An archaeological evaluation at Stanhope Park, Wharf Road, Stanford-le-Hope, Essex July 2008

report prepared by
Chris Lister

with contributions by Dr P Allen and Dr D R Bridgland,
Dr I Candy, Dr R Preece, Dr D Schreve, Dr J Whittaker

on behalf of
the Hills Group and Mersea Homes

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Colchester Archaeological Trust
12 Lexden Road,
Colchester,
Essex CO3 3NF

tel.: (01206) 541051
(01206) 500124
email: archaeologists@catuk.org

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1 Summary

The site is located on the Thames estuary in an area that has been densely populated from the Roman period onwards, and consequently was considered to be potentially archaeologically rich. An evaluation by 35 trial-trenches revealed thinly-spread evidence of activity ranging from the Mesolithic to the modern period. Features of note were a Roman pit and a medieval ditch. An interesting find was a collection of unstratified Palaeolithic flints deposited on the site from the river margin somewhere upstream. The low incidence of datable archaeological features is surprising given the proximity of the Mucking site to the south-west, and the number of findspots of Roman pottery from the foreshore and Mucking Creek.

Approximately one-third of the features excavated were modern, reflecting the impact of developing industries in the area over the past 100 years. This probably explains the paucity of surviving archaeological features and finds here, as the industrial use of the site and, later, stripping of topsoil to remove contaminants, has severely affected in situ *preservation.*

A geological appraisal of the site included palaeontological identification of molluscs which indicate that the shallow channels crossing the site were active in the Roman or later periods.

2 Introduction (Fig 1)

2.1 This is the archive report on an archaeological trial-trenching evaluation on an approximately 14 hectare, former industrial site, intended for the construction of a mixed-use development, at Stanhope Park, Wharf Road, Stanford-le-Hope, Essex.

2.2 The site is situated approximately 1 km south-east of Stanford-le-Hope (site centre NGR TQ 698 815), overlooking the Thames estuary and close to the inter-tidal zone. The site was divided into two areas: the northern part consisted of open ground around functioning industrial units, and the southern part of undeveloped land on the edge of the inter-tidal zone. Earthwork banks surrounded most of the site. These were probably formed of soil stripped off the site.

2.3 The archaeological work was commissioned by Mr Malcolm Judd and Partners, on behalf of the Hills Group and Mersea Homes, and was carried out by the Colchester Archaeological Trust (CAT) between 21st and 29th July 2008. Post-excavation work was carried out in August 2008.

2.4 The Historic Environment Management (HEM) team of Essex County Council (ECC) were consulted by Thurrock Council in July 2004 on an outline application (THU/0793/04) for the construction of a mixed-use development comprising residential development, business uses (B1), community uses, local retail outlet, landscaping and access improvements. A scooping opinion was submitted to the Thames Gateway Development Corporation in 2008. In response to consultation, the HEM team made the following recommendation in line with DoE Planning Policy Guidance Note 16: Archaeology and Planning (PPg16):

> *'The applicant should be required to conduct a field evaluation to establish the nature and complexity of the surviving archaeological deposits. This should be undertaken prior to a planning decision being made. This evaluation would enable due consideration to be given to the archaeological implications and would lead to proposals for mitigation of disturbance and/or the need for further investigation.'*

2.5 A brief detailing the required archaeological work (a 5% evaluation by trial-trenches) was written by the HEM team officer (Mr Richard Havis). All archaeological work was carried out in accordance with a WSI (Written Scheme of Investigation) produced by CAT in response to the HEM team brief and agreed with the HEM team.

2.6 In addition to the WSI, all fieldwork and reporting was done in accordance with the Colchester Archaeological Trust's *Policies and procedures* (CAT 1999), and the Institute of Field Archaeologists' *Standard and guidance for archaeological field evaluation* (IFA 2001a) and *Standard and guidance for the collection, documentation, conservation and research of archaeological materials* (IFA 2001b). The guidance contained in the documents *Management of archaeological projects* (MAP 2), and *Research and archaeology: a framework for the Eastern Counties 1.*

Resource assessment (EAA **3**), *Research and archaeology: a framework for the Eastern Counties 2. Research agenda and strategy* (EAA **8**), and *Standards for field archaeology in the East of England* (EAA **14**) was also followed.

3 Archaeological background

3.1 This archaeological background is based on the Essex Historic Environment Record (EHER) held by Essex County Council, County Hall, Chelmsford, Essex.

3.2 The site is located on the Thames estuary in an area that has been densely populated from the Roman period onwards, and consequently is potentially archaeologically rich.

3.3 A desk-based assessment of this site has listed and discussed the archaeological background (CAT Report 261).

3.4 Only two sites listed on the EHER are within the site boundaries. These are the Fisons Fertilizer Factory (Stanford-le-Hope Industrial Park, EHER no 7131), built between 1955 and 1963 and in operation until 1983. The second site is listed by the EHER as an explosives factory (EHER no 15128). However, there appears to be some confusion about its location; the reference is likely to relate to the explosives factory on Corringham Marsh to the east (EHER no 14769).

3.5 Other sites beyond the development site boundaries give the following archaeological background.

Prehistoric

NGR: TQ 6930 8110
EHER: 19212
Stanford Marshes (700 m south-west of the site). During a watching brief on test-pits dug for a new wildlife pond in 2001, peat deposits were recorded more than 1 m below ground-level. These were sealed by redeposited gravel and clay (ECC FAU 2002). The report states that Palaeolithic remains (300,000-10,000 BP) in conjunction with palaeoenvironmental deposits may be buried either within or below alluvial deposits.

NGR: TQ 690 813
EHER: 1896
Iron Age 'A' pottery is recorded from the Crown Gravel Pits 800 m south-west of the site.

Roman

Roman remains in the search area mainly consist of findspots of pottery from the foreshore and Mucking Creek. Roman burials found in Mucking village indicate an early Roman settlement nearby (the Mucking site; EHER no 1891). This part of the Essex coast is well known for its Roman salt-making ('red hill' sites).

NGR: TQ 699 807
EHER: 5186
In 1970, 650 m south of the site, Romano-British pottery including grey ware was found at Mucking Creek (Stanford Marshes) which had been exposed due to sea erosion outside the sea wall.

NGR: TQ 695 810
EHER: 5188
In a field 400 m south of the site, Romano-British pottery and brick plus bone and wood from a flint-lined well were found in 1967.

NGR: TQ 703 812
EHER: 7223-7225, 7138-7139
Roman pottery from the foreshore at Stanford-le-Hope and from Stanford Marshes, found 400-500 m south-east of the site, collected 1971-73.

NGR: TQ 6901 8114
EHER: 1893
1st-century Roman pottery from the Crown Gravel Pits (800 m south-west of the site), near Mucking Creek, found in 1931 (*VCH* **3**, 181).

NGR: TQ 690 811
EHER: 1894
Pottery collected from the Crown Gravel Pits (800 m south-west of the site), near Mucking Creek, include a 2nd- to 3rd-century dish (*VCH* **3**, 181).

NGR: TQ 6905 8122
EHER: 1895
Colchester and Ipswich Museums has pottery from the Crown Gravel Pits (800 m south-west of the site), near Mucking Creek.

NGR: TQ 695 809
A red hill site was identified at Stanford Marshes (600 m south-west of the site, now destroyed), consisting of briquetage and Belgic and early Roman pottery. This was recorded by Barford as being the same grid reference as EHER no 5188, ie behind the sea wall; the EHER makes no mention of it (Fawn *et al* 1990, 65).

Medieval
In the medieval period, a major phase of reclamation of the marshland through drainage and sea-wall construction was begun as the marshes became economically important. On the higher ground to the north and north-east of the site, there is some evidence of medieval settlement. It is likely that medieval farms would have been linked to the marshland by trackways. The development site, being between two topographical areas, ie the gravel terraces and the marshland, may have been a key location for medieval occupation.

NGR: TQ 703 816
EHER: 7132
'Deserted medieval village', 300 m east-north-east of the site at Broadhope Farm (CAT Report 261). There is a possibility of medieval rural settlement along the higher ground, where the gravels meet the clays at Stanford-le-Hope and Corringham, and that Great Garlands Farm and Cabborns (Manor Farm) may have medieval origins.

NGR: TQ 699 807
EHER: 5187
Medieval shelly and glazed pottery found 700 m south of the site in 1970 at Mucking Creek.

Modern
During the last 100 years, the Thames estuary has been developed with explosives factories and oil refineries. World War 2 defences have also left their mark. The development site appears to have remained free of modern disturbance until the construction of the industrial buildings that are still present today or have been demolished.

NGR: TQ 696 815
The Thames Haven branch of the London, Tilbury and Southend Railway with its embankment was built some time between 1839 and 1869; the now-disused railway line and embankment forms the northern boundary of the development site.

NGR: TQ 7009 8088
EHER: 20303
A World War 2 bomb decoy behind the sea wall on Stanford Marshes, 600 m south of the site, can be seen on a 1946 aerial photo. (CAT Report 261). Nothing remains of it now except the concrete base and reinforcement rods of part of the night shelter plus concrete storage bays for fuel drums.

4 Aims

The aim of the evaluation was to recover sufficient evidence to characterise the nature, date, function and importance of the archaeological features in the development site.

5 Results of the evaluation (Figs 2-8)

This section gives an archaeological summary of each of the 35 trenches (T1-T35) on the evaluation site, with context and finds dating information.

A topsoil layer across the site was stripped prior to evaluation. Consequently all features were sealed by a thin lower horizon (L1), and all features cut natural ground L3. L1 was removed by machine. All excavation below that level was done by hand.

Trench 1: summary and dating (Figs 2, 3, 8)
T1 contained an undated pit (F2) and two natural features (F1 and F3).

Trench 2: summary and dating (Figs 2-3)
T2 contained three features (F3, F5, F8). F4 was a pit. F5 was a ditch and F8 was a natural feature. F4 was undated and F5 contained fragments of peg-tile, suggesting a post-medieval date. F5 was roughly aligned with F9 in T4 and was most likely a post-medieval or modern field boundary.

Trench 3: summary and dating (Figs 2-3)
T3 contained an undated pit (F7) and a modern pit (F6) that was filled with industrial waste, including a modern ironstone sherd.

Trench 4: summary and dating (Figs 2-3, 8)
T4 contained five archaeological features. These were natural feature F10, pits F11 and F13-F14, and ditch F9. F14 was a prehistoric pit containing one flint flake. F11 and F13 were undated pits

F9 was an undated ditch, roughly in alignment with F5 in T2, and probably formed part of a post-medieval or modern field boundary.

Trench 5: summary and dating (Figs 2-3)
T5 contained a ditch (F18). This contained modern finds and one residual flint flake.

Trench 6: summary and dating (Figs 2-3, 8)
T6 contained a ditch (F12). A single sherd of sandy orange ware suggests that this was medieval in date.

Trench 7: summary and dating (Figs 2-3)
T7 contained three features (F15-F17), all of which were modern. F15 was a post-hole, F16 was a brick and concrete foundation and F17 was a geotechnical pit.

Trench 8: summary and dating (Figs 2, 4, 8)
T8 contained three features (F19-F20 and F33). F20 was an undated pit. F19 was a modern brick-built drainage hub, associated with the former industrial buildings on what is now Stanhope Park, and F33 was a modern pit.

Trench 9: summary and dating (Figs 2, 4)
T9 contained four features (F21-F24). F21 and F24 were modern pits. F22 was a modern foundation that cut natural feature F23.

Trench 10: summary and dating (Figs 2, 4)
T10 contained three modern features (F25-F27). F25 was a pit. F26 and F27 were the remains of concrete and brick foundations, both of which had been partially removed.

Trench 11: summary and dating (Figs 2, 4)
T11 contained six features (F28-F32 and F34), all of which were modern. F28 was a geotechnical pit. F29, F30 and F34 were all poured concrete foundation pads, whilst F31 and F32 were the remains of brick foundations. It is highly likely that all of these foundations were associated with the demolished cement works.

Trench 12: summary and dating (Figs 2, 4, 8)
T12 contained an undated pit (F35).

Trench 13: summary and dating (Figs 2, 4)
T13 contained an undated pit or possible tree-throw pit (F36) and a small, undated pit (F37).

Trench 14: summary and dating (Figs 2, 4, 8)
T14 contained two undated post-holes (F38, F40) and a natural feature (F39).

Trench 15: summary and dating (Figs 2, 5)
T15 contained two undated ditches (F41 and F42).

Trench 16: summary and dating (Figs 2, 5)
T16 contained three features (F43-F45). F43 was an undated pit and F44 was an undated post-hole. F45 was a natural feature or possibly a tree-throw pit.

Trench 17: summary and dating (Figs 2, 5, 8)
T17 contained four features (F46-F49). F46 was a post-medieval ditch, probably part of a field boundary, and contained two small sherds of post-medieval red earthenware pottery. F47 was a natural feature and F48 was a geotechnical pit. F49 was a small, undated pit.

Trench 18: summary and dating (Figs 2, 5, 8)
T18 contained four undated features (F50-F53). F50 was a ditch, and F51 and F52 were small pits. F53 was a natural feature or possibly a tree-throw pit.

Trench 19: summary and dating (Figs 2, 5)
T19 contained an undated ditch (F54).

Trench 20: summary and dating (Figs 2, 5)
No archaeological features or deposits were found in this trench.

Trench 21: summary and dating (Figs 2, 5)
T21 contained an undated pit (F56).

Trench 22: summary and dating (Figs 2, 6)
T22 contained an undated pit (F55).

Trench 23: summary and dating (Figs 2, 6, 8)
T23 contained a natural feature (F57) and a small, undated pit (F58).

