Cambridge Waste Water Treatment Plant Relocation Project
Anglian Water Services Limited

Appendix 13.5: Geophysical Surveys

Application Document Reference: 5.4.13.5
PINS Project Reference: WW010003
APFP Regulation No. 5(2)a

Revision No. 02
April 2023

CWRP21

Cambridge Waste Water Treatment Plant, Cambridgeshire

GEOPHYSICAL SURVEY REPORT

PLANNING REF. n/a

Headland Archaeology Yorkshire & North
Units 23–25 & 15 | Acorn Business Centre | Balme Road | Cleckheaton BD19 4EZ

for Mott MacDonald for Anglian Water

19/04/2021

HEADLAND ARCHAEOLOGY

PROJECT INFORMATION:

PROJECT NAME	Cambridge Waste Water Treatment Plant
TYPE OF WORK	Geophysical Survey
PLANNING REF.	DCO Application
CAMBRIDGE EVENT CODE	ECB6587
CONSULTANT/AGENT	Mott MacDonald
CLIENT	Anglian Water
PROJECT CODE	CWRP21
HAS. NO (HEREFORD ONLY)	n/a
NGR	TL 4950, 6100
PARISH	Horningsea
LOCAL AUTHORITY	Cambridgeshire County Council
FIELDWORK DATES	17/03/2021 – 26/03/2021
OASIS REF.	Headland5-?????
ARCHIVE REPOSITORY	Headland Archaeology

PROJECT TEAM:

PROJECT MANAGER	Alistair Webb
AUTHOR	Alistair Webb
FIELDWORK	Peter Heykoop, Ross Bishop, Matt Berry, Eleanor Culverhouse, Neil Paveley, Andrew Marke
GRAPHICS	Sam Harrison, Ross Bishop, Matt Berry

PROJECT SUMMARY

Headland Archaeology (UK) Ltd undertook a geophysical (magnetometer) survey on the north-eastern periphery of Cambridge on behalf of Anglian Water who are currently engaging in preliminary studies and investigations for the relocation of the Cambridge Waste Water Treatment Plant (WWTP). The results of the survey will be used to support a Development Consent Order (DCO) application for the proposed scheme and will also inform future archaeological strategy at the site, if required. The survey covered 126 hectares of agricultural land which comprises Site Area 3 (hereafter the proposed development area – PDA). The PDA comprised three zones; the main site (108ha), the site access route (12ha) and the treated effluent pipeline corridor (6ha).

The survey has identified numerous linear and discrete anomalies across all parts of the PDA. Most of these anomalies are due to activity associated with the drainage and subsequent farming of this former fenland landscape being caused by drains, relict field boundaries, ridge and furrow and modern ploughing. However, the survey has identified a single area of definite archaeological potential in the field immediately south of Biggin Abbey (Zone C – the treated effluent pipeline corridor). Part of the moat and possible associated features within the moated complex have been recorded. Other anomalies beyond the moat may also have an archaeological origin.

A cluster of discrete pit-type anomalies is recorded (in Zone A – the main site) adjacent to the Horningsea Road and close to an area of cropmarks (HER MCB13592) which have been interpreted as indicative of Roman settlement. The cropmarks, which are very clearly visible on an air photograph taken in 1970, have not been recorded by the survey. It is possible that the underlying features causing the cropmark may have been degraded by deep ploughing over the last 50 years since the images were taken and by the construction of the A14 in 1990. The anomalies are, however, outside the proposed footprint of the new water treatment works; no anomalies of archaeological potential are recorded within the footprint of the works. It should be noted that this and two other clusters of discrete anomalies, which have also been interpreted as of possible archaeological origin, could equally be due to natural infilled features eroded in the soft chalky bedrock. Within Zone B (the access road corridor) a single curvilinear anomaly of uncertain (and therefore potentially archaeological) origin is recorded. The relatively narrow survey corridor here makes further interpretation difficult.

Sedimentary bedrock (such as chalk) generally provides good results to magnetic survey particularly when there are no overlying superficial deposits and therefore, it is assessed that the survey has given a good indication of the likely archaeological potential of the PDA.

TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

CAMBRIDGE WASTE WATER TREATMENT PLANT, CAMBRIDGESHIRE

GEOPHYSICAL SURVEY REPORT

1. INTRODUCTION

Headland Archaeology (UK) Ltd was commissioned by Mott MacDonald, on behalf of Anglian Water Ltd (The Client) to undertake a geophysical (magnetometer) survey on land north-east of Cambridge, where Anglian Water is currently engaging in preliminary studies and investigations for the relocation of the Cambridge Waste Water Treatment Plant (WWTP) to make the land currently occupied by the WWTP, available for housing development. The results of the survey will be used to support a Development Consent Order (DCO) application for the proposed scheme and will also inform future archaeological strategy at the site, if required.

The survey (Site Area 3) covered approximately 126 hectares in three zones (Illus 1) and was undertaken to assess the impact of the proposed development on the historic environment. It was undertaken in accordance with a Written Scheme of Investigation for Geophysical Survey (WSI) (Headland 2021) which in turn was informed by a Brief for Archaeological Geophysical Survey provided by Cambridgeshire County Council Historic Environment Team (CCCHET). The WSI was approved by Andy Thomas, Senior Archaeologist on the CCCHET, prior to the commencement of the survey; CCCHET provide archaeological advice to Cambridgeshire County Council. The survey also follows guidance contained in the National Planning Policy Framework (MHCLG 2019) and was carried out in line with current best practice (Chartered Institute for Archaeologists 2014, Europae Archaeologia Consilium 2016).

The survey was carried out between March 17th 2021 and March 26th 2021.

1.1. SITE LOCATION, TOPOGRAPHY AND LAND-USE

The Proposed Development Area (PDA – Illus 1) is located on land north-east of Cambridge, between Milton to the north-west, Horningsea to the north and Stow Cum Quy to the east, centred approximately 1km north-east of Fen Ditton at NGR TL495610.

The land within the PDA is currently all under arable agricultural production (Illus 2 to Illus 5 inclusive) with open farmland extending to all sides.

The PDA comprised all or part of 16 fields in three specific zones (Illus 6) :-

- The main site (Zone A - 108ha). This comprises the WWTP footprint, construction areas, including compounds and laydown areas,
- The site access route (Zone B - 12ha). This comprises construction and operation access routes; and
- The treated effluent pipeline corridor (Zone C - 6ha). The waste-water transfer corridor to the existing WWTP will be tunnelled and is therefore excluded from the survey area. The Waterbeach transfer pipeline corridor will be subject to a separate phase of survey.

The main site (Zone A) is bound by the A14 to the south-west, by Horningsea Road (B1047) to the north-west and field boundaries to the north.

The access route (Zone B) approaches the main site from the southern side forming a corridor either side of the A14 aligned from south-west to north-east before dog-legging to the south east before connecting to High Ditch Road and Newmarket Road (A1303) just to the south of the A14.

The effluent pipeline (Zone C) approaches the main site at the north-western side of the PDA, just east of the River Cam and south of Biggin Abbey on a broadly east/west alignment corridor.

Topographically all three zones are essentially flat varying between approximately 6m and 10m above Ordnance Datum (AOD).

1.2. GEOLOGY AND SOILS

The underlying bedrock geology comprises West Melbury Marly Chalk Formation across Zone A, Zone B and most of Zone C but Gault Formation Mudstone along the pipeline route between Biggin Abbey and the River Cam. There are no recorded superficial deposits except adjacent to the River Cam in Zone C where there are deposits of Alluvium (UKRI 2021).

The soils are classified in the Soilscape 5 Association which are described as freely draining lime-rich loamy soils (Cranfield University 2021).

2. ARCHAEOLOGICAL BACKGROUND

Information included within the Brief (CCCHET 2021) assessed the area within Design Option L (equivalent to Site Option 3 which encompasses the PDA) as being 'located in an area of high archaeological potential with substantial evidence for prehistoric and Roman settlement within and in the vicinity of the site', although noting that a cropmark complex indicating the location of a Roman settlement within the shortlisted area is outside the indicative WWTP footprint (HER MCB13592). The Brief also stated that the south-western extent of this site falls under the A14, the construction of which was considered likely to have had a substantial impact on any currently unknown assets immediately adjacent to the Roman settlement. There is high potential for archaeological assets to survive within the proposed WWPT site and transfer corridor.

A high-level archaeological overview is provided in the WWTP Stage 4 Historic Environment Assessment. The list below (abstracted from this document) provides a list of the archaeological assets identified by the Cambridgeshire Historic Environment Record (CHER) located within or directly adjacent to the three survey zones.

Main Site (Zone A)

- Prehistoric pottery, A45 Quy fieldwalking survey field 8, Horningsea (CHER: 11195)
- Roman pottery, A45 Quy fieldwalking survey field 8, Horningsea (CHER: 11195A)
- Medieval pottery, A45 Quy fieldwalking survey field 8, Horningsea (CHER: 11195B)
- Post-medieval pottery, A45 Quy fieldwalking survey field 8, Horningsea (CHER: 11195C)
- Roman cropmark system, Horningsea (CHER: 11555);
- Medieval earthworks, Horningsea (CHER: 05324a);
- Roman artefact scatter (CHER: 05324);
- Ridge and furrow, Horningsea (CHER: 05612)

Site Access Route (Zone B)

- Roman cropmark system, Horningsea (CHER: 11555)
- Medieval earthworks, Horningsea (CHER: 05324a)
- Ridge and furrow, Horningsea (CHER: 05612)
- Multiperiod finds, A45 Girton to Stow cum Quy fieldwalking survey, field 5 (CHER: 11192)
- High Dyke/ northern section of Fleam Dyke (CHER: MCB12150)
- Anglo-Saxon inhumation, Fleam Dyke at junction of Fen Ditton and Newmarket Roads (CHER: 06303)
- Milestone, Newmarket Road (CHER: MCB18062)

Treated Effluent Pipeline Corridor (Zone C)

- Multiperiod finds, A45 Girton to Stow cum Quy fieldwalking survey, field 6 (CHER: 11193)
- Late Saxon - early medieval pottery, Fen Ditton (CHER: 11765)
- Cropmark site, Fen Ditton (CHER: 08327)
- Cropmarks and earthworks associated with Biggin Abbey (CHER: 01095)
- Former clay pit, Fen Ditton (CHER: MCB27455)

3. AIMS, METHODOLOGY AND PRESENTATION

The principal aim of the programme of geophysical survey was to gather information to establish the presence/absence, character and extent of any archaeological remains within the PDA. This will therefore enable an assessment to be made of the impact of the proposed development on any sub-surface archaeological remains, if present, and thereby inform the DCO application and any further investigation strategies, as appropriate.

The specific archaeological objectives of the geophysical survey were:

to gather enough information to inform the extent, condition, character and date (as far as circumstances permit) of any archaeological features and deposits within the PDA;

to obtain information that will contribute to an evaluation of the significance of the scheme upon cultural heritage assets; and

to prepare a report summarising the results of the survey.

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 V3.0.36.0 (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 1:25,000. Illus 2 to Illus 5 inclusive are site condition photographs. Illus 6 shows the GPS swaths at 1:10,000 and also the three zones within the PDA. Illus 7 presents the greyscale data for the whole PDA, showing Sector boundaries, with Illus 8 an overall interpretation of the data, both illustrations at a scale of 1:10,000. Fully processed (greyscale) data, minimally processed data (XY trace plot) data and an interpretative plot (by Sector) are presented, at a scale of 1:2,500, in Illus 9 to Illus 26 inclusive. Large scale (1:1,000) plots of the Area of Archaeological Potential (AAP) are presented as Illus 27 to Illus 29 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 survey methodology, report and any recommendations comply with the Written Scheme of Investigation (Headland 2021), guidelines outlined by Europae Archaeologia Consilium (EAC 2016) and by the Chartered Institute for Archaeologists (CIfA 2014). All illustrations from Ordnance Survey (OS) 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' (minimally processed) and processed formats and over a range of different display levels. All illustrations are presented to display and interpret the data to best effect. The interpretations are based on the experience and knowledge of management and reporting staff.

4. RESULTS AND DISCUSSION

Ground conditions were generally good across the PDA, although heavy underfoot in places. Data quality was also good with only minimal post-processing required. All the PDA was suitable for survey, with the exception of the eastern half of F8 which was overgrown with teazles (Illus 5). No problems were encountered during the fieldwork.

Overall, the magnetic background was homogenous across the PDA (but with some geological variations – see Section 4.3 below) with numerous anomalies, agricultural, geological, archaeological and modern being identified. This confirms that the soils and geology are suitable for magnetometry and that the results likely provide a reasonably good indication of the extent of sub-surface archaeological features within the PDA, notwithstanding the limitations of magnetometer survey to identify certain types and sizes of archaeological feature and period.

The non-archaeological anomalies have been classified into categories and are discussed generally. Anomalies of probable archaeological origin have been identified at a single location and this area of archaeological potential (AAP) is discussed separately, and in more detail, below.

4.1. 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 introduced into the topsoil during manuring or tipping/infilling. There is no obvious clustering to the ferrous anomalies within any of the fields or across the PDA more generally to 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.

Halos of magnetic disturbance in F3 and F4 are caused by the proximity of extant electricity pylons. The sub-surface remains of two former pylons are identified on the eastern edge of F7 and at the northern end of F9 as the characteristic arrangement of four equally spaced iron 'spikes' arranged in a square; each 'spike' caused by the steel foot at each corner of the former pylon.

An area of disturbance in the south-eastern corner of F7 correlates with the position of a former building recorded on the first edition OS map. Two linear dipolar anomalies (Illus 8 – SP1 and SP2), one of which terminates at the location of the former building, locate sub-surface pipes. A third pipe (Illus 8 – SP3) is identified running parallel with the disused railway line along the south-eastern boundaries of F5, F6, F10 and F11.

Other linear bands of disturbance located along field edges are due to the accumulation of ferrous debris along the boundary or to the presence of barbed wire or wire mesh in the boundary itself.

4.2. AGRICULTURAL ANOMALIES

Analysis of the first edition Ordnance Survey (OS) County series mapping from the late 19th century and more recent mapping shows that there has been a rationalisation of boundaries over the past 130 years to create larger fields, particularly around the southern ends of F5, F6, F12 and F13. Some of the former boundaries are also inferred by the change in orientation of the ridge and furrow cultivation strips (see below), which are identified as the slightly curving parallel linear anomalies, which are ubiquitous throughout with the notable exception of the field south of Biggin Abbey (F1). The best example of this is the area either side of the current boundary between F5 and F6. The more closely spaced, parallel very straight linear trends are due to modern cultivation.

Also recorded throughout are other linear trend anomalies that are interpreted as field drains. These may form a regular pattern, such as those in F3, although some are also curvilinear and much less regular such as those aligned broadly east/west in the northern half of F5.

4.3. GEOLOGICAL ANOMALIES

Vague low magnitude anomalies forming a 'crazy paving' like effect in the data are noted in three locations; in the north-eastern quarter of F3, towards the southern end of F5 and, to a lesser extent, the western third of F4. These anomalies are all interpreted as geological in origin.

Chalk bedrock is particularly susceptible to erosion by water and ice and so this patterning may be due to fissuring in the bedrock. Similarly, some of the discrete anomalies interpreted as of archaeological potential might also be due to infilled geological water worn hollows or depressions. However, in all instances (see Section 4.4 below) any clusters of discrete anomalies have been interpreted as of possible archaeological origin given the local archaeological context.

4.4. AREA OF ARCHAEOLOGICAL POTENTIAL

Most of F1 has been identified as an AAP. Of clearest potential is a broad low magnitude anomaly (Illus 8 – M1) which locates part of the infilled moat surrounding the eastern side of the Biggin Abbey complex – the moat is also clearly visible on satellite images of the site taken at the end of 2005. The southern side of the moat is also visible as a cropmark in 2005 but has not been recorded as a magnetic anomaly, possibly because the direction of survey traverse was directly along the line of the moat. Within the moated area four short linear anomalies, on the same alignment as the eastern moat, are also recorded possibly suggesting division/partition within the moated area. A single linear ditch type anomaly (Illus 8 – D1), also on the same alignment as the eastern moat, and which terminates (and possibly intersects with the inferred southern moat), is also recorded. Discrete anomalies within the moated area are also interpreted as of possible archaeological origin as they stand out against a very homogenous magnetic background in this field. This 'flat' magnetic background in this field is likely due to the presence of superficial alluvial deposits from the River Cam which are not present elsewhere in the PDA.

Two other clusters of anomalies of possible potential are noted in F1. In neither instance can any coherent pattern be discerned but vague linear and discrete anomalies again clearly stand out against the homogenous magnetic background.

The first cluster is defined by three vague linear anomalies describing a possible small square 'enclosure' with a fourth linear anomaly extending eastward from the 'enclosure'. Discrete, pit-type responses are identified within the possible 'enclosure'.

The second area is in the south-east corner of the F1 survey area and is a cluster of discrete anomalies which again form no definite pattern but which are clearly anomalous against the prevailing magnetic background.

4.5. OTHER ANOMALIES OF POSSIBLE ARCHAEOLOGICAL POTENTIAL

In the south-western corner of F3 another cluster of discrete anomalies is identified just inside the junction of Horningsea Road and the A14. It is also adjacent to the Roman cropmark complex CHER 11555/13592. Potentially these anomalies could be due to archaeological activity associated with the road and/or the settlement complex. Alternatively, the anomalies could be caused by infilled natural geological features (see Section 4.3 above). No anomalies that correspond with the previously identified cropmarks are recorded.

Two other clusters of discrete anomalies, which again stand out against the magnetic background, are recorded towards the southern end of F6. These anomalies have also been interpreted as of possible archaeological origin although a geological origin is considered equally plausible.

In F14 and in F16, either side of the A14, a curvilinear anomaly (Illus 8 – D2) is recorded which cannot be interpreted with certainty as of agricultural origin. For this reason a possible archaeological origin must be considered.

5. CONCLUSION

Across the whole of the PDA the overwhelming majority of magnetic anomalies are due to agricultural activity; ridge and furrow and modern cultivation, field drains and former boundaries.

However, the survey has identified a single area of archaeological potential in the field immediately south of Biggin Abbey (Zone C – the treated effluent corridor). Part of the moat and possible associated features within the moated complex have been recorded. Other anomalies beyond the moat may also have an archaeological origin although no clear pattern can be discerned that would lead to a more confident archaeological interpretation being made.

Elsewhere a cluster of discrete anomalies is recorded (in Zone A – the main site) adjacent to the Horningsea Road and an area of cropmarks which have been interpreted as indicative of Roman settlement. The cropmarks, which are very clearly visible on an air photograph taken in 1970, have not been recorded by the survey. It is possible that the underlying features may have been degraded by deep ploughing over the last 50 years since the images were taken and by the construction of the A14 in 1990. The anomalies are, however, outside the proposed footprint of the new water treatment works; no anomalies of archaeological potential are recorded within the footprint of the works.

Within Zone B (the access road corridor) a single curvilinear anomaly of uncertain (and therefore potentially archaeological) origin is recorded. The relatively narrow survey corridor here makes further interpretation difficult.

Sedimentary bedrock (such as chalk) generally provides good results to magnetic survey particularly when there are no overlying superficial deposits. Therefore, it is assessed that the survey has given a good indication of the likely archaeological potential of the PDA.

6. REFERENCES

Cambridgeshire County Council Historic Environment Team 2020 Brief for Archaeological Geophysical Survey Unpublished Cambridgeshire County Council Document

Chartered Institute for Archaeologists (CIfA) 2014 Standard and guidance for archaeological geophysical survey (Reading) [redacted] 2021

Natural Environment Research Council (NERC) 2018 British Geological Survey [redacted] accessed 19th April 2021

Europae Archaeologia Consillium (EAC) 2016 EAC Guidelines for the Use of Geophysics in Archaeology: Question to Ask and Points to Consider (Namur, Belgium) [redacted] accessed 19th April 2021

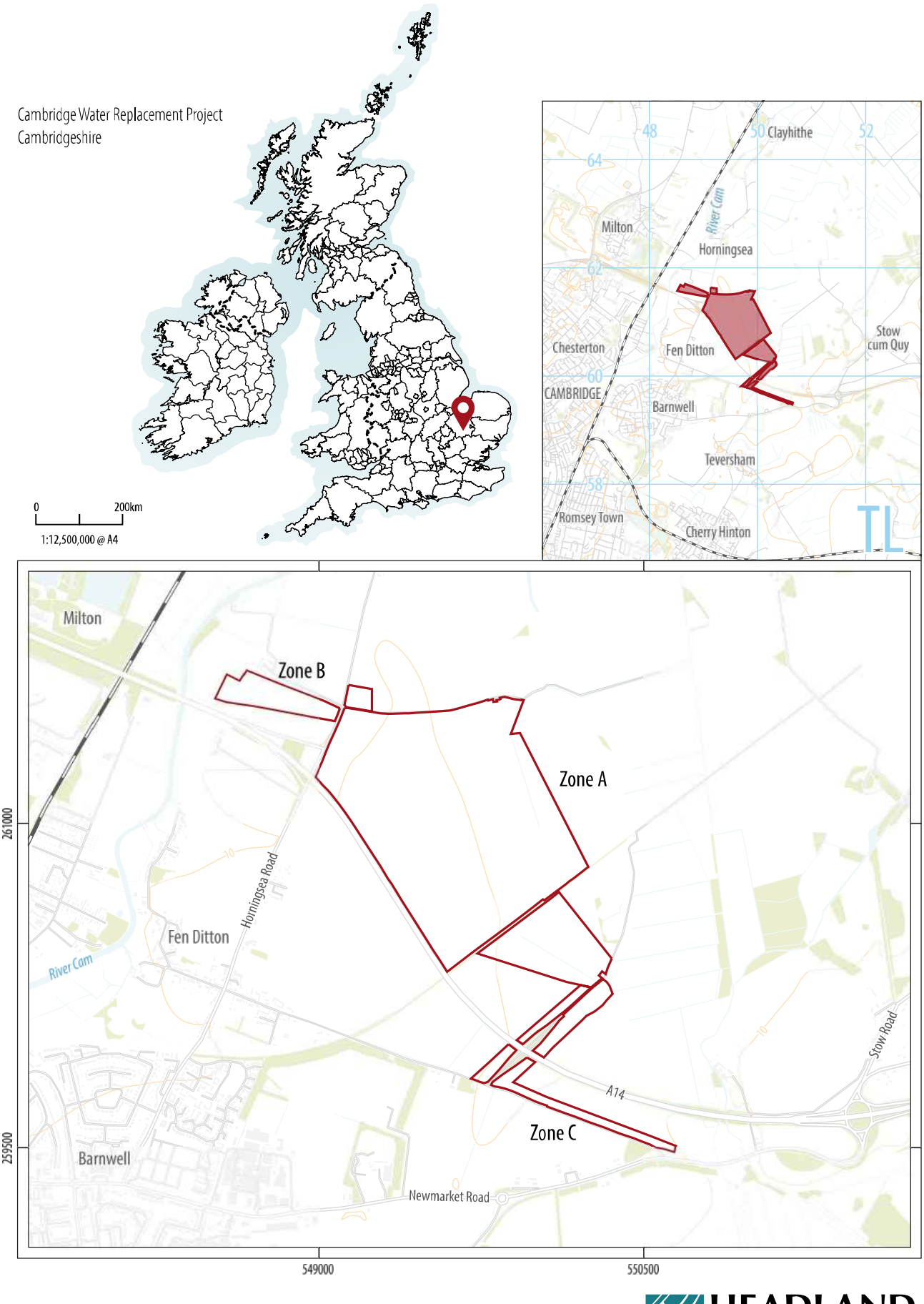
Gaffney, C & Gater, J 2003 Revealing the Buried Past: Geophysics for Archaeologists Stroud

Headland 2021 Cambridgeshire Waste Water Treatment Plant Relocation Written Scheme of Investigation for Geophysical Survey Unpublished Client Document Ref. CWRP21

Ministry of Housing, Communities and Local Government MHCLG) 2019 National Planning Policy Framework https://assers.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/810017/NPPF_Feb_2019_revised.pdf accessed 19th April 2021

Mott MacDonald 2021 Cambridge Waste Water Treatment Plant Relocation Scope of Works Unpublished Client Document Ref. 415458-EN-SOW-001

Mott MacDonald 2021 Cambridge Waste Water Treatment Plant Relocation WWTP Stage 4 Historic Environment Assessment Unpublished Client Document



HEADLAND ARCHAEOLOGY
Headland Archaeology Yorkshire & North
Units 23–25 & 15 | Acorn Business Centre | Balme Road | Cleckheaton BD19 4EZ
t 0127 493 8019
e yorkshireandnorth@headlandarchaeology.com
w www.headlandarchaeology.com

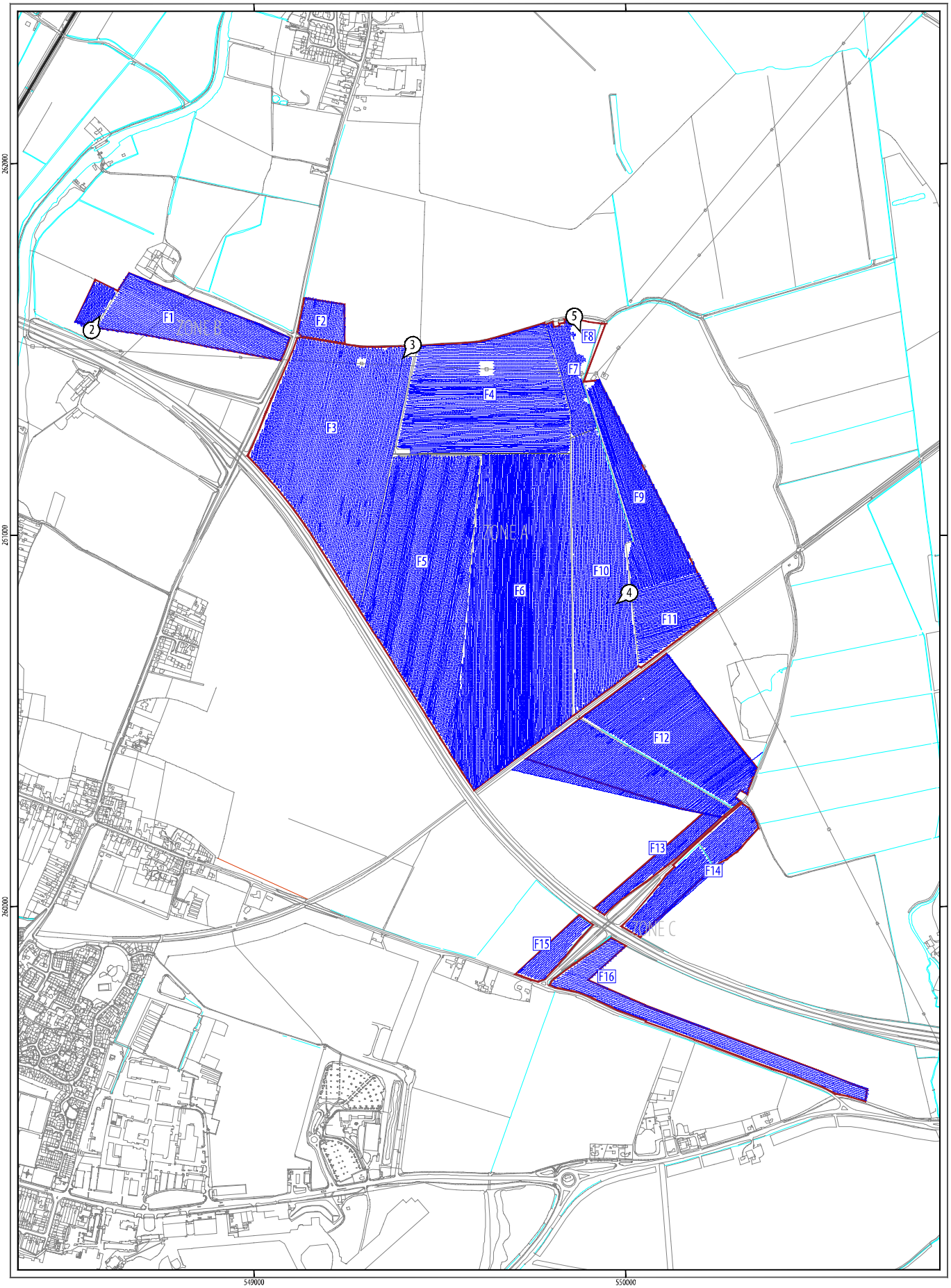
ILLUS 1 Site location

Illus 2. F1 looking north-east

Illus 3. F3 looking south-west

Illus 4. F10 looking south-west

Illus 4. F8 looking south-east



geophysical survey area

GPS swaths

area unsuitable for survey

location and direction of ILLUS 2–5

0 200m

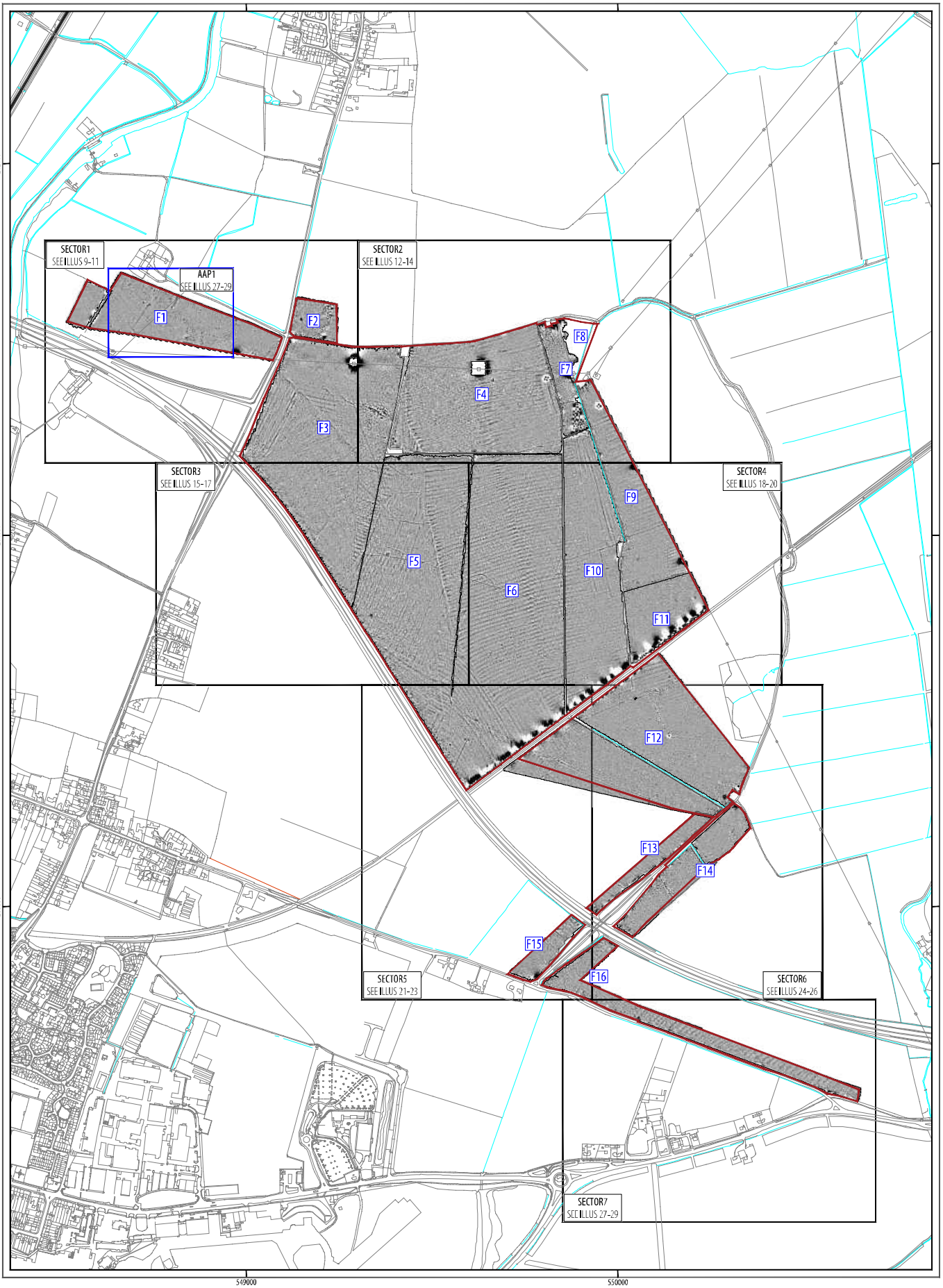
1:10,000 @ A3

ILLUS 6 Geophysical survey location showing GPS swaths and photo locations

PROJECT CWRP21
Cambridge Waste Water Treatment Plant
Cambridge

CLIENT Anglian Water

HEADLAND ARCHAEOLOGY
Headland Archaeology Yorkshire & North
Units 23-25 | Acorn Business Centre | Skibeden Road
Cleckheaton | BD19 4EZ
: 0127 493 8019
w www.headlandarchaeology.com



geophysical survey area

-1.0 nT 2.0

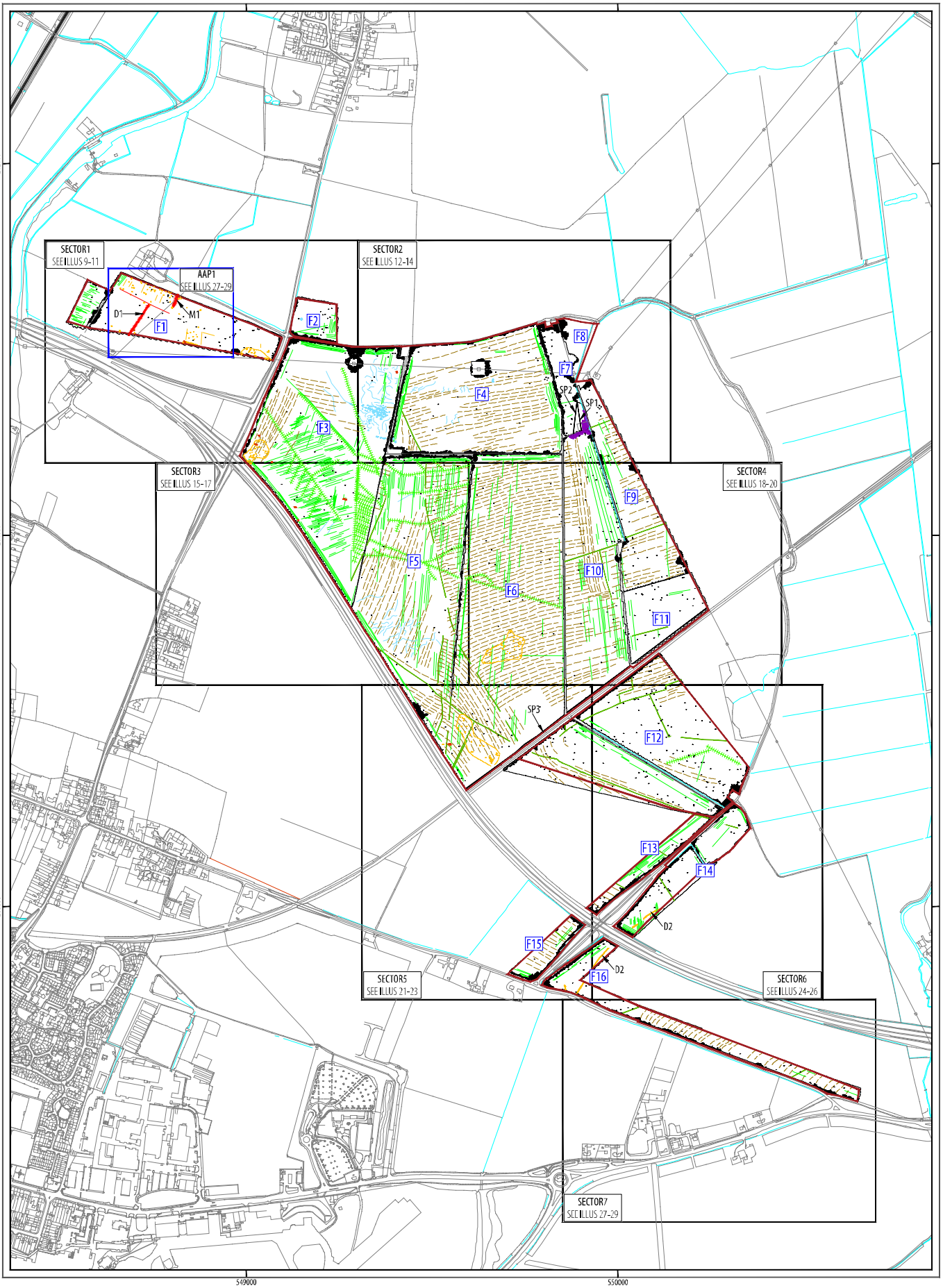
0 200m
1:10,000 @ A3

PROJECT CWRP21
Cambridge Waste Water Treatment Plant
Cambridge

CLIENT Anglian Water

HEADLAND ARCHAEOLOGY
Headland Archaeology Yorkshire & North
Units 23-25 | Acorn Business Centre | Bolton Road
Cleckheaton | BD19 4EZ
: 0127 493 8019
w www.headlandarchaeology.com

