



**PROPOSED E-SCRAP FACILITY
(Britannia Refined Metals)
Swanscombe Peninsula
Northfleet DA11 9BG**

County of Kent

Report on a geoarchaeological evaluation

March 2024



Proposed E-Scrap Facility (Britannia Refined Metals) Swanscombe Peninsula Northfleet DA11 9BG

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Summary

This report presents the results of a geoarchaeological evaluation carried out by Museum of London Archaeology (MOLA) at the Proposed E-Scrap Facility (Britannia Refined Metals), Swanscombe Peninsula, Kent DA11 9BG (NGR 561209, 175806). The report was commissioned from MOLA by WSP UK Ltd, on behalf of their client, and follows on from a deposit model exercise carried out before the site work (MOLA 2023a)

The site is located off Botany Road, Northfleet, adjacent to the River Thames to the east and marshland to the west. The site was formerly marshland (Broadness Marsh) until development in the late 20th century. The site lies just to the east of a site of special scientific interest (SSSI) as designated by Natural England (2021) and near a location where boreholes were undertaken by Devoy (1979, 1982) as part of his seminal work on the Lower Thames Holocene stratigraphic sequence. The proposed development of the site involves the redevelopment of the site for use as an e-scrap sampling facility, involving the construction of a large building with associated below ground interventions such as piling and drainage.

Five geoarchaeological boreholes (MOLA_BH01 to MOLA_BH05) were sunk across the site in accordance with the Written Scheme of Investigation (WSI) (MOLA 2023b) and intact sediment sequences successfully retrieved. The primary objective of the evaluation was to determine the nature of the geoarchaeological resource in the area of impact.

All five boreholes reached the levels of the Pleistocene sand and gravel deposits which belonged to the Shepperton Gravel Formation. The average surface height of the Pleistocene deposits was -13.30m OD, varying from -15.45m to -10m OD. A plot of the Early Holocene land surface was produced using the surface of the Pleistocene deposits which approximates the topography at the beginning of the Mesolithic. This confirms the topographic trends identified during the previous geomodel (MOLA 2023a), with elevation declining from above -11m OD in the southern portion of the site, to below -13m OD in the central and northern parts of the site.

Overlying the Pleistocene deposits were interbedded Holocene alluvial sediments and peats. The Holocene sequence varied in thickness from 10m to 20m. Local site data (Devoy 1979, 1982; Stastney et al 2021) indicates the Holocene sequence has a moderate to high potential for the preservation of palaeoenvironmental proxy indicators (e.g. pollen, diatoms, plant macrofossils) which can be used to reconstruct past environments. Organic material can also be used for radiocarbon dating which can provide a chronostratigraphic framework for the sequence.

According to the wider landscape modelling, the low-lying topography of the site means that it would have been dry land until the Early Mesolithic because of relative sea level rise affecting the Thames. The site is unlikely to have been permanently settled, and there is a low potential for archaeological remains of medium heritage significance to be preserved within the alluvial peats and clays, such as branch-lain trackways and artefacts associated with riverside activities (e.g. jetties, boats, fish traps).

The Holocene deposits are capped by made ground deposits varying in thickness from 0.7m to 5m thick and relate to the development of the site in the late 20th century, therefore being of no archaeological interest.

Although considered deposits of medium heritage significance, given the location of the site near to where Devoy's seminal investigations within the inner Thames estuary took place (Devoy 1979, 1982) and because the planned piling will lead to sediment disturbance or loss, a targeted programme of palaeoenvironmental assessment is recommended to fully answer the research questions. At the request of the Kent County Council Senior Archaeological Officer, this will include post excavation assessment (PXA) of a range of palaeoenvironmental proxies and geochemical analyses from three cores to ascertain the survival and quality of the proxies and to assess the history of environmental change on the site. No further fieldwork is required, and as such this report supports the discharge of part (i) of Condition 3. Part (ii) would be discharged on agreement of the results and submission of the PXA and agreement on any final analysis.

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1 Introduction

1.1 Site background

- 1.1.1 This report presents the results of a geoarchaeological evaluation at the site of the Proposed E-Scrap Facility (Britannia Refined Metals), Swanscombe Peninsula, Northfleet, Kent DA11 9BG. The site is located off Botany Road, Northfleet, adjacent to the River Thames on the east and marshland to the west. The site is centred at NGR 561209, 175806 (Fig 1).
- 1.1.2 The site lies just to the east of a site of special scientific interest (SSSI) (Fig 8) as designated by Natural England (2021) and near a location where boreholes were undertaken by Devoy (1979, 1982) as part of his seminal work on the Lower Thames Holocene stratigraphic sequence.
- 1.1.3 A geoarchaeological deposit model (MOLA 2023a) and Written Scheme of Investigation (MOLA 2023b) were previously prepared for the site. These documents should be referred to for further information on the geological, archaeological, and historical background of the site.
- 1.1.4 The proposed development of the site comprises the redevelopment of the site for use as an e-scrap sampling facility. This will involve the construction of a large building with associated below ground interventions including extensive piling and drainage (MOLA 2023b). It is anticipated that the interventions are likely to destroy deposits of archaeological and palaeoenvironmental significance and potential (MOLA 2023a).

1.2 Planning and legislative framework

- 1.2.1 The planning and legislative background to the site is summarised in the WSI (MOLA 2023b).

1.3 Origin and scope of the report

- 1.3.1 This report presenting the results of the geoarchaeological borehole evaluation has been commissioned from Museum of London Archaeology (MOLA) by WSP UK Ltd on behalf of their client.
- 1.3.2 The report has been prepared within the terms of the relevant standards specified by the Chartered Institute for Archaeologists (CIfA 2023).

1.4 Aims and objectives

- 1.4.1 The primary objective of the evaluation is to determine the nature of the archaeological resource in the area of impact (MOLA 2023b).
- 1.4.2 The assessment of significance of any surviving remains is undertaken in the context of the wider archaeological research priorities for the region (Williams and Brown 1999; Museum of London 2002; Bates and Corcoran 2018).
- 1.4.3 A number of broad aims and objectives have been identified for this evaluation (MOLA 2023b):
 - What is the extent of modern disturbance?
 - What are the earliest deposits?
 - What is the depth and thickness of the floodplain deposits (i.e. peat and

alluvium)?

- Are prehistoric land surfaces present within the alluvial sequence?
- What is the potential of the alluvial sequence to reconstruct past environments from the prehistoric to historic periods (i.e. what levels of preservation of palaeoenvironmental proxy indicators, such as ostracods, diatoms, foraminifera, pollen, plant macrofossils)?
- How does the alluvial sequence on the site contribute to the understanding of the development of the Thames floodplain?
- Can evidence of the human occupation/activity be inferred from the alluvial sequence (i.e. land reclamation, evidence of dry land surfaces)?
- What are the latest deposits on the site?

1.4.4 The specific aims and objectives of this phase of field evaluation are:

- To ground-truth and enhance the MOLA deposit model for the site
- To enhance our understanding of the depth and extent of any former land surfaces, peat horizons and associated alluvial deposits
- To record and interpret any artefact or ecofact evidence for past human activity
- To record and interpret any evidence for past environmental change, including evidence and date of relative sea level change
- To sample for and interpret evidence for pollen, diatoms, macrofossils and for C14 dating of key horizons within the sequences
- To produce a report on the findings, including an updated deposit model, assessment of archaeological potential and a piling risk assessment for the site, with options for mitigation measures

