



Tween Bridge Solar Farm

A Nationally Significant Infrastructure Project in the Energy Sector

Preliminary Environmental Information Report

Technical Appendix 8.2 – Written Scheme of Investigation

October 2023



Visit: www.tweenbridgesolar.co.uk
Email: info@tweenbridgesolar.co.uk



**magnitude
surveys**

**Written Scheme of Investigation
For a Geophysical Survey
of**

**Tween Bridge
Thorne, Doncaster South Yorkshire
To
Crowle, North Lincolnshire**

**For
Pegasus Planning Group**

Magnitude Surveys Ref: MSSE1548

South Yorkshire HER Event Number: TBC

North Lincolnshire HER Event Number: TBC

OASIS Number: TBC

June 2023



magnitude surveys

3 Captain Street

Bradford

BD1 4HA

01274 926020

info@magnitudesurveys.co.uk

Version	Purpose/Revision	Author	Figures	Approved By	Date Issued
0.1	WSI	Krasimir Dyulgerski BA MRes	Krasimir Dyulgerski BA MRes	Alison Langston BA PCIfA	16 May 2023
0.2	Edits to text	Sacha O'Connor	Sacha O'Connor	Krasimir Dyulgerski BA MRes	30 May 2023
0.3	Redline boundary change	Sacha O'Connor	Sacha O'Connor	Krasimir Dyulgerski	15 June 2023
0.4	Edit to title and main text	Sacha O'Connor	Sacha O'Connor	Krasimir Dyulgerski BA MRes	21 June 2023
0.5	Corrections from LPA	Krasimir Dyulgerski BA MRes	Krasimir Dyulgerski BA MRes	Alison Langston BA PCIfA	22 June 2023

Contents

1. Introduction	4
2. Objective	4
3. Quality Assurance	4
4. Geographic Background	5
5. Archaeological Background.....	5
6. Risk Assessment	7
7. Methodology.....	7
7.1. Data Collection.....	7
7.2. Data Processing.....	8
7.3. Data Visualisation and Interpretation.....	9
8. Reporting.....	9
9. Archiving	10
10. Copyright.....	10
11. References	11
12. Data Management Plan	12
Figure 1 – Site Location	1:60,000 @ A4
Figure 2 – Survey Area	1:35,000 @ A3

1. Introduction

- 1.1. This document details a Written Scheme of Investigation for a non-intrusive geophysical survey by Magnitude Surveys Ltd (MS) for Pegasus Planning Group. The survey comprises a c. 1602ha area of land at Tween Bridge located between the villages of Thorne, South Yorkshire and Crowle, North Lincolnshire (SE 70473 12078).
- 1.2. The survey area consists of two land parcels separated by the Stainforth and Keadby Canal, these measure 664ha (North) and 938ha (South) respectively. In the northern parcel, 18 exclusion zones around existing wind turbines have been added.
- 1.3. The geophysical survey will comprise hand-pulled/quad-towed, cart-mounted or hand-carried GNSS-positioned fluxgate gradiometer survey. Magnetic survey is the standard primary geophysical method for archaeological applications in the UK for its ability to detect a range of different features. The technique is particularly suited to detecting fired or magnetically enhanced features, such as ditches, pits, kilns, sunken featured buildings (SFBs) and industrial activity (David *et al.*, 2008).
- 1.4. The survey will be conducted in line with the current best practice guidelines produced by Historic England (David *et al.*, 2008), the Chartered Institute for Archaeologists (CIfA, 2020) and the European Archaeological Council (Schmidt *et al.*, 2015).
- 1.5. The survey area is located between the boundaries of the South Yorkshire and North Lincolnshire HER. It has been agreed by both the South Yorkshire Local Planning Archaeologist (LPA) and North Lincolnshire LPA that a non-intrusive archaeological gradiometer survey will be undertaken on the site. The survey will be conducted in line with both South Yorkshire and North Lincolnshire guidance.

2. Objective

- 2.1. The objective of this geophysical survey is to assess the subsurface archaeological potential of the survey area.

