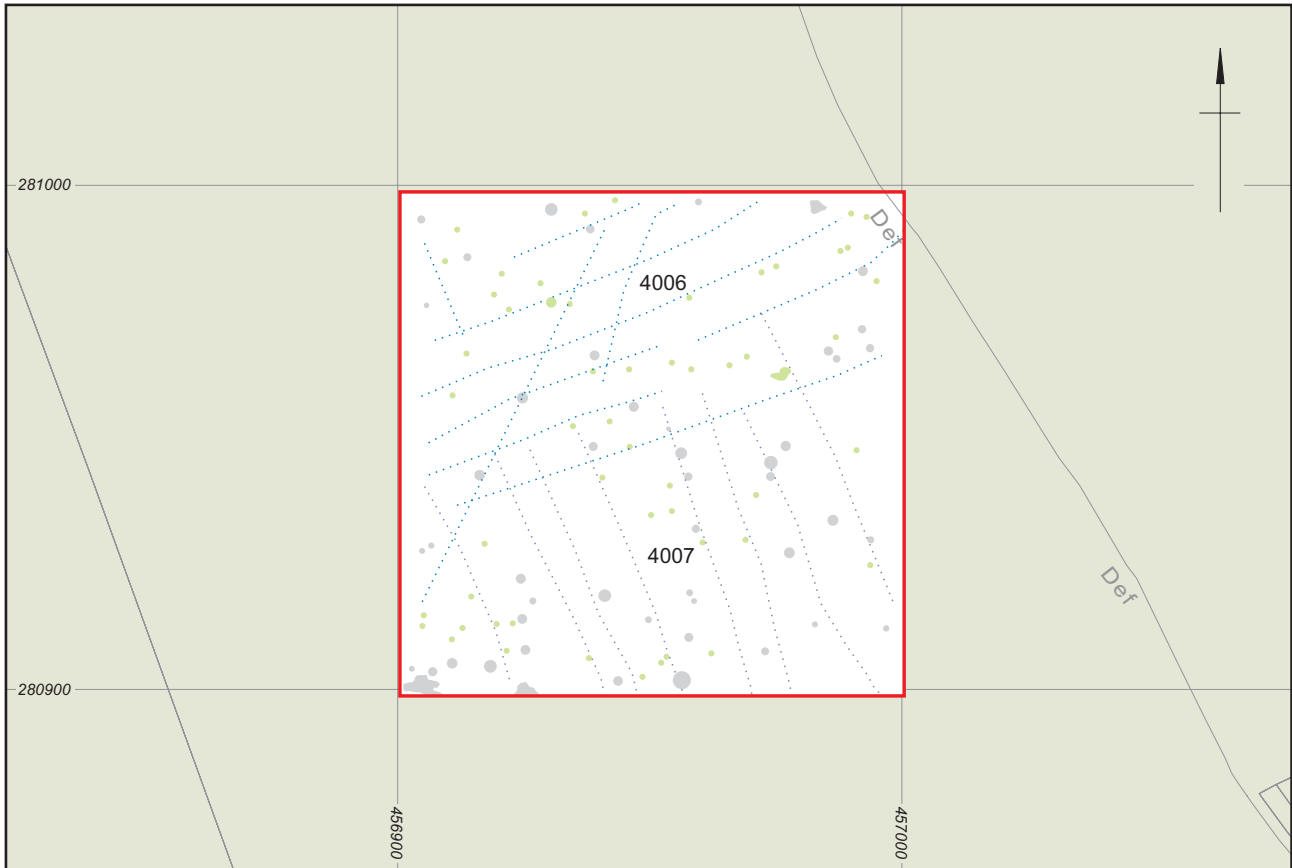
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Turbine 2: Greyscale plot and XY trace

Figure 6



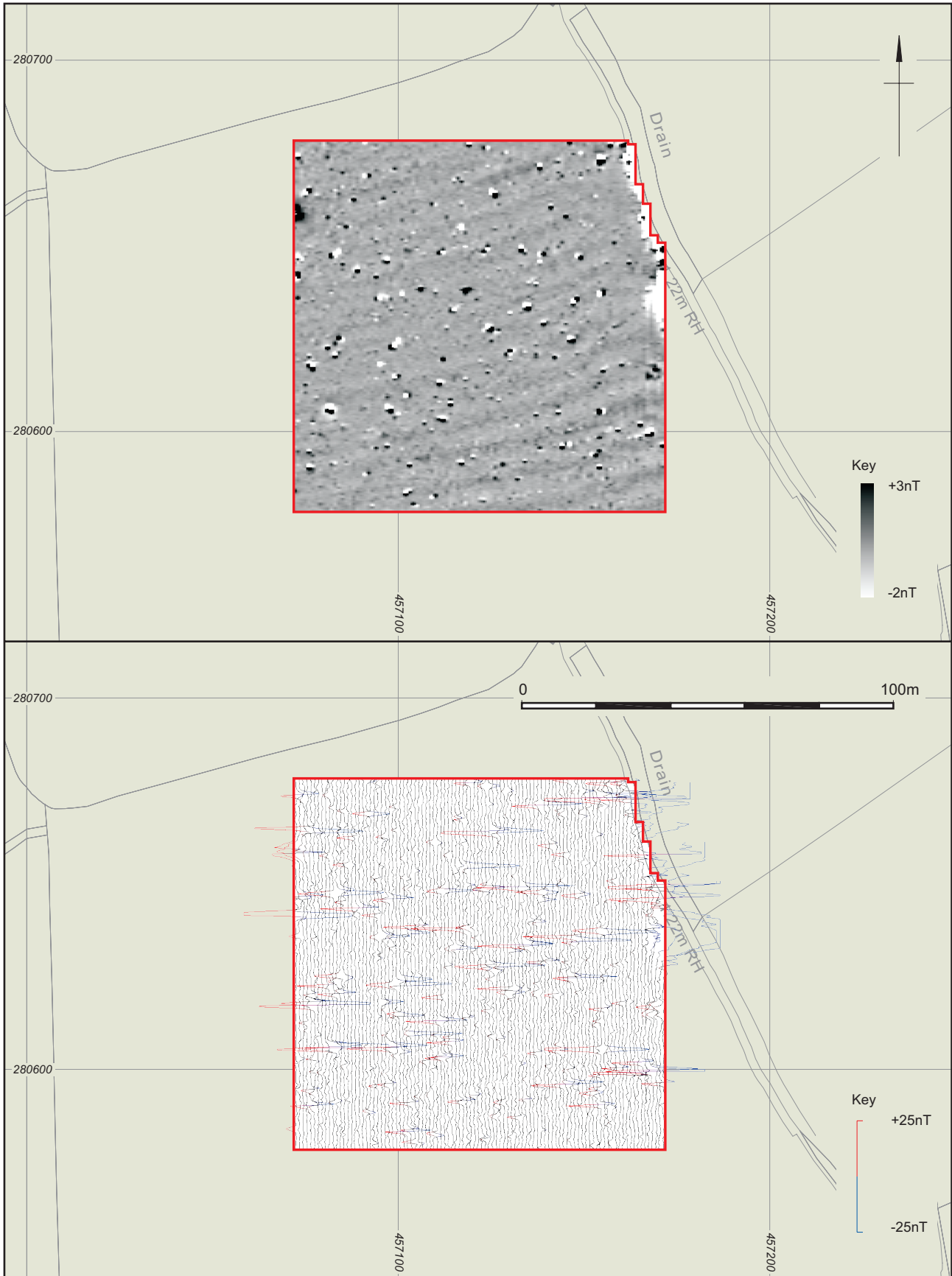
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- Archaeology (possible)
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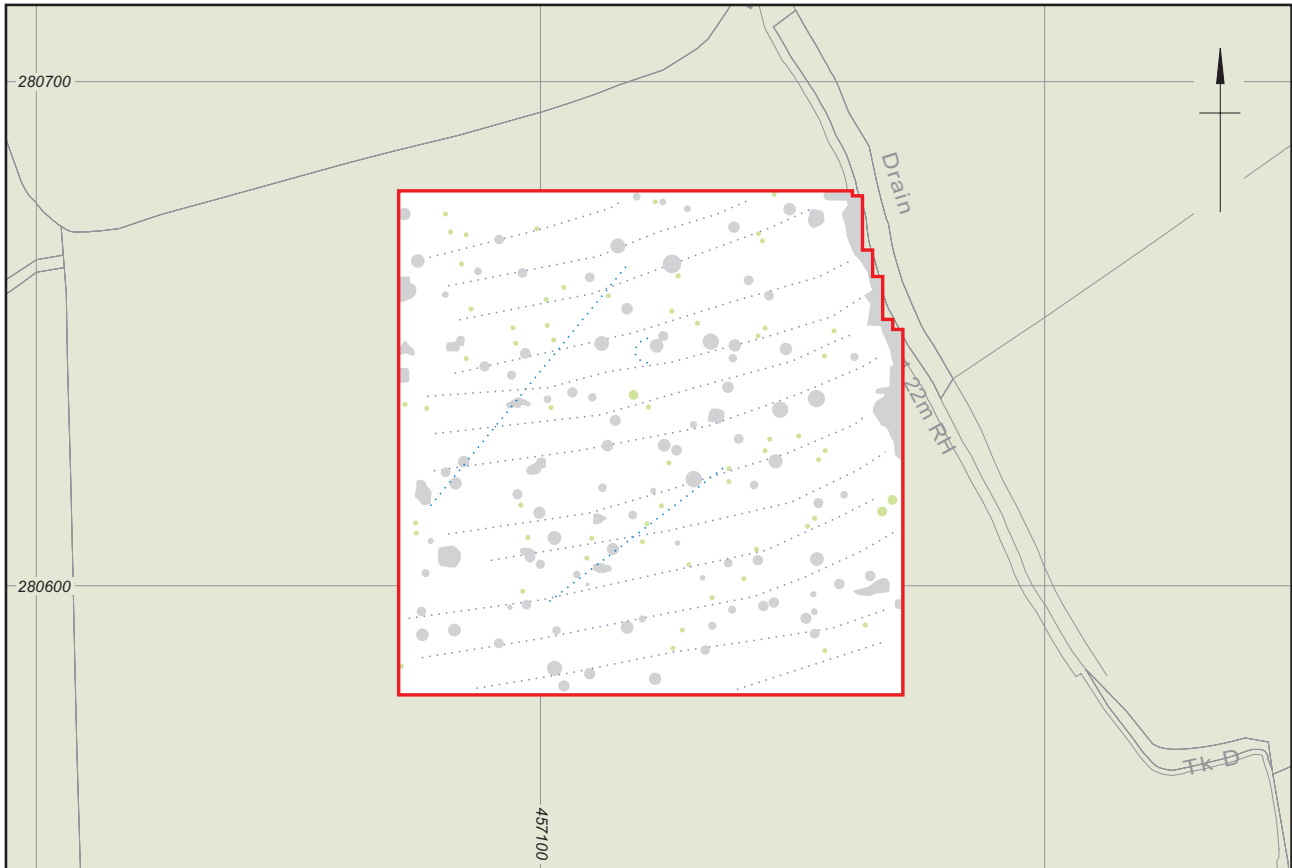
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Turbine 3: Greyscale plot and XY trace

