Lower Thames Crossing

Environmental Statement Appendices
Appendix 6.7 – Geophysical survey reports (2 of 2)

APFP Regulation 5(2)(a)

Infrastructure Planning (Applications: Prescribed Forms and Procedure) Regulations 2009

Volume 6

Geophysical Survey Report

of

Lower Thames Crossing

Essex

For

Lower Thames Crossing

Magnitude Surveys Ref: MSTQ550

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Abstract

Magnitude Surveys was commissioned to assess the subsurface archaeological potential of c.235ha of land located between East Tilbury and North Ockendon, Essex. Electromagnetic induction (EM) and magnetic surveys were successfully undertaken across c.177.6ha of the site. The EM survey was employed to map geological/sedimentological variation and palaeochannels at a broad scale, while the magnetic survey was used to inform the interpretation of these results through the potential identification of smaller scale archaeological and natural features. Anomalies have been detected that relate to the drainage system of the Mar Dyke river, indicating former channels and sedimentation on the floodplain and lower valley sides. Towards the coast, survey results have been interpreted as indicative of a saltmarsh environment. Throughout the landscape, anomalies of anthropogenic origin are predominantly related to agricultural activity, which appears to have been focused on areas of elevated ground. Interference from modern activity is generally limited and largely restricted to the effects of buried services, overhead power cables.

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1. Introduction

1.1. Magnitude Surveys Ltd (MS) was commissioned by Lower Thames Crossing to undertake a geophysical survey on a c.235ha area of land at four locations across Lower Thames Crossing.

1.2. These comprised; Zone O at North Ockendon, Essex (TQ 59079 86906); Zone P at Orsett, Essex (TQ 62421 82972); Zones S and J at East Tilbury, Essex (TQ 68973 77127 and TQ 68411 77891); and Zone V at Gravesend, Kent (TQ 67013 70520). Of the c.235ha, c.177.6ha were surveyed, c.43.7 were descoped, and c.13.7ha had the access agreed but were overgrown (Appendix I).

1.3. The geophysical survey comprised quad-towed and cart-mounted GNSS-positioned fluxgate gradiometer and electromagnetic (EM) induction survey. The EM survey was collected simultaneously with the gradiometer survey on the quad-towed, cart-mounted systems Electromagnetic survey is particularly suited for the detection of paleo-landscape environments such as paleochannels. Electromagnetic survey measures both the soil's electrical conductivity and magnetic susceptibility making it a complementary technique to the fluxgate gradiometer. Magnetic survey is the standard primary geophysical method for archaeological applications in ▮▮▮▮▮▮▮▮▮▮▮▮▮▮▮▮▮▮▮▮▮▮▮ atures. The technique is particularly suited for detecting fired or magnetically enhanced features, such as ditches, pits, kilns, sunken earth houses, and industrial activity (David *et al*., 2008).

1.4. The survey was conducted in line with the current best practice guidelines produced by Historic England (David et al., 2008), the Chartered Institute for Archaeologists (CIfA, 2014) and the European Archaeological Council (Schmidt et al., 2015).

1.5. It was conducted in line with a WSI produced by MS (Magnitude Surveys, 2020).

1.6. The survey commenced on 10/06/2020 and was completed on 03/09/20.

2. Quality Assurance

2.1. Magnitude Surveys is a Registered Organisation of the Chartered Institute for Archaeologists (CIfA), the chartered UK body for archaeologists, and a corporate member of ISAP (International Society of Archaeological Prospection).

2.2. The directors of MS are involved in the cutting edge of research and the development of guidance/policy. Specifically, Dr. Chrys Harris has a PhD in archaeological geophysics from the University of Bradford, is a Member of CIfA and is the Vice-Chair of the International Society for Archaeological Prospection (ISAP); Finnegan Pope-Carter has an MSc in archaeological geophysics and is a Fellow of the London Geological Society, as well as a member of GeoSIG (CIfA Geophysics Special Interest Group); Dr. Kayt Armstrong has a PhD in archaeological geophysics from Bournemouth University, is a Member of CIfA, the Editor of ISAP News, and is the UK Management Committee representative for the COST Action SAGA; Dr. Paul Johnson has a PhD in archaeology from the University of Southampton, has been a member of the ISAP Management Committee since 2015, and is currently the nominated representative for the EAA Archaeological Prospection Community to the board of the European Archaeological Association.

2.3. All MS managers have relevant degree qualifications to archaeology or geophysics. All MS field and office staff have relevant archaeology or geophysics degrees and/or field experience.

3. Objectives

3.1. The geophysical survey aimed to assess the subsurface archaeological potential of the survey area.

3.2. The EM survey was used to analyse broad-scale changes within the natural soils and geology and map the presence of any buried palaeochannels. The magnetic survey was used to analyse both broad-scale natural changes across the site and to identify any smaller scale or discrete features of archaeological origin.

4. Archaeological Background

4.1. The following is a summary of information relating to archaeological activity within the survey areas and their local landscape, as available in a Written Scheme of Investigation for Trial Trenching produced by Oxford Archaeology (Oxford Archaeology, 2020) and provided by Highways England.

4.2. Evidence for early prehistoric activity is limited for all the reporting zones; however, a Palaeolithic hand-axe was recovered at Ockendon Hall, c.700m south of Zone P (see Appendix I for delimitation of the zones). Within Zone S, an Acheulian hand-axe is recorded as having been found c.100m east of Princess Margaret Road. No Mesolithic activity is recorded within the survey areas or their immediate surroundings.

4.3. A large sub-circular enclosure, 45m in diameter, is visible in aerial photography 300m west of Zone P and has been interpreted as a possible Late Neolithic henge; a smaller penannular enclosure is located 150m west of Zone P. Cropmarks indicate a possible long barrow or mortuary enclosure 800m southwest of Zone P. To the west of Zone J, two possible ring ditches have been identified from aerial photography, possibly indicating ploughed out barrows located on the north slopes of the higher ground above the estuary. A possible Neolithic burial is recorded west of Zone S, and an excavation 700m north of the survey area in Zone J uncovered cremation remains within a sub-rectangular enclosure. Neolithic and early Bronze Age flint implements have been dredged from the Thames at Tilbury.

4.4. Extensive evidence for later prehistoric and Romano-British activity is documented in the surrounding landscape. Cropmarks indicating multiple phases of trackways, field systems and settlement are widespread to the south and west of Zone P, with particularly dense concentrations at Grey Goose Farm and Barrington's Farm on the A13 and Ockendon Hall, South Ockendon. Orsett cropmark complex (SM1002134) comprises multiple enclosures, ring ditches, trackways and field systems, and is situated on the gravel terrace along the southern edge of the Mar Dyke Valley; evaluation has confirmed the presence of Bronze Age, Iron Age and Romano-British features (including pits, postholes and gullies) and flints, however, recent evaluation showed many of the cropmarks have natural origins. A cropmark site 900m southwest of Zone P was excavated in 1960-70, revealing a farmstead in use from the late Iron age to late Romano-British periods, with enclosures, ditches, pits, cremations, and a corn drying oven. An unaccompanied late Bronze Age cremation was identified 360m south of Zone

O. Within survey Area 24 (Zone P), a cropmark associated with two rectilinear enclosures on higher ground above the flood plain, has been identified as a former field boundary of Romano-British (or possibly post-medieval) date.

4.5. Three former burial mounds, only one of which now survives (SM1019106), indicate Romano-British (and possibly earlier) funerary activity on the high ground of the terrace edge west of the Mar Dyke river valley (South Ockendon Old Hall). The exact location of a Romano-British cemetery excavated in the 19th century is unknown and may either be c.170m north of Zone P or c.900m east of the northern end of Zone P. Roman pottery has been found c.600m southeast of Zone J, at South Ockendon hospital (west of Zone P) and c.900m northeast of Zone P. Ditch formations stretching for 700m along the foreshore southeast of Zone J may represent the site of an Iron Age/Romano-British saltern; four additional possible salterns were identified nearby.

4.6. Two suspected Romano-British routeways have been recorded along survey area boundaries: the first follows Princess Margaret Road, the western boundary of Zone J, given that a Romano-British settlement is known on the Thames foreshore; the second projects the route of the east-west London to Bradwell road along the northern boundary of Zone O.

4.7. Limited evidence of early medieval activity is documented in the area, although artefacts including a baked clay loomweight have been recovered from features within the Orsett Fen cropmark complex. During the late Saxon period, Zone P was likely to have been part of the manorial estate of North and South Ockendon, and the manor of Orsett; divisions between these estates formed later medieval parish boundaries and the area remained undeveloped into 20th century. A middle Saxon settlement was likely to have been located at East Tilbury (Zones S and J) and at least 20 Saxons coins have been discovered in an arable field here. Zones S and J were probably part of small manors of East or West Tilbury during the late Saxon period. Excavations have revealed 5th-6th century settlement at Mucking, Linford and Orsett.

4.8. Several moated medieval sites have been identified in the vicinity of the survey area, including a scheduled site (SM1002155) located at South Ockendon Hall, c.700m south of survey Area 21 (Zone P), which may have late Saxon origins. Cropmarks identified 400m northwest of the moated site comprise rectangular enclosures, linear features, pits and a trackway. These may represent stock enclosures and field systems associated with the manor, although they may be post-medieval. Cropmarks within the south of Zone P (around Area 12) indicate a possible further moated medieval site on the slope of the valley. Further possible moated sites within the parish of Orsett include a possible double medieval moated site. Warley Franks Manor (SM1079879), a moated manor located c.500m northwest of Zone O, was established by 1086.

4.9. Aerial photography suggests further evidence of possible medieval or post medieval field boundaries and possible trackways across the survey zones, and evidence for ridge and furrow cultivation was detected by a geophysical survey at South Ockendon Hall. Pipeline works immediately east of survey Area 17 have revealed medieval ditches containing 12-13th century pottery. A number of coaxial ditches and earthworks c.530m south of Zone S are likely to be medieval or post-medieval in date, possibly representing a drainage system essential for the use of low-lying area for pasture.

4.10. Tithe maps and later 19th century OS maps indicate that the centre of Zone P (around Area 8) formed part of Orsett Fen, indicating the land was too wet for arable or pastural purposes. In the south of Zone P, 1840 tithe maps record multiple field boundaries; all recorded farmsteads of medieval and post-medieval date are located on the slopes above the floodplain of the Mar Dyke. Tithe maps for Zones S and J show that the survey area was agricultural land, surrounded by a mixture of pastoral and arable land. Historic quarrying activity is marked on the 1923 OS map, directly southwest of Zone S.

4.11. An artillery blockhouse dating from 1540 was located on the Thames at East Tilbury. In the later 17th century it was turned into a coastal fort and two additional forts were constructed nearby during the 19th century; earthworks identified close by may be associated with fort defences. The Tilbury fort (SM1021092) and Coalhouse Fort (SM1013943) were reused during WW2.

5. Methodology
5.1. Data Collection

5.1.1. ████████████████████████████████████ ctromagnetic (EM) and magnetic methods as described in the following table.

5.1.2. Table of survey strategies:

Method	Instrument	Traverse Interval	Sample Interval
Electromagnetic Induction – Conductivity and Magnetic Susceptibility	GF Instruments CMD Explorer in HCP orientation	4m	5Hz reprojected to 0.25m
Magnetic	Bartington Instruments Grad-13 Digital Three-Axis Gradiometer	1m	200Hz reprojected to 0.125m

5.1.3. The EM and magnetic data were collected using MS' bespoke hand-pulled/quad-towed cart system GNSS-positioned system.

5.1.4. MS' cart system was comprised of GF Instruments CMD Explorer mounted below the bars in HCP orientation to facilitate a greater depth penetration and Bartington Instruments Grad 13 Digital Three-Axis Gradiometers. Positional referencing was through a multi-channel, multi-constellation GNSS Smart Antenna RTK GPS outputting in NMEA mode to ensure high positional accuracy of collected measurements. The RTK GPS is accurate to 0.008m + 1ppm in the horizontal and 0.015m + 1ppm in the vertical.

5.1.5. Electromagnetic, magnetic and GPS data were stored on an SD card within MS' bespoke datalogger. The datalogger was continuously synced, via an in-field Wi-Fi unit, to servers within MS' offices. This allowed for data collection, processing and visualisation to be monitored in real-time as fieldwork was ongoing.

5.1.6. A navigation system was integrated with the RTK GPS, which was used to guide the surveyor. Data were collected by traversing the survey area along the longest possible lines, ensuring efficient collection and processing.

5.2. Data Processing

5.2.1. Electromagnetic data

5.2.1.1. Electromagnetic data were processed in bespoke in-house software produced by MS. Processing steps conform to Historic England's standards for "raw or minimally processed data" (see sect 4.2 in David et al., 2008: 11).

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

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

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

5.2.2. Magnetic data

5.2.2.1. Magnetic data were processed in bespoke in-house software produced by MS. Processing steps conform to Historic England's standards for "raw or minimally processed data" (see sect 4.2 in David et al., 2008: 11).

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

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

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

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

5.3. Data Visualisation and Interpretation

5.3.1. Electromagnetic data

5.3.1.1. The quadrature-phase and in-phase results are presented as greyscale images. Multiple greyscales images at different plotting ranges have been used for data interpretation. The EM interpretation is partly derived from the quadrature phase, which is a proxy for apparent electrical conductivity. These datasets roughly correspond with a bulk soil volume equated to c. 2.2m, 4.2m and 6.7m deep, respectively. However, as the EM is measuring a bulk soil volume, it will be sensitive to features above and below these theoretical exploration depths. The second set of EM interpretation is derived from the in-phase component of the EM response which relates to the soil's magnetic susceptibility, making it a complementary technique to the fluxgate magnetometer. The in-phase roughly corresponds with a bulk soil volume of half that of the quadrature-phase. The different receiving coil responses are referred to as I1, I2, and I3 configurations for the magnetic susceptibility and C1, C2, and C3 configurations for the conductivity. These depths are described as comparatively shallow, middle, and deep soil volumes, respectively. From this point onward, the respective quadrature-phase and in-phase datasets will be referred to as EM conductivity and EM magnetic susceptibility, respectively.

5.3.2. Magnetic data

5.3.2.1. This report presents the gradient of the sensors' total field data as greyscale images. The gradient of the sensors minimises external interferences and reduces the blown-out responses from ferrous and other high contrast material. However, the contrast of weak or ephemeral anomalies can be reduced through the process of calculating the gradient. Consequently, some features can be clearer in the respective gradient or total field datasets. Multiple greyscale images at different plotting ranges have been used for data interpretation. Greyscale images should be viewed alongside the XY trace plots. XY trace plots visualise the magnitude and form of the geophysical response, aiding in anomaly interpretation.

5.3.3. Geophysical results have been interpreted using greyscale images and XY traces in a layered environment, overlaid against open street maps, satellite imagery, historic maps, LiDAR data, and soil and geology maps. Google Earth (2021) was consulted as well, to compare the results with recent land usages.

5.3.4. Geodetic position of results - All vector and raster data have been projected into OSGB36 (ESPG27700) and can be provided upon request in ESRI Shapefile (.SHP) and Geotiff (.TIF) respectively. Figures are provided with raster and vector data projected against OS Open Data.
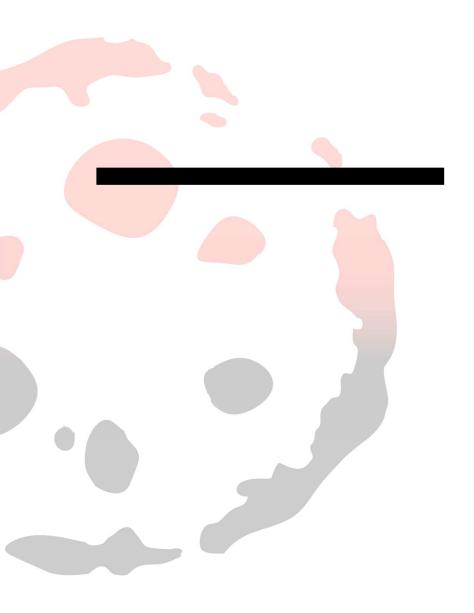
6. Qualification of Results

6.1. Geophysical results are not a map of the ground and are instead a direct measurement of subsurface properties. Detecting and mapping features requires that said features have properties that can be measured by the chosen techniques and that these properties have sufficient contrast with the background to be identifiable. The interpretation of any identified anomalies is inherently subjective. While the scrutiny of the results is undertaken by qualified, experienced individuals and rigorously checked for quality and consistency, it is often not possible to classify all anomaly sources. Where possible an anomaly source will be identified along with the certainty of the interpretation. The only way to improve the interpretation of results is through a process of comparing excavated results with the geophysical reports. MS actively seek feedback on their reports as well as reports of further work in order to constantly improve our knowledge and service.

6.2. General Statements

6.2.1. Geophysical anomalies will be discussed broadly as classification types across the survey area. Only anomalies that are distinctive or unusual will be discussed individually.

6.2.2. **Magnetic Disturbance** – The strong anomalies produced by extant metallic structures along the edges of the field have been classified as 'Magnetic Disturbance'. These magnetic 'haloes' will obscure the response of any weaker underlying features, should they be present, often over a greater footprint than the structure they are being caused by.

6.2.3. **Ferrous (Spike)** – Discrete ferrous-like, dipolar anomalies are likely to be the result of isolated modern metallic debris on or near the ground surface.

6.2.4. **Ferrous/Debris (Spread)** – A ferrous/debris spread refers to a concentrated deposition of discrete, dipolar ferrous anomalies and other highly magnetic material.

6.2.5. **Undetermined** – Anomalies are classified as Undetermined when the anomaly origin is ambiguous through the geophysical results and there is no supporting or correlative evidence to warrant a more certain classification. These anomalies are likely to be the result of geological, pedological or agricultural processes, although an archaeological origin cannot be entirely ruled out. Undetermined anomalies are generally not ferrous in nature.

6.2.6. **Service/Modern Disturbance** – As noted in 6.2.1.2, extant metallic structures will commonly cause high magnitude magnetic anomalies, or 'haloes', over a large area, which will have the effect of masking any weaker anomalies. This effect is commonly detected over buried services; similarly, interference from overhead power lines can impede data interpretation. While the same sources often generate strong anomalies in the EM data, the halo effect is typically significantly reduced. This survey has detected interference from multiple services, power cables and bore holes.

6.2.7. **Modern Boundary Effect** – This classification refers to strong linear EM anomalies located along field boundaries and likely to be caused by modern fencing materials or objects causing electromagnetic interference. On this site, the classification also relates

to similar anomalies probably caused by ground conditions (e.g. saturation) that are most likely to be the result of the extant field boundary.

