Essex Part 1:

The Kesgrave Sands and Gravels

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Introduction

The first of the three divisions of this chapter is devoted to sites associated with the pre-diversion Thames deposits of the Kesgrave Group. These deposits have only been accepted as the direct products of Thames drainage since the definition of the Kesgrave Sands and Gravels (Rose *et al.,* 1976; Rose and Allen, 1977). However, the typical sequence of Pleistocene sediments in which they occur, which is widespread in East Anglia, has been the subject of research extending back over a century. The main components of this sequence are the Kesgrave Sands and Gravels, mapped until very recent years as 'Glacial' by the Geological Survey, and the (Anglian Stage) Lowestoft Till, which overlies the early Thames gravels over much of their distribution. Localized occurrences of outwash gravel and aeolian deposits (coversand and loess) have been observed between the Thames gravels and the till. Other stratigraphically important parts of the sequence are superimposed warm- and cold-climate fossil soils, which occur at the top of the Kesgrave Group deposits throughout the area.

Early research

The occurrence of gravels beneath the East Anglian till sheet was first noted by Wood (1867, 1870; Wood and Harmer, 1868), who devised a tripartite stratigraphical scheme, based on the till-sand-till sequence of north-eastern Norfolk (now classified as Cromer Till, overlain by Corton Sands, overlain in turn by Lowestoft Till). In this scheme, the three divisions were respectively classified as 'Lower Glacial', 'Middle Glacial' and 'Upper Glacial'. Wood's classification was subsequently used by the Geological Survey when mapping Essex (Whitaker, 1877, 1889; Dalton, 1880). The upper (Lowestoft) till was widely recognized in this area and gravels underlying it were assumed to equate with those classified as 'Middle Glacial' in Norfolk. This view was strengthened by the recognition, at a few sites (such as Maldon — see below), of a till below gravel of similar type (Whitaker, 1889).

Prestwich (1881) observed that the majority of gravels underlying the till in eastern Suffolk were composed of large quantities of rounded flint and quartz, with significant amounts of subangular flint and Lower Greensand material, suggesting a southern derivation, in contrast to the northern provenance associated with the 'Glacial' drifts (including the 'Middle Glacial Gravel' of north-east Norfolk). He noted that these gravels, which he termed Westleton Beds', ranged as far afield as Essex and the Thames valley. He later traced possible equivalents of these beds, which he regarded as pre-'Glacial' marine deposits, over much of southern England (Prestwich, 1890b, 1890c). The distinction between the 'Glacial Beds' and Westleton Beds' of the Braintree area was outlined in some detail by French (1891). Despite these early attempts at clarification, the deposits later to be recognized as early Thames gravels (belonging to the Kesgrave Group) were variously classified by early workers as both 'Glacial Gravel' and Westleton Beds'. Furthermore, the early Geological Survey mapping recognized only 'Glacial Gravel', a category that included both the early Thames deposits and true glaciofluvial deposits. Whitaker (1889, p. 299) emphasized that the term 'Glacial' (with a capital G), as applied by the Geological Survey, was 'a proper name for a geologic period' (this can be correlated broadly with the post-Cromerian Pleistocene of modern usage) and not to be confused with the adjective meaning associated with or produced by ice. Unfortunately, such confusion became commonplace, the deposits mapped as 'Glacial Gravel' being widely interpreted as glaciofluvial outwash until the 1970s (see below).

Salter (1896) disputed the evidence for the marine origin of the deposits in Essex classified as Westleton Beds' by Prestwich. He pointed out that the rounded character of many of the flints in these gravels was inherited from the Palaeogene pebble beds that were their immediate source. Salter (1905) later included these beds in a series of gravels, traceable along the Chiltern dip slope from the Goring Gap towards the North Sea (Chapter 3), which he regarded as the product of an early northeastward flowing drainage system that existed prior to the formation of the modern Lower

Thames valley. Important evidence for the former existence of this drainage system, according to Salter, was the concentration of southern rocks in high-level deposits between the Lower Thames valley and the Chilterns. He realized that such gravels, containing abundant clasts of southern origin, were the products of right-bank tributaries of the old north-eastward flowing river.

Gregory (1894, 1922) regarded the bulk of the gravels of central Essex as 'pre-glacial' and divided them into 'High Level Quartzite Gravels' (or 'Danbury Gravels') and 'Low Level Quartzite Gravels' (or 'Brain Valley Gravels'), the latter coinciding largely with Prestwich's 'Westleton Beds'. Gregory believed that all these gravels had been deposited by streams flowing from the west, on a regional slope resulting from late Oligocene to early Miocene uplift. However, Solomon (1935) considered the two levels of 'Quartzite Gravels' recognized by Gregory to belong to a single series disturbed by tectonic activity, incorporating the Westleton Beds' (*sensu* Prestwich) and Wood's 'Middle Glacial Gravel'. Solomon classified these deposits as his Westleton Series', which he regarded as marine, although with a glacial intercalation in Norfolk. He ascribed lateral differences in composition to local variations in provenance within a single depositional basin. Solomon (in Clayton, 1957) claimed a distinction, based on heavy-mineral analysis, between two types of gravels in Essex: one, previously classified as 'Middle Glacial Gravel' or 'Westleton Gravel', pre-dated the Essex till sheet, whereas the other he regarded as a true outwash deposit, intimately associated with the till.

Warren (1955, 1957) reported that gravels deposited by the Thames in pre-Chalky/Jurassic Till (Lowestoft Till) times had been traced by Baden-Powell and himself from Oxford, across central Essex to the Clacton area. This interpretation, which confirmed the views of Salter (1905), was the first to indicate that Thames deposits could be recognized within the Pleistocene record of southern East Anglia. Based on clast lithology, but without systematic analyses, it anticipated the results of later work by Rose *et al.* (1976; Rose and Allen, 1977; see below).

Tills in Essex

Whilst progress was being made in the interpretation of the early gravel aggradations of southern East Anglia, research was being carried out in parallel on the glacial deposits that commonly overlie them. The 'monoglacial' model favoured by the 19th century workers was replaced by one that recognized four separate glaciations, as first envisaged in the Alpine region by Penck and Bruckner (1901–1909). However, deposits of only the last three of these were identified in East Anglia, with the last confined to the extreme north-western corner of Norfolk (West, 1963). The two previous glaciations were considered to be represented by superimposed tills in East Anglia, differentiated on the basis of composition by Baden-Powell (1948) into a lower 'Lowestoft Till' and an upper 'Gipping Till'. Confirmation of this distinction was provided by studies of till fabrics by West and Donner (1956), who found significant differences in this respect between the Lowestoft and Gipping Tills and suggested respective correlations with the continental Elsterian and Saalian glaciations.

Clayton (1957) proposed a complex subdivision of the glacial deposits of the Chelmsford area, in which he recognized an older, weathered and dissected till (Hanningfield Till), largely covering plateaux, and a younger 'sandwich' of deposits filling valleys, comprising lower and upper tills separated by gravel. To this later tripartite sequence he applied the names Maldon Till, Chelmsford Gravels and Springfield Till, in ascending stratigraphical sequence. The Maldon Till was thought to be highly localized, whereas the Springfield Till was considerably more widespread. The Chelmsford Gravels, generally equivalent to the 'Middle Glacial Gravel' of Wood and Harmer (1868), were interpreted as outwash deposits. Clayton (1957) suggested a correlation between the Hanningfield Till and the continental Elsterian (= Anglian) glaciation and between the later tripartite sequence (Maldon Till, Chelmsford Gravels and Springfield Till) and the Saalian Stage. However, in an appendix to a later paper he proposed correlations with glacial drifts in Norfolk and Suffolk that implied an Anglian age for the Hanningfield and Maldon Tills (seen as equivalent to the Cromer and Lowestoft Tills, respectively) and a Saalian (Gipping Till) age for the Springfield Till (Clayton, 1960). In this later paper he suggested a Hoxnian age for the Chelmsford Gravels, which would seem to preclude their interpretation as glaciofluvial sediments, although no explanation of the change of view was provided. Clayton's earlier interpretation of the gravels as glaciofluvial was largely reiterated by Baker (1971), who suggested that the area may have been occupied by a pre-glacial Thames and that the deposits of this river may have been reworked and incorporated in the outwash.

