Lower Thames Crossing

6.3 Environmental Statement Appendices

Appendix 6.5 – Lower Thames Crossing: Palaeolithic and Quaternary Deposit Model (PQDM) and Desk-based Assessment of Palaeolithic Potential

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1 Executive summary

1.1.1 The new Lower Thames Crossing (LTC) is in an area of high Palaeolithic archaeological and Quaternary geological importance. Pleistocene sediments in the area are mostly so-called “terraces” of silts/sands/gravels forming geomorphological features up the sides of the current Thames valley. They represent deposition by early courses of the Thames through the Middle and Late Pleistocene, approximately from 500,000 BP [years Before Present] through to 12,000 BP. While Holocene sediments from approx. 12,000 BP through to the post-Roman era up to approx. 1000 BP tend to be alluvial deposits (clayey silts and fine sands, with peat) associated with the modern Thames floodplain and its tributaries. Many well-known and important archaeological sites with both artefactual and palaeoenvironmental remains are documented in the lower Thames. These are mostly in the better-investigated deposits to the west of the project route corridor. Relatively little detailed work has yet been undertaken on Pleistocene or Holocene deposits in the area of Project impact. Undiscovered sites of similar high importance are likely to be present in the impact footprint of the new Lower Thames Crossing, in the areas identified as of high importance in this report.

1.1.2 The new Lower Thames Crossing (LTC) is in an area of high Palaeolithic archaeological and Quaternary geological importance. Pleistocene sediments in the area are mostly so-called “terraces” of silts/sands/gravels forming geomorphological features up the sides of the current Thames valley. They represent deposition by early courses of the Thames through the Middle and Late Pleistocene, approximately from 500,000 BP [years Before Present] through to 12,000 BP. While Holocene sediments from approx. 12,000 BP through to the post-Roman era up to approx. 1000 BP tend to be alluvial deposits (clayey silts and fine sands, with peat) associated with the modern Thames floodplain and its tributaries. Many well-known and important archaeological sites with both artefactual and palaeoenvironmental remains are documented in the lower Thames. These are mostly in the better-investigated deposits to the west of the project route corridor. Relatively little detailed work has yet been undertaken on Pleistocene or Holocene deposits in the area of Project impact. Undiscovered sites of similar high importance are likely to be present in the impact footprint of the new Lower Thames Crossing, in the areas identified as of high importance in this report.

a. provide an overview of varying Quaternary deposit character and archaeological potential along the route of the project;

b. highlight areas of uncertainty, where a staged approach is required to refine mitigation scope and methods;

c. and finally, present these results as a report (this report) with suitable figures and appendices, to contribute to the ES for the DCO application.

1.1.3 This PQDM report identifies 29 Palaeolithic and Quaternary (PQ) deposit character areas for the Project's impact footprint, represented by 34 distinct zones on the ground, since some areas of similar character are not directly contiguous: PQ1-11, 12a-b, 13-19, 20a-c, 21, 22a-b, 23a-b and 24-29. Each zone was attributed to one of three categories of Palaeolithic and geo-archaeological potential: UNCERTAIN (n=7), LOW-MODERATE (n=20) and MODERATE-HIGH (n=7) (Section 7, Table 7.1).

2 Introduction

2.1 Project background

2.1.1 A major new road crossing is proposed across the Lower Thames (Highways England project 540039). The new crossing will involve a double-bore motorway tunnel under the Thames between Gravesend and Thurrock (passing c. 10km to the east of the existing Dartford crossing), as well as overland link roads between the south and north tunnel portals, and the A2 and M25 respectively (Figure 1). This route was chosen in April 2017 as the preferred option (Option C) following several years of consultation. The overall length of the route is c. 27km and the impact footprint of the road and associated development is a little over 2630ha, as defined in the current Statutory Consultation footprint (revised version issued in January 2020).

2.1.2 In accordance with the requirements of the National Planning Policy Framework (initially issued in 2012, but updated in 2018) and those specifically for large national infrastructure projects such as this (National Policy Statement for National Networks 2014), various processes are being followed to ensure that the development takes place in a sustainable manner and with due consideration to avoid (and if necessary mitigate) impact upon cultural heritage. In summary, as a Nationally Significant Infrastructure Project (NSIP), authority to proceed with the project will be granted as a Development Consent Order (DCO) by the Secretary of State. The application for the DCO must be supported by various documentation, including an Environmental Statement (ES). The contents and scope of this latter document are to a large extent statutorily defined, and follow from various stages of preliminary work and reports.

2.1.3 Following from initial identification of the preferred route, an Environmental Impact Assessment (EIA) Scoping Report was issued in October 2017 (Highways England 2017). This outlined (in Chapter 7, Cultural Heritage) the general approach that would be taken to assessing the environmental impact of the proposed new crossing. It identified:

a. national and regional bodies for consultation, such as Historic England and Local Authority planning archaeologists

b. relevant heritage datasets, such as nationally important heritage lists and, for non-designated heritage assets, local Historic Environment Records

c. major research projects recently carried out in the area, such as the Medway Valley Palaeolithic Project (Wenban-Smith et al. 2007a, b) and the Thames Estuary Survey of Mineral Extraction Sites (Essex and Kent County Councils, 2004)

d. work that would be undertaken to contribute to an Environmental Statement (ES) to be submitted as part of the process for gaining formal government planning consent to proceed with the Project, such as a desk-based assessment of cultural affects and field evaluation of areas with insufficient desk-based information for the impact of the Project to be adequately predicted

e. parameters and criteria for assessing the significance of heritage assets, and the magnitude of impact relating to the proposed new crossing

2.1.4 The initial scoping report was followed by a more-detailed Preliminary Environmental Information Report (PEIR) in September 2018 (Highways England 2018a). This reviewed the legislative framework applicable to cultural heritage in relation to the new crossing, and reiterated the requirements of the Environmental Statement (ES) that will accompany the DCO application, and the proposed approach to addressing these requirements. In relation to cultural heritage (Chapter 7 of the PEIR), these include:

a. a detailed and up-to-date Desk-based Assessment (DBA) of heritage assets (designated and undesignated) affected by the proposed new crossing, with an assessment of their significance, will be included as an appendix to the ES

b. for assets of uncertain significance, methodologies for field evaluation will be agreed with heritage stakeholders and presented as appendices to the ES

c. where suitable, and for key areas of greatest uncertainty, suitable preliminary (stage 1) field evaluation will be carried out to try and identify the nature and significance of any unrecognised or poorly-known heritage assets, and the results included as an appendix to the ES, and taken account of in the ES chapter itself

d. the assessment of heritage assets will include a consideration of the level of impact on them from the proposed development, and in particular whether there is a risk of substantial harm or total loss of significance

e. an outline of mitigation measures to record and advance understanding of any heritage assets that will have their significance diminished by the project, proportionate to their significance and the impact

f. to identify areas with the greatest potential for new discoveries of heritage assets during the project, and specification of measures to identify and suitably investigate any such new discoveries

2.1.5 Both the EIA Scoping Report and the PEIR specified that the principles of the "Rochdale envelope" should be followed (PEIR para 2.1.14-2.1.16, pp6-7). This specifies that the parameters of a project design may not be fixed at the stage of ES production. Therefore worst-case variations should be considered in the ES and accompanying technical documents, to ensure that likely significant environmental effects of a project are properly assessed. From a Palaeolithic and Quaternary geo-archaeological view, this means that (a) worst-case impacts of project design will be considered, and (b) worst-case possibilities for harm to the historic environment will be considered, where there is uncertainty over the nature/importance of remains.

2.1.6 Thus, the scope and content of the ES should be sufficient for the Secretary of State to make an informed decision for the project to proceed with confidence that the impact upon any cultural heritage assets is well-understood and will be suitably mitigated. Some pre-DCO field investigations that complement desk-based assessment have taken place during the Archaeological Trial Trenching and inform the ES, but the bulk of archaeological fieldwork (comprising phased post-assessment mitigation) typically follows granting of the DCO

2.1.7 This document has been prepared by Francis Wenban-Smith (University of Southampton) and Martin Bates (University of Wales, Trinity St. David) as part of the specialist Palaeolithic and geo-archaeological work package.

2.2 Palaeolithic and Quaternary Deposit Model (PQDM): rationale and scope

2.2.1 The PEIR also provided substantially more detail than the EIA Scoping Report on cultural heritage research frameworks for the project area, sources of heritage data, and details of the assets already known. Many of the research frameworks (Annex B of this document provides a full list of relevant research frameworks) draw attention to the international importance of the Lower Thames valley for the rare survival of a suite of Quaternary deposits spanning the last 1,000,000 years. These contain evidence of Stone Age (Palaeolithic) hunter-gatherer ancestors spanning the time from the earliest occupation of Britain c. 800,000 BP [years Before Present] through to the end of the last ice age c. 11,700 BP, as well as later prehistoric presence (Mesolithic, Neolithic and Bronze Age) through the earlier part of the post-Last-Glacial Holocene period up to c. 2,700 BP, and even evidence of the Roman and Saxon periods buried in higher-level floodplain alluvial sediments.

2.2.2 The main text of the PEIR drew attention to the potential impact of the project upon Palaeolithic remains in gravel deposits north and south of the Thames, in particular possibly associated with the tunnel portals. The PEIR also listed known heritage assets as appendices, based on a search of the main sources it identified, in particular the Kent and Essex Historic Environment Records (HER). There are no designated Palaeolithic assets in the project footprint, but this more reflects the statutory difficulty of giving Palaeolithic assets this level of recognition, rather than the lack of presence of nationally significant Palaeolithic assets.

2.2.3 Appendix E.5 of the PEIR listed all non-designated heritage assets from the Kent and Essex HERs for a 1km buffer around the project's impact footprint. There were c. 50 records for Palaeolithic remains, in amongst many hundreds of post-Palaeolithic cultural heritage records. However, the PEIR did not review data from several major sources such as the Southern Rivers Palaeolithic Project (Wessex Archaeology 1993), the English Rivers Palaeolithic Project (Wessex Archaeology 1996), and various other specialist reviews and publications with important Palaeolithic records from the project area (see Appendices C and D of this document). This initial Palaeolithic listing was, therefore, not-at-all exhaustive (and nor was it intended to be so, rather it can be taken as initially indicative). Nonetheless, the Palaeolithic assets listed in the PEIR include a Palaeolithic occupation and flint working site at Upminster (Havering), as well as numerous instances of handaxes, flakes and flake-tools having been found in situ in deposits in gravel pits and other works in the vicinity of the project footprint.

2.2.4 Building on the initial review of the PEIR, the heritage stakeholder consultees further emphasised the potential importance of Palaeolithic assets likely to be affected by the project, and identified suitable approaches to addressing their potential for the DCO. In particular, comments from Historic England (East of England office, provided by D. Priddy on 18th December 2018, ref PL-0021 762) included:

a. it is likely that the greatest impact of the project (numerically and in terms of significance) may arise from the disturbance of buried remains (designated, undesignated and as-yet-unidentified). It is essential that the ES, as well as listing sites and assessing the impact upon them of the Project, gives consideration to their significance on a landscape scale and in the context of national and regional research frameworks.

b. deposit models have a valuable role to play in the DBA for the ES Palaeolithic and Geo-archaeological specialists should be consulted to help determine the potential for buried archaeological remains, using existing information (including that from separate geological and soils work areas) to develop an initial deposit model, and then to enhance this using new data from ground investigations done for the project.

c. the route should be divided into zones of varying character and potential, illustrating depths and deposits of interest on a schematic section; this initial model should be included in the DBA and ES, and should inform the design of preliminary investigative fieldwork, and should be iteratively updated as new information becomes available.

d. several key Palaeolithic and Pleistocene geo-archaeological sources have not yet been taken account of for data gathering, such as the Southern Rivers Project, the English Rivers Survey, and relevant Quaternary Research Association Field Guides.

e. the Palaeolithic sections of relevant regional research frameworks should be included in the baseline assessment, and several nationally significant sites in the close vicinity of the project (Purfleet, Aveley, Swanscombe and Tilbury) are not considered in the PEIR, but their relevance to deposits affected by the project needs to be considered.

f. the DBA and ES should include a more detailed discussion of the archaeological potential of the alluvial and peat sequences at Tilbury, and also nearby gravel terrace deposits, than is provided in the PEIR.

2.2.5 Complementing these post-PEIR comments, other Historic England comments from the earlier consultation on the project (collated in the Tender Specification for the provision of Palaeolithic archaeological advice - Highways England 2018b), when it was considered as Option C alongside other options, included:

a. Thames deposits are an important archive of human occupation in northwest Europe. Gravel terraces and fine-grained interglacial and estuarine deposits laid down over the last 400,000 years contain regionally, nationally and internationally significant archaeological finds complemented by palaeo-environmental remains. Several key sites in Kent and Essex have been designated as nationally important Sites of Special Scientific Interest (SSSIs) and Local Geological sites (LGSs) due to their significance for Palaeolithic archaeology and Quaternary geology. There is a high likelihood that significant or highly significant Palaeolithic archaeology will be encountered during the project.

b. Thames gravel terrace deposits occur on both the Kent and Essex sides of the Thames, although are more abundant on the Essex side. Any intrusive development on these deposits is likely encounter Palaeolithic archaeology.

c. significant Palaeolithic archaeology may be more likely to be encountered at interfaces between different gravel terraces, and between Chalk bedrock and gravel terraces. Particular deposits where an impact is projected and where Palaeolithic archaeology is likely includes Corbets Tey and Mucking gravels near the southern tunnel portal in Kent, and Orsett Heath gravels at the junction with the A13 in Essex.

d. specialists in Palaeolithic archaeology and Quaternary geology should be engaged early in the development process to understanding the impact risks, to develop tailored approaches to determine the best evaluation strategy, and ultimately to minimise risk to the Project and develop the best mitigation strategy.

e. the assessment of Palaeolithic sites and potential should take a deposit-led approach (considering evidence from deposits in conjunction with their depositional process), and include consideration of finds from relevant analogue deposits that may be several km from the project area

2.2.6 Generally, it was clear from the prior scoping work and the stakeholder comments that the project passes through an area of high Palaeolithic significance, and that the DBA work and ES (as well as complementary and subsequent field investigations) would benefit from specialist Palaeolithic and Quaternary geo-archaeological input.

2.2.7 Therefore, suitably qualified specialists (Francis Wenban-Smith of University of Southampton for Palaeolithic archaeology, and Martin Bates of University of Wales for Quaternary geo-archaeology) were commissioned by LTC to deliver the following material as part of the environmental impact assessment for the DCO:

a. a Palaeolithic and Quaternary Deposit Model (PQDM), which takes a deposit-led approach and divides the project footprint into zones of varying deposit character and Quaternary archaeological potential

b. a Standalone Palaeolithic Archaeological Assessment (SPAA) that builds on and complements the PQDM

2.2.8 This material will complement, and inform, the wider post-Palaeolithic cultural heritage contribution to the ES. Parts may also be submitted as standalone appendices to the ES.

2.3 Scope of this document

2.3.1 This document comprises the Palaeolithic and Quaternary Deposit Model (PQDM). It provides an overview of varying Quaternary deposit character and archaeological potential along the route of the project as specified above, it:

a. takes a deposit-led approach and divides the project footprint into zones of varying deposit character and Quaternary archaeological potential (Table 7.1; Figures 31-33, 35-47; Appendices H-I)

b. highlights zones of greatest uncertainty (Table 7.1), where following the precautionary approach taken in the assessment, the presence of Quaternary archaeological potential has been assumed. The mitigation will be refined as more information from a range of sources, such as other mitigation becomes available

c. presents these results as figures and appendices with accompanying text that provides a robust assessment of the character and potential of the Palaeolithic and Quaternary deposits, to contribute to the Environmental Statement (ES) for the DCO

2.3.2 The PQDM includes a sub-surface deposit model, developed from primary geological logs held by the British Geological Survey and new Ground Investigation data. These are presented as a series of sub-surface deposit transects (Figures 21-30). It also includes an inventory of Palaeolithic and important Quaternary sites within, and near to, a 3km buffer around the Project's impact footprint (as defined in the Statutory Consultation boundary issued in January 2020 - Figure 1). These are collated in an annex (Annex E), and also shown on maps in relation to geological mapping and topography (Figures 2-5).

2.3.3 The distribution of previous sites provides a useful guide to the Palaeolithic potential of different parts of the project footprint on two grounds. Firstly, if there is a history of Palaeolithic finds within an area, then more might be expected in the same area. Secondly, for areas without a history of previous investigation, even if no finds are known, then a history of previous finds from other areas with similar geological deposits can indicate high Palaeolithic potential.

2.3.4 Finally, as briefly reviewed below (Section 5.8) and in more detail in the complementary Standalone Palaeolithic Archaeological Assessment (SPAA - in prep. for April 2020), a deposit-centred approach is taken to assessing Palaeolithic importance and potential. This involves considering more than just the presence and prevalence of Palaeolithic finds. It also involves consideration of their context, the degree of spatial disturbance undergone, and the level of chronological integrity of finds, in combination with other factors such as their association with palaeo-environmental remains and with other stratigraphically distinct artefact-bearing sediments. All these factors are then taken into account in assessing the importance (or potential) of a deposit within the context of its potential contribution to national and regional research framework priorities.

3 Background

3.1 Geology and landscape context

3.1.1 As outlined above (Section 2.2), the LTC Project is in an area in which extensive spreads of Quaternary sediments are preserved. The Thames valley contains an internationally important archive of deposits spanning the last 1,000,000 years (the later Lower Pleistocene, the Middle Pleistocene and the Late Pleistocene) (Bridgland 1994; Gibbard 1994). The recent geological development of the Lower Thames area and the establishment of the modern topography, including the Thames estuary, have been a result of major drainage basin modifications during the Quaternary and in particular events during the last 500,000 years. The early Middle Pleistocene course of the river Thames has been identified to the north of the modern channel where drainage occurred through the Vale of St. Albans and into eastern Essex (Gibbard, 1977 and 1985). During this time the river Medway would have been a south-bank tributary of this ancestral Thames, draining northward across the present-day mouth of the Thames (passing across what is now the Hoo peninsula, east of the LTC footprint) to converge with the ancestral Thames in eastern Essex (Bridgland, 1983, 1994, 1999 and 2003). During this time drainage across the LTC area would similarly have been from southwest to northeast, with the river (maybe an ancestral Cray, Darent or even Ebbsfleet) forming another more-westerly south-bank tributary of the then-more-northern course of the river Thames.

3.1.2 Elements of this ancestral drainage network are only likely to be preserved on the Kent site of the LTC, on the higher ground at the southern boundary of the study area. The creation of the modern Thames valley downstream of Reading and through the LTC area, by channel disruption in the Thames basin associated with the major Anglian glaciation (Gibbard, 1977 and 1985), has removed all traces of prior fluvial activity associated with these south-bank tributaries of the ancestral Thames. Thus almost all deposits in the LTC area - including on the southern bank of the Thames in Kent, on the northern side of the Thames valley in Essex, and further to the northwest where the LTC route heads towards the M25 - represent sediments that have accumulated since the major late Anglian re-arrangement of river systems in southeast Britain, dating from approx. 500,000 BP.

3.1.3 Thus in the present-day Lower Thames valley, to the east of London and in the area of the new crossing where the Thames is tidal and begins to widen into a major estuary between Kent and Essex, the dominant deposits (Figures 2-5) relate to the late Anglian and post-Anglian period Middle and Late Pleistocene (representing an alternating series of cold glacial episodes and warm interglacial episodes over the last 500,000 years). These occur as a "staircase" of terrace deposits down both sides of the Thames valley, with progressively younger deposits occurring at lower elevations down the valley side, as the river course eroded down throughout the Pleistocene towards its present level in the base of the valley (see below, Section 5.4).

3.1.4 Holocene sediments associated with the modern river and its tributaries are also significant. Works associated with High Speed 1 (Bates & Stafford 2013) and infrastructure works in the Medway estuary (Bates *et al.* 2017) have documented their potential. Sequences may be up to 35m in thickness and are likely to thicken both in a downstream direction and from the edge of the floodplain towards the river channel.

3.1.5 Although many well-known sites containing both archaeological and palaeoenvironmental remains (see below, Section 3.2 and Section 6) are documented in the lower Thames, many of these are west of the project route corridor and relatively little detailed work has been undertaken on Holocene or Pleistocene deposits in the area of Project impact. Nonetheless, based on geological mapping and extrapolating from the known information a short distance to the west of the project area, it is to be anticipated that:

a. interglacial sediments, including both riverine and estuarine, may be preserved within the study area

b. the interglacial sediments are likely to rest on older, cold stage, fluvial sediments

c. these fluvial/estuarine sequences are likely to be buried by slopewash and solifluction (cold climate mass movement deposits) sequences

d. thick, potentially in excess of 35m deep, Holocene sequences are likely to be present adjacent to the Thames. These sequences may contain interbedded clay-silts and peats

e. younger parts of the Pleistocene terrace succession are likely to be buried beneath the Holocene alluvium in places; older parts of the terrace succession are likely to be present at shallow depths below the ground surface away from the river (although the sequences themselves may be of considerable thickness)

f. both the Holocene and Pleistocene parts of the record are often rich in palaeoenvironmental remains that include large and small mammals, molluscs and microfossils (including pollen, ostracods, diatoms and foraminifera); these remains not only provide a record of changing environmental conditions but may also aid in constructing chronological frameworks for the sequences.

3.1.6 The Quaternary geology of the project area is reviewed in more detail below (Section 3.2).

3.2 Quaternary archaeology

3.2.1 The Middle and Late Pleistocene Thames terrace deposits in the vicinity of the project contain abundant Palaeolithic archaeological remains (mostly flint artefacts) as well as vertebrate fossils and other palaeo-environmental remains (such as molluscs, ostracods, plant macro-remains, insects and pollen). Some of the mammalian fossils have cut marks and other signs of damage that relate directly to hominin behaviour, but mostly these are of significance for the additional information they provide on climate, local environment and dating. The contained Palaeolithic archaeological evidence (including artefacts, and faunal and other palaeoenvironmental remains) is a major factor in the international importance of this part of the Thames terrace archive.

3.2.2 During this time Britain was at the northern edge of the hominin-inhabited world, and was periodically colonised from continental Europe during periods of warmer climate when these early hominins were able to survive, but hominins became locally extinct during the coldest glacial episodes. Thus the Thames valley is an important laboratory for investigating the behaviour and survival capability of early hominins at this time, which mostly represents a period when one of Europe's early colonisers (*Homo heidelbergensis*) was evolving into Neanderthals. This settlement history and evolutionary transition is reflected in changing types of lithic artefacts through the Middle and Late Pleistocene deposits of the project area; however, the absence of skeletal material (apart from one early skull from deposits at Swanscombe that seems to show a transitional form between *H. heidelbergensis* and Neanderthal) means that attempts to link specific tool-types and manufacturing practices with this evolutionary transition remain speculative.

3.2.3 There are also likely to be terminal Pleistocene (Late Palaeolithic) and Holocene (including Mesolithic and late Prehistoric) archaeological remains associated with the alluvium of the Thames and its tributaries. Here, note that we are only considering Holocene archaeology that forms part of the alluvial tract and where the archaeology is enclosed in (or buried by) natural alluvium; we are not concerned with Holocene evidence in the form of archaeological features cut into the present ground-surface, whether bedrock, Pleistocene sediments or the top of the alluvium.

3.2.4 Holocene remains in the alluvium (with the exception of the most recent archaeology), are likely to be buried at depths ranging from less than 1m to the full depth of the alluvial sequences (35m plus). Remains will span the final hunter-gatherers of the terminal Palaeolithic and Mesolithic through a range of late Prehistoric archaeologies and historic archaeology. Site types might vary from isolated finds associated with hunting activities through to substantial construction activities associated with water-fronts and bridges, to ships and boats. Preservation in these circumstances, where full waterlogging is likely, might be exceptionally high quality.

3.2.5 The proposed footprint of works for the new crossing passes broadly SSE-NNW across the Lower Thames valley, intersecting the terrace staircase on both sides of the Thames and cutting through major spreads of Holocene alluvium flanking the current river channel. As outlined in the PEIR and reviewed in more detail below (Section 6; Annex E) numerous Palaeolithic and later prehistoric sites are known from deposits that will be impacted by the project. It is therefore necessary to carry out this systematic deposit-led desk-based assessment of the project area, supplemented initially by field evaluation and later where necessary by mitigating excavations, to ensure that the project is carried out with due regard for heritage impact, and maximises its potential to promote appreciation and increase understanding of our shared past and the wide span of European and British history and prehistory that is represented in deposits of the Lower Thames valley in Kent and Essex.

3.3 Ground investigations and Stage 1 archaeological work

3.3.1 Various phases of ground investigations (GI) and Stage 1 archaeological trial-trenching have been completed, or are currently in progress or planned. Phase 1 GI work has been completed. Phase 2 GI work is in progress, comprising five packages A, B, C, D and E. In addition to the GI work itself, some targeted geo-archaeological monitoring of the Phase 2 GI work is being done by Wessex Archaeology, in accordance with a WSI prepared by AECOM (2019a,b).

3.3.2 Data from the existing review of historical BGS sequence logs in the development footprint and from completed GI and archaeological trial-trenching work was made available to the Palaeolithic and geo-archaeological specialists for integration in this PQDM. A certain amount of data was received, including from Phase 1 of the GI work, and from Wessex Archaeology monitoring of Packages A and C of the Phase 2 GI work. These datasets have been taken account of in the PQDM.

3.3.3 A site visit was made on 11th February 2020 to archaeological trial-trenching in Land Parcel 5 (Brooks Farm - site-code LTC 5, BF 19) in the Essex side of the Project, north of the Thames. Here useful field observations were made of Boyn Hill Gravel deposits appearing in the floor of trial trenches, and of sections through colluvial slopewash deposits overlying the pre-Quaternary bedrock. These observations were taken into account when assessing the nature and Palaeolithic potential of the deposits in this area of the Project.

4 Aims and objectives

4.1 General aims

4.1.1 The general aims of the PQDM are:

a. to provide an overview of varying Quaternary deposit character and archaeological potential along the route of the project (in particular of Palaeolithic potential, but also Mesolithic and Late Prehistoric so far as evidence of these later periods is associated with Quaternary deposit bodies)

b. to highlight zones of greatest uncertainty where following the precautionary approach taken in the assessment, the presence of Quaternary archaeological potential has been assumed.

c. presents these results as figures and appendices with accompanying text that provides a robust assessment of the character and potential of the Palaeolithic and Quaternary deposits, to contribute to the Environmental Statement (ES) for the DCO

4.2 Specific objectives

4.2.1 Specific objectives of the PQDM are:

a. to construct a model of the nature, distribution and depth of sub-surface natural deposits along the route of the project, both Quaternary ("Drift") and pre-Quaternary ("Solid")

b. to interpret the model in terms of likely ages and environments of deposition of the different sequences

c. to relate the model to other litho-stratigraphic and interpretive models in use for the Lower Thames region, and in particular to geological mapping and the Thames terrace frameworks of Bridgland (1994) and Gibbard (1994)

d. to assess archaeological potential and importance along the project route, with reference to relevant national and regional research frameworks (Annex A), and taking account of artefactual and palaeo-environmental remains, and sedimentological sequences, as contributors to our understanding of the historic environment

e. to produce a Palaeolithic and Quaternary characterisation for the project footprint, dividing it into different areas of varying sub-surface geology and Quaternary archaeological potential, with predictions of the likely depth and spatial extent of archaeological remains

f. to consider the likely impact of the project upon these areas, from available information

g. to identify areas of uncertainty requiring a staged mitigation approach which will be refined as more information from a range of sources, such as other mitigation becomes available

5 Methods

5.1 Desk-based study

5.1.1 The PQDM has been produced mostly on the basis of a desk-based synthesis of all available relevant information on the Palaeolithic and Quaternary background of the project footprint and its surrounding area. Sources with information on Palaeolithic remains and Quaternary sequences in the project area have been reviewed (see below, Section 5.2), and the data collated to inform (a) development of a site-wide deposit model, and (b) an understanding of the archaeological remains known (or likely) to be associated with the various deposits recognised.

5.1.2 The results have been collated into this PQDM report, and include:

a. maps showing the locations of all the Palaeolithic and other Quaternary sites identified in the desk-based review, categorised as to their type, and the accuracy of their provenance (Figures 2-5)

b. maps showing the project footprint and areas (PQ zones) of varying Quaternary deposit character and archaeological potential, labelled with unique identifiers (Figures 31-33, 34-47)

c. diagrams showing annotated cross-section profiles through the deposit sequences of key areas (Transects 1-7, Figures 21-30)

d. an annex listing all the Palaeolithic and other Quaternary sites identified in the desk-based review (Annex E)

e. an annex with tabular summaries of the deposit character and Quaternary archaeological potential of each uniquely identified deposit character area (Annex H)

5.1.3 A walk-over survey (see below, Section 5.3) was also carried out, to aid in interpretation of the desk-based data. This survey targeted areas identified in this desk-based review as of greatest interest, or where direct observation of current conditions, exposures and/or topography can help in resolving any interpretive uncertainties.

5.1.4 The PQDM report was circulated to heritage stakeholders, and any other relevant parties. It incorporates results from the walkover survey and available field data from GI and archaeological trial-trenching work done as part of the LTC project (see below, Sections 5.6, 5.7).

5.1.5 The PQDM is complemented by a separate document, the *Stand-alone Palaeolithic Archaeological Assessment and Research Framework* (SPAA-&-RF), which provides more detail on the Palaeolithic remains (known and potential) in the zones identified in the PQDM. Both documents inform the ES for the DCO, and are themselves constituent parts of the ES submission.

5.2 Sources

Quaternary sequence data

5.2.1 Construction of the ground model will be undertaken on the basis of extant information only. Modification of the model during the lifespan of the project may be undertaken on the basis of newly collected data (from geotechnical investigations) as well as purposive geoarchaeological and archaeological field programs.

5.2.2 Primary sources for the construction of a model will include:

a. published academic papers, grey literature reports and any existing published works

b. borehole data from the British Geological Survey archive

c. mapped geological data from the British Geological Survey.

d. archive data from extant phase of ground investigation for the project

e. information from archives held by organisations and individuals

f. other forms of ground investigation data including results of geological geophysical surveys, Lidar, and remote sensing

5.2.3 Key sources have been collated as appendices, grouped into sources that are primarily geological mapping and memoirs (Annex C) and those that primarily relate to Palaeolithic archaeological reviews and projects (Annex D). However, there is substantial cross-over in these sources between archaeological and geological sequence data, and both areas of data have been collated from all these sources and integrated in this PQDM report as appropriate.

5.2.4 Due to the high number of records in the vicinity of the LTC footprint, geological data collection focused on the project footprint. Supplementary open access records available on-line through the British Geological survey were explored within a 3km buffer zone around the project footprint, and were taken into consideration when modelling key areas with particular Quaternary complexity and Palaeolithic importance. Similarly, to other previous largescale projects such as High Speed 1 (see Bates and Stafford, 2013), sub-sets of the total extant data base were used to characterise each zone due to the high number of records available for individual zones.

5.2.5 Nonetheless, despite this extensive coverage, there were several areas with no, or very little, ground-truthed sequence data, (specified below, Section 7). Notwithstanding this the deposit model is robust enough to assess the potential for impacts on Palaeolithic archaeology as it assumes the presence of such deposits unless their absence can be demonstrated. Further work to the deposit model will allow more refined mitigation that will be secured through the AMS-OWSI (Appendix 6.9).

Palaeolithic site data

5.2.6 The primary resources for Palaeolithic site data were the Historic Environment Records for Kent and Essex, within which the project footprint is located. However previous work on the Kent HER (for instance for the Stour Basin Palaeolithic Project, Kent County Council 2015) has indicated that county HERs may have substantial omissions and inaccuracies for Palaeolithic data when compared with key primary sources (such as the pioneering national synthesis of Evans in the late 19th century - Evans 1872 and 1897) and the more-recent syntheses of Roe (1968) and the Southern and English Rivers Projects (Wessex Archaeology 1993 and 1996 being the relevant reports for this project area). Previous research has also shown that important Palaeolithic archaeological data can be found in primarily geological sources such as early 20th century sheet memoirs, and in series such as the regular Field Guides produced by the Quaternary Research Association for annual visits to various parts of Britain (the area of this project was visited in 1995 and 2014, reflecting its high Quaternary importance - Bridgland et al. 1995, and Bridgland et al. 2014).

5.2.7 Therefore, while the Kent and Essex HERs were the starting point for collation of Palaeolithic find records, these were supplemented by a systematic review of (a) key sources that have already collated Palaeolithic site information for the project area, and (b) primary published sources for each site. The primary data were then checked against and cross-referenced with the HER data, to arrive at an overall optimum collation of the location and characteristics of known Palaeolithic sites in and near the project area. These were collated into an annex (Annex E), and shown on maps in conjunction with geological mapping and landscape topography (Figures 2-5) to aid in identification of zones of different Palaeolithic and Quaternary character and potential.

5.2.8 The full list of sources that were initially consulted are given as appendices (Annex C for primarily geological sources, and Annex D for primarily archaeological sources). And the full list of primary sources for individual sites are included as a separate section within the annex listing all the Palaeolithic sites identified in and around the project footprint (Annex E, Section E.3). Geological sequence data from Palaeolithic sites were, when recorded, collated and included in the geo-archaeological model.

5.2.9 In accordance with best practice and the principles of the deposit-led approach (Wenban-Smith et al. 2010 and 2014) advocated by Historic England and the planning archaeologists of both Kent and Essex local authorities (eg. Kent County Council 2016), the area to be investigated for this desk-based PQDM included a substantial buffer zone beyond the immediate impact footprint of the project. The EIA Scoping Report and PEIR both specified a 1km before zone as being appropriate. However, best practice for Palaeolithic desk-based assessment (as recognised in Historic England heritage Professional training courses and in Kent County Council specifications for Palaeolithic assessments) is to take a wider 3km buffer since Palaeolithic remains, and relevant geological outcrops, can be rare in the landscape. Therefore, to ensure that the best information was obtained to ensure a robust assessment for the ES, the PQDM collated Palaeolithic site information from within a 3km buffer zone around the project footprint, covering an overall area of c. 270km2, as well as from several nearby nationally important sites that are not quite within the 3km buffer, but which nonetheless are informative about the potential of deposits within the buffer and the development footprint.

5.2.10 Palaeolithic site data was collated in a systematic framework, and the data recorded for each site are listed below (Table 5.1). Sites identified in the initial investigation of published site lists, grey literature and primary sources were then cross-referenced against information in the Kent and Essex HERs. This led to recognition of numerous duplications, omissions and inconsistencies. Many HER records included information on more than one Palaeolithic site, and conversely, many sites in the HER were represented by more than entry. Furthermore, many sites in the primary literature were not listed in the HER, although conversely the HER did provide the only information on a few sites, particularly those originating from relatively-recent fieldwork and the Portable Antiquities Scheme (PAS).

5.2.11 Overall, all the information on Palaeolithic sites was conflated into a single site list (Annex E, Section E.2), with each site allocated a unique number from the overall LTC cultural effects list. Information was cross-circulated within the LTC team on which sites in the final conflated Palaeolithic list were valid Palaeolithic HER records with LTC numbers, and which ones needed deleting as unnecessary duplicates. A block of new LTC site-numbers (4000-4500, inclusive) was allocated for use for new Palaeolithic sites that were not already in the LTC list, which was based on HER records. Of these 59 have been used to-date (4000-4058, inclusive).

Table 5.1. Data recorded for Palaeolithic sites [listed in Annex E, Section E.2].

Site data	Explanation
LTC list no.	Unique LTC identifier for cultural effects across whole Lower Thames Crossing heritage work
FWS proxy	Unique working proxy identifier for Palaeolithic cultural effects, used/assigned by Palaeolithic Lead (Francis Wenban-Smith, University of Southampton)
Site name	Site name, and summary information
HER MonUID	Unique identifier for previous finds within Kent/Essex HERs, if applicable
SR/ER PP, map.site	Site identification (if applicable) within the two national Palaeolithic surveys of (a) the Southern Rivers Project (Wessex Archaeology 1993) for the Kent side of the LTC, and (b) the English Rivers Survey for the Essex side

Site data	Explanation
Rec-Type	Record type, one of: Mon - flint artefact/s well-provenanced to a known context Mon/PE - flint artefact/s well-provenanced to a known context, in association with faunal or other palaeoenvironmental remains F-spot - location of flint artefact find/s, with less-reliable info on its/their provenance PEFS (Pleistocene environmental find-spot) - site with faunal or other palaeoenvironmental remains Geo - a significant geological sequence or feature, but lacking artefactual or palaeoenvironmental remains
NGR-E	OS grid easting, to nearest metre
NGR-N	OS grid northing, to nearest metre
Acc	Accuracy of OS grid location, one of: A (Accurate) - site is accurately located based on reliable primary sources E (Estimated) - site location can be estimated with reasonable confidence based on primary sources G (General) - sites and finds from a general area, lacking good information on location and provenance
Artefacts	Information on the quantity and variety of artefactual remains found
Palaeo-environmental remains	Information on the quantity and variety of faunal and other palaeo-environmental remains found
Geo attribution	Interpretation of likely geological context for Palaeolithic finds (see Annex E, Section E.1, Table E-2, for details, and their interpreted depositional and post-depositional history
Primary sources	Key primary source references (listed in Annex E, Section E.3)

5.3 Walk-over survey

5.3.1 A short walk-over survey was conducted jointly by the Palaeolithic and Quaternary geo-archaeological specialists working on the PQDM. This supplemented the desk-based collation of information, by direct observation of geological exposures and landforms in key parts of the project area. The survey focused on areas identified in the PQDM as of greatest interest. The following areas were selected for particular attention:

a. the small quarry (LTC 4018, on the southeast side of the A1013, Stanford Road) where Palaeolithic finds were made in the 19th century, where no development seems to have taken place since, other than slight re-routing of the road, and which is within the impact footprint of the LTC Project;

b. the area just to the southeast of the Mar Dyke (Cuckoo Lane, *c.* NGR 560800 180200) where some impact is proposed at the southeast valley-side edge of the spread of Lynch Hill terrace gravel, and in an area that might have been favoured for Palaeolithic occupation due to the proximity of Chalk bedrock that could have provided flint raw material for tool manufacture;

c. visible landforms, and possible Pleistocene terraces (a) on the south side of the Thames, in the vicinity of the proposed southern portal east of Gravesend, so far as can be viewed from publicly accessible locations, and (b) on the north side of the alluvial floodplain, between Chadwell St. Mary and East Tilbury.

d. areas where mapped Boyn Hill outcrops are adjacent to higher-level outcrops mapped as Black Park Gravel: (a) between Orsett Heath and Southfields, and (b) vicinity of North Ockendon

e. the higher northern part of the LTC project footprint where it encroaches into an area with glacio-fluvial sediments and outcrops of the Stanmore Gravel

5.3.2 The walkover survey was carried out 10th-11th March 2020. Its results are taken account of in the PQ zone assessments presented here in the PQDM, and are fully reported in the accompanying SPAA-&-RF.

5.4 Pleistocene terraces and conceptual models

5.4.1 Models describing the geological succession and landscape evolution of the Lower Thames have most recently been described by Bridgland (2006) and his work (often called the Bridgland Model) forms the basis for our current understanding of the Quaternary geology of the route corridor (including the contained Palaeolithic archaeology) (Figure 6). However, other workers, including some dating back to the early 20th century, have provided important details on the nature of the Quaternary geology while researchers such as Gibbard (1994), have provided alternative models for some of the sequences (e.g. the interpretation of the earliest post-diversion Thames deposits at Dartford Heath in Kent, see discussion by Bridgland (2006 page 287).

5.4.2 In the lower Thames (as is common elsewhere in the geological record), ancient river deposits have been attributed to distinct terrace bodies based on historical type sites identified in early geological mapping; however, these frameworks are often inconsistently applied, even in adjacent areas. The LTC project area is a good example of an area where numerous and complex suites of Pleistocene deposits have been given different nomenclature by different workers (Table 5.2). Within key areas such as the Lower Thames, keystone sites can also be representative of local terrace bodies, independent of wider debate over their date and nomenclature. For example, for the Boyn Hill Gravel Member or Orsett Heath Gravel, the site at Barnfield Pit, Swanscombe (Conway *et al*., 1996) provides the yardstick against which other sites are compared, as well as providing the information that contextualises and provides a chronology for the wider landscape, as well as the contained Palaeolithic archaeology. The sequences in the lower Thames area are particularly well-suited to such an approach as they often contain a sequence of deposits containing faunal remains as well as Palaeolithic stone tool industries. The sediments in the Bridgland model represent fluvial environments under both cold climate and temperate conditions that span a wide chronological range and some of the deposits (e.g. the Middle Gravels at Swanscombe) can be traced both upstream and downstream and act as regional sequences for correlation (Bates and Wenban-Smith, 2011).

Table 5.2. Stratigraphic nomenclature for Pleistocene terrace mapping of the Lower Thames, in vicinity of Lower Thames Crossing footprint. [* Ellison et al., 2004; ** on-line 2020; * based on BGS revision survey of the South London district in 1981]**

British Geological Survey (BGS)				**Other specialists**	
London *; Romford and Dartford **	**South London, 1981 *****	**Southend ****	**Chatham ****	**Gibbard (1994)**	**Bridgland (2006)**
Alluvium				Tilbury Deposits	
				Shepperton Gravel	
Kempton Park Gravel	Terrace 1	Not seen - below alluvium		East Tilbury Marshes Gravel	East Tilbury Marshes Gravel
Taplow Gravel	Terrace 2	River Terrace Deposits 2	River Terrace Deposits 1	Mucking Gravel/West Thurrock Gravel	Mucking Gravel
Hackney Gravel	Terrace 3a (River Lea)			Hackney Gravel	
Lynch Hill Gravel	Terrace 3b	River Terrace Deposits 3	River Terrace Deposits 2	Corbets Tey Gravel	Corbets Tey Gravel
Finsbury Gravel					
Boyn Hill Gravel	Terrace 4			Orsett Heath Gravel	Orsett Heath Gravel
Black Park Gravel				Dartford Heath Gravel	

5.4.3 Bridgland has exploited the type site approach within the model he has developed for the Lower Thames (Figure 6) (Bridgland 2006, 2014) that integrates lithology based on key sites with faunal biostratigraphy, archaeological evidence and amino stratigraphy in order to provide users with a simplified model for sequence development in the region (terrace stratigraphic framework) that is correlated with the Marine Isotope Record (Figure 7). This model has been developed over time and its most recent iteration (Bridgland, 2006, 2014) has been used for a variety of purposes (e.g. see White et al., 2018). Of relevance to the LTC corridor the following key points are noted:

a. Five main bodies of sediment are present at differing elevations in the lower Thames valley (Figure 6) (Table 5.2);

b. Four of these aggradations are associated with interglacial sediments containing faunal/floral remains;

c. Type sites for each stage are identified as Swanscombe (Boyn Hill/Orsett Heath Gravel), Purfleet (Lynch Hill/Corbets Tey Gravel), Aveley (Taplow/Mucking Gravel) and Trafalgar Square (Kempton Park/East Tilbury Marshes Gravel);

d. Each interglacial sequence is associated with an odd numbered marine isotope stage (MIS) (Figure 7). The most recent aggradation (the Shepperton Gravel) is overlain by the Holocene Thames estuary sequences;

e. No sediments older than MIS 12 exist within the Lower Thames valley because the valley was only created as part of the rearrangement of the fluvial systems in southern Britain associated with glaciation in MIS 12 (the Anglian) (Gibbard, 1985);

f. Palaeolithic archaeological material (artefacts, mammalian fossils and other faunal/palaeoenvironmental remains) may be associated with many of the gravel bodies.

5.4.4 The geological evolution of the landscape and sequences envisaged in this model is explained through a series of conceptual phases of deposition and erosion that link to climate change (Figure 8). This model requires uplift of the landscape to be taking place throughout the last 450,000 years in order for sequences to be created and preserved as discrete bodies of sediment at differing elevations in the valley. The conceptual processes taking place in each cold/warm/cold cycle allow elements of the geological record to be accommodated in the terrace stratigraphic framework even where faunal remains are absent due to the physical-spatial relationships between sediments that are predicted by the model (i.e. upstream and downstream correlation of sediments at similar elevations in the landscape). The result of this conceptual model can be illustrated in an idealised section through a terrace in the Lower Thames (Figure 9). In this a number of discreet units can be identified:

a. Basal high-energy sands and gravel (cold climate)

b. Interglacial sands/silts (fluvial)

c. Interglacial sands/silts (brackish)

d. High-energy sands and gravels (cold climate)

e. Slopewash/head including buried soils (warm/cold stage)

5.4.5 It should be noted that this idealised model, whether clearly articulated or not by researchers, is the framework by which all recorded lithologies are compared and contrasted.

