NAA

GEOPHYSICAL SURVEY

CRACOE TO RYLESTONE PIPELINE SCHEME, CRAVEN

prepared for
Morrison Utilities

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CRACOE TO RYLSTONE PIPELINE SCHEME, CRAVEN
GEOPHYSICAL SURVEY REPORT

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Disclaimer

The results of geophysical survey may not reveal all potential archaeology and do not provide a comprehensive map of the sub-surface, but only responses relative to the environment. Geological, agricultural and modern responses may mask archaeological features. Short-lived features may not give strong responses. Only clear features have been interpreted and discussed in this report.

CRACOE TO RYLSTONE PIPELINE SCHEME, CRAVEN
GEOPHYSICAL SURVEY REPORT

Summary

Northern Archaeological Associates (NAA) was commissioned by Morrison Utility Services on behalf of Yorkshire Water to undertake a geophysical survey of accessible areas along the proposed route of a new water service pipeline between the villages of Cracoe and Rylstone in Craven, North Yorkshire, BD23 6LA (Fig. 1; SD 97696 60078).

The geophysical survey was carried out on 19 August 2020 and it aimed to assess the archaeological potential of the investigated area and help inform subsequent archaeological mitigation, if required. Five areas containing pasture were targeted, with the geophysical survey totalling c. 2.7ha. Two further areas requiring survey could not be accessed at the time of the fieldwork.

Two areas located to the north of Thorpe Lane – which runs between Cracoe and Threapland House Farm – contain anomalies that are likely to be either modern or agricultural in nature. There are several regularly spaced linear anomalies indicative of agricultural activity, but weak increases in magnetic value meant that it was not possible to determine if they are associated with modern farming or an earlier phase of cultivation. Several linear bipolar anomalies are present that relate to buried utilities. Isolated bipolar anomalies and areas of magnetic disturbance were identified that are likely to be caused by material in the topsoil with a high magnetic susceptibility. A desk-based appraisal for the scheme (NAA 2020) speculated that it was possible for features and material associated with a mid-20th century military camp, formerly located to the north of the scheme, to be present within the survey area. Although the geophysics has not conclusively identified any features associated with the military camp, a high number of bipolar and dipolar anomalies, along with several amorphous anomalies of unknown origin, were recorded in the east of the survey area. Although it is likely that these anomalies are caused by modern activity, the potential for them to be in part caused by material associated with the military camp cannot be completely dismissed.

A third survey area was located to the west of Cracoe in land between the Yorkshire Dales Railway line and an unnamed road linking Cracoe to Hetton. Anomalies here were considered to be caused by either modern or agricultural activity, including cultivation practices of an unknown date, buried utilities and ferrous material in the topsoil.

The desk-based appraisal (NAA 2020) suggested that there was a potential for medieval and post-medieval occupational deposits to be present in survey areas located near to the village cores. Two survey areas were located in the direct hinterland of Rylstone: the first ran through agricultural land behind houses fronting Raikes Lane; the second was located in the east of the village between the B6265 and St Peter's Church. Several anomalies were identified that are indicative of buried archaeological features associated with a shrunken medieval village. In the area behind the houses fronting Raikes Lane, there were several rectilinear and linear anomalies that are likely to belong to former medieval village settlement plots, and two linear anomalies were identified in the area in the east of the village that were suggested to denote a former enclosure. Both areas also contained evidence of ridge and furrow, several trends of unknown origin, as well as anomalies indicative of modern activity.

1.0 INTRODUCTION

1.1 Northern Archaeological Associates (NAA) was commissioned by Morrison Utility Services on behalf of Yorkshire Water to undertake a geophysical survey across five areas totalling c.2.7ha in relation to the proposed upgrading and renewal of water service pipes between Cracoe and Rylstone villages, Craven, North Yorkshire BD23 6LA (Fig. 1; SD 97696 60078).

1.2 This report details the setting (location, topography, geology) and archaeological background of the scheme and sets out the methodology used for the geophysical survey. The interpretation of the geophysical survey was achieved through the analysis of identified anomalies and was aided by a rapid examination of supporting published information. The results of the geophysical survey are discussed below and the interpretations are supported by illustrations. Where feasible, a detailed synopsis of anomalies is provided and, if possible, the features that the anomalies are likely to relate to are suggested.

2.0 LOCATION, GEOLOGY AND SOILS, TOPOGRAPHY

Location

2.1 The proposed scheme comprises the installation of a new pipeline route running between the villages of Cracoe and Rylstone in the Craven district of the Yorkshire Dales National Park (Fig. 1).

2.2 The geophysical survey targeted sections of the route running through undeveloped pasture fields in the hinterland of the villages of Cracoe and Rylstone. Seven areas were identified as requiring survey and are labelled Areas A to G on Figure 2. Areas A and B ran through fields to the north of Thorpe Lane, which links Cracoe village and Threapland House Farm. Area C was located in a pasture field to the north of an unnamed road between Cracoe and Hetton, and south of the Yorkshire Dales Railway line. Areas D and E traversed agricultural land to the south of Fleets Lane but could not be accessed during the survey works, so were not surveyed. Area F was located to the north of houses fronting Raikes Lane in Rylstone, and Area G comprised land in the east of Rylstone between the B6265 and St. Peter's Church.

Geology and soils

2.3 The bedrock geology of the scheme consists of limestone of various formations, with the exception of a small area comprising mudstone of the Bowland Shale Formation that occurs to the west of Cracoe. Superficial deposits across most of the scheme are recorded as Devensian Till, with some small areas of clay, silt and gravel alluvium at the meeting point of Fleets Lane and Raikes Lane, and to the west of Cracoe village (BGS 2020). The soils are mapped as Brickfield 3 Association, consisting of loamy and clayey surface-water gley soils (Soil Survey of England and Wales 1983; Jarvis *et al.* 1984, 123).

Topography

2.4 The scheme is located in a valley in the south of the Yorkshire Dales National Park. The natural topography gently undulates with the lowest elevation at the west end of Raikes Lane at 178m above Ordnance Datum (aOD), while the highest elevation is to the north of Cracoe at 217m aOD. The centre of Rylstone is situated at c.200m aOD.

3.0 ARCHAEOLOGICAL AND HISTORICAL BACKGROUND

3.1 This section summarises information provided in the Archaeology and Built Heritage Appraisal (NAA 2020).

3.2 Evidence of prehistoric or Roman activity within the environs of the scheme is limited to isolated finds of a Bronze Age perforate hammerstone and socketed axe, and a Roman coin in Cracoe.

3.3 Although the villages of Cracoe and Rylstone are both suggested to have early-medieval origins, there is an absence of early-medieval features in the direct hinterland of the scheme. Therefore, there is a low potential for features of this date to occur within the scheme.

