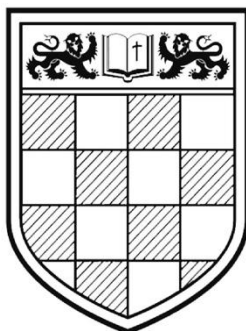


April 2025

**TKRE CABLE
REPLACEMENT PROJECT
(TILBURY TO GRAVESEND):
GEOARCHAEOLOGICAL
WATCHING BRIEFS ON
GEOTECHNICAL
BOREHOLES AND SHAFT
EXCAVATION**

**WRITTEN SCHEME OF
INVESTIGATION**

Prepared for National Grid



UNIVERSITY OF

WINCHESTER

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1. Introduction

- 1.1 This Written Scheme of Investigation (WSI) sets out the approaches and methodologies to be used during a geoarchaeological watching brief of geotechnical boreholes and shaft excavation works being conducted as part of the TKRE Cable Tunnel Replacement Project (Tilbury to Gravesend) (henceforth 'the project') (Figures 1, 2a and 2b). The WSI has been commissioned by National Grid.
- 1.2 The proposed development will see the replacement of a current TKRE 400kV cable route with polyethylene cables, these passing through a newly bored tunnel beneath the River Thames between Tilbury (NGR 566295 175834) and Gravesend (NGR 567429 174097) (Figure 1). Associated infrastructure will also be constructed at both tunnel headhouse locations (these latter henceforth 'the sites') (Figure 2a and 2b).
- 1.3 Both the Tilbury and Gravesend sites are in the former (prior to reclamation) intertidal zone of the River Thames, and coincide with bedrock of the Lewes Nodular Chalk Formation, a unit that is of Late Cretaceous date (93.9–72.1 million years ago) (British Geological Survey 2025a, 2025b). The British Geological Survey (2025a) map superficial 'Alluvium' as overlying the bedrock. However, as a prior desk-based assessment and deposit modelling exercise have highlighted, the 'Alluvium' is in fact Late Pleistocene River Terrace Deposits¹ overlain by a complex of fine grained alluvial and intertidal muds and peats (AECOM 2023, Quaternary Scientific 2023). Indeed, multiple peat levels have been found on both sites, these dating throughout the Holocene². While Tilbury is also the stratotype for the lower Thames Holocene sequence (Devoy 1979).
- 1.4 A geoarchaeological borehole survey was carried out by of the two headhouse locations in July 2024 (Wilkinson et al. 2024). Two boreholes were advanced at each site using a dynamic drilling rig and collecting continuous cores from the base of a 1.2m-deep inspection pit to the top of the Late Pleistocene fluvial gravels (the latter being the Shepperton Gravel Member *sensu* British Geological Survey 2025a). Holocene stratigraphy at the Gravesend headhouse (ARCA BH01–BH02, Figure 2b) was found to be 12.40m thick (extending to -10.19m OD) and that at the Tilbury headhouse (ARCA BH03–BH04, Figure 2a) 16.68m (-13.91m OD). Three organic strata (termed 'Lower', 'Middle' and 'Upper Peat') sandwiched between grey silt/clays were found above the Pleistocene gravel on both sites, while two possible palaeosols (one associated with sands overlying the Shepperton Gravel and the other at the top of the Middle Peat) were also present on the Gravesend site. The peat units were ¹⁴C dated to c. 7450–5950 cal. BC (Tilbury Lower Peat), 5700–5450 cal. BC (Gravesend Lower Peat), 4400–3500 cal. BC (Gravesend Middle Peat) and 3450–850 cal. BC (Tilbury Middle Peat), while the Upper Peat must date to the Iron Age or later (post 850 cal. BC). Diatom assessment indicated that the grey silt/clays sub-cropping between the peats formed in an intertidal environment, i.e. most probably mud flats, albeit that some freshwater input is associated with the top of the Middle Peat. Pollen was poorly preserved in the Lower Peat, but well preserved in the Middle Peat, and indicated that dryland vegetation at

¹ The Pleistocene is the geological epoch between 2.6 million and 11.7 thousand years ago, while the Late Pleistocene is the period 130.0–11.7 thousand years ago

² The geological epoch extending from 11.7 thousand years ago to the present day

the time the peat formed was of deciduous woodland, albeit that the latter was much reduced in the top of the Upper Peat.