Trench 24: summary and dating (Figs 2, 6)
T24 contained three features (F60-F62). F62 was a natural feature. F60 was a ditch containing fragments of a post-medieval or modern field drain and F61 was a ditch with no finds. As these two features were parallel to each other, this suggests that F61 was a field boundary ditch with F60 having been a drainage ditch for the field.

Trench 25: summary and dating (Figs 2, 6)
T25 contained a natural feature (F59).

Trench 26: summary and dating (Figs 2, 6)
No archaeological features or deposits were found in this trench.

Trench 27: summary and dating (Figs 2, 6, 8)
T27 contained an undated pit (F63).

Trench 28: summary and dating (Figs 2, 6)
T28 contained an undated pit or possible ditch terminus (F64).

Trench 29: summary and dating (Figs 2, 7)
No archaeological features or deposits were found in this trench.

Trench 30: summary and dating (Figs 2, 7)
T30 contained a natural feature (F65) and an undated post-hole (F66).

Trench 31: summary and dating (Figs 2, 7)
T31 contained a natural feature, possibly an erosion hollow (F67) and an undated pit (F68).

Trench 32: summary and dating (Figs 2, 7-8)
T32 contained three undated pits (F69-F71) and an undated post-hole (F72).

Trench 33: summary and dating (Figs 2, 7)
T33 contained a pit (F73) in which was found a single sherd of Roman coarse pottery. F74 was a natural feature.

Trench 34: summary and dating (Figs 2, 7)
No archaeological features or deposits were found in this trench.

Trench 35: summary and dating (Figs 2, 7)
No archaeological features or deposits were found in this trench.

6 Finds

6.1 The Roman and post-Roman pottery

by H Brooks, with S Benfield

Description of pottery
Roman pottery fabric descriptions are after *CAR* **10**. Post-Roman pottery fabrics are after Cunningham 1985 and *CAR* **7**: fabrics present include Fabric 21 (sandy orange ware); Fabric 40 (post-medieval red earthenware or PMRE); and Fabric 48d (modern ironstone). A list of fabrics by context is given in the catalogue below.

Comment
This is group of pottery is very small, in relation to the number of evaluation trenches. The single Roman and medieval sherds, and the three later sherds, demonstrate that there has been hardly any human activity on this site. This is perhaps surprising, given the proximity of the Mucking site (EHER no 1891). However, there is probably no doubt that the quantity of surviving archaeological features and finds here has been greatly affected by the industrial use of the site and by the later stripping of topsoil to remove contaminants.

Catalogue of pottery
F6
Finds number 3
1 sherd Fabric 48 (modern ironstone), 10g. 19th-20th century.

F12
Finds number 4
1 sherd Fabric 21 (sandy orange ware). Overall whiter slip with traces of glaze (green or yellow?), 3g. Overall slips are usually indicative of an early date, so this is probably 12th-13th century

F46
Finds number 9
2 small sherds Fabric 40 (post-medieval red earthenware or PMRE), 3g.17th-18th century.

F73
Finds number 11
1 small abraded sherd of Roman coarse pottery, weighing 3g, in a fine grey fabric with reddish-brown core and oxidised outer surface.

6.2 The flints

by A Wightman

Summary

This collection of nine worked flints consisted of five formal tools and four waste flakes. Seven of these were unstratified surface finds from across the site, whilst one was recovered from a prehistoric context and one was residual in a modern context. Both of the stratified flints came from the north of the site.

The most notable feature of two of the flint tools is the high degree of rolling that they appear to have undergone. The flake scars are notable on the flakes but the flake ridges have been worn smooth as have the edges of the flakes themselves. The flakes also seem to have undergone some degree of patination, which, although not directly attributable to age, does suggest a prolonged exposure to taphonomic factors. The abrasion and patination observable on these flints would likely suggest their derivation from the Thames gravels in the vicinity.

The choice of flakes, condition, and types of retouch exhibited on four of the unstratified flint tools suggest that they may originate from the Thames gravels which are located to the north-west and south-east of the site. Located between the Mucking Gravel and the Corbets Tey Gravel, flints of Lower and Middle Palaeolithic origin could conceivably be present on the headland site. However, as the gravels represent the 'mid-stream' edge of the river terrace rather than the 'bank' edge, it is highly unlikely that the four unstratified flint tools represent areas of Palaeolithic activity on the site itself. It is far more likely that they represent sweepings from the river margin further upstream and were rolled onto the site. With the topsoil-stripping of the site, these flints were exposed and found as unstratified surface finds.

The other three unstratified flints and the flakes from F14 and F18 are more likely to be of a later date (Mesolithic-Bronze Age), in particular the snapped blade.

Catalogue

T4
F14, finds number 5
1 flake, tertiary
This is a thin flake with no definite evidence of retouch on the edges. The flake scars on the dorsal face have all been removed earlier in the core-reduction process and have not been knapped from the flake itself. The flake is a piece of debitage from the knapping process as opposed to a formal tool; however, its size, shape and sharp edges would not have precluded its use as a tool. The flake could feasibly be a Palaeolithic hand-axe thinning flake but is more likely later (Mesolithic-Bronze Age).

T5
F18, finds number 6.
1 flake, tertiary.

U/S, finds number 2
1 flake, tertiary
This may possibly have been used as a formal tool although the thinness of the flake and nature of damage to the lateral edges does suggest it may be a damaged piece of debitage.

1 flake, primary
This is a large flake struck from the outside edge of a flint nodule that has cortex over 75% of its dorsal surface. This flake has a pronounced cone of percussion, a large platform and has flakes removed from the dorsal surface suggesting that it is unlikely to be debitage from the core-reduction sequence. It may have been used as a crude tool.

1 blade fragment, secondary
This is a formal tool that has been made on a small flake that has been subsequently retouched. It is a small, snapped blade that has retouch on the left lateral edge of the dorsal face. This is likely to have been undertaken to strengthen the working edge of the tool.

1 flake, tertiary
This is a formal tool that has been made on a small flake which has been subsequently retouched. It is an oval flake with heavy retouch on both its dorsal and ventral faces. The retouch is not of a type that denotes use as a scraper and is likely to have been undertaken to strengthen the working edge of the tool.

1 flake, tertiary
This tool has been made on a thin, medium-sized flake by removing a notch from each of the right and left lateral edges near the proximal end of the flake. This has removed the striking platform and created a rounded point. Whether the morphology of this flake was intentional or whether it has been created fortuitously by the removal of the two notches near to one end is uncertain.

1 flake, tertiary
This tool is an offset transverse scraper (scraper retouch on the distal end, striking platform off-centre) made on a large flake with further flakes removed from the dorsal surface, presumably to thin the flake. This tool type is observable from the Lower Palaeolithic onwards.

1 flake, secondary
This is a multiple tool exhibiting scraper retouch on the distal edge and denticulated lateral edges. The tool is in extremely good condition and is very ‘fresh’. It was made on quite a large flake with the tool having three intentionally retouched notches, two on the left lateral edge and one on the right lateral edge. One notch on the left lateral edge is inverse (knapped from the ventral face), and inverse retouch is observable in conjunction with dorsal retouch on the significantly larger notch on the right lateral edge. The scraper retouch is confined to the distal edge. The proximal end of the tool also exhibits a high degree of retouch. On the left hand side of the flake, this proximal retouch is on the dorsal face, and, on the right side of the flake, it is on the ventral face. This retouch is likely to be preparation of the platform for striking as opposed to the creation of a usable edge. This characteristic is notably Middle Palaeolithic (as opposed to Lower Palaeolithic), although a later date could, of course, be possible.

7 Discussion

The scarcity of finds from this evaluation site would seem to suggest little evidence of human occupation prior to modern times. However, if this were true, then Stanhope Park would be quite anomalous in the context of the rich and varied archaeological landscape of the surrounding area. Whilst only single instances of datable prehistoric, Roman and medieval archaeology were found on the site, it should be noted that 45% of the 74 features recorded were not datable and could still form part of occupation landscapes from these periods in history. The quantity and quality of surviving archaeological features at Stanhope Park were clearly affected by the industrial use of the site over the past 100 years, latterly as Stanford-le-Hope Industrial Park. This is particularly notable in the northern part of the site, which had a high concentration of modern disturbance. The stripping of the topsoil to remove contaminants from this industrial usage has damaged or destroyed much of the archaeological record, leaving behind a blank spot in the historical landscape.

Probably the most interesting point arising from this evaluation is the presence of the unstratified Palaeolithic flints. Although it should be stressed that these finds are not an indication of Palaeolithic human activity on the site itself, they are probably indicative of human activity of that date in the wider area.

8 Acknowledgements

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The project was monitored for the ECC HEM team by Mr Richard Havis.

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10 Abbreviations and glossary

AOD	above Ordnance Datum
BGS	British Geological Survey
BP	Before Present era, alternative to BC
CAT	Colchester Archaeological Trust
context	specific location on an archaeological site, especially one where finds are made
core	flint lump from which flakes or blades are detached by percussion
denticulate	having small tooth-like notches (which give it a sawing function)
ECC	Essex County Council
EHER	Essex Historic Environment Record, held by ECC
feature	an identifiable thing like a pit, a wall, a drain, a floor; can contain 'contexts'
fill	the soil filling up a hole such as a pit or ditch
flake	a flint piece knocked off a larger core (will sometimes be retouched)
HEM	Historic Environment Management
IFA	Institute of Field Archaeologists
Iron Age	period immediately before the Romans, dating from 800 BC to AD 43
Middle Iron Age	period dating from 5th century BC to mid 2nd century BC

natural	geological deposit undisturbed by human activity
NGR	National Grid Reference
prehistoric	belonging to the Stone, Bronze or Iron Ages (before the Romans)
retouched	a flint flake which has been modified to make it a functional tool
Roman	the period from AD 43 to around AD 430

11 Archive deposition

The paper and digital archive is currently held by the Colchester Archaeological Trust at 12 Lexden Road, Colchester, Essex CO3 3NF, but will be permanently deposited with Thurrock Museum (accession code not yet allocated).

Distribution list:
Jonathan Hills of the Hills Group
Tribal MJP
Essex Historic Environment Record, Essex County Council

Colchester Archaeological Trust
12 Lexden Road,
Colchester,
Essex CO3 3NF

tel.: (01206) 541051
(01206) 500124
email: archaeologists@catuk.org

Checked by: Howard Brooks
Date: 09.02.09

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12 Appendices
Appendix 1: trench co-ordinates

Table 1: trench co-ordinates.

T1	E 570191 N 181485	E 570166 N 181478
T2	E 570149 N 181475	E 570157 N 181449
T3	E 570133 N 181486	E 570133 N 181455
T4	E 570050 N 181465	E 570052 N 181435
T5	E 570034 N 181463	E 570004 N 181461
T6	E 570036 N 181445	E 570005 N 181442
T7	E 569983 N 181461	E 569984 N 181438
T8	E 569975 N 181460	E 569977 N 181430
T9	E 569955 N 181457	E 569940 N 181456
T10	E 569951 N 181450	E 569935 N 181448
T11	E 569904 N 181451	E 569906 N 181423
T12	E 570082 N 181392	E 570052 N 181389
T13	E 570030 N 181387	E 570034 N 181357
T14	E 570011 N 181386	E 570014 N 181355
T15	E 569987 N 181383	E 569957 N 181379
T16	E 569985 N 181370	E 569988 N 181340
T17	E 569964 N 181369	E 569966 N 181338
T18	E 569948 N 181349	E 569917 N 181345
T19	E 569936 N 181390	E 569939 N 181359
T20	E 569914 N 181388	E 569917 N 181357
T21	E 569894 N 181373	E 569864 N 181370
T22	E 569891 N 181360	E 569893 N 181330
T23	E 569869 N 181358	E 569872 N 181327
T24	E 569854 N 181339	E 569823 N 181335
T25	E 569843 N 181383	E 569845 N 181352
T26	E 569820 N 181380	E 569824 N 181350
T27	E 569800 N 181363	E 569770 N 181360

T28	E 569797 N 181348	E 569799 N 181333
T29	E 569786 N 181347	E 569787 N 181331
T30	E 569775 N 181345	E 569777 N 181316
T31	E 569749 N 181377	E 569751 N 181346
T32	E 569734 N 181373	E 569736 N 181343
T33	E 569716 N 181344	E 569686 N 181341
T34	E 569679 N 181348	E 569681 N 181318
T35	E 569719 N 181318	E 569689 N 181315

Appendix 2: geological appraisal – final report (02.02.09)

(Figs 2, 9-13)
by Dr P Allen and Dr D R Bridgland, with specialist reports by Dr I Candy, Dr R Preece, Dr D Schreve and Dr J Whittaker

Background information

The Stanhope Park site lies mostly on a bluff linking the Corbet's Tey Gravel higher up the local slope, on which Stanford-le-Hope lies, and the Mucking Gravel below, on which Mucking lies (Bridgland 1994; Bridgland *et al* 1995; Gibbard 1994; Fig 9). The gravels rest on London Clay, which in places is exposed at the surface on the bluff, although usually it is masked by slumped material (head), comprising a mixture of London Clay and Corbet's Tey Gravel.

British Geological Survey (BGS) mapping has been interpolated onto the site map provided (Fig 10). The geological boundaries are approximate.

The BGS map indicates that there is sand and gravel of the 3rd Terrace in the northern part of the site. The rest of the site is mapped as being on head deposits. Immediately west of the site there are worked-out quarries from which sand and gravel was extracted from the 2nd Terrace.