7. Reporting Zones S and J
7.1.Geographic Background

7.1.1. The Zone S survey area was located c.1.5km southeast of East Tilbury, immediately inside the sea wall and c.150m from the mean highwater mark of the River Thames (Figure 1). Survey was undertaken across five fields under pasture. The survey area was bounded by a track and drainage ditch to the north, the sea wall to the east, additional paddocks and trees surrounding St Katherine's church to the south, and housing on Princess Margaret Road to the west (Figure 5).

7.1.2. The Zone J survey area was located on the edge of East Tilbury, c.900m northwest of the Zone S survey area. Survey was undertaken across one field that was divided between pasture and arable use. The survey area was bounded by field boundaries to the north and south, a farm track to the east and Princess Margaret Road to the west (Figure 5).

7.1.3. Survey considerations:

Survey Area	Ground Conditions	Further Notes
1	Flat pasture with long grass.	Bounded on all sides by wire fencing. A gas line marker was located just outside the northern corner of the field. Metal debris and other rubbish was scattered across the site.
2	Flat pasture with long grass.	Bounded on all sides by wire fencing. A gas line marker was located just outside the northern corner of the field. Metal debris and other rubbish was scattered across the site.
3	Flat pasture with long grass.	Bounded on all sides by wire fencing. Metal debris and other rubbish was scattered across the site.
4	Flat pasture with long grass.	Bounded on all sides by wire fencing. Metal debris and other rubbish was scattered across the site.
5	Flat pasture with long grass.	Bounded on all sides by wire fencing. Metal debris and other rubbish was scattered across the site.
13	Divided into thirds: short pasture grassland in the north and south; arable land with a young brassica crop in the centre. The terrain sloped down from the southwestern corner towards the northeast.	Bounded by trees and hedgerows to the south, west and north, and to the east by a farm track. Vans were parked in south-eastern corner.

7.1.4. The underlying geology in Zone S comprises undifferentiated chalk of the Lewes nodular, Seaford and Newhaven formations. This is overlain across the majority of the survey area by alluvium (i.e. clay, silt, sand and peat). Head (clay, silt, sand and gravel)

and a narrow band of undifferentiated river terrace deposits (clay and silt), are recorded across the western third of the survey area (British Geological Survey, 2021).

7.1.5. The underlying geology in Zone J comprises sand, silt and clay of the Thanet formation. Superficial deposits occur in bands across the survey area and are recorded as Lynch Hill gravel member (sand and gravel) in the southwest, head (clay, silt, sand and gravel) in the centre and Taplow gravel member (sand and gravel) in the northeast; undifferentiated river terrace deposits (clay and silt) are recorded across the eastern tip of the survey area (British Geological Survey, 2021).

7.1.6. Zone S soils consist of loamy and clayey soils of coastal flats with naturally high groundwater across most of the survey area; saltmarsh soils occur over the eastern end and freely draining slightly acid loamy soils occur in the west (Soilscapes, 2021).

7.1.7. Zone J soils are recorded as freely draining slightly acid loamy soils (Soilscapes, 2020).

7.2. Results

7.2.1. Discussion

7.2.1.1. The respective EM and magnetic surveys have generally responded well to the environment of the survey area. Differences in the geological background within and between the survey areas of S and J are apparent in the geophysical results, with the distribution of EM anomalies in both zones also corresponding closely with local topographic variations noted in LiDAR data. Discernible alignments within the detected geology in Area 13 (Figure 4) follow the contour and it is suspected that they reflect relative physical and chemical properties of bedding within the superficial and underlying deposits. A probable former watercourse, morphologically similar to examples draining the surrounding coastal marshes, has been detected on the lower ground in the southeast of Area 13; its course extends beyond the extent of the survey area (Figure 16).

The complex geochemistry of salt marsh environments is known to affect the detection of archaeological anomalies in such areas, potentially reducing the magnetic contrasts between infilled features and the surrounding natural deposits, while also resulting in magnetic enhancement of geological features of similar scale (such as small creek beds); both factors can make it difficult to distinguish between anomalies of natural and anthropogenic origin. The proximity of the Zone S survey area to the estuarine Thames, with saltings extending up to the eastern site boundary, suggests the likelihood of multiple marine inundations, while historic mapping records that the eastern half of the survey area, although inside the sea wall, was marsh until at least 1777. In addition to contributing to the relatively 'noisy' magnetic background, salinity is also likely to be a factor in fluctuating conductivity levels observed across Zone S, although broader-scale trends are more difficult to confidently attribute in this case, given the lower spatial resolution of the EM data and the limited size (and internal divisions) of the survey area.

7.2.1.2. Former field boundaries and ploughing trends associated with modern agricultural activity were identified across Zone J. Isolated areas of magnetic disturbance in Zones J and S are suggestive of extraction activity; sand/gravel, clay and chalk extraction pits are mapped in the wider area.

7.2.1.3. Interference from two buried services is apparent in the data, and high magnitude anomalies related to modern field boundaries and ferrous surface debris (observed at the time of survey) also have the potential to mask any weaker anomalies of archaeological origin that may be present.

7.2.2. Electromagnetic and Magnetic Results - Specific Anomalies

7.2.2.1. **Undetermined (EM) (Zone S)** – The EM anomalies identified in Zone S correspond closely with topographic variation indicated in the LiDAR data. They are likely to reflect a combination of natural ground conditions, however, they have been classified as Undetermined as the extent of anthropogenic influence cannot be confidently quantified. Pockets of higher conductivity are more frequent across the lowest land (Area 5 – Figure 9) suggesting they reflect variations in groundwater, salinity and clay content associated with the naturally wet and saline saltmarsh soils in this area. Loamier soils and slightly increased elevation in the southwest coincide with elevated magnetic susceptibility levels, which may be explained by proximity to settlement related activity along Princess Margaret Road.

7.2.2.2. **Natural (Magnetic) (Zone S)** – A relatively noisy geological background has been detected in the magnetic data across Areas 1-5 (Figure 11), probably reflecting the combined effects of chalk bedrock, varied clay content of superficial deposits, and increased salinity. The eastern half of the survey area (Areas 2 and 5) is marginally 'quieter' (most apparent in the XY traces – Figure 14), which may be the direct result of soil properties, but may also imply less intensive ground disturbance in this (historically marshy) area compared to the western portion of the site. The magnetic anomalies classified as Natural occur as amorphous spreads [**1a**] and in bands of various magnitudes roughly aligned NE-SW [**2a-5c**] (Figure 12). In the eastern corner of the survey area, a strong branching linear anomaly [**5d**] has been identified, the morphology of which suggests it reflects a small creek bed or former drainage channel; it shares the alignment of the field boundary dividing Areas 2 and 5, which is known from historic mapping to utilise a drainage ditch (probably a modified natural watercourse).

7.2.2.3. **Natural (Zone J) (Palaeochannel)** – At [**13a**] a highly conductive sinuous linear anomaly (Figure 16), c.15-30m in width and clearly identifiable at all three depths, is located in the south-eastern corner of the survey area and is likely to indicate a former watercourse. It has not been identified in the LiDAR or magnetic data (Figures 17-18) (although the area is partially obscured by high magnitude responses from a buried service running along the eastern edge of the survey area and from nearby parked vehicles), which may indicate a greater depth of burial. Although the detected feature extends beyond the survey area

edge, the zigzagging course of this section suggests drainage of flat ground and similar channels are present on historic and modern mapping of the surrounding coastal marshes.

7.2.2.4. **Natural (Zone J) (Superficial Deposits) –** Across Area 13, patches of lower conductivity have been detected that are most likely to reflect the physical and chemical properties of the shallow geology and soils (Figure 16). Those identified are amorphous in shape, and generally c.50-100m wide; while evident in all data depths, they are better defined in the shallower and middle datasets, broadening out at depth. These anomalies appear in several loose bands that run along the contour, orientated roughly NW-SE (most clearly visible at [**13b**] but also running between [**13c**-**13d**], and [**13e**-**13f**]) before turning slightly to the south. This also corresponds with the recorded changes in superficial deposits across the survey area (Figure 4); lower conductivity could be expected to be detected over the sand/gravel beds present in the southwest and northeast, which may exhibit better drainage, and corresponding lower conductivity levels, than the central band of head (depending on composition). The 'speckled' background present in the magnetic data (Figure 18) is typical of data collected over superficial geology of this type.

7.2.2.5. **Agricultural (Field Boundaries) –** Running NE-SW across Area 13, linear EM and magnetic anomalies (including [**13g**] and [**13h**]) have been detected that correspond to current and former field boundaries known from historic mapping and remote sensing imagery (Figures 16 & 19). The broad EM anomaly at [**13b**] is abruptly truncated at [**13h**], suggesting the application of different agricultural regimes in adjacent fields. Linear trends in the EM and magnetic data have been identified that indicate ploughing activity.

7.2.2.6. **Industrial/Modern (Extraction) –** Located in the south-eastern corner of Area 13, an L-shaped area (c.34 x 26m) of high magnitude anomalies in the magnetic data may indicate past sand and/or gravel extraction. Although this is not marked on historic mapping, a number of such pits occur in the surrounding area, including industrial-scale extraction to the immediate east of Area 13. Small subcircular anomalies of a similar nature have been identified in Area 2, which may indicate previous extraction of chalk or clay.

7.2.2.7. **Undetermined (Magnetic) –** A number of small anomalies of uncertain origin have been identified in the gradient data. The majority of these are weak, linear or curvilinear anomalies and could indicate human activity or have natural origins.

7.2.2.8. **Service/Modern Disturbance –** Buried services have been detected running along the eastern edge of Areas 1 and 3, and the eastern edge of Area 13, which have introduced interference in the magnetic results. Further interference (largely limited to the perimeter in Area 13 but more widespread across Zone S) is related to modern field boundaries (e.g. barbed wire) and metal debris.

8. Reporting Zone P

8.1. Geographic Background

8.1.1. Zone P was located c.2.5km northwest of Orsett and c.3km southeast of North Ockendon (Figure 1). Survey was undertaken across 16 fields covering a total of c.163.6ha. The area was predominantly under arable conditions, with fields containing cereal crops, stubble or fallow at the time of survey. The survey area was surrounded by additional arable fields, a number of current/previous mineral extraction sites, and was bisected by the Mar Dyke (Figure 1). C.12.5ha of survey area was not surveyed due to tall and dense barley crop present on the field.

8.1.2. Survey considerations:

Survey Area	Ground Conditions	Further Notes
8	Flat arable field with c. 0.75m tall barley crop.	Bounded by ditches to the north and south, a trackway in the west, and an open boundary in the east, ███████ was attempted but could not be completed due to the presence of a tall and dense barley crop.
81	Arable field with winter wheat. The terrain gently sloped down from south to north.	Bounded by hedgerows and trees to the north, east and south, and an open boundary to the west. Pylons were located within the area, with two sets of overhead powerlines crossing the area from northwest to southeast.
10	Flat arable (fallow) field.	Bounded by a hedgerow to the east and open boundaries in the north, east and south.
11	Flat arable field; fallow (overgrown) in the northern half; mature spring wheat in the southern half.	Bounded by hedgerows in the north, east and west, and an open boundary in the south.
12	Arable field with harvested OSR crop. Flat with slight undulations.	Bounded by hedgerows to the north, west and south, and a track to the east. Utility access points were located on the southern and northern boundaries of the survey area.
14	Flat arable field with short OSR crop stubble.	Bounded by a track to the north, a discontinuous hedge to the east, a ditch and trees to the south, and a hedge to the west. A gas pipe marker was located on the southern boundary.
15	Flat arable field with short OSR crop stubble.	Bounded to the north and east by a track, a hedge to the south and a discontinuous hedge to the west.
16	Flat arable field with short OSR crop stubble.	Bounded to the north by a copse, to the east by a fence, and to the south and west by tracks. A pylon was located in the southern corner of the area, with a gas pipe marker on the southern corner boundary.
17	Flat arable field with cereal crop stubble.	Bounded to the south, west and north by ditches and trees, and to the east by a copse. Five boreholes were located within the survey area.

18	Flat arable field with cereal crop stubble.	Bounded to the north by a ditch, to the east by a copse, and by an open boundary to the south and west. Overhead powerlines crossed the area from north to south.
19	Flat arable field with short cereal crop stubble.	Bounded to the west and north by a ditch and trees, to the east by a track and to the south by an open boundary.
20	Flat undifferentiated grassland with long grass, extensive weed cover, and uneven ground.	Bounded to the north by trees, to the east by a trackway, to the south by dense undifferentiated grassland with brambles, and to the west by a compound with HERAS fencing and temporary matting. Overhead powerlines ran north to south across the centre of the survey area with a pylon located just inside the northern boundary. A trackway ran northeast to southwest across the survey area.
21	Arable field with short cereal stubble and rough ground ▬▬▬▬▬▬▬ The terrain sloped down towards the southeast, with a depression in the eastern part of the field.	Bounded to the north by a trackway, to the east by a hedge, to the south by a ditch and trees, and west by trees. A storehouse was located in the northwest corner. A temporary trackway with matting ran along the western and western half of the southern boundaries, c.20m in from the field edge. Three boreholes (one surrounded by HERAS fencing) were located within the survey area. Gas pipe markers were located on the eastern and western boundaries.
22	Flat harvested arable field.	Bounded to the north and south by a ditches and hedges, and to the east and west by copses, with a fence along the northwest corner. An overhead powerline ran northwest to southeast across the centre of the survey area, with pylons located inside the northern and southern boundaries.
23	Flat harvested arable field.	Bounded to the north by a ditch, to the east and west by hedges, and to the south by a copse. An overhead powerline ran north to south across the centre of the survey area with a pylon located inside the northern boundary. Three boreholes were located in the area. Two gas pipe markers were located along the northern boundary.
24	Flat harvested arable field	Bounded by ditches and trees to the north and south, arable land and a ditch to the east, and a hedge to the west. A gas substation was located immediately to the southeast of the survey area; gas pipe markers were located along the southern and western boundaries. Overhead powerlines ran north to south across the west of the survey area.

8.1.3. The underlying geology in Zone P comprises clay, silt and sand of the London clay formation. This is overlain by alluvium (clay, silt, sand and gravel) in the central part of the zone, with head (clay, silt, sand and gravel) recorded around the periphery (British Geological Survey, 2021).

8.1.4. The soils in the centre of the zone consist of loamy and clayey floodplain soils with naturally high groundwater, and are surrounded by slowly permeable seasonally wet slightly acid but base-rich loamy and clayey soils (Soilscapes, 2021).

8.2. Results – Zone P Discussion - Overview

8.2.1. The respective magnetic and electromagnetic surveys have generally responded well to the environment of the survey area. The EM survey, informed by LiDAR and satellite imagery, has been effective in detecting broader geological variations across the site that have been interpreted as reflecting superficial deposits and landforms relating to the Mar Dyke drainage system (see Figures 108-110). In particular, a number of palaeochannels have been recognised on the lower elevations, presumably relating to ██████████████████████████████ river and its tributaries. The most clearly identifiable examples are located in Orsett Fen, where less intensive later enclosure of land probably held in common is likely to have ensured greater preservation of the shallow subsurface features. Anomalies of a similar nature have been identified along the western and southern parts of the valley floor, suggesting multiple channel migrations and/or abandonments, although these anomalies are generally less pronounced (in terms of morphology and electromagnetic contrast); this may be due to factors including later channel truncation, ground disturbance by agricultural activity and deeper overburden. As such, some anomalies have been classified as Possible Palaeochannels. Responses identified as representative of palaeochannels in this environment are characterised by low conductivity values, which may suggest the influence of a sand and/or gravelly stream bed is being detected, with more rapid drainage and a lower clay content contributing to a decrease in conductivity relative to surrounding sediments. This is supported by consistent detection of these features as anomalies of decreased magnetic susceptibility in the inphase data.

8.2.2. Across the survey area, broader EM anomalies have been identified that are classified as being of natural origin and are considered to reflect superficial geology. The interpretation of geophysical anomalies relating to deposits such as head and alluvium is complicated by their potentially heterogeneous nature - deposits such as head can be expected to contain localised variation of poorly sorted material depending on source and deposition circumstances. Consequent variations in, for example, porosity (due to grain shape and packing), saturation levels and clay/mineral content can have a significant impact on electromagnetic properties. However, the natural deposits detected in Zone P appear to correlate well with recorded superficial deposits as well as the microtopography.

8.2.3. The EM and magnetic data suggest contrasting anthropogenic land use between the flood plain and the elevated valley sides, with anomalies identified as evidence of agricultural activity predominantly detected on the (in places only very slightly) raised

ground. On the southern side of Orsett Fen, this activity includes land division that correlates closely with post-medieval boundaries on historic mapping, although these boundaries contribute to a much larger coaxial landscape that extends across southern Essex from the Thames to the gravels and boulder clay plateau further north, elements of which have Roman origins (Rippon et al. 2015, 143). In the north-western part of the Zone P survey area, anomalies suggestive of multiple phases of agriculture have been detected – this presumably reflects their location on drier ground. No anomalies directly indicative of intensive settlement activity have been identified within the survey area, although the prevalence of detected palaeochannels, land drains and ditched field boundaries suggests more favourable locations may have been sought; the same features, in combination with the natural topography do, however, indicate a probable resource-rich environment for early and/or more mobile populations.

8.2.4. For clarity, survey results in the southern, central and northern portions of Zone P are discussed separately in the following sections. Figures 108-110 provide an overview of selected geophysical anomalies in their wider landscape context.

8.2.5. Zone P South - Discussion

8.2.5.1. Zone P South incorporates Areas 81, 12, 19, 11 and 10 (Figures 22 - 45). The northern edge of this part of the survey area is delineated by the canalised watercourse marking the southern edge of Orsett Fen; the survey area is located on the very gradually rising ground of the valley side, ranging from c. 4m aOD along the northern perimeter to c. 7m aOD on Green Lane to the south. The EM survey has detected indications of former watercourses and their possible modification in this area, with concentrations of anomalies in the northern, southern and eastern parts of the survey area suggesting the presence of former Mar Dyke tributaries. Although not as clearly defined as those in Zone P Centre (see Sections 8.2.7.1 and 8.2.8.1), many of the anomalies identified as palaeochannels correspond closely with slight depressions in the LiDAR data, and most collocate with linear magnetic anomalies identified as land drains, presumably installed to prevent water accumulating in these low lying areas. It should be noted that it is not possible to identify chronological sequencing or contemporaneity of the subsurface features from the EM and magnetic data alone.