The distinction of the products of two separate glaciations in southern East Anglia was seriously questioned by Baker (1971), who found that the Hanningfield and Springfield tills could not be differentiated either by lithological, stratigraphical or morphological evidence in north-west Essex. Baker also suggested that the Maldon Till resulted from a minor advance of the main 'Chancy Boulder Clay' glaciation of East Anglia (see below, Maldon), implying that all the glacial deposits of Essex are the product of a single glaciation. Subsequent mapping and lithological analyses of tills throughout East Anglia and the East Midlands led to confirmation that only a single glacial episode is represented amongst the Chalk-rich glacial deposits of these areas, equivalent to the Lowestoft Till of Norfolk (Bristow and Cox, 1973; Perrin *et al.,* 1973; Perrin *et al.,* 1979). Separate recognition of the partly Scandinavian Cromer Tills/ North Sea Drift glaciation was maintained, but the Gipping Till in its type area (the Gipping valley, near Ipswich) was found to be nothing more than a weathered profile in the upper part of the Lowestoft Till. Evidence for a glaciation equivalent to the continental Saalian was, however, accepted in the West Midlands and, with a good deal of caution, in the Breckland (Turner, 1973); a new name Wolstonian' was given to this post-Hoxnian and pre-Ipswichian glaciation (Shotton, 1973b; Chapter 1). Straw (1979, 1983) has continued to argue for an earlier 'Wolstonian' glaciation in northern East Anglia, principally on geomorphological grounds, and Wymer (1985b) has described sites in Suffolk and Norfolk where glacial deposits might overlie Hoxnian sediments. However, the view that only a single (Anglian Stage) glaciation, albeit with multiple ice advances, can be recognized in Essex has been consolidated in recent reviews (Baker and Jones, 1980; Whiteman, 1987; Allen *et al.,* 1991).

Even in the Wolstonian type area around Coventry there is growing uncertainty over the distinction between the deposits attributed to this glaciation and the Anglian deposits to the east (Perrin *et al.,* 1979; Sumbler, 1983; Rose, 1987). There are clear stratigraphical reasons for considering the whole of the 'Chalky till' to have been deposited during a single glaciation, during the Anglian Stage. Doubts have, however, been expressed elsewhere in this volume about the tenability of any model that places all these glacial deposits within a single glacial episode. These doubts stem from stratigraphical correlations of Chalk-rich tills on the Cotswolds and in the Vale of St Albans with the Thames terrace sequence, which suggest that the glaciations recognized in these two areas may have been separated by a temperate episode (see Chapter 1; Chapter 2, Long Hanborough and Wolvercote; Chapter 3, Part 2). It may be feasible, in the light of the more complex chronology indicated by the record from deep-sea cores (Chapter 1), for two separate glacial episodes to be represented within the 'Chalky Till' of eastern England, both of them post-Cromerian (*sensu* West Runton) and pre-Hoxnian (*sensu* Hoxne).

The recognition of early Thames deposits in southern East Anglia

Re-evaluation of the gravels underlying the till sheet of southern East Anglia has also taken place over the past quarter of a century. Hey (1967), following considerable reinvestigation of the deposits, concluded that the Westleton Beds' of the type area in north-east Suffolk were truly marine. However, he found elsewhere that gravels described by Prestwich (1881, 1890b, 1890c) under that name, and attributed by Solomon (1935) to his Westleton Series', differed from the type Westleton Beds and could frequently be shown to be younger. These gravels, generally mapped by the Geological Survey as part of the glacial sequence, were defined as the Kesgrave Sands and Gravels by Rose *et al.* (1976) and Rose and Allen (1977), who interpreted them as periglacial fluvial deposits of probable Thames origin. These authors demonstrated a distinction, on the basis of clast-composition, between the early Thames gravels and less extensive glacial outwash deposits, which they named Barham Sands and Gravels. They confirmed, therefore, the distinction made by Solomon (in Clayton, 1957) using heavy-mineral analysis.

Rose *et al.* (1976) proposed an important new stratigraphical scheme for southern East Anglia. From a study of sites throughout the area between Ongar (in the south-west), Thetford (in the north-west) and the coast, they found that the Lowestoft Till overlies widespread fluvial deposits of the pre-diversion Thames, their Kesgrave Sands and Gravels. The upper part of these deposits was frequently found to be rubified and clay-enriched, features indicative of pedogenic activity in a warm climate (Rose and Allen, 1977; Kemp, 1985a; Rose *et al.,* 1985b). This horizon occurs immediately beneath the Lowestoft Till or its associated outwash (Barham Sands and Gravels), indicating that soil development occurred prior to the Anglian glaciation. It was therefore concluded that the uppermost parts of the Kesgrave Group gravels incorporate the illuvial horizon of an interglacial soil, named the Valley Farm Soil (Rose *et al.,* 1976; Rose and Allen, 1977; Kemp, 1985a). As the Kesgrave Sands and Gravels overlie the Chillesford Beds at Chillesford Church Pit, which at that time were ascribed to the Pastonian Stage (Turner, 1973), the early Thames gravels were placed by Rose *et al.* (1976) and Rose and Allen (1977) in the subsequent cold stage, the Beestonian, and the palaeosol, its age constrained by the overlying Anglian glacial sediments, in the Cromerian Stage.

It is clear that intensely cold conditions prevailed following the formation of the Valley Farm Soil, even before the deposition of the Lowestoft Till; at many localities, including the GCR site at Newney Green, a periglacial soil is superimposed on the earlier warm-climate one. This periglacial soil, termed the Barham Soil, was recognized from both large- and small-scale structures related to frost activity; the larger structures include involutions and ice-wedge casts, whereas the smaller ones include disrupted clay skins and fractured gravel clasts (Rose *et al.,* 1976, 1985a; Rose and Allen, 1977). As well as being developed in the upper parts of the Kesgrave Group gravels (incorporating the earlier Valley Farm Soil), the Barham Soil has been shown to have developed in Cromerian interglacial sediments in north Norfolk. In such cases, where overlain by Anglian Stage tills, this soil has been established as a 'soil stratigraphic unit' of early Anglian age (Rose *et al.,* 1985a). Without these overlying deposits, in areas where Kesgrave Group gravels form the present land surface, it is possible to identify relict features of both the Barham and Valley Farm Soils (Rose *et al.,* 1976, 1985a, 1985b; Rose and Allen, 1977; Kemp, 1985a). However, later temperate■ climate soils have been developed in the top of the Lowestoft Till (Rose *et al.,* 1978; Sturdy *et al.,* 1978) and cryoturbation has probably occurred during several cold episodes since the Anglian glaciation, so the recognition of pedogenic features characteristic of the Valley Farm and Barham Soils is of equivocal stratigraphical value beyond the glaciated area. Loess and coversand have also been recorded between the Kesgrave Sands and Gravels and the Lowestoft Till (Rose *et al.,* 1976, 1985a; Rose and Allen, 1977). These sediments, ascribed to the Anglian Stage, are frequently incorporated in the large-scale cryoturbation structures of the Barham Soil.