3. Quality Assurance

- 3.1. Project management, survey work, data processing and report production will be carried out by qualified and professional geophysicists to standards exceeding the current best practice (CIfA, 2020; David *et al.*, 2008; Schmidt *et al.*, 2015). All MS managers, field and office staff have degree qualifications relevant to archaeology or geophysics and/or field experience.
- 3.2. Magnitude Surveys is a Registered Organisation of the Chartered Institute for Archaeologists (CIfA), the chartered UK body for archaeologists, and a corporate member of ISAP (International Society for Archaeological Prospection).
- 3.3. The directors of MS are involved in cutting edge research and the development of guidance/policy. Specifically, Dr Chrys Harris has a PhD in archaeological geophysics from the University of Bradford, is a Member of CIfA and is the Vice-Chair of the International Society for Archaeological Prospection (ISAP); Finnegan Pope-Carter has an MSc in archaeological geophysics and is a Fellow of the London Geological Society, as well as a member of GeoSIG

(ClfA Geophysics Special Interest Group); Dr Paul Johnson has a PhD in archaeology from the University of Southampton, is a Fellow of the Society of Antiquaries of London and is a Member of ClfA, has been a member of the ISAP Management Committee since 2015, and is currently the nominated representative for the EAA Archaeological Prospection Community to the board of the European Archaeological Association.

- 3.4. MS has developed a bespoke geophysical system whereby data is live-streamed from the field back to the office while fieldwork is ongoing. This allows for data to be regularly monitored not only in the field, but by managers in a controlled office environment. Coverage gaps or small errors within the data can be quickly identified and rectified, improving quality control of field survey. The live data streaming allows MS to provide processed data to the client at regular intervals, allowing all parties to be informed of the field survey's progress. Should it become apparent that the survey is being compromised by local conditions, such as the spreading of green waste, this will be reported back to the client and a mitigation strategy can be devised if necessary.

4. Geographic Background

- 4.1. The survey area is located between the villages of Thorne, South Yorkshire and Crowle, North Lincolnshire. The survey area, which consists of a total of 1602ha, is segmented into two land parcels separated by the Stainforth and Keadby Canal measuring 664ha (North) and 938ha (South) respectively. The survey area is bordered by the villages of Moorends and Thorne to the west, the M180 to the south, the villages of Ealand and Crowle to the east and the Thorne Moors to the north.
- 4.2. The underlying geology of the survey area consists of Sherwood Sandstone to the west and Mercia Group- Mudstone to the east. A mosaic of superficial deposits of glaciofluvial and alluvial nature overlay the area. In the centre and northeast of the survey area a deposit of Alluvium-clay, silt, sand and gravel has been recorded. In the northwest of the survey area is overlain by Hemingborough Glaciolacustrine formation - Clay and Silt. To the southwest and southeast superficial deposits of Sutton Sand deposits and Peat have been recorded. Deposits of peat have also been identified in the north and northeast in close proximity to the Thorne Moors.
- 4.3. The soils consist of slowly permeable seasonally wet, slightly acid but base-rich loamy and clayey soils in the south and northwest of the survey area. The central part of the survey area consists of loamy and clayey soils of coastal flats with naturally high groundwater. While in the north and northeast raised bog peat soils have been recorded.

5. Archaeological Background

- 5.1. The archaeological background is compiled from data obtained from the South Yorkshire Historic Environment Record (SYHER, 2022) and the North Lincolnshire Historic Environment Record (NLHER, 2022).
- 5.2. The survey area is situated on the northern boundary of the Isle of Axholme, an area which, prior to being drained in the 17th century, was an area characterised by marshland which was navigable by small craft, with settlements being located on areas of high ground. The Isle was bounded by the River Don in the north and west, the River Idle in the west and the River Trent

in the south. There is a considerable archaeological record surrounding the survey area, from the prehistoric to the modern period.