ILLUS 7 Processed greyscale magnetometer data



geophysical survey area

TYPE OF ANOMALY	INTERPRETATION
dipolar isolated	ferrous material
magnetic disturbance	ferrous material
dipolar linear	service pipe
magnetic disturbance	former building

TYPE OF ANOMALY	INTERPRETATION
linear trend	ridge and furrow
linear trend	agricultural
linear trend	field drain
linear	former field boundary
linear	former field boundary?
linear trend	geological variation

TYPE OF ANOMALY	INTERPRETATION
magnetic enhancement	geology
linear trend	archaeology?
magnetic enhancement	archaeology?
magnetic enhancement	archaeology
magnetic enhancement	kiln/burning

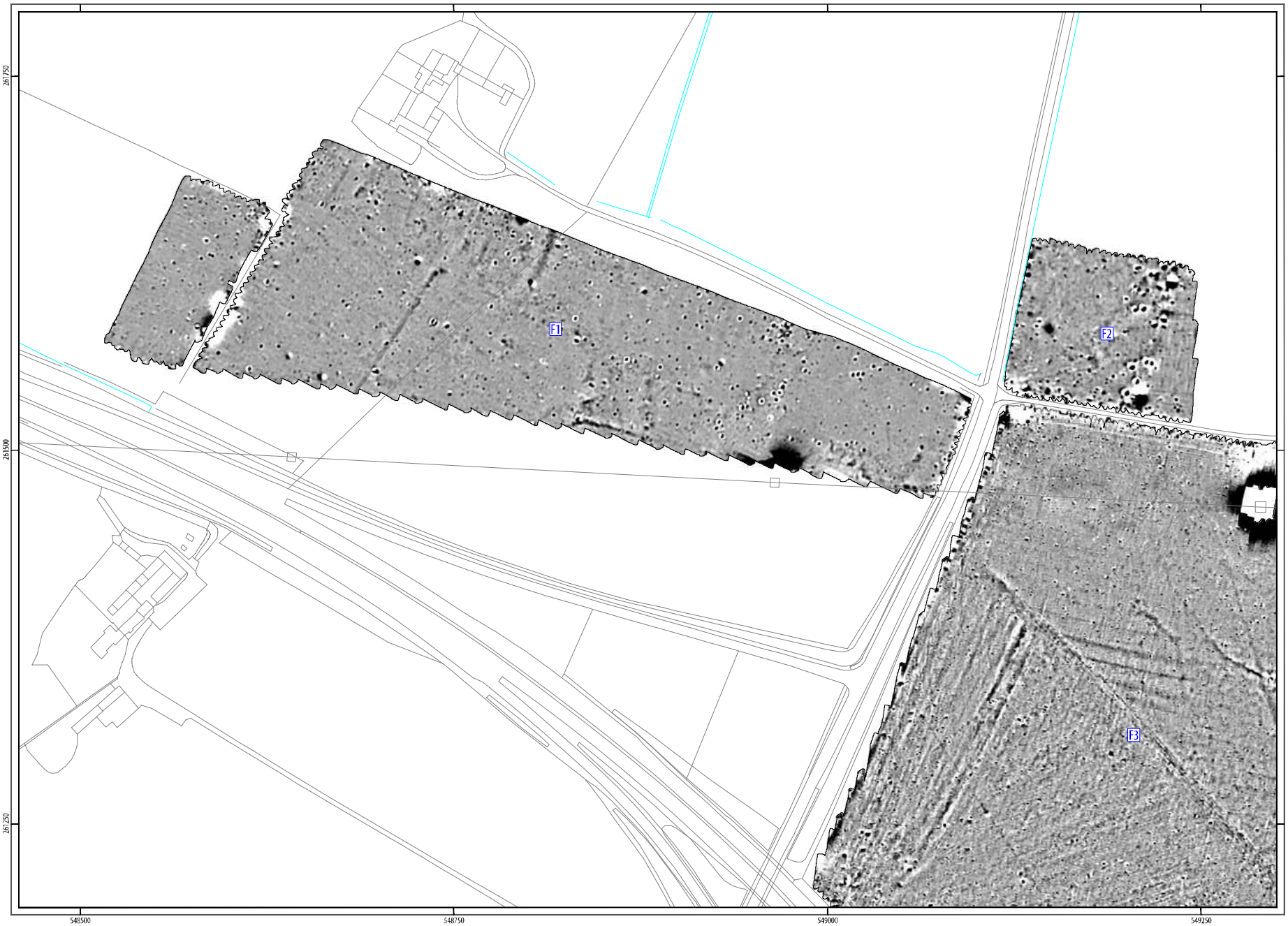
0 200m
1:10,000 @ A3

PROJECT CWRP21
Cambridge Waste Water Treatment Plant
Cambridge

CLIENT Anglian Water

ILLUS 8 Interpretation of magnetometer data

HEADLAND ARCHAEOLOGY
Headland Archaeology Yorkshire & North
Units 23-25 | Acorn Business Centre | Skibeden Road
Cleckheaton | BD19 4EZ
t: 0127 493 8019
w: www.headlandarchaeology.com



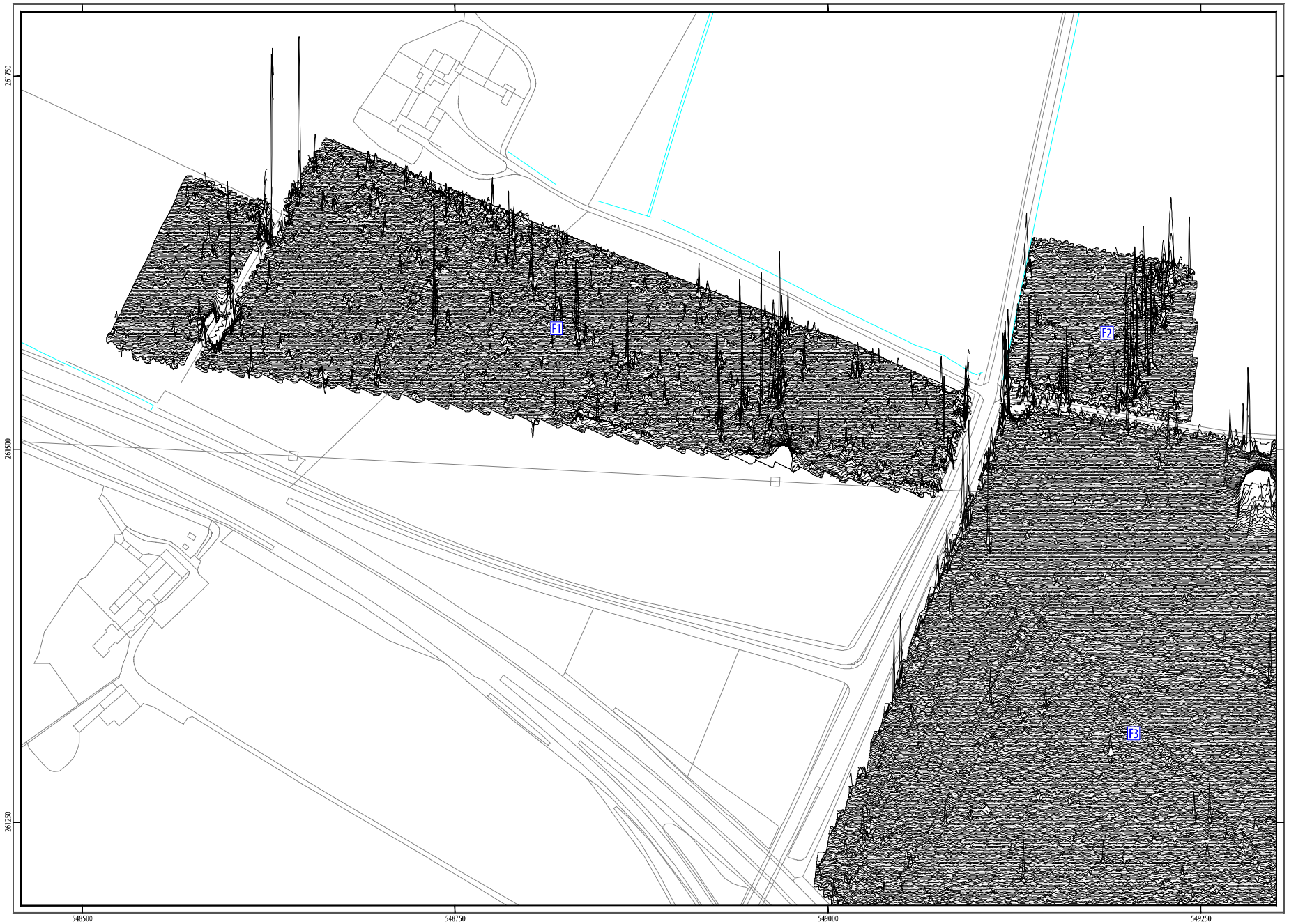
PROJECT CWRP21
Cambridge Waste Water
Treatment Plant
Cambridge

CLIENT Anglian Water

HEADLAND ARCHAEOLOGY

Headland Archaeology Yorkshire & North
Units 23-25 | Acorn Business Centre | Bairne Road
Cleckheaton | BD19 4FZ
t 0127 493 8019
w www.headlandarchaeology.com

ILLUS 9 Processed greyscale magnetometer data; Sector 1



25.0nT/cm

0 50m

1:2,500 @ A3

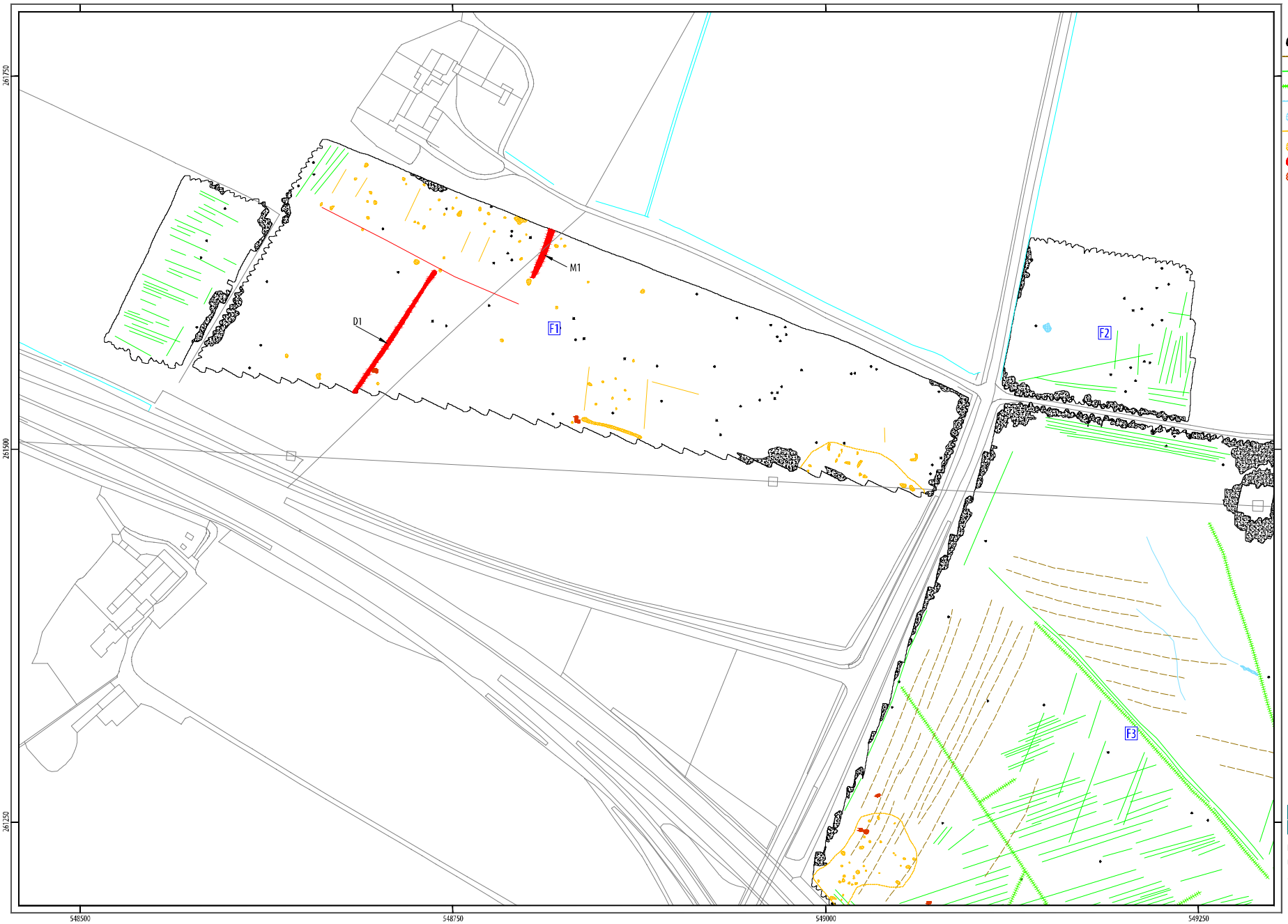
PROJECT CWRP21
Cambridge Waste Water Treatment Plant
Cambridge

CLIENT Anglian Water

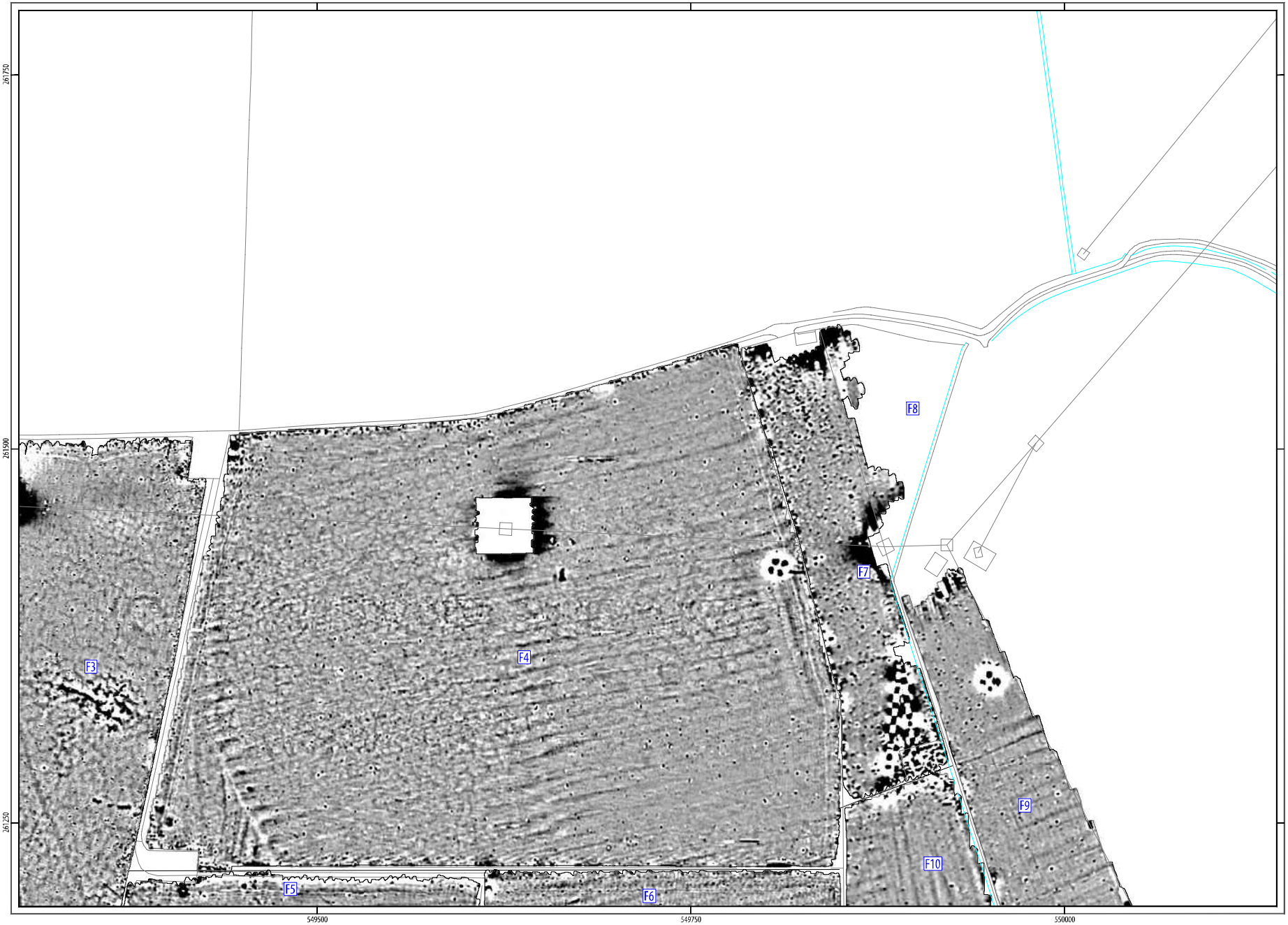
HEADLAND ARCHAEOLOGY

Headland Archaeology Yorkshire & North
Units 23-25 | Acorn Business Centre | Bathe Road
Cleckheaton | BD19 4EZ
t 0127 493 8019
w www.headlandarchaeology.com

ILLUS 10 XY trace plot of minimally processed magnetometer data; Sector 1



ILLUS 11 Interpretation of magnetometer data; Sector 1

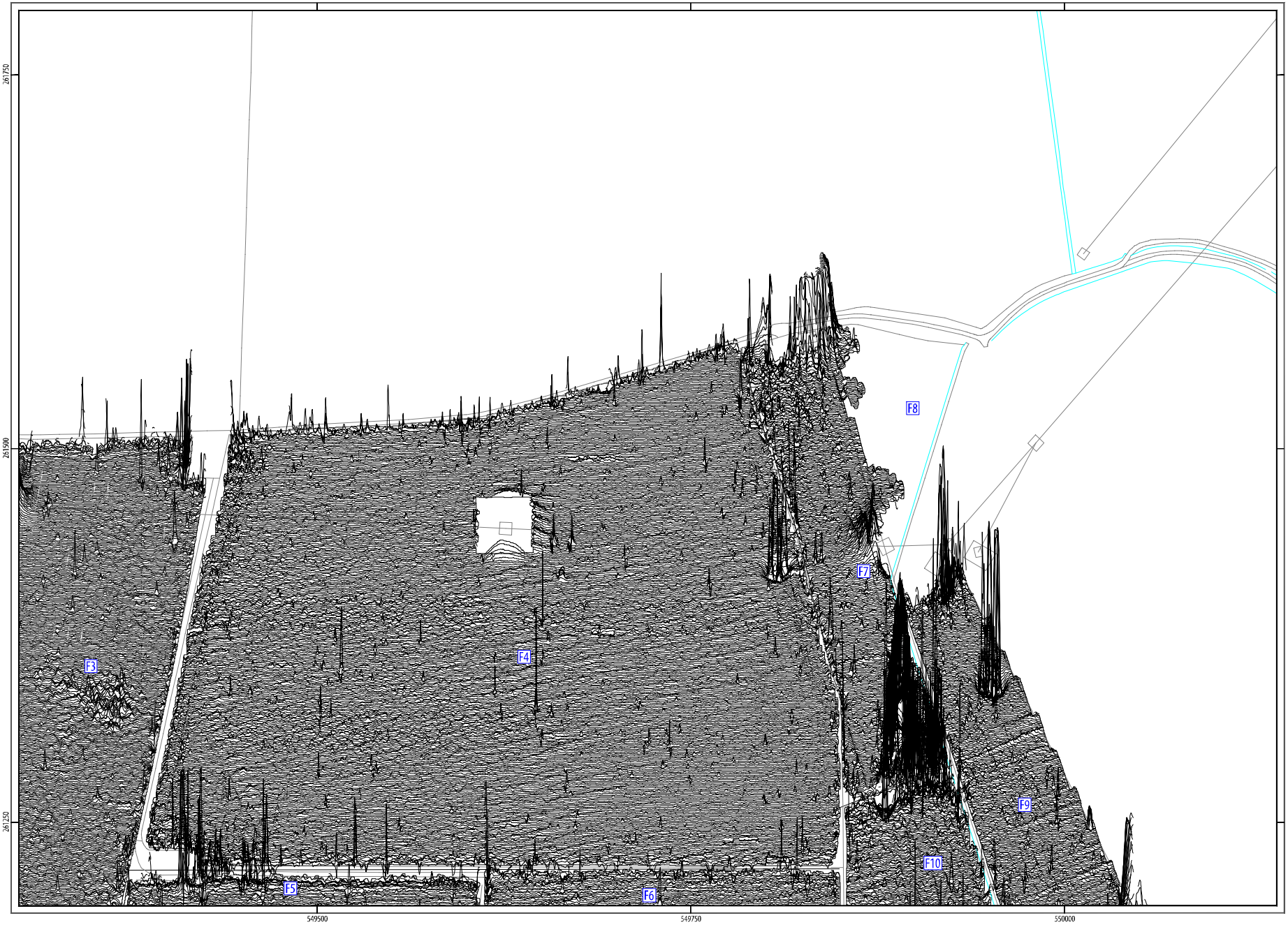


PROJECT CWRP21
Cambridge Waste Water
Treatment Plant
Cambridge

CLIENT Anglian Water

HEADLAND ARCHAEOLOGY
Headland Archaeology Yorkshire & North
Units 23-25 | Acorn Business Centre | Barnoldswick Road
Cleckheaton | BD19 4EZ
t 0127 493 8019
w www.headlandarchaeology.com

ILLUS 12 Processed greyscale magnetometer data; Sector 2



25.0nT/cm

0 50m

1:2,500 @ A3

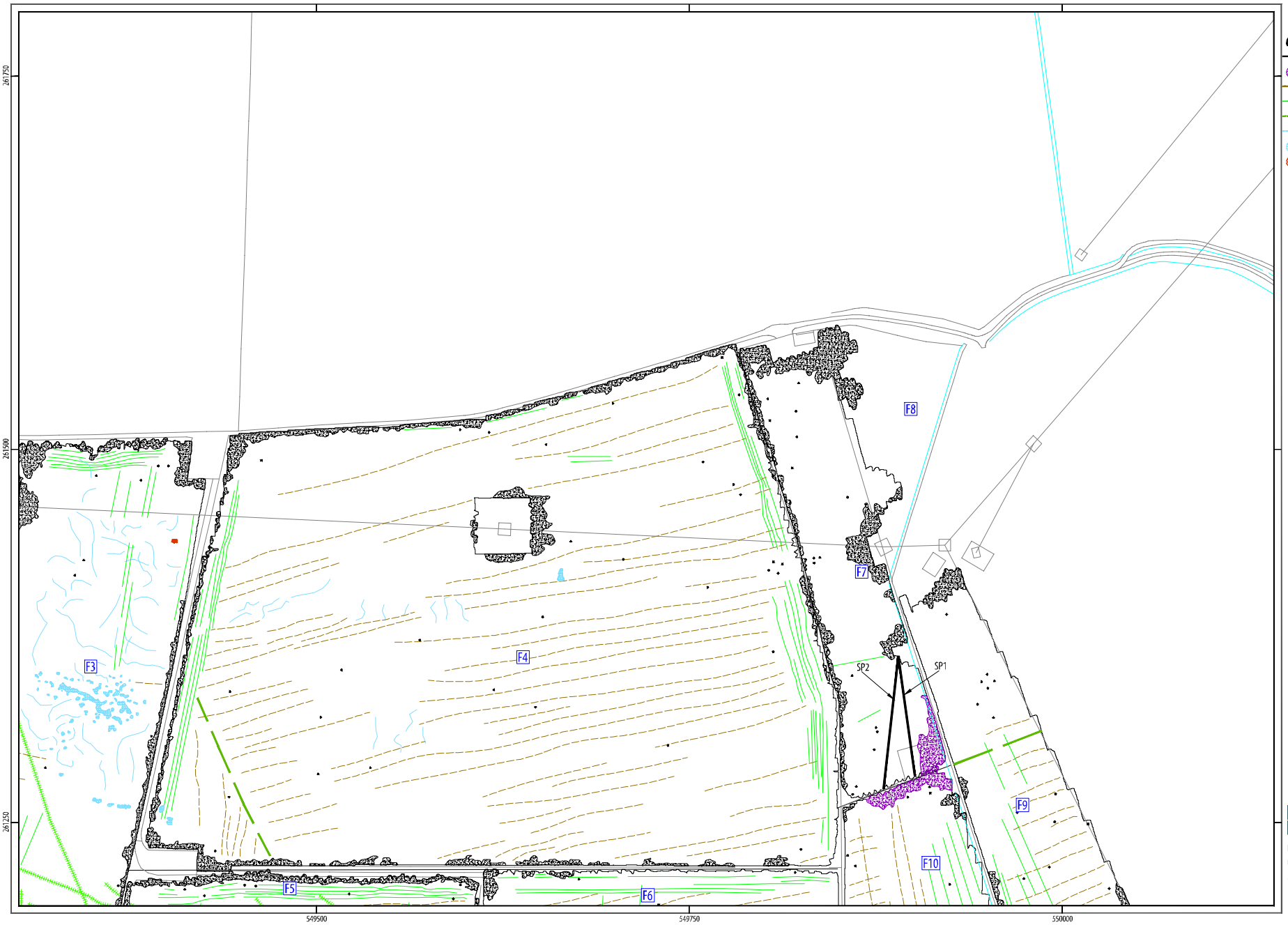
PROJECT CWRP21
Cambridge Waste Water
Treatment Plant
Cambridge

CLIENT Anglian Water

HEADLAND ARCHAEOLOGY

Headland Archaeology Yorkshire & North
Units 23-25 | Acorn Business Centre | Balme Road
Cleckheaton | BD19 4EZ
t 0127 493 8019
w www.headlandarchaeology.com

ILLUS 13 XY traceplot of minimally processed magnetometer data; Sector 2



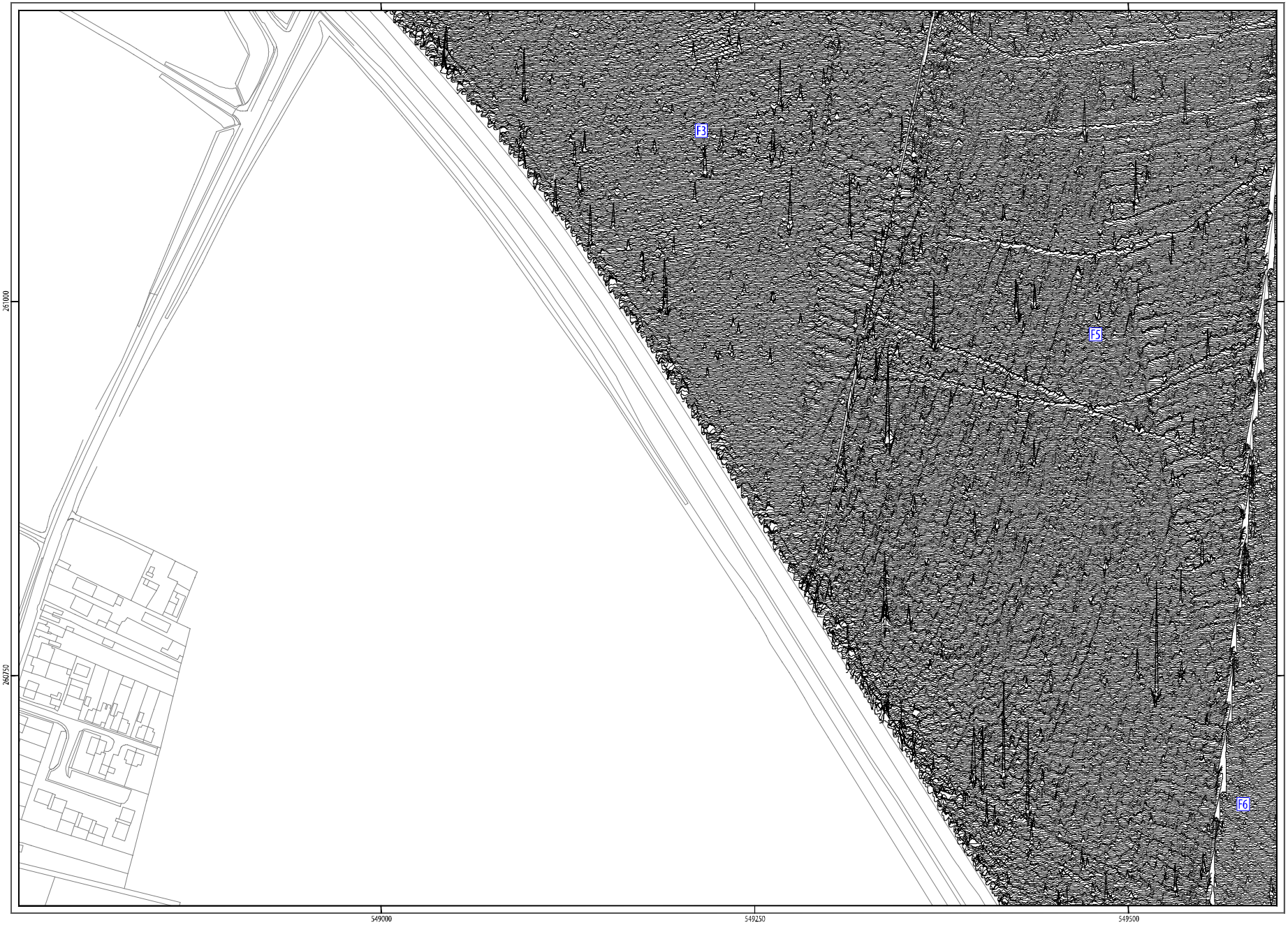
ILLUS 14 Interpretation of magnetometer data; Sector 2

PROJECT CWRP21
Cambridge Waste Water
Treatment Plant
Cambridge

CLIENT Anglian Water

HEADLAND ARCHAEOLOGY
Headland Archaeology Yorkshire & North
Units 23-25 | Acorn Business Centre | Barnie Road
Cleckheaton | BD19 4EZ
t 0127 493 8019
w www.headlandarchaeology.com

ILLUS 15 Processed greyscale magnetometer data; Sector 3



25.0nT/cm

0 50m

1:2,500 @ A3

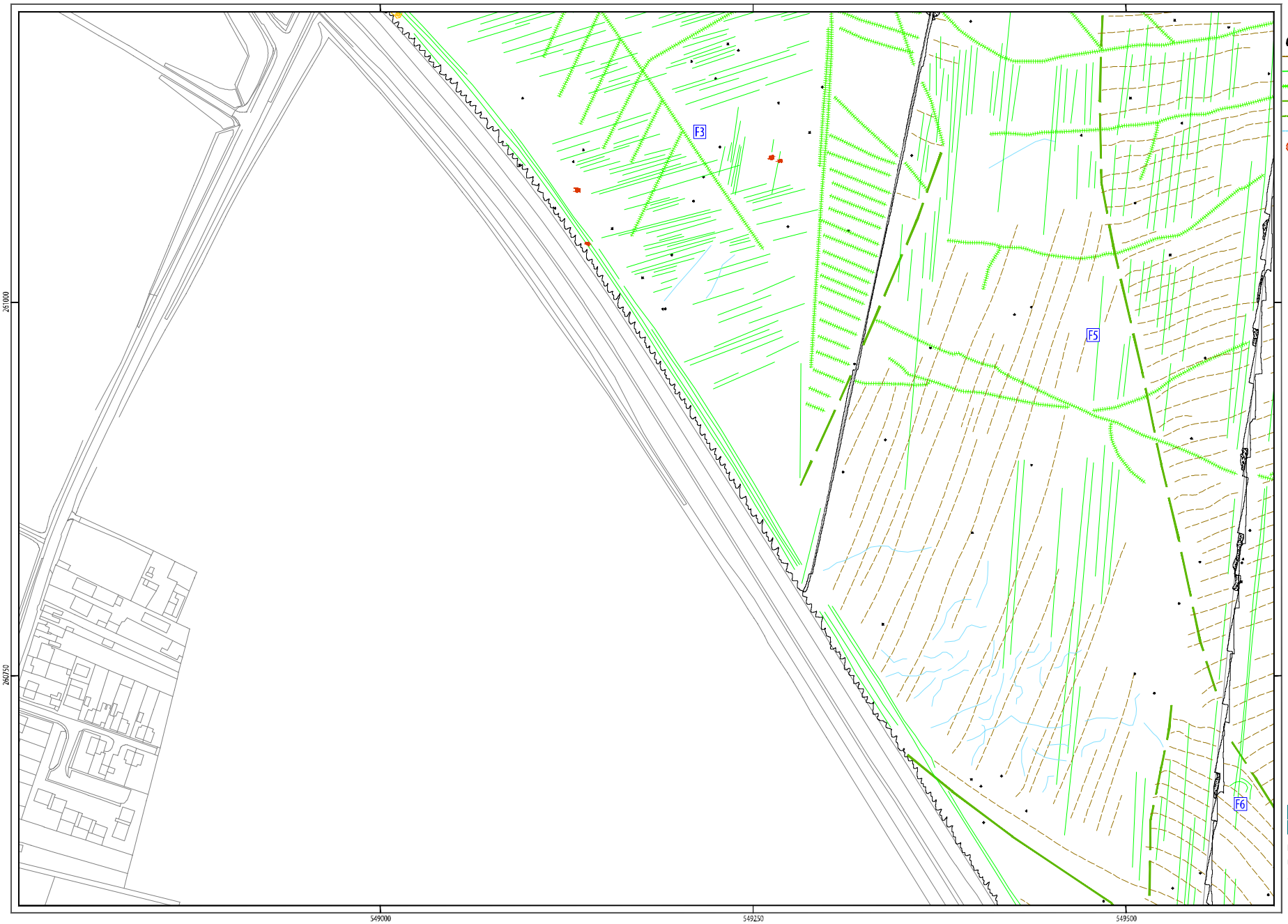
PROJECT CWRP21
Cambridge Waste Water
Treatment Plant
Cambridge

