THE RIVER THAMES IN LONDON IN THE MID 1ST CENTURY AD

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1. Introduction

There has been much discussion recently regarding the nature of the River Thames and its banks in London[1] during the mid 1st century AD (Willcox 1975, 285–92; Bird, Graham *et al* 1978, 46 and 512–3; Willcox 1980, 24–8). The debate is of considerable interest because of the influences of bank topography and river levels on Roman engineers and surveyors laying roads, bridging the river and establishing settlements in the area, while the position of the tidal head is of primary importance in assessing 1st-century *Londinium* as a port. Previous attempts to determine Roman river levels are contradictory because of the uncritical use of archaeological data, poor liaison between archaeologists, geographers and other research workers, and because of inaccuracies and false assumptions in relating data from the outer to the inner estuary (eg. Akeroyd 1972, 160–162). Likewise the associated question of the tidal head in Roman times has also been the subject of dispute. Akeroyd (1972, 155) claimed that freshwater conditions prevailed not only at London, but as far downstream as Dagenham and Crossness (Fig. 1). This position was cautiously supported by Willcox (1975), in a paper which was accorded general acceptance, at least by archaeologists working in the City (eg. Marsden 1980, 12).

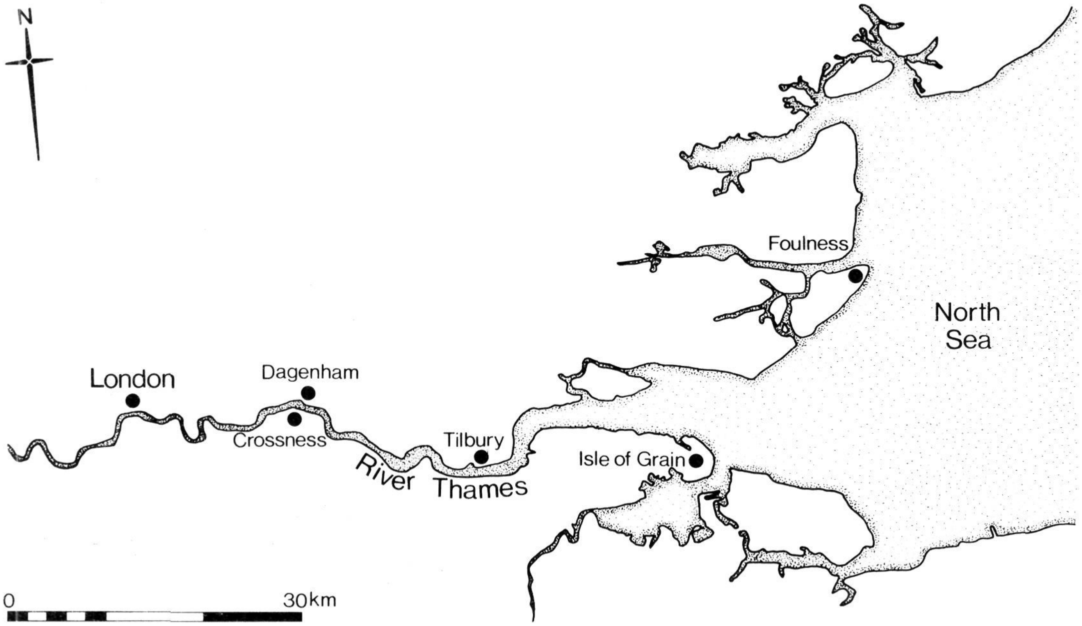

Fig. 1. Sketch map of River Thames, showing inner and outer estuary and places mentioned in text.

In this paper new evidence from excavations on both banks of the Thames is presented that allows 1st-century river levels to be fixed more confidently and demonstrates that, contrary to the accepted view, the River Thames in Roman London was tidal.

In conclusion, some of the topographical, nautical and engineering implications of these findings are discussed.

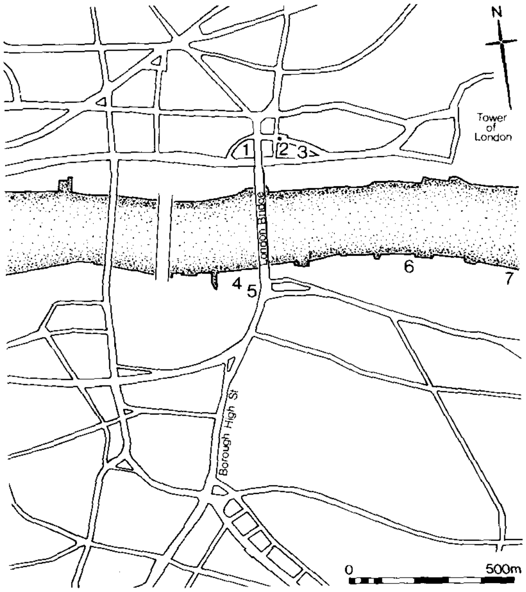

Fig. 2. The present-day River Thames (stippled) in London. Archaeological excavations numbered 1) Miles Lane; 2) Pudding Lane; 3) Peninsular House; 4) Hibernia Wharf; 5) Bonded Warehouse; 6) Willson's Wharf; 7) Mark Brown's Wharf.