- 5.3. Peat deposits have been recorded in several boreholes to the west of Medge Hall, c. 10 m south of the survey area. These deposits lay between at 0.30 m – 0.70 m and sat above an old and relatively undisturbed land surface. Radiocarbon dating from the base of the peat layers suggested that the paleo-land surface beneath dated to the mid-late Neolithic (NLHER, 2022).
- 5.4. A Bronze Age trackway was recorded during the excavation of a drain c. 87 m south of the survey area, to the west of Warpings Farm. This consisted of several large split timbers forming a 3m wide trackway (NLHER, 2022).
- 5.5. Within the survey area, to the north of Poultry Farm, a large area of linear and curvilinear cropmarks has been recorded via aerial photography. These were investigated in 1975, with the excavations revealing several ditches, pits and possible roundhouses which overlaid earlier field systems. Pottery and coin finds confirmed that these features formed part of a Romano-British settlement, one that is suggested to relate to other surrounding cropmarks, in an area that stretches at least c. 500 m south and c. 850 m northeast of the survey area (NLHER, 2022).
- 5.6. Further linear, curvilinear and rectilinear were observed on aerial photography within the survey area, to the southeast of Belton Grange, to the northwest of Marsh Road and to the northeast of the Thorne Waste Drain Road. Although these cropmarks have not been excavated, an Iron Age or Romano-British origin is the most probable based on similar investigated features in the local vicinity (NLHER, SYHER, 2022).
- 5.7. Linear, curvilinear and rectilinear cropmarks in the form of enclosures and field systems are located c. 400 m southeast of the survey area at Briar Hill Farm, and c. 750 m southeast of the survey area at Swans Grove Farm (SYHER, 2022).
- 5.8. Early Medieval activity within the study area is limited to Crowle, c. 980 m to the east of the survey area. This includes an 10th century Anglo-Scandinavian cross fragment, incorporated into St Oswald's Church. Although St Oswalds is 12th century in date, the cross fragment suggests that an earlier religious structure stood nearby. Two early medieval pits were also discovered during a redevelopment of Crowle Market, both of which contained pottery, animal bone and spelt and wheat grains (NLHER, 2022).
- 5.9. A Medieval moated enclosure sits c. 400 m east of the survey area at Hirst Priory. This was the site of an Augustinian cell of Nostell Priory which was founded in the early 12th century, and dissolved in c.1540 (NLHER, 2022).
- 5.10. It is postulated that Tudworth deserted Medieval village lies c.180 m south of the survey area, to the south of Sandtoft Road. This village was named in the Domesday Book as comprising of twenty eel ponds. It was depopulated in the 17th century (SYHER, 2022).
- 5.11. In the Post-Medieval period, the marshland of North Lincolnshire was extensively drained to accommodate more farmland. The result of this was a network of large drains that run throughout Lincolnshire and across/around the survey area.

- 5.12. Within the survey area, to the northwest of Marsh Road, there is a World War Two aircraft crash site. A Lancaster Bomber crashed on the 5th of April 1945, with the loss of all seven airmen, two of whom were not recovered along with the aircraft and are presumably still buried at the crash site (NLHER, 2022).
- 5.13. Located c. 800 m south of the survey area, Sandtoft Airfield was constructed during the Second World War and opened for use by Bomber Command in 1943. Decoys were placed in the surrounding area to mislead German bombing raids, one of these is situated within the survey area to the south of the A18, whilst another lies c. 130 m south of the survey area, to the north of the M180.

6. Risk Assessment

- 6.1. MS has a Risk Assessment and Method Statement (RAMS) for survey that can be provided on request and will be updated to reflect any site conditions we are notified of in advance. Before geophysical survey commences, a brief walkover will be undertaken to identify any additional hazards of an unusual or site-specific nature. If any additional hazards are identified, an additional site-specific risk assessment will be updated to include these hazards and all surveyors will be informed of the risk. If appropriate mitigation factors cannot be put in place, then the field or part thereof will not be surveyed.
- 6.2. Field staff will attend a site induction if required. Necessary PPE will be supplied and worn. Wet and cold/hot weather protection is also supplied.
- 6.3. All surveyors have been issued company mobile phones. Survey teams are expected to make regular contact with the office to keep all parties updated with survey progress. Any change in conditions that may affect the health and safety of the survey team must be reported immediately.
- 6.4. The survey van contains suitable welfare facilities. Antiseptic hand gel is provided, as is bottled drinking water. A first aid kit is stored in the cab of the van, with a second kit near personnel within the survey area.
- 6.5. The nearest NHS urgent care centre is at Doncaster Royal Infirmary, Armthorpe Road, Doncaster DN2 5LT. Should toilets be unavailable on site, the nearest public accessible toilet is located at Shell Petrol Station, 614 Selby Road, Thorne, Doncaster, DN8 4JD.