8.2.5.2. Broad EM anomalies detected across the northern edge of this part of the survey area (Areas 12, 19, 11 and 10 – Figure 23) are likely to relate to a combination of natural and anthropogenic factors. The distribution of raised conductivity values corresponds closely with the lowest parts of the survey area as indicated in the LiDAR, and as such may reflect a greater degree of ground saturation and/or possibly increased clay content (e.g. influenced by alluvial deposition). Sharp delineation of raised or lowered conductivity values (as seen in Area 11, for example) is likely to be the result of differential agricultural regimes (Figures 39, 40 & 44) – historic mapping indicates a line of farms located along the fen edge in the 19th and 20th century.

8.2.5.3.   A dense network of former field boundaries has been detected across the area, the axis of which shares the dominant NNW-SSE orientation of current land division. The majority of the detected field boundaries correspond closely with 19th and 20th century mapping and remote sensing data, and relate to narrow plot divisions and sub-enclosures that have been removed relatively recently as fields have been consolidated into larger parcels. They may, however, have earlier origins (see Section 8.2.3). While the EM and magnetic data do not indicate chronological sequence or time depth, the lack of identifiable anomalies indicating alternative boundary alignments or overlapping field systems is noted. The detection of the majority of field boundaries as low conductivity and raised magnetic susceptibility anomalies is consistent with historic mapping indications that many boundaries in this area took the form of ditches; the need for drainage is reinforced by the frequency with which land drains and infilled ponds have been identified in the magnetic data.

8.2.6.   Zone P South - Specific Anomalies

of sinuous curvilinear and amorphous EM anomalies, interpreted as relating to former watercourses, occurs across the northern third of Areas 81, 12 and 19 (Figures 23, 32, 33, 39 & 40). Within this zone, the most clearly defined anomalies include those running between [**81a**] and [**81b**], [**81c**] and [**81d**], [**81e**] and [**19a**], and [**12b**] and [**12c**] (Figures 33 & 40), paths of some of which correspond with shallow depressions in the LiDAR. These take the form of roughly linear and/or curvilinear anomalies, typically around c.25-30m wide and present in all EM depths, though most clearly defined in the middle depth. They have not been identified in the gradient data, probably owing to the depth of overburden and limited magnetic enhancement. The enlarged area of low conductivity at [**81d**-**81b**-**81e**] is likely to represent the overlap or convergence of multiple, not necessarily contemporary, channels, although the EM data resolution is insufficient to allow more specific observations; moreover, groundwater and conductivity values here are likely to be influenced by additional surrounding features (i.e. known field boundaries and a farmstead/pond). The particularly straight section of palaeochannel detected between [**81e**] and [**19a**] may indicate canalisation. Evidence for its continuation beyond the service at [**19a**] has not been identified, but it is noted that a land drain (visible in the magnetic data Figure 43) continues this line towards [**19b**] and Hobbets Farm.

8.2.6.2.   **Palaeochannels (South) –** A zone of EM anomalies, similar in nature and morphology, to those noted in Section 8.2.6.1, has been identified across the southern third of Areas 81 and 12 (Figures 23, 25 & 26). Although interrupted by anomalies indicating former field boundaries, comparison with LiDAR data (Figures 27 & 108) suggests these EM anomalies mark the channels of watercourses draining the valley side, probably flowing west into the Mar Dyke main channel. Two distinct probable channels have been identified, running west and northwest from [**12e**] and [**12f**] respectively, each coinciding at the microtopgraphical level with slight depressions cutting across the contour and,

at [**12e**], with a band of low magnetic susceptibility. A possible confluence occurs at [**81e**], although the EM data does not indicate whether the two channels were contemporary. At [**12g**] a field boundary is known (from historic mapping) to run north-south across the area, coinciding with magnetic anomalies (Figures 28-30) indicating a concentration of field drains; although the strong linear EM anomaly has been categorised here as Agricultural, the extent to which this is masking weaker natural anomalies is unclear. A similar anomaly at [**81f**] is also interpreted as related to the drainage system.

8.2.6.3. **Possible Palaeochannels –** The group of EM responses noted in Section 8.2.6.1 appears to extend further east along the contour from [**12a**] (Figure 33), to incorporate similar, though weaker, anomalies at [**12d**] and across the southern edge of Areas 19, 11 and 10. They are interpreted as representing possible palaeochannels, due to their form and morphology, although their fragmentation and curtailment by the edge of the survey area make them more difficult to confidently identify as such, and an agricultural or alternative natural origin cannot be ruled out.

8.2.6.4. **Natural –** Broad EM anomalies indicative of areas of raised conductivity occur along the northern edge of the survey area between [**12i**] and [**19c**] (Figures 33 & 36). This area marks the recorded transition from seasonally wet loamy-clayey soils (to the south) to alluvial floodplain soils (to the north); increased ground water and/or clay mineral content in the latter are likely to raise ground conductivity. Their location at the 'break of slope' fen edge and adjacent to the drainage ditch running along the survey boundary, suggests hydrological factors may also be influential. However, agricultural activity may have contributed to elevated conductivity in this area (see Section 8.2.6.6).

8.2.6.5. **Agricultural (Former Field Boundaries) –** A complex of former field boundaries has been detected extending across this area. [**12h**] (Figures 23 & 33) identifies a representative example of the linear EM anomalies, the majority of which exhibit relatively low conductivity and high magnetic susceptibility – these properties are consistent with infilled drainage ditches. The majority have not been identified in the magnetic data, most likely as a result of limited magnetic enhancement of the infill material and relatively deep overburden. Most correspond closely to known boundaries on various historic maps (Figures 30, 37 & 44), while some are evident in remote sensing data. The anomalies conform to an orthogonal layout, sharing the NNW-SSE alignment of current boundaries, to form a series of square and rectangular enclosures. Phasing and date cannot be determined from the geophysical results.

8.2.6.6. **Agricultural (Spread) –** Elevated magnetic susceptibility levels have been detected along the northern edge of the survey area, which may be a reflection of a focus of settlement and agricultural activity in this area, as indicated by the line of farms located on historic mapping along the edge of the fen, although natural variations in superficial deposits may also contribute to this effect. In Area 11 recent changes in agricultural activity are evident in historic mapping

(Figure 44) and satellite imagery [**11a**], while abrupt changes in soil properties associated with a former field boundary and resulting in a more geometric spread suggest differential agricultural regimes, such as manuring cycles or ploughing methods, that have been constrained by former plot extents [**11a** and **11b**].

8.2.6.7. **Drainage –** An extensive complex of land drains has been detected across the survey area in the magnetic data; a small number of these are also identifiable in the shallowest EM results, suggesting limited depth.

8.2.6.8. **Infilled Ponds –** Six anomalies have been identified as representative of former ponds, now backfilled. They appear as discrete areas of high magnitude magnetic values, which correspond with low conductivity, generally c.25-35m in diameter. Several collocate with isolated shallow depressions visible in the LiDAR and/or are known from historic mapping; additional unmapped examples have been classified as such based on similarity of morphology and form (Figrues 23, 26, 27, 33 & 34).

8.2.7. Zone P Middle – Discussion

8.2.7.1. Zone P Middle incorporates Areas 6, 7, 18, 22, 17, 20, 23 and 24 (Figures 46-83), all of which are located on the lower lying ground of the valley floor. The current Mar Dyke channel runs north-south along the eastern edge of Areas 17, 22 and 18. The EM data contains anomalies that correspond with the drainage system as evident in remote sensing data and historic mapping, with responses indicative of palaeochannels (probably relating to former courses of the Mar Dyke river itself) widely distributed to the east and immediate west of the current watercourse. The sinuous channels to the east of the current Mar Dyke (Areas 6 and 7) are clearly discernible against the 'quiet' magnetic background of the gradient data, with indications of sediment bars present inside meanders; to the west of the dyke, their detection in the magnetic data is much more limited, which may be a reflection of increased depth of overburden, alongside increased (agricultural) ground disturbance and the obscuring effects of modern services.

8.2.7.2. More amorphous EM responses, interpreted as indicative of superficial and underlying geology, have also been identified across the survey area (Figure 47). As noted above (see Section 8.2.2), mineral content and hydrological properties can be expected to vary within deposits of head and alluvium, resulting in the detection of patchy conductivity levels. The interpretation of these EM anomalies is reinforced by the coincidence of the more prominent examples with the location of a recorded outlying head deposit (Area 7 – Figures 50 & 57) and a lobe of slightly higher ground projecting into the valley from the west (Area 23 – Figure 71).

8.2.7.3. Anomalies that have been identified as representative of cultivation activity have predominantly been detected, as plough trends and former field boundaries, along the western side of the valley (Figures 47 & 48). The high

density of land drains identified elsewhere on the floodplain is likely to explain this restricted distribution.

8.2.8.   Zone P Middle – Specific Anomalies

8.2.8.1.   **Palaeochannels/Natural (Areas 6 and 7) –** Most clearly identified at [**6a-c**] and [**7a**-**c**], sinuous linear EM anomalies c.20-30m wide have been interpreted as indicative of former watercourses due to their shape, arrangement and location (Figures 50 & 57). The buried features are also evident in the gradient results, which include strong curvilinear anomalies, indicative of meandering channels (Figures 52 & 53). Associated 'mottled' anomalies, predominantly occurring on the inside of curves, are characteristic of sand/gravel deposition. Considered in association with LiDAR data (Figures 51 & 108-110), it appears likely that these channels form part of the pre-canalisation course of the Mar Dyke river. The location and morphology of the detected channel at [**7a**] – [**7b**] correlates closely with historic map (Figure 61) evidence for a watercourse draining the fen and subsequently redirected into a drainage ditch (the current eastern ▮▮▮▮▮▮▮▮▮▮▮▮▮▮▮▮▮▮▮▮▮**7c**] and [**6a**], a network of EM anomalies similar in character but of weaker magnitude and less coherent layout, are likely to be explained by more deeply buried features; parallels for these have not been identified in the gradient data, and the EM anomalies are better defined in the middle and deeper conductivity data (Figure 47).

8.2.8.2.   **Natural (Head Deposits – Area 7) –** In the centre of Area 7 (figures 50 & 57), a strong anomaly of high conductivity and slightly increased magnetic susceptibility has been detected [**7d**]. Irregular in shape, and decreasing in strength towards the north, it has a maximum NW-SE diameter of c.190m, but appears to extend beyond the edge of the survey area to the west. This correlates with the recorded location of an isolated head deposit (see Figure 4) and is likely to reflect the difference in electromagnetic properties between these deposits and the surrounding alluvial sediments. A low conductivity anomaly of similar morphological nature is located immediately to the south [**7e**] (Figures 49 & 50) and is likely to have similar origins, albeit reflecting contrasting electromagnetic properties (for example, due to a higher proportion of sand/gravel).

8.2.8.3.   **Palaeochannels (Areas 22 and 17) –** A group of irregularly shaped low conductivity anomalies have been detected in the north-eastern quadrant of Area 22 [**22a**] and south-eastern part of Area 17 [**17a**] (Figure 47, 63, 64, 70 & 71). The strongest anomalies are located on the eastern side of the group, with lower values recorded around the western periphery. This group is likely to represent further fluvial activity – their location adjacent to the current course of the Mar Dyke, along with LiDAR evidence, supports the possibility of an abandoned (naturally or deliberately) meander, although more specific identification of spatial extent and detail are hampered by the detection of anthropogenic features of more recent origin in this area (see Section 8.2.8.4). It is not clear whether similar anomalies at [**17b**] (Figures 70 & 71) indicate

spatially separate palaeochannels or the northern extent of features detected at [**17a**], due to strong responses (relating to a buried service, borehole and field boundary) located between these locations.

8.2.8.4. **Agricultural (Former Field Boundaries - Area 22 and 17)** – At [**22b**], a former field boundary, known from historic mapping, is detected running WSW-ENE across the survey area (Figure 68). This feature is associated with a well (located c.38m north) on historic mapping, detected in the EM and magnetic data (Figure 66). Running northeast from the well, an additional linear EM anomaly suggests a further boundary and/or drain, which cuts through the anomalies likely to represent palaeochannels. A similar linear anomaly runs southeast from [**22b**], with a subsquare area (c. 65 x 75m) of high conductivity located at its junction with the east-west field boundary (Figure 63); this linear runs parallel to the narrow linear EM anomalies classified as drains [**22c**] (Figure 64). Together, these anomalies suggest agricultural activity and water management, with high groundwater in the area (evidenced by the well and drains) increasing conductivity within subsurface features.

8.2.8.5. **Palaeochannels (Area 17 North)** – At [**17c**] a well-defined curvilinear EM anomaly (Figures 70 & 71) running across the north-eastern corner of the survey area is interpreted as indicative of a further palaeochannel. At this location, a moderately-well defined linear anomaly has been identified in the magnetic data (Figures 73 & 74); this anomaly also runs NW-SE, but turns east at a pronounced corner c.25m inside the survey boundary. The straightness and angle of return suggest an anthropogenic origin, and it appears that the magnetic results have detected a more recent (shallower) feature (i.e. a drainage channel infilled with magnetically enhanced material), whereas the EM results reflect an underlying natural channel (with possible indications of movement/branching). An amorphous group of anomalies spreading west from [**17c**] to [**17d**] may indicate additional channels and depositions (Figures 70 & 71).

8.2.8.6. **Possible Palaeochannels (Area 24)** – Across Area 24, EM anomalies that are indicative of possible palaeochannels have been detected (Figures 77 & 78), though they are not evident in the magnetic data (perhaps due to burial depth). Although their apparent curvilinear morphology is characteristic of past fluvial activity, they are difficult to define clearly and appear to have been masked in part by modern and agricultural activity.

8.2.8.7. **Natural (Western Areas)** – Throughout the survey area, patches of relatively high and low conductivity have been identified and classified as relating to superficial geology and soils (Figure 47). The majority of these reflect areas of lower conductivity that may indicate a higher proportion of sand/gravel; although similar in strength to anomalies classified as palaeochannels, they lack the distinctive sinuous morphology and appear patchy and less easily defined. Other amorphous anomalies, such as [**24c**] (Figures 77 & 78), indicate areas of

high conductivity, perhaps reflecting pockets of clay and/or more saturated ground.

8.2.8.8. **Agricultural -** At [**17e**], a narrow linear low conductivity anomaly (Figure 70) is interpreted as relating to an unmapped field boundary on the grounds of anomaly form and morphology; this becomes more difficult to trace at the eastern end of the boundary, where it has been more broadly classified as Agricultural (although an origin linked to the adjacent service and borehole cannot be ruled out). Modern ploughing trends have been detected across most Areas.

8.2.8.9. **Drainage Features –** A network of land drains have been detected in the magnetic data; they occur most densely across the lowest lying areas (including Areas 6, 7 and 17).

8.2.8.10. **Undetermined (Area 23) –** A low conductivity anomaly [**23a**] (c.128 x 105m) has been detected in the centre of Area 23 (Figures 70 & 71). On its western side, it ▬▬▬▬▬▬▬▬▬▬▬▬▬▬▬▬▬ within the angle created by a narrow linear anomaly (possibly indicating a drainage feature) that runs west-east across the survey area, before branching to run northeast and southeast of [**23a**] (although the apparent relationship of the two may be coincidental). An infilled pond, identified as such from historic mapping, has been identified to the north of [**23a**]. To the south, an elongated area of high conductivity [**23b**] (c.100 x 65m) has also been detected. The origins of these anomalies are difficult to identify; as they appear most clearly in the shallowest datasets, they are likely to relate to modern activity such as agricultural practices, drainage or interference from overhead power cables.

8.2.9. Zone P North – Discussion

8.2.9.1. Zone P North incorporates Areas 16, 15, 14 and 21 (Figures 47, 48 & 77-97), which cover a transect across the valley side as it rises from c.4m aOD on the floodplain to c.24m aOD at its western end. This area also covers the recorded limit of alluvial deposits, which runs roughly SW-NE across Area 14 (Figures 4 & 5). Broad scale variations detected in the EM data are consistent with the recorded deposits; changes in conductivity may represent saturation influenced by topography, grainsize and mineral composition, although the soil properties are also likely to have been influenced by agricultural practices. For example, a discontinuous band of lower conductivity present along parts of the southern edge of the survey area may reflect the dewatering effects of drainage channels located along (outside) this boundary.

8.2.9.2. The detection of linear anomalies and trends indicating former field boundaries and ploughing regimes on three primary axes (i.e. parallel with the NNW-SSE orientation of current field boundaries, perpendicular to this, and aligned NW-SE) is suggestive of more intensive use of this raised part of the survey area. The NW-SE land division orientation is not recorded on available historic mapping or satellite imagery and is likely to predate these sources. In contrast to other

phases of land use elsewhere within the survey extent (e.g. Zone P South), responses relating to these boundaries indicate low conductivity ground conditions. Although a complex range of factors are known to influence conductivity levels recorded over buried features, in the case of this survey, it is notable that the difference corresponds broadly to separate parts of the topographic landscape. As such, it may reflect 'real' differences in boundary construction practice (e.g. use of hedgerows as opposed to drainage channels), although it could also result from similar features under different physical circumstances (e.g. the detection of dewatering effects rather than saturation over ditches depending on hydraulic conductivity and ground water levels at the time of survey).

8.2.10. Zone P North – Specific Anomalies

8.2.10.1. **Natural** – EM anomalies identified as natural in this area are generally large scale and similar in nature to those identified as having geological/pedological origins elsewhere across Zone P. They include pockets of high (e.g. [**14a**] Figures ▓▓-92) conductivity that are considered to reflect contrasting substrate properties consistent with recorded clay, alluvium and head deposits. Many of these anomalies, however, exhibit relatively geometric morphologies and it is likely that their detection has also been influenced by agricultural activity. For example, elongated anomalies aligned north-south at [**21a**] appear to have been 'cut' into multiple sections, while [**15a**-**c**] are also separated by trends in the data identified as reflecting plough events.

8.2.10.2. **Agricultural** – Several former field boundaries evidenced in historic mapping and satellite imagery have been detected across the survey area, including [**14b**] (Figures 87 & 89) and [**21b**] (Figures 94 & 96), with ploughing trends also detected on these alignments (parallel with extant boundaries). A series of linear anomalies aligned NW-SE have been detected ([**21c**], [**21d**], [**14c**], [**14d**]) that probably indicate field boundaries related to an unmapped phase of land division, although the alignment is perpetuated in the extant boundary track between Areas 15 and 16.