2 Background

- 2.1.1 The site lies on the southern side of the wider floodplain of the River Thames and is situated on the Swanscombe Peninsula approximately 1.2km north of Swanscombe. The site lies between 4m and 6m above Ordnance Datum (AOD).
- 2.1.2 According to BGS mapping the underlying bedrock at the site is Cretaceous Chalk (BGS 2024). The bedrock pre-dates the evolution of hominin groups and therefore has no archaeological potential. Within the floodplain the influence of the bedrock on the landscape is negligible due to the considerable thickness of the overlying Quaternary deposits.
- 2.1.3 Throughout the Quaternary (Ice Age), climatic oscillations have created cycles of downcutting and aggradation within the Thames Valley, which together with gradual tectonic uplift has led to a sequence of progressively younger Quaternary deposits down the valley sides (Bridgland 1994; Gibbard 1994). These gravelly deposits form a series of terraces which represent former floodplains of the river.
- 2.1.4 The present floodplain represents the most recent stage in the sequence of floodplain incision and aggradation. It was created as the river cut down from a former, higher floodplain as a result of the low sea level and large influx of glacial meltwater which followed the end of the Last Glacial Maximum c. 18,000 before present (BP; Gibbard 1994). The river subsequently deposited coarse grained sediments (i.e. sands and gravels) across the valley floor and these deposits (Shepperton Gravel Formation) underlie the alluvium across the present floodplain and across the site.
- 2.1.5 At the interface between the Pleistocene and the Holocene, c. 10,000 BP, sea level is estimated as being as low as c. -30m OD (Devoy 1979). Sea level was rising and continued to do so rapidly until attaining its present levels by c. 6,000 BP. However, southeast England has been sinking as a result of isostatic rebound, so relative sea level (RSL) has continued to rise, drowning the Lower Thames Valley. The rate of RSL rise throughout the Holocene has not been continuous, so the alluvial sequence of the Lower Thames is punctuated by interbedded organic deposits and peats. These deposits reflect periods of slowing or hiatus in RSL rise which facilitated vegetational growth (Devoy 1979; Sidell 2003; Bates and Whittaker 2004).
- 2.1.6 Quaternary scientists and geographers are interested in the alluvial sequence for the information it provides on the pattern of local RSL rise and its implications for Holocene sea level fluctuations and climate change at a wider scale (e.g. Long et al 2000). Archaeologically, the significance of the interbedded peats and clays within the floodplain lies in the information they provide about past fluctuations in environment and thus the changing landscape available to be exploited and inhabited by people in the past.
- 2.1.7 The peat and alluvial sequence at World's End, Tilbury, on the north side of the Thames, c. 2.5km east of the site, has been extensively studied and used to form the typology for sediments in the Lower Thames / inner estuary area to which other sites have been correlated (including some from the Swanscombe Peninsula, near the current site) (Devoy 1979, 1982). The Devoy model of eustatic change details phases of inundation and minerogenic sedimentation (Thames Phases I-IV) that are interleaved with radiocarbon dated phases of marine regression defined by peat accumulation (Tilbury Phases I-IV; Table 1).
- 2.1.8 Of the five boreholes undertaken by Devoy across the Swanscombe Peninsula, the nearest borehole to the site that was examined was SB6/5, c. 550m to the north Devoy (1979). Four biogenic units were identified within the sequence from Swanscombe and correlated with Tilbury Phases II, III, IV and V. These biogenic units were interleaved with blueish grey silt/clay alluvium correlated to Thames Phases I-V.

- 2.1.9 Further to this, borehole SB6/2, c. 900m northwest of the site, was selected for radiocarbon dating and pollen assessment (Devoy 1979). The first phase of peat growth (Tilbury II) commenced 5979-5628 cal BC, from -8.79m OD, immediately above the clayey sand which capped the Pleistocene gravels in that location. This was overlain by alluvial silt/clay with pollen indicating a sedge fen or reedswamp environment. The second phase of peat growth (Tilbury III) was the most substantial and was characterised by oak-fen woodland, from -4.84m OD, 4243-3816 cal BC. This was followed by alluvial silt/clay with pollen indicated a return to reedswamp with open saltmarsh, and indicators of anthropogenic with cereal pollen. Two further small organic silt units with reeds and sedges were correlated with Tilbury IV and V.

Table 1: Chronology and height range of the Thames and Tilbury Phases (Devoy 1982).

Event	Commencement	Cessation /Height at surface
Thames V	c. 1600 cal BP (-0.75 to +0.44m OD)	No data
Tilbury V		+0.40m to -0.90m OD
Thames IV	2750 cal BP (-1.8 to -0.8m OD)	No data
Tilbury IV		-0.80m to -1.80m OD
Thames III	4250 cal BP	2900 cal BP
Tilbury III		-1.90m to -5.20m OD
Thames II	7550 cal BP	5700 cal BP
Tilbury II		-6.80m to -10.07m OD
Thames I	9200 cal BP	7800 cal BP
Tilbury I		-12.3m to -25.5m OD

- 2.1.10 More recently, a cultural landscape model for the likely impact of RSL rise in the Lower Thames Valley has been proposed (Bates and Whittaker 2004; Stafford et al 2012; Table 2). This model proposes a series of stages of Lower Thames sedimentation and suggests that areas where the topography of the 'pre-Holocene template', i.e. the surface of the Pleistocene gravels, lay below -6m OD were wetland areas at least by the late Mesolithic; by the early Neolithic land around -2m OD was inundated; and from the Late Neolithic to Early Bronze Age surfaces below 0m OD were inundated. Such wetland expansion caused islands of higher land to be created, as the surrounding lower-lying land turned to marsh and mudflats. These islands may have become targeted for exploitation and are often associated with evidence for prehistoric activity. Finally, during the late prehistoric period onwards, large scale submergence of the floodplain occurred, depositing minerogenic sediments up to the level that underlies modern made ground today.
- 2.1.11 Prior to development of the site, the land was uninhabited saltmarsh at the edge of the River Thames probably used for seasonal pasture from the medieval period onward and managed to some degree (e.g. drainage channels, flood defences) as map regression indicates (Wood Group UK 2022). As late as 1872 the site is mapped as uninhabited salt marsh with creeks and an embankment on the western side. Development followed in the latter half of the 20th century.

Table 2: Stages of Lower Thames sedimentation and environment (after Bates and Whittaker 2004).

Stage	Time period	Characteristics
1 Late Glacial	(1a) 30-15ka BP	Late glacial period; low sea level; reworking of river terraces under periglacial conditions; downcutting by river greatest at Glacial Maximum (height of cold period) c.18ka BP.
	(1b) 15ka-10kaBP	Valley infilling and deposition of Shepperton gravels; late glacial braided channel system; high fluvial energy.
2 Early Holocene	10 – 6/7ka BP	Early period of landscape stability across floodplain; low fluvial energy; complex vegetation mosaics; sedimentation largely sand bodies within river channels and areas of localised peat growth. Mesolithic
3 Middle Holocene	6/7 - 5 ka BP	Major landscape instability; sea level rise associated with extensive flooding (initially freshwater then brackish); expansion of wetland environments across previously dryland areas; mainly minerogenic sedimentation (clay/silts); numerous temporary and ephemeral land surfaces existing within flooded zone. Mesolithic / Neolithic
4 Late Holocene	5 - 3ka BP	Apparent sea level fall and associated reduction of tidal influence; period of organic sedimentation under brackish conditions (alder carr peat development) equating with Devoy's Tilbury III; expansion of wetland environments inland; topographic variation lost. Neolithic / Bronze Age
5 Later Holocene	3-1ka BP	Final submergence of floodplain with minerogenic (clay/silt) sedimentation dominating; no organic sedimentation; brackish tidal conditions as tidal head moves up lower Thames. Late Bronze Age; Iron Age; Roman; Medieval periods.
6 Later Holocene	1ka BP - present	Human manipulation of floodplain (flood defences and drainage channels); sedimentation rates reduce. Medieval post-medieval periods.

3 The geoarchaeological boreholes

3.1 Introduction

- 3.1.1 Five geoarchaeological boreholes (MOLA_BH01 to MOLA_BH05; Fig 2) were sunk across the site in accordance with the WSI (MOLA 2023b). The borehole locations were designed to complement the data previously obtained for the site from geotechnical boreholes and trial pits completed by CC Ground Investigations Ltd (WSP 2023).