7. Methodology

7.1. Data Collection

- 7.1.1. Magnetometer surveys are generally the most cost effective and suitable geophysical technique for the detection of archaeology in England. Therefore, a magnetometer survey should be the preferred geophysical technique unless its use is precluded by any specific survey objectives or the site environment. For this site, no factors precluded the recommendation of a standard magnetometer survey.
- 7.1.2. For this reason, geophysical survey will comprise the magnetic method as described in the following table.

7.1.3. Table of survey strategies:

Method	Instrument	Traverse Interval	Sample Interval
Magnetic	Bartington Instruments Grad-13 Digital Three-Axis Gradiometer	1 m	200 Hz reprojected to 0.125 m

7.1.4. MS employs a modular cart system, which can easily be configured to be towed by quad, pulled by hand, or carried depending on what is most suitable for the site configuration and conditions. The system can be hand-carried so that survey can be undertaken should conditions preclude survey with the wheels. The hand carried system retains all of the advantages of a cart system because it is still GNSS positioned and the sensors are maintained at a consistent height.

7.1.5. Magnetic data will be collected using MS' bespoke, hand-pulled/quad-towed cart system OR hand-carried GNSS-positioned system. MS' cart OR hand-carried system will be comprised of Bartington Instruments Grad 13 Digital Three-Axis Gradiometers. Positional referencing will be through a multi-channel, multi-constellation GNSS Smart Antenna RTK GPS outputting in NMEA mode to ensure high positional accuracy of collected measurements. The RTK GPS is accurate to 0.008m + 1ppm in the horizontal and 0.015m + 1ppm in the vertical.

7.1.6. Magnetic and GPS data will be stored on an SD card within MS' bespoke datalogger. The datalogger is continuously synced, via an in-field Wi-Fi unit, to servers within MS' offices. This allows data collection, processing and visualisation to be monitored in real-time as fieldwork is ongoing (see Section 3.4).

7.1.7. A navigation system integrated with the RTK GPS will be used to guide the surveyor, whether the system is being quad towed, hand pulled or carried. Where possible, allowing for terrain, crops and obstacles, data will be collected by traversing the survey area along the longest possible lines, ensuring efficient collection and processing.

7.1.8. The data from each survey parcel will be quality checked before survey commences in a new area. This will identify any data collection errors or areas where magnetic disturbance has the potential to obscure archaeological anomalies. If data collection is being severely compromised, for example by green waste or by the extant the Tween Bridge Wind Farm, a suitable mitigation strategy will be devised between MS, South Yorkshire LPA, North Lincolnshire LPA and the client.

7.2. Data Processing

7.2.1. Magnetic data will be processed in bespoke in-house software produced by MS. Processing steps conform to the EAC and Historic England guidelines for 'minimally enhanced data' (see Section 3.8 in Schmidt *et al.*, 2015: 33 and Section IV.2 in David *et al.*, 2008: 11). Data plots contained within the report also conform to these guidelines.

Sensor Calibration – The sensors will be calibrated using a bespoke in-house algorithm, which conforms to Olsen *et al.* (2003).

Zero Median Traverse – The median of each sensor traverse will be calculated within a specified range and subtracted from the collected data. This removes striping effects caused by small variations in sensor electronics.

Projection to a Regular Grid – Data collected using RTK GPS positioning requires a uniform grid projection to visualise data. Data will be rotated to best fit an orthogonal grid projection and are resampled onto the grid using an inverse distance-weighting algorithm.

Interpolation to Square Pixels – Data will be interpolated using a bicubic algorithm to increase the pixel density between sensor traverses. This produces images with square pixels for ease of visualisation.

7.3.Data Visualisation and Interpretation

7.3.1. The report will present the gradient of the sensors' total field data as greyscale images, as well as the total field data from the upper and/or lower sensors, where appropriate. The gradient of the sensors minimises external interferences and reduces the blown-out responses from ferrous and other high contrast material. However, the contrast of weak or ephemeral anomalies can be reduced through the process of calculating the gradient. Consequently, some features can be clearer in the respective gradient or total field datasets. Multiple greyscale images at different plotting ranges will be used for data interpretation.