3.4 According to the Yorkshire Dales National Park Historic Environment Record (HER), there has been settlement at Threapland since the medieval period. Settlements at Cracoe and Rylstone are first documented following the Norman Conquest when William I granted the surrounding land to the Norman baron Robert de Romille. During the medieval period, Cracoe comprised a small compact village belonging to Marton Priory. From the 15th century until the mid-16th century, Rylstone was located at the centre of the Norton family estate and would have formed a high-status late-medieval settlement. Following the family's demise, the estate was sold at the beginning of the

17th century and several of the high-status buildings fell out of use and were quarried for stone. Material relating to these structures can be seen in several post-medieval buildings in the village and earthworks relating to former buildings. Both villages retain their medieval fabric and there is a high volume of medieval earthworks in the rural lands surrounding them. There is a high potential for buried features associated with medieval agriculture to be present within the scheme and, where works are undertaken near the village cores, there is a potential for medieval occupational deposits.

3.5 There are numerous post-medieval buildings within Cracoe and Rylstone, many of which are designated as Grade II Listed. The majority of these comprise farmhouses and associated auxiliary farm buildings or residential buildings. Threapland House Farm in the north-east of the scheme is a post-medieval construction, with many of the buildings dating to the 18th century. Land surrounding the settlements was farmed during the post-medieval period and it is likely that features associated with agricultural activity of this date survive within the survey area. Where sections of the scheme are located close to the three settlements there is also potential for post-medieval occupation deposits to be present.

3.6 The Yorkshire Dales Railway – constructed between 1902 and 1906 – runs to the north of Area C. There is no evidence from historic mapping to suggest that structural remains associated with the railway infrastructure are likely to be present within the proposed pipeline corridor. However, in areas of the scheme that are located near the railway line, there is potential for surface debris and ground disturbance associated with the construction of the railway.

3.7 Threapland's Second World War military camp was located in a field to the north of Thorpe Lane known as Raikes Plantation. It has been suggested that the camp was equipped with a canteen, and separate red-brick bath houses for men and women, and operated in conjunction with a nearby searchlight battery. Area B runs through the south of the field where the military camp is thought to have been located, so there is potential for associated features and material to be present.

4.0 AIMS AND OBJECTIVES

4.1 The aim of the geophysical survey was to map and record potential buried features located within the water pipeline scheme. Through analysis and interpretation of the results of the geophysical survey, NAA aimed to provide a detailed assessment of the

archaeological potential of the scheme, which would inform future archaeological mitigation strategies.

4.2 The objectives of the survey were to:

- undertake a geophysical survey across areas deemed suitable for data collection;
- attempt to identify, record and characterise any sub-surface remains within the survey boundary;
- assess the archaeological significance of identified anomalies; and
- identify possible concentrations of past activity in order to inform the requirement for any further archaeological investigation.

5.0 METHODOLOGY

5.1 The geophysical survey was undertaken as a gradiometer survey using the Bartington Grad601-2 dual magnetic gradiometer system with data logger. The readings were recorded at a resolution of 0.01nT, and data was collected with a traverse interval of 1m and a sample interval of 0.25m. All recorded survey data was collected with reference to a site survey grid comprising individual 30m x 30m squares. The grid was established using Real Time Kinematic (RTK) differential GPS equipment and marked out using non-metallic survey markers. All grid nodes were set out with a positional accuracy of at least 0.1m as per guidelines (CIfA 2014; Schmidt *et al.* 2015) and could be relocated on the ground by a third party. The base lines used to create the survey grids are shown on Figure 2 and further details are available in Appendix A.

5.2 The processing was undertaken using Geoplot 3.0 software and consisted of standard procedures. For details of the processing steps applied to collected data, see Appendix B.

5.3 On the greyscale plot (Figs. 3, 4, 6 and 8), positive readings are shown as increasingly darker areas, and negative readings are shown as increasingly lighter areas.

5.4 Interpretation of identified anomalies is generally achieved through analysis of anomaly patterning and increases in magnetic response, and is often aided by examining supporting information (including, but not limited to, historic maps, LiDAR survey data, aerial photographs, geophysical survey data and excavation results in the direct hinterland of the scheme). The interpreted data uses colour coding to highlight specific readings in the survey area (Figs. 5, 7 and 9).

Surface conditions and other mitigating factors

5.5 At the time of the survey, the majority of the scheme area contained pasture.

5.6 It was not possible to collect data in several areas: a small farm trackway ran through the north of Area C; land-owner permission had not been attained to access Areas D and E; and the east of Area F and west of Area G contained overgrown vegetation.

5.7 Areas affected by above-ground features that were likely to have a high magnetic susceptibility, such as metal fencing, were avoided when possible while surveying to minimise the potential for their magnetic responses to impinge on the results and to mask potential buried features.

6.0 GEOPHYSICAL SURVEY RESULTS

General anomalies

6.1 Linear anomalies have been characterised to denote the greater or lesser potential for them to relate to buried archaeological features. Anomalies interpreted as of 'greater' potential are considered more likely to be of an archaeological nature, whereas a more tentative interpretation is applied to those with 'lesser' potential as a consequence of weaker increases in magnetic value or the anomalies' incomplete patterning or irregular form.

6.2 There were several weak and diffuse linear trends. These generally failed to produce the necessary increases in magnetic response or patterning in order to be interpreted fully, therefore their origin is unknown. Where trends are located in proximity to anomalies interpreted as plausibly being archaeological in origin, there is a higher potential for them to relate to buried infilled features. Conversely, trends that are located in isolation or near anomalies not suggested to relate to archaeological features are likely to be of a modern, agricultural or geological nature.

6.3 There are several possible alignments of regularly spaced linear anomalies likely to relate to agricultural activity. In the north of the scheme – Areas A, B and C – anomalies are generally composed of weak increases in magnetic value and so it is not possible to identify their origin conclusively. It is plausible that those with a broader spacing are indicative of earlier agricultural features, such as ridge and furrow, while those with a narrow spacing are likely to denote modern ploughing. In the south of the scheme near

Rylstone – Areas F and G – regularly spaced linear anomalies with a broad spacing are likely to be indicative of ridge and furrow.

6.4 Linear bipolar anomalies are likely to be caused by buried ferrous objects. It should be noted that the strength and size of the anomaly reflects the highly magnetic responses of the ferrous material of the buried object rather than actual feature dimensions.

6.5 Isolated dipolar and bipolar anomalies are likely to relate to ferrous or modern objects buried in the topsoil; therefore, only those with broad responses have been depicted in the interpretation plots.

6.6 Areas of magnetic disturbance are composed of concentrations of dipolar and bipolar anomalies. As mentioned above, these are likely to be caused by modern magnetic debris in the topsoil or near the surface.

6.7 Concentrations of isolated amorphous bipolar anomalies on the periphery of the survey area are considered to be caused by external interference. They correspond with the location of areas containing, or are near to, above-ground modern features including metal fences and gates that have a high magnetic susceptibility.

Areas A and B (Figs. 4 and 5)

6.8 Area A contains a high level of magnetic disturbance caused by ferrous material in the topsoil and above-ground features with a high magnetic susceptibility in the periphery of the survey area.