8.2.10.3. **Undetermined (EM)** – A band of low conductivity c.40m wide has been detected running parallel to the southern boundary of the survey area in Area 15 [**15d**] and extending into Area 16 [**16a**] (although it is disrupted in Area 16 by strong responses from a buried service) (Figures 77 & 78). Similar anomalies occur along the southern boundary of Area 21 ([**21e**-**g**], although these are more fragmented due to the presence of anomalies relating to modern activity and field boundaries (Figures 91 & 92). These anomalies have been classified as Undetermined as their origin remains unclear; a high conductivity [**15e**] may be associated. Low conductivity in this area may relate to dewatering effects resulting from extant drainage ditches forming the survey boundary. Alternatively, undulations visible in LiDAR data extending across the floodplain to the northeast of Area 16 (Figure 79) are likely to result from historical

cultivation or land drainage; the strips and divisions they form share the alignment and width of [**15d**].

8.2.10.4. **Extraction –** Distributed across the southern edge of Area 15, several subcircular anomalies c.10m in diameter have been identified in the magnetic data (Figures 80 & 81). They correlate with depressions visible in satellite imagery and probably reflect former clay or gravel pits; similar features are known across the surrounding landscape.

8.2.10.5. **Undetermined (Magnetic)** – A number of faint narrow linear anomalies have been detected, occurring most frequently in Area 21. Their origins are uncertain and, although they may be associated with agricultural activity detected in the EM results, other anthropogenic or natural causes cannot be ruled out.

9. Reporting Zone O
9.1.Geographic Background

9.1.1. The survey area was located c.1.8km north from North Ockendon (Figure 1). Survey was undertaken across four fields under pasture. The survey area was bounded by the B187 St Mary's Lane to the north, the B186 Clay Tye Road to the east, a watercourse to the south and the M25 to the west (Figure 1).

9.1.2. Survey considerations:

Survey Area	Ground Conditions	Further Notes
25	Flat grassland (pasture).	Bounded to the north by a hedgerow with discontinuous wire fencing and an adjacent road, to the east and south by hedgerows, and to the west by dense vegetation and a steep embankment up to the M25.
26	Flat grassland (pasture).	Bounded to the north and east by hedgerows, to the south by a hedgerow (eastern half) and discontinuous wire fencing and dense vegetation (western half), and to the west by dense vegetation and a steep embankment up to the M25.
27	Flat grassland (pasture).	Bounded on all sides by hedgerows with additional discontinuous sections of wire fencing and a road immediately outside the eastern boundary.
28	Flat grassland (pasture).	Bounded to the north by a ditch with a road immediately beyond it, to the east by dense vegetation and a road, and to the south and west by hedgerows.

9.1.3. The underlying geology comprises clay, silt and sand of the London Clay. Superficial deposits of alluvium (clay, silt, sand and gravel) and head (clay, silt, sand and gravel) are recorded across the eastern and western halves of the survey area respectively (British Geological Survey, 2021).

9.1.4. The soils consist of slowly permeable seasonally wet slightly acid but base-rich loamy and clayey soils, with a band of loamy and clayey floodplain soils with naturally high groundwater recorded across the south-eastern corner of the survey area (Soilscapes, 2021).

9.2. Results

9.2.1. Discussion

9.2.1.1. The respective EM and magnetic surveys have generally responded well to the environment of the survey area. The survey results primarily reflect post-medieval agricultural activity, in the form of ploughing regimes, infilled ponds and land-drains. EM anomalies have been detected that are consistent with the recorded head and alluvial sediments across the survey area, and are similar to anomalies identified in other survey zones that are interpreted as such. Their categorisation here as Undetermined, however, reflects the unquantifiable possibility that the anomalies are also influenced by agricultural or other anthropogenic factors – this is difficult to resolve without broader spatial context. No anomalies have been detected that are suggestive of significant archaeological settlement.

9.2.2. Electromagnetic and Magnetic Results - Specific Anomalies

9.2.2.1. **Undetermined (EM)** – A number of EM anomalies indicating amorphous areas of elevated conductivity (represented by [**25a**], [**26a**], [**27a**], [**28a**] Figures 101 & 102) have been identified across the survey area. As noted above (Section 9.5.1.1), they are consistent with recorded superficial geology and may indicate increased clay content or groundwater accumulation, but their origins are difficult to confidently identify from the geophysical data alone. Undetermined anomalies representing smaller patches of low conductivity are located within Areas 25, 26 and 27, the origins of which are unclear.

9.2.2.2. **Agricultural –** Historical and/or modern ploughing is evident in both the EM (Figures 101 & 102) and magnetic results (Figures 104 & 105). These trends are aligned north-south in the western half of the site, and east-west in the eastern half. Discrete anomalies probably indicative of infilled ponds have been identified in Areas 28 and 27.

9.2.2.3. **Drainage Features –** A number of linear land drains have been detected across the area, running east-west across Areas 27 and 28, and approximately north-south in Area 25.

9.2.2.4. **Undetermined (Magnetic) –** Several small, isolated subcircular anomalies have been identified in the gradiometer data (Figures 104 & 105), the origins of which are uncertain. Given the geology of the survey area, and historic mapping evidence for extraction activity and 'clay' place names, they may indicate small clay pits.

10. Overall Conclusions

10.1. Electromagnetic induction and magnetic surveys have been successfully undertaken over 235ha, divided between four zones (S, J, P and O). 13.7ha could not be surveyed due to overgrown vegetation or tall and dense crop and 43.7ha were descoped. Both techniques have generally responded well to the environment of the survey area and, by targeting different ground properties, have provided complementary data. The EM survey was effective for understanding broader sedimentological and geomorphological elements of the landscape, while the magnetic data contributed to a more nuanced interpretation of detected features.

10.2. In Zone P, the survey data suggests a landscape dominated by the dynamic drainage system of the Mar Dyke river. The area surveyed effectively formed a transect across the drainage basin and anomalies were detected on the lower-lying ground that are interpreted as indicative of palaeochannels. Other anomalies relate to natural variations in superficial geology and soils. Many of the geophysical anomalies correlate closely with features indicated in remote sensing data or British Geological Survey mapping; others (particularly at the deeper depths) suggest the presence of additional features or facilitate a more refined interpretation ██████████████████████████████████████ nomalies indicating former watercourses, possible watercourse canalisation, ditched field boundaries and extensive land drain networks contribute to the impression of a wet low-lying environment, albeit one with evidence for human modification and management.

10.3. Anthropogenic activity was most apparent on the more elevated land of the southern and western valley sides. Although no anomalies were detected to directly suggest intensive settlement, historical and modern agricultural activity has been detected. To the south and east of the Mar Dyke (Zone P), this takes the form of a network of field enclosure that conforms to the wider coaxial landscape of this region; while well documented as post-medieval boundaries, they are likely to have earlier origins. To the west of the Mar Dyke (Zones P and O), multiple phases of agricultural activity have been detected, including an unmapped phase of land division.

10.4. In the southeast of the survey area (Zones S and J), anomalies reflecting agricultural activity have been detected on the higher ground of Zone J, while the character of further anomalies (including those indicating palaeochannels and increased salinity levels) reflect the low-lying coastal location of the site.

10.5. Interference from modern sources was minimal in the EM results. Although a number of buried services, as well as the effects of overhead power cables, were detected across the survey area, their impact was confined to the immediate vicinity of the features. Interference from the same sources was more significant in the magnetic data, producing prominent magnetic 'haloes' across wider areas; other broad ferrous anomalies were generally restricted to field perimeters.

11. Archiving

11.1. MS maintains an in-house digital archive, which is based on Schmidt and Ernenwein (2013). This stores the collected measurements, minimally processed data, georeferenced and un-georeferenced images, XY traces and a copy of the final report.

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

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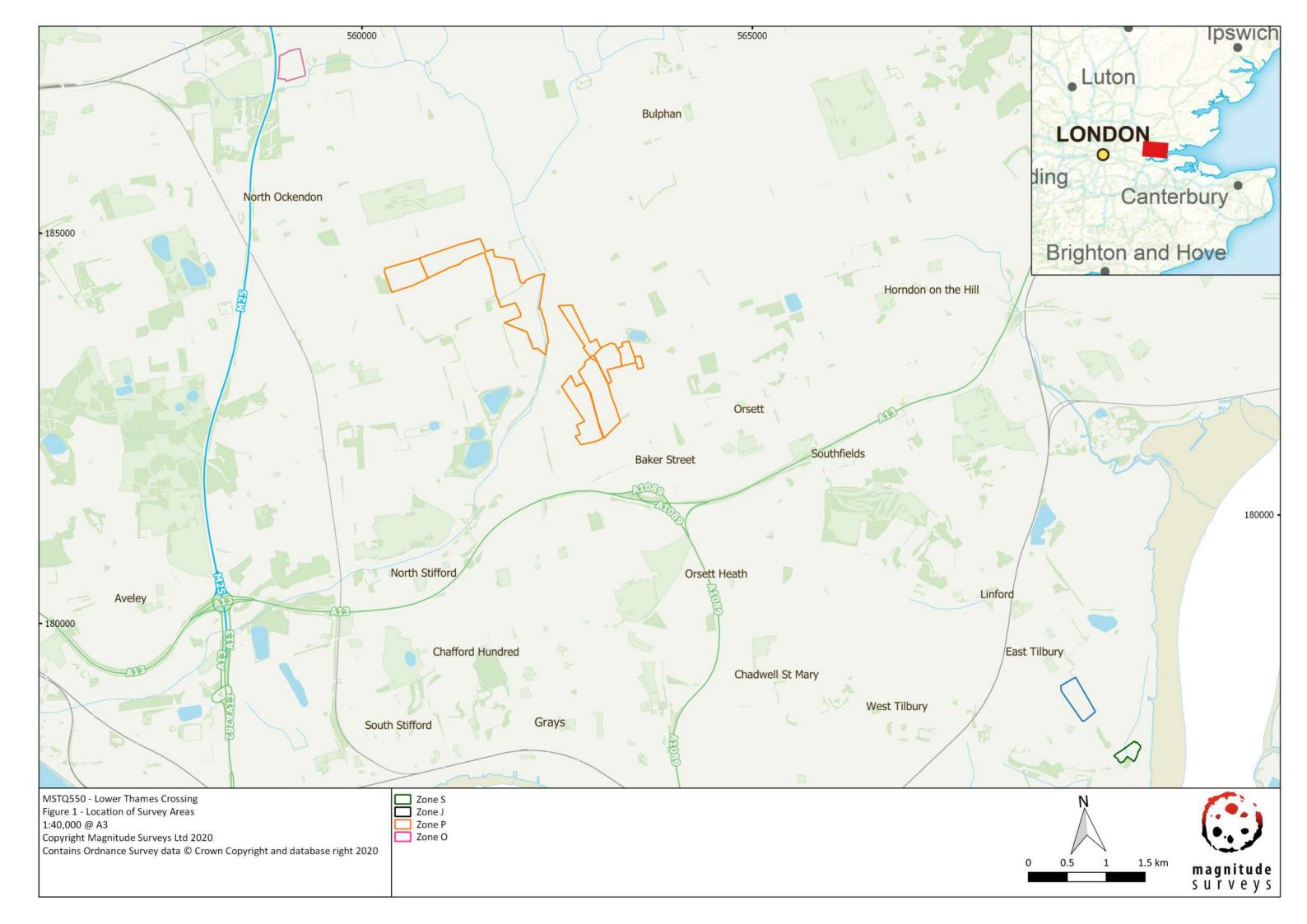
Soilscapes, 2021. [Orsett, Essex]. Cranfield University, National Soil Resources Institute ███████████████. [Accessed 23/09/2021].
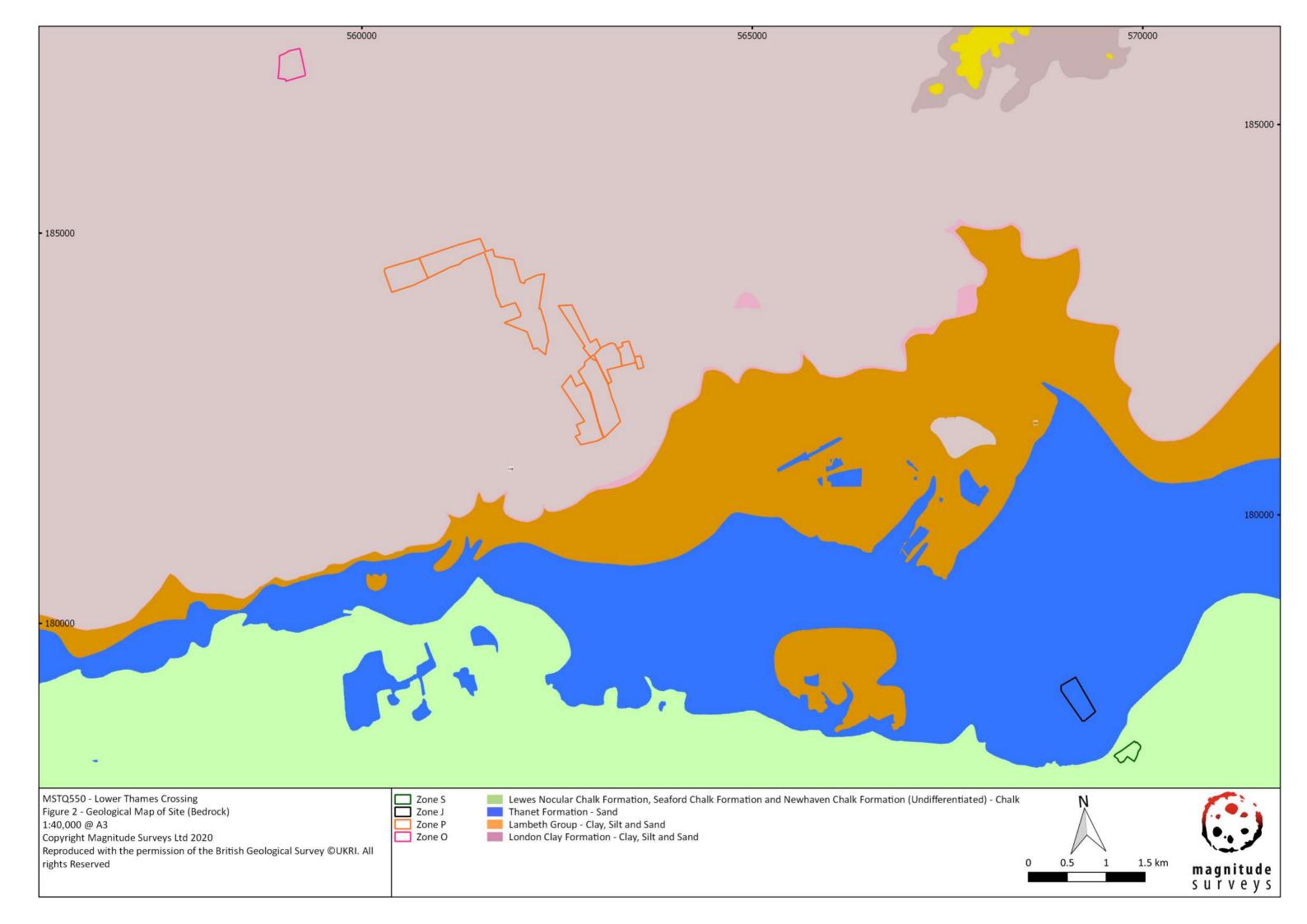
14. Project Metadata
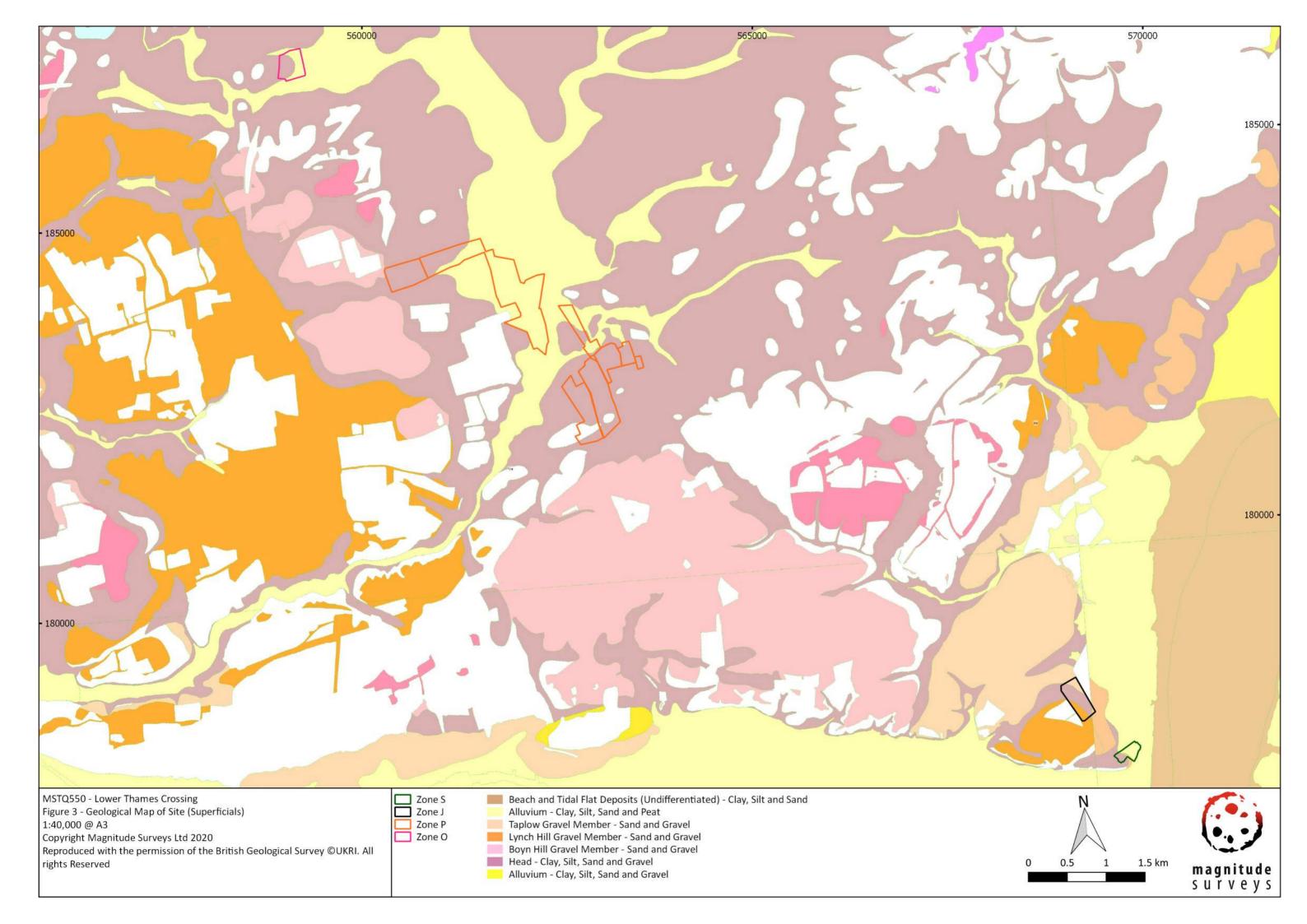
MS Job Code	MSTQ550
Project Name	Lower Thames Crossing
Client	Lower Thames Crossing
Grid Reference	TQ 59079 86906, TQ 62421 82972, TQ 68973 77127, TQ 68411 77891 and TQ 67013 70520
Survey Techniques	Magnetometry, EM
Survey Size (ha)	c.235ha magnetic and electromagnetic. c.177.6ha of which could be surveyed
Survey Dates	10/06/2020 to 03/09/2020
Project Lead	Finnegan Pope-Carter BSc (Hons) MSc FGS
Project Officer	Julia Cantarano Ingénieur PCIfA
HER Event No	N/A
OASIS No	N/A
S42 Licence No	N/A
Report Version	1.0