The recognition of a widespread Cromerian soil developed on the early Thames deposits of central and northern Essex led Rose *et al.* (1976) to suggest that the river had migrated to a more southerly route by that stage. However, subsequent work in the Vale of St Albans (Gibbard, 1974, 1977, 1978a; Green and McGregor, 1978a, 1978b; Chapter 3) and in eastern Essex (Bridgland, 1980, 1983a, 1983b, 1988a; Part 2 of this chapter) has indicated that the Thames was not diverted from its early course through Hertfordshire and central Essex until the Anglian glacial maximum. A possible explanation for this apparent contradiction is that the palaeosol seen beneath the Lowestoft Till in many gravel pits in southern East Anglia was formed on the terraces of the pre-glacial Thames valley, whereas the valley floor and channel occupied by the river immediately prior to its diversion, in the centre of the Mid-Essex Depression of Wooldridge and Henderson (1955), is deeply buried by Lowestoft Till and not exposed. In the unglaciated area east of Colchester, the lowest formation within the Low-level Kesgrave Subgroup has been ascribed to the Anglian Stage (Bridgland, 1980, 1983a, 1988a; Bridgland *et al.,* 1988, 1990). The Valley Farm Soil is not developed on this formation (see below, St Osyth and Holland-on-Sea).

Study of the clast composition of the Kesgrave Sands and Gravels reveals important minor components of value as provenance indicators. The gravels generally contain 0.5–2% sponge-spicular chert derived from the Lower Greensand of Kent and Surrey (Bridgland, 1980, 1986b; Green *et al.,* 1982). Carboniferous chert, for which there are a number of potential sources to the north and west, all of them outside the London Basin (Bridgland, 1986b), typically accounts for 1–2% of the total gravel content (Bridgland *et al.,* 1990). Also important is a restricted suite of volcanic rocks, some of which have been tentatively traced to sources in North Wales (Hey and Brenchley, 1977; Whiteman, 1983). The abundant quartz and quartzite (up to 35%) must also have been derived from outside the London Basin, the Midlands and Welsh borderlands representing the most likely source areas (Bridgland, 1986b). As was recognized by Rose *et al.* (1976), these various non-flint components are, when found in gravels in the London Basin, indicative of a Thames origin. A similar assemblage of component rocks has been recognized in the early terrace gravels of the Middle Thames (Green and McGregor, 1978a; McGregor and Green, 1978; Gibbard, 1985) and in the Northern Drift of Oxfordshire, also believed to represent early Thames aggradations (Hey, 1986; Chapter 2). Whether these rock-types were introduced into the Thames system by glaciation(s), by fluvial transport in a more extensive catchment or by a combination of the two remains a subject of controversy (Bowen *et al.,* 1986a; Bridgland, 1986b, 1988c; Hey, 1986; Whiteman, 1990; see Chapter 1).

Rose *et al.* (1976) and Rose and Allen (1977) recognized that their Kesgrave Sands and Gravels might represent a series of terrace aggradations, but the first formal subdivision was proposed by Hey (1980), who recognized the downstream continuation of his Westland Green Gravels of the Middle Thames (Hey, 1965; Chapter 3) within the older, higher-level part of the group (Figure 5.1). Hey's distinction of the Westland Green Gravels from other Kesgrave Group deposits was based on both altitudinal and compositional considerations, which enabled him to trace that unit to Suffolk and Norfolk. Allen (1983, 1984) has further subdivided the Kesgrave Group in Suffolk, recognizing new terrace formations immediately above and below Hey's 'Westland Green Gravels', the Baylham Common Gravel and Waldringfield Gravel respectively. The Waldringfield Gravel has also been identified in northern Essex (Bridgland, 1988a; (Figure 5.2)). Later studies of the Valley Farm Soil have shown that it is more complex than previously recognized, particularly on the older and higher formations within the Kesgrave Group, where evidence for several alternating phases of temperate-climate pedogenesis and periglacial disturbance have been determined from micromorphological studies (Rose, 1983a; Kemp, 1985a; Rose *et al.,* 1985b; see below, Newney Green). A distinction, based partly on clast lithologies, between high-level and low-level divisions of the Kesgrave Sands and Gravels, was first recognized by Hey (1980) and was adopted in the Chelmsford area by Bristow (1985). These divisions are each made up of a number of component formations and are regarded here as subgroups. Similar categories to these subgroups were proposed by Gregory (1922), his High Level and Low Level Quartzite Gravels.

Recent work by Whiteman (1990) has shown that the Westland Green Gravels as recognized in Suffolk do not, in fact, correlate with the unit of the same name originally defined by Hey (1965) in Hertfordshire and the Middle Thames. By determining (largely from borehole records) the distribution of the various formations within the Kesgrave Group in Essex and Suffolk, Whiteman has demonstrated that the formation in Suffolk that has been termed Westland Green Gravels is, in fact, the downstream continuation of the Gerrards Cross Gravel of the Middle Thames (see Chapters 1 and 3). It is therefore necessary to make considerable changes to the schemes for correlating the pre-diversion gravels of the Thames valley with the formations of the Kesgrave Group that have been published in recent years (Hey, 1980; Green *et al.,* 1982; Gibbard, 1983; Green and McGregor, 1983; Bowen *et al.,* 1986a; Bridgland, 1988a).

Whiteman's work has wider repercussions than are outlined above. He was able to suggest correlations, based on altitude and variations in clast composition, between central Essex and the higher parts of the terrace sequences upstream in both the Middle and Upper Thames regions (see Chapters 3 and 2 respectively). He concluded that the earliest true Thames deposits, from the Stoke Row Gravel up to and including the Gerrards Cross Gravel, are the product of a very large river, with a catchment extending far beyond the present Upper Thames (as already envisaged by Hey (1986)). In East Anglia these formations have all been included within the High-level Kesgrave Subgroup.

The formations of the Low-level Kesgrave Subgroup, thought until recently to represent the downstream continuation of Middle Thames terrace formations between the Satwell and Winter Hill Gravels (inclusive), have been shown by Whiteman to fall entirely between the deposition of the Gerrards Cross Gravel (last of the High-level Kesgrave Subgroup formations) and the diversion of the river. Therefore an interval that in the Middle Thames is represented only by the Winter Hill and Rassler Gravels (see Chapters 1 and 3) is more fully represented by the Low-level Kesgrave Subgroup in Essex, which comprises four separate formations. Despite this revision, the correlation of the lowest of these with the Winter Hill Formation of the Middle Thames (Bridgland, 1980, 1983a, 1988a), based on stratigraphical evidence resulting from the diversion of the river, is upheld (see below, St Osyth and Holland-on-Sea).

Bridgland (1988a) has suggested that the deposits in northern Essex that are now classified as Low-level Kesgrave Sands and Gravels occupy a separate valley from that in which the formations of the High-level Kesgrave Subgroup were deposited. The latter valley lies further to the north and west and is separated from the former, in south-east Suffolk, by an interfluve of residual Red Crag (Allen, 1983). Further upstream the Low-level Kesgrave Subgroup formations are preserved in central Essex as the lowest tiers in a terrace 'staircase' of Kesgrave gravels that is largely obscured by later (Anglian) glacial deposits. Formations within the High-level Kesgrave Subgroup form the higher part of this 'staircase', which declines from north-west to south-east, towards the modern Chelmer and Blackwater valleys. To the south and east of these valleys, possible outliers of High-level Kesgrave Sands and Gravels have been identified on Danbury Hill and on the Tiptree Ridge (Hey, 1980; Bristow, 1985; (Figure 5.1)). All these deposits, unfortunately, appear on the Geological Survey map (Sheet 241) as 'Glacial Sand and Gravel', a category that, in the Maldon area, appears also to include true glaciofluvial sediments as well as early post-glaciation Blackwater terrace deposits (see Part 3 of this Chapter, Maldon). Furthermore, the high-level outliers at Danbury and Tiptree have been thought to be affected by glaciotectonic processes at the edge of the ice sheet that filled the old Thames valley (Clayton, 1957; Hey, 1980; Bristow, 1985), which raises the possibility that they might have been substantially disturbed, elevated or even transported for some distance by the ice.