7.3.2. Geophysical results will be interpreted using greyscale images and XY traces in a layered environment, overlaid against OS Open Data, satellite imagery, historical maps, LiDAR data, and soil and geology mapping. Google Earth (2023) will also be consulted, to compare the results with recent land use.

7.3.3. Geodetic position of results – All vector and raster data will be projected into OSGB36 (ESPG27700) and provided upon request in ESRI Shapefile (.SHP) and Geotiff (.TIF) respectively. Figures will be provided with raster and vector data projected against OS Open Data/vector mapping.

8. Reporting

8.1. A detailed report of the survey will be produced after data collection is completed. The Planning Archaeologist of South Yorkshire SMR and North Lincolnshire HER will be provided with a draft report for approval, and the approved report will be submitted to the respective HERs. The final report will include as standard:

- Abstract
- Introduction – Details survey location and client details.
- Quality Assurance – Details the expertise of Magnitude Surveys and Magnitude Surveys employees undertaking the work.
- Objectives – Details survey objectives.
- Geographic Background – Details the soils and geology of the survey area, as well as providing a general summary of site conditions at time of survey.

- Survey Considerations – Details specific points of note for each survey area, including topography, upstanding obstructions or neighbouring objects.
- Archaeological Background – Details a brief summary of the archaeological and historical background of the survey area and its immediate environs. While this will not be an exhaustive assessment, it will draw on elements relevant to the results obtained during survey.
- Methodology – Details survey strategy employed, instruments used, data collection strategy, data processing and visualisation methods.
- Results – Details the results and interpretation of the geophysical survey, both in a general context and in terms of specific anomalies of archaeological interest. Geophysical results will be discussed in combination with satellite imagery, historical mapping and LiDAR data - if freely available - as supporting interpretative evidence.
- Conclusions
- Archiving
- Copyright
- References
- Figures – The survey location and individual survey areas will be presented. Georeferenced greyscale images of the minimally enhanced data, XY traces and corresponding interpretations will be displayed at appropriate scales. Interpretations will also be displayed over satellite imagery, historical mapping and LiDAR - as applicable - to provide further context for the interpretations. All figures will include a detailed scale bar, north arrow and key.

9. Archiving

9.1. MS maintains an in-house digital archive, which is based on Schmidt and Ernenwein (2013). This archive stores the collected measurements, minimally processed data, georeferenced and un-georeferenced images, XY traces and a copy of the final report. A copy of this archive will be included on a disk with a final printed report.

9.2. MS contributes reports to the ADS Grey Literature Library upon permission from the client, subject to any dictated time embargoes.

9.3. An OASIS form will be filled in on completion of the survey, providing permission has been granted by the client.

10. Copyright

10.1. Copyright and the intellectual property pertaining to all reports, figures and datasets produced by Magnitude Services Ltd is retained by MS. The client is given full licence to use such material for their own purposes. Permission must be sought by any third party wishing to use or reproduce any IP owned by MS.

11. References

British Geological Survey, 2023. BGS Geology Viewer <https://www.bgs.ac.uk/map-viewers/bgs-geology-viewer/> (accessed 13/06/2023)

Chartered Institute for Archaeologists, 2020. Standard and guidance for archaeological geophysical survey. ClfA.

David, A., Linford, N., Linford, P. and Martin, L., 2008. Geophysical survey in archaeological field evaluation: research and professional services guidelines (2nd edition). Historic England.

Google Earth, 2023. Google Earth Pro V 7.1.7.2606.

LandIS, 2023. Soilscales <https://www.landis.org.uk/soilscales/> (accessed 13/06/2023)

North Lincolnshire Historic Environment Record, 2022. Historic Environment Data (Data received 11/08/2022)

Olsen, N., Toffner-Clausen, L., Sabaka, T.J., Brauer, P., Merayo, J.M.G., Jorgensen, J.L., Leger, J.M., Nielsen, O.V., Primdahl, F., and Risbo, T., 2003. Calibration of the Orsted vector magnetometer. Earth Planets Space 55: 11-18.

Schmidt, A. and Ernenwein, E., 2013. Guide to good practice: geophysical data in archaeology. (2nd edition). Oxbow Books: Oxford.

