The Pleistocene stratigraphy and palaeoenvironments of the Cambridge district

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The Pleistocene Stratigraphy and Palaeoenvironments of the Cambridge District

Steve Boreham

Dissertation submitted to the Open University for the degree of Doctor of Philosophy

June 2002

Volume 1 - Text
Dedications

To Mum and Dad

For you whose eyes were open wide
Whilst mine refused to see
I'm sore in need of saving grace
Be kind and humour me
I'm lost amidst a sea of wheat
Where people speak, but seldom meet....
Though nothing shows, someone knows
I wish that one was me.

QUITE RIGHTLY SO
Keith Reid

Colin and Jane Forbes

Sincere thanks for all your help and support throughout this project.

Richard West

Who inspired me to begin and to continue this undertaking.
Declaration

I hereby declare that this dissertation is not substantially the same as any that I have submitted for a degree or diploma or any other qualification at this or any other University.

I further state that no part of this dissertation has already been or is being concurrently submitted for any degree, diploma or any other qualification.

Except for commonly understood and accepted ideas, or where specific reference is made to the work of others, the content of this dissertation is entirely my original work and does not include any work carried out in collaboration.

This dissertation does not exceed 120,000 words

Steve Boreham
June 2002
Abstract

This study attempts to record and interpret Pleistocene geological data from the Cambridge District in a comprehensive format. The author has established a central study area comprising twenty 5km squares, embracing part of the lower Ouse valley and much of the Cam valley. This area has yielded some 5000 individual existing borehole and trial pit records. In addition, about a hundred boreholes and trial pits have carried out during this project. These have yielded detailed stratigraphic data, and more than three hundred sediment samples to which a variety of laboratory analyses have been applied. The author has used a novel rigorous lithostratigraphic approach as the primary line of evidence for correlation in this study, in place of the traditional morphostratigraphic paradigm. Existing stratotype localities in the study area have been reviewed and modified where appropriate, and several new stratotypes for lithostratigraphic members have been proposed.

Many classic Cambridge sites including Traveller’s Rest Pit, Histon Road, Barnwell Abbey, Barnwell Station, Grantchester and Barrington have been re-evaluated and new exposures investigated wherever possible, allowing the construction of databases of stratigraphic, physical and palaeontological information from a myriad of sources. Geochronological techniques including OSL, radiocarbon dating and aminostratigraphy have also been used for the correlation of deposits, together with biostratigraphic evidence. The presence of deposits from more than one temperate stage has been confirmed or strongly inferred for many of the major sites investigated. The relative antiquity of deposits at the Traveller’s Rest Pit has been confirmed, and the dating of the most recent phase of temperate deposition at Barrington and Histon Road established as Ipswichian (MIS 5e). In contrast, the majority of deposits at sites such as Grantchester and Swan’s Pit are strongly correlated with MIS 7. This study has enabled confident correlation of Anglian glacial, and post-Anglian fluvial deposits of the Great Ouse and Cam systems within the Cambridge District. It has also allowed the correlation of these deposits with others elsewhere in southern England. However, the reworking of faunal and floral remains between interglacials has been highlighted, and has major implications for biostratigraphy.

This study has unravelled a complex Pleistocene geological history including the advance of the Anglian ice sheets, the genesis of the Ouse and Cam river systems, major landscape change and the development of the drainage patterns observed today. The Ouse and Cam river systems initially developed along lines of Anglian sub-glacial drainage. In cold stages these rivers occupied high-energy braidplains characterised by episodic erosion, and the aggradation of gravels and sands. In temperate stages, they occupied relatively stable low-energy channels, resulting in the accretion of fines and organics. The study has also allowed the interpretation and understanding of many different Pleistocene palaeoenvironments within the Cambridge District including, subglacial, proglacial, tundra, scrub-tundra, steppic grassland, boreal forest and temperate woodland.
Acknowledgements

Firstly, I would like to thank my supervisors Dr Charles Turner and Dr Colin Forbes for their help and support throughout this project. I also gratefully acknowledge financial assistance towards the costs of amino acid, OSL and radiocarbon dating provided by Colin Forbes, and by a New Research Workers Award from the Quaternary Research Association. I am indebted to the following fellow workers who provided practical help and assistance at various stages of the study; Peter Christensen and Will Gosling (field assistance), Mike Hall and James Rolfe (technical assistance), Mike Dorling and Rod Long (access to specimens in the Sedgwick Museum), Danielle Schreve (vertebrate analyses), Alex Dixon and Russell Coope (beetle analyses), Mark Bateman and Becky Briant (OSL dating), Charles Hart (amino acid ratios), Fiona Petchey (radiocarbon dating), Richard Preece (mollusc analyses), Charles Turner (plant macrofossil analyses).