Figure 8



- Archaeology (probable)
- Archaeology (possible)
- Ferrous
- Increased magnetic response
- Modern services
- Trend
- Ploughing trend



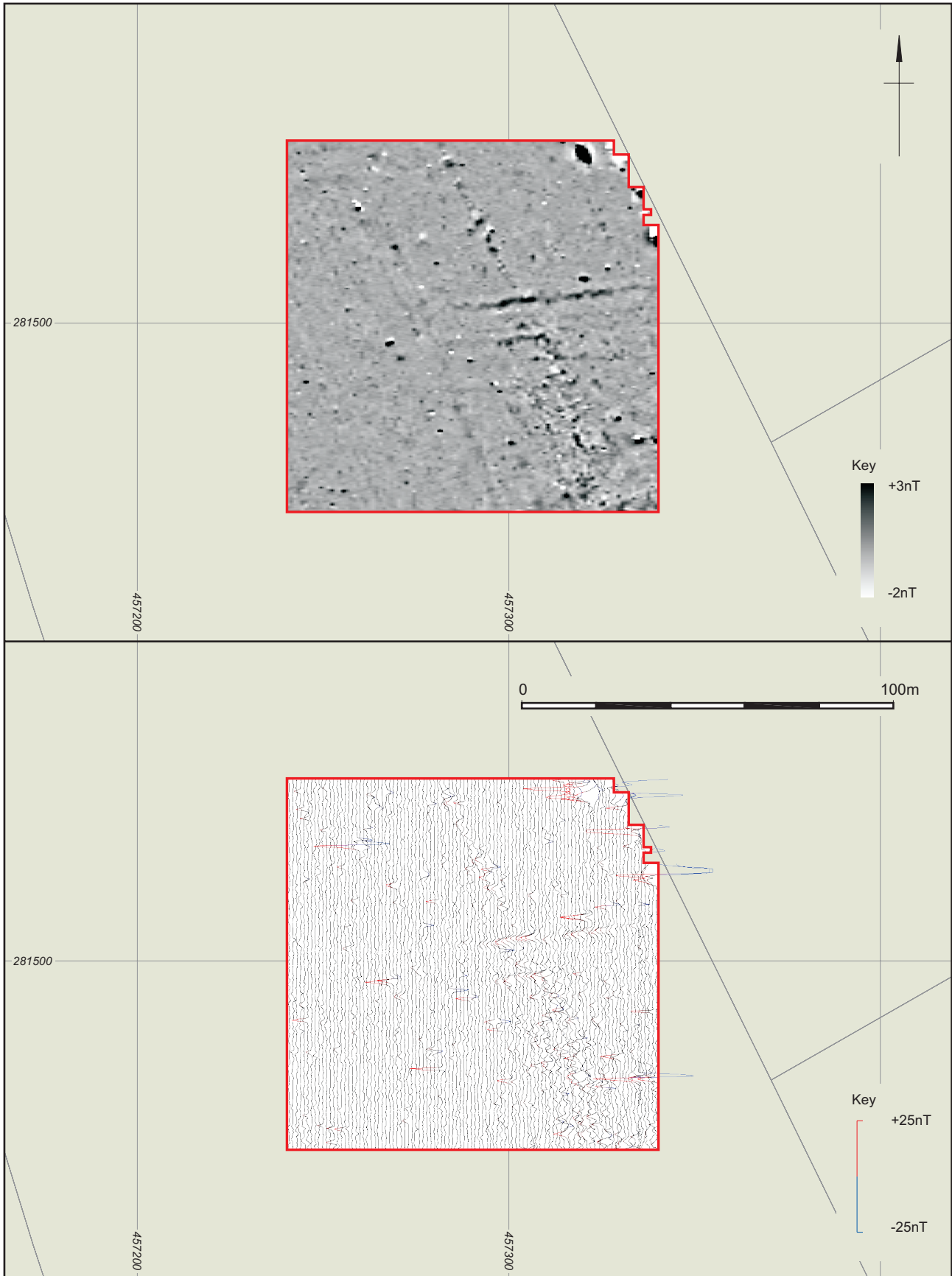
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Turbine 3: Interpretation

Figure 9



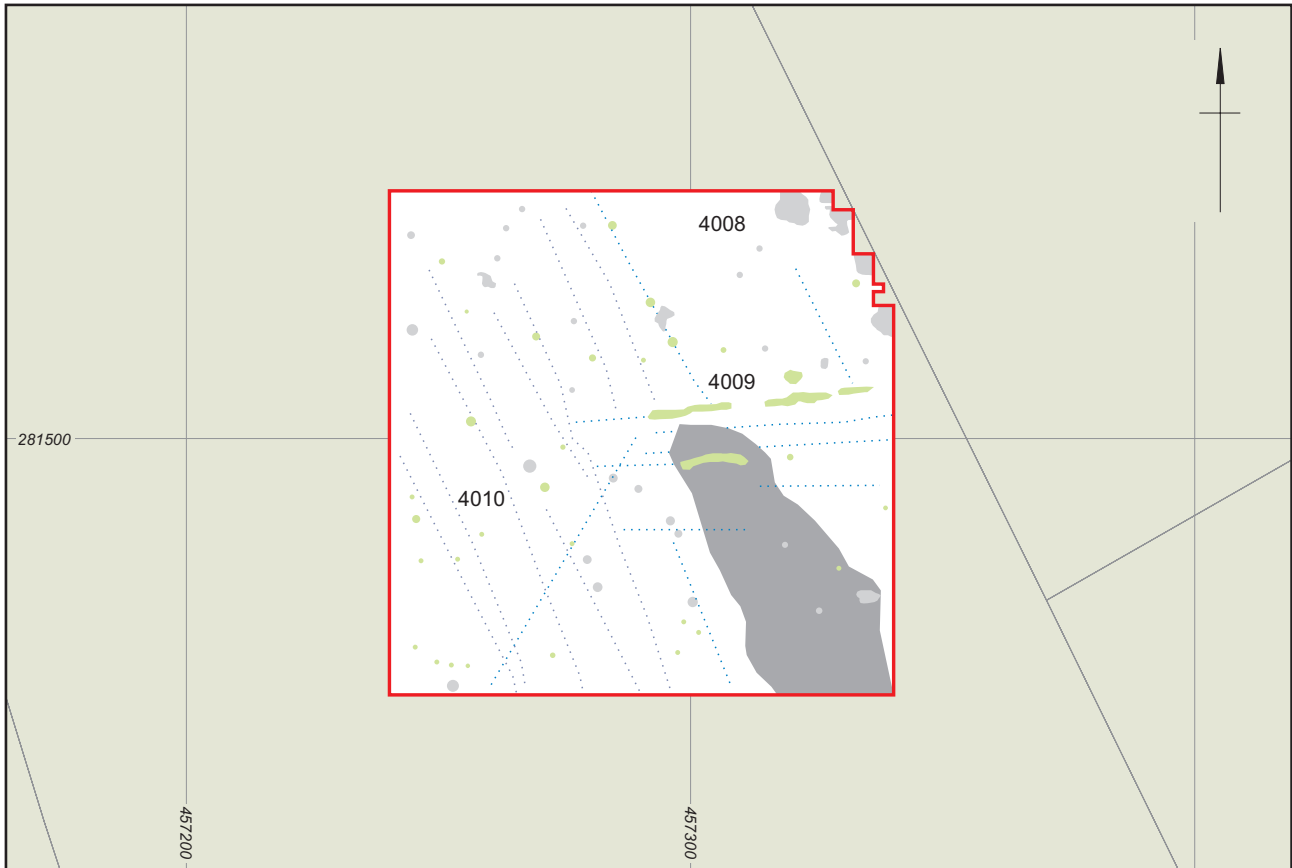
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Turbine 4: Greyscale plot and XY trace