CLIENT Anglian Water

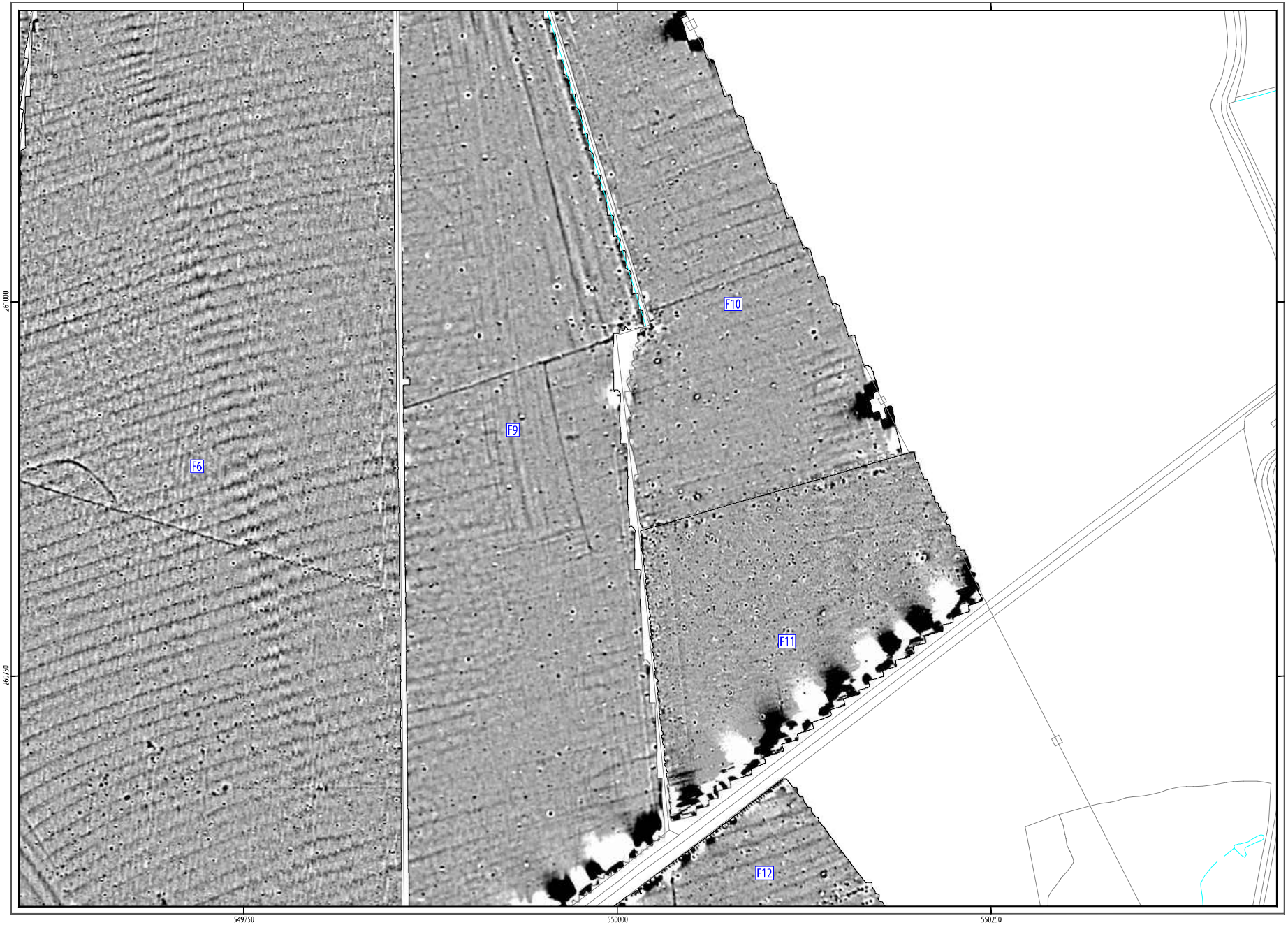
HEADLAND ARCHAEOLOGY

Headland Archaeology Yorkshire & North
Units 23-25 | Acorn Business Centre | Balme Road
Cleckheaton | BD19 4EZ
t 0127 493 8019
w www.headlandarchaeology.com

ILLUS 16 XY trace plot of minimally processed magnetometer data; Sector 3



ILLUS 17 Interpretation of magnetometer data; Sector 3



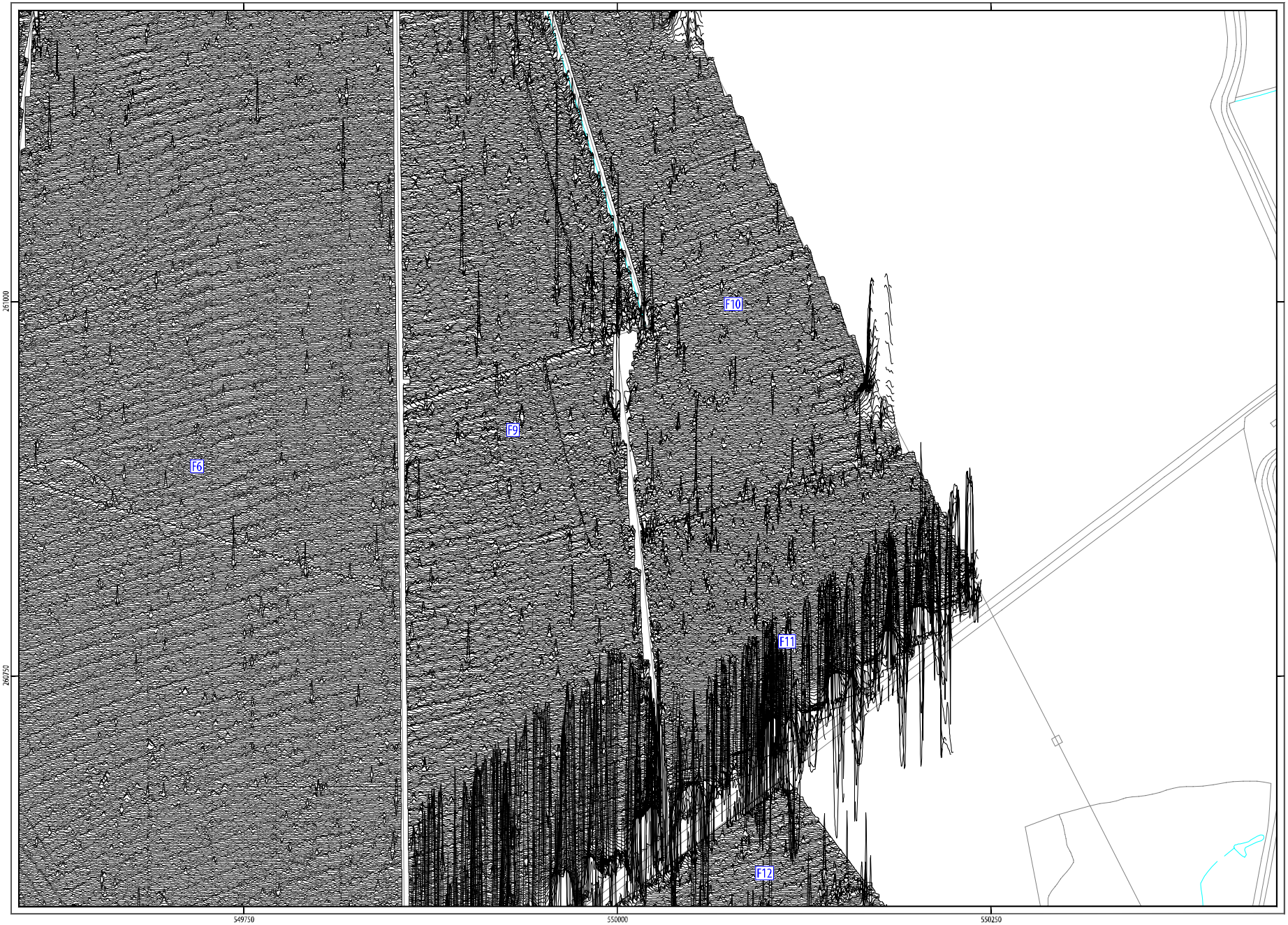
PROJECT CWRP21
Cambridge Waste Water
Treatment Plant
Cambridge

CLIENT Anglian Water

HEADLAND ARCHAEOLOGY

Headland Archaeology Yorkshire & North
Units 23-25 | Acorn Business Centre | Balme Road
Cleckheaton | BD19 4EZ
t 0127 493 8019
w www.headlandarchaeology.com

ILLUS 18 Processed greyscale magnetometer data; Sector 4



25.0nT/cm

0 50m

1:2,500 @ A3

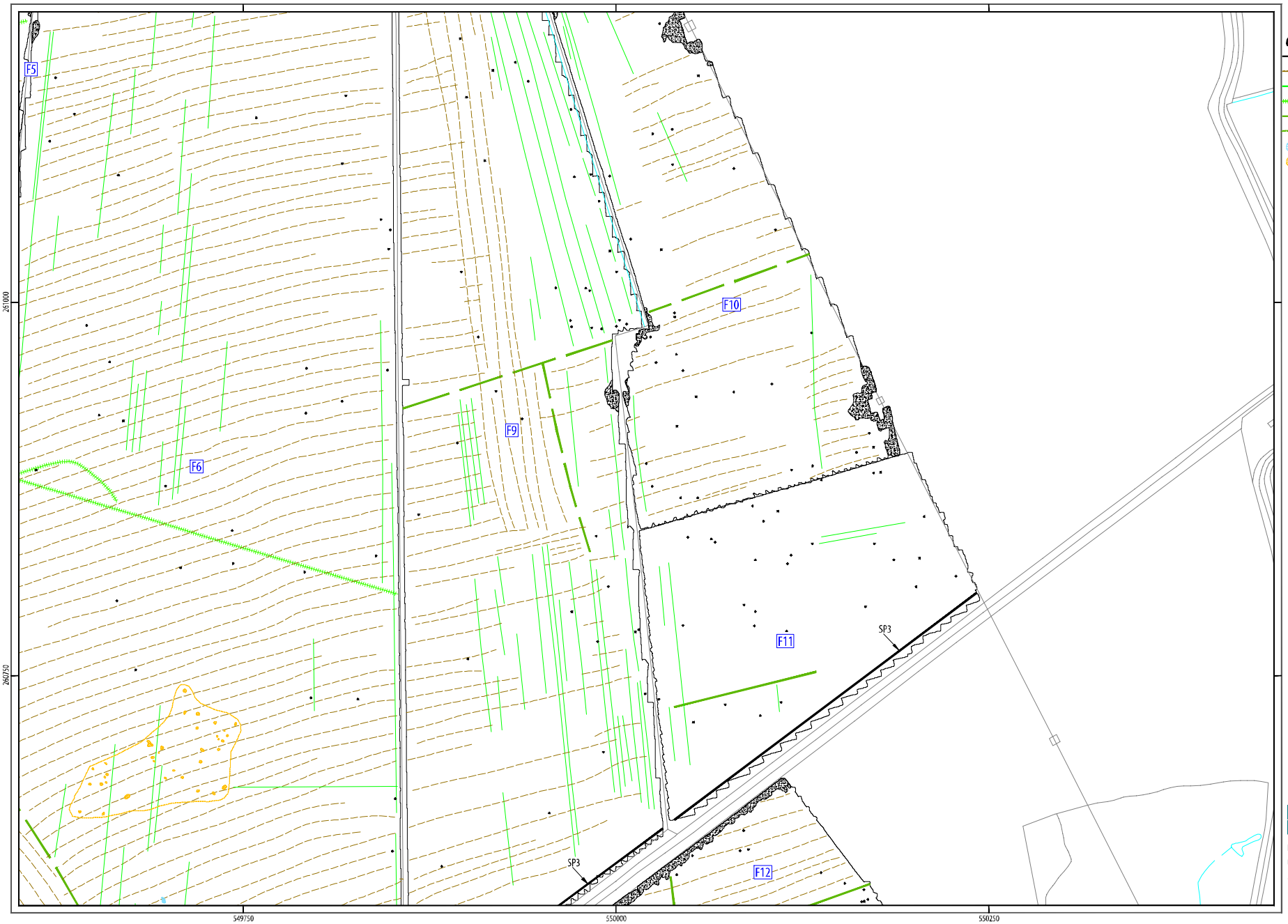
PROJECT CWRP21
Cambridge Waste Water
Treatment Plant
Cambridge

CLIENT Anglian Water

HEADLAND ARCHAEOLOGY

Headland Archaeology Yorkshire & North
Units 23-25 | Acorn Business Centre | Barnie Road
Cleckheaton | BD19 4EZ
t 0127 493 8019
w www.headlandarchaeology.com

ILLUS 19 XY trace plot of minimally processed magnetometer data; Sector 4

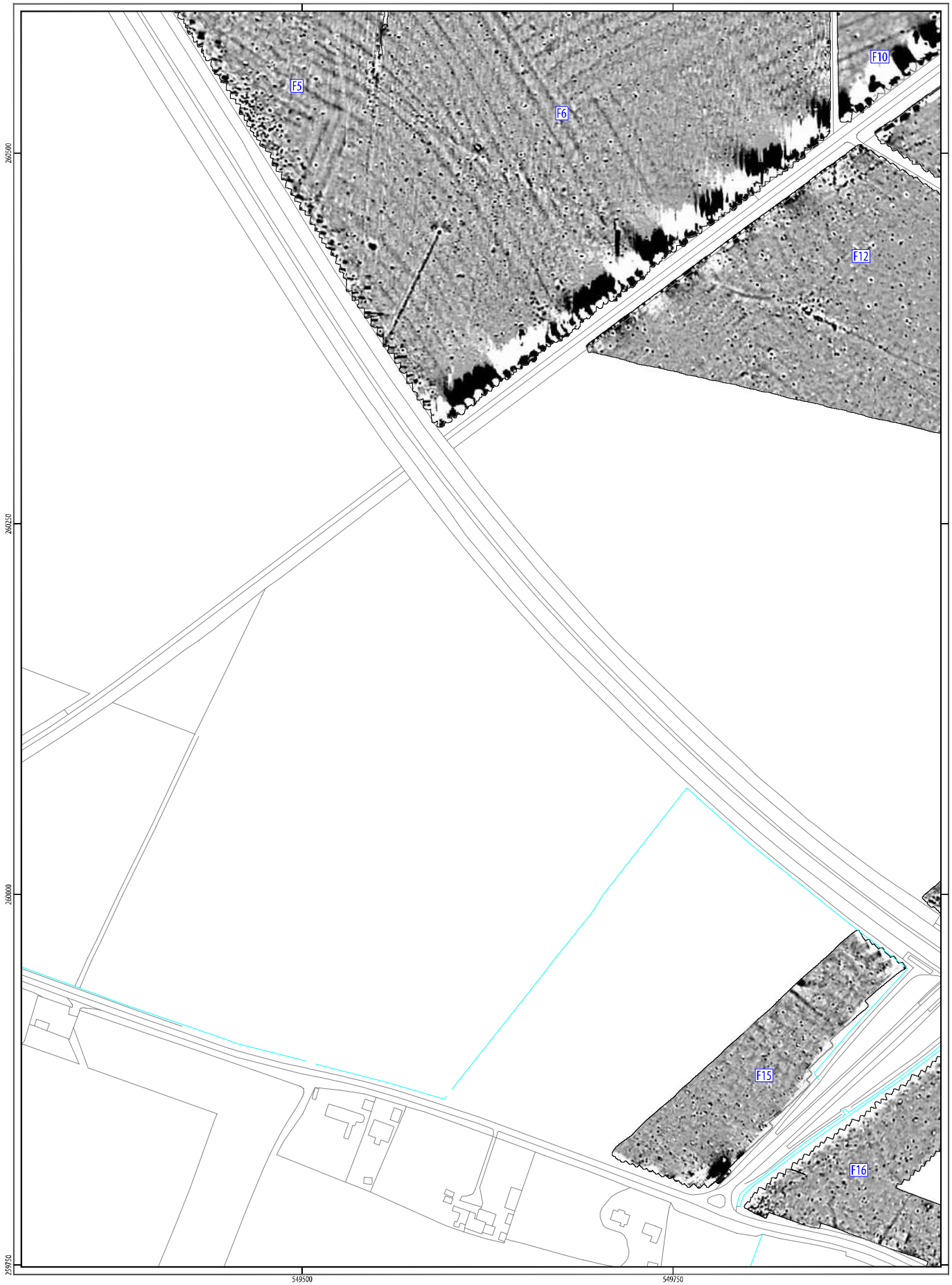


PROJECT CWRP21
Cambridge Waste Water Treatment Plant
Cambridge

CLIENT Anglian Water

HEADLAND ARCHAEOLOGY
Headland Archaeology Yorkshire & North
Units 23-25 | Acorn Business Centre | Balme Road
Cleckheaton | BD19 4EZ
t 0127 493 8019
w www.headlandarchaeology.com

ILLUS 20 Interpretation of magnetometer data; Sector 4



-1.0 nT 2.0

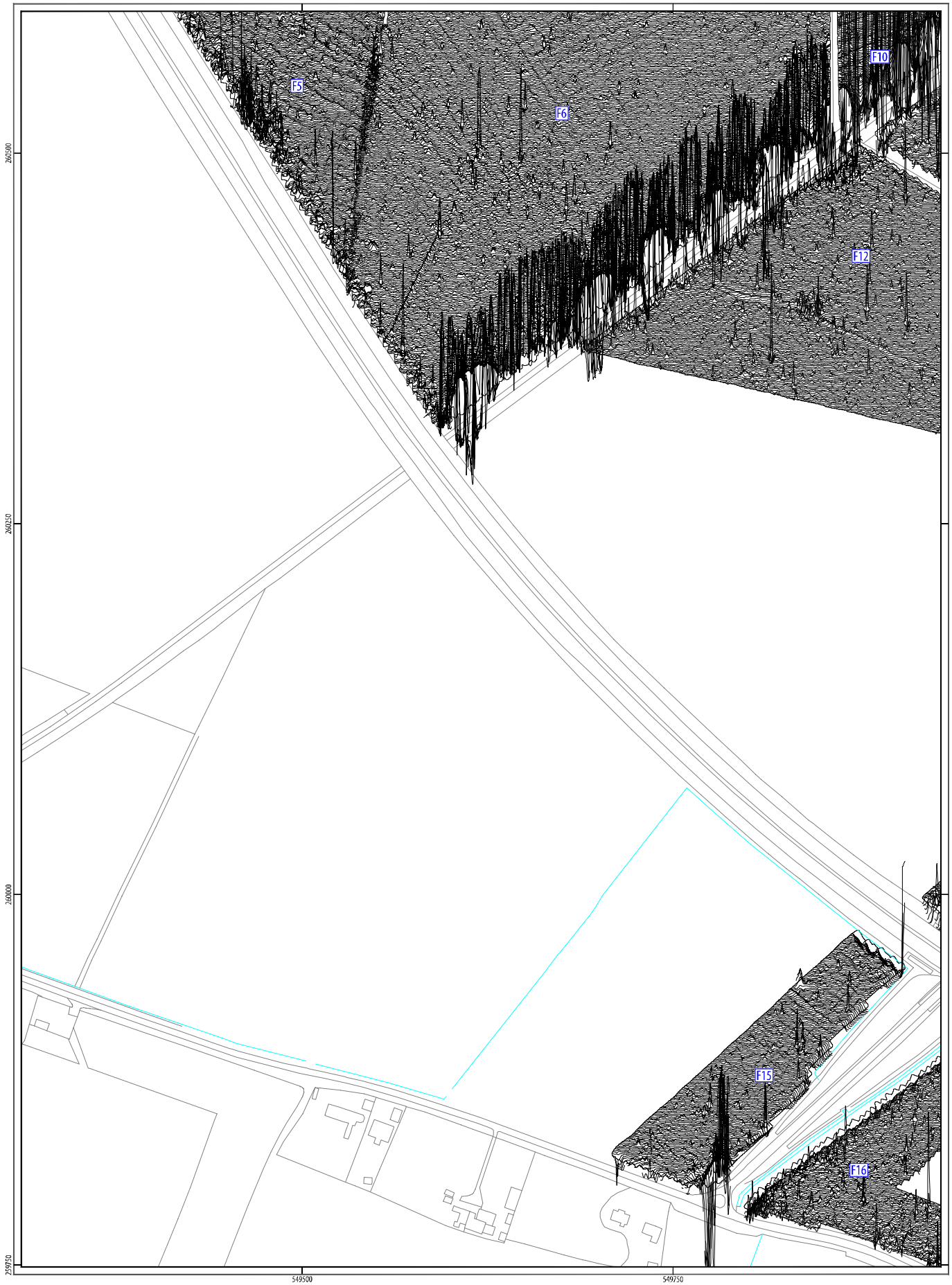
0 50m
1:2,500 @ A3

PROJECT CWRP21
Cambridge Waste Water
Treatment Plant
Cambridge

CLIENT Anglian Water

HEADLAND ARCHAEOLOGY
Headland Archaeology Yorkshire & North
Units 23-25 | Acorn Business Centre | Bolton Road
Cleckheaton | BD19 4EZ
: 0127 493 8019
w www.headlandarchaeology.com

ILLUS 21 Processed greyscale magnetometer data; Sector 5



25.0nT/cm

0 50m

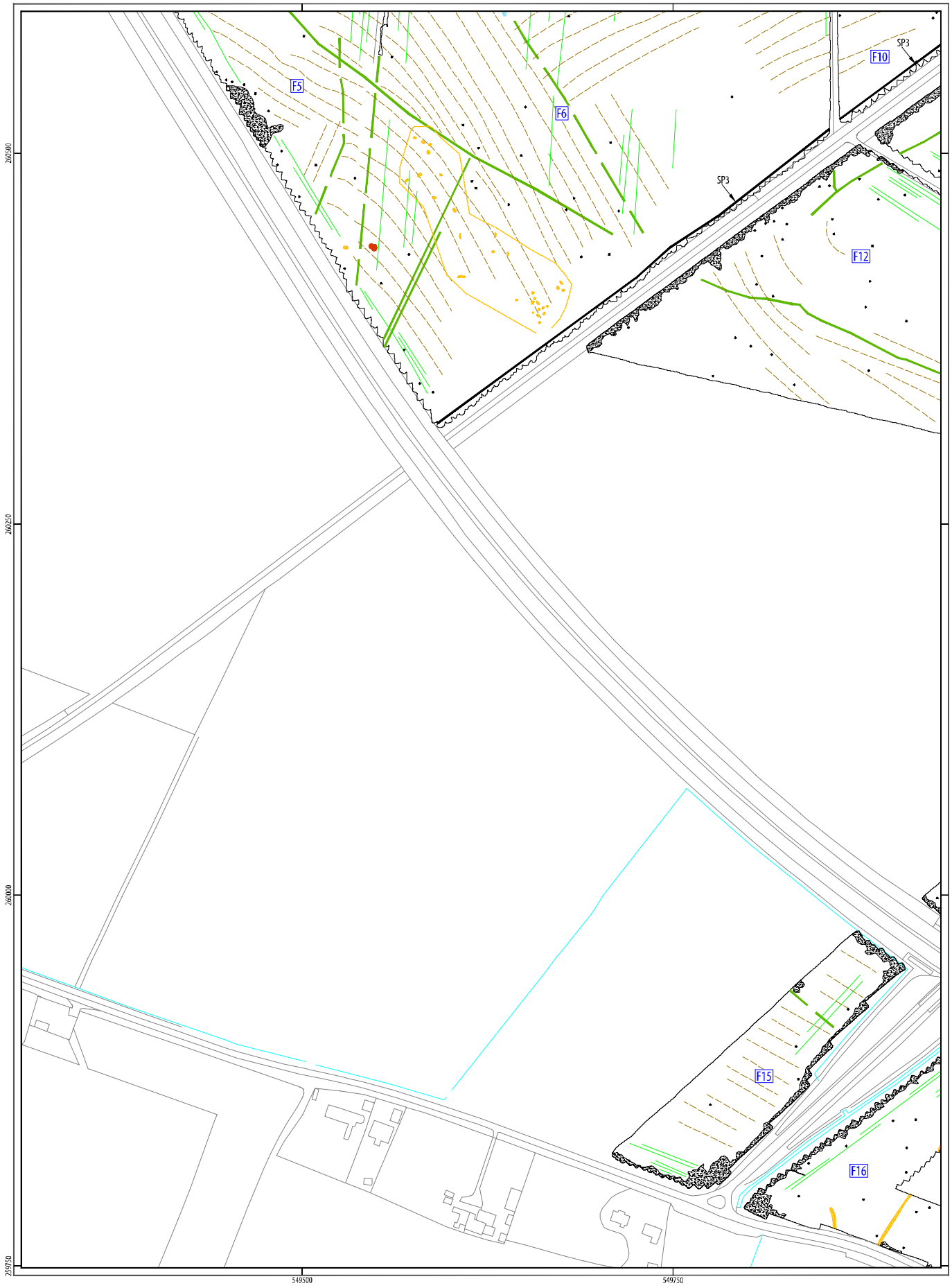
1:2,500 @ A3

PROJECT CWRP21
Cambridge Waste Water Treatment Plant
Cambridge

CLIENT Anglian Water

HEADLAND ARCHAEOLOGY
Headland Archaeology Yorkshire & North
Units 23-25 | Acorn Business Centre | Bolton Road
Cleckheaton | BD19 4EZ
: 0127 493 8019
w www.headlandarchaeology.com

ILLUS 22 XY trace plot of minimally processed magnetometer data; Sector 5



TYPE OF ANOMALY	INTERPRETATION	TYPE OF ANOMALY	INTERPRETATION
dipolar isolated	ferrous material	linear	former field boundary?
magnetic disturbance	ferrous material	magnetic enhancement	geology
dipolar linear	service pipe	magnetic enhancement	archaeology?
linear trend	ridge and furrow	magnetic enhancement	kiln/burning
linear trend	agricultural		
linear	former field boundary		

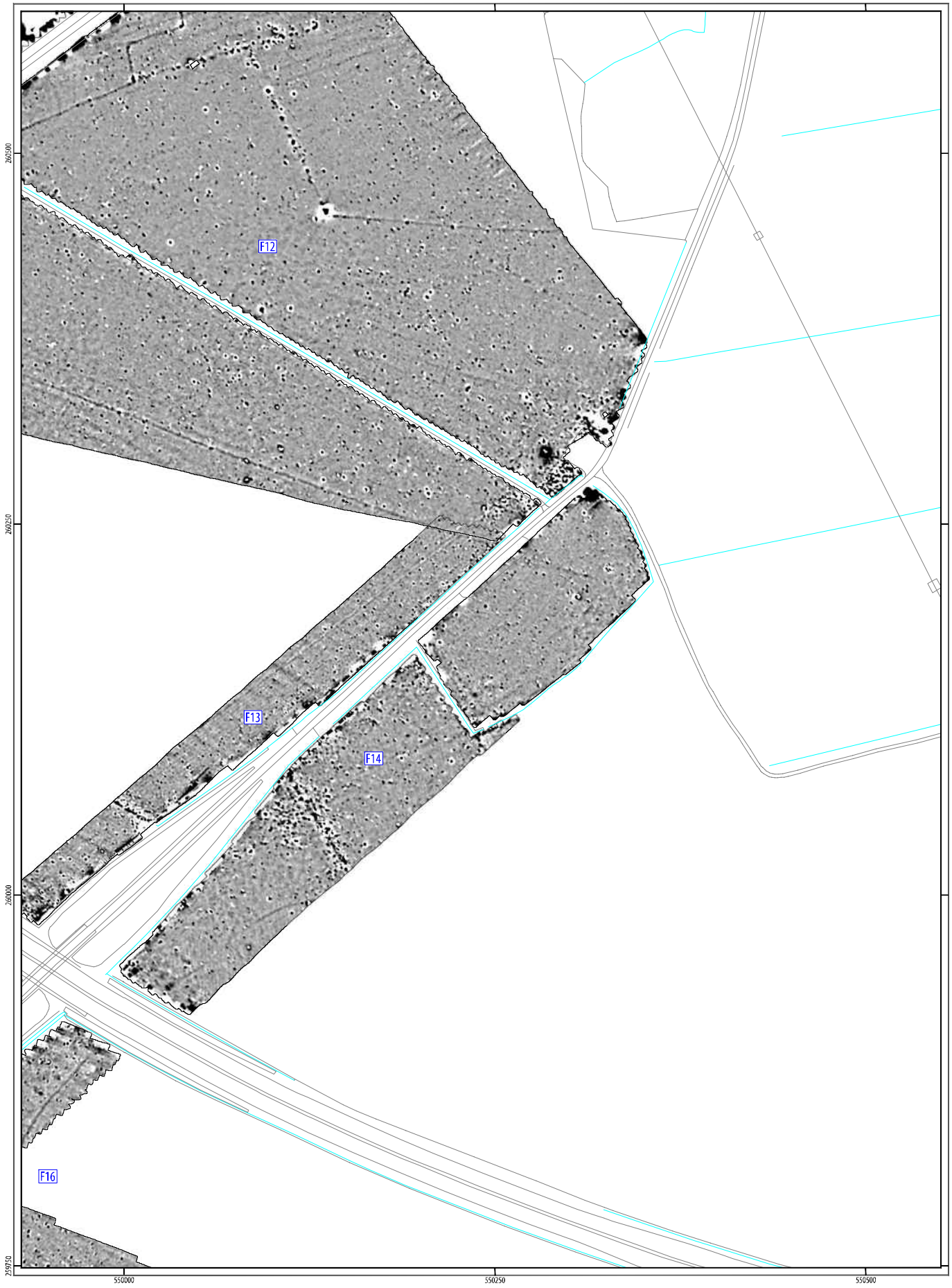
0 50m
1:2,500 @ A3

PROJECT CWRP21
Cambridge Waste Water Treatment Plant
Cambridge

CLIENT Anglian Water

HEADLAND ARCHAEOLOGY
Headland Archaeology Yorkshire & North
Units 23-25 | Acorn Business Centre | Bolton Road
Cleckheaton | BD19 4EZ
: 0127 493 8019
w www.headlandarchaeology.com

ILLUS 23 Interpretation of magnetometer data; Sector 5

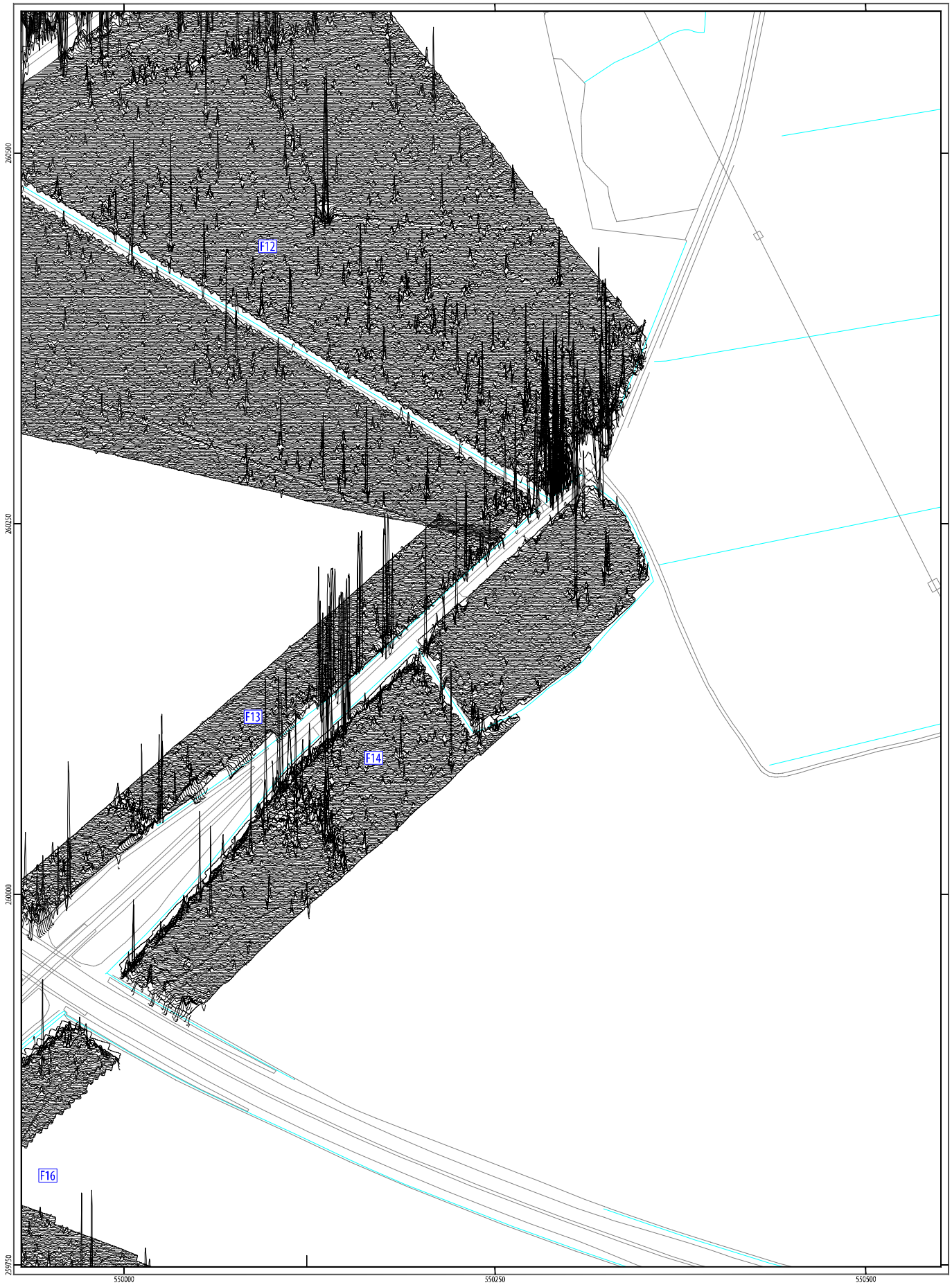


PROJECT CWRP21
Cambridge Waste Water
Treatment Plant
Cambridge

CLIENT Anglian Water

HEADLAND ARCHAEOLOGY
Headland Archaeology Yorkshire & North
Units 23-25 | Acorn Business Centre | Skibeden Road
Cleckheaton | BD19 4EZ
: 0127 493 8019
w www.headlandarchaeology.com

ILLUS 24 Processed greyscale magnetometer data; Sector 6



25.0nT/cm

0 50m

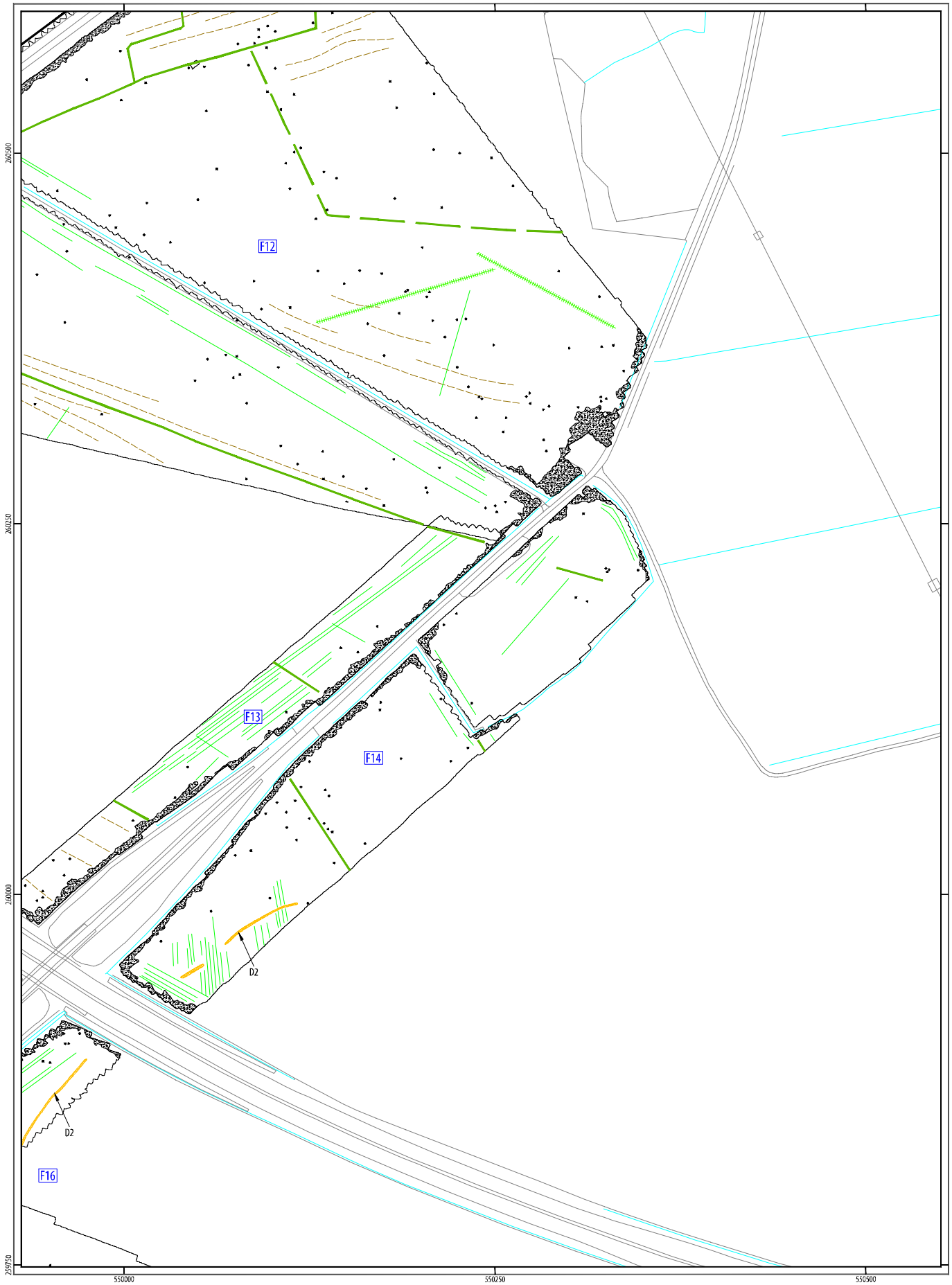
1:2,500 @ A3

PROJECT CWRP21
Cambridge Waste Water
Treatment Plant
Cambridge

CLIENT Anglian Water

HEADLAND ARCHAEOLOGY
Headland Archaeology Yorkshire & North
Units 23-25 | Acorn Business Centre | Skibeden Road
Cleckheaton | BD19 4EZ
: 0127 493 8019
w www.headlandarchaeology.com

ILLUS 25 XY trace plot of minimally processed magnetometer data; Sector 6



TYPE OF ANOMALY	INTERPRETATION
dipolar isolated	ferrous material
magnetic disturbance	ferrous material
dipolar linear	service pipe
linear trend	ridge and furrow
linear trend	agricultural
linear trend	field drain

TYPE OF ANOMALY	INTERPRETATION
linear	former field boundary
linear	former field boundary?
magnetic enhancement	archaeology?