3.2 Methodology

On site

- 3.2.1 The five boreholes were drilled with a tracked rotary drilling rig fitted with a 1.5m core sampler, under the supervision of a MOLA Geoarchaeologist. The boreholes were drilled to the surface of the Pleistocene gravels, in accordance with the WSI (MOLA 2023b).
- 3.2.2 The deposits were split and recorded on site before being labelled, sealed, and transported back to the MOLA geoarchaeological laboratory. Recovery of the sedimentary sequences was considered good overall
- 3.2.3 The boreholes reached just over 19m depth on average, where gravels and sands of the Shepperton (Thames floodplain) gravels were encountered (the limit of archaeological significant deposits).
- 3.2.4 The depths and nature of the alluvial deposits concur well with the previous geoarchaeological deposit modelling for the site and have the potential to track environmental change throughout the Holocene adding data and understanding to the environments of the past.
- 3.2.5 No archaeological artefacts were encountered in the boreholes.

Off site

- 3.2.6 Following the fieldwork, the data recorded from the site was entered into the MOLA geoarchaeological digital (RockWorks) database.
- 3.2.7 Correlations were made between strata by examining the horizontal and vertical relationships between lithological units, and groups were formulated on a site wide basis. The grouping of deposits was based on lithological descriptions, each being the product of distinct depositional environments. Thus, a sequence of stratigraphic units (facies) representing certain depositional environments or landforms were reconstructed both laterally and chronologically across the site. The information is displayed in transects (i.e. cross sections) across the targeted area of site in Figs 4-7.
- 3.2.8 Elevation data for the surface of the Pleistocene gravels was interpolated by kriging to provide an approximation of the early Holocene topography at the site. This deposit elevation model (DEM) is presented in Fig 3.

3.3 Results of geoarchaeological borehole survey

- 3.3.1 Lithostratigraphic logs describing the deposits encountered in the five boreholes (MOLA_BH01 to MOLA_BH05) are presented in Appendix 1.

3.4 Discussion of the geoarchaeological borehole survey

- 3.4.1 This section discusses the deposits in terms of the identified facies, from the oldest to the most recent. Three main facies were identified across the site: the pre-Holocene deposits, the Holocene deposits, and made ground deposits. The facies and lithology recorded within the boreholes are illustrated in the transects drawn across the site (Figs 4-7).

Facies 1: Pre-Holocene deposits

- 3.4.2 The lowermost deposits recorded in the geoarchaeological boreholes across the site were grey or olive green coloured sandy flint gravel deposits, overlain in some cases by fine to coarse sands and gravelly sands (Figs 4-7). These deposits belong to the Shepperton Gravel Formation which was deposited by the Thames during the Late Pleistocene.
- 3.4.3 The Pleistocene gravels have the potential to contain Palaeolithic artefactual remains but these tend to be reworked from older, higher river terrace deposits (Wenban-Smith et al 2010). Therefore, any Palaeolithic remains within the Shepperton Gravel would be of low archaeological significance due to their *ex situ* context.
- 3.4.4 The surface of the Pleistocene gravels approximates the topography of the site at the beginning of the Holocene when river energy levels declined and aggradation of sands and gravels ceased. The plot of the early Holocene surface produced using the surface heights of Pleistocene gravels provides both an approximate of the Early Mesolithic landscape and a topographic template for further sedimentation during the Holocene (Fig 3).
- 3.4.5 The mean average elevation of the early Holocene surface across the site, combining data from the geoarchaeological boreholes with data from the geotechnical boreholes from the site, was -13.33m OD. The elevation ranged from a low point of -15.43m OD in CC_BH105, in the southeastern part of site, to a high point of -9.99m OD in CC_BH104, in the southwestern part of the site (Table 3).
- 3.4.6 As the model demonstrates (Fig 3), the early Holocene topography of the site was undulating. The surface elevation of the gravels was highest in the southern part of the site, above -11m OD, and the elevation declines markedly to the central and northern parts of the site where elevation was found to be below -13m OD, with particularly low areas in the northern edge of site and in the central-eastern part of the site (Fig 3). The early Holocene surface model displays the same topographical trends as the model produced for the previous deposit model report (MOLA 2023a), indicating that the five geoarchaeological boreholes have produced data that is consistent with the results of the earlier geotechnical investigations.
- 3.4.7 Wider modelling of the Lower Thames Valley indicates that the site would have been dry ground at the beginning of the Holocene, but completely inundated during the Early Mesolithic as a result of relative sea level rise (Bates and Whittaker 2004; Stage 2, Table 2). By the end of the Mesolithic, topography up to -6m OD would have been inundated, by which time the entirety of site would have been underwater (Bates and Whittaker 2004; Stafford et al 2012).
- 3.4.8 The sands recorded in several of the boreholes as capping the Pleistocene deposits have the potential to hold evidence of Mesolithic soil development during the dryland phase at the beginning of the Holocene. Artefactual remains such as flint scatters may also survive, reflecting human occupation of the landscape at this time. Similar evidence of Mesolithic occupation has occasionally been found at other sites within the Lower Thames Valley (MOLA 2017), although none were retrieved in the core samples.

- 3.4.9 In MOLA_BH02, in the central eastern part of the site, the Pleistocene sandy gravel was found to grade into a gravelly peat at -12.92m OD, which may reflect the development of a semi-terrestrial wetland in this part of the site during the early Mesolithic, prior to the full inundation of the site. This unit may correlate to one of the early Tilbury Phases (Devoy 1979).

Table 3: Facies 1 depths and elevation within the site.

Facies 1	Depth (m bgl)	Elevation (m OD)
Average	18.48	-13.33
Maximum	21.50	-9.99
Minimum	15.00	-15.43

Facies 2: Holocene deposits

- 3.4.10 Across the site, all the geotechnical and geoarchaeological boreholes recorded the full Holocene sedimentary sequence. The Holocene sequence was substantial, with a mean average thickness of 15.93m, varying between 20m thick in CC_BH105 and 10m thick in CC_BH106 (Table 4). The sequence consists of alluvial silts and clays which were occasionally organic and occasionally including lenses or pockets of peat. Additionally, several of the boreholes recorded a thick layer of peat in the middle of the Holocene sequence, sandwiched above and below by minerogenic sediment.
- 3.4.11 During the Holocene, as relative sea level rose, the land surface would have become progressively inundated, causing alluviation and burying the underlying gravel topography. These deposits represent Stages 3-5 in the Lower Thames cultural landscape model (Table 2; Bates and Whittaker 2004). The deposits have a moderate to high potential for the preservation of palaeoenvironmental proxy indicators, for example pollen, diatoms and plant macrofossils, which can be used to reconstruct environmental change and provide material suitable for radiocarbon dating which can provide a chronostratigraphic framework for the sequence.
- 3.4.12 The tripartite sequence of lower alluvium, peat and upper alluvium is typical of the Lower Thames Valley. The thick peat unit is associated with a hiatus in sea level rise allowing for the extensive development of semi-terrestrial wetlands during the mid-Holocene. This is associated with Tilbury III phase in the Tilbury type sequence (Table 1; Devoy 1979), and Stage 4 in the cultural landscape model (Table 2; Bates and Whittaker 2004).
- 3.4.13 Indeed, in borehole SB6/2, c.900m northwest of the site on Broadness Marsh, studied by Devoy as part of triptych of sites within the Thames inner estuary (the others being Crossness and Dartford), a substantial phase of peat growth attributed to Tilbury Phase III was dated to 4243-3816 cal BC (Devoy 1979, 1982). This peat layer was present from -4.84m OD, which is similar to the elevations where the thick peat layer was recorded within the site. The pollen recorded indicated a fen environment with alder and oak (ibid 1979, 1982).
- 3.4.14 Importantly, less substantial peat layers are also recorded in the geoarchaeological boreholes which reflect shorter phases of peat accretion and recall the nuances of the sequence described by Devoy where several phases of peat accretion linked to marine regression events were identified (Table 1; Devoy 1979).
- 3.4.15 The site would not have been permanently settled as it was completely inundated from the Early Mesolithic, but artefactual and structural remains such as wooden trackways and jetties have occasionally been discovered in the Lower Thames floodplain, often associated with substantial peat layers (Meddens 1996). These structures were built by communities seeking to access and exploit the rich resources

of the floodplain (Carew et al 2009). However, no evidence of such remains were discovered during the evaluation.