5.4.6 Despite the widespread adoption of Bridgland's model (terrace stratigraphic framework) a number of issues emerge when the model is applied to individual sites and sequence. The model was developed to provide regional frameworks for correlation with patterns of climate change and inter-regional correlations (Bridgland and Westaway, 2014; Bridgland and White, 2014; Chauhan et al., 2017; White et al., 2017) and the model appears to work well when applied at this scale of the river catchment and for ordering and categorising material recovered from individual sites. However, problems with the application of the model do appear when applied locally in the study area and these issues do need to be considered when discussing the Quaternary geology and associated Palaeolithic archaeology of the route corridor. These include:

a. It is often hard to relate specific horizons from deep sequences to the wider model.

b. Nomenclature and terminology used within the study area varies. In this study we accept the nomenclature of Bridgland (2006) however, this nomenclature is at odds with that used by the British Geological Survey mapping (indeed BGS mapping terminology varies across the 4 sheets covering the study area). Table 5.2 sets out the differing nomenclature applied to the study area.

c. Differences in the interpretation of mapped bodies of sediment. For example, because Bridgland does not recognise the Black Park Gravel in the Lower Thames area he maps as Orsett Heath Gravel sediments mapped by the British Geological Survey as Black Park terrace (Figure 10). Furthermore, the British Geological Survey have identified an additional deposit (the Hackney Gravel Member) in the Romford area that Bridgland argues cannot be distinguished from the Lynch Hill Gravel (Bridgland, 2014).

d. Differences in the geomorphological interpretation of deposits. For example, when considering the geomorphology of the river during the Boyn Hill/Orsett Heath times Dines and Edmunds (p35, 1925) state "The position of the Boyn Hill terrace shows that, in Boyn Hill times, the Thames crossed the anticline of the Chalk between Purfleet and Grays". They go on to state "The change of conditions at the close of the Boyn Hill period resulted in the lowering, by about 50ft., of the river-level. This brought the Thames against the Chalk barrier behind which its water ponded". By contrast Bridgland (2006) clearly suggests in his mapping that the river depositing the Boyn

Hill/Orsett Heath Gravel swung south westwards around the Chalk anticline at Purfleet in the so-called Ockendon Loop.

5.4.7 Another significant factor in the application of the Bridgland model to the Lower Thames Crossing region is the fact that nowhere in the model are estuarine or brackish sedimentary sequences specifically accommodated in the framework. This is a particular weakness of the Bridgland model because the geomorphology of the river system is likely to have changed through time with the truncation and erosion of the downstream segment of the Thames in successive interglacials. The impact of this truncation would result in the tidal head of the Thames extending ever further upstream in successive interglacials. Thus, while there is some evidence at Swanscombe for brackish water conditions (White et al., 2013) there is better evidence for brackish conditions at Purfleet during MIS 9 that appears to suggest the site was close to the tidal head at this time (Bridgland et al., 2013). Ward (1984) indicates that brackish water conditions existed at Upminster at a similar time. Sediments at Lion Pit (Hollin, 1977; Bridgland, 1994) in the Thurrock area that are associated with the Mucking Gravel have been interpreted to contain estuarine sediments while low brackish conditions at Trafalgar Square have been inferred by Gibbard (1985) during the last interglacial (East Tilbury Marshes Gravel) suggest the tidal head of the river had moved a considerable distance west by the last interglacial. Consequently, it is important to factor into our consideration the nature of estuarine sequences in the estuary as these are likely to have become increasingly important elements from Middle to Late Pleistocene times.

5.4.8 In order to provide a complementary model to the Bridgland terrace model Pleistocene sequences in southern England have been examined in order to understand the nature of estuarine filling in the pre-Holocene period. A model that complements that of Bridgland is proposed here (for the first) time (Figure 11). This model has been based on Holocene evolution of both the Thames and Solent systems in which the onset of sedimentation in the valley base begins with the deposition of fluvial sands and gravels at the transition from cold to warm climates (Phase I, Figure 11). This is succeeded by the onset of fine-grained sediment accumulation of a basal peat horizon as sea levels rise and result in backing up of waters on the topographic template of the late cold stage landscape (Phase II, Figure 11). This is subsequently followed by inundation by brackish water conditions resulting in the deposition of laminated sands and silts under estuarine tidal conditions (Phase III, Figure 11). Phases of temporary decrease in brackish water conditions, due to localised sea level fall, may result in peat formation within this Phase. Phase III represents that time in the system in which the estuary accommodation space is filled, perhaps by the mid interglacial period, resulting in stability of the system and a cessation of major sequence accumulation in the estuarine segment of the system at this time. A Pleistocene example of such a system can be found at Lepe in the Solent system (Briant et al., 2019). Subsequently cooling conditions, resulting in sea level fall, leads to erosion of the sediments and a return to fluvial conditions

(Phase IV/V). The estuarine model proposed here can be linked to that of Bridgland's river terrace formation (Figure 8) as follows:

a. Phase 1 Main Downcutting (cold/warming).

b. Phase 2 Aggradation (cold/warming). Phase I

c. Phase 3 Interglacial (temperate). Phase II/III Onset of peat formation followed by estuarine sedimentation. Accommodation space filled by mid interglacial

d. Phase 4 Minor Downcutting (cooling/cold). Phase IV

e. Phase 5 Main Aggradation (cooling/cold). Phase V

f. Phase 6 Glacial (cold and stable)

5.4.9 In order to accommodate both models within the idealised terrace model a modified idealised terrace transect is shown (Figure 12) in which the brackish water elements of the model are expanded.

5.5 Geoarchaeology of the Pleistocene sediments

5.5.1 An important consideration in a study of this kind is to consider the geoarchaeological status of expected/recovered finds. Links may exist between location in the landscape, sedimentary characteristics of landscape zones (i.e. sedimentary facies) and their contained archaeology (Annex F). Defining the relationships between sedimentary facies and the nature of contained archaeological record can therefore:

a. Provide predictive information on the likely types/focus of occupation/activity within a stratigraphic stack and

b. Provide predictive information on the likely taphonomic status (and history) of any material present within that stack.

5.5.2 The factors defining the facies within the sedimentary stack are a function of the location of the space occupied by the sediments (i.e. the accommodation space) in the environment and the interaction of a range of factors within that accommodation space (Figure 13). These characteristics related to the nature of the environment of deposition can therefore be linked to site types known to habitually occur in such environments. Additionally, the nature of the environments of deposition will influence the preservational status of those deposits, i.e. whether or not artefacts etc. remain in situ after loss/discard.

5.5.3 In order to illustrate the principle involved the following examples is provided:

5.5.4 Locations associated with animal capture/discovery and subsequent butchery are often in water edge situations, on meander inside bend slip off slopes or on floodplain flats. Many archaeological examples of such sites are known, e.g. the tool production and butchery areas at the Uxbridge late-glacial site (Lewis, 1991; Lewis and Rackham, 2011). Sediments within such areas exhibit grain sizes from gravels to fine silts that can be used to identify facies types associated with these situations in field sections or drill core data. This information can be used to indicate the presence of contexts within which evidence of past human activity may be found. Consideration of the grain size relative to the size/status of any contained artefacts will provide information on any potential for reworking within the deposit. For example, gravel substrates, deposited under high-energy conditions, indicate a high likelihood that any contained artefacts will be reworked. Artefacts such as axes, contained within finer grained sediments, are less likely to have been reworked (Brown, 1997).

5.5.5 Another factor to consider is the recognition of buried surfaces (used here to refer to presently buried former landsurfaces). This is of critical importance not only within archaeology but also within geology and geomorphology. The identification of buried surfaces within stratigraphic sequences has been used to divide up stratigraphies into packages of sediments (contexts) considered to display genetically and temporally related features. The surfaces identified may be the result of changes in the nature of sedimentation, breaks or hiatuses in sedimentation or represent phases of erosion. The identification of buried surfaces within the stratigraphic stack can be considered as an element of a greater set of attributes within the stack that can be used to reconstruct the palaeolandscape (Widdowson, 1997). Typically, integration of a range of geological and geomorphological data within a conceptual model containing palaeosurface information is often the objective of geoarchaeologists tasked within placing the archaeological site/area of investigation within a (pre)historical context.

5.5.6 Within the stratigraphic stacks key zones of considerable archaeological importance are those indicating the presence of former landsurfaces. The inundation or burial of landsurfaces on which human activity has taken place can result in the sudden, in situ burial of human and animal remains For example, buried landsurfaces such as those preserved by the volcanic eruption of in the Neuweid Basin in the Central Rhineland that deposited the Laacher See Tuff (Street, 1986; Ikinger, 1990; Baales and Street, 1996). Within the Thames two well-known examples of buried landsurfaces have been recorded, one at Swanscombe associated with large mammals (Davies, 1996) and the surface at Happisburgh in the ancestral Thames that preserved a substantial number of hominid footprints (Ashton et al., 2014).

5.5.7 Identifying and determining the lateral distribution of buried palaeolandsurfaces is of critical importance in the archaeological evaluation of an area. These features represent positions within the stack at which in situ assemblages of material may occur in the context of the landscape in which they were used. They may be identified by a series of features that can be used singly or in combination to determine the presence of a buried landsurface:

a. Sudden changes in lithology within a core profile either seen as a sudden change in sediment types or shifts in properties such as loss-on-ignition and total phosphates (Barham, 1995).

b. The presence of a palaeosol.

c. The presence of zones of weathering, rooting horizons or enhancement of magnetic susceptibility signals (Allen, 1987; Barham, 1995).

d. The presence of major bedding planes.

5.5.8 The presence of these features may imply the location of a landsurface. However, in order to determine the significance of these features their lateral extent needs to be determined through the identification and correlation of these features within a number of boreholes. This is most easily achieved using the principles of facies analysis and the construction of a sub-surface stratigraphical model.

5.6 Quaternary deposit model: principles, construction and revision

Geo-archaeological principles

5.6.1 Understanding of the geology of the route corridor is based on the understanding of the background data, coupled with extant boreholes and excavation data from the area of the route corridor articulated within the context of the geology of the wider Lower Thames region. Additionally, information on bedrock geology and local geomorphology is utilised. Consequently, a number of considerations are made:

a. What is the nature of the bedrock geology and how is that likely to have an impact on the nature and content of the overlying Quaternary sequences?

b. What evidence do we have for the nature of sequences in the study area?

c. Where are we missing data for the study area?

d. What types of sequences do we anticipate finding in the area?

e. What does the local geomorphology and sedimentary sequences imply for the any archaeology or palaeoenvironmental finds in the area?

f. Where do we need additional data in order to begin to create a robust narrative for the route corridor?

Sediment types

5.6.2 Base on the known geology and the likely range of sedimentary units we would expect in the study area the following groups of deposits are noted:

a. High energy fluvial gravels (Figure 14). These are likely to consist of coarse to fine gravels that may be well stratified or lack any clear bedding. Laterally they may grade into homogenous or bedded sand units and typically (although not always) are devoid of fossil material. They represent cold stage river environments in which braided channels dominated. They belong to Bridgland's Phase 2 and Phase 5 stages. Artefacts present in the sediments are typically likely to be reworked.

b. Low energy fluvial sands and silts (Figure 15). These may be structured or massive. Under the right circumstances they may be carbonate rich, and locally rich in tufa, elsewhere they may contain organic content or peats (Figure 16). They represent warm stage rivers where meandering river systems dominate. Locally higher energy gravels may exist. They are often faunal rich and belong to Bridgland's Phase 3.

c. Low energy well-stratified sands and silts (Figure 17). These are often very well bedded with a variety of being structures. They may be carbonate rich in places. They represent low energy intertidal, mudflat or saltmarsh environments in the mid interglacial phase. They can be faunal rich and belong to the Phase II/III of the brackish model described above.

d. Variable sand, silts and gravels (Figure 18). These deposits are often associated with slopes and valley sides and represent colluvium and head deposits moving under gravity downslope. Often deposited in cold climate conditions these deposits typically bury underlying fluvial sediments. In places palaeosols may be developed in these deposits (Figure 19).

e. Finally, a group of sediments belonging to the true estuary environments are likely to exist (certainly in the Holocene sequences but also perhaps in the East Tilbury Marshes Gravel) (Figure 20). These consist of homogenous to very well laminated sands and silts, sometimes interbedded with peat deposits of variable thickness.

Construction and iterative revision

5.6.3 The ground model was initially constructed using Rockworks 16 and Surfer 12 software to archive, manipulate and export the data. Data from extant sources was examined, logged and integrated into the software systems by the two specialists (FWS and MRB). Project sub-contractors were responsible for data recording from geoarchaeological field programs undertaken by them.

5.6.4 The model has utilised extant borehole data in the British Geological Survey Geology of Britain repository coupled with geotechnical data from the GI Phase 1 investigations for the Lower Thames Crossing. Additionally published and unpublished data from archaeological and geological investigations in the Lower Thames have been consulted. The approach adopted has been to construct transects through the landscape (where data is sufficient) in order to characterise the nature, thickness and distribution of Quaternary deposits across the LTC project footprint (Figures 21-30). These figures have subsequently been used in conjunction with current geological mapping and landscape topography to designate a series of Palaeolithic and Quaternary (PQ) character zones (see below, Section 5.8 and Section 7).

5.6.5 The deposit model produced by this study should not be thought of as a static resource through the lifetime of the project. The model will require updating as additional information becomes available from both the geotechnical data sources and geoarchaeological monitoring of works. The 7 transects that have been constructed typify the character of much of the route corridor however it should be noted that additional transects would have helped resolve some of the questions and issues along the route corridor. It is hoped that as GI Phase 2 data becomes available additional transects, and potential refinements to the PQ zones will be possible.

5.6.6 Additionally, purposive investigations, undertaken during the lifetime of the project, will be required for areas of the route corridor which the current project identifies as lacking sufficient data for robust model construction. The data from these investigations will need to be fed back into the model in order to refine our understanding of the archaeological potential of the route corridor.

5.6.7 Other forms of data (e.g. geophysical terrestrial and marine survey data) is also likely to become available during the lifetime of the project. How such information will be transferred to the sub-surface model remains to be fully realised. Interpretation of the data and the generation of synthetic-borehole logs from a variety of data forms may be possible. Alternatively, such data may be used to inform interpretation of the borehole-generated models.

5.7 Integration of ground investigation and Stage 1 archaeological data

5.7.1 The Palaeolithic and Quaternary Deposit Model (PQDM) has, as far as data is available, integrated desk-based data derived from the sources mentioned (Section 5.2; Appendices C and D) with new data from ground investigation (GI) work. As well as all data from Phase 1 of GI work, a certain amount of new data from packages A and C of the Phase 2 GI work was made available through the monitoring reports (AECOM 2020a, b) (**Table 5.3**), and has been taken account of in the deposit modelling.

Table 5.3. Phase 2 GI data incorporated in the PQDM.

Intervention	Package A	Package C	Total
Borehole - cable percussion	3	7	10
Borehole - rotary follow-on	20	16	36
Borehole - dynamic sampling	21	-	21
Windowless sampling	20	26	46
Machine-dug trial pit	32	11	43
Total monitored interventions			**156**

5.8 Palaeolithic and Quaternary (PQ) zones: identification and assessment

5.8.1 Based on the desk-based and GI information outlined above (**Sections 5.2** and 5.7), and in conjunction with geological mapping and the Quaternary deposit model (**Section 5.6**), the LTC project footprint was divided into 29 character areas, represented in the landscape as 34 actual Palaeolithic and Quaternary

(PQ) zones (PQ 1-11, 12a-b, 13-19, 20a-c, 21, 22a-b, 23a-b and 24-29, see Figures 31-33) since several areas of similar character are not directly contiguous, (full details below, Section 7). These zones supersede the preliminary model developed by Wessex Archaeology based on geological mapping and incorporated in the Addendum to the WSI for archaeological monitoring of GI work (AECOM 2019b).

5.8.2 Each zone was defined as a unique polygon in a GIS project, overlain on the LTC project footprint so as that every part of the project footprint was attributed as a PQ zone. A range of key information was systematically collated for each zone (Table 5.4), and an assessment was made of its Palaeolithic and geo-archaeological potential. This latter was assessed as one of three broad categories, as outlined below (Table 5.5). This assessment then guides the pathway for staged mitigating archaeological investigation.

Table 5.4. Information collated for PQ zones

Zone	**PQ-no.**	**Name of PQ zone**
Topography/geomorphology Bedrock geology	• Summary description of topography (including ground surface elevation) and geomorphology • Solid (pre-Quaternary) bedrock geology	
Sediment sequences	Summary description of Quaternary sediment sequences	
Geological interpretation	Current geological interpretation, including presumed depositional process and stratigraphic attribution (for instance to a particular Lower Thames terrace or gravel body)	
Palaeoenvironmental potential	Review of palaeo-environmental potential, so far as known	
Palaeolithic remains	Review of Palaeolithic artefact finds from zone, and potential based on recoveries from similar deposits, with specific sites referenced to LTC cultural effects list (Annex E)	
Pal./geo-arch. assessment	One of three categories: Uncertain, Moderate-High, or Low-Moderate (see criteria below, Table 5.5)	
Stage 1 mitigation priorities	Key priorities to address in stage 1 Palaeolithic/geo-archaeological fieldwork	
Key reference/s	Most important sources for up-to-date information on zone	

Table 5.5. Categories of Palaeolithic/geo-archaeological assessment for PQ zones

Pal./geo-arch. assessment	Criteria, explanation
Uncertain	Too little primary information on Quaternary sequence for mitigation programme to be determined; requires stage 1 Palaeolithic/geo-archaeological fieldwork, with further stages of mitigation contingent upon results of stage 1
Moderate-High	Likely to contain sites with Medium-Very High Palaeolithic potential (see Annex G for criteria for Palaeolithic potential); requires stage 1 mitigation fieldwork to clarify distribution and potential of key deposits, followed by further mitigation work in stages 2 and 3, scope to be determined in light of the stage 1 and 2 results respectively
Low-Moderate	Likely to contain sites with Negligible-Medium Palaeolithic potential (see Annex G for criteria for Palaeolithic potential); scope of stage 1 mitigation to be specified zone-by-zone, and then scope of further work in stage 2 tbc in light of stage 1 results

5.9 Staffing and Health-and-Safety

5.9.1 Work for this PQDM was carried out by the two specialists commissioned for this purpose (Francis Wenban-Smith, University of Southampton; and Martin Bates, University of Wales). The two specialists worked as part of the LTC team under direction of the CASCADE JV. GIS support was provided by Tim Sly (University of Southampton).

5.9.2 Almost all of the work done was desk-based, and was carried out at the places of employment of the respective specialists and the GIS support worker. There was some travel to examine records at various libraries and at institutions such as the British Geological Survey, and for LTC meetings and specialist liaison. All of these activities were at institutions with well-developed Health and Safety protocols, or were carried out as part of normal day-to-day activity. Thus a separate specific Risk Assessment was deemed unnecessary for this desk-based phase of work. Existing practices and protocols in these workplaces were adhered to, and normal care was taken when travelling and going about business away from these work premises.

6 Palaeolithic sites: desk-based overview

6.1.1 In total, having investigated all the desk-based sources and removed duplicate entries, 99 separate Palaeolithic sites were identified within, and near, a 3km buffer around the LTC project footprint. These are collated as an annex (Annex E), and their locations are shown in relation to the LTC footprint and geological mapping (Figures 3-5).

6.1.2 The general abundance of Palaeolithic sites confirms the LTC Project as taking place within a key area for the Palaeolithic in Britain, and the site list includes several iconic British sites such as the HS1 elephant (LTC 4043), the Belhus Park Cutting (LTC 4020-4021), the Purfleet pits (LTC 4008-4010) and the Baker's Hole Levallois site (LTC 4058).

6.1.3 In terms of LTC project impact, 17 known sites (two of them only generally located) are directly affected by the development footprint, and a further 11 (one of which only generally located) have their locations very near to it (Table 6-1, below). However, this cannot be taken as a direct prediction of impact by the works. The historic discovery of Palaeolithic sites can be a very haphazard affair, strongly influenced by areas of previous deep quarrying (or other infrastructural works) and by whether or not avid local collectors were active in an area. Rather, historic patterns of discovery can be used to model likely potential on the basis of the similarity of deposits in an area of interest to those that have previously produced material in the same general region. This is why the desk-based review has collated information up to (and in some cases, slightly beyond) a 3km buffer around the Project's impact footprint.

6.1.4 The attribution of specific sites to specific Palaeolithic-and-Quaternary zones of the Project's footprint is discussed further below (Section 7). Pending that, the sites identified in the desk-based review highlight the following general themes of interest for the Palaeolithic in and around the LTC footprint:

6.1.5 *Boyn Hill Gravel, and equivalent deposits*. These deposits are extensive across the LTC footprint in Essex. They have produced numerous Palaeolithic finds, especially in the area of Orsett and Chadwell St Mary. Slightly further afield, on the south side of the Thames, deposits of this age have also produced abundant and important remains, including the HS1 elephant site (LTC 4043) and at Barnfield Pit, Swanscombe (not listed here in the LTC site list, but another iconic British Lower Palaeolithic site of the Lower Thames - Ovey et al 1964; Bridgland 1994: 193-218, Conway et al. 1996). It remains possible that the local geography on the south side of the Thames (in particular the abundant very local availability of flint from nearby Chalk bedrock, and possibly also a slightly different fluvial depositional regime) has meant that Palaeolithic occupation was focused there, and/or sites are more likely to be preserved there with less disturbance. However, unless/until there is robust evidence to confirm the relative absence of important Palaeolithic remains in other parts of Boyn Hill Gravel (and equivalent deposits) it has to be presumed that they may contain similar remains in nearby as-yet-uninvestigated areas.

6.1.6 *Lynch Hill Terrace (and equivalent deposits)*. These deposits are likewise extensive near to the LTC footprint in Essex. The greatest spread occurs mostly to the west of the LTC footprint, although the eastern side of this spread is directly affected by LTC Project in several places These deposits have also produced numerous Palaeolithic finds, especially at the Belhus Park Cutting (LTC 4020-4021) between M25 junctions 29 and 30 where minimally-disturbed lithic remains have been found associated with a deep sequence of deposits very rich in diverse botanical, molluscan and vertebrate remains. Slightly further to the west, and a little beyond the 3km buffer, similar and rich remains have been found at the Purfleet pit complex (LTC 4008-4010). In contrast to the situation for the Boyn Hill Terrace (see para 6.1.5) here there is every likelihood that similar remains to those of the Belhus Cutting will be affected by the LTC work, since the same deposit body extends into the LTC footprint. It is also possible that similar remains to those found at Purfleet may be present in the small part of the project footprint that encroaches near to where Lynch Hill deposits approach Chalk bedrock on the Essex side of the Thames (near NGR 560750 180250 - see below, Section 7, zone PQ-17).

6.1.7 *Middle Palaeolithic (British Mousterian) sites*. Sites of this period (from the middle part of the Devensian Glacial, representing late Neanderthal incursions into Britain from the European continental landmass) are rare in Britain, but there is at least one characteristic handaxe (described as a fine *bout coupé*) from Tilbury dockyard (LTC 4028), and two other handaxes likely to be of the same age from the same area, one of them reported as having been recovered during extension of the dock in 1913 (LTC 4029). It therefore seems likely that the wide spread of alluvium representing the Thames floodplain on the north side of the current river channel may seal deposits with remains of this period, and possibly palaeo-landsurfaces.

6.1.8 *Final Upper Palaeolithic Long Blade sites*. Sites of this period are also generally rare in Britain, but those that we do know about seem to be concentrated in the Southeast, and especially in the Thames basin, perhaps indicative of the Thames as a primary access route into southern Britain from the North Sea area. In particular, relative numerous sites and find-spots, including two instances of concentrated scatters with refitting material representing minimally-disturbed material (LTC 2370 and 4045) and a third instance that probably also represents undisturbed material (LTC 3406) have been found on the south side of the Thames, in the vicinity of the Ebbsfleet valley. Two of these sites (LTC 2370 and 3406) were found under Holocene alluvium, as were many of the isolated findspots of Long Blade material in the Swanscombe area (not in the LTC site list). However, one site (LTC 4045) was found away from the alluvial floodplain, in a dry valley infilled with fine-grained colluvium dating to the Last Glacial maximum. A palaeo-landsurface had formed on the surface of the Last Glacial colluvium, and this preserved a dense scatter of undisturbed lithic remains, which was then buried by subsequent Early Holocene slopewash deposition. This highlights the potential of similar remains to be found in other analogous landscape situations in the LTC footprint, especially on the southern side of the Thames, where the more-chalky landscape would have led to a more abundant supply of fresher flint raw material, essential for the large-scale blade production associated with the Final Upper Palaeolithic Long Blade industry.

Table 6-1. Known Palaeolithic sites affected by, or near to, the LTC footprint

Site-type	In LTC footprint				Near LTC footprint			
	Acc.	**Est.**	**Gen**	**Key sites [by LTC list no.]**	**Acc.**	**Est.**	**Gen**	**Key sites [by LTC list no.]**
Mon	4	1	-	468 - Gun Hill Pit 1661 - handaxe found *in situ* under colluvium during HS1 evaluation, southeast of Tollgate, ARC TGS 97 4018 - pit NE of Hangman's Wood	1	1	-	3452 - handaxe from brickearth bank, TP 25 4053 - gravel pits east of Higham
Mon/PE	-	-	-	-	1	-	-	4043 - the HS1 Ebbsfleet elephant butchery site
F-spot	4	3	1	4049 - handaxe and debitage from brickearth bank, north of HS1 elephant site 4007 - sharp cordate at South Ockendon windmill	4	3	1	503, 2021, 2143 and 4017 - handaxe finds from Chadwell St. Mary 4028, 4029 - handaxes (including *bout coupé*) from Tilbury docks
PEFS	2	-	-	4046-4047 - ostracods and molluscs from Hoxnian lake sediments at Ebbsfleet, east of HS1 elephant site	-	-	-	-
Geo	1	1	-	173 - Boyn Hill Terrace at M25 Ockendon Cutting	-	-	-	-
Totals	**11**	**5**	**1**		**6**	**4**	**1**	

7 Palaeolithic and Quaternary (PQ) zones

7.1.1 Based on the information and approaches outlined above (Section 5), the LTC project footprint was divided into 29 character areas. These are represented in the landscape (Figures 31-33) as 34 actual Palaeolithic and Quaternary (PQ) zones (PQ 1-11, 12a-b, 13-19, 20a-c, 21, 22a-b, 23a-b and 24-29) since several areas of similar character are not directly contiguous. These zones supersede the preliminary model developed by Wessex Archaeology (AECOM 2019b), which placed greater reliance on the accuracy of current geological mapping and Bridgland's interpretive framework for Pleistocene terrace deposits in the LTC area.

7.1.2 A desk-based assessment was made for each zone of its Palaeolithic and geo-archaeological potential, attributed to one of three categories (UNCERTAIN, MODERATE-HIGH, or LOW-MODERATE) on the basis of the rationale outlined above (Table 5.5). A zone-by-zone summary of the assessments is provided below (Table 7.1). Full details of each PQ zone are provided as two appendices (Appendices H, I), and a series of larger-scale maps are also provided, showing each zone in relation to known Palaeolithic sites, geological mapping, topography and previous quarrying (Figures 35-47).

Table 7.1. PQ zones: Palaeolithic/geo-archaeological Assessments

PQ zone	Name - summary description	Ha	Pal./geo-arch. assessment
PQ-1	Ebbsfleet International car park - asphalt surface over deep thickness of made/backfilled ground onto Chalk, previously Chalk quarry	11.03	Low-Moderate
PQ-2	Ebbsfleet Valley (unquarried southwest part) - northward continuation of similar deposits to those at the HS1 Ebbsfleet Elephant site	3.46	Uncertain
PQ-3	Ebbsfleet Valley upland catchment - Chalk and Thanet Sand bedrock, with Head infilling dry valleys and as intermittent spreads/patches on valley sides and less-sloping areas	23.97	Uncertain
PQ-4	Shorne Woods Plateau - high-ground interfluve between Thames and Medway, formed of outcrop of Lambeth and Thames Group bedrock	42.00	Low-Moderate
PQ-5	Jeskyns shelf - broadly-level high-ground interfluve between Thames and Medway to southwest of, and slightly lower than, PQ-4; Thanet Sand with wide spreads of Head and possibly small outcrops of high "plateau gravels"	71.68	Uncertain
PQ-6	Thong Lane, dip slope of North Downs - Chalk and Thanet Sand bedrock with Head in dry valleys and intermittently across bedrock sides and plateau surface	419.94	Low-Moderate

PQ zone	Name - summary description	Ha	Pal./geo-arch. assessment
PQ-7	Filborough - Thames terraces (Lynch Hill and Taplow) lying on Chalk bedrock at foot of dip slope above south bank of Thames	6.87	Moderate-High
PQ-8	Thames, southern floodplain edge - Holocene alluvium overlying potential buried Pleistocene terrace deposits	8.88	Moderate-High
PQ-9	Thames, main floodplain - Holocene alluvium overlying Late Pleistocene gravel (Shepperton)	301.53	Low-Moderate
PQ-10	Thames, northern floodplain edge - Holocene alluvium overlying potential buried Pleistocene terrace deposits	84.37	Moderate-High
PQ-11	Goshems Farm - outcrop of Lynch Hill Gravel surrounded by apron of Head deposits	58.83	Low-Moderate
PQ-12a,b	Shearwater Avenue (PQ-12a) and Sutton’s Farm (PQ-12b) - Mucking/Taplow Gravel spread with possible Lynch Hill outcrop at northwest edge of PQ-12a	132.91	Low-Moderate
PQ-13	Chadwell Saint Mary - wide spread of Orsett Heath/Boyn Hill gravel	280.33	Moderate-High
PQ-14	Southfields - local high, Black Park Gravel (mapped as Orsett Heath Gravel by Bridgland)	64.38	Low-Moderate
PQ-15	Brook Farm Channel - Head-filled channel-like feature between Mar Dyke Basin and main Thames estuary	102.01	Uncertain
PQ-16	Loft Hall Farm - Bedrock-dominated zone (Lambeth Group) on southwest side of Mar Dyke basin	53.53	Low-Moderate
PQ-17	Cuckoo Lane - small outcrop of Lynch Hill/Corbets Tey Gravel on southern side of Mar Dyke, with Head infilling minor dry valley	3.95	Low-Moderate
PQ-18	Mederbridge Road - southeast margin of wide spread of Lynch Hill Gravel on northwest side of Mar Dyke	0.37	Moderate-High
PQ-19	Kemps Farm, Dennis Road and Manor Farm - wide spread of Lynch Hill Gravel (including the Belhus Organic Channel) to west and north of the curving course of the Mar Dyke	54.65	Moderate-High
PQ-20a,b,c	East side of Mar Dyke basin (PQ-20a - Green Lane; PQ-20b - Castles Grove; PQ-20c - Bulphan) - Head with patches of London Clay bedrock	170.93	Low-Moderate
PQ-21	Mar Dyke narrows - narrowing channel of Mar Dyke as it passes south-westward towards the north side of the Purfleet anticline, infilled with Holocene alluvium	2.35	Uncertain

PQ zone	Name - summary description	Ha	Pal./geo-arch. assessment
PQ-22a,b	Mar Dyke basin (PQ-22a - main part, Fen Farm; PQ-22b - northwest part, Puddle Dock) - Holocene alluvium (thin?) over Head or bedrock	161.25	Uncertain
PQ-23a,b	Mar Dyke, eastern margins (PQ-23a - Orsett Fen, Hobletts; PQ-23b - Stringcock Fen) - Head outcrops at edge of Mar Dyke basin, interspersed with spreads of presumed Holocene alluvium	28.21	Low-Moderate
PQ-24	Mar Dyke basin, west side - Head on western edge of Mar Dyke, with occasional outcrops of London Clay bedrock	163.88	Low-Moderate
PQ-25	Hall Farm - major spread of Orsett Heath/Boyn Hill Gravels, overlain in places by Head-filled depressions or minor channels	141.54	Moderate-High
PQ-26	White Post Farm - local high ground, Black Park Gravel outcrops	0.48	Low-Moderate
PQ-27	Mar Dyke, northern edge - Head on edge of Mar Dyke (possible glacial till of Lowestoft Formation and glacio-fluvial outwash present beneath Head)	137.98	Low-Moderate
PQ-28	Foxburrow Wood - Mainly Eocene bedrock (London Clay, Claygate Member, and Bagshot Formation) with occasional patches of Head	23.33	Low-Moderate
PQ-29	Park Pale - South Downs (Medway basin), chalk downs with Palaeocene outcrops (Thanet Sand, Lambeth Group) dissected by Head-filled dry valleys	75.94	Low-Moderate

8 Complementarity with Stand-alone Palaeolithic Archaeological Assessment and Research Framework (SPAA-&-RF)

8.1.1 This report - the *Palaeolithic and Quaternary Deposit Model* (PQDM) - forms one part of a complementary pair of reports, the other being the *Stand-alone Palaeolithic Archaeological Assessment and Research Framework* (SPAA-&-RF). The PQDM, although incorporating a substantial amount of Palaeolithic site information and being (in accordance with the deposit-centred approach adopted for this work) an integral aspect of addressing the needs of the Palaeolithic heritage for the LTC Project, is focused upon the Quaternary deposits.

8.1.2 The SPAA-&-RF provides more detail on the Palaeolithic remains in the zones identified in the PQDM. It reviews the national and regional research frameworks for the Palaeolithic in the area of the LTC Project (as listed in Annex B), and establishes a project-specific Palaeolithic Research Framework for the LTC archaeological programme. The Palaeolithic Research Framework defines themes, priorities and landscape zone research objectives for Palaeolithic investigations, and ties these in with the assessments of each PQ zone.

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Figures

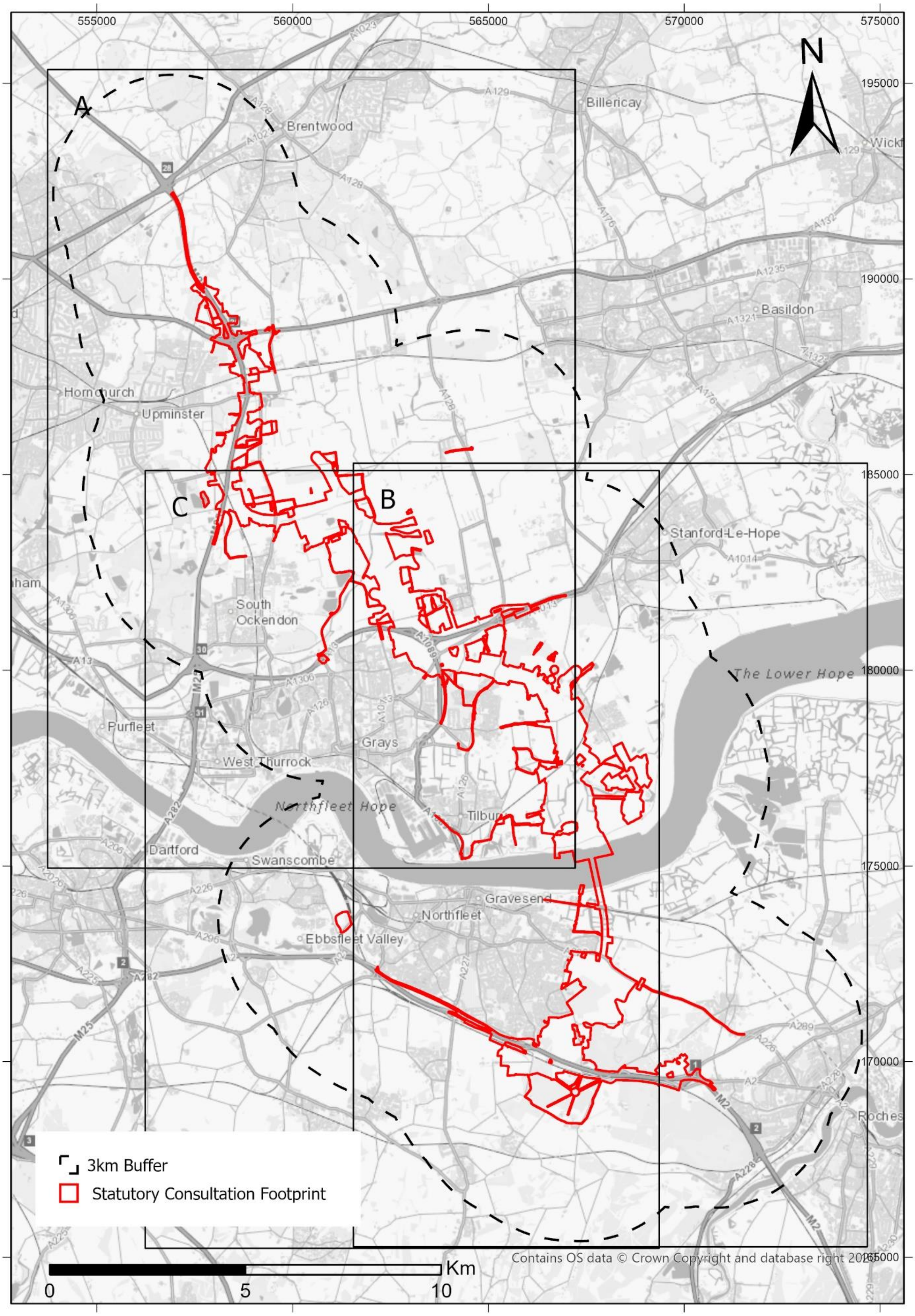


Figure 1. Lower Thames Crossing, whole project area: statutory consultation footprint (as revised in January 2020) with 3km buffer. [Crown copyright OS mapping data reproduced under HE Licence 100030649]

Figure 2. Geological mapping key, and legend for other data. [Geological mapping data reproduced under Licence 2017/004 British Geological Survey © NERC. All rights reserved]

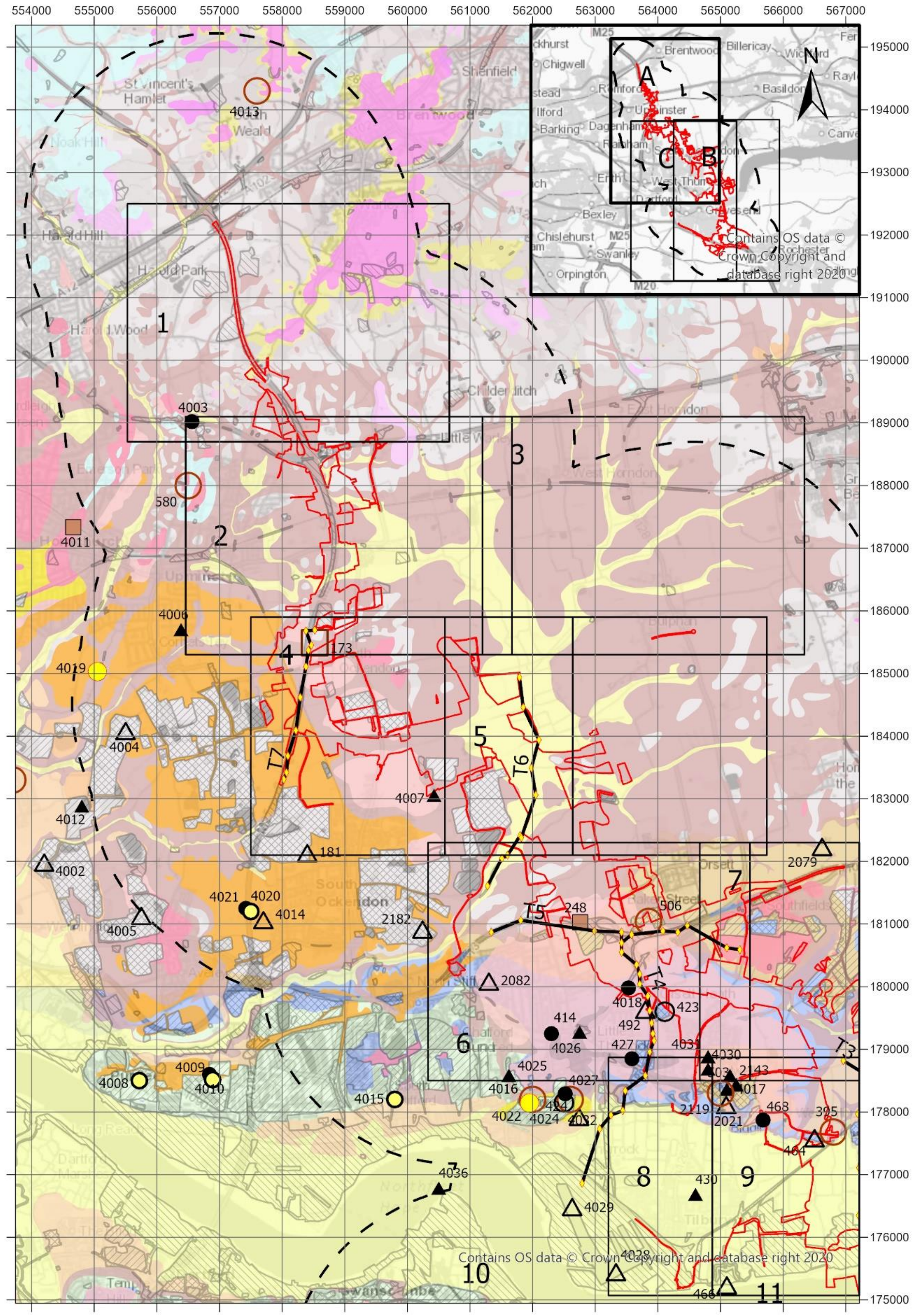


Figure 3. Lower Thames Crossing (north - Map A): statutory consultation footprint (January 2020) with 3km buffer, Quaternary transects and Palaeolithic sites [see **Figure 2** for geological key]. [Crown copyright OS mapping data reproduced under HE Licence 100030649; geological mapping reproduced under Licence 2017/004 British Geological Survey © NERC. All rights reserved]

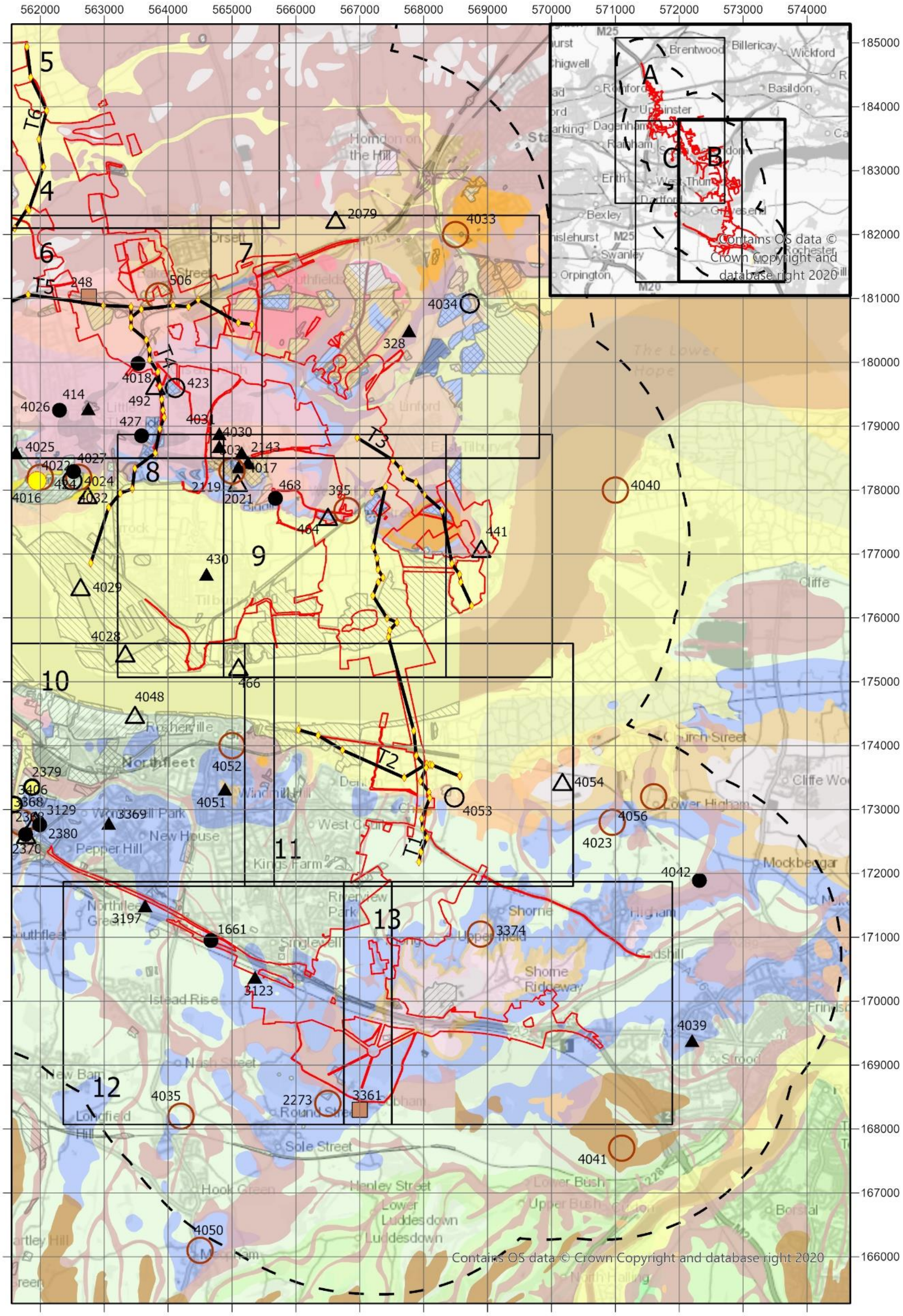


Figure 4. Lower Thames Crossing (southeast - Map B): statutory consultation footprint (January 2020) with 3km buffer, Quaternary transects and Palaeolithic sites. [see **Figure 2** for geological key]. [Crown copyright OS mapping data reproduced under HE Licence 100030649; geological mapping reproduced under Licence 2017/004 British Geological Survey © NERC. All rights reserved]