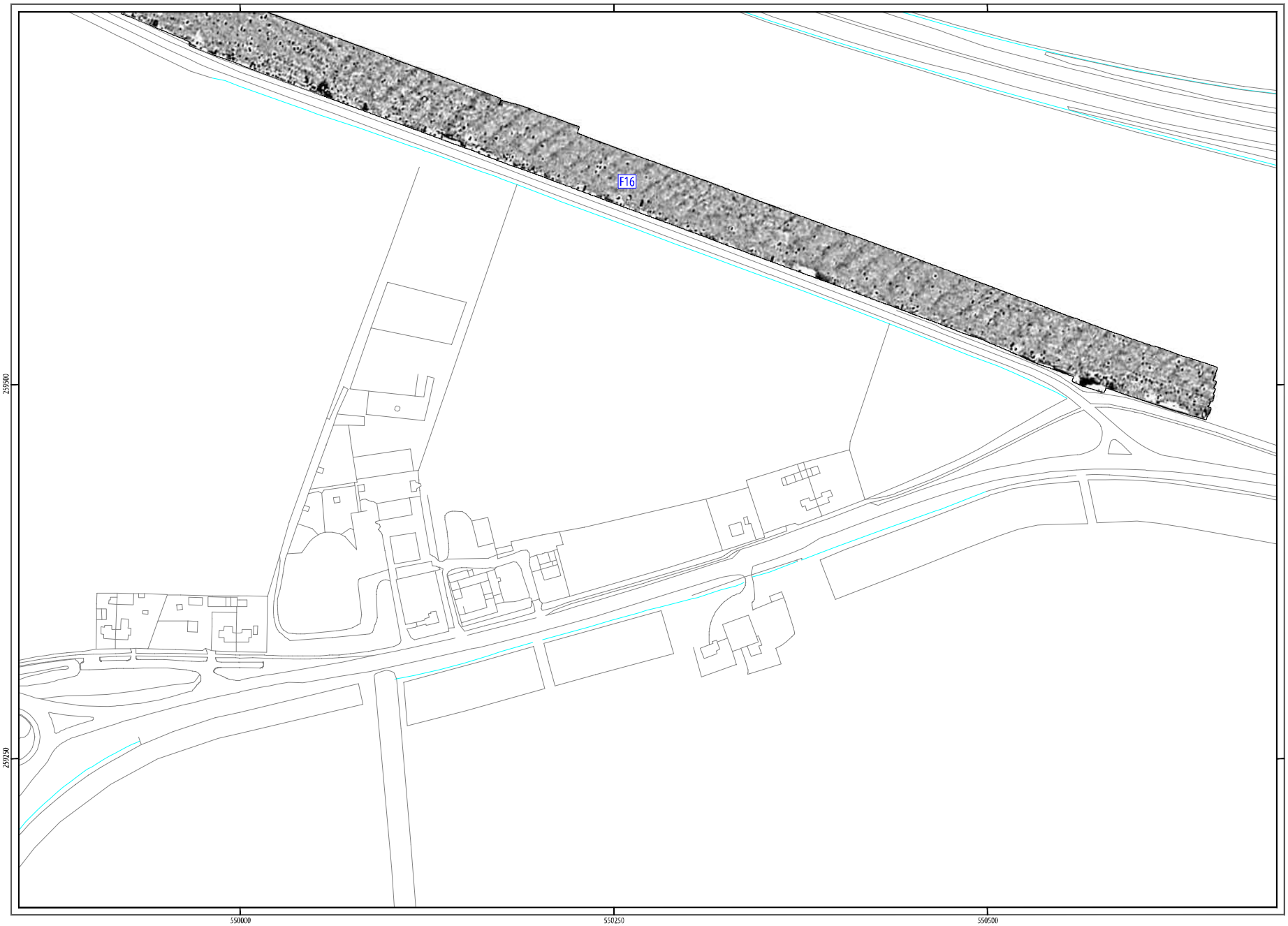
0 50m
1:2,500 @ A3

PROJECT CWRP21
Cambridge Waste Water Treatment Plant
Cambridge

CLIENT Anglian Water

HEADLAND ARCHAEOLOGY
Headland Archaeology Yorkshire & North
Units 23-25 | Acorn Business Centre | Skibeden Road
Cleckheaton | BD19 4EZ
: 0127 493 8019
w www.headlandarchaeology.com

ILLUS 26 Interpretation of magnetometer data; Sector 6

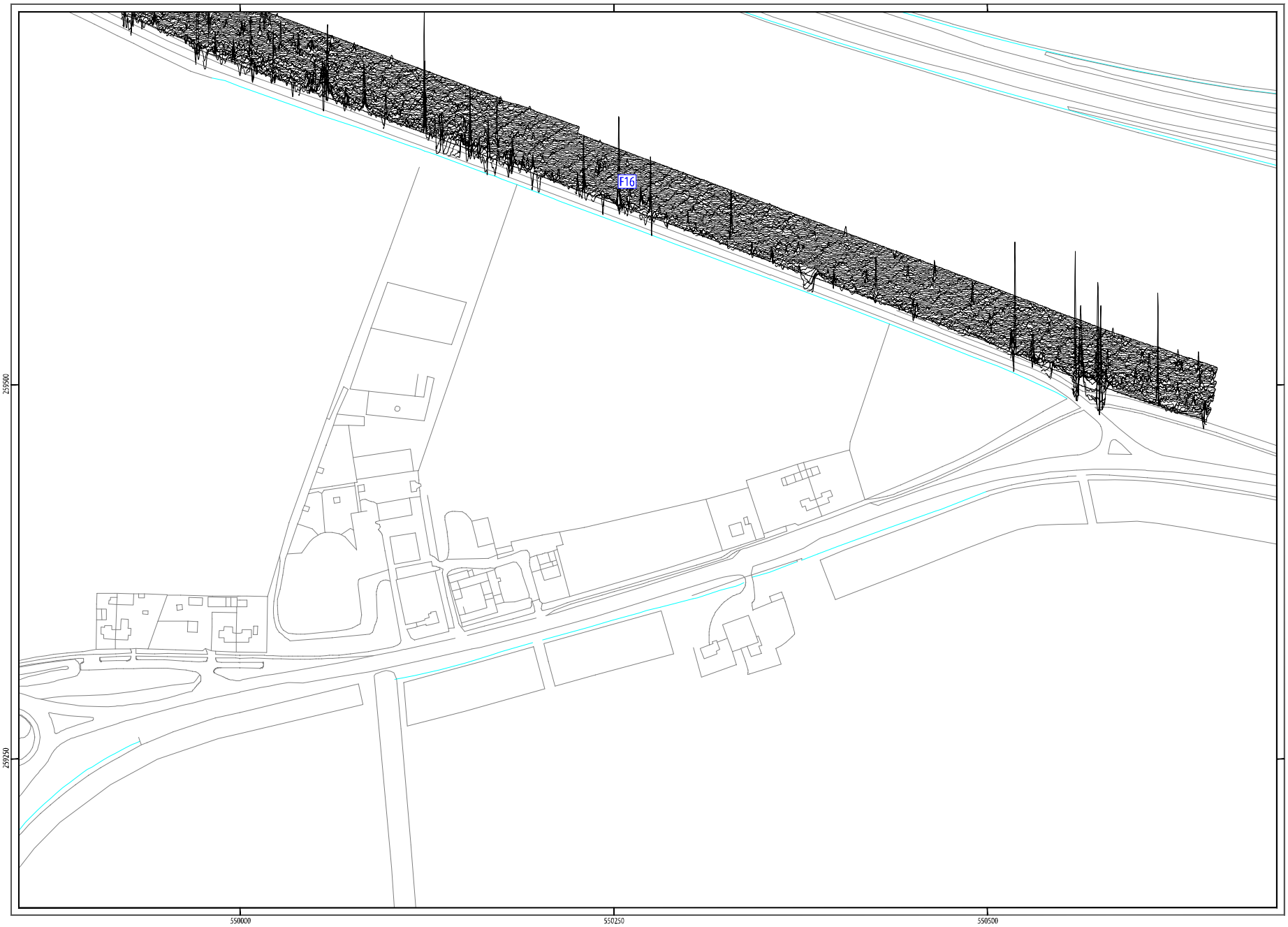


PROJECT CWRP21
Cambridge Waste Water
Treatment Plant
Cambridge

CLIENT Anglian Water

HEADLAND ARCHAEOLOGY
Headland Archaeology Yorkshire & North
Units 23-25 | Acorn Business Centre | Balme Road
Cleckheaton | BD19 4EZ
t 0127 493 8019
w www.headlandarchaeology.com

ILLUS 27 Processed greyscale magnetometer data; Sector 7



25.0nT/cm

0 50m

1:2,500 @ A3

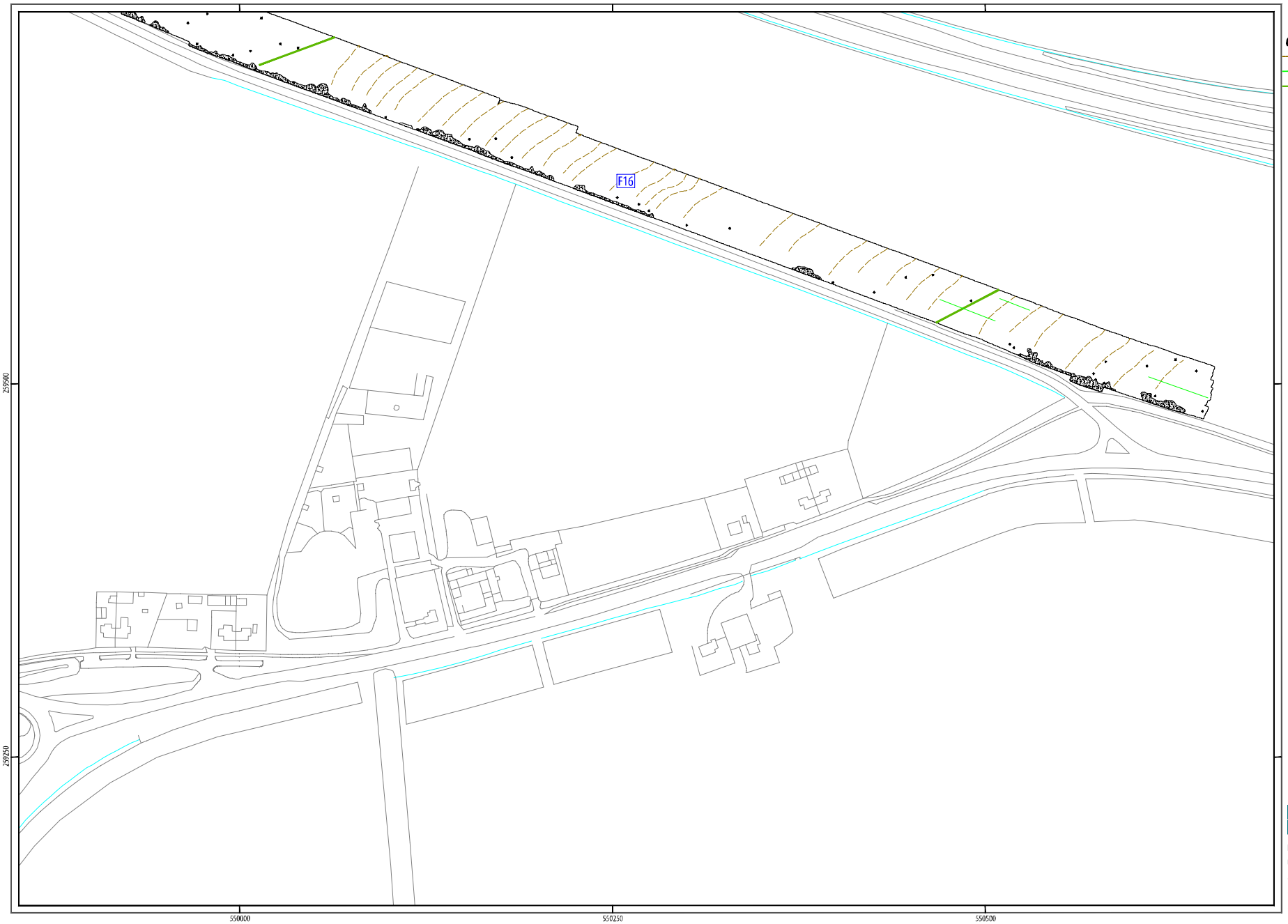
PROJECT CWRP21
Cambridge Waste Water
Treatment Plant
Cambridge

CLIENT Anglian Water

HEADLAND ARCHAEOLOGY

Headland Archaeology Yorkshire & North
Units 23-25 | Acorn Business Centre | Balme Road
Cleckheaton | BD19 4EZ
t 0127 493 8019
w www.headlandarchaeology.com

ILLUS 28 XY trace plot of minimally processed magnetometer data; Sector 7



TYPE OF ANOMALY	INTERPRETATION
dipolar isolated	ferrous material
magnetic disturbance	ferrous material
linear trend	ridge and furrow
linear trend	agricultural
linear	former field boundary

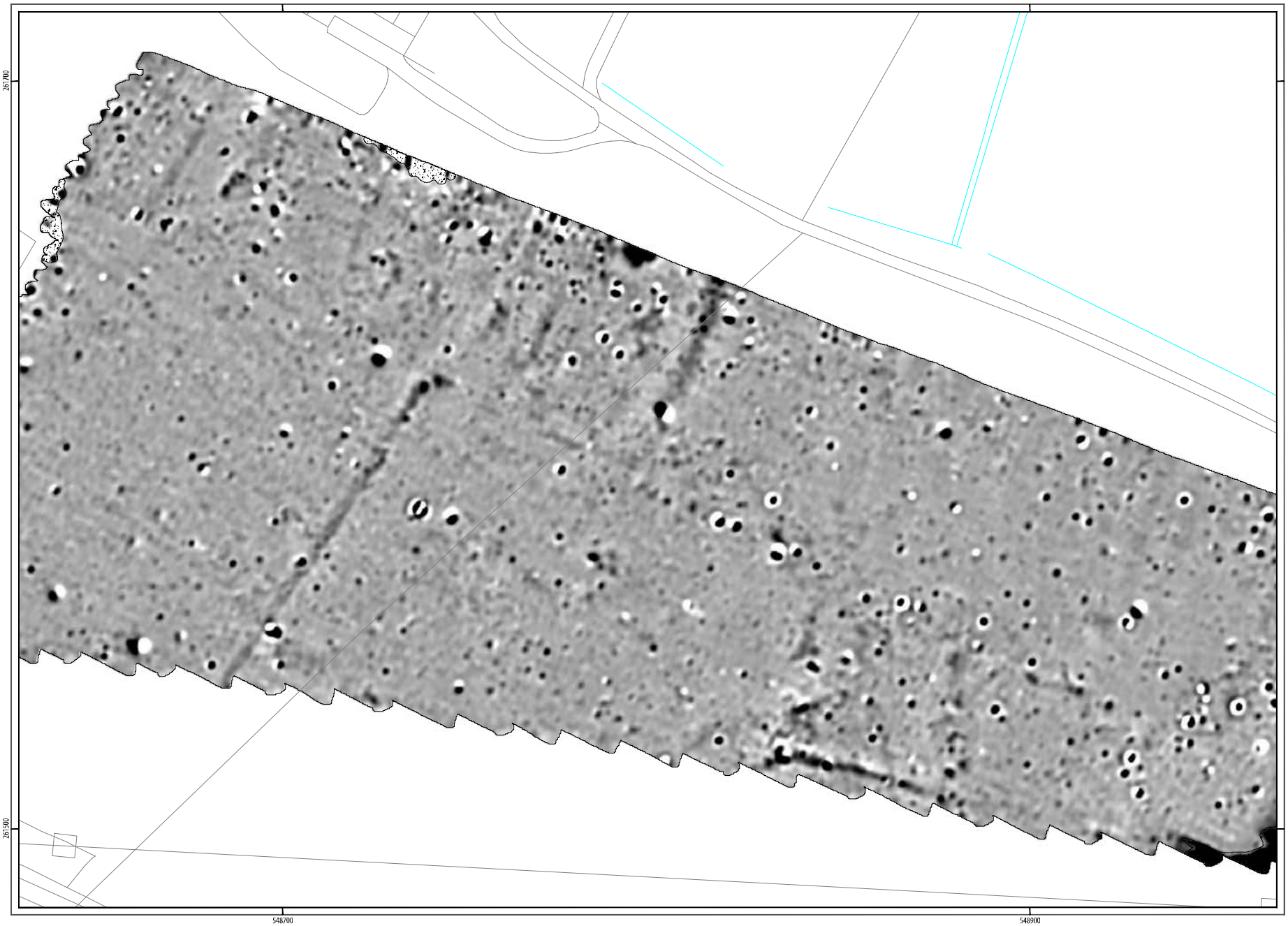
0 50m
1:2,500 @ A3

PROJECT CWRP21
Cambridge Waste Water Treatment Plant
Cambridge

CLIENT Anglian Water

HEADLAND ARCHAEOLOGY
Headland Archaeology Yorkshire & North
Units 23-25 | Acorn Business Centre | Balme Road
Cleckheaton | BD19 4EZ
t 0127 493 8019
w www.headlandarchaeology.com

ILLUS 29 Interpretation of magnetometer data; Sector 7

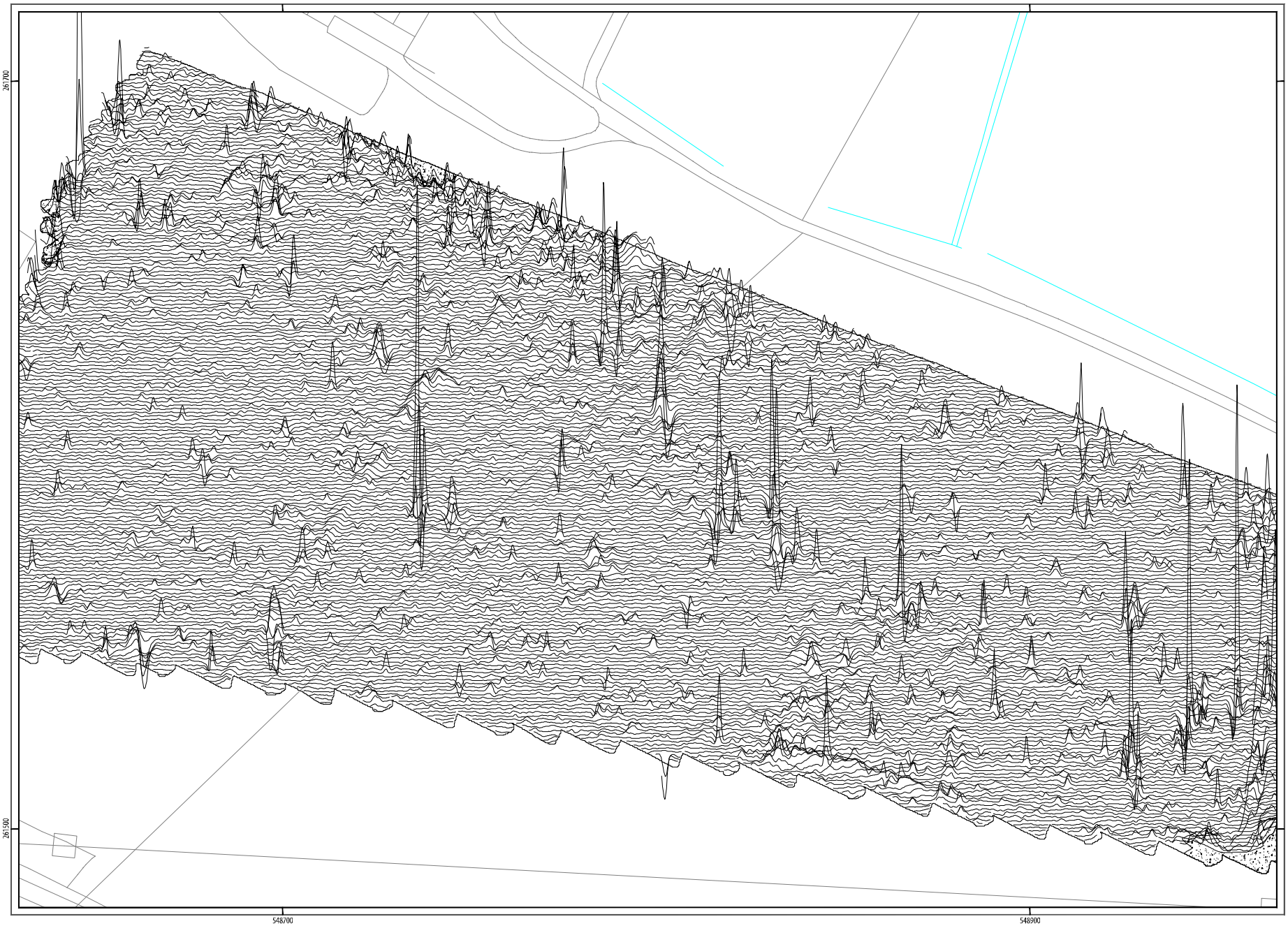


PROJECT CWRP21
Cambridge Waste Water
Treatment Plant Relocation
Cambridge

CLIENT Anglian Water

HEADLAND ARCHAEOLOGY
Headland Archaeology Yorkshire & North
Units 23-25 | Acorn Business Centre | Barnoldswick Road
Cleckheaton | BD19 4EZ
t: 0127 493 8019
w: www.headlandarchaeology.com

ILLUS 30 Processed greyscale magnetometer data; AAP1



62.5nT/cm

0 25m

1:1,000 @ A3

PROJECT CWRP21
Cambridge Waste Water
Treatment Plant Relocation
Cambridge

CLIENT Anglian Water

HEADLAND ARCHAEOLOGY

Headland Archaeology Yorkshire & North
Units 23-25 | Acorn Business Centre | Bairne Road
Cleckheaton | BD19 4FZ
t 0127 493 8019
w www.headlandarchaeology.com

ILLUS 31 XY trace plot of minimally processed magnetometer data; AAP1

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.

Lightning-induced remnant magnetisation (LIRM)

LIRM anomalies are thought to be caused in the near surface soil horizons by the flow of an electrical current associated with lightning strikes. These observed anomalies have a strong bipolar signal which decreases with distance from the spike point and often appear as linear or radial in shape.

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 [redacted] 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 ARCHIVE

WGPL21

Waterbeach Growth Pipeline, Cambridgeshire

GEOPHYSICAL SURVEY REPORT

PLANNING REF. n/a

Headland Archaeology Yorkshire & North
Units 23–25 & 15 | Acorn Business Centre | Balme Road | Cleckheaton BD19 4EZ

for Anglian Water

01/10/2021

HEADLAND ARCHAEOLOGY

PROJECT INFORMATION:

PROJECT NAME	Waterbeach Growth Pipeline, Cambridge
TYPE OF WORK	Geophysical Survey
PLANNING REF.	n/a
CAMBRIDGE EVENT CODE	TBC
CONSULTANT/AGENT	n/a
CLIENT	Anglian Water
PROJECT CODE	WGPL21
HAS. NO (HEREFORD ONLY)	n/a
NGR	Click or tap here to enter text.
PARISH	Waterbeach, Horningsea
LOCAL AUTHORITY	Cambridgeshire County Council
FIELDWORK DATES	13/09/2021 – 20/09/2021
OASIS REF.	
ARCHIVE REPOSITORY	Archaeological Data Service

PROJECT TEAM:

PROJECT MANAGER	Alistair Webb
AUTHOR	Alistair Webb
FIELDWORK	Eleanor Culverhouse, Neil Paveley
GRAPHICS	Sam Harrison, Ross Bishop, Matt Berry

PROJECT SUMMARY

Headland Archaeology (UK) Ltd was commissioned by Anglian Water Ltd to undertake a geophysical (magnetometer) survey along the proposed route of the Waterbeach Growth Pipeline, north-east of Cambridge, which will run from Waterbeach in the north to Cambridge (Milton) Wastewater Treatment Plant (WWTP) in the south. The pipeline will also connect to the new Cambridge WWTP once this has been constructed. The survey also covered areas required for associated infrastructure including trackways, compound and laydown areas; in total an area of approximately 31 hectares was surveyed. The results of the survey will help assess the impact of the proposed development on the historic environment and will be used to support a Development Consent Order (DCO) application for the proposed scheme. The results will also inform future archaeological strategy for the project.

The geophysical survey has identified numerous linear and discrete anomalies across all parts of the survey corridor. The narrow survey corridor makes confident interpretation difficult for some anomalies. However, most of these anomalies are clearly due to activity associated with the drainage and subsequent farming of this low-lying fenland landscape being caused by drains, relict field boundaries, ridge and furrow and more recent ploughing/cultivation or by modern activity. Anomalies of possible or probable archaeological origin are few and concentrated in two main areas towards the southern end of the pipe corridor; either side of the point at which it crosses the A14 and immediately east of Horningsea.

In F24, south of the A14, linear anomalies are interpreted as ditches defining a likely trackway. Other linear and curvilinear ditch type anomalies, which are not on the same alignment as the agricultural anomalies, are also recorded in the vicinity of the trackway although there is no obvious or coherent pattern of land division/enclosure and these anomalies are interpreted as of possible archaeological origin. Immediately north of the A14 a single discrete anomaly is recorded close to a cluster of discrete anomalies (identified by a previous survey and outside the current survey area). Both the trackway and the discrete anomalies are recorded in an area where cropmarks interpreted as of Roman date have been previously identified and a scatter of Roman artefacts recorded. Both these events are recorded on the Cambridge HER. This part of the pipe corridor, approximately 100m either side of the A14 crossing point, is assessed as of moderate archaeological potential.

The second area is due east of Horningsea. Here too no clear pattern can be discerned but a clear area of possible archaeological activity has been defined which is again very close to recorded cropmarks and a cluster of Roman finds. Anomalies possibly indicative of copralite extraction are also recorded within this area of archaeological activity. This defined area is also assessed as of moderate archaeological potential.

The remainder of the pipe corridor is assessed as having low archaeological potential, based solely on the results of the geophysical survey.

TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

WATERBEACH GROWTH PIPELINE, CAMBRIDGESHIRE

GEOPHYSICAL SURVEY REPORT

1. INTRODUCTION

Headland Archaeology (UK) Ltd was commissioned by Anglian Water Ltd (The Client) to undertake a geophysical (magnetometer) survey along the route of the Waterbeach Growth Pipeline, north-east of Cambridge, which will run from Waterbeach in the north to Cambridge (Milton) Wastewater Treatment Plant (WWTP) in the south (Illus 1). The pipeline will also connect to the new Cambridge WWTP once it has been constructed (see below).

This new rising main (pipeline) is required in order support the development of Waterbeach New Town as there is currently insufficient capacity to treat flows within the existing Waterbeach Wastewater Recycling Centre (WRC). The new town development (when built out) will comprise 11,000 new homes along with associated business, retail, community and leisure units. The new rising main will also accommodate flows from the existing Waterbeach catchment.

The developer need date, based upon the existing capacity within the network and the predicted built out rates of Waterbeach New Town is expected to be before the new WWTP is operational. Therefore, the pipeline has been designed to take flows into the existing Cambridge (Milton) WWTP for an interim period as a reasonable worst-case scenario. It is expected that once the new WWTP is constructed the southernmost section of the pipeline (to the south of the new WWTP), will become redundant.

A new pumping station will be required within the Waterbeach New Town development area, to pump flows into the new rising main. It is expected that this will be located either within the existing Waterbeach WRC, located off Bannold Drove, or the adjacent area.

The geophysical survey covered land required for new access tracks, laydown areas, construction compounds and other necessary infrastructure as well as a 30m wide easement centred on the line of the pipe, an overall area of approximately 36 hectares; some parts of the pipe corridor had been surveyed previously as part of other schemes associated with the current project. The results of the survey will help assess the impact of the proposed scheme on the historic environment and will be used to support a Development Consent Order (DCO) application. The results will also inform future archaeological strategy.

The survey was undertaken in accordance with a Written Scheme of Investigation for Geophysical Survey (WSI) (Headland 2021a), which was submitted to Anglian Water prior to the survey commencing. The WSI was also in part informed by a Brief for Archaeological Geophysical Survey provided by Cambridgeshire County Council Historic Environment Team (CCCHET) to Anglian Water for a previous (and associated) adjacent project (Cambridge Wastewater Treatment Works – Headland 2021b) part of the survey for which overlaps with the current survey area.

The survey also follows guidance contained in the National Planning Policy Framework (MHCLG 2021) and was carried out in line with current best practice (Chartered Institute for Archaeologists 2014, Europae Archaeologia Consilium 2016).

The survey was carried out between September 13th 2021 and September 20th 2021.

1.1. SITE LOCATION, TOPOGRAPHY AND LAND-USE

The survey corridor extends from the north-eastern edge of Waterbeach, at the northern end, immediately to the west of the mainline railway, before crossing the railway line and turning due south before crossing the River Cam immediately north-east of Cambridge Sailing Club. The pipe corridor then heads on a south-easterly and then southerly bearing before crossing the A14 and then heading north-west, re-crossing the River Cam and the railway line to finish at Cambridge (Milton) WTW, an overall distance of approximately 7.5kms.

The land along the pipe corridor was mostly under arable agricultural production with most of the 29 fields which the survey crossed either still stubble or recently re-drilled. There were occasional small stretches of rough pasture in use as horse paddocks; some of these were semi-overgrown and only partially suitable for survey. A single field of sugar beet was also omitted as unsuitable for survey (Illus 2 to Illus 4 inclusive).

Topographically the landscape is predominantly low lying and flat at between 3m and 5m above Ordnance Datum (AOD) west of the river (on the flood plain) but rising slightly to the east between 5m and 9m AOD as the corridor approaches the A14 crossing point with a maximum elevation of 11m AOD immediately just south of the A14 before reducing back to between 3m and 5m AOD on the river flood plain.

1.2. GEOLOGY AND SOILS

The underlying solid geology comprises sedimentary bedrock, mostly Gault Formation and Upper Greensand (Mudstone, Sandstone and Limestone) overlain by River Terrace Deposits of Sand and Gravel to the north of the corridor and Grey Chalk overlain with Alluvium to the south (UKRI 2021).

The soils are mostly classified in the Soilscape 5 Association which are described as freely draining lime-rich loamy soils. Loamy and clayey floodplain soils (Soilscape 20) are recorded adjacent to the River Cam (Cranfield University 2021).

2. ARCHAEOLOGICAL BACKGROUND

Information included within the Brief (CCCHET 2021) for the Cambridge WWTW scheme assessed the area for that project, which is located at the southern end of the current survey corridor, is '*located in an area of high archaeological potential with substantial evidence for prehistoric and Roman settlement within and in the vicinity of the site*'. The Brief also noted that the south-western extent of the CWWTW site falls under the A14, the construction of which was considered likely to have had a substantial impact on any currently unknown assets; this area overlaps with the current pipe corridor and is immediately adjacent to the Roman settlement.

Information provided by the Cambridgeshire Historic Environment Record (CHER) for the current project, at the request of Anglian Water, confirms that the scheme is located within an area of high archaeological potential, particularly relating to the Roman period. Specific examples with most relevance to this project (and within the current survey corridor) are Roman cropmarks and Roman pottery scatter, HER No's. MCB6845 and MCB6492 respectively, that are recorded in F24 immediately north of the A14 and Roman cropmarks and pottery scatter (MCB 6581 and MCB 13594) that are recorded 50m east of the survey corridor (in F21), immediately east of Horningsea. Numerous other Roman artefacts have been recovered in and around Horningsea. Also of note are cropmarks of rectangular features (MCB30567) which are recorded immediately adjacent to the survey corridor, to the west.

It should also be noted that spot finds of artefacts from other periods, most notably the prehistoric, have also been recovered from the immediate vicinity surrounding the survey corridor, attesting to the archaeological potential of this area.

3. AIMS, METHODOLOGY AND PRESENTATION

3.1. AIMS & OBJECTIVES

The principal aim of the programme of geophysical survey was to gather information to establish the presence/absence, character and extent of any archaeological remains within the pipe corridor and associated infrastructure areas. This will therefore enable an assessment to be made of the impact of

the proposed development on any sub-surface archaeological remains, if present, and thereby inform the DCO application and any further investigation strategies, as appropriate.

The specific archaeological objectives of the geophysical survey were:

to gather enough information to inform the extent, condition, character and date (as far as circumstances permit) of any archaeological features and deposits within the PDA;

to obtain information that will contribute to an evaluation of the significance of the scheme upon cultural heritage assets; and

to prepare a report summarising the results of the survey.

3.2. METHODOLOGY

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.

Magnetometry is the most widely used geophysical survey technique in archaeology as it can quickly evaluate large areas and, under favourable conditions, identify a wide range of archaeological features including infilled cut features such as large pits, gullies and ditches, hearths and areas of burning and kilns and brick structures. It is therefore good at locating settlements of all periods, prehistoric field systems and enclosures and areas of industrial or modern activity, amongst others. It is less successful in identifying smaller features such as post-holes and small pits (except when using a non-standard sampling interval), unenclosed (prehistoric) settlement sites and graves/burial grounds. However, magnetometry is by far the single most useful technique and was assessed as the best non-intrusive evaluation tool for this site.

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 (Illus 2). 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 V3.0.37.0 (DWConsulting) software was used to process and present the data.

3.3. DATA PRESENTATION& TECHNICAL DETAIL

A general site location plan is shown in Illus 1 at a scale of 1:50,000. Illus 2 to Illus 4 inclusive are site condition photographs. Illus 5 shows the GPS swaths at 1:17,500. Illus 6 and Illus 7 present the greyscale data and an overall interpretation of the data, by Sector, also at a scale of 1:17,500. Fully processed (greyscale) data, minimally processed data (XY trace plot) data and an interpretative plot (by Sector) are presented, at a scale of 1:2,500, in Illus 8 to Illus 34 inclusive. Large scale (1:1,000) plots of the area around the A14 crossing point are presented in Illus 35 to Illus 37 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 survey methodology, report and any recommendations comply with the Written Scheme of Investigation (Headland 2021), guidelines outlined by Europae Archaeologia Consilium (EAC 2016) and by the Chartered Institute for Archaeologists (CIfA 2014). All illustrations from Ordnance Survey (OS) 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' (minimally processed) and processed formats and over a range

of different display levels. All illustrations are presented to display and interpret the data to best effect. The interpretations are based on the experience and knowledge of management and reporting staff.