- 3.4.16 Although interbedded peats were observed in most of the geotechnical and geoarchaeological boreholes, in MOLA BH01 and BH02 boreholes no substantial peat layers were recorded. This could be indicative of a channel running off the higher ground to the west or later, Thames tidal river scour.
- 3.4.17 The upper alluvium recorded in the boreholes, overlying the thick peat layer where present, is typically associated with the later Holocene and the onset of brackish, estuarine conditions as the tidal head progressed upstream through the Lower Thames Valley (Stage 5, Table 2; Bates and Whittaker 2004). Archaeological remains relating to waterside activities such as fish traps and boats can be found in association with these alluvial sediments (MOLA 2017), though no such remains were found during the evaluation.

Table 4: Facies 2 depths and elevation within the site.

Facies 2	Thickness (m)	Surface depth (m bgl)	Surface elevation (m OD)
Average	15.93	2.55	2.60
Maximum	20.00	5.00	4.57
Minimum	10.00	1.20	-0.08

Facies 3: Made ground

- 3.4.18 The extent of the made ground was recorded in all interventions across the site, including geotechnical trial pits as well as geotechnical and geoarchaeological boreholes. The made ground was found to vary in thickness from 0.7m in CC_WS101 to 5m in CC_BH106, with a mean average thickness of 2.14m. The mean average ground level was 5.30m above OD.
- 3.4.19 The made ground deposits were found to directly overlie the Holocene alluvial sequence and probably has truncated the upper levels of the Holocene sequence to some extent. The made ground deposits represent the development of the site in the latter half of the 20th century and are of no archaeological interest.

Table 5: Facies 3 depths and elevation within the site.

Facies 3	Thickness (m)	Surface elevation (m OD)
Average	2.15	5.30
Maximum	5.00	6.07
Minimum	0.70	4.19

4 Archaeological potential and significance

4.1 Original research questions

- 4.1.1 This section provides a preliminary assessment of the extent to which the original site objectives defined in the WSI (MOLA 2023b) have been addressed by the investigation.
- 4.1.2 *What is the extent of modern disturbance?*
Modern disturbance is represented by the made ground deposits which reflect the late 20th century development of the site. The thickness of these deposits, i.e. the extent of modern disturbance, varies across the site from 0.7m to 5m, with a mean average of 2.15m.
- 4.1.3 *What are the earliest deposits?*
The earliest deposits recorded in the geoarchaeological boreholes were sandy gravel deposits belonging to the Shepperton Gravel Formation, deposited at the end of the Pleistocene after the Last Glacial Maximum c. 18,000 years ago (Gibbard 1994).
- 4.1.4 *What is the depth and thickness of the floodplain deposits (i.e. peat and alluvium)?*
The thickness of the Holocene floodplain sequence across the site ranged from 10m to 20m, with a mean average of 15.95m. The depth to the surface of these deposits ranged between 1.20m and 5m below ground level, and the base of the sequence was found to lie between -10m and -15.45m OD.
- 4.1.5 *Are prehistoric land surfaces present within the alluvial sequence?*
No prehistoric land surfaces were identified within the alluvial sequence, although the sand deposits which cap the Pleistocene gravels may contain evidence of soil development relating to the period of landscape stability in the Early Mesolithic. Additionally, the presence of peat overlying the Pleistocene gravels in MOLA_BH02 at -12.90m OD may reflect the development of an early Holocene semi-terrestrial wetland in the eastern, lower lying area of the site.
- 4.1.6 *What is the potential of the alluvial sequence to reconstruct past environments from the prehistoric to historic periods (i.e. what levels of preservation of palaeoenvironmental proxy indicators, such as ostracods, diatoms, foraminifera, pollen, plant macrofossils)?*
From the palaeoenvironmental data examined by Devoy locally on Broadness Marsh (Devoy 1979, 1982) and data from MOLA sites within the inner Thames estuary (e.g. Stastney et al 2021) the alluvial sequence is likely to have moderate to high potential for the preservation of palaeoenvironmental proxy indicators which can be assessed for the purposes of reconstructing environmental change at the site. Additionally, thick biogenic sequences suitable for radiocarbon dating appear well preserved within the sequence, which can provide a chronostratigraphic framework for the site as a whole. In particular, the presence of peat at low elevations within the sequence, i.e. below -9m OD, presents good potential for the reconstruction of Mesolithic environments at the site, which would be of particular interest (Bates and Corcoran 2018). If present, proxy indicators would be of medium heritage significance.
- 4.1.7 *How does the alluvial sequence on the site contribute to the understanding of the development of the Thames floodplain?*
The alluvial sequence on the site is deep and characteristic of the Lower Thames floodplain in this area of Kent, where the Thames approaches the estuary. This stands in marked contrast to the more frequently studied, shallower sequences encountered further up river closer to London (Sidell, 2003; MOLA 2017). Given the depth of the

sequence (averaging 19m) these Holocene sediments have potential of providing very good resolution of environmental change within the Thames from early in the Holocene such as recorded by MOLA at other locations in the inner estuary (e.g. at Littlebrook Power Station, Dartford; Stastney et al 2021). The site also provides a unique opportunity for comparison with the palaeoenvironmental work carried out by Devoy on the Holocene sequence in the northern part of the Swanscombe Peninsula (Broadness Marsh) in the late 1970s (Devoy 1979, 1982), which can be used to contextualise the Holocene sequence within the site.

4.1.8 *Can evidence of the human occupation/activity be inferred from the alluvial sequence (i.e. land reclamation, evidence of dry land surfaces)?*

No evidence of human occupation or activity was observed in the alluvial sequence, although the lower sands may contain evidence of early Holocene soil formation, and palaeoenvironmental proxy indicators may contain evidence of anthropogenic influences in the local environment. There is also a low potential for the preservation of structures and artefacts reflecting the exploitation of the wetlands in the alluvium and peat.

4.1.9 *What are the latest deposits on the site?*

The latest deposits on the site are made ground deposits associated with the development of the site in the latter part of the 20th century and are of no archaeological interest.

4.2 Overall potential

4.2.1 The geoarchaeological deposit model and borehole survey have investigated and sampled the deposits present on site and allowed a clearer understanding of where deposits with archaeological and palaeoenvironmental potential are likely to exist.

4.2.2 The Holocene sequence features interleaved minerogenic and biogenic deposits which are of medium significance and high palaeoenvironmental potential. Proxy environmental indicators such as pollen and diatoms which can be used to reconstruct past environments and trace environmental changes are likely to be present. Additionally, organic material is preserved which may be suitable for radiocarbon dating which can provide a chronostratigraphic framework for the sequence.

4.2.3 Due to the low potential for identifying artefactual or structural remains (boats, fish traps and trackways for example) given the depths of the Holocene deposits encountered and the fact that no prehistoric land surfaces or evidence of human occupation or activity were identified, the overall archaeological potential remains uncertain. The heritage significance of the site lies mainly in the rare opportunity this investigation presents to compare and refine Devoy's results from the Swanscombe peninsula and track palaeoenvironmental change in this under investigated area of the Lower Thames valley in an attempt to address, in part, the relevant objectives outlined in the South East Research Framework (SERF) guidance Kent County Council (KCC) (2018).

5 Proposed development impact and recommendations

5.1 Impact of the development

- 5.1.1 The proposed development of the site involves numerous below ground interventions including Controlled Modulus Columns (CMC) piling and drainage works (Vibro Menard 2022, 2023 and 2023a) which will displace the Holocene floodplain deposits of high palaeoenvironmental potential and medium heritage significance. The worst-case scenario for the extent of the CMC installation (visual assessment based on current plans) would result in approximately 20% of sediment disturbance across the site.