Schmidt, A., Linford, P., Linford, N., David, A., Gaffney, C., Sarris, A. and Fassbinder, J., 2015. Guidelines for the use of geophysics in archaeology: questions to ask and points to consider. EAC Guidelines 2. European Archaeological Council: Belgium.

South Yorkshire Archaeology Service, 2022. (Data received 06/09/2022)

12. Data Management Plan

MS Job Code	MSSE1548: Tween Bridge		
Project Name	Tween Bridge - Thorne, Doncaster, South Yorkshire to Crowle, North Lincolnshire		
Client	Pegasus Planning Group		
Grid Reference	SE 70473 12078		
Survey Techniques	Magnetometer		
Survey Size (ha)	1602ha		
Survey Dates	TBC		
Project Lead	Krasimir Dyulgerski BA MRes		
Project Officer	TBC		
Section 42	N/A		
South Yorkshire HER Event No	TBC		
North Lincolnshire HER Event No	TBC		
Planning Application	TBC		
Oasis No	TBC		
Author	Sacha O'Connor BA	Revisor:	
Initiation Date	15 July 2023	Last Date of Revision:	
Version	0.5		
Status	Draft		
Summary of Changes	N/A		
Data Collection and Generation			
<ul style="list-style-type: none"> • GNSS-positioned fluxgate gradiometer data will be collected and stored in digital format by Magnitude Surveys Ltd. (MS) for the purposes of archaeological applications. • Data collected in the field will be stored on MS servers as CSV files (raw data) and GeoTiffs (processed data). Other data collected and generated in the field such as site photos (.JPEG), SSRAs (MS Word), site diaries (MS Word) and site notes (.PNG). • Data will be collected to a high quality as ensured by on site processing, allowing for real-time data QA and trouble shooting. Duplicate traverses will be collected to provide evidence for the repeatability of the survey method. • Analysis of the data includes the generation of topography contours and XY traces (.SHP) Interpretation of the data is carried out in QGIS through the creation of polygons, polylines and points. This data is stored on a PostGres GIS database on MS servers. • Deliverables, including the WSI and final report (MS Word) will be available to clients as PDF files. 			
Metadata and Documentation			

- Sufficient metadata is stored by MS to allow for other users of the data to be able to repeat both collection and processing methods if desired, as well as understand the generation and evolution of the data collected in the field.
- Any changes to standard practice will be clearly recorded in the metadata documentation.

Data Storage, Access and Preservation

- All data produced by MS for this project will be stored on MS network which is backed up daily.
- Data is accessible to MS staff through the company's network, and deliverables and any other data requested will be provided to the client upon the completion of the project.
- MS maintains an in-house digital archive, which is based on Schmidt and Ernenwein (2013). This stores the collected measurements, minimally processed data, georeferenced and un-georeferenced images, XY traces and a copy of the final report.
- MS contributes reports to the ADS Grey Literature Library along with the completion of an OASIS form following survey, providing permission has been granted by the client.
- Copyright and intellectual property pertaining to all reports, figures and datasets produced by Magnitude Services Ltd is retained by MS. The client is given full licence to use such material for their own purposes. Permission must be sought by any third party wishing to use or reproduce any IP owned by MS.