Figure 10



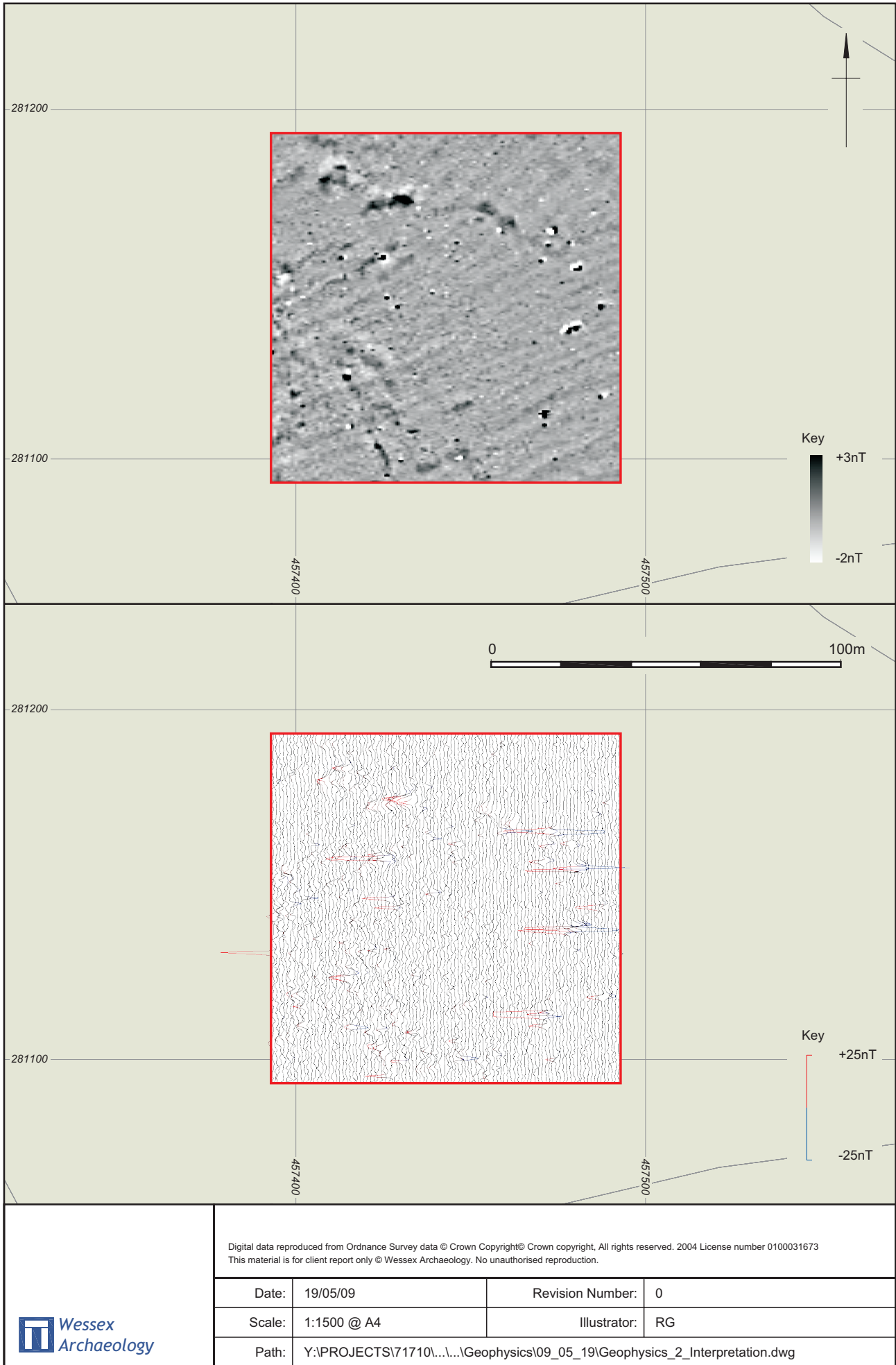
- Archaeology (probable)
- Archaeology (possible)
- Ferrous
- Increased magnetic response
- Modern services
- Trend
- Ploughing trend



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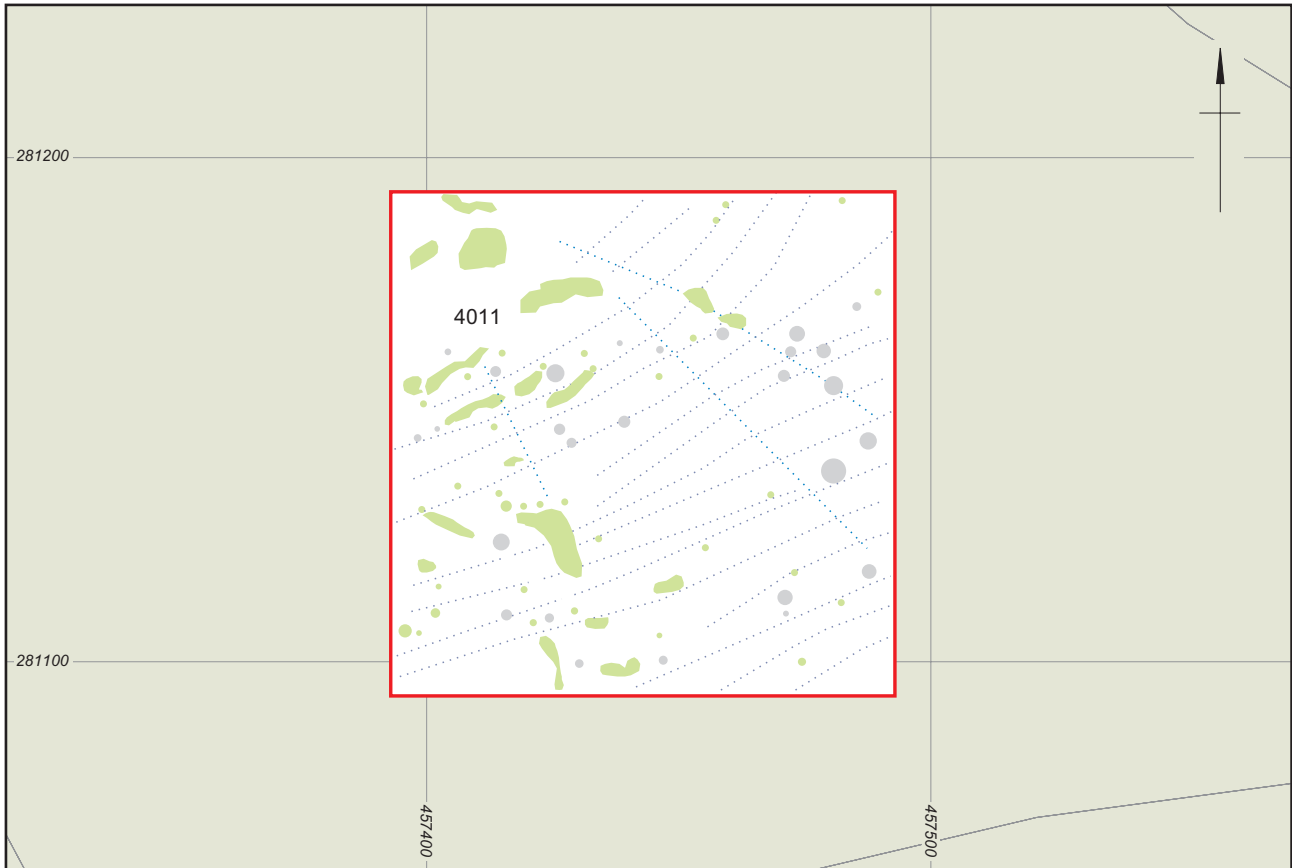
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Turbine 5: Greyscale plot and XY trace

Figure 12



- Archaeology (probable)
- Archaeology (possible)
- Ferrous
- Increased magnetic response
- Modern services
- Trend
- Ploughing trend



