The London Resort Development Consent Order

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Appendix 14.7 – Earth Resistivity Tomography and Electromagnetic Induction Survey Report, 2017

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The London Resort Company Holdings Limited

The London Resort

Environmental Statement

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Appendix 14.7
London Resort
Earth Resistivity Tomography and
Electromagnetic Induction Survey Report

wessexarchaeology

London Resort, Swanscombe Peninsula, Kent

Earth Resistivity Tomography and
Electromagnetic Induction Survey Report

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Document Information

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Summary

An Electrical Resistivity Tomography (ERT) and Electromagnetic Induction (EMI) survey was conducted over land on the Swanscombe Peninsula, Kent (centred on NGR 560379 175682). The project was commissioned by Savills with the aim of providing information on the stratigraphic units across the site, in particular regarding the locations of any raised sand and gravel islands, major channels, and alluvium/ peat deposits and, thus characterise the landscape in terms of archaeologically relevant topographic features.

The Site is currently occupied by marshland, with some improved areas of agricultural land and extensive tracts of made ground. This made ground consists largely of built-up areas of cement kiln dust (CKD), a result of the previous industrial activities within the peninsula and surrounding landscape, with infilled quarries at its southern end; former industrial sites north of Manor Way are represented by building platforms, disused roadways, and tramways. To the south and east of Manor Way are extant industrial units that serve several industries.

The ERT survey was successful in detecting a wide range of stratigraphic units across the Site. These predominantly comprise deposits of made ground, alluvial silts/clays, river terrace sands/gravels and chalk. The resistivity dataset largely corresponds with anticipated values for each of these sub-surface materials, for example alluvial clays and silts are represented by low resistivity values, and sands and gravels by more moderate to high resistivity values.

Deposits of alluvial clays/silts can be mapped across most of the site, but vary significantly in thickness. These are perhaps thinnest (<4 m) in the northeasternmost corner, and the central southern parts of the Site. These areas also show the greatest variation within the deposits of river terrace gravels/sands, and several undulations were identified that could be attributed to possible channels or topographic variation. However, these are not easily defined and are often located at significant depth.

At the northernmost point of the peninsula, significant deposits (>6 m) of alluvial clays/silts were recorded. This suggests that a largely homogenous area of riverine deposits is located within this area to a significant depth. However, responses consistent with river terrace deposits of sand and gravels were identified at the very base of these ERT profiles, at a depth of -10 m OD and greater.

Evidence for chalk bedrock was limited, with a single ERT profile in the south of the site consistent with this interpretation. There is also limited evidence for raised sand and gravel islands within the ERT survey results, although the moderate resistivity values thought to be associated with river terrace deposits of sand/gravel are notably higher topographically in the centre of the Site.

The EMI survey was successful in detecting a number of areas of high and low conductivity across the Site. Where high conductivity has been encountered, it generally corresponds with areas of high magnetic susceptibility. Most of this variation is considered to be associated with features of relatively modern origin; structures associated with industrial activity at the site have been identified, as well as a pier and wharf and several areas of modern disturbance/made ground.

The results of the ERT and EMI survey corroborate each other well and have also shown the extent of made ground and modern disturbance across much of the site. Whilst attempts were made to use existing subsurface data to assist in this interpretation, there are only a limited number of relevant boreholes available. Thus, the understanding of the geophysical survey results would be greatly improved by a more targeted borehole survey as it is important to emphasise that the pseudo-sections are not an absolute representation of the underlying deposits.

Acknowledgements

Wessex Archaeology would like to thank London Resort Company Holdings for commissioning the geophysical survey.

The fieldwork was undertaken by Nicholas Crabb, Patricia Voke, Adrian Serbanescu, Rok Plesnicar and Alexander Schmidt. Nicholas Crabb, Tom Richardson, Patricia Voke and Alexander Schmidt processed and interpreted the geophysical data. Nicholas Crabb wrote the report and produced the illustrations. The geophysical work was quality controlled by Ben Urmston and the project was managed on behalf of Wessex Archaeology by Mark Williams.

London Resort

Swanscombe Peninsula, Kent

Electrical Resistivity Tomography and Electromagnetic Induction Survey Report

1 INTRODUCTION

1.1 Project background

1.1.1 Wessex Archaeology (WA) has been commissioned by Savills on behalf of the London Resort Company Holdings Limited to carry out geophysical surveys at Swanscombe Peninsula, Kent, which is the site for the proposed London Resort. The area specified for survey is focused primarily on the northern part of the Peninsula (hereafter "the Site", centred on NGR 560379 175682) (**Figure 1**).

1.1.2 The purpose of these geophysical surveys is to investigate the type, depth, and distribution of sediments across the Peninsula, in order to map the topography of the former ground surface upon which prior human activity would have taken place, and which has since been buried by significant thicknesses of Thames alluvial deposition.

1.1.3 The results, in conjunction with existing borehole data, should provide a starting point for characterising areas of the Peninsula in terms of differing archaeological potential, and therefore inform subsequent intrusive works.

1.2 Scope of document

1.2.1 This report presents a brief description of the methodology, followed by the detailed survey results and the archaeological interpretation of the geophysical data.

1.3 The Site

1.3.1 Swanscombe Peninsula is located on gently undulating ground lying at approximately 1m to 6m above Ordnance Survey Newlyn Datum (OD). The majority of the Peninsula is marshland, with some areas of improved agricultural land and extensive tracts of made ground. This made ground consists largely of built-up areas of cement kiln dust (CKD), a result of the previous industrial activities within the peninsula and surrounding landscape, along with infilled quarries at its southern end; former industrial sites north of Manor Way are represented by building platforms, disused roadways, and tramways. To the south and east of Manor Way are extant industrial units that serve a number of industries.

1.3.2 A flood defence bund surrounds the Peninsula along the water's edge, which protects the Peninsula from flooding from the Thames; however, the high water table across the Peninsula results in frequent flooding episodes throughout the year.

1.3.3 The underlying geology of the Peninsula has been mapped as the Seaford and Newhaven Chalk Formations with superficial deposits of alluvium, comprising clay, silts, peats, and sands (British Geological Survey 2017). This alluvium overlies gravel islands.

1.3.4 The soils underlying the Site are likely to consist of marine alluvium of the 813f (Wallasea 2) association (SSEW SE Sheet 6). Soils derived from such geological parent material have been shown to produce electrical and magnetic contrasts acceptable for the detection of archaeological remains through ERT and EMI surveys.

2 ARCHAEOLOGICAL AND HISTORICAL BACKGROUND

2.1 Introduction

2.1.1 A previous Archaeological Desk-Based Assessment (DBA) was undertaken by Wessex Archaeology (2015), which examined the potential for the survival of buried archaeological remains within a 1km Study Area centred on the Site and the wider development area. This DBA used information provided by the Kent Historic Environment Record (KHER), Essex Historic Environment Record (EHER) and the National Heritage List for England (NHLE). The following historical and archaeological background is summarised from relevant parts of the DBA.

2.2 Summary of the known archaeological resource

2.2.1 There are no designated historical assets within the Site; however, there are a number of Scheduled monuments (NHLE No. 1003557) associated with Palaeolithic activity 1.8km to the south, near Baker's Hole. The Palaeolithic Scheduled Monument lies within a larger Site of Special Scientific Interest (SSSI, Natural England ref. 1000259).

2.2.2 There are no Listed buildings within the Site, but *c.* 500 m south of the Site there is a Grade II* listed Church of All Saints (NHLE no. 1085781). Along the western boundary of the Site there is also a Grade II listed Garden Bridge at Ingress Park (NHLE No. 1410227) and a Boundary Stone (NHLE no. 1085781).

2.2.3 A plethora of prehistoric evidence has been recovered from the area surrounding the Site. Fieldwork was undertaken in 1930s within the Scheduled Monument known as Baker's Hole (NHLE: 1003557), with a large number of Levalloisian lithic remains recovered. Surviving islands of Pleistocene deposits were also identified at six locations within the area (Wenban-Smith 2013) and probable human remains of Upper Palaeolithic date have also been found from the Site. Immediately east of the Scheduled Monument, in the 19th century, "many thousands" (*ibid*.) of lithic artefacts were also discovered, which included Levalloisian cores, flakes, and hammer-stones.

2.2.4 There are several prehistoric finds spots within the vicinity of the Peninsula. These include four Palaeolithic handaxes, two Palaeolithic cores, a Neolithic polished axe head and some Neolithic flint implements. Neolithic human remains were recovered from the southwestern section of the Peninsula (HER No: MKE1667). Neolithic human remains were found in 1888 and were named the 'Galley Hill Man'.

2.2.5 The remains of a Bronze Age trackway were found on the foreshore near the mouth of Broadness Creek and a Bronze Age hoard is also thought to have been found within the Peninsula. Two areas of organic clay were exposed on Broadness saltmarsh within the northeastern section of the Peninsula and organic material recovered from the deposits dated to this period.

2.2.6 No finds dating to the Iron Age have been found within the Peninsula or its immediate surroundings. It is believed that during this period the Peninsula was marshland making it inhospitable. The nearest Iron Age sites include an Iron Age denehole containing human remains 350m to the southwest of the Peninsula, an Iron Age uninscribed gold stater 1km to the south, and an Iron Age spearhead and scraper 800m to the northeast.

2.2.7 Within the Site, a single piece of Roman tile was recovered on the Thames Foreshore near Broadness Creek in the northwestern part of the Peninsula. Finds recovered from the vicinity of the Site include a Romano-British pottery kiln 300m to the south, a possible

Romano-British cremation burial to the 450m to the southwest, and a Romano-British vase and cremation urn 420m to the south-west. An early Romano-British military encampment is also thought to have been located 450m to the southwest of the peninsula, where a large enclosure ditch, an oven and a cobbled surface were identified.

2.2.8 No Anglo-Saxon or medieval finds have been found within the Peninsula, suggesting it was still likely to have been marshland largely inhospitable for settlement. Finds recovered from the surrounding area include a medieval seal matrix 230m to the southwest of the Peninsula and a possible early medieval settlement thought to have been present at Greenhithe 890m to the south-west.

2.2.9 The nearest recorded medieval settlement was located in Swanscombe to the south of the Peninsula. The Domesday Book of 1086 records the settlement as very large comprising of 47 households with 33 villagers, three smallholders, 10 slaves and one man-at-arms. The Lord in 1086 was recorded as Richard, son of Count Gilbert, with the tenant-in-chief being Bishop Odo of Bayeux.

2.2.10 Much of the evidence dating to the post-medieval period has been found along the shoreline areas. A wooden structure thought to be the remains of a wharf, consisting of vertical wooden piles and beams, was identified in the southwestern section of the foreshore. Located close by upon the foreshore were further planks with drilled holes (HER No: MWX0283). To the north of this a long parallel line of wooden stakes and piles was identified along the foreshore, perhaps representing the remains of a sea wall dating from the post-medieval period. The possible remains of a wooden vessel have been identified partially buried within the sand and mud. The hard, or wharf, was represented by vertical piles or stakes, which may be associated with the front of a retaining wall as chalk rubble and debris were recorded behind the planks.

2.2.11 A series of five concrete pontoons believed to date to the post-medieval period. However, these are thought to have been removed as they were not present on previous site walkover surveys. At the tip of the Peninsula is a recorded derelict vessel and a wooden structure also thought to date to the post-medieval period.

2.2.12 Due to the estuarine location of the Peninsula it is likely that drainage ditches and land reclamation occurred during the post-medieval period. Therefore, it is likely that associated features may still be present within the Peninsula.

2.2.13 During the 19th century North Kent was the focus of industrial-scale cement production. In 1811 James Frost patented his ‘Portland Cement’ and developed its manufacture using a higher burning temperature at his works in Swanscombe located immediately south of the Peninsula (Eve 1999). In 1824 Joseph Aspdin patented another type of cement and his son set up works at Northfleet. One of Aspdin’s Kiln survives as a Scheduled Monument located 810m to the east of the Peninsula and is a distinctive beehive shape (List Entry: 1004227). The works were bought by Francis and White in 1833 and subsequently operated by J.B. White and Sons from 1838. In 1854 a kiln developed at the Swanscombe site was patented by Robert Owen White.

2.2.14 The development of the cement works to the south of the Peninsula can be seen on Ordnance Survey maps and through photographs of the works. In 1864-1884 the Portland Cement works occupied a triangular area between what is now Manor Way and the A228. Associated industry can be seen through the chalk pit to the south and the Cement Pits to the north. By the late 1890s the Cement works had expanded with larger square buildings covering the entirety of the previous triangular area and also expanding northwards and eastwards, covering a much larger area. The chalk pit to the south was disused by this time and a cement works building had been constructed within the old quarry. Tramways can also be seen upon the Ordnance Survey mapping leading between the buildings and also to Bell Wharf and Barge Yard Wharf, which were located on the foreshore of the Peninsula. At this time the cement works were building their own barges at Barge Yard Wharf, later referred to as Black Duck Barge Yard. The first barge built by the J.B. White company was called the Black Duck and was launched from Black Duck Wharf in 1892 (Willmott 1977).

2.2.15 The Black Duck Barge Yard was located within the northwestern corner of the Peninsula (HER No: MKE17099). The Yard comprised two square buildings to east of a slipway. By 1909 an additional building had been added and was named Black Duck Barge Yard. By the 1930s the yard had been removed. Several maritime features have been recorded close to the yard. These include the 19th-century wharf, a derelict vessel at Broadness Creek and a beacon at Broadness.

2.2.16 A tramway was established in the 19th century to link the Portland Cement works with its quarries and to White's Wharf and Bell Wharf at the northern part of the Peninsula. Over time the tramway adapted and expanded to include working extraction pits and the mainline railway. Some tram tunnels are recorded as still existing on the KHER and a number of derelict sections of tramline are still present within the Peninsula. White's Jetty was the Jetty associated with J.B. White's cement works and exists north of the former cement works in the north-west section of the Peninsula.

2.2.17 By the late 1890s the quarrying had been relocated to the east of the Peninsula. By 1909 the works had extended further still to the east with a large square building within what was the previous quarry to the east. The quarry was also moved further east. The building to the north of Manor Way had also been expanded north and the buildings south of Manor Way had also extended to the west.

2.2.18 The cement industry was in decline during the early 1900s and, with the event of WWI, many cement works were closed including Aspdin's works at Northfleet. After WWI, many works were taken over by Blue Circle including JB White's works at Swanscombe (Eve 1999; Francis 1977). By 1934 the cement works consisted of a few larger buildings rather than the previous profusion of smaller buildings. Black Duck Barge Wharf appears to be out of use by this time with the focus shifted to Bell Wharf at the northern part of the Peninsula. Travelling cranes, rectangular buildings and circular tanks can all be seen inland of the pier.

2.2.19 By 1962 the Swanscombe plant was producing 30,000 tonnes of cement and employed 750 people and in the 1970s a small amount of expansion had taken place to the west of the existing works to the north of Manor Way. The facility remained around the same size through the 1970s and 1980s, with some buildings to the south of Manor Way removed by the 1990s.

2.2.20 Along the riverside, what is thought to be a WWII tank trap is recorded comprising of 24 concrete blocks. However, it has also been suggested that it may be a collapsed sea defence erected to protect the beacon at Broadness.

2.2.21 An electricity pylon 190m high is recorded at the edge of the Peninsula, which connects to an identical pylon on the opposite side of the Thames close to the location of the former West Thurrock Power Station. The power station has been identified by Historic England as being of potential national importance due to its layout during the 1950s and 1960s.

2.2.22 A number of maritime features dated to the modern period have been recorded within the Peninsula. These include a small concrete pier, an abandoned wooden vessel in saltmarsh Broadness Creek, wooden posts, wooden foundations on foreshore at Botany Salt Marshes and a pier at Broadness. A mine-watching observation post was established at Bell Wharf on the edge of the Peninsula.

2.3 Recent investigations at the Site

2.3.1 Geoarchaeological investigations were undertaken within the Peninsula in advance of the construction of Channel Tunnel Rail Link (CTRL). These investigations revealed the presence of peat deposits upon the Peninsula, perhaps of prehistoric date and an assemblage of Palaeolithic and Neolithic flint as well as a small amount of pottery of this date (Bates *et al.* 2007; Bates *et al.* 2013).

2.3.2 A watching brief was undertaken on the Peninsula in 2012, but no archaeological finds or features were encountered. Another watching brief on the Peninsula, towards the western part, monitored four geotechnical test pits but did not reveal any archaeological remains.

2.3.3 Further geotechnical test pitting was subject to watching brief in 2003 at Swanscombe Peninsula West. Geotechnical testing was also undertaken in advance of the South Thames-side Development Route (STDR). The stratigraphy was recorded, but no archaeological features were mentioned. An evaluation was undertaken for this development, which extends outside the Peninsula. An assemblage of finds was recovered from deposits but not from definable features; this included prehistoric pottery, worked flint, and worked wood.

2.3.4 The monitoring of test pits and boreholes was undertaken in the eastern part of the Peninsula in advance of a sewerage pipeline route.

2.3.5 The North Kent Coast Rapid Coastal Zone Assessment was undertaken between 1999 and 2005. This included a field survey and visual assessment of the coastline. A watching brief undertaken at the western boundary of the Peninsula at Ingress Park did not reveal any finds or features.