6.9 There are several amorphous-shaped anomalies in the east of Area B (Fig. 7 **B1**) that have an informal curvilinear patterning. It is not known if the patterning of these anomalies is suggestive of buried features, or if it is instead associated with modern activity.

6.10 Several bipolar linear anomalies are present in Area B (Fig. 7 **B2**) that are caused by buried pipes.

6.11 There is a high concentration of isolated bipolar anomalies in the east of Area B that are considered likely to relate to buried ferrous objects. Although very speculative, a former military camp was located to the north of Area B and there is a potential that anomalies in part relate to activity associated with the camp.

6.12 There are several regularly spaced linear anomalies that are indicative of agricultural activity. Generally, these anomalies are composed of very weak increases in magnetic value and so their exact origin is not known.

Area C (Figs. 6 and 7)

6.13 Anomalies identified in Area C were considered to either be modern or agricultural in origin.

6.14 There are two bipolar linear anomalies (Fig. 9 **C1**) that denote buried utilities, and several concentrations of dipolar anomalies, which are caused by magnetic debris in the topsoil.

6.15 Regularly spaced linear anomalies run on a north-northwest to south-southeast orientation. These anomalies are composed of weak increases in magnetic value and, although they are likely to be caused by agricultural activity, their exact origin is not known.

Area F (Figs. 8 and 9)

6.16 Features that are magnetically susceptible have both positive and negative magnetic properties and there is a direct correlation between the magnetic susceptibility of a feature and the strength of its dipolar values. For example, the more magnetically susceptible a feature is, the more visible the dipolar values are. Where a buried anomaly appears with a dipolar or bipolar response, the positive values are used to form the interpretation of the anomaly. Analysis of the geophysical survey data in Area F, has suggested that several of the negative linear responses do not form the negative counterpart of nearby positive anomalies. Instead they are plausibly indicative of buried features with lesser magnetic properties than the surrounding soil. Where this is the case, the negative linear anomalies are identified in the interpretation plots and are discussed below.

6.17 Several rectilinear anomalies (Fig. 11 **F1**) were identified in the west of Area F that are indicative of medieval settlement activity. It is likely that the positive anomalies denote buried structural and occupational deposits, while the negative anomalies are indicative of sunken lanes or hollow ways. To the north of F1, there is a series of parallel linear anomalies (Fig. 11 **F2**). Although tentative, it is plausible that these anomalies relate to

ditches associated with a track or road that was a back lane to the village during the medieval period.

6.18 Several linear anomalies (Fig. 11 **F3**) were identified to the north of F1 and F2 but were composed of inconsistent increases in magnetic value and poor patterning. Consequently, it is not possible to determine if they are contemporary with anomalies suggested to belong to medieval occupation deposits, or to later activity. Although very tentative, it can be speculated that they are agricultural in origin and denote former enclosures, field boundaries or a headland between different cultivation regimes.

6.19 Several amorphous anomalies (Fig. 11 **F4**) were identified in the south of Area F. It is uncertain if these anomalies are associated with the medieval settlement activity or, given their strong increases in magnetic value and lack of patterning, if they are of a modern origin.

6.20 Several linear anomalies (Fig. 11 **F5**) with very weak increases in magnetic value correspond with the location of former field boundaries recorded on the First Edition 1853 Ordnance Survey map (not illustrated in this report).

6.21 Several alignments of regularly spaced linear anomalies were identified with a broad spacing that is suggestive of ridge and furrow.

6.22 Bipolar anomalies (Fig. 11 **F6**) were identified in the south of Area F that are composed of increases in magnetic value that is usually considered indicative of ferrous material.

6.23 Bipolar anomalies (Fig. 11 **F7**) in the west of Area F are likely to be modern in origin and associated with above ground objects with a high magnetic susceptibility.

Area G (Figs. 8 and 9)

6.24 In the west of Area G, there is a series of linear anomalies (Fig. 11 **G1** and **G2**) that are likely to belong to the same feature and denote an enclosure.

6.25 It is unknown if the linear areas of magnetic disturbance (Fig. 11 **G3**) to the east of G1 and north of G2 also denote an infilled feature or relate to a build-up of magnetic debris.

6.26 Several trends (Fig. 11 **G4**) have been identified between G1 and G2, that may be associated with archaeological deposits, but lack the necessary increases in magnetic value to be conclusively interpreted and so their origin is unknown. Trends (Fig. 11 **G5**)

in the east of Area G generally have a patterning and form that is suggestive of agricultural activity, and so although very tentative these are considered less likely to be archaeological in origin.

6.27 There are two alignments of regularly spaced linear anomalies that are associated with agricultural activity. Those on a west-southwest to east-northeast orientation are likely to denote ridge and furrow. It is uncertain if those on a north-northwest to south-southeast orientation are also indicative of ridge and furrow or instead are caused by a headland.

7.0 CONCLUSIONS

7.1 NAA undertook a geophysical survey of five areas totalling c.2.7ha in advance of a proposed upgrading and renewal of water service pipes between Cracoe and Rylstone villages.

7.2 The results of the survey have not conclusively identified any buried archaeological features in the north of the scheme. Instead, the observed anomalies largely relate to modern and agricultural activity. The desk-based appraisal (NAA 2020) detailed that a former Second World War military camp was located in fields to the north of Thorpe Lane, which runs between Cracoe and Threapland House Farm. Geophysical survey directly to the south of the suggested location of the camp did not identify any anomalies that were likely to belong to the camp. Several bipolar and amorphous anomalies were identified as being either of a modern or an unknown origin but the potential for them, at least in part, to be caused by material associated with the military camp cannot be completely dismissed.

7.3 Two survey areas were located in the direct hinterland of Rylstone village and identified extensive anomalies suggestive of a shrunken medieval village. In particular, numerous rectilinear anomalies were identified directly to the north of houses fronting Raikes Lane that are indicative of medieval settlement plots. It is possible to distinguish between buried anomalies likely to be associated with structural and occupational deposits, and hollow ways running between building platforms. Several parallel linear anomalies were also identified to the north of the settlement, which, although tentative, are plausibly indicative of ditches associated with a trackway or road that formed a back lane to the village. The second survey area was located in the east of Rylstone and contained several linear anomalies that are likely to relate to a buried former enclosure.

Both areas also contained trends of unknown origin, evidence of possible ridge and furrow and anomalies likely to be of a modern origin.

8.0 STORAGE AND CURATION

8.1 At the time of writing this report, the records of the geophysical survey are held by NAA. All material will be appropriately packaged for long-term storage in accordance with national guidelines (CIfA 2014; Schmidt *et al*. 2015). An online OASIS form will be completed within three months of the completion of the project. This will include submission of a PDF version of the final report to the Archaeology Data Service via the OASIS form.

REFERENCES

Aspinal, A., Gaffney., C. and Schmidt, A. (2008) *Magnetometry for Archaeologists*. Plymouth: Altamira Press.