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Chapter 1

Quaternary Stratigraphy and the Study Area

On the hill we viewed the silence of the valley,
Called to witness cycles only of the past.
And we reach all this with movements in between the said remark.
Close to the edge, down by the river.
Down at the end, round by the corner.
Seasons will pass you by,
I get up, I get down...

CLOSE TO THE EDGE
Jon Anderson
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Chapter 1

Quaternary Stratigraphy and the Study Area

1.1 Aims

1.1.1 Aims of the project

The chief aims of this study are to describe, record and interpret Pleistocene geological (lithostratigraphic, chronostratigraphic) and palaeontological (biostratigraphic) evidence from the Cambridge District to enable the creation of a rigorous lithostratigraphic framework and the reconstruction of past vegetation, climates, landscapes and fluvial regimes. It is hoped that this will provide a greater understanding of the significance of various Pleistocene deposits in the study area, thus facilitating their correlation with British terrestrial sediments and deep ocean sequences.

In the decades since the publication of the classic British Geological Survey geology maps of the Cambridge District (Sheet 205 Saffron Walden and Sheet 188 Cambridge), there have been fundamental changes in the interpretation and classification of British Quaternary stratigraphy. The system of morphostratigraphic ‘Terraces’ used to classify ‘superficial’ or ‘drift’ deposits, has been found to be flawed (cf. Gibbard 1985). Thus many of the implicit and explicit correlations and associations shown by these maps and suggested by other workers have been called into question. This study sets out to address these problems by applying a systematic and to some extent novel lithostratigraphic approach to a large body of geological data, some of it new, and much of it never previously considered (Section 2.3.2). It attempts interpretation and correlation of diverse deposits to create a new coherent stratigraphic framework in a time of changing, and sometimes conflicting views on Quaternary stratigraphy. Cambridge has an abundance of Quaternary sites and records, but these have never before been examined as a whole in terms of depositional processes, palaeoenvironmental changes and morphogenetic landscapes.

1.1.2 Scope of study

The greater study area is centred on Cambridge, and broadly covers an area with a radius 15 to 20km from the city centre. This is the Cambridge District. It is divided into ten 10km squares, and each of these is further subdivided into four 5km squares equivalent to the Quarter Sheets originally used for mapping by the British Geological Survey (Figure
1.1.2-1). The constraints of limited geological data in outlying areas, available time and length of the final report have led to the establishment of a central study area concentrating on twenty 5km squares, including central Cambridge and surrounding sites of principal interest. The central study area includes a substantial part of the River Cam valley, but extends northwest to include important sites in the valley of the River Great Ouse. Ultimately, for purposes of stratigraphic correlation the central study area has been divided into the lower Ouse valley, the lower Cam valley and the middle Cam valley.

Temporally, this study encompasses the QuaternaryEpoch, but focuses on the Middle and Late Pleistocene. The Flandrian (Holocene) Stage has not been investigated in great detail, and the paucity of demonstrably pre-Anglian deposits in the area has restricted the scope of the study. The marine oxygen isotope record, and British and European terrestrial Quaternary Stratigraphy adapted from Mitchell et al. (1973), Mangerud et al. (1974), Mangerud & Berglund (1978), Zagwijn (1985), Mangerud (1989), Rose (1988), Ehlers et al. (1991), Ballantyne and Harris (1994), Lowe and Walker (1997) and Bowen (1999), is shown in Figure 1.1.2-2.