2: Post Glacial Changes in River and Sea Levels: the Background[2]

The level of the River Thames relative to the land has been subject to continuous and considerable change over at least the last 10,000 years. This was, and still is, a result of changes in sea level (eustatic change), as well as uplift (isostatic change) or subsidence (tectonic change) of the land. A significant factor responsible for changes in sea-level relative to the land in the temperate zones of the northern hemisphere was eustatic rise, largely brought about when great quantities of ice began melting after the last glaciation 10 – 14,000 years ago.[3]

During the Holocene there were also changes in the level of the land relative to that of the sea associated with isostatic uplift in parts of the British Isles and subsidence in part of the North Sea Basin, including the Thames estuary (West 1972, 87). The evidence for subsidence in south-east England has been summarised by Dunham (1972, 81 – 6); Devoy (1979, 393) has discussed subsidence within the Thames area together with east-west subsidence in southern Britain,[4] and north-south subsidence trends, while D'Olier (1972, 121 – 130) has examined subsidence and sea level variations in the Thames estuary itself. This situation is further complicated by the fact that factors influencing sea-level change and subsidence are all potentially interactive, and as a consequence it is difficult to establish an absolute datum level.[5] However, it is possible to measure net change. Across most of the London Basin, compensatory isostatic uplift has occurred in association with subsidence throughout the Quaternary, thus the inland areas show net uplift, the coastal areas net subsidence.

Recent work by Devoy (1977, 712 – 5; 1979, 355 – 407; 1980, 134 – 48) has helped to clarify the situation. A stratigraphic study was made of post-glacial biogenic[6] and inorganic deposits in the Thames estuary between Crossness and the Isle of Grain (Fig. 1), and the heights of relative sea-level movements calculated from this work. By plotting these values against time, the rate of sea-level change relative to the land in south-east England was tabulated and compared with evidence from south-west England. As a result Devoy (1979, 348) tentatively suggested that south-east England had subsided 2 to 3m relative to the south-west in the last 10,000 years, while the sea level had risen by a figure in excess of 25m over the same period.

The relative increase in sea-level is not, however, a smooth progression but appears to involve five marine transgressions (periods of sea-level rise) and five phases of regression (periods when the sea-level dropped). The transgressions are indicated by depositions of inorganic muds with silt and clay-size particles. The regressions are recognised in a series of biogenic deposits including peats representing the decayed remains of such material as riverside marsh plants. Radiocarbon dates for the changes were obtained from samples at the point of contact between the transgression and regression deposits. The five regressive phases were identified at Tilbury, and are therefore termed Tilbury I to V.

The present paper is concerned with the period before the latest of these events, the transgression marked by sea-level reaching +0.4m OD at Tilbury in *c.* AD 200 (*c.* 1750 BP). Subsequently, the Tilbury V regression occurred, represented by a thin silty peat at this level (Devoy 1979, 391). This could suggest that during the first and second centuries AD, the river was approaching its maximum level in London before the onset of the Tilbury V regression (Fig. 3). However, since the data concerning the transgressions and regressions were collected outside the City reach (Fig. 1) the results cannot be directly related to areas upstream. Even within his area of study Devoy (1979, 394) noted differential down warping (localised contortions in the strata) of about 1.5m between Crossness and Tilbury for the post-glacial period. He stresses that it may be hard to correlate the timing and amplitude of relative sea-level movements between the inner and outer estuary owing to possible differences in the environmental, geological and sedimentological histories of the areas and in the sources of information used (Devoy 1977, 714). For these reasons, the curve for the river level in the inner estuary (Devoy 1977, 714) does not parallel the sea-level curve compiled by Greensmith and Tucker for the outer estuary (Greensmith and Tucker 1973, 193–202) as shown in Fig. 3.[7]

The course of the Thames has also changed, as Nunn's study of the river in central London during the post-glacial period has demonstrated (Nunn 1983). Five chronological stages in the predominantly northward movement of the river are identified. Nunn argues that the five stages are possibly compatible with the Tilbury I–V regressions, implying that the regressions caused a halt in the lateral migration of the Thames, and initiated downcutting. Clearly, with such profound changes in the course and level of the Thames, the position of the tidal head of the river must also have fluctuated. Diatom analysis[8] of sites in the Thames estuary (Devoy 1977, 1979, 1980) indicates an early and increasing degree of salinity in the post-glacial period, and implies movement of the tidal limit upstream towards London.

3: Evidence for the level of the 1st-century Thames—The South Bank[9]

The evidence both for the topography of north Southwark and for a river level at *c.* +1m OD in the mid-1st century has recently been published by Graham. He showed that the river flowed as much as 700m south of the modern Southwark waterfront along braided channels intersecting islands of relatively high ground (but mostly below +1.5m OD) and mud flats. Roads providing access to London were constructed in *c.* AD 50–55 across this very marginal ground (Graham 1978, 501–17; Fig. 4). The estimation of river levels was based on what appeared to be the original tops of 1st-century revetments, and on the heights of water-laid deposits, which are difficult to relate to actual river levels.