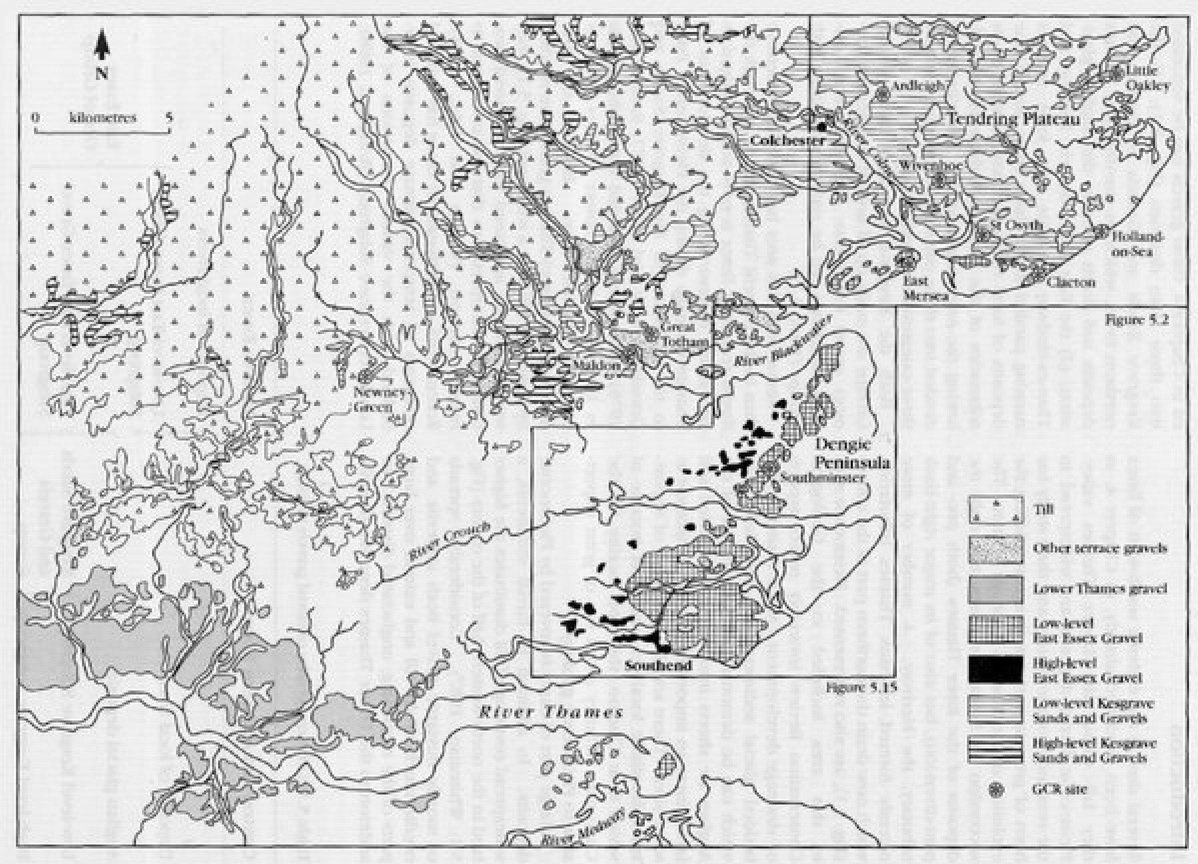
Important information about the age and stratigraphy of the Low-level Kesgrave Sands and Gravels has been gained in recent years from the discovery, at a number of sites in Essex, of inter glacial sediments interbedded with these early Thames gravels (Bridgland, 1988a; Bridgland *et al.,* 1988, 1990; see below, Ardleigh, Little Oakley and Wivenhoe). It is hoped that the detailed interpretation of these sites will provide a framework for the relative dating of the lower Middle Pleistocene Low-level Kesgrave Subgroup, which can be extended to assist with the dating of the sequences in other parts of the Thames Basin and permit correlation with the sequences further north in East Anglia and on the Continent.

In addition to the recognition of individual (terrace) formations within the Low-level Kesgrave Subgroup, differences in gravel composition enable the distinction of western and eastern subdivisions of the lowest three of these formations on the Tendring Plateau (Bridgland, 1988a; Bridgland et al, 1990; (Table 5.2) and (Table 5.3)), a name given by Warren (1957) to the peninsula between the Colne and Stour estuaries. The western subdivisions are lithologically typical of the Low-level Kesgrave Subgroup, but these pass eastwards (downstream) into deposits containing significantly more clasts of southern origin, predominantly Lower Greensand chert, with a complementary decrease in 'exotic' material such as quartz, quartzite and Palaeozoic chert (Figure 5.2) and (Figure 5.3). This change in gravel composition has been shown to result from the contemporary confluence between the Kesgrave Thames and the early Medway, which flowed from the Weald across eastern Essex to join the Thames in the area of the present Tendring Plateau (Bridgland, 1980, 1983a, 1988a; (Figure 5.4)). The highest Low-level Kesgrave Subgroup formation, the Waldringfield Gravel, cannot be divided in this way, perhaps because the contemporary Thames-Medway confluence lay to the east, beyond the present coast (Bridgland, 1988a). The sequence of Low-level Kesgrave Subgroup formations on the Tendring Plateau is therefore as follows (Figure 5.2) and (Figure 5.3) and (Table 5.3):