The sand and gravel of the 3rd Terrace corresponds to the Corbet's Tey Gravel and that of the of the 2nd Terrace to the Mucking Gravel of Bridgland (1994) and Gibbard (1994). Both Gravels are palaeontologically prolific in the Thurrock area, with vertebrates, Mollusca, Ostracoda and pollen (Bridgland *et al* 1995; Schreve *et al* 2002; Fig 11). In the Thurrock area, the Corbet's Tey Gravel has been, and still is, rich in Palaeolithic flint artefacts, particularly around Purfleet. For the most part, the Mucking Gravel has yielded only a limited number of flint artefacts (Wymer 1968; Wymer 1985), although the basal gravels at the Lion Pit Tramway Cutting, with refits, are a notable exception (Bridgland 1994; Bridgland *et al* 1995).

There is a three-stage cycle of deposits within each terrace and the terraces are dated by reference to Marine oxygen Isotope Stages (MIS; Fig 12). These are discussed in more detail in Appendix 3.

Local Palaeolithic archaeological finds

From the Corbet's Tey Gravel, Wymer (1985) recorded a rolled primary flake from near Corringham (at NGR TQ 710 832), approximately 2 km to the north-east of the site, but he also noted that, despite prolonged investigation by experienced archaeologists, no artefacts were found in workings near Bluehouse Farm (at NGR TQ 675 805), again approximately 2 km from the site, to the west.

In the Mucking area, the type-site for the Mucking Gravel lies in the quarry complex to the west of the site. Despite extensive quarrying of the Mucking Gravel, there appears to be no occurrence of palaeontological or Palaeolithic artefactual material in the written record. These quarries are now water-filled, so it may be that they were worked wet, thereby reducing the chance of recovering artefacts and fossil material.

Geological investigation

The site lies primarily on a bluff between the Corbet's Tey and Mucking Gravels. As such, it has been a feature of the present landscape for up to 300,000 years. Thus it has the potential to yield archaeological and environmental information about the Palaeolithic period.

Object

The objects of the investigation were:
To establish whether gravels of either terrace were present
To assess whether an archaeological investigation for Palaeolithic material would be worthwhile
To present an environmental reconstruction of the site at the time that the sediments were deposited
To confirm the stratigraphic position and age of those sediments.

Site investigation

As part of the archaeological investigation of the site, 35 shallow trenches were cut by CAT (Fig 2). The trenches were approximately 0.3 m deep, unless otherwise indicated, and each was 30 m long. The nature of the sub-soil geology, exposed at the bottom of each trench, was briefly noted.

On-site descriptions of trench bases

Trench 1
Predominantly a mix of London Clay and gravel, less gravelly at the western end (head). Two zones showed significant precipitation of calcium carbonate, partly nodular (oncoidal), but much was dispersed as a thin coating lining fissures.

Trench 2
Predominantly a mix of London Clay and gravel (head), less gravelly than T1. A deeper cut at one point, to 0.5 m, showed *in situ* London Clay. There was also less calcium carbonate.

Trench 3
Similar to T2, mostly head, but with very little gravel in the northern 6 m and southern 3.5 m of the trench floor. The matrix was more sandy between 5 m and 9 m and 14 m to 16 m from the southern end. There were zones of calcium carbonate precipitation.

Flecks of chalk were seen in the southern part of the trench, but these were thought to be humanly introduced.

Trench 4
This trench was predominantly floored by head, but there were a number of other features. The southern 4 m showed London Clay, often disturbed by fissuring, with few flints and occasional chalk flecks (?humanly introduced). The head was more sandy at 9 m and at 11 m from the southern end, crossing the trench in a linear fashion, possibly indicating that the head was not fully homogenised as it had more sandy 'streaks' in it. At 22.5 m and 24 m from the southern end were two channels infilled with ?redeposited London Clay. The bases of the channel were concave. It was not clear whether these were natural or artificial features.

Trench 5
This trench was floored by London Clay with very little gravel. From the eastern end, the London Clay appeared to be *in situ* for 23 m, although precipitated calcium carbonate coated fissures between 11 m and 23 m. Between 23 m and 25 m, a silty clayey gravel (head) crossed the trench in a linear fashion, suggesting channelling. Between 25 m and 30 m, there was London Clay, with minor amounts of gravel and calcium carbonate precipitation.

Trench 6
From the eastern end, for 13 m this trench was floored by gravelly London Clay (head). Beyond that the London Clay appeared to be *in situ*, but showing later features in the form of patches of silty clay, possibly infills of minor pools (the size of puddles) and, at 25-26 m, the silty clay, with Mollusca, crossed the trench in a linear fashion. This was a typical quiet-water channel infill.

Trench 7 (22 m long)
The southernmost 12.5 m showed what appeared to be *in situ* London Clay, but with an artificial feature at between 9 m and 10.5 m. Beyond that the floor was initially clayey gravel (12.5-14.7 m), then sandy gravel, with a minor clay component (14.7-15.5 m), becoming sand (15.5 m and 16.7 m), sandy gravel, some clay (16.7-18 m), and sandy again, but with intrusions of sandy clayey gravel (18-22 m).

The sand was mottled – 7.5YR5/8 (strong brown), 10YR7/4 (very pale brown), and 2.5Y7/4 (pale yellow) – indicating repeated wetting and drying, and it also showed a degree of linear patterning possibly suggesting desiccation and fissuring of the ground surface.

The sequence became more sandy to the north and could represent the edge of a local channel or the edge of the channel of the Corbet's Tey Gravel.

Trench 8
From the south, the first 16 m comprised disturbed blocky London Clay. Between 16 m and 18.5 m, there was an artificial fill of gravel. Beyond that was sandy silty clay with much precipitated calcium carbonate (18-19 m), becoming clayey sand (19-22.5 m), with mottling and lineation (22.5-25 m). This gave way at a clear linear boundary to gravel.

The sequence became more sandy and then gravelly to the north and was considered to represent the edge of the channel of the Corbet's Tey Gravel.

Trench 9 (13 m long)
From the east end, there was disturbed, artificial ground at 0-4 m, 6-7 m, and 8-13 m. Between 4 m and 6 m there was sandy gravel, the sand matrix being 7.5YR5/8 (strong brown). Possibly there was further such gravel between 8 m and 11 m, but its disturbed nature made it difficult to interpret with confidence.

This trench may also have impinged on the edge of the Corbet's Tey Gravel.

Trench 10 (16 m long)
From the east end, this trench exposed disturbed ground at 0-9 m and 11-11.5 m. Between 9 m and 11 m, there was clayey sandy gravel and from 11.5 m to 16 m, London Clay with occasional gravel inclusions, approximately 0.2 x 0.3 m, and patches of intense calcium carbonate precipitation along root voids.

Trench 11
London Clay, stoneless, frequently fissured and blocky.

Trench 12
London Clay, relatively stoneless, gravelly patches in central area.

Trenches 13-14
Sand and gravel alternating with London Clay, sometimes gravelly (head), sometimes stoneless.

Trench 15
Gravelly London Clay (head) (0-12 m), gave way to clayey sandy gravel (12-24 m) with occasional rounded patches (0.3-0.5 m) of London Clay. From 24 m to 30 m, silt and silty clay alternated with gravel. The rounded features between 12 m and 24 m would be consistent with loading and diapiring. The silt and silty clay may represent quiet water infill of shallow ponds (puddle-sized) on slightly lower ground, corresponding to the London Clay, between the gravel outcrops.

Trench 16
Gravelly London Clay becoming patchy, resting on London Clay, in the northern 9 m (loading and diapirism).

Trench 17
Sandy gravel (7.5YR5/8, strong brown) with rounded patches of stoneless London Clay (diapirism).

Trench 18
From the north, clayey sandy gravel (head) alternated with linear patches of London Clay, approximately 30 cm across, trending south-west/north-east (loading and diapirism; 0-6 m). The majority of the trench (6-30 m) comprised rapidly alternating London Clay (30-60 cm across) and clayey sandy gravel, trending south-west/north-east (loading and diapirism).

An unusual feature of this trench was the occurrence of coarse flint gravel, individual flints often being up to 3 cm in diameter, occasionally up 9 cm.

Trench 19
Sandy clayey gravel with some patches of London Clay (?diapirism).

Trench 20
From the east, the trench was floored by a coarse gravel (flints up to 6 cm in diameter) with rounded patches of London Clay (?diapirism; 0-5.5 m), giving way to clayey sand and gravel (5.5-14.0 m), and then returning to coarse gravel with rounded patches of London Clay (14-20 m). Between 20 m and 25.5 m, the coarse gravel continued, but without the patches of London Clay. From 25.5 m to 30 m, there was sandy gravel alternating with linear outcrops of London Clay trending south-east/north-west (loading and diapirism). The sandy matrix of the gravel was mostly 7.5YR5/8 (strong brown).

Trench 21
Gravelly London Clay (head) with patches of relatively stoneless London Clay (?diapirism).

Trench 22
From the north, gravelly London Clay (0-14 m) becoming clayey sandy gravel (14-30 m), with patches of relatively stoneless London Clay throughout.

Trench 23
From the north, relatively stoneless London Clay dominated, with patches of gravelly London Clay (0-16.5 m), becoming sandy gravelly clay (16.5-30 m).

Trench 24
From the west, gravelly London Clay, with linear outcrops of relatively stoneless London Clay towards east end, trending north-south.

Trench 25
From the south, gravelly London Clay (0-17.9 m) becoming London Clay with gravelly patches (18.5-30 m), crossed obliquely (south-west/north-east) by linear outcrops of sand (17.9-18.5 m + 24-26.7 m).

Trench 26
From the south, gravelly London Clay (0-17.3 m), with patches of relatively stoneless London Clay (0-10 m). This gave way to relatively stoneless London Clay with patches of

gravelly London Clay (17.3-25 m). Between 25 m and 30 m, there was a fine sand on the east side of the trench with north-south linear patterning picked by grey sand against the host yellow sand. The west side of the trench had gravelly London Clay and relatively stoneless London Clay.

Trenches 27-30
Relatively stoneless London Clay with patches of gravelly clay.

Trench 31
From the north (0-2 m), relatively stoneless London Clay with nodular calcium carbonate and two patches of gravel, flints up to 30-40 cm. Relatively stoneless London Clay (2-14 m), becoming patchily stony (14-20.5 m) and then gravelly London Clay.

Trench 32
From the north, London Clay alternating linearly with stony London Clay with some rounded patches of gravel (0-5 m), becoming gravelly London Clay (5-30 m).

Trench 33
Gravelly London Clay.

Trench 34
Gravelly London Clay, disturbed at the west end, alternating linearly with less stony clay at the east end (?loading and diapirism)

Trench 35
Gravelly London Clay.

Sampling
Samples were collected as follows:
For geochemical analyses, calcium carbonate samples (oncoids) were collected from T11, L2 (finds no 13).

For palaeontological (Ostracoda, Mollusca, vertebrates) identifications, two bags were collected from T6, F12 (finds no 12).

Geochemical analyses – carbonate nodules from Stanford-le-Hope (L2 finds no 13)
Nodules of secondary carbonate were studied from the Stanford-le-Hope sequence. These were supplied in bag samples so the *in situ* arrangement and distribution of these features could not be analysed. Morphologically the nodules exhibit a range of sizes and forms but they are mostly elongate features. The largest nodules are 7 cm in length but more commonly these features are only 1 or 2 cm in size. The general structure of these features consists of a densely cemented outer surface but an internal matrix that contains numerous voids and cracks. These cracks are either linear features which run across the width of the nodule or radial features with cracks which spread out from a central point. In some of the studied nodules, the internal voids are much larger and comprise over 70% of the nodule form. The micro-structure of these nodules comprises a heterogeneous micrite/microspar cement within which grains of the host sediment are suspended. There are no clear structures within the cement and its formation appears to represent a progressive cementation by secondary carbonate within the sediment matrix.

Procedure and results
Seven samples were taken from different nodules for stable oxygen and carbon isotopic analysis. Powdered samples were dried overnight at 60°C and then weighed into steel crucibles for analysis. The stable $\delta^{18}O$ and $\delta^{13}C$ isotopic composition was established by analysing CO_2 liberated from sample reaction with phosphoric acid at 90°C. Internal (RHBNC-PRISM) and external (NBS-19) standards were analysed after every 10 samples.

Carbonate stable isotopes were analysed using a VG PRISM Series 2 mass spectrometer. All isotopic data presented here are quoted in reference to PDB. The mean $\delta^{18}O$ value is -5.33 (standard deviation = 0.16), whilst the mean $\delta^{13}C$ value is -8.93 (standard deviation = 0.24).

Interpretation

The morphology (shape), micromorphology (internal structure) and stable isotopic composition of the nodules found at Stanford-le-Hope are characteristic of groundwater carbonates found in Quaternary deposits at a range of sites across southern and eastern England. In particular, the densely cemented outer surface and the 'cracked' void-rich centre is common at sites such as West Stow, Suffolk (Preece *et al* 2007) and Clacton-on-Sea, Essex (Candy in press). This form most likely stems from an initial phase of nodule growth followed by a successive growth of carbonate round the outer surface once the nodule has formed. The growth of this carbonate rind will produce internal stresses within the carbonate precipitate which leads to the generation of cracks which become propagated as carbonate precipitation continues (see Preece *et al* 2007 for discussion).

The oxygen and carbon isotopic composition of the nodules are typical of interglacial groundwater/pedogenic carbonates from southern and eastern England (Fig 13). The origin of these isotopic signatures have been widely discussed in Andrews *et al* (1993), Candy *et al* (2006) and Candy (in press). The strongly negative $\delta^{13}C$ signal reflects the uptake of plant respired soil CO_2 by meteoric waters during groundwater recharge. The $\delta^{18}O$ values are primarily controlled by the oxygen isotope values of meteoric waters which are primarily controlled by the $\delta^{18}O$ values of rainfall (see Appendix 3: dating the Terrace sequence, p 22). As the $\delta^{18}O$ composition of rainfall is mainly controlled by air temperature, the $\delta^{18}O$ of the carbonates reflects the temperature regime during the period of formation. The $\delta^{18}O$ composition of the Stanford-le-Hope carbonates is typical of carbonates from the Holocene and other interglacials, suggesting that these nodules have formed as a result of groundwater processes under interglacial conditions. There is no evidence to indicate whether the precipitation of the carbonates is synchronous with the accumulation of the Stanford-le-Hope sediments or whether these features formed much later.