Although Graham's topographical map of the south bank (Graham 1978, Fig. 4) has since been modified to take account of information from recent excavations and borehole

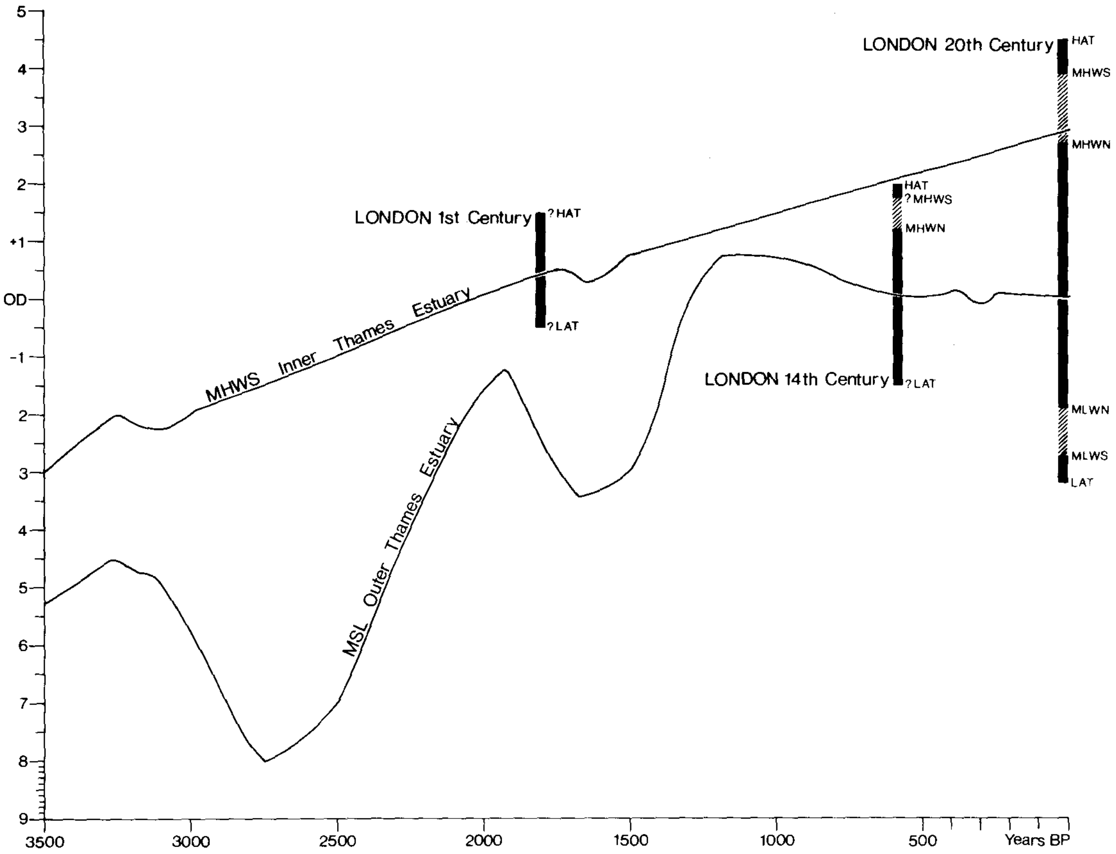

Fig. 3. The changing level of the Thames over the last 3,500 years. Curve for the inner estuary at Tilbury (after Devoy 1979) and curve for outer estuary near Foulness (after Greensmith & Tucker 1973) plotted with levels of River Thames in London in 1st, 14th (after Milne & Milne 1982) and 20th centuries AD (PLA 1983). LAT = lowest astronomical tide; MLWS or N = mean low water spring or neap tide; MHWS or or N = mean high water spring or neap tide; HAT = highest astronomical tide; MSL = mean sea-level.

records, the exact edges of most of the higher ground and of the channels shown on Figs. 7 and 8 still remain conjectural. It should also be noted that medieval river erosion removed the northern limits of the Roman settlement (Graham 1978, Fig. 5).

Two Southwark waterfront sites provide evidence for a late Bronze Age marine regression, which may be equivalent to Tilbury IV (See Fig. 3 and p. 00), when the river was probably not tidal and may have reached a level of just above Ordnance Datum. At Willson's Wharf (Fig. 2 No. 6) samples from the bottom and top of a peat horizon between +0.10m and +0.38m OD had radiocarbon dates of 1060 +/− 70 bc and 620 +/− 80 bc respectively. Wood from the top of a peat horizon between −0.5m and −0.15m OD at Mark Brown's Wharf (Fig. 2 No 7) had a radiocarbon date of 860 +/− 80 bc.