3 METHODOLOGY

3.1 Introduction

3.1.1 The geophysical survey was undertaken by Wessex Archaeology's in-house geophysics team between 5th June and 14th July 2017. Weather at the time of the survey was generally dry throughout, with some limited rainfall. Ground conditions at the Site prevented the collection of geophysical survey data in an orthogonal 200m x 200m grid system, as was proposed in the Written Scheme of Investigation (Wessex Archaeology 2017). The marshland in the south-western of the peninsula was waterlogged and overgrown, and the field in the south-eastern extent was occupied by cattle. The southernmost portion of the Site is occupied by tarmac, hardstanding, and a number of quarry buildings and storage bays. Large parcels of land on the northern part of the peninsula were severely overgrown making it impossible to cover with either technique in the intended layout. Despite this, it was possible to survey the paths and trackways that traverse the Site, as well as some of the more open areas.

3.1.2 A total distance of 7.08km of Earth Resistivity Tomography (ERT) data was collected across 52 transects. For the Electromagnetic Induction (EMI) data, a total distance of 34.84km was achieved over a series of transects, surrounding areas covered by the ERT survey, as well as some of the more open areas on the Site.

3.1.3 Although the arrangement of both techniques varies significantly from what was set out by the WSI, where survey was possible, a good coverage was achieved with both geophysical techniques.

3.2 Aims and objectives

3.2.1 The aims for this geophysical survey comprise the following:

- to conduct a detailed survey covering as much of the specified area as possible, allowing for artificial obstructions;
- to use existing subsurface data (i.e. borehole data) to interpret the geophysical results;
- to provide information on the stratigraphic units across the site, in particular regarding the locations of any raised sand and gravel islands, major channels, and alluvium/ peat deposits; and
- in cooperation with the geoarchaeological team, to characterise the landscape as far as possible in terms of archaeologically relevant topographic features.

3.3 Fieldwork methodology

Electrical Resistivity Tomography

3.3.1 The ERT data was collected using an IRIS Syscal Pro with up to 72 electrodes arranged with a spacing of 2.5 m between electrodes. These were positioned along a series of linear transects distributed across the accessible parts of the Site.

3.3.2 ERT works by injecting electrical current into the ground between a pair of electrodes and measuring the voltage between another pair. By repeating these measurements along an array of probes on the surface, and using a number of different electrode separations, it is possible determine changes in resistivity (Ω·m) with increasing depth. Different subsurface materials respond differently to this applied electrical current and generally, areas with high clay content are characterised by lower resistivity values, and those with low clay content, such as sands and gravel or bedrock, will be displayed as higher resistivity. However, the specific resistivity values for any material are dependent on lithology, ground-water content, and porosity.

3.3.3 Prior to the recording of ERT data points a resistance measurement (Rs check) is taken of the whole dipoles in order to check that all the electrodes are correctly connected and that there is good ground contact. If this indicated that the line was open (electrode not correctly connected), improvements were made to the contact resistances at the ground surface, thus reducing the collection of 'bad' data points.

3.3.4 A Leica RTK GNSS GPS instrument, which is precise to approximately 0.02 m, was used to record the position of each electrode. This GPS data was used to correct the ERT profiles for topographic changes.

Electromagnetic Induction

3.3.5 The EMI survey was conducted using a GF Instruments CMD Explorer. This is a multi-receiver EMI conductivity instrument with two coils (a transmitter and receiver) at three inter-coil separations - 1.48, 2.82 and 4.49 m providing measurements from several depths consecutively. It made use of a CMD-4/6 probe assembled to its maximum length and setup to offer full depth penetration to approximately 6 m.

3.3.6 The EMI survey works by measuring the conductivity of different subsurface materials by injecting electrical currents into the ground with a transmitter coil and measuring the secondary induced magnetic field with a separate tuned receiver coil. Readings are simultaneously recorded for the quadrature component (apparent conductivity) and the in-phase component (magnetic susceptibility). High conductivity values can be associated with clays and silts, whilst with low conductivity values are likely to relate to deposits such as sands and gravels, which have higher electrical resistance. However, if anomalies of both high magnetic susceptibility and high conductivity are coincident, then it is likely that the feature is metallic and therefore likely to be modern or artificial in origin.

3.3.7 The EMI data was collected in transects surrounding the ERT transects, as well some additional open areas where the ERT was impractical.

3.3.8 A SBAS GPS system was used in order to facilitate continuous measurement which is precise to ±0.3 m. The location of these areas was compared against survey data collected using a Leica RTK GNSS GPS instrument, which is precise to approximately 0.02 m, in order to ensure accurate correspondence between the datasets.

3.4 Data processing

Electrical Resistivity Tomography

3.4.1 Data from the ERT survey was processed using the commercially available RES2DINV software to produce topographically corrected pseudo sections. Where necessary, 'bad' data points were exterminated in order to remove erroneously high or low data values before the calculation of an inverted model. Such values do not represent true resistivity measurements and are usually caused by systematic or random noise due to poor ground contact.

3.4.2 An inversion process is undertaken to convert the apparent resistivity values into pseudo-sections of estimated subsurface resistivity. The inversion routine used by the RES2DINV program is an iterative process based on the smoothness-constrained least-squares method. The results of this are then plotted against the depth for each midpoint in the electrode configuration. The main advantage of this method is that the damping factor and roughness filters can be adjusted to suit different types of data.

3.4.3 Further details of the geophysical and survey equipment, methods and processing are described in **Appendix 1**.

Electromagnetic Induction

3.4.4 Data from the EMI survey was subject to minimal data correction processes. This comprised a zero-median traverse function (1 SD thresholds) applied to correct for any variation between the different transect calibrations.

3.4.5 The EMI point data was gridded using GPR-SLICE software in order to produce 2D depth slices of conductivity (mS/m) and magnetic susceptibility (ppt) across the area at varying depths. This was undertaken for each nominal depth using GPR-Slice software for the quadrature component (apparent conductivity), and in-phase component (magnetic susceptibility).

3.4.6 Further details of the geophysical and survey equipment, methods and processing are described in **Appendix 2**.

3.1 Ground-truthing

3.1.1 Ideally, an accompanying borehole survey distributed across the area targeted by the geophysical survey would provide detailed ground-truthing data in order to aid interpretation of the results, in particular to correlate the ERT results with identified sediment types.

3.1.2 In the absence of a purposive borehole survey, a comparison of the results of this survey with data from previous investigations at the Site (e.g**. Figure 1**; Bates and Stafford 2013). Being concentrated in a specific area of the Site however, it is possible that not all sediment types encountered by the geophysical survey will be represented in this data. Should further borehole data be acquired in the future, it may be advantageous to reinterpret the results of this survey.

4 GEOPHYSICAL SURVEY RESULTS AND INTERPRETATION

4.1 Introduction

4.1.1 The results of each geophysical survey technique are discussed separately in the following section. A brief description of the location, site conditions and topography is made for each area and where possible, and relevant, reference will be made to any relevant borehole data from previous investigations at the Site that extend below a depth of 4 m.

4.1.2 The ERT survey results are presented as a series of colour-scale pseudo-sections with annotative interpretations. These are presented at the same vertical and horizontal scale, with a vertical exaggeration of 1.5. In order to enhance the resistivity contrasts, the pseudo-sections for each profile has been assigned the same logarithmic colour scale (**Figures 2** to **7**). This is designed to enhance lower resistivity features, as well as facilitate comparison across the entire dataset. Low resistivity values are displayed as blue (*c.* 0 Ω·m) and high resistivity as red/purple (*c.* >100-150+ Ω·m).

4.1.3 The EMI data are presented as two-dimensional colour-scale maps (depth-slices) displaying changes in apparent conductivity (mS/m) and magnetic susceptibility (ppt) at each of the three inter-coil separations (1.48m, 2.82m and 4.49m). The data for this survey was collected in the Horizontal coplanar (HCP) coil orientation, which offers greater depth penetration, but is less sensitive to shallow features. The has resulted in an effective depth range of 2.2m for the 1.48m coil, 4.2m for the 2.82m coil, 6.7m for the 4.49m coil (**Figures 8** to **13**). All of the depth slices are presented with the same linear colour scale with high conductivity/magnetic susceptibility displayed as red and low conductivity/magnetic susceptibility as blue.

4.1.4 The interpretation of the datasets highlights the presence of archaeologically relevant topographic features and provides information on the identifiable stratigraphic units across the site. This is based on the result of the ERT and EMI survey alone and would be subject to revision should any other information be provided by a subsequent borehole survey.

4.1.5 It is important to stipulate that all the depths referred to in this report are approximate levels below the current ground surface. As the ERT profile data is topographically corrected, these values are given in metres relative to the Ordnance Survey Newlyn Datum (m OD).

4.1.6 It should be noted that the specific resistivity response of the ERT survey depends on moisture contrasts in the soil, and that these fluctuate depending on the time of year, weather, vegetation, etc. EMI instruments are also sensitive to near-surface conductive objects; electrical interference from power lines and atmospheric sources can have a negative impact upon the survey results. Excessive disturbance can also impede the ability of geophysical techniques to detect archaeology. It may therefore be the case that more features are present than it has been possible to identify through the geophysical survey.

4.2 ERT survey results and interpretation

4.2.1 A total of 52 ERT profiles was recorded across the accessible areas of the Site. These transects were predominantly located in the northern portion of the Peninsula along the paths and trackways that cross the overgrown areas. The technique has been successful in identifying different subsurface materials that may be associated with archaeologically relevant topographic features, as well as evidence for made ground and other deposits of more recent origin. In the following section, the survey results for each pseudo-section are discussed in terms of their geophysical and topographic character.

4.2.2 Profile 1 (**Figure 2**) was located in the south-western extent of the Peninsula, north of the waterlogged Swanscombe marshes area, and approximately 45m south of the edge of the River Thames. It was directly north of the banked river defence and extended for a total distance of 240m. The topography of the profile rose gently from south-west (4.4m OD) to north-east (6m OD), although there was a slight dip towards the north-eastern end.

4.2.3 The uppermost 5m of the pseudo-section is characterised by resistivity values in the order of 2.5 to 7.5 Ω·m. This is consistent with made ground, probably associated with flood defences in this area of the Site. Below this, between 0m OD to approximately -6m OD there is a band of low resistivity (*c.* 0 to 2.5 Ω·m) that is likely due to riverine deposits of silts and clays. From this point to the deepest extent of the pseudo-section (*c.* -7.5m OD) the profile shows increasing resistivity, from 5 to 30 Ω·m. This could signify the presence sands and gravels associated with river terrace deposits. It is not thought that this response is associated with a chalk bedrock material as this would typically produce higher resistivity measurements in the order of 40 – 100 Ω·m.

4.2.4 Profile 2 (**Figure 2**) was located 23m to the north-east of Profile 1, on the southern side of the large flood defence bank close to the tarmac track that runs through the area. It extended for 152.5m and the topography sloped gradually from the southwest (4.8m OD) to the centre (3.5m OD), before rising gradually again to the northwest (4m OD).

4.2.5 From the ground surface to approximately -2m OD, the dataset is characterised by resistivity values of around 7.5 Ω·m. However, between 35m and 100m along the profile there is a region of moderately high resistivity (15 to 50 Ω·m). It is likely that this is an approximately 6m thick layer of made ground. Below this, lower resistivity values of 2 to 4 Ω·m are recorded to a depth of -10m to -12m OD, which are associated with alluvial silts and clays. It is possible that the subtle differences in the values recorded here may be different bands of alluvial clay and silts, however it is not possible to define this based on the results of this geophysical survey alone. From this depth to the base of the ERT profile (*c.* -17.5m OD) a slight increase in resistivity is recorded (5 to 20 Ω·m). This is thought to be associated with river terrace gravels/sands.

4.2.6 Profile 3 (**Figure 2**) was located approximately 30m north of the northeastern end of ERT profile 2. It was aligned southwest to northeast and measured 132.5m in length. The topography was relatively consistent, at around 7m OD at each end with a dip in the centre of around 6.3m OD. It was also located closer to the edge of the river on the northern side of the tarmac track.

4.2.7 The uppermost part of Pseudo-section 3 is characterised by resistivity values in the order of 4 to 20 Ω·m to a depth of *c.* 3m OD, which is associated with made ground. Extending below this to a depth of -4m OD is a band of low resistivity (0.5 to 2 Ω·m) that is consistent with wet alluvial clays/silts. This is followed by evidence for probable river terrace sands and gravels, which is represented by a 12m-thick band of moderate resistivity (4 to 20 Ω·m). It is possible that the higher resistivity values recorded at the very deepest part of the profile could be chalk bedrock, but these values are lower than would be expected for such material.

4.2.8 Profile 4 (**Figure 2**) was situated on a narrow and overgrown pathway, which extended for 125m. This was located approximately 40m south-east of the eastern end of Profile 3, and further from the river's edge. Although it was not possible to record topographic values for every electrode due to the tree coverage nearby, some values were recorded that indicate that the profile gradually slopes down from north-west to south-east (*c.* 3.8m to 2m OD).

4.2.9 From the ground surface to a depth of *c.* 0.5m OD a range of moderate resistivity values (4 to 20 Ω·m) were recorded. They are higher towards the northwestern extent, where values of up to 100 Ω·m were seen. For the most part, this is associated with made ground, and the higher values may represent a deposit of higher resistance materials such as concrete or rubble. Below this is a layer of lower resistivity values (0 to 3 Ω·m), which increases in thickness towards the southeast, extending to a depth of -7m OD. It is probable that these are alluvial silts and clays, which increase in thickness from the northwest to southeast. Underneath this, to the base of the recorded profile at -19m OD, there is a consistent layer moderate resistivity (*c.* 10 Ω·m). This is likely representative of river terrace gravels/sands. The similar nature of the response of this may suggest a degree of homogeneity.

4.2.10 Profile 5 (**Figure 2**) was 150m east of Profile 4 and was located on a track leading up to the large mound of CKD waste. It extended for 87.5m and was aligned northeast to southwest. The topography inclined relatively sharply from southwest (5.1m OD) to north-east (10.2m OD).

4.2.11 The uppermost part of Pseudo-section 5 is characterised by high resistivity values in the order of 100 Ω·m. It is likely that this is an area of made ground. Below this is a relatively thick band of moderately high resistivity (10 to 50 Ω·m) which extends to a depth of *c.* 8m OD that probably represents further deposits of CKD waste.

4.2.12 Profiles 6 to 8 (**Figure 2**) were all located on a large spoil heap of CKD waste. They were situated upon relatively flat ground on the top of the mound at *c.* 11m to 12m OD and each extended for 87.5m. Profile 6 was orientated WSW to ENE, Profile 7 was approximately west to east and Profile 8 was north to south. Profile 7 also intersected Profiles 6 and 8 at their eastern and northern extents respectively.

4.2.13 The resistivity values across Pseudo-sections 6 to 8 are very consistent, showing a 4m thick, high resistivity response in the uppermost section (from *c.* 12m OD to 8m OD). Below this they also show a more moderate response, albeit inconsistently, varying in magnitude from 4 to 20 Ω·m. It is likely that this response is largely associated with CKD waste, and the variations within the data are probably associated with different substrata within this.

4.2.14 Profile 9 (**Figure 3**) extended for 110m and was located directly south of the large electricity pylon previously mentioned in the historic background (para 2.2.21). It was situated approximately 65m southeast of the river's edge, along a track that leads to the pylon. The profile was aligned SSW to NNE and was relatively flat, standing at *c*. 5.2m.

4.2.15 The uppermost part of Pseudo-section 9 shows high resistivity values (5 to 75 Ω·m) from the ground surface to *c.* 1m OD, although it is apparently thicker in the north where it extends to a depth of around 0m OD. It is probable that this is an area of made ground and that the higher resistivity values are associated with large stones/boulders visible on the surface, which are assumed to be associated with flood defence in this area. Below this, to a depth of -10m OD, there is a thick band of low resistivity in the region of 0 to 2 Ω·m that is thought to relate to alluvial clays/silts. Deeper still, there is a thin band of higher resistivity 3 to 15 Ω·m that extends to the base of the profile at -16m OD. It is possible that this may be associated with terrace deposits of sand/gravel.

4.2.16 Profile 10 (**Figure 3**) intersected the northern part of Profile 9 and was also located close to the large electricity pylon by the Thames. It extended for 132.5m and was orientated approximately north - south. There was a very gradual incline from north to south (5.3m to 5.7m OD).

4.2.17 The upper and northern parts of the ERT profile is dominated by high resistivity values (20 to >150 Ω·m). This extends from the ground surface to -7m OD at its deepest point, and is most likely associated with made ground. The strength and depth of this response suggest that a significant deposit of high resistance material is located within this area. This is associated with some of the loose boulders that are visible on the surface. There is a discrepancy in the thickness of this material between Pseudo-section 9 and 10, suggesting a deeper deposit of made ground towards the south, perhaps associated with a localised depression in the area. Below this, there is a lower, more moderate range of values (*c.* 4 to 10 Ω·m) that may be terrace deposits of sand/gravel. On the southern side of Pseudo-section 10, there is a small area of low resistivity (0 to 2 Ω·m), which is likely to be alluvial silts and clays. However, this is poorly defined within this dataset due to the strength of the recorded resistivity values recorded in the near surface.