Although the dating of these sediments is problematic, some success has been achieved through the dating of soil/groundwater carbonates using U-series dating (Candy *et al* 2005). This could have been attempted here; however, the nodules are relatively poorly preserved and the potential for the removal or addition of uranium during burial was high. Consequently this approach was not undertaken.

Palaeontological sampling – sieving and sorting

by Dr D Schreve

Sample THS 108

Received on 04/11/2008, two bags of sediment from the same sample as above, for a total of 22.792 kg (and a small bag with 10 nodules of sediment containing larger intact or fragmented molluscs, from the same sample; this was left unprocessed).

A sub-sample of 1.000 kg was removed for ostracods and foraminifers.

As the bulk sample had not been stratigraphically taken, this sub-sample was made up from randomly selected lumps of sediment in sizes from 4 cm to 10 cm.

The sediment was dried for 48 hours at 55° C and then soaked in a 5% (per weight) solution of sodium hexametaphosphate (NaPO3)6 in deionised water until fully broken down.

This was sieved down to 63µm, with fractions of 125µm, 250µm and >500µm, the residues being dried for 24 hours at 55° C and each fraction bagged separately.

Total weight of the residues: 0.202 kg, with individual fractions weights:

63µm-125µm	0.067 kg
125µm-250µm	0.051 kg
250µm-50 µm	0.040 kg
> 500µm	0.044 kg

The fraction > 500µm was sorted for vertebrates and molluscs.

Remaining bulk sample (21.792 kg)

Sieving

The sediment was dried for 48 hours at 55℃, soaked in tap water and sieved in a large 500µm-mesh sieving tray. To fully break down the sediment without the use of chemicals, the sieved residue required repeating the above operations.

While sieving, the larger clasts were manually removed to avoid damage to potential finds.

The final clean residue, total weight 0.992 kg, was graded to ease sorting, with fractions' weights as follows:

Large clasts	0.274 kg
> 2mm	0.197 kg
2mm-1mm	0.126 kg
1mm-500µm	0.395 kg

Sorting

In addition to sorting for vertebrate remains, the residue was examined for other proxies (molluscs, beetles, plant macros, charcoal) and a selection of the 'better' specimens of all of these was also picked. Most molluscan fragments were picked from the fraction >2 mm to avoid further fragmentation.

Palaeontological identifications

Ostracoda and Foraminifera

by Dr J Whittaker

The sub-sample of 1.00 kg removed for ostracods and foraminifers proved sterile.

Mollusca

by Dr R Preece

On a preliminary examination of the sample, *Helix aspersa* was identified. This is a Roman introduction, so the host sediment is Roman or younger. Further analysis was not undertaken as the material was not prehistoric.

Beetle

Fragment (1) of jaw, not diagnostic (identified by Prof S Elias).

Vertebrates

by Dr D Schreve

Procedure

Bones and teeth were identified using modern and comparative reference material, as well as appropriate keys and drawings. Dentitions are described as follows: L = left; R = right; upper case denotes upper dentition; lower case denotes lower dentition; m/M = molar.

Identification

PISCES

Pisces sp.: 1 fin spine fragment of undetermined fish.

REPTILIA

Ophidia sp., undetermined snake: 1 partial trunk vertebra.

AVES

Aves sp.: distal tarsometatarsus of undetermined small perching bird.

MAMMALIA

Rodentia

Microtus agrestis L., short-tailed field vole: R M2

Microtus sp., undetermined vole: juvenile L M2

Undetermined small mammal: lumbar vertebra, proximal right femur, 1 fragment of distal condyle of femur, 29 long-bone and other fragments including metapodials and phalanges 14 very small indeterminate bone fragments.

Interpretation
The bone material is generally well preserved, implying relatively rapid deposition after death, with the exception of a fragment of distal femoral condyle of an indeterminate small mammal. The latter is extremely eroded, possibly the result of digestion by an avian predator. The sole mammal identifiable to species level is *Microtus agrestis*, which is the only representative of the genus inhabiting mainland Britain today. The species is widespread in Britain and occupies mainly rough, often damp grassland (Corbet & Harris 1991). *M. agrestis* (vole) has an extended stratigraphical range over at least 500,000 years. Its first appearance in Britain was during the early Middle Pleistocene (Cromerian Complex) at sites such as Boxgrove (West Sussex; Roberts & Parfitt 1999) and it occurs during every subsequent interglacial (Schreve 1997), including the Holocene (Yalden 1999). Unfortunately, its presence in the Stanford-le-Hope samples therefore cannot assist in refining the age of the sediments, since they could represent any temperate part of the Pleistocene or the last 10,000 years. The remaining microtine molar is juvenile (indicated by a lack of closure of the enamel triangles on the occlusal surface) and cannot thus be identified with confidence. It might be possible to further improve the identification of the reptile and bird fragments after consultation with appropriate specialists.

Assessment

Sediments
The BGS mapping suggested that there would be gravels of the Corbet's Tey Gravel on the northern part of the site. Apart from in T8, these gravels were not identified. However, terrace boundaries are particularly difficult to determine as the terrace deposits peter out rather than having a clearly defined limit. Thus it is not surprising that there was not close correspondence between the finding on the ground and the boundary shown on the geological map.

The Corbet's Tey Gravel was seen in the northern part of T8. Post-excavation site development prevented further investigation. However, I believe that this was a feather-edge and of no great thickness. I would further add that this terrace boundary represents the 'mid-stream' edge rather than the 'bank' edge of the terrace, which is far less likely to produce artefacts, and any present are likely to be derived rather than representing the presence of human occupation. The chance of significant Palaeolithic material being present is low.

Where gravel was seen, it was predominantly flint (rounded Tertiary flint or sub-rounded to sub-angular flint, mostly broken and rolled Tertiary flint) with minor amounts of quartzite and vein quartz. This is in keeping with the clast lithologies of the gravels of the Thames terraces. Given the quality of the BGS mapping and its acceptance by Bridgland (1994) and Gibbard (1994), it was not deemed necessary to carry out clast lithological analyses (stone counts) to confirm the situation.

The most common type of sediment seen was head, either as London Clay mixed with gravel from the Corbet's Tey Gravel or as sandy gravel with a strong clay component in the matrix, derived from the London Clay.

The London Clay and the head were noted frequently to occur in rounded to sub-rounded patches or alternating in a linear fashion. This may indicate post-depositional deformation. These features would be consistent with gravelly material overlying saturated London Clay, leading to the gravelly material sinking into the Clay (loading) and the Clay injecting upwards in response (diapiring). In plan, the latter may form rounded structures, like domes, or ridges. The loading will form complementary structures of rounded basins or linear depressions. The saturated conditions necessary for this type of disturbance to occur are usually associated with thawing after periods of ground freezing, at the end of cold (glacial) periods. This process could have occurred at the end the cold period (MIS 8) when the upper part of the Corbet's Tey Gravels were deposited or the two subsequent cold periods (MISs 6 or 2).

Frequently the sandy matrix of the gravels within the gravels was mottled, indicating prolonged wetting and drying. Strong brown or orange colours indicate that iron coating the sand grains has oxidised to its ferric state in warm, dry conditions, while paler yellow or grey colours indicate wetting and reduction of the iron to its ferrous form. The mottling is an indication of temperate (interglacial) conditions, but this could have occurred at any time during or after the deposition of the gravel.

Thus the sediment observations suggest a complex history of cold (glacial) and warm (interglacial) stages, but there was not sufficient evidence to establish a chronological sequence.

Geochemistry

Within the London Clay, precipitated calcium carbonate was common, in nodular form (oncoids) or as a coating along fissures in the clay or coating the voids of root channels. This material indicates periods of tufa formation in temperate conditions after deposition of the London Clay and can be geologically old or quite recent. A geochemical investigation was carried out to gain further palaeoenvironmental information. The results again indicate temperate, interglacial conditions. The graph in Figure 13 shows that temperatures at the time of formation of the oncoids was similar to those prevailing both during the Hoxnian Interglacial (about 400,000 years ago) and today. The graph can be used only to infer temperature and not age. The oncoids could have formed at the time that the Corbet's Tey Gravels were laid down or in any of the three subsequent temperate periods.

The geochemical analyses confirm that temperate conditions prevailed for at least one stage, but were not robust enough to determine when.

Palaeontology

The palaeontological analyses were not significantly productive.

No Ostracoda or Foraminifera were found. This is not overly significant as they are not always present.

The Mollusca included *Helix aspersa* which is a Roman introduction. Thus the channels at the site were functioning in historical times.

The vertebrates bones indicated the presence of fish, snake, bird and mammals. Of these, the only identification to species level was vole, *Microtus agrestis*. Snake is associated with temperate conditions and the vole, another temperate indicator, has an age from *c* 500,000 years ago to today. A more refined outcome could possibly have been achieved with further work on the snake and bird fragments, but the general paucity of material means that further work would be of limited value.

The palaeontological evidence further confirms that temperate conditions prevailed when minor river channels crossing the site silted up. However, the oldest date that could be ascribed is Roman.

Conclusion

A remnant of the Corbet's Tey Gravel was present on the northern edge of the site, seen in T8 and possibly T9. The gravels were indicative of cold stage deposition during MIS 10 or MIS 8. However, there was no evidence that the gravels were of any great thickness and their position, distal to the bank, was unfavourable to the finding of Palaeolithic artefacts, particularly *in situ*.

Much of the rest of the site was covered by head, a cold stage mud slurry or hillwash slope deposit in the form of a mixture of clay and gravel. A number of trenches also showed ground disturbance in the form of loading structures and diapirs as gravelly deposits sank into saturated London Clay, during thaw stages. The evidence was not strong enough to indicate in which cold stage the slope movements and ground disturbances occurred.

In contrast, there was geochemical evidence of warm conditions. Mottling of sands, either bedded or as matrix in the gravel, showed strong brown or orange colours indicating the presence of iron which had formed or chemically changed in warm and/or dry conditions. Within finer sediments, carbonate in the groundwater precipitated out to form nodules, the oxygen component of the carbonate indicating formation in temperate conditions, although the evidence was not robust enough to indicate which temperate stage. Further evidence of temperate conditions came from the palaeontological material (molluscs and vertebrates) recovered from silts infilling shallow channels that crossed the site. However, these channels are likely to be Roman or younger.

Appendix 3: dating the Terrace sequence – Marine oxygen Isotope Stages (MIS)

by Dr P Allen

Sediments from ocean floors have been found to contain an important, globally valid record of Quaternary climatic fluctuation, based on oxygen isotopes within the hard shells of marine planktonic animals that are present in these deposits. Oxygen can exist in three isotopic forms ($\delta^{16}O$, $\delta^{17}O$, $\delta^{18}O$). Most oxygen exists as $\delta^{16}O$ (the most common) or $\delta^{18}O$, the ratio between the two being 500:1. As part of the hydrological cycle of evaporation, cloud formation, rain and return of water by rivers to the oceans, during glacial episodes, more and more of the water removed from the oceans gets locked up in global ice and is delayed in its return to the oceans. At such times, because of the preferential evaporation of water containing $\delta^{16}O$, the ocean water becomes depleted in the light isotope relative to its condition during interglacials. This effect can be measured by analysing the oxygen isotope content of the calcium carbonate in the shells of planktonic micro-organisms called Foraminifera, which are common constituents of ocean floor sediments. It is assumed that their composition is in equilibrium with the sea water at the time they were alive. The results are expressed as a ratio between the two isotopes. It is a measure of global ice volume and, at the same time, an indirect measure of both eustatic sea level and climate. The variations in the ratios between the types of oxygen can be plotted and an oxygen isotope curve drawn up (Fig 12). The swings on the curve are numbered, with the colder periods ($\delta^{18}O$-rich) being given even numbers and the warmer periods odd numbers. Oscillations within a warm or cold period are given letters, a-c-e being warmer and b-d-f colder.

The Lynch Hill Terrace (Corbet's Tey Gravel) and Taplow Terrace (Mucking Gravel) each have a 'sandwich' of cold stage gravel – interglacial fines – cold stage gravel (see below), dated as follows:

Mucking Upper Gravel	MIS	6
Aveley Interglacial Deposits		7
Mucking Lower Gravel		8
(downcutting)		8
Corbet's Tey Upper Gravel		8
Purfleet Interglacial Deposits		9
Corbet's Tey Lower Gravel		10

River terraces

River terrace sequences are relatively flat areas, usually underlain by (or composed of) fluvial sediments and usually cut into the slopes of river valleys. They are interpreted as fragments of former valley bottoms, or floodplains (since these are where river sediments accumulate) that have been left above river level by fluvial downcutting.

The downcutting occurs in pulses, each pulse being followed by accumulation of sediment. It is this process that creates the sequence of flats/terraces, the lower the terrace, the younger its age. In more detail, where the sequence is complete, each terrace comprises a cold-warm-cold sandwich of deposits formed by a sequence of lower and upper cold-climate gravels between which temperate-climate, often fossiliferous, sediments occur. These climatic cycles are argued to occur in synchrony with glacial-interglacial climatic cycles described by the MIS record.

In situ palaeontological and archaeological material is mostly restricted to the finer-grained sediments of the interglacial part of the 'sandwich'. Finds in the gravels are likely to be derived and so of less value.