The marine transgression which followed Tilbury IV may have reached its height by the mid 1st century, when extensive areas of the higher sands and gravels in Southwark had been subject to the flooding evidenced by inorganic sandy clays deposited at up to

+ 1.4m OD close to the modern riverfront, though generally up to *c.* + 1.2m or *c.* 1.3m OD further south. This flooding may have been of relatively short duration, and Roads 1 and 2 were laid over what appeared to be the recently exposed surface of the clay. North of the southern channel (see Fig. 7 a, b) Road 1 was laid across the highest available ground, much of it *c.* + 1.25m OD, and over infilled channels (Sheldon 1978, 22). Road construction involved the laying of a timber raft over which sand and gravel metalling were packed. The resulting road agger may have stood *c.*0.5m high and represented a raised causeway, its surface between *c.* + 1.50m and *c.* + 1.75m OD, across the low-lying land. At the Bonded Warehouse site (Fig. 2 No. 5), Road 2 was constructed of gravel without a timber corduroy foundation, with the primary road surface at *c.* + 1.8m OD, *c.* 0.4m above the surface of the clay (Graham 1978, 239; Fig. 105).

With the exception of two sites north-west of Road 2, there is no evidence for flooding subsequent to road construction. At the Bonded Warehouse site (Graham 1978, 239) and Hibernia Wharf (Dennis forthcoming) (Fig. 2 Nos. 4,5) the clay which filled the road gravel quarry pits may represent inundation to a level of at least + 1.4m OD. George Dennis has suggested (personal communication) that the bridge to the City (presumably constructed at the same time as Roads 1 and 2) may have partially dammed the river leading to flooding upstream in this area, while Road 2 would have presented a barrier to flooding further south. In the absence of proven Roman flood defences protecting the southern approach roads to London, the evidence indicates that the river level was not expected to exceed + 1.5m OD, the height of the lowest operative road surfaces.

4: Evidence for the levels of the 1st-Century River Thames: the North Bank[10]

Work on the material from the sites near Pudding Lane and Miles Lane excavated in 1979–81 (Fig. 2) provided clear evidence for the level of the Roman river, when a late 1st-century quay was recorded surviving to its full height (Fig. 4).

Plate 1. Pudding Lane Excavation, Area C. Late 1st-century timber-faced quay; looking north; high tide. 5 x 100mm scale on working surface, 10 x 100mm scale in waterfront warehouse building. River level at *c.* + 1m OD, flowing into dugout drain.

A gravel bank *c.* 0.8m high with its top at *c.* + 1.6m OD was found on the Pudding Lane site,[11] to the north of the quay mentioned above. It had been raised earlier than the quay, whose infilling deposits sealed it (Fig. 4). It was aligned E–W on the southern edge of what had originally been the 'natural' north bank of the Thames, over 100m north of the present day river channel. On the adjacent site,[12] a post and plank revetment was recorded 15m to the east of the bank but on the same alignment, the surviving top of which was at *c.* + 1.7m OD. It too was earlier than the late 1st-century quay, and both bank and

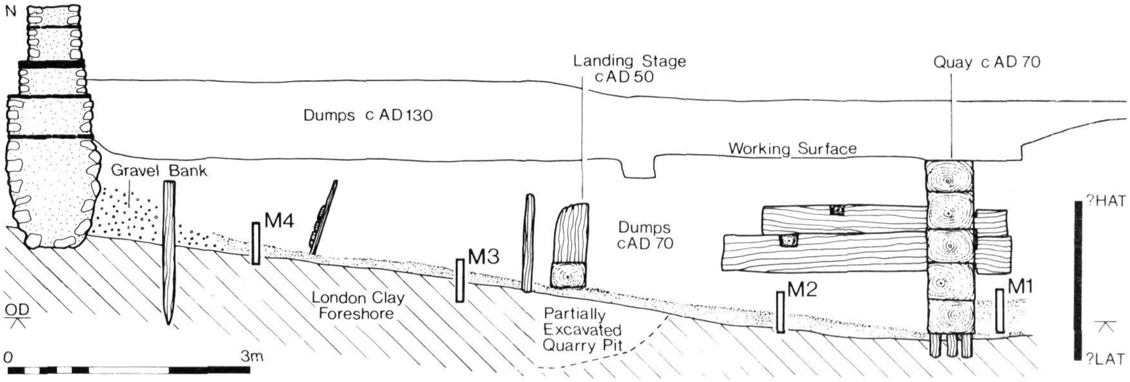

Fig. 4. West-facing north-south section across Pudding Lane excavation, showing 1st-century timber quay and associated features. Position of samples (monoliths) taken from foreshore sediments marked M1 – M4.

Plate 2. Pudding Lane Excavation, Area C. Late 1st-century timber-faced quay; looking north; low tide. 10 × 100mm scale rests in dugout drain set in facing of quay between protruding heads of tiebacks. River level at Ordnance Datum.

revetment are interpreted as part of an early Roman attempt to strengthen and straighten the river and to curb flooding, up to a level of c. + 1.6m OD (Bateman and Milne 1983).

Several well-preserved timber waterfront structures were also found on the Pudding Lane site one of which was a timber faced quay provisionally dated to the late 1st century[13]. Sandy waterlaid deposits had accumulated up against its south face and were also found to the north of it,[14] showing that the structure had been built out over the foreshore into the open Roman river (Fig. 4). The analysis of these foreshore sediments is discussed in Part Five p. 00).