4. RESULTS AND DISCUSSION

4.1. SITE CONDITIONS

Magnetometer survey is generally recommended over any sedimentary bedrock geology with the response reported as 'average' to 'good' on limestone and chalk and 'average' on sandstone (English Heritage 2008) although results can be variable when there are overlying superficial deposits, as there on in this case. Nevertheless, it was considered that magnetometry was an appropriate methodology for evaluating the pipe corridor given the prevailing geology and taking account of the limitations noted in Section 3.2 above.

Ground conditions were generally average to good across the PDA, although heavy underfoot in places. Data quality was also average to good with only minimal post-processing required. Small areas of overgrown vegetation restricted survey in F5 and the field to the east of F6 was also unsuitable for survey as it contained a sugar beet crop. No problems were encountered during the fieldwork.

Overall, the magnetic background was homogenous across the survey corridor but with some geological variations (see Section 4.4 below) with numerous anomalies, mostly agricultural, geological and modern being identified. Possible and probable archaeological anomalies are also recorded at two main locations. This confirms that the soils and geology are suitable for magnetometry and that the results likely provide a good indication of the extent of sub-surface archaeological features within the corridor, notwithstanding the limitations of magnetometer survey to identify certain types and sizes of archaeological feature and period.

The anomalies have been classified into categories and are discussed below.

4.2. 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 introduced into the topsoil during manuring or tipping/infilling. There is no obvious clustering to the ferrous anomalies within any of the fields or across the survey corridor more generally to 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.

Dipolar, linear anomalies SP1 (F7), SP2 (F24) and SP3 (F29) are caused by sub-surface service pipes.

Other areas of more widespread magnetic disturbance are recorded around the southern boundary in F3, in the paddocks in F4 and F5, the north-western corner of F7, the southern end of F9, across most of F11, adjacent to Mulberry Farm in F13, around the southern edge of F16 and in F29. This disturbance is likely due to the proximity of current buildings or structures or the tipping or spreading of magnetic debris along boundaries or in gateways. Other linear bands of disturbance located along field edges are due to the accumulation of ferrous debris along the boundary or to the presence of barbed wire or wire mesh in the boundary itself. None of these areas of ferrous disturbance are interpreted as of any archaeological interest; all are interpreted as being probably modern in origin.

4.3. AGRICULTURAL ANOMALIES

Analysis of the first edition Ordnance Survey (OS) County series mapping from the late 19th century and more recent mapping shows that there has been a rationalisation of boundaries over the past 130 years to create larger fields. Linear anomalies that correlate with former boundaries are identified in F9 (F1, F2 and F3), F15 (FB4), F25 (FB5), F28 (FB6 and F29 (FB7 and FB8).

Numerous other linear anomalies and linear trends in the data also have an agricultural origin. Most of the anomalies are closely spaced and are indicative of recent cultivation. More widely spaced linear anomalies, for example those in F3 aligned north-north-east/south-south-west or those in F24, are interpreted as likely field drains. Of note are parallel curvilinear anomalies on the western edge of the survey corridor in F21. These are also ploughing lines

around a fence which previously enclosed a large tree immediately to the west of the survey corridor.

Slightly curving parallel anomalies aligned broadly east/west, that just extend into the current survey area in F24, but which are more extensively seen in the earlier survey (Headland 2021b), are due to ridge and furrow cultivation. These cultivation strips are also recorded south of the A14 in F25, aligned north-west/south-east.

4.4. GEOLOGICAL ANOMALIES

Numerous low magnitude discrete anomalies as well as broad, low magnitude, irregular anomalies are recorded throughout the survey corridor, being particularly noticeable adjacent to the River Cam on the eastern side in F9. These anomalies are all interpreted as geological in origin.

4.5. AREAS OF ARCHAEOLOGICAL POTENTIAL

Two areas of archaeological potential have been identified.

The first is in F21 where a cluster of poorly defined and amorphous linear, curvilinear and discrete anomalies is recorded east of Horningsea (Illus 23 to Illus 25 inclusive). No definite pattern can be discerned but the extent of an area where the magnetic background is much more variable than elsewhere can be clearly defined and this has been illustrated by a dashed line (Illus 25); an area of possible copralite extraction is also recorded within this defined area. This demarcated area is within 50m west of the recorded location of Roman settlement cropmarks and pottery scatter (MCB6581 and MCB13594) and a similar distance east of other recorded features (MCB30567). Based on this additional evidence these anomalies are interpreted as of possible archaeological origin.

Of more certain archaeological origin are parallel linear anomalies (Illus 37 – L2) which are recorded on a south-west/north-east alignment in F25, immediately south of the A14 (Illus 35 to Illus 37 inclusive). These anomalies are interpreted as ditches defining either side of a trackway. Crossing the trackway at right angles is another ditch type anomaly, L3, which is aligned oblique to the orientation of the ridge and furrow anomalies also recorded in this field. On the western edge of the survey corridor, immediately west of the trackway, are concentric curvilinear anomalies, (ring ditch - RD1), which may be a possible barrow or enclosure. To the east of the trackway, also oblique to the former ploughing, is L-shaped anomaly, L4. All these anomalies, except the trackway, are interpreted as of possible archaeological origin and all are located immediately adjacent to the recorded position of Roman cropmarks and pottery scatter (MCB 13594 and MCB6581) which again provides supporting evidence for an archaeological interpretation for these anomalies.

On the northern side of the A14 a single discrete anomaly, B?2, is identified. This possible burnt feature may be associated with the cluster of other discrete anomalies identified by a previous survey (Headland 2021b) immediately outside the survey corridor on the western side (Illus 26 to Illus 28 inclusive). This anomaly, and those recorded by the earlier survey, are also possibly associated with the Roman cropmarks although they may also be linked with the construction of the A14.

4.6. OTHER ANOMALIES OF POSSIBLE ARCHAEOLOGICAL ORIGIN

In the survey corridor west of the trackway in F26 linear anomalies L5 and L6 are identified as well as a small cluster of linear trends, L7, (Illus 19 to Illus 21 inclusive). All these anomalies have been interpreted as potentially archaeological on the basis that they are slightly oblique to the orientation of ploughing anomalies or former or extant boundaries. Nevertheless, an agricultural origin cannot be discounted.

5. CONCLUSION

The geophysical survey has identified numerous linear and discrete anomalies across all parts of the survey corridor. The relatively narrow survey corridor makes confident interpretation difficult for some anomalies. However, most of these anomalies are clearly due to activity associated with the drainage and subsequent farming of this low-lying fenland landscape being caused by drains, relict field boundaries, ridge and furrow and more recent ploughing/cultivation or by modern activity.

Anomalies of possible or probable archaeological origin are few and concentrated in two main areas of potential towards the southern end of the pipe

corridor, firstly either side of the point at which the corridor crosses the A14 and secondly immediately to the east of Horningsea.

The first area is in F24, south of the A14, where two parallel linear anomalies are interpreted as ditches defining a likely trackway. Other linear and curvilinear ditch type anomalies, which are not on the same alignment as the agricultural anomalies, are also recorded in the vicinity of the trackway although there is no obvious or coherent pattern of land division/enclosure and so these anomalies are therefore interpreted as of possible archaeological origin.

Immediately north of the A14 a single discrete anomaly is recorded close to a cluster of discrete anomalies (identified by a previous survey and outside the current survey area). Both the trackway and the discrete anomalies are in an area where cropmarks interpreted as being caused by features of Roman date have been previously identified and a scatter of Roman artefacts recorded. Both these events are recorded on the Cambridge HER. This section of the pipe corridor, approximately 100m either side of the A14 crossing point, is assessed as of moderate archaeological potential.

The second area of archaeological potential is due east of Horningsea. Here too no clear pattern to the anomalies can be discerned within the narrow survey window but a clear area of possible archaeological activity has been defined which is again very close to recorded cropmarks and a cluster of Roman finds. Anomalies possibly indicative of copralite extraction are also recorded within this identified area of archaeological activity which is also assessed as of moderate archaeological potential.

The remainder of the pipe corridor is assessed as having low archaeological potential, based solely on the results of the geophysical survey.

6. REFERENCES

Cambridgeshire County Council Historic Environment Team 2020 Brief for Archaeological Geophysical Survey Unpublished Cambridgeshire County Council Document

Chartered Institute for Archaeologists (CIfA) 2014 Standard and guidance for archaeological geophysical survey (Reading) [redacted] 2021

Natural Environment Research Council (NERC) 2018 British Geological Survey [redacted] accessed 1st October 2021

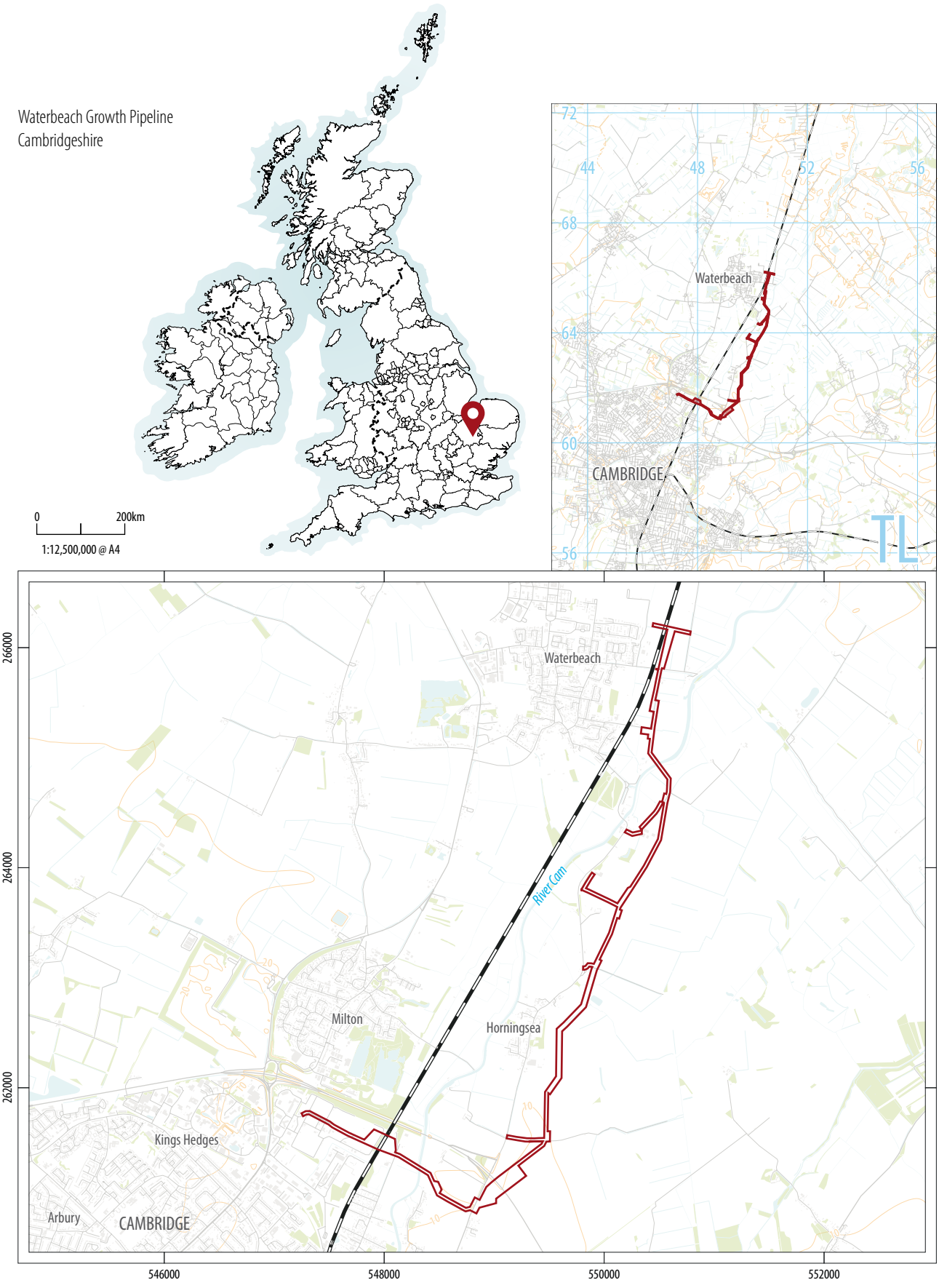
Europae Archaeologia Consillium (EAC) 2016 EAC Guidelines for the Use of Geophysics in Archaeology: Question to Ask and Points to Consider (Namur, Belgium) [redacted] accessed 1st October 2021

Gaffney, C & Gater, J 2003 Revealing the Buried Past: Geophysics for Archaeologists Stroud

Headland 2021a Waterbeach Growth Pipeline Cambridge Written Scheme of Investigation for Geophysical Survey Unpublished Client Document Ref. WGPL21

Headland 2021b Cambridge Waste Water Treatment Plant, Cambridgeshire Geophysical Survey Report Unpublished Client Document Ref. CWRP21

Ministry of Housing, Communities and Local Government MHCLG) 2019 National Planning Policy Framework https://assers.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/810017/NPPF_Feb_2019_revised.pdf accessed 1st October 2021



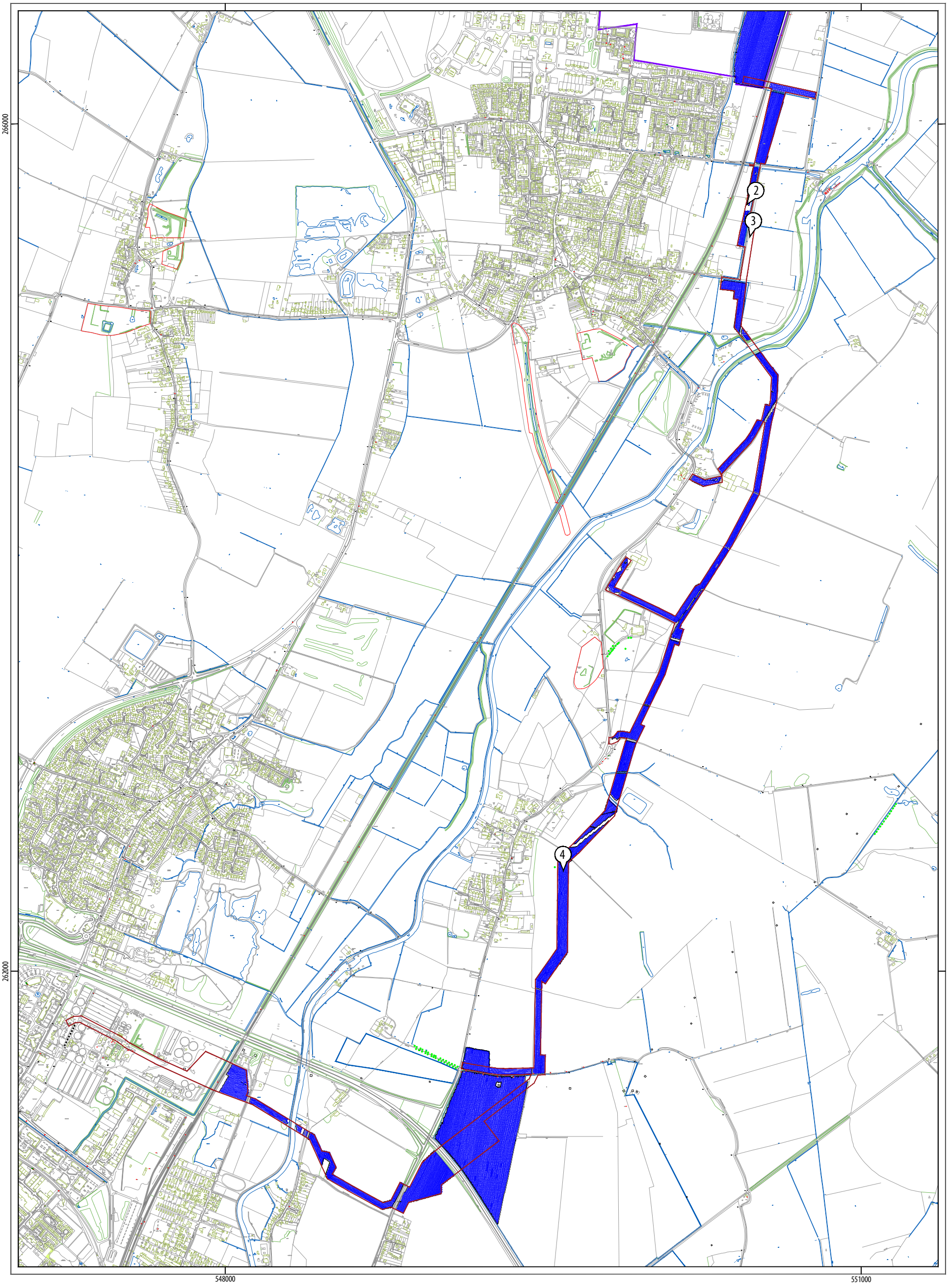
HEADLAND ARCHAEOLOGY
Headland Archaeology Yorkshire & North
Units 23–25 & 15 | Acorn Business Centre | Balme Road | Cleckheaton BD19 4EZ
t 0127 493 8019
e yorkshireandnorth@headlandarchaeology.com
w www.headlandarchaeology.com

ILLUS 1 Site location

Illus 2. F5, looking south-southeast

Illus 3. North of F7 adjacent Burgess's Drove, looking south

Illus 4. F21, looking south



geophysical survey area
WBCA18 geophysical survey area
CWRP21 geophysical survey area
GPS swaths
location and direction of ILLUS 2-4

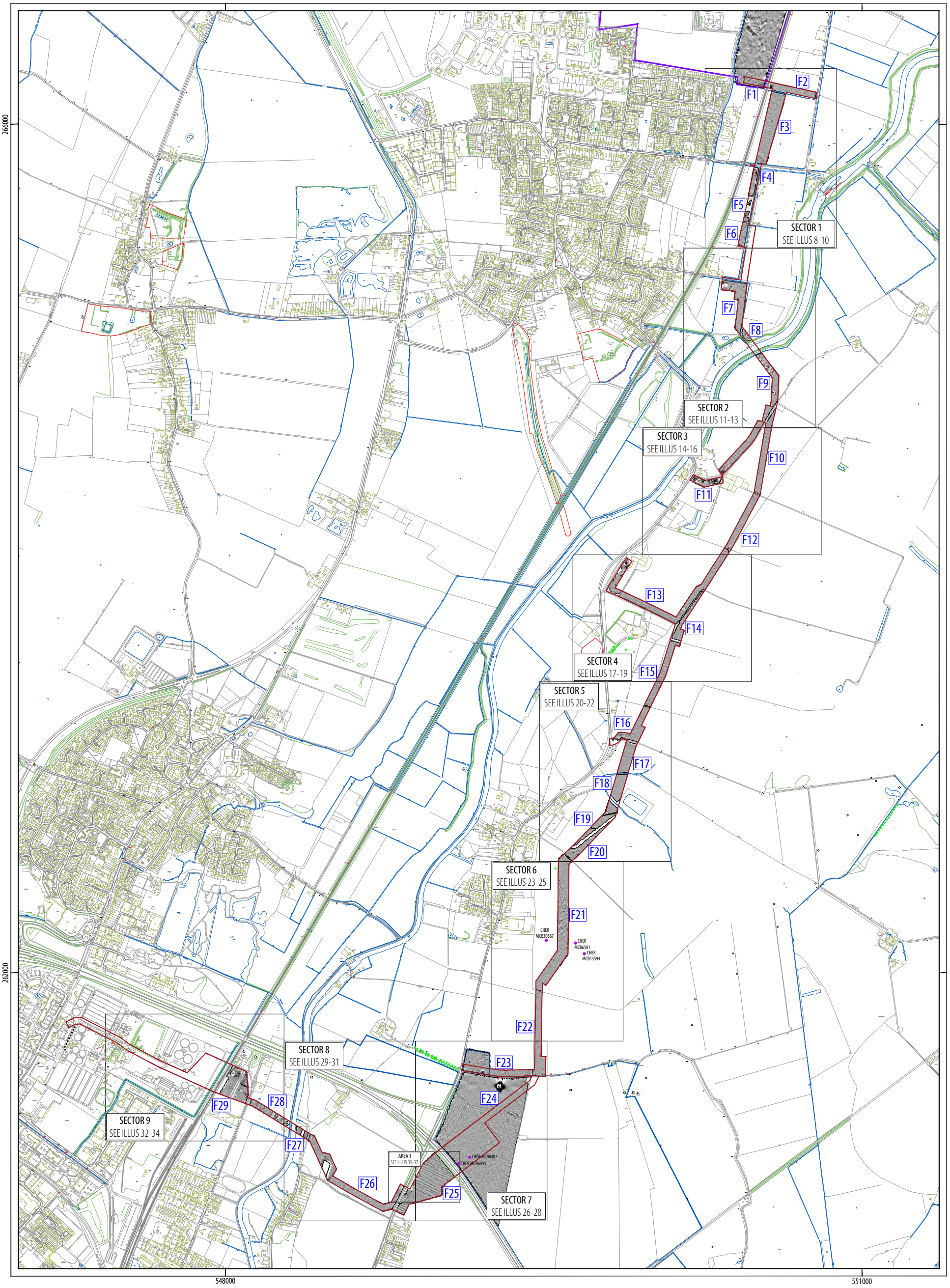
0 350m
1:17,500 @ A3

PROJECT WGPL21
Waterbeach Growth Pipeline
Cambridgeshire

CLIENT Anglian Water

HEADLAND ARCHAEOLOGY
Headland Archaeology Yorkshire & North
Units 23-25 | Acorn Business Centre | Balme Road
Cleckheaton | BD19 4EZ
t 0127 493 8019
w www.headlandarchaeology.com

ILLUS 5 Survey location showing GPS swaths and photograph locations



geophysical survey area
WBCA18 geophysical survey area
CWRP21 geophysical survey area
CHER numbers

nT
-1.0 2.0

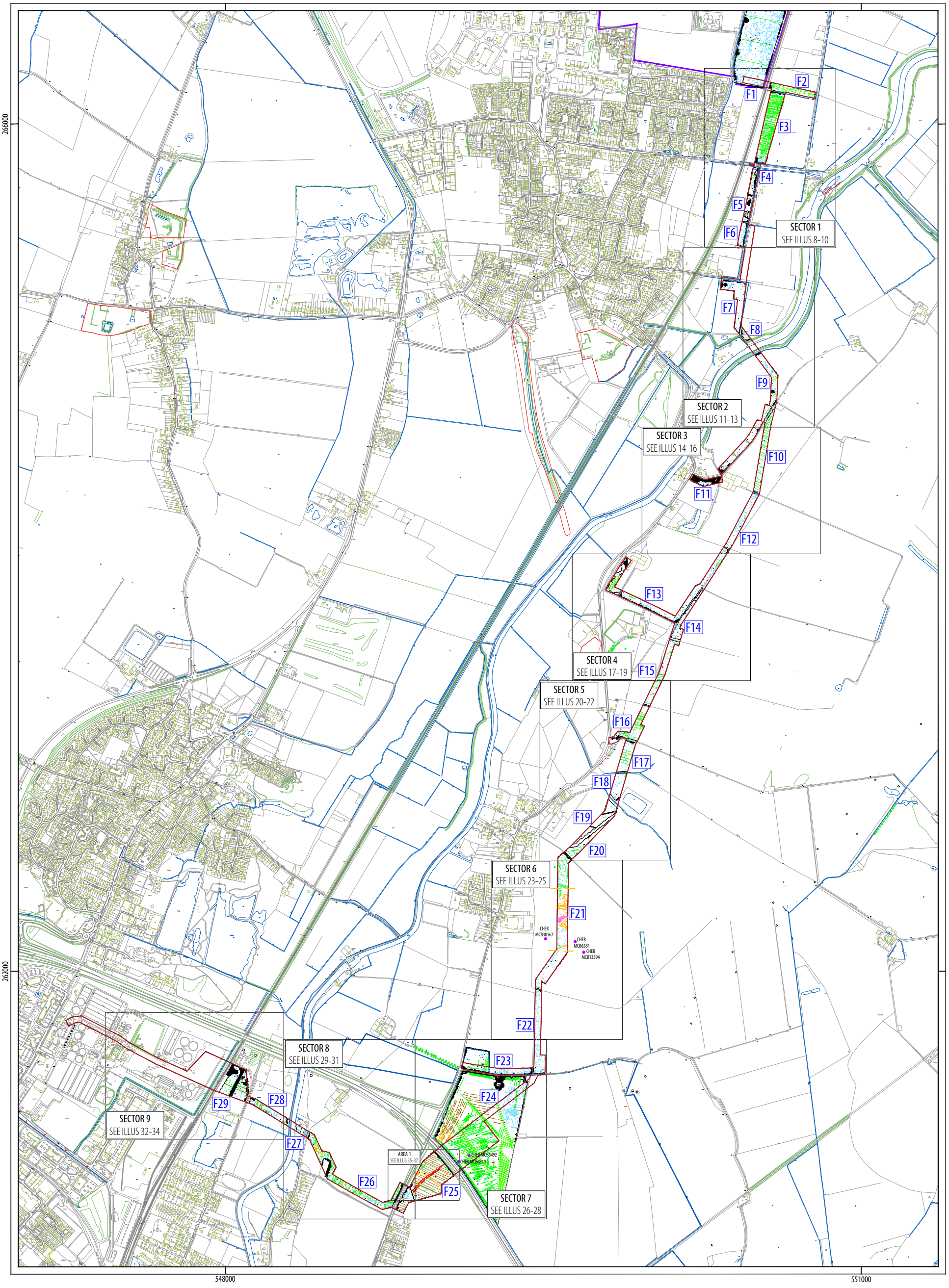
0 350m
1:17,500 @ A3

PROJECT WGPL21
Waterbeach Growth Pipeline
Cambridgeshire

CLIENT Anglian Water

HEADLAND ARCHAEOLOGY
Headland Archaeology Yorkshire & North
Units 23-25 | Acorn Business Centre | Balme Road
Cleckheaton | BD19 4EZ
t 0127 493 8019
w www.headlandarchaeology.com

ILLUS 6 Overall processed greyscale magnetometer data



TYPE OF ANOMALY	INTERPRETATION
dipolar isolated	ferrous material
magnetic disturbance	ferrous material
dipolar linear	service pipe
magnetic enhancement	extraction?
linear trend	ridge and furrow
linear trend	agricultural

TYPE OF ANOMALY	INTERPRETATION
linear trend	field drain
linear	former field boundary
linear trend	geological variation
magnetic enhancement	geology
magnetic enhancement	archaeology?
magnetic enhancement	kiln/burning?

magnetic enhancement | archaeology

geophysical survey area
WBCA18 geophysical survey area
CWRP21 geophysical survey area
CHER numbers

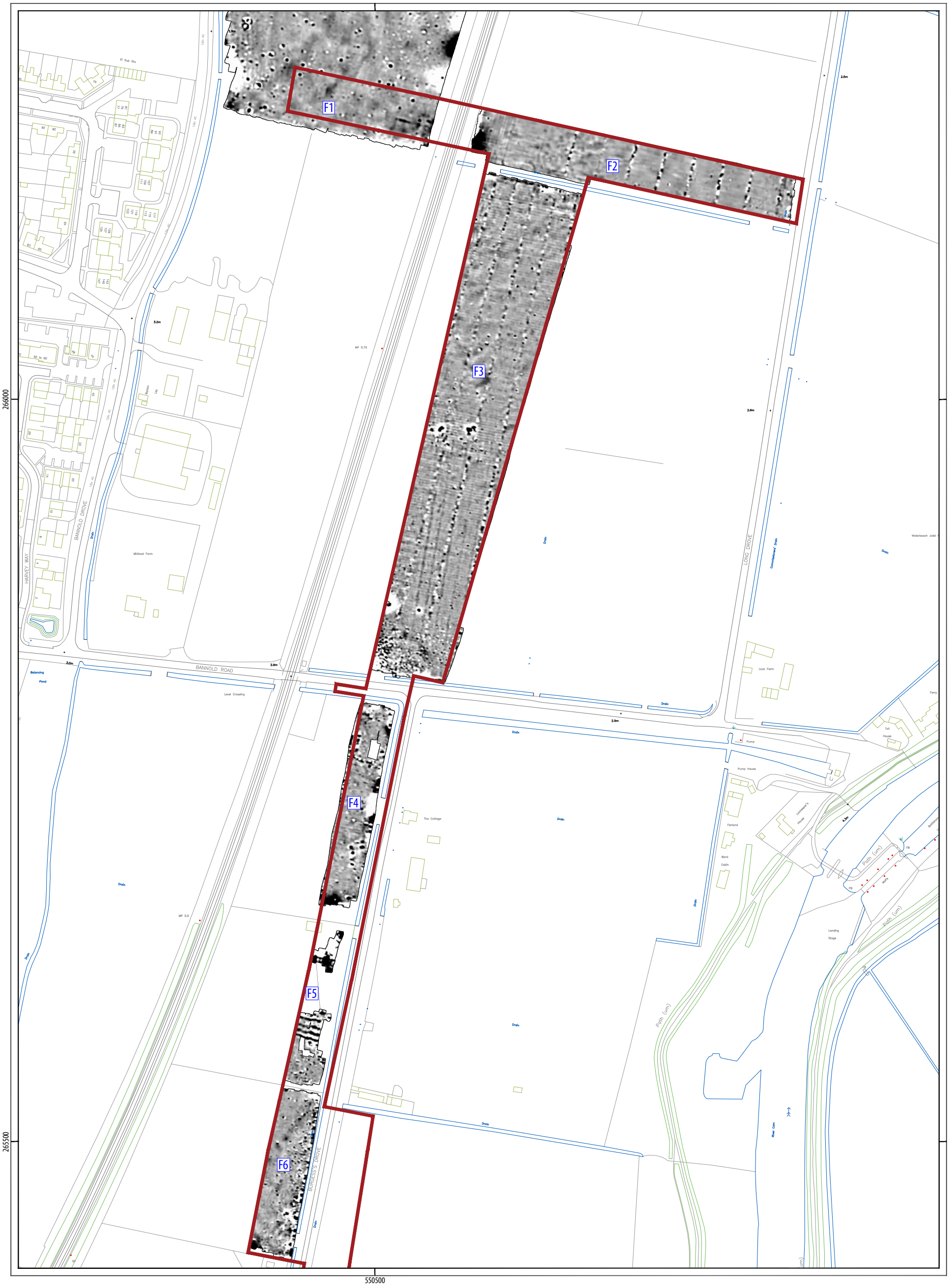
0 350m
1:17,500 @ A3

PROJECT WGPL21
Waterbeach Growth Pipeline
Cambridgeshire

CLIENT Anglian Water

HEADLAND ARCHAEOLOGY
Headland Archaeology Yorkshire & North
Units 23-25 | Acorn Business Centre | Balme Road
Cleckheaton | BD19 4EZ
t 0127 493 8019
w www.headlandarchaeology.com

ILLUS 7 Overall interpretation of magnetometer data



geophysical survey area

nT
-1.0 2.0

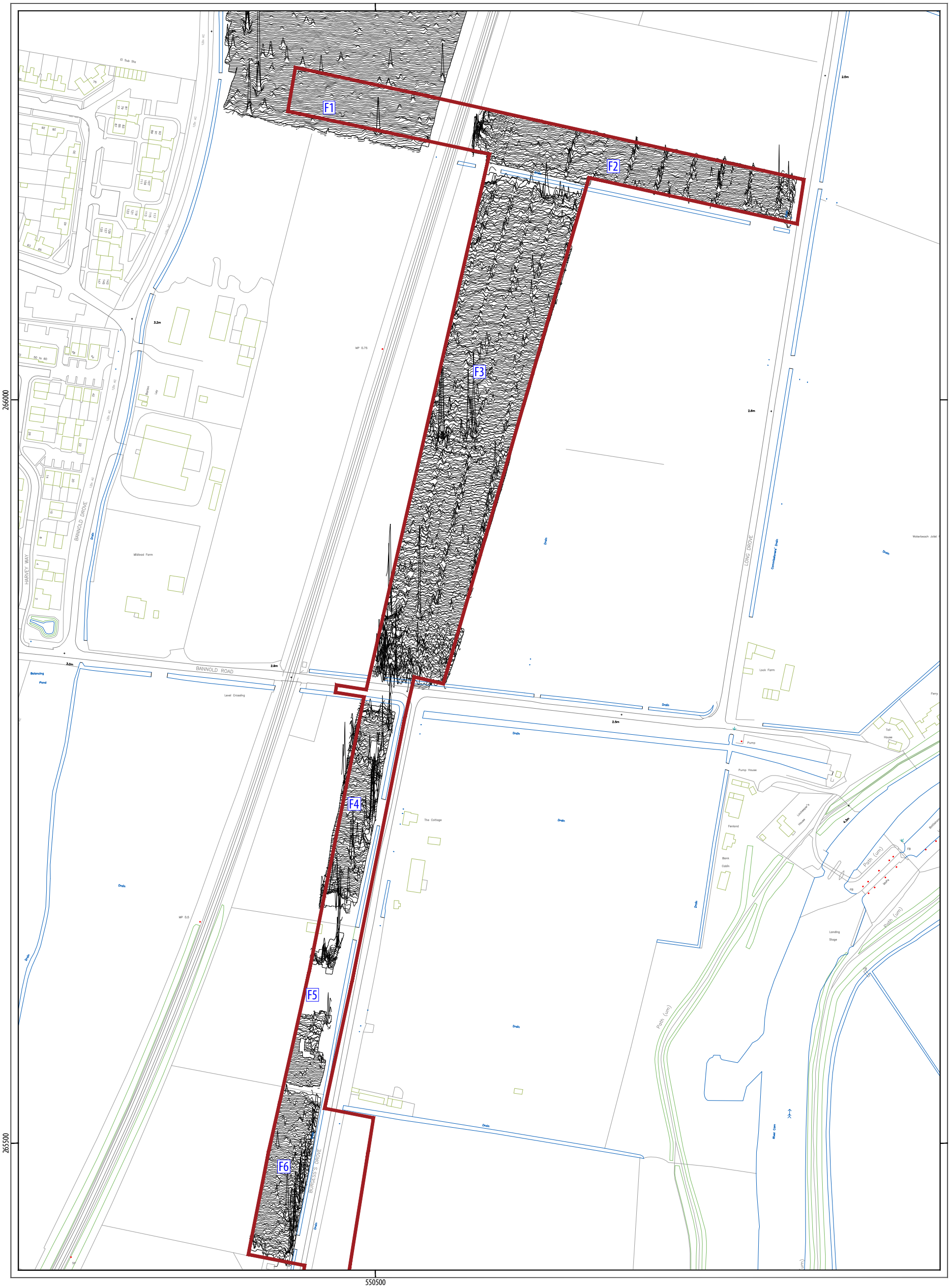
0 50m
1:2,500 @ A3

PROJECT WGPL21
Waterbeach Growth Pipeline
Cambridgeshire

CLIENT Anglian Water

HEADLAND ARCHAEOLOGY
Headland Archaeology Yorkshire & North
Units 23-25 | Acorn Business Centre | Balme Road
Cleckheaton | BD19 4EZ
t 0127 493 8019
w www.headlandarchaeology.com