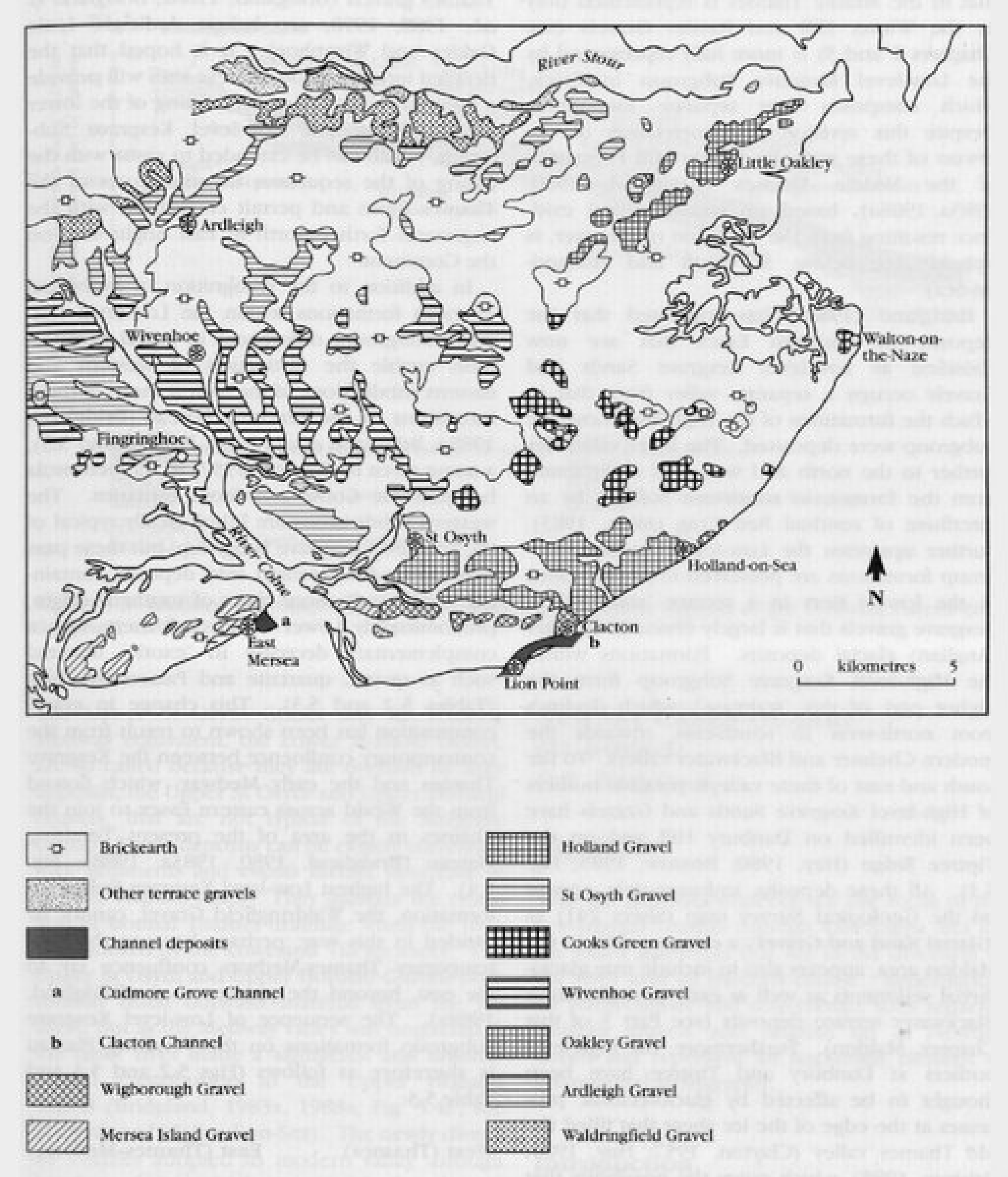
West (Thames)	East (Thames-Medway)
Waldringfield Gravel	
Ardleigh Gravel	Oakley Gravel
Wivenhoe Gravel	Cooks Green Gravel
Lower St Osyth Gravel	Lower Holland Gravel

The Lower St Osyth Gravel and its Thames-Medway equivalent, the Lower Holland Gravel, are so called because they are overlain by later deposits, the Upper St Osyth and Upper Holland Gravels, that are not typical of the Kesgrave Group. These deposits can be closely correlated with sediments and events further upstream in the old Thames valley. They indicate the cessation of normal Thames drainage when the river was blocked by the Lowestoft Till ice sheet. The Upper St Osyth and Upper Holland Gravels both contain distal outwash material from the ice sheet, but as the Medway valley was unglaciated, the latter river made a significant and uninterrupted contribution to the Upper Holland Gravel (Bridgland, 1983a, 1988a; (Figure 5.4)F; see St Osyth and Holland-on-Sea). The newly diverted Thames adopted its modern valley through London, from which it joined the former Medway valley across eastern Essex (Bridgland, 1980, 1983a, 1983b, 1988a). The deposits of this newly diverted Thames are represented on the Tendring Plateau as part of the Low-level East Essex Gravel Subgroup ((Figure 5.5)A and 5.5B; see Part 2 of this chapter, especially Clacton-on-Sea).

References



(Figure 5.1) Pleistocene geology of Essex, showing the various types of gravel described in this chapter, the extent of the Anglian till sheet and the relation of these to the existing drainage systems (modified from Bridgland, 1988a).



(Figure 5.2) Pleistocene gravels of the Tendring Plateau (after Bridgland, 1988a).