4.2.18 Profile 11 (**Figure 3**) was located approximately 30m east of Profile 10. It extended for 177.5m in length and descended very gradually from north-east (8.4m OD) to south-west (7.7m OD), although there was a sharper break of slope and dip in the centre at around 85m to 100m along the profile.

4.2.19 High resistivity values in the order of 10 to 100 Ω·m are recorded from the ground surface to approximately 2m OD, suggesting that the there is a *c.* 6 m-thick layer of made ground around Pseudo-section 11. This is thicker and stronger at the north-eastern end of the profile, perhaps accounting for the gentle rise in topography. Descending below this, until around -11m OD is a thick low resistivity layer (0 to 2 Ω·m), which is consistent with deposits of alluvial clays/silts. Beyond this to the base of the ERT profile (-18m OD), there is a band of moderate resistivity (3 to 15 Ω·m), thought to relate to terrace sands/gravels.

4.2.20 Profiles 12 and 13 (**Figure 3**) were located roughly perpendicular to one another, directly north of a large lake or balancing pond along a track that traverses the area. Profile 12 was orientated WNW to ESE and extended for 107.5 m. It descended sharply from the north-west (8.6m OD), before plateauing at around 4.8m OD, 40m along the profile. Profile 13 was more gradual and inclined gradually from the south-west (4.4m OD) to the north-east (5.1m OD).

4.2.21 Both Pseudo-section 12 and 13 show a similar range of responses, with the uppermost segment being largely characterised by high resistivity readings around 10 to 100 Ω·m. This is consistently the same thickness between 3m to 4m and extending to a depth of 1m to 4m OD, depending on the height of the ground surface. This is most likely an area of made ground that was probably overlain at a consistent thickness over the pre-existing topography of the area. Below this there is a thick band of low resistivity (0 to 2 Ω·m), which is visible to a depth of -9m to -11m OD. This associated with alluvial clays and silts. Following this, the resistivity increases, with values in the order of 3 to 10 Ω·m recorded to a depth of -12m to -14m OD. This is potentially due to deposits of terrace sands/gravels.

4.2.22 Profiles 14 and 15 (**Figure 3**) were situated on a WNW to ESE orientation and were roughly parallel with one another and separated by approximately 30m. Profile 14 was 132.5m long, and Profile 15 extended for 117.5 m and both were located adjacent to different tracks.

4.2.23 Both pseudo-sections are characterised by a relatively thin band of moderate resistivity (3 to 10 Ω·m) close to the surface, which represents made ground. Below this, until approximately -3m to -5m OD, there is a band of low resistivity values (*c.* 0 to 2 Ω·m) that are most likely associated with alluvial clays and silts. From this point, until the base of the profiles at *c.* -19m OD, there is a band of material characterised by more moderate resistivity (5 to 10 Ω·m), which is thought to relate to river terrace gravels or sands.

4.2.24 Profile 16-18 (**Figures 3 and 4**) were located on large a spoil heap containing CKD waste. This was located directly north of the sewage works located in the centre of the Site. Profile 16 extended for 177.5m and sharply inclined from west (4m OD) to east (12.1m OD), although it peaked at around 130m along the profile at 13.6m OD. Profile 17 was 87.5m long and was situated on a plateau at the top of the mound, and was very flat at approximately 12.5m OD. Profile 18 was approximately 30m to the east of the eastern end of Profile 16. This was 132.5m long and was located on the western side of the mound. The topography declined gently from northwest (12.1m OD) to southeast, steepening in the west (*c.* 5.6m OD).

4.2.25 All three pseudo-sections located in this area (16 to 18) show particularly high resistivity readings in the order of 10 to 100 Ω·m close to the surface. This is representative of made ground associated with the CKD waste heap in this area. Below this, mixed responses varying from relatively low resistivity (0 to 5 Ω·m) to moderate resistivity (10 to 50 Ω·m) are visible from a depth of 0 m OD. It is possible that these values could relate to river terrace gravels, with limited or no alluvial overburden above this, extending to a depth of *c.* -13m OD. However, the mixed nature of the responses makes this difficult to confirm and it may be that the disturbance caused by the CKD waste mound is more extensive.

4.2.26 Pseudo-sections 19 to 21 (**Figure 4**) were also positioned on approximate north-west to south-east alignments to the north-east of the large CKD spoil heap, and south of an electricity pylon, in the centre of the site. They all lay on relatively flat ground with little topographic change. However, there was a slight decline from north-west to south-east across all three profiles with levels recorded at *c.* 6m OD for Profile 19, 2.5m OD for Profile 20 and 5m OD for Profile 21.

4.2.27 Pseudo-section 19 is located closest to the mound, approximately 75m northeast of Pseudo-section 18. In the north-eastern part of the section there is an area of high resistivity (10 to 100 Ω·m), which is visible to a depth of 3m OD and is associated with made ground. In the south-western part of the profile there is a thicker band of low resistivity (0 to 2 Ω·m), which relates to alluvial silts and clays to an approximate depth of 1m OD. Below this there is a relatively consistent band of moderate resistivity (2 to 10 Ω·m) throughout the remainder of the profile to -16m OD.

4.2.28 Pseudo-sections 20 and 21 display a very similar range of characteristics. In both profiles, there is evidence for made ground in the form of a thin band of higher resistivity (5 to 20 Ω·m) close to the surface. This extends to a depth of 0m OD and 2.5m OD respectively. Following this, low resistivity values (0 to 2 Ω·m) are recorded to depths of -2m to -4m OD, which may be alluvial clays and silts. Within the centre of Pseudo-section 21, there is an area of low resistivity extending deeper (*c.* -8m OD), which could represent a palaeochannel present within this area. However, as this is not reciprocated in any other ERT profiles, this interpretation is not conclusive on the basis of these results alone. Both Pseudo-sections 20 and 21 display moderate resistivity values in the order of 4 to 10 Ω·m for the remainder of the profile, extending to a depth of around -20m OD.

4.2.29 Profile 23 (**Figure 4**) extends from the south-western end of Profile 22 and both are located 90 m north-east of Profile 21 along a track. The topography of both profiles is relatively flat, but Profile 22 inclines very gradually from 8.0 m OD in the north-east to 8.5 in the south-west. Profile 23 then declines along the same orientation form 8.5 m OD to 8.2 m OD.

4.2.30 The upper sections of Pseudo-section 22 and 23 are characterised by high resistivity values associated made ground, with readings of 10 to 100 Ω·m recorded to a depth of *c.* 3m OD. However, there is notably less made ground in the south-western part of Pseudo-section

22, where it can only be seen to reach a depth of 4m OD. Below this both profiles are characterised by low resistivity values (0 to 2 Ω·m) to a depth -8m OD and -13m OD.

4.2.31 Profile 24 (**Figure 4**) was located 230m southeast of Profile 23; it measured 132.5m in length and was orientated on roughly west-east. The topography was largely flat at *c.* 4.3m OD at both the eastern and western ends, with a lower area in the centre at a 3.6m OD.

4.2.32 There is no evidence for made ground within Pseudo-section 24 and the profile is characterised by low resistivity values of 0 to 2 Ω·m from the ground surface until an approximate depth of -5 m OD. This is probably associated with alluvial silts and clays, but there is a deeper aspect to this in the western half of the section, which extends to -8m OD. This also coincides with the slight dip in topography and may be a possible palaeochannel, however this surface correlation is too small and shallow to ascertain within any great degree of confidence. Below this, to a depth of -22m OD, an area of moderate resistivity (2 to 10 Ω·m) is probably associated with river terrace sands/gravels.

4.2.33 Profile 25 (**Figure 5**) was situated on a northwest to southeast orientation and extended for 132.5m. It was located directly north of Profile 24 and south of Profiles 26-29, close to the electricity substation, which lay 90 m to the northeast. The topography of the profile was relatively flat, with consistent levels recorded at around 5.2 mOD.

4.2.34 Within the uppermost part of Pseudo-section 25, moderate to high resistivity values are recorded between the ground surface and 2m OD. The resistivity values are lower in the north west (5 to 20 Ω·m) and higher across the centre and southwest (5 to 100 Ω·m), although both relate to made ground. Below this, to a depth of -7m OD, low resistivity values (0 to 2 Ω·m) are recorded that are consistent with alluvial clays and silts. This is subsequently followed by more moderate resistivity (3 to 20 Ω·m) to a depth of -18m OD that is thought to represent river terrace gravels/sands. Within the centre of the profile, this area of moderate resistivity can be seen to arch upwards ranging in depth rom 3m OD to -12 m OD on the south-western side. It is possible that this may relate to more pronounced area of terrace gravels and sands that might indicate an archaeological significant topographic feature, such as a gravel island. However, further investigation would be required to confirm this.

4.2.35 Profiles 26-29 (**Figure 5**) were positioned in a roughly rectangular arrangement with its longest axis on a northwest to southeast alignment. This comprised two shorter profiles measuring 87.5m (Profiles 26 and 29) and two longer ones, measuring 132.5m (Profiles 28 and 29). These were all located on a small plateau to the west of the working quarry. The topography was relatively consistent throughout at *c.* 8m to 9m OD, with a small notable decline at the south-eastern end of Profile 26, to 5.4m OD.

4.2.36 Pseudo-sections 26 to 29 display a very similar arrangement of values. For example, the upper section of all four display a band of high resistivity (10 to >150 Ω·m) from the ground surface to a depth of 1m to 2m OD. This suggests that this area of the site is covered with a significant (10m to 12m thick) deposit of made ground. From this point throughout the remainder of the profiles, an area of low resistivity (0 to 3 Ω·m) is attributable to alluvial silts/clay to a depth of -8m to -14m OD.

4.2.37 Directly north-east of Profile 29, Profile 30 (**Figure 5**) extended for 177.5m on a similar northeast to south-west alignment. It was located on a track on the outside of the working quarry to the southeast and was general flat, with recorded levels consistently around 8m to 8.2m OD.

4.2.38 From the ground surface to approximately 2m OD, there is a thick band of high resistivity values (10 to >150 Ω·m) that may be a further deposit of made ground. From this depth to approximately -10m OD, low resistivity values (0 to 2 Ω·m) are associated with alluvial silts and clays. In the north-eastern part of the pseudo-section, moderate resistivity readings are recorded that could represent river terrace deposits of sands and gravels.

4.2.39 Profiles 31 and 32 (**Figure 5**) were located towards the northwest of the survey area, south of Broadness creek, and were approximately orthogonal. Profile 31 was oriented northeast to southwest and extended for 207.5m, whereas Profile 32 extended for 177.5 m WNW to ESE. The topography of both profiles was very flat with no notable features and levels recorded at around 8m to 8.5m OD.

4.2.40 Both Pseudo-section 31 and 32 display a thick layer of high resistivity response (10 to >150 Ω·m) from the ground surface to approximately 1m OD, which is related to made ground. Below this is a band of low resistivity (0 to 2 Ω·m), which is characteristic of alluvial silts and clays. Within Pseudo-section 31, this extends deeper to approximately -14m OD, whereas within Pseudo-section 32, it does not extend beyond *c.* -9m OD. Below this to the base of the profile, both datasets show moderate resistivity values around 4 to 10 Ω·m, which relates to river terrace sands/gravels. The relative change in topography may indicate a slight rise in levels of these deposits from southwest to northeast in this area.

4.2.41 Profile 33 (**Figure 6**) was located approximately 50m inshore, east of the river's edge, and was oriented north-east to south-west. It extended for 87.5m with a very slight incline from southwest (5.3m OD) to northeast (5m OD).

4.2.42 From the ground surface to 2m OD, there are high resistivity values in the order of 10 to 100 Ω·m, which are most likely associated with made ground. Below this there is a thick deposit of probable alluvial clay and silts, extending to a depth of -11m OD, which is represented by low resistivity values (0 to 2 Ω·m).

4.2.43 Profile 34 (**Figure 6**) intersected Profile 33 at the north-eastern end and as oriented north-west to southeast. It was located on a track that traversed three tiers of flood defence bunds. These can be identified in the profile's topography, and there is a stepped incline from northwest (5.1m OD) to southeast (8.3m OD).

4.2.44 Pseudo-section 34 displays high resistivity values (10 to >150 Ω·m) in the near-surface zone to a depth of -1 to 1 m OD, showing strong correlation with the topographic features. Below this there are likely alluvial silts and clays represented by low resistivity values (0 to 2 Ω·m) present to a depth of -6m OD. At this point, a thin layer of moderate resistivity (2 to 10 Ω·m) is visible, consistent with terrace deposits of sands/gravels that are probably associated with those identified in Pseudo-sections 31 and 32.

4.2.45 Profile 35 (**Figure 6**) was situated close to the southern edge of Broadness creek; currently used as a boat yard, it has several pontoons, wooden buildings, and a series of derelict vessels surrounding it. The topography was generally very flat around this area, measuring around 5.5m OD and the profile extended roughly east-west for 222.5m.

4.2.46 Pseudo-section 35 is more complicated than most others nearby, particularly within its upper portion. From the ground surface to approximately 1.5m OD, high resistivity values (10 to 100 Ω·m) are apparent and, just west of the centre of the profile, there are a series of vertical higher resistivity segments that continue deeper, to a depth of -2m OD. For the most part, it is likely that this is representative of an area of made ground, but the deeper and irregularly shaped responses could relate to other landscape features. It is difficult to postulate precisely what this may represent, but it is likely that it may be associated with the previous industrial landscape or use of the area as a boatyard.

4.2.47 From approximately 2m OD to -12m OD, there is a band of low resistivity (0 to 2 Ω·m) in Pseudo-section 35 that probably indicates alluvial clays and silts. This is interrupted at three intervals along the base of the profile by undulating blocks of moderate to high resistivity (5 to 100 Ω·m). This is probably an area of river terrace gravels/sands that has been interrupted by channels leading into Broadness creek. However, the irregular and stronger responses make this interpretation less certain.

4.2.48 Profiles 36 and 37 (**Figure 6**) were oriented on north-south, to the west of the boatyard at Broadness Creek. They both measured 87.5m in length and were located on a trackway. The topography of Profile 36 was generally flat (*c.* 6.8m OD), with a slight camber at the centre (7.2m OD). Profile 37 was also relatively flat at around 6.3m OD, but with a slight depression in the centre at around 5.8m OD.

4.2.49 Within pseudo-section 36, an area of moderately high resistivity (10 to 100 Ω·m) is present from the ground surface to a depth of *c.* 1m OD. Within Pseudo-section 37, the same region exhibits markedly lower resistivity (4 to 15 Ω·m) and only extends to a depth of 3m OD. However, both are thought to represent areas of made ground. The greater depth and resistivity values seen in Pseudo-section 36 may indicate a larger deposit of made ground, possibly the infilling of a channel extended eastwards from Broadness Creek, visible on historic mapping as recently as 1937 (WA 2015). Below this, there is a fairly uniform band of low resistivity (0 to 3 Ω·m) in both pseudo-sections, which is indicative of alluvial clays/silts to a depth of -9m OD.

4.2.50 Profiles 38 to 40 (**Figure 6**) were all located on the western extent of the Peninsula that protrudes into the River Thames. Profile 38 was the longest of these, measuring 132.5m on an east-west orientation. Profiles 39 and 40 were almost north-south and measured 87.5m and 107.5m respectively. The topography of Profiles 39 and 40 was generally very flat at around 5m OD, but there was a gradual incline from east (5.1m OD) to west (5.8m OD) along Profile 38.

4.2.51 The three pseudo-sections display very similar sequence of results. There is a *c.* 2m thick moderate resistivity response in the order of 4 to 20 Ω·m visible from the ground surface to an approximate depth to 3m OD. This is consistent with a relatively thin layer of made ground across the area. Below this, all three pseudo-sections display low resistivity values (0 to 3 Ω·m) to depths of -18m OD, although resistivity increases with depth with more moderate values in the order of 5 to 7 Ω·m. This is typical of alluvial clays and silts, but the increased resistivity towards the base of these profiles suggest that deposits of terrace gravels are present towards the base of these profiles. Pseudo-section 40 shows the most convincing evidence for this.

4.2.52 Profiles 41 and 42 (**Figure 6**) were located *c.* 75m west of Profile 38, close to the northern limit of the peninsula. Profile 41 was aligned northwest to southeast and measured 87.5m with a very gradual decline from northwest (8.4m OD) to southeast (7.9m OD). Profile 42 was located 15m northwest of Profile 41 and extended for 60m north-south, with topography ascending in a stepped manner from north (5.1m OD) to south (7.1m OD).

4.2.53 In Pseudo-section 41, high resistivity values (5 to >150 Ω·m) are recorded from the ground surface to a depth of approximately 0m OD. This layer is thickest in the northern part of the profile, which also corresponds with the highest readings recorded. This implies an area of made ground, which is deeper in the north and shallower in the south. The stepped nature of the topography is also matched in the thickness of this made ground. Below this, to a depth of *c.* 5m OD, low resistivity values in the order of 0 to 2 Ω·m are visible. This is attributable a 5m to 6m thick layer of alluvial silts/clays. From this point to the base of the profile (-7m OD) ,a slight increase in resistivity (2 to 10 Ω·m) is recorded, which is probably attributable to river terrace gravels/sands.