ILLUS 8 Processed greyscale magnetometer data; Sector 1



geophysical survey area

25.0nT/cm

0 50m

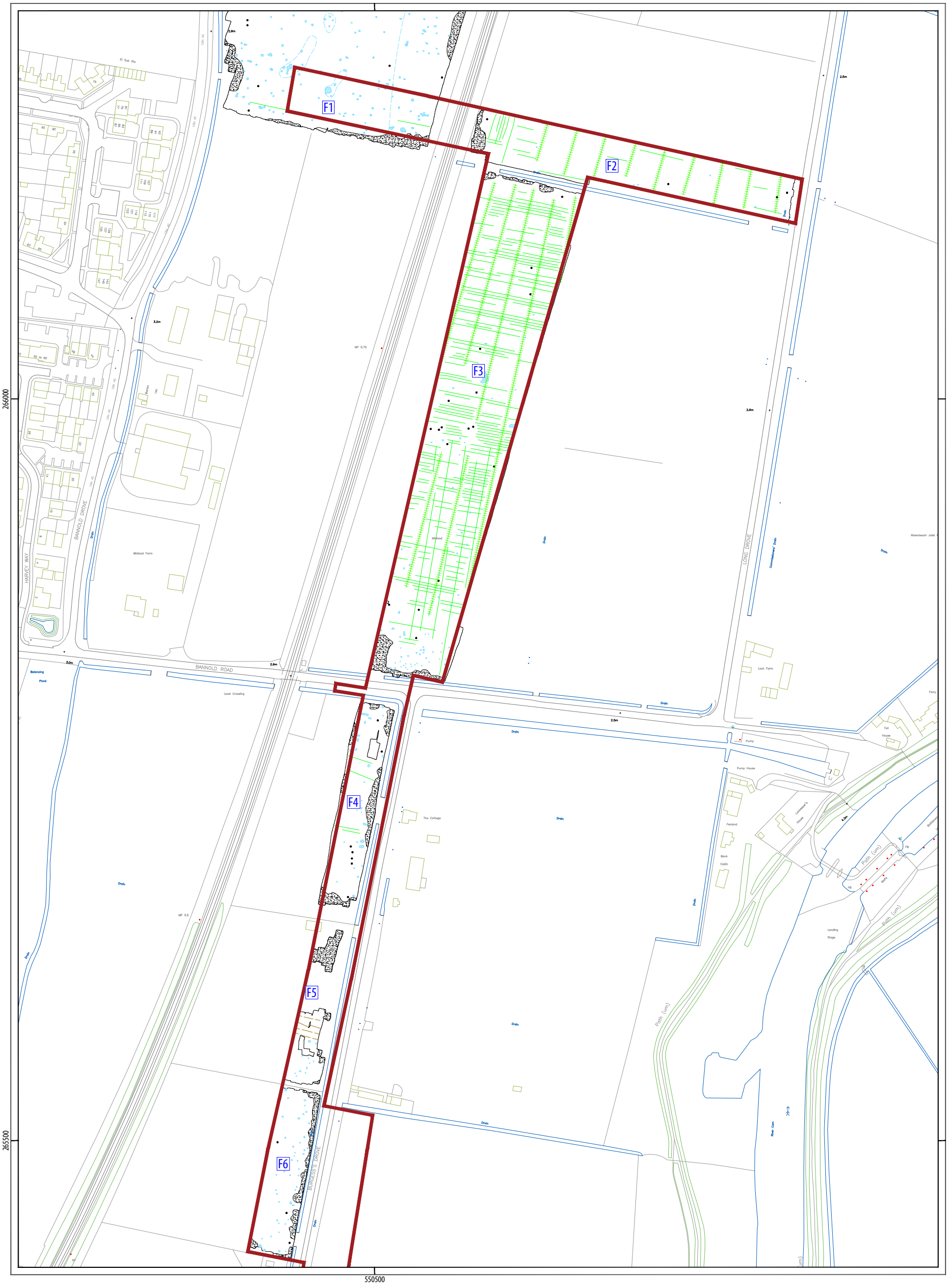
1:2,500 @ A3

PROJECT WGPL21
Waterbeach Growth Pipeline
Cambridgeshire

CLIENT Anglian Water

Headland Archaeology Yorkshire & North
Units 23-25 | Acorn Business Centre | Balme Road
Cleckheaton | BD19 4EZ
t 0127 493 8019
w www.headlandarchaeology.com

ILLUS 8 XY trace plot of minimally processed magnetometer data; Sector 1



TYPE OF ANOMALY	INTERPRETATION
dipolar isolated	ferrous material
magnetic disturbance	ferrous material
linear trend	ridge and furrow
linear trend	agricultural
linear trend	field drain
linear trend	geological variation

TYPE OF ANOMALY	INTERPRETATION
magnetic enhancement	geology

geophysical survey area

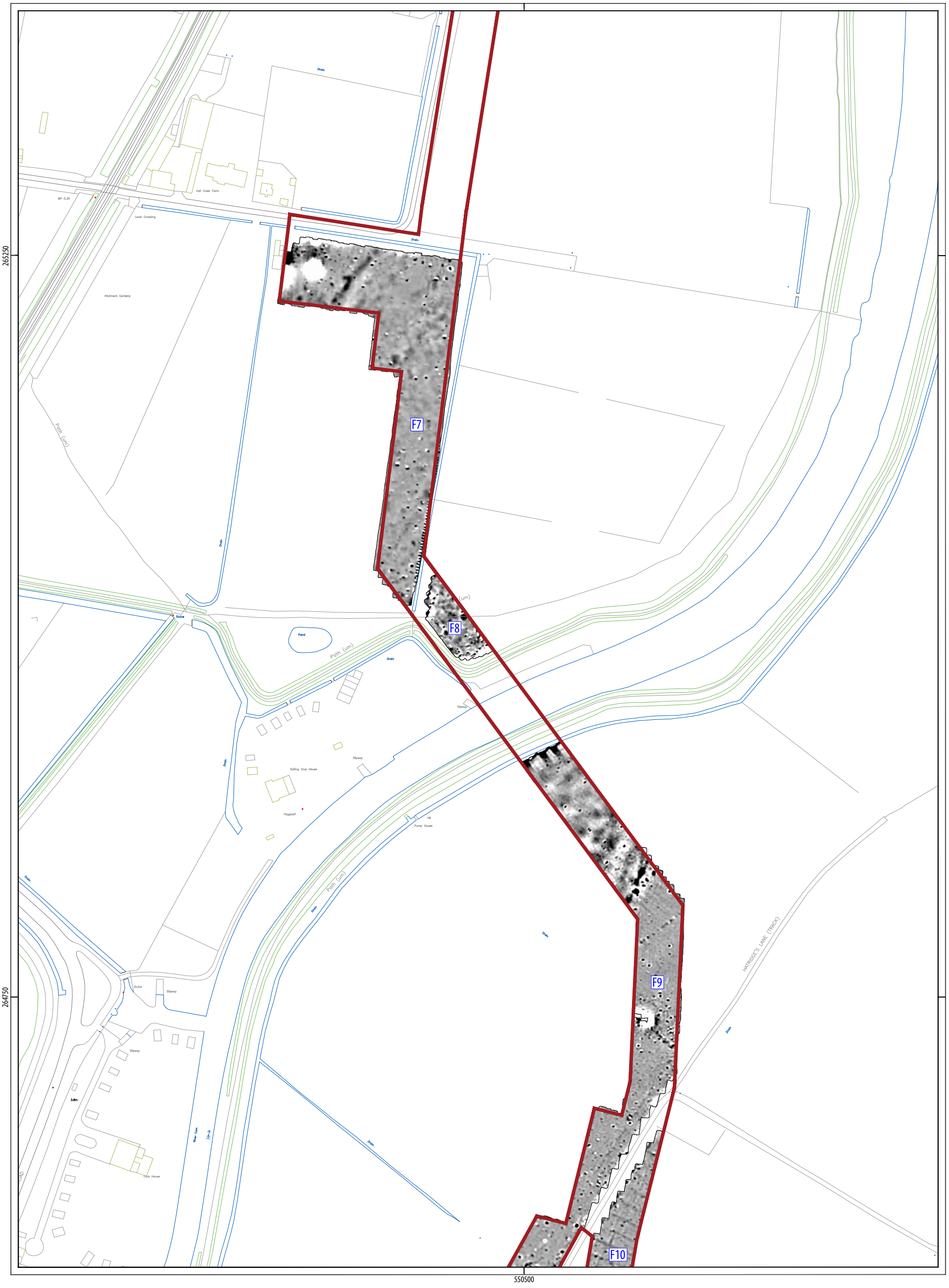
0 50m
1:2,500 @ A3

PROJECT WGPL21
Waterbeach Growth Pipeline
Cambridgeshire

CLIENT Anglian Water

HEADLAND ARCHAEOLOGY
Headland Archaeology Yorkshire & North
Units 23-25 | Acorn Business Centre | Balme Road
Cleckheaton | BD19 4EZ
t 0127 493 8019
w www.headlandarchaeology.com

ILLUS 10 Interpretation of magnetometer data; Sector 1



geophysical survey area

nT
-1.0 2.0

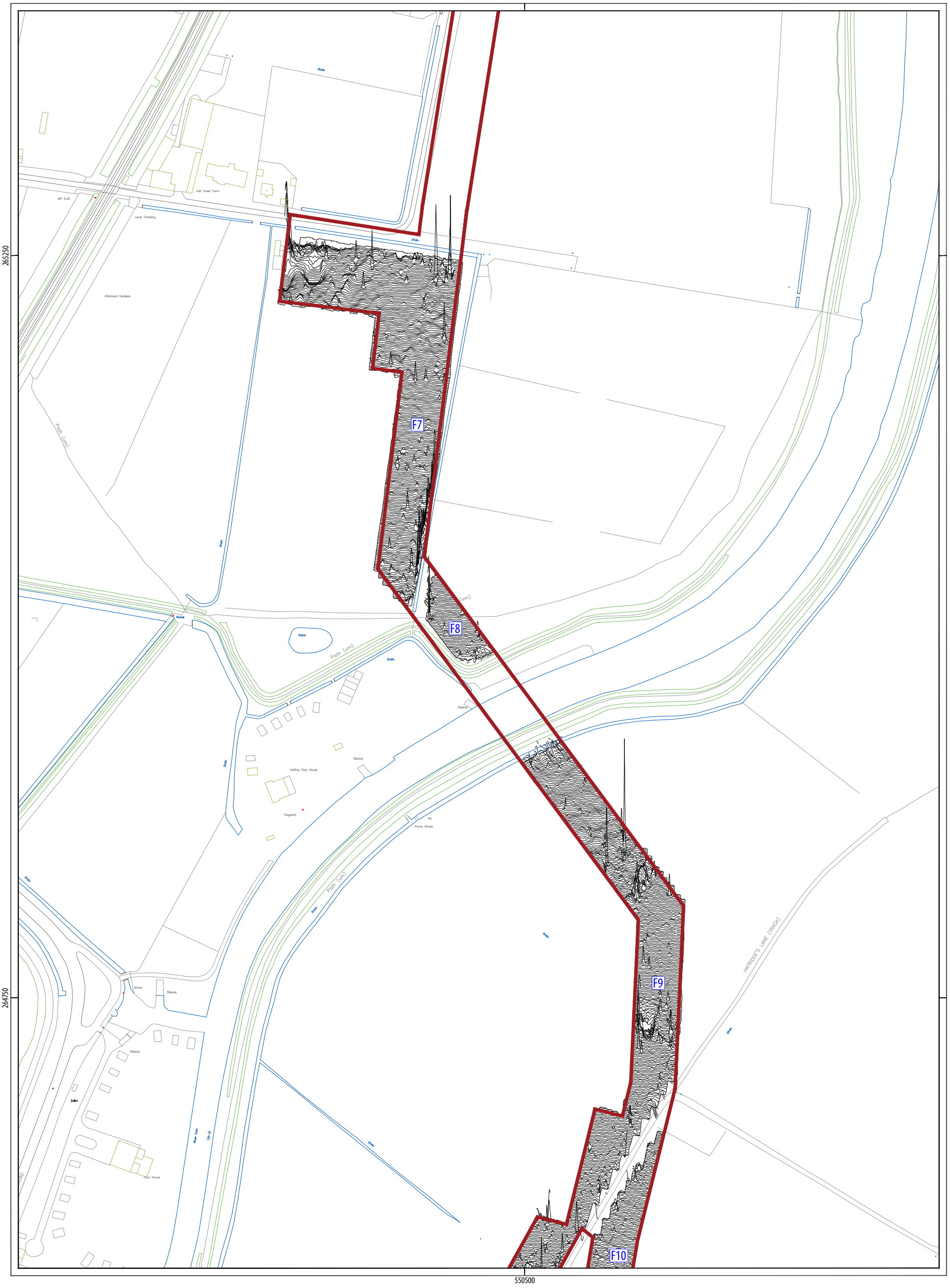
0 50m
1:2,500 @ A3

PROJECT WGPL21
Waterbeach Growth Pipeline
Cambridgeshire

CLIENT Anglian Water

HEADLAND ARCHAEOLOGY
Headland Archaeology Yorkshire & North
Units 23-25 | Acorn Business Centre | Balme Road
Cleckheaton | BD19 4EZ
t 0127 493 8019
w www.headlandarchaeology.com

ILLUS 11 Processed greyscale magnetometer data; Sector 2



geophysical survey area

25.0nT/cm

0 50m

1:2,500 @ A3

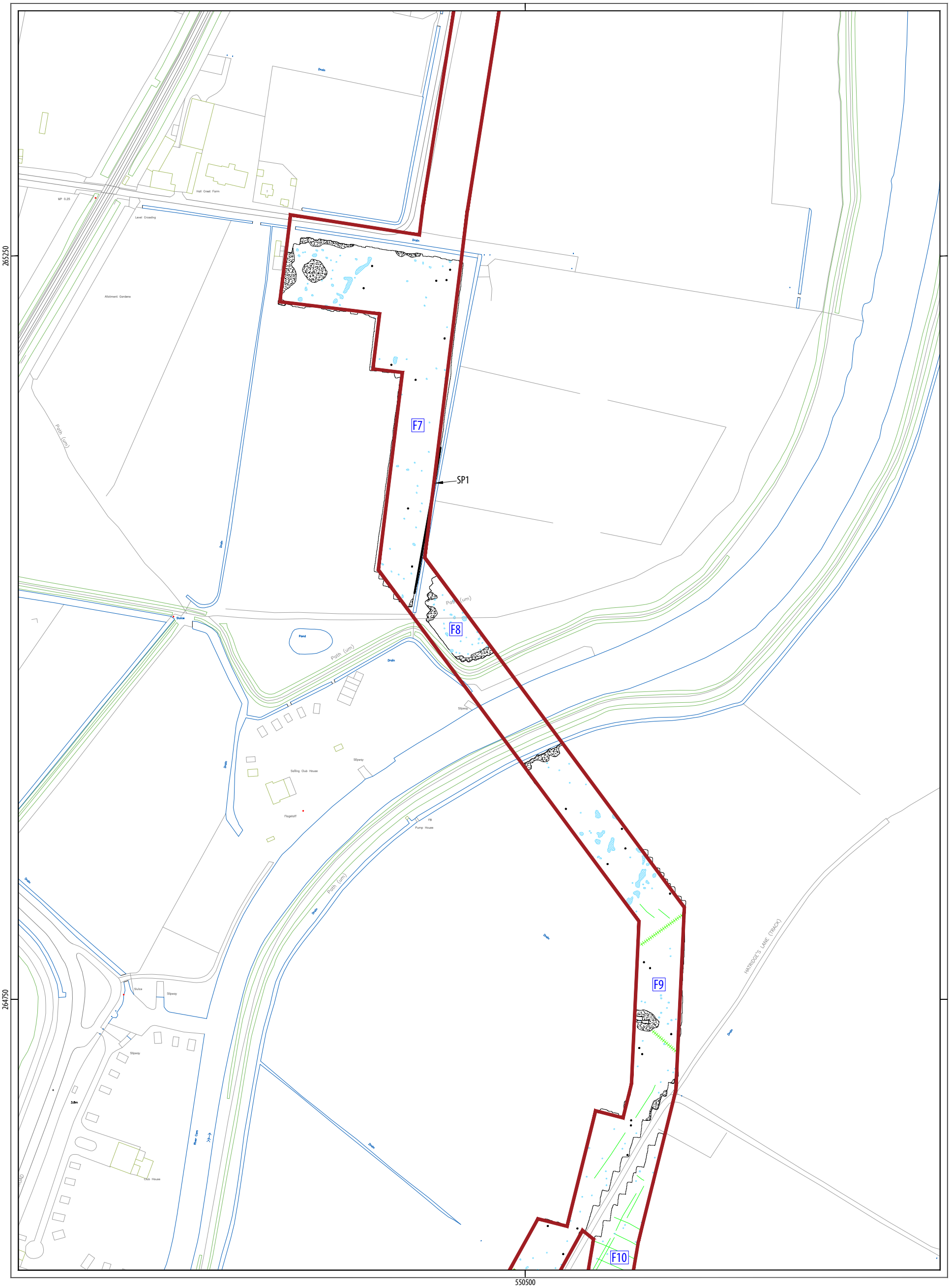
PROJECT WGPL21
Waterbeach Growth Pipeline
Cambridgeshire

CLIENT Anglian Water

HEADLAND ARCHAEOLOGY

Headland Archaeology Yorkshire & North
Units 23-25 | Acorn Business Centre | Balme Road
Cleckheaton | BD19 4EZ
t 0127 493 8019
w www.headlandarchaeology.com

ILLUS 12 XY trace plot of minimally processed magnetometer data; Sector 2



TYPE OF ANOMALY	INTERPRETATION
dipolar isolated	ferrous material
magnetic disturbance	ferrous material
dipolar linear	service pipe
linear trend	agricultural
linear trend	field drain
magnetic enhancement	geology

geophysical survey area

ABBREVIATIONS

SP Service pipe

0 50m

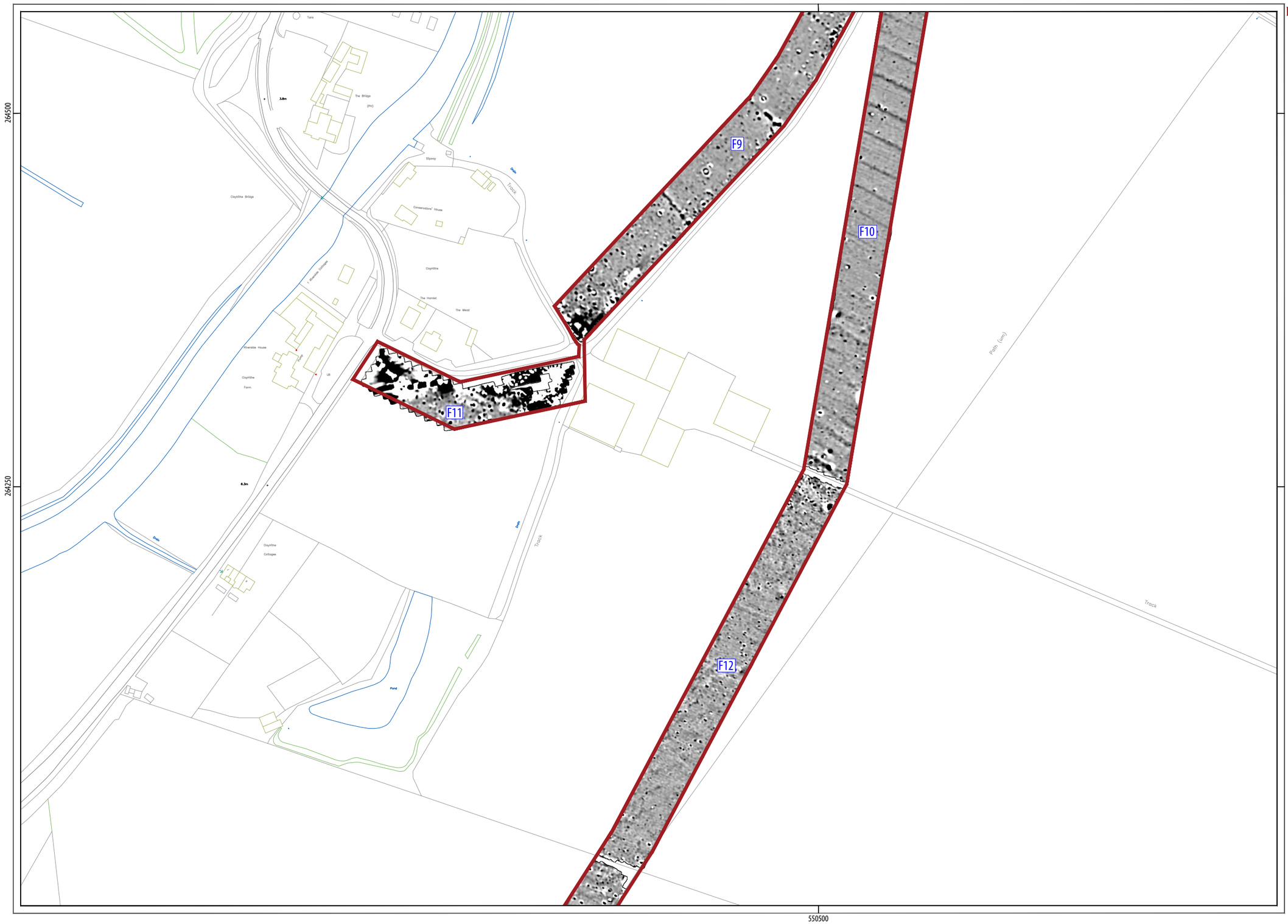
1:2,500 @ A3

PROJECT WGPL21
Waterbeach Growth Pipeline
Cambridgeshire

CLIENT Anglian Water

HEADLAND ARCHAEOLOGY
Headland Archaeology Yorkshire & North
Units 23-25 | Acorn Business Centre | Balme Road
Cleckheaton | BD19 4EZ
t 0127 493 8019
w www.headlandarchaeology.com

ILLUS 13 Interpretation of magnetometer data; Sector 2



PROJECT WGPL21
Waterbeach Growth Pipeline
Cambridgeshire

CLIENT Anglian Water

HEADLAND ARCHAEOLOGY
Headland Archaeology Yorkshire & North
Units 23-25 | Acorn Business Centre | Balme Road
Cleckheaton | BD19 4EZ
t 0127 493 8019
w www.headlandarchaeology.com

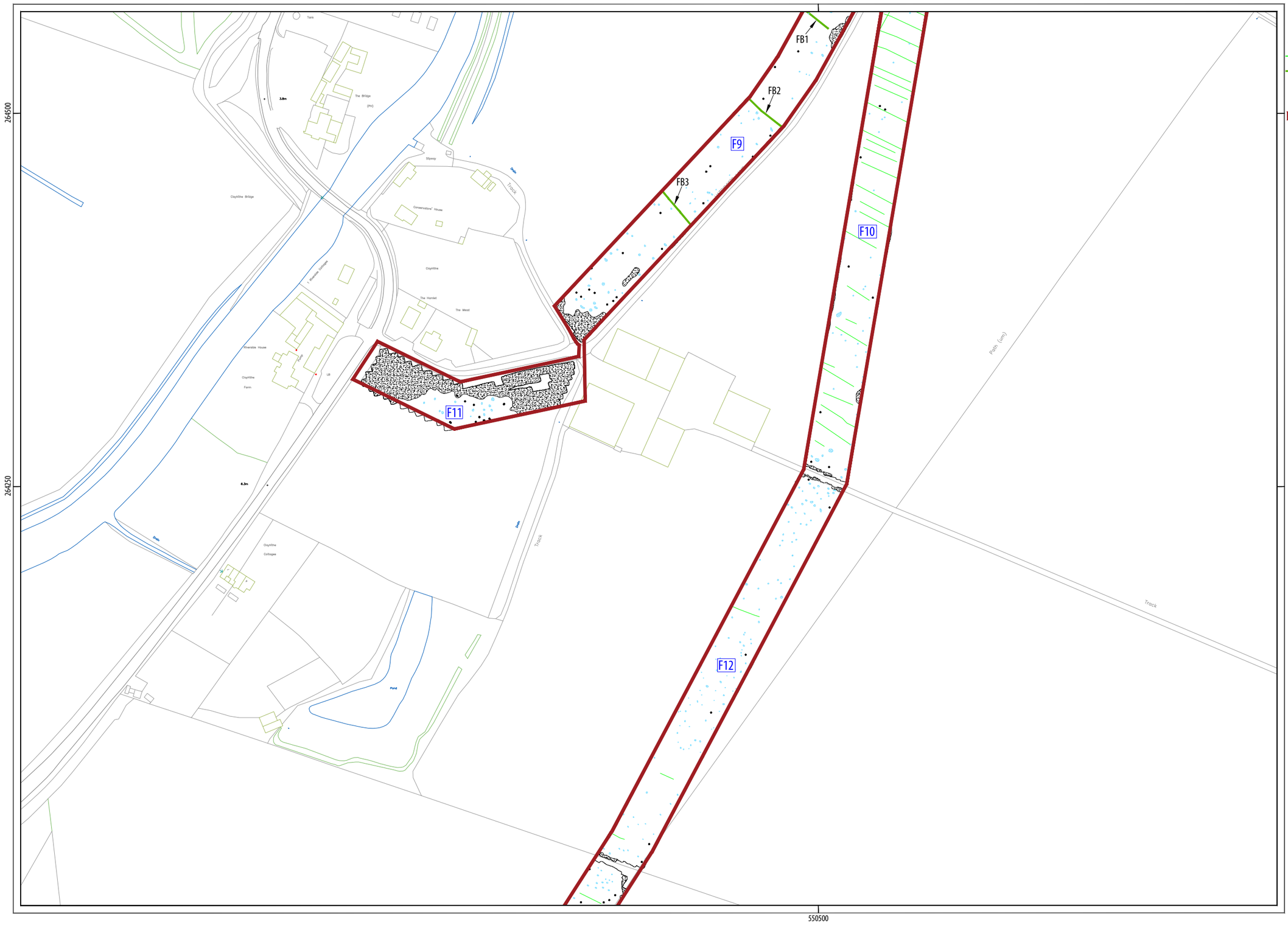
ILLUS 14 Processed greyscale magnetometer data; Sector 3

PROJECT WGPL21
Waterbeach Growth Pipeline
Cambridgeshire

CLIENT Anglian Water

HEADLAND ARCHAEOLOGY
Headland Archaeology Yorkshire & North
Units 23-25 | Acorn Business Centre | Balme Road
Cleckheaton | BD19 4EZ
t 0127 493 8019
w www.headlandarchaeology.com

ILLUS 15 XY trace plot of minimally processed magnetometer data; Sector 3



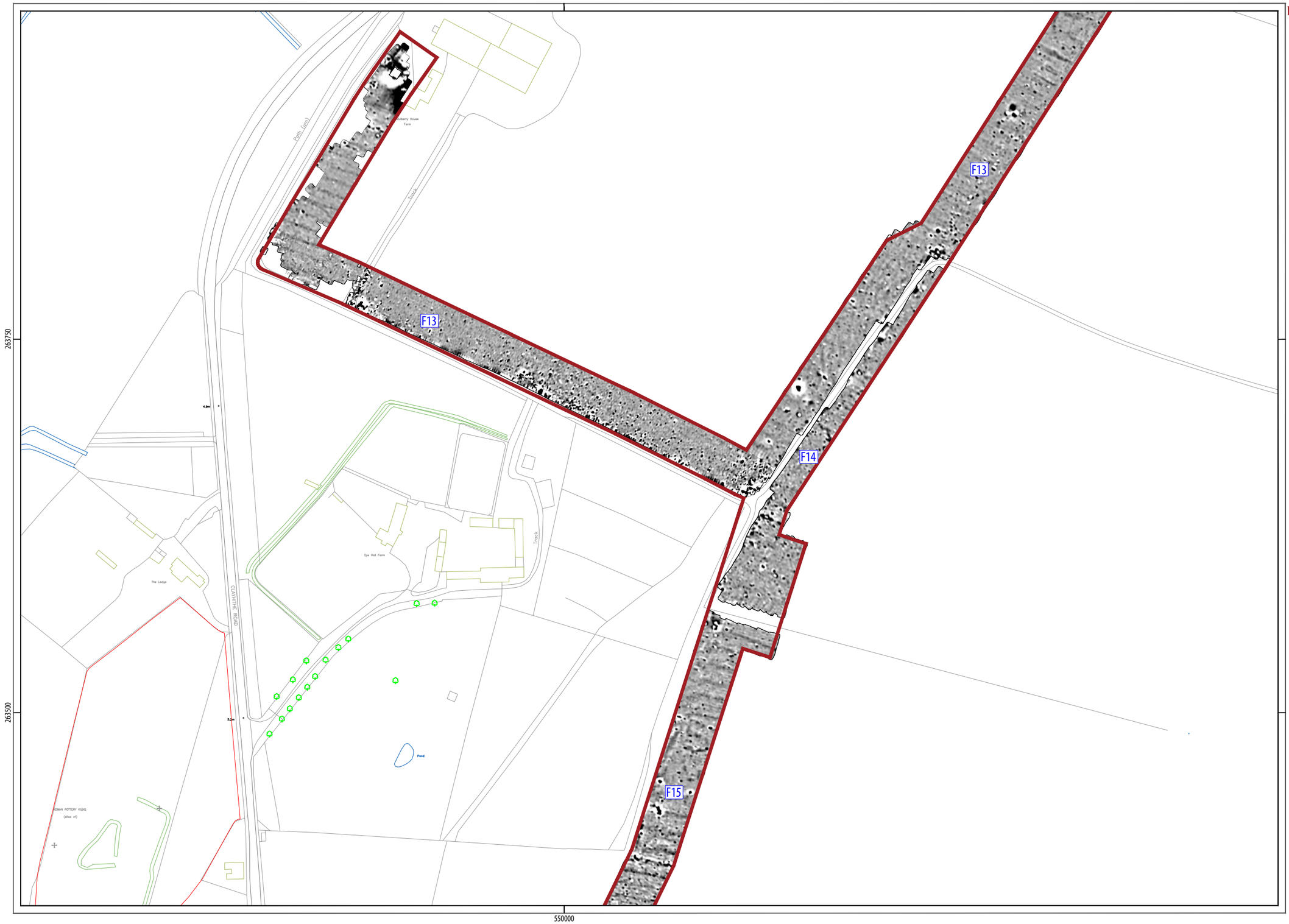
PROJECT WGPL21
Waterbeach Growth Pipeline
Cambridgeshire

CLIENT Anglian Water

HEADLAND ARCHAEOLOGY

Headland Archaeology Yorkshire & North
Units 23-25 | Acorn Business Centre | Balme Road
Cleckheaton | BD19 4EZ
t 0127 493 8019
w www.headlandarchaeology.com

ILLUS 16 Interpretation of magnetometer data; Sector 3



nT
-1.0 2.0

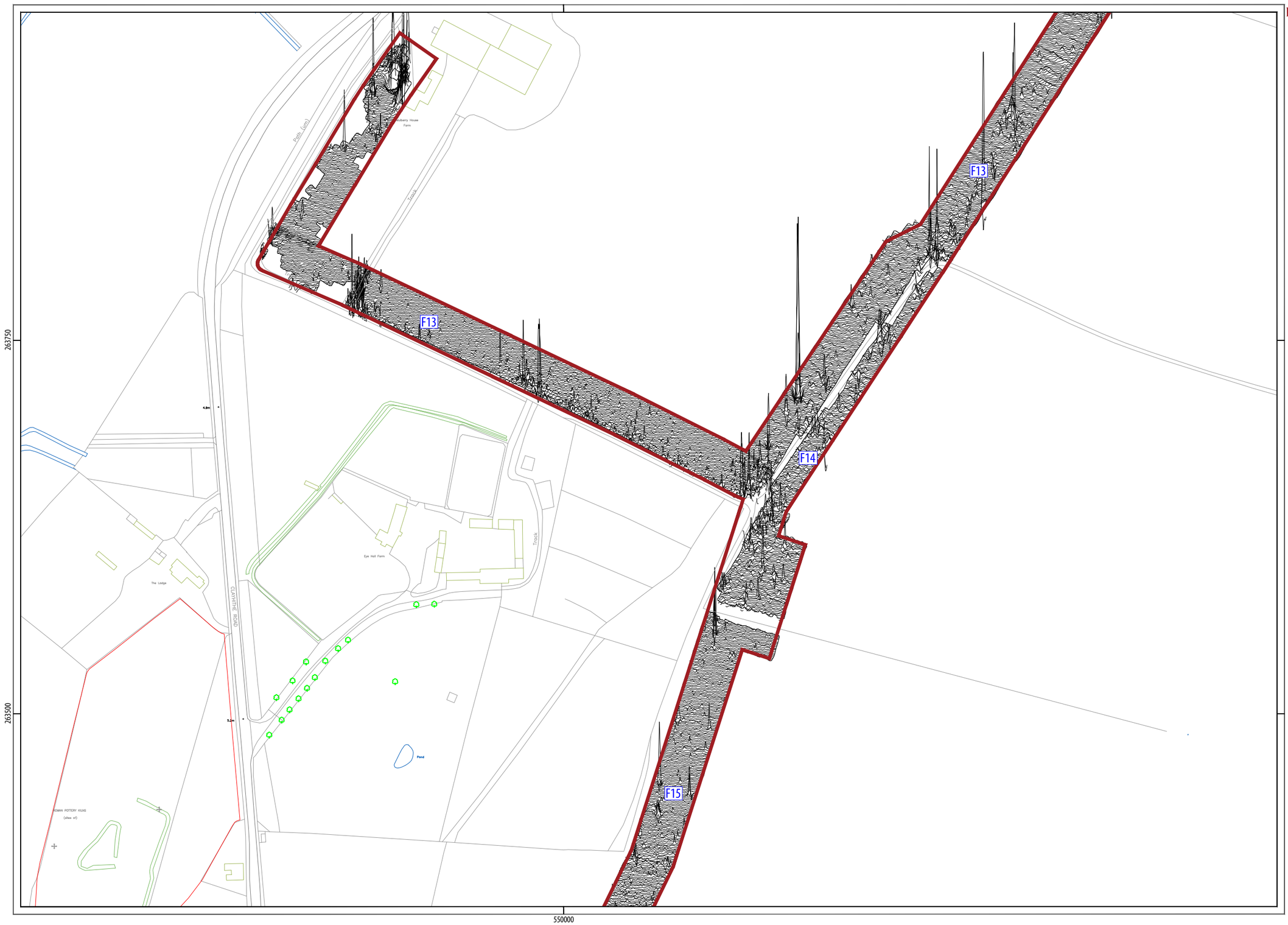
0 50m
1:2,500 @ A3

PROJECT WGPL21
Waterbeach Growth Pipeline
Cambridgeshire

CLIENT Anglian Water

HEADLAND ARCHAEOLOGY
Headland Archaeology Yorkshire & North
Units 23-25 | Acorn Business Centre | Balme Road
Cleckheaton | BD19 4EZ
t 0127 493 8019
w www.headlandarchaeology.com

ILLUS 17 Processed greyscale magnetometer data; Sector 4

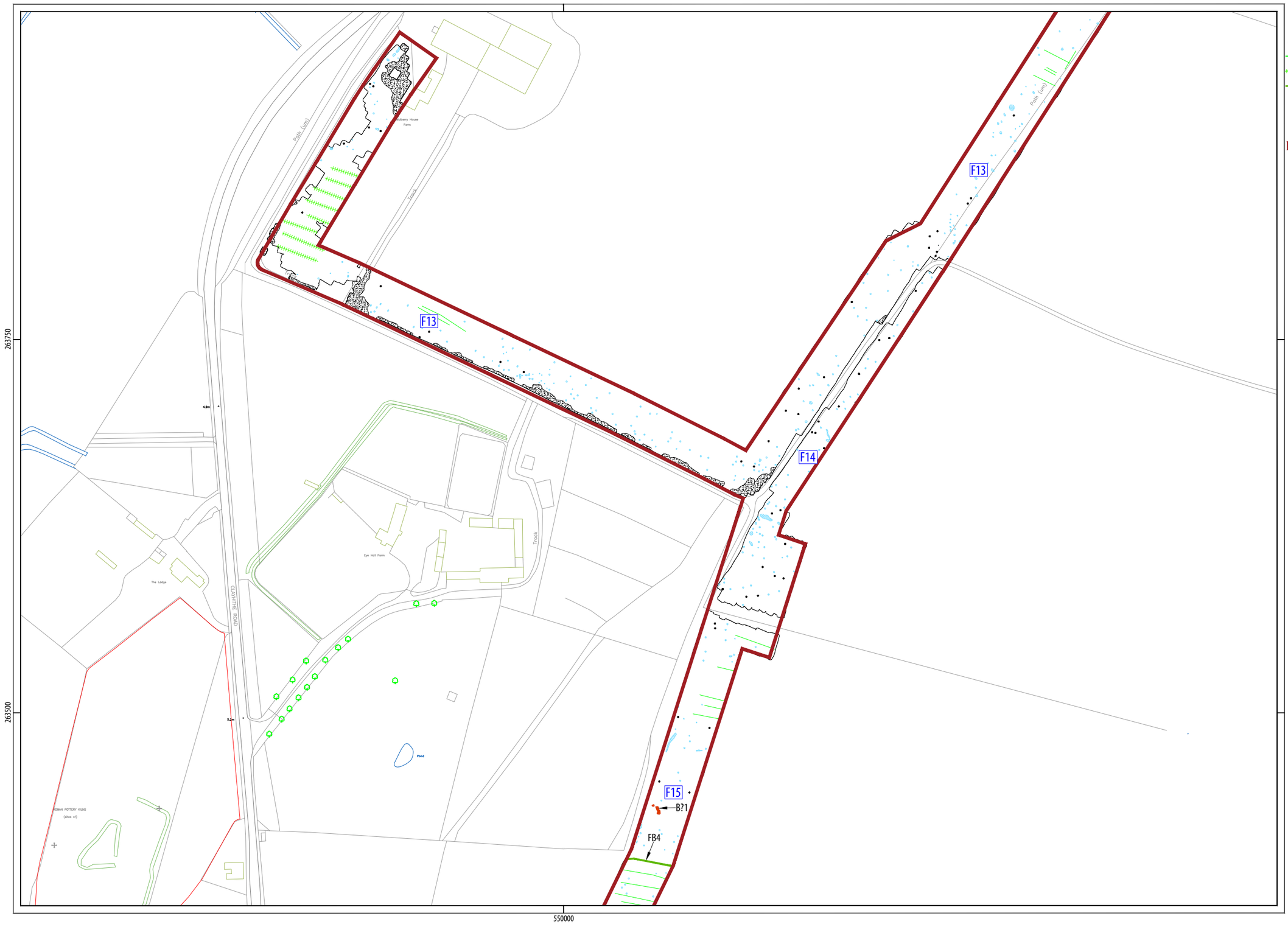


PROJECT WGPL21
Waterbeach Growth Pipeline
Cambridgeshire

CLIENT Anglian Water

HEADLAND ARCHAEOLOGY
Headland Archaeology Yorkshire & North
Units 23-25 | Acorn Business Centre | Balme Road
Cleckheaton | BD19 4EZ
t 0127 493 8019
w www.headlandarchaeology.com

ILLUS 18 XY trace plot of minimally processed magnetometer data; Sector 4



TYPE OF ANOMALY / INTERPRETATION

TYPE OF ANOMALY	INTERPRETATION
dipolar isolated	ferrous material
magnetic disturbance	ferrous material
linear trend	agricultural
linear trend	field drain
linear	former field boundary
magnetic enhancement	geology
magnetic enhancement	burning?

geophysical survey area

ABBREVIATIONS

FB - Former boundary

B? - Burning?