- 1.5 The new cable tunnel will pass through the Chalk bedrock and will not of itself have an archaeological impact. However, the 15m diameter shafts at each headhouse location will be excavated to 45m depth and will remove the intertidal/alluvial/peat stratigraphy, together with any enclosed archaeological and biological remains.
- 1.6 The geoarchaeological watching briefs described here are intended to record the Quaternary³ stratigraphy encountered during the geotechnical and construction works and to ensure that any archaeological remains are properly recorded (and where possible, recovered). At the same time, the watching briefs provide an opportunity to collect samples of suitable size for biological macrofossil assessment (which due to the small sample window [112mm diameter], was not possible in the previous geoarchaeological borehole survey [Wilkinson et al. 2024]). Further, the watching briefs will allow samples for microfossil assessment to be collected from strata that were either not encountered or were partially sampled by the geoarchaeological boreholes. To these ends the aims of the geoarchaeological watching brief are (as modified from the aims in the WSI for the 2024 geoarchaeological boreholes [AECOM 2023, 9]):
 - 1.6.1 Record the location, depth, extent, character and state of preservation of the buried deposit sequence in boreholes and shaft excavation pits;
 - 1.6.2 Determine the presence, nature and distribution of Holocene alluvial floodplain, estuarine and tidal deposits and palaeoenvironmental sequences across the two sites and assess their potential for archaeological and a palaeoenvironment remains to be preserved;
 - 1.6.3 Identify and recover samples for off-site assessment/analysis, these samples capable of providing a range of proxy biological and environmental indicators that will provide new information on Late Quaternary deposition, climate, hydrology, vegetation and land-use (human activity) of the two sites;
 - 1.6.4 Identify and recover samples for off-site assessment/analysis, suitable for chronometric dating (e.g. ¹⁴C dating, dendrochronology) in order to augment the existing chronostratigraphic framework for each site;
 - 1.6.5 Interpret the Holocene palaeoenvironmental and depositional setting of each headhouse and their surrounding environs;
 - 1.6.6 Update and refine the deposit model produced as a result of the geoarchaeological borehole study (Wilkinson et al. 2024) with stratigraphic data recovered from the GI boreholes and the walls of the shaft excavation pits;
 - 1.6.7 Assess the potential impact of the proposed development on deposits of high geoarchaeological and archaeological potential; and
 - 1.6.8 Present the results of the geoarchaeological investigation in a report for dissemination to relevant stakeholders.

³ The Quaternary is the geological period lasting from 2.6 million years ago to the present and encompassing the Pleistocene and Holocene epochs

2. Methodology

- 2.0.1 The approach and methods used in the watching briefs will accord with the tenets set out in the Chartered Institute for Archaeologists (2023a, 2023b) Standards and Guidance for monitoring and recording, and Historic England's (2015) geoarchaeology guidelines.

2.1 *Geotechnical boreholes (field and warehouse)*

- 2.1.1 The methodology the ground investigation (GI) contractor will employ to drill the geotechnical boreholes is set out in a specification (Mott MacDonald 2025) and Addendum to the specification (FBjv 2025), from which the following description is derived. Nine geotechnical boreholes are planned for the Tilbury site (BH101–105, BH110, BH301–303) and seven for Gravesend (BH106–109, and BH304–306). All will be drilled through the base of a 1.2m deep inspection pit. Boreholes (BH101–104 and BH107–109) will be advanced using a cable percussion rig and employing gouge and bailer augers of >200mm diameter. A 100mm diameter piston core sampler will also be used to collect samples where sediments are suitable and 100mm diameter UT100 core samplers where the sediments are too stiff for piston cores. Cable percussion drilling will continue until contact is made with Chalk strata at which point a rotary drilling rig will continue to advance the borehole until a maximum depth of 60m bgl is reached. At each site, two boreholes will be sampled as continuous piston cores where sediments are suitable. The remaining boreholes will be sampled by piston or UT100 core in alternation with standard penetration tests (SPT) and at 1m intervals, the former being removed to the warehouse/laboratory of the GI contractor for testing. Boreholes BH104, BH105 and BH106 will be drilled with rotary apparatus only with rotary open hole to the top of the Chalk. Boreholes BH301–BH306, scoped in the Addendum to the specification, will be drilled to 2m below the top of the Chalk using the Cable Percussion method for the purpose of installing survey deep datums and not for geotechnical purposes. SPTs and UT100 cores samples are not planned to be taken to facilitate rapid installation with minimum geotechnical sampling to confirm the strata.
- 2.1.2 The geoarchaeological monitoring brief will be conducted on those boreholes drilled using the cable percussion method and from which piston or UT100 cores are recovered, i.e. BH101–103 and BH110 at Tilbury and BH107–109 at Gravesend (Figure 2a and 2b).
- 2.1.3 Depending on the means by which the GI contractor surveys their boreholes, locational data will either be obtained from the former organisation (if an RTK GPS device was employed) or re-surveyed. If the latter is required, data of better than ±15mm precision will be obtained (i.e. by using an RKT GPS or total station).
- 2.1.4 Strata retained in the gouge auger heads will be photographed and described by a geoarchaeologist using standard geological criteria (Jones *et al.* 1999, Munsell Color 2000, Tucker 2011). Sediment retained in gouge auger heads will not be sampled.
- 2.1.5 Piston and UT100 cores will be recorded (as set out in Section 2.1.4) by a geoarchaeologist at the GI contractor's warehouse (after contamination test samples have been acquired/measured). Sub-samples will be obtained from the cores on an opportunistic basis from both organic (e.g. peat) and