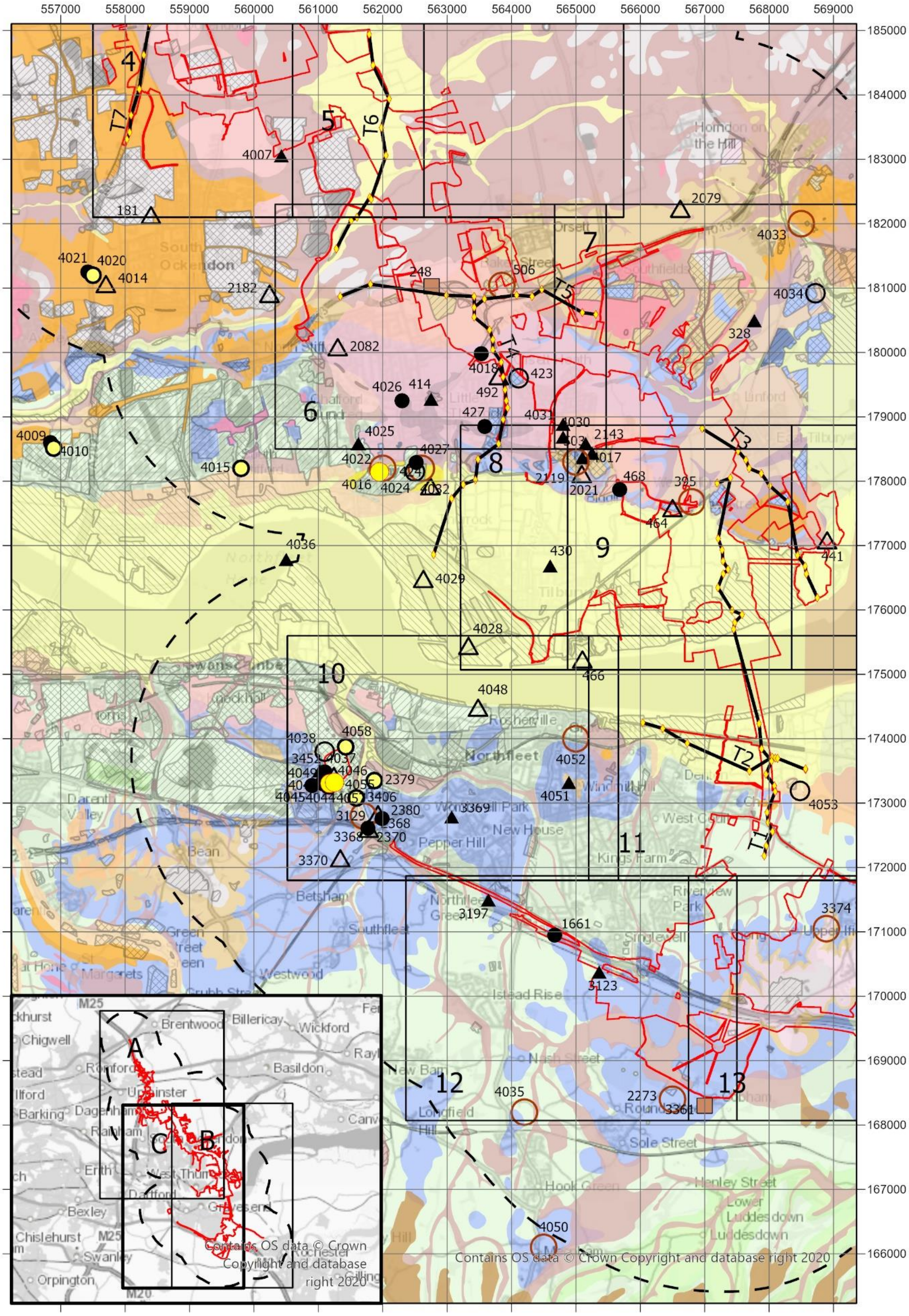


Figure 5. Lower Thames Crossing (southwest - Map C): statutory consultation footprint (January 2020) with 3km buffer, Quaternary transects and Palaeolithic sites. [see **Figure 2** for geological key]. [Crown copyright OS mapping data reproduced under HE Licence 100030649; geological mapping reproduced under Licence 2017/004 British Geological Survey © NERC. All rights reserved]

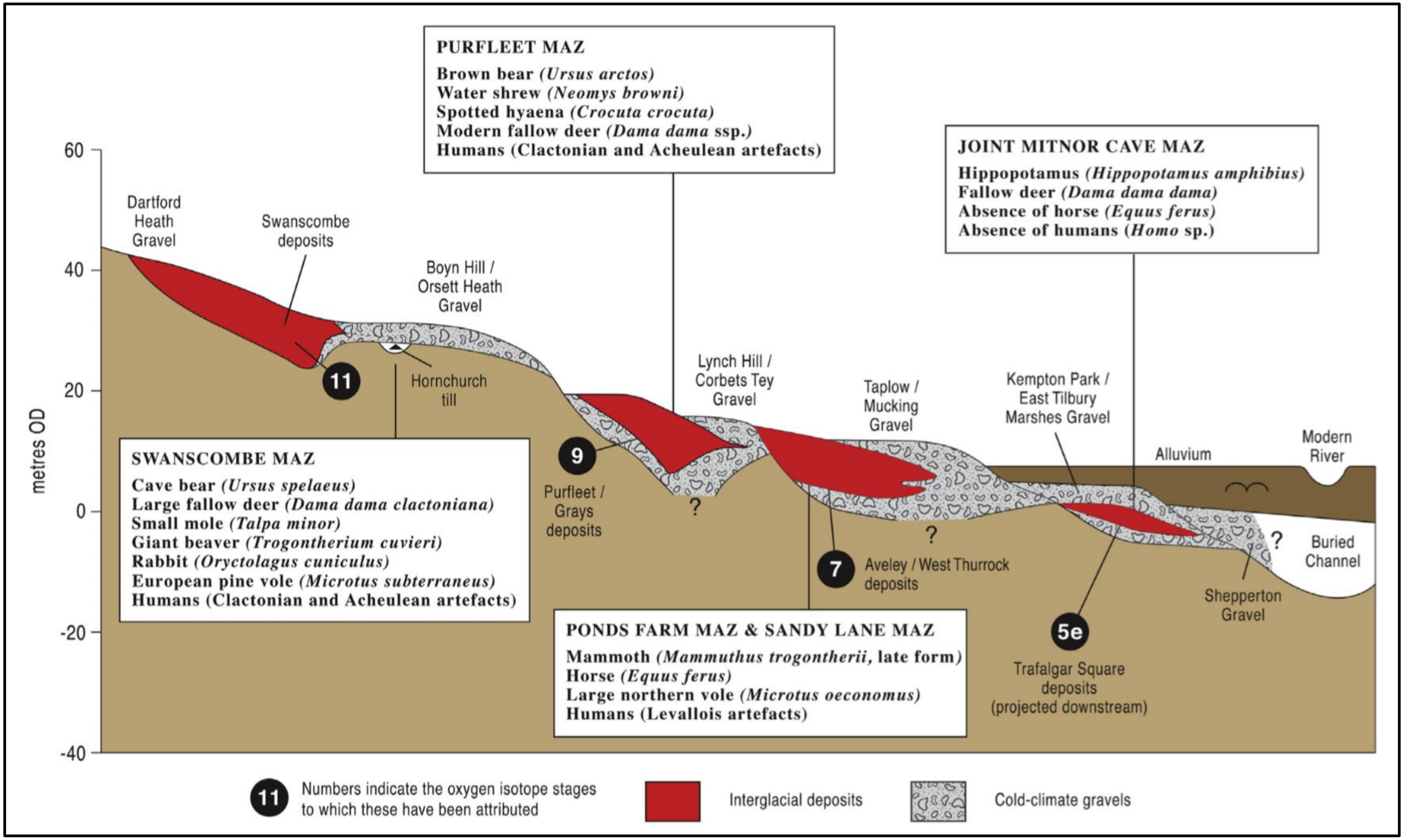


Figure 6. Idealized transverse section through the Thames terrace staircase with features of the Mammalian Assemblage-Zones (MAZ). Correlation with the marine oxygen isotope record indicated (from White *et al.*, 2018).

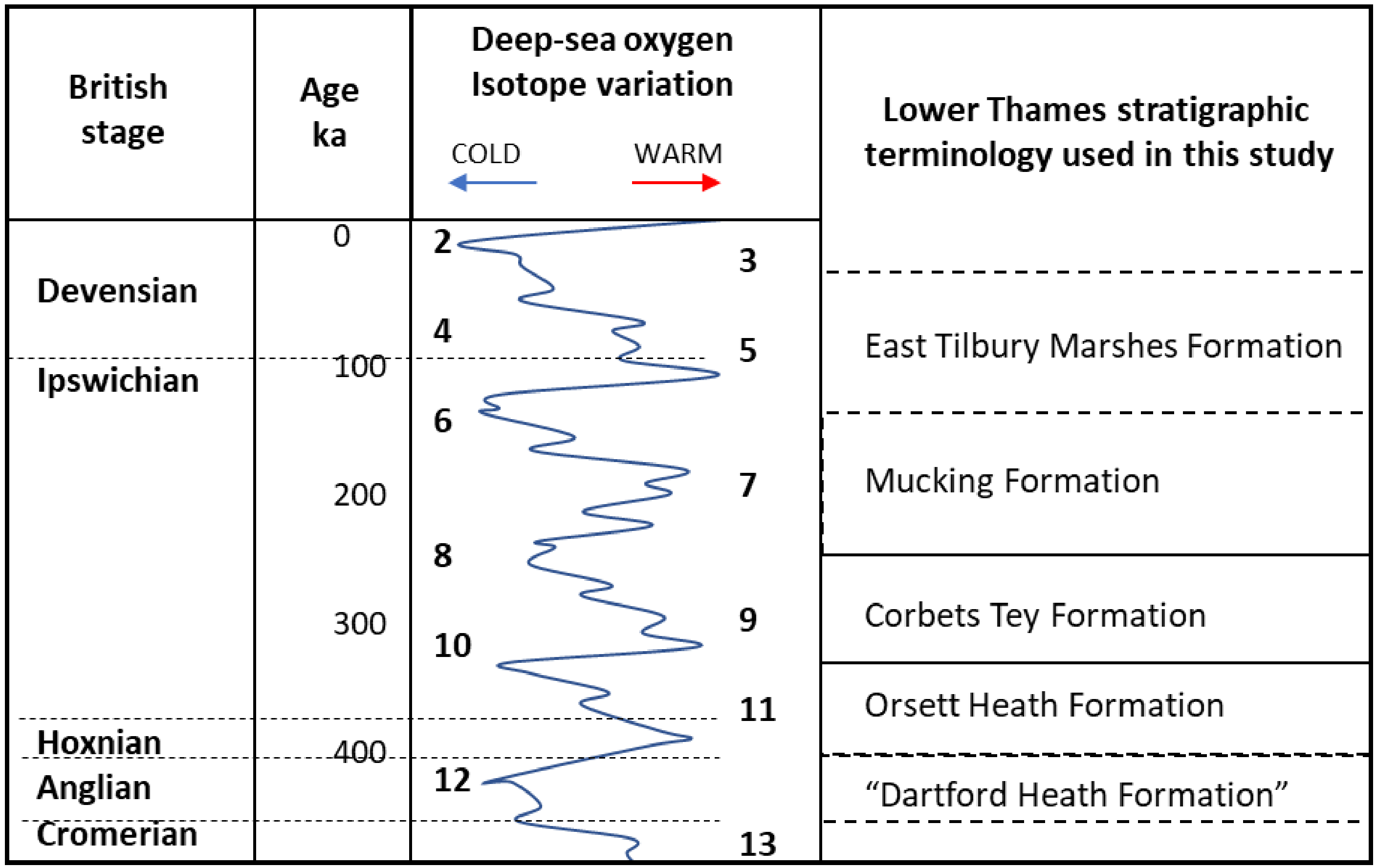


Figure 7. British Stage names, ages and marine isotope stages for the key stratigraphic units recognised in the Lower Thames Valley.

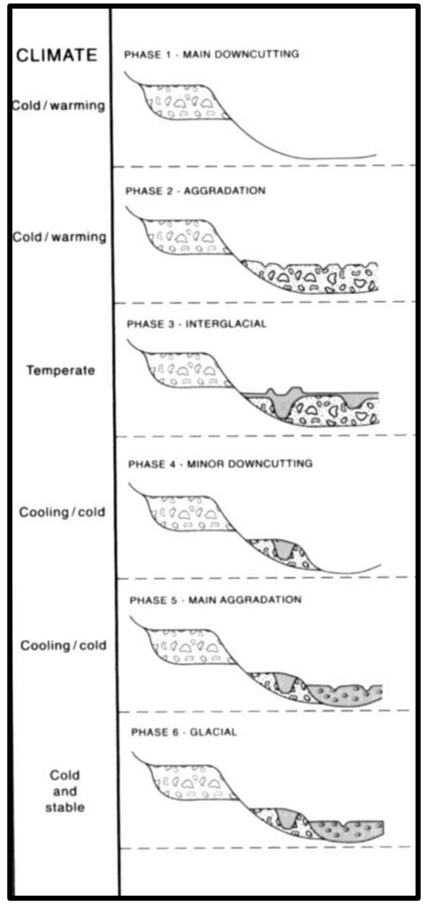


Figure 8. Formation of river terraces in synchrony with Quaternary climate change based on evidence from the Lower Thames (Bridgland, 2006).

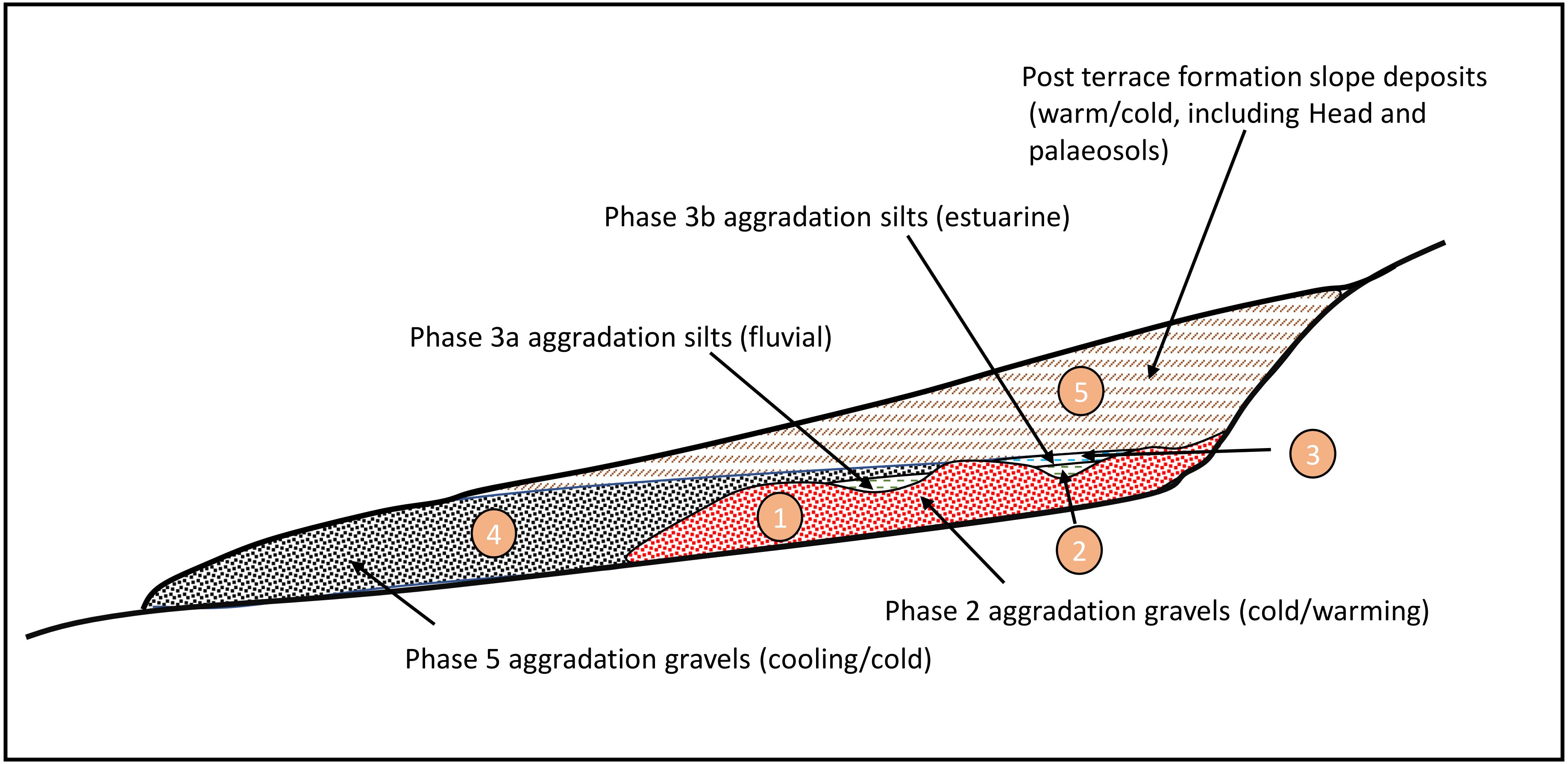


Figure 9. Idealised Lower Thames terrace sequence (based on Bridgland 2006, Figure 3b).

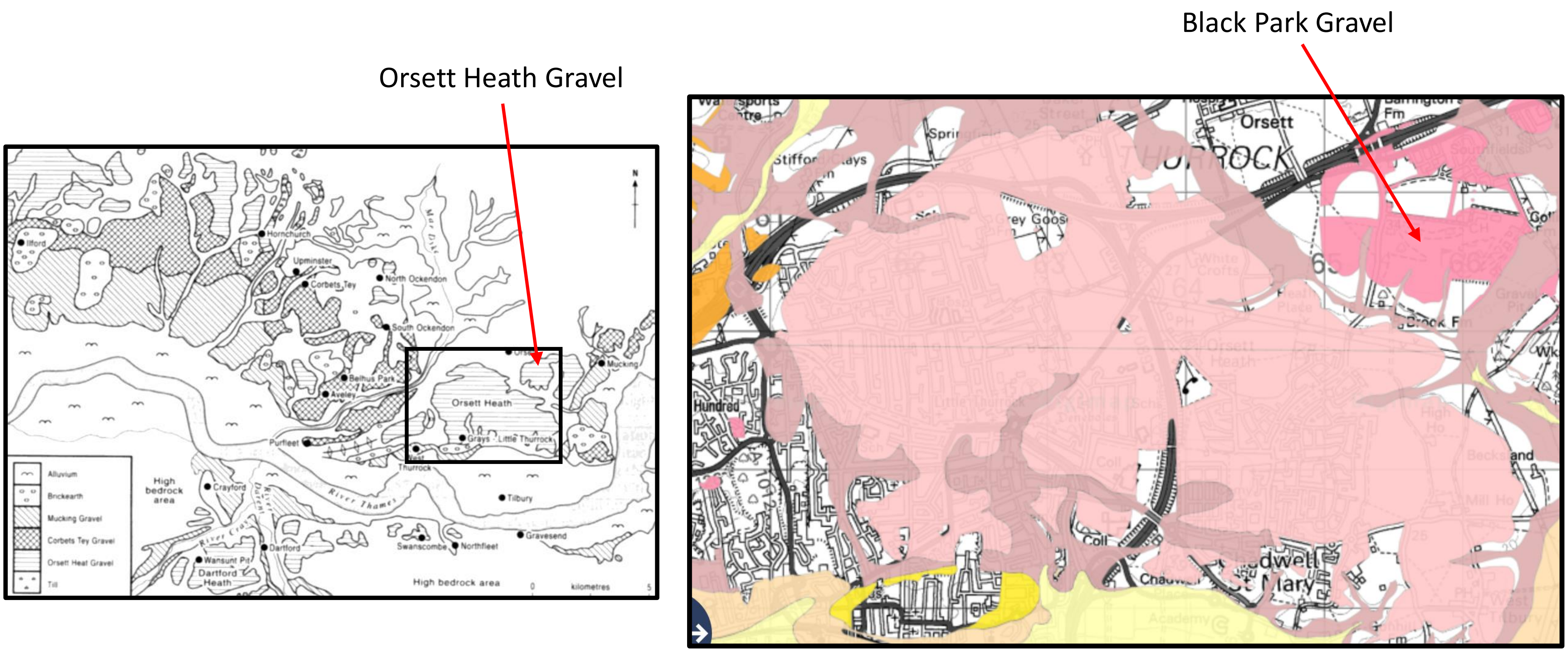


Figure 10. The Lower Thames terrace mapping sequence, differing interpretation of the same body of sediment: A) from Bridgland 2006; B) inset from British Geological Survey mapping (2020, Digimap).

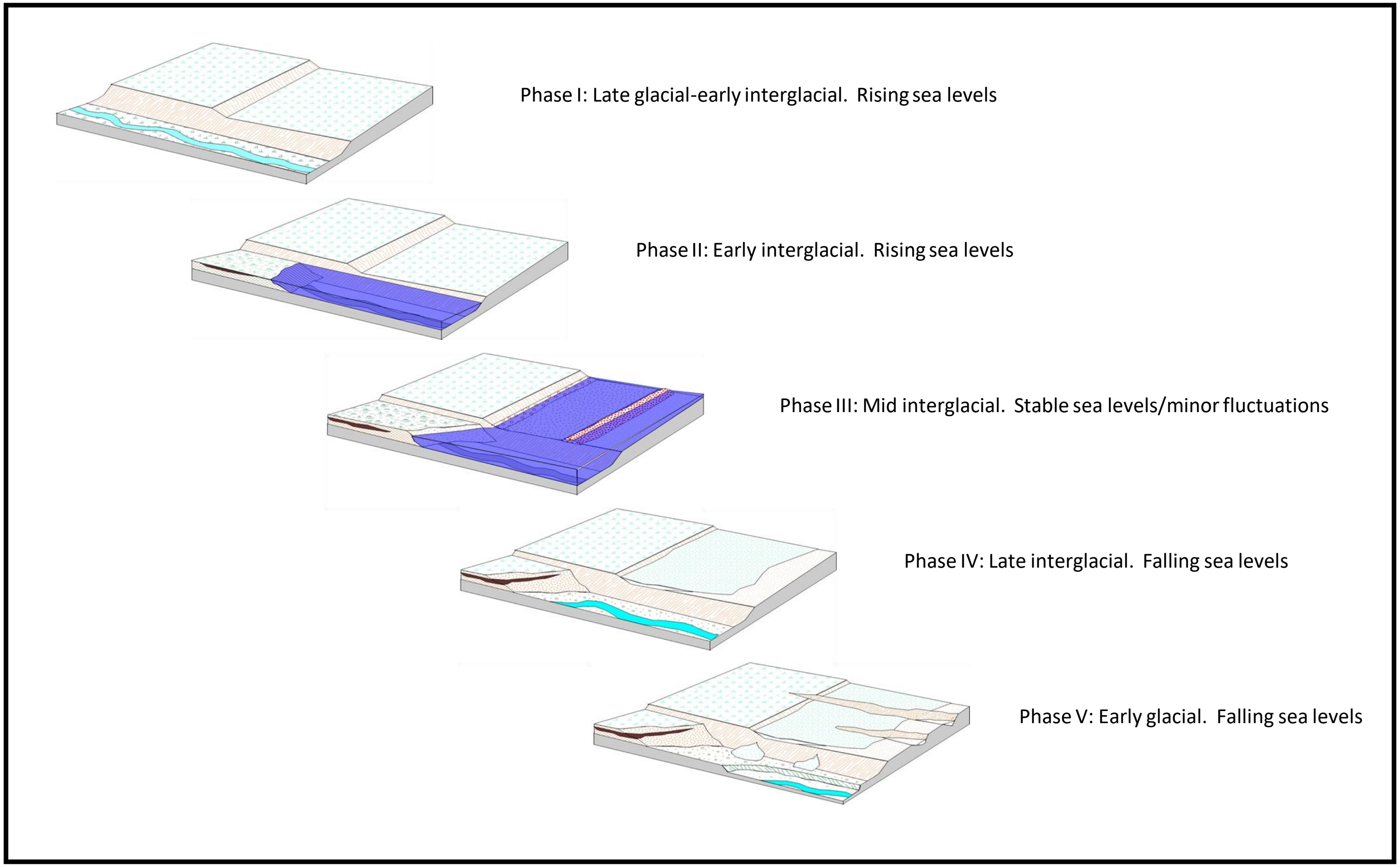


Figure 11. A theoretical model for the evolution of the estuarine part of the Lower Thames estuary.

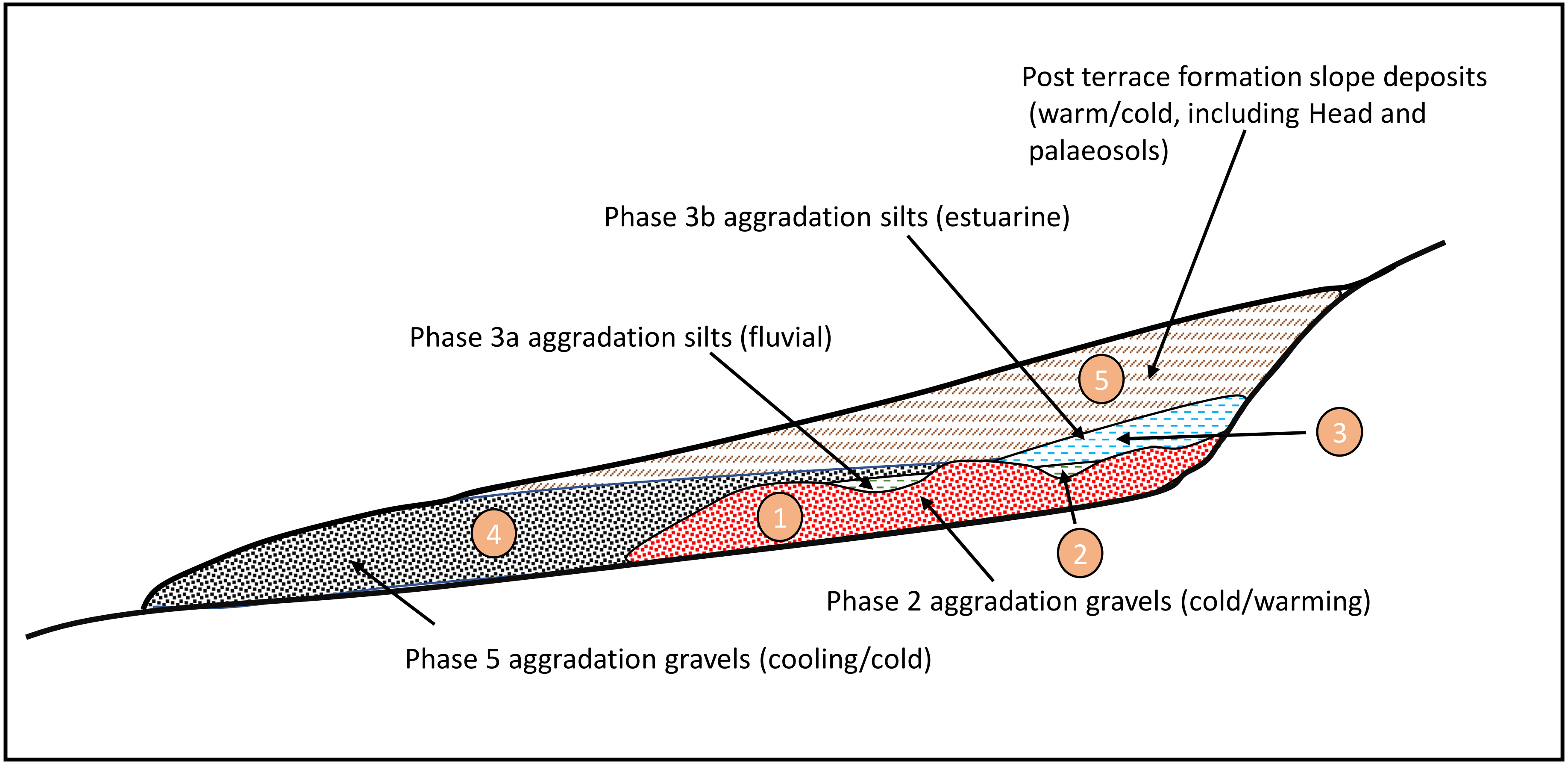


Figure 12. Idealised Lower Thames terrace sequence (based on Bridgland 2006, Figure 3b) modified in consideration of the estuarine elements of the system.

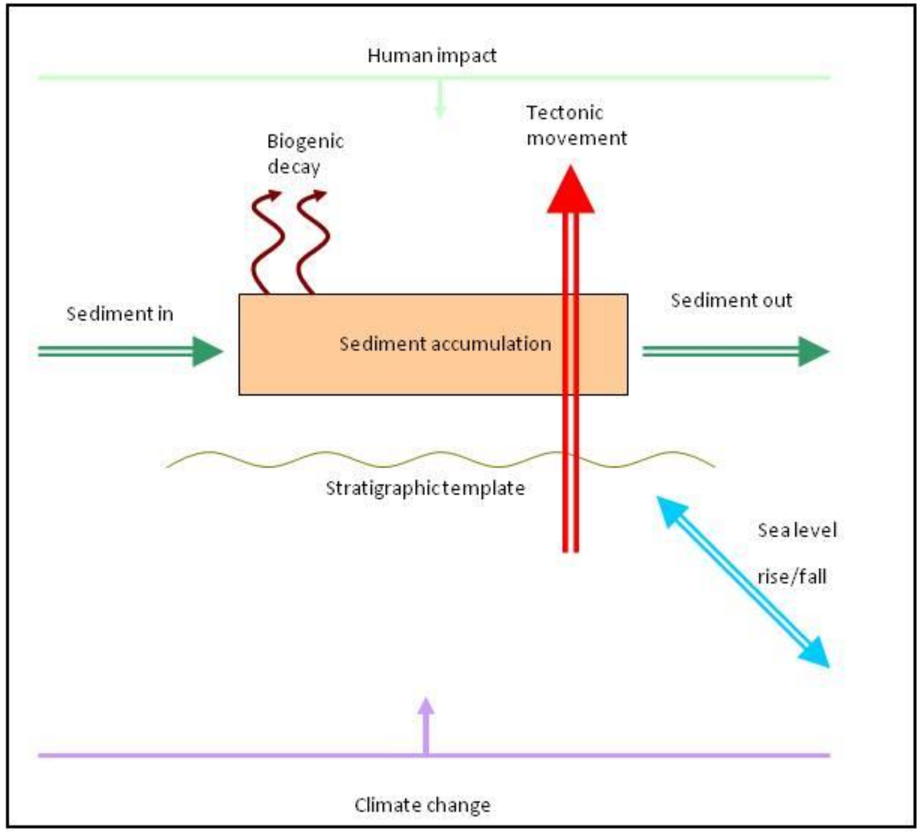


Figure 13. Schematic to show major factors controlling sediment accumulation patterns in a depositional basin (from Bates and Stafford, 2013)

Figure 14. Fluvial deposits: A) coarse-grained fluvial sediments at Southfleet Road, Swanscombe probably deposited in high energy periglacial fluvial systems; B) high-energy gravels from the Taplow Gravel at Liverpool Street Station, London.

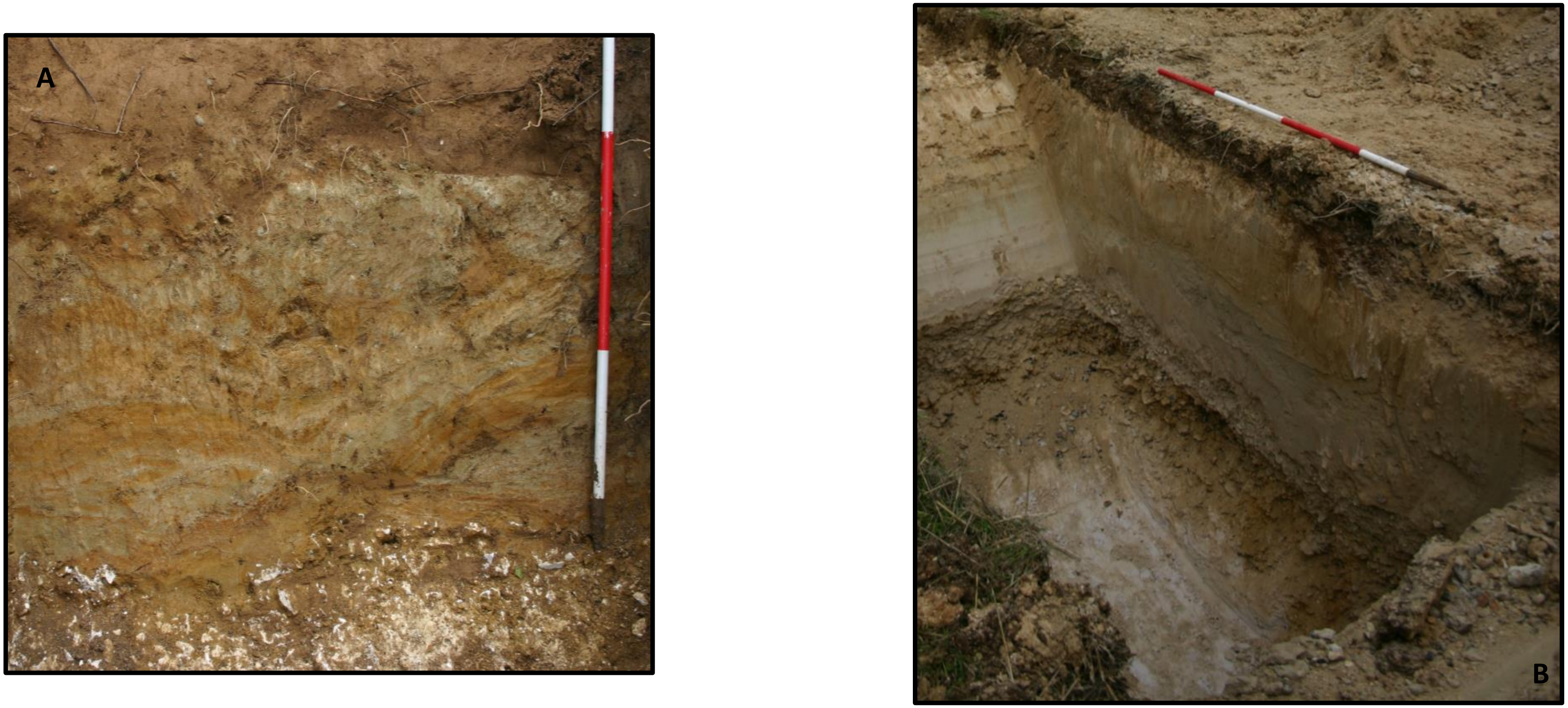
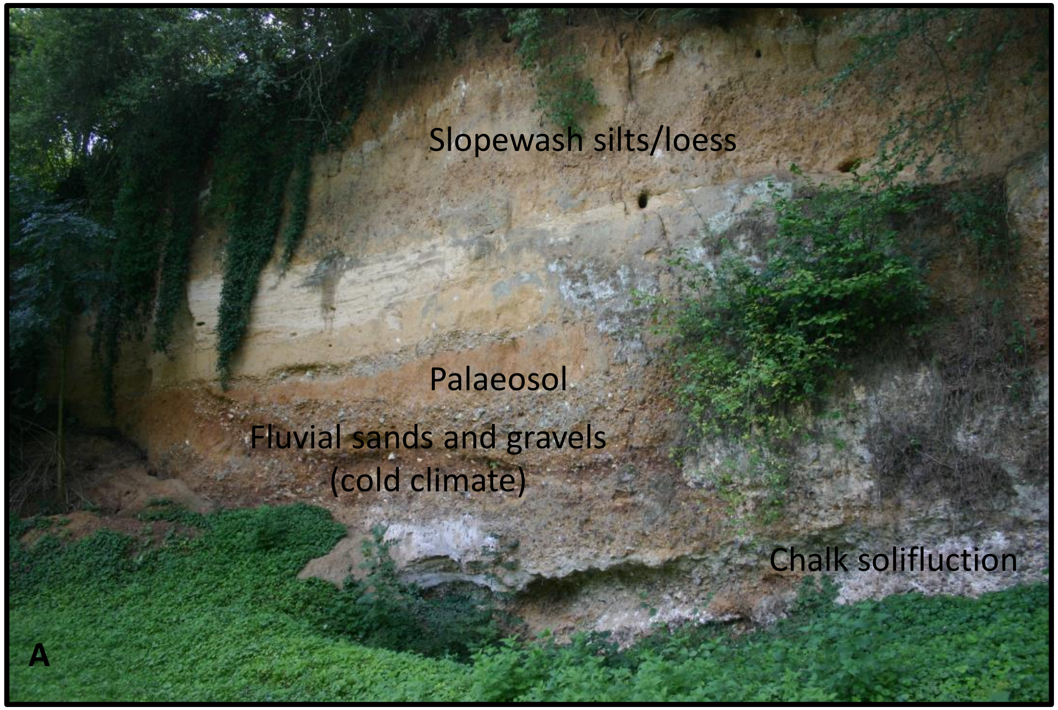


Figure 15. Fluvial deposits: A) Fine grained interglacial fluvial sands and silt at Chislet Farm, Kent (Stour system); B) High energy gravels overlain by fine grained interglacial fluvial sands at Harnham, Salisbury.

Figure 16. Belhus Park cutting: **A:** Clayey/silty organic-rich channel-fill above Corbets Tey Gravel, dipping north. **B:** Belhus Cutting organic-rich channel-fill below fluvial sand/gravel deposits. **C:** fluvial sand/gravel beds in bottom part of Belhus Cutting organic-rich channel.

Figure 17. Intertidal zone deposits: A) aminated intertidal sands and silts at Happisburgh in the estuary of the pre-diversion Thames; B) laminated intertidal sands and silts at Pear Tree Knap, West Sussex.

Figure 18. Slopewash deposits: A) slopewash sands and gravels probably deposited under periglacial conditions at Dartford (M25/A2 junction, Link C, TP 8800); B) slopewash sands (derived from Thanet Sand) overlying cold stage fluvial gravels at Northfleet Waste-water Treatment Works.



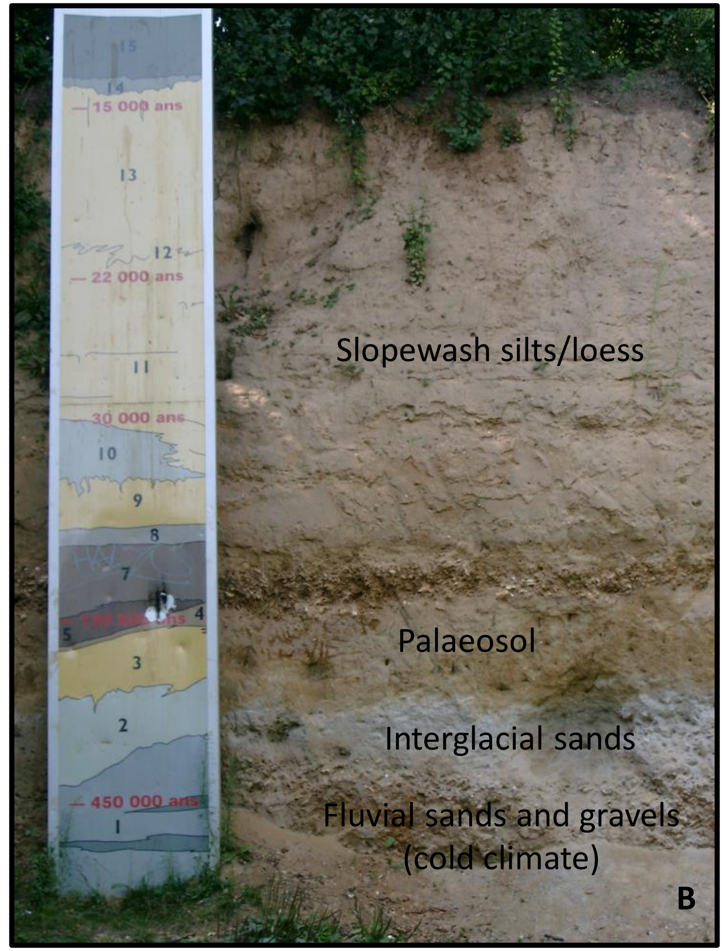


Figure 19. Deposit sequence complexity: A) Full sequence through a Middle Pleistocene terrace at Cagny-la-Garenne, Somme; B) Detail of fluvial and slopewash sediments at St.Acheul, Somme.

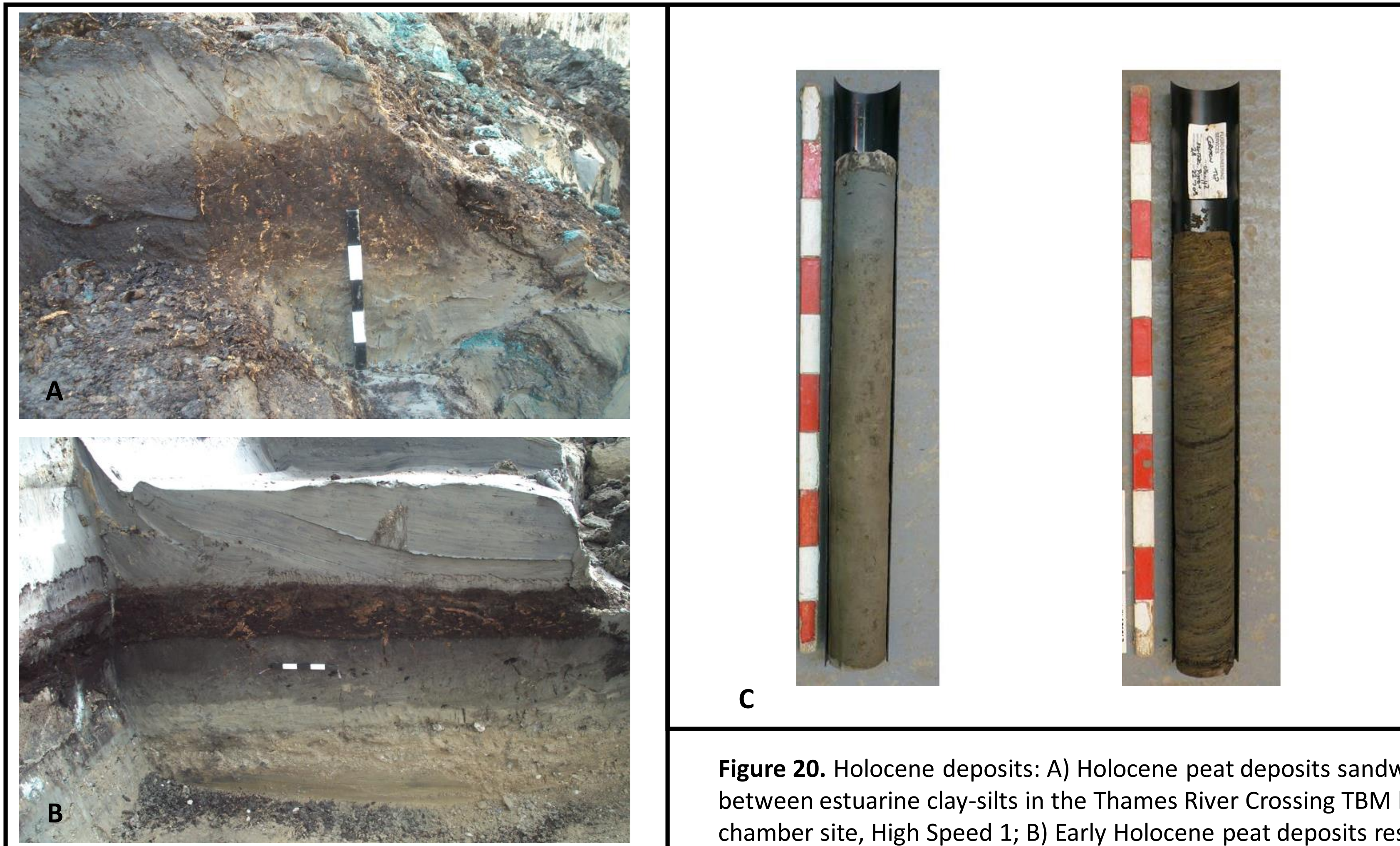


Figure 20. Holocene deposits: A) Holocene peat deposits sandwiched between estuarine clay-silts in the Thames River Crossing TBM launch chamber site, High Speed 1; B) Early Holocene peat deposits resting on top of the late Pleistocene/early Holocene fluvial sediments at the Thames River Crossing TBM launch chamber site, High Speed 1; C) two examples of Holocene minerogenic sediments from the Shellhaven site, Essex.

