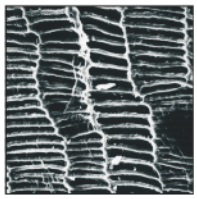
TORK18










# TORKSEY EMBANKMENT, LINCOLNSHIRE

## GEOPHYSICAL SURVEY

commissioned by Arcadis
on behalf of the Environment Agency

September 2018

HEADLAND ARCHAEOLOGY

REGISTERED CIfA ORGANISATION

# TORKSEY EMBANKMENT, LINCOLNSHIRE

## GEOPHYSICAL SURVEY

commissioned by Arcadis
on behalf of the Environment Agency

September 2018



This report adheres to the quality standard of ISO 9001:2015

PROJECT INFO:

HA Project Code **TORK18** / NGR **SK 8366 7814** / Parish **Torksey** / Local Authority **West Lindsey** / OASIS Ref. **headland5-328381**

PROJECT TEAM:

Project Manager **Sam Harrison** / Author **David Harrison** / Fieldwork **<names in alphabetical order>** / Graphics **Caroline Norrman, David Harrison, Julia Bastek-Michalska**

Approved by **Sam Harrison**

Headland Archaeology North
Unit 16 | Hillside | Beeston Rd | Leeds LS11 8ND
t 0113 387 6430
e north@headlandarchaeology.com
w www.headlandarchaeology.com

HEADLAND ARCHAEOLOGY

# PROJECT SUMMARY

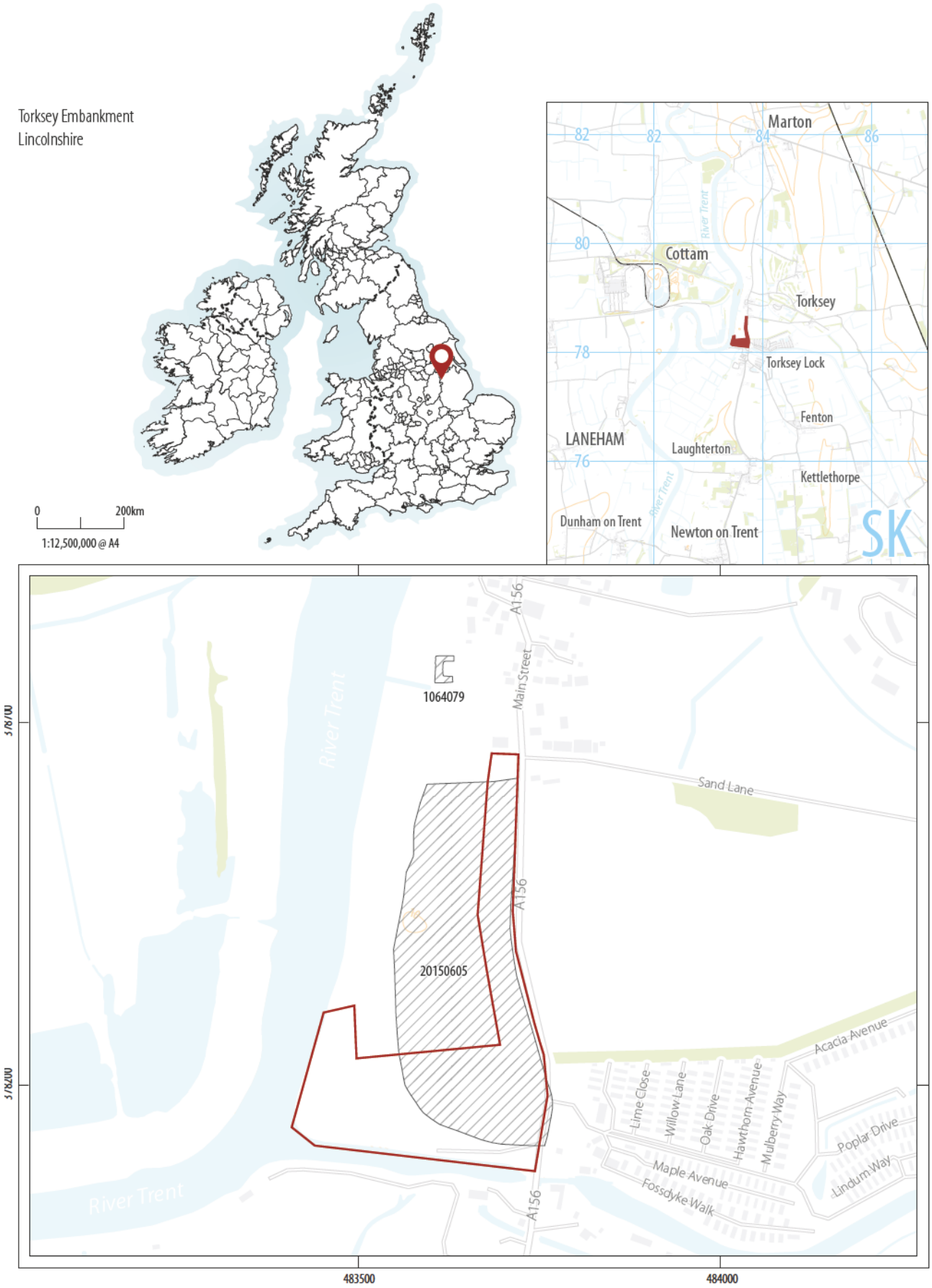
Headland Archaeology (UK) Ltd undertook a geophysical (magnetometer) survey over 6 hectares at Castle Field, part of which encompasses Torksey Medieval Town, a Scheduled Monument in Lincolnshire. The survey was carried out in advance of improvements to existing flood defences which will shortly be undertaken by the Environment Agency. Castle Field has been the subject of several phases of archaeological work including excavation, geophysical survey and fieldwalking which have identified multi-phase activity including an Anglo-Saxon cemetery, and eight medieval pottery kilns. Recent badger activity has revealed notable quantities of human remains within the west of the field.

The survey has identified anomalies consistent with the continuation of features identified by the 2012 geophysical survey (carried out by the University of York) including pits, ditches, a possible road/track as well as a further ten possible kilns or areas of burning. The anomalies are more densely concentrated within the northern half of Castle Field, at the northern end of the access track that is the proposed route in to the main works area. In the south of the field, linear and rectilinear negative anomalies may be due to structural remains, perhaps a building. These anomalies may locate the site of a Roman building/Roman pavement and/or an early medieval priory which are all shown on 20th century Ordnance Survey maps approximately 30m to the north. No anomalies of archaeological potential have been identified on the floodplain to the south-west of Castle Field. It is unclear whether the absence of archaeological anomalies on the floodplain reflects a lack of archaeology (probable) or whether the magnetic response from archaeological features, if present, is being masked by deep and/or homogenous alluvial deposits (possible).

Overall the survey has confirmed that any groundworks will adversely impact on sub-surface archaeological remains across much of the survey area (with the possible exception of the floodplain) and that further archaeological work will likely be required before and during the flood improvement works. The magnetometer survey is assessed as having given a good indication of the nature and extent of the archaeological remains. On balance it is considered that any further remote sensing survey techniques, such as ground penetrating radar, earth resistance or electromagnetic surveys, are unlikely to add significant information on the extent of those archaeological remains and that a limited programme of trial trenching would be more cost effective. One possible exception to this might be a tightly focussed resistance survey centred on the possible structure.

# CONTENTS

# LIST OF ILLUSTRATIONS




HEADLAND ARCHAEOLOGY
Headland Archaeology North
Unit 16 | Hillside | Beeston Rd | Leeds LS11 8ND
t 0113 387 6430
e north@headlandarchaeology.com
w www.headlandarchaeology.com

**ILLUS 1** Site location

# TORKSEY EMBANKMENT, LINCOLNSHIRE

## GEOPHYSICAL SURVEY

## 1 INTRODUCTION

Headland Archaeology (UK) Ltd was commissioned by Arcadis (the Client), on behalf of the Environment Agency, to undertake a geophysical (magnetometer) survey at Torksey, Lincolnshire, where alterations and improvements to the existing flood defences are proposed. The survey was undertaken in order to minimise the risk to the development which may be posed by the archaeology and to inform further strategies should they be necessary. Most of the survey area falls within the Scheduled Monument of Torksey Medieval Town (Historic England List Entry 1004991) and the fieldwork and report conform to the requirements of a Section 42 licence which was obtained by the Client prior to commencement.