1.2 Characteristics of the Study area

1.2.1 Relief

The study area can be divided into five main physio-geographical units: the Cam-Rhee valley, the Ouse Valley, the Chalk Uplands, the Western Plateau, and the Fenland (cf. Sparks and West 1965) (Figure 1.2.1-1). The Cam-Rhee valley is characterised by a low-lying (0-30m OD) depression developed on Cretaceous Gault Clay and Lower Chalk, running across the central part of the study area from southwest to northeast following the regional strike of the bedrock. The valley of the River Great Ouse in the north of the study area occupies a similar low-lying depression (5-15m OD) developed largely on Jurassic Oxford Clay and Ampthill Clay. Both valleys contain extensive Pleistocene fluvial deposits. As the northeastern extension of the Chiltern Hills, the Chalk Uplands run approximately southwest to northeast across the southern part of the study area rising to over 120m OD. This ridge of high ground comprises Middle and Upper Chalk overlain by Boulder Clay (till) and forms the watershed between the Cam and Thames catchments. The height of this periglacially degraded escarpment gradually declines towards the northeast. The Western Plateau lies between the valley of the River Great Ouse and the valley of the River Cam. This area of elevated land rises to 80m OD. The plateau is underlain by glacial Boulder Clay (till) which occupies the Hatley Channel (Edmonds and Dinham 1965), a deep southwest-northeast trending buried channel-form, flanked by a rampart of Lower Chalk covered by till along much of its southeastern margin. In the northeast of the study area, the valley of the River Cam opens into a broad expanse of low-lying Fenland (c.0m
OD) characterised by a tract of Flandrian peat largely developed on Gault Clay bedrock. This represents the extreme southeast corner of the Fenland Basin.

1.2.2 Drainage

The study area is largely drained by the River Cam and its tributaries, which upstream of Cambridge include the River Rhee, the River Granta and the Bourn Brook. These streams have a meandering single-thread morphology, which has been artificially straightened, particularly downstream of Cambridge (Figure 1.2.4-1). The River Cam at Jesus Lock, Cambridge has a mean annual discharge of c.100m$^3$s$^{-1}$, although minimum flows occur in September and maximum flows of c.500m$^3$s$^{-1}$ occur in February (cf. Ward, 1981). Upper courses appear to be valley-confined streams, but the lower reaches show ample evidence for past drainage diversion, avulsion and river capture.

The River Cam is a tributary of the River Great Ouse, and is confluent with the artificial course of the Old West River some 18km downstream of Cambridge near Stretham. From this point the River Great Ouse flows northwards in a canalised course past Ely and Littleport to join the New Bedford River at Denver, near Downham Market in the Fenland, some 50km downstream of Cambridge. The River Great Ouse joins the sea through an artificial channel at King’s Lynn, a further 20km downstream. However, these artificial courses are rather different from those adopted by the River Cam and River Ouse through much of the Flandrian. It is clear that in the early Flandrian, the River Cam occupied a course distinct from that of the River Great Ouse, joining it near Wisbech in the centre of Fenland (Astbury 1958, Fowler 1946).

Upstream of Cambridge, the northward flowing River Cam is a scarp stream with a length of c.30km rising near Quendon, Essex, in the Chalk Uplands. It is one of the largest obsequent streams in the area and with the southward flowing River Stort forms a major through-valley system connecting the Fenland Basin with the London Basin.

The River Granta is another obsequent scarp stream draining the Chalk Uplands, which flows northwestward to join the River Cam near Stapleford. At Hauxton, the River Cam is also joined by the northeastward flowing River Rhee, which is a subsequent stream following the regional bedrock strike. Nearby at Grantchester, the River Cam is joined by the eastward flowing Bourn Brook, which drains the Western Plateau. It is estimated that the catchment of the entire River Cam system upstream of Cambridge is in the region of 1000km$^2$. Throughout the catchment, the annual precipitation is no higher than 750mm and the annual maximum snow depth is 50-100mm; the values for potential and actual evapotranspiration are 500-550mm (Ward, 1981).
1.2.3 Bedrock geology

All of the bedrock within the study area is of Mesozoic age, and these Jurassic and Cretaceous strata dip towards the southeast at an angle of $1\text{-}2^\circ$. Some monoclinic and anticlinal flexures have been recorded, particularly near Upware and Cottenham. The Jurassic geological formations outcropping in the study area include the Oxford Clay, the Ampthill Clay and Elsworth Rock (the Corallian), and the Kimmeridge Clay. These are overlain by Cretaceous rocks including the Lower Greensand, the Gault Clay and the Lower, Middle and Upper Chalk (Figure 1.2.3-1). An understanding of the local bedrock lithology is important, since it forms the source material of the Pleistocene deposits in the study area.