SH: Shepperton Gravel
ETMG: East Tilbury Marshes Gravel
MG: Mucking Gravel
LHG: Lynch Hill Gravel
OH: Orsett Heath Gravel
BP: Black Park Gravel

Figure 21. Lithological key. Transects 1-7.

Transect 1 South

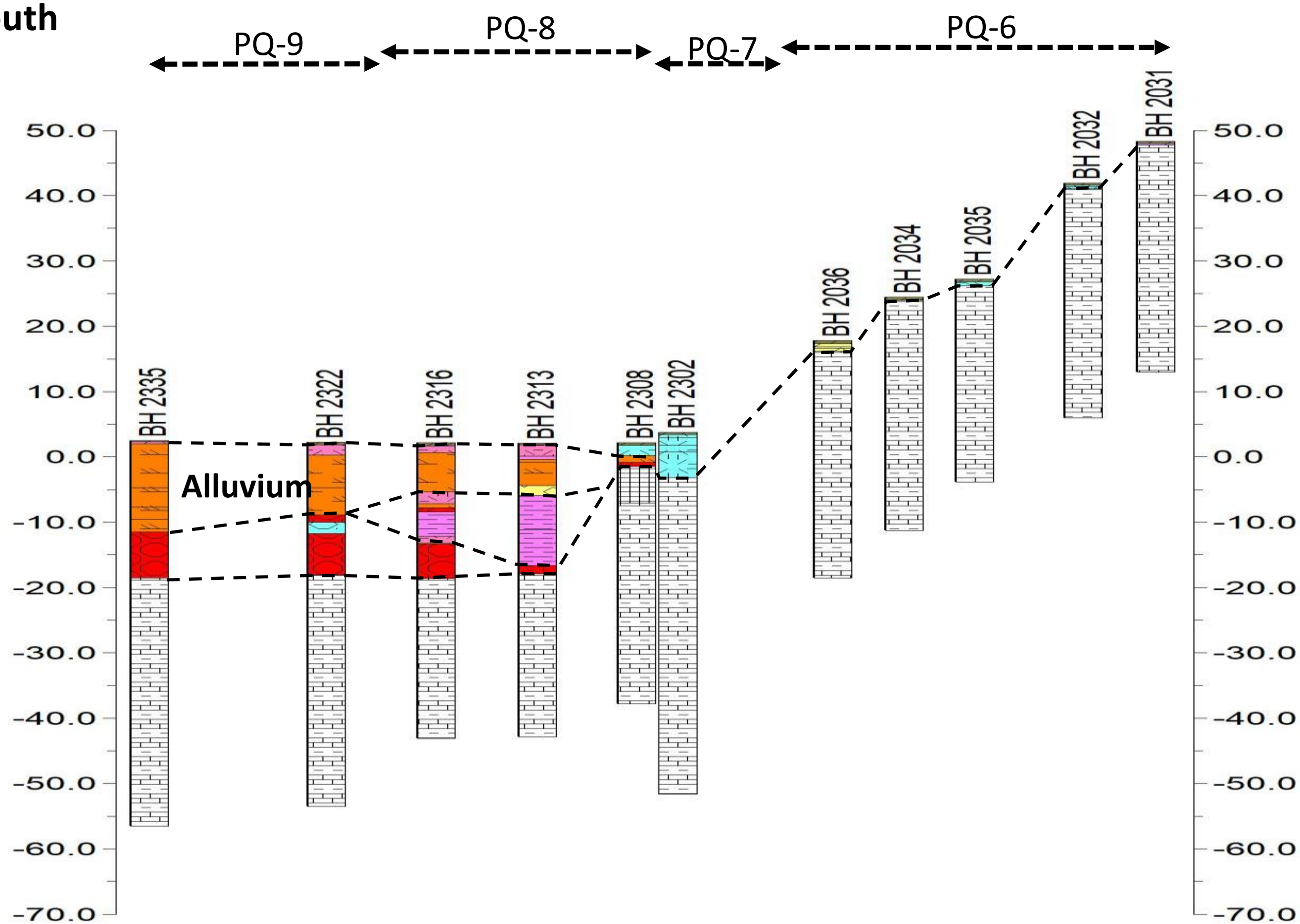


Figure 22. Transect 1, south.

Transect 1 North

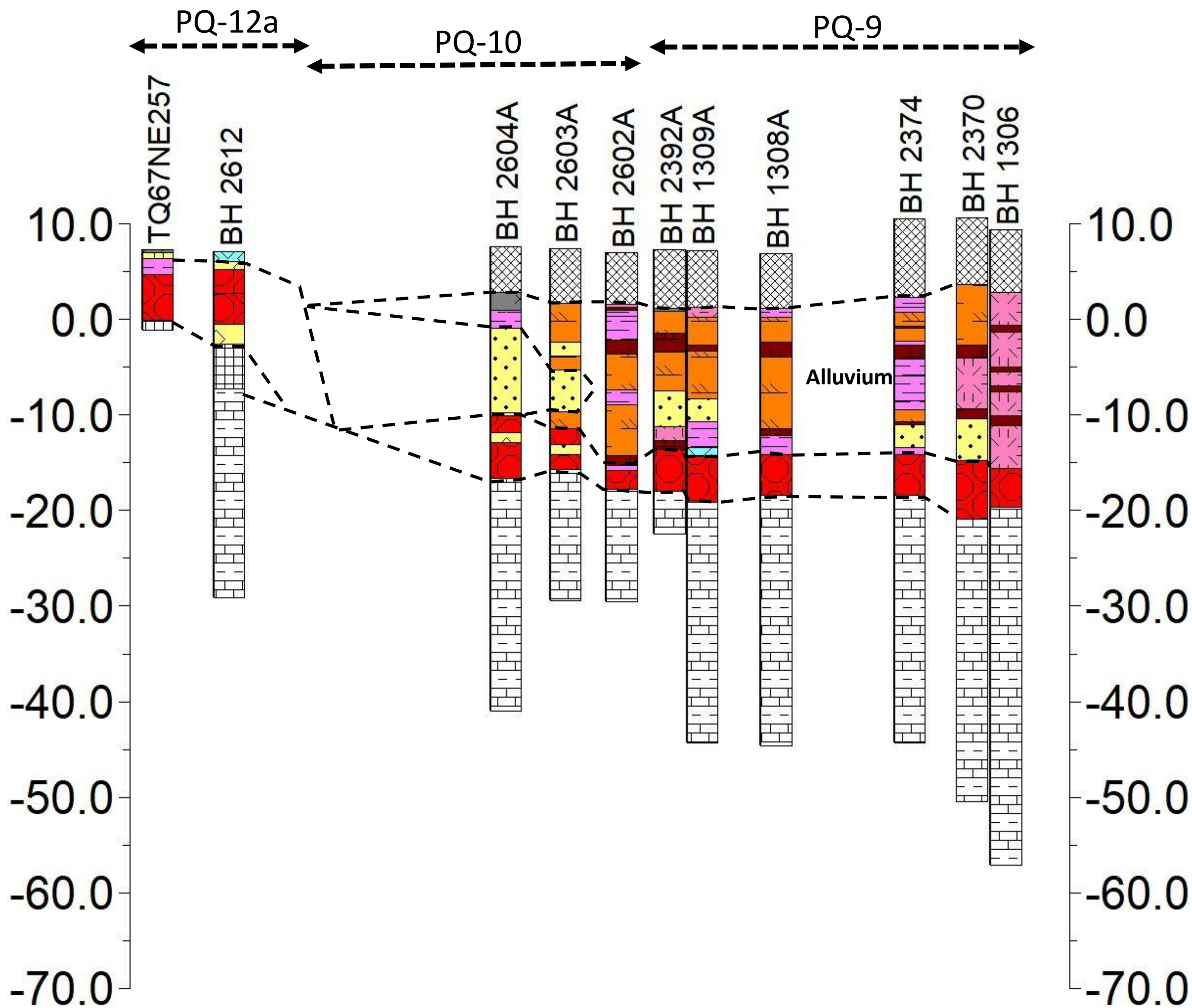


Figure 23. Transect 1, north.

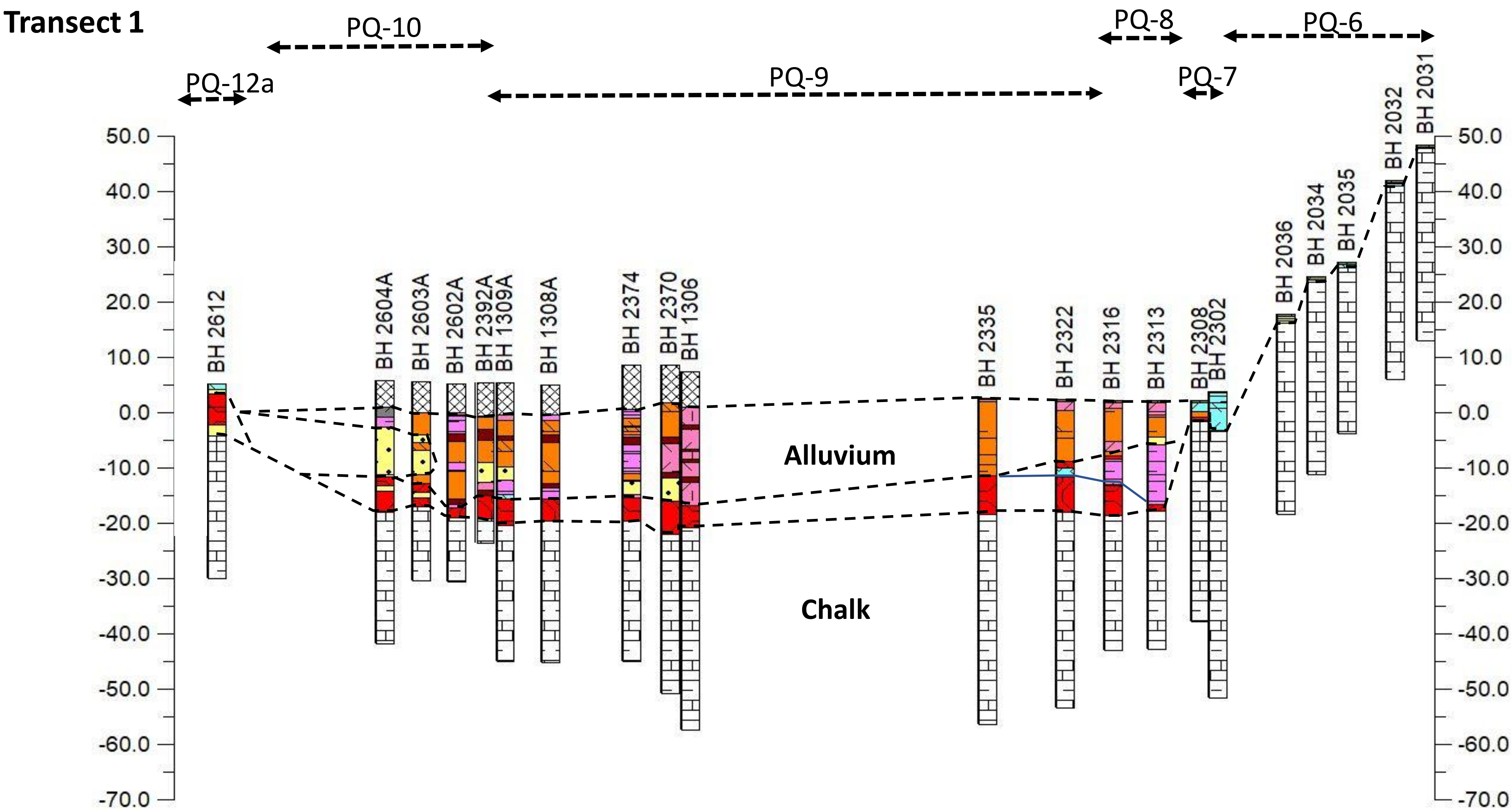


Figure 24. Transect 1.

Transect 2

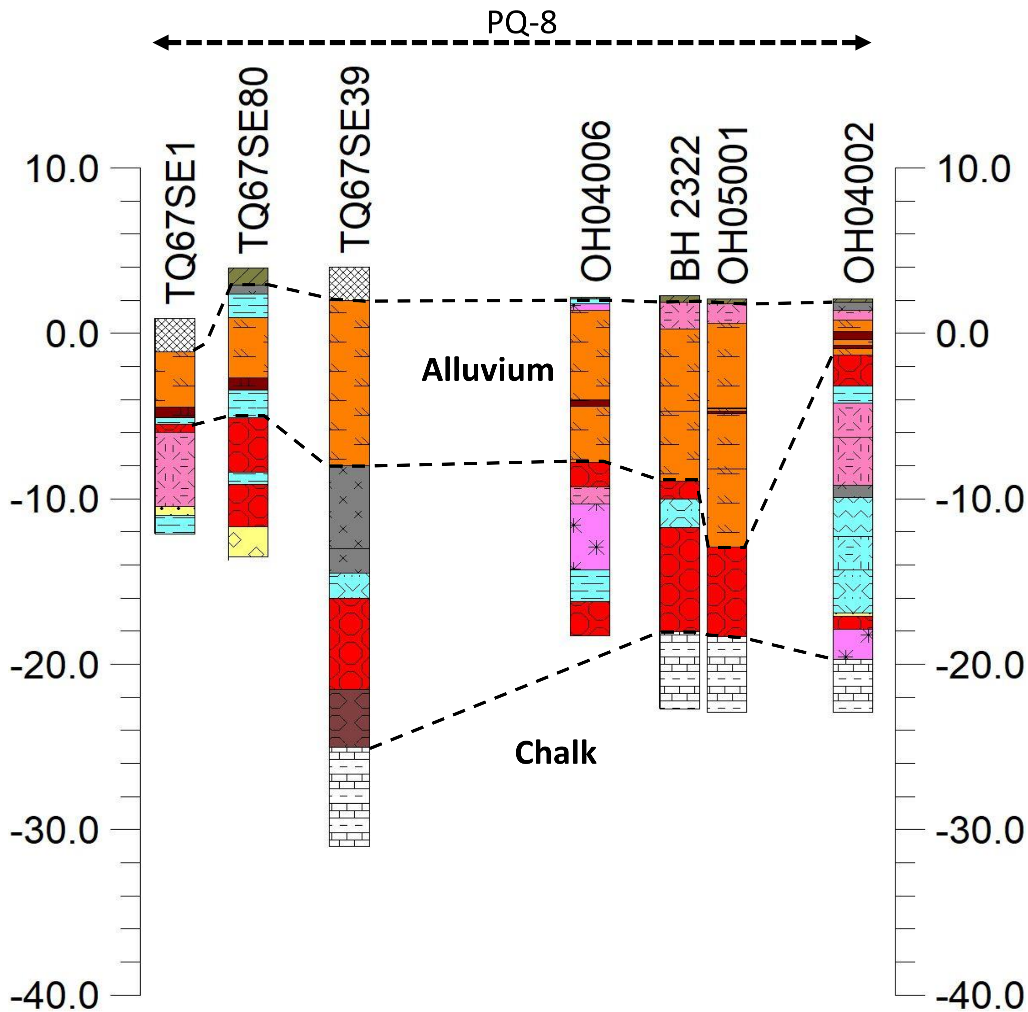


Figure 25. Transect 2.

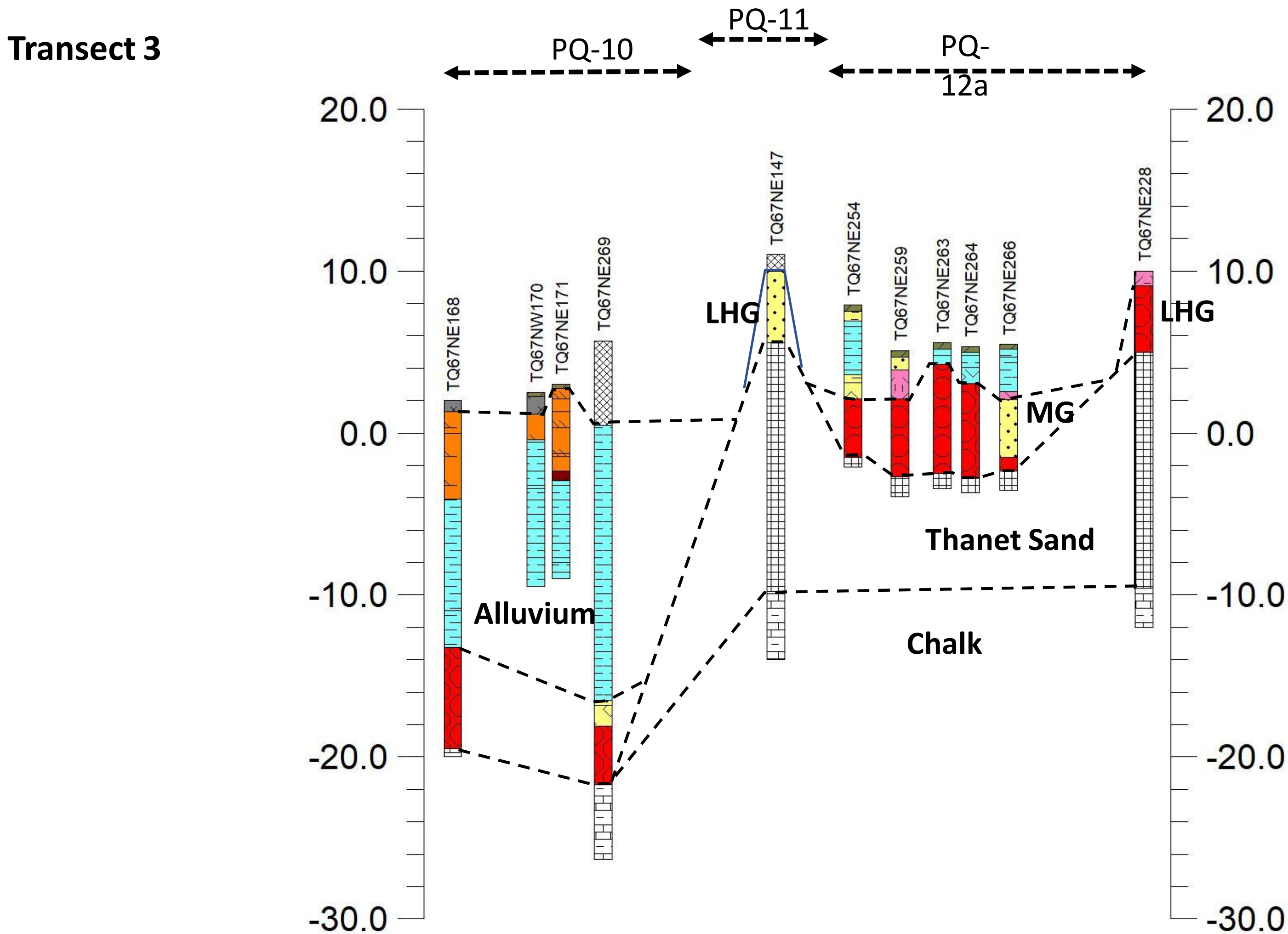


Figure 26. Transect 3.

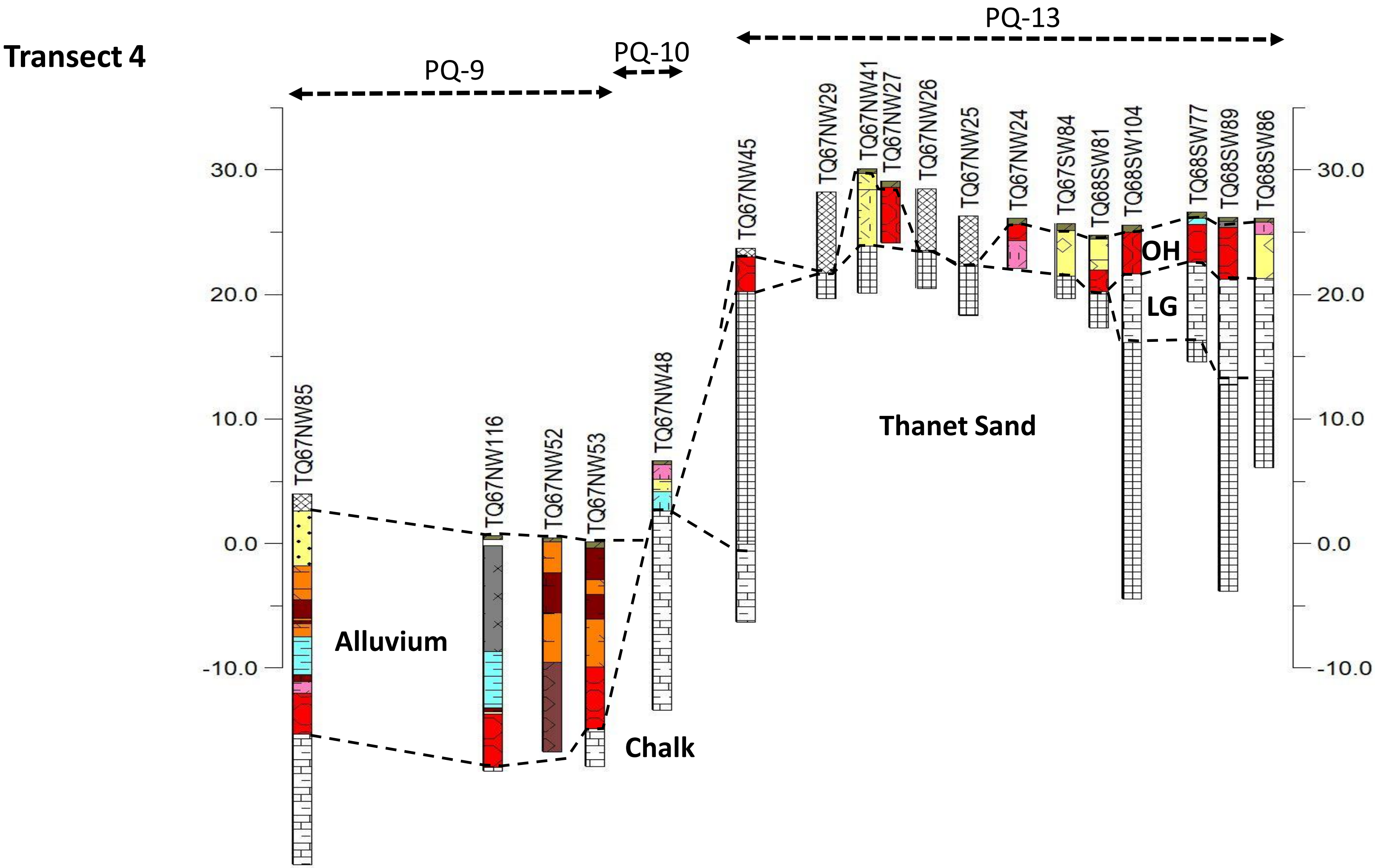


Figure 27. Transect 4.

Transect 5

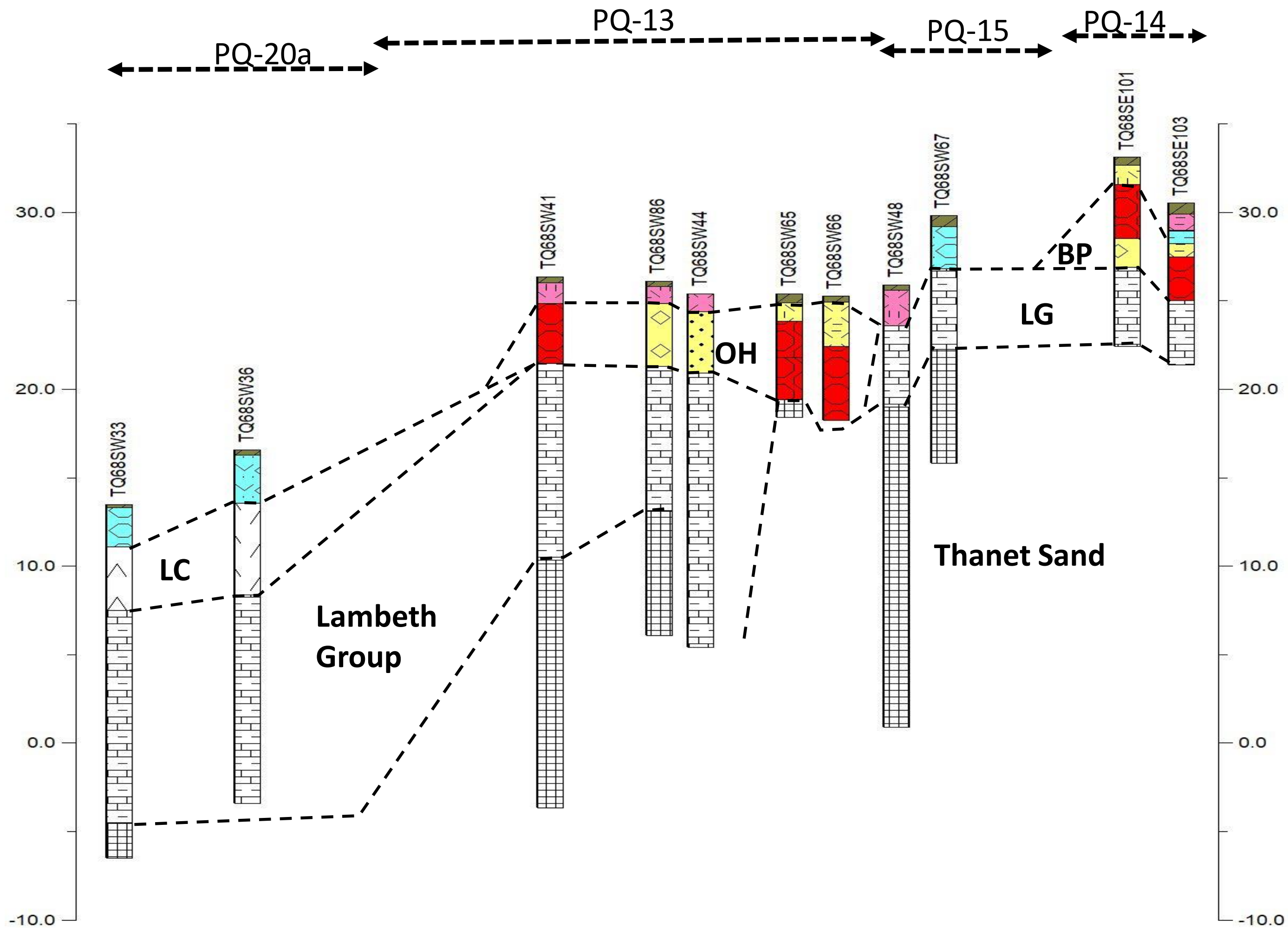


Figure 28. Transect 5.

Transect 6

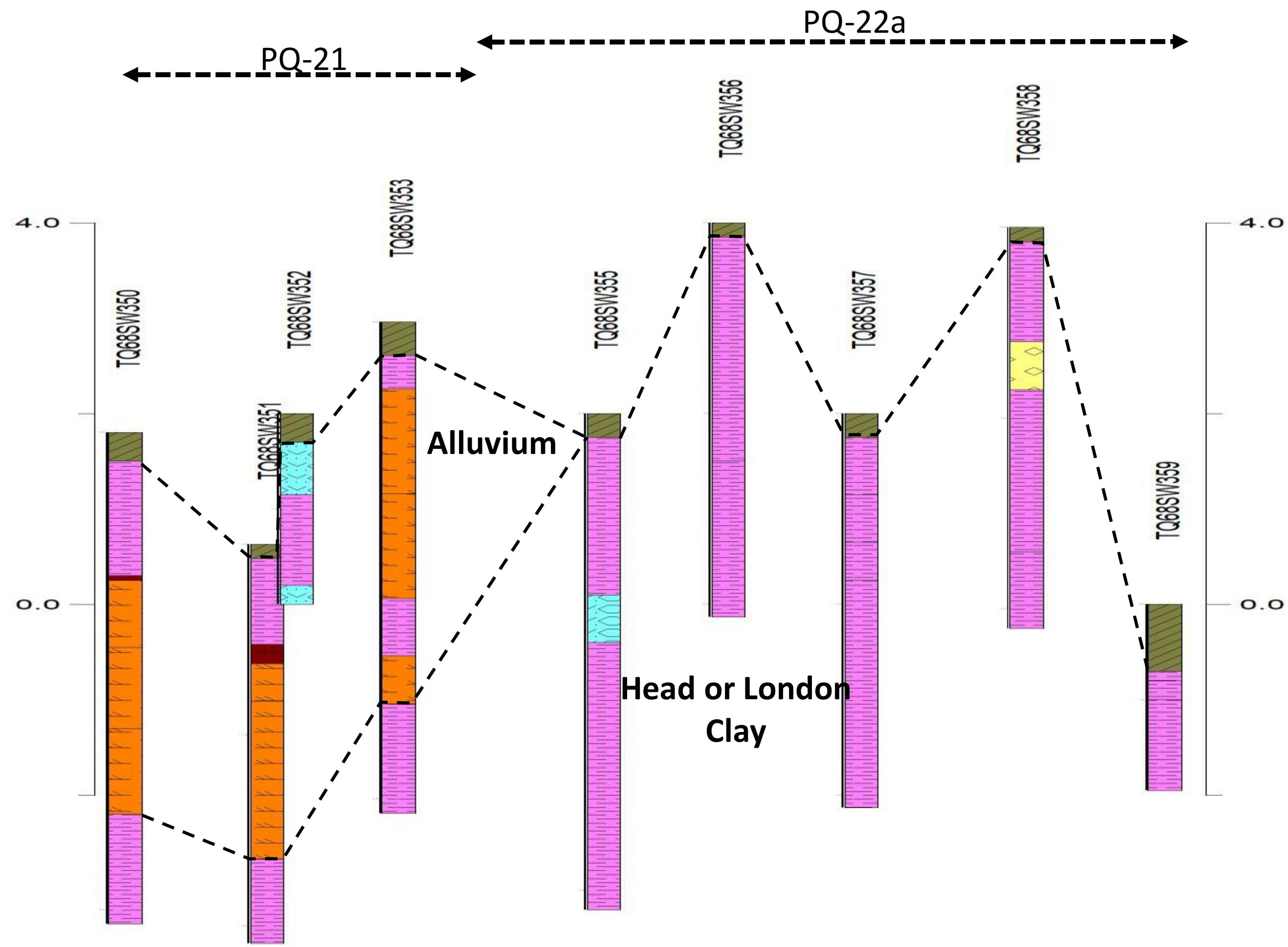


Figure 29. Transect 6.

Transect 7

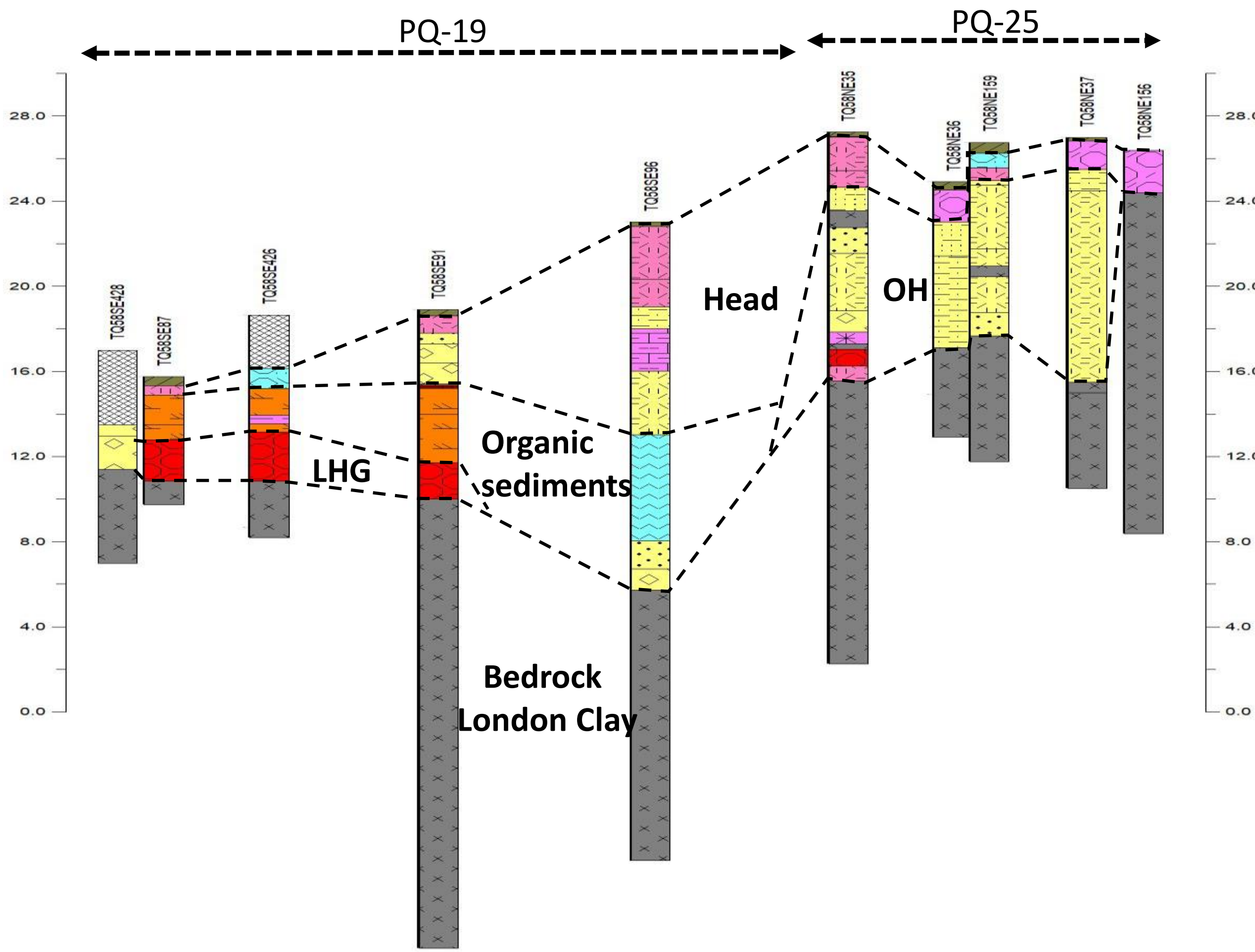


Figure 30. Transect 7.

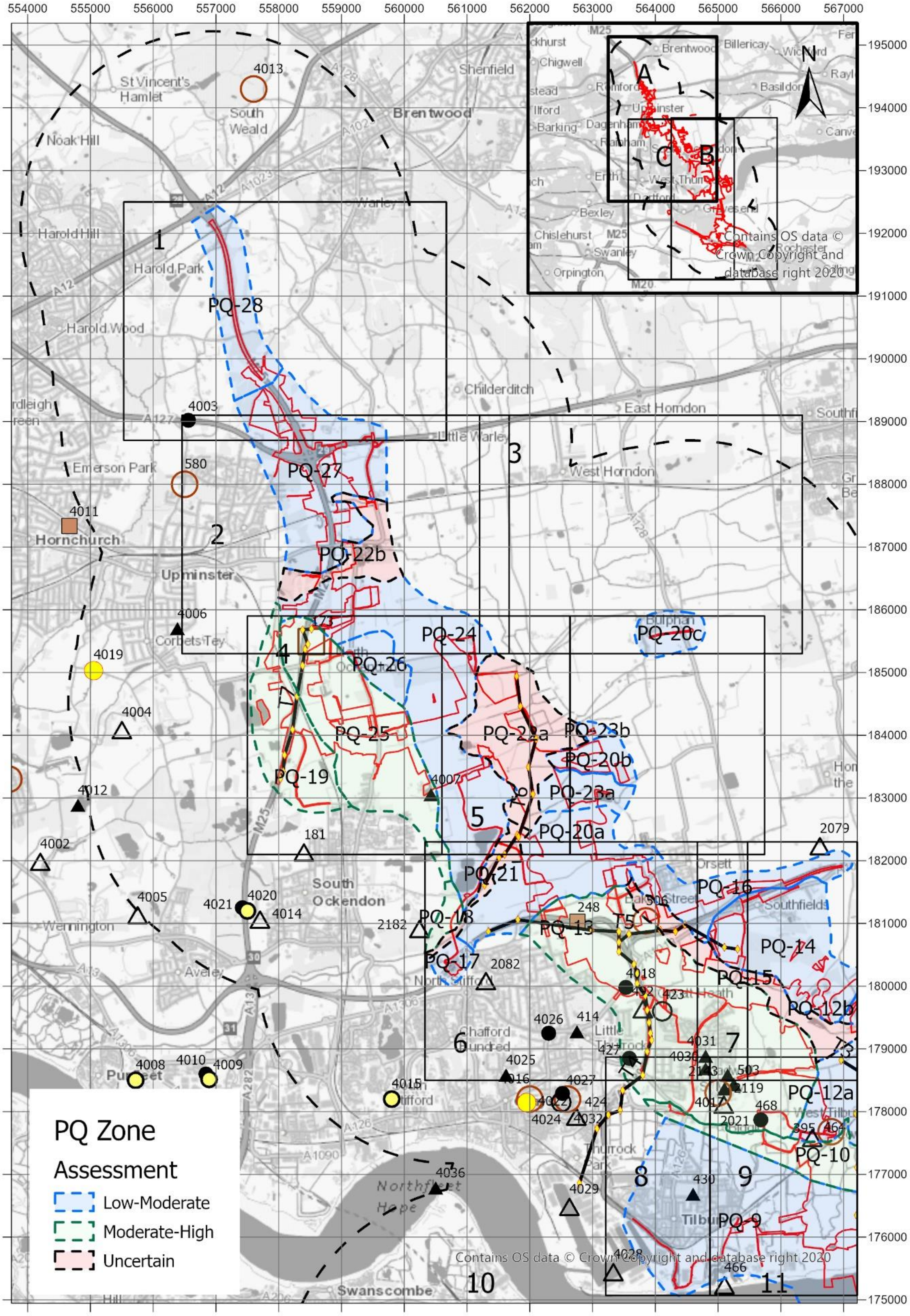


Figure 31. PQ zones overview (north), Map A.. [Crown copyright OS mapping data reproduced under HE Licence 100030649]

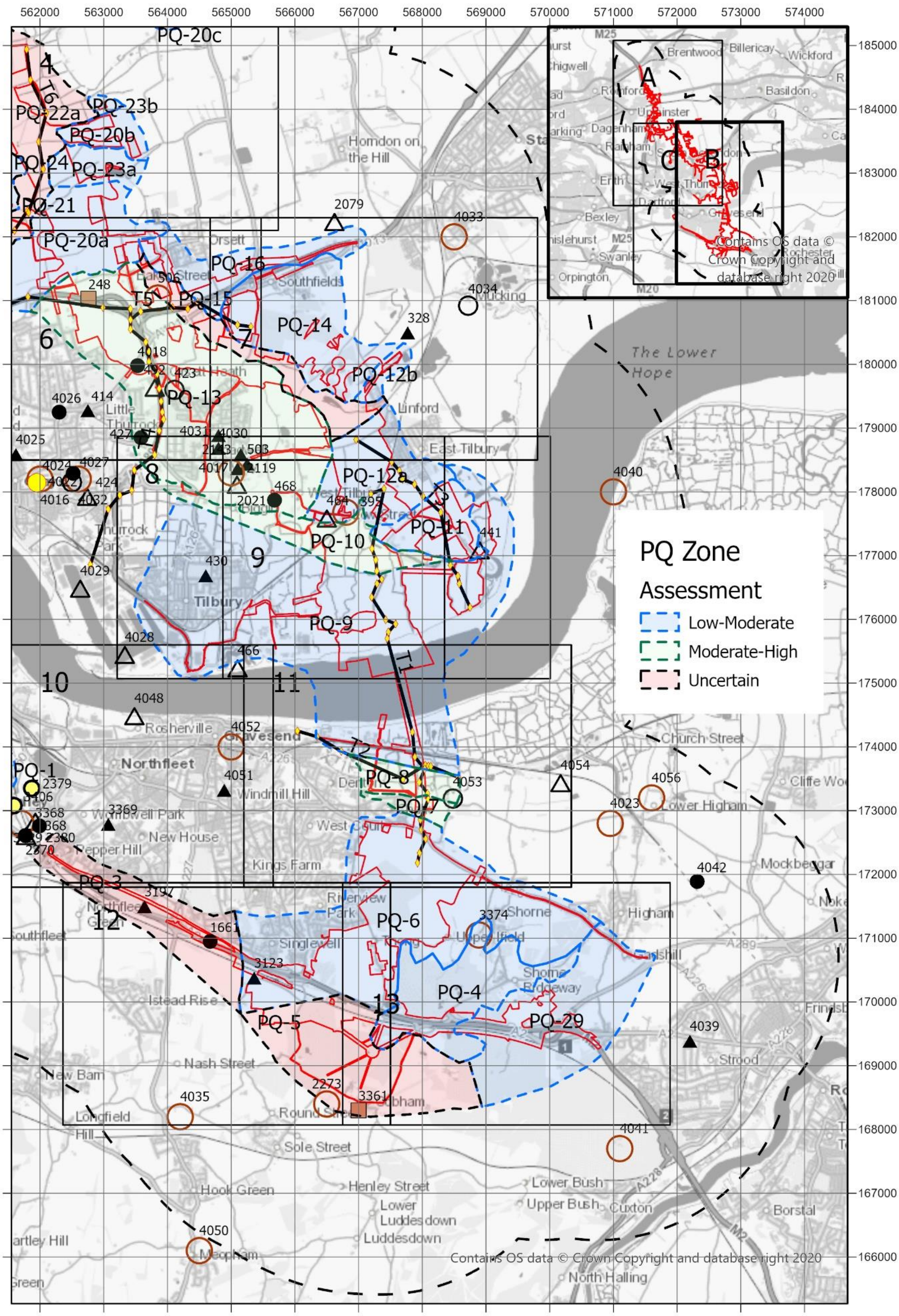


Figure 32. PQ zones overview (southeast), Map B. [Crown copyright OS mapping data reproduced under HE Licence 100030649]