The work was undertaken in accordance with a Written Scheme of Investigation (Harrison 2018) which was submitted to and approved by the Client, with guidance within the National Planning Policy Framework (DCLG 2012) and in line with current best practice (Chartered Institute for Archaeologists 2014, English Heritage 2008).

The survey was carried out on 11th July 2018.

### 1.1 SITE LOCATION, TOPOGRAPHY AND LAND-USE

The proposed development area (PDA) is located on the eastern bank of the River Trent, south of the village of Torksey, Lincolnshire, and is centred at SK 8366 7814 (see Illus 1) and comprises part of Castle Field, most of which is a scheduled area. The survey covered an irregularly-shaped block of land either side of the current flood defence embankment in the south of the PDA as well as a narrow strip of land (a proposed access track) along the western side of the A165. The PDA is bound to the south by the Fosse Dyke and by the River Trent to the west. Castle Field is positioned on a low elongated hill within a low-lying landscape. The land falls from 10m Above Ordnance Datum (AOD) in the centre of the field to 8m along the A165 and also at the base of the existing flood defence embankment from where the land falls more steeply to 5m AOD on the flood plain next to the River Trent.

At the time of the survey Caste Field, F1, was under a semi-mature maize crop whereas the flood plain, F2, was under short grass (see Illus 2–5).

Dense vegetation along the bottom of a dry ditch (canal outfall) precluded survey immediately west of the embankment in F1.

### 1.2 GEOLOGY AND SOILS

The bedrock geology comprises of Mercia Mudstone which is overlain by Pierrepont Sand and Gravel over F1 and alluvium (clay, silt, sand and gravel) over F2 (NERC 2018).

The soils are similarly divided according to their topographical setting with those over F1 being classified in the Soilscape 15 association, characterised as naturally wet, very acidic sands and loams, and those on the lower-lying floodplain (F2) classified in the Soilscape 20 association, characterised as naturally wet loams and clays (Cranfield University 2018).

It was not considered likely that either the geology or soils would have a detrimental impact on either the results or interpretability of the magnetic data.

# 2 ARCHAEOLOGICAL BACKGROUND

Torksey has a rich archaeological background from at least the Roman period with the Roman town of Tiovulfingacester being founded at the junction of the Foss Dyke and the River Trent. The Foss Dyke is a canal of probable Roman origin which connects the Trent to Lincoln. Findspots of Roman 'pavement' and 'coins' are recorded within the south of Castle Field (within the PDA) on early 20th century Ordnance Survey (OS) maps (see Illus 6) with a Roman building and Ciscercian nunnery or priory also transcribed here on later 20th century maps.

A series of field evaluations have been undertaken around Torksey as part of the University of York's Viking Torksey Project. These have mostly focused on the Viking Winter Camp 2km north of the village although investigations within Castle Field have identified several medieval pottery kilns, a house and, in the west of the field (outside of the current survey area), a number of burials which are thought to be associated with an unlocated medieval church. The most recent archaeological work comprised a geophysical survey of Castle Field (also undertaken by the University of York) in 2012 which identified several possible kilns and a series of soil-filled ditches suggestive of multi-phase archaeological activity. This data is combined with the current data set in Illus 7).

# 3 AIMS, METHODOLOGY AND PRESENTATION

The ultimate aim of the project is to reduce the risk to development posed by the archaeology by:

- providing information about the nature and possible interpretation of any anomalies identified by the techniques used;
- determining the likely presence/absence and extent of any buried archaeological features; and
- producing a comprehensive site archive and report.

The general objective of the geophysical survey, as stated in the WSI, was to provide sufficient information to establish the presence/absence, character and extent of any archaeological remains within the site. This will therefore enable an assessment to be made of the impact of the proposed flood defence works on any sub-surface archaeological remains, if present.

A secondary objective of the survey was to identify the presence of previously unidentified services and areas of badger or rabbit disturbance within the existing embankment.

## 3.1 MAGNETOMETER SURVEY

Magnetic survey methods rely on the ability of a variety of instruments to measure very small magnetic fields associated with buried archaeological remains. A feature such as a ditch, pit or kiln can act like a small magnet, or series of magnets, that produce distortions (anomalies) in the earth's magnetic field. In mapping these slight variations, detailed plans of sites can be obtained as buried features often produce reasonably characteristic anomaly shapes and strengths (Gaffney & Gater 2003). Further information on soil magnetism and the interpretation of magnetic anomalies is provided in Appendix 1.

The survey was undertaken using four Bartington Grad601 sensors mounted at 1m intervals (1m traverse interval) onto a rigid carrying frame. The system was programmed to take readings at a frequency of 10Hz (allowing for a 10–15cm sample interval) on roaming traverses (swaths) 4m apart. These readings were stored on an external weatherproof laptop and later downloaded for processing and interpretation. The system was linked to a Trimble R8s Real Time Kinetic (RTK) differential Global Positioning System (dGPS) outputting in NMEA mode to ensure a high positional accuracy for each data point.

MLGrad601 and MultiGrad601 (Geomar Software Inc.) software was used to collect and export the data. Terrasurveyor V3.0.32.4 (DWConsulting) software was used to process and present the data.

## 3.2 REPORTING

A general site location plan is shown in Illus 1 at a scale of 1:15,000. Illus 2–5 are site condition photographs. Illus 6 is a 1:2,500 survey location plan showing the direction of survey as GPS swaths. The processed greyscale data, together with the data from the 2012 survey, is presented at a scale of 1:2,500, in Illus 7. Illus 8 is an overall interpretation of the data from the current survey only, at the same scale. Large-scale, fully processed (greyscale) data, minimally processed data (XY traceplot) and accompanying interpretative plots are presented at a scale of 1:1,000 in Illus 9–14 inclusive.

Technical information on the equipment used, data processing and magnetic survey methodology is given in Appendix 1. Appendix 2 details the survey location information and Appendix 3 describes the composition and location of the site archive. Data processing details are presented in Appendix 4. A copy of the OASIS entry (Online Access to the Index of Archaeological Investigations) is reproduced in Appendix 5. The Section 42 Licence from Historic England is located in Appendix 6.

The survey methodology, report and any recommendations comply with the Written Scheme of Investigation (Harrison 2018), guidelines outlined by Historic England (English Heritage 2008) and by the Chartered Institute for Archaeologists (CIfA 2014). All illustrations from Ordnance Survey mapping are reproduced with the permission of the controller of Her Majesty's Stationery Office (© Crown copyright).

The illustrations in this report have been produced following analysis of the data in 'raw' and processed formats and over a range of different display levels. All illustrations are presented to most suitably display and interpret the data from this site based on the experience and knowledge of management and reporting staff.


**ILLUS 2** F1, looking north

# 4 RESULTS AND DISCUSSION

The ground conditions varied from flat short grass on the floodplain to steep uneven ground over the existing embankment and high crop across Castle Field. Whilst this was challenging for the surveyors there has been no visible effect on data quality which is of a high standard throughout.

The survey has however, identified a clear difference between the data collected in Castle Field (F2) and that collected on the flood plain, west of the embankment (F1). The data in F2 is characterised by broad high and low magnitude anomalies indicative of alluvial deposits and the soils from which they are derived. No anomalies other than the occasional 'spike' response are identified on the flood plain.

By contrast in F1 the magnetic background is much more heterogenuous resulting in numerous discrete anomalies which are due to variations in the depth and composition of the soils and the Pierrepont sands and gravels from which they derive. Against this background, numerous linear and discrete anomalies have been identified and these are discussed below and cross-referenced to specific examples on the interpretive figures, where appropriate.