4.2.54 The uppermost part of Pseudo-section 42 is dominated by strong high resistivity values in the order of 10 to >150 Ω·m. This layer extends to a depth of 2m OD and is associated with made ground. Below this to a depth of -8m OD, low resistivity values (0 to 2 Ω·m) are thought to relate to alluvial clays and silts.

4.2.55 Profiles 43 to 46 (**Figure 7**) traversed the north-eastern edge of the peninsula and were situated close to the river's edge on a roughly north-west to southeast alignment. Profiles 43 and 44 both measured 177.5m in length, with Profile 45 shorter at 82.5m. Profile 46 was the most southerly and was 267.5m long. The topography was generally very flat across the profiles with no notable features and heights recorded around 5m to 6m OD.

4.2.56 Pseudo-sections 43-46 all show a very similar sequence of deposits. However, there is a thicker band of probable made ground in the north of the peninsula in Pseudo-sections 43 and 44. This is visible from the ground surface to a depth of *c.* 2m OD as moderate to high resistivity readings in the order of 4 to 20 Ω·m. In Pseudo-sections 45 and 46, there are only very thin patches of moderate resistivity (4 to 10 Ω·m) near the surface, suggesting that there is little to no made ground in these areas. All four pseudo-sections subsequently show a consistent band of low resistivity values (0 to 2 Ω·m) from this point to *c.* -10m OD that is consistent with alluvial clays/silts. Below this, more moderate values ranging from 4 to 10 Ω·m are recorded. This implies that there is a relatively consistent band of river terrace deposits of sands and gravels in this area.

4.2.57 Profiles 47 to 49 (**Figure 7**) were positioned around 90m southwest of Profiles 43 to 46 and were also oriented northwest to southeast along a trackway. It was not possible to collect data in one single straight profile due to slight variance in the orientation of the trackway. Profile 47 was the shortest at 52.5m, and Profiles 48 and 49 both measured 132.5m. The topography was flat across all three profiles with a very gradual decline from northeast (9.1m OD) to southwest (8.3m OD).

4.2.58 From the ground surface to approximately 3m OD, high resistivity values (10 to >150 Ω·m) appear in each of the pseudo-sections. This suggests that there is a consistent 6m thick layer of made ground covering this part of the Site. It is, however, notably deeper at the south-eastern end of Pseudo-section 49, where these values extend to a depth of -1m OD. This might imply that a channel or similar feature has been backfilled. As there is a channel traversing this area on historic mapping of the area dating to 1811, this interpretation seems likely. However, subsequent mapping of the area from the 19th century onwards does not clearly identify this feature, making the interpretation somewhat less confident.

4.2.59 An area of low resistivity (0 to 2 Ω·m) is recorded below the area of made ground in Pseudo-sections 47 to 49, which extends to the base of the profiles at -10m to -15m OD. This is associated with alluvial clays/silts, below which there is no evidence for river terrace deposits. This may suggest the alluvial silts and clays are thicker than has been recorded to the northeast in Pseudo-sections 43 to 46. However, as Pseudo-sections 47 to 49 could only reach a maximum depth of -15m OD due to their length, this is difficult to confirm.

4.2.60 Profiles 50 and 51 (**Figure 7**) were situated south-west of Profiles 47 and 48. Profile 50 was oriented north-east to southwest and was 87.5 m long. Profile 51 was perpendicular to this and longer, measuring 132.5m. The topography was very flat with levels recorded at around 9m OD.

4.2.61 The upper parts of both Pseudo-sections 50 and 51 are characterised by moderately high resistivity values in the order of 4 to 10 Ω·m, visible to a depth of approximately 2m OD and relating to a *c.* 6m thick layer of made ground. In the centre of Pseudo-section 51, there is a markedly higher resistivity anomaly, which corresponds with a feature visible on the ground that is thought to be a backfilled balancing pond or similar modern feature. The higher resistivity is associated with an increased porosity, as opposed to a more resistant material. Below this, to a depth of *c.* -10m OD, low resistivity values (0 to 2 Ω·m) are recorded that are consistent with alluvial silts/clays.

4.2.62 Profile 52 was the most southerly of the ERT profiles recorded at the Site. It was located along the side of a tarmac track to the east of Botany marshes, where it was not possible to survey. It extended for 147.5m, on a roughly north-south alignment and was relatively flat at around 2m OD.

4.2.63 From the ground surface to *c.* -1m OD, moderately high resistivity values in the order of 4 to 10 Ω·m are visible. These are typically higher in the south where values greater than 100 Ω·m are recorded to -3m OD. This is all likely to be made ground some 3m to 4 thick. Below this is an area of low resistivity (0 to 3 Ω·m), which is present until -6m OD and probably relates to a deposit of alluvial silts/clays. From this point to the base of the profile, moderate resistivity values, predominantly around 5 to 20 Ω·m, can be identified. These are stronger in character than has been seen in many of the other resistivity profiles and may therefore represent the chalk bedrock, as opposed to river terrace deposits of sands/gravel. However, further investigation would be required to confirm this.

4.3 EMI survey results and interpretation

4.3.1 The EMI survey was undertaken in the same general locations as the ERT survey, but covered a wider area due to the greater mobility of the equipment. In addition, several larger, more open areas could not be subjected to ERT survey, but were covered by the EMI survey. All the 2D depth slices are discussed individually in the following section and presented together with an interpretation. The interpretation of the datasets highlights the presence of high/low apparent conductivity and magnetic susceptibility, many of which are attributable to features of modern origin, although some may be archaeologically relevant topographic features.

4.3.2 Perhaps the clearest feature within the EMI survey can be identified in the first depth-slice at 2.2 m below the ground surface (**Figure 8**), located in the southernmost part of the Site at **4000**. Here a roughly rectangular feature can be identified as an approximately 70 x 90 m area. This is characterised by a strong high conductivity response, which is surrounded by very low conductivity readings. To the south of this a similar rectangular area of high conductivity response measuring 100 x 30 m is also visible at **4001**. These features both correspond with areas of high magnetic susceptibility, which suggests that they are associated with metallic objects.

4.3.3 In the subsequent depth-slices at 4.2 m and 6 m below the ground surface (**Figures 10 and 12**), both **4000** and **4001** can be identified as rectangular areas of low conductivity and magnetic susceptibility, with localised high conductivity and susceptibility anomalies. It is likely that the strength of the responses at near the surface is masking the data from deeper targets. These regions correspond with former buildings identifiable on historic mapping of the area that were associated with the cement works. The strong highly magnetic response is likely to indicate the presence of reinforced concrete structures.

4.3.4 Close to the north-eastern river edge at the Site, in the same area as ERT Pseudo-sections 1 to 3, a series of linear high and low conductivity responses is visible at **4002** and is consistent throughout all depth-slices from 2.2m to 6m (**Figures 8, 10 and 12**) and extends for c. 450m south-west to north-east. It is characterised by low conductivity responses nearest the river edge, followed by high conductivity, returning to a more moderate response further inland. In the first depth-slice (2.2m), this is not matched by high magnetic susceptibility although there are isolated higher values recorded within the depth slice at 4.2m and 6m. This response is associated with the large flood defence banks present in this area, and the difference in conductivity is most likely attributable to the topographic difference as well as the material from which the banks are composed. However, the susceptibility data suggest that this is unlikely to comprise much metallic material.

4.3.5 Along the central tarmac track that bisects the Site on an approximate north-south alignment, there is a series of high conductivity responses at **4003** and **4004**. These are predominantly in the south of the track in the 2.2 m depth-slice (**4003**), and in the north in the deeper, 4.2 m and 6 m depth-slices (**4004**). These also both correspond with areas of high magnetic susceptibility, which implies that they are buried metallic objects. It is likely that these features are therefore associated with the sewage works, track way or other modern industrial features present at the Site.

4.3.6 At **4005** there is a cluster of irregularly shaped highly conductive responses. These are visible throughout all three depth-slices (2.2m to 6m) and are also visible high magnetic susceptibility (**Figures 8, 10 and 12**). This implies that this anomaly is modern in origin and, given its location close to the foreshore, it is likely to be associated with the pier and Bell Wharf at Broadness.

4.3.7 Close to a large pylon in the central-western part of the site, there is a series of high conductivity responses in all three depth-slices at **4006**. This also corresponds with higher magnetic susceptibility and is most likely caused by the pylon and other strongly magnetic items in the vicinity such as fences and substations. Similarly, at **4007** a similar range of responses can be identified (**Figures 9, 11 and 13**), which is also thought to be associated modern industrial features, rather than the result of deposits of clays and silts.

4.3.8 At **4008**, there is a 95m wide area of high conductivity (**Figures 9, 11 and 13**). This correlates with an area of increased magnetic susceptibility, but not to the degree that would be expected for buried metallic features. As such it is possible that it could be deposits of clays/silts. However, it is perhaps more likely that this represents a possible channel which has been infilled with material associated with industrial activity on the site.

4.3.9 Along the northern edge of the tip of the Peninsula, several areas are characterised by higher conductivity (**4009** to **4012**). These largely correspond with regions of increased magnetic susceptibility, although this is only clearly apparent within the deepest depth-slice at 6m. As these features are poorly defined and do not appear to correspond with each other, it is probable that they are made ground, as opposed to any near-surface channels containing highly conductive soils. Furthermore, as this response is consistent throughout the entirety of the dataset, it is probable that such material extends for a significant depth.

4.3.10 At **4013**, there is a small area of low conductivity. This corresponds with an area identifiable on the ground surface as a backfilled balancing pond. However, as this is also identifiable as an area of low magnetic susceptibility, it is possible that this was backfilled historically with little metallic material.

4.3.11 In the north-western part of the Peninsula, it was possible to survey a larger contiguous area and this displays a concentration of higher conductivity at **4014**. This is visible from the first depth-slice at 2.2m through to the deepest at 6m. It also corresponds with an area of increased magnetic susceptibility. This can be attributed to an area of tarmac next to a large substation and metal fence; it is therefore likely that this response is associated with modern features close to the ground surface.

4.3.12 There are several isolated responses of high conductivity across the Site, but these are difficult to define and are probably isolated metallic objects, or areas of modern disturbance.

5 DISCUSSION

5.1 ERT Survey

5.1.1 The ERT survey has been successful in detecting a wide range of stratigraphic units across the Site. These predominantly comprise deposits of made ground, alluvial silts/clays, river terrace sands/gravels, and chalk bedrock. The resistivity readings recorded correspond largely with anticipated values for each of these subsurface materials, with alluvial clays/silts typically represented by low resistivity and sands and gravels by more moderate to high resistivity. The precise values, however, are dependent on the ground water content and porosity of specific areas of the Site, and it likely that some of the subtler variations within the pseudo-sections can be attributed to this.

5.1.2 Two large mounds of CKD waste occupy the centre of the site, although the relevant pseudo-sections for these areas display significant thicknesses of this made ground and do not provide a great deal of information regarding deposits below the former ground surface (e.g. Pseudo-sections 6 to 8 and 16 to 18). This is also the case where highly resistant/porous made ground has been deposited in significant volumes and can be identified on the existing ground surface (e.g. Pseudo-sections 10 and 51). There is evidence for made ground in many of the Pseudo-sections across the Site, but it is deeper in the central part of the site across Broadness Saltmarsh, where it is consistently between 4m and 6m thick (e.g. Pseudo-sections 22, 23, 25 to 35, 41, 42, and 47 to 48). This also corresponds with available borehole data (BGS 2017), which records “flue-ash by-product made ground”, although none of these boreholes penetrated below 2.5m in depth.

5.1.3 Deposits of alluvial clays/silts are mapped across most of the site, but vary significantly in thickness. These are generally thinnest (<4m) towards the north-eastern extent of the Site (Pseudo-sections 1 to 4) and the central southern part of the Site (Pseudo-sections 14, 15, 19 to 22, 24, and 25). Within these areas, the most significant variations are seen within the upper surface of the deposits of river terrace gravels/sands; for example, Pseudo-sections 14, 21, 24, and 25 all display undulations that could be attributed to possible channels or topographic variations. However, these are not always well defined and often located at significant depth, where the clarity of the dataset is reduced.

5.1.4 At the northernmost point of the Peninsula, significant deposits (>6m) of alluvial clays/silts have been recorded (Pseudo-sections 28 to 33, 37 to 39, and 43 to 51). The ERT survey results suggest that a significant area has been covered by largely homogenous riverine deposits to a significant depth. However, river terrace deposits of sand and gravels have been identified with some certainty at the very base of these profiles, at a depth typically greater than *c.* -10m OD.

5.1.5 The only resistivity profile that displays evidence for chalk bedrock is Pseudo-section 52, which is the most southerly. This corresponds with geological mapping of the area, which indicates that chalk of the Seaford and Newhaven formation are located directly to the south of the site (BGS 2017).

5.1.6 There is limited evidence for raised sand and gravel islands within the ERT survey results, although the moderate resistivity values considered to be river terrace deposits of sand/gravel are notably higher at *c.* -5 m OD in the centre of the Site, as opposed to *c.* -10m OD elsewhere. It is possible therefore that such raised areas may be of archaeological interest.

5.2 EMI Survey

5.2.1 The EMI survey was successful in detecting a number of areas of high and low conductivity across the Site. Where high conductivity has been encountered, it generally corresponds with areas of high magnetic susceptibility. This has largely been taken to imply that these anomalies are associated with features of relatively modern origin. For example, structures associated with industrial activity at the site have been identified (**4000**, **4001**), as well as a pier and wharf (**4005**) and a number of areas of modern disturbance (**4006**, **4007**, **4014**) and made ground (**4002**, **4008** – **4012**).

5.2.2 The results of the EMI survey largely support that of the ERT survey and it is apparent that a significant depth of made ground is present, particularly across the northern part of the Peninsula. It was hoped that the EMI survey would identify any near-surface channels that may be present across this area, but it is obvious that the thickness of made ground across much of the Site extends beyond that of the possible detection sensitivity of the EMI survey (some 6m below the current ground surface)

5.3 Conclusion

5.3.1 In conclusion, the combination of the ERT and EMI survey has been successful in fulfilling the overarching geophysical survey objectives. Both datasets corroborate well with each other and have also shown the extent of made ground and modern disturbance across much of the site. The survey has contributed to the current understanding of stratigraphic units across the site and has attempted to characterise the landscape, in terms of archaeologically relevant topographic features. Whilst attempts were made to use existing subsurface data to assist in this interpretation, only a limited number of relevant borehole logs were available at the time of writing. The understanding of the geophysical survey results, and the attendant confidence in the interpretation, would therefore be greatly improved by a more targeted borehole survey, and it is important to emphasise that the pseudo-sections are not an absolute representation of the underlying deposits.

5.4 Recommendations

5.4.1 Following the results of the geophysical survey, it is possible that further archaeological investigations could be required by the Local Planning Authority as part of the development control strategy. It is possible that this may comprise a trial trenching evaluation and/or borehole survey. Should this be the case, it is recommended that the anomalies identified by the geophysical survey are targeted and the resulting information is used to re-evaluate the geophysical and geoarchaeological interpretations.

5.4.2 Additionally, if possible in future, further data should be collected from the areas not covered by this investigation, particularly as large parts of the Site were inaccessible at the time of survey.

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https://www.old-maps.co.uk

APPENDICES

Appendix 1: ERT Survey Equipment and Data Processing

Survey methods and equipment

ERT data were acquired using an IRIS Syscal Pro with up to 72 electrodes arranged with a spacing of 2.5 m between electrodes. The system uses four of these electrodes at a time to measure each reading. By varying the position and separation of the four electrodes used, the position along each transect and the depth of the reading can be controlled. A series of roll-along sequences was created prior to the commencement of the survey using ElectrePro software, which was then uploaded onto the switch console. This then runs through the sequence(s), automatically switching between probes used. Readings are logged automatically on the Prosys Switch system and then downloaded to a computer for processing.

Readings are taken by passing an electrical current through the ground and measuring the resistivity within the path the current takes. The electrical resistivity of the earth is dependent partly upon the chemical and geological composition of the soils and the geometry of the electrode array used but also largely upon the soil moisture content. Wet, briny environments will typically exhibit low electrical resistivity, whereas dry sands will exhibit high resistivity. Very low resistivity values can also be obtained where a large conductive structure such as a steel pipe or a reinforced concrete structure is present.

Typical ERT surveys consist of the collection of a series of linear transects with electrodes spaced at regular intervals along the line. The type of array, the number of electrodes used and the separation between them dictates the maximum depth of investigation of the survey. The array used is determined by the application and requirements of the site. If transects are collected on a regular grid the individual 2D transects can be combined and processed to give a 3D output although it is recommended that 3D ERT data is collected from a grid of electrodes using appropriate equipment rather than collecting individual 2D transects.