Oxford Clay comprises a fossiliferous dark bluish-grey clay with beds of limestone and calcareous sandstone (Taylor 1963, Edmonds and Dinham 1965) with a total thickness in excess of $50\text{m}$. The rock is soft and easily-weathered, and as a consequence often forms low-lying areas of the landscape. The Corallian Ampthill Clay is inter-bedded with bands of limestone (Edmonds and Dinham 1965, Rayner 1967). The basal part of Ampthill Clay, the Elsworth Rock and West Walton Beds comprise buff oolitic limestones. The Corallian in this area reaches a thickness of $c.50\text{m}$. The Kimmeridge Clay comprises dark blue-grey clay with beds of shale and limestone reaching $c.35\text{m}$ in thickness. It is a soft rock that forms areas of subdued relief. Jurassic rocks are confined to the northwest part of the study area.

The Lower Greensand consists of $10\text{m}$ of iron stained quartzose sands (Edmonds and Dinham, 1965; Rayner, 1967; Horton et al., 1974) with phosphatic nodules and abundant pebbles of quartz, quartzite and Palaeozoic rocks (Kirkaldy, 1947; Nicholls, 1947; Rayner, 1967). It outcrops in a narrow strip in the north of the study area and forms a low ridge near Oakington and Cottenham. This ridge has been breached by ancient abandoned courses of the River Cam, which converge at a place known as the Oakington Gap. In contrast, to the southwest in Bedfordshire and Buckinghamshire the Lower Greensand is of greater thickness and forms prominent scarps above the Jurassic clays. Gault Clay is a stiff dark clay that becomes more calcareous and contains phosphatic nodules in the upper part of the sequence (Rayner, 1967). It reaches $45\text{m}$ in thickness and outcrops in a broad clay vale occupied by the Cam-Rhee valley at the foot of the Chalk Uplands. The Chalk comprises white marls and limestones $170\text{m}$ in thickness, and outcrops across a large part of the study area.

The Chalk is split into three stratigraphic divisions; Lower, Middle and Upper Chalk. In addition, the Chalk contains three hard bands named the Totternhoe Stone (within the Lower Chalk), the Melbourn Rock (at the base of the Middle Chalk) and the Chalk Rock (at the base of the Upper Chalk) (Edmonds and Dinham 1965; Rayner 1967). Although
relatively thin, these hard bands have a considerable influence on the hydrology and topography of the region. The base of the Lower Chalk includes the Cambridge Greensand, a sandy glauconitic marl with phosphatic nodules, which in the past was mined as a source of agricultural fertiliser. The lower part of the Lower Chalk beneath the Totternhoe Stone is rather soft and clayey and is often termed the Chalk Marl. The Lower Chalk above the Totternhoe Stone is harder, but still clayey and has been referred to as the Chalk Marl. The Middle Chalk comprises white marly limestone with an abundance of the lamelliibranch *Inoceramus* (Worssam and Taylor, 1969). Towards the top of the Middle Chalk flint makes its first appearance. This is an important observation, since flint is the only durable component of the Chalk to survive fluvial transport for any great distance. The Upper Chalk is an exceptionally pure white limestone with flints that outcrops on the highest parts of the Chalk Uplands in the southeast of the study area.

### 1.2.4 Quaternary deposits mapped by the British Geological Survey

#### 1.2.4.1 Introduction

The British Geological Survey (BGS) geology maps covering the Cambridge District are the Saffron Walden Sheet 205 and Cambridge Sheet 188. The western parts of the study area also include portions of the Huntingdon Sheet 187 and Biggleswade Sheet 204. These maps are accompanied by memoirs (White 1932, Worssam and Taylor 1969, Edmonds and Dinham 1965) which set out the ‘superficial’ or ‘drift’ deposits of the area in morphostratigraphic groupings evolved from a century of geological investigation (see Section 1.3). These have provided a stable system of classification, into which these sediments could be conveniently placed. An increasing body of evidence from southern England and elsewhere has shown that this morphostratigraphic paradigm is at best an over-simplification and at worst a serious misrepresentation of the actual stratigraphic arrangement of Quaternary deposits (see Section 1.4.7.2).