Gravel	Site	Sample	Flint: Tertiary	Flint: Nodular	Flint: Total	Southern: Greensand chert	Southern: Total	Quartz	Quartzite	Carb chert	Rhax chert	Igneous	Exotics: Total	Ratio (others q/qtzt)	Ratio (q/qtzt)	Total count	National Grid Reference
Anglian glacial gravels**	Ugley	1	61.9	25.7	87.9			5.5	0.8	1.5	0.4	1.9	11.9		4.55	520	TL 516278
		2	3.6	37.6	87.1			2.6	1.7	2.1	1.7	1.9	12.6		1.56	420	
Upper St Osyth Gravel	Fingringhoe	1A	15.4	15.0	80.8	2.4	2.4	4.1	4.5	4.1	1.4	0.8	16.8	0.29	0.95	509	TM 0119 2017
		1B	15.9	13.7	80.7	3.7	3.7	5.7	6.8	0.9	0.9	0.9	17.7	0.05	0.84	455	
	St Osyth	2	8.7	19.1	89.8	2.1	2.1	4.2	0.9	2.1		0.2	8.5	0.41	4.35	530	TM 1196 1704
	11.2-16	2(B)	24.9	9.4	78.4	2.4	2.4	11.0	1.0	2.7	0.4	0.3	18.8	0.18	12.50	704	
Upper Holland Gravel	Bypass Rd.	1A	9.9	21.5	82.1	8.8	3.5	5.8	0.4	2.5		0.4	8.4	2.27	2.50	203	TM 1161 1705
		1B	12.6	16.1	74.8	18.6	13.6	2.5	0.6	1.5		0.6	5.7	6.20	4.00	517	
	Earls Hall 1	1	13.5	11.5	75.8	21.7	21.7	0.5	0.8	0.5			2.2	19.75	0.53	364	TM 1432 1635
	11.2-16	2(B)	26.0	8.8	80.2	10.2	10.5	4.2	1.5	2.7	0.3	0.2	9.1	1.60	2.79	352	
		2	13.6	*	77.6	15.0	15.0	3.0	0.3	7.8		0.8	7.2	4.50	11.11	301	TM 1439 1635
	Burrs Road	1	10.8	*	64.8	30.0	30.4	0.7		1.4	1.4		3.8	45.00		287	TM 1920 1759
		2	11.6	*	66.0	28.4	28.8	5.5		1.5	0.6		5.5	9.20		520	TM 1927 1754
	Holland-on-Sea	1	15.5	8.7	70.7	26.5	26.7	2.2	0.2	1.0	0.5		4.6	18.20	11.11	415	TM 2108 1662
		2A	15.7	9.8	68.9	25.1	25.1	3.0	0.7	0.7		0.5	6.0	6.70	4.35	207	TM 2109 1660
	Greenfields(?)	2B	25.7	13.5	73.3	15.6	15.1	4.7	5.2	1.6	0.2		12.6	1.62	0.90	432	
Lower St Osyth Gravel	Fingringhoe	1C	31.4	12.5	85.1			6.8	8.0	1.0			15.9		0.60	376	TM 0119 2017
	Moverons	1	29.0	16.8	80.0	3.6	3.6	8.4	7.0	1.4		1.0	18.1	0.06	1.20	429	TM 0711 1818
		2	30.8	16.5	79.6	1.1	1.1	11.2	5.3	0.7		0.5	19.3	0.07	2.13	1101	TM 0712 1819
	11.2-16	2	32.3	5.9	73.1	1.6	1.7	14.2	7.6	1.7		0.8	24.7	0.08	1.89	1180	
		3	31.8	13.1	77.3	3.6	3.7	11.4	7.8	1.3		0.7	21.7	0.06	1.47	956	TM 0699 1825
	St Osyth	1A	35.4	*	77.1	3.5	3.5	11.1	7.7	1.8		0.2	22.6	0.05	1.45	550	TM 1161 1706
		1B	36.6	*	79.8	1.5	1.5	10.4	4.9	1.5		0.7	18.6	0.10	2.13	748	
	11.2-16	1B	38.1	7.7	78.0	1.7	1.7	12.5	4.8	2.0		0.3	20.2	0.20	2.61	1129	
Lower Holland Gravel	St Osyth	3	31.6	16.8	83.1	1.4	1.4	10.3	2.7	1.6		0.5	15.5	0.11	3.29	561	TM 1201 1703
		5	21.8	20.8	83.0	4.6	4.2	5.8	6.8	1.8		0.5	15.2	0.30	0.85	525	TM 1215 1605
		6	29.5	16.6	81.3	2.2	2.5	8.8	5.3	1.5			16.0	0.18	1.67	519	TM 1225 1600
	Bush Paddock	1	43.3	20.5	83.9	4.6	5.1	5.8	3.7	0.8		0.5	11.8	0.55	1.59	567	TM 1257 1611
	11.2-16	1	49.8	5.7	75.8	10.5	10.8	9.2	2.4	0.8	0.1	0.2	13.8	0.79	3.87	1275	
	Holland-on-Sea	2C	32.8	11.9	80.6	2.2	2.2	8.0	7.5	1.0		0.2	17.2	0.15	1.00	412	TM 2109 1663
		2D	26.7	13.9	80.5	1.8	1.8	9.2	5.6	1.3		0.5	16.5	0.12	1.64	575	
	Holland Haven	1A	21.9	*	81.0	2.1	2.9	7.3	3.7	1.6	0.3	0.5	13.3	0.26	1.96	582	TM 2208 1741
		1B	31.6	14.6	83.1	2.5	3.1	9.0	4.6	0.4			13.9	0.26	2.00	200	
		2	25.3	*	82.2	2.0	3.0	8.4	3.9	1.7	0.2	0.2	14.8	0.21	2.17	536	TM 2205 1743
	11.2-16	2	31.9	7.2	78.8	1.2	1.2	12.4	2.2	1.4	0.2	0.9	18.0	0.06	5.64	939	
	Clacton cliffs	4C	30.9	15.2	81.3	8.5	3.3	3.2	4.4	1.2	0.7		9.7	1.18	0.72	453	TM 1730 1433
		4D	38.7	12.6	81.3	5.5	5.5	6.4	2.8	2.0		0.5	12.9	0.61	2.27	357	
	11.2-16	4D	39.9	6.6	78.7	10.2	10.8	5.5	3.0	1.2	0.4		10.8	1.15	1.52	864	
Wivenhoe Gravel	Wivenhoe	1B	25.1	17.8	83.1	3.8	3.8	5.4	5.7	2.7		0.5	16.3	0.05	0.96	371	TM 0456 2330
	(Wiv.2/Gr.)	2A	30.4	14.7	74.5	0.4	0.7	12.4	5.5	1.4		0.6	26.7	0.05	1.31	205	TM 0455 2336
	Alresford	1	36.0	8.1	73.5	0.4	0.6	16.2	8.1	2.6		0.7	26.4	0.02	1.75	158	TM 0711 2102
	11.2-16	1	32.2	4.7	66.3	1.4	1.4	27.7	10.0	2.3		1.7	32.4	0.05	2.67	735	
		2	21.5	16.9	82.5	0.9	0.9	7.3	7.0	1.5		0.6	16.6	0.01	1.04	344	TM 0711 2192
Cooks Green Gravel	Cooks Grn	1A	21.5	*	85.8	3.2	3.2	7.2	3.5	1.0		0.5	13.6	0.30	2.06	325	TM 1880 1850
		1B	27.7	14.4	86.2	2.0	2.0	8.3	2.2	2.8			13.8	0.23	3.76	402	
	11.2-16	1B	26.9	7.8	72.5	3.7	3.7	15.4	4.7	3.2		0.3	23.7	0.17	3.47	1205	
		2	29.6	12.7	85.3	3.3	3.5	8.1	4.1	1.3		0.3	13.5	0.27	1.90	394	TM 1898 1640
	Gt Holland	1	25.5	19.1	86.3	3.7	3.7	8.4	6.0	0.7			16.0	0.12	1.41	419	TM 2112 1932
	11.2-16	1	25.9	8.6	60.5	3.1	3.2	9.9	5.9	1.0	0.1	0.2	16.5	0.22	1.61	1205	
Little Oakley Silts and Sands	L Oakley	AB	33.6	12.6	87.4	0.8	0.8	4.2	3.5	1.7			1.8	0.08	0.71	119	TM 2233 2952
	11.2-16	AB	26.4	7.3	73.0	2.9	2.9	17.2	6.8	2.0			24.8	0.05	1.12	205	
	AC	33.7	16.7	80.7	0.4	0.6	9.5	4.8	0.4			0.6	15.9	0.05	1.96	252	TM 2225 2951
	11.2-16	AC	20.7	8.5	73.4	2.6	2.6	13.2	8.1	1.2	0.1	0.6	25.2	0.07	2.45	670	
		AF	26.0	14.3	80.3	1.9	1.9	9.8	6.2	1.2			17.9	0.13	1.46	223	TM 2233 2946
	11.2-16	AF	29.8	6.9	79.9	2.2	2.3	15.3	6.9	1.8		0.6	26.3	0.11	2.21	640	
Martello Gravel	Ardleigh	3	20.5	14.1	76.5	3.6	3.6	10.4	6.2	1.4	0.2	0.8	21.9	0.08	1.26	312	TM 0515 2800
		4C	19.5	13.2	76.7	0.7	0.7	13.7	7.3	2.5	0.1	0.5	21.6	0.03	1.61	605	TM 0530 2807
	11.2-16	4C	26.2	6.5	72.5	2.0	2.2	14.5	7.0	2.7	0.1	1.0	27.8	0.05	2.09	556	
Ardleigh Gravel	Ardleigh	1	26.8	15.4	75.0	0.7	0.7	13.9	7.5	0.8		1.5	23.6	0.04	1.58	590	TM 0530 2812
	11.2-16	1	27.1	7.7	72.1	1.2	1.7	15.4	7.3	2.2		0.2	25.0	0.07	2.11	2008	
		2	23.7	10.2	80.0	1.5	1.5	9.5	5.8	2.0			17.7	0.10	1.72	615	TM 0553 2805
	11.2-16	2	29.0	6.4	69.9	0.7	1.0	16.9	8.5	3.0		0.7	29.1	0.04	1.57	1219	
		4B	29.5	13.0	75.4	1.5	1.5	9.8	9.1	1.1		1.1	23.0	0.07	1.06	617	TM 0520 2867
	Ardleigh L.G-1	4A	35.5	12.7	72.0	0.4	0.4	11.6	13.5	1.1		0.9	27.5	0.01	0.82	551	
Oakley Gravel	Dovercourt	D6	30.5	12.1	79.2	3.1	3.4	9.8	4.7	1.6		1.1	18.5	0.17	2.08	379	TM 2328 3127
	11.2-16	D6	25.3	6.3	75.0	4.7	4.9	12.2	5.5	1.7			20.1	0.28	2.13	785	
	Little Oakley	K6	30.3	15.5	80.2	2.0	2.6	8.8	7.3	0.6	0.1	0.3	17.4	0.15	1.19	653	TM 2191 2947
	11.2-16	K6	25.7	9.1	76.4	2.1	2.2	13.9	7.0	1.9	0.2	0.3	21.3	0.12	1.70	673	
Waldringfield Gravel	Newney	1	52.9	*	72.5	0.5	0.5	10.5	11.7	0.8		1.2	26.5	0.02	0.90	395	TL 645064
	Green	2	55.3	4.1	70.6	0.6	0.6	14.7	10.2	0.8		3.6	26.9	0.02	1.45	400	
	Moxley Hth.	1	26.3	13.7	82.7	1.6	1.6	9.8	9.8	1.6			15.6	0.09	1.06	305	TM 1282 3125