0 50m

1:2,500 @ A3

PROJECT WGPL21
Waterbeach Growth Pipeline
Cambridgeshire

CLIENT Anglian Water

HEADLAND ARCHAEOLOGY

Headland Archaeology Yorkshire & North

Units 23-25 | Acorn Business Centre | Balme Road

Cleckheaton | BD19 4EZ

t 0127 493 8019

w www.headlandarchaeology.com

ILLUS 19 Interpretation of magnetometer data; Sector 4

263250

262750

549750

F15

F16

F17

F18

F19

F20

Track

Path (um)

Pond

Eye Hall Farm Cottages

Post

Stones

Kings Cottages

CLAYMYRE ROAD

Gayton House

Gayton Farm

Caravan Site

Camp Site

Drain

4.9m

4.8m

5.8m

geophysical survey area

nT

-1.0

2.0

0

50m

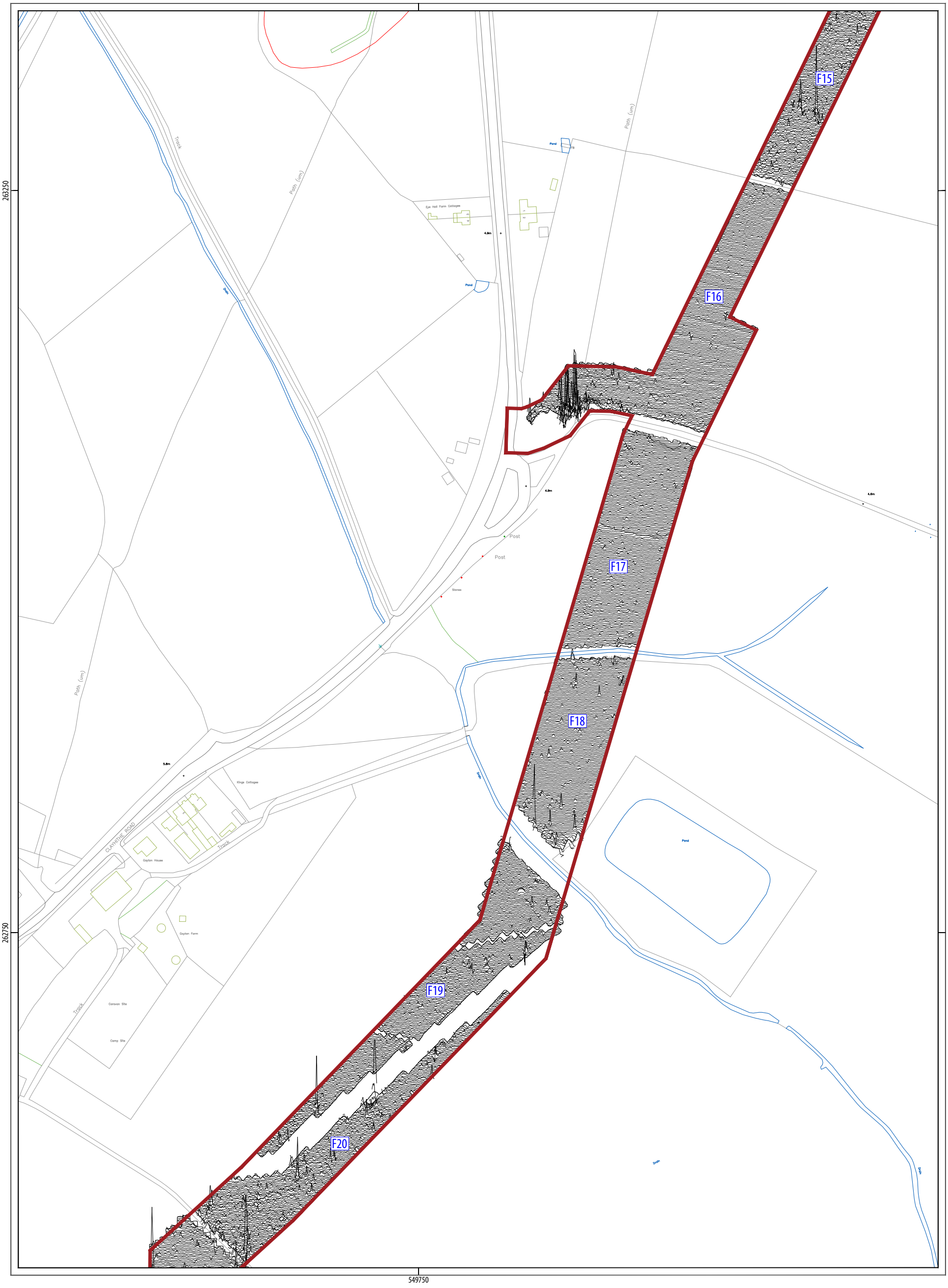
1:2,500 @ A3

PROJECT WGPL21
Waterbeach Growth Pipeline
Cambridgeshire

CLIENT Anglian Water

HEADLAND ARCHAEOLOGY
Headland Archaeology Yorkshire & North
Units 23-25 | Acorn Business Centre | Balme Road
Cleckheaton | BD19 4EZ
t 0127 493 8019
w www.headlandarchaeology.com

ILLUS 20 Processed greyscale magnetometer data; Sector 5



geophysical survey area

25.0nT/cm

0 50m

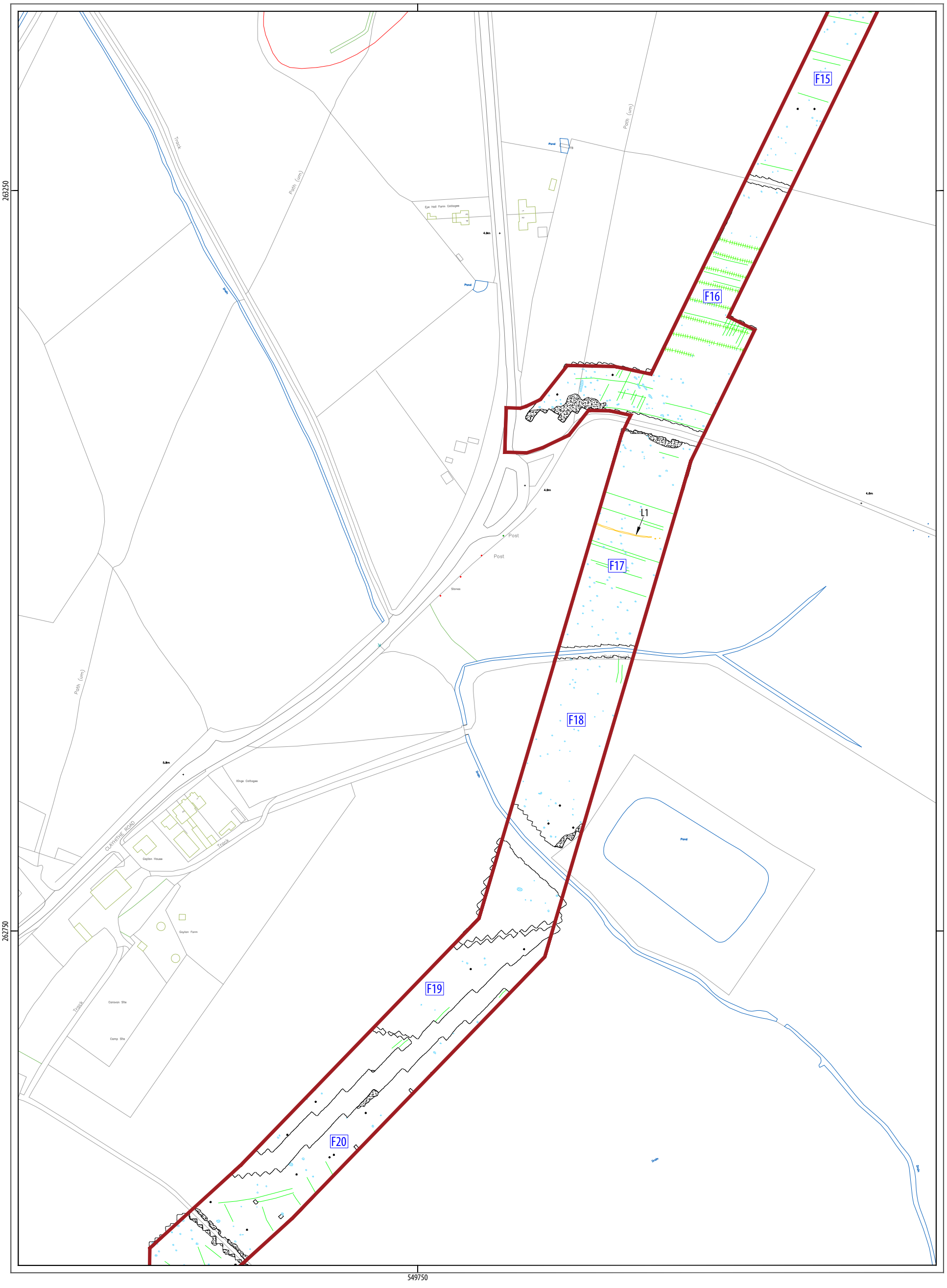
1:2,500 @ A3

PROJECT WGPL21
Waterbeach Growth Pipeline
Cambridgeshire

CLIENT Anglian Water

HEADLAND ARCHAEOLOGY
Headland Archaeology Yorkshire & North
Units 23-25 | Acorn Business Centre | Balme Road
Cleckheaton | BD19 4EZ
t 0127 493 8019
w www.headlandarchaeology.com

ILLUS 21 XY trace plot of minimally processed magnetometer data; Sector 5



TYPE OF ANOMALY	INTERPRETATION
dipolar isolated	ferrous material
magnetic disturbance	ferrous material
linear trend	agricultural
linear trend	field drain
magnetic enhancement	geology
magnetic enhancement	archaeology?

geophysical survey area

ABBREVIATIONS

L Linear

0 50m

1:2,500 @ A3

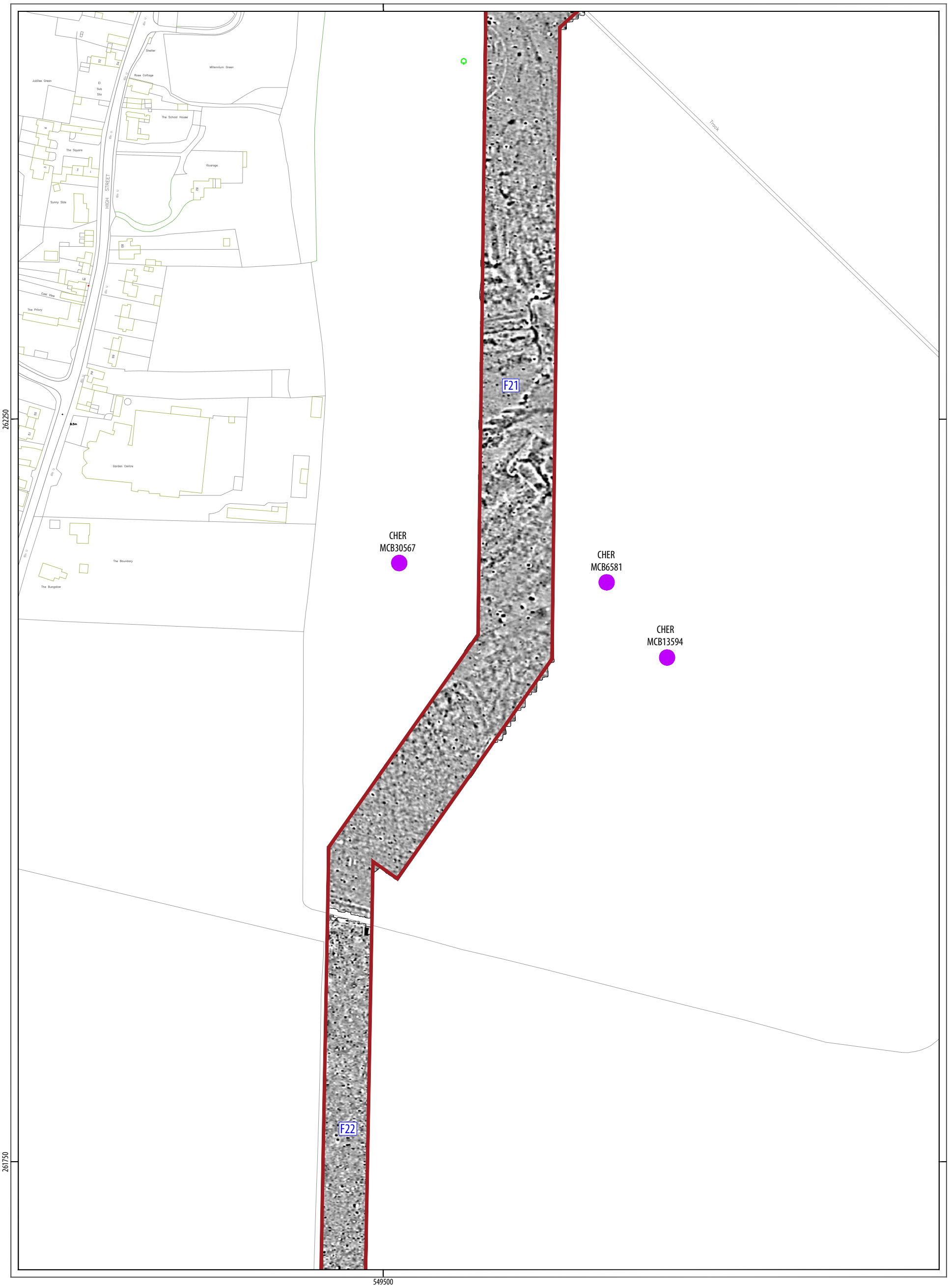
PROJECT WGPL21
Waterbeach Growth Pipeline
Cambridgeshire

CLIENT Anglian Water

HEADLAND ARCHAEOLOGY

Headland Archaeology Yorkshire & North
Units 23-25 | Acorn Business Centre | Balme Road
Cleckheaton | BD19 4EZ
t 0127 493 8019
w www.headlandarchaeology.com

ILLUS 22 Interpretation of magnetometer data; Sector 5



geophysical survey area

CHER numbers

nT
-1.0 2.0

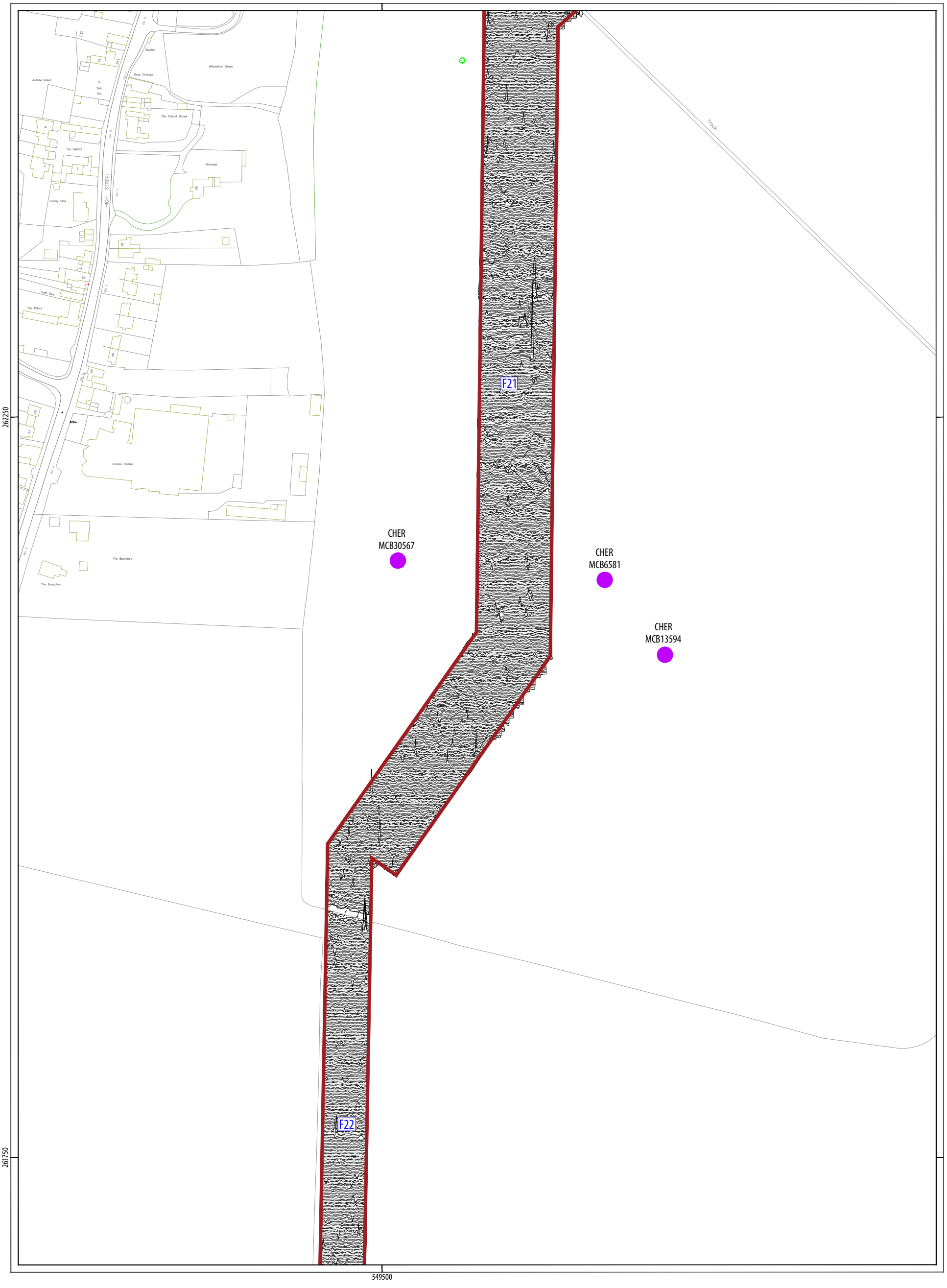
0 50m
1:2,500 @ A3

PROJECT WGPL21
Waterbeach Growth Pipeline
Cambridgeshire

CLIENT Anglian Water

HEADLAND ARCHAEOLOGY
Headland Archaeology Yorkshire & North
Units 23-25 | Acorn Business Centre | Balme Road
Cleckheaton | BD19 4EZ
t 0127 493 8019
w www.headlandarchaeology.com

ILLUS 23 Processed greyscale magnetometer data; Sector 6



geophysical survey area

CHER numbers

25.0nT/cm

0 50m

1:2,500 @ A3

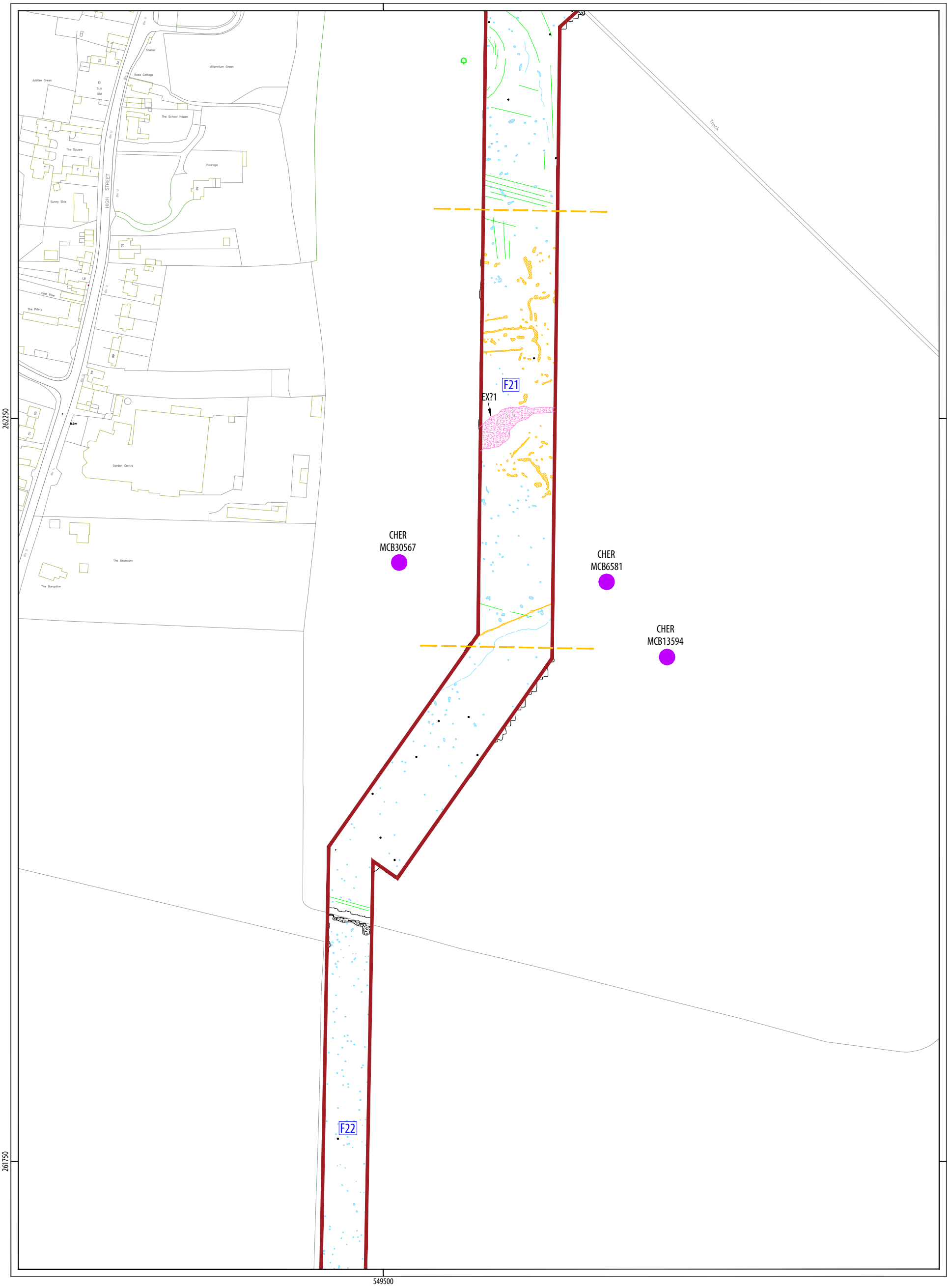
PROJECT WGPL21
Waterbeach Growth Pipeline
Cambridgeshire

CLIENT Anglian Water

HEADLAND ARCHAEOLOGY

Headland Archaeology Yorkshire & North
Units 23-25 | Acorn Business Centre | Balme Road
Cleckheaton | BD19 4EZ
t 0127 493 8019
w www.headlandarchaeology.com

ILLUS 24 XY trace plot of minimally processed magnetometer data; Sector 6



TYPE OF ANOMALY	INTERPRETATION
dipolar isolated	ferrous material
magnetic disturbance	ferrous material
magnetic enhancement	extraction?
linear trend	agricultural
linear trend	geological variation
magnetic enhancement	geology

TYPE OF ANOMALY	INTERPRETATION
magnetic enhancement	archaeology?

geophysical survey area

CHER numbers

ABBREVIATIONS

EX? Extraction?

0 50m

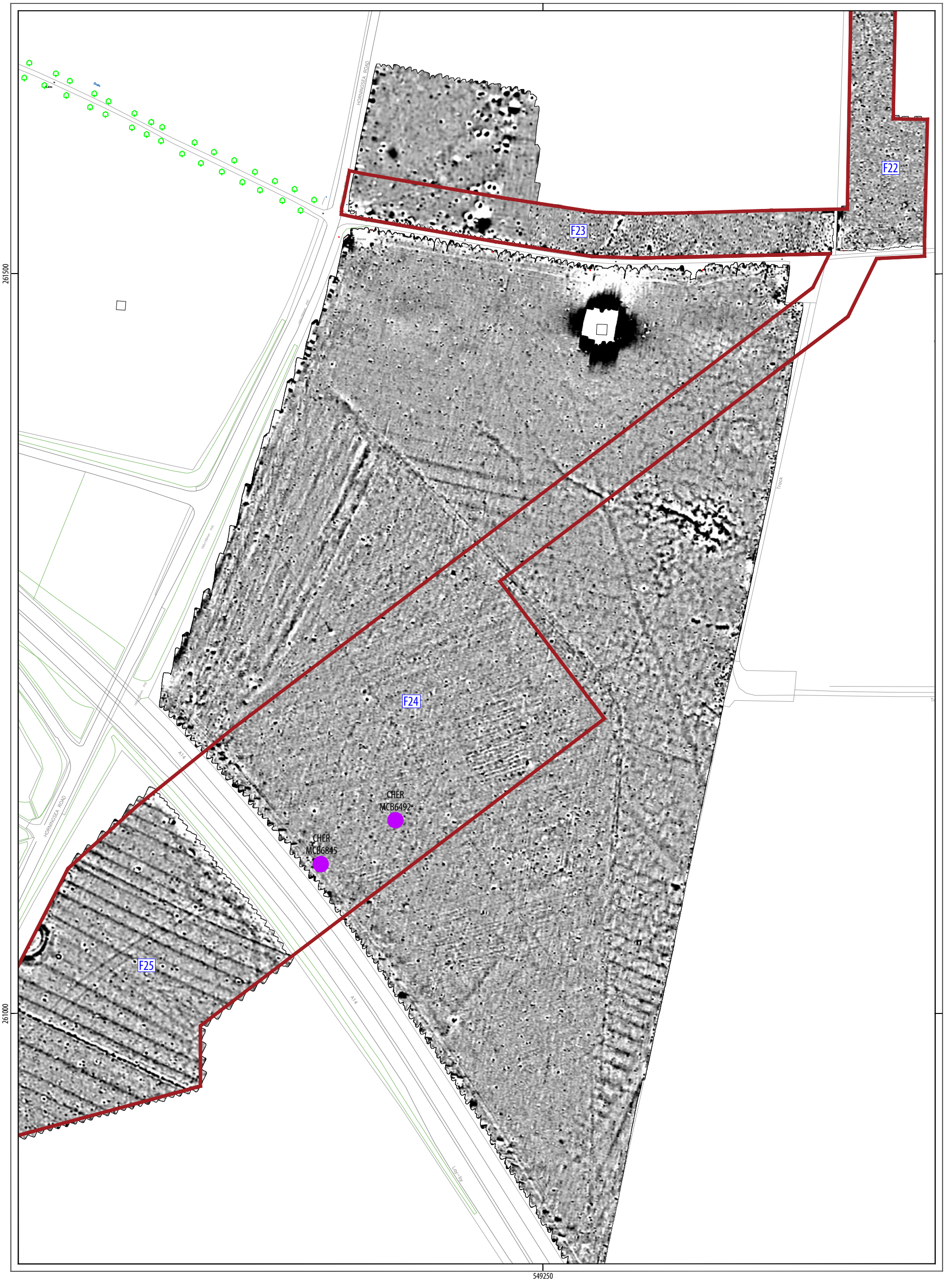
1:2,500 @ A3

PROJECT **WGPL21**
Waterbeach Growth Pipeline
Cambridgeshire

CLIENT Anglian Water

HEADLAND ARCHAEOLOGY
Headland Archaeology Yorkshire & North
Units 23-25 | Acorn Business Centre | Balme Road
Cleckheaton | BD19 4EZ
t 0127 493 8019
w www.headlandarchaeology.com

ILLUS 25 Interpretation of magnetometer data; Sector 6



geophysical survey area

CHER numbers

nT
-1.0 2.0

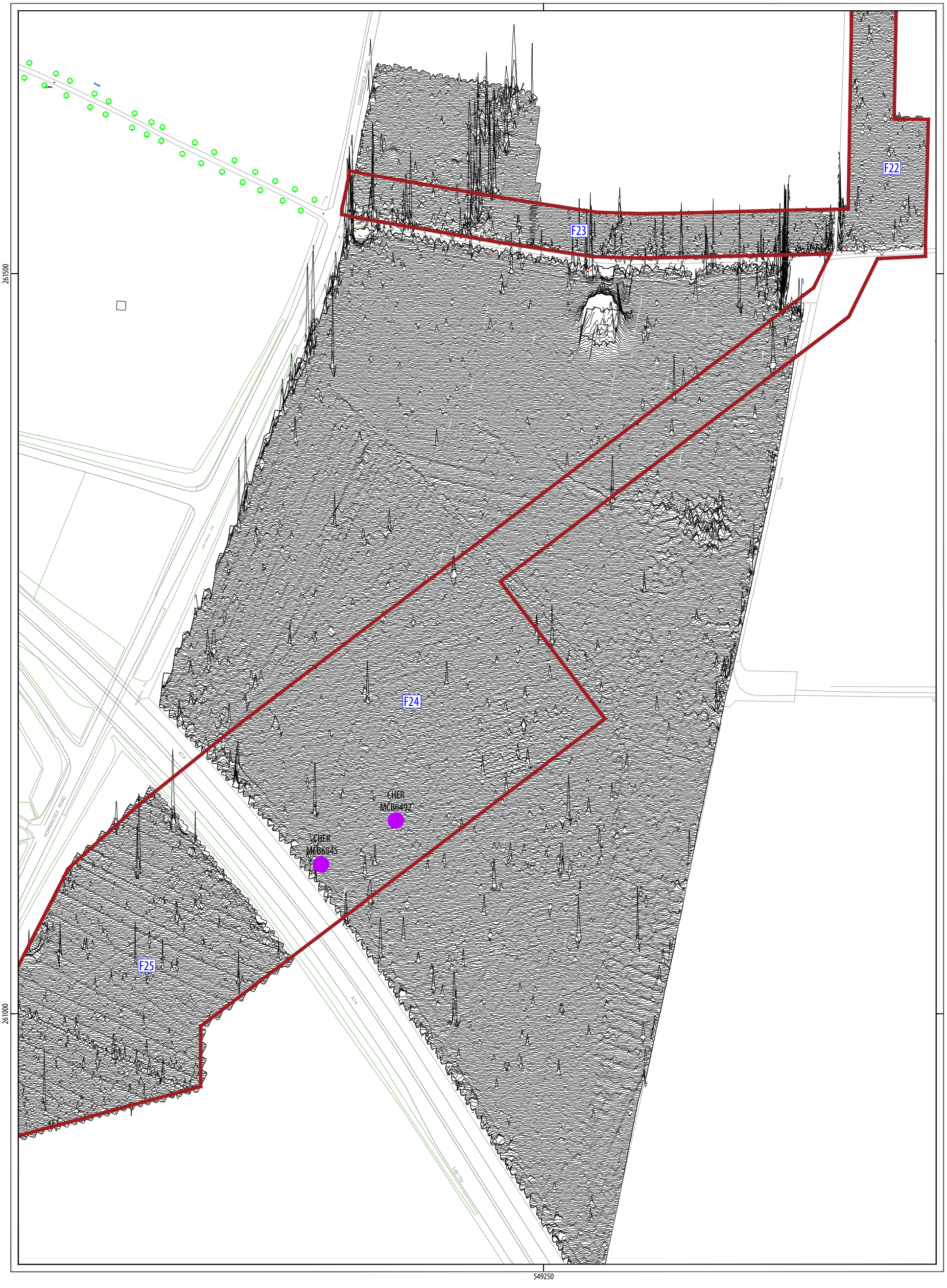
0 50m
1:2,500 @ A3

PROJECT WGPL21
Waterbeach Growth Pipeline
Cambridgeshire

CLIENT Anglian Water

HEADLAND ARCHAEOLOGY
Headland Archaeology Yorkshire & North
Units 23-25 | Acorn Business Centre | Balme Road
Cleckheaton | BD19 4EZ
t 0127 493 8019
w www.headlandarchaeology.com

ILLUS 26 Processed greyscale magnetometer data; Sector 7



geophysical survey area

CHER numbers

25.0nT/cm

0 50m

1:2,500 @ A3

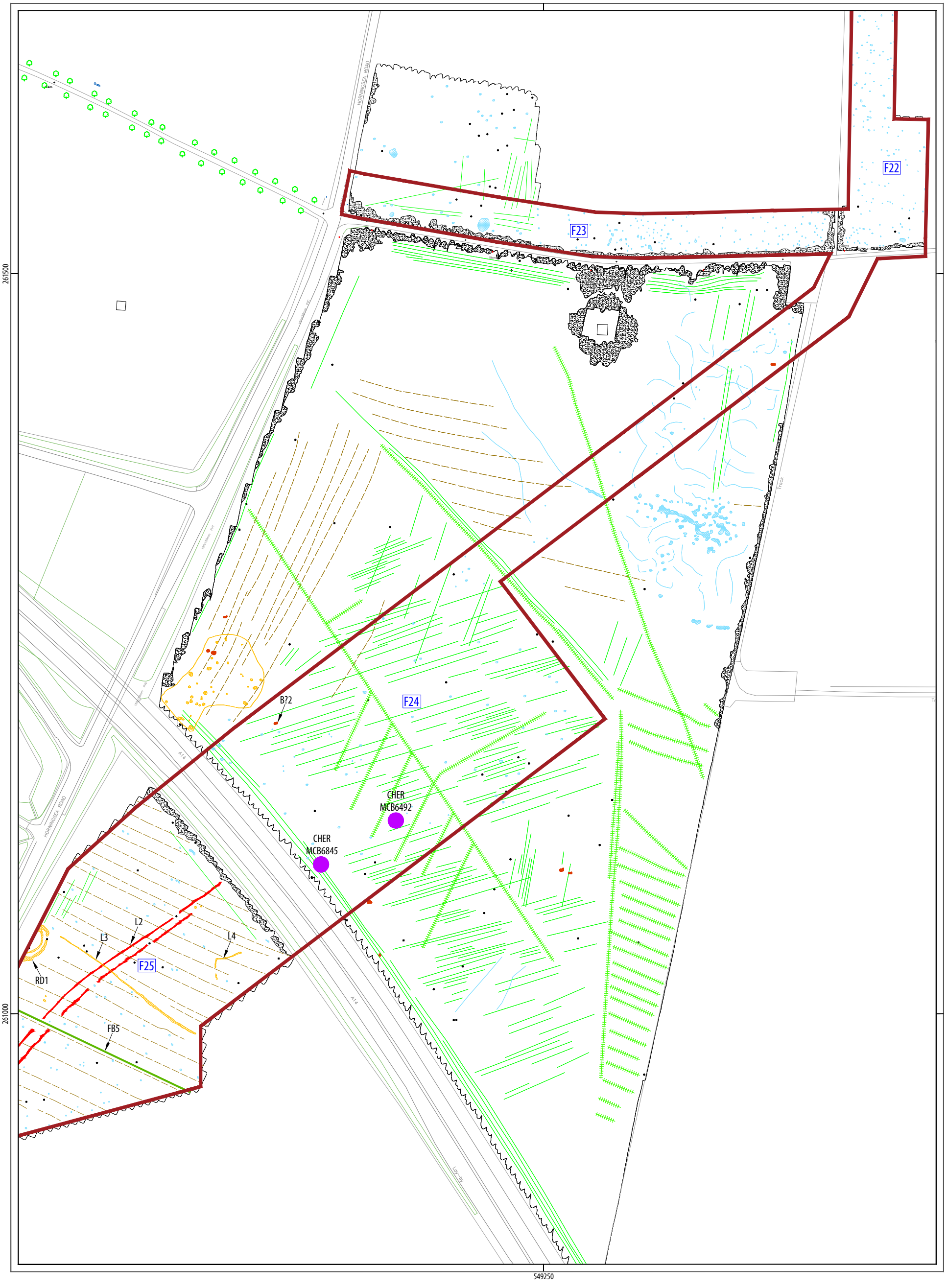
PROJECT WGPL21
Waterbeach Growth Pipeline
Cambridgeshire