Long Term Curation of Archive

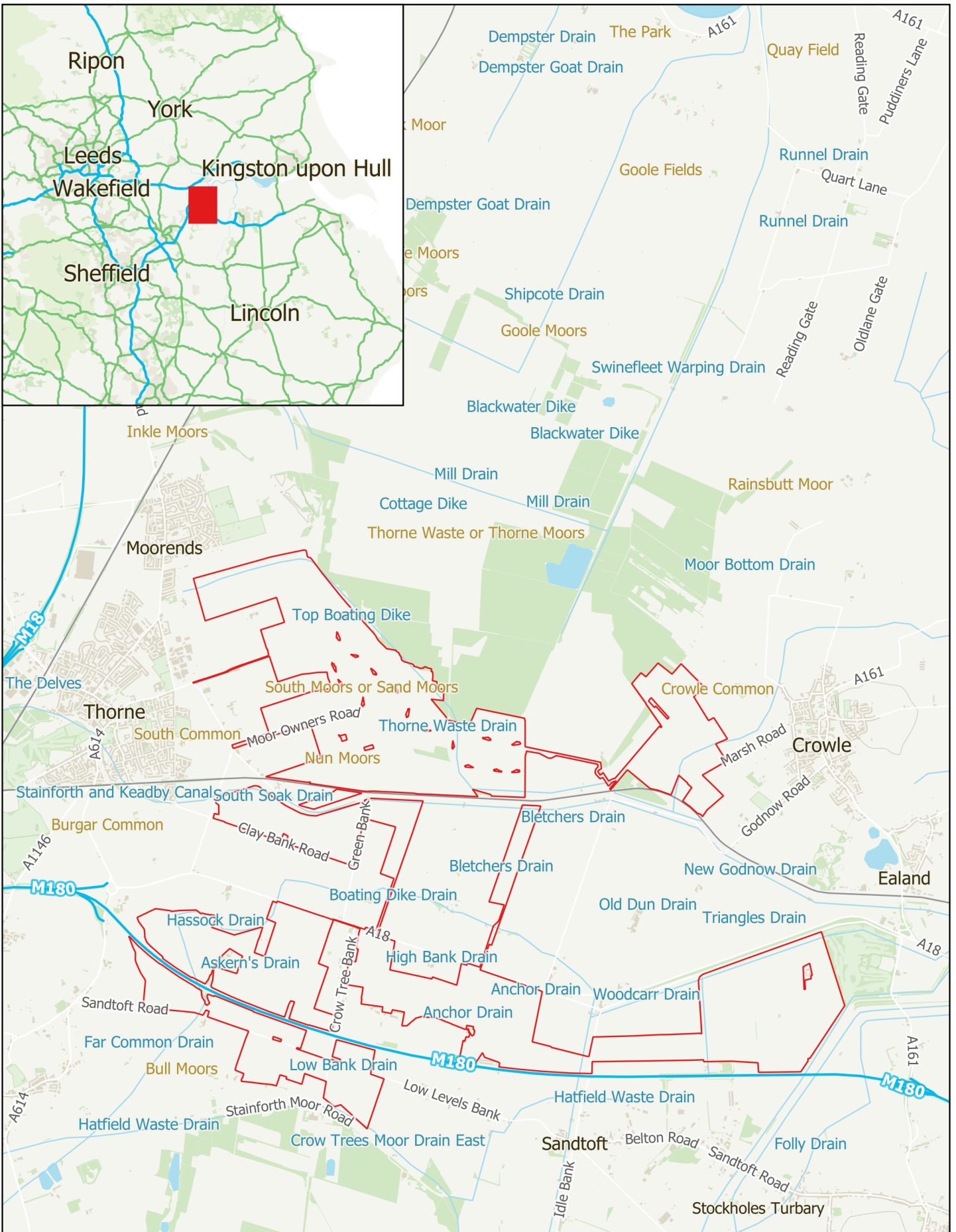
- A copy of the digital archive will be deposited with the Archaeology Data Service (ADS) if requested by the client, which is a Core Trust Seal approved repository in line with CHET requirements (Croft *et al.*, 2020).

Resources and Responsibilities

- The project officer is responsible for ensuring that this data management plan is adhered to.

References

Schmidt, A. and Ernenwein, E., 2013. Guide to good practice: geophysical data in archaeology. (2nd edition). Oxbow Books: Oxford.



MSE1548: Tween Bridge - Thorne, Doncaster, South Yorkshire to Crowle, North Lincolnshire