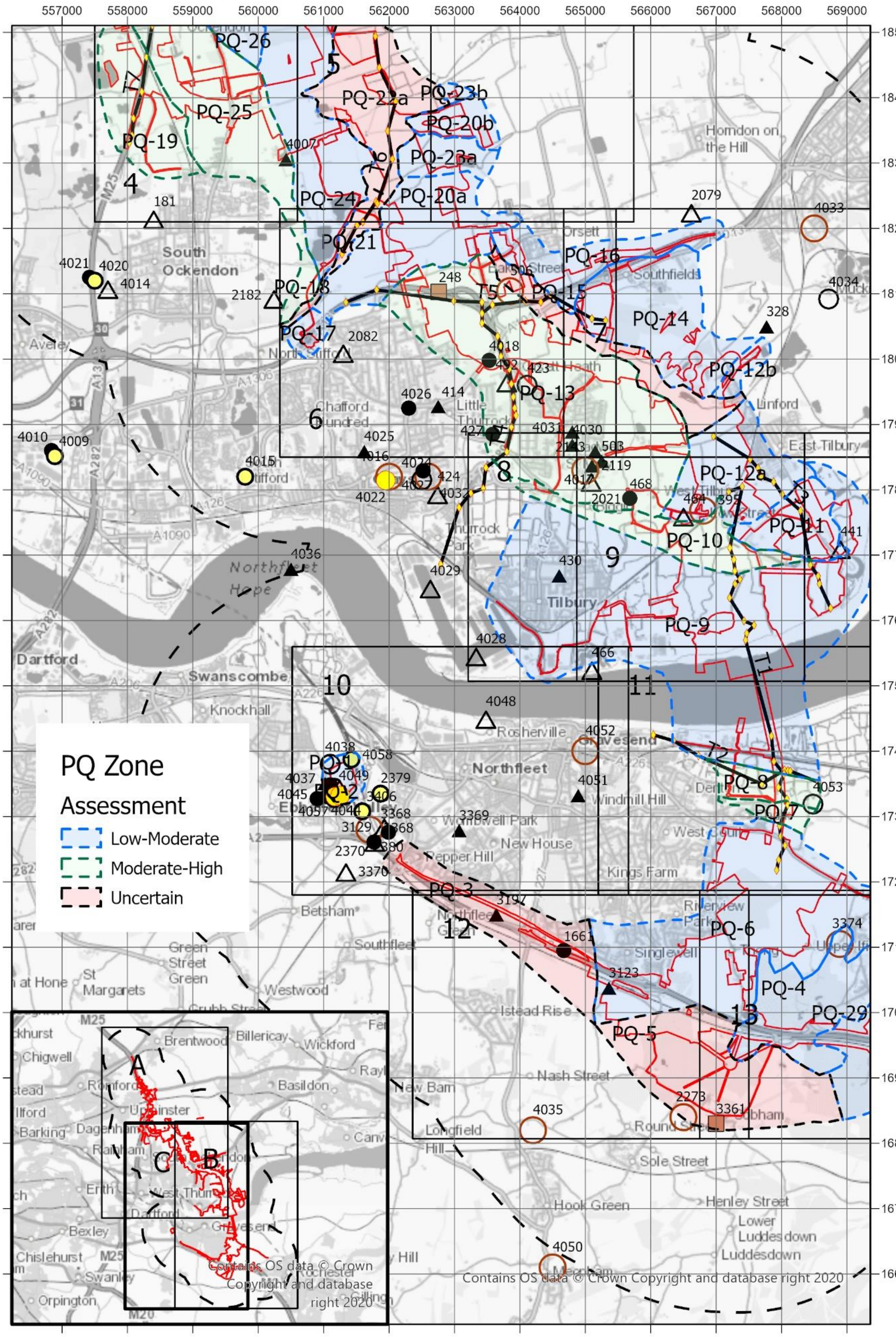


Figure 33. PQ zones overview (southwest), Map C. [Crown copyright OS mapping data reproduced under HE Licence 100030649]

Legend

Palaeolithic Sites

Rec-Type,Acc

- ▲ F-Spot,A
- △ F-Spot,E
- ○ F-Spot,G
- ■ Geo,A
- □ Geo,E
- ● Mon,A
- ○ Mon,E
- ○ Mon/PE,A
- ● PEFS,A

Borehole Locations

Borehole Transect

Archaeological Assessment

- Low-Moderate
- Moderate-High
- Uncertain

Footprint

- 3km Buffer
- Statutory Consultation Footprint

Artificial

LEX_RCS_I

- LSGR-ARTGR
- MGR-ARTDP
- WGR-VOID
- WMGR-ARTDP

Superficial

LEX_RCS_I

ALV-XCZSP	ALLUVIUM - CLAY, SILT, SAND AND PEAT
ALV-XCZSV	ALLUVIUM - CLAY, SILT, SAND AND GRAVEL
T1T2-XSV	RIVER TERRACE DEPOSITS, 1 TO 2 - SAND AND GRAVEL
TFD-XCZ	TIDAL FLAT DEPOSITS - CLAY AND SILT
TFD-XSZ	TIDAL FLAT DEPOSITS - SAND AND SILT
LHGR-XSV	LYNCH HILL GRAVEL MEMBER - SAND AND GRAVEL
TPGR-XSV	TAPLOW GRAVEL MEMBER - SAND AND GRAVEL
LOFT-DMTN	LOWESTOFT FORMATION - DIAMICTON
GFDMP-XSV	GLACIOFLUVIAL DEPOSITS, MID PLEISTOCENE - SAND AND GRAVEL
STGR-XSV	STANMORE GRAVEL FORMATION - SAND AND GRAVEL
BSA-S	BLOWN SAND - SAND
BTFU-SDSH	BEACH AND TIDAL FLAT DEPOSITS (UNDIFFERENTIATED) - SEDIMENT, SHELL (SHELLS)
BTFU-XCZS	BEACH AND TIDAL FLAT DEPOSITS (UNDIFFERENTIATED) - CLAY, SILT AND SAND
HEAD-XCZ	HEAD - CLAY AND SILT
HEAD-XCZSV	HEAD - CLAY, SILT, SAND AND GRAVEL
MBD-SDSH	MARINE BEACH DEPOSITS - SEDIMENT, SHELL (SHELLS)
RTD1-XCZ	RIVER TERRACE DEPOSITS, 1 - CLAY AND SILT
RTD1-XSV	RIVER TERRACE DEPOSITS, 1 - SAND AND GRAVEL
RTD2-XCZ	RIVER TERRACE DEPOSITS, 2 - CLAY AND SILT
RTD2-XSV	RIVER TERRACE DEPOSITS, 2 - SAND AND GRAVEL
RTD3-XCZ	RIVER TERRACE DEPOSITS, 3 - CLAY AND SILT
RTD3-XSV	RIVER TERRACE DEPOSITS, 3 - SAND AND GRAVEL
RTD4-XSV	RIVER TERRACE DEPOSITS, 4 - SAND AND GRAVEL
RTFD-XCZ	RAISED TIDAL FLAT DEPOSITS - CLAY AND SILT
SUPD-XSV	SAND AND GRAVEL OF UNCERTAIN AGE AND ORIGIN - SAND AND GRAVEL
T1T3-XCZ	RIVER TERRACE DEPOSITS, 1 TO 3 - CLAY AND SILT
T1T3-XSV	RIVER TERRACE DEPOSITS, 1 TO 3 - SAND AND GRAVEL
T2T3-XSV	RIVER TERRACE DEPOSITS, 2 TO 3 - SAND AND GRAVEL

Bedrock

LEX_RCS_I

LNM-XSV	LENHAM FORMATION - SAND AND GRAVEL
BGS-S	BAGSHOT FORMATION - SAND
CLGB-XCZS	CLAYGATE MEMBER - CLAY, SILT AND SAND
HWH-XSV	HARWICH FORMATION - SAND AND GRAVEL
LC-XCZ	LONDON CLAY FORMATION - CLAY AND SILT
LC-XCZS	LONDON CLAY FORMATION - CLAY, SILT AND SAND
LMBE-XSZC	LAMBETH GROUP - SAND, SILT AND CLAY
TAB-XSZC	THANET FORMATION - SAND, SILT AND CLAY
SECK-CHLK	SEAFORD CHALK FORMATION - CHALK
LECH-CHLK	LEWES NODULAR CHALK FORMATION - CHALK
LSNCK-CHLK	LEWES NODULAR CHALK FORMATION, SEAFORD CHALK FORMATION AND NEWHAVEN CHALK FORMATION (UNDIFFERENTIATED) - CHALK
NPCH-CHLK	NEW PIT CHALK FORMATION - CHALK
HCK-CHLK	HOLYWELL NODULAR CHALK FORMATION - CHALK
HNCK-CHLK	HOLYWELL NODULAR CHALK FORMATION AND NEW PIT CHALK FORMATION (UNDIFFERENTIATED) - CHALK
WMCH-CHLK	WEST MELBURY MARLY CHALK FORMATION - CHALK
WZCK-CHLK	WEST MELBURY MARLY CHALK FORMATION AND ZIG ZAG CHALK FORMATION (UNDIFFERENTIATED) - CHALK
ZZCH-CHLK	ZIG ZAG CHALK FORMATION - CHALK
GLT-MDST	GAULT FORMATION - MUDSTONE
FO-SDST	FOLKESTONE FORMATION - SANDSTONE

Figure 34. Geological mapping key, and legend for other data. [Geological mapping data reproduced under Licence 2017/004 British Geological Survey © NERC. All rights reserved]

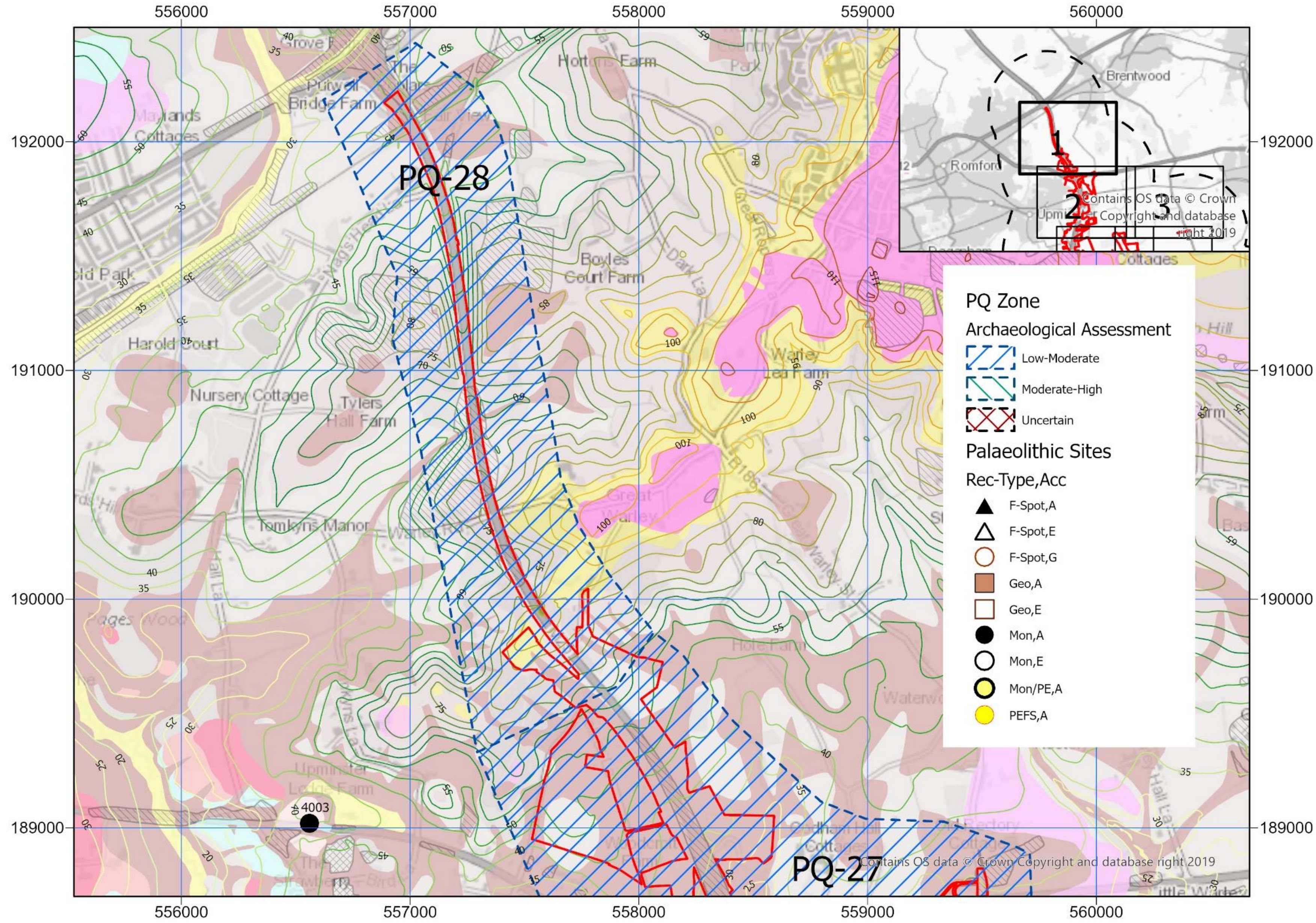


Figure 35. PQ zones, Map 1. [Crown copyright OS mapping data reproduced under HE Licence 100030649; geological mapping reproduced under Licence 2017/004 British Geological Survey © NERC. All rights reserved]

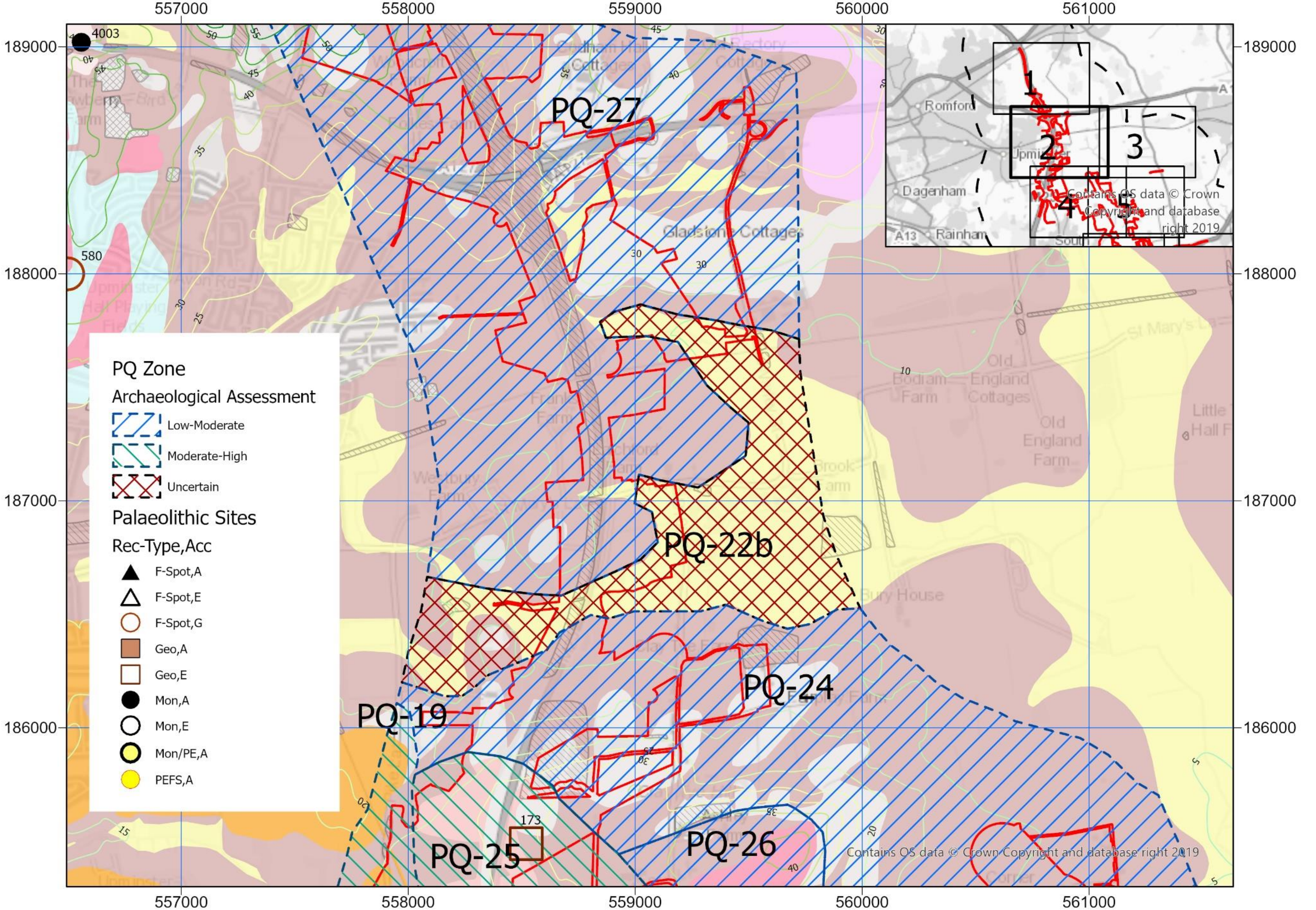


Figure 36. PQ zones, Map 2. [Crown copyright OS mapping data reproduced under HE Licence 100030649; geological mapping reproduced under Licence 2017/004 British Geological Survey © NERC. All rights reserved]

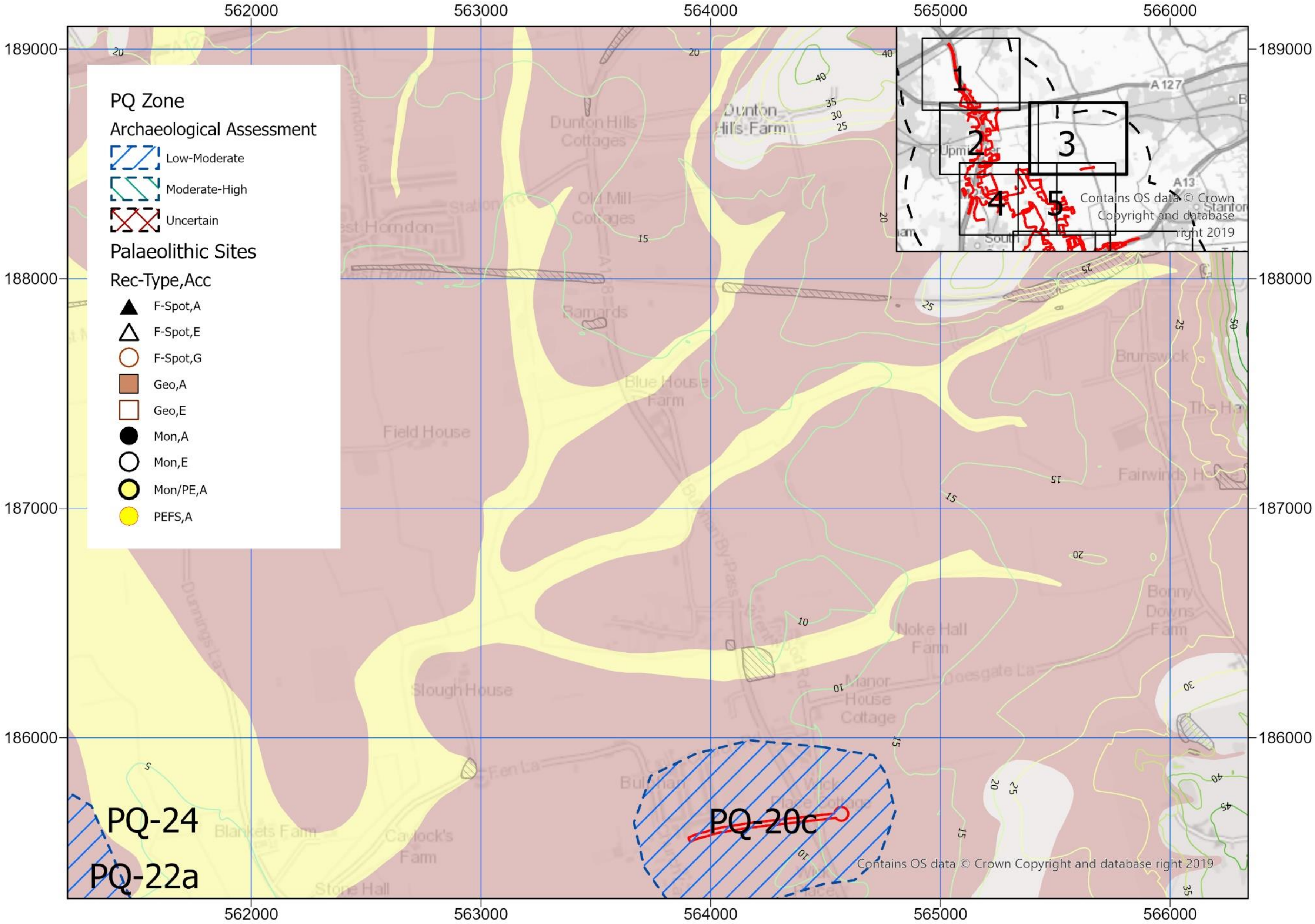


Figure 37. PQ zones, Map 3. [Crown copyright OS mapping data reproduced under HE Licence 100030649; geological mapping reproduced under Licence 2017/004 British Geological Survey © NERC. All rights reserved]

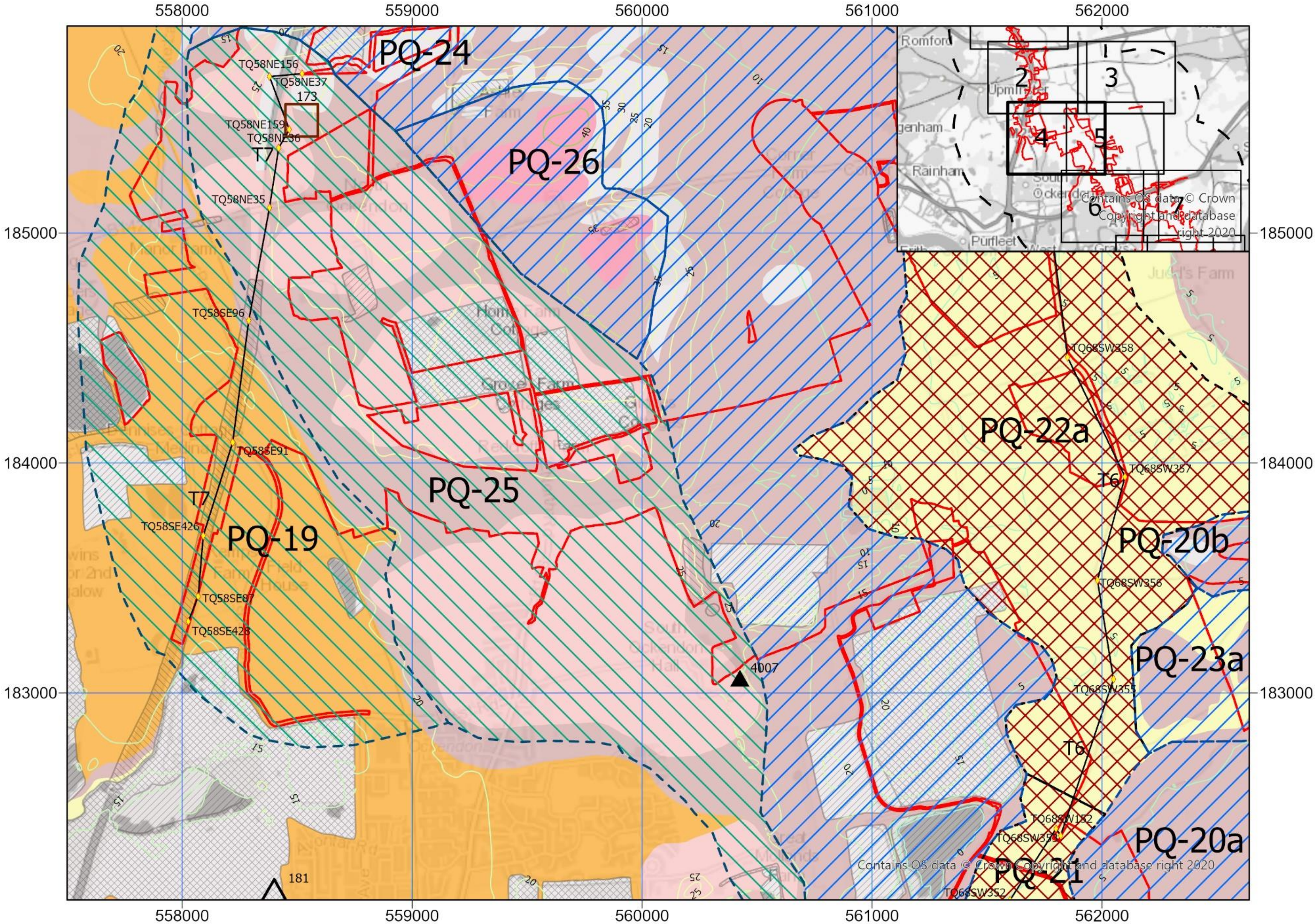


Figure 38. PQ zones, Map 4. [Crown copyright OS mapping data reproduced under HE Licence 100030649; geological mapping reproduced under Licence 2017/004 British Geological Survey © NERC. All rights reserved]

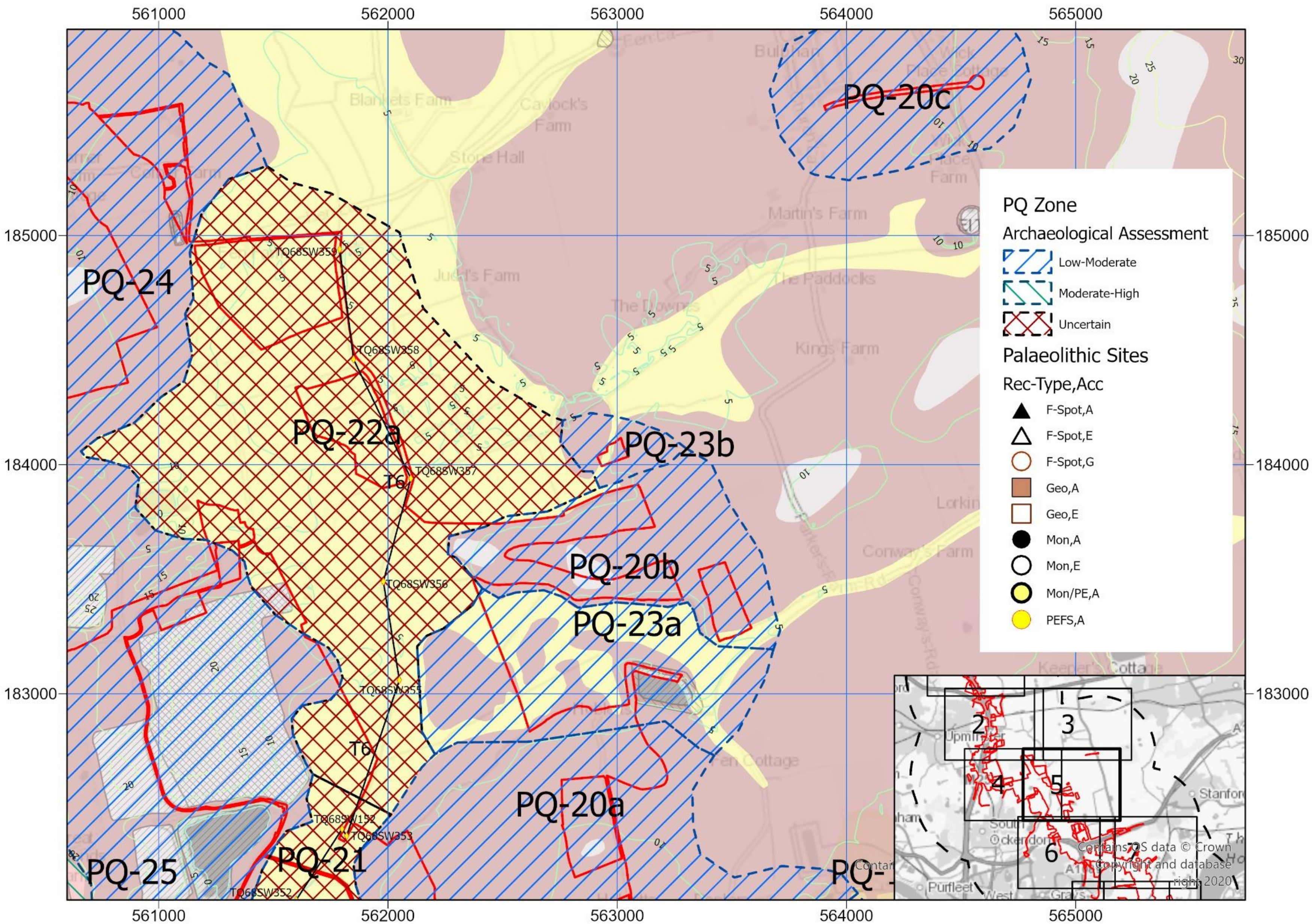


Figure 39. PQ zones, Map 5. [Crown copyright OS mapping data reproduced under HE Licence 100030649; geological mapping reproduced under Licence 2017/004 British Geological Survey © NERC. All rights reserved]

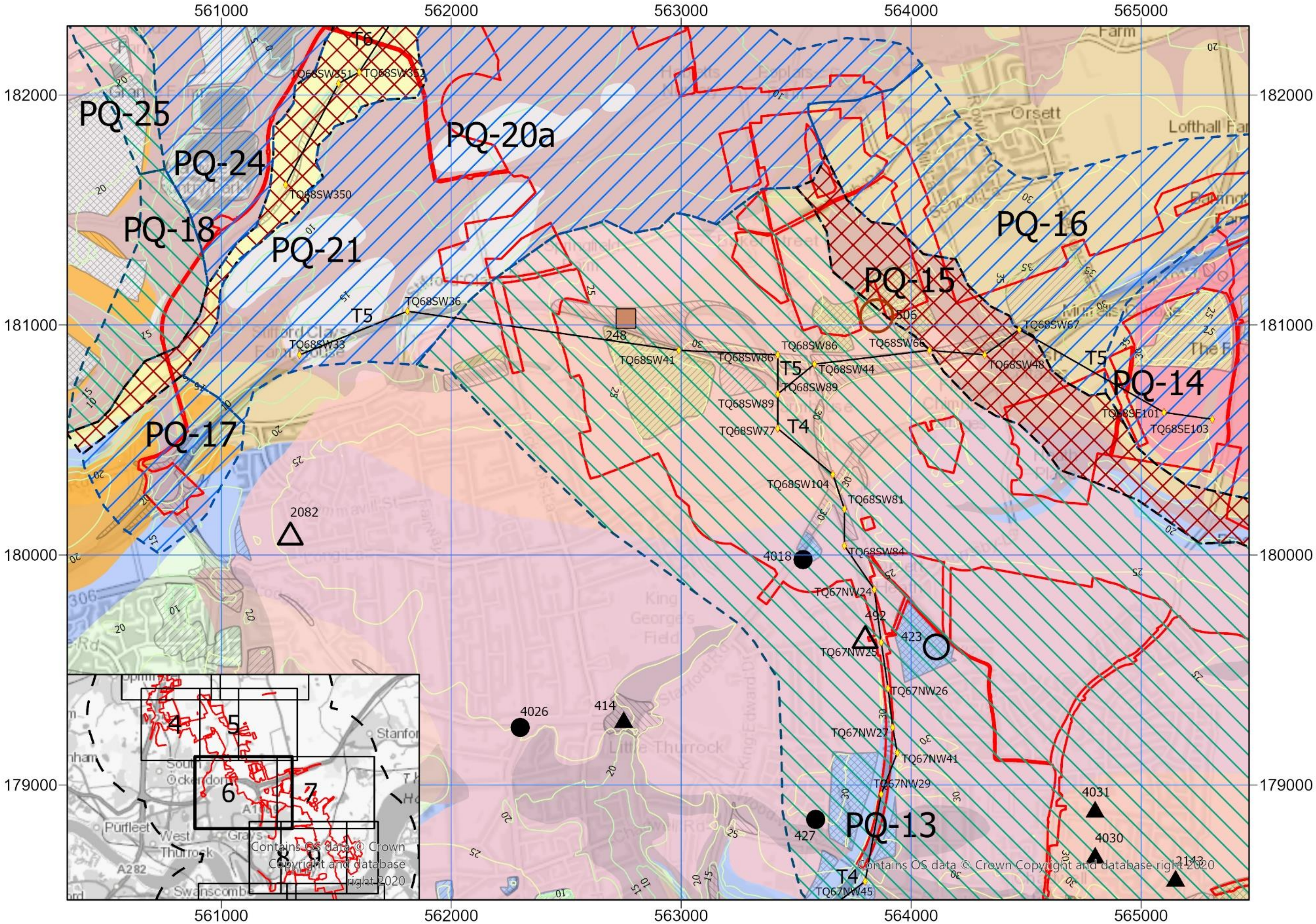


Figure 40. PQ zones, Map 6. [Crown copyright OS mapping data reproduced under HE Licence 100030649; geological mapping reproduced under Licence 2017/004 British Geological Survey © NERC. All rights reserved]

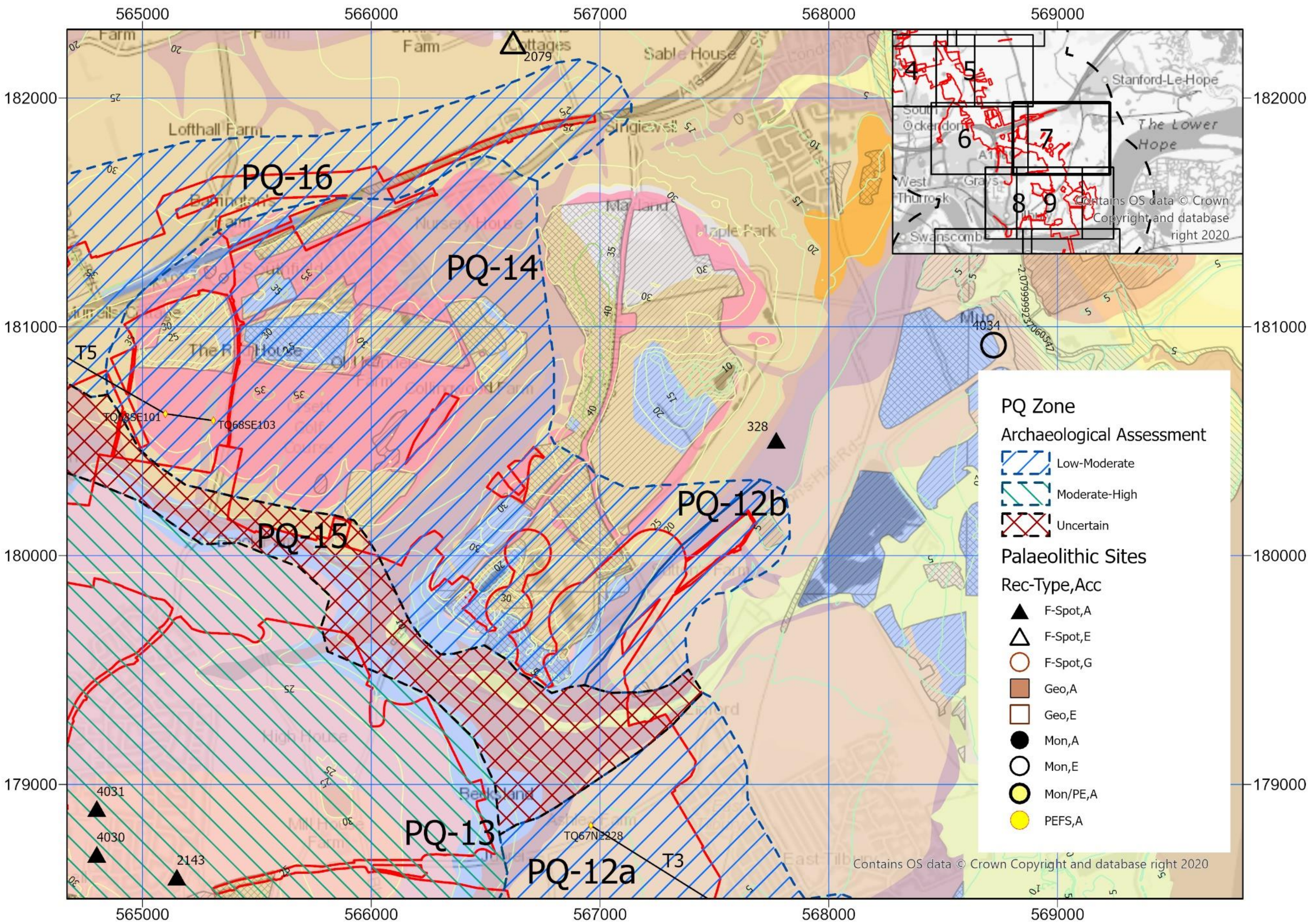


Figure 41. PQ zones, Map 7. [Crown copyright OS mapping data reproduced under HE Licence 100030649; geological mapping reproduced under Licence 2017/004 British Geological Survey © NERC. All rights reserved]

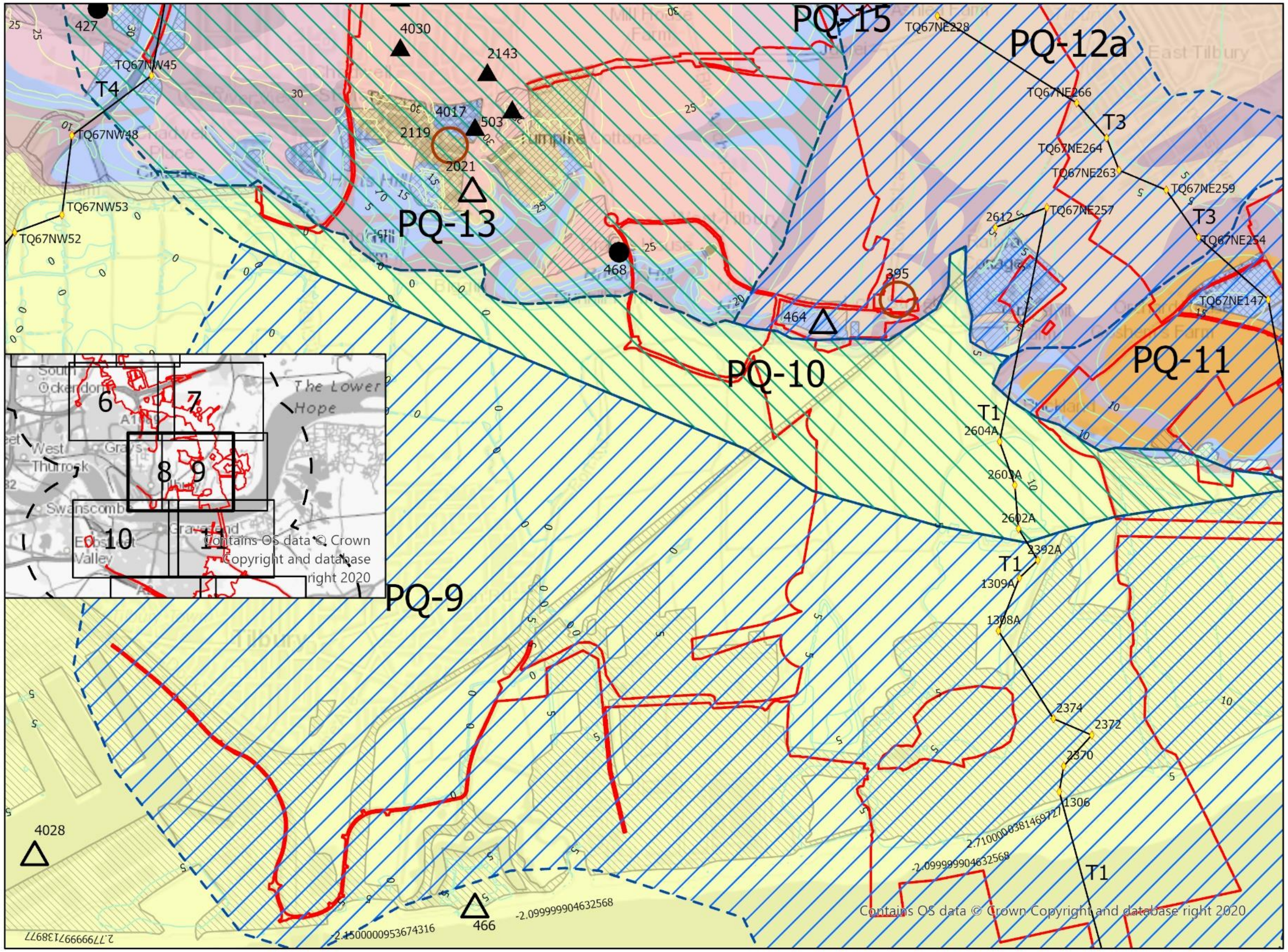


Figure 42. PQ zones, Map 8. [Crown copyright OS mapping data reproduced under HE Licence 100030649; geological mapping reproduced under Licence 2017/004 British Geological Survey © NERC. All rights reserved]

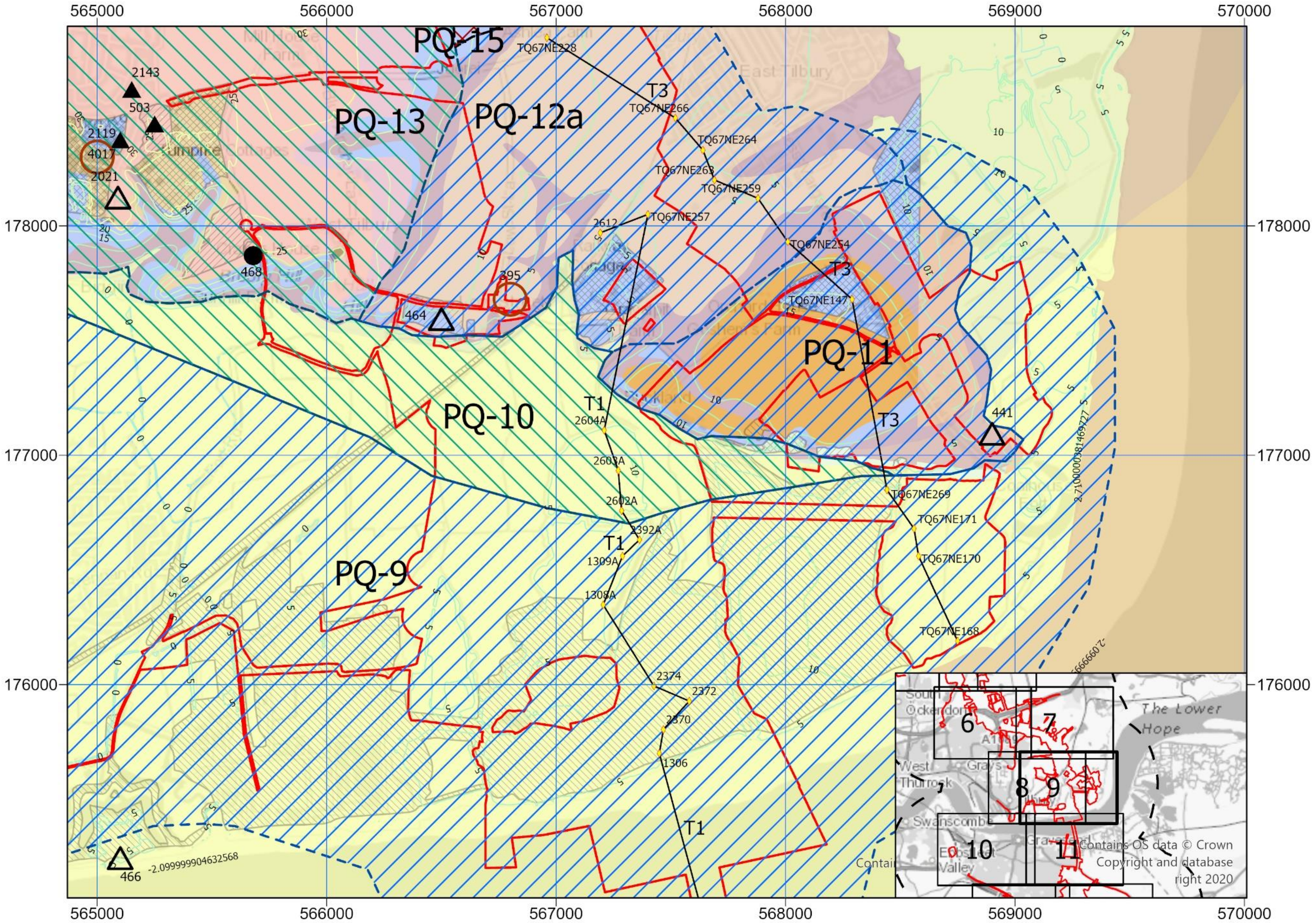


Figure 43. PQ zones, Map 9. [Crown copyright OS mapping data reproduced under HE Licence 100030649; geological mapping reproduced under Licence 2017/004 British Geological Survey © NERC. All rights reserved]