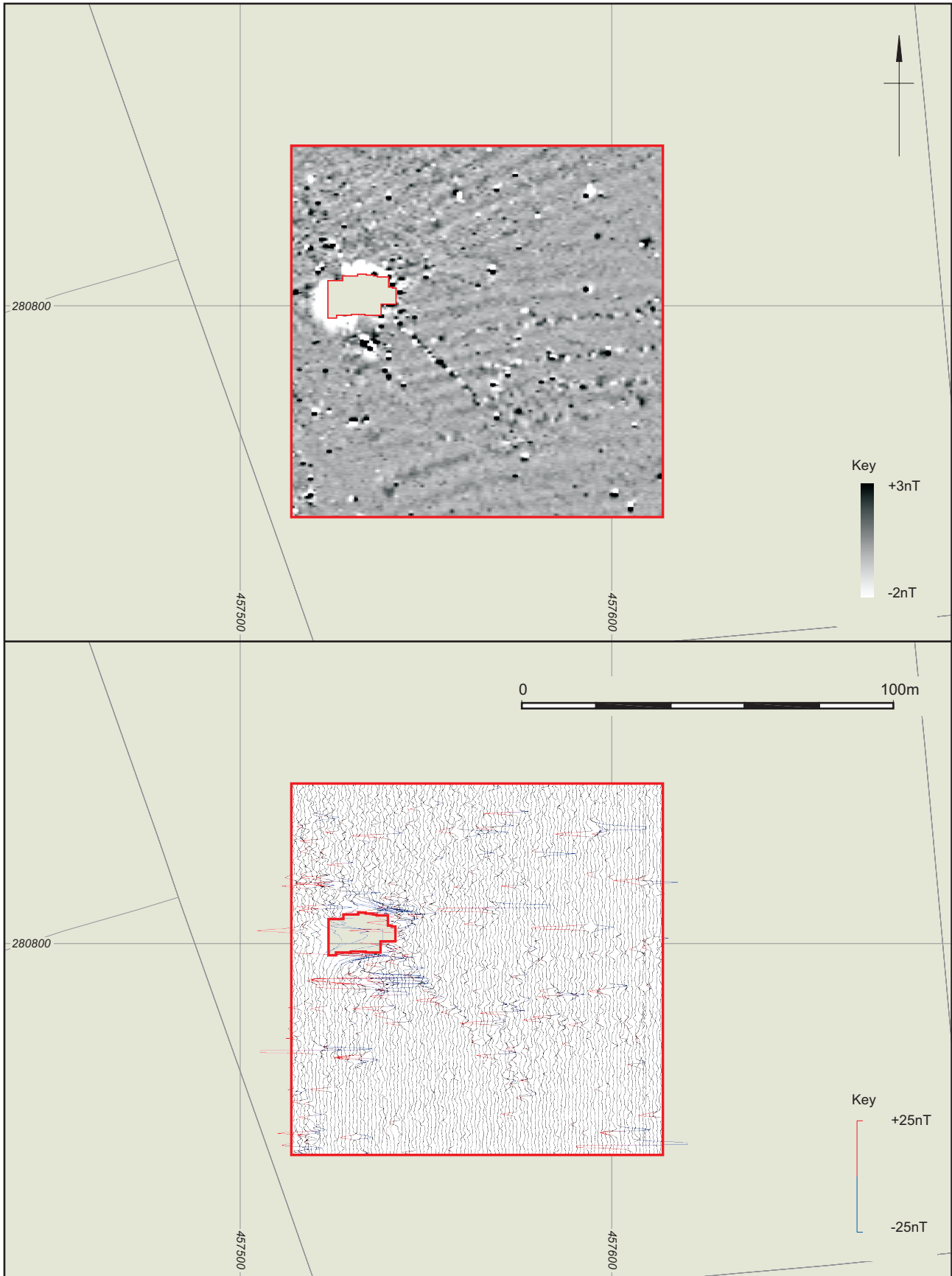
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Turbine 5: Interpretation

Figure 13



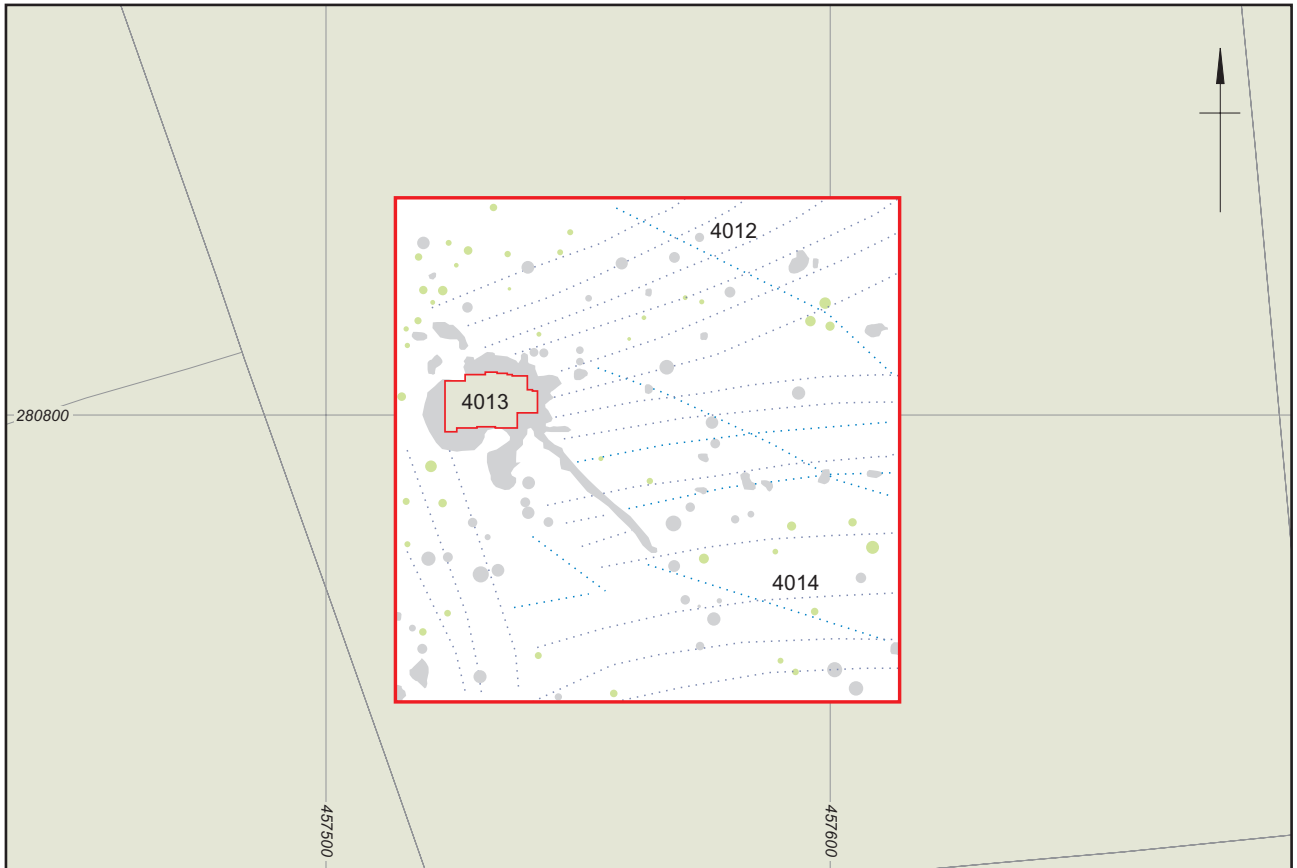
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Turbine 6: Greyscale plot and XY trace