5.2 Recommendations

- 5.2.1 Firstly, no further field work is recommended due to the low potential for the preservation of artefactual or structural remains, and the significant depth of the Holocene deposits.
- 5.2.2 However, although of medium heritage significance, the site lies adjacent to a site of special scientific interest (SSSI), and due to the thickness of the sedimentary sequence and the moderate to high potential for the preservation of palaeoenvironmental proxy indicators (e.g. pollen and diatoms), a post-excavation assessment (PXA) is recommended. Typically, the 'best' core is selected at the PXA stage for presence/absence of microfossils, following guidance which states assessment should be 'sufficient to establish the potential to address research questions' (Historic England 2015, paragraph 3.6). One core, e.g. MOLA_BH03, would represent the site sequence in this respect.
- 5.2.3 Given the interest of the KCC Senior Archaeological Officer and Historic England and through consultation, PXA of three boreholes has been requested by KCC. Assessment of the potential for environmental change and human land use is requested on MOLA_ BH02, MOLA_ BH03 and MOLA_ BH04 to compare and contrast the sequences within the site. This will provide a good indication of macro- and microfossil survival and species diversity, and if suitable material is present for radiocarbon dating, establish a site chronology. The PXA will focus on the key research question of whether indicators of human land-use in prehistory can be identified and at what date.
- 5.2.4 Samples will be taken following Historic England and SERF recommendations and guidelines (HE 2018 & 2022; Kent County Council 2019; Campbell et al 2011) although these may change in terms of sediment type and volume:
- 36 pollen samples in total (approximately 12 each at similar levels) from boreholes MOLA_ BH02, MOLA_ BH03 and MOLA_ BH04 from the biogenic (peat) and minerogenic (silts/ clay) deposits to track regional and local vegetation change
 - 12 diatom or ostracod samples in total from boreholes MOLA_ BH03 from the minerogenic deposits to track changes in hydrological conditions
 - Up to 18 bulk samples (approximately 6 each) from the peats in MOLA_ BH02, MOLA_ BH03 and MOLA_ BH04 for botanical and microcharcoal assessment, and, if possible, assessment for the survival of insects/microfauna
 - Up to 6 samples for radiocarbon dating will be undertaken should appropriate

material (e.g. terrestrial plant macrofossils) be identified within peat deposits (following Historic England 2022 flow diagram Figure 19). Dating will focus on the top and bottom of peat horizons in MOLA_BH03 and MOLA_BH04 (top, middle and bottom of the woody peat between 6.42 to 8.52m below OD) and the peaty gravel at the base of MOLA_BH02. This aims to provide a range of dates for the sequence and achieve correlation between cores. Other dating techniques such as Optically Stimulated Luminescence (OSL) of the sands is not recommended because of the disaggregated / loose nature of these deposits in the sample tubes and the poor 'bleaching' conditions of fluvial/alluvial depositional environments)

- 24 samples for chemical assessment, including pH, Redox potential (Eh), and electrical conductivity (EC) to understand chemical processes that occur in the sedimentary column enabling salinity changes to be tracked and provide an indication of taphonomic conditions from MOLA_BH03.
- 5.2.5 The PXA will be completed within approximately 9 months from instruction (currently by January 2025).
- 5.2.6 This assessment will fully address the original research questions (Section 4.1) and allow for an initial assessment of both the survival of the environmental proxies on site and the history of environmental change on site.
- 5.2.7 Following the completion of the PXA, the report will be submitted to the KCC Senior Archaeological Officer for agreement on the scope of any recommended analysis, final reporting/publication and project archiving.
- 5.2.8 Given the medium heritage significance of the sediments and contained proxies and the fact that cores have been collected from site for investigation, it is considered that this evaluation report will be used to support the discharge of part (i) of Condition 3 with the understanding that part (ii) would be discharged on agreement of the results and submission of the PXA and agreement on any final analysis, reporting and archiving. With part (i) fully discharged it would be possible for development to commence (in respect of archaeology) as no further field work would be required, and mitigation would be in the form of any remaining analysis, reporting and archiving.
- 5.2.9 Should assessment lead to further analysis, the site could be particularly useful in refining the understanding of the landscape history of the Swanscombe Peninsula and associating it with the wider development of the Lower Thames landscape and correlating with Devoy's seminal work on reconstructing Holocene sea level and vegetational change in the Lower Thames Valley (Devoy 1979, 1982).

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Vibro Menard 2023a Controlled Modulus Columns (CMC) Layout – Externals Drawing No. V28876-2

7 Appendix 1 – Borehole logs

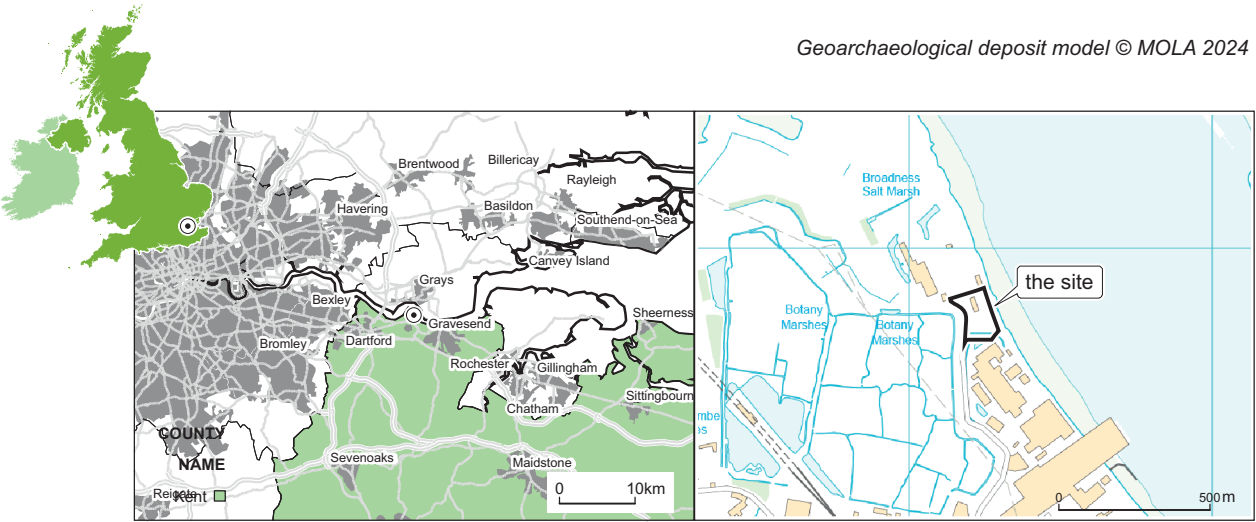
MOLA BH01						
561204	175768	OD height of bore:		5.84		
Depth to top of unit (m bgl)	Depth to base of unit (m bgl)	OD height of top of unit (m)	OD height at base of unit (m)	Thickness	Description	Interpretation
0.00	2.65	5.84	3.19	2.65	Compact bed of fragmented brick, concrete, plastic and sand (piling mat)	Made ground
2.65	3.40	3.19	2.44	0.75	Compact yellow medium to coarse sand with fine fragments of building material throughout	Holocene deposits
3.40	5.50	2.44	0.34	2.10	Soft black silty clay	
5.50	10.20	0.34	-4.36	4.70	Soft greyish brown silty clay with very occasional organic material throughout	
10.20	11.50	-4.36	-5.66	1.30	Soft mid brown peaty silty clay	
11.50	19.00	-5.66	-13.16	7.50	Soft grey silty clay with occasional organic/peat fragments throughout lessening with depth	
19.00	19.40	-13.16	-13.56	0.40	Soft grey sandy silt	
19.40	19.70	-13.56	-13.86	0.30	Soft grey gravelly clay	
19.70	19.90	-13.86	-14.06	0.20	Firm olive green medium to coarse sand	Pre-Holocene deposits
19.90	21.00	-14.06	-15.16	1.10	Compact olive green coarse sand and rounded medium to coarse gravel	