In order to comprehend the Quaternary geology of the Cambridge District it is necessary to become familiar with the nature and distribution of the deposits mapped by the BGS. The author has attempted a description and critical appraisal of this morphostratigraphic system of classification, so that the relative strengths and deficiencies of the scheme can be understood.

#### 1.2.4.2 Flandrian deposits

Flandrian (Holocene) Alluvium is mapped on the floodplain of the River Cam and its main tributaries, in the valley of the River Great Ouse near Swavesey and Offord Cluny, and in several other minor valleys (Figure 1.2.4-1). North of Cambridge at Adventurers’ Fen (near Wicken Fen) there is a broad low-lying spread of Flandrian Peat adjacent to the modern course of the River Cam. Peaty deposits also mark the courses of several
northward flowing streams fed by Chalk springs, and occupy the floor of the low-lying depression at Little Wilbraham Fen.

The mean gradient of the long profile on the surface of the Flandrian Alluvium shown on the BGS maps in the Granta, Rhee, Cam, and Bourn Brook valleys, measured over a distance of 10km upstream from Cambridge, shows that there are considerable differences between these tributaries. The Bourn Brook drains the east-facing slopes of the Western Plateau and gives a relatively steep gradient \((c. 1.4 m/km)\). Of the three major Cam tributaries, the River Granta has the steepest gradient \((c. 0.9 m/km)\), which is attributable to its position as an obsequent scarp slope stream at \(c.90°\) to the local bedrock strike. In contrast the River Rhee has a considerably shallower gradient \((c. 0.5 m/km)\) commensurate with its situation as a subsequent strike-aligned stream. The River Cam has a somewhat intermediate long profile gradient \((c. 0.8 m/km)\). Although the River Cam is superficially an obsequent scarp slope stream, there is clear evidence that its upper course occupies a ‘tunnel-valley’ filled with glacial sediments that was deeply incised during the Anglian glaciation (White 1932, Baker 1977). This suggests that the genesis of the upper Cam valley may be fundamentally different from other streams in the area. Downstream of Cambridge the surface of the Flandrian Alluvium has a modest gradient of \(c.0.4 m/km\).

1.2.4.3 1st and 2nd Terrace Deposits

Beneath the Flandrian deposits of the River Cam at St. John’s College, Cambridge, there is a well documented buried channel-form cut into bedrock containing gravel thought to be of Late Devensian age (Sparks and West, 1965). Where these gravels are believed to outcrop at the surface, as at Barnwell Station, they are mapped as 1st Terrace Deposits (Cambridge Sheet 188), and occur in a relatively narrow strip adjacent to the Flandrian floodplain in the River Cam downstream of Cambridge (Figure 1.2.4-2). The 1st Terrace surface has been assigned to the Late Devensian, based on a radiocarbon date of 19,500 ±650 years BP (Godwin and Willis, 1964) on museum material collected from ‘arctic’ peat beds within gravel formerly exposed at Barnwell Station, Cambridge (Hughes 1888, Marr and Gardner 1916, Marr 1920, Chandler 1921, Coope 1968). The 1st Terrace is mapped at the margin of the floodplain and is in places partly overlain by Flandrian Alluvium and Peat. North of Waterbeach at North Fen, the 1st Terrace forms a broad spread with a shallow gradient \((c.0.4 m/km)\) partly overlain by Flandrian Peat at \(c.1 m\) OD.