As at Miles Lane,[15] the base plates were laid at c. Ordnance Datum, and the original top of the structure survived at c. + 2m OD, approximately level with the contemporary working surface to the north (Plates 1 and 2; Fig. 4). It is argued that when this structure was built and these surfaces were laid, the river was not expected to rise above + 2m OD, except perhaps in unforseen circumstances. A mean high water level of between + 1 and + 1.5m OD[16] in the mid 1st century would therefore be consistent with the structural evidence from the Pudding Lane and Miles Lane sites. This also agrees with the evidence from Southwark.

5: Evidence for the tidal nature of the Roman Thames

Evidence that the River Thames was tidal in the early Roman period is based on both archaeological and palaeoecological data. Excavators on the Miles Lane and Pudding Lane sites found clay quarry pits on the foreshore. At Miles Lane (Miller 1982, 143 - 4) a pit c. 12m by 9m had been cut from Ordnance Datum to a depth of - 1.28m OD. At Pudding Lane, a much smaller pit at least 1.5m in diameter had been dug into the London Clay at Ordnance Datum (Bateman and Milne 1983) to a depth of - 0.8m (Fig. 4). Pottery from the fill of the pits showed that they had been exposed—and presumably dug— in the 1st century AD. Although it has already been argued that the contemporary river must have risen to a height of between + 1 and + 1.5m OD, it must also have receded below Ordnance Datum in this period to facilitate the quarrying activity. Such a fluctuating level suggests that the river was tidal, and had a tidal amplitude (range) in excess of 1.5m.

Diatom analysis of the 1st-century foreshore sediments confirms this inference.[17] Four column samples (monoliths) up to 560mm in height were taken from the foreshores exposed on the Pudding Lane site, to north and south of the late 1st-century quay (see Fig. 4). The foreshore sediments themselves varied from 420mm thick in Monolith 1 to 110mm thick in Monolith 3. These sediments were sub-sampled at consecutive 10mm intervals, and sub-samples for diatom analysis prepared at 40mm intervals using standard procedures (Battarbee 1979). Fig. 5 shows the relative contributions of the most common taxa from the samples in Monolith 1 both stratigraphically and as a composite spectrum.[18] The dominant taxon at all levels was the mesohalobous (brackish water) species *Cyclotella striata,* a very common planktonic diatom in European river estuaries (Hustedt 1957). It occurs in the contemporary Thames, and has been found in other early sediments of the River including deposits on the Swan Lane site (Battarbee, Unpubl.) and the medieval sediment from the River Fleet (Boyd 1981). In the Pudding Lane material it is exceptionally well preserved with both valves of the frustules often occurring together. This, as well as its numerical dominance, suggests that it was derived directly from the adjacent river. Other brackish forms include *Nitzschia sigma, Synedra tabulata* var. *affinis* and *Bacillaria paradoxa.*

There is a small number of euhalobous (marine) taxa in the sediments such as *Cymatosira belgica, Raphoneis surirella, R. amphiceros* and *Cocceneis scutellum.* These are infrequent and either small forms or small fragments, but nevertheless they demonstrate the tidal nature of the river.

The majority of the taxa in the assemblages are oligohalobous (freshwater) forms, although many of the dominants e.g. *Fragilaria pinnata, Surirella ovata, Cocconeis placentula,* are often also found in weakly brackish environ-

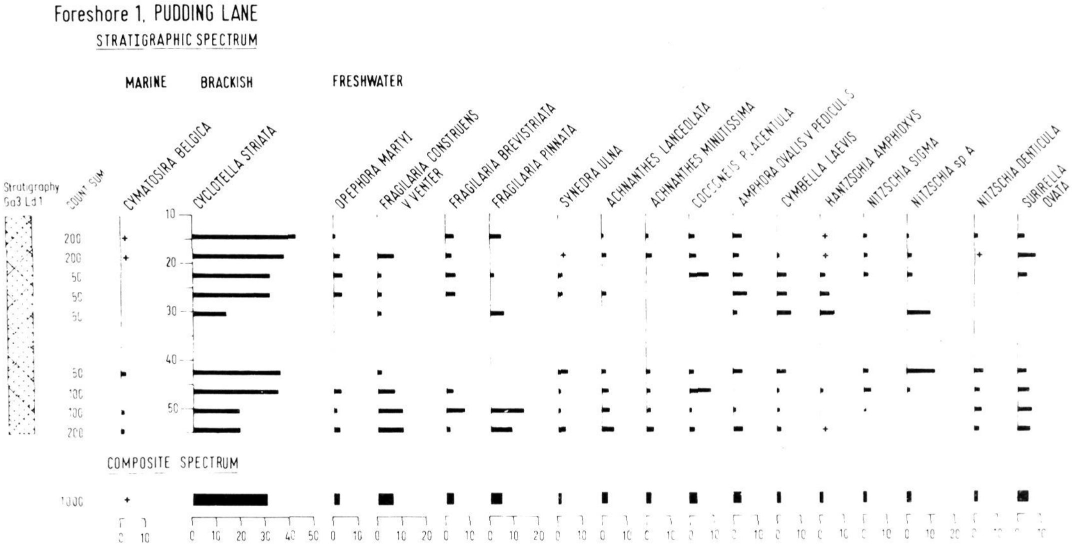

Fig. 5. Diagram of diatoms from Monolith 1 from foreshore sediment at Pudding Lane: see Fig. 4.

ments. Consequently they could have been growing close to the site of deposition. Other freshwater forms are likely to have carried down the river from sites upstream above the tidal head. No freshwater plankton was observed.