minerogenic (e.g. grey silt/clays) strata for microfossil assessment (pollen and diatoms) and AMS ^{14}C measurement. Such samples will be taken volumetrically (2cm^3 for microfossils, 4cm^3 or of recognisable terrestrial macrofossils for ^{14}C dating) from strata that (a) were not seen/sampled by the prior geoarchaeological boreholes survey (e.g. the Upper Peat [above -2m OD] at both Tilbury and Gravesend, and the Middle Peat [below -4m OD] at Tilbury). Bulk ('Large specialist samples' sensu Campbell et al. 2011, 12) samples will then be collected from organic-rich (e.g. peat) strata by removing continuous 100m-thick slices of the core. All sub-samples and samples will be labelled (site code, borehole number, depth interval and purpose), sealed and suitably stored pending decisions on assessment (see Section 2.3).

2.2 *Shaft excavation (field)*

- 2.2.1 The pit to be excavated prior to insertion of the vertical shaft sinking machinery (VSM) will initially be excavated to 2.8m bgl depth using a 360° mechanical excavator. The pit sides will be battered and available for inspection. A collar will be inserted at 2.8m bgl prior to (vertical) excavation continuing and therefore the shaft walls will not be visible below this depth.
- 2.2.2 The nature of the watching brief on the shaft pit will depend on the contractor's working practices and Health and Safety constraints. Ideally all section faces of each shaft pit will be examined on multiple occasions by a geoarchaeologist/archaeologist as the pit is advanced. Strata so-exposed will be photographed and described using standard geological criteria (Jones *et al.* 1999, Munsell Color 2000, Tucker 2011), while contacts between individual sediment beds will be surveyed using RTK GPS or a total station (or measured by tape on the basis of points provided by RTK GPS or total station). Should contacts be other than horizontal, a series of GPS, total station or tape measured points will be recorded to accurately record undulations/variation. Safe working practices are likely to mitigate against the continuation of the watching brief once the collar is installed (i.e. below 2.8m bgl).
- 2.2.3 Archaeological artefacts and/or vertebrate remains and wood observed in section or on the pit floor will be photographed in situ, referenced to the relevant layer (bed), surveyed as described in Section 2.2.2 and then placed in a suitably labelled (site code, bed number and cross reference to the relevant GPS, total station or taped survey point) container (i.e. a sealable tub or zip lock bag). Artefacts, bones and wood will thereafter be removed from site for study (see Section 2.3).
- 2.2.4 Shaft section faces will be sampled opportunistically as follows:
 - 2.2.4.1 Monolith samples (sensu Campbell et al. 2011, 14) will be taken from organic rich and immediately adjacent minerogenic strata, and which were not sampled or only partially sampled by the previous geoarchaeological boreholes (Wilkinson et al. 2024), i.e. the Upper Peat above -2m OD. Such samples will be taken by inserting a monolith tin into a cleaned (vertical) section face, photographing in situ and surveying the top and base of the tin as described in Section 2.2.2, wrapping the extracted block in plastic film, labelling (see Section 2.2.3) and transported off site for study (see Section 2.3);
 - 2.2.4.2 Bulk/large specialist samples will be collected on an opportunistic basis from organic strata. Such samples will be of a minimum 20 litre volume (Campbell et al. 2011, 12) and will either be taken as <100mm-thick

‘spits’ from beds that are greater than this thickness or the entire vertical span of the bed for lesser thicknesses. Bulk samples will be placed in sealable tubs or ziplock bags, labelled (Section 2.2.3) and removed from the site for study (Section 2.3).