The driving force for the downcutting is progressive uplift of the land. However, the pulsed reaction to this uplift, rather than continuous downcutting, is because the rivers generate sufficient power to downcut only at certain points in the MIS climatic cycle, when water volumes are high and the protective effects of vegetation are at a minimum. The downcutting occurs in cold periods. Thus deposition of the uppermost gravel of one terrace is followed by downcutting and then deposition of the lowermost gravel of the next terrace later in the same cold stage.

Loading and diapirism
Approximately every 100,000 years for the last 500,000 years the world has experienced extremely cold (glacial) conditions. During the glacial periods, glaciers did not necessarily extend far south in Britain, if at all, but the ground became permanently frozen. At the end of these stages, thawing caused the ground to become highly saturated. The local London Clay, when saturated, could not always bear the weight of gravels that slumped down on to it during the thaw process. The gravels sank into the clay forming, in cross-section, rounded U-shaped structures (load structures). As the gravel sank, the displaced London Clay injected upwards forming, in cross-section, pointed /\-shaped structures (diapirs). The loading and diapirism could occur in a linear fashion creating, in plan, troughs and ridges, or in a rounded manner creating, in plan, basins and domes. Both linear and rounded forms were seen in the trench floors.

Calcium carbonate
Groundwater, when it evaporates during warm and/or dry periods, precipitates out any minerals it may contain. If it is carrying calcium carbonate (lime/chalk, $CaCO_3$), the carbonate precipitates out to coat any fissures, voids or channels left by roots or worms, or may cluster to form nodules (technically ‘oncoids’, informally ‘dolls’). By examining the nature of the oxygen component of the carbonate in the nodules, assessments of the isotopic nature of the oxygen in the groundwater and, indirectly, the rainfall and temperature can be made, as explained above in ‘Dating the Terrace sequence – Marine oxygen Isotope Stages (MIS)’ (p 22).

The calcium carbonate precipitates out in the form of **micrite**, if the crystals are 4 microns or less in size, or **microspar**, if the crystals are larger.

Ostracoda and Foraminifera
Ostracods and forams are microfossils that can give useful environmental information as different species often occupy particular ecological niches, reflecting freshwater, brackish or marine environments, flowing or still water, clear or muddy water, and so on. Forams live in marine or brackish water, while ostracods have a wider range, although also occupying freshwater habitats.

Ostracoda are small crustaceans typically about 1mm long (living forms range from 0.3-30 mm long) which occur in practically every aquatic environment. In today's oceans they are found living from the abyssal depths to the shoreline. They also inhabit estuaries, lagoons, freshwater lakes, ponds and streams, salt lakes, hot springs and damp vegetation.

Foraminifera are single-celled organisms. Their fossils have been found in rocks from the Cambrian period onwards and they are still living and abundant today. Forams generally inhabit marine and brackish environments and, although some do live freely in the upper ocean amongst the plankton, the majority of species are benthic, ie they live in amongst the particles of the top few centimetres of the sea floor.

Essex Historic Environment Record/
Essex Archaeology and History

Summary sheet

Site address: Stanhope Park, Wharf Road, Stanford-le-Hope, Essex	
Parish: Stanford-le-Hope	***District:*** Thurrock
NGR: TQ 698 815 (c)	***ECC HEM site code:*** THSI 08
Type of work: Trial-trenching evaluation	***Site director/group:*** Colchester Archaeological Trust
Date of work: July 2008	***Size of area investigated*:** approximately 14ha
Location of finds/curating museum: Thurrock Museum (accession code not yet allocated)	***Funding source:*** Developers
Further seasons anticipated? No	***Related EHER nos:*** 7131, 15128, 14769
Final report: CAT Report 488 and summary in *EAH*	
Periods represented: prehistoric, Roman, medieval, modern	

Summary of fieldwork results:

The site is located on the Thames estuary in an area that has been densely populated from the Roman period onwards, and consequently was considered to be potentially archaeologically rich. An evaluation by 35 trial-trenches revealed thinly-spread evidence of activity ranging from the Mesolithic to the modern period. Features of note were a Roman pit and a medieval ditch. An interesting find was a collection of unstratified Palaeolithic flints deposited on the site from the river margin somewhere upstream. The low incidence of datable archaeological features is surprising given the proximity of the Mucking site to the south-west, and the number of findspots of Roman pottery from the foreshore and Mucking Creek.

Approximately one-third of the features excavated were modern, reflecting the impact of developing industries in the area over the past 100 years. This probably explains the paucity of surviving archaeological features and finds here, as the industrial use of the site and, later, stripping of topsoil to remove contaminants, has severely affected in situ *preservation.*

A geological appraisal of the site included palaeontological identification of molluscs which indicate that the shallow channels crossing the site were active in the Roman or later periods.

Previous summaries/reports: CAT Report 261	
Keywords: flints, Palaeolithic	***Significance:*** neg
Author of summary: Chris Lister	***Date of summary:*** February 2009

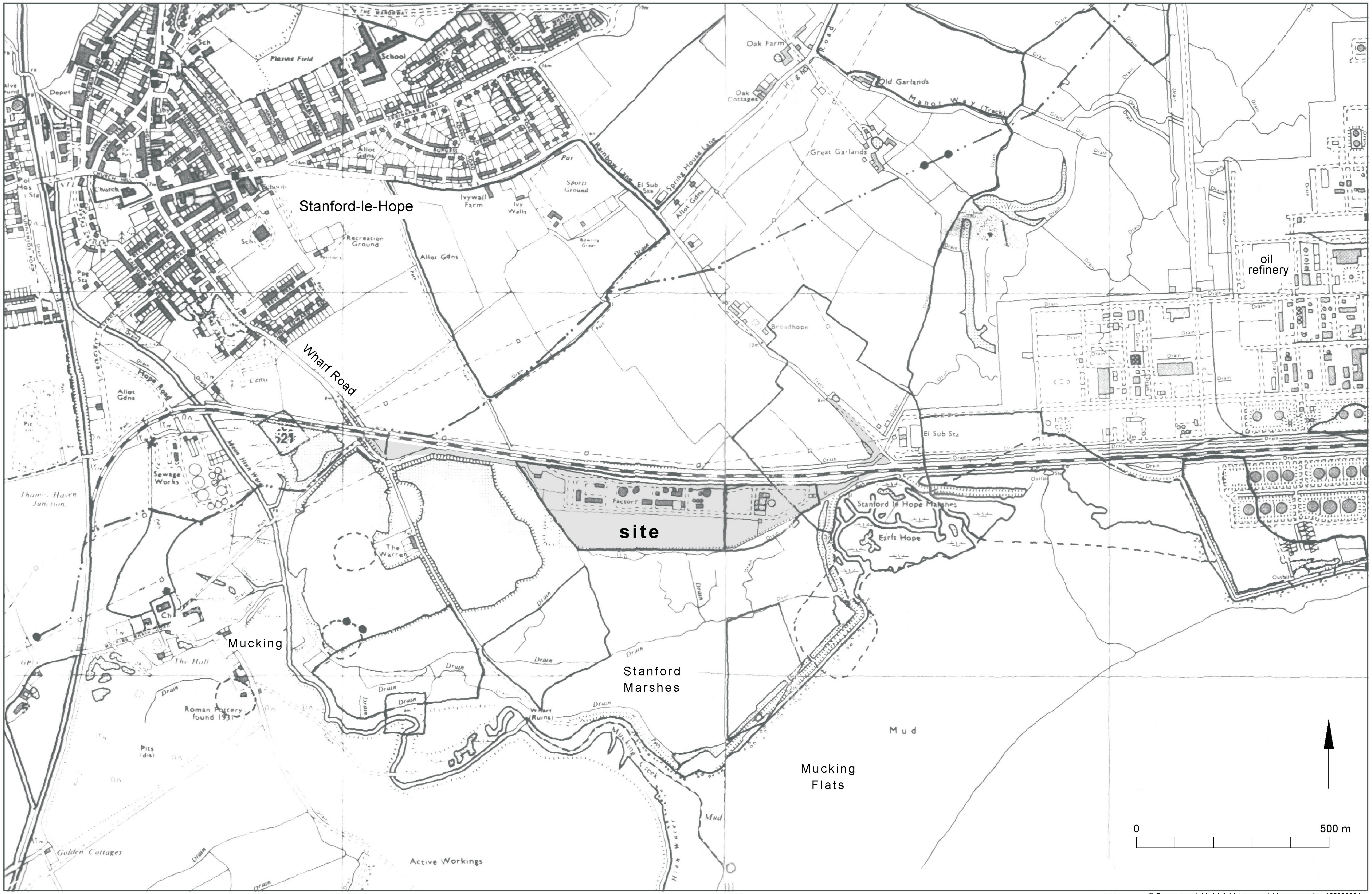


Fig 1 Site location.

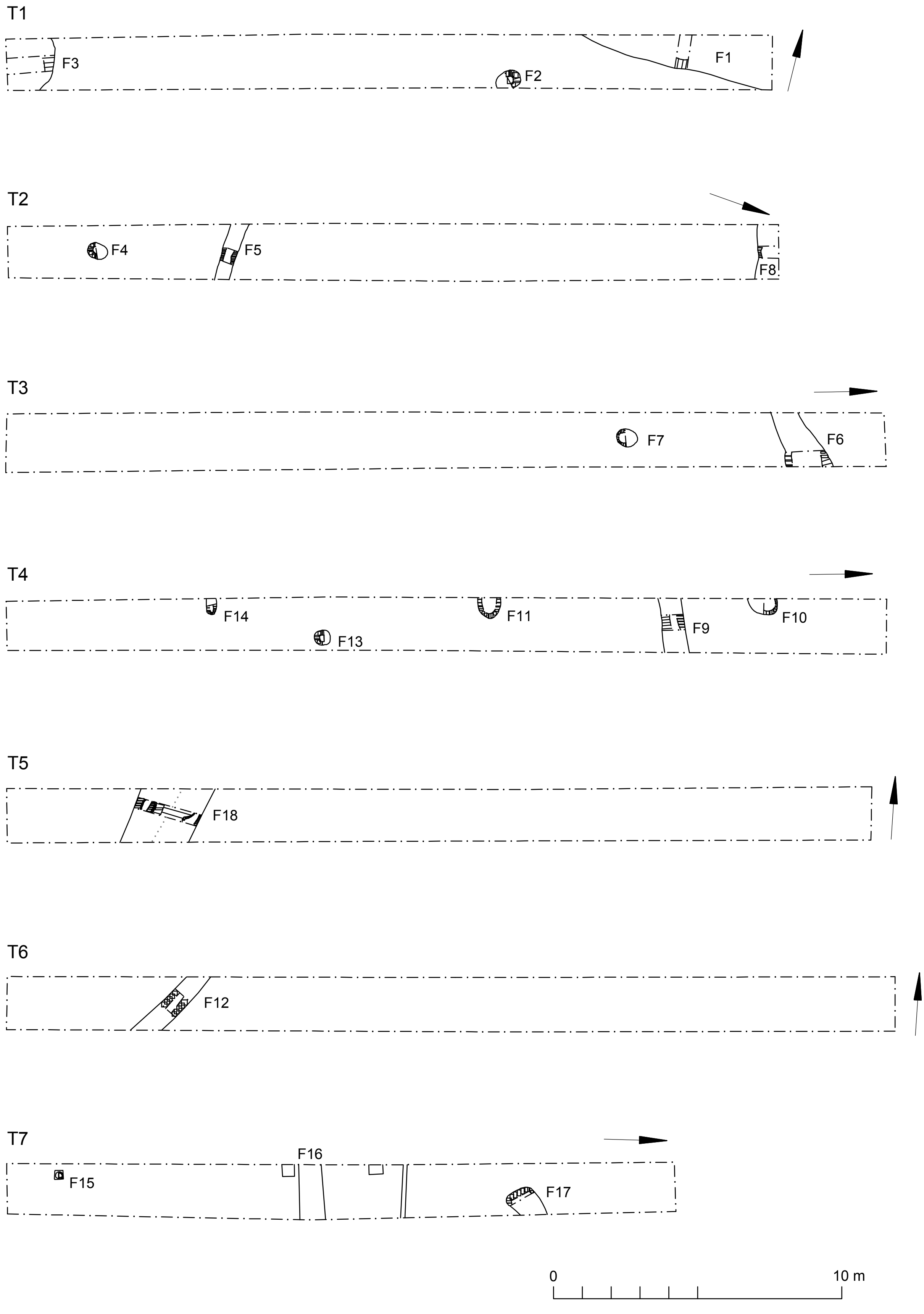


Fig 2 T1-T7: plans.