The nine samples examined from Monolith 1 cover 400m of foreshore accumulation. Fig. 6 shows variations in the salinity spectrum after grouping the individual taxa according to the halobian (salinity) classification (Hustedt 1957). It can be seen that there are no clear stratigraphical trends in the data indicating, as would be expected over such a short period, no significant changes in the salinity of the river during the thirty year period of deposition. The variations that do occur are more likely to be related to statistical artifacts associated with the relatively large standard errors of small sample counts and to such factors as short term variations in flooding and river discharge. Because of this it is probably valid and environmentally more representative to regard the data as a single assemblage. Fig. 6 therefore, also shows mean values for each salinity group.

The samples examined from Monolith 2 material showed assemblages not significantly

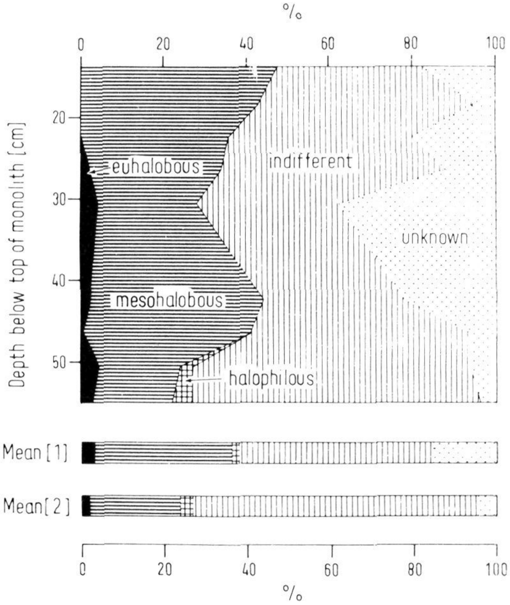

Fig. 6. Salinity spectra for diatoms from Pudding lane foreshore sediments.

different from Monolith 1 either in relation to the pattern of dominance or range of flora. As in Monolith 1 the results were combined to form a single assemblage and Figure 6 shows the salinity spectrum.[19] The palaeoecological analysis clearly demonstrates that during the period the sampled foreshore sediments were accumulating, the river adjacent to the Pudding Lane site was estuarine. In other words that it was influenced by tides, and that the tidal head lay further upstream to the west. It is difficult to estimate likely salinities of the water with accuracy, although the Pudding Lane spectrum, with 2% marine forms, is less saline than that from the early medieval Swan Lane site, where 11% of the assemblage was marine. This may indicate that the tidal head of the river was closer to the City in the first century than in the medieval period.

6: Discussion and conclusions

The structural, stratigraphic and environmental evidence from 1st-century sites in London on both banks is consistent with the suggestions that the contemporary River Thames was tidal, that it reached a height of at least + 1.25m OD but was not expected to rise above *c.* + 1.8m to + 2m OD, though receded below Ordnance Datum, and had a tidal amplitude of at least *c.* 1.5m. The figures of + 1.25m OD and Ordance Datum do not represent the highest and lowest tides, or Mean High and Mean Low Water, or any other specific water level, but are levels which it can be argued the Roman river attained, although it almost certainly exceeded them.

If it is accepted that the 1st-century tidal river attained at least the levels suggested, then a width of the river *during* high and low tides can be calculated by plotting the 1.25 and Om contours for both banks, as on Fig. 7a and b. Though this exercise