* Not separately recorded

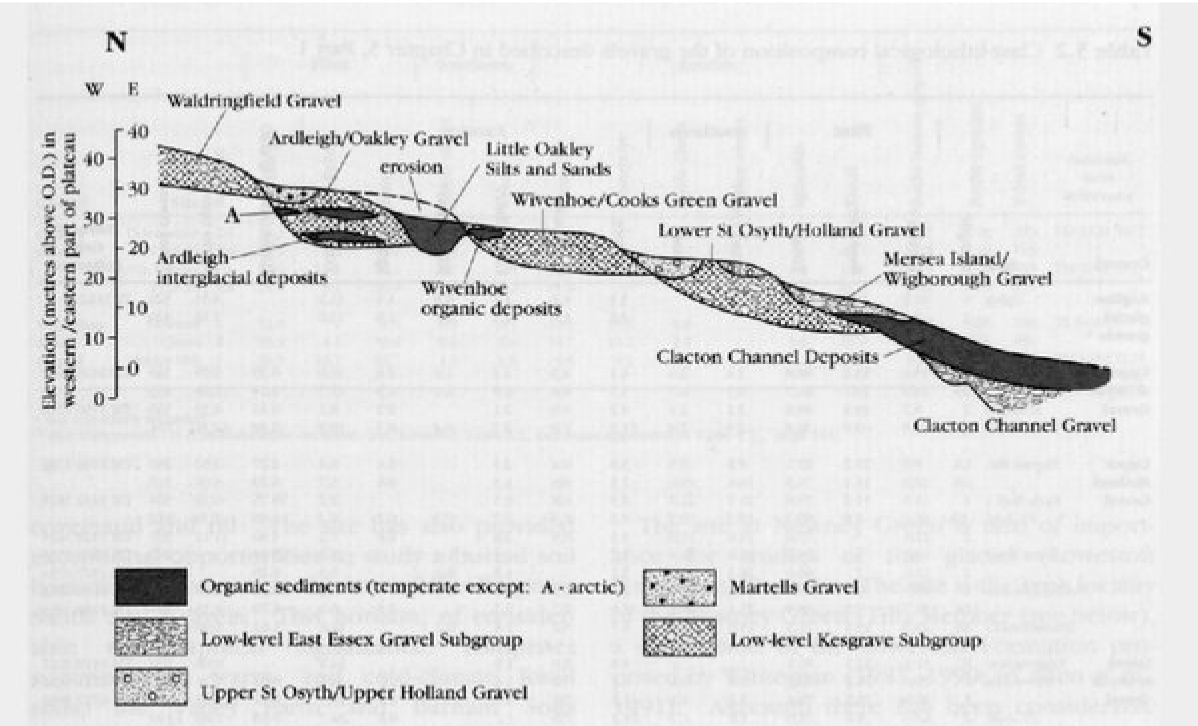
** (for comparison. N.B. non-durables excluded - see, however Table 3.1, and notes appended to Table 4.2., page 101)

(Table 5.2) Clast-lithological composition of the gravels described in Chapter 5, Part 1.

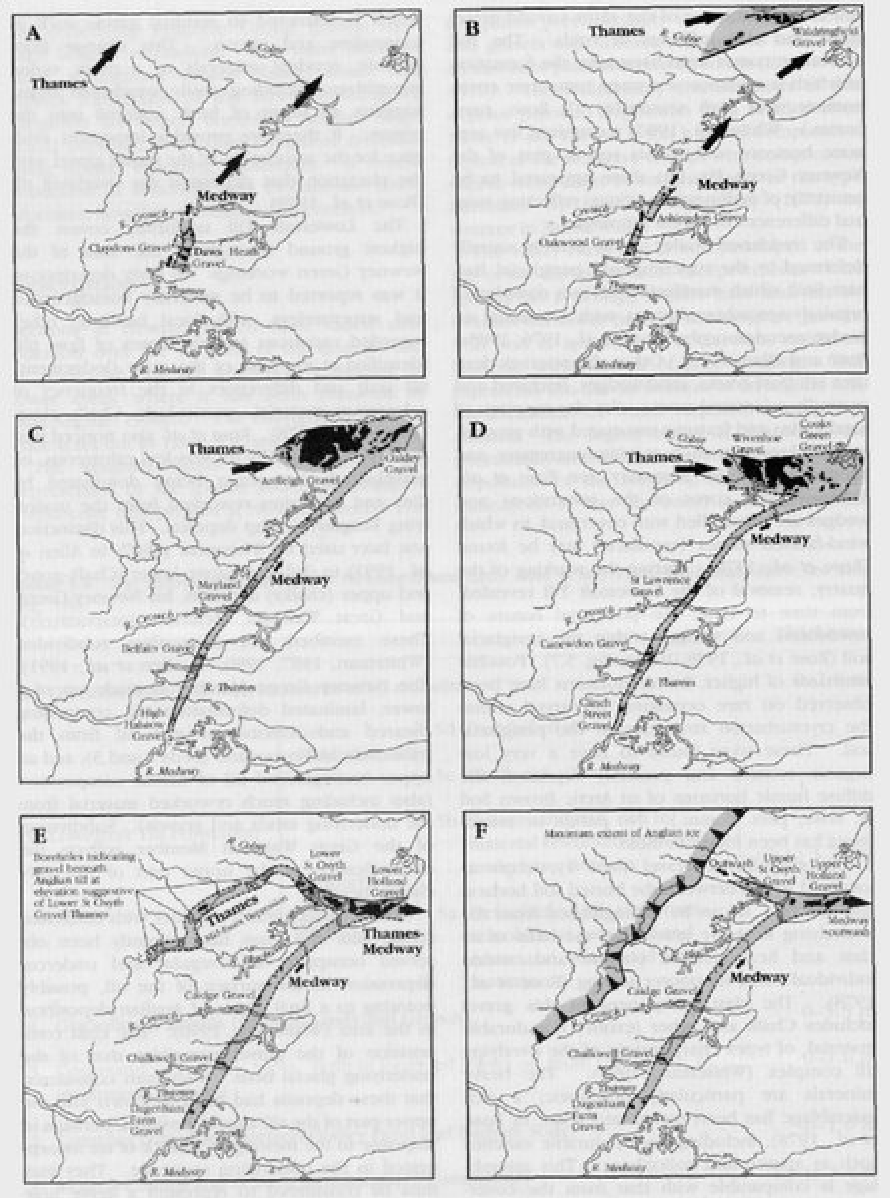
See Chapter 3, Part 2		Tendring Plateau		South of Blackwater		
Middle Thames	**Vale of St Albans**	**Low-level Kesgrave Thames**	**Low-level Kesgrave Thames - Medway**	**High-level East Essex Gravel Medway**	**Climate**	**Stage**
Winter Hill U.Gr.	Moor Mill Clay	Upper St Osyth Gr.[1]	Upper Holland Gr.[1]	Chalkwell/Caidge Gr.	Glacial	Anglian[2]
Winter Hill L.Gr.	Westmill L.Gravel	Lower St Osyth Gr.	Lower Holland Gr.	Chalkwell/Caidge Gr.	Periglacial	early Anglian
		Rejuvenation event				
No equivalent formations recognized in the area upstream from Essex, with the possible exception of the Rassler Gravel of the Reading area (see Chapter 1 and Fig. 1.3)		Wivenhoe Formation: Wiv.U.Gr. intgl.seds Wiv.L.Gr.	Cooks Green Gravel	Canewdon/St Lawr.Gr.	Periglacial Temperate Periglacial	
		Rejuvenation event				
		Ardleigh Formation: Ard.U.Gr. intgl.seds Ard.L.Gr.	? L.Oakley Silts & Sds[3] Oakley Gravel	Belfairs/Mayland Gr.	Periglacial Temperate Periglacial Temperate Periglacial	'Cromerian Complex'
		Rejuvenation event				
		Waldringfield Gr.	None recognized	Ashingdon Gravel?	Periglacial	