15. Document History
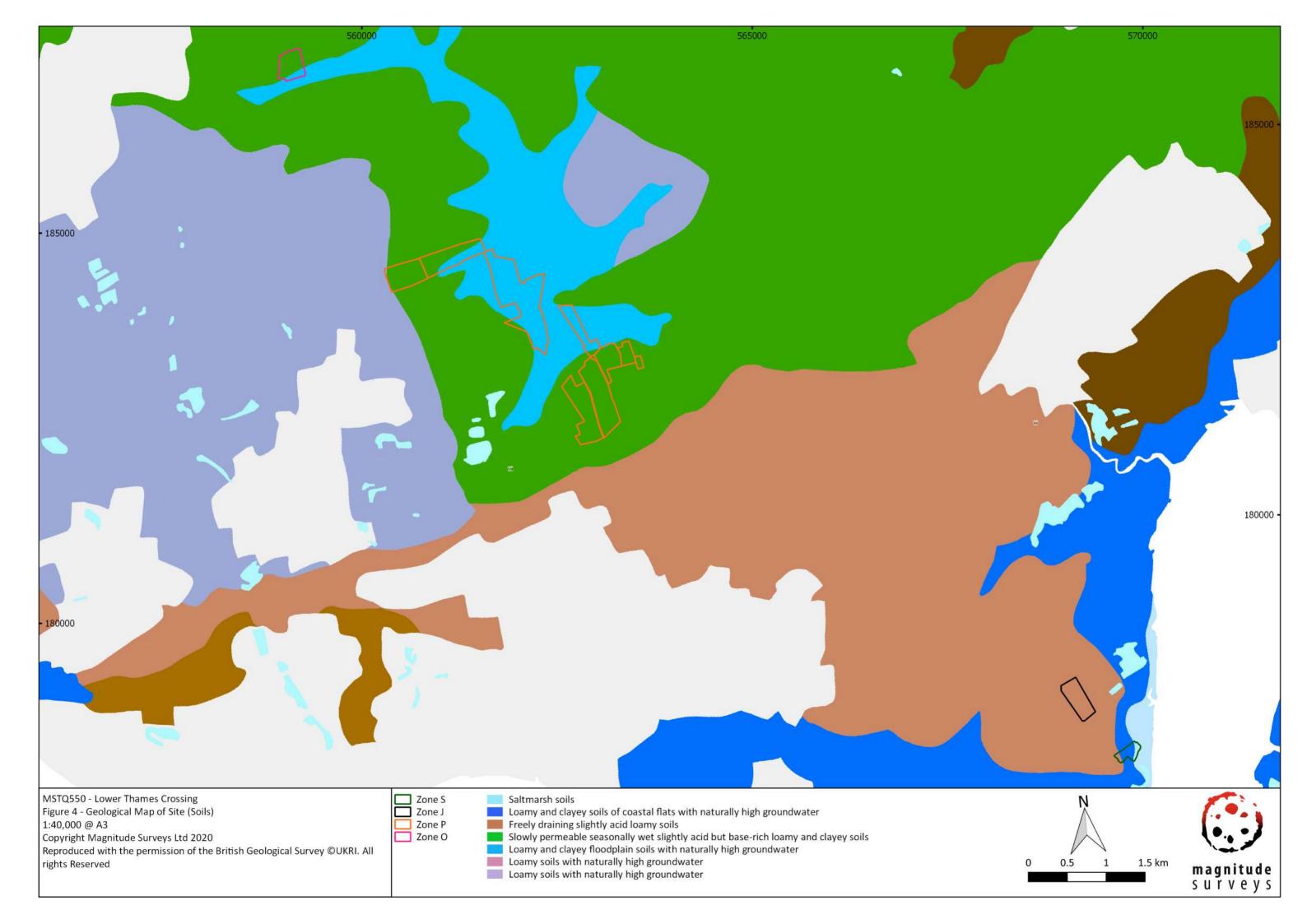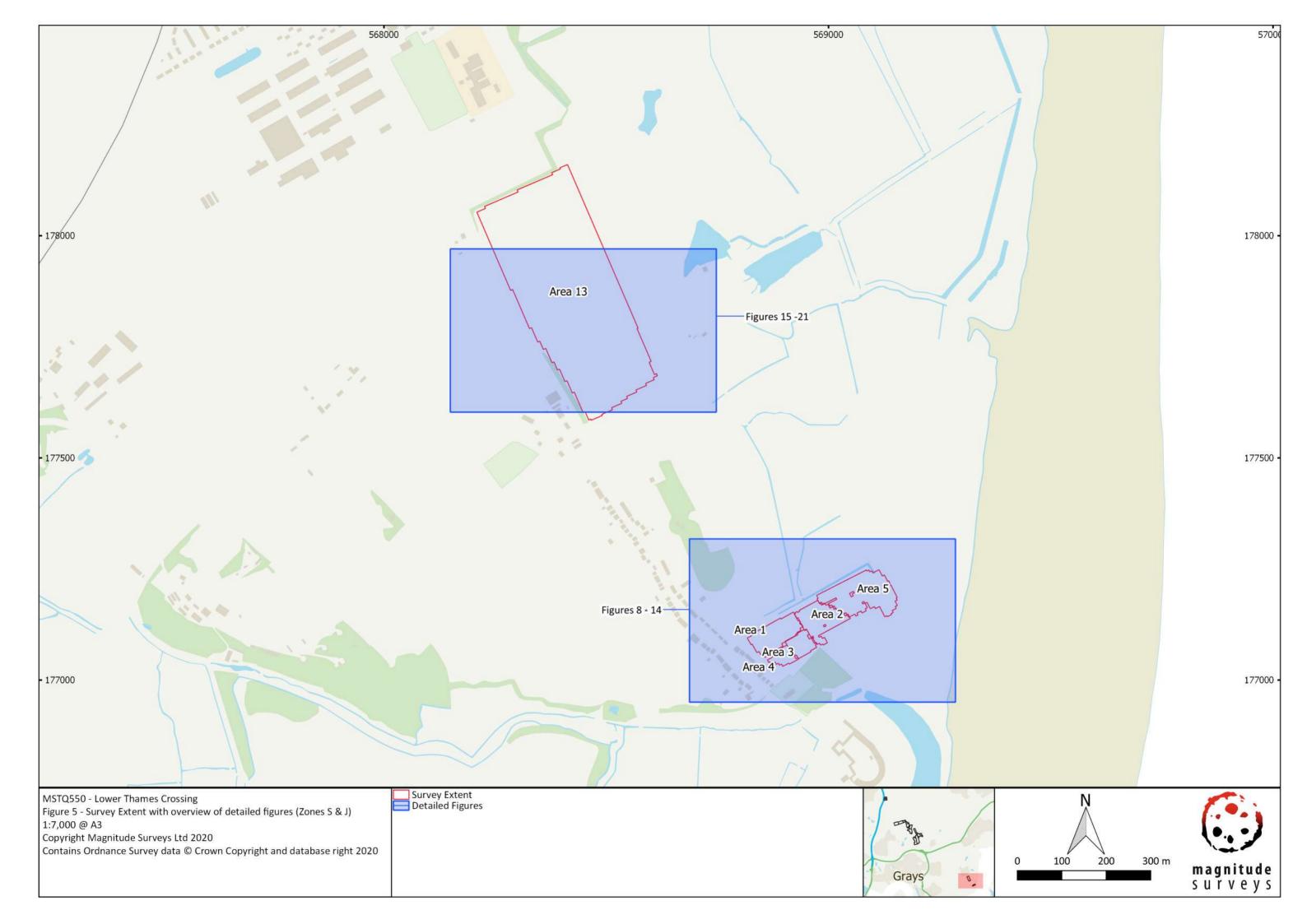
Version	Comments	Author	Checked By	Date
0.1	Initial draft for Project Lead to Review	HB	JC	02 October 2020
0.2	Draft for Director Approval	HB	KA, FPC	06 October 2020
1.0	Issued as Final	JC	FPC	24 February 2021

Inset map locations: Ipswich, Luton, LONDON, Canterbury, Brighton and Hove, ding

Map labels:
Bulphan
North Ockendon
Horndon on the Hill
Orsett
Southfields
Baker Street
North Stifford
Orsett Heath
Linford
Aveley
Chafford Hundred
Chadwell St Mary
East Tilbury
South Stifford
Grays
West Tilbury

560000
565000
185000
180000
180000
180000

M25
A13
A1089
A13/A282

MSTQ550 - Lower Thames Crossing
Figure 1 - Location of Survey Areas
1:40,000 @ A3
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Zone S
Zone J
Zone P
Zone O

N

0   0.5   1   1.5 km

magnitude
s u r v e y s

Zone S
Zone J
Zone P
Zone O

Lewes Nocular Chalk Formation, Seaford Chalk Formation and Newhaven Chalk Formation (Undifferentiated) - Chalk
Thanet Formation - Sand
Lambeth Group - Clay, Silt and Sand
London Clay Formation - Clay, Silt and Sand

N

0   0.5   1   1.5 km

magnitude
s u r v e y s

MSTQ550 - Lower Thames Crossing
Figure 3 - Geological Map of Site (Superficials)
1:40,000 @ A3
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Zone S
Zone J
Zone P
Zone O

Beach and Tidal Flat Deposits (Undifferentiated) - Clay, Silt and Sand
Alluvium - Clay, Silt, Sand and Peat
Taplow Gravel Member - Sand and Gravel
Lynch Hill Gravel Member - Sand and Gravel
Boyn Hill Gravel Member - Sand and Gravel
Head - Clay, Silt, Sand and Gravel
Alluvium - Clay, Silt, Sand and Gravel

0   0.5   1   1.5 km

N

magnitude
s u r v e y s

MSTQ550 - Lower Thames Crossing
Figure 4 - Geological Map of Site (Soils)
1:40,000 @ A3
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Zone S
Zone J
Zone P
Zone O

Saltmarsh soils
Loamy and clayey soils of coastal flats with naturally high groundwater
Freely draining slightly acid loamy soils
Slowly permeable seasonally wet slightly acid but base-rich loamy and clayey soils
Loamy and clayey floodplain soils with naturally high groundwater
Loamy soils with naturally high groundwater
Loamy soils with naturally high groundwater

N

0   0.5   1   1.5 km

568000

569000

57000

178000

178000

Area 13

Figures 15 -21

177500

177500

Figures 8 - 14

Area 5

Area 2

Area 1

Area 3

Area 4

177000

177000

MSTQ550 - Lower Thames Crossing
Figure 5 - Survey Extent with overview of detailed figures (Zones S & J)
1:7,000 @ A3
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Survey Extent
Detailed Figures

N

0   100   200   300 m

Grays

magnitude
s u r v e y s

Conductivity Coil 1

Conductivity Coil 2

Conductivity Coil 3

Area 13

Area 5
Area 1
Area 2
Area 3
Area 4

Low Conductivity High

MSTQ550 - Lower Thames Crossing
Figure 6 - Conductivity (Overview) (Zones S & J)
1:7,000 @ A3
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Palaeochannel - Strong
Natural - Low Conductivity
Field Boundary - Agricultural (Weak)
Modern Boundary Effect
Service

High Conductivity (Strong) - Undetermined
Low Conductivity (Strong) - Undetermined
Low Conductivity (Weak) - Undetermined
Agricultural (Trend)

Grays

N

0   250   500   750 m

magnitude
surveys

Inphase

Gradient

Total Field

Area 13
Area 5
Area 1
Area 2
Area 3
Area 4

Low   Inphase   High

-1   nT   2

48997   nT   49005

Agricultural (Strong)
Agricultural (Weak)
Possible Extraction (Strong)
Possible Extraction (Weak)
Natural (Strong)
Natural (Weak)
Natural (Zone)

Magnetic Disturbance
Ferrous/Debris (Spread)
Undetermined (Strong)
Undetermined (Weak)
Agricultural (Trend)
Service
Ferrous (Spike)

Grays

N

0   250   500   750 m

magnitude
surveys

Low   Conductivity   High

Zone J
Zone S

N

0   20   40   60 m

magnitude
surveys

568800
569000
569200

177200
177200

177000
177000

5c
5d
2b
2a
1a

Modern Boundary Effect
High Conductivity (Strong) - Undetermined
Low Conductivity (Strong) - Undetermined
Low Conductivity (Weak) - Undetermined
Zone J
Zone S

N

0   20   40   60 m

magnitude
surveys

Modern Boundary Effect
High Conductivity (Strong) - Undetermined
Low Conductivity (Strong) - Undetermined
Low Conductivity (Weak) - Undetermined
Zone J
Zone S

N

0   20   40   60 m

magnitude
s u r v e y s

568800

569000

569200

177200

177200

177000

177000

Area 5

Area 2

Area 1

Area 3

Area 4

-1   nT   2

Zone J
Zone S

N

0   20   40   60 m

magnitude
s u r v e y s

Figure 12 - Magnetic Interpretation (Areas 1 - 5)

Legend:
- Natural (Strong)
- Natural (Weak)
- Natural (Zone)
- Possible Extraction (Strong)
- Possible Extraction (Weak)
- Magnetic Disturbance
- Ferrous/Debris (Spread)
- Undetermined (Strong)
- Undetermined (Weak)
- Service
- Ferrous (Spike)
- Zone J
- Zone S

MSTQ550 - Lower Thames Crossing
Figure 12 - Magnetic Interpretation (Areas 1 - 5)
1:1,500 @ A3
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0   20   40   60 m

magnitude surveys

Map labels (as printed on the historic map):

W ↑ D

East Tilbury

S.P.O.

Ship (P.H.)

B. Ss W ↑ D

B. Ss W ↑ D

Ss W ↑ D

B. Ss W ↑ D

P

St. Katherine's

B. Ss W ↑ D

Coordinate labels: 568800, 569000, 569200, 177200, 177000

Legend:

Natural (Strong)
Natural (Weak)
Natural (Zone)
Possible Extraction (Strong)
Possible Extraction (Weak)
Magnetic Disturbance
Ferrous/Debris (Spread)
Undetermined (Strong)
Undetermined (Weak)
Service
Ferrous (Spike)
Zone J
Zone S

N

0   20   40   60 m

magnitude
s u r v e y s

568800   569000   569200

177200   177200

Area 5

Area 2

Area 1

Area 3

Area 4

177000   177000

Zone J
Zone S

N

0   20   40   60 m

magnitude
s u r v e y s

568200　　　　　　　　　　568400　　　　　　　　　　568600

177800　　　　　　　　　　　　　　　　　　　　　　　　　177800

MSTQ550 - Lower Thames Crossing
Figure 15 - Conductivity (Area 13)
1:1,500 @ A3
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Low　Conductivity　High

Zone J
Zone S

East Tilbury

N

0　20　40　60 m

magnitude
surveys

Figure 16 - EM Interpretation (Area 13)

568200
568400
568600

177800
177800

13g
13d
13b
13h
13i
13a

MSTQ550 - Lower Thames Crossing
Figure 16 - EM Interpretation (Area 13)
1:1,500 @ A3
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Palaeochannel - Strong
Natural - Low Conductivity
Field Boundary - Agricultural (Weak)
Modern Boundary Effect
Service
Agricultural (Trend)

Zone J
Zone S

East Tilbury

N

0   20   40   60 m

magnitude
s u r v e y s

Palaeochannel - Strong
Natural - Low Conductivity
Field Boundary - Agricultural (Weak)
Modern Boundary Effect
Service
Agricultural (Trend)
Zone J
Zone S

East Tilbury

N

0   20   40   60 m

magnitude
s u r v e y s

568200
568400
568600

Area 13

177800
177800

MSTQ550 - Lower Thames Crossing
Figure 18 - Magnetic Gradient (Area 13)
1:1,500 @ A3
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-1   nT   2

Zone J
Zone S

East Tilbury

N

0   20   40   60 m

magnitude
surveys

Area 13

13g
13d
13b
13h
13i
13a

East Tilbury

Agricultural (Strong)
Agricultural (Weak)
Possible Extraction (Weak)
Magnetic Disturbance
Undetermined (Weak)
Agricultural (Trend)
Service
Ferrous (Spike)

Zone J
Zone S

N

0   20   40   60 m

magnitude
surveys

G.P   B.S.W ↑ D. Nº 38

W

B.S.W ↑ D. Nº 37

B.S.W ↑ D

East Tilbury

Agricultural (Strong)
Agricultural (Weak)
Possible Extraction (Weak)
Magnetic Disturbance

Undetermined (Weak)
Agricultural (Trend)
Service
Ferrous (Spike)

Zone J
Zone S

N

0   20   40   60 m

magnitude
surveys

568200   568400   568600

Area 13

177800   177800

MSTQ550 - Lower Thames Crossing
Figure 21 - XY Trace Plot (Area 13)
30nT/cm at 1:1,500 @ A3
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Zone J
Zone S

East Tilbury

N

0   20   40   60 m

magnitude
surveys

Figures 63 - 69

Area 22

Area 7

Area 18

Area 6

Figures 49 - 55

Area 19

Area 11

Figures 39 - 45

Area 10

Figures 32 - 38

Area 12

Area 81

Figures 25 - 31

183000
183000
182500
182500
182000
182000

562000
563000

Survey Extent
Detailed Figures

MSTQ550 - Lower Thames Crossing
Figure 22 - Survey Extent with overview of detailed figures (Zone P (South))
1:7,000 @ A3
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Grays