Figure 14



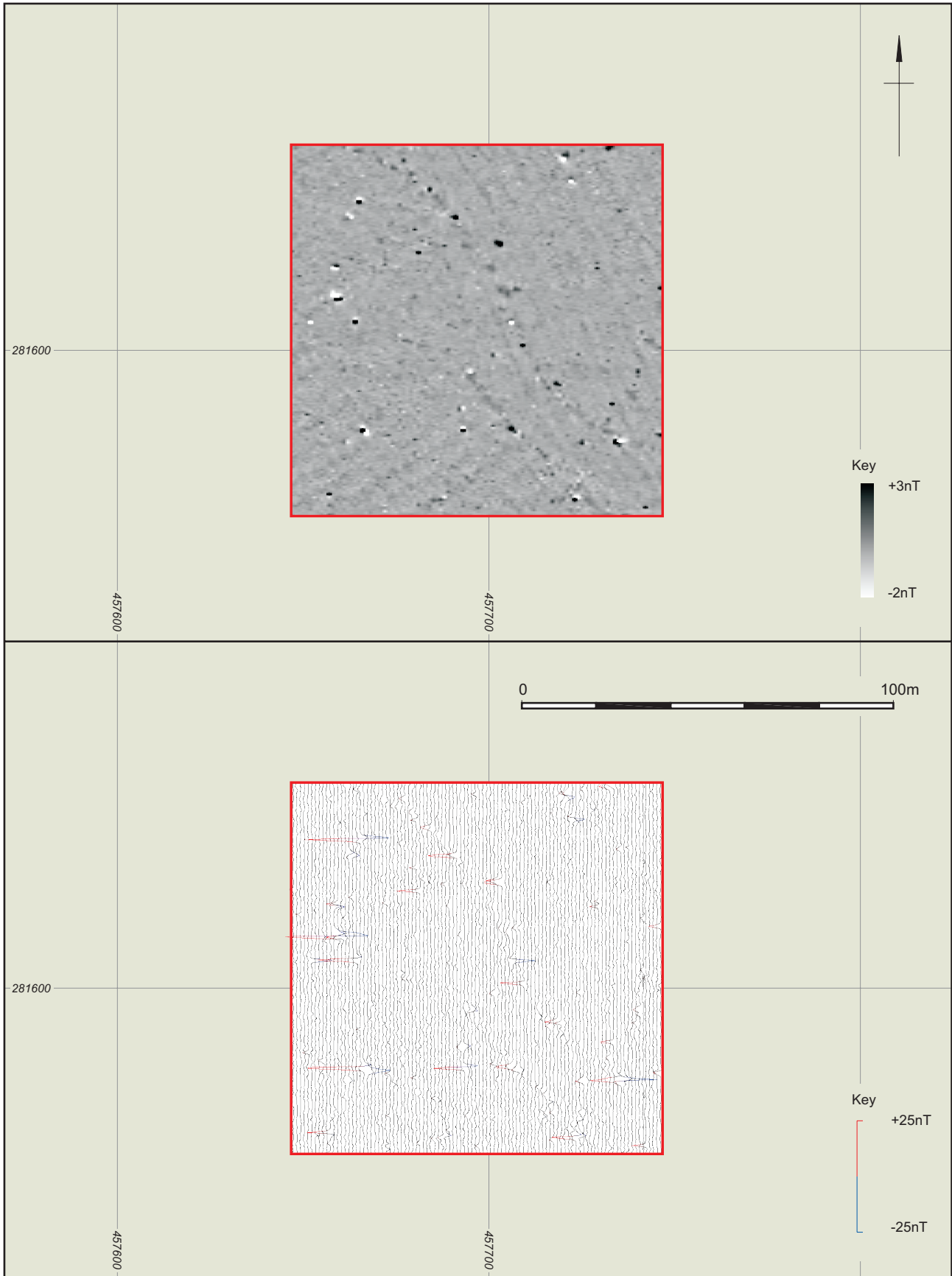
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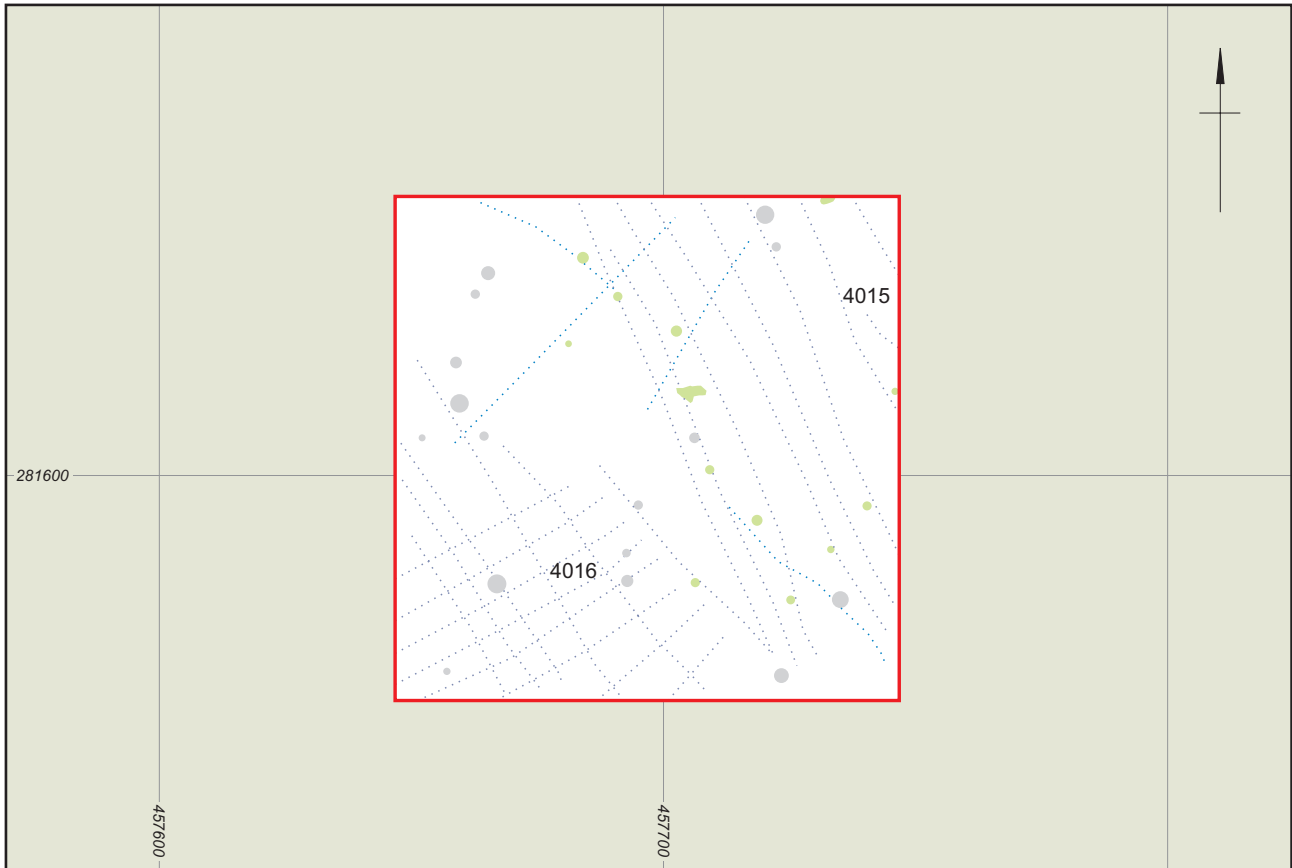
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Turbine 7: Greyscale plot and XY trace