2.3 Assessment

- 2.3.1 All monolith samples collected from the shaft pit walls will be examined in the laboratories of the geoarchaeological contractor and as follows. Plastic film will be removed and c. 1mm removed from the sampled sediment to expose a fresh surface. The latter will be photographed and the strata will then be described using the same geological protocols as employed on site and with the piston and UT100 cores (Sections 2.1.5, 2.2.2). Sub-samples for biological microfossil assessment and AMS ¹⁴C dating will be collected opportunistically as described for the UT100 cores (Section 2.1.5)
- 2.3.2 Lithological and positional data obtained from/for (a) the cable percussion gouge augers (Section 2.1.4) and UT100 samples (Section 2.1.5), (b) the walls of the shaft pits (Section 2.2.2) and (c) the monoliths (Section 2.4.1), will be incorporated in the same RockWorks (RockWare 2025) database as used for the previous geoarchaeological borehole study of the site (Wilkinson et al. 2024). RockWorks (or other appropriate software packages) will then be employed to plot (a) at least one composite cross section for each site, and (b) update the deposit model that was previously produced as a result of the geoarchaeological borehole survey⁴. Deposit models will be constructed in accordance with Historic England’s (2020) guidelines.
- 2.3.3 Approaches to sample processing and subsequent assessment of biological remains will follow those outlined by Campbell et al. (2011). Methodologies for studying specific biological proxies will be those described in general by Lowe and Walker (2014, 228–262) and in detail by relevant specialist texts (e.g. Vos and de Wolf 1988, Moore et al. 1991). It is anticipated that assessments will be made of the following palaeoenvironmental proxies: pollen, diatoms, plant macro remains (including wood) and insects (Coleoptera), and carried out by the specialists listed in Appendix 1.
- 2.3.4 Samples taken on a volumetric basis for AMS ¹⁴C dating will not be processed, while samples of individual plant macrofossils taken for the same purpose (including wood) (Sections 2.1.5, 2.2.3) will be taxonomically identified.
- 2.3.5 Sufficient sub-samples and samples will be assessed for the proxies listed in Section 2.4.1 to adequately supplement similar assessments reported by the prior geoarchaeological borehole study (Wilkinson et al. 2024), and thereby allowing the aims outlined in Section 1.6 to be fully addressed. The same statement also applies to samples collected for AMS ¹⁴C and dendrochronological dating, while choice for these latter will also be informed by Historic England’s radiocarbon dating guidance (Bayliss and Marshall 2022). A proposal will be made to the stakeholders setting out how many and which

⁴ A solid model was produced using a Kriging algorithm, the eight nearest neighbours and constrained to a radius of 100m around each data point (Wilkinson et al. 2024, 14). The solid model was then sliced to show strata ‘exposed’ at 1m intervals between +2m and 14m OD (Wilkinson et al. 2024, appendix 6).

samples/sub-samples are recommended for biostratigraphic assessment and chronometric dating (Section 3.1).

- 2.3.6. Archaeological artefacts and vertebrate bones recovered from the shaft pit (and less likely, the UT100 cores and gouge augers of the cable percussion boreholes), will be identified by suitable specialists (Appendix 1).