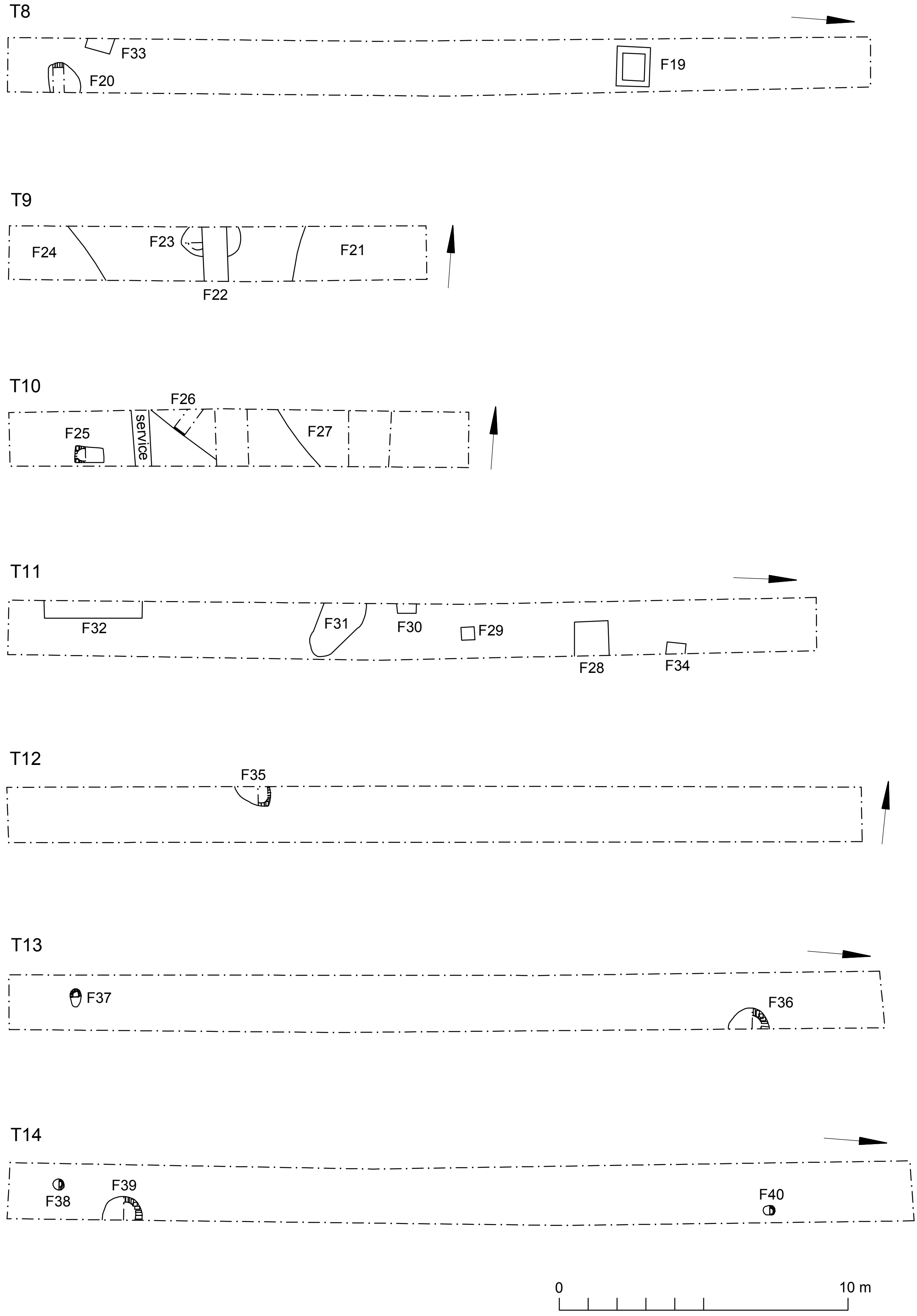


Fig 3 T8-T14: plans.

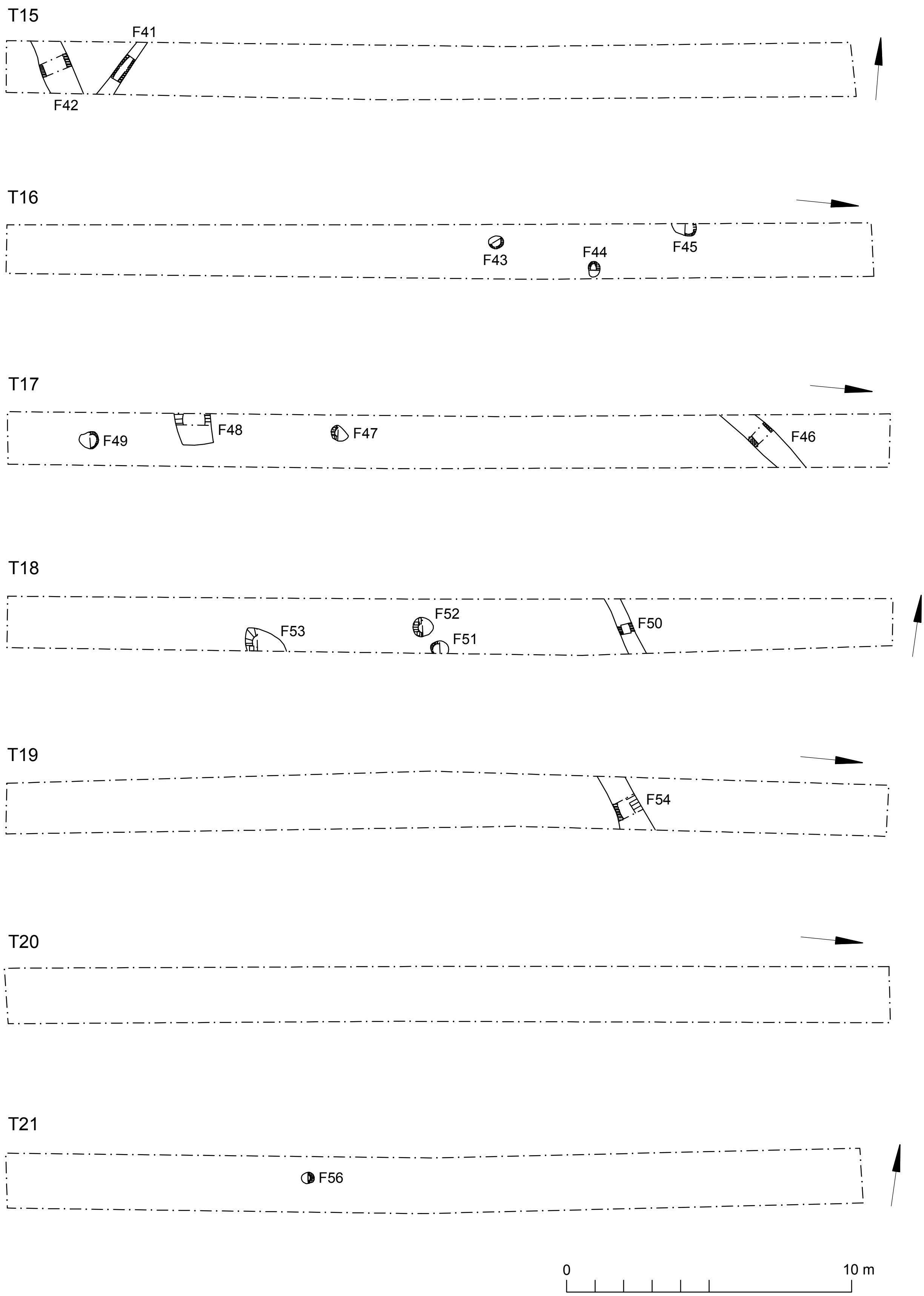


Fig 4 T15-T21: plans.

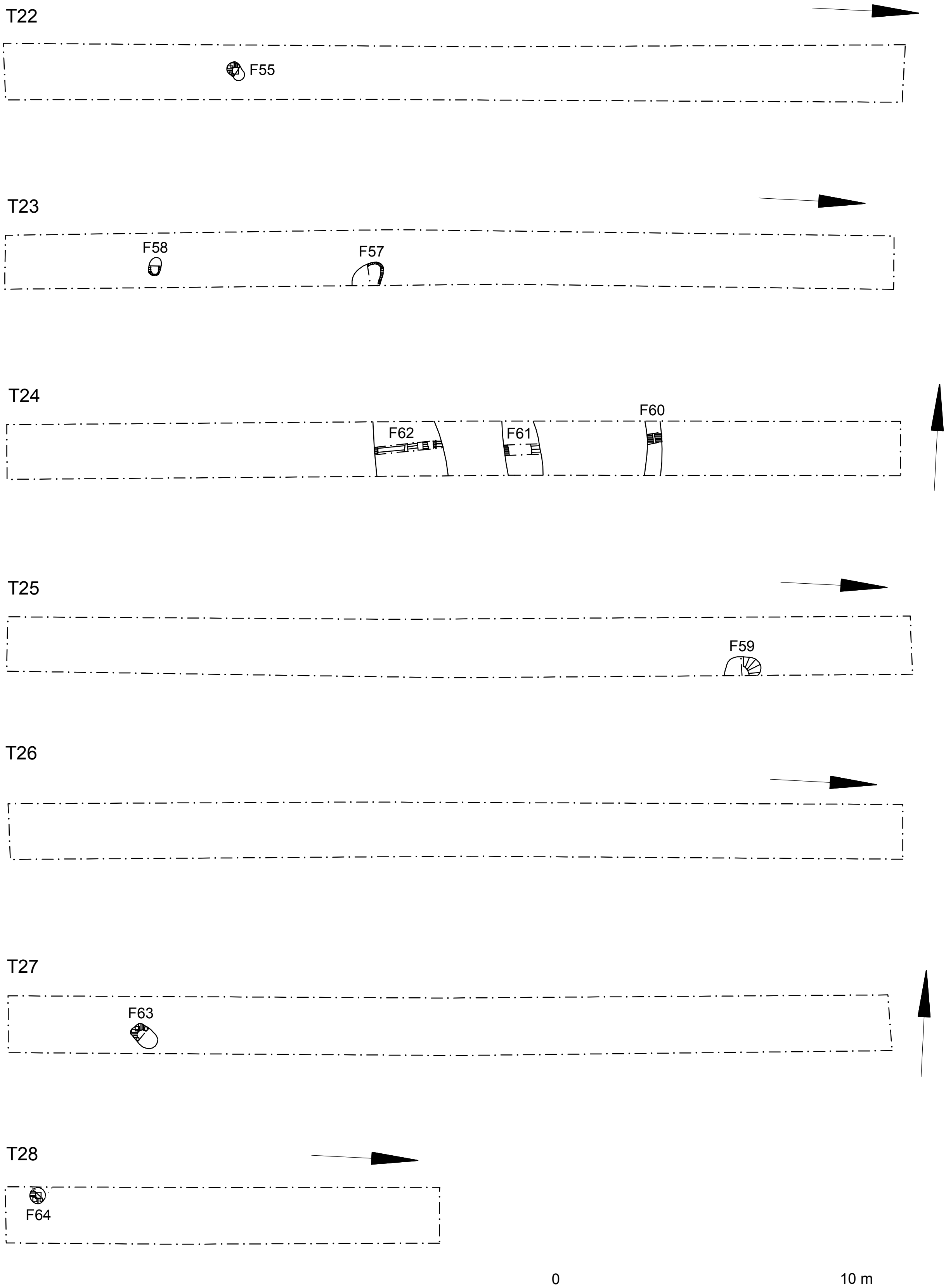


Fig 5 T22-T28: plans.