A number of standard arrays are available for use in an ERT survey, including Wenner alpha, Wenner beta, Wenner gamma, dipole-dipole, Wenner-Schlumberger, pole-pole, and pole-dipole. The array selection is important as the array chosen can dictate the form of the anomaly in the data, signal strength, the depth of investigation, horizontal data coverage and the sensitivity of the array to vertical and horizontal changes in the subsurface resistivity. For full 3D surveys the use of either the pole-pole, pole-dipole or dipole-dipole arrays is recommended as other arrays have poorer data coverage near the edges of the survey grid. It should be noted that it is possible to use other arrays for 3D surveys.

The Wenner alpha array is most commonly used by Wessex Archaeology as it is a robust array that is sensitive to vertical changes in the subsurface resistivity and has the highest signal to noise ratio compared to the other main arrays. The one drawback to this array that it is less sensitive to horizontal changes and this sensitivity drops as the electrode separation is increased.

Post-Processing

The ERT data collected during the survey are downloaded from the ERT system using ImagerPro 2006, then processed and analysed using commercial software (RES2DINV). This software allows for the inversion of the collected 2D transects in isolation and the inversion of several 2D transects collected in a regular grid at the same time. The software uses the least-squares and smoothness-constrained least-squared inversion methods. The parameters of the particular inversion can be altered to suit the data being processed more closely and can also incorporate topographic data during the inversion process. The inversion process creates a model and calculates the resistivity values that would have been recorded over it from this model. By comparing the model data with the field data, an error value can be calculated and the software goes through a number of iterations to minimise this error by altering the modelled values. A more detailed description of the different variations of the smoothness-constrained least-squares method can be found in Loke (2016).

Typical inversion parameters that may be altered include:

- Robust inversion – This option is typically used where sharp boundaries exist between subsurface bodies that would be smeared by the standard least-squares inversion method. The robust model constrain inversion method minimises the absolute changes in the resistivity values producing models with sharp interfaces;
- Smoothing of model resistivity values – This is used for particularly noisy data sets where the smoothness constraint used in the standard least-squares inversion method is not sufficient on its own.

Typical displays of the data used during processing and analysis:

- 3D Output – Outputs of 3D models generated in the Rockworks software package;
- 2D Vertical Pseudo-Section – Presents each ERT transect in a vertical view with distance along the profile expressed along the x axis and depth along the y axis. Topography data can be displayed along with the inverted data. The varying resistivity is expressed using a colour scale;
- 2D Horizontal Pseudo-Slice – Presents the data as a series of successive plan views of the variation in resistivity from the surface to the deepest inversion layer. The variation in resistivity is represented using a colour scale.

Appendix 2: EMI Survey Equipment and Data Processing

Survey Methods and Equipment

The electromagnetic induction (EMI) data for the project were acquired using a GF Instruments CMD Explorer. This multi receiver EM conductivity instrument uses two coils (a transmitter and receiver) at three inter-coil separations, (1.48m, 2.82m, and 4.49m) providing measurements from several depths. The depth of investigation is dependent on the orientation of the coils. Horizontal coplanar (HCP) offers greater depth penetration, but is less sensitive to shallow features. This depth is 2.2m for the 1.48 m coil, 4.2m for the 2.82 m coil, 6.7m for the 4.49m coil. The shallower depth penetration gives a better near surface sensitivity (vertical coplanar – VCP) is 1.1m for the 1.48 m receiver, 2.1 m for the 2.82 m receiver and 3.3 m for the 4.49 m receiver. At each nominal depth, readings are recorded for the in-phase component (or magnetic susceptibility), which represents the ratio between the primary and secondary magnetic fields in parts per trillion (ppt), and the quadrature component (apparent conductivity), an average of all measured conductivities within the measured volume, (milliSiemens per metre (mS/m)). Thus, at any point, there will be 3 readings for the quadrature component and 3 readings for the in-phase component. The measuring range is up to ±80 ppt for magnetic susceptibility and 1000 mS/m for apparent conductivity.

Readings are taken by the transmitter coil outputting a primary electrical field in to the ground, which in turn induces a secondary field in buried features. The receiving coil measures the magnitude of the secondary field (quadrature component) and the ratio between primary and secondary fields (in-phase component). Quadrature fields are proportional to ground conductivity. The presence of metal produces strong secondary fields. The electrical conductivity of the earth is dependent upon the chemical and geological composition of the soils. Wet, briny environments will typically exhibit high electrical conductivity, whereas dry sands will exhibit low conductivity.

Typical EM surveys consist of the collection of a series of point readings along linear transects at regular intervals. Readings can also be recorded along transects using continuous measurement with GPS. This is based on the automatic measurement of data continuously with GPS coordinates as the operator maintains a quasi-constant speed along a line. The speed of movement affects the density of the data, but a typical measuring time of 0.5 seconds and travel speed of 1.4 m per second provides a measured point every *c*. 0.7 m. The accuracy of the position depends on the GPS receiver accuracy.

Post-processing

The electromagnetic data collected during the detail survey are downloaded from the CMD Explorer data logger for processing and analysis using both commercial and in-house software. This software allows for both the data and the images to be processed to enhance the results for analysis; however, it should be noted that minimal data processing is conducted so as not to distort the anomalies. The data is then gridded to produce a two-dimensional map of changing conductivity values (measured in mS/m) and magnetic susceptibility (ppt) across the site.

Typical data and image processing steps may include:
- Applying a zero-median traverse to remove differences caused by directional effects inherent in the magnetometer;

Typical displays of the data used during processing and analysis:
- 2D conductivity depth slices – Presents the data as a series of successive plan views of the apparent conductivity and magnetic susceptibility for each of the three inter-coil separations.

Appendix 3: OASIS form

Project Details:

Project name	London Paramount Entertainment Resort: Swanscombe Peninsula	
Type of project	ERT and EMI survey	
Project description	The ERT survey identified a wide range of stratigraphic units across the Site. These predominantly comprise deposits of made ground, alluvial silts/clays, river terrace sands/gravels and chalk. The resistivity readings recorded largely correspond with anticipated values for each of these sub surface materials and, for example alluvial clays/silts are represented by low resistivity and sands and gravels by more moderate-high resistivity. The EMI was successful in detecting a number of areas of high and low conductivity across the Site. Where high conductivity has been encountered, it generally corresponds with areas of high magnetic susceptibility. Most this is thought to be associated with features of relatively modern origin. For example, structures associated with industrial activity at the site have been identified, as well as a pier and wharf and a number of areas of modern disturbance/made ground. The results of the ERT and EMI survey corroborated well with each other and have also shown the extent of made ground and modern disturbance across much of the site. Whilst attempts were made to use existing subsurface data to assist in this interpretation, there are only a limited number of relevant boreholes available. Thus, the understanding of the geophysical survey results would be greatly improved by a more targeted borehole survey as it is important to emphasise that the pseudo-sections are not an absolute representation of the underlying deposits.	
Project dates	**Start:** 05-06-2017	**End:** 14-07-2017
Previous work	Boreholes, DBA, Trial-trench evaluation	

Project Code:	106571	**HER event no.**	N/A	**OASIS form ID:**	wessexar1-294458
		NMR no.	N/A		
		SM no.	N/A		

Planning Application Ref.			
Site Status	N/A		
Land use	Marsh land and CKD waste mounds		
Monument type	None	**Period**	

Project Location:

Site Address	Swanscombe Peninsula			**Postcode**	DA10 0PP
County	Kent	**District**	Dartford	**Parish**	Swanscombe
Study Area	58 ha	**Height OD**	0 – 15 m OD	**NGR**	560379 175682

Project Creators:

Name of Organisation	Wessex Archaeology		
Project brief originator	Client	**Project design originator**	
Project Manager	Mark Williams	**Project Supervisor**	Nick Crabb
Sponsor or funding body	Savills	**Type of Sponsor**	

Project Archive and Bibliography:

Physical archive	N/A	**Digital Archive**	Geophysics, survey and report	**Paper Archive**	N/A
Report title	London Paramount Entertainment Resort: Swanscombe Peninsula			**Date**	2016
Author	Wessex Archaeology	**Description**	Unpublished report	**Report ref.**	106571.02

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Coordinate system:
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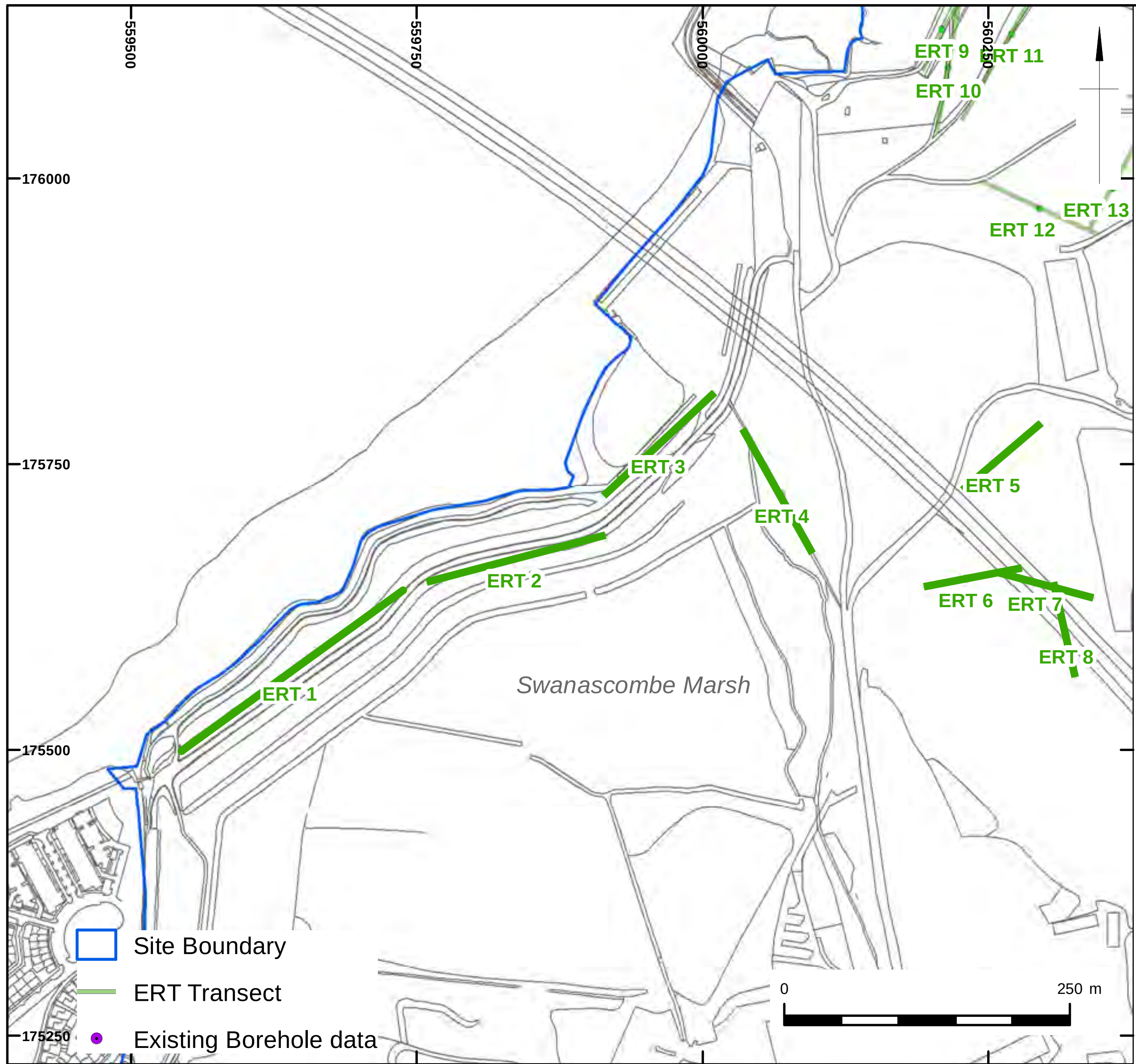
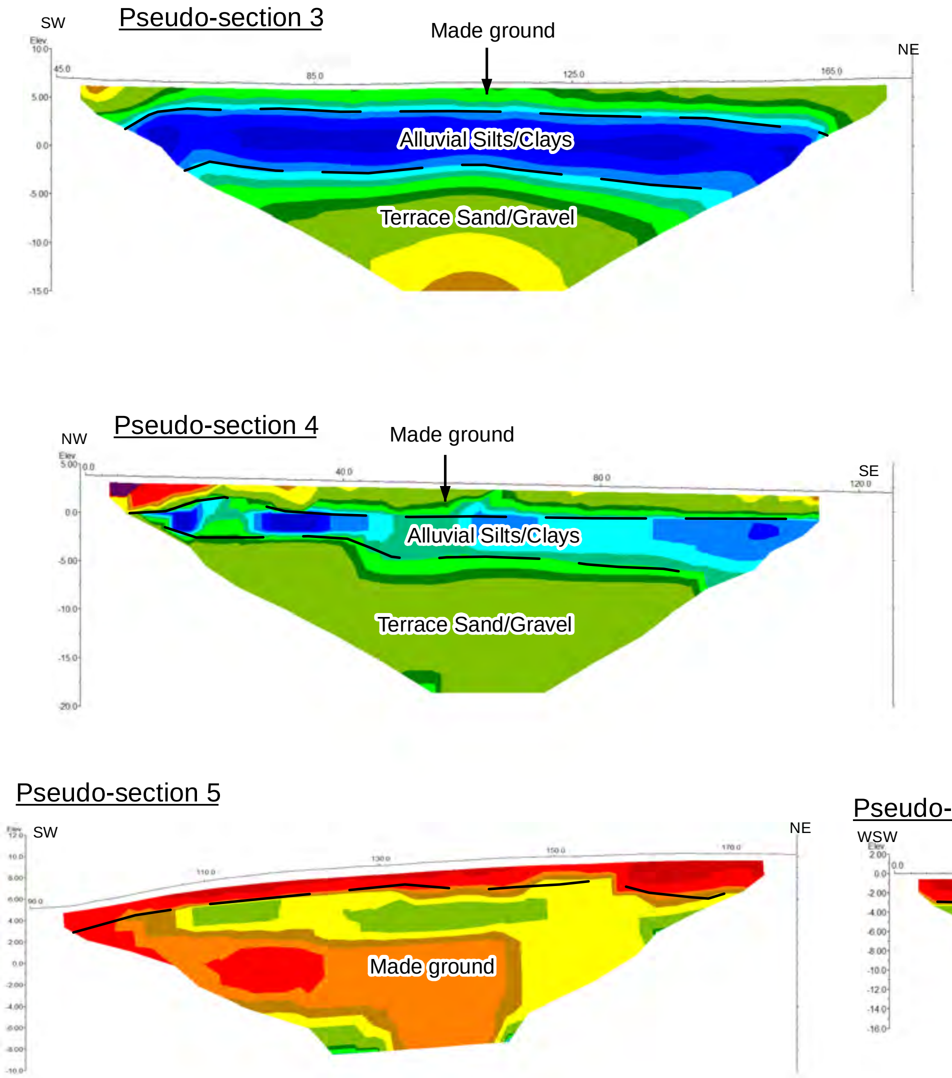
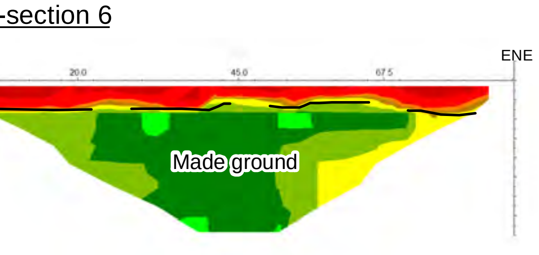
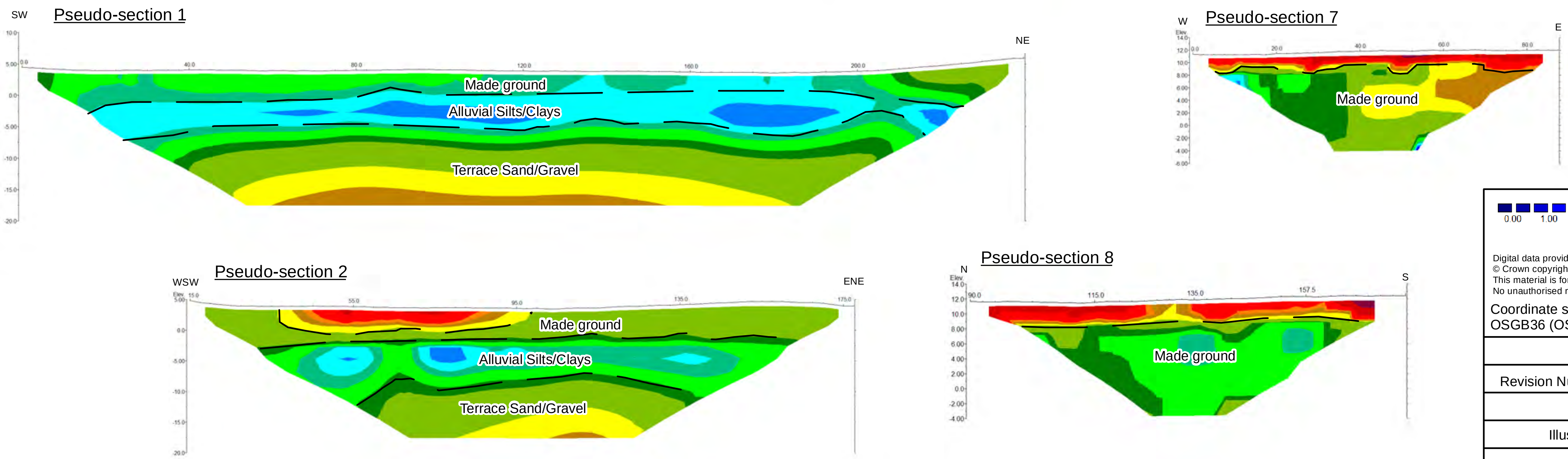
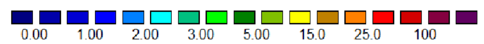
Figure 1: Site location and survey extents