3. Reportage

- 3.1 A stratigraphic report will be produced within four weeks of the completion of the watching brief fieldwork. The report will cross reference/correlate the stratigraphy of the geotechnical boreholes and shaft pit walls with that identified during previous phases of geoarchaeological work on the site. By doing so aims 1.6.1–1.6.4 and 1.6.6 will be addressed. A proposal recommending samples for biostratigraphic assessment and chronometric dating will be appended to the report (Section 2.3.5). The relevant results of the archaeological investigations that will be undertaken by Network Archaeology alongside the geoarchaeological works governed by this WSI will be incorporated into the stratigraphic report and any subsequent geoarchaeological analysis process, so that the final report can synthesise the relevant results of both disciplines.
- 3.2 A further report combining that on the stratigraphy (Section 3.1) with biostratigraphic assessments and the results of chronometric dating will be produced within 12 weeks of the approval by relevant stakeholders of samples for examination (Section 2.3.5). This integrated geoarchaeological report will address all project aims (1.6.1–1.6.8) and will make recommendations for analysis, publication and archiving. Any recommended analyses, reporting and archiving would ensure appropriate synthesis of the relevant results of the work undertaken by Network Archaeology.
- 3.3 Reports will be issued in digital (PDF) format only.

4. Archive

- 4.1 The archive will be compiled in accordance with Archaeology Data Service (2025) guidelines. It will be both digital (locations of the boreholes [CSV format], a RockWorks database [SQL Lite format] containing stratigraphic data, photographs [of the shaft pit walls, and sediment retained in gouge auger heads and UT100 cores] and the reports [PDF]), and material. The material archive will comprise unprocessed samples and sub-samples taken for biostratigraphic assessment and chronometric dating purposes (Sections 3.3–2.3.5), microscope slides with pollen and diatom residues, bulk sample residues and extracted macrofossils (plants and insects) stored in water or alcohol.
- 4.2 The digital archive will be stored in perpetuity by the geoarchaeological contractor (and disseminated to stakeholders on request). Various retention policies might apply to the material archive depending on the organisation employing the relevant specialist (Appendix 1). However, there will be a minimum retention period of 12 months following the approval of the integrated geoarchaeological report (Section 3.2), this pending decisions on analysis.

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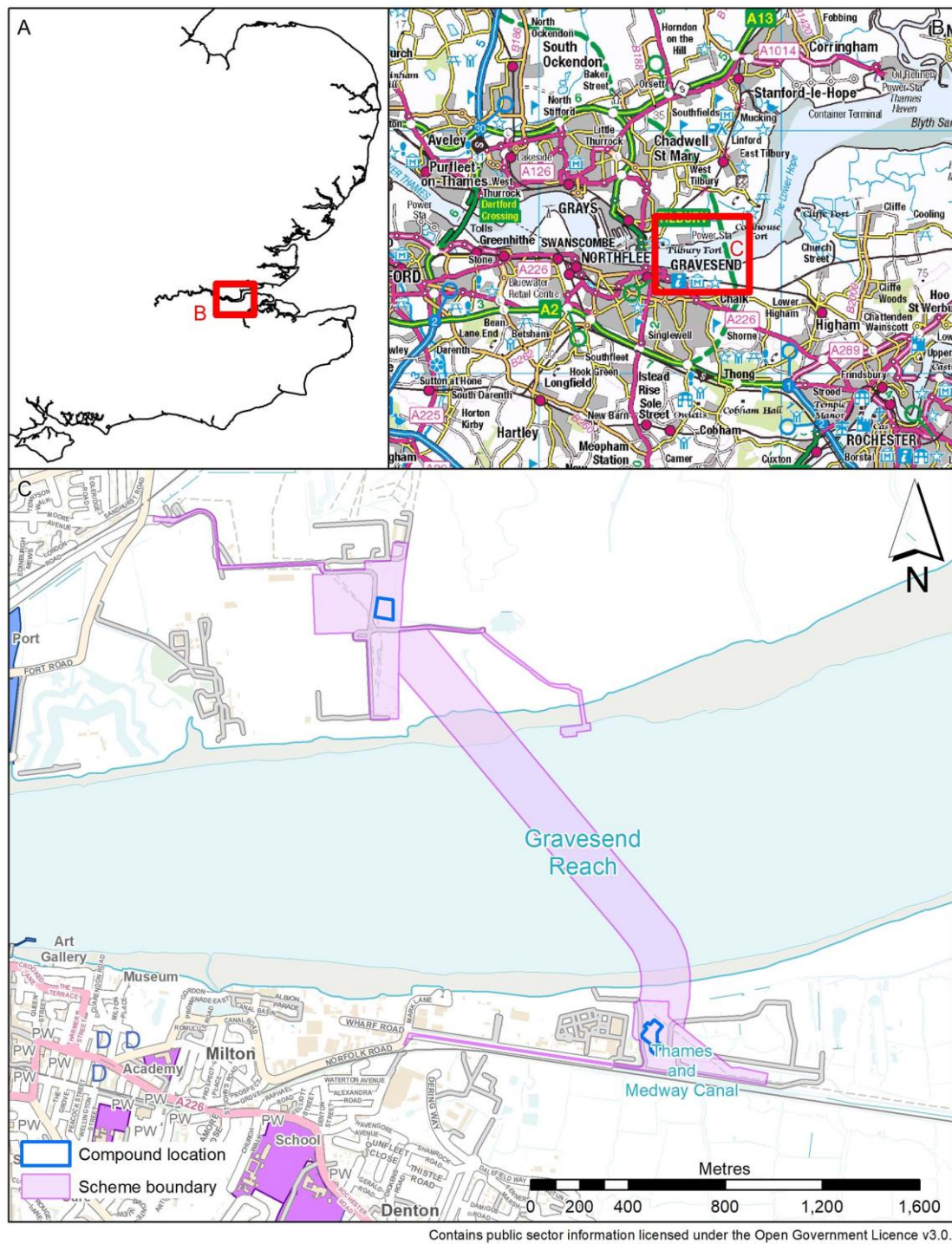