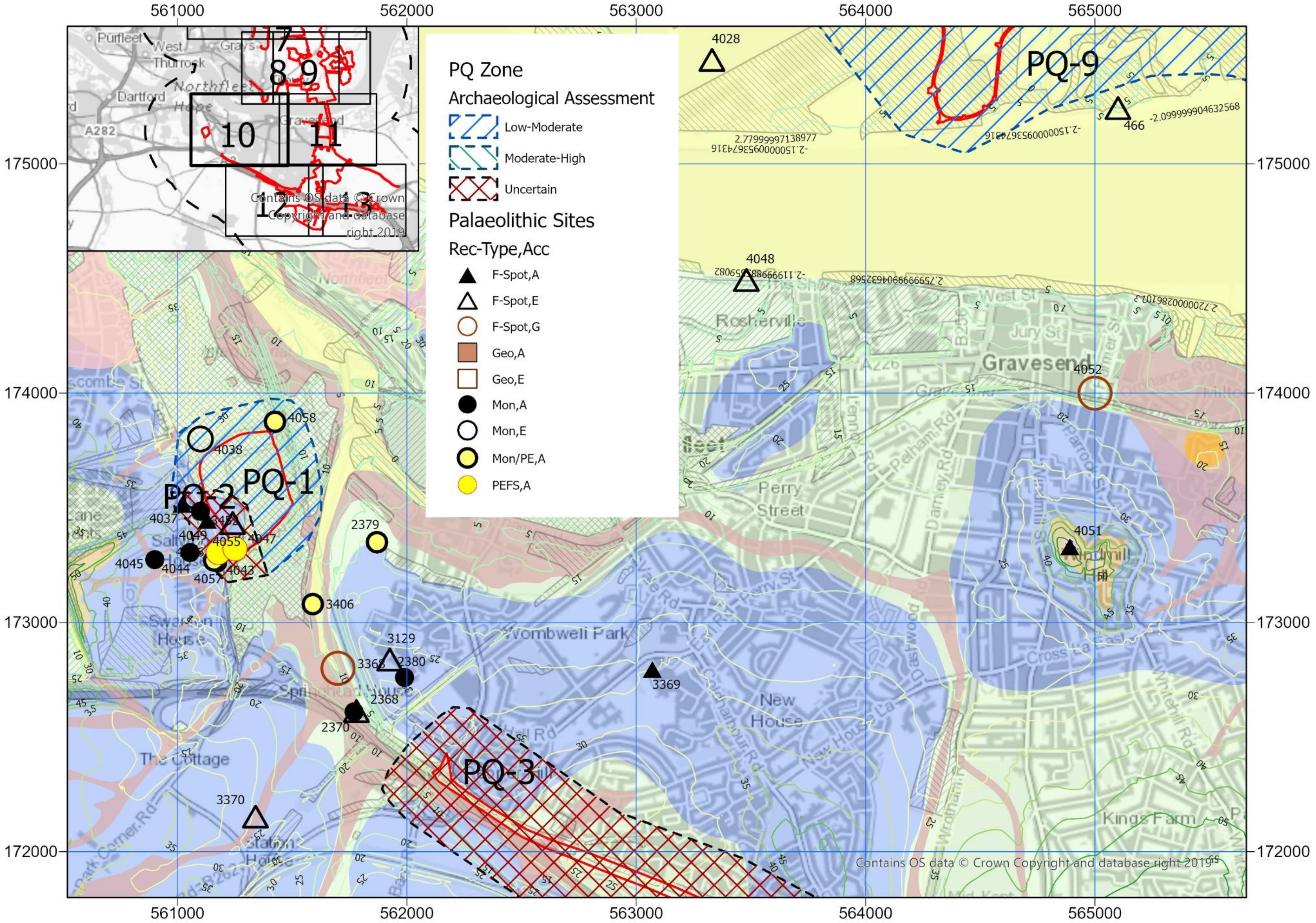


Figure 44. PQ zones, Map 10. [Crown copyright OS mapping data reproduced under HE Licence 100030649; geological mapping reproduced under Licence 2017/004 British Geological Survey © NERC. All rights reserved]

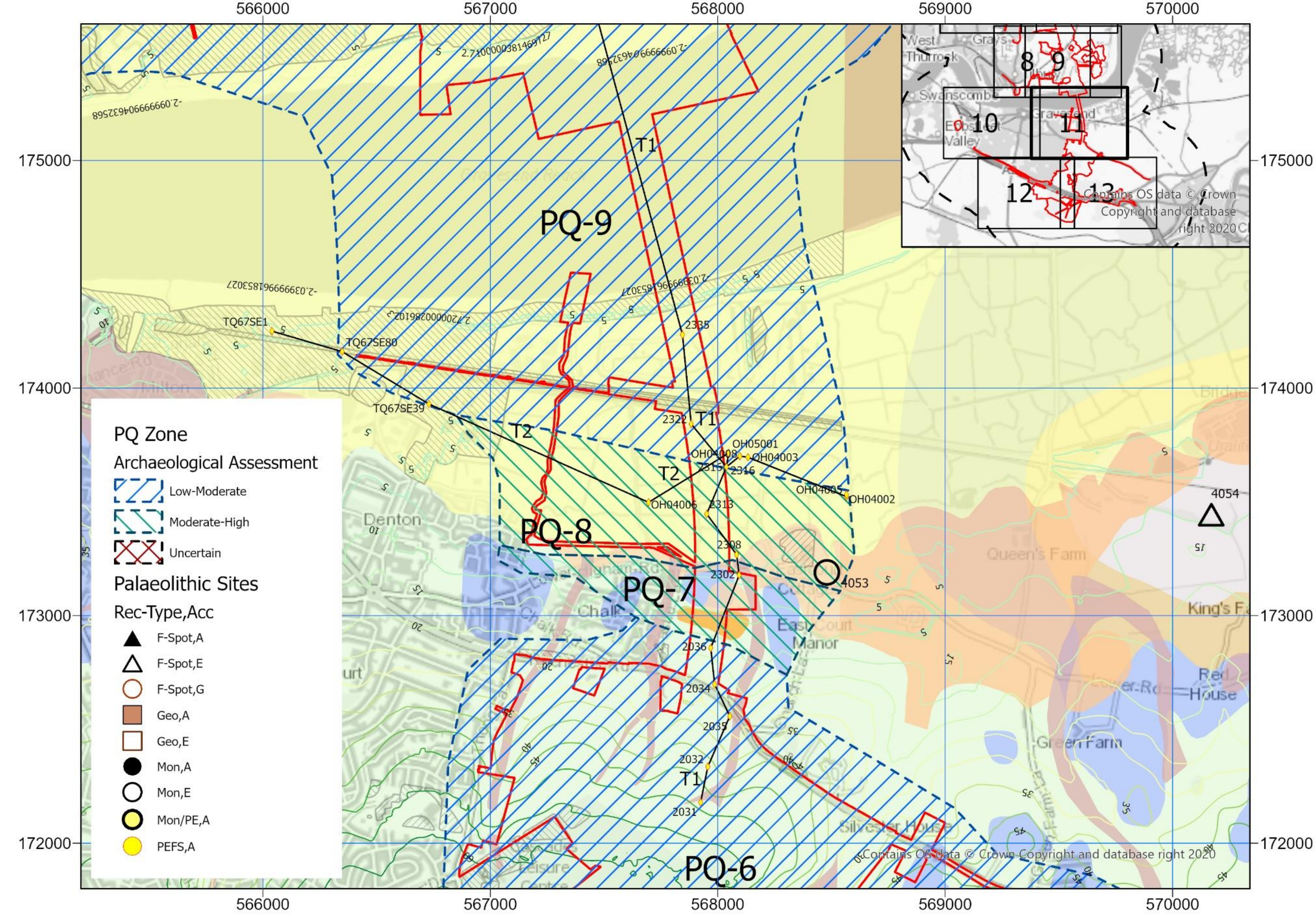


Figure 45. PQ zones, Map 11. [Crown copyright OS mapping data reproduced under HE Licence 100030649; geological mapping reproduced under Licence 2017/004 British Geological Survey © NERC. All rights reserved]

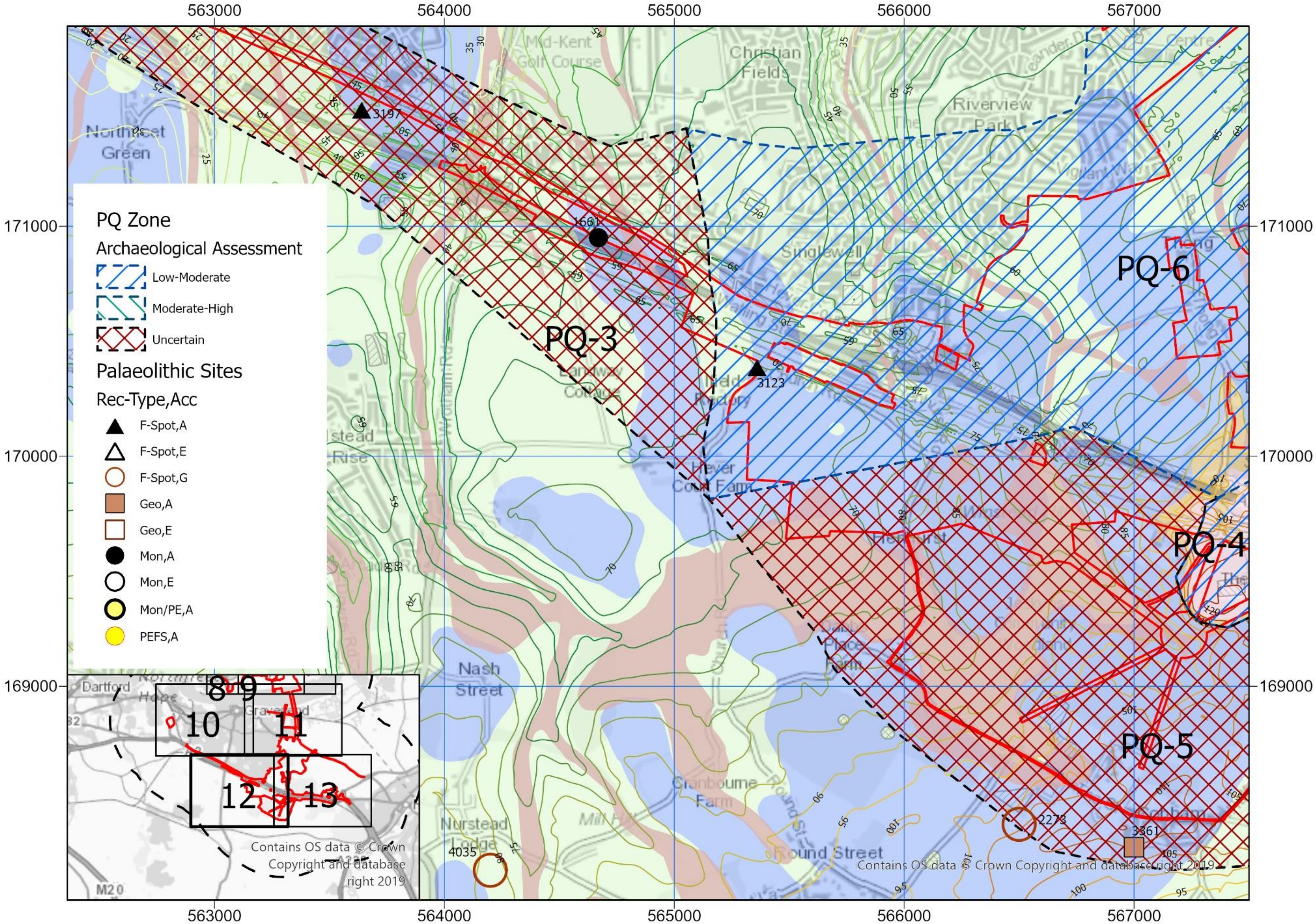


Figure 46. PQ zones, Map 12. [Crown copyright OS mapping data reproduced under HE Licence 100030649; geological mapping reproduced under Licence 2017/004 British Geological Survey © NERC. All rights reserved]

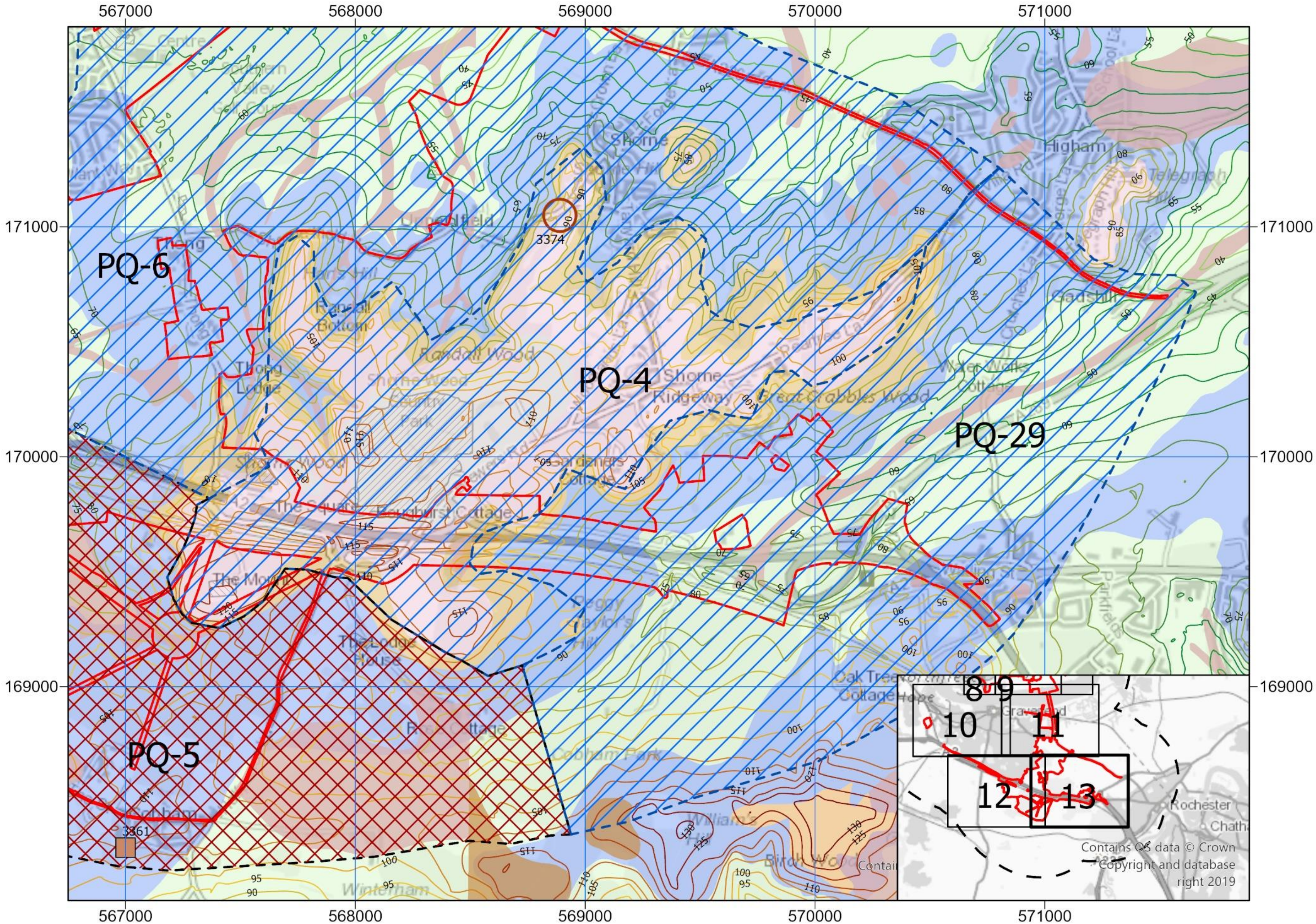


Figure 47. PQ zones, Map 13. [Crown copyright OS mapping data reproduced under HE Licence 100030649; geological mapping reproduced under Licence 2017/004 British Geological Survey © NERC. All rights reserved]

Annexes

Annex A Glossary of acronyms and technical terms

Annex A.

Glossary of acronyms and technical terms

A.1. Glossary, and acronyms

AAR - acronym for *amino acid dating* (qv)

Amino acid dating - a form of *chronometric dating* (qv) that relies on identifying chemical changes (racemisation) in snail shell during sustained burial

BP - years Before Present; the "present" is technically defined as being in 1950 AD, but precision between AD and BP is mostly unnecessary in the Palaeolithic (apart from in its younger Upper Palaeolithic stage) since its timescales are mostly in the 10s and 100s of thousands of years

Bio-stratigraphy, Bio-stratigraphic dating - dating correlation based on faunal remains, either by a distinctive assemblage of species, with key indicator species present or absent; or by distinctive characteristics of a species, such as changing root-length of water-vole molars or changing spacing of mammoth tooth enamel plates

Chronometric dating - methods of dating that rely directly upon measuring a quantifiable attribute or characteristic, such as proportions of certain chemical compounds (C14 dating or *AAR* - qv), or red light emitted when heated (*OSL dating* - qv)

Clast - a larger-sized constituent in a generally fine-grained deposit, such as a flint pebble in a silty/sandy matrix

DBA - Desk-based Assessment

DCO - Development Consent Order [Act of Parliament that supports delivery of a major project such as LTC (qv)]

Designated - when not being used in a non-specific way, this refers to particular heritage assets that have been designated as having some particular important status, such as being a Scheduled Monument or Site of Special Scientific Interest

EIA (Scoping Report) - *Environmental Impact Assessment Scoping Report* [LTC (qv) project document produced in October 2017 that reviews the general approach to assessing and mitigating environmental impact, and summarises key relevant information]

Epoch - technical term for sub-divisions of the geological record; *Pleistocene* (qv) and *Holocene* (qv) are properly epochs of the *Quaternary Period* (qv)

ES - Environmental Statement [document produced to support the DCO (qv)]

Fluvial - river-related

Glacial - a distinctly cold episode in the climatic oscillations of the *Quaternary* (qv); this is the correct term for a cold *stage* (qv), and is not synonymous with *glaciation* (qv), which specifically relates to ice-sheet development

Glaciation - ice-sheet development; this typically occurs during cold *stages* or *glacials* (qv), but is not synonymous with these broader terms

HE - Highways England

HER - acronym for *Historic environment record* (qv)

Historic environment record - lists maintained by local authorities of heritage assets in their area; these underpin curatorial decision-making, so their maintenance with up-to-date records and house-keeping for their accuracy and the inclusion of Palaeolithic remains are essential

Holocene - the warm climatic stage (MIS 1) that has continued since the end of the last glacial (the Devensian) approximately 11,700 BP (years Before Present) up to the present day

Hominin - the branch of the human family tree that includes all species, living or extinct, since its divergence from the line that leads to the living apes that are our closest evolutionary relatives (chimpanzees and gorillas)

Interstadial - a warm oscillation within a prolonged and predominantly cool, or cold, stage of the *Pleistocene* (qv), but not so warm or so long as to qualify for full *interglacial* (qv) status

Knap, Knapping - making stone tools by direct percussion, such as with a hammerstone

Lithic - stone, or made of stone; most common raw material for Palaeolithic stone tools in the UK is flint, but other lithic raw material such as chert, quartzite and volcanic tuff were also used, so should not be overlooked

LGS (Local Geological Site) - a site that is considered worthy of protection/recognition for its Earth Science or landscape importance, but is not already protected as SSSI (qv)

LTC - Lower Thames Crossing

Marine isotope stage - numbered peaks and troughs of the global climate curve for the last two million years derived from continuous sedimentary records from the sea-bed; odd numbers represent warm episodes, and even numbers represent cold ones

MIS - acronym for *marine isotope stage* (qv)

NSIP - Nationally Significant Infrastructure Project

Optically stimulated luminescence - form of *chronometric dating* (qv) applicable to buried sand grains; natural background radiation causes changes in buried sand grains that lead to variation in how brightly they glow when given a controlled optical stimulus

OSL - acronym for *optically stimulated luminescence* (qv)

PEIR - *Preliminary Environmental Information Report* [LTC (qv) project report issued in September 2018 that reviewed the legislative framework applicable to cultural heritage in relation to the new crossing, and reiterated the requirements of the Environmental Statement (ES - qv) that will accompany the DCO (qv) application, and the proposed approach to addressing these requirements.

Quaternary, Quaternary Period - The most recent period of geological time, starting *c.* 2.6 million years ago, and containing two epochs, the *Pleistocene* (qv) and the *Holocene* (qv)

Palaeolithic, the "Old Stone Age" - the oldest cultural stage of human, or *hominin* (qv), cultural history, characterised by the manufacture of *lithic* (qv) artefacts; clearly this will occur (and in particular, <u>start</u>) at different times in different parts of the world, depending upon the spread of early artefact-making hominins - has been sub-divided into Lower, Middle and Upper phases in Britain and western Europe

Pleistocene - the older part (or *epoch* - qv) of the Quaternary Period, lasting from c. 2.6 million years BP through to the end of the Last Glacial *c.* 11,700 BP; the Pleistocene is distinguished by a series of cold and warm climatic oscillations, leading to alternating *glacials* (qv) and *interglacials* (qv), marked (in higher latitudes and more mountainous regions) by expansion and retraction of glaciers and more widespread ice-sheets

PQDM - *Palaeolithic and Quaternary Deposit Model* [LTC (qv) project document produced in February 2020 (v1) and then updated in April 2020 (v2) that provides a preliminary assessment of Palaeolithic and geo-archaeological potential for the proposed impact footprint of the LTC (qv)]

SPAA-&-RF - *Stand-alone Palaeolithic Archaeological Assessment and Research Framework* [LTC (qv) project document that complements the PQDM (qv) and provides more-detailed information on the Palaeolithic potential for different zones of the proposed impact footprint of the LTC (qv), and a project-specific LTC Palaeolithic Research Framework]

SSSI (Site of Special Scientific Interest) - designation by Natural England, of sites that have special scientific interest, usually for geological or environmental reasons; from an archaeological heritage perspective this designation does not have the same statutory weight as being a Scheduled Monument, but it can include important Quaternary sites, and these are almost always of national Palaeolithic importance

Stadial - a cold oscillation within a prolonged and predominantly warm stage of the *Pleistocene* (qv), but not so cold or so long as to qualify for full *glacial* (qv) status

Stage - when not being used in a non-specific way, generally refers to one of the numbered *marine isotope stages* (qv)

Terrace - in the context of Pleistocene (qv) geology, a broadly horizontal landform occurring as a visible step in the side of a river valley; some larger river valleys (such as the Thames, the Trent, the Wiltshire Avon, and the Hampshire Test) can have a staircase of terraces down their valley sides, with each terrace representing a separate series of cold/warm/cold stages of the *Pleistocene* (qv), and with higher terraces being older

Thermoluminescence dating - a form of *chronometric dating* (qv) whereby the time elapsed since a crystalline mineral (such as flint or sediment) was heated can be calculated from the amount of light emitted during controlled heating

TL - acronym for *Thermoluminescence dating* (qv)

Annex B Research framework documents: national and regional

Annex B.

Research framework documents: national and regional

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Wenban-Smith FF, Bates MR, Bridgland DR, Harp P, Pope MI, Roberts MB, 2010 (rev 2017, and then 2019). *The Early Palaeolithic in the South-East: South-East Research Framework (SERF), Resource Assessment and Research Agenda for the Early Palaeolithic*. Report submitted to Kent County Council for joint English Heritage and ALGAO project "Research Framework for South-East England" (SERF). https://www.kent.gov.uk/__data/assets/pdf_file/0010/98938/Early-Palaeolithic-chapter.pdf

Annex C Geological mapping and memoirs

Annex C.

Geological mapping and memoirs

Geological mapping for the project area

Sheet, 1:50,000 (Solid and Drift)	*BGS reference*	*Memoir reference/s*
257	British Geological Survey, 1996. *Romford. England and Wales Sheet 257, Solid and Drift Geology, 1:50,000 Series*. British Geological survey, Keyworth, Nottingham.	Dines & Edmunds 1925; Ellison 2004
258-259	British Geological Survey, 1976. *Southend & Foulness: England and Wales Sheet 258/259, Solid and Drift Geology, 1:50,000*. Ordnance Survey, Southampton.	Lake *et al.* 1986
271	British Geological Survey. 1998. *Dartford: England and Wales Sheet 271, Solid and Drift Geology, 1:50,000*. British Geological Survey, Keyworth, Nottingham.	Dewey *et al.* 1924; Ellison 2004
272	British Geological Survey. 1977. *Chatham: England and Wales Sheet 272, Solid and Drift Geology, 1:50,000*. British Geological Survey, Keyworth, Nottingham.	Dines *et al.* 1954

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Annex D Key sources and “grey” literature

Annex D.

Key sources and "grey" literature

Key published sources

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Evans J, 1897 (2nd ed.). *The Ancient Stone Implements, Weapons and Ornaments of Great Britain*. Longmans, London.

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Wymer, J.J. 1968. *Lower Palaeolithic Archaeology in Britain as represented by the Thames Valley*. John Baker, London.

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Annex E Palaeolithic site-list

Contents

Annex E.

Palaeolithic site-list

Contents:

E.1. Introductory tables

Column heading	*Explanation*
LTC list	Unique identifier for cultural effects across whole Lower Thames Crossing heritage work
FWS proxy	Unique working proxy identifier for Palaeolithic cultural effects, used/assigned by Palaeolithic Lead (Francis Wenban-Smith, University of Southampton)
Geo attribution	Interpretation of likely geological context for Palaeolithic finds - see below, **Table E-2**, for details
PQ zone	Attribution of the Palaeolithic-Quaternary zone for which previous known finds provide relevant information; - suffix "..-nr" represents "very near to zone" - suffix "..-eq" represents "equivalent to zone"
HER MonUID	Unique identifier for previous finds within Kent/Essex HERs, if applicable
Site name	Site name, and summary information
SR/ER PP, map.site	Site identification (if applicable) within the two national Palaeolithic surveys of (a) the Southern Rivers Project (Wessex Archaeology 1993) for the Kent side of the LTC, and (b) the English Rivers Survey for the Essex side
Rec -Type	Record type, one of: Mon - flint artefact/s well-provenanced to a known context Mon/PE - flint artefact/s well-provenanced to a known context, in association with faunal or other palaeoenvironmental remains F-spot - location of flint artefact find/s, with less-reliable info on its/their provenance PEFS (Pleistocene environmental find-spot) - site with faunal or other palaeoenvironmental remains Geo - a significant geological sequence or feature, but lacking artefactual or palaeoenvironmental remains
NGR-E	OS grid easting, to nearest metre
NGR-N	OS grid northing, to nearest metre
Acc	Accuracy of OS grid location, one of: A (Accurate) - site is accurately located based on reliable primary sources E (Estimated) -site location can be estimated with reasonable confidence based on primary sources G (General) - sites and finds from a general area, lacking good information on location and provenance

Table E-1. Explanation of Palaeolithic site-list table entries.

Geo attribution	*Detailed explanation*
Alluv - Ebbsfleet	Ebbsfleet Valley, alluvium on floodplain
Alluv/Shepp	Thames floodplain alluvium, overlying late Last Glacial Shepperton Gravel, infilling current Thames channel, often 10s of metres deep
BH	Boyn Hill Gravel, Thames Terrace - BGS mapping (Sheet 257, Romford) - attributed to Orsett Heath Gravel by Bridgland and Gibbard, and broadly attributed to MIS 12/11/10
BH(Ebbs)	Palaeo-Ebbsfleet fluvial terrace (sand/silt/gravel), of similar age to Thames Boyn Hill Terrace
BP	Black Park Gravel, Thames Terrace - BGS mapping (Sheet 257, Romford) - equated with Dartford Heath Gravel by Gibbard, but many BP outcrops in LTC area attributed to Orsett Heath Gravel by Bridgland
BP or earlier river gravel, Kent	High level outcrops of fluvial terrace, Anglian or pre-Anglian on S side of Thames estuary
BP(Ebbs)	Palaeo-Ebbsfleet fluvial terrace (sand/silt/gravel), of similar age to Thames Black Park Terrace
BP-BH(Ebbs)?	BP(Ebbs) or BH(Ebbs) as defined above - uncertain which, without further investigation
CWF	Clay-with-flints plateau, residual, or maybe from pockets of brickearth infilling depressions in CWF surface
Gl-Lac	Mid-Pleistocene glacio-lacustrine (acc BGS) - over remnant lobe of Anglian till
HA	Hackney Gravel, outcrops appear to west of LTC area, intermediate levels between Lynch hill and Taplow
Head - CR	Head Coombe Rock, chalk-rich fill where dry valleys have passed through chalk bedrock landscape, and thus a dominant variably sandy chalk-silt context for other clasts such as flint pebbles
Head - valley-side spread	Valley-side spread of fine-grained brickearth, esp at We side of ebbsfleet Valley
Head DVF	Head, can be gravelly clay/silt, or brickearth - infilling dry valleys
Head over Tap/Muck	Head slopewash, over deposits of Taplow/Mucking terrace
Head/BH?	From general area with spreads of Head and also BH outcrops; insufficient provenance to attribute material reliably
Head/BP?	Head, overlying BP terrace gravel - material could be from within Head, or derived from underlying gravel
Head/BP-BH(Ebbs) - residual?	Head, overlying BH(Ebbs) as defined above - material could be from within Head, or derived from underlying gravel, or residual on surface
Head/LMB - residual?	Head, unmapped in places, overlying Lambeth Group outcrops - uncertain whether any finds within/under Head, or residual
Head/T?	Head, or unmapped patches of terrace sand/gravel
Head/ThS	Head, unmapped in places, overlying Thanet Sand - find def within/under Head
Head/ThS - residual?	Head, unmapped in places, overlying Thanet Sand - uncertain whether any finds within/under Head, or residual
Head/ThS/Chk - residual?	Head, unmapped in places, overlying Thanet Sand and Chalk landscape - uncertain whether any finds within/under Head, or residual
Head/ThS-LMB - residual?	Head, unmapped in places, overlying Thanet Sand and Lambeth Group outcrops - uncertain whether any finds within/under Head, or residual

LH(CT)	Lynch Hill Gravel, Thames Terrace - BGS mapping (Sheet 271, Dartford) - Purfleet area just to north of Purfleet anticline, at valley-side edge of this deposit, beyond Belhus organic channel; broadly attributed to MIS 10/9/8
LH(CT-BOC)	Lynch Hill Gravel, Thames Terrace - BGS mapping (Sheet 257, Romford), attributed to Corbets Tey Gravel by Bridgland and Gibbard, and incorporating Belhus organic channel; broadly attributed to MIS 10/9/8
Residual, plateau gravel?	Residual surface finds on plateau, often associated with Lower Pleistocene or Pliocene high-level fluvial gravel outcrops, or maybe Tertiary gravel outcrops
Shore, redeposited	Residual shore finds, poss. originating from transported/dumped deposits
Tap/Muck	Taplow Gravel, Thames Terrace - BGS mapping (Sheet 257, Romford, and Sheet 271, Dartford), attributed to Mucking Gravel by Bridgland, broadly MIS 8/7/6
Tap/Muck/Ilf	Taplow/Mucking Gravel, and also possibly Ilford Silt (= Grays Brickearths), date range from MIS 9 to early MIS 6
Tap/Muck/LH	Uncertain whether Tap/Muck, or LH - as defined above

Table E-2. Explanation of entries for column 3, “Geo attribution”.

E.2. Palaeolithic sites, in/near 3km buffer around consultation footprint

LTC list	FWS proxy	Geo attribution	PQ zone	HER MonUID	Site name	SR/ER PP, map.site	Rec - Type	NGR-E	NGR-N	Acc
173	P-19	BH	25	MEX1049370	Ockendon cutting Palaeolithic Watching Brief, M25 - exposure of fluvially-bedded sand/gravel deposits	-	Geo	558520	185490	E
181	P-16	LH(CT-BOC)	17-eq, 18-eq, 19-eq	MEX17513	Little Belhus Farm Pit, one flint debitage, or miscellaneous presumed-Palaeolithic, implement - uncertain provenance	-	F-Spot	558400	182150	E
248	P-102	BH	13	MEX18096	Grey Goose Farm - group of sub-circular crop-mark features, interpreted as of natural origin (periglacial upward-injection of sub-surface sediments?)	-	Geo	562760	181028	A
328	P-18	Head/BP?	14-nr	MEX38151	Mucking Late Prehistoric and Saxon excavations - "a few rolled artefacts" possibly Palaeolithic	-	F-Spot	567550	180510	A
395	P-1	Tap/Muck	12a	MEX6015	Tilbury, general area - handaxe listed by Roe in Bradford Museum	ERPP 1, LTV4A.20	F-Spot	566800	177680	G
414	P-2	BH	13	MEX6188	Handaxe found in 1970 at Dene Holes roundabout, Socketts Heath	ERPP 1, LTV4A.08	F-Spot	562750	179290	A
423	P-3	BH	13	MEX6214	Four handaxes, thought to be from pit west of Greyhound Lane, Orsett Heath	ERPP 1, LTV4A.18a	Mon	564110	179600	E
424	P-4	Tap/Muck/Ilf	-	MEX6218	Handaxe from Terrels Hall, Little Thurrock - taken as likely location for mis-read "Terrels Hill"	ERPP 1, LTV4A.11a	F-Spot	562740	177940	E
427	P-5	BH	13-eq	MEX6229	Chadwell St. Mary, handaxe found in situ during construction of Technical College, c. 1957	ERPP 1, LTV4A.12	Mon	563585	178850	A
430	P-7	Alluv/Shepp	8-eq, 9-eq, 10-eq	MEX6238	Tilbury Town, handaxe found on/near Feenan Highway, c. 1967	ERPP 1, LTV4A.21	F-Spot	564600	176700	A
441	P-8	Tap/Muck/LH	11	MEX6286	East Tilbury, handaxe surface find to north of church (at marsh level)	ERPP 1, LTV4.09	F-Spot	568900	177100	E
464	P-9	Tap/Muck	12a	MEX6455	West Tilbury, WG Smith finds in Luton Museum - 16 flakes, of which more than half may have secondary working (according to Roe's 1968 examination)	ERPP 1, LTV4A.20a	F-Spot	566500	177600	E
466	P-10	Alluv/Shepp	8-eq, 9-eq, 10-eq	MEX6469	"worked flint, possibly Palaeolithic" from Tilbury Fort, West Tilbury	-	F-Spot	565100	175250	E

LTC list	FWS proxy	Geo attribution	PQ zone	HER MonUID	Site name	SR/ER PP, map.site	Rec - Type	NGR-E	NGR-N	Acc
468	P-11	BH	13	MEX6475	West Tilbury, Gun Hill Pit - four handaxes and three debitage	ERPP 1, LTV4A.19	Mon	565680	177870	A
492	P-12	BH	13	MEX6587	Orsett, Heath Farm - surface find of one handaxe	-	F-Spot	563800	179650	E
503	P-13	BH	13-nr	MEX6633	Chadwell St. Mary, Pigg's Pit, to east of Sandy Lane, at its top/northern end - one handaxe attributed to this pit specifically	ERPP 1, LTV4A.16	F-Spot	565250	178450	A
506	P-14	Head/BH?	13-eq, 15-eq, 16-eq	MEX6657	Orsett, general area - four handaxes and several debitage in various museum collections	ERPP 1, LTV4A.18	F-Spot	563850	181040	G
580	P-66	BH	-	-	Upminster, general area - two handaxes in the Warren Collection, held at the British Museum	ERPP 1, LTV4.05	F-Spot	556500	188000	G
1661	P-47	Head/ThS	3, 5-eq, 6-eq, 29-eq	MKE20609	Fine pointed handaxe found in situ in May 1997, during HS1 evaluation at site "South-East of Tollgate" - site code ARC TGS 97, trench 1863TT	-	Mon	564670	170950	A
2021	P-39	BH	13-nr	MEX1032236	Two handaxes from unspecified pit at "Sandy Lane, Chadwell St Mary" - the estimated location is the oldest of several pits in the area	-	F-Spot	565090	178130	E
2079	P-36	Head/LMB - residual?	16-eq	MEX18037	Saffron Garden, handaxe found on surface near farm buildings	-	F-Spot	566620	182250	E
2082	P-37	BH	13-eq	MEX18179	Stifford, Thurrock, general area - handaxe and a scraper in museum collections, no info on location/context	ERPP 1, LTV4A.04	F-Spot	561300	180100	E
2119	P-20	BH	13-eq	MEX5915	Chadwell St. Mary (or "Chadwell"), general area - more than 100 handaxes in various museum collections, as well as several debitage	ERPP 1, LTV4A.17	F-Spot	565000	178300	G
2143	P-29	BH	13-nr	MEX6249	Chadwell St. Mary, two handaxes from shallow diggings in gardens of 57 and 67 Sabina Road	ERPP 1, LTV4A.14	F-Spot	565150	178600	A
2182	P-41	LH(CT-BOC)	17-eq, 18-eq, 19-eq	MEX1036488	South Ockendon, two flakes found by BO Wymer at unlocated pit "on west side of the road from South Ockendon to Stifford" (Wymer 1985: 314), later modified to "South Ockendon, north of Buckles Lane" (ERPP: 131).	ERPP 1, LTV4A.03	F-Spot	560240	180930	E

LTC list	FWS proxy	Geo attribution	PQ zone	HER MonUID	Site name	SR/ER PP, map.site	Rec - Type	NGR-E	NGR-N	Acc
2273	P-55	Head/ThS - residual?	5-nr	MKE1376	Cobham, general area - "broken implements of Palaeolithic type" found by W Whitaker (Evans - 1872: 533 & 1897: 611)	SRPP 2, M5.01	F-Spot	566500	168400	G
2368	P-84	Head/BP-BH(Ebbs) - residual?	3-eq	MKE20292	Three Lower/Middle Palaeolithic handaxes, unstratified surface finds during HS1 fieldwork at Springhead Roman Town, towards head of the Ebbsfleet	-	F-Spot	561780	172620	E
2370	P-85	Head DVF	3-eq, 6-eq, 29-eq	MKE20294	Late Upper Palaeolithic (Long Blade) knapping scatter, found during HS1 fieldwork at Springhead Roman Town	-	Mon	561770	172610	A
2379	P-99	Head over Tap/Muck	-	MKE20307	Six Palaeolithic debitage (varied consition), and part of mammoth tusk, found at Springhead Quarter, Ebbsfleet (field evaluation test pits, TPs 1115-1117)	-	Mon/PE	561870	173350	A
2380	P-100	BP-BH(Ebbs)?	-	MKE20308	Two Palaeolithic flint flakes, found during sieving of palaeo-Ebbsfleet gravels at higher southern part of Springhead Quarter, Northfleet	-	Mon	561990	172760	A
3123	P-48	Head/ThS - residual?	6	MKE80459	Church Road, Tollgate - ?Pal ?Levallois flake found in Bronze Age pit during work by MoLAS	-	F-Spot	565360	170390	A
3129	P-101	Head/BP-BH(Ebbs) - residual?	-	MKE80563	Residual Palaeolithic flints (two debitage and a flake-tool), found during open-area Saxon excavation at Springhead	-	F-Spot	561925	172845	E
3197	P-45	Head/ThS - residual?	3-eq, 6-eq, 29-eq	MKE90970	A2 Activity Park, Gravesend - 3 residual Palaeolithic flakes	-	F-Spot	563640	171510	A
3361	P-51	Residual, plateau gravel?	-	MWX20768	Geological marks at Cobham Park - site apparently identified by MR Bates, and referenced to sources by DR Bridgland - may just reflect BGS mapping of high level gravel outcrops	-	Geo	567000	168300	A
3368	P-82	Head/BP-BH(Ebbs) - residual?	-	MWX20814	Springhead (general area), surface finds of 3 Palaeolithic handaxes and a flake, made prior to early 1960s	SRPP 2, NWK5.8	F-Spot	561700	172800	G
3369	P-96	Head/BP-BH(Ebbs) - residual?	-	MWX20820	Palaeolithic handaxe from near Wombwell Hall, Gravesend - no info on provenance, presumably a surface find	SRPP 2, NWK5.16	F-Spot	563070	172800	A

LTC list	FWS proxy	Geo attribution	PQ zone	HER MonUID	Site name	SR/ER PP, map.site	Rec - Type	NGR-E	NGR-N	Acc
3370	P-83	Head DVF	3-eq	MWX20821	One Tree Field, near Southfleet Station - surface finds of 8 handaxes and 11 pieces of debitage (Stopes Collection)	SRPP 2, NWK5.17	F-Spot	561340	172160	E
3374	P-54	Residual, plateau gravel?	4-eq	MWX20836	One handaxe and two Levallois flakes, from general Shorne area - presumed surface finds but no provenance info	SRPP 2, M5.03	F-Spot	568890	171050	G
3406	P-81	Alluv - Ebbsfleet	8-eq, 10-eq	MKE104432	Late Upper Palaeolithic flints (Long Blade - cores, blades and flake-tools), Burchell's "Springhead Lower Floor", Ebbsfleet Valley	-	Mon/PE	561590	173080	A
3452	P-88	Head - valley-side spread	2-nr	MKE99903	Very fine pointed Palaeolithic handaxe from Ebbsfleet, Station Quarter South evaluation, TP 25	-	Mon	561100	173485	A
4000	P-60	Tap/Muck	-	-	Rainham, a few handaxes, cores and debitage from vicinity of 23 Berwick Road	ERPP 1, LTV3.24	F-Spot	553700	183300	G
4001	P-61	HA	-	-	Hornchurch, handaxe from 24 Globe Road (found in garden, post-1945)	ERPP 1, LTV3.25	F-Spot	552210	188190	A
4002	P-62	Tap/Muck	-	-	Havering, Launders Lane Pit - two handaxe fragments listed in Essex HER, but no other info on circumstances of discovery or present whereabouts	ERPP 1, LTV3.26	F-Spot	554200	182000	E
4003	P-63	Gl-Lac	-	-	Havering, Upminster, A127 cutting - "North of Martins" - fluvial terrace sequence above till, with mint condition flint artefacts (including two handaxes and a flake-tool) in terrace sequence, as well as burnt flints	ERPP 1, LTV4.01	Mon	556560	189020	A
4004	P-64	LH(CT-BOC)	19-eq	-	Rainham, Gerpins Pit - 8 handaxes found in 1930s, when extensive workings in Lynch Hill/Corbets Tey terrace, with its surface c. 18m OD	ERPP 1, LTV4.03	F-Spot	555500	184100	E
4005	P-65	Head/BH?	-	-	Rainham, Moor Hall Farm - broken tip of handaxe	ERPP 1, LTV4.04	F-Spot	555750	181150	E
4006	P-67	LH(CT-BOC)	19-eq	-	Havering, 54 Coniston Avenue - one handaxe found in rear garden, in 1939	ERPP 1, LTV4.06	F-Spot	556385	185715	A
4007	P-68	BH	25	-	South Ockendon, sharp cordate handaxe found at site of windmill (found on surface after demolition)	ERPP 1, LTV4.10	F-Spot	560425	183070	A

LTC list	FWS proxy	Geo attribution	PQ zone	HER MonUID	Site name	SR/ER PP, map.site	Rec - Type	NGR-E	NGR-N	Acc
4008	P-69	LH(CT)	-	-	Purfleet, Botany Pit - handaxes, debitage, Levallois cores/flakes and fossils mammalian remains - BUT, mostly from talus and channel-side areas where interdigitated with chalk-rich valley-side slopewash, rather than in situ in main fluvial gravel bed, so uncertainty over provenance/age	ERPP 1, LTV4.11	Mon/PE	555720	178500	A
4009	P-70	LH(CT)	-	-	Purfleet Greenlands Pit - classic sequence in NE corner. Lowest part of sequence is peak MIS 9 interglacial, but few/no artefacts from this horizon, so uncertain how the more-implementiferous horizons higher up the very thick sequence relate to peak MIS 9.	ERPP 1, LTV4.12	Mon/PE	556890	178515	A
4010	P-71	LH(CT)	-	-	Purfleet, Bluelands Pit: early artefact recovery by Palmer (1975), then tripartite interpretation by Wymer (1985), then further artefact recovery from upper levels by Schreve, but latter unpublished and artefacts are missing.	ERPP 1, LTV4.13	Mon	556840	178600	A
4011	P-72	BH	-	-	Hornchurch rail cutting - Boyn Hill/Orsett Heath (sensu Bridgland) deposits at 29-32m OD, cut into chalky till - "boulder clay" - associated with Anglian glaciation. NB - BGS mapping shows the terrace deposits as Black Park Gravel	ERPP 1, LTV4.15	Geo	554665	187335	A
4012	P-73	HA	-	-	Rainham, two handaxes from Aylett's Pit, Warwick Lane	ERPP 1, LTV4.16	F-Spot	554800	182900	A
4013	P-74	Residual, plateau gravel?	-	-	Brentwood, South Weald - large ovate handaxe, found pre-1977, but otherwise no provenance info.	ERPP 1, LTV4.N of	F-Spot	557600	194300	G
4014	P-75	LH(CT-BOC)	17-eq, 18-eq, 19-eq	-	South Ockendon, Gate Hope Drive - core, possibly for Levalloisian blade production, according Wymer. No info on provenance.	ERPP 1, LTV4A.02	F-Spot	557700	181080	E