Figure 16



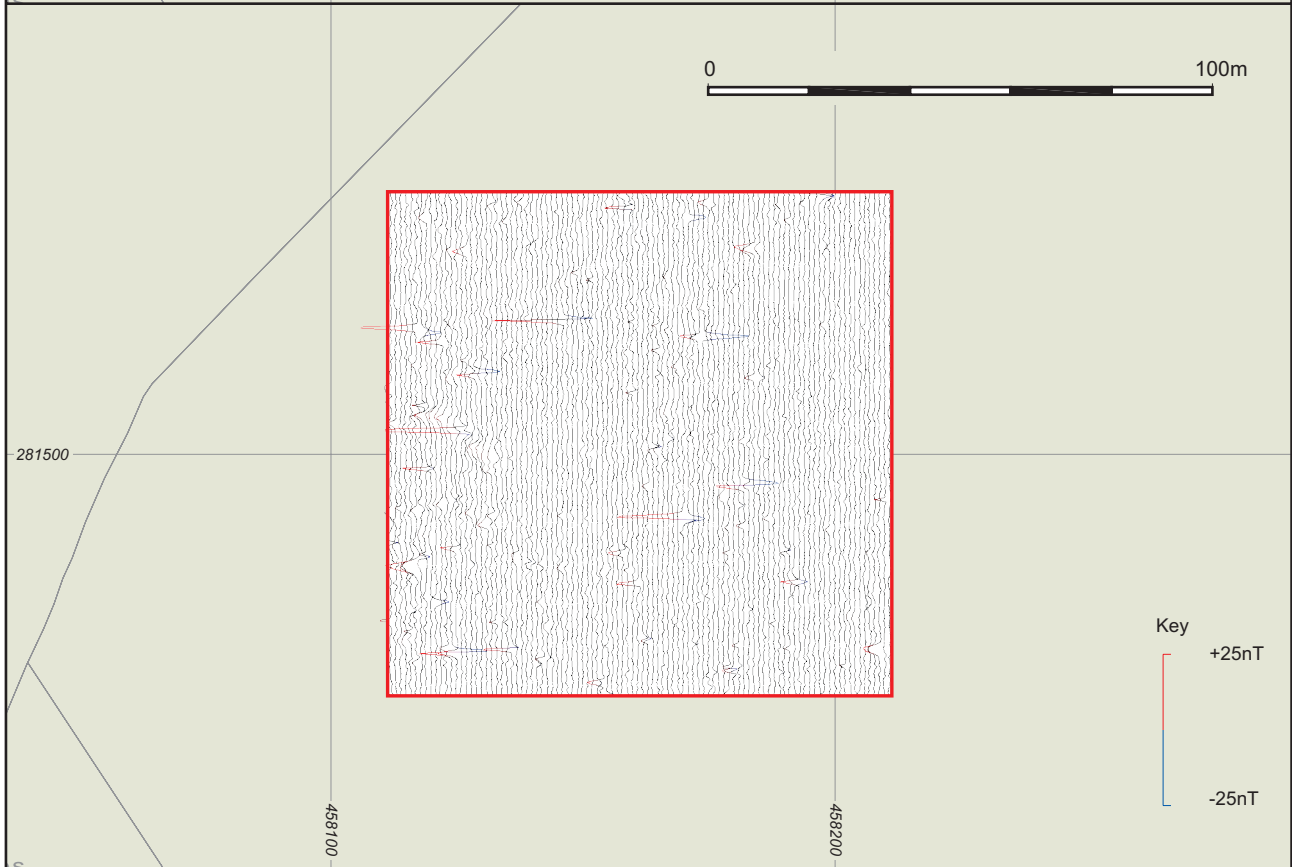
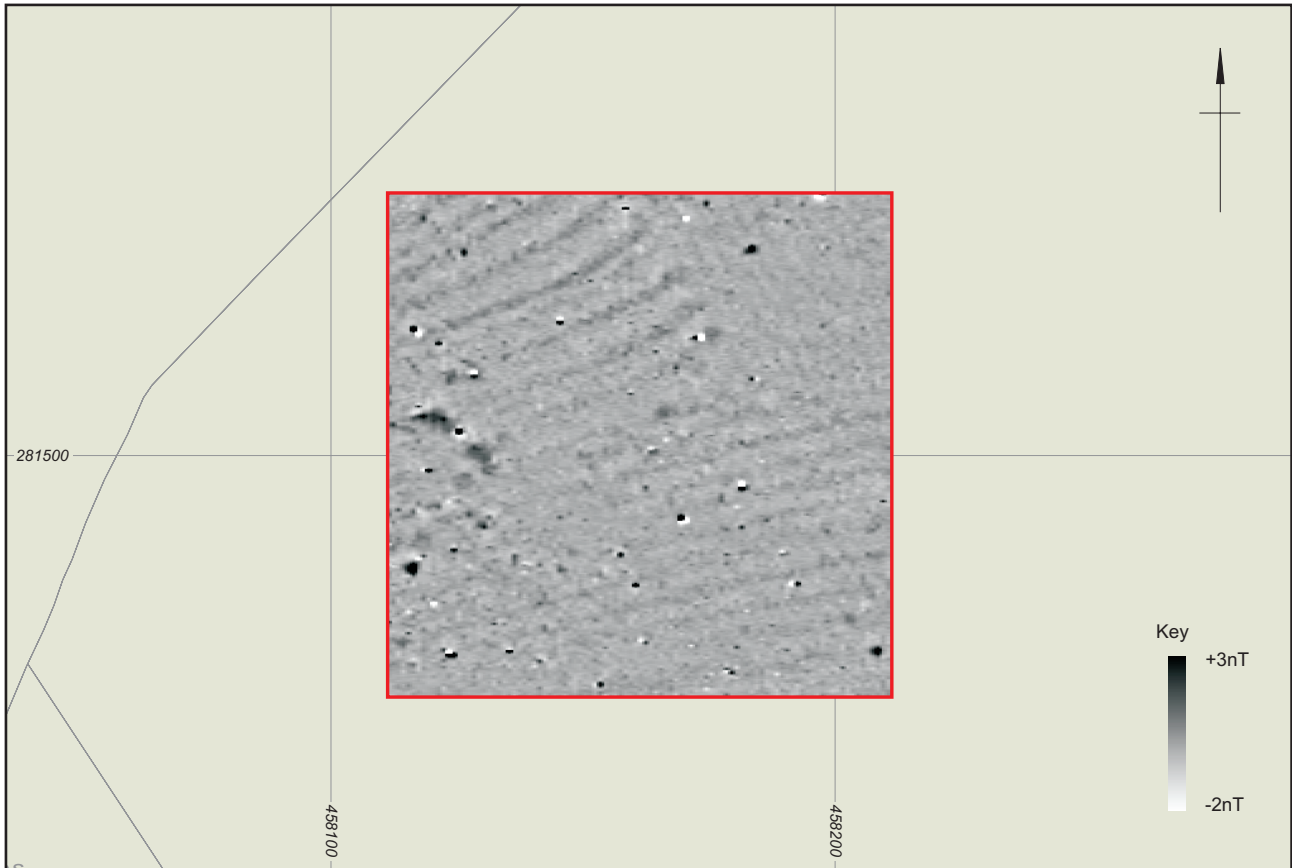
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- Archaeology (possible)
- Ferrous
- Increased magnetic response
- Modern services
- Trend
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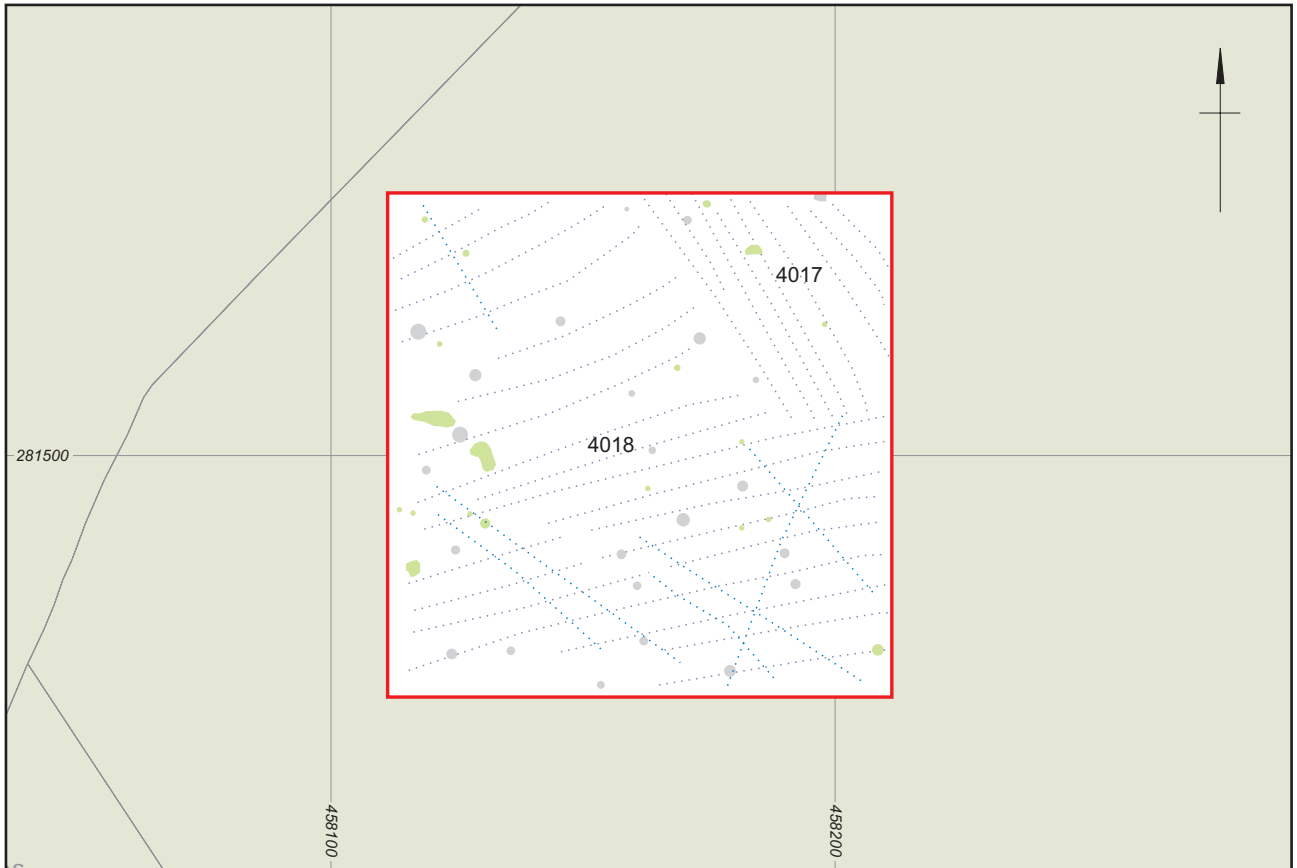
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Turbine 8: Greyscale plot and XY trace