## *Ferrous and modern anomalies*

Ferrous anomalies, characterised as individual 'spikes', are typically caused by ferrous (magnetic) material, either on the ground surface or in the plough-soil. Little importance is normally given to such anomalies, unless there is any supporting evidence for an archaeological interpretation, as modern ferrous debris is common on most sites, often being present as a consequence of manuring or tipping/infilling. There is no obvious clustering to these ferrous anomalies which might indicate an archaeological origin. Far more probable is that the 'spike' responses are likely caused by the random distribution of ferrous debris in the upper soil horizons although given the location a higher proportion than normal may be due to archaeological artefacts.

Magnetic disturbance along the line of the embankment in F1 was caused by metal mesh fencing put in place to limit the movement and activity of badgers on the embankment.

Magnetic disturbance around the perimeter of the survey areas and along the field edges is due to ferrous material within, or adjacent to the boundaries is of no archaeological interest. However, it should be noted that magnetic disturbance may mask any low magnitude anomalies of archaeological potential, if present, within the affected area.

North/south aligned linear anomalies (FD1–FD2; see Illus 12–14) in F2 correlate with an extant open ditch in this field. This ditch feature, identified as a canal outfall by the DBA, and recorded as such on the first edition OS map (1886), is likely to be of low archaeological interest.

The broad curving band of magnetic disturbance (FD3; see Illus 12–14) at the boundary between F1 and F2 corresponds to the existing


**ILLUS 3** Existing flood defence embankment (south), looking west

flood defence embankment (see Illus 3–5) and is likely caused by ferrous material within the embankment.

No anomalies consistent with buried services have been identified anywhere within the survey area.

## *Agricultural anomalies*

Analysis of historical OS mapping indicates that two east/west aligned field boundaries have been removed from F1 since the publication of the first edition OS map in 1886. Neither of these former boundaries has been detected by the survey perhaps indicating low magnetic contrast in the soils or, more likely, by later agricultural erosion of the former boundaries.

Several broadly-spaced east/west aligned parallel linear trends are identified throughout the north of F1. These are caused by the medieval and post-medieval practice of ridge and furrow cultivation. The characteristic striping effect is due to the contrast between the soil-filled furrows and the surrounding soils.

Closely-spaced linear trend anomalies in the south of F1 and the east of F2 are due to modern ploughing.

## *Geological anomalies*

There is a distinct difference between the data in F2 and F1 (see above). In F2 (west of the current embankment) the data is characterised by broad areas of high and low susceptibility which is typical of the magnetic response from alluvial deposits and the flood plain soils which are derived from them. In F1, other than the anomalies described below, the data is generally characterised by numerous discrete anomalies which are due to variations in the composition of the soils and the Pierrepont sands and gravels from which they derive.

## *Archaeological and possible archaeological anomalies*

Unless otherwise specified the anomalies of possible and probable archaeological potential are caused by soil-filled features such as ditches or pits or by spreads of magnetically enhanced material within the upper soil horizons. Whilst these anomalies form no definite regular pattern they clearly continue the broad overall pattern of anomalies identified in 2012 and which form part of the medieval town of Torksey. These anomalies are described in greater detail below.

Ten high magnitude anomalies (K1–K10; see Illus 9–11) have been identified throughout the northern half of the dataset and are interpreted as possible kilns or areas of intense burning. Seven of these possible kilns (K1–K7) are concentrated in the north-east corner of the field, suggesting an area of increased industrial activity. Torksey ware pottery kilns are known in the surrounding landscape with eight kilns identified in Castle Field by the 2012 survey (see Illus 6).

**ILLUS 4** Existing flood defence embankment (south), looking east

Three high magnitude curvilinear anomalies (D1–D3, see Illlus 9–11) correlate with and are continuations of anomalies identified by the University of York in 2012. These anomalies are interpreted as of high archaeological potential and locate soil-filled ditches. The origins of six further, mostly east/west, soil-filled ditches (D4–D9; see Illus 9–14) are less certain and they may be agricultural in origin, perhaps locating unmapped former field boundaries, although an archaeological origin is equally plausible. Parallel linear anomalies (D7 and D8; see Illus 12–14), 5m apart, may flank either side of a road or trackway. The possible trackway is in close proximity to the site of a Roman pavement/Roman building and a priory which are shown on 20th century OS maps.

Three linear and rectilinear negative anomalies (W1–W3; see Illus 12–14) have been identified within a broad area of increased magnetic response in the south of F2, centred at SK 8365 7820. The anomalies measure 37m east/west and 7m north/south and may locate buried stone walls, perhaps a building or buildings. The possible building is located 30m south of the Roman building on the 20th century OS maps.

possible kilns or areas of burning have been identified with the densest cluster towards the northern end of the field along the route of the proposed access track. Within the south of the field, linear and rectilinear negative anomalies within a broad area of increased magnetic variation are thought may be due to structural remains, perhaps locating a structure. The anomalies may locate the site of a Roman building/Roman pavement and/or an early medieval priory which are shown on 20th century OS maps 30m to the north. Only the flood plain is devoid of anomalies of likely archaeological potential. It should be noted, however, that smaller archaeological anomalies may not be identified by magnetometer survey and that therefore an absence of such anomalies may not necessarily be indicative of an absence of archaeological remains. Overall the survey has successfully defined the likely extent of archaeological activity. On balance it is considered unlikely that further survey work using other techniques will add significantly to the understanding of the site although a small resistance survey focussed on the possible structure may be of some use. However, this could not be carried out until the maize crop has been harvested.

## 5 CONCLUSION

The survey has revealed the continuation of the anomalies identified in 2012 by the University of York confirming the current survey area to be within an area of high archaeological potential. Anomalies indicative of pits, ditches, a possible road/track and ten

## 6 REFERENCES

Chartered Institute for Archaeologists (CIfA) 2014 ***Standard and guidance for archaeological geophysical survey*** (Reading) http://www.archaeologists.net/sites/default/files/CIfAS%26GGeophysics_2.pdf accessed 27 July 2018


**ILLUS 5** F2, looking north-west

Cranfield University 2018 ***Cranfield Soil and Agrifood Institute Soilscapes*** http://www.landis.org.uk/soilscapes/ accessed 27 July 2018

Department of Communities and Local Government (DCLG) 2012 ***National Planning Policy Framework*** https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/6077/2116950.pdf accessed 27 July 2018

English Heritage 2008 ***Geophysical Survey in Archaeological Field Evaluation: Research and Professional Services Guidelines*** (2nd edn) http://content.historicengland.org.uk/images-books/publications/geophysical-survey-in-archaeological-field-evaluation/geophysics-guidelines.pdf accessed 27 July 2018