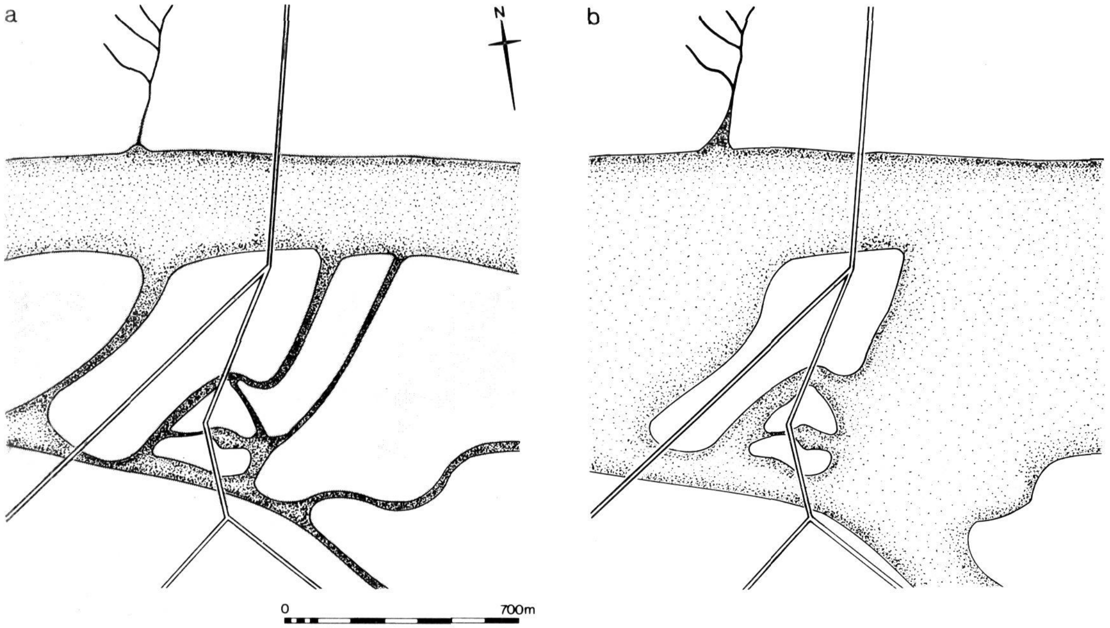

Fig. 7. Sketch plan of mid 1st-century River Thames showing conjectured edges of banks, islands and channels and suggested line of Road 1 and Road 2 (to north), and early bridge. cf Fig. 2.
a) river during ebb tide at OD, with inter-tidal mud flats shown tinted;
b) river during flood tide at *c.* 1.25m OD.

does not depict the situation associated with the highest and lowest tides, it suggests that the river may have been up to 1000m wide (including marshland) at high tide to the south of *Londinium*. At low tide, it would have decreased to *c.* 275m wide at its narrowest point, substantially wider than the present day channel which is *c.* 200m across (cf Fig. 2).

Although Fig. 7a and b represent a change in river level of only 1.25m, the effect of even this modest tidal range on the topography of the south bank is dramatic. Clearly much of the foreshore was inter-tidal marsh land,[20] a situation recalling the description by Cassius Dio which may refer to the London area during the advance of the Roman army in AD 43:

'Thence the Britons retired to the River Thames at a point near where it . . . at flood tide forms a lake. This they easily crossed because they knew where the firm ground . . . (was) . . . to be found . . . But the Romans . . . got into swamps from which it was difficult to make their way out, and so lost a number of men.' (Dio Cassius LX.20; RCHM 1928,2)

The problems facing the Roman engineers who considered bridging the Thames in *c.* AD 50, and the crucial importance of the 'islands' on the southern shore to that project are obvious. The narrowest part of the river was east of the tributary River Walbrook, north of the largest southern 'island' (assuming that there were no other islands in mid stream), a distance of *c.* 300m in the 1st century. This point is due south of the 1st-century timber feature recorded on the Pudding Lane site just east of Fish Street Hill (Milne 1982) thought to represent a pier base for an early timber bridge.[21]

The first bridge over the Thames at London was a major road crossing, and can now be shown to have spanned a tidal reach of the Roman river. This suggests that *Londinium* was deliberately founded as a major distributive centre, ideally situated to exploit river and sea-bourne traffic as well as the road system. Of the two bridgehead settlements, the northern one was destined to become the more important, a reflection of the unfavourable natural topography to the south. Nevertheless it was precisely because dry land was so limited on the southern shore that Southwark's topography dictated where the roads, the bridge—and therefore ultimately the City—would be built.

A brief assessment of Roman London's potential as a port may be attempted, now that the general range of 1st-century AD river levels and of the tidal amplitude is known. Apart perhaps from the northern edge of Southwark's island (which no longer survives), the inter-tidal marshland on the southern shore was unsuitable for the unloading of goods. However, the firmer ground on the north bank with its shelving foreshore of London Clay could have accommodated shallow-draught flat-bottomed river craft similar to that found at New Guy's House in 1958, (Marsden 1965) and barges of the Zwammerdam 2, 4 and 6 type and size (the latter may have been up to 34m long) (de Weerd, 1978) as well as coastal craft of similar dimensions to the Blackfriars I ship (Marsden, 1966). All these types of vessel could have floated in 1.5m of water or could be successfully beached at low tide, so were ideally suited to the tidal conditions prevalent in 1st-century AD London. Deep draught round-hulled sea-going vessels larger than the 3rd-century County Hall ship (Marsden, 1974) could not have berthed directly against the London harbour works of the 1st century AD (Fig. 4. Plates 1 and 2) since the water would be less than 1m deep for most of the day. Vessels of this size would have had to moor in midstream or at the end of jetties from where their cargoes would have been transferred to lighters.

It is suggested that the harbour of *Londinium* in the 1st century AD was not developed to accommodate the largest contemporary sea-going ships directly (cf. Marsden, 1981, 10). However, the harbour was capable of accommodating the smaller river and coastal craft, some of which presumably carried cargoes collected from, or destined for, larger vessels which may have been berthed in midstream near London; or between Poplar and Barking if a suggestion by Morris (1982, 269–270) is accepted; or even in the channel and east coasts ports serving the *Classis Britannica* (Cunliffe 1968, 255–60; Cleere 1977, 16–19; Cleere 1978, 32–8). These smaller vessels could therefore be the equivalent of the *lenunculi auxiliarii* and *naves codicariae* which transported merchandise transferred from the larger sea-going merchantmen (berthed in the deep water port outside Ostia) up the River Tiber to Rome (Casson 1965, 31–9).