Figure 18



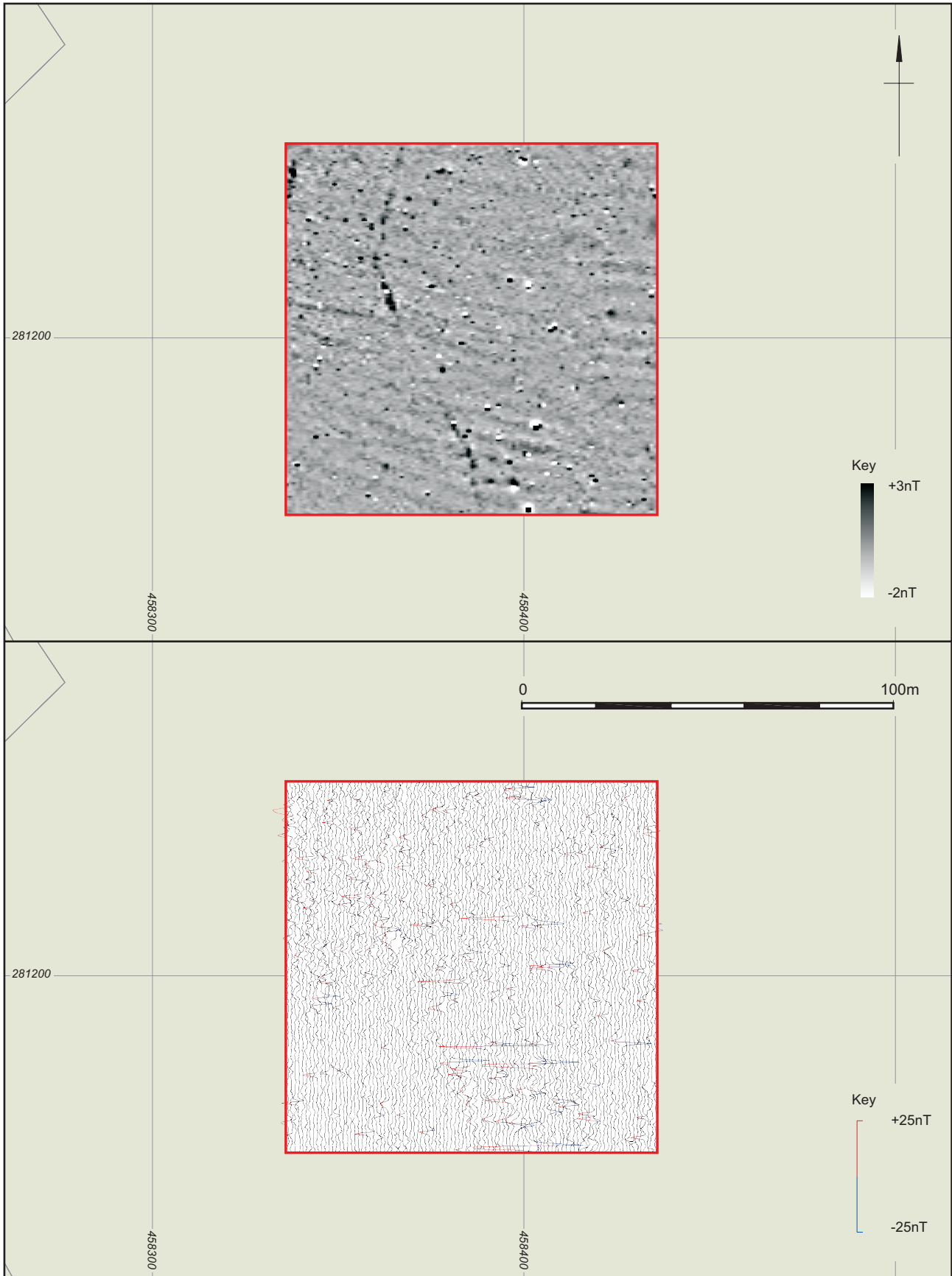
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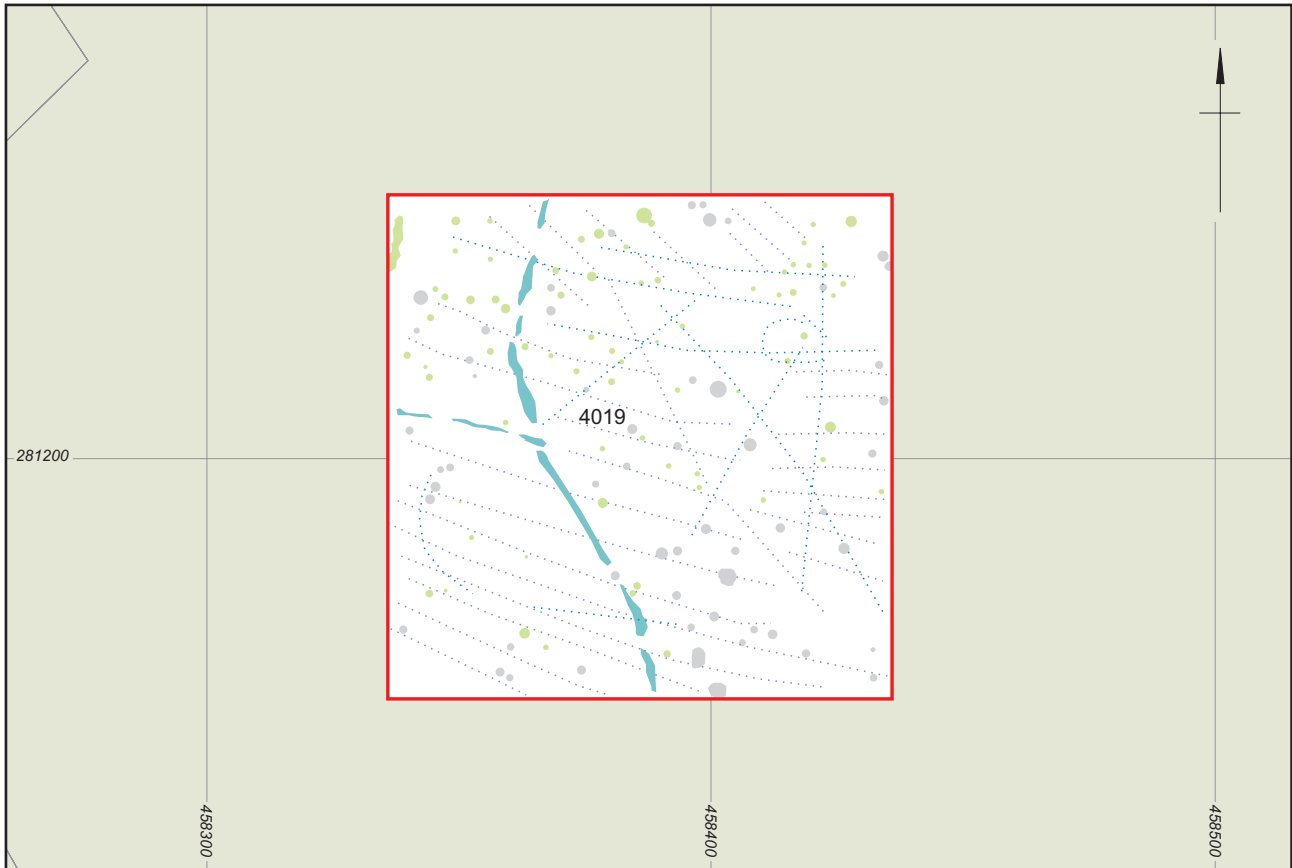
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Turbine 9: Greyscale plot and XY trace