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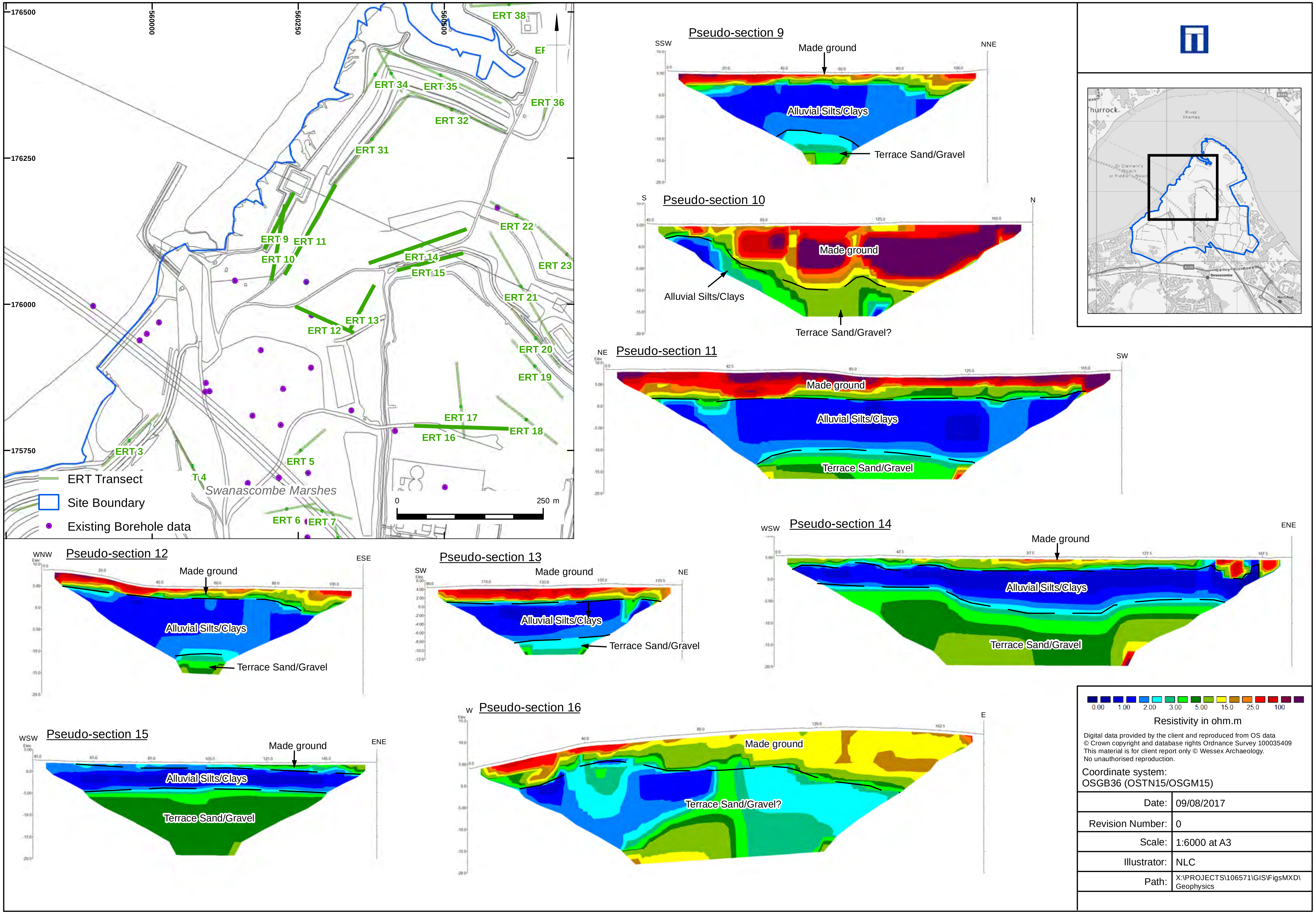
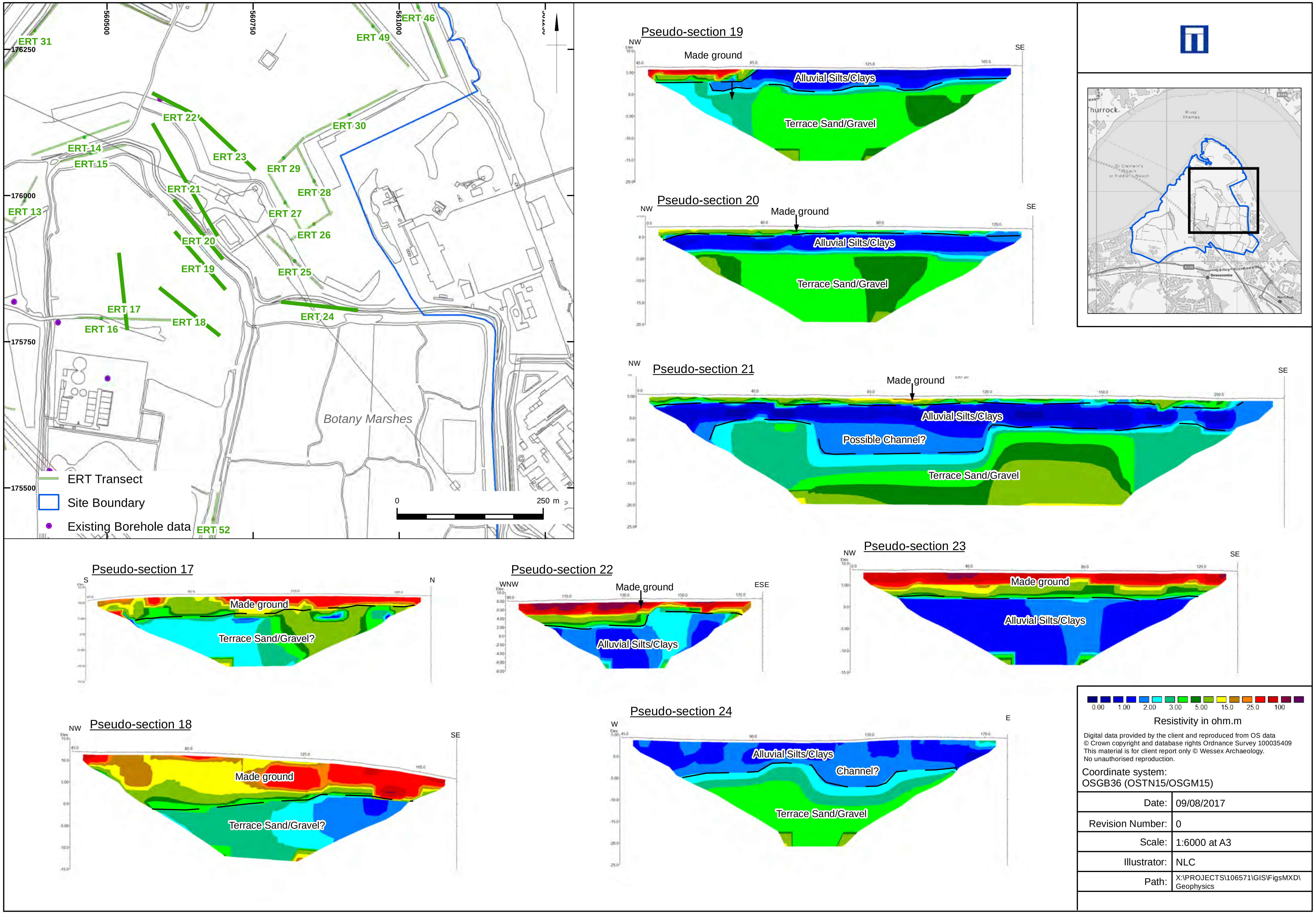
ERT Survey Results: Swanscombe Marsh (west)

Figure 2



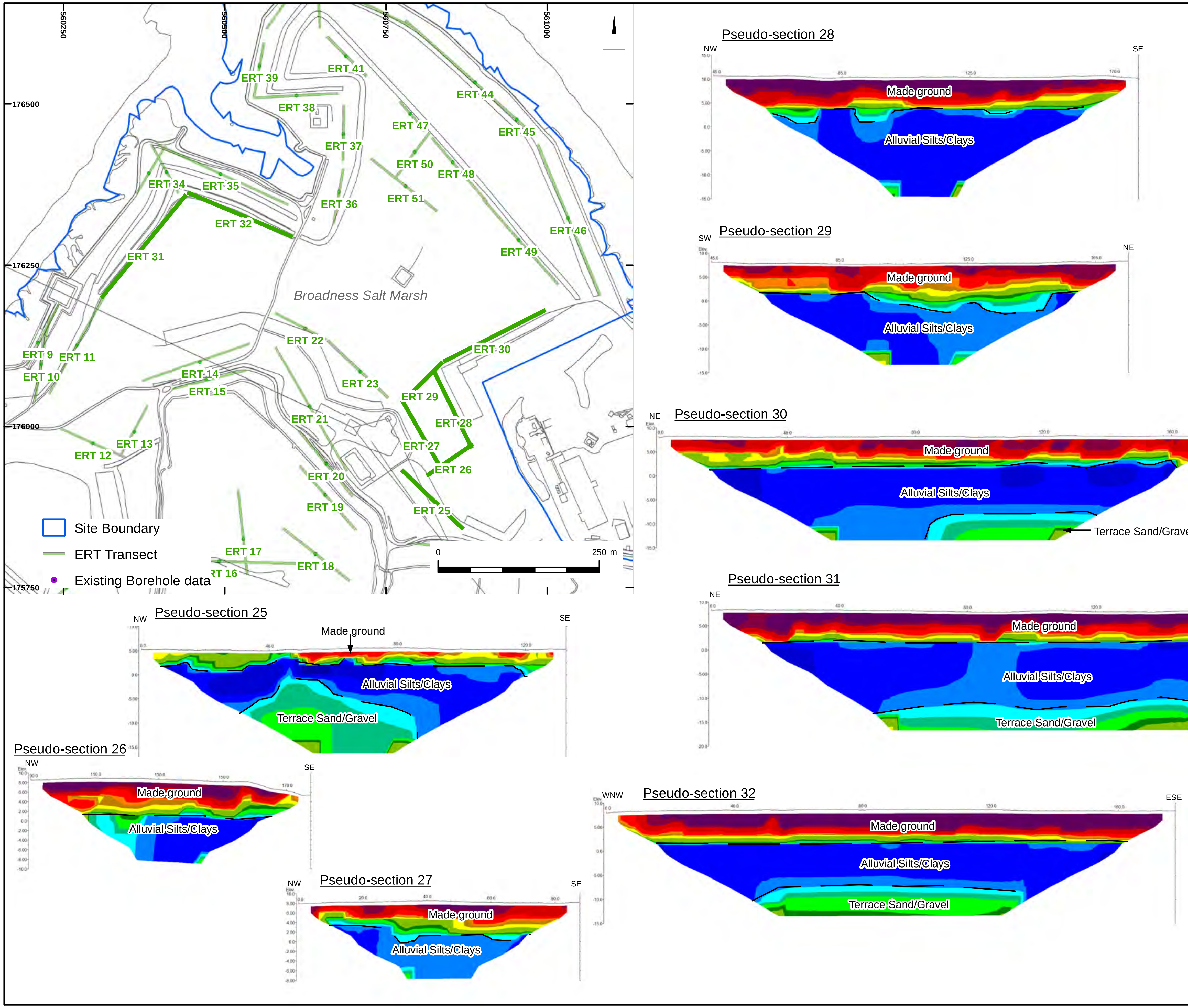
ERT Survey Results: Swanscombe Marshes (north-east)

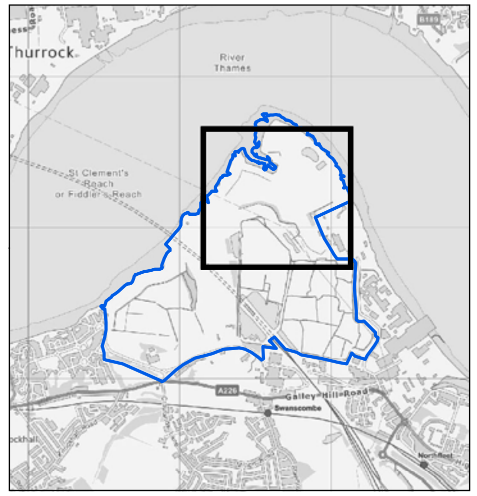
Figure 3



ERT Survey Results: Botany Marshes (north)

Figure 4





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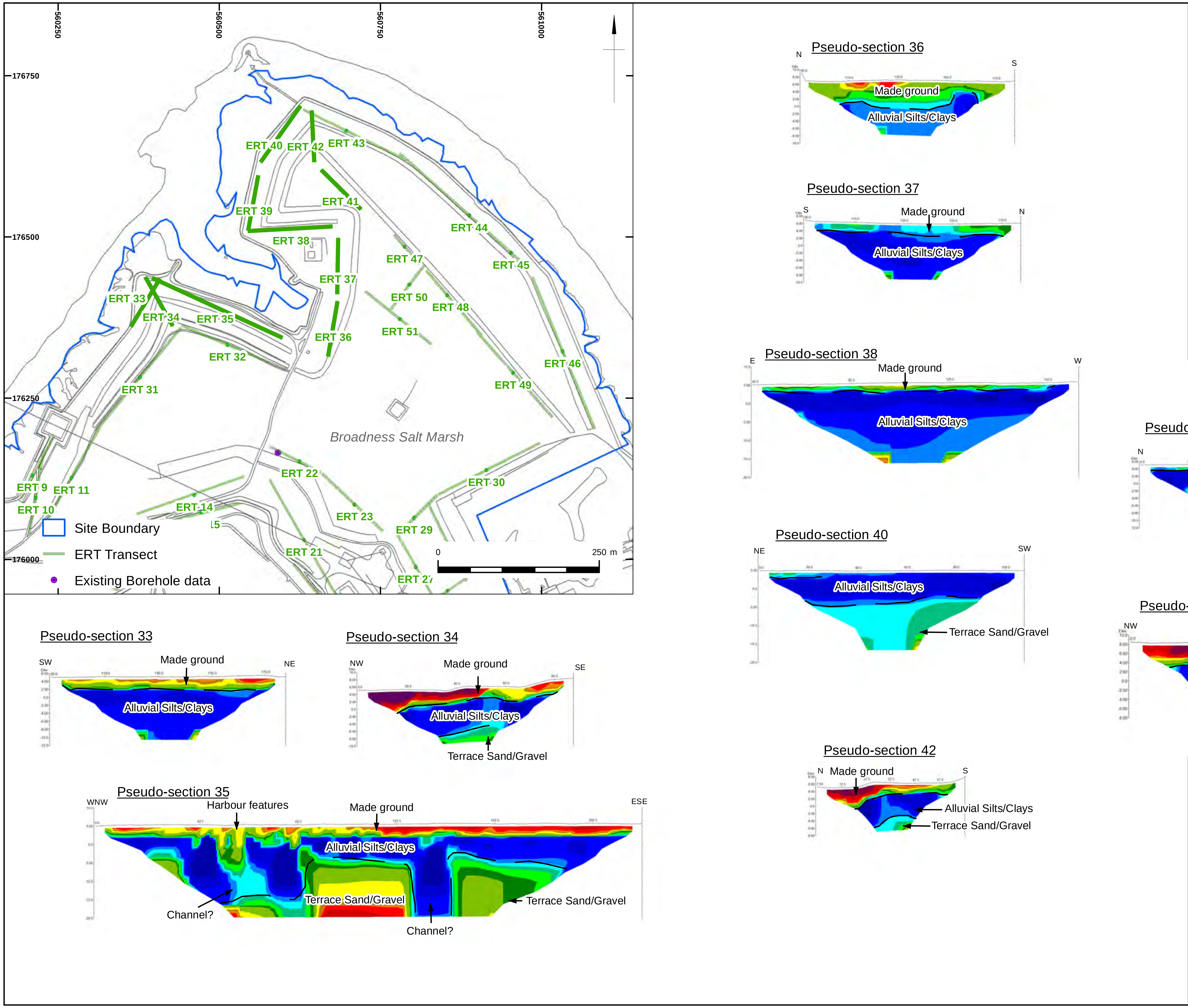
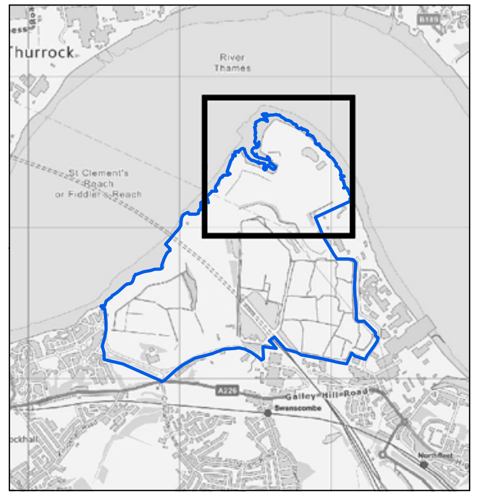
ERT Survey Results: Broadness Salt Marsh (north)