MOLA BH02						
561255	175773	OD height of bore:		5.98		
Depth to top of unit (m bgl)	Depth to base of unit (m bgl)	OD height of top of unit (m)	OD height at base of unit (m)	Thickness	Description	Interpretation
0.00	1.50	5.98	4.48	1.50	Piling mat	Made ground
1.50	3.00	4.48	2.98	1.50	Compact yellow medium to coarse sand with frequent fine CBM fragments	
3.00	4.30	2.98	1.68	1.30	Compact yellow medium to coarse sand with frequent fine CBM fragments	
4.30	4.50	1.68	1.48	0.20	Soft black silty sand	Holocene deposits
4.50	5.60	1.48	0.38	1.10	Void - poor recovery	
5.60	6.50	0.38	-0.52	0.90	Soft black silty sand	
6.50	7.40	-0.52	-1.42	0.90	Soft black (initially) becoming rapidly grey silty clay	
7.40	8.55	-1.42	-2.57	1.15	Soft brown fibrous peaty silty clay	
8.55	11.80	-2.57	-5.82	3.25	Soft brownish grey laminated silty clay with occasional organics (peat fragments) throughout	
11.80	11.90	-5.82	-5.92	0.10	Crumbly very dark brown fibrous peat	
11.90	16.06	-5.92	-10.08	4.16	Soft light grey silty clay	
16.06	16.40	-10.08	-10.42	0.34	Large fragment of wood (alder)	
16.40	18.80	-10.42	-12.82	2.40	Light grey soft silty clay with fine wood fragments	
18.80	18.90	-12.82	-12.92	0.10	Soft dark brown gravelly peat	Pre-Holocene deposits
18.90	20.00	-12.92	-14.02	1.10	Compact dark grey fine to medium subrounded to rounded flint sandy gravel	

MOLA BH03						
561241	175810	OD height of bore:		5.29		
Depth to top of unit (m bgl)	Depth to base of unit (m bgl)	OD height of top of unit (m)	OD height at base of unit (m)	Thickness	Description	Interpretation
0.00	1.93	5.29	3.36	1.93	Piling mat	Made ground
1.93	2.20	3.36	3.09	0.27	Moderately firm greenish grey 1cm bands of fine to medium sand and silty clay	Holocene deposits
2.20	2.60	3.09	2.69	0.40	Moderately firm dark grey to black 1cm bands of fine to medium sand and silty clay	
2.60	2.72	2.69	2.57	0.12	Moderately firm greenish grey 1cm bands of fine to medium sand and silty clay	
2.72	2.88	2.57	2.41	0.16	Moderately firm dark grey to black 1cm bands of fine to medium sand and silty clay	
2.88	3.00	2.41	2.29	0.12	Soft fine very dark grey fine to medium sand	
3.00	4.20	2.29	1.09	1.20	Moderately firm black becoming grey laminated silty clay with manganese speckling and fine organic fragments moderately frequently throughout	
4.20	7.00	1.09	-1.71	2.80	Moderately firm black becoming grey laminated silty clay with manganese speckling	
7.00	7.13	-1.71	-1.84	0.13	Firm dark brown fibrous clayey peat	
7.13	11.50	-1.84	-6.21	4.37	Soft grey laminated silty clay with fine peaty/wood fragments throughout	
11.50	12.00	-6.21	-6.71	0.50	Firm dark brown fibrous peat	
12.00	13.50	-6.71	-8.21	1.50	Soft grey laminated silty clay with fine peaty/wood fragments throughout	
13.50	14.70	-8.21	-9.41	1.20	Soft grey silty clay	
14.70	15.00	-9.41	-9.71	0.30	Soft dark brown clayey peat	
15.00	17.80	-9.71	-12.51	2.80	Soft grey laminated silty clay with fine peaty/wood fragments throughout	
17.80	19.50	-12.51	-14.21	1.70	Soft grey laminated silty clay	
19.50	20.00	-14.21	-14.71	0.50	Soft grey medium sand with occasional bands of clay; occasional fine to medium subangular to subrounded gravel at depth	
20.00	21.00	-14.71	-15.71	1.00	Compact dark grey fine to medium subrounded to rounded flint sandy gravel	Pre-Holocene deposits

MOLA BH04						
561230	175845	OD height of bore:		4.68		
Depth to top of unit (m bgl)	Depth to base of unit (m bgl)	OD height of top of unit (m)	OD height at base of unit (m)	Thickness	Description	Interpretation
0.00	2.50	4.68	2.18	2.50	Piling mat	Made ground
2.50	3.00	2.18	1.68	0.50	Concrete dry mix	
3.00	4.00	1.68	0.68	1.00	No recovery	Holocene deposits
4.00	4.30	0.68	0.38	0.30	Soft black silty clay	
4.30	4.50	0.38	0.18	0.20	Soft brownish grey silty clay with discrete patch of sand and gravel	
4.50	6.60	0.18	-1.92	2.10	Soft grey silty clay with occasional manganese staining and discrete pockets of peat	
6.60	6.82	-1.92	-2.14	0.22	Soft dark brown peaty clay	
6.82	10.40	-2.14	-5.72	3.58	Soft grey silty clay with occasional fibrous peaty material throughout	
10.40	10.60	-5.72	-5.92	0.20	Moderately dark brown to dark brownish grey peaty clay	
10.60	11.10	-5.92	-6.42	0.50	Moderately dark brown to dark brownish grey clayey peat	
11.10	13.20	-6.42	-8.52	2.10	Moderately firm very dark brown woody peat	
13.20	13.97	-8.52	-9.29	0.77	Soft grey silty clay with occasional fibrous peaty material throughout	
13.97	14.07	-9.29	-9.39	0.10	Moderately firm dark grey organic laminated silty clay with thin layers of peat	
14.07	14.35	-9.39	-9.67	0.28	Firm dark brown fibrous peat	
14.35	14.40	-9.67	-9.72	0.05	Moderately firm dark grey silty clay	
14.40	14.80	-9.72	-10.12	0.40	Moderately firm woody peat	
14.80	15.70	-10.12	-11.02	0.90	Soft grey silty clay with occasional fibrous peaty material throughout	
15.70	16.20	-11.02	-11.52	0.50	Soft light grey silty clay	
16.20	17.00	-11.52	-12.32	0.80	No recovery	
17.00	18.00	-12.32	-13.32	1.00	Moderately firm greenish grey silt with 1cm bands of fine sand occasionally throughout from 16.38m bgl onward	Pre-Holocene deposits
18.00	18.38	-13.32	-13.70	0.38	Soft wet olive green fine sand	
18.38	19.36	-13.70	-14.68	0.98	Moderately firm olive green medium sands and occasional gravel	
19.36	21.00	-14.68	-16.32	1.64	Compact olive green subrounded to subangular gravel and sand	

MOLA_BH05						
561184	175822	OD height of bore:		4.19		
Depth to top of unit (m bgl)	Depth to base of unit (m bgl)	OD height of top of unit (m)	OD height at base of unit (m)	Thickness	Description	Interpretation
0.00	2.30	4.19	1.89	2.30	Piling mat over dry mix concrete	Made ground
2.30	2.90	1.89	1.29	0.60	Moderately firm black silty clay	Holocene deposits
2.90	6.00	1.29	-1.81	3.10	Moderately firm grey silty clay	
6.00	6.90	-1.81	-2.71	0.90	Moderately firm grey silty clay with manganese staining and occasional peaty fragments throughout	
6.90	7.05	-2.71	-2.86	0.15	Moderately firm dark brown peaty clay	
7.05	7.30	-2.86	-3.11	0.25	Moderately firm grey silty clay with manganese staining and occasional peat	
7.30	10.40	-3.11	-6.21	3.10	Moderately firm dark grey silty clay with manganese staining and occasional peat	
10.40	10.50	-6.21	-6.31	0.10	Firm dark brown clayey peat	
10.50	13.25	-6.31	-9.06	2.75	Very soft dark brown fibrous peat	
13.25	17.80	-9.06	-13.61	4.55	Soft dark grey silty clay with fine wood fragments throughout	
17.80	18.00	-13.61	-13.81	0.20	Soft grey clay silt with moderately frequent fine to medium rounded gravel of flint	
18.00	19.00	-13.81	-14.81	1.00	No recovery	
19.00	19.40	-14.81	-15.21	0.40	Soft olive green medium sand with occasional very fine gravel throughout	Pre-Holocene deposits
19.40	21.00	-15.21	-16.81	1.60	Compact olive green medium to coarse sand and frequent fine to medium subrounded to subangular flint gravel	