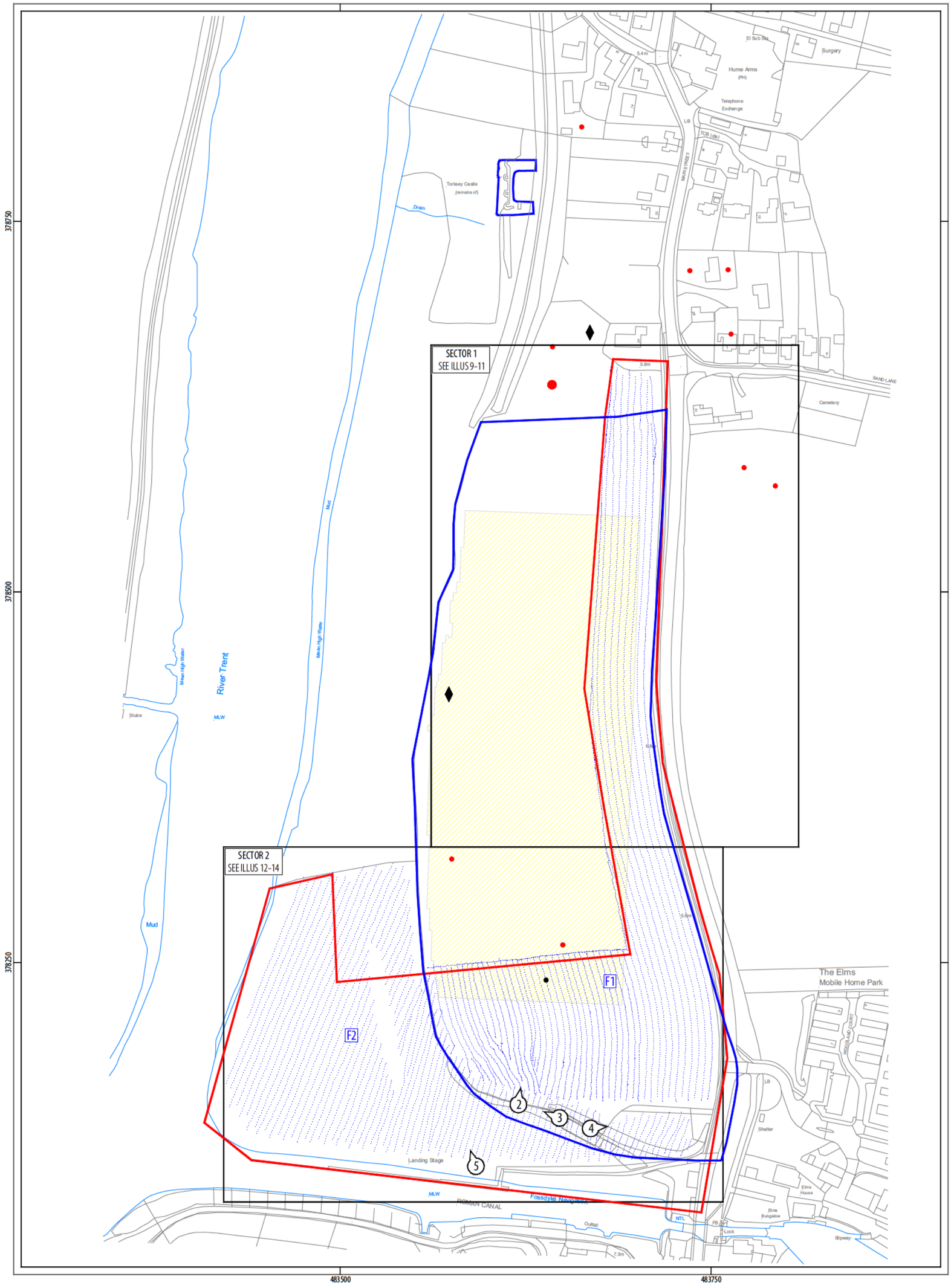
Gaffney C & Gater J (2003) ***Revealing the Buried Past: Geophysics for Archaeologists*** Stroud

Hadley DM & Richards JD (2016) 'The Winter Camp of the Viking Great Army, AD 872-3, Torksey' in ***Lincolnshire Proceedings of the Society of Antiquaries*** 96, 23–67

Harrison S 2018 ***Torksey Embankment: Written Scheme of Investigation for Geophysical Survey*** [unpublished client document] Headland Archaeology, Ref TORK18

Natural Environment Research Council (NERC) 2018 ***British Geological Survey*** http://www.bgs.ac.uk/ accessed 27 July 2018

University of York 2012 ***Geophysical Survey at Torksey, Lincolnshire: Magnetometer Survey of Land South of Torksey Castle*** [unpublished client document] University of York, Ref TORK12




- geophysical survey area
- scheduled monument
- area of previous survey (University of York 2012)
- GPS swaths
- location and direction of ILLUS 2-5
- Roman pavement found 1878 / site of Roman building / site of priory
- kiln (after Hadley & Richards 2016)
- cemetery (after Hadley & Richards 2016)