Figure 1: The cable tunnel route and construction compound locations

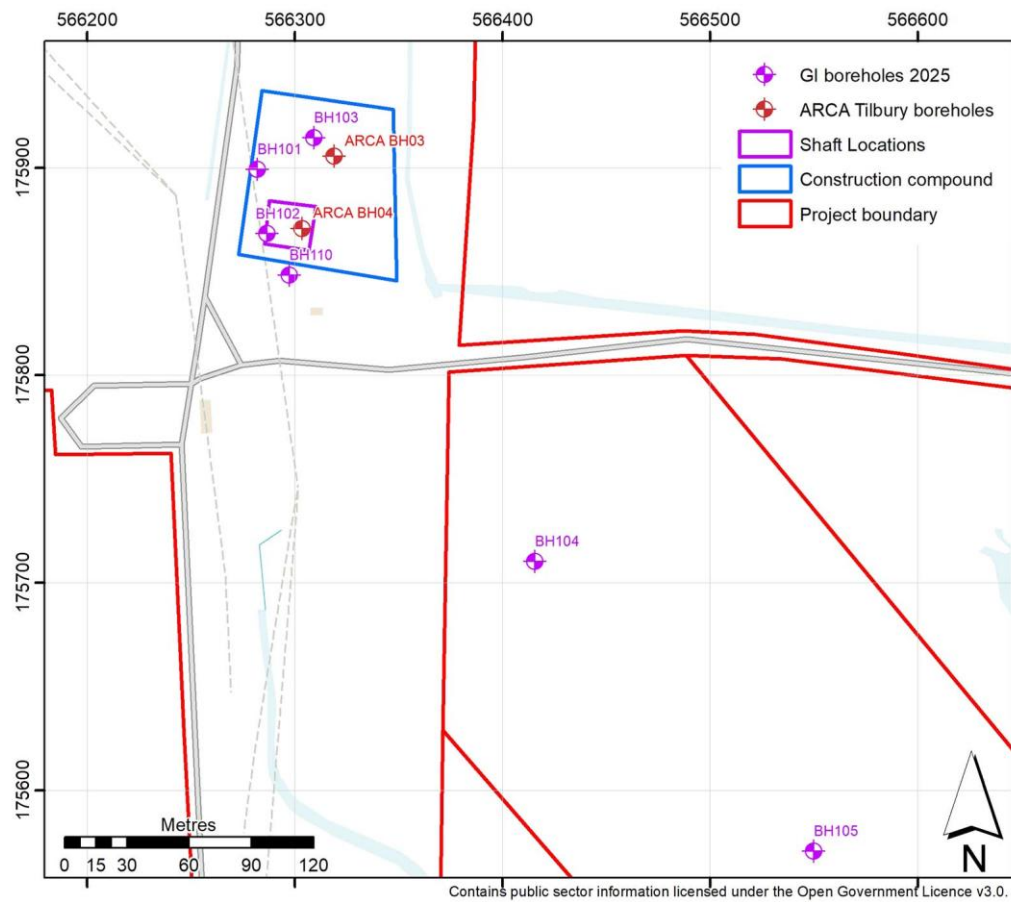


Figure 2a. Location of intended GI and previous geoarchaeological boreholes on the Tilbury site