561000



Fig 1 Site location



Fig 2 Borehole and transect locations



Fig 3 Early Holocene surface model (0.5m contour)

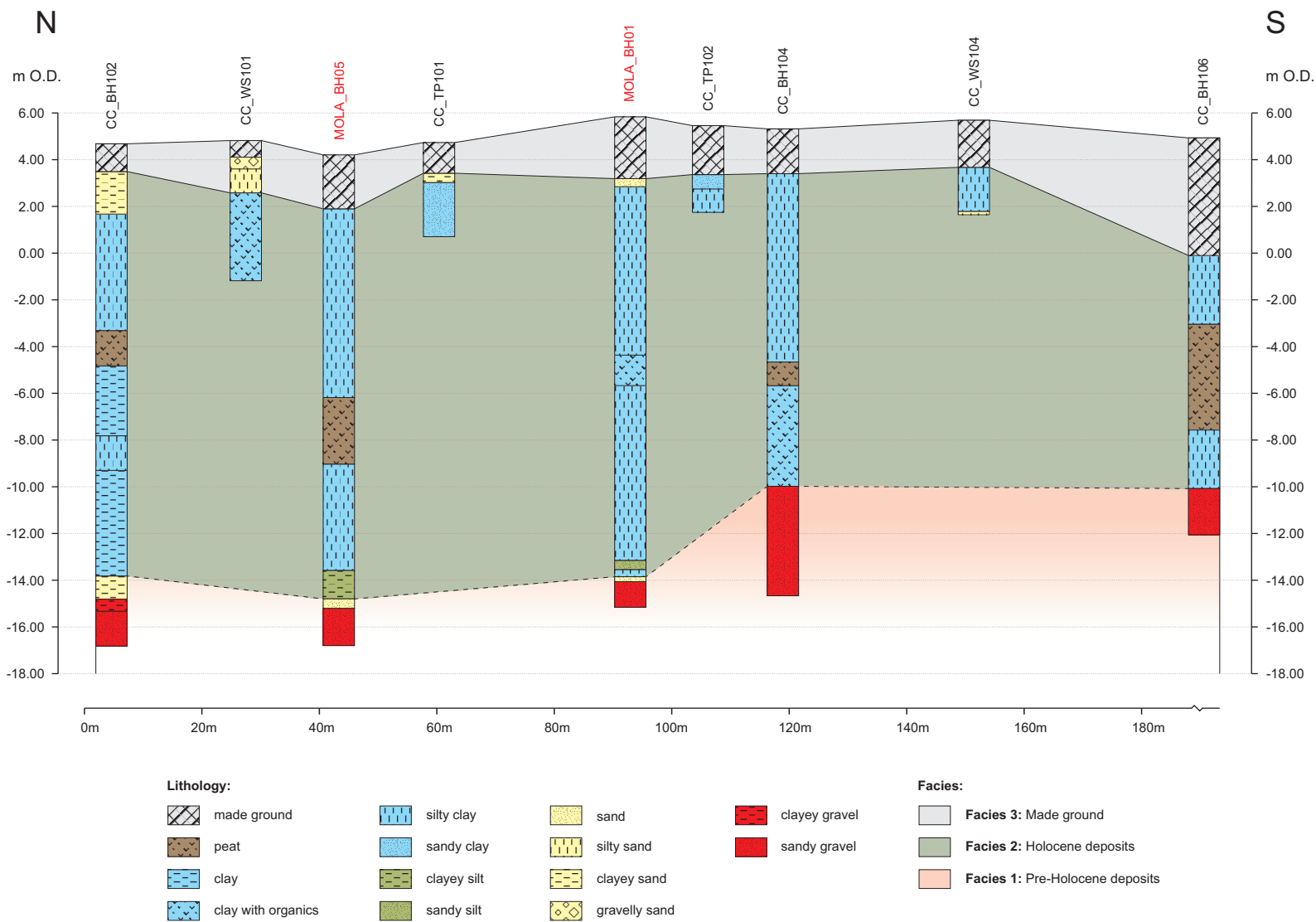


Fig 4 Transect 1 N-S (west)

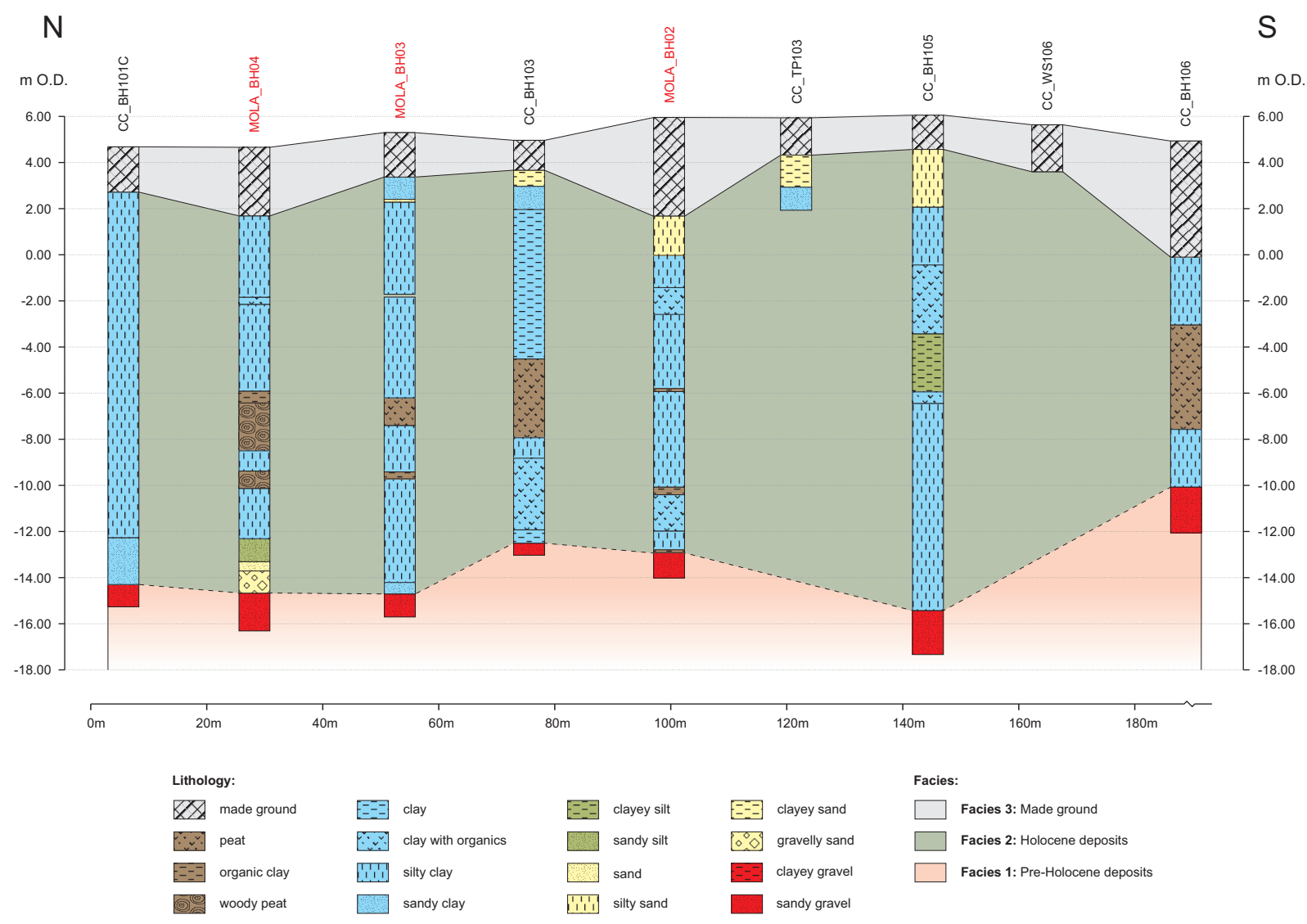


Fig 5 Transect 2 N-S (east)