Bartington Instruments Ltd. (n.d.) *Grad601 Single Axis Magnetic Field Gradiometer system*. Oxford: Bartington Instruments Ltd.

British Geological Survey (BGS) (2020) *Geology of Britain Viewer*. [Online] Available at: https://www.bgs.ac.uk/discoveringGeology/geologyOfBritain/viewer.html (accessed on 24/07/2020).

Chartered Institute for Archaeology (CIfA) (2014) *Standard and Guidance for Archaeological Geophysical Survey*. Reading: Chartered Institute for Archaeologists.

Gaffney, C. and Gater, J. (2003) *Revealing the Buried Past*. Stroud: Tempus Publishing.

Jarvis, R. A., Bendelow, V. C., Bradley, R. I., Carroll, D. M., Furness, R. R., Kilgour, I. N. L. and King, S. J. (1984) *Soils and their use in Northern England*. Soil Survey of England and Wales Bulletin No. 10. Harpenden: Rothamsted Experimental Station.

National Library of Scotland (2020) *Explore Georeferenced Maps.* [Online] Available at: https://maps.nls.uk/geo/find/#zoom=13&lat=54.01031&lon=-2.10553&layers=102&b=1&z=1&point=54.02760,-2.04804 (accessed on 27/08/2020).

NAA (2020) *Cracoe to Rylstone Pipeline Scheme, Craven: Archaeology and Built Heritage Appraisal.* Northern Archaeological Associates. Unpublished Report 20–47.

Schmidt, A., Linford, P., Linford, N., David, A., Gaffney, C., Sarris, A. and Fassbinder, J. (2015) *EAC Guidelines for the Use of Geophysics in Archaeology*. EAC Guidelines 2. Belgium: Europae Archaeologiae Consilium.

Soil Survey of England and Wales (1983) *Soils of England and Wales 1:250 000 Map Sheet 1: Northern England*. Southampton: Ordnance Survey.

APPENDIX A
TECHNICAL INFORMATION

GRADIOMETER SURVEY

Magnetic surveys measure distortions in the earth's magnetic field caused by small magnetic fields associated with buried features (Gaffney and Gater 2003, 36) that have either remanant or induced magnetic properties (Aspinal *et al*. 2008, 21–26). Human activity and inhabitation often alter the magnetic properties of materials (*ibid*., 21) resulting in the ability for numerous archaeological features to be detected through magnetic surveys. Intensive burning or heating can result in materials attaining a thermoremanent magnetisation; examples of which include kilns, ovens, hearths and brick structures (*ibid*., 27; Gaffney and Gater 2003, 37). When topsoil that is rich with iron oxides fills a man-made depression in the subsoil, it creates an infilled feature, such as a pit or ditch, with a higher magnetic susceptibility compared to the surrounding soil (Aspinal *et al*. 2008, 37–41; Gaffney and Gater 2003, 22–26). Magnetic surveys can also detect features with a lower magnetically susceptibility than the surrounding soil, an example of which is a stone wall.

LIMITATIONS

Poor results can be due to several factors including short-lived archaeological occupation/use or sites with minimal cut or built features. Results can also be limited in areas with soils that are naturally deficient in iron compounds, or in areas with soils overlying naturally magnetic geology, which will produce strong responses masking archaeological features.

Overlying layers, such as demolition rubble or layers of made ground, can hide any earlier archaeological features. The presence of above-ground structures and underground services containing ferrous material can distort or mask nearby features.

Particularly uneven or steep ground can increase the processing required, or distort results beyond the capabilities of processing. It is also possible in areas containing dramatic topographical changes that natural weathering, such as hillwash, often in combination with intensive modern ploughing, will reduce the topsoil on slopes and towards the peaks of hills, and possibly destroy or truncate potential archaeological features. Conversely, features at the bottom of slopes may be covered by a greater layer of topsoil and so, if buried features are present, they appear faint within the results, if at all.

Over processing of data can also obscure or remove features, especially if they are on the same orientation as the direction of data collection. Consequently, where possible, attempts are made to ensure that data is not collected on the same orientation as known potential features and that data quality is sufficient to minimise the required data processing.

INSTRUMENTATION

The data was collected using handheld Bartington Grad 601-2 fluxgate gradiometers. The Bartington 601-2 is a single-axis, vertical component fluxgate gradiometer comprising a data logger battery cassette and two sensors. The sensors are Grad-01-1000L cylindrical gradiometer sensors mounted on a rigid carrying frame; each sensor contains two fluxgate magnetometers with 1m vertical separation.

The difference in the magnetic field between the two fluxgates in each sensor is measured in nanoTesla (nT). NAA gradiometer data is recorded with a range of ±100nT, which equates to a resolution of 0.01nT. It should be noted that the actual resolution is limited to 0.03nT as a consequence of internal instrumental noise (Bartington Instruments Ltd n.d., 23).

The gradiometer records two lines of data on each traverse, the grids are walked in a zig-zag pattern amounting to 15 traverses. The gradiometers are calibrated at the start of every day and recalibrated whenever necessary.

SURVEY DETAILS

Table A1: survey summary

Item	Survey
Grid size	30m x 30m
Traverse interval	1m
Reading interval	0.25m
Direction of first traverse	N
Number of grids	54
Area covered	2.7ha

Table A2: baseline coordinates

Item	Survey
gpA	398229.614 460437.074
gpB	398245.878 460411.865
gpC	397276.822 459878.966
gpD	397303.711 459891.857
gpE	396854.795 458755.449
gpF	396859.872 458726.06
gpG	396974.579 458782.944
gpH	396977.120 458753.037

Table A3: site information and conditions

Item	Detail
Geology	Limestone (various Formations)
Superficial deposits	Devensian Till
Soils	Brickfield 3 Association
Topography	Highest: 217m aOD/Lowest: 178m aOD
Land use	Agricultural – pasture
Weather conditions prior to and during survey	Overcast

APPENDIX B

DATA PROCESSING INFORMATION

Gradiometer survey data is downloaded using the Bartington Grad 601 software and the processing was undertaken using Geoplot 3.0 software.

Table B1: commonly applied techniques

Process	Effect
Zero mean traverse	Removes stripping that can occur as a consequence of using multi-sensor arrays or a zig-zag data collection method by setting the mean reading for each traverse to zero.
Destagger	Removes stagger in the data introduced through inconsistent data collection pace and often exacerbated through the zig-zag methodology.
Clip	Clips data above or below a set value to enhance potential weaker anomalies.
Despike	Removes random spikes or high readings to reduce the appearance of dominant readings, often created by modern ferrous objects that can distort the results.
Low pass filter	Removes low-frequency waves or broad anomalies such as those caused by strong or large gradual variations in the soil's magnetic susceptibility often caused by geological or natural changes in the substrata.
Interpolation	Used to smooth or reduce the blocky appearance of data by improving the spatial density and increase the quantity of data points in the Y direction.