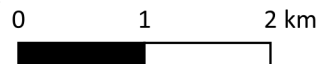
Figure 1 - Site Location

1:60,000 @ A4

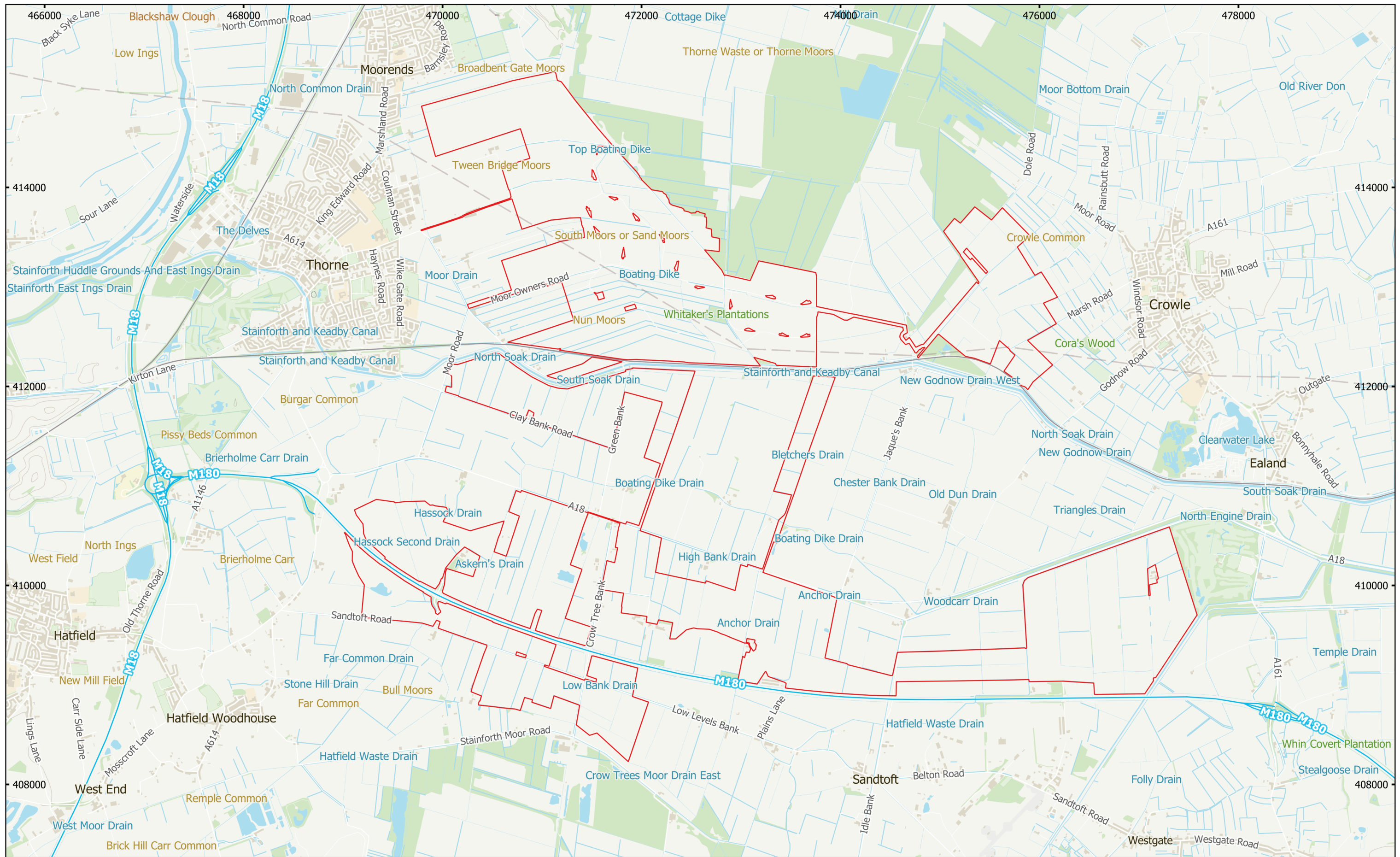
Copyright Magnitude Surveys Ltd 2023

Contains Ordnance Survey data © Crown Copyright and database right 2023


 Site Boundary

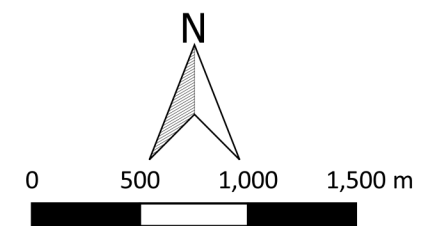


magnitude
surveys



MSSE1548: Tween Bridge - Thorne, Doncaster, South Yorkshire to Crowle, North Lincolnshire
 Figure 2 - Location of Survey Areas
 1:35,000 @ A3
 Copyright Magnitude Surveys Ltd 2023
 Contains Ordnance Survey data © Crown Copyright and database right 2023

 Survey Area



magnitude
surveys