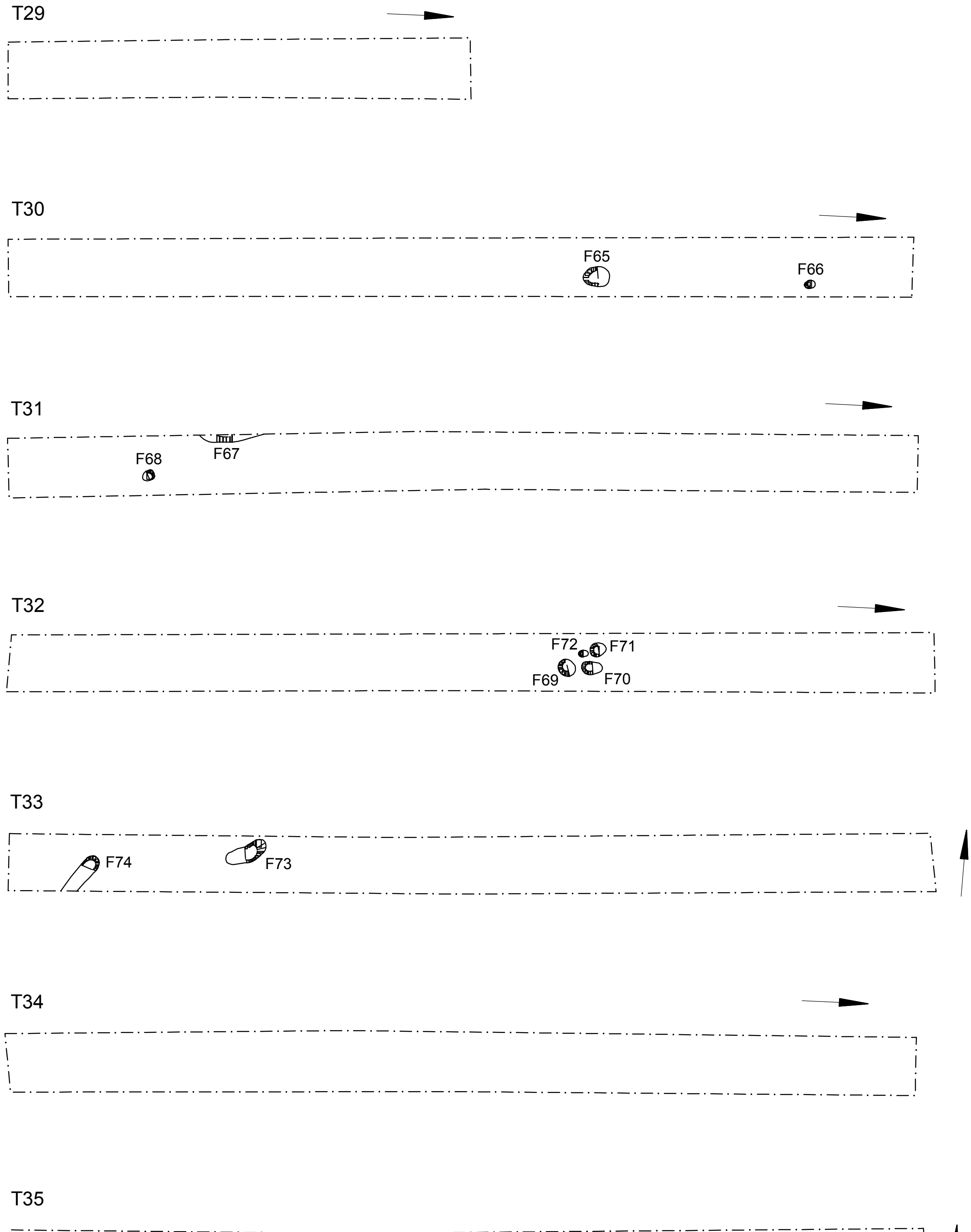


Fig 6 T29-T35: trench plans

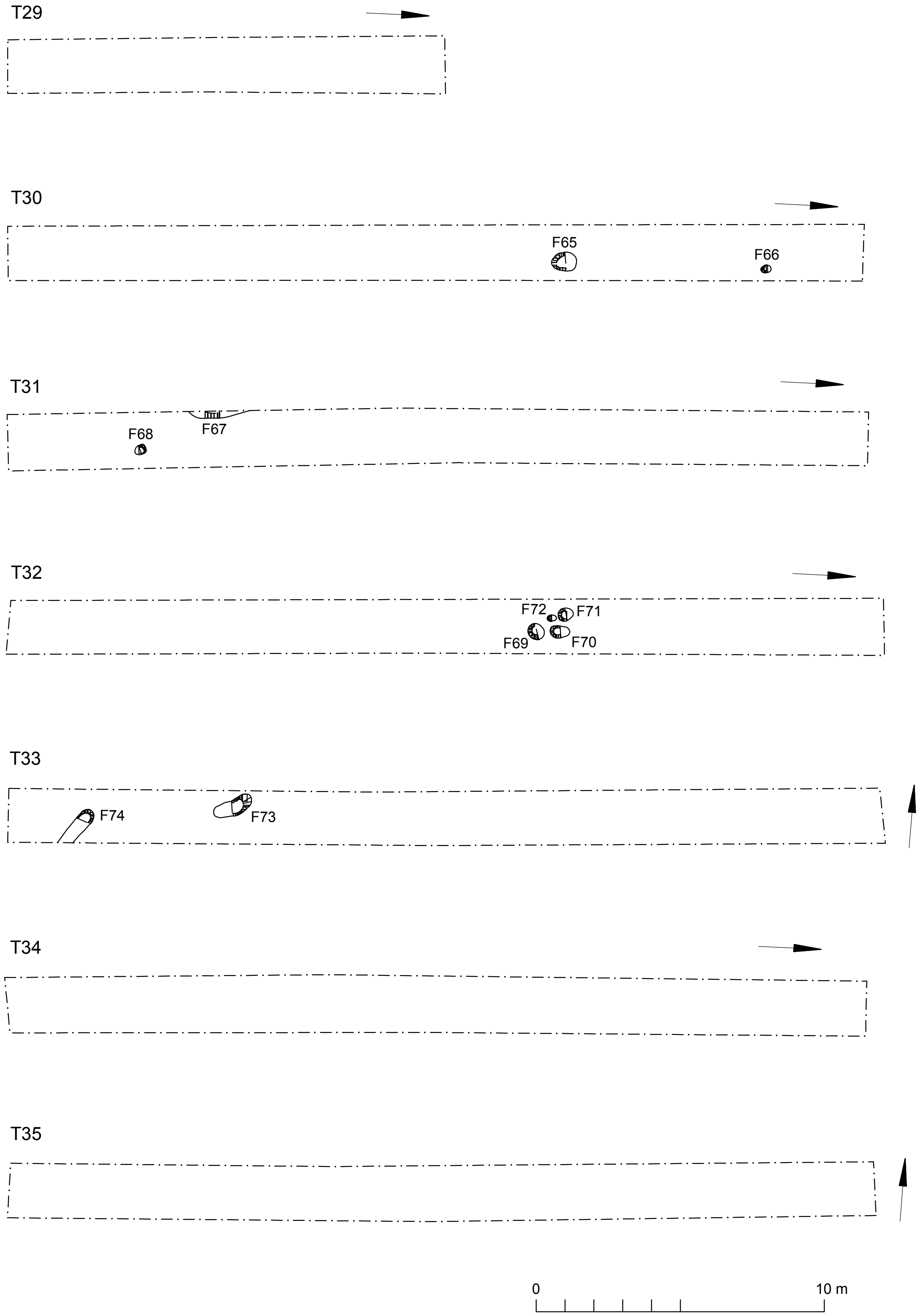


Fig 7 T29-T35: trench plans.

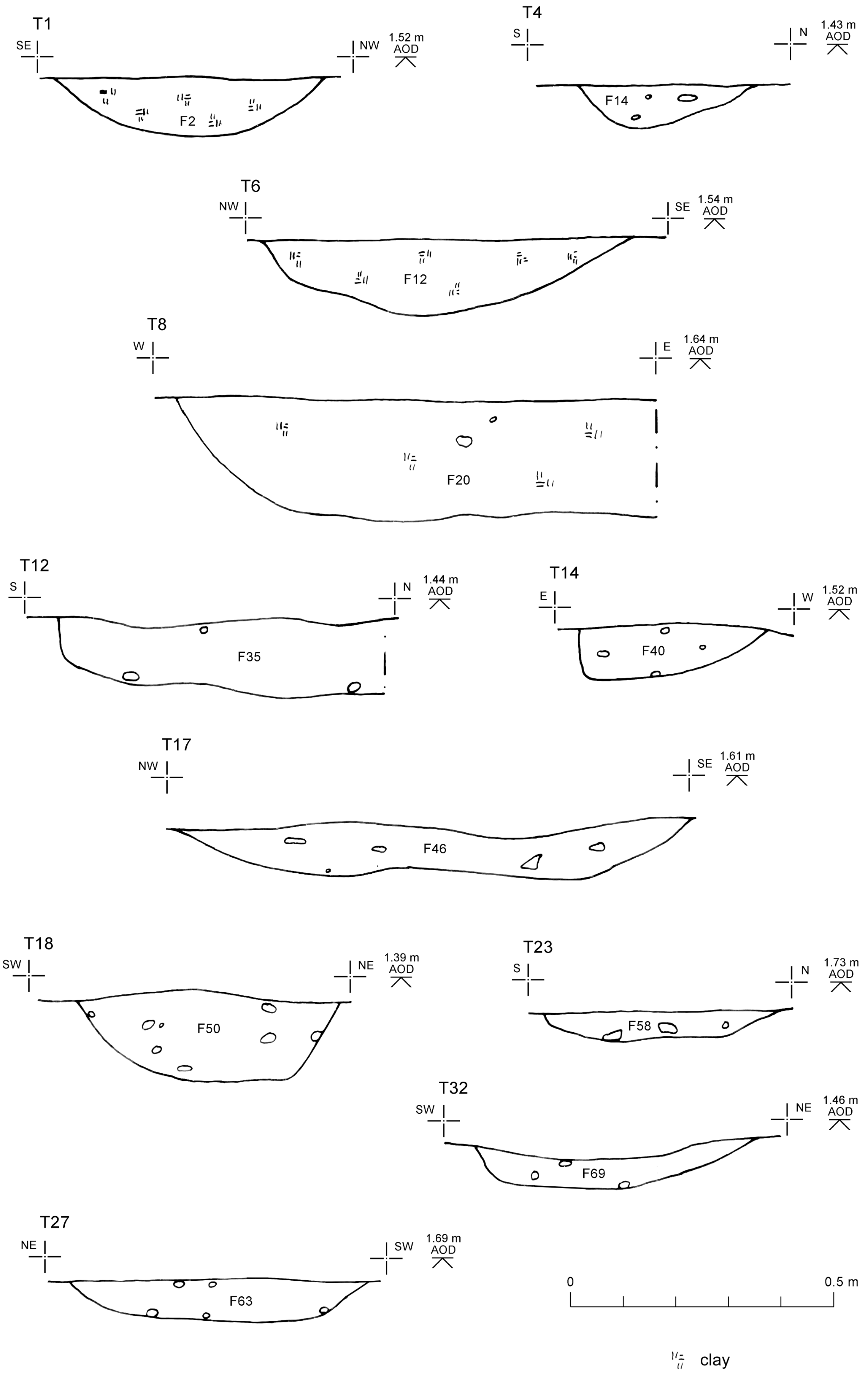


Fig 8 T1, T4, T6, T8, T12, T14, T17, T18, T23, T27, T32: sections.

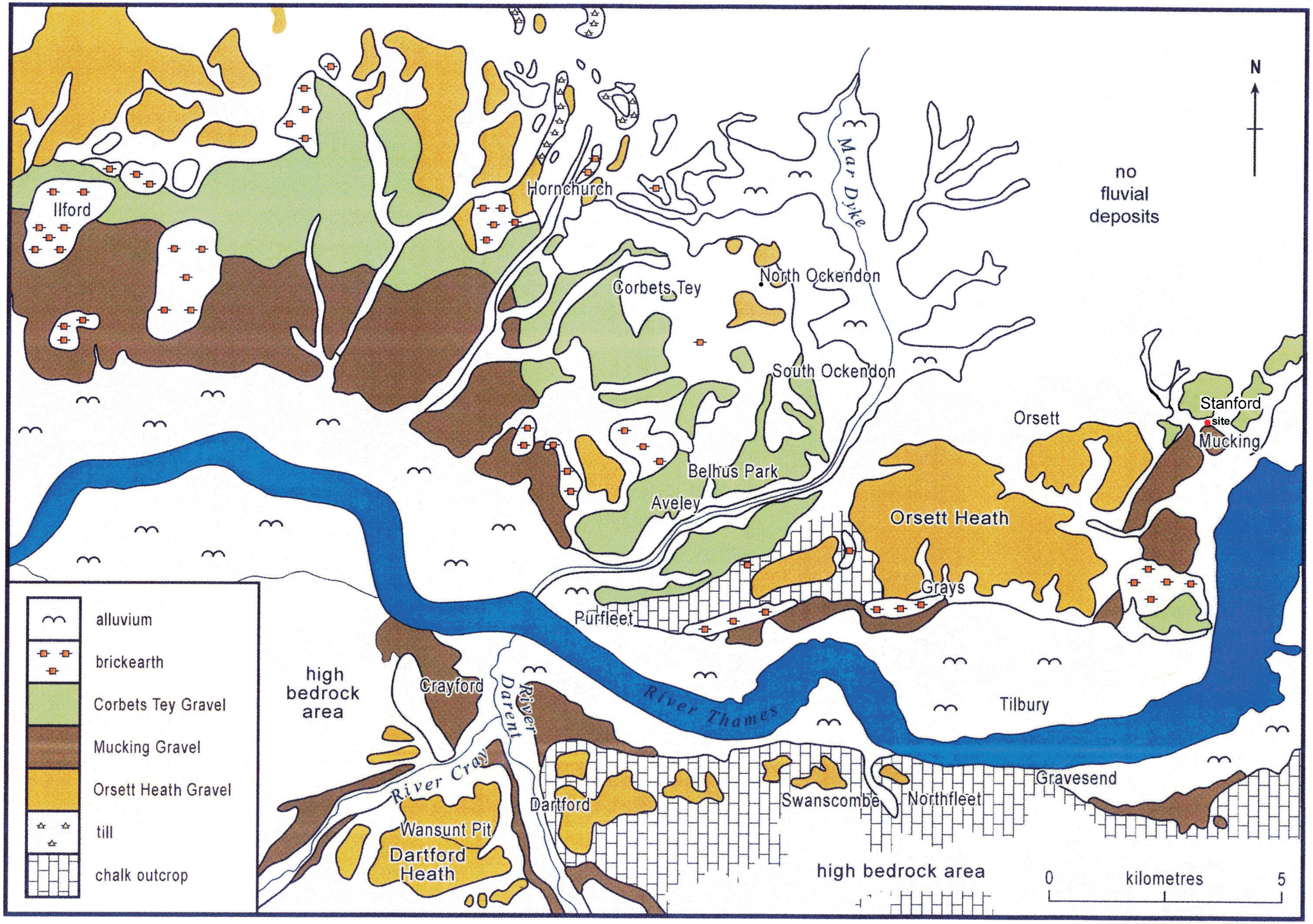


Fig 9 Terraces of the Lower Thames, showing location of the site. (Adapted from Bridgland 1994.)