N

0   100   200   300 m

magnitude
s u r v e y s

Conductivity Coil 1

Low Conductivity High

Conductivity Coil 2

Low Conductivity High

Conductivity Coil 3

Low Conductivity High

Area 22
Area 7
Area 18
Area 6
Area 11
Area 10
Area 19
Area 12
Area 81

MSTQ550 - Lower Thames Crossing
Figure 23 - Conductivity (Overview) (Zone P (South))
1:7,000 @ A3
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Palaeochannel - Strong
Palaeochannel - Weak
Possible Paleochannel
Possible Paleochannel (Weak)
Natural - High Conductivity
Natural - Low Conductivity
Infilled Pond - Mapped
Infilled Pond - Not Mapped
Field Boundary - Agricultural (Strong)
Field Boundary - Agricultural (Weak)

Drain - Agricultural (Weak)
Agricultural (Strong)
Agricultural (Weak)
Pylon - Strong
Pylon - Weak
Modern Boundary Effect
Service
Low Conductivity (Strong) - Undetermined
Agricultural (Trend)
Natural (Trend)

Grays

N

0   250   500   750 m

magnitude
surveys

Inphase

Low　Inphase　High

Gradient

-1　nT　2

Total Field

48997　nT　49005

Area 22　Area 7
Area 18
Area 6
Area 11
Area 10
Area 19
Area 12
Area 81

MSTQ550 - Lower Thames Crossing
Figure 24 - Inphase and Magnetic (Overview) (Zone P (South))
1:7,000 @ A3
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Agricultural (Strong)
Agricultural (Weak)
Agricultural (Spread)
Possible Extraction (Strong)
Natural (Strong)
Natural (Weak)
Magnetic Disturbance
Ferrous/Debris (Spread)

Undetermined (Strong)
Undetermined (Weak)
Undetermined (Spread)
Agricultural (Trend)
Service
Drainage Feature
Ferrous (Spike)

Grays

N

0　250　500　750 m

magnitude
surveys

562200
182000
562400
562600
562200
562800
181800
182000

Zone P

Low   Conductivity   High

N

0   20   40   60 m

magnitude
s u r v e y s

A13   A1089

Figure 26 - EM Interpretation (Areas 12 & 81 (South))

81e

81f

12e

12g

12f

562200
182000
562400
562600

562200

562800

181800

182000

MSTQ550 - Lower Thames Crossing
Figure 26 - EM Interpretation (Areas 12 & 81 (South))
1:1,500 @ A3
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Palaeochannel - Strong
Palaeochannel - Weak
Possible Paleochannel
Infilled Pond - Not Mapped
Field Boundary - Agricultural (Strong)

Field Boundary - Agricultural (Weak)
Pylon - Strong
Pylon - Weak
Modern Boundary Effect
Service

Zone P

N

0   20   40   60 m

magnitude
surveys

Legend:

- Palaeochannel - Strong
- Palaeochannel - Weak
- Possible Paleochannel
- Infilled Pond - Not Mapped
- Field Boundary - Agricultural (Strong)
- Field Boundary - Agricultural (Weak)
- Pylon - Strong
- Pylon - Weak
- Modern Boundary Effect
- Service
- Zone P

magnitude surveys

MSTQ550 - Lower Thames Crossing
Figure 28 - Magnetic Gradient (Areas 12 & 81 (South))
1:1,500 @ A3
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Zone P

-1   nT   2

N

0   20   40   60 m

magnitude
s u r v e y s

Agricultural (Strong)
Agricultural (Weak)
Magnetic Disturbance
Ferrous/Debris (Spread)

----- Service
Drainage Feature
· Ferrous (Spike)

Zone P

N

0   20   40   60 m

magnitude
s u r v e y s

Agricultural (Strong)
Agricultural (Weak)
Magnetic Disturbance
Ferrous/Debris (Spread)

Service
Drainage Feature
Ferrous (Spike)

Zone P

N

0   20   40   60 m

magnitude
s u r v e y s

562200
182000
562200
562400
562600
181800
562600
562800

MSTQ550 - Lower Thames Crossing
Figure 31 - XY Trace Plot (Areas 12 & 81 (South))
30nT/cm at 1:1,500 @ A3
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☐ Zone P

N

0   20   40   60 m

A13 A1089

magnitude
s u r v e y s

MSTQ550 - Lower Thames Crossing
Figure 32 - Conductivity (Areas 12 & 81 (North))
1:1,500 @ A3
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Zone P

Low   Conductivity   High

0   20   40   60 m

magnitude
s u r v e y s

Coordinate labels visible on map: 562200, 562400, 562600, 182400, 182600

Area labels: 81a, 81b, 81c, 81d, 81e, 12a, 12b, 12c, 12d, 12i

Legend:
- Palaeochannel - Strong
- Palaeochannel - Weak
- Possible Paleochannel
- Possible Paleochannel (Weak)
- Natural - High Conductivity
- Infilled Pond - Not Mapped
- Field Boundary - Agricultural (Strong)
- Field Boundary - Agricultural (Weak)
- Drain - Agricultural (Weak)
- Agricultural (Strong)
- Agricultural (Weak)
- Pylon - Strong
- Modern Boundary Effect
- Service
- Zone P

0 20 40 60 m

magnitude
surveys

MSTQ550 - Lower Thames Crossing
Figure 34 - EM Interpretation over LiDAR (Areas 12 & 81 (North))
1:1,500 @ A3
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Contains LiDAR data: © Environment Agency copyright and/or database right 2020

Legend:
- Palaeochannel - Strong
- Palaeochannel - Weak
- Possible Paleochannel
- Possible Paleochannel (Weak)
- Natural - High Conductivity
- Infilled Pond - Not Mapped
- Field Boundary - Agricultural (Strong)
- Field Boundary - Agricultural (Weak)
- Drain - Agricultural (Weak)
- Agricultural (Strong)
- Agricultural (Weak)
- Pylon - Strong
- Modern Boundary Effect
- Service
- Zone P

N

0   20   40   60 m

magnitude
s u r v e y s

Zone P

-1   nT   2

N

0   20   40   60 m

magnitude
s u r v e y s

562200 562600 562400 562600

182400

182600

562200

12i

12c

12b

12a

81a

81e

81d

81c

81b

12d

MSTQ550 - Lower Thames Crossing
Figure 36 - Magnetic Interpretation (Areas 12 & 81 (North))
1:1,500 @ A3
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Agricultural (Strong)
Agricultural (Weak)
Agricultural (Spread)
Magnetic Disturbance
Ferrous/Debris (Spread)

Agricultural (Trend)
Service
Drainage Feature
Ferrous (Spike)

Zone P

N

0 20 40 60 m

magnitude
surveys

Spring

Chantry Farm

F.P.

16

21

562200 562400 562600
182400 182600

Agricultural (Strong)
Agricultural (Weak)
Agricultural (Spread)
Magnetic Disturbance
Ferrous/Debris (Spread)

Agricultural (Trend)
Service
Drainage Feature
Ferrous (Spike)

Zone P

N

0   20   40   60 m

magnitude
s u r v e y s

562800 562600 562400 562600

182400 182600

562200

☐ Zone P

N

0   20   40   60 m

magnitude
s u r v e y s

Low   Conductivity   High

Zone P

N

0   20   40   60 m

magnitude
s u r v e y s

MSTQ550 - Lower Thames Crossing
Figure 40 - EM Interpretation (Areas 11 & 19)
1:1,500 @ A3
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Legend:
- Palaeochannel - Strong
- Palaeochannel - Weak
- Possible Paleochannel
- Natural - High Conductivity
- Natural - Low Conductivity
- Field Boundary - Agricultural (Strong)
- Field Boundary - Agricultural (Weak)
- Agricultural (Strong)
- Modern Boundary Effect
- Service
- Low Conductivity (Strong) - Undetermined
- Agricultural (Trend)
- Natural (Trend)
- Zone P

N

0   20   40   60 m

magnitude
s u r v e y s

MSTQ550 - Lower Thames Crossing
Figure 41 - EM Interpretation over LiDAR (Areas 11 & 19)
1:1,500 @ A3
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Contains LiDAR data: © Environment Agency copyright and/or database right 2020

Legend:
- Palaeochannel - Strong
- Palaeochannel - Weak
- Possible Paleochannel
- Natural - High Conductivity
- Natural - Low Conductivity
- Field Boundary - Agricultural (Strong)
- Field Boundary - Agricultural (Weak)
- Agricultural (Strong)
- Modern Boundary Effect
- Service
- Low Conductivity (Strong) - Undetermined
- Agricultural (Trend)
- Natural (Trend)
- Zone P

magnitude
surveys

Area 11

Zone P

-1   nT   2

N

0   20   40   60 m

magnitude
s u r v e y s

MSTQ550 - Lower Thames Crossing
Figure 43 - Magnetic Interpretation (Areas 11 & 19)
1:1,500 @ A3
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■ Agricultural (Strong)	■ Undetermined (Strong)
■ Agricultural (Weak)	■ Undetermined (Weak)
■ Natural (Strong)	▨ Undetermined (Spread)
■ Natural (Weak)	Agricultural (Trend)
■ Possible Extraction (Strong)	--- Service
■ Magnetic Disturbance	Drainage Feature
⬚ Ferrous/Debris (Spread)	· Ferrous (Spike)

Zone P

N

0   20   40   60 m

magnitude
surveys

Agricultural (Strong)
Agricultural (Weak)
Natural (Strong)
Natural (Weak)
Possible Extraction (Strong)
Magnetic Disturbance
Ferrous/Debris (Spread)

Undetermined (Strong)
Undetermined (Weak)
Undetermined (Spread)
Agricultural (Trend)
Service
Drainage Feature
Ferrous (Spike)

Zone P

magnitude
surveys

Area 11

Zone P

N

0   20   40   60 m

magnitude
s u r v e y s

Area 16

Area 15

Area 14

Area 24

Figures 77 - 83

Area 21

Figures 84 - 90

Area 23

Figures 70 - 76

Figures 91 - 97

Area 17

Area 20

Figures 56 - 62

Area 22

Figures 63 - 69

Area 7

Area 18

Area 6

Figures 49 - 55

MSTQ550 - Lower Thames Crossing
Figure 46 - Survey Extent with overview of detailed figures (Zone P (North))
1:7,000 @ A3
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Survey Extent
Detailed Figures

Grays

N

0   100   200   300 m

magnitude
surveys

Conductivity Coil 1

Conductivity Coil 2

Conductivity Coil 3

Low Conductivity High

Palaeochannel - Strong
Palaeochannel - Weak
Possible Paleochannel
Possible Paleochannel (Weak)
Natural - High Conductivity
Natural - Low Conductivity
Infilled Pond - Mapped
Infilled Pond - Not Mapped

Field Boundary - Agricultural (Strong)
Field Boundary - Agricultural (Weak)
Drain - Agricultural (Weak)
Agricultural (Strong)
Industrial/Modern Structure
Industrial/Modern Track
Pylon - Strong
Pylon - Weak

Modern Boundary Effect
Service
High Conductivity (Strong) - Undetermined
High Conductivity (Weak) - Undetermined
Low Conductivity (Strong) - Undetermined
Agricultural (Trend)
Natural (Trend)

Grays

N

0   250   500   750 m

magnitude
surveys

Inphase

Low   Inphase   High

Gradient

-1   nT   2

Total Field

48997   nT   49005

MSTQ550 - Lower Thames Crossing
Figure 48 - Inphase and Magnetic (Overview) (Zone P (North))
1:7,000 @ A3
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Agricultural (Strong)
Agricultural (Weak)
Agricultural (Spread)
Possible Extraction (Strong)
Possible Extraction (Weak)
Natural (Strong)
Natural (Weak)
Natural (Zone)
Magnetic Disturbance

Ferrous/Debris (Spread)
Undetermined (Strong)
Undetermined (Weak)
Undetermined (Spread)
Agricultural (Trend)
Service
Drainage Feature
Ferrous (Spike)

Grays

N

0   250   500   750 m

magnitude
surveys

MSTQ550 - Lower Thames Crossing
Figure 49 - Conductivity (Areas 6 & 7)
1:1,500 @ A3
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Low   Conductivity   High

Zone P

N

0   20   40   60 m

magnitude
s u r v e y s

562200 562400 562600

183000

182800

7e

6a

6b

6c

	Palaeochannel - Strong		Natural - Low Conductivity		Zone P
	Palaeochannel - Weak		Field Boundary - Agricultural (Weak)		
	Possible Paleochannel		Modern Boundary Effect		
	Possible Paleochannel (Weak)		Service		
	Natural - High Conductivity		Natural (Trend)		

N

0   20   40   60 m

magnitude
s u r v e y s

MSTQ550 - Lower Thames Crossing
Figure 51 - EM Interpretation over LiDAR (Areas 6 & 7)
1:1,500 @ A3
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Palaeochannel - Strong
Palaeochannel - Weak
Possible Paleochannel
Possible Paleochannel (Weak)
Natural - High Conductivity

Natural - Low Conductivity
Field Boundary - Agricultural (Weak)
Modern Boundary Effect
Service
Natural (Trend)

Zone P

0   20   40   60 m

magnitude
surveys

562200 562400 562600

183000 183000

182800 182800

Area 6

MSTQ550 - Lower Thames Crossing
Figure 52 - Magnetic Gradient (Areas 6 & 7)
1:1,500 @ A3
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Zone P

-1   nT   2

N

0   20   40   60 m

magnitude
s u r v e y s

183000
183000

7e

6a

6b

6c

Area 6

182800
182800

MSTQ550 - Lower Thames Crossing
Figure 53 - Magnetic Interpretation (Areas 6 & 7)
1:1,500 @ A3
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	Agricultural (Weak)		Ferrous/Debris (Spread)
	Natural (Strong)		Agricultural (Trend)
	Natural (Weak)		Drainage Feature
	Magnetic Disturbance		Ferrous (Spike)

Zone P

N

0   20   40   60 m

magnitude
s u r v e y s

562200　　　　　　　　562400　　　　　　　　562600

183000

182800

Agricultural (Weak)
Natural (Strong)
Natural (Weak)
Magnetic Disturbance

Ferrous/Debris (Spread)
Agricultural (Trend)
Drainage Feature
Ferrous (Spike)

Zone P

N

0　20　40　60 m

magnitude
s u r v e y s

562200   562400   562600

183000   183000

182800   182800

Area 6

MSTQ550 - Lower Thames Crossing
Figure 55 - XY Trace Plot (Areas 6 & 7)
30nT/cm at 1:1,500 @ A3
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☐ Zone P

N

0   20   40   60 m

magnitude
surveys

Low   Conductivity   High

Zone P

N

0   20   40   60 m

magnitude
s u r v e y s

Legend:
- Palaeochannel - Strong
- Palaeochannel - Weak
- Natural - High Conductivity
- Zone P

MSTQ550 - Lower Thames Crossing
Figure 57 - EM Interpretation (Area 7)
1:1,500 @ A3
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0   20   40   60 m

N

magnitude
surveys

MSTQ550 - Lower Thames Crossing
Figure 58 - EM Interpretation over LiDAR (Area 7)
1:1,500 @ A3
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Contains LiDAR data: © Environment Agency copyright and/or database right 2020

Palaeochannel - Strong   Natural - High Conductivity   Zone P
Palaeochannel - Weak

N

0   20   40   60 m

magnitude
surveys

562200 562400 562600

183400 183400

183200 183200

Area 7

MSTQ550 - Lower Thames Crossing
Figure 59 - Magnetic Gradient (Area 7)
1:1,500 @ A3
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☐ Zone P

-1   nT   2

N

0 20 40 60 m

magnitude
s u r v e y s

562200 562400 562600

183400 183400

183200 183200

7c

7b

7a

7d

Area 7

Natural (Strong)
Natural (Weak)
Magnetic Disturbance
Ferrous/Debris (Spread)
Agricultural (Trend)
Drainage Feature
Ferrous (Spike)
Zone P

N

0 20 40 60 m

magnitude
surveys

562200 562400 562600

183400 183400

183200 183200

MSTQ550 - Lower Thames Crossing
Figure 61 - Magnetic Interpretation over Historic Map(Area 7)
1:1,500 @ A3
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Contains historic maps: Ordnance Survey, 6" 2nd edition c. 1882-1913 ©
National Library of Scotland

Natural (Strong)
Natural (Weak)
Magnetic Disturbance
Ferrous/Debris (Spread)

Agricultural (Trend)
Drainage Feature
Ferrous (Spike)

Zone P

N

0 20 40 60 m

magnitude
surveys

562200   562400   562600

183400   183400

Area 7

183200   183200

MSTQ550 - Lower Thames Crossing
Figure 62 - XY Trace Plot (Area 7)
30nT/cm at 1:1,500 @ A3
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Zone P

N

0   20   40   60 m

magnitude
surveys

Zone P

Low   Conductivity   High

N

0   20   40   60 m

magnitude
surveys

Legend:

- Palaeochannel - Strong
- Palaeochannel - Weak
- Natural - Low Conductivity
- Field Boundary - Agricultural (Strong)
- Field Boundary - Agricultural (Weak)
- Drain - Agricultural (Weak)
- Pylon - Strong
- Modern Boundary Effect
- Service
- Zone P

MSTQ550 - Lower Thames Crossing
Figure 64 - EM Interpretation (Area 22)
1:1,500 @ A3
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0 20 40 60 m

magnitude
surveys

Legend:

- Palaeochannel - Strong
- Palaeochannel - Weak
- Natural - Low Conductivity
- Field Boundary - Agricultural (Strong)
- Field Boundary - Agricultural (Weak)
- Drain - Agricultural (Weak)
- Pylon - Strong
- Modern Boundary Effect
- Service
- Zone P

0 20 40 60 m

magnitude surveys

Area 22

3000
183200
183400

561800
561800

562000
562000

MSTQ550 - Lower Thames Crossing
Figure 66 - Magnetic Gradient (Area 22)
1:1,500 @ A3
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Zone P

-1   nT   2

N

0   20   40   60 m

magnitude
surveys

Area 22

22b

22c

22a

17a

Agricultural (Weak)
Agricultural (Spread)
Magnetic Disturbance
Ferrous/Debris (Spread)
Agricultural (Trend)
Service
Drainage Feature
Ferrous (Spike)
Zone P

0   20   40   60 m

magnitude
s u r v e y s

183000　　　　　　　　183200　　　　　　　　183400

561800

562000

Agricultural (Weak)　　　　Agricultural (Trend)
Agricultural (Spread)　　　　Service
Magnetic Disturbance　　　　Drainage Feature
Ferrous/Debris (Spread)　　·　Ferrous (Spike)