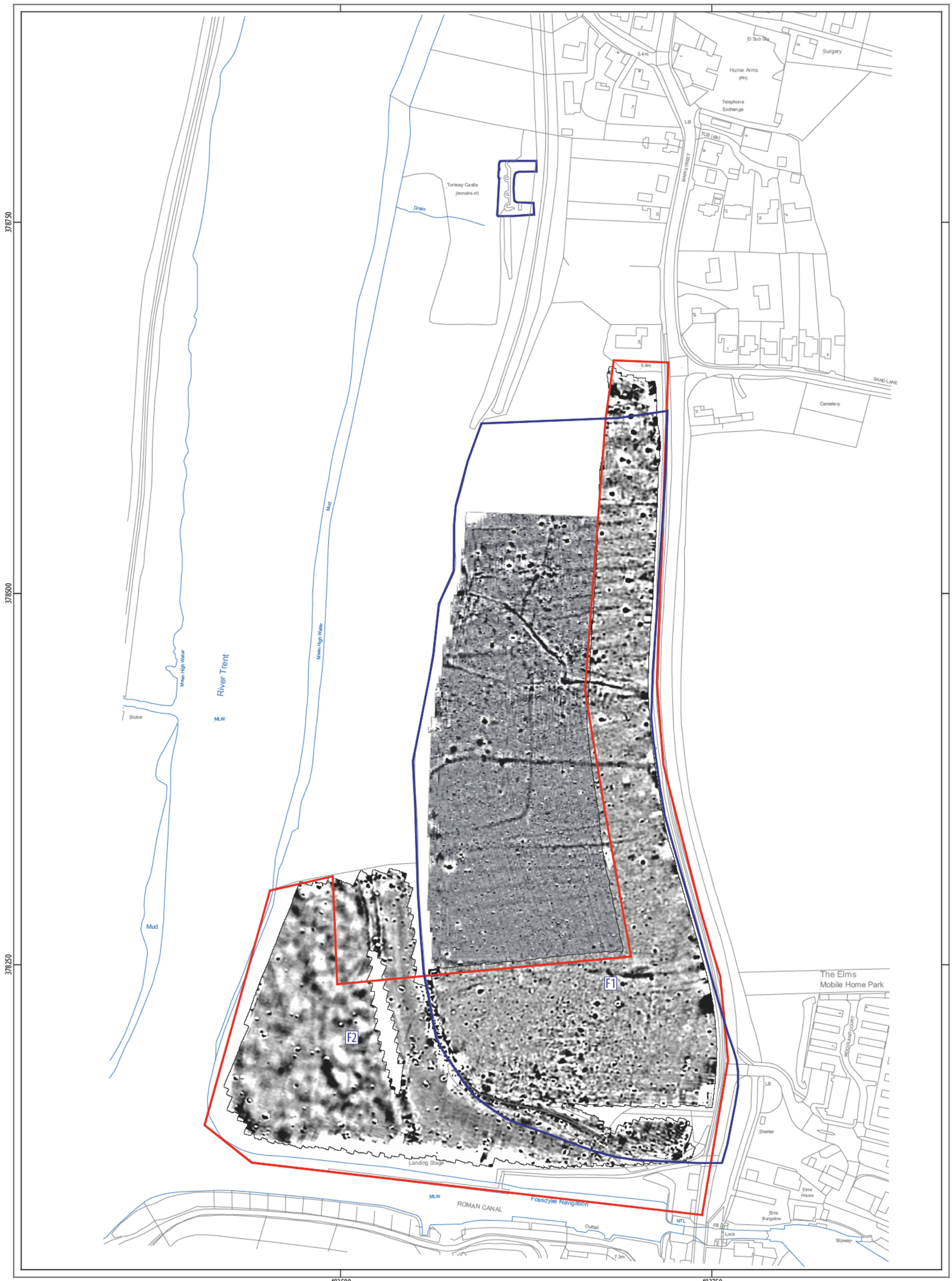
0 50m
1:2,500 @ A3

PROJECT TORK18
Torksey Embankment
Lincolnshire

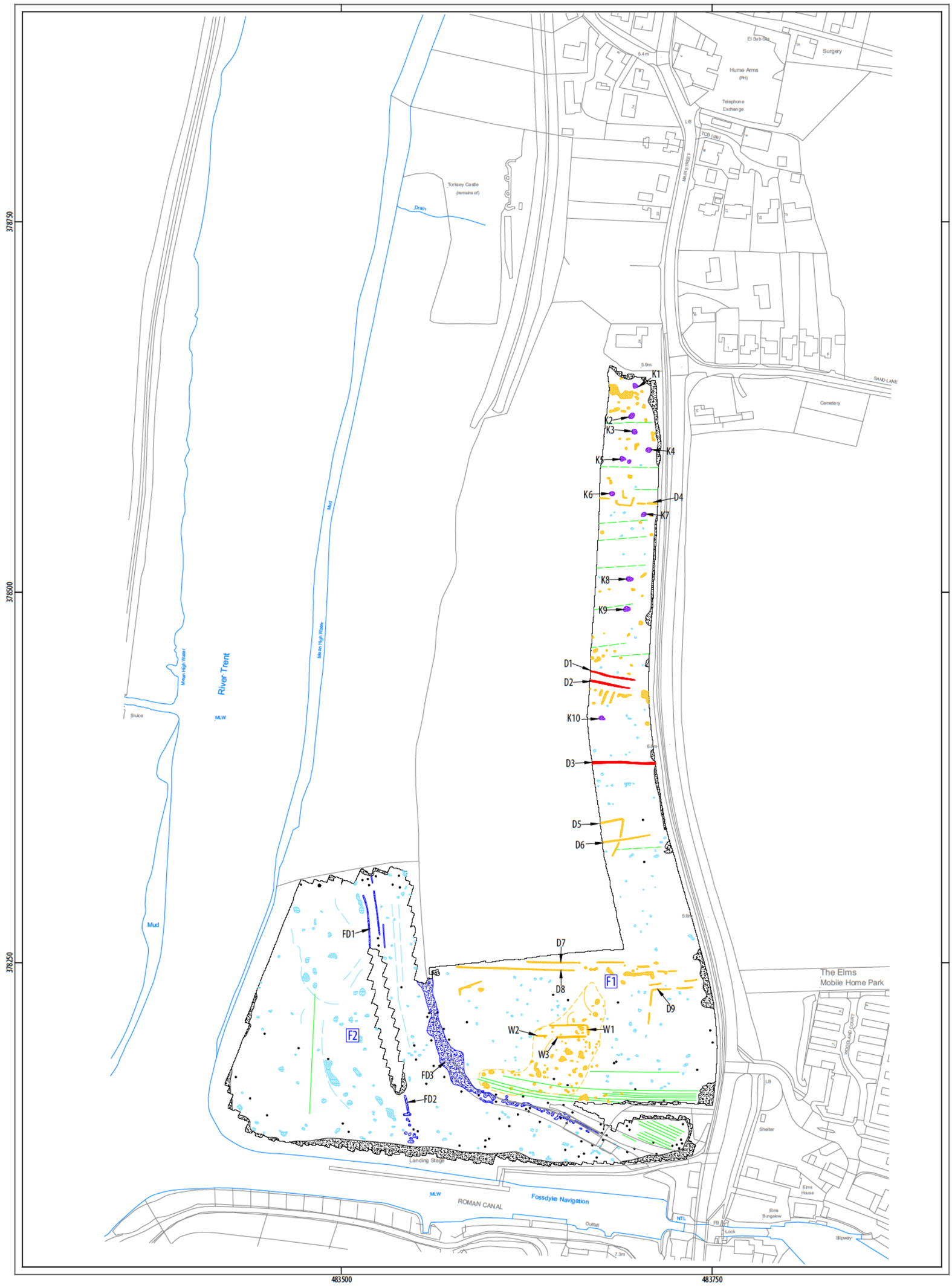
CLIENT Arcadis

HEADLAND ARCHAEOLOGY
NORTH Unit 16, Hillside, Beeston Road
Leeds LS11 8ND
0113 387 6430
www.headlandarchaeology.com

**ILLUS 6** Survey location showing GPS swaths (1:2,500)




**ILLUS 7** Processed greyscale magnetometer data showing previous survey data (1:2,500)




| TYPE OF ANOMALY | INTERPRETATION |
|---|---|
| dipolar isolated | ferrous material |
| magnetic disturbance | ferrous material |
| magnetic enhancement | modern |
| linear trend | ridge and furrow |
| linear trend | agricultural |
| linear trend | geological variation |

| TYPE OF ANOMALY | INTERPRETATION |
|---|---|
| magnetic enhancement | geology |
| magnetic enhancement | kiln? |
| linear trend | archaeology? |
| negative linear | wall? |
| magnetic enhancement | archaeology? |
| magnetic enhancement | archaeology |

ABBREVIATIONS

D ditch
FD flood defence
K kiln
W wall

0 50m
1:2,500 @A3

PROJECT TORK18
Torksey Embankment
Lincolnshire

CLIENT Arcadis

HEADLAND ARCHAEOLOGY
NORTH Unit 16, Hillside, Beeston Road
Leeds LS11 8ND
0113 387 6430
www.headlandarchaeology.com

**ILLUS 8** Interpretation of magnetometer data (1:2,500)


nT
-1.0 2.0

0 25m
1:1,000 @ A3

PROJECT TORK18
Torksey Embankment
Lincolnshire

CLIENT Arcadis

HEADLAND ARCHAEOLOGY
NORTH Unit 16, Hillside, Beeston Road
Leeds LS11 8ND
0113 387 6430
www.headlandarchaeology.com

**ILLUS 9** Processed greyscale magnetometer data; Sector 1 (1:1,000)


15.0nT/cm

0 25m

1:1,000 @ A3

PROJECT TORK18
Torksey Embankment
Lincolnshire

CLIENT Arcadis

HEADLAND ARCHAEOLOGY

NORTH Unit 16, Hillside, Beeston Road
Leeds LS11 8ND
0113 387 6430
www.headlandarchaeology.com

**ILLUS 10** XY trace plot of minimally processed magnetometer data; Sector 1 (1:1,1000)


| TYPE OF ANOMALY | INTERPRETATION |
|---|---|
| dipolar isolated | ferrous material |
| magnetic disturbance | ferrous material |
| linear trend | ridge and furrow |
| linear trend | agricultural |
| magnetic enhancement | geology |
| magnetic enhancement | kiln? |

| TYPE OF ANOMALY | INTERPRETATION |
|---|---|
| magnetic enhancement | archaeology? |
| magnetic enhancement | archaeology |