Table B2: processing steps

Minimal processing	Increased processing
• Zero mean traverse +5/-5 • Destagger:	• Low pass filter • Interpolate Y, expand – linear, x2

APPENDIX C

DATA VISUALISATION INFORMATION

FIGURES

The data was used to produce a series of images to demonstrate the results of surveys, which are detailed below:

- Greyscale/colourscale plot – this visualised the results as a shaded drawing with highest readings showing as black, running through different shades to lowest showing as white.
- XY-trace plot – this creates a line drawing showing the peaks and troughs of the readings as vertical offset from a centreline.
- Interpreted plot – through detailed analysis, anomalies have been interpreted and possible features identified. Interpretation drawings are used to show potential features and in particular to reinforce and clarify the written interpretation of the data. Anomalies have been characterised using the terminology detailed in the following section, and have been assigned colour coding outlined in keys found on the relevant figures associated with this report.

MAGNETIC ANOMALIES AND TERMINOLOGY

Table C1: lexicon of terminology

Terminology	Detail
Anomaly	Any outstanding high or low readings forming a particular shape or covering a specific area within the survey results.
Feature	A man-made or naturally created object or material that has been detected through investigation works and has sufficient characteristics or supporting evidence for positive identification.
Magnetic susceptibility	The ability of a buried feature to be magnetically induced when a magnetic field is applied.
Magnetic response	The strength of the changes in magnetic values caused by a buried feature with either a greater or lesser ability to be magnetised compared with the soil around it. Anomalies are considered to have either strong/weak or positive/negative responses. The strength of magnetic response (along with patterning) can be essential in determining the nature of an anomaly, but it should be noted that the size or strength of the magnetic response does not correlate with the size of the buried feature.
Patterning of an anomaly	The shape or form of an individual anomaly.
Thermoremanence	The affect caused when a material has been magnetically altered through a process of heating. Thermoremanent magnetisation occurs when an object or material is heated passed the Curie Point and acquires a permanent magnetisation that is associated with the magnetic field that they cooled within (Gaffney and Gater 2003, 37).

Anomalies can represent different features created by human, agricultural or modern activity, or natural pedological or geological changes in the substrata.

Anomalies interpreted with a 'greater' categorisation are considered more likely to be of the interpreted characterisation; whereas a more tentative interpretation is applied to those with a 'lesser' categorisation as a consequence of weaker increases in magnetic response or the anomaly's incomplete patterning or irregular form.

The strength and size of anomalies can vary depending on the magnetic properties of the feature, the magnetic susceptibility of the soil, the depth to which the feature is buried, and the state of preservation.

Table C2: characterisation of anomalies

Characterisation	Detail
Archaeology	
Linear anomaly (archaeology)	Linear anomalies with a positive or negative magnetic responses and composed of a patterning or shape that is suggestive of a buried archaeological feature. These are often indicative of structural remains or infilled features such as ditches. The strength of anomaly signal can be suggestive of the properties of the feature. Negative linear anomalies represent upstanding or infilled features that are less magnetically susceptible than background readings, for example structures or ditches composed of a non-igneous stone material. Bipolar linear anomalies considered to be of an archaeological nature are indicative of material with a high magnetic susceptibility, such as a brick wall.
Isolated anomaly (archaeology)	Isolated anomalies, or anomalies with a more amorphous form, possibly represent infilled features or thermomagnetic features such as areas of heating/burning of an archaeological origin. Unless associated with conclusively identified archaeological remains, such as linear anomalies, absolute identification of positive responses can be problematic as it is often not possible to decipher if they are of an archaeological, modern or agricultural origin. Consequently, isolated positive responses are not shown within the interpretation unless composed of a broad form or belonging to a series of isolated positive responses. Bipolar responses considered likely to be of an archaeological feature are also interpreted as isolated anomaly (archaeology). These are considered to relate to material with a very strong magnetic susceptibility or thermoremanent magnetisation.
Trends	Weak and diffuse anomalies with an uncertain origin are denoted by trends. It is possible that these belong to archaeological features but, given their weak signatures or incomplete patterning, it is equally plausible that they relate to agricultural features or natural soil formations.
Agriculture	
Field boundary	Isolated linear anomalies that are likely to be indicative of former land divisions. A more conclusive interpretation is given to linear anomalies that correspond with the location of field boundaries recorded on historic maps, aerial photos or LiDAR coverage of the site.
Ridge and furrow?	Broadly spaced linear anomalies that are likely to be indicative of earlier forms of agriculture, such as ridge and furrow. These often correspond with

Characterisation	Detail
	the location of earthworks visible on the ground or identified on aerial photos or LiDAR survey coverage.
Agriculture?	Regularly spaced linear anomalies that are likely to be of an agricultural nature. However, the lack of supporting information, weak responses, or non-uniform distribution means that it is unclear as to the nature or origin of the agricultural process they are caused by.
Modern	
Bipolar response (modern)	Positive anomalies with associated negative 'halo' (bipolar) denote features with a strong magnetic response that are likely to be of a modern origin. Isolated bipolar responses of a modern nature are likely to relate to buried ferrous material or objects, such as metallic agricultural debris. If a trend is noted in the alignment or spacing of isolated bipolar responses, it is possible that they are indicative of ferrous fittings or connectors used on non-magnetic buried utilities. Linear bipolar anomalies are likely to be indicative of modern services.
Magnetic disturbance	Areas of increased magnetic response denote areas of disturbance containing a high concentration of dipolar and/or bipolar responses, or above-ground features external to the development area. These are generally considered to be caused by modern debris in the topsoil, although it is possible that the disturbance is in part caused by isolated archaeological material or geological or pedological changes in the substrata.

APPENDIX D

OASIS FORM

OASIS DATA COLLECTION FORM: England

OASIS ID: northern1-403437

Project details

Project name	Cracoe to Rylstone Pipeline Scheme
Short description of the project	Geophysical Survey
Project dates	Start: 19-08-2020 End: 19-08-2020
Previous/future work	Yes / Not known
Type of project	Field evaluation
Monument type	NONE None
Significant Finds	NONE None
Methods & techniques	"Geophysical Survey"
Development type	Pipelines/cables (e.g. gas, electric, telephone, TV cable, water, sewage, drainage etc.)
Prompt	National Planning Policy Framework - NPPF
Position in the planning process	Pre-application
Solid geology (other)	Limestone (various formations)
Drift geology (other)	Devensian Till
Techniques	Magnetometry

Project location

Country	England
Site location	NORTH YORKSHIRE CRAVEN CRACOE Cracoe to Rylstone, Craven
Postcode	BD23 6LA
Study area	2.7 Hectares
Site coordinates	SD 97696 60078 54.036491610698 -2.035183156918 54 02 11 N 002 02 06 W Point
Height OD / Depth	Min: 178m Max: 217m