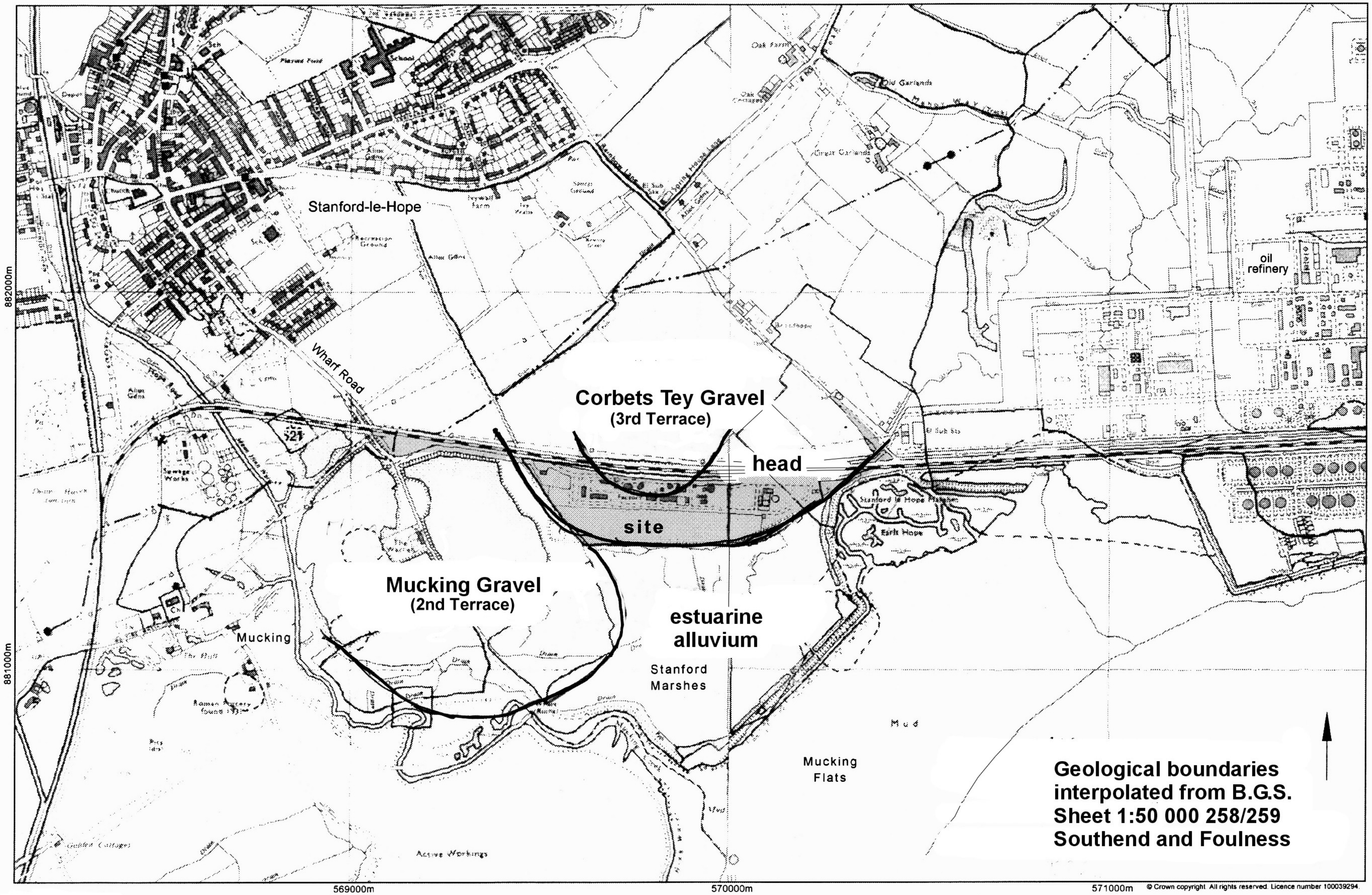


Fig 10 Local geology.

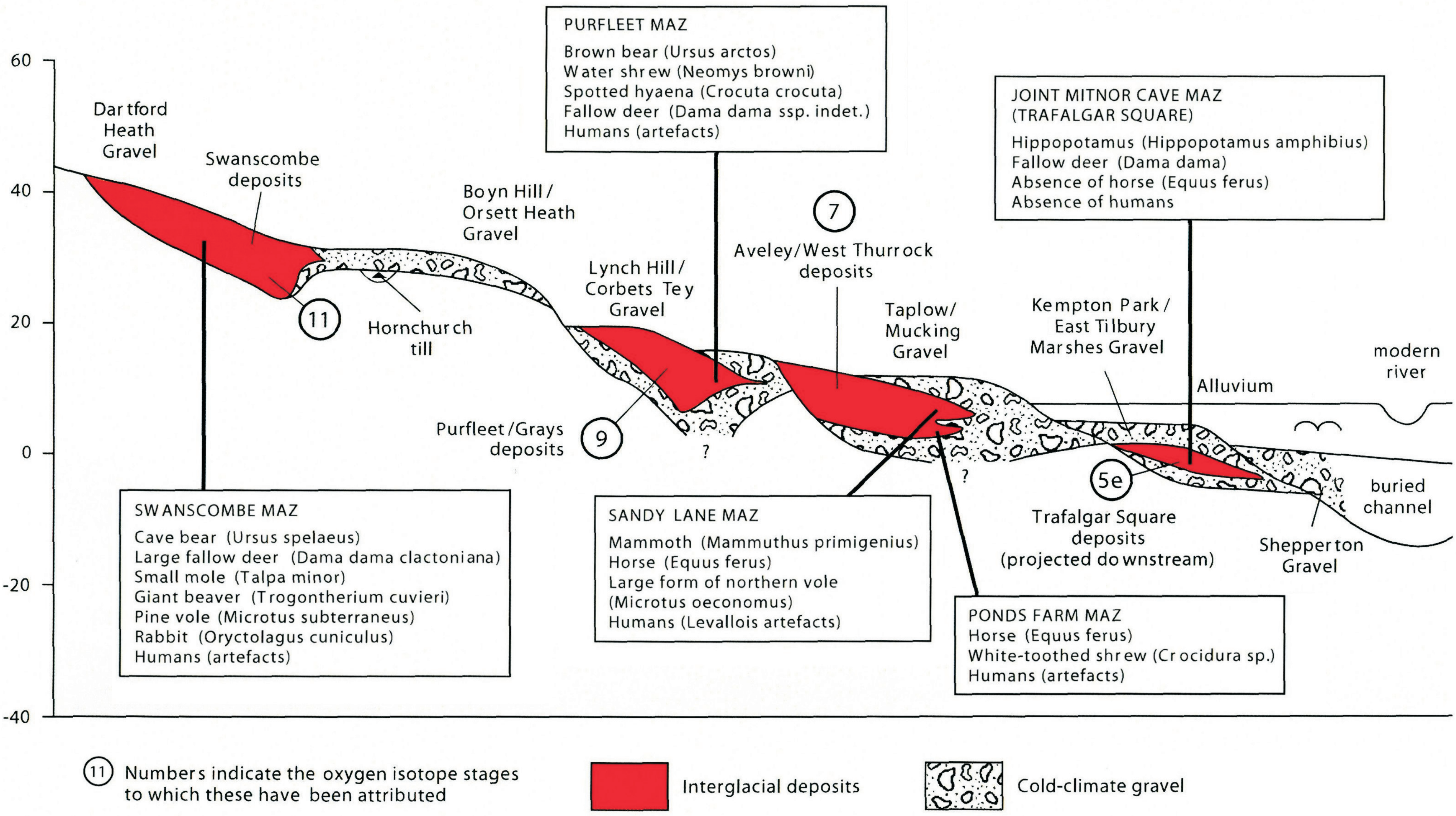
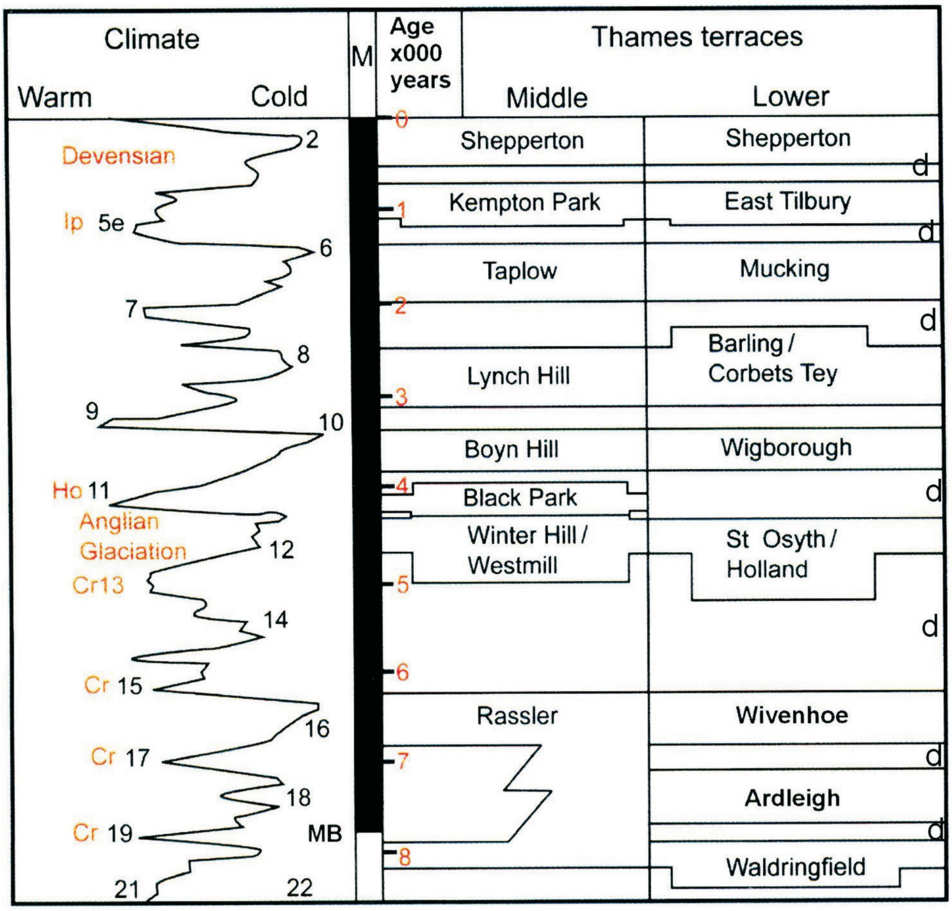


Fig 11 Cross-section of Lower Thames terraces indicating mammal assemblage zones (MAZ).



Cr - Cromerian Ho - Hoxnian Ip - Ipswichian Interglacial

Climate - 2, 5e, etc - Marine oxygen Isotope Stages (MIS)

MB - Matuyama - Brunhes magnetic polarity switch;

black - normal polarity; white - reversed polarity.

d - downcutting

Fig 12 Terraces, climate and Marine oxygen Isotope Stages.

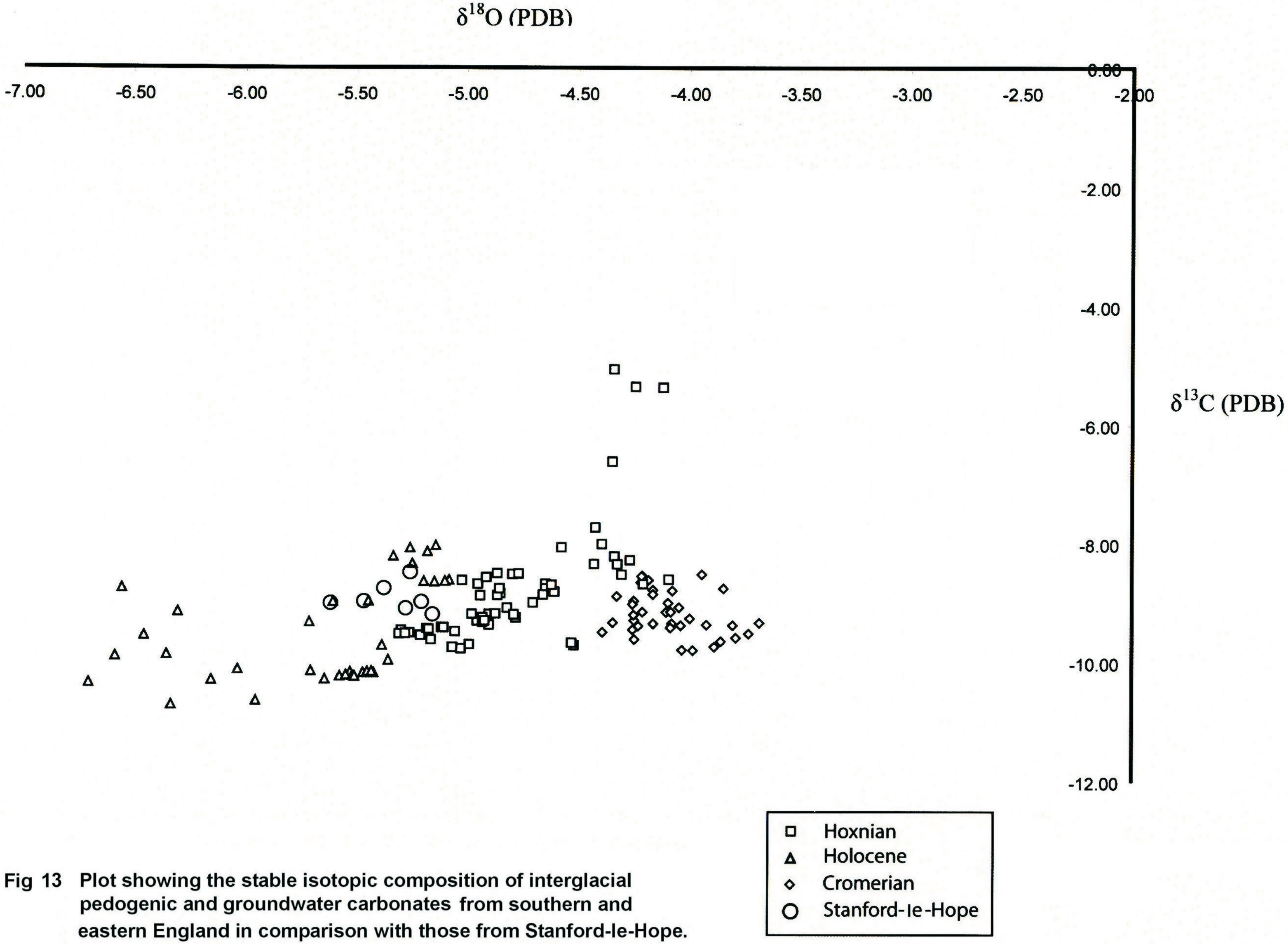


Fig 13 Plot showing the stable isotopic composition of interglacial pedogenic and groundwater carbonates from southern and eastern England in comparison with those from Stanford-le-Hope.