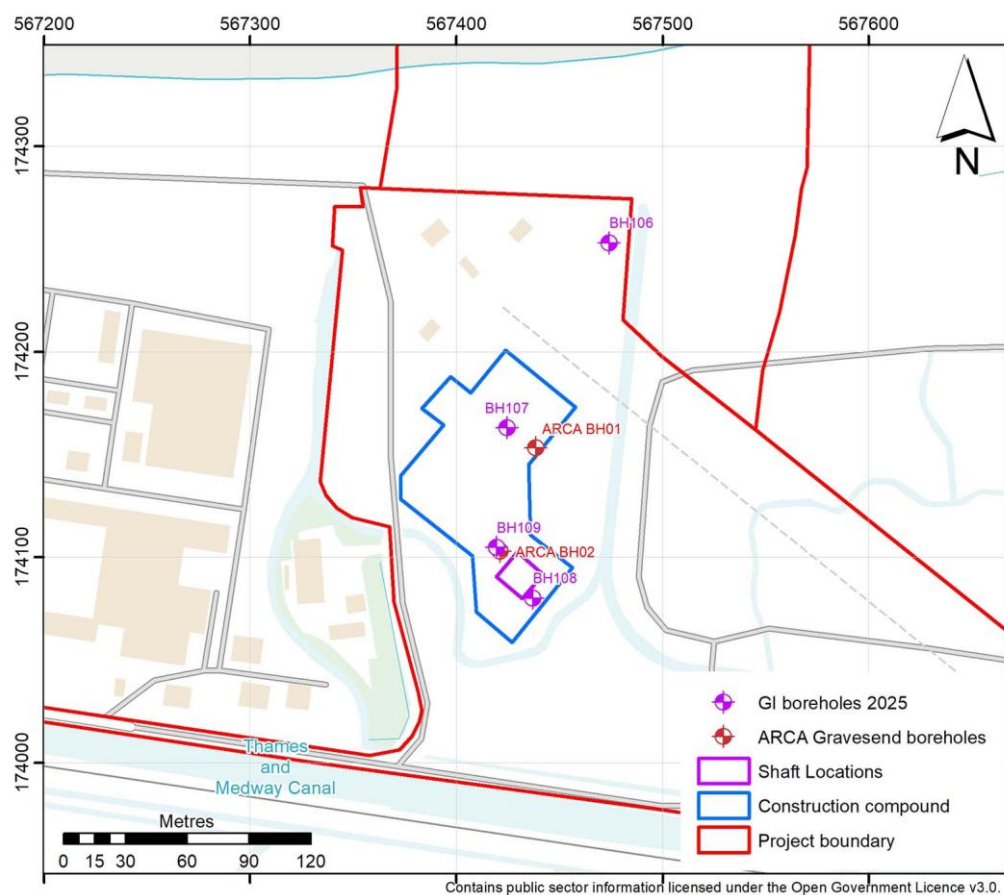


Figure 2b. Location of intended GI and previous geoarchaeological boreholes on the Gravesend site

Appendix 1: Specialists

The following specialists would be commissioned (as relevant) should ARCA geoarchaeology be appointed the geoarchaeological contractor for the TKRE watching brief on geotechnical boreholes and excavation of the shaft pit:

Specialism	Individual/Organisation
¹⁴ C dating	Beta Analytic Inc, Miami, Florida, USA or Scottish Universities Environmental Research Centre (SUERC), East Kilbride, Scotland
Artefacts	TBA
Coleoptera (beetles)	Dr Enid Allison, Canterbury Archaeological Trust
Dendrochronology	TBA
Diatoms	Dr Tom Hill, PalaeoEnvironment Research and Consultancy Services
Mollusca (snails)	Prof Keith Wilkinson, ARCA geoarchaeology, University of Winchester
Palynology (pollen)	Dr Rob Batchelor, Quaternary Scientific (Quest), University of Reading
Plant macrofossils	Dr Rob Batchelor or Dr Mike Simmonds, Quaternary Scientific (Quest), University of Reading
Stratigraphy	Prof Keith Wilkinson, ARCA geoarchaeology, University of Winchester
Vertebrate bones	Dr Monika Knul, ARCA geoarchaeology, University of Winchester
Wood identification	TBA