1 Not part of the Kesgrave Group (deposited while the Thames was blocked).
2 Anglian glacial maximum.
3 The Little Oakley Silts and Sands may date from the same temperate episode as the Ardleigh interglacial deposits.

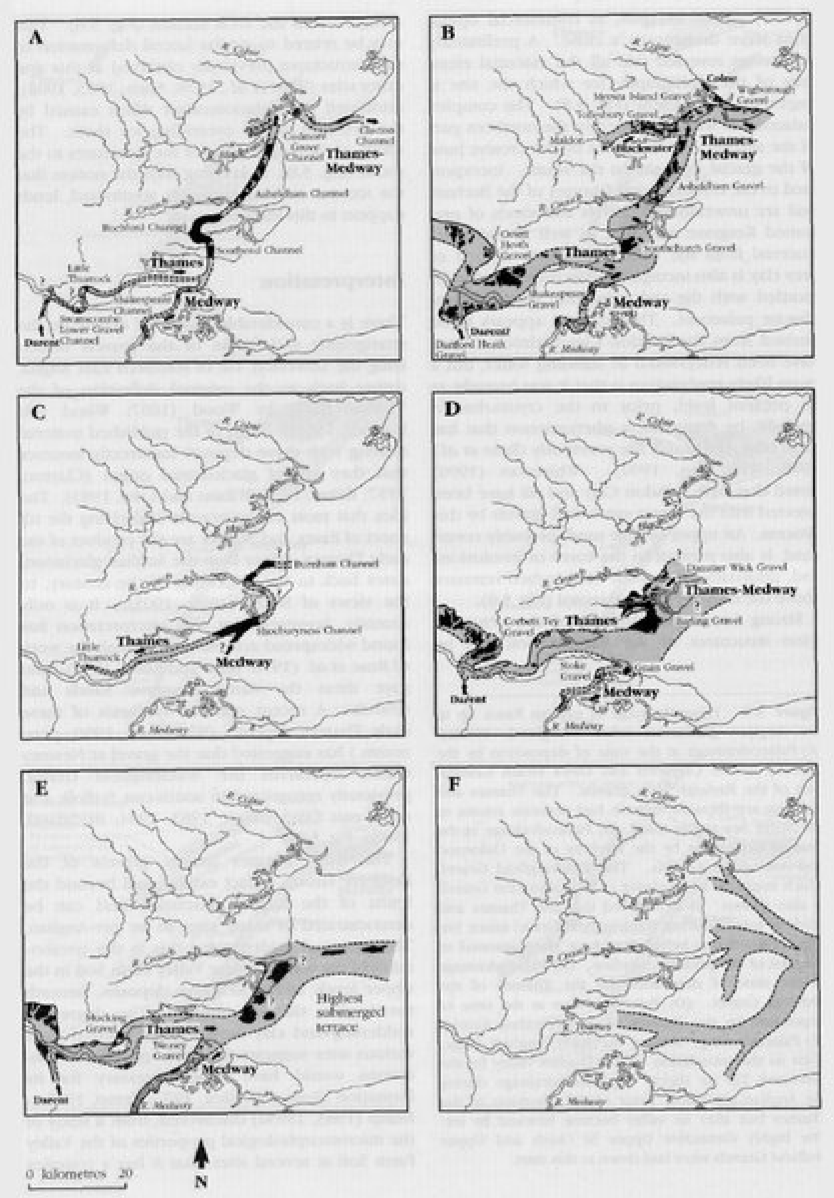
(Table 5.3) Correlation of gravel formations in Essex within the Kesgrave Group with deposits in other areas.



(Figure 5.3) Idealized N—S transverse section through the Pleistocene deposits of the Tendring Plateau (after Bridgland, 1988a).



(Figure 5.4) Palaeodrainage of eastern Essex up to the Anglian glaciation (after Bridgland, 1988a): (A) Palaeodrainage at the time of deposition by the Medway of the Claydons and Daws Heath Gravels, part of the Rayleigh Hills gravels. The Thames and Medway are thought to have had separate routes to the North Sea at this time. (B) Palaeodrainage at the time of deposition by the Medway of the Oakwood and Ashingdon Gravels. The Waldringfield Gravel, which might be a correlative of the Ashingdon Gravel, is also shown. It is believed that the Thames and Medway joined during Waldringfield Gravel times, but this confluence is believed to have been situated to the east of the present coastline. (C) Palaeodrainage at the time of deposition by the Thames of the Ardleigh Gravel. (D) Palaeodrainage at the time of deposition by the Thames of the Wivenhoe Gravel. (E) Palaeodrainage during the early Anglian Stage, prior to the inundation of the Thames valley by the Lowestoft Till ice sheet. (F) Palaeodrainage during the Anglian glaciation, prior to the diversion of the Thames but after its valley became blocked by ice. The highly distinctive Upper St Osyth and Upper Holland Gravels were laid down at this time.



(Figure 5.5) Palaeodrainage of Essex following the Anglian glaciation (modified from Bridgland, 1988a). (A) Palaeodrainage during the filling of the Southend/Asheldham/Clacton Channel. The Swanscombe Lower Gravel Channel and the Cudmore Grove Channel are both thought to be lateral equivalents. The Rochford Channel is now thought to represent an overdeepened section of the same feature (see text). This channel was excavated in the late Anglian by the newly diverted Thames and filled during the Hoxnian Stage (sensu Swanscombe). (B) Palaeodrainage during the deposition of the Southchurch/Asheldham Gravel.. This aggradational phase is believed to have culminated during the earliest part of the Saalian Stage, early in Oxygen Isotope Stage 10. (C) Palaeodrainage during the filling of the Shoeburyness Channel. The channel beneath the Corbets Tey Gravel of the Lower Thames is believed to be an upstream equivalent of this feature. It is thought that both the excavation and filling of the channel were intra-Saalian events, dating from Oxygen Isotope Stages 10 and 9 respectively. (D) Palaeodrainage during the deposition of the Barling Gravel. This is regarded as an intra-Saalian deposit, aggraded during Oxygen Isotope Stage 8. (E) Palaeodrainage during the deposition of the Mucking Gravel of the Lower Thames. The Thames-Medway equivalent of this formation is buried beneath the coastal alluvium east of Southend and can be traced offshore (Bridgland et ed., 1993). This aggradational phase occurred towards the end of the complex Saalian Stage, culminating early in Oxygen Isotope Stage 6. (F) Palaeodrainage during the last glacial. The submerged valley of the Thames-Medway has been recognized beneath Flandrian marine sediments in the area offshore from eastern Essex (after D'Olier, 1975).