Figure 5





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Resistivity in ohm.m

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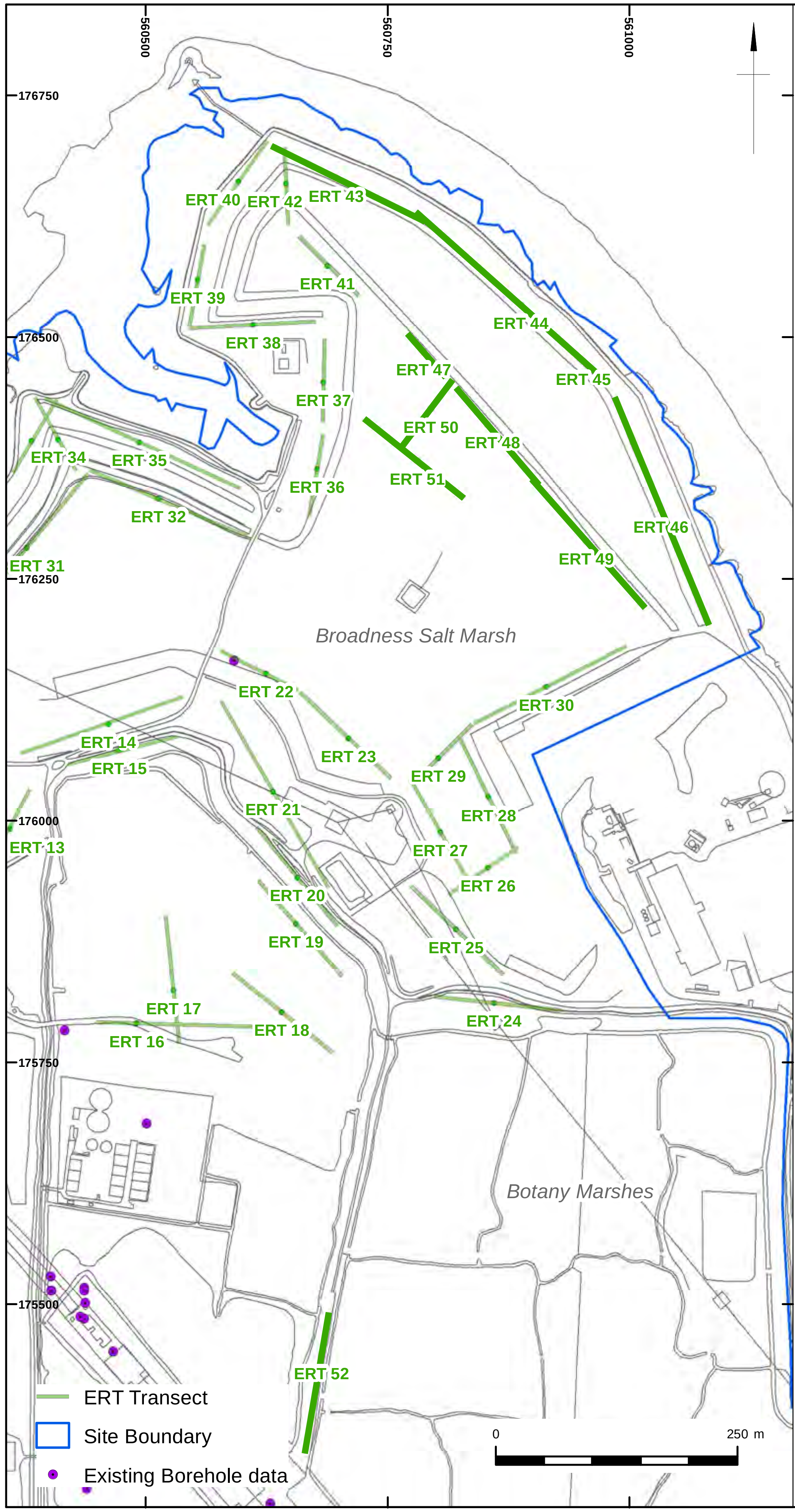
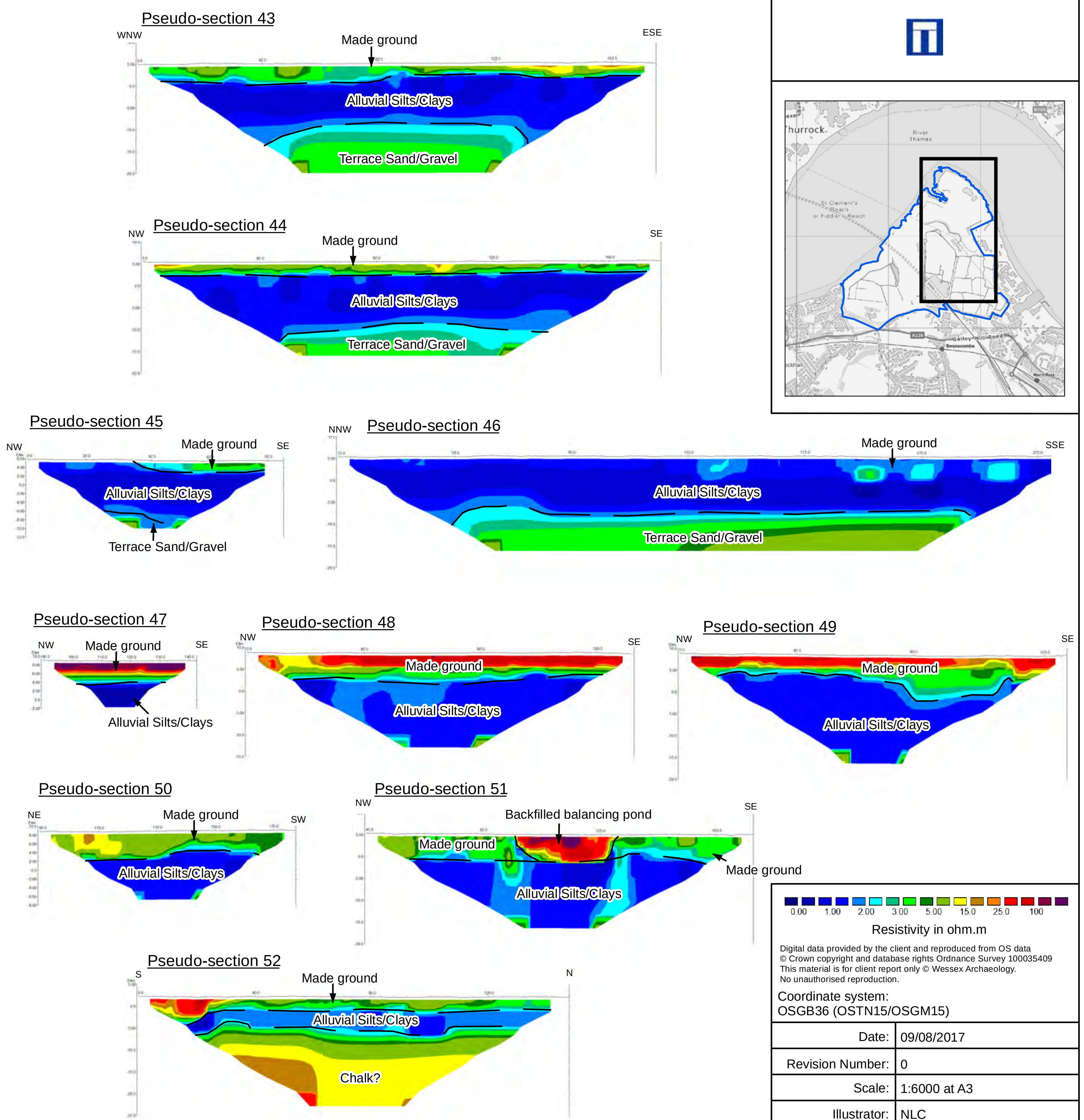
ERT Survey Results: Broadness Salt Marsh (South)

Figure 6





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Resistivity in ohm.m

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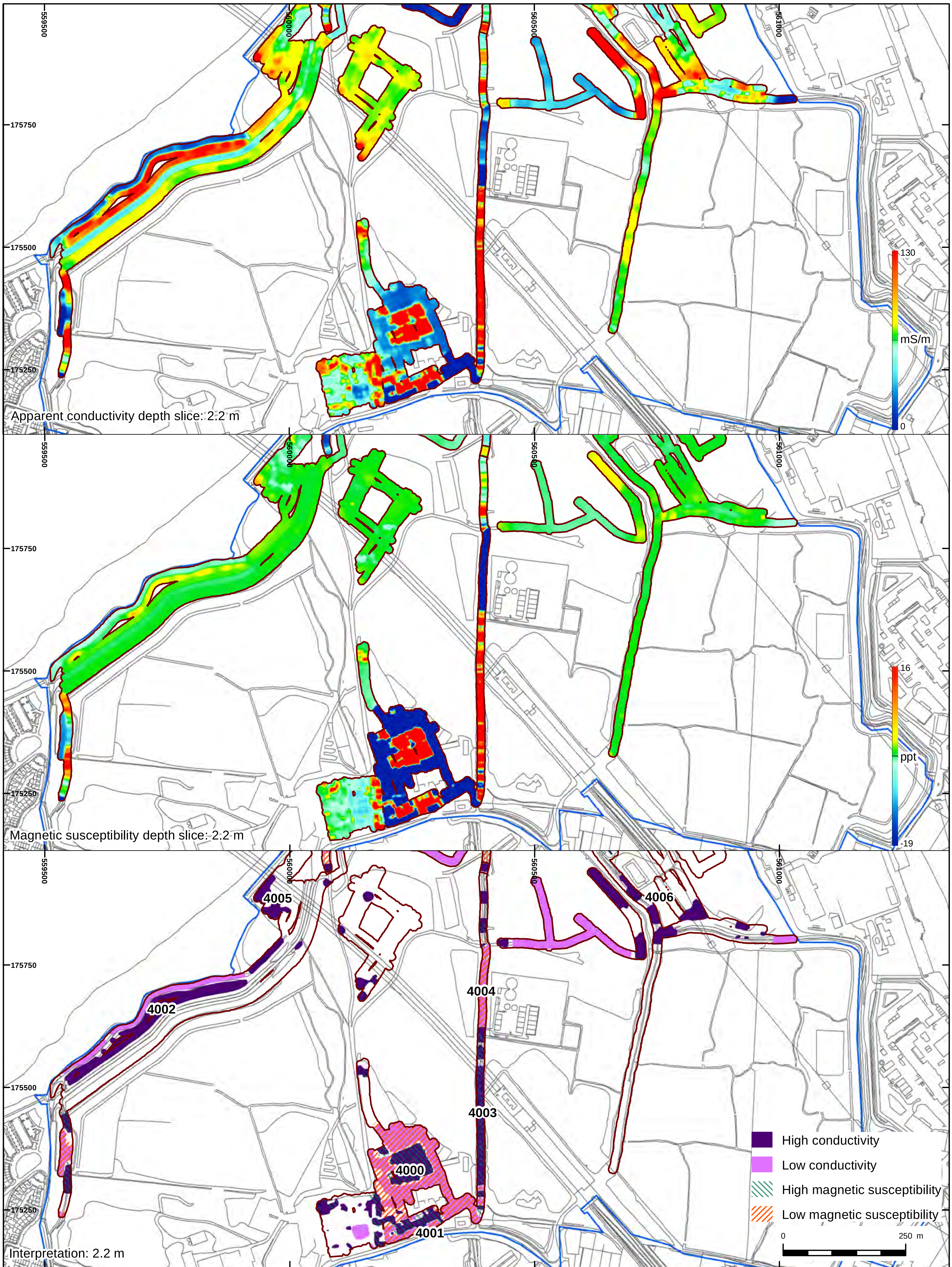
ERT Survey Results: Broadness Salt Marsh and Botany Marsh



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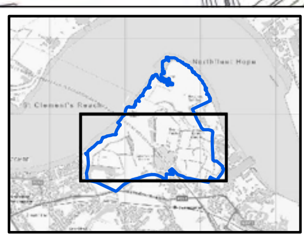
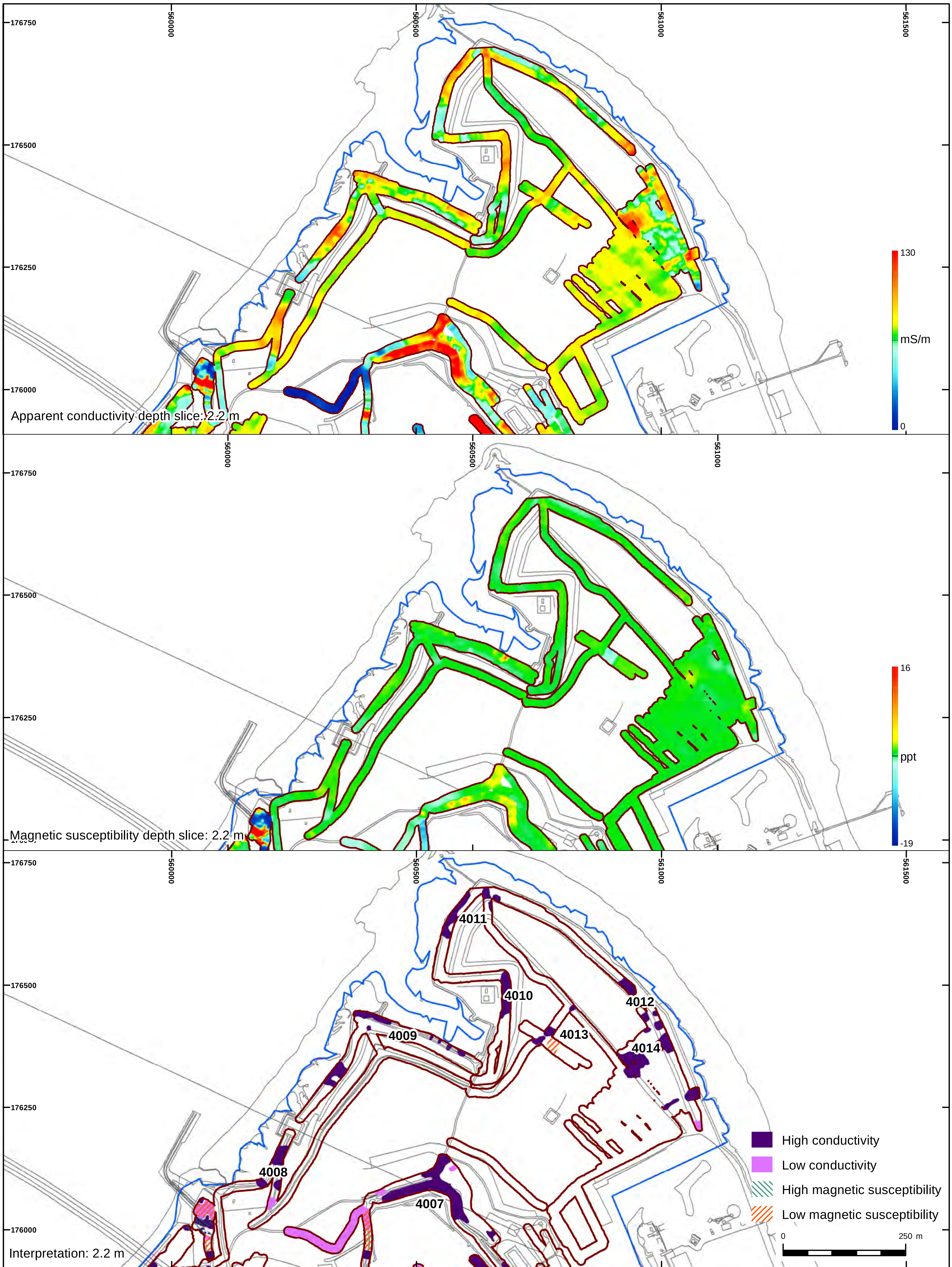


EMI Survey Extent
Site Boundary

Date:	16/08/2017	Revision Number:	0
Scale:	1:7500	Illustrator:	NLC
Path:	X:\PROJECTS\106571\GIS\FigsMXD\Geophysics		

EMI Survey Results and Interpretation - 1.48 m coil seperation (south)



Coordinate system:
OSGB36 (OSTN15/OSGM15)