Zone P

0　　20　　40　　60 m

magnitude
s u r v e y s

Area 22

Zone P

0   20   40   60 m

magnitude
s u r v e y s

Zone P

Low   Conductivity   High

N

0   20   40   60 m

magnitude
s u r v e y s

Figure 71 - EM Interpretation (Areas 17 & 23)

MSTQ550 - Lower Thames Crossing
1:1,500 @ A3
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Palaeochannel - Strong
Palaeochannel - Weak
Possible Paleochannel
Possible Paleochannel (Weak)
Natural - High Conductivity
Natural - Low Conductivity
Infilled Pond - Mapped
Field Boundary - Agricultural (Weak)
Agricultural (Strong)

Industrial/Modern Structure
Industrial/Modern Track
Pylon - Weak
Modern Boundary Effect
Service
High Conductivity (Strong) - Undetermined
High Conductivity (Weak) - Undetermined
Low Conductivity (Strong) - Undetermined
Agricultural (Trend)

Zone P

N

0   20   40   60 m

magnitude
surveys

Palaeochannel - Strong
Palaeochannel - Weak
Possible Paleochannel
Possible Paleochannel (Weak)
Natural - High Conductivity
Natural - Low Conductivity
Infilled Pond - Mapped
Field Boundary - Agricultural (Weak)
Agricultural (Strong)

Industrial/Modern Structure
Industrial/Modern Track
Pylon - Weak
Modern Boundary Effect
Service
High Conductivity (Strong) - Undetermined
High Conductivity (Weak) - Undetermined
Low Conductivity (Strong) - Undetermined
Agricultural (Trend)

Zone P

N

0   20   40   60 m

magnitude
s u r v e y s

MSTQ550 - Lower Thames Crossing
Figure 73 - Magnetic Gradient (Areas 17 & 23)
1:1,500 @ A3
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Zone P

-1   nT   2

N

0   20   40   60 m

magnitude
s u r v e y s

561600   561800   562000

23a

Area 17

17c

183800   17d   183800

23b

17e   17b

Agricultural (Weak)   Undetermined (Weak)   Zone P
Natural (Weak)   Agricultural (Trend)
Magnetic Disturbance   Service
Ferrous/Debris (Spread) Drainage Feature
Undetermined (Strong)   Ferrous (Spike)

N

0   20   40   60 m

magnitude
surveys

Agricultural (Weak)
Natural (Weak)
Magnetic Disturbance
Ferrous/Debris (Spread)
Undetermined (Strong)

Undetermined (Weak)
Agricultural (Trend)
Service
Drainage Feature
Ferrous (Spike)

Zone P

N

0   20   40   60 m

magnitude
surveys

561600   561800   562000

183800   183800

MSTQ550 - Lower Thames Crossing
Figure 76 - XY Trace Plot (Areas 17 & 23)
30nT/cm at 1:1,500 @ A3
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Zone P

N

0   20   40   60 m

magnitude
surveys

MSTQ550 - Lower Thames Crossing
Figure 77 - Conductivity (Area 15, 16 & 24)
1:1,500 @ A3
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Low   Conductivity   High

Zone P

N

0   20   40   60 m

magnitude
surveys

Legend:
- Possible Paleochannel
- Possible Paleochannel (Weak)
- Natural - High Conductivity
- Natural - Low Conductivity
- Infilled Pond - Not Mapped
- Modern Boundary Effect
- Service
- High Conductivity (Strong) - Undetermined
- Low Conductivity (Strong) - Undetermined
- Agricultural (Trend)
- Zone P

0 20 40 60 m

magnitude
surveys

Figure 79 - EM Interpretation over LiDAR (Area 15, 16 & 24)

MSTQ550 - Lower Thames Crossing
Figure 79 - EM Interpretation over LiDAR (Area 15, 16 & 24)
1:1,500 @ A3
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Possible Paleochannel
Possible Paleochannel (Weak)
Natural - High Conductivity
Natural - Low Conductivity
Infilled Pond - Not Mapped

Modern Boundary Effect
Service
High Conductivity (Strong) - Undetermined
Low Conductivity (Strong) - Undetermined
Agricultural (Trend)

Zone P

magnitude
surveys

Area 16

Area 24

Zone P

-1   nT   2

N

0   20   40   60 m

magnitude
surveys

Area 16

16a

15c

15b

15d

15e

24b

24c

24a

Area 24

Zone P

561200　　561400　　561600

184400　　184400

184200　　184200

Possible Extraction (Strong)	Agricultural (Trend)	Zone P
Possible Extraction (Weak)	Service	
Magnetic Disturbance	Drainage Feature	
Undetermined (Strong)	Ferrous (Spike)	
Undetermined (Weak)		

N

0　20　40　60 m

magnitude
surveys

561200　　　　　　561400　　　　　　561600

184400

16

184200

■ Possible Extraction (Strong)	—— Agricultural (Trend)	☐ Zone P	
▦ Possible Extraction (Weak)	---- Service		
■ Magnetic Disturbance	—— Drainage Feature		
■ Undetermined (Strong)	· Ferrous (Spike)		
■ Undetermined (Weak)			

N

0　20　40　60 m

magnitude
s u r v e y s

Area 16

Area 24

561200 561400 561600
184400 184400
184200 184200

Zone P

N

0 20 40 60 m

magnitude
s u r v e y s

MSTQ550 - Lower Thames Crossing
Figure 84 - Conductivity (Area 14)
1:1,500 @ A3
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Zone P

Low   Conductivity   High

N

0   20   40   60 m

magnitude
surveys

Natural - High Conductivity
Natural - Low Conductivity
Infilled Pond - Not Mapped
Field Boundary - Agricultural (Strong)
Field Boundary - Agricultural (Weak)

Modern Boundary Effect
Service
Low Conductivity (Strong) - Undetermined
Agricultural (Trend)

Zone P

magnitude
surveys

MSTQ550 - Lower Thames Crossing
Figure 86 - EM Interpretation over LiDAR (Area 14)
1:1,500 @ A3
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Natural - High Conductivity
Natural - Low Conductivity
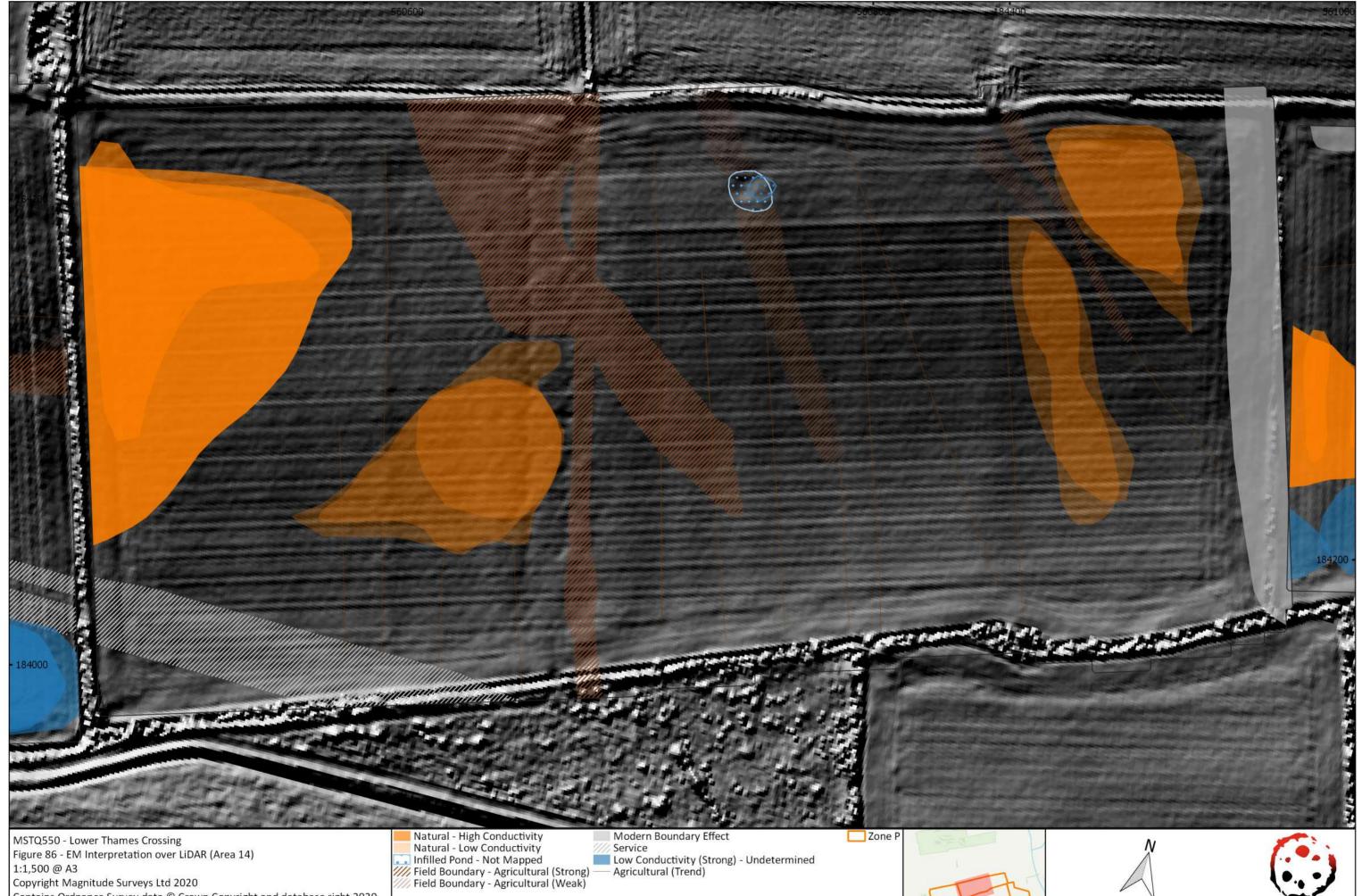Infilled Pond - Not Mapped
Field Boundary - Agricultural (Strong)
Field Boundary - Agricultural (Weak)
Modern Boundary Effect
Service
Low Conductivity (Strong) - Undetermined
Agricultural (Trend)
Zone P

0   20   40   60 m

magnitude
s u r v e y s

Area 14

MSTQ550 - Lower Thames Crossing
Figure 87 - Magnetic Gradient (Area 14)
1:1,500 @ A3
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Zone P

-1   nT   2

0   20   40   60 m

magnitude
surveys

Area 14

560600   Area 14   560800   184400   561000

184400

184200

14d

14a

14c

15a

184200

14b

184000

Agricultural (Strong)   Agricultural (Trend)   Zone P
Magnetic Disturbance   ----- Service
Ferrous/Debris (Spread)   · Ferrous (Spike)
Undetermined (Strong)

N

0   20   40   60 m

magnitude
surveys

560600 560800 184400 561000

184400

184200

184200

184000

Agricultural (Strong) — Agricultural (Trend)
Magnetic Disturbance ---- Service
Ferrous/Debris (Spread) · Ferrous (Spike)
Undetermined (Strong)

Zone P

N

0 20 40 60 m

magnitude
surveys

560600

560800

184400

561000

184400

184200

184200

184200

Zone P

N

0   20   40   60 m

magnitude
s u r v e y s

560000 184200 560200 560400

184200

184000

560600

184000

Zone P

Low   Conductivity   High

N

0   20   40   60 m

magnitude
s u r v e y s

Coordinate labels: 560000, 184200, 560200, 560400, 184200, 184000, 560600

Zone labels: 21a, 21b, 21c, 21d, 21e, 21f, 21g, 14a

Legend:
- Natural - High Conductivity
- Natural - Low Conductivity
- Field Boundary - Agricultural (Strong)
- Field Boundary - Agricultural (Weak)
- Industrial/Modern Structure
- Industrial/Modern Track
- Modern Boundary Effect
- Service
- Low Conductivity (Strong) - Undetermined
- Agricultural (Trend)
- Zone P

N

0   20   40   60 m

magnitude
surveys

MSTQ550 - Lower Thames Crossing
Figure 93 - EM Interpretation over LiDAR (Area 21)
1:1,500 @ A3
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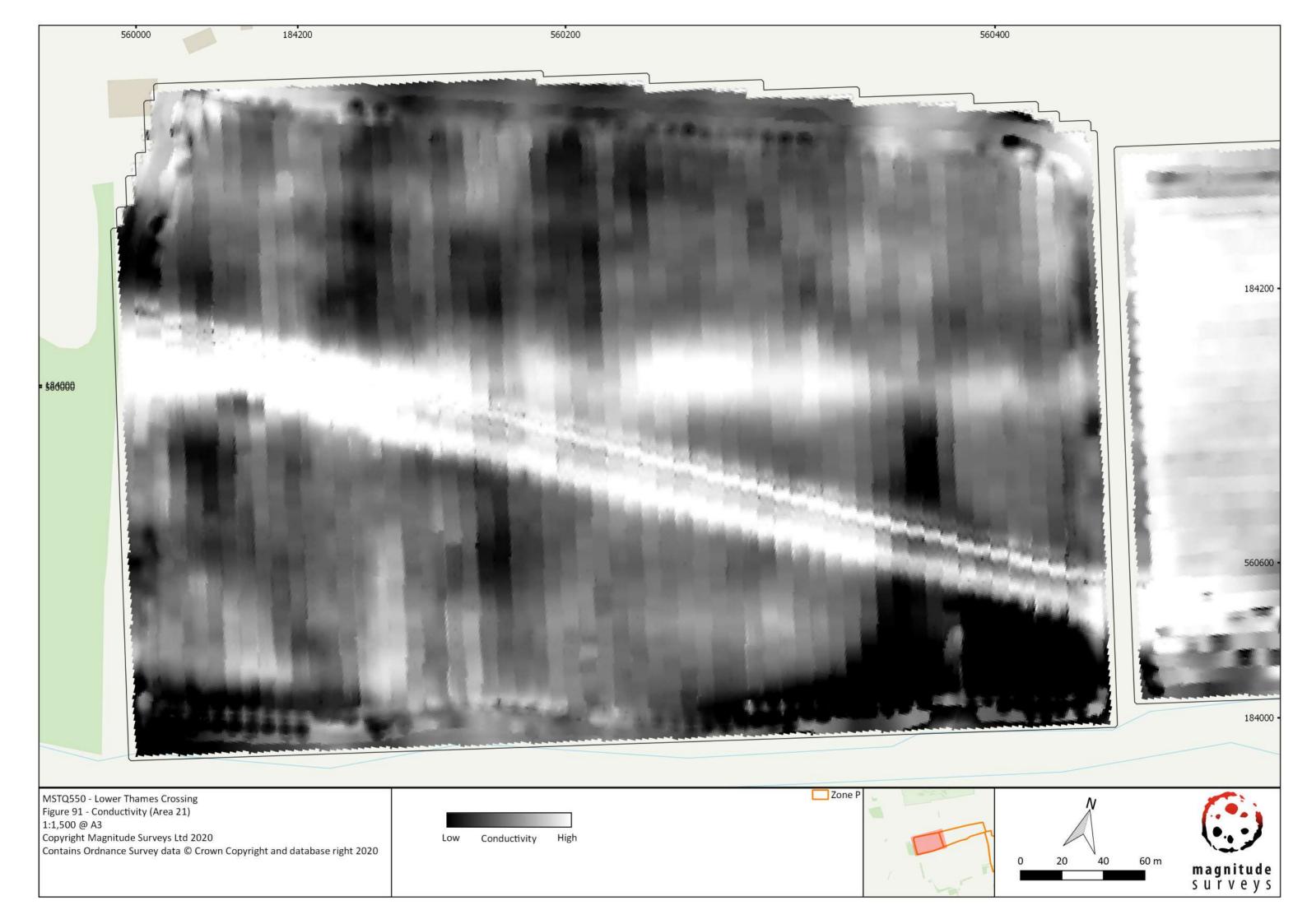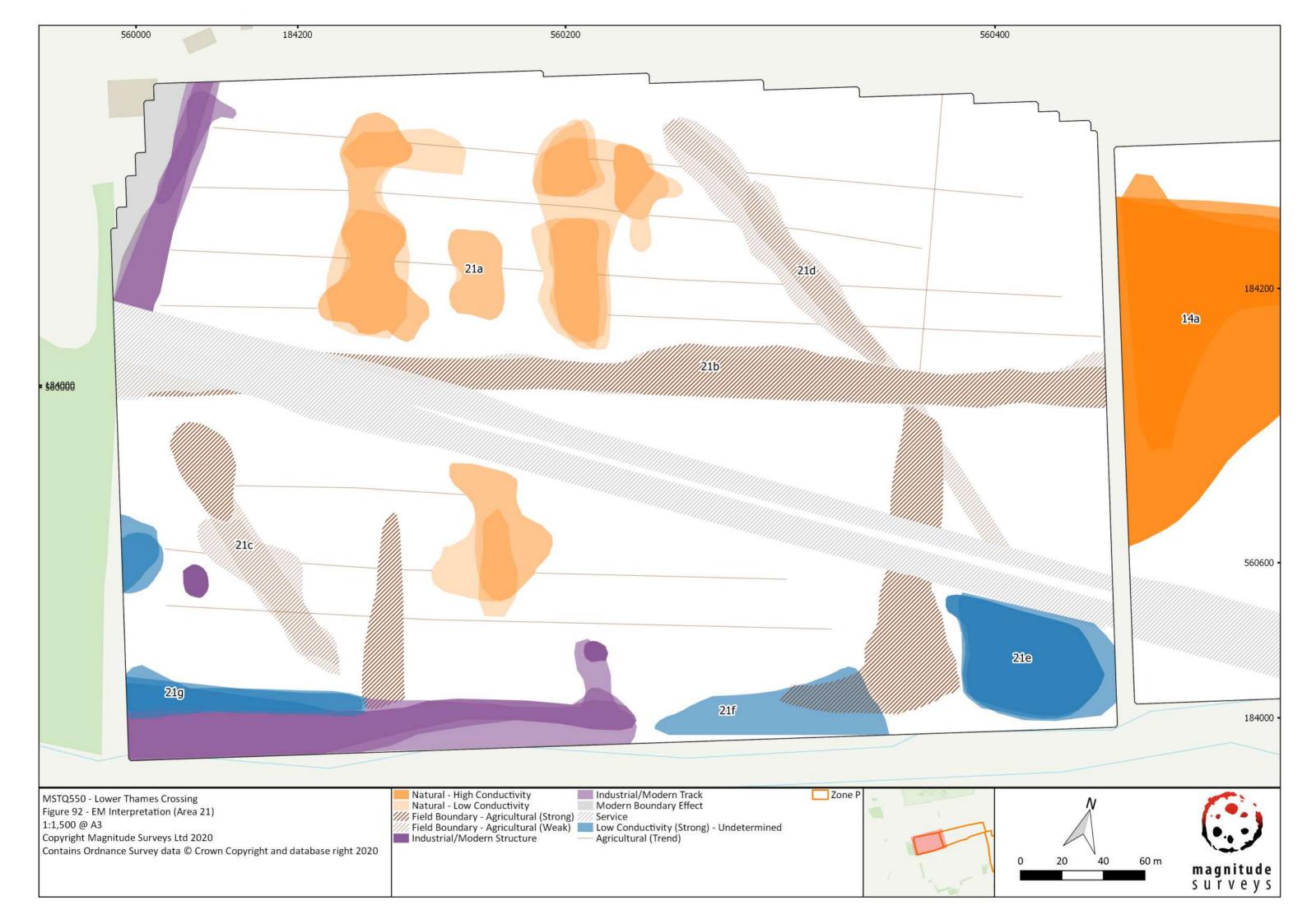Contains LiDAR data: © Environment Agency copyright and/or database right 2020