Project creators

Name of Organisation	Northern Archaeological Associates
Project brief originator	Morrison Utility Services Ltd
Project design originator	Northern Archaeological Associates
Project director/manager	Alice James
Project supervisor	Oskar Sveinbjarnarson
Type of sponsor/funding body	Developer

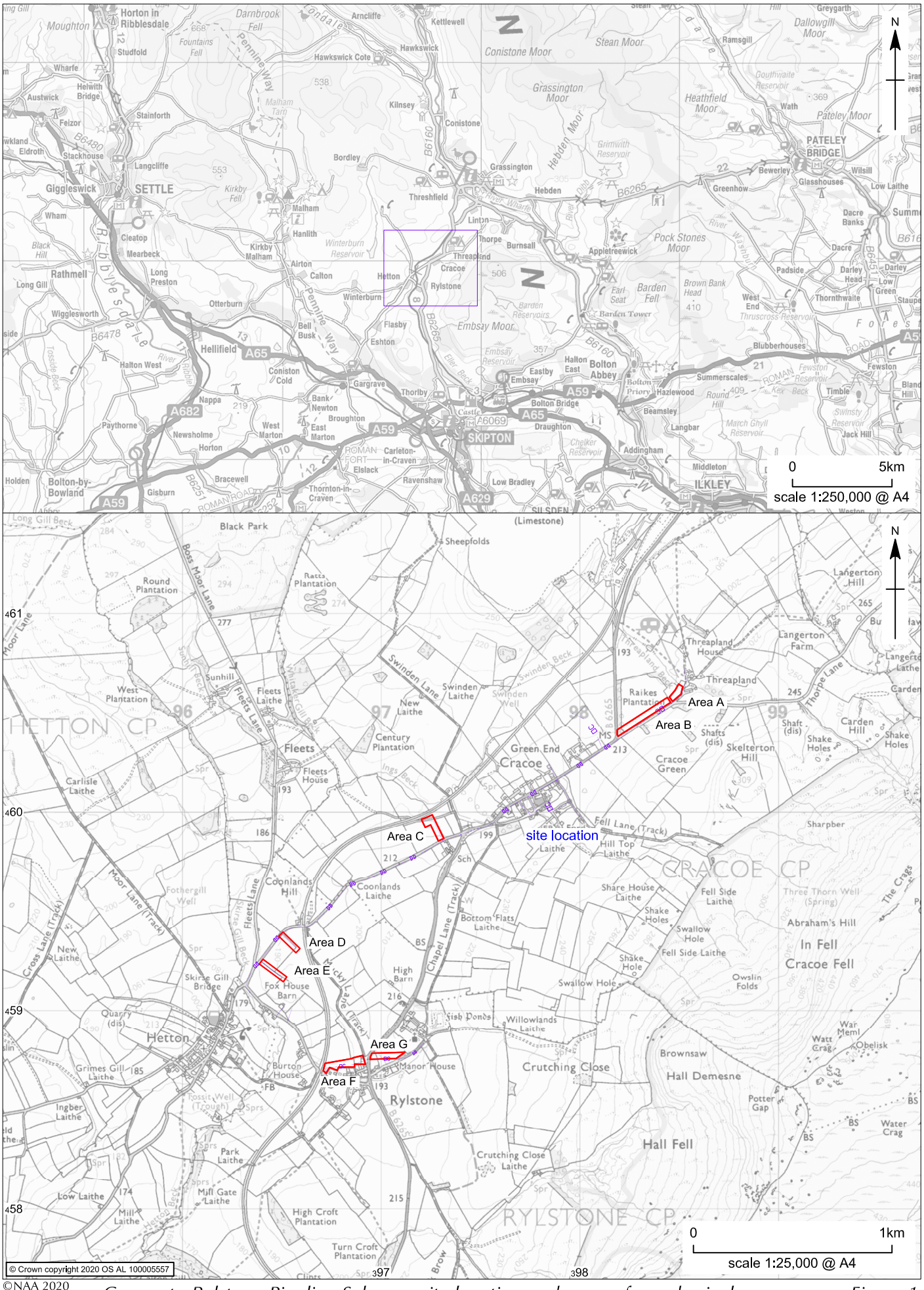
Project archives

Physical Archive Exists?	No
Digital Archive recipient	Northern Archaeological Associates
Digital Contents	"none"
Digital Media available	"Geophysics"
Paper Archive Exists?	No

Project bibliography 1

Publication type	Grey literature (unpublished document/manuscript)
Title	Cracoe to Rylstone Pipeline Scheme, Craven: Geophysical Survey
Author(s)/Editor(s)	James, A
Other bibliographic details	20-75
Date	2020
Issuer or publisher	NAA
Place of issue or publication	Barnard Castle
Description	Blue Spine

Entered by	Alice (aj@naaheritage.com)
Entered on	11 September 2020



Cracoe to Rylstone Pipeline Scheme: site location and areas of geophysical survey *Figure 1*

NAA
HERITAGE & ARCHAEOLOGY

KEY
- geophysical survey baseline
- geophysical survey grid
- geophysical survey area
- proposed pipeline route
- proposed survey area