Figure 20



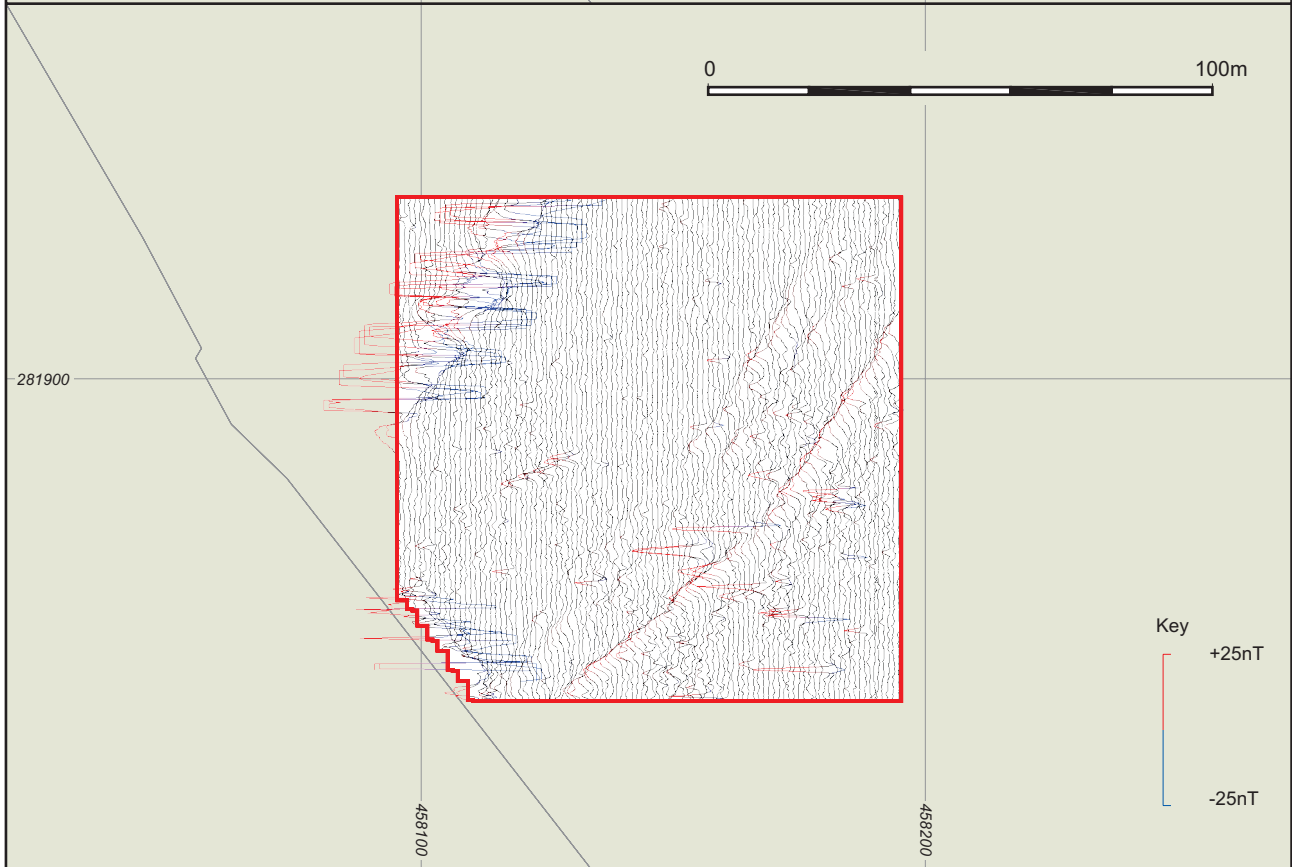
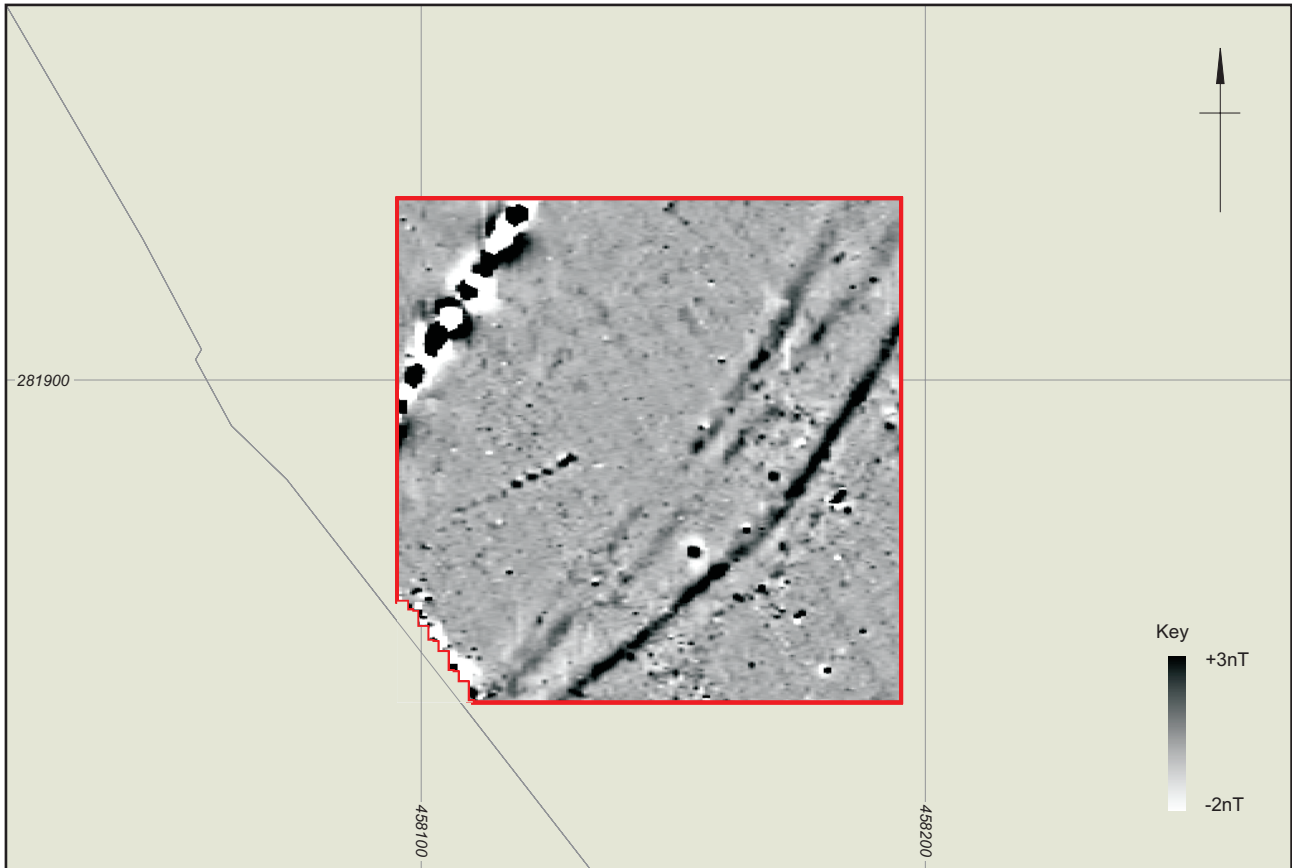
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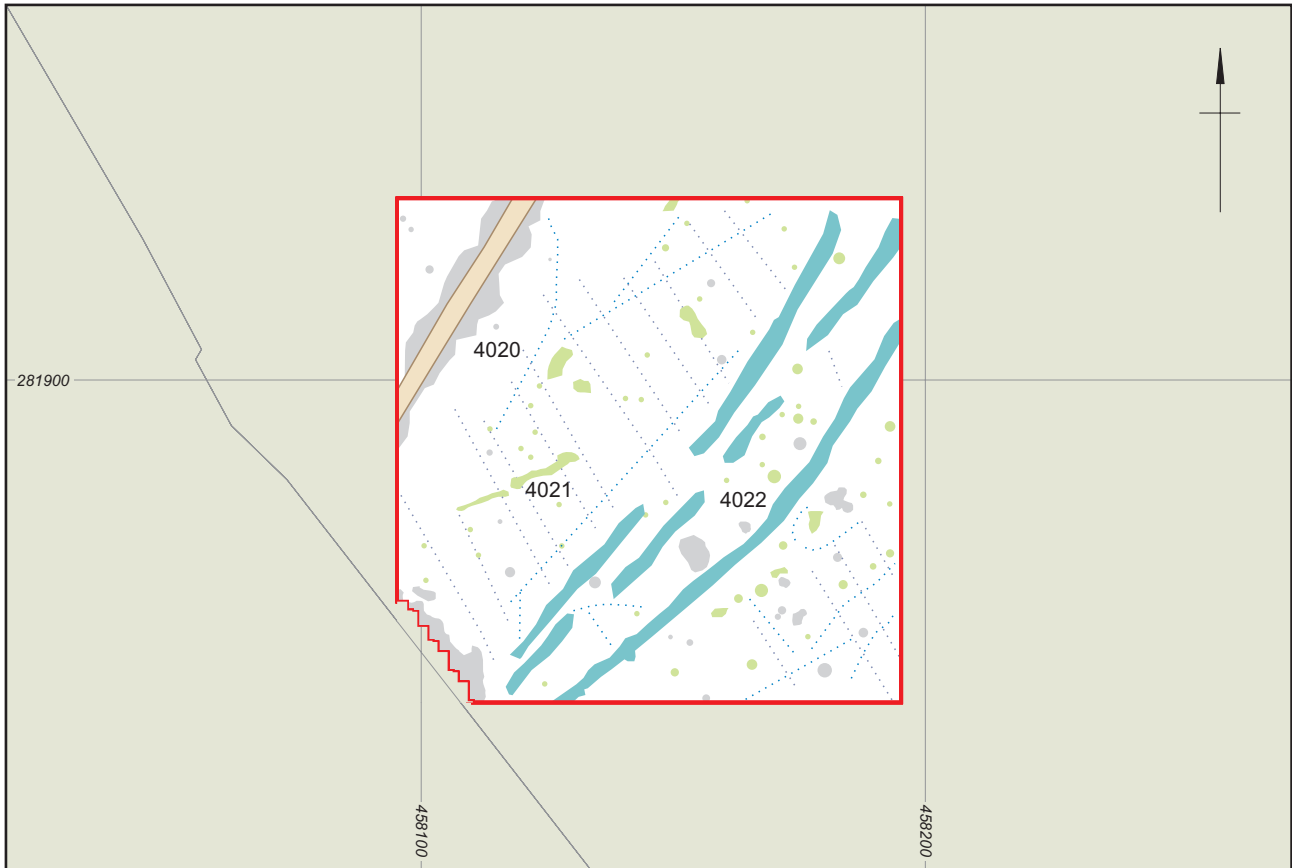
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Turbine 10: Greyscale plot and XY trace

Figure 22



- Archaeology (probable)
- Archaeology (possible)
- Ferrous
- Increased magnetic response
- Modern services
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