Upstream of Cambridge (Saffron Walden Sheet 205) and in the valley of the River Great Ouse (Huntingdon Sheet 187) the 1st and 2nd Terraces are mapped as a single undifferentiated unit. As their elevation above the Flandrian floodplain increases, the gradient becomes steeper \((c.0.8 m/km)\). The undifferentiated 1st and 2nd Terrace Deposits between Harston and Grantchester, and in the valley of the River Rhee, form a profile with an elevation clearly lower than the 2nd Terrace Deposits mapped in the Hobson’s Brook
valley between Great Shelford and Cambridge. Further upstream in the Cam and Granta valleys the 1st Terrace becomes indistinct and apparently disappears beneath the Flandrian surface. To the east of Cambridge 1st and 2nd Terrace Deposits have been mapped, partly covered by Flandrian Peat, on the floor of the broad depression known as Little Wilbraham Fen. Their gradient broadly concords with that of the 2nd Terrace in the main Cam valley. Further north near Horningsea there is a larger expanse of 1st and 2nd Terrace Deposits, also partly overlain by Flandrian Peat. Although adjacent to the spread of 1st Terrace Deposits at North Fen, it appears to be deposits of a tributary stream, and has a separate steeper profile.

Downstream of Cambridge the 2nd Terrace surface occupies a distinct elevated c.2km wide strip with a shallow gradient (c.0.5m km\(^{-1}\)) in the vicinity of Waterbeach that is clearly separate from the 1st Terrace (Figure 1.2.4-2). The 2nd Terrace is of presumed Middle Devensian age, based on floral and faunal evidence from silt beds within gravel exposed at Sidgwick Avenue, Cambridge (Lambert, Pearson and Sparks 1962). It is believed that the Middle Devensian course of the River Cam once stretched north from Cambridge towards Cottenham ultimately connecting with the River Great Ouse valley at a point considerably to the west of the present course. Undifferentiated 1st & 2nd Terrace Deposits are also recorded in the River Great Ouse valley, for example at Woolpack Farm, Galley Hill (Gao et al. 2000). Upstream of Cambridge, the 2nd Terrace surface is mapped along the Hobson’s Brook valley to Great Shelford. In the Cam, Granta and Rhee valleys the undifferentiated 1st & 2nd Terrace Deposits are taken to represent the 2nd Terrace (White 1932). Within the 10km above Cambridge the gradient of the Granta 2nd Terrace surface (c.1.3m km\(^{-1}\)) is steeper than that of the Cam 2nd Terrace (c.1.1m km\(^{-1}\)), and the Rhee 2nd Terrace (c.0.8m km\(^{-1}\)).

1.2.4.4 3rd Terrace Deposits

Deposits mapped as belonging to the 3rd Terrace outcrop to the north and northwest of Cambridge, and form a braided course with a modest gradient (c.0.6m km\(^{-1}\)) in the vicinity of Histon and Impington (Figure 1.2.4-3). This ancient course of the River Cam is separate and distinct from both the Flandrian and 1st Terrace course, and the 2nd Terrace course, and leads northwest through the Oakington Gap towards Willingham. Deposits attributed to the 3rd Terrace are also mapped in the Great Ouse valley at Fenstanton and Buckden, where they occur at a somewhat higher elevation than the 2nd Terrace. It appears that the 3rd Terrace includes Early Devensian deposits, those assigned by the BGS and other authors to the Ipswichian (Eemian) interglacial and deposits belonging to later part of the ‘Wolstonian’ interval. These age determinations have been based on floral and faunal evidence from exposures and a borehole at Histon Road, Cambridge (Hollingworth,
Allison and Godwin 1950, Walker 1953, Sparks and West 1959), and from exposures at Barrington (Fisher 1879, Gibbard and Stuart 1975).

Above Cambridge the 3rd Terrace is somewhat fragmentary, but can be traced to Grantchester, Trumpington and Great Shelford, along the north side of the valley of the Bourn Brook, and for some considerable distance along the Granta valley. In the 10km above Cambridge the gradients of the 3rd Terrace surface of the Granta (c.1.0m km\(^{-1}\)) and Cam (c.0.8m km\(^{-1}\)) are apparently those observed for the 2nd Terrace surface. Between Comberton and Grantchester, the 3rd Terrace surface of the Bourn Brook is somewhat erratic in height, suggesting that it is composed of more than one profile. In the Cam valley it is remarkable that for several kilometres between Little Shelford and Whittlesford, virtually no 3rd Terrace deposits have been mapped. Near Whittlesford, the Flandrian deposits (Figure 1.2.4-1) and the undifferentiated 1st and 2nd Terrace (Figure 1.2.4-2) diverge and occupy separate courses, constrained in a manner quite uncharacteristic of the river deposits in