LTC list	FWS proxy	Geo attribution	PQ zone	HER MonUID	Site name	SR/ER PP, map.site	Rec - Type	NGR-E	NGR-N	Acc
4015	P-76	Tap/Muck	-	-	Lion Pit tramway cutting, West Thurrock - Levallois working floor (attrib MIS 8) below thick sequence of fossiliferous sands/silts that are attributed to MIS 7.	ERPP 1, LTV4A.05	Mon/PE	559800	178200	A
4016	P-77	Tap/Muck/LH	-	-	Grays, Grays Thurrock - numerous handaxes, cores, debitage and flake-tools from general area	ERPP 1, LTV4A.11	F-Spot	562000	178200	G
4017	P-78	BH	13-nr	-	Chadwell St. Mary, Sandy Lane - two handaxes from the pit opened in the 1960s at top/northern end of Sandy Lane, and to its west	ERPP 1, LTV4A.15	F-Spot	565100	178380	A
4018	P-79	BH	13	-	Pit to north-east of Hangman's Wood, by road to Orsett - "implements" obtained from c. 7 feet of gravel/sand in late 19th C	-	Mon	563530	179080	A
4019	P-80	LH(CT-BOC)	19-eq	-	Palaeo-environmental remains (molluscs, ostracods, fish, insects and plant macro-fossils) from brown clayey/sandy silt deposits in sewer cutting at Park Corner Farm, Upminster	-	PEFS	555050	185030	A
4020	P-19a	LH(CT-BOC)	17-eq, 18-eq, 19-eq	-	Belhus Park cutting, M25 - 2011 investigations, rich palaeo-environmental remains and some flint artefacts found in situ	ERPP 1, LTV4A.01	Mon/PE	557500	181200	A
4021	P-19b	LH(CT-BOC)	17-eq, 18-eq, 19-eq	-	Belhus Park cutting, M25 - 1980-1981 Essex Field Club monitoring, several handaxes and debitage found in situ	ERPP 1, LTV4A.01a	Mon	557420	181250	A
4022	P-21a	Tap/Muck/Ilf	-	-	Grays Brickearths - early faunal recovery, rich variety of (mostly interglacial) mammalian fossils, as well as a flake-tool	-	PEFS	561950	178145	A
4023	P-53a	Head/T?	-	-	Five debitage in Stopes Collection from Higham Pits, "Brown's findings" - pits between Dartford and Higham, gravels resting on Chalk, levels ranging from 70 ft to 105 ft OD (Stopes 1895b)	SRPP 2, M5.04c	F-Spot	570950	172800	G
4024	P-21	Tap/Muck	-	MEX5918	Globe Pit, Grays - early find of flake-tool	ERPP 1, LTV4A.07a	Mon	562500	178150	E

LTC list	FWS proxy	Geo attribution	PQ zone	HER MonUID	Site name	SR/ER PP, map.site	Rec - Type	NGR-E	NGR-N	Acc
4025	P-23	Head/BH?	-	MEX6120	Grays, Dell Road, old chalk pit - handaxe find in base of pit, presumed to have come from terrace deposits at top of quarry face	ERPP 1, LTV4A.06	F-Spot	561620	178600	A
4026	P-24	BH	13-eq	MEX6135	Socketts Heath Pit, Palaeolithic finds "failry abundant", and two handaxes in modern museum collections	ERPP 1, LTV4A.09	Mon	562300	179250	A
4027	P-25	LH(CT)	-	MEX6144	Globe Pit, Little Thurrock - large assemblage of cores, debitage and flake-tools from Wymer and Snelling excavations (1950s-1960s) in preserved deposits at wooded/thorny area at foot of garden of Mr/Mrs Croot (13 Overcliff Road).	ERPP 1, LTV4A.07	Mon	562520	178290	A
4028	P-27	Alluv/Shepp	8-eq, 9-nr, 10-eq	MEX6172	Grays/Tilbury, two "Mousterian" handaxes, one of them a fine bout coupe, possibly found during expansion of Tilbury docks c. 1910-1913, or dredging Thames or tidal basin at/near dock entrance.	ERPP 1, LTV4A.10	F-Spot	563330	175460	E
4029	P-27a	Alluv/Shepp	8-eq, 9-nr, 10-eq	MEX6172	Tilbury, ovate HA found by R Doyle during dockyard extension in 1968	ERPP 1, LTV4A.22	F-Spot	562630	176500	E
4030	P-6	BH	13-eq	MEX6235	Chadwell St. Mary, handaxe found in 1971 during construction of housing estate to north-east of church	ERPP 1, LTV4A.13	F-Spot	564800	178700	A
4031	P-6a	BH	13-eq	MEX6235	Chadwell St. Mary, handaxe found in 1971 during construction of housing estate to north-east of church	ERPP 1, LTV4A.13a	F-Spot	564800	178900	A
4032	P-31	Tap/Muck/Ilf	-	MEX6465	Little Thurrock, general area - listed by Roe as "Grays, Little Thurrock" which is slightly to east of main Grays/Grays Thurrock area.	-	F-Spot	562600	178200	G
4033	P-33	LH(CT)	-	MEX6681	Stanford le Hope - reports of three handaxes and several debitage from general area, but no specifics on location or context	ERPP 1, LTV4.14	F-Spot	568500	182000	G
4034	P-34	Tap/Muck	12b-eq	MEX6894	Mucking - gravel pit/s; two handaxes and several flakes reported, but no specific info on location/context	ERPP 1, LTV4.08	Mon	568720	180920	E

LTC list	FWS proxy	Geo attribution	PQ zone	HER MonUID	Site name	SR/ER PP, map.site	Rec - Type	NGR-E	NGR-N	Acc
4035	P-49	Head/ThS /Chk - residual?	3-eq, 5-eq, 6-eq	MKE1440	Nursted/Nurstead, general area - "broken implements of Palaeolithic type" found by W Whitaker (Evans - 1872: 533 & 1897: 611)	SRPP 2, NWK2.61	F-Spot	564200	168200	G
4036	P-59	Alluv/Shepp	9-eq	MKE1525	Broadness - handaxe (crude/roughout) and flake dredged from Thames bed	SRPP 2, NWK5.15	F-Spot	560500	176800	A
4037	P-87	Head - valley-side spread	2-eq	MKE1716	More than 20 Palaeolithic handaxes from Bevan's Wash-pit, opposite New Barn farmhouse [Treadwell's], and also a Levallois flake and undiagnostic debitage	-	F-Spot	561020	173520	A
4038	P-86	Head - valley-side spread	2-eq	MKE1727	Palaeolithic handaxe from near New Barn Farm House [Treadwell's]	SRPP 2, NWK5.7	Mon	561100	173800	E
4039	P-57	Head/ThS - residual?	3-eq, 5-eq, 6-eq, 29-eq	MKE2330	Surface find of handaxe at Strood Hill, Rochester	SRPP 2, M5.06	F-Spot	572200	169400	A
4040	P-98	Shore, redeposited	-	MKE2606	Five Palaeolithic handaxes found on foreshore between Cliffe Creek and Lower Hope Point, Cliffe	-	F-Spot	571000	178000	G
4041	P-58	CWF	-	MKE39905	Cuxton, Ranscombe - four handaxes in Rochester Museum, presumed surface finds	SRPP 2, M5.05	F-Spot	571100	167700	G
4042	P-56	BP or earlier river gravel, Kent	-	MKE39923	Core with Levalloisian characteristics, found in situ in high-level gravels near Higham in 2005 (Medway Valley Project, Whitehouse Farm, TP 9)	-	Mon	572315	171890	A
4043	P-95	BH(Ebbs)	2-nr	MKE43400	Palaeolithic (Clactonian) HS1 elephant butchery site, Southfleet Road, Ebbsfleet	-	Mon/PE	561160	173270	A
4044	P-90	BP(Ebbs)	-	MKE97553	Lower Palaeolithic 'Clactonian' occupation surface, Ebbsfleet Green - numerous debitage, cores and flake-tools, with several refitting groups	-	Mon	561055	173305	A
4045	P-97	Head DVF	3-eq, 6-eq, 29-eq	MKE97555	Ebbsfleet Green LUP (Long Blade) scatter - dense scatter with numerous cores, flake-tools and debitage and high proportion of refitting - found in colluvium infilling dry valley cutting into Thanet Sand and ambeth Group bedrock.	-	Mon	560901	173274	A

LTC list	FWS proxy	Geo attribution	PQ zone	HER MonUID	Site name	SR/ER PP, map.site	Rec - Type	NGR-E	NGR-N	Acc
4046	P-92	BH(Ebbs)	2	MKE99904	PEFS - Hoxnian lake-bed sediments with ostracod and mollusc remains - Ebbsfleet, Station Quarter South, TP 31	-	PEFS	561178	173305	A
4047	P-92a	BH(Ebbs)	2	MKE99904	PEFS - Hoxnian lake-bed sediments with ostracod and mollusc remains - Ebbsfleet, Station Quarter South, TP 33	-	PEFS	561251	173321	A
4048	P-42	Shore, redeposited	-	MKE99905	Several handaxes and debitage from unspecified locations along Northfleet Shore, found late 19th C	-	F-Spot	563480	174500	E
4049	P-89	Head - valley-side spread	2	MKE99907	Surface finds of one handaxe and several pieces of debitage, much in fresh condition, from brickearth bank cutting to north of HS1 elephant site	-	F-Spot	561130	173450	A
4050	P-50	Head/ThS /Chk - residual?	5-eq	MWX20789	Meopham, general area - "broken implements of Palaeolithic type" found by W Whitaker (Evans - 1872: 533 & 1897: 611)	SRPP 2, NWK2.60	F-Spot	564500	166100	G
4051	P-43	Head/ThS-LMB - residual?	4-eq	MWX20815	Two handaxes from Gravesend (Milton), Windmill Hill - surface finds	SRPP 2, NWK5.11	F-Spot	564890	173335	A
4052	P-44	Head/T?	7-eq	MWX20816	Gravesend, surface finds from the general area - 12 handaxes and two debitage in various museums.	SRPP 2, NWK5.12	F-Spot	565000	174000	G
4053	P-46	Tap/Muck	7-Nr	MWX20835	Gravesend, Chalk - handaxe ("implement") and a flake-tool from gravel pits to east of Chalk, north side of Higham Road, at Filborough	SRPP 2, M5.02	Mon	568480	173190	E
4054	P-52	Head/T?	7-eq	MWX20837	Three Pal HAs from Higham: one in Cambridge Museum (A and E), and two in Maidstone - one of these latter from unlocated site of "Grain Pit"	SRPP 2, M5.04	F-Spot	570170	173450	E
4055	P-91	Head - valley-side spread	3-eq, 6-eq	MWX20863	Two Palaeolithic handaxes, and two pieces of debitage, surface finds near Treadwell's Farm [= New Barn Farm] - Stopes Collection	-	F-Spot	561240	173440	E

LTC list	FWS proxy	Geo attribution	PQ zone	HER MonUID	Site name	SR/ER PP, map.site	Rec - Type	NGR-E	NGR-N	Acc
4056	P-53	Head/T?	-	MWX20867	Four handaxes in Stopes Collection from Higham, "Odgers Street" - site not located, grid reference given for general spot on higher ground between Chequers Street and Higham [aka Church Street in early 20th C]	SRPP 2, M5.04b	F-Spot	571600	173200	G
4057	P-93	BH(Ebbs)	2	MWX20876	More than 30 Palaeolithic handaxes (and also several flake-tools and >100 debitage) from fluvial (palaeo-Ebbsfleet) gravel capping the sequence at the HS1 Southfleet Road "Ebbsfleet elephant" site	-	Mon	561175	173260	A
4058	P-94	Head - CR	-	MWX20959	Baker's Hole Palaeolithic (Levallois) site (Southfleet Pit, NW corner), Ebbsfleet valley - Levallois cores, flakes and waste debitage, with associated mammalian remains (mammoth, horse, red deer and rhinoceros)	SRPP 2, NWK5.5	Mon/PE	561425	173875	A

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Annex F Depositional environments, sediments and archaeological remains

Annex F.

Depositional environments, sediments and archaeological remains

ENVIRONMENT ZONE	ENVIRONMENT OF DEPOSITION	DOMINANT GRAIN SIZES	STRATIGRAPHIC CHARACTERISTICS	ORGANIC CONTENT	ARCHAEOLOGICAL STATUS
DEEP GRAVEL BED BRAIDED RIVER (DONJEK TYPE)[1]	Gravel bar (GB)	Gravel	Massive, matrix supported gravel (Gm) becoming horizontally crude bedded with planar cross-bedded (Gp) and trough cross-bedded (Gt) gravels.	Low – rare reworked bones and shells.	Mostly reworked
	Sandy bed (SB)	Sand and Gavel	Solitary or grouped trough cross-beds (St) and planar cross-beds (Sp), ripple cross laminae (Sr), horizontal cross laminae (Sh), low-angle cross-beds (Sl) and broad, shallow scours (Ss).	Low – rare reworked bones and shells.	Mostly reworked
	Floodplain floor (FF)	Sand, Silt, Clay	Massive with desiccation cracks (Fm) and fine laminated with very small ripples (Fl).		Larger elements may be *in situ*, smaller elements may be reworked
MEANDERING RIVER[2]	Active channel	Coarse gravels	Indistinct bedding but imbrication of pebbles and cobbles is common (Gh, Gt, Gp) - deposits are thin and discontinuous.	Low - occasional waterlogged plan remains.	Mostly reworked
	Point bars	Sands fine upwards along bar to silts	Large-scale trough cross-bedded coarse sands (St) in lower part of the bar to small-scale trough cross-beds higher on the bar, cross-beds show dip in downstream direction. Plane bed parallel laminae (Sh) may also be present.	Low- occasional waterlogged plant remains and isolated faunal elements.	Mostly reworked
	Natural levees	Fine sands and silts	Ripple and horizontally stratified units (Fl) overlain by laminates formed on the concave or steep-bank side of the meander loop adjacent to channel. Deposits are thickest and coarsest nearest to channel	Low to moderate and may include organic plant material.	Larger elements may be *in situ*, smaller elements may be reworked.
	Floodplains	Fine sands, silts and clays	Fine laminations and ripple structures (Fl) to massive with desiccation cracks (Fm).	Considerable plant debris, faunal remains and showing considerable signs of bioturbation.	Larger elements may be *in situ*, smaller elements may be reworked.
	Abandoned cut-	Fine silt and clay	Commonly well laminated with small	Plant remains, molluscs and other	Larger elements may be *in situ*,

[1] Based on Miall 1996

[2] Based on Walker and Cant 1984

	offs		ripples (Fl) to massive (Fsm) with desiccation cracks (Fm).	faunal elements common.	smaller elements may be reworked.
TIDE DOMINATED ESTUARY[3]	Elongated tidal sand bar zone (Marine dominated zone)	Sand	Cross bedded sand bars seaward of the tidal-energy maximum.	Faunal remains and extensive bioturbation.	Mostly reworked.
	Upper flow regime sand flats (Marine dominated zone)	Sand	Braided channel patterns becoming confined to a single channel headwards.	Faunal remains and extensive bioturbation.	Mostly reworked, occasional *in situ* elements.
	Straight-meandering-Straight (mixed zone)	Sands and silts	Bank attached bars and some mid-channel bars, meanders exhibit symmetrical point bars.	Faunal remains may be extensive with common bioturbation.	Mostly reworked but local *in situ* material possible.
SALTMARSH	Supratidal zone	Silts and clays	Fine laminated beds.	Bioturbation common, plant remains present becoming peat in places.	Larger elements may be *in situ*, smaller elements may be reworked.
	Intertidal zone	Sands, silts	Small scale ripple cross-stratification and dune bedforms in channels, lenticular, wavy and flaser bedding common. Alternating thin sand and silt beds change higher up to silt with thin sand beds.		Mostly reworked but some *in situ.*
	Subtidal zone	Sands	Lateral accretion in tidal channels and point bars characterized by dunes and internal cross-bedding showing bimodal directions of forset dip. Mud drapes also present.		Mostly reworked.

[3] Based on Dalrymple *et al*. 1992

Annex G Matrix and criteria for assessment of Palaeolithic potential

Annex G.

Matrix and criteria for assessment of Palaeolithic potential

Categories for *likelihood* and *importance* of Palaeolithic remains

Attribution	*Likelihood*	*Importance*
VERY HIGH	Certain knowledge of Pleistocene deposits with lithic or palaeo-environmental remains	Internationally important remains: undisturbed or minimally-disturbed remains; abundant remains from deposits of good stratigraphic and chronological integrity, with biological associations and lithostratigraphic relationships
HIGH	High likelihood of Pleistocene deposits with lithic or palaeo-environmental remains	Nationally important remains: undisturbed or minimally disturbed concentrations; deposits with abundant remains (artefactual and/or faunal); important lithostratigraphic sequences and relationships
MEDIUM	Reasonable likelihood of deposits with remains	Assets that contribute to regional research objectives: less abundant and disturbed artefactual and/or faunal remains from units of reasonable stratigraphic and chronological integrity; deposits with moderately valuable lithostratigraphic sequences and relationships
LOW	Remains are known to occur, but rare	Disturbed and poorly preserved remains from deposits of low stratigraphic and chronological integrity; deposits with minimal lithostratigraphic sequences and relationships
NEGLIGIBLE	Deposits with remains very unlikely to occur	Any remains found will be residual and reworked; assets with little or no potential to contribute to research objectives
UNKNOWN	Insufficient information on which to assess likelihood	Insufficient information on which to assess importance

Table G-1. Criteria for categories for *likelihood* and *importance* of Palaeolithic remains, mapped onto levels of importance in relation to international, national and regional research frameworks as defined in the EIA Scoping Report (Table 7-3, p87).

Assessment of Palaeolithic potential

Palaeolithic potential	*Likelihood*	*Likely importance*
VERY HIGH	Very high	High
	High	Very high
HIGH	High	High, Medium
	Medium	High, Very high
MEDIUM	High	Low
	Medium	Medium
	Low	Very high, High
LOW	Medium	Low
	Low	Medium
	Negligible	Very high, High, Medium,
NEGLIGIBLE	Medium	Negligible
	Low, Negligible	Low, Negligible
UNKNOWN	Unknown	High, Medium, low or Negligible
	High, Medium, low or Negligible	Unknown

Table G-2. Matrix for assessment of Palaeolithic potential, combining categories of *Likelihood* and *Importance* as defined in Table G-1 above.

Annex H Palaeolithic-Quaternary (PQ) ones: tabular summaries

Contents

Annex H.

Palaeolithic-Quaternary (PQ) zones: tabular summaries

Contents:

H.1. Introductory tables

Zone	PQ-no. Name of PQ zone
- Topography/ geomorphology **- Bedrock geology**	- Summary description of topography (including ground surface elevation) and geomorphology - Solid (pre-Quaternary) bedrock geology
Sediment sequences	Summary description of Quaternary sediment sequences
Geological interpretation	Current geological interpretation, including presumed depositional process and stratigraphic attribution (for instance to a particular Lower Thames terrace or gravel body)
Palaeoenvironmental potential	Review of palaeo-environmental potential, so far as known
Palaeolithic remains	Review of Palaeolithic artefact finds from zone, and potential based on recoveries from similar deposits, with specific sites referenced to LTC cultural effects list (**Annex E**)
Pal./geo-arch. assessment	One of three categories: UNCERTAIN, MODERATE-HIGH, or LOW-MODERATE (see criteria below, **Table H-2**)
Stage 1 mitigation priorities	Key priorities to address in stage 1 Palaeolithic/geo-archaeological fieldwork
Key reference/s	Most important sources for up-to-date information on zone

Table H-1. Explanation of PQ zone summary table entries.

Pal./geo-arch. assessment	*Criteria, explanation*
UNCERTAIN	Too little primary information on Quaternary sequence for an informed assessment to be made; requires stage 1 Palaeolithic/geo-archaeological fieldwork to gather more information, before assessing whether and what further work for stage 2
MODERATE-HIGH	Likely to contain sites with Medium-Very High Palaeolithic potential (see **Annex G** for criteria for Palaeolithic potential); requires stage 1 fieldwork to clarify distribution and potential of key deposits, followed by further work in stages 2 and 3, scope to be determined in light of the stage 1 and 2 results respectively
LOW-MODERATE	Likely to contain sites with Negligible-Medium Palaeolithic potential (see **Annex G** for criteria for Palaeolithic potential); scope of stage 1 fieldwork to be specified zone-by-zone, and then need for (or scope of) further work in stage 2 tbc in light of stage 1 results

Table H-2. Categories of Palaeolithic/geo-archaeological assessment for PQ zones.

H.2. Palaeolithic-Quaternary zones, PQ-1 to PQ-29 (including PQ-12a,b, PQ-20a,b,c, PQ-22a,b and PQ-23a,b)

Zone	PQ-1 Ebbsfleet Valley, HS 1 Car Park
- Topography/ geomorphology **- Bedrock geology**	- Low-lying flat ground on west side of Ebbsfleet river, below 20m O.D. - Lewes Nodular Chalk Formation, Seaford Chalk Formation and Newhaven Chalk Formation
Sediment sequences	Made ground onto Chalk/backfilled quarry. This zone is a previously-excavated quarry.
Geological interpretation	Industrial activity and backfilling of old quarry
Palaeoenvironmental potential	None - numerous important finds pre-quarrying, in particular Pleistocene megafauna such as mammoth and woolly rhinoceros, but all Quaternary sediments thought to be gone
Palaeolithic remains	Numerous important finds pre-quarrying, in particular the Baker's Hole Levallois site (LTC 4058), but all Quaternary sediments thought to be gone in LTC consultation footprint
Pal./geo-arch. assessment	LOW-MODERATE
Stage 1 mitigation priorities	NA - this zone is now outside the latest iteration of the project footprint
Key reference/s	Wenban-Smith, 1995

Zone	PQ-2 Ebbsfleet Valley (west), to north of HS1 elephant site
- Topography/ geomorphology **- Bedrock geology**	- Valley-side on west of Ebbsfleet river. Elevation between 20m and 25m O.D. - Thanet Formation
Sediment sequences	Brickearth (probably colluvium) overlying fluvial gravels of palaeo-Ebbsfleet river and, maybe in places, fine-grained sediments containing faunal remains and Palaeolithic archaeology
Geological interpretation	Sequence of sediments associated with the palaeo-Ebbsfleet as previously recorded at the Southfleet Road Elephant site. Probably belonging to MIS 11. Mixture of *in situ* and reworked artefacts and faunal remains depending on context of deposition.
Palaeoenvironmental potential	High if elements of fine-grained sediments exist in the area; large/small mammals, molluscs, ostracods and pollen all potentially present.
Palaeolithic remains	Numerous important remains have been found in and beside this area, from deposits likely to extend into it; key sites are the undisturbed HS1 elephant site (LTC 4043), handaxes from palaeo-Ebbsfleet gravels (LTC 4057), handaxes and flakes from the brickearth (LTC 3452, 4049), and palaeo-environmental remains from fluvial/lacustrine sediments (LTC 4046, 4047)
Pal./geo-arch. assessment	UNCERTAIN
Stage 1 mitigation priorities	NA - this zone is now outside the latest iteration of the project footprint
Key reference/s	Wenban-Smith, 2013 (Chapter 21)

Zone	PQ-3 Ebbsfleet Valley (upland catchment)
- Topography/ geomorphology **- Bedrock geology**	- Upland catchment of both tributaries of the Ebbsfleet river. Valleys trend parallel to zone and cut across zone at 90° Ground surface elevation between 25m and >65m O.D. - Lewes Nodular Chalk Formation, Seaford Chalk Formation, Newhaven Chalk Formation and Thanet Formation.
Sediment sequences	Valley sides and plateau surfaces devoid of sediments although thin discontinuous spreads of superficial sediments less than 1m may exist. Valley base contains Head/Colluvial deposits. Sequences in valley base may be consist of course, poorly sorted flint gravels as well as finer grained clay-silts. Potential exists for the presence of buried soils in the sequences.
Geological interpretation	Cold climate solifluction processes resulting in deposition of Head, probably in late Pleistocene (<20ka B.P.) but earlier phases of slope wash and solifluction may be locally present. Colluviation in late Holocene following deforestation of Chalk from Neolithic/Bronze Age. Any artefacts and faunal remains likely to be reworked although colluvium may contain elements of in situ faunas.
Palaeoenvironmental potential	Low although colluvium may contain molluscan remains
Palaeolithic remains	Three Palaeolithic findspots within this area (LTC 1661, 2368, 3197), the former probably representing an undisturbed palaeo-landsurface under older pre-Devensian colluvium on which was found a handaxe and knapping debitage. Other nearby remains from outside the area, but from deposit-types likely to be present in the area, include minimally disturbed Late Upper Palaeolithic knapping scatters (LTC 2370, 4045) from fine-grained colluvial sediments infilling dry valleys, as well as various more-derived lithic finds (LTC 3197, 3370).
Pal./geo-arch. assessment	UNCERTAIN
Stage 1 mitigation priorities	LTC 1661 is a rare type of site, associated with an unmapped spread of Pleistocene colluvium. LTC 4045 is likewise a rare site-type, although associated with mapped dry valley deposits. It is worth doing some preliminary evaluation test pitting to (a) evaluate whether other Lower/Middle Palaeolithic sites are present in this zone in similar topographic locations to LTC 1661, and (b) to evaluate for pre-Last-Glacial-Maximum sequences (including pre-Devensian), and for Late Upper Palaeolithic occupation associated with dry valley colluvial infill.
Key reference/s	Wenban-Smith and Bates, 2011; CgMs/MOLA 2015

Zone	PQ-4 Shorne Woods Plateau
- Topography/ geomorphology **- Bedrock geology**	- This area forms an interfluve between the Thames and Medway catchment at the present day. Ground surface elevations vary from 75m to at least 120m O.D. Small dry valleys exist and have their origin in the plateau area. - Lambeth Group, Harwich Formation and London Clay Formation
Sediment sequences	Narrow strips of Head deposits likely to consist of gravels and clay/silt/sands, some possible colluvium may also be present filling the heads of the dry valleys. Thin discontinuous spreads of superficial sediments (?Head) less than 1m thick may exist across parts of the area infilling depressions in plateau, and higher points may have an upper degraded zone of pre-Quaternary bedrock which may contain residual Palaeolithic material.
Geological interpretation	Topographic high forming the source of a number of small dry valleys. Sediments from solifluction and colluviation present ranging from ?Late Devensian to Holocene. Any artefacts and faunal remains likely to be reworked.
Palaeoenvironmental potential	Low
Palaeolithic remains	None reliably known from within zone, but finds of a handaxe and Levallois flakes from general Shorne area (LTC 3374) and two handaxes from the analogous high point of Windmill Hill, Gravesend (LTC 4051)
Pal./geo-arch. assessment	LOW-MODERATE
Stage 1 mitigation priorities	Is there residual Lower/Middle Palaeolithic material on the high ground?
Key reference/s	Wenban-Smith and Bates, 2011

Zone	PQ-5 Jeskyns shelf
- Topography/ geomorphology **- Bedrock geology**	- High-ground plateau edge west of PQ-4. Ground surface elevations between 85m and 100m O.D. at the head of dry valleys trending into both the Thames and Medway. - Lewes Nodular Chalk Formation, Seaford Chalk Formation, Newhaven Chalk Formation and Thanet Formation.
Sediment sequences	Head deposits consisting of gravels with sand/silt/clay distributed in widespread valley features.
Geological interpretation	Cold climate Late Pleistocene slopewash (Head) in dry valleys, and possibly some accumulations of Middle Pleistocene colluvium. Any artefacts and faunal remains most-likely to be reworked, although less-disturbed material may be preserved in localised infilled sub-horizontal depressions.
Palaeoenvironmental potential	Low
Palaeolithic remains	Several records of surface finds of Lower/Middle Palaeolithic artefacts from general area (LTC 4035, 4039, 4050), as well as nearby discovery of handaxe and debitage from palaeo-landsurface under unmapped colluvium (LTC 1661)
Pal./geo-arch. assessment	UNCERTAIN
Stage 1 mitigation priorities	Basic characterisation of sequences - is there evidence for pre-Devensian colluvial deposits in the area, do they contain Palaeolithic remains of any type, and are there any artefacts less-disturbed than in dry valley fill deposits.
Key reference/s	Wenban-Smith and Bates, 2011

Zone	PQ-6 Thong Lane
- Topography/ geomorphology **- Bedrock geology**	- Dip slope of North Downs (Thames valley) with a series of dry valleys with ground surface elevations between 35m and 80m O.D. - Lewes Nodular Chalk Formation, Seaford Chalk Formation, Newhaven Chalk Formation and Thanet Formation and localised outcrops of Lambeth Group and Harwich Formation
Sediment sequences	Valley sides and plateau surfaces devoid of sediments although unmapped spreads of superficial colluvial sediments may exist. Valley base contains Head/Colluvial deposits. Sequences in valley base may be consist of course, poorly sorted flint gravels as well as finer grained clay-silts. Potential exists for the presence of buried soils and undisturbed palaeo-landsurfaces in the sequences.
Geological interpretation	Cold climate solifluction processes resulting in deposition of Head, probably in late Pleistocene (<20ka B.P.) but earlier phases of slopewash and solifluction may be locally present, especially on level parts of higher ground in southern part of zone. Colluviation in lower parts of dry valleys in late Holocene following deforestation of Chalk from Neolithic/Bronze Age. Any artefacts and faunal remains likely to be reworked although colluvium may contain elements of in situ material.
Palaeoenvironmental potential	Low although colluvium may contain molluscan remains
Palaeolithic remains	One reworked Palaeolithic findspot within this area (LTC 3123). Some important nearby finds from deposit-types likely to occur in this zone, notably a handaxe and knapping debitage from unmapped colluvium (LTC 1661), and minimally disturbed Late Upper Palaeolithic knapping scatters (LTC 2370, 4045) from fine-grained colluvial sediments infilling dry valleys, as well as several nearby finds of most-likely residual/re-worked material (LTC 3197, 4035, 4039, 4055).
Pal./geo-arch. assessment	LOW-MODERATE
Stage 1 mitigation priorities	Is there evidence for pre-Devensian colluvial deposits in the area, do they contain Palaeolithic remains of any type, and is there evidence for Late Upper Palaeolithic occupation associated with dry valley colluvium?
Key reference/s	Wenban-Smith and Bates, 2011

Zone	PQ-7 Filborough
- Topography/ geomorphology **- Bedrock geology**	- Lower part of dip slope of North Downs. Ground surface elevations 5-15m O.D., immediately above floodplain of the Thames. Series of small dry valleys running south/north through area. - Lewes Nodular Chalk Formation, Seaford Chalk Formation, Newhaven Chalk Formation and Thanet Formation
Sediment sequences	Consists of a series of fluvial bodies of sand and gravel as well as Head deposits. Head sequences in valley base may be consist of course, poorly sorted flint gravels as well as finer grained clay-silts. Fluvial deposits likely to consist of basal gravels overlain by finer grained sands/silt and capped by gravel (fluvial or Head).
Geological interpretation	BGS mapping (Dartford) indicates two terraces present as Lynch Hill (Corbets Tey Gravel) and Taplow Terraces (Mucking Gravel). Only place in study area where two (possibly three, see PQ-8) terraces occur in close proximity to each other. Mixture of in situ and reworked artefacts and faunal remains depending on context of deposition.
Palaeoenvironmental potential	Moderate
Palaeolithic remains	Several Lower/Middle Palaeolithic artefacts known from nearby area (LTC 4052, 4054), and some specifically from gravel deposits that are likely equivalent to the mapped terrace deposits of this zone (LTC 4053)
Pal./geo-arch. assessment	MODERATE-HIGH
Stage 1 mitigation priorities	Test pits/boreholes to investigate whether the different mapped terraces are really there? What is the nature of the sedimentary sequences in the different terraces? Are there artefacts, faunal remains and/or materials for dating present?
Key reference/s	Gibbard, 1994

Zone	PQ-8 Thames, southern floodplain edge
- Topography/ geomorphology **- Bedrock geology**	- Margins of floodplain of the modern Thames with ground surface below 5m O.D. Modern floodplain reclaimed from former saltmarsh. - Lewes Nodular Chalk Formation, Seaford Chalk Formation, Newhaven Chalk Formation and Thanet Formation
Sediment sequences	Holocene alluvial sediments consisting of clay/silts and sands with some intercalated peats resting on a series of sandy clay-silts intercalated between flint rich gravels between -5m and -20m O.D. Important buried landsurface likely to be developed at the base of the Holocene sediments.
Geological interpretation	Holocene alluvium from Mid-Late Holocene overlying a buried landsurface. Sediments beneath the Holocene (i.e. below -5m O.D.) likely to be Pleistocene in age and probably form part of the East Tilbury Marshes Gravel. The fine-grained sediments within the ETMG may be brackish water/estuarine. Range of depositional context in the Holocene indicate in situ and reworked artefacts may occur. Surface of the ETMG may represent a long-developed surface on which in situ material of Late Pleistocene/Early Holocene age may occur. Artefacts unlikely in ETMG due to estuarine context and apparent absence of hominids in MIS 5e. However, unmapped Devensian deposits may be present.
Palaeoenvironmental potential	Moderate-high
Palaeolithic remains	Late Upper Palaeolithic remains known from base of alluvium at several sites along southern side of Thames floodplain (eg. LTC 3406). Also, nearby records of Mousterian *bout coupé* handaxes from Tilbury (LTC 4028) suggest there may be unrecognised deposits/remains of this era in places
Pal./geo-arch. assessment	MODERATE-HIGH
Stage 1 mitigation priorities	Boreholes and test pits to address what are the nature and age of the sub-alluvial Pleistocene sediments in the zone, and do they have any Palaeolithic remains? What is the nature of the surface of the Pleistocene sediments, and what, if any archaeology rests on this surface? When did Holocene sedimentation being, and are there Holocene archaeological remains in the alluvium?
Key reference/s	Bates and Stafford, 2013

Zone	PQ-9 Thames, main floodplain
- Topography/ geomorphology **- Bedrock geology**	- Main part of floodplain of the modern Thames with ground surface below 5m O.D. Modern floodplain reclaimed from former saltmarsh. - Lewes Nodular Chalk Formation, Seaford Chalk Formation, Newhaven Chalk Formation.
Sediment sequences	Thick intercalated sequences of peats, clay/silts and occasional sands(3m to -15m O.D.) resting on coarse flint gravels (-15m to -20m O.D.).
Geological interpretation	Holocene alluvium from Early-Late Holocene overlying a buried landsurface. Sediments beneath the Holocene (i.e. below -15m O.D.) likely to be Pleistocene in age and probably form part of the Shepperton Gravel of Late Devensian age. Range of depositional context in the Holocene indicate in situ and reworked artefacts may occur. Surface of the Shepperton Gravel may represent the late Devensian/early Holocene surface on which in situ material of Late Pleistocene/Early Holocene age may occur. Artefacts unlikely in Shepperton Gravel and likely to be reworked if present.
Palaeoenvironmental potential	High in Holocene deposits, low in underlying Pleistocene gravels
Palaeolithic remains	Late Upper Palaeolithic remains known from base of alluvium at several sites along southern side of Thames floodplain (eg. LTC 3406). Also, nearby records of Mousterian *bout coupé* handaxes from Tilbury (LTC 4028) suggest there may be unrecognised deposits/remains of this era in places, although most Palaeolithic remains are most-likely derived and transported (LTC 4036).
Pal./geo-arch. assessment	LOW-MODERATE
Stage 1 mitigation priorities	Are the sands seen on the northern side of the zone Holocene or Pleistocene (i.e. the equivalent of those in PQ-8)? When did sedimentation being across the surface of the Shepperton Gravels?
Key reference/s	Bates and Stafford, 2013

Zone	PQ-10 Thames, northern floodplain edge
- Topography/ geomorphology **- Bedrock geology**	- Margins of floodplain of the modern Thames with ground surface below 5m O.D. Modern floodplain reclaimed from former saltmarsh. - Lewes Nodular Chalk Formation, Seaford Chalk Formation, Newhaven Chalk Formation
Sediment sequences	Holocene alluvial sediments consisting of clay/silts and sands with some intercalated peats resting on a series of sands between 0m and -12m O.D. Important buried landsurface likely to be developed at the base of the Holocene sediments
Geological interpretation	Holocene alluvium from Mid-Late Holocene overlying a buried landsurface. Sediments (sands) beneath the Holocene (i.e. below 0m O.D.) may be Pleistocene in age and probably form part of the East Tilbury Marshes Gravel or major Holocene sand bars. Range of depositional context in the Holocene indicate in situ and reworked artefacts may occur. Surface of the ETMG (if present) may represent a long-developed surface on which in situ material of Late Pleistocene/Early Holocene age may occur. Artefacts unlikely in ETMG due to estuarine context and apparent absence of hominids in MIS 5e. However, unmapped Devensian deposits may be present.
Palaeoenvironmental potential	Moderate-high
Palaeolithic remains	Late Upper Palaeolithic remains known from base of alluvium at several sites along southern side of Thames floodplain (eg. LTC 3406). Also, nearby records of Mousterian *bout coupé* handaxes from Tilbury (LTC 4028) and another ovate from Tilbury dock enlargement (LTC 4029) suggest there may be unrecognised deposits/remains of this era in places, although most finds from the floodplain and its margins are probably residual/transported (LTC 430, 466, 4036).
Pal./geo-arch. assessment	MODERATE-HIGH
Stage 1 mitigation priorities	Boreholes and test pits to address what are the nature and age of the sub-alluvial Pleistocene sediments in the zone, and do they have any Palaeolithic remains? What is the nature of the surface of the Pleistocene sediments, and what, if any archaeology rests on this surface? When did Holocene sedimentation being, and are there Holocene archaeological remains in the alluvium?
Key reference/s	Bates and Stafford, 2013

Zone	PQ-11 Goshems Farm
- Topography/ geomorphology **- Bedrock geology**	- Small topographic high on edge of floodplain with elevations between 5m and 15m O.D. - Lewes Nodular Chalk Formation, Seaford Chalk Formation, Newhaven Chalk Formation and Thanet Formation
Sediment sequences	Sands and gravels between 6m and 10m O.D. (ground surface level mostly 12-15m Od) resting on Thanet Formation
Geological interpretation	Mostly an outcrop of the Corbets Tey Gravel (= Lynch Hill Terrace, dating to MIS 10-8) as an isolated remnant with younger Pleistocene sediments on all sides, and a small spread at lower elevation forming the southeast part of this zone may represent the younger Taplow Terrace (Mucking Gravel).
Palaeoenvironmental potential	Low? None known here, although deposits of this age have produced faunal and other palaeo-environmental remains at various nearby locations
Palaeolithic remains	One findspot from within this zone, a handaxe found on the marsh surface at its southeast corner (LTC 441); its origin uncertain, although it may well have derived from the terrace deposits that dominate this zone. Other nearby terrace deposits of the same age have produced abundant material in places, so this outcrop has some Palaeolithic potential.
Pal./geo-arch. assessment	LOW-MODERATE
Stage 1 mitigation priorities	Normal Qs for Pleistocene terrace deposits: what is presence/prevalence of artefactual remains? What is presence/quality/range of biological remains? What is the age of the deposits?
Key reference/s	BGS mapping; Bridgland 1983 (Ch 4; vol 2: p45)

Zone	PQ-12a Shearwater Avenue
- Topography/ geomorphology **- Bedrock geology**	- Low lying terrace surface with elevations between 5 and 10m O.D. - Thanet Formation
Sediment sequences	Sands and gravels outcropping between -2m and 4m O.D. with a single exception of a higher subcrop of sand and gravel at 7m to 9m O.D. at northwestern end of zone
Geological interpretation	Fluvial sediments of the Taplow/Mucking Gravel with a possible outcrop of Corbets Tey Gravel at the northwestern end. It is possible that the BGS mapping here has missed a local outcrop of the older terrace. The inside part of the Mucking Gravel is likely to be preserved in this zone where sequences may be more complete than usual.
Palaeoenvironmental potential	Low
Palaeolithic remains	There are moderately-common Lower/Middle Palaeolithic handaxes and debitage found in the late 19th century from unspecified gravel pits in the West Tilbury and Mucking area (LTC 464, 4034)
Pal./geo-arch. assessment	LOW-MODERATE
Stage 1 mitigation priorities	- Normal Qs for Pleistocene terrace deposits: what is presence/prevalence of artefactual remains? What is presence/quality/range of biological remains? What is the age of the deposits? - Also: is the BGS mapping wrong in the northwestern part of the zone? What is the nature of the sequences in the northwestern part of the zone? Is there any material for dating sequences here?
Key reference/s	BGS mapping

Zone	PQ-12b Sutton's Farm
- Topography/ geomorphology **- Bedrock geology**	- Low lying terrace surface with elevations between 5 and 10m O.D. - Thanet Formation
Sediment sequences	Sands and gravels outcropping between -2m and 4m O.D.
Geological interpretation	Fluvial sediments of the Mucking Gravel
Palaeoenvironmental potential	Low
Palaeolithic remains	There are moderately-common Lower/Middle Palaeolithic handaxes and debitage found in the late 19th century from unspecified gravel pits in the West Tilbury and Mucking area (LTC 464, 4034)
Pal./geo-arch. assessment	LOW-MODERATE
Stage 1 mitigation priorities	Normal Qs for Pleistocene terrace deposits: what is presence/prevalence of artefactual remains? What is presence/quality/range of biological remains? What is the age of the deposits?
Key reference/s	BGS mapping

Zone	PQ-13 Chadwell Saint Mary
- Topography/ geomorphology **- Bedrock geology**	- Broadly-horizontal terrace surface with elevations between 20m and >25m O.D, dissected by surface run-off valleys in places around periphery. - Thanet Formation and Lambeth Group.
Sediment sequences	Sands and gravels with outcrops between 20m and 25m O.D.
Geological interpretation	Orsett Heath Gravel (mapped as Boyn Hill Terrace by BGS) with valley-side edge of the floodplain potentially preserved along the northwest side of this zone; however this valley-side zone may have been removed by the cutting of the valley associated with PQ-15
Palaeoenvironmental potential	No faunal remains known, although should not be ruled out bearing in mind abundant palaeo-environmental remains from nearby Lynch Hill deposits.
Palaeolithic remains	Numerous records of well-provenanced handaxe and debitage finds from the Boyn Hill/Orsett Heath deposits in this zone (LTC 414, 468, 4018) and around it (503, 4017), as well as further afield (LTC 427, 2119, 4030, 4031).
Pal./geo-arch. assessment	MODERATE-HIGH
Stage 1 mitigation priorities	- Some investigations to characterise sequence in area lacking information in central and south-eastern part of zone, as well as in parts of zone near known Palaeolithic sites. - And, normal Qs for Pleistocene terrace deposits: what is presence/prevalence of artefactual remains? What is presence/quality/range of biological remains? What is the age of the deposits?
Key reference/s	BGS mapping, English Rivers Palaeolithic Survey (Wessex Archaeology 1996)

Zone	PQ-14 Southfields
- Topography/ geomorphology **- Bedrock geology**	- Topographic high, with elevations from 20m to 35m O.D. - Lambeth Group and Thanet Formation
Sediment sequences	Sands and gravels with some superficial clays and silts with subcrops from 25m to >30m O.D.
Geological interpretation	BGS mapping attributes this zone to the Black Park Terrace, while Gibbard records essentially the same as Dartford Heath Gravel. By contrast Bridgland describes this as Orsett Heath Gravel. It is noted that elevations of the sediments here are considerably above the Orsett Heath Gravel in PQ-13. Head deposits are also present in small valley systems cut into the Black Park Gravel.
Palaeoenvironmental potential	Low
Palaeolithic remains	One wouldn’t normally expect Palaeolithic remains associated with the (presumed Late Anglian) Black Park Gravel, although palaeo-landsurfaces with undisturbed remains have been found on its surface on the south side of the Thames, in Dartford, and Ebbsfleet (LTC 4044), where the surviving outcrops are overlooked by higher ground that provided a source for colluvial slopewash to over-ride Palaeolithic remains (not the case in this zone). There is one record near to this zone (LTC 328), of rolled possibly-Palaeolithic artefacts from Late Prehistoric and Saxon excavations at Mucking.
Pal./geo-arch. assessment	LOW-MODERATE
Stage 1 mitigation priorities	What is the age of these deposits? Are they equivalent to the Orsett Heath Gravel? And other normal Qs for Pleistocene terrace deposits: what is presence/prevalence of artefactual remains? What is presence/quality/range of biological remains?
Key reference/s	Gibbard, 1994. Bridgland, 1994