ABBREVIATIONS

D ditch

K kiln

0 25m

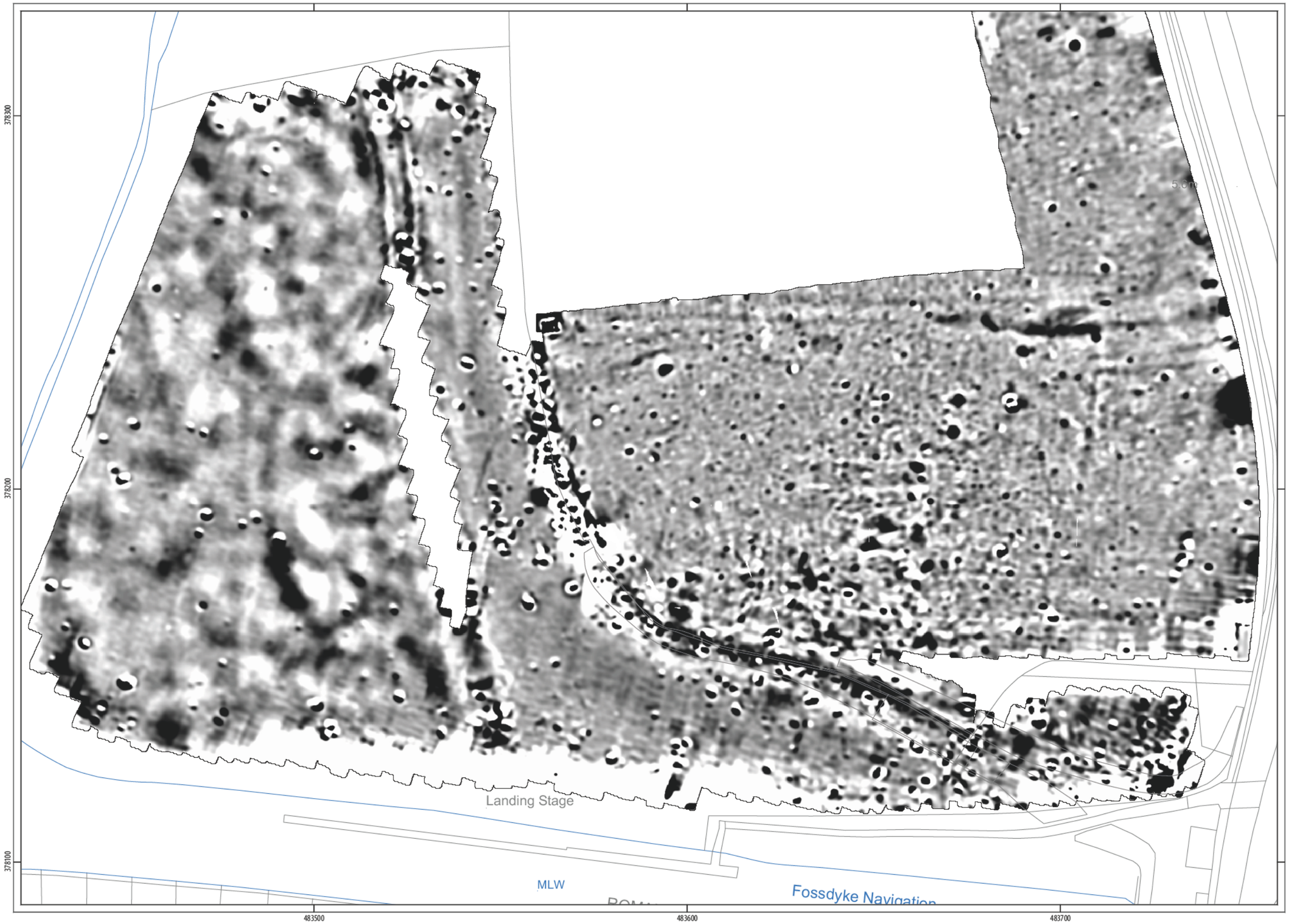
1:1,000 @ A3

PROJECT TORK18
Torksey Embankment
Lincolnshire

CLIENT Arcadis

HEADLAND ARCHAEOLOGY
NORTH Unit 16, Hillside, Beeston Road
Leeds LS11 8ND
0113 387 6430
www.headlandarchaeology.com

**ILLUS 11** Interpretation of magnetometer data; Sector 1 (1:1,000)



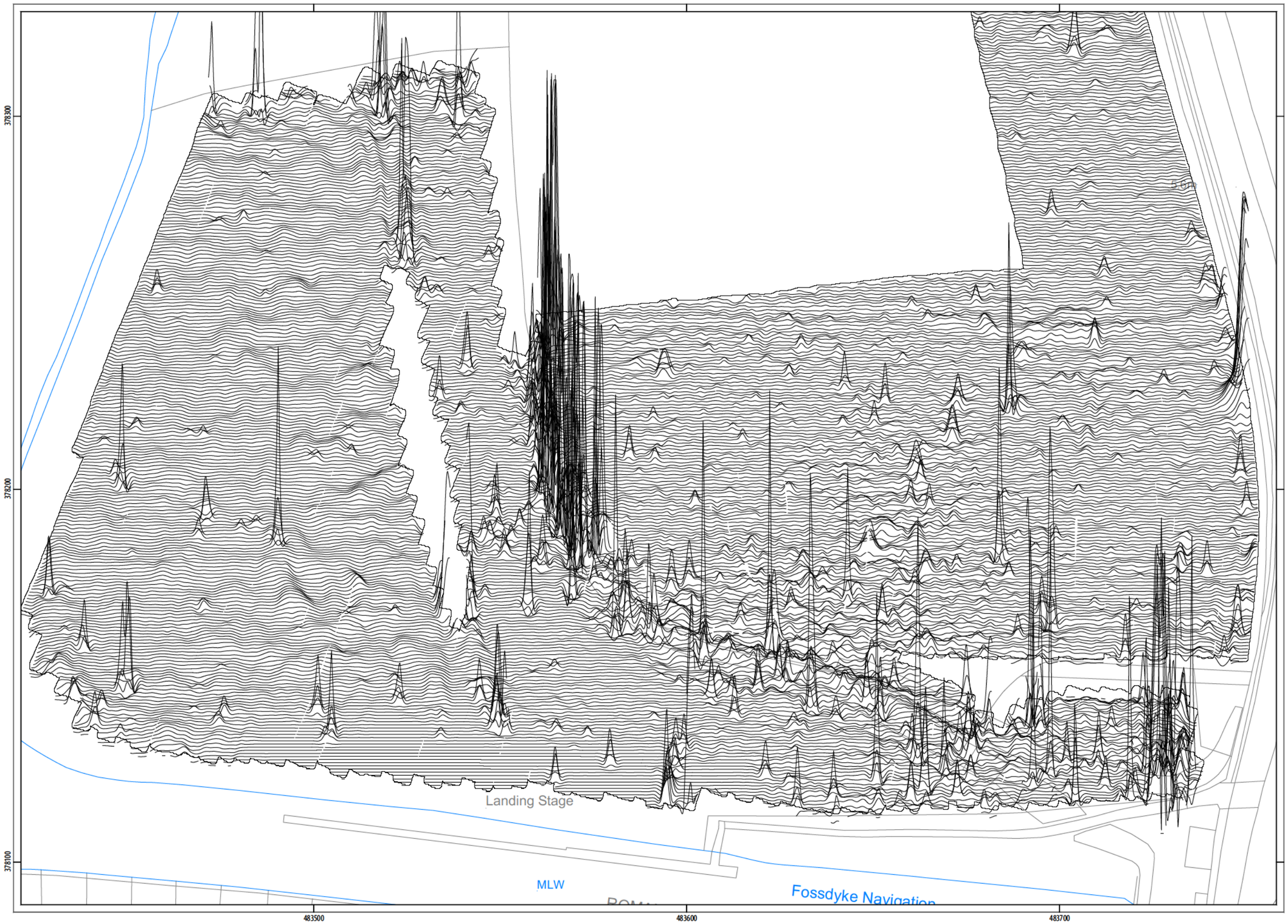

PROJECT TORK18
Torksey Embankment
Lincolnshire

CLIENT Arcadis

HEADLAND ARCHAEOLOGY

NORTH Unit 16, Hillside, Beeston Road
Leeds LS11 8ND
0113 387 6430
www.headlandarchaeology.com