N

0 500 m

scale 1:10,000 @ A3

Area A
Area B
Area C
Area D
Area E
Area F
Area G
gpA
gpB
gpC
gpD
gpE
gpF
gpG
gpH

Cracoe to Rylstone Pipeline Scheme: geophysical survey areas

Figure 2

NAA
HERITAGE & ARCHAEOLOGY

KEY
proposed pipeline route
proposed survey area
0 500 m
scale 1:10,000 @ A3
N

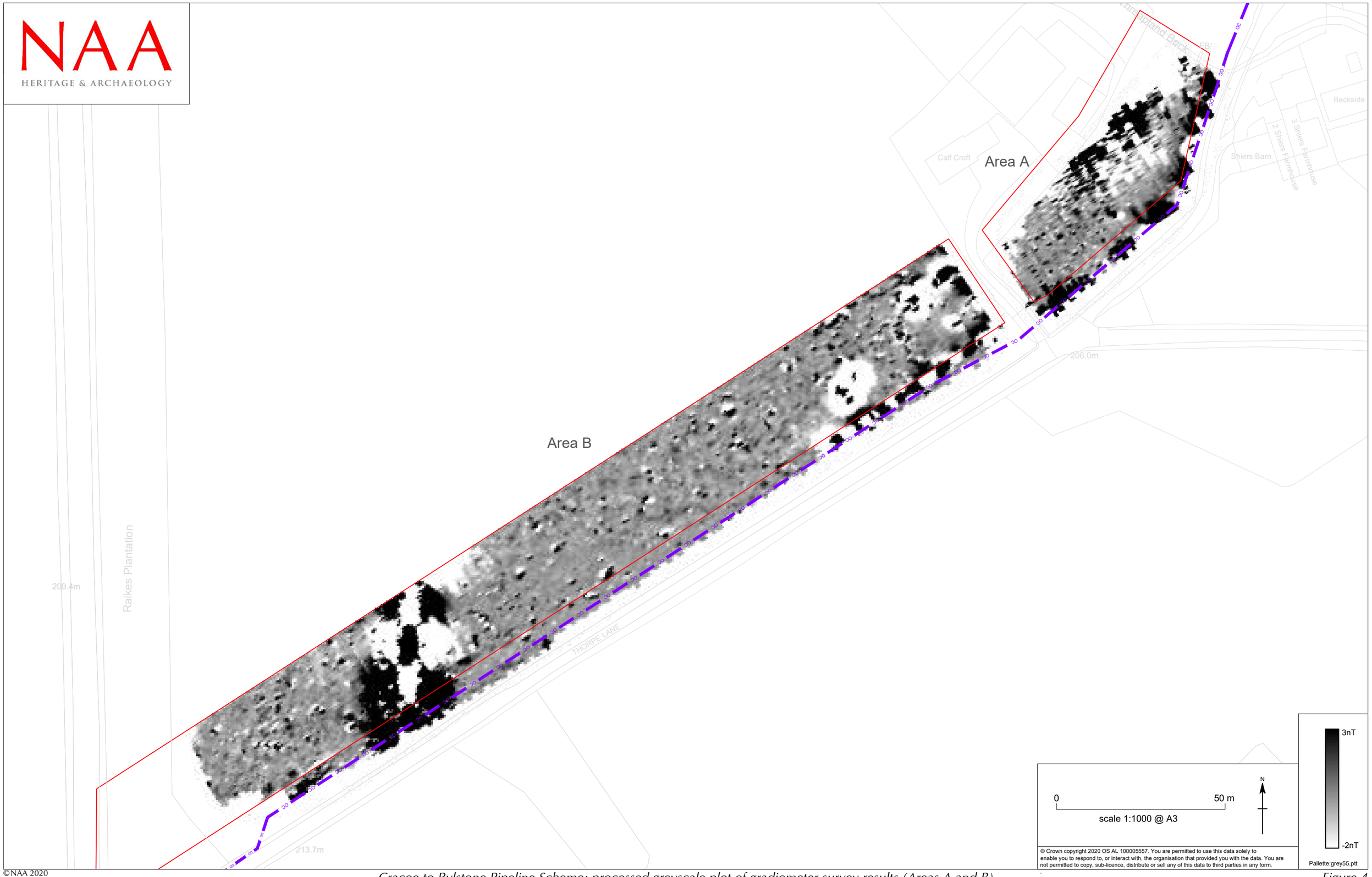
5nT
-4nT
Pallette:grey55.ptt

Area A
Area B
Area C
Area D
Area E
Area F
Area G

Cracoe to Rylstone Pipeline Scheme: unprocessed greyscale plots of gradiometer survey results

Figure 3

NAA
HERITAGE & ARCHAEOLOGY



Cracoe to Rylstone Pipeline Scheme: processed greyscale plot of gradiometer survey results (Areas A and B)

Figure 4

NAA
HERITAGE & ARCHAEOLOGY

Area A

Area B

B1

B2

B2

Calf Croft

Shiers Barn

2 Shiers Farmhouse

3 Shiers Farmhouse

Beckside

206.0m

209.4m

Railkes Plantation

213.7m

THORPE LANE

KEY

positive amorphous anomaly (unknown origin)

agriculture?

bipolar response (modern)

magnetic disturbance (modern)

edge of geophysical survey

proposed pipeline route

proposed survey area

N

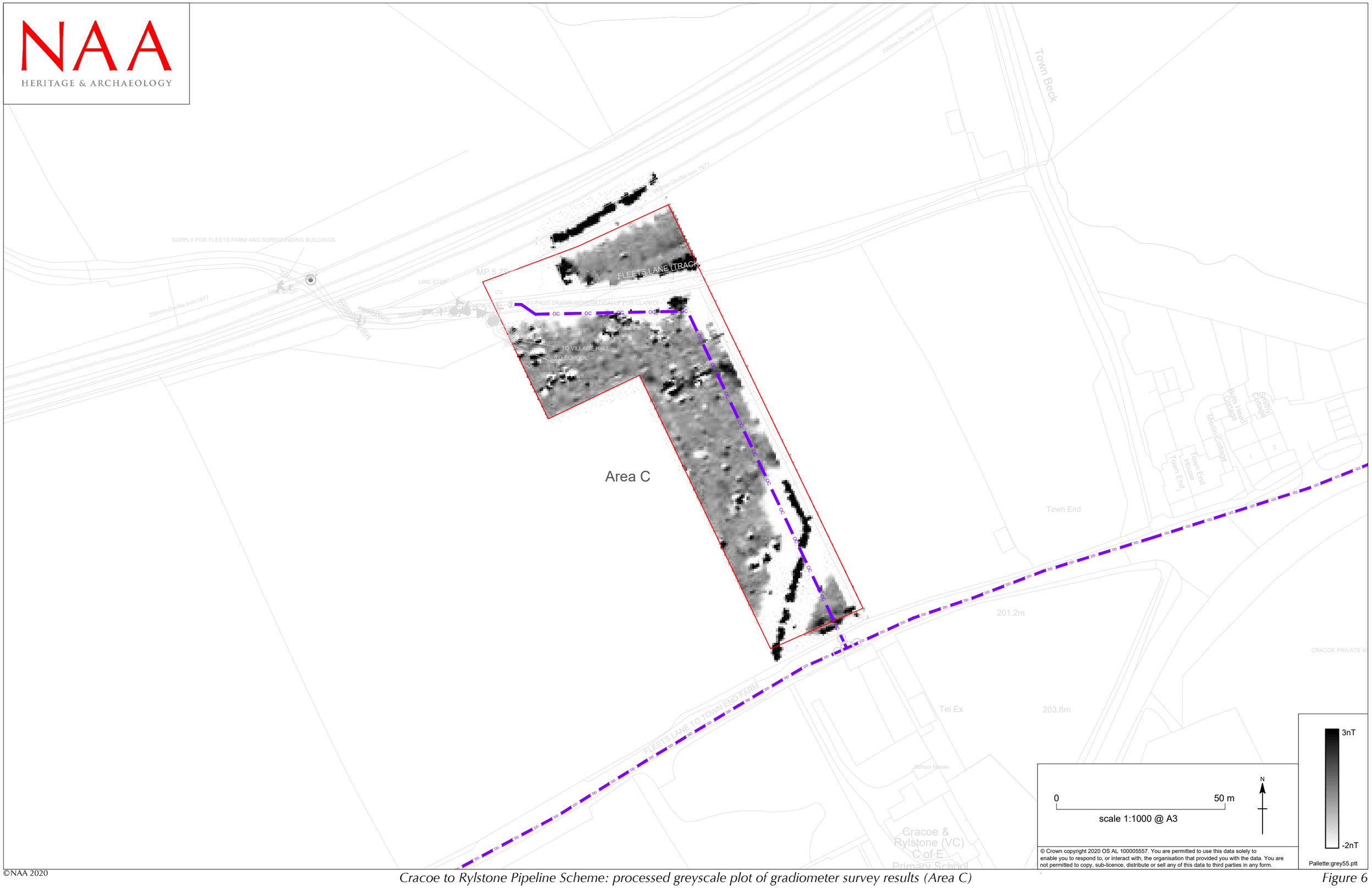
0 50 m

scale 1:1,000 @ A3

Cracoe to Rylstone Pipeline Scheme: interpretation of gradiometer survey results (Areas A and B)