The figures argued above for the level of the highest and lowest 1st century tides as yet identified do not represent as broad a range as those suggested for the 14th century (Milne and Milne 1982, 60–62), and are considerably less than the present-day values (PLA 1983). On Fig. 3 columns displaying the suggested tidal range in the 1st and 14th centuries AD and one showing the present day values have been plotted against curves for Mean Sea Level and Mean High Water Spring Tides in the Outer and Inner estuary respectively. Although the basis on which the information was gathered is different in each case, some general statements are possible.

The pattern of the changing water level exhibited in the inner and outer estuary curves is broadly similar (with the noteworthy exception of the most modern data) although the outer estuary readings are more exaggerated. The suggested difference in the absolute heights of the two curves is to be expected: present day Highest Astronomical Tide at Tilbury (inner estuary) is *c.* 0.9m higher than at Southend (outer estuary), which is itself 1.6m below the corresponding level at London Bridge (PLA 1983, 41). The 1st-century data seems broadly compatible with the inner estuary curve, although it must be stressed that the latter is dated by radio carbon determinations, and cannot therefore be plotted precisely. The 14th-century data does not match so well, suggesting that either it (Milne and Milne 1982, Fig. 43) or the curve (Devoy 1979) need modification at that point.

Results from more Roman and medieval waterfront sites are now needed before a curve for London can be established for comparison with the inner and outer estuary curves, and to plot the changing level and salinity of the River Thames over the last 2,000 years.

NOTES

1. In this paper, 'London' refers specifically to the area of the Roman town of *Londinium* and the contemporary settlement of Southwark.
2. By Vanessa Straker, DUA, Museum of London.
3. Changes in the volume of water in the river channel could also result from alterations in climate or drainage pattern, as well as from artificial projects such as reclamation, bridge building, dredging etc. causing changes in the tidal amplitude.
4. Other relevant factors such as compaction and consolidation of desposits; progresive increase in tidal amplitude; freshwater discharge upstream and differential downwarping are also considered.
5. West (1972, 88) questioned the possibility of finding 'any part of the earth's crust, in a coastal area or otherwise, that has been stable long enough for it to be used as a reference point for assaying sea-level changes'.

   The levels in this paper are all related to *Ordnance Datum* (OD), the mean Sea Level calculated by the Ordnance Survey at Newlyn in Cornwall from observations made since 1915. However, it has been suggested that a better reference level for calculating Mean Sea Level movements in Europe during the last 15,000 years may be the *Normaal Amsterdam Peil* (NAP), since records of Mean Sea Level change have been kept in Amsterdam since 1682 (Jardine 1976). NAP is the zero for the Unified European Levelling Network (UELN). Port of London Authority and Admiral;ty charts calculate water levels relative to *Chart Datum* a figure which coincides approximately with the level of the Lowest Astronomical Tide, which varies from place to place. *Trinity High Water* (THW) on the other hand, is taken as being at + 3.475m OD, and approximates to a Mean High Water level at London Bridge
6. Biogenic deposits are derived from biological material but need not have an entirely organic content.
7. Some of the differences between the curves may be attributable to the differences in methodology employed.
8. Diatoms are microscopic unicellular algae.

9. By Brian Yule, Southwark and Lambeth Archaeological Excavation Committee.
10. By Gustav Milne, DUA Museum of London
11. The Pudding Lane excavations (PDN 81) were funded by English Property Corporation and National Provident Institution. The material in this article is discussed in the archive reports for Area C (N. Bateman) and Area F (G. Milne). See also Bateman and Milne (1983).
12. The Peninsular House excavations (PEN 79) were funded by Vitiglade and Verronworth. See archive report for Areas B and C by N. Bateman and G. Milne, and Bateman and Milne (1983).
13. All pottery dates are provisional, and were kindly supplied by Dr P. Tyers, DUA Museum of London.
14. For the position of the samples, Monoliths 1, 2, 3, and 4, taken from these foreshore sediments, see Fig. 4.
15. Excavations funded by Land Securities (Management) Ltd at Miles Lane (ILA 79). Archive report by L. Miller. See also Miller (1982).
16. Excavations in the Tower of London recorded waterlaid silts containing 1st-century material up to a height of *c.* + 1.7m OD sealed by Roman surfaces. The sites in question are Salt Tower 1976 and Inmost Ward, 1955–77. G. Parnell (DoE), personal communication.
17. Diatom analysis by Dr R. Battarbee, Department of Geography, University College, London. For detailed archive report, see Battarbee (1983).
18. For complete list of taxa, see Battarbee (1983), Table 1.
19. The diatoms found in Monoliths 3 and 4 deposits were insufficient to make percentage counts, but their general similarity with Monoliths 1 and 2 diatoms was clear, *Cyclotella striata* being the dominant.
20. V. Straker suggests that this zone could have supported the growth of such plants as salt marsh grass, (*Puccienella maritima* salt marshrush (*Juncus maritima*), sea Aster (*Aster tripolium*) or Oraches (*Atriplex* spp). These and other plants can be found growing between the low and high tide marks on flat area along estuaries (Rose 1981).
21. Fifteen to twenty such pier bases would have been required to support a timber bridge across the narrowest part of the River Thames in the 1st century.

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