**ILLUS 12** Processed greyscale magnetometer data; Sector 2 (1:1,1000)




15.0nT/cm

0 2.5m

1:1,000 @ A3

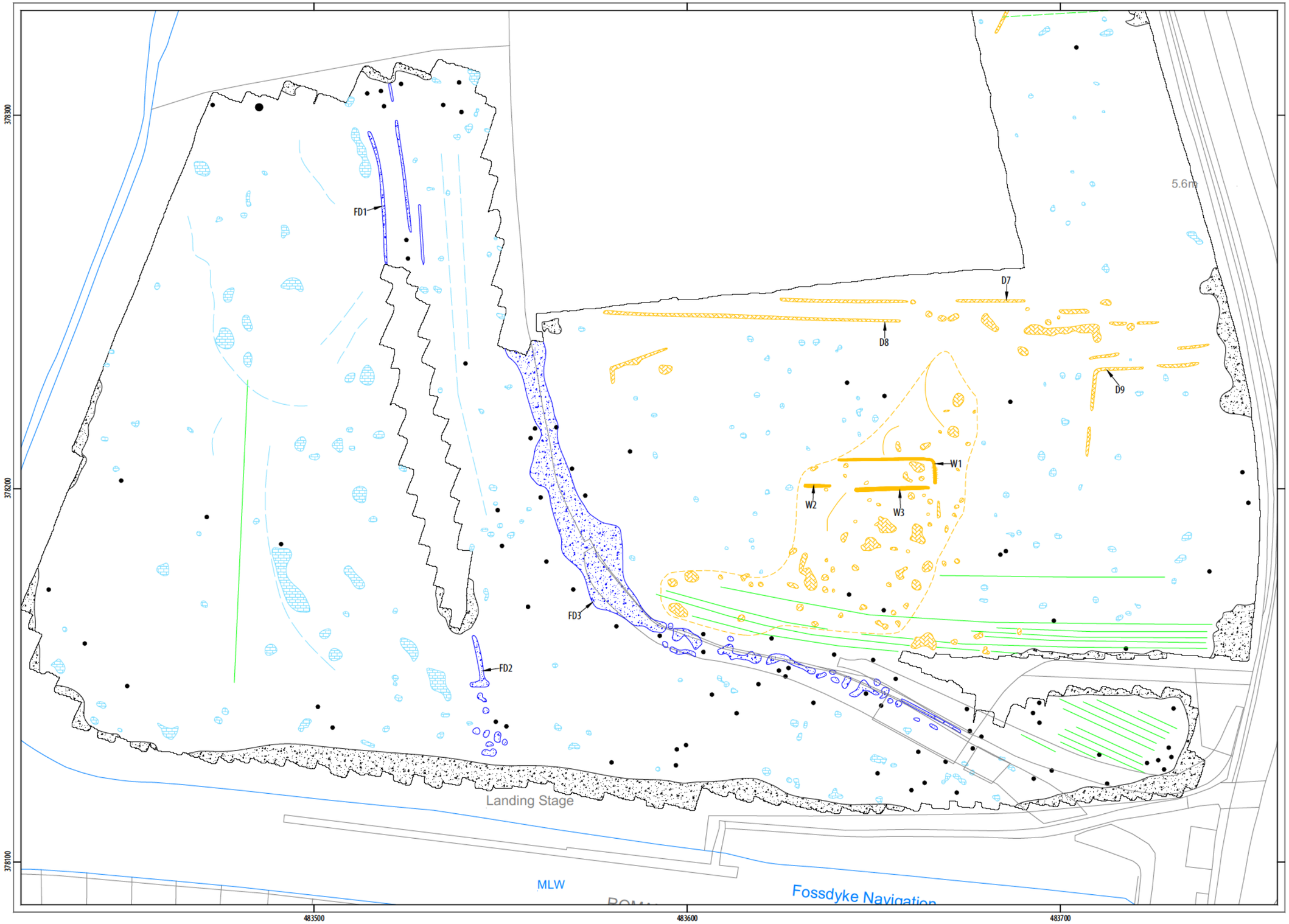
PROJECT TORK18
Torksey Embankment
Lincolnshire

CLIENT Arcadis

HEADLAND ARCHAEOLOGY

NORTH Unit 16, Hillside, Beeston Road
Leeds LS11 8ND
0113 387 6430
www.headlandarchaeology.com

**ILLUS 13** XY trace plot of minimally processed magnetometer data; Sector 2 (1:1,000)




PROJECT TORK18
Torksey Embankment
Lincolnshire

CLIENT Arcadis

HEADLAND ARCHAEOLOGY
NORTH Unit 16, Hillside, Beeston Road
Leeds LS11 8ND
0113 387 6430
www.headlandarchaeology.com

**ILLUS 14** Interpretation of magnetometer data; Sector 2 (1:1,000)

# 7 APPENDICES

## APPENDIX 1 MAGNETOMETER SURVEY

### *Magnetic susceptibility and soil magnetism*

Iron makes up about 6% of the earth's crust and is mostly present in soils and rocks as minerals such as maghaemite and haematite. These minerals have a weak, measurable magnetic property termed magnetic susceptibility. Human activities can redistribute these minerals and change (enhance) others into more magnetic forms so that by measuring the magnetic susceptibility of the topsoil, areas where human occupation or settlement has occurred can be identified by virtue of the attendant increase (enhancement) in magnetic susceptibility. If the enhanced material subsequently comes to fill features, such as ditches or pits, localised isolated and linear magnetic anomalies can result whose presence can be detected by a magnetometer (fluxgate gradiometer).

In general, it is the contrast between the magnetic susceptibility of deposits filling cut features, such as ditches or pits, and the magnetic susceptibility of topsoils, subsoils and rocks into which these features have been cut, which causes the most recognisable responses. This is primarily because there is a tendency for magnetic ferrous compounds to become concentrated in the topsoil, thereby making it more magnetic than the subsoil or the bedrock. Linear features cut into the subsoil or geology, such as ditches, that have been silted up or have been backfilled with topsoil will therefore usually produce a positive magnetic response relative to the background soil levels. Discrete feature, such as pits, can also be detected.

The magnetic susceptibility of a soil can also be enhanced by the application of heat. This effect can lead to the detection of features such as hearths, kilns or areas of burning.

### *Types of magnetic anomaly*

In the majority of instances anomalies are termed 'positive'. This means that they have a positive magnetic value relative to the magnetic background on any given site. However some features can manifest themselves as 'negative' anomalies that, conversely, means that the response is negative relative to the mean magnetic background.

Where it is not possible to give a probable cause of an observed anomaly a '?' is appended.

It should be noted that anomalies interpreted as modern in origin might be caused by features that are present in the topsoil or upper layers of the subsoil. Removal of soil to an archaeological or natural layer can therefore remove the feature causing the anomaly.

The types of response mentioned above can be divided into five main categories that are used in the graphical interpretation of the magnetic data:

**Isolated dipolar anomalies (iron spikes)** These responses are typically caused by ferrous material either on the surface or in the topsoil. They cause a rapid variation in the magnetic response giving a characteristic 'spiky' trace. Although ferrous archaeological artefacts could produce this type of response, unless there is supporting evidence for an archaeological interpretation, little emphasis is normally given to such anomalies, as modern ferrous objects are common on rural sites, often being present as a consequence of manuring.

**Areas of magnetic disturbance** These responses can have several causes often being associated with burnt material, such as slag waste or brick rubble or other strongly magnetised/fired material. Ferrous structures such as pylons, mesh or barbed wire fencing and buried pipes can also cause the same disturbed response. A modern origin is usually assumed unless there is other supporting information.

**Linear trend** This is usually a weak or broad linear anomaly of unknown cause or date. These anomalies are often caused by agricultural activity, either ploughing or land drains being a common cause.

**Areas of magnetic enhancement/positive isolated anomalies** Areas of enhanced response are characterised by a general increase in the magnetic background over a localised area whilst discrete anomalies are manifest by an increased response (sometimes only visible on an XY trace plot) on two or three successive traverses. In neither instance is there the intense dipolar response characteristic exhibited by an area of magnetic disturbance or of an 'iron spike' anomaly (see above). These anomalies can be caused by infilled discrete archaeological features such as pits or post-holes or by kilns. They can also be caused by pedological variations or by natural infilled features on certain geologies. Ferrous material in the subsoil can also give a similar response. It can often therefore be very difficult to establish an anthropogenic origin without intrusive investigation or other supporting information.

**Linear and curvilinear anomalies** Such anomalies have a variety of origins. They may be caused by agricultural practice (recent ploughing trends, earlier ridge and furrow regimes or land drains), natural geomorphological features such as palaeochannels or by infilled archaeological ditches.

## APPENDIX 2 SURVEY LOCATION INFORMATION

An initial survey base station was established using a Trimble VRS differential Global Positioning System (dGPS). The magnetometer data was georeferenced using a Trimble RTK differential Global Positioning System (Trimble R8s model).

Temporary sight markers were laid out using a Trimble VRS differential Global Positioning System (Trimble R8s model) to guide the operator and ensure full coverage. The accuracy of this dGPS equipment is better than 0.01m.

The survey data were then super-imposed onto a base map provided by the client to produce the displayed block locations. However, it should be noted that Ordnance Survey positional accuracy for digital map data has an error of 0.5m for urban and floodplain areas, 1.0m for rural areas and 2.5m for mountain and moorland areas. This potential error must be considered if coordinates are measured off hard copies of the mapping rather than using the digital coordinates.

Headland Archaeology cannot accept responsibility for errors of fact or opinion resulting from data supplied by a third party.

## APPENDIX 3 GEOPHYSICAL SURVEY ARCHIVE

The geophysical archive comprises an archive disk containing the raw data in XYZ format, a raster image of each greyscale plot with associate world file, and a PDF of the report.

The project will be archived in-house in accordance with recent good practice guidelines (http://guides.archaeologydataservice.ac.uk/g2gp/Geophysics_3). The data will be stored in an indexed archive and migrated to new formats when necessary.

## APPENDIX 4 DATA PROCESSING

The gradiometer data has been presented in this report in processed greyscale and minimally processed XY trace plot format.