Natural - High Conductivity
Natural - Low Conductivity
Field Boundary - Agricultural (Strong)
Field Boundary - Agricultural (Weak)
Industrial/Modern Structure
Industrial/Modern Track
Modern Boundary Effect
Service
Low Conductivity (Strong) - Undetermined
Agricultural (Trend)
Zone P

magnitude
surveys

560000　184200　560200　560400

184200

184000

580600

184000

Zone P

-1　nT　2

N

0　20　40　60 m

magnitude
surveys

Legend:
- Agricultural (Strong)
- Natural (Zone)
- Magnetic Disturbance
- Undetermined (Strong)
- Undetermined (Weak)
- Undetermined (Spread)
- Agricultural (Trend)
- Service
- Ferrous (Spike)
- Zone P

21a, 21b, 21c, 21d, 21e, 21f, 21g, 14a

magnitude surveys

Agricultural (Strong)
Natural (Zone)
Magnetic Disturbance
Undetermined (Strong)
Undetermined (Weak)
Undetermined (Spread)
Agricultural (Trend)
Service
Ferrous (Spike)
Zone P

0   20   40   60 m

magnitude
surveys

184200

184000

MSTQ550 - Lower Thames Crossing
Figure 97 - XY Trace Plot (Area 21)
30nT/cm at 1:1,500 @ A3
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Zone P

N

0   20   40   60 m

magnitude
s u r v e y s

Figures 101 - 107

Area 25
Area 28
Area 26
Area 27

M25

558000
559000
560000

187500
187000
186500

Survey Extent
Detailed Figures

Grays

N

0   100   200   300 m

magnitude
s u r v e y s

Conductivity Coil 1

Conductivity Coil 2

Conductivity Coil 3

Low Conductivity High

Area 25
Area 26
Area 28
Area 27

MSTQ550 - Lower Thames Crossing
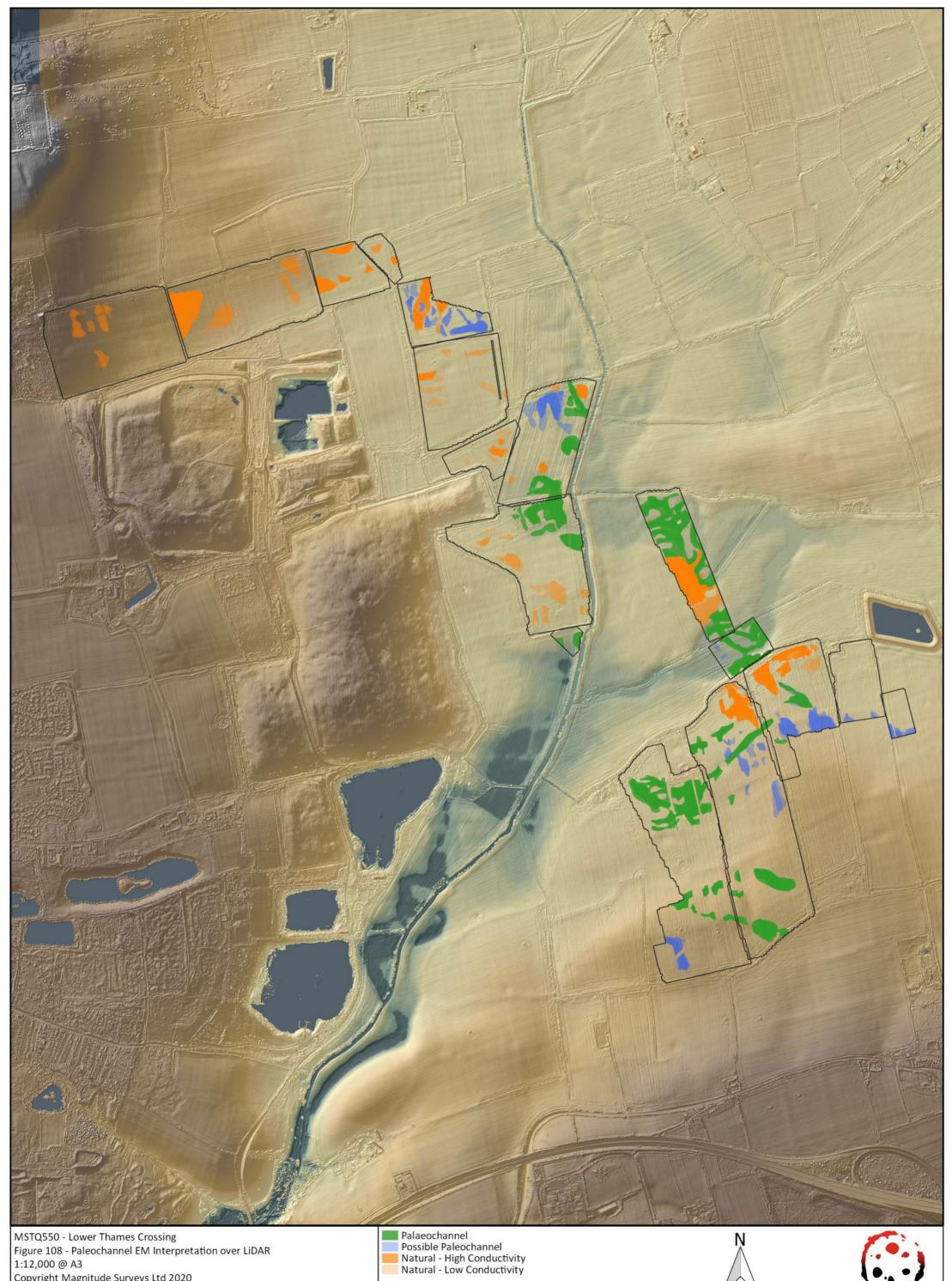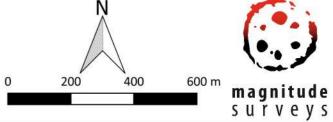Figure 99 - Conductivity (Overview) (Zone O)
1:7,000 @ A3
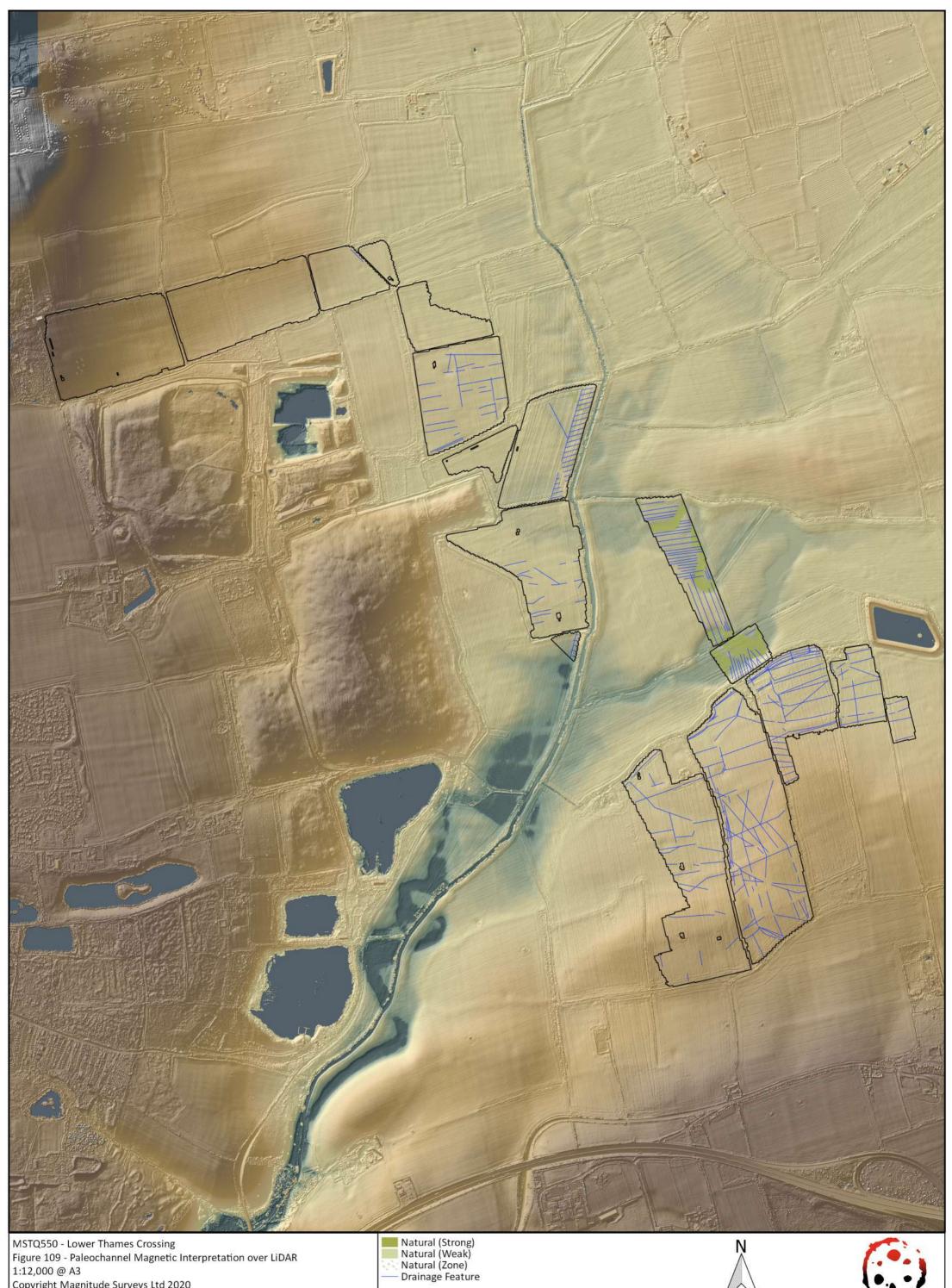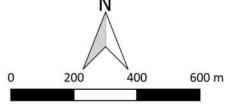Copyright Magnitude Surveys Ltd 2020
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Infilled Pond - Not Mapped
Modern Boundary Effect
High Conductivity (Strong) - Undetermined
Low Conductivity (Strong) - Undetermined
Low Conductivity (Weak) - Undetermined
Agricultural (Trend)

Grays

0   250   500   750 m

N

magnitude
surveys

Inphase

Low — Inphase — High

Gradient

-1 — nT — 2

Total Field

48997 — nT — 49005

Area 25
Area 26
Area 27
Area 28

M25

Natural (Weak)
Magnetic Disturbance
Ferrous/Debris (Spread)
Undetermined (Strong)
Undetermined (Weak)
Agricultural (Trend)
Natural (Trend)
Drainage Feature
Ferrous (Spike)

Grays

N

0   250   500   750 m

magnitude surveys

558800 · 187000 · 559000 · 559200

187000

186800

186800

Zone O

Low   Conductivity   High

N

0   20   40   60 m

magnitude
s u r v e y s

Infilled Pond - Not Mapped
Modern Boundary Effect
High Conductivity (Strong) - Undetermined
Low Conductivity (Strong) - Undetermined
Low Conductivity (Weak) - Undetermined
Agricultural (Trend)
Zone O

N

0   20   40   60 m

magnitude
surveys

Infilled Pond - Not Mapped
Modern Boundary Effect
High Conductivity (Strong) - Undetermined
Low Conductivity (Strong) - Undetermined
Low Conductivity (Weak) - Undetermined
Agricultural (Trend)
Zone O

N

0   20   40   60 m

magnitude
s u r v e y s

M25

187000

186800

187000

186800

MSTQ550 - Lower Thames Crossing
Figure 104 - Magnetic Gradient (Areas 25 - 28)
1:1,500 @ A3
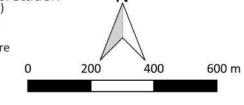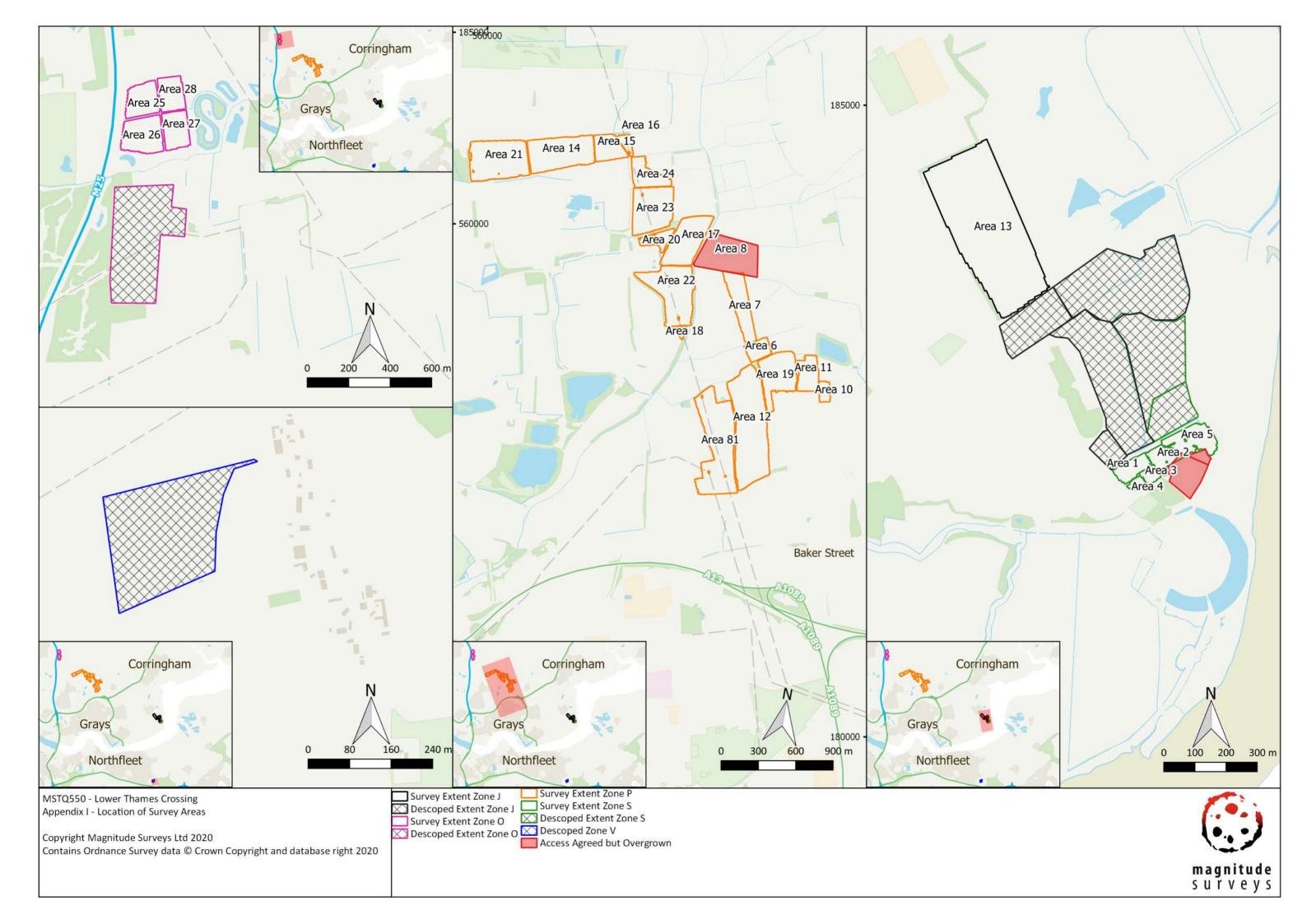Copyright Magnitude Surveys Ltd 2020
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Zone O

-1   nT   2

N

0   20   40   60 m

magnitude
s u r v e y s

Coordinate labels: 187000, 558800, 559000, 559200, 187000, 186800, 186800

Area labels: 25a, 28a, 26a, 27a, M25

Legend:
Natural (Weak)
Magnetic Disturbance
Ferrous/Debris (Spread)
Undetermined (Strong)
Undetermined (Weak)
Agricultural (Trend)
Natural (Trend)
Drainage Feature
Ferrous (Spike)
Zone O

N

0   20   40   60 m

magnitude
surveys

Natural (Weak)
Magnetic Disturbance
Ferrous/Debris (Spread)
Undetermined (Strong)
Undetermined (Weak)
Agricultural (Trend)
Natural (Trend)
Drainage Feature
Ferrous (Spike)
Zone O

magnitude
surveys

187000 558800 · 559000 · 559200

187000

186800

187000

186800

MSTQ550 - Lower Thames Crossing
Figure 107 - XY Trace Plot (Areas 25 - 28)
30nT/cm at 1:1,500 @ A3
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Zone O

N

0 20 40 60 m

magnitude
s u r v e y s

Palaeochannel
Possible Paleochannel
Natural - High Conductivity
Natural - Low Conductivity

N

0   200   400   600 m

magnitude
s u r v e y s

Natural (Strong)
Natural (Weak)
Natural (Zone)
Drainage Feature

N

0   200   400   600 m

magnitude
s u r v e y s

Conductivity Interpretation
- Palaeochannel
- Possible Paleochannel
- Natural - High Conductivity
- Natural - Low Conductivity

Magnetic Interpretation
- Natural (Strong)
- Natural (Weak)
- Natural (Zone)
- Drainage Feature

N

0   200   400   600 m

magnitude
surveys

MSTQ550 - Lower Thames Crossing
Appendix I - Location of Survey Areas

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☐ Survey Extent Zone J	☐ Survey Extent Zone P		
☒ Descoped Extent Zone J	☐ Survey Extent Zone S		
☐ Survey Extent Zone O	☒ Descoped Extent Zone S		
☒ Descoped Extent Zone O	☒ Descoped Zone V		
☐ Access Agreed but Overgrown			

magnitude
surveys

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