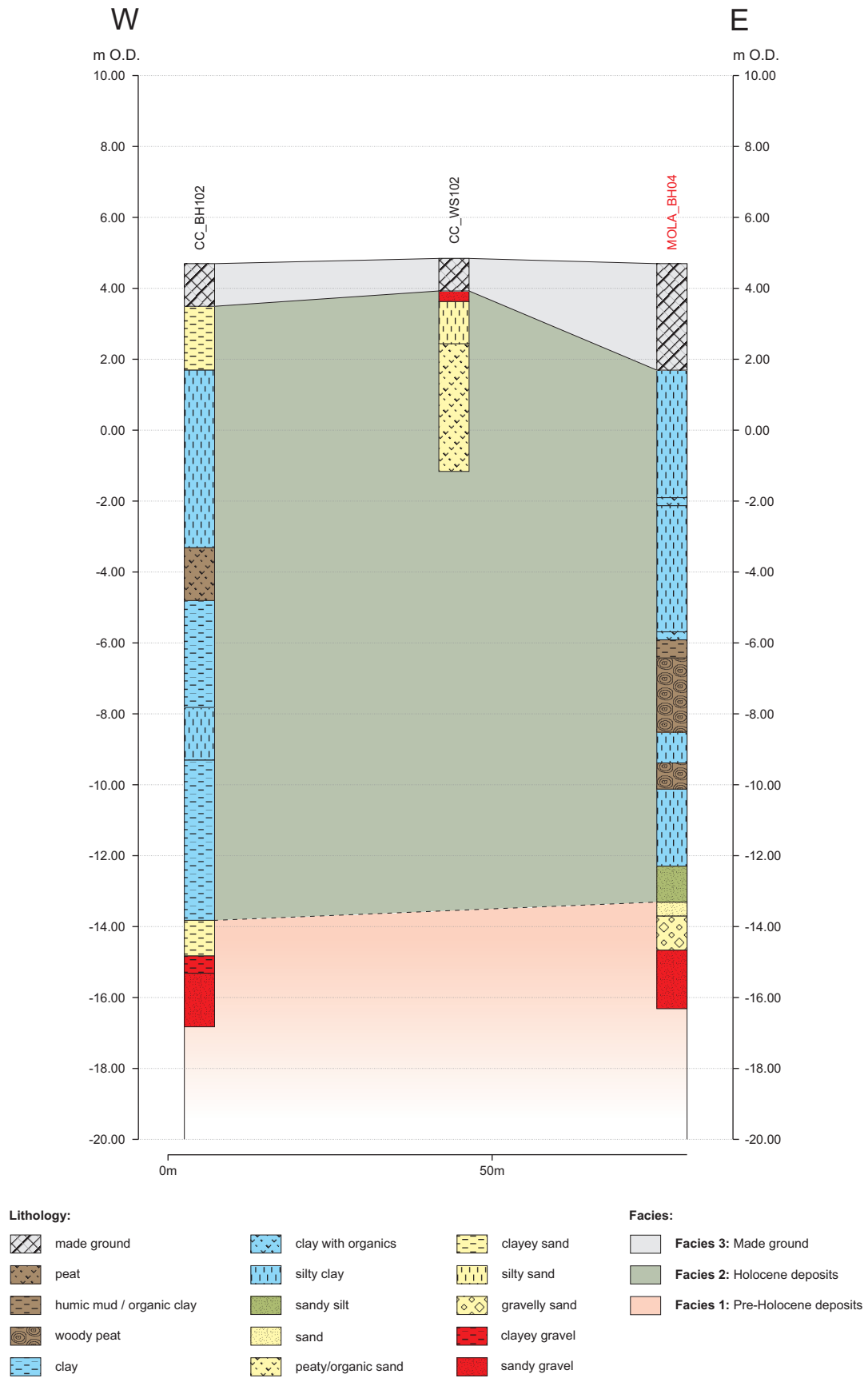


Fig 6 Transect 3 W-E (north)

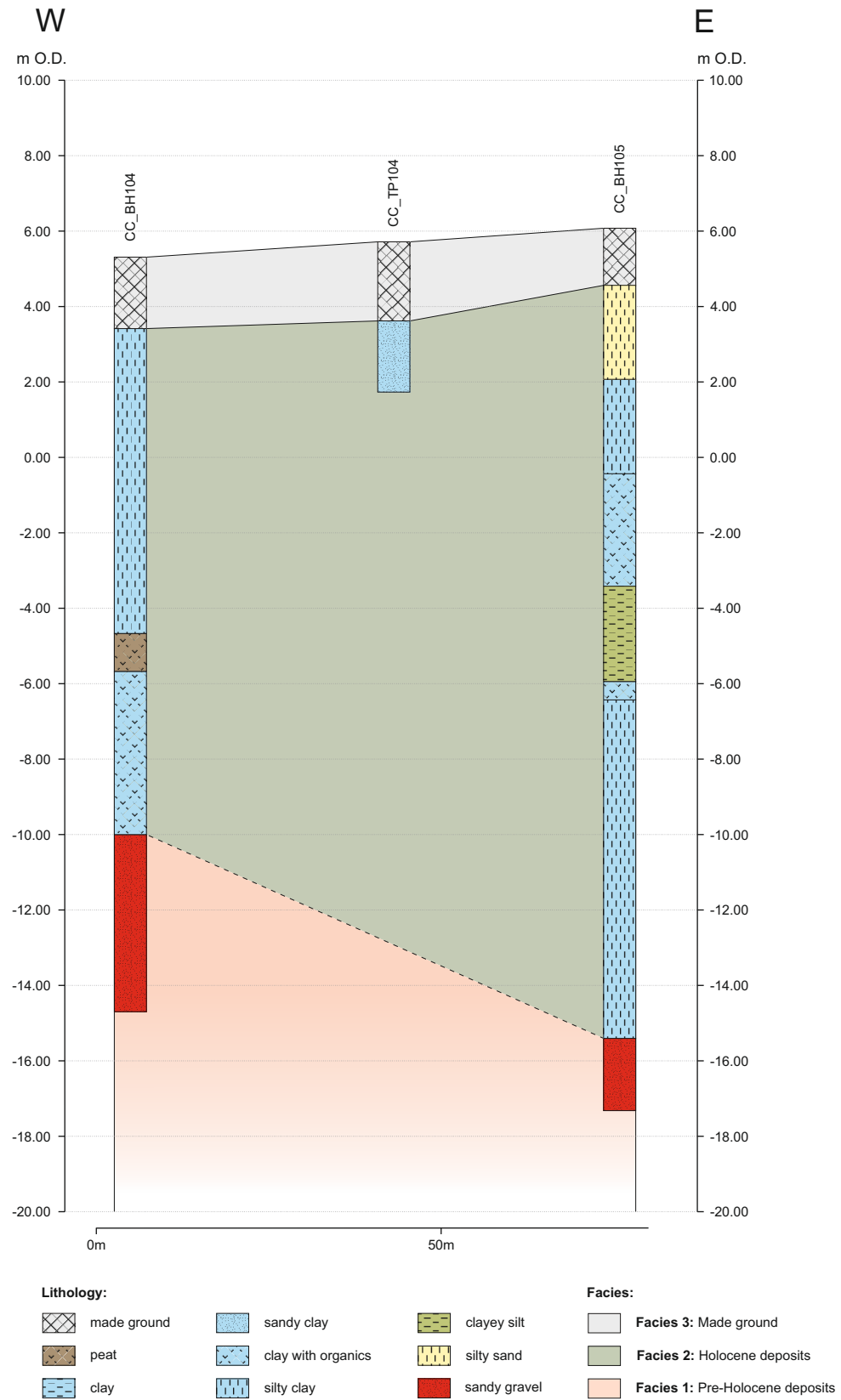


Fig 7 Transect 4 W-E (south)



Fig 8 SSSI location relative to the site (Natural England 2021)