EMI Survey Extent
Site Boundary

Date:	16/08/2017	Revision Number:	0
Scale:	1:7500	Illustrator:	NLC
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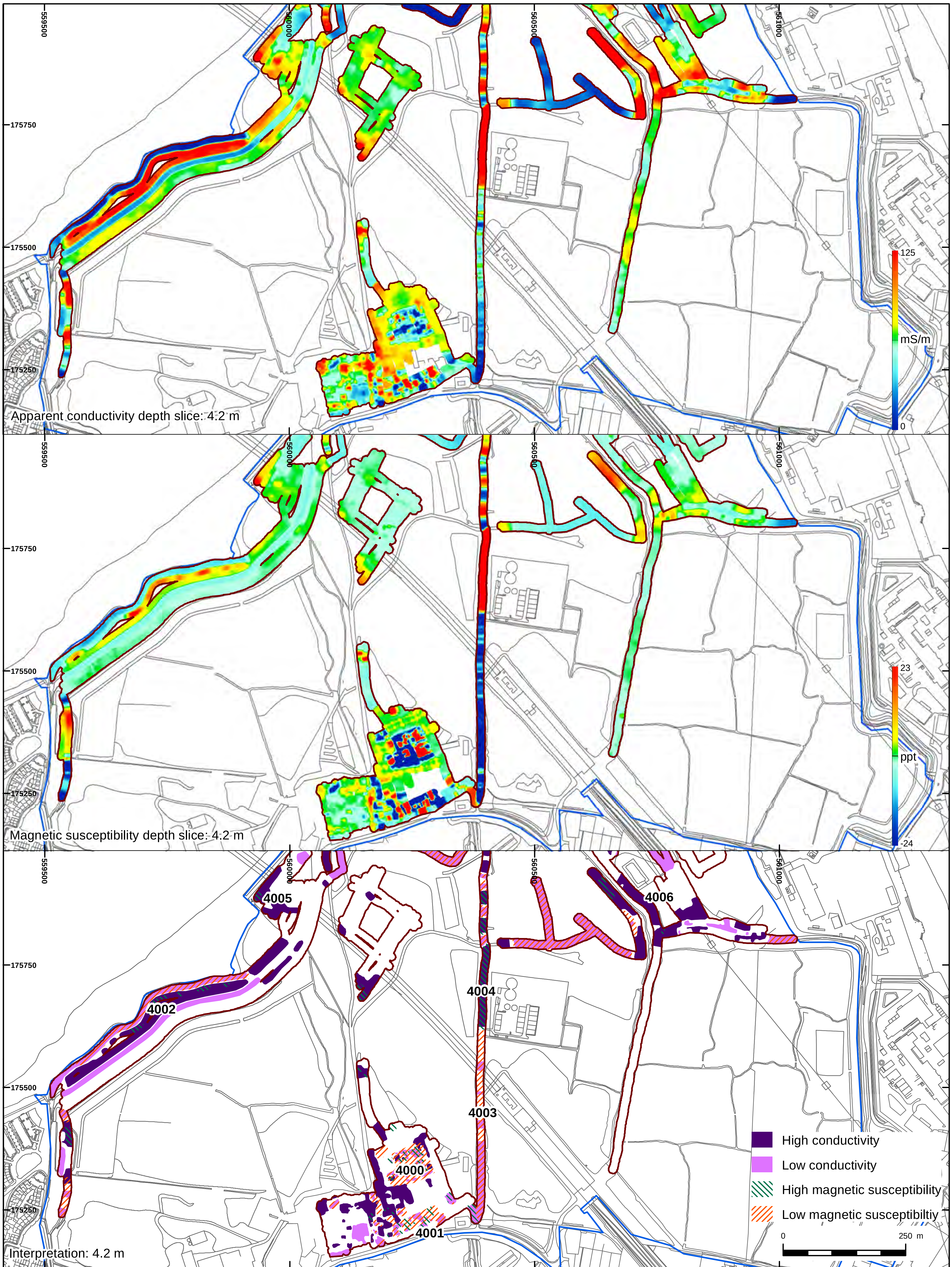
EMI Survey Results and Interpretation - 2.82 m coil seperation (north)

Figure 9



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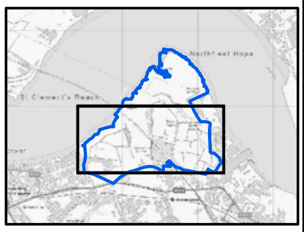

EMI Survey Extent
Site Boundary

Date:	16/08/2017	Revision Number:	0
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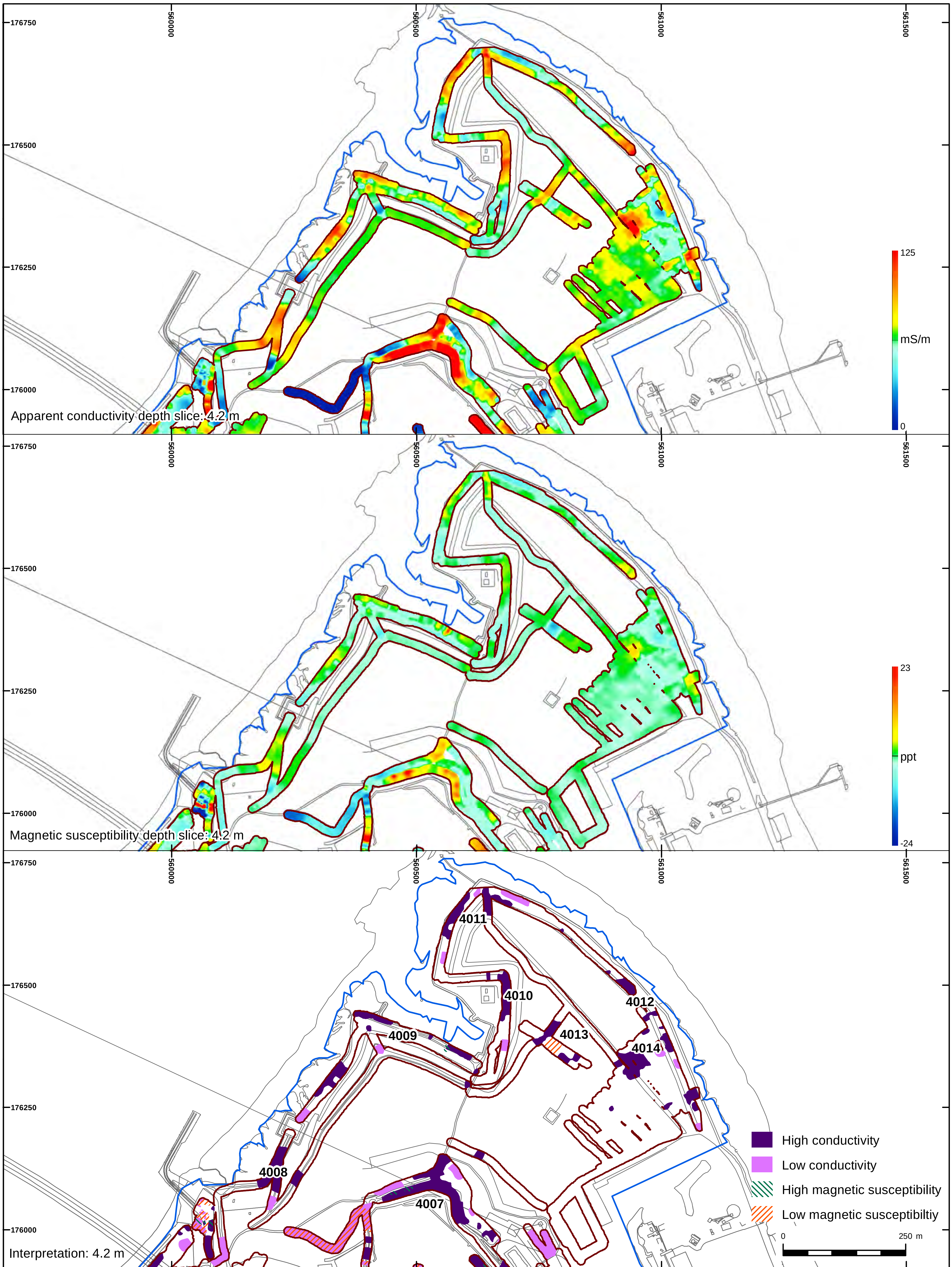
EMI Survey Results and Interpretation - 2.82 m coil seperation (south)

Figure 10



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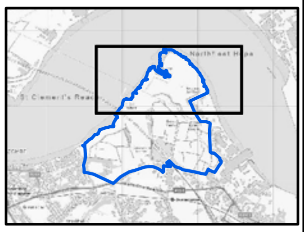

EMI Survey Extent
Site Boundary

Date:	16/08/2017	Revision Number:	0
Scale:	1:7500	Illustrator:	NLC
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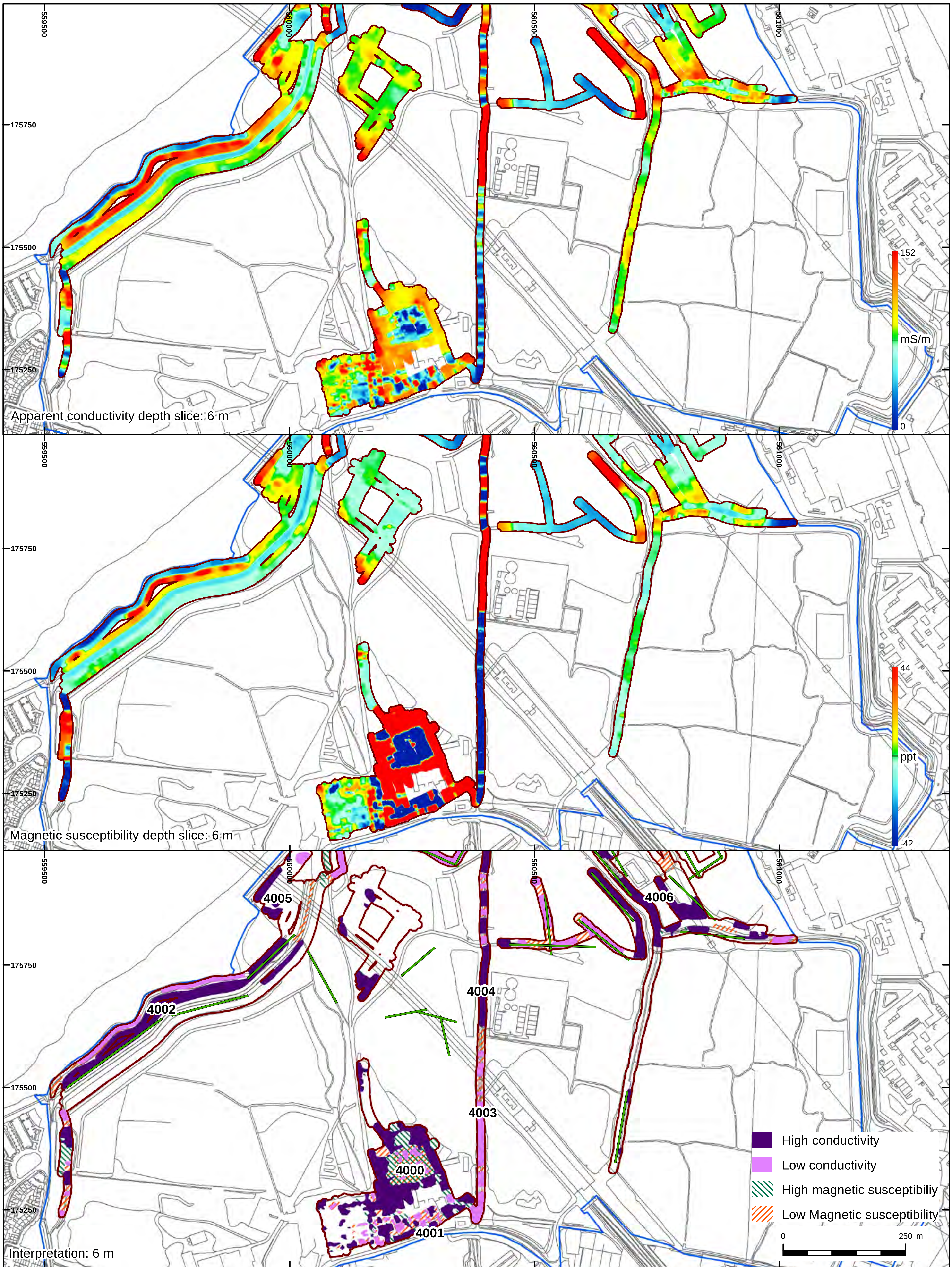
EMI Survey Results and Interpretation - 2.82 m coil seperation (north)

Figure 11



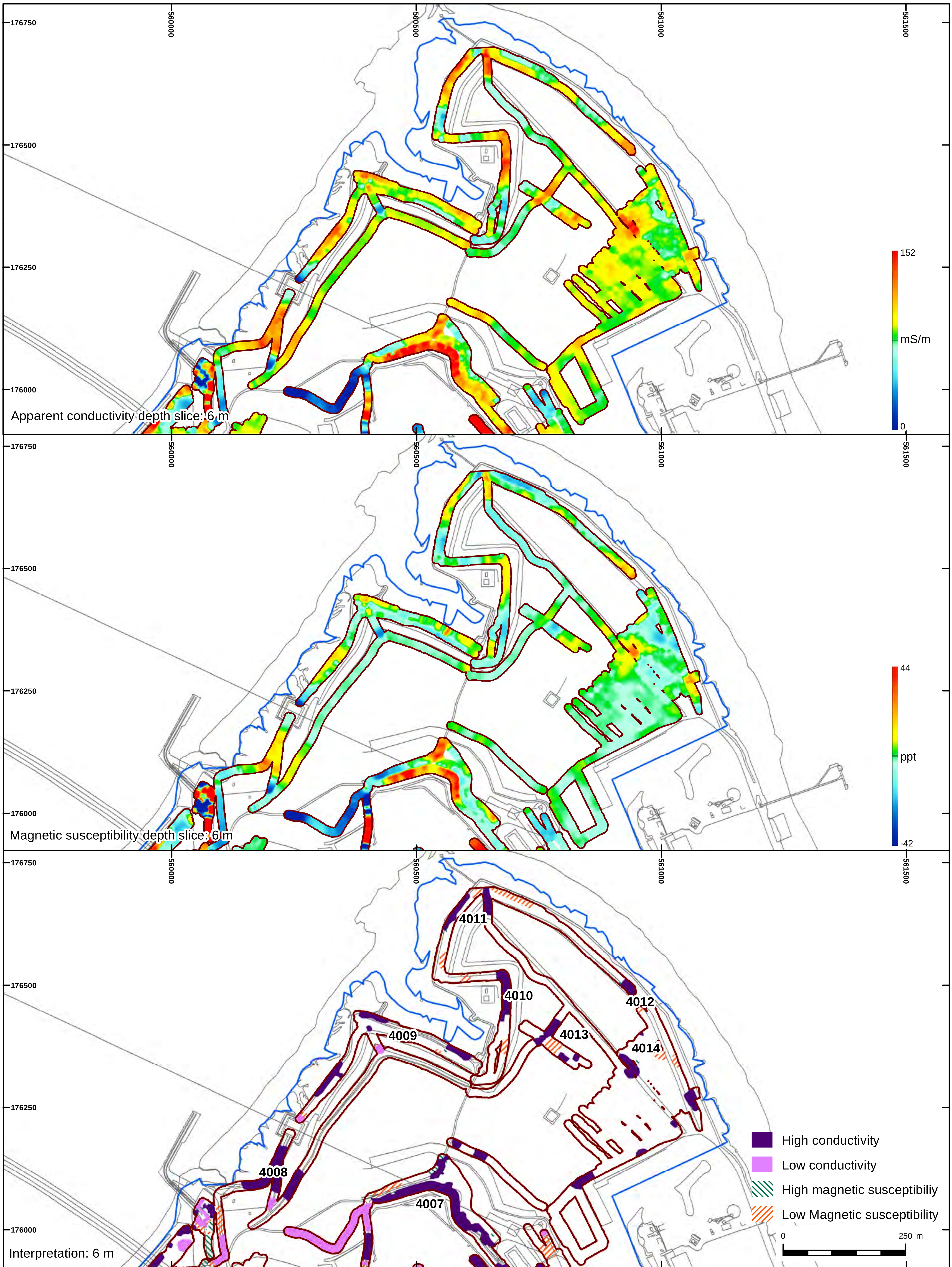
Coordinate system:
OSGB36 (OSTN15/OSGM15)

EMI Survey Extent
Site Boundary

Date:	16/08/2017	Revision Number:	0
Scale:	1:7500	Illustrator:	NLC
Path:	X:\PROJECTS\106571\GIS\FigsMXD\Geophysics		

EMI Survey Results and Interpretation - 4.49 m coil seperation (south)

Figure 12



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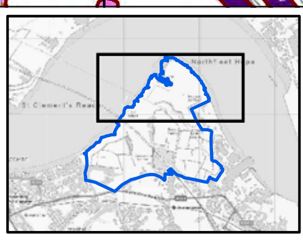

EMI Survey Extent

Site Boundary

Date:	16/08/2017	Revision Number:	0
Scale:	1:7500	Illustrator:	NLC
Path:	X:\PROJECTS\106571\GIS\FigsMXD\Geophysics		

EMI Survey Results and Interpretation - 4.49 m coil seperation (north)

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