Data collected using RTK GPS-based methods cannot be produced without minimal processing of the data. The minimally processed data has been interpolated to project the data onto a regular grid and de-striped to correct for slight variations in instrument calibration drift and any other artificial data.

A high pass filter has been applied to the greyscale plots to remove low frequency anomalies (relating to survey tracks and modern agricultural features) in order to maximise the clarity and interpretability of the archaeological anomalies.

The data has also been clipped to remove extreme values and to improve data contrast.

# APPENDIX 5 OASIS DATA COLLECTION FORM: ENGLAND

## *OASIS ID: headland5-328381*

| Project details | |
|---|---|
| Project name | Torksey Embankment |
| Short description of the project | Headland Archaeology (UK) Ltd undertook a geophysical (magnetometer) survey over 6 hectares at Castle Field, part of which encompasses Torksey Medieval Town, a Scheduled Monument in Lincolnshire. The survey was carried out in advance of improvements to existing flood defences. The survey has identified anomalies consistent with the continuation of features identified by the 2012 geophysical survey including pits, ditches, a possible road/track as well as a further ten possible kilns or areas of burning. The anomalies are more densely concentrated within the northern half of Castle Field. Llinear and rectilinear negative anomalies may be due to structural remains. These anomalies may locate the site of a Roman building/Roman pavement and/or an early medieval priory. No anomalies of archaeological potential have been identified on the floodplain to the south-west of Castle Field). Overall the survey has confirmed that any groundworks will adversely impact on sub-surface archaeological remains across much of the survey area (with the possible exception of the floodplain) and that further archaeological work will likely be required before and during the flood improvement works. The magnetometer survey is assessed as having given a good indication of the nature and extent of the archaeological remains. On balance it is considered that any further remote sensing survey techniques, such as ground penetrating radar, earth resistance or electromagnetic surveys, are unlikely to add significant information on the extent of those archaeological remains and that a limited programme of trial trenching would be more cost effective. One possible exception to this might be a tightly focussed resistance survey centred on the possible structure. |
| Project dates | Start: 11-07-2018 End: 11-07-2018 |
| Previous/future work | Yes / Yes |
| Any associated project reference codes | TORK12 - Contracting Unit No. |
| Type of project | Field evaluation |
| Site status | None |
| Current Land use | Cultivated Land 2 - Operations to a depth less than 0.25m |
| Monument type | MEDIEVAL TOWN Medieval |
| Monument type | NONE None |
| Significant Finds | BONE Medieval |
| Significant Finds | NONE None |
| Methods & techniques | "Geophysical Survey" |
| Development type | Not recorded |
| Development type | Flood Alleviation work |
| Prompt | National Planning Policy Framework - NPPF |
| Position in the planning process | Not known / Not recorded |
| Solid geology | LUDLOW |
| Solid geology (other) | Mercia Mudstaone |
| Drift geology | ALLUVIUM |
| Techniques | Magnetometry |
| Project location | |
| Country | England |
| Site location | LINCOLNSHIRE LINCOLN LINCOLN Torksey |
| Postcode | LN1 2EQ |
| Study area | 6 Hectares |
| Site coordinates | SK 8366 7814 53.293330549156 -0.74472403766 53 17 35 N 000 44 41 W Point |
| Project creators | |
| Name of Organisation | Headland Archaeology |

| | |
|---|---|
| Project brief originator | Headland Archaeology |
| Project design originator | Headland Archaeology |
| Project director/manager | Alistair Webb |
| Project supervisor | Bishop, R |
| Type of sponsor/funding body | Environment Agency |
| Project archives | |
| Physical Archive Exists? | No |
| Digital Archive recipient | In house |
| Digital Contents | "other" |
| Digital Media available | "Geophysics" |
| Paper Archive Exists? | No |
| Project bibliography 1 | |
| Publication type | Grey literature (unpublished document/manuscript) |
| Title | Torksey Embankment |
| Author(s)/Editor(s) | Webb, A |
| Other bibliographic details | TORK18 |
| Date | 2018 |
| Issuer or publisher | Headland Archaeology |
| Place of issue or publication | Headland |
| Entered by | Alistair Webb (alistair.webb@headlandarchaeology.com) |
| Entered on | 13 September 2018 |

# APPENDIX 6 SECTION 42 LICENCE

## *Historic England Geophysical Survey Summary Questionnaire*

### Survey Details

| | |
|---|---|
| Name of Site: | Torksey Embankment |
| County: | Lincolnshire |
| NGR Grid Reference:<br>*(Centre of survey to nearest 100m)* | SK 83685 78389 |
| Survey Dates:<br>*(Survey to take place within this time bracket)* | Start Date: 09/07/18 End Date: 20/07/18 |
| Geology at site:<br>*(Drift and Solid)* | The bedrock geology comprises Mercia Mudstone Group- Mudstone which is overlain by Alluvium- clay, silt, sand and gravel in Sector C, and the western half of Sector B, and Holme Pierrepont Sand and Gravel Member- sand and gravel in Sector A and the eastern half of Sector B (NERC 2018).<br><br>The soils are classified in the Soilscape 20 classification described as naturally wet loamy and clayey floodplain soils over Section C and the western half of Section B, and in the Soilscape 15 classification described as naturally wet very acidic sandy and loamy soils over Section A and the eastern half of Section B (Cranfield University 2018). |
| Known archaeological Sites/Monuments covered by the survey:<br>*(Scheduled Monument No. or National Archaeological Record No. if known)* | Medieval Town of Torksey (Monument Number 1004991) |
| Archaeological Sites/Monument types detected by survey:<br>*(Type and Period if known. "?" where any doubt).* | – |
| Surveyor:<br>*(Organisation, if applicable, otherwise individual responsible for the survey):* | Headland Archaeology (North) |
| Name of Client, if any: | Environment Agency |
| Purpose of Survey: | To help establish the nature and extent of archaeological features in areas likely to be affected by forthcoming embankment stabilisation works, in order to plan an appropriate mitigation strategy. |
| Location of: | |
| a) Primary archive, i.e. raw data, electronic archive etc: | The project will be archived in-house (Headland Archaeology) in accordance with recent good practice guidelines (http://guides.archaeologydataservice.ac.uk/g2gp/Geophysics_3). The data will be stored in an indexed archive and migrated to new formats when necessary. |
| b) Full Report: | Following completion and submission of the report to the client, copies of the report will be sent to the relevant Historic Environment Record, local authority Planning Officer and/or Conservation Officer. In addition, Headland Archaeology will make their work accessible to the wider research community by submitting digital data and copies of the report on line to OASIS. |

### Technical Details

(Please fill out a separate sheet for each survey technique used)

| | |
|---|---|
| Type of Survey:<br>*(Use term from attached list or specify other)* | Magnetometer |
| Area Surveyed, if applicable:<br>*(In hectares to one decimal place)* | 6.5ha (entirety of Site) |
| Traverse Separation, if regular: | 1m |
| Reading/Sample Interval: | 10Hz (allowing for a 10-15cm sample interval) |
| Type, Make and model of Instrumentation: | Four Bartington Grad601 sensors mounted at 1m intervals. The magnetometer system will be linked to a Trimble R8s and R2 Real Time Kinetic (RTK) differential Global Positioning System (dGPS) outputting in NMEA mode to ensure a high positional accuracy of each data point. |
| Land use at the time of the survey:<br>*(Use term/terms from the attached list or specify other)* | Arable and Grassland – Undifferentiated. |

**Headland Archaeology** South & East
Building 68C | Wrest Park | Silsoe | Bedfordshire MK45 4HS
t 01525 861 578
e southandeast@headlandarchaeology.com

**Headland Archaeology** Midlands & West
Unit 1 | Clearview Court | Twyford Rd | Hereford HR2 6JR
t 01432 364 901
e midlandsandwest@headlandarchaeology.com

**Headland Archaeology** North
Unit 16 | Hillside | Beeston Rd | Leeds LS11 8ND
t 0113 387 6430
e north@headlandarchaeology.com

**Headland Archaeology** Scotland
13 Jane Street | Edinburgh EH6 5HE
t 0131 467 7705
e scotland@headlandarchaeology.com

www.headlandarchaeology.com