Zone	PQ-15 Brook Farm Channel
- Topography/ geomorphology **- Bedrock geology**	- A valley-like landform running from northwest to southeast between the southeast side of the Mar Dyke valley and the northwest side of the main Thames estuary. It has a central high of around 30m O.D. dropping to less that 20m O.D. to the northwest and 10m O.D. to the southeast. - Lambeth Group and Thanet Formation
Sediment sequences	No ground-truthed information; probably infilled with a mixture of poorly-sorted flint gravel mixed with clay/silt/sand.
Geological interpretation	Head filling narrow 'valley-like' feature running northwest to southeast connecting the Mar Dyke basin with the main Thames - a possible Pleistocene drainage exit from the Mar Dyke?
Palaeoenvironmental potential	Low
Palaeolithic remains	None known associated with this zone.
Pal./geo-arch. assessment	UNCERTAIN
Stage 1 mitigation priorities	Boreholes/test pits to characterise sequence and investigate for artefactual and/or palaeoenvironmental remains
Key reference/s	BGS mapping

Zone	PQ-16 Loft Hall Farm
- Topography/ geomorphology **- Bedrock geology**	- Mar Dyke southwest side, valley-side situation with slopes dipping northwards into Mar Dyke with ground surface elevations of around 30m O.D, abutting north side of Black Park Gravel high that forms zone PQ-14. - Lambeth Group
Sediment sequences	None recorded above bedrock
Geological interpretation	Nothing above bedrock (Lambeth Group)
Palaeoenvironmental potential	Low
Palaeolithic remains	There is one surface find of a handaxe from Saffron Garden Farm (LTC 2079), a little to the northeast of this zone, and possibly derived from the Black Park Gravel (BPG), or residual evidence of post-BPG activity in the area.
Pal./geo-arch. assessment	LOW-MODERATE
Stage 1 mitigation priorities	Ascertain whether any Quaternary sediments present, and if so what is their distribution, and if they have any Palaeolithic potential
Key reference/s	BGS mapping

Zone	PQ-17 Cuckoo Lane
- Topography/ geomorphology **- Bedrock geology**	- Above southern side of Mar Dyke, where it cuts through southern part of wide spread of Lynch Hill terrace deposits of the Ockendon Loop; ground slopes northward into Mar Dyke along minor south bank dry valley tributary, sloping down northward from c. 20m to 10m O.D. - Thanet Formation and Lambeth Group
Sediment sequences	Made-up modern ground mostly, although natural sediments may be closer to ground surface nearer the Mar Dyke channel
Geological interpretation	Corbets Tey Gravel (= BGS Lynch Hill Terrace) with elements of Head deposit infilling dry valley dissecting surface of terrace outcrop
Palaeoenvironmental potential	High (if terrace deposits encountered); boreholes record peaty deposits, and other nearby parts of the Lynch Hill Terrace have produced rich palaeoenvironmental remains
Palaeolithic remains	Moderate; none known from this specific locality, but equivalent deposits have produced good and minimally-disturbed remains, including fresh condition artefacts (LTC 181, 2182, 4014, 4020, 4021)
Pal./geo-arch. assessment	LOW-MODERATE
Stage 1 mitigation priorities	Ascertain whether any Quaternary sediments present, and if so what is their distribution, and if they have any Palaeolithic potential
Key reference/s	BGS mapping

Zone	PQ-18 Mederbridge Road (Ockendon Loop)
- Topography/ geomorphology **- Bedrock geology**	- Southeast margin of wide spread of Lynch Hill Gravel on northwest side of Mar Dyke, ground surface sloping down into Mar Dyke valley from 15m to 5m O.D. - Lambeth Group and London Clay Formation
Sediment sequences	Sand and gravels with peat, clay-silt and poorly-sorted coarse sandy gravels
Geological interpretation	Corbets Tey Gravel (= BGS Lynch Hill Terrace) with elements of Head deposit infilling dry valleys cut through Corbets Tey Gravel
Palaeoenvironmental potential	High; boreholes record peaty deposits, and other nearby parts of the Lynch Hill Terrace have produced rich palaeoenvironmental remains
Palaeolithic remains	Moderate/High; none known from this specific locality, but nearby equivalent deposits have produced good and minimally-disturbed remains, including fresh condition artefacts (LTC 181, 2182, 4014, 4020, 4021)
Pal./geo-arch. assessment	MODERATE-HIGH
Stage 1 mitigation priorities	Characterise sequence affected by LTC footprint, and investigate Palaeolithic and palaeo-environmental potential
Key reference/s	BGS mapping

Zone	PQ-19 Kemps Farm, Dennis Road and Manor Farm
- Topography/ geomorphology **- Bedrock geology**	- Terrace surface dipping form east to west from 20m to 15m O.D. - London Clay Formation
Sediment sequences	Sediment subcrop from 8m up to surface elevations of c.24m. Sequences consist of sands and gravels from 8m to 13m O.D. Overlain by organic sediments (including peat) thickening in a northwards direction. These sequences are in turn overlain by gravelly clays and sands.
Geological interpretation	Part of the Corbets Tey Gravel sequence (= BGS Lynch Hill Terrace) including sediments potentially belonging to the Belhus Organic Channel (Aveley Silts and Sands, *sensu* Gibbard, 1994). Zone covers an area from the middle of the terrace spread to its inner valley-side edge, where it abuts mapped outcrops of Boyn Hill Terrace (Orsett Heath Gravel) at its northern end.
Palaeoenvironmental potential	Very high; faunal and floral remains anticipated in these deposits.
Palaeolithic remains	High; nearby equivalent deposits have produced lithic artefacts in moderate abundance, including sharp finds thought to represent minimally-disturbed evidence of contemporary occupation (LTC 181, 2182, 4014, 4020, 4021)
Pal./geo-arch. assessment	MODERATE-HIGH
Stage 1 mitigation priorities	Bearing in mind the high potential of this zone, and the major impact upon it, some stage 1 investigations are recommended to establish how/if Palaeolithic and palaeoenvironmental potential vary within it, and to see if any areas of particularly high potential can be identified at an early stage
Key reference/s	Wenban-Smith et al., 2013; Gibbard, 1994

Zone	PQ-20a Green Lane, east side of Mar Dyke basin
- Topography/ geomorphology **- Bedrock geology**	- Above eastern side of the Mar Dyke basin with topography sloping down westwards from about 15m to 5m O.D. - London Clay Formation
Sediment sequences	Clay with sand and gravel
Geological interpretation	Spread of Head deposits, with occasional bedrock highs poking through
Palaeoenvironmental potential	Low
Palaeolithic remains	None known
Pal./geo-arch. assessment	LOW-MODERATE
Stage 1 mitigation priorities	Ascertain whether any Quaternary sediments present, and if so what is their distribution, and if they have any Palaeolithic potential
Key reference/s	BGS mapping

Zone	PQ-20b Castle's Grove, east side of Mar Dyke basin
- Topography/ geomorphology **- Bedrock geology**	- Above eastern side of the Mar Dyke basin with topography sloping down westwards from about 15m to 5m O.D. - London Clay Formation
Sediment sequences	Clay with sand and gravel
Geological interpretation	Spread of Head deposits, with occasional bedrock highs poking through
Palaeoenvironmental potential	Low
Palaeolithic remains	None known
Pal./geo-arch. assessment	LOW-MODERATE
Stage 1 mitigation priorities	Ascertain whether any Quaternary sediments present, and if so what is their distribution, and if they have any Palaeolithic potential
Key reference/s	BGS mapping

Zone	PQ-20c Bulphan, east side of Mar Dyke basin
- Topography/ geomorphology **- Bedrock geology**	- Above eastern side of the Mar Dyke basin with topography sloping down westwards from about 15m to 5m O.D. - London Clay Formation
Sediment sequences	Clay with sand and gravel
Geological interpretation	Spread of Head deposits, with occasional bedrock highs poking through
Palaeoenvironmental potential	Low
Palaeolithic remains	None known
Pal./geo-arch. assessment	LOW-MODERATE
Stage 1 mitigation priorities	Ascertain whether any Quaternary sediments present, and if so what is their distribution, and if they have any Palaeolithic potential
Key reference/s	BGS mapping

Zone	PQ-21 Mar Dyke narrows
- Topography/ geomorphology **- Bedrock geology**	- Narrow channel of Mar Dyke from inner basin south-westwards to main Thames floodplain - London Clay Formation
Sediment sequences	Silt/clay and peat
Geological interpretation	Holocene alluvium
Palaeoenvironmental potential	High
Palaeolithic remains	None known
Pal./geo-arch. assessment	UNCERTAIN
Stage 1 mitigation priorities	Characterise sequence, and evaluate palaeoenvironmental and archaeological potential. When did sedimentation begin in the Mar Dyke in the Holocene?
Key reference/s	BGS mapping

Zone	PQ-22a Mar Dyke Basin, main (Fen Farm)
- Topography/ geomorphology **- Bedrock geology**	- Main central part of the Mar Dyke basin with topography below 10m O.D. - London Clay Formation
Sediment sequences	Clay with sand and gravel
Geological interpretation	Alluvium or Head deposits on valley floor – potentially a mixture of both. Possible London Clay throughout
Palaeoenvironmental potential	Low
Palaeolithic remains	None known
Pal./geo-arch. assessment	UNCERTAIN
Stage 1 mitigation priorities	Characterise sequence, and evaluate palaeoenvironmental and archaeological potential. Where is the base of the alluvium, if present? Has the Mar Dyke infilled with Head in the past?
Key reference/s	Moorlock and Smith, 1991

Zone	PQ-22b Mar Dyke Basin, northwest (Puddle Dock)
- Topography/ geomorphology **- Bedrock geology**	- Northwest part of the main Mar Dyke basin with topography below 10m O.D. - London Clay Formation
Sediment sequences	Clay with sand and gravel
Geological interpretation	Alluvium or Head deposits on valley floor – potentially a mixture of both. Possible London Clay throughout
Palaeoenvironmental potential	Low
Palaeolithic remains	None known
Pal./geo-arch. assessment	UNCERTAIN
Stage 1 mitigation priorities	Characterise sequence, and evaluate palaeoenvironmental and archaeological potential. Where is the base of the alluvium, if present? Has the Mar Dyke infilled with Head in the past?
Key reference/s	Moorlock and Smith, 1991

Zone	PQ-23a Mar Dyke, eastern margin (Orsett Fen, Hobletts)
- Topography/ geomorphology **- Bedrock geology**	- Eastern margins of the Mar Dyke basin with small topographic highs in marshland. - London Clay Formation
Sediment sequences	Clay with sand and gravel surrounded by sands and silts?
Geological interpretation	Head deposits outcropping on bedrock that have been eroded by fluvial activity or cold climate downcutting.
Palaeoenvironmental potential	Low
Palaeolithic remains	None known
Pal./geo-arch. assessment	LOW-MODERATE
Stage 1 mitigation priorities	Characterise deposits, investigate presence and date of alluvial and/or colluvial deposition, evaluate archaeological and palaeoenvironmental potential
Key reference/s	BGS mapping

Zone	PQ-23b Mar Dyke, eastern margin (Stringcock Fen)
- Topography/ geomorphology **- Bedrock geology**	- Eastern margins of the Mar Dyke basin with small topographic highs in marshland. - London Clay Formation
Sediment sequences	Clay with sand and gravel surrounded by sands and silts?
Geological interpretation	Head deposits outcropping on bedrock that have been eroded by fluvial activity or cold climate downcutting.
Palaeoenvironmental potential	Low
Palaeolithic remains	None known
Pal./geo-arch. assessment	LOW-MODERATE
Stage 1 mitigation priorities	Characterise deposits, investigate presence and date of alluvial and/or colluvial deposition, evaluate archaeological and palaeoenvironmental potential
Key reference/s	BGS mapping

Zone	PQ-24 West side of Mar Dyke basin, east of South Ockendon Hall
- Topography/ geomorphology **- Bedrock geology**	- Western side of the Mar Dyke basin with topography sloping down eastwards from about 30m to 5m O.D. - London Clay Formation
Sediment sequences	Clay with sand and gravel
Geological interpretation	Spread of Head deposits, with occasional bedrock highs poking through
Palaeoenvironmental potential	Low
Palaeolithic remains	None known - NB, extensive quarrying for clay has provided no indication of any unmapped Pleistocene terrace deposits, nor produced any Palaeolithic finds
Pal./geo-arch. assessment	LOW-MODERATE
Stage 1 mitigation priorities	- To investigate for Quaternary sediments near east margin of zone, that continue sequences from zone PQ-22a - To investigate for glacial till or other glacigenic sediments in northwest part of zone, where abuts PQ-25
Key reference/s	Moorlock and Smith, 1991

Zone	PQ-25 Hall Farm
- Topography/ geomorphology **- Bedrock geology**	- Terrace shelf with ground-slope trending down from east to west from >30m to c. 20m O.D, and with higher ground above 25m OD in northern part of zone - London Clay Formation
Sediment sequences	Clay over laminated sands and silts with a basal gravel. Sediments outcrop between 16m and 24m O.D.
Geological interpretation	Main aggradation of the Orsett Heath Gravel (mapped by BGS as Boyn Hill Terrace). Inner edge of terrace preserved by the rising ground at east of zone, where abuts mapped outcrops of Black Park Gravel (PQ-26). This spread may include two distinct terraces, a more-northerly one with its surface >25m OD, and a southerly one with its surface >20m OD. Good potential for complete sequence records close to inner margin of terrace, which may clarify terrace attribution and mapping.
Palaeoenvironmental potential	Moderate to high. Shells occasionally reported from boreholes. Laminated sequences may suggest brackish water sediments potentially containing microfossils
Palaeolithic remains	Moderate potential; one handaxe record from this zone (LTC 4007), and numerous findspots from nearby zone of equivalent deposits at Chadwell St Mary (see PQ-13)
Pal./geo-arch. assessment	MODERATE-HIGH
Stage 1 mitigation priorities	Bearing in mind the moderate-high potential of this zone for both archaeological and palaeoenvironmental remains, and the major impact upon it, stage 1 investigations are recommended to establish how/if Palaeolithic and palaeoenvironmental potential vary within it, and to see if any areas of particularly high potential can be identified at an early stage
Key reference/s	BGS mapping; Wessex Archaeology 1996

Zone	PQ-26 White Post Farm
- Topography/ geomorphology **- Bedrock geology**	- Topographic high with elevations from 30m to >40m O.D. - London Clay Formation
Sediment sequences	Sands and gravels with some clays with outcrops from 25m to >35m O.D.
Geological interpretation	BGS mapping attributes this high ground to the Black Park Gravel terrace (while Gibbard attributes it as Dartford Heath Gravel, which he regards as the downstream equivalent of the Black Park Gravel). By contrast Bridgland appears to equate these outcrops with his Orsett Heath Gravel, although it isn't totally clear from the scale of his diagrams how his interpretations equate with the outcrops mapped by the BGS in this zone
Palaeoenvironmental potential	Low
Palaeolithic remains	None known. One wouldn't normally expect Palaeolithic remains associated with the (presumed Late Anglian) Black Park Gravel, although palaeo-landsurfaces with undisturbed remains have been found on its surface on the south side of the Thames, in Dartford, and Ebbsfleet (LTC 4044), where the surviving outcrops are overlooked by higher ground that provided a source for colluvial slopewash to over-ride Palaeolithic remains (not the case in this zone). However, the southeast edge of this zone abuts a spread mapped as Boyn Hill Gravel, which is of higher potential (see PQ-25), so some evaluation is worthwhile on both artefact recovery and geological framework grounds.
Pal./geo-arch. assessment	LOW-MODERATE
Stage 1 mitigation priorities	The LTC footprint crosses the east side of this zone, near its boundary with PQ-25. This is an area that might preserve the valley-side edge of the Boyn Hill Terrace abutting the truncated spread of Black Park Gravel. Investigating and, if present, recording this transition should be the priority for evaluation, as well as evaluating the presence/prevalence of any archaeological or palaeoenvironmental remains.
Key reference/s	Bridgland 1994: 176; Gibbard 1994: 3; BGS mapping

Zone	PQ-27 Mar Dyke, northern edge
- Topography/ geomorphology **- Bedrock geology**	- Sloping ground to the north of Mar Dyke dipping down to south from *c.*70m to 10m O.D. - London Clay Formation
Sediment sequences	Sands and gravels with variable clay content
Geological interpretation	Mostly Head covering bedrock. Some isolated patches of Glaciofluvial deposits from the Anglian Ice margins.
Palaeoenvironmental potential	Low
Palaeolithic remains	None known, and none likely
Pal./geo-arch. assessment	LOW-MODERATE
Stage 1 mitigation priorities	Ascertain whether any Quaternary sediments present, and if so what is their distribution, and if they have any Palaeolithic potential
Key reference/s	BGS mapping

Zone	PQ-28 Foxburrow Wood
- Topography/ geomorphology **- Bedrock geology**	- Zone of higher undulating topography at the northernmost end of the LTC scheme footprint - London Clay Formation, Claygate Member and Bagshot Formation
Sediment sequences	Sand, gravel and clay/silts
Geological interpretation	Stanmore Gravel Formation (Pliocene or Early Pleistocene) and Glaciofluvial deposits locally present. Head outcrops also widespread across the area.
Palaeoenvironmental potential	Low
Palaeolithic remains	None known, and none likely
Pal./geo-arch. assessment	LOW-MODERATE
Stage 1 mitigation priorities	Ascertain whether any Quaternary sediments present, and if so what is their distribution, and if they have any Palaeolithic potential
Key reference/s	BGS mapping; Bridgland 1994 (101-105)

Zone	PQ-29 Park Pale
- Topography/ geomorphology **- Bedrock geology**	- Dip slope of South Downs (Medway valley) with a series of dry valleys with ground surface elevations between 35m and 80m O.D. - Lewes Nodular Chalk Formation, Seaford Chalk Formation, Newhaven Chalk Formation and Thanet Formation and localised outcrops of Lambeth Group and Harwich Formation at north west edge of zone.
Sediment sequences	Valley sides and plateau surfaces devoid of sediments although thin discontinuous spreads of superficial sediments less than 1m may exist. Valley base contains Head/Colluvial deposits. Sequences in valley base may be consist of course, poorly sorted flint gravels as well as finer-grained clay-silts. Potential exists for the presence of buried soils in the sequences.
Geological interpretation	Cold climate solifluction processes resulting in deposition of Head, probably in late Pleistocene (<20ka B.P.) but earlier phases of slope wash and solifluction may be locally present, and may seal relatively-undisturbed Lower/Middle Palaeolithic activity areas where bedrock forms sub-horizontal depressions or plateaux. Colluviation in late Holocene following deforestation of Chalk from Neolithic/Bronze Age; any artefacts and faunal remains likely to be reworked although Holocene colluvium may contain elements of *in situ* faunas.
Palaeoenvironmental potential	Low, although colluvium may contain molluscan remains
Palaeolithic remains	None known, although Lower/Middle Palaeolithic remains have been found in areas with similar deposits (LTC 1661 in PQ-3; and LTC 4039), and may represent relatively-undisturbed Lower/Middle Palaeolithic activity areas where bedrock forms sub-horizontal depressions or plateaux, and then these have been infilled by Middle Pleistocene colluvium. Late Upper Palaeolithic remains have also (albeit rarely) been found in fine-grained colluvium infilling dry valleys in chalk bedrock landscapes (LTC 4045).
Pal./geo-arch. assessment	LOW-MODERATE
Stage 1 mitigation priorities	(a) Are there unmapped spreads of older colluvium, covering areas of Lower-Middle Palaeolithic activity on less-sloping parts of dry valley sides, and (b) are there areas of Late Upper Palaeolithic activity in/below spreads of late Last Glacial or early Holocene colluvium?
Key reference/s	-

H.3. Key references for PQ zone summaries

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Annex I Palaeolithic-Quaternary (PQ) zones: details and interpretation

Annex I.

Palaeolithic-Quaternary (PQ) zones: details and interpretation

I.1. Zone-by-zone interpretive details

PQ-1. Ebbsfleet Valley, HS 1 Car Park. This zone does not fall on any of the transects and is one considered to lie within the footprint of a previously excavated Chalk quarry (Wenban-Smith, 1995). The site is currently a car park for HS 1 and overlying the Chalk is a considerable thickness of Made Ground. While unlikely to contain any remnants of Pleistocene sediments there remains the possibility that isolated pockets of such material do exist within the zone (perhaps close to the edge of the zone).

PQ-2. Ebbsfleet Valley (west). This zone does not fall on any of the transects falls at the western edge of PQ-1 and is underlain by Thanet Sand bedrock. There is a high possibility that elements of the sequence previously excavated by Wenban-Smith (2013) may extend into the area, this represents the sediments at the unquarried edge of the former Chalk quarry to the east. If present a range of different lithologies may exist. Faunal material preservation in these sediments is deemed to be high and associated Palaeolithic archaeological material may also exist in the sediments. Demonstrting the presence of these sediments in the impact zone is a Stage 1 task, mapping and delimiting the edge of these deposits is considered to be a Stage 2 task. This zone is potentially of the Highest archaeological and geological importance.

PQ-3. Ebbsfleet Valley (upland catchment). This zone does not fall on any transect. It is a linear zone parallel with the A2 and represents the upland catchment of both tributaries of the Ebbsfleet river. Ground surface elevation are between 25m and >65m O.D. and Chalk and Thanet Formation form the bedrock throughout the zone. BGS mapping suggests the valley sides and plateau surfaces are devoid of sediments although thin discontinuous spreads of superficial sediments, less than 1m thick, may exist in some places. The valley base is likely to contain Head/Colluvial deposits that are likely to be a mixture of poorly sorted flint rich gravels derived from solifluction processes in the last cold stage (however, pre-Devensian or early Devensian deposits should not be ruled out – see Wenban-Smith and Bates, 2011) and colluvium consisting of finer grained sediments resulting from Middle to Late Holocene soil erosion. The potential exists for the presence of buried soils in the sequences that may be of late glacial or Holocene age. Chalk bedrock suggests that preservation of molluscs and vertebrate material is possible. No works are recommended for Stage 1 however in Stage 2 a number of key questions are identified such as how complex are the sequences in the valley base, is there evidence for pre last glacial maximum sequences (including pre-Devensian), is there evidence for Late Upper Palaeolithic occupation associated dry valley/colluvium?

PQ-4. Shorne Woods Plateau. This zone does not fall on any transect and forms an interfluve between the Thames and Medway catchment at the present day. Ground surface elevations vary from 75m to at least 120m O.D. Small dry valleys exist and have their origin in the plateau area. Lambeth Group, Harwich Formation and London Clay Formation form the bedrock throughout the zone. Narrow strips of Head deposits are mapped by the BGS and are likely to consist of gravels and clay/silt/sands, some possible colluvium may also be present filling the heads of the dry valleys. Thin discontinuous spreads of superficial sediments (?Head), less than 1m thick, may exist across parts of the area. Preservational potential for the sediments is unknown. Sediments may range in age from ?Late Devensian to Holocene, although the possibility exists that older sediments may exist in pockets through the area. Any artefacts and faunal remains are likely to be reworked although potential patches of older sediments may contain less disturbed material. No works are recommended for Stage 1, in Stage 2 the possibility that residual material of Lower/Middle Palaeolithic material on the high ground should be investigated.

PQ-5. Jeskyns high ground shelf. This zone does not fall on any transect and consists of the high ground plateau edge west of PQ-4. Ground surface elevations are between 85m and 100m O.D. and the zone lies at the head of dry valleys trending into both the Thames and Medway systems. Chalk and Thanet Formation forming the bedrock that indicate that at least in places preservation of carbonate based palaeoenvironmental material be possible. Head deposits are mapped by the BGS and probably consist of gravels with sand/silt/clay distributed in widespread valley features. Any artefacts and faunal remains present likely to be reworked. Stage 1 investigation need to focus on the basic characterisation of sequences. Stage 2 investigations should focus on any evidence for pre-Devensian deposits in the area. An additional question can be addressed at examining whether the sequences and preservational potential of large spreads of Head deposits in this zone differs from the narrower strips of head in restricted valley bottom areas in zones PQ-3/4.

PQ-6. Thong Lane. This zone appears on Figures x23 and x25. The zone is part of the dip slope of North Downs and contains a series of dry valleys in which the ground surface elevations between 35m and 80m O.D. Chalk bedrock dominates by Thanet Formation and localised outcrops of Lambeth Group and Harwich Formation are also present. The valley sides and plateau surfaces are devoid of sediments although thin discontinuous spreads of superficial sediments, less than 1m thick, may exist. The base of the valleys contains Head/Colluvial deposits likely to consist of coarse, poorly sorted flint gravels as well as finer grained clay-silts in which the potential exists for the presence of buried soils in the sequences. Cold climate solifluction processes are likely to have resulted in the deposition of the majority of the Head, probably in late Pleistocene (<20ka B.P.) but earlier phases of slope wash and solifluction may be locally present. Colluviation in late Holocene following deforestation of the Chalk during the Neolithic/Bronze Ages may have taken place. Carbonate based palaeoenvironmental material may survive in these deposits and any artefacts and faunal remains likely to be reworked although colluvium may contain elements of *in situ* material. No Stage 1 evaluation is suggested, in Stage 2 evidence for any Late Upper Palaeolithic occupation associated with the dry valley/colluvium should be investigated.

PQ-7. Filborough. This zone appears on Figures x23 and x25 and is the lower part of dip slope of North Downs. Ground surface elevations decline from 15m to 5m O.D. and the zone lies immediately above the floodplain of the Thames. The zone includes a series of small dry valleys running south/north through area. Bedrock consists of Chalk and Thanet Formation. BGS mapping suggests a series of two terraces, fluvial sand and gravel, as well as Head deposits exist in the area. Head sequences occur in the base of the dry valleys and may consist of course, poorly sorted flint gravels as well as finer grained clay-silts. Although the data on the bodies mapped by the BGS as terraces of the Thames is poor the deposits are likely to consist of basal gravels overlain by finer grained sands/silt and capped by gravel (fluvial or Head). The BGS mapping (Dartford sheet) equates the two terraces with the Lynch Hill (Corbets Tey Gravel) and Taplow Terraces (Mucking Gravel) and sequencers may well reflect those of the Bridgland terrace model (**Figures x8/x9**). This situation is one of the few in the route corridor in which two (possibly three, see PQ-8) terraces occur in close proximity to each other. The bedrock geology suggests preservation of carbonate based fossils is likely while the possibility of high ground water tables close to the floodplain indicate palaeobotanical material may also be preserved. Artefacts are likely to consist ofo a mixture of *in situ* and reworked artefacts and faunal remains depending on context of deposition. In Stage 1 investigations a series of test pits/boreholes are required to address the differences between the mapped terraces, what the nature of the sedimentary sequences in the different terraces are and whether or not materials for dating are present. Stage 2 objectives will depend on the results of Stage 1 investigations.

PQ-8. South Thames floodplain edge. This zone appears on Figures x23, x25 and x26 and represents the margins of floodplain of the modern Thames where the ground surface lies below 5m O.D. Bedrock consists of Chalk and Thanet Formation. Sediments consist of Holocene alluvial sediments consisting of clay/silts and sands with some intercalated peats resting on a complex series (**Figure x28**) of sandy clay-silts intercalated between flint rich gravels between -5m and -20m O.D. These lower sediments exhibit laminated silts in places that are noted to contain pockets of peat. An important buried landsurface is likely to be developed at the base of the Holocene sediments around -5m O.D. Palaeoenvironmental potential for both plant and animal remains is considered moderate-high in both Holocene and underlying sediments. The sediments beneath the Holocene (i.e. below -5m O.D.) are likely to be Pleistocene in age and probably form part of the East Tilbury Marshes Gravel (MIS 6-5e-5 in age). At least some parts of the fine grained sedimentary sequence within the ETMG may be brackish water/estuarine conforming to the model of Pleistocene estuarine sequences (**Figures x11/12**) rather than to the standard Bridgland model (**Figures x8/9**). A range of depositional contexts in the Holocene indicate *in situ* and reworked artefacts may occur while the surface of the ETMG may represent a long developed surface on which *in situ* material of Late Pleistocene/Early Holocene age may occur. Artefacts are considered unlikely in ETMG due to potential estuarine context of much of the sequence and apparent absence of hominids in MIS 5e (although see Wenban-Smith *et al.*, 2010). In Stage 1 works boreholes and test pits are required to address the nature and age of the Pleistocene sediments in the zone, what is the nature of the surface of the Pleistocene sediments and what, if any archaeology rests on this surface and finally when did Holocene sedimentation being? Stage 2 objectives remain to be determined.

PQ-9. Thames Floodplain (Main). This zone appears on Figures x23, x24, x25 and x28 and is the main part of floodplain of the modern Thames where ground surface elevations are below 5m O.D. Chalk forms the bedrock throughout this zone. Sedimentary sequences are relatively simple and consist of thick intercalated sequences of peats, clay/silts and occasional sands(3m to -15m O.D.) resting on coarse flint gravels (-15m to -20m O.D.). Preserved material in the Holocene is likely to be high while that from the Pleistocene gravels is low. Holocene alluvium from Early-Late Holocene will overlie a buried landsurface developed on the surface of the underlying gravels. This surface represents the early Holocene topographic template (sensu Bates and Whittaker, 2004) of Mesolithic age. Sediments beneath the this surfacea (i.e. below -15m O.D.) are likely to be Pleistocene in age and probably form part of the Shepperton Gravel of Late Devensian age. The range of depositional contexts in the Holocene indicate *in situ* and reworked artefacts may occur. While the surface of the Shepperton Gravel may represent the late Devensian/early Holocene surface on which *in situ* material of Late Pleistocene/Early Holocene age may occur. Artefacts are unlikely to be preserved in the Shepperton Gravel and if present will be reworked. No Stage 1 investigations are recommended. In Stage 2 questions include are the sands seen on the northern side of the zone Holocene or

Pleistocene (i.e. the equivalent of those in PQ-8)? When did sedimentation being across the surface of the Shepperton Gravels?

PQ-10. North Thames floodplain edge. This zone appears on Figures x24, x25 and x28 and is the margins of floodplain of the modern Thames with ground surface below 5m O.D. Chalk bedrock exists in this zone. Holocene alluvial sediments consisting of clay/silts and sands with some intercalated peats rest on a series of sands between 0m O.D. and c-12m O.D. Basal sediments consist of gravels. An important buried landsurface likely to be developed at the base of the Holocene sediments. Palaeoenvironmental potential in the Holocene sediments is high. Sediments (sands) beneath the Holocene (i.e. below 0m O.D.) may be Pleistocene in age and form part of the East Tilbury Marshes Gravel or may be part of major Holocene sand bars. A range of depositional contexts in the Holocene indicate *in situ* and reworked artefacts may occur. The surface of the ETMG (if present) may represent a long developed surface on which *in situ* material of Late Pleistocene/Early Holocene age may occur. The basal gravels (whether basal ETMG or Shepperton Gravel) are only likely to contain reworked artefacts. Stage 1 survey requires boreholes and test pits to address the nature and age of the sands in the zone, what is the nature of the surface of the Pleistocene sediments and what, if any archaeology rests on this surface? Finally when did Holocene sedimentation being in this zone? Stage 2 works remain to be confirmed.

PQ-11. Goshems Farm. This zone features on Figure x27 and forms a small topographic high on the edge of the Thames floodplain with elevations between 5m and 15m O.D. Bedrock consists of Chalk and Thanet Formation. Sands and gravels are clearly seen between 6m and 10m O.D. resting on Thanet Formation. The palaeoenvironmental potential of the zone is unknown. This zone represents a small outcrop of the Corbets Tey Gravel as an isolated remnant surrounded by younger Pleistocene sediments on all sides. The former edge of the terrace gravels is not preserved. Dating of these deposits is likely to be within MIS 10-8. No Stage 1 works are recommended while Stage 2 questions include are biological remains present and what are the age of the deposits?

PQ-12. Shearwater Avenue. This zone features on Figure x27 and is a low lying terrace surface with elevations between 5 and 10m O.D. Bedrock consists of Thanet Formation. Borehole data indicate sands and gravels outcrop between -2m and 4m O.D. with a single exception of a higher subcrop of sand and gravel at 7m to 9m O.D. at northwestern end of zone. Palaeoenvironmental potential is difficult to assess but appears to be low. BGS mapping Fluvial sediments of the Taplow Terrace (Mucking Gravel) but the borehole data (Figure x27) suggests an outcrop of a higher, older sequence of deposits to the northwestern end of the transect, possibly correlating with the Corbets Tey Gravel. If this interpretation is correct it suggests that the BGS mapping here has missed a local outcrop of the older terrace and remapping of this part of the zone is required. The inside sector of the Mucking Gravel is likely to be preserved in this zone where sequences may be more complete than usual in the northwest of the zone. Artefacts are likely to be reworked in much of the sediments in this zone. No works are suggested for Stage 1 here. In Stage 2 the issue of the BGS mapping wrong in the northwestern part of the zone? What is the nature of the sequences in the northwestern part of the zone should be addressed along side determining whether any suitable material for dating sequences exists in this zone.

PQ-13. Chadwell Saint Mary. This zone features on Figure x28 and x29 and exhibits a terrace surface with elevations between 20m and >25m O.D. Bedrock consists of Thanet

Formation and Lambeth Group. Boreholes indicate that sands and gravels, with outcrops between 20m and 25m O.D., exist through this area. Palaeoenvironmental potential in this zone is unknown. The deposits in this zone have been mapped as Boyn Hill by the BGS (Orsett Heath Gravel) and it appears that the inside of the floodplain of this terrace is, or was, potentially preserved along the northwest side of this zone. However, this critical zone may have been removed by the cutting of the valley associated with PQ-15 (Figure x29). Little data is currently available for much of this zone. Investigations in Stage 1 will be required to obtain data from those areas lacking information in central and southeastern part of zone as well as in the southern area adjacent to P-6 where Palaeolithic material has been recovered in the past. Stage 2 remains to be determined.

PQ-14. Southfields. This zone features on Figure x29 and consists of a topographic high with elevations from 20m to 35m O.D. Bedrock consists of Lambeth Group and Thanet Formation. Boreholes indicate that sediments are dominated by sands and gravels with some superficial clays and silts with subcrops from 25m to >30m O.D. BGS mapping attributes this zone to the Black Park Terrace while Gibbard (1994) records essentially the same as Dartford Heath Gravel. By contrast Bridgland (1994, 2006) describes this as Orsett Heath Gravel. It is noted here that elevations of the sediments here are considerably above the Orsett Heath Gravel in PQ-13 (Figure x29) and we consider that this patch has been miscorrelated by Bridgland. Head deposits are also present in small valley systems cut into the Black Park Gravel. Palaeoenvironmental potential is low in this zone. No Stage 1 investigations are recommended. In Stage 2 questions to address include what is the age of these deposits and are they equivalent to the Orsett Heath Gravel?

PQ-15. Brook Farm Channel. This zone features on Figure x29 and consists of a valley-like form running in a northwest to south east direction from the Mar Dyke area towards the Thames. A central high of around 30m O.D. drops to less that 20m O.D. in the northwest and 10m O.D. in the southeast. Bedrock consists of Lambeth Group and Thanet Formation. BGS mapping indicates Head deposits in this zone and these area a probable mixture of poorly sorted flint gravel mixed with clay/silt/sand. Palaeoenvironmental potential is considered low but is also unknown. The origin of this feature is intriguing, is this a possible Pleistocene drainage exit from the Mar Dyke? Stage 1 investigation of this area should include Boreholes/test pits. Stage 2 works are contingent on the results of Stage 1.

PQ-16. Loft Hall Farm. This zone is a valley side situation with slopes facing northwards into Mar Dyke with ground surface elevations of around 30m O.D. Bedrock consists of Lambeth Group sediments. No Quaternary sediments are mapped in this area and topsoils are likely to sit on bedrock throughout the zone. However, unmapped patches of thin Quaternary sediments may exist locally. Palaeoenvironmental potential is low. No Stage 1 investigations are recommended.

PQ-17. Cuckoo Lane. This zone consists of a marginal slope into Mar Dyke valley where the land slopes from 20m to 10m O.D. Bedrock consists of Thanet Formation and Lambeth Group.

Sand and gravels with peat exist on either side of this zone with a central portion associated with a dry valley containing Head with poorly sorted coarse sandy gravels. BGS mapping shows the sands and gravels either side of the dry valley are part of the Lynch Hill terrace (Corbets Tey Gravel) with elements of Head deposit infilling dry valleys cut through

Corbets Tey Gravel. The presence of sediments associated with the Corbets Tey Gravel, containing pea,t indicates a high palaeoenvironmental potential and this feature exhibits similarities with the sequences to the north at Belhus cutting (Wenban-Smith *et al*., 2013) and the Aveley Silts and Sands (Gibbard, 1994). These belong to MIS 10-9-8. Stage 1 investigation should focus on boreholes and test pits in order to determine what sequences are preserved in the Corbets Tey Gravel in this area. Stage 2 targets are contingent on Stage 1 results.

PQ-18. Mederbridge Road (Ockendon Loop). This zone consists of a marginal slope into the Mar Dyke valley where land slopes from 15m down to 5m O.D. Bedrock consists of Lambeth Group and London Clay Formation. Sand and gravels with peat exist on either side of this zone with a central portion associated with a dry valley containing Head with poorly sorted coarse sandy gravels. BGS mapping shows the sands and gravels either side of the dry valley are part of the Lynch Hill terrace (Corbets Tey Gravel) with elements of Head deposit infilling dry valleys cut through Corbets Tey Gravel. The presence of sediments associated with the Corbets Tey Gravel, containing pea,t indicates a high palaeoenvironmental potential and this feature exhibits similarities with the sequences to the north at Belhus cutting (Wenban-Smith *et al*., 2013) and the Aveley Silts and Sands (Gibbard, 1994). These belong to MIS 10-9-8. Stage 1 investigation should focus on boreholes and test pits in order to determine what sequences are preserved in the Corbets Tey Gravel in this area. Stage 2 targets are contingent on Stage 1 results.

PQ-19. Kemps Farm. This zone features on Figure 31 and forms a terrace surface dipping form east to west from 20m to 15m O.D. Bedrock consists of the London Clay Formation. Sediment seen in the borehole logs range from 8m up to surface elevations of c.24m. Sediment sequences consist of sands and gravels from 8m to 13m O.D. that are overlain by organic sediments (including peat) thickening in a northwards direction. These sequences are in turn overlain by gravelly clays and sands (possibly both fluvial and Head deposits). These sediments are mapped by the BGS as Lynch Hill (Corbets Tey Gravel) and include sediments potentially belonging to the Belhus Channel (Aveley Silts and Sands sensu Gibbard, 1994). This zone describes a transect through the terrace towards the inner edge of the terrace (northern end of transect) where sequences may be at their most complete. Faunal and floral remains are anticipated in these deposits and their potential is deemed high. Investigations in Stage 1 thorugh boreholes and test pits should investigate what are the differences in preserved sequences and preservation across the zone? Stage 2 investigation remains to be deteremined.

PQ-20. Green Lane. This zone forms the eastern margins of the Mar Dyke basin where the topography slopes westwards from about 15m to 5m O.D. Bedrock consists of the London Clay Formation. Head deposits are recorded on bedrock in this zone that consist of clay with sand and gravel. Palaeoenvironmental potential is low and no Stage 1 investigations are recommended.

PQ-21. Mar Dyke narrows. This zone features on Figure 30 and forms the narrow channel of Mar Dyke running from inner basin south-westwards to main Thames floodplain. Bedrock consists of London Clay Formation. Sediments include silt/clay and peat and are thought to be Holocene in age although very little work has been undertaken in the area (Moorlock and Smith, 1991). Palaeoenvironmental potential in the alluvium is high. Stage 1 survey should focus on boreholes/test pits in order to ascertain when sedimentation began in the Mar Dyke in the Holocene?

PQ-22. Mar Dyke Basin. This zone features on Figure 30 and forms the central, basin-like part of the Mar Dyke with topography below 10m O.D. Bedrock is London Clay Formation. Borehole logs indicate sediments are dominated by clay with sand and gravel present. No logs report organic silts or peats. It is unclear as to the origin of these sediments. They look unlike the expected low energy Holocene alluvial sequences and the possibility exists that they represent Head or low angle solifluction deposits or weathered London Clay (or an admixture of both). Consequently it is difficult to determine where the base of the Holocene sequences (i.e. buried landsurface) is here. Oh the basis of the recorded logs palaeoenvironmental potential is low. Stage 1 using boreholes/test pits should focus on identifying where the base of the alluvium is, if present and whether the Mar Dyke has infilled with Head in the past?

PQ-23. Mar Dyke margins (east). This zone forms the eastern margins of the Mar Dyke basin dominated by small topographic highs of Head within the alluvial marshland. Bedrock in this location is London Clay Formation. Quaternary sediments in the zone consist of clay with sand and gravel surrounded by gravelly sands and silts (mapped as alluvium by the BGS). Palaeoenvironmental potential is considered low. This zone appears to be dominated by Head deposits outcropping on bedrock that have been eroded by fluvial activity or cold climate downcutting. No Stage 1 works recommended.

PQ-24. Mar Dyke margins (west). This zone forms the western margins of the Mar Dyke basin with topography sloping eastwards from about 30m to 5m O.D. Bedrock consist of London Clay Formation. Sediments are likely to be clay with sand and gravel. Palaeoenvironmental potential is considered low. The zone is dominated by Head deposits outcropping on bedrock

No Stage 1 recommendations are made.

PQ-25. Hall Farm. This zone features on Figure x31 and is formed of a terrace flat with ground sloping from east to west from >30m to c. 20m O.D. Bedrock consists of London Clay Formation. Sediments consist of clay over laminated sands and silts with a basal gravel. Sediments outcrop between 16m and 24m O.D. Shells occasionally reported from boreholes and laminated sequences may suggest brackish water sediments potentially containing microfossils. Palaeoenvironmental potential is considered moderate to high. These deposits represent the main aggradation of the Orsett Heath Gravel (mapped as Boyn Hill by the BGS). The inner edge of terrace may be preserved by the rising ground at east of zone where more complete sequences of stratigraphy may be preserved. Stage 1 boreholes and test pits should focus on determining what are the differences in preserved sequences and preservation across the zone?

PQ-26. White Post Farm. This zone contains a topographic high with ground surface elevations from 30m to 40m O.D. Bedrock consists of London Clay Formation. Boreholes indicate sands and gravels with some clays are present and where sediments outcrop from 25m to >35m O.D. BGS mapping suggests this zone is dominated by the Black Park Terrace while Gibbard (1995) records essentially the same as Dartford Heath Gravel. By contrast Bridgland (1995) appears to omit these gravels from his mapping. Palaeoenvironmental potential is considered low. No Stage 1 works are recommended.

PQ-27. Mar Dyke margins (north). This zone forms a sloping topography to the north of Mar Dyke dipping down from c.70m to 10m O.D. Bedrock consists of London Clay

Formation. Sediments present above bedrock are likely to be sands and gravels with variable clay content

Palaeoenvironmental potential is low. The sediments are mostly Head covering bedrock. Some isolated patches of Glaciofluvial deposits from the Anglian Ice margins may locally exist. No Stage 1 works recommended.

PQ-28. Foxburrow Wood. This zone is one of undulating topography in the northernmost area of the route corridor. Bedrock consists of London Clay Formation, Claygate Member and Bagshot Formation. Head consisting of sand, gravel and clay/silts is widespread and may bury older sediments of the Stanmoor Gravel Formation as well as Glaciofluvial deposits. No Stage 1 works are recommended.

PQ-29. Park Pale. This zone is part of the dip slope of South Downs (Medway valley) in which there are a series of dry valleys with ground surface elevations varying between 35m and 80m O.D. Bedrock consists of Chalk, Thanet Formation and localised outcrops of Lambeth Group and Harwich Formation at north west edge of zone. Valley sides and plateau surfaces devoid of sediments although thin discontinuous spreads of superficial sediments, less than 1m thick, may exist. The bottom of dry valleys contains Head/Colluvial deposits. Sequences in the valley base may consist of course, poorly sorted flint gravels as well as finer grained clay-silts. The potential exists for the presence of buried soils in the sequences. Palaeoenvironmental potential is low although colluvium may contain molluscan remains. Cold climate solifluction processes resulted in the deposition of Head, probably in late Pleistocene (<20ka B.P.) but earlier phases of slope wash and solifluction may be locally present. Colluviation in late Holocene following deforestation of Chalk from Neolithic/Bronze Age. Any artefacts and faunal remains likely to be reworked although colluvium may contain elements of *in situ* faunas. No Stage 1 investigation recommended. At Stage 2 questions include is there evidence for Late Upper Palaeolithic occupation associated dry valley/colluvium?

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