Figure 5

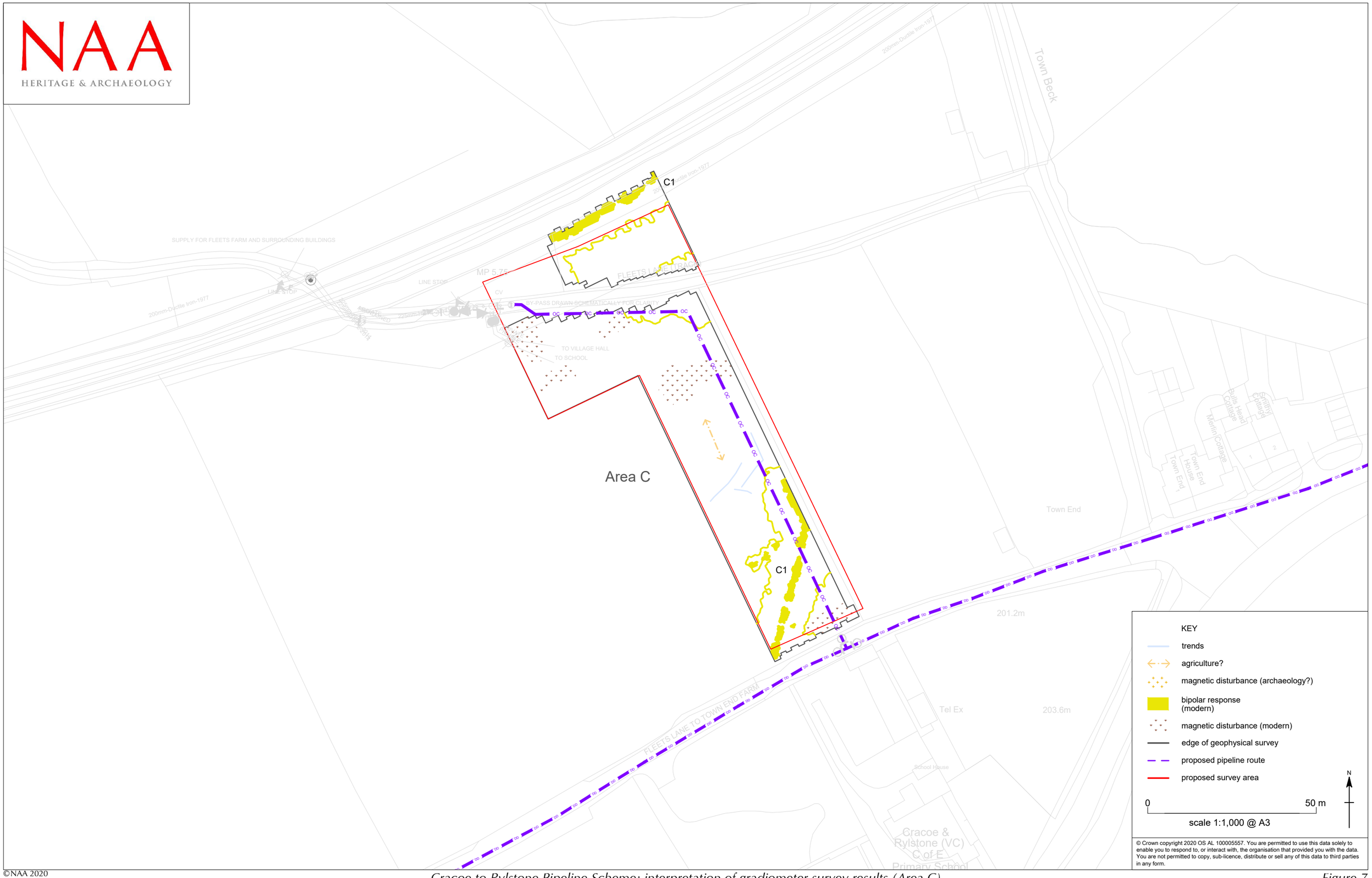
NAA
HERITAGE & ARCHAEOLOGY



Cracoe to Rylstone Pipeline Scheme: processed greyscale plot of gradiometer survey results (Area C)

Figure 6

NAA
HERITAGE & ARCHAEOLOGY



Cracoe to Rylstone Pipeline Scheme: interpretation of gradiometer survey results (Area C)

Figure 7

NAA
HERITAGE & ARCHAEOLOGY

Area F

Area G

193.2m

196.9m

201.2m

196.3m

B 6265

Lay-by

CHURCH LANE

RAIKES LANE

Manor Cottage

Manor Croft

Ivy Cottage

Manor House

Garris Lodge

Garris Croft

Mill House

Yew Tree Farm

Yew Tree Barn

The Croft

The Barn

Lodge Cottage

Rylstone Lodge

Lodge Farm

No 2

No 1

Lodge Farm Cottage

Rylstone

Trough

Pond

LB

FB

GP

0

50 m

scale 1:1000 @ A3

N

3nT

-2nT

Pallette:grey55.ptt

Cracoe to Rylstone Pipeline Scheme: processed greyscale plot of gradiometer survey results (Areas F and G)

Figure 8

NAA
HERITAGE & ARCHAEOLOGY

Area F

Area G

F1
F2
F3
F4
F5
F6
F7

G1
G2
G3
G4
G5
G5

193.2m
196.9m
201.2m
196.3m
193.2m
B 6265
CHURCH LANE
RAIKES LANE
Jay-by
Manor Cottage
Ivy Cottage
Manor House
Rylstone Lodge
Lodge Farm
No 1
No 2
Lodge Farm Cottage
The Barn Lodge Cottage
Lodge Cottage
Garris Lodge
Garris Croft
Mill House
Yew Tree Farm
Yew Tree Barn
The Croft
Trough
Pond
LB
FB
GP
MP 4.7
Rylstone

KEY

- positive linear anomaly (greater / lesser)
- negative linear anomaly (greater / lesser)
- positive amorphous anomaly (unknown origin)
- field boundary?
- trends
- ridge and furrow?
- magnetic disturbance (archaeology?)
- bipolar response (modern)
- magnetic disturbance (modern)
- edge of geophysical survey
- proposed pipeline route
- proposed survey area

N

0 50 m

scale 1:1,000 @ A3

Cracoe to Rylstone Pipeline Scheme: interpretation of gradiometer survey results (Areas F and G)

Figure 9