CLIENT Anglian Water

HEADLAND ARCHAEOLOGY

Headland Archaeology Yorkshire & North
Units 23-25 | Acorn Business Centre | Balme Road
Cleckheaton | BD19 4EZ
t 0127 493 8019
w www.headlandarchaeology.com

ILLUS 27 XY trace plot of minimally processed magnetometer data; Sector 7



TYPE OF ANOMALY	INTERPRETATION
dipolar isolated	ferrous material
magnetic disturbance	ferrous material
linear trend	ridge and furrow
linear trend	agricultural
linear trend	field drain
linear	former field boundary

TYPE OF ANOMALY	INTERPRETATION
linear trend	geological variation
magnetic enhancement	geology
magnetic enhancement	archaeology?
magnetic enhancement	kiln/burning?
magnetic enhancement	archaeology

geophysical survey area

CHER numbers

ABBREVIATIONS

FB	Former boundary
L	Linear
B?	Burning?
RD	Ring Ditch

0 50m

1:2,500 @ A3

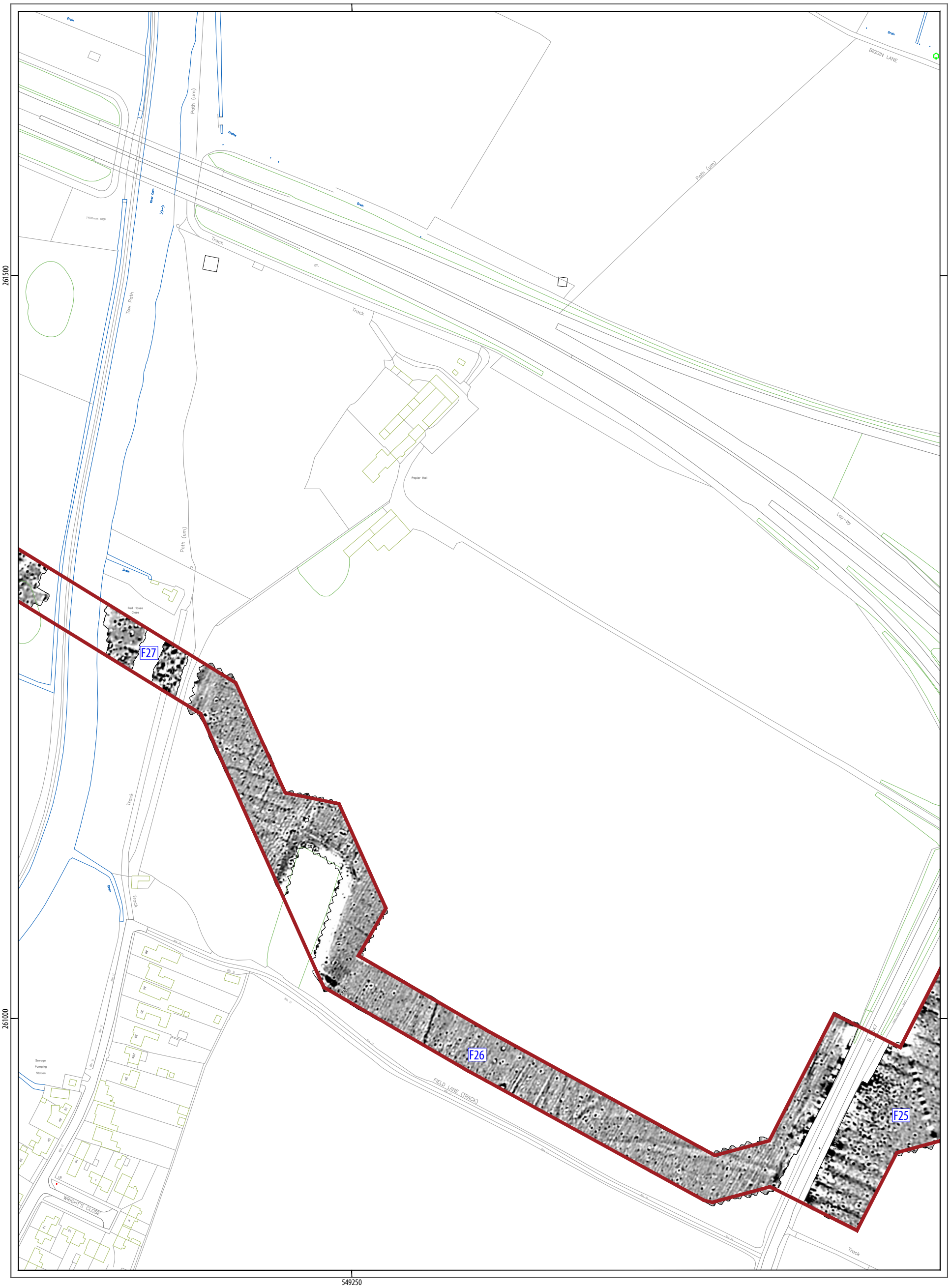
PROJECT WGPL21
Waterbeach Growth Pipeline
Cambridgeshire

CLIENT Anglian Water

HEADLAND ARCHAEOLOGY

Headland Archaeology Yorkshire & North
Units 23-25 | Acorn Business Centre | Balme Road
Cleckheaton | BD19 4EZ
t 0127 493 8019
w www.headlandarchaeology.com

ILLUS 28 Interpretation of magnetometer data; Sector 7



geophysical survey area

nT
-1.0 2.0

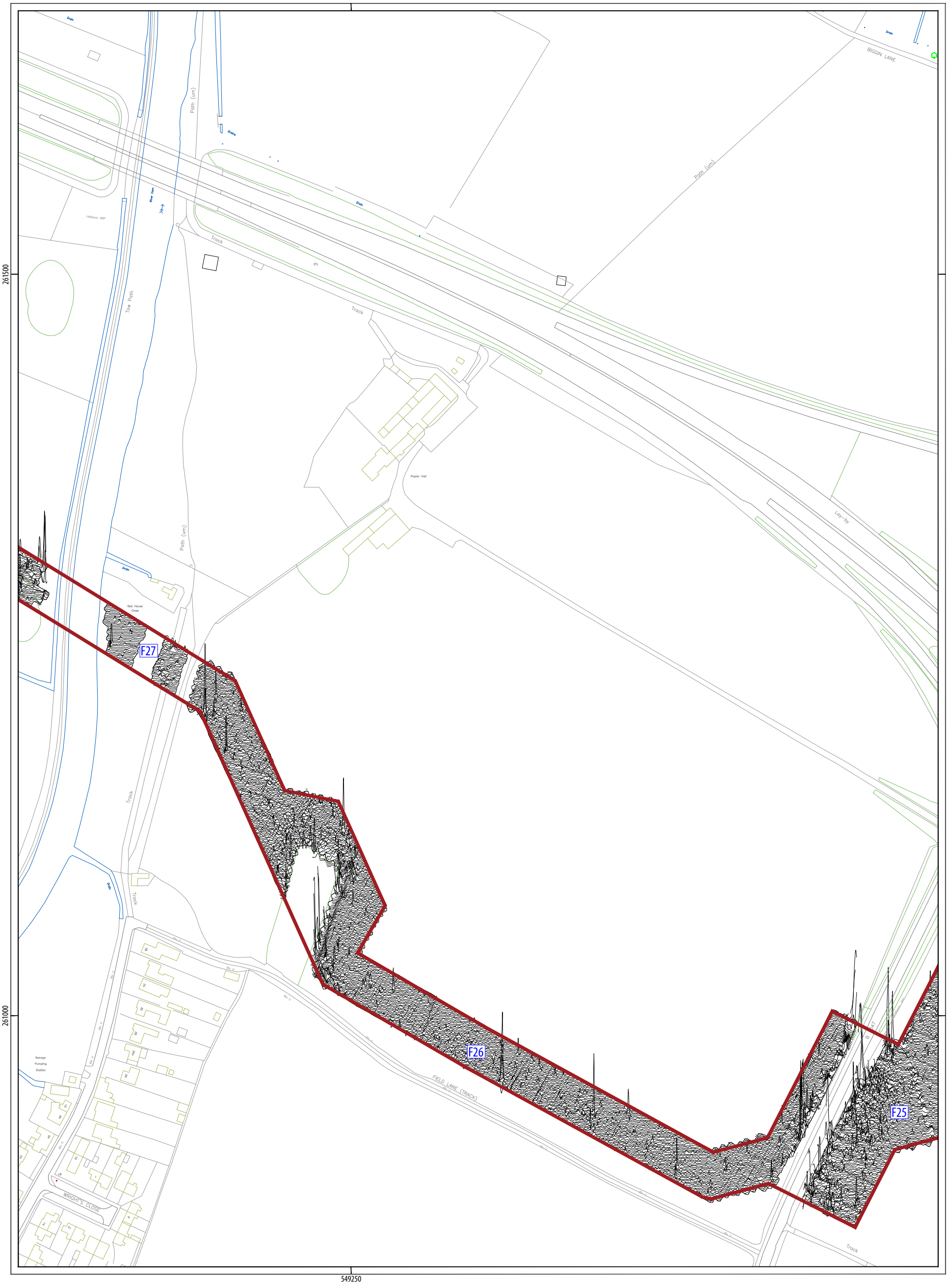
0 50m
1:2,500 @ A3

PROJECT WGPL21
Waterbeach Growth Pipeline
Cambridgeshire

CLIENT Anglian Water

HEADLAND ARCHAEOLOGY
Headland Archaeology Yorkshire & North
Units 23-25 | Acorn Business Centre | Balme Road
Cleckheaton | BD19 4EZ
t 0127 493 8019
w www.headlandarchaeology.com

ILLUS 29 Processed greyscale magnetometer data; Sector 8



geophysical survey area

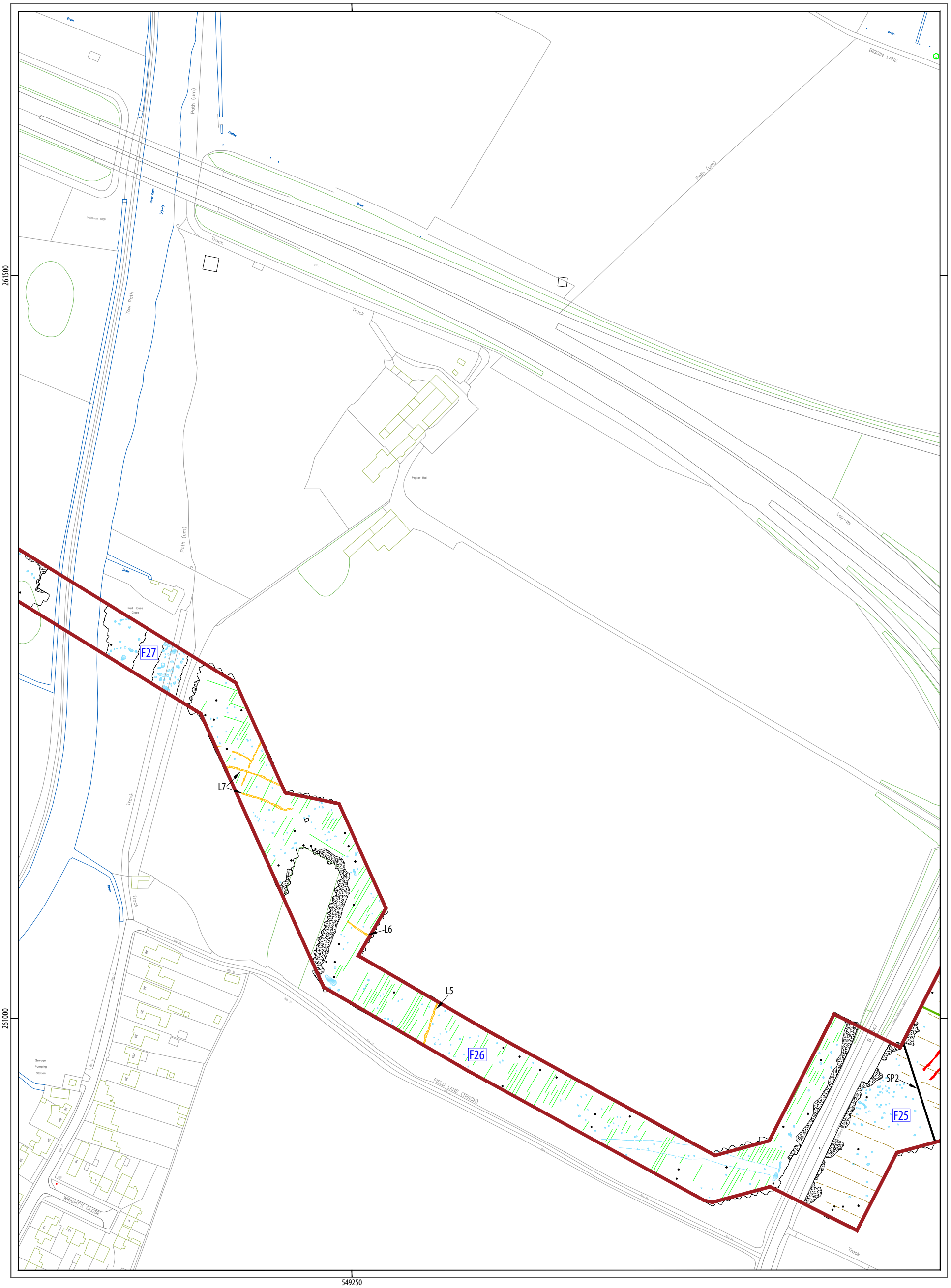
0 50m
1:2,500 @ A3

PROJECT WGPL21
Waterbeach Growth Pipeline
Cambridgeshire

CLIENT Anglian Water

HEADLAND ARCHAEOLOGY
Headland Archaeology Yorkshire & North
Units 23-25 | Acorn Business Centre | Balme Road
Cleckheaton | BD19 4EZ
t 0127 493 8019
w www.headlandarchaeology.com

ILLUS 30 XY trace plot of minimally processed magnetometer data; Sector 8



TYPE OF ANOMALY	INTERPRETATION
dipolar isolated	ferrous material
magnetic disturbance	ferrous material
dipolar linear	service pipe
linear trend	ridge and furrow
linear trend	agricultural
linear	former field boundary

TYPE OF ANOMALY	INTERPRETATION
linear trend	geological variation
magnetic enhancement	geology
magnetic enhancement	archaeology?
magnetic enhancement	archaeology

geophysical survey area

ABBREVIATIONS

SP	Service pipe
L	Linear

0 50m

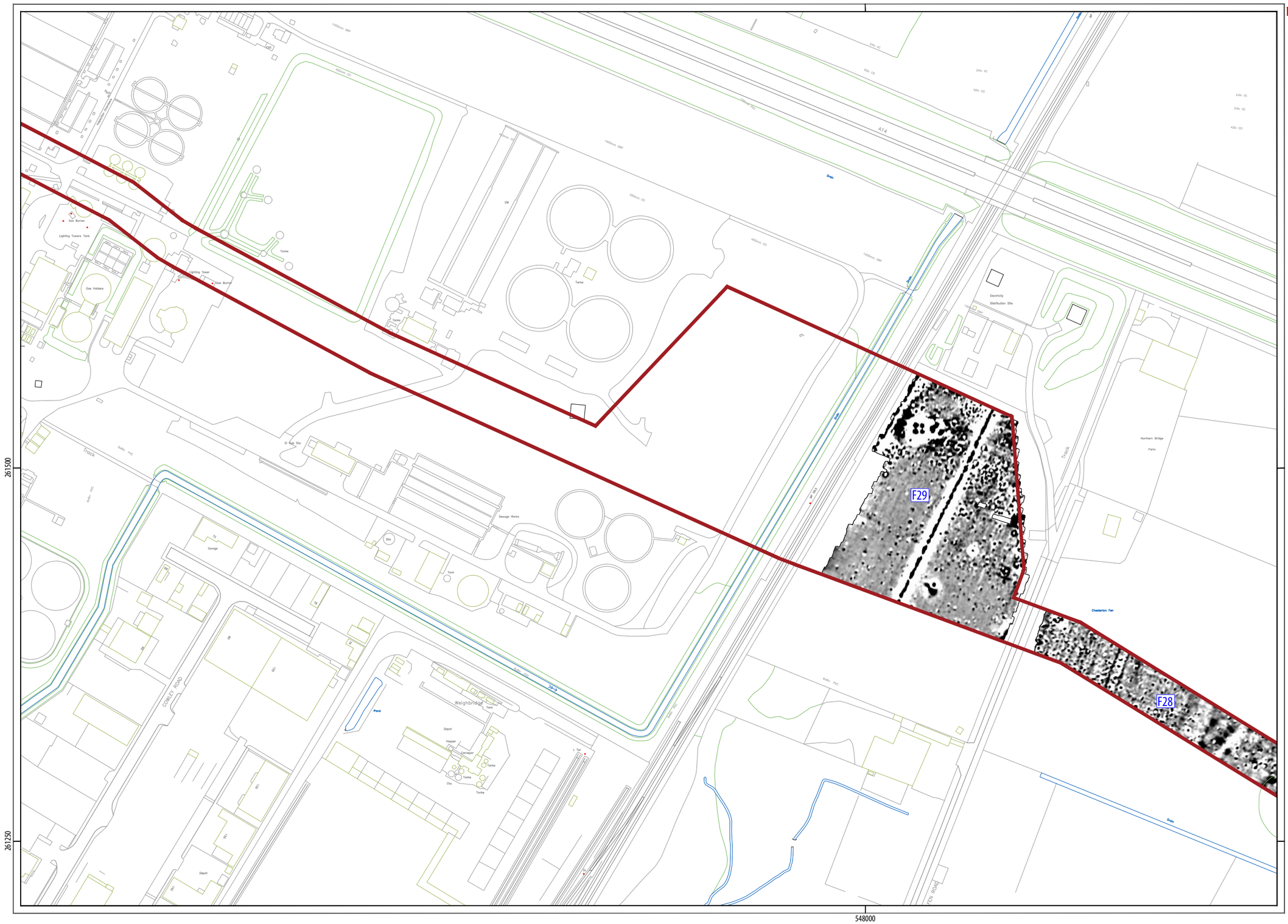
1:2,500 @ A3

PROJECT WGPL21
Waterbeach Growth Pipeline
Cambridgeshire

CLIENT Anglian Water

Headland Archaeology Yorkshire & North
Units 23-25 | Acorn Business Centre | Balme Road
Cleckheaton | BD19 4EZ
t 0127 493 8019
w www.headlandarchaeology.com

ILLUS 31 Interpretation of magnetometer data; Sector 8



geophysical survey area

-1.0 nT 2.0

0 50m

1:2,500 @ A3

PROJECT WGPL21
Waterbeach Growth Pipeline
Cambridgeshire

CLIENT Anglian Water

HEADLAND ARCHAEOLOGY

Headland Archaeology Yorkshire & North
Units 23-25 | Acorn Business Centre | Balme Road
Cleckheaton | BD19 4EZ
t 0127 493 8019
w www.headlandarchaeology.com

ILLUS 32 Processed greyscale magnetometer data; Sector 9

geophysical survey area

F29

F28

261500

261250

548000

25.0nT/cm

0 50m

1:2,500 @ A3

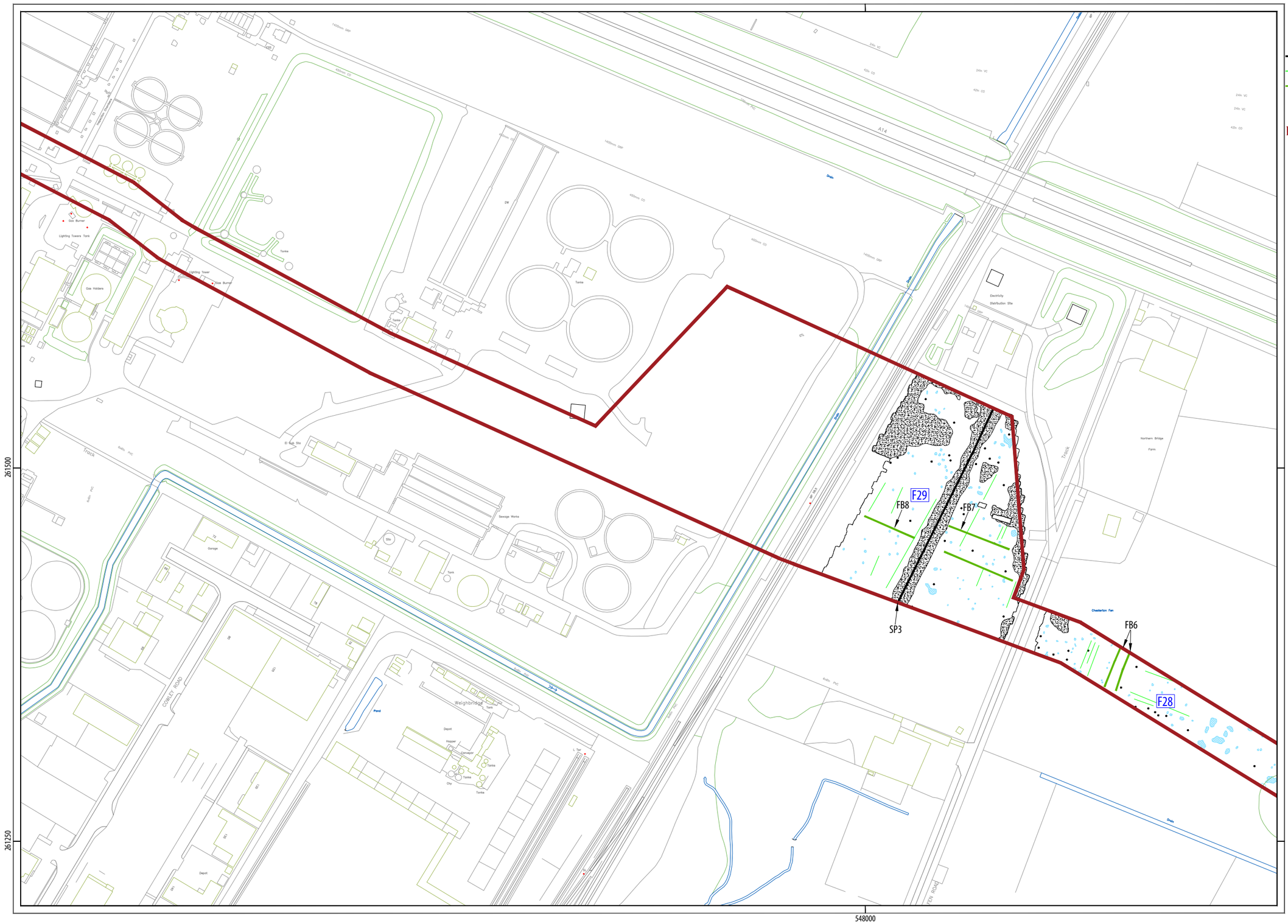
PROJECT WGPL21
Waterbeach Growth Pipeline
Cambridgeshire

CLIENT Anglian Water

HEADLAND ARCHAEOLOGY

Headland Archaeology Yorkshire & North
Units 23-25 | Acorn Business Centre | Balme Road
Cleckheaton | BD19 4EZ
t 0127 493 8019
w www.headlandarchaeology.com

ILLUS 33 XY trace plot of minimally processed magnetometer data; Sector 9



TYPE OF ANOMALY	INTERPRETATION
dipolar isolated	ferrous material
magnetic disturbance	ferrous material
dipolar linear	service pipe
linear trend	agricultural
linear	former field boundary
magnetic enhancement	geology

geophysical survey area

ABBREVIATIONS

SP - Service pipe

FB - Former boundary

0 50m

1:2,500 @ A3

PROJECT WGPL21
Waterbeach Growth Pipeline
Cambridgeshire

CLIENT Anglian Water

HEADLAND ARCHAEOLOGY

Headland Archaeology Yorkshire & North

Units 23-25 | Acorn Business Centre | Balme Road

Cleckheaton | BD19 4EZ

t 0127 493 8019

w www.headlandarchaeology.com

ILLUS 34 Interpretation of magnetometer data; Sector 9

geophysical survey area

CHER number

nT
-1.0 2.0

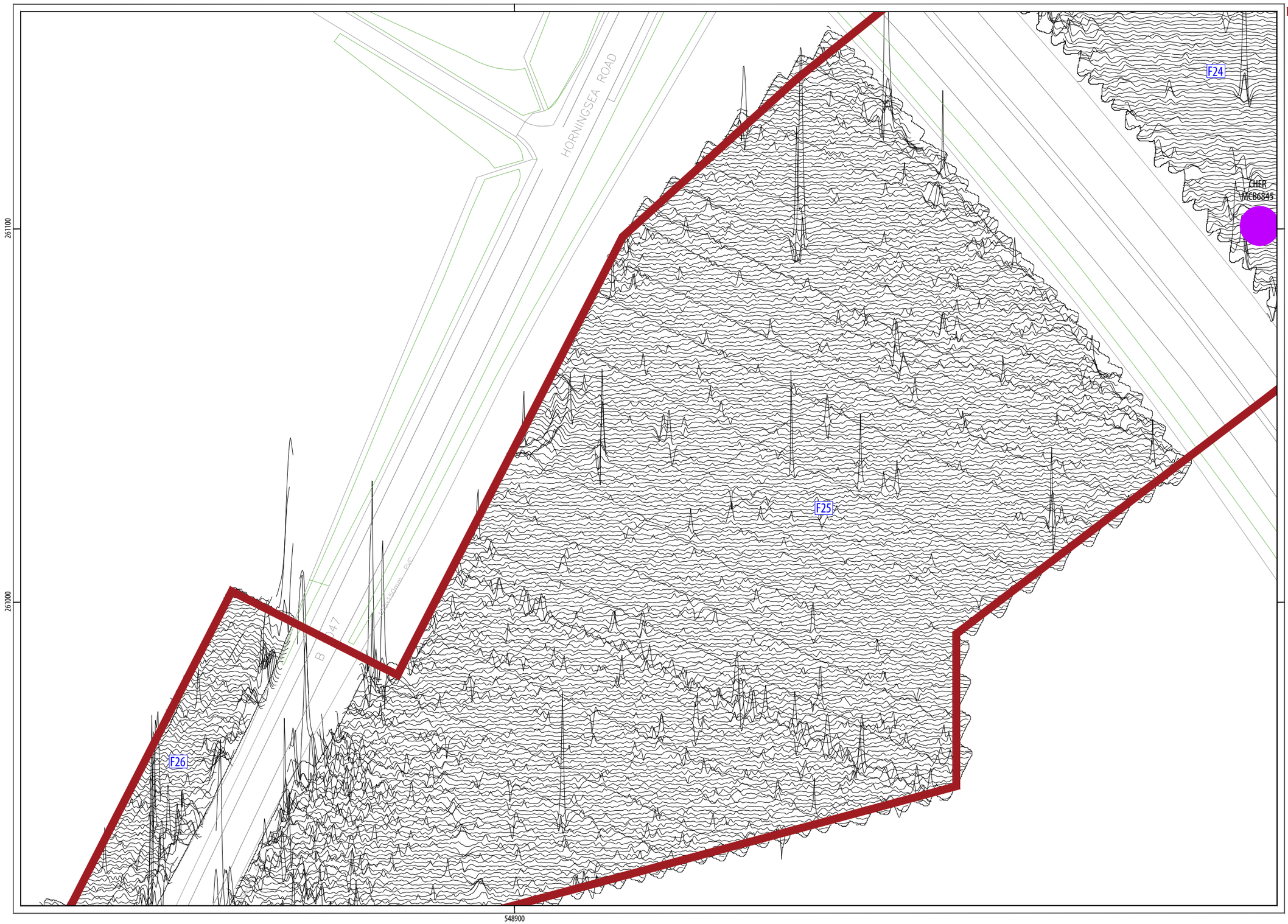
0 25m
1:1,000 @ A3

PROJECT WGPL21
Waterbeach Growth Pipeline
Cambridgeshire

CLIENT Anglian Water

HEADLAND ARCHAEOLOGY
Headland Archaeology Yorkshire & North
Units 23-25 | Acorn Business Centre | Balme Road
Cleckheaton | BD19 4EZ
t 0127 493 8019
w www.headlandarchaeology.com

ILLUS 35 Processed greyscale magnetometer data; Area 1



geophysical survey area

CHER number

62.5nT/cm

0 25m

1:1,000 @ A3

PROJECT WGPL21
Waterbeach Growth Pipeline
Cambridgeshire

CLIENT Anglian Water

HEADLAND ARCHAEOLOGY

Headland Archaeology Yorkshire & North

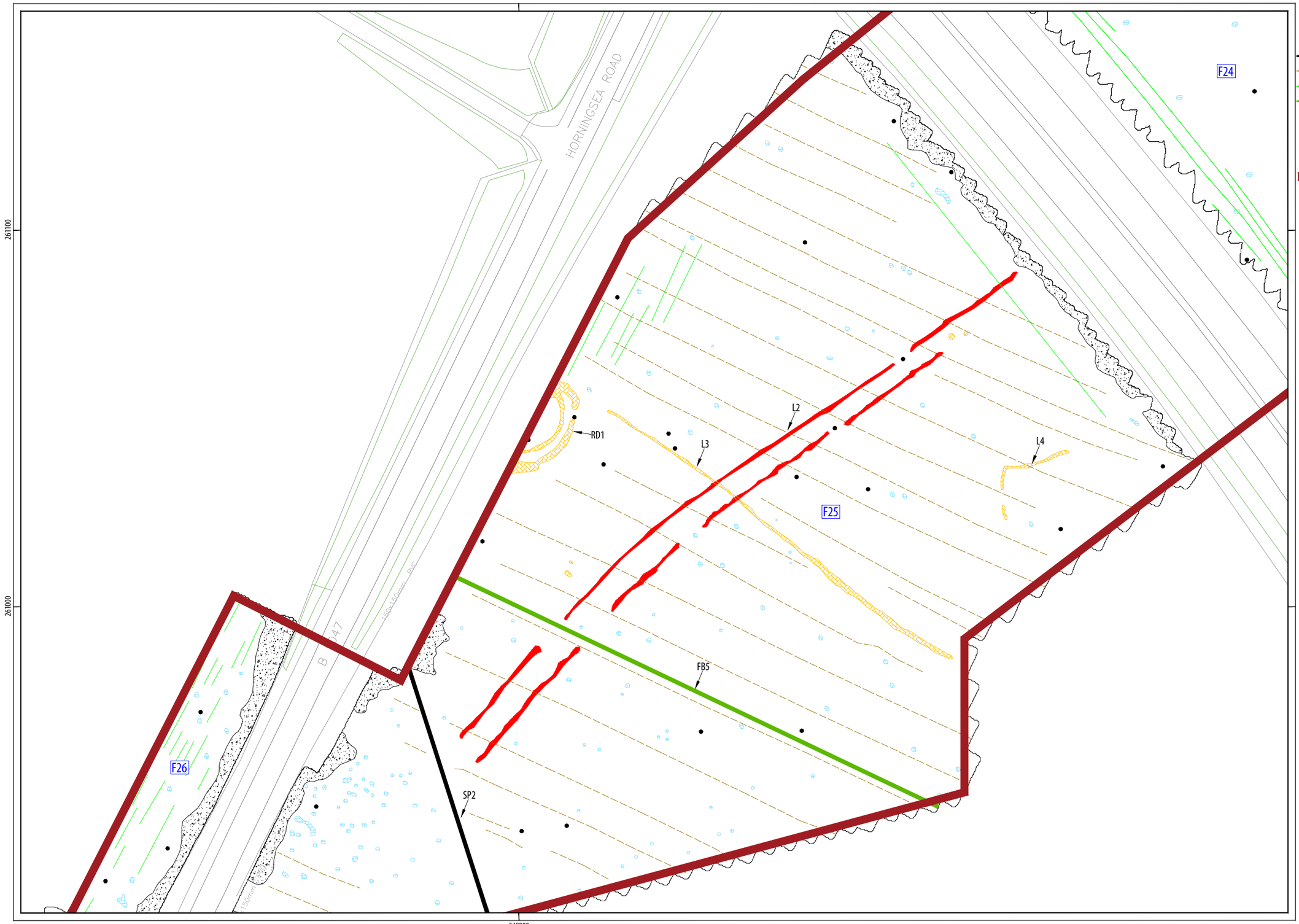
Units 23-25 | Acorn Business Centre | Balme Road

Cleckheaton | BD19 4EZ

t 0127 493 8019

w www.headlandarchaeology.com

ILLUS 36 XY trace plot of minimally processed magnetometer data; Area 1



TYPE OF ANOMALY / INTERPRETATION

TYPE OF ANOMALY	INTERPRETATION
dipolar isolated	ferrous material
magnetic disturbance	ferrous material
dipolar linear	service pipe
linear trend	ridge and furrow
linear trend	agricultural
linear	former field boundary
magnetic enhancement	geology
magnetic enhancement	archaeology?
magnetic enhancement	archaeology

geophysical survey area

ABBREVIATIONS

SP - Service pipe
FB - Former boundary
L - Linear
RD - Ring ditch

0 25m
1:1,000 @ A3

PROJECT WGPL21
Waterbeach Growth Pipeline
Cambridgeshire

CLIENT Anglian Water

HEADLAND ARCHAEOLOGY
Headland Archaeology Yorkshire & North
Units 23-25 | Acorn Business Centre | Balme Road
Cleckheaton | BD19 4EZ
t 0127 493 8019
w www.headlandarchaeology.com

ILLUS 37 Interpretation of magnetometer data; Area 1

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.

Lightning-induced remnant magnetisation (LIRM)

LIRM anomalies are thought to be caused in the near surface soil horizons by the flow of an electrical current associated with lightning strikes. These observed anomalies have a strong bipolar signal which decreases with distance from the spike point and often appear as linear or radial in shape.

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 [redacted]. 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 ARCHIVE

Get in touch

You can contact us by:


Emailing at **info@cwwtpr.com**


Calling our Freephone information line on **0808 196 1661**

Writing to us at **Freepost: CWWTPR**


Visiting our website at [redacted]

You can view all our DCO application documents and updates on the application on The Planning Inspectorate website:

https://infrastructure.planninginspectorate.gov.uk/projects/eastern/cambridge-waste-water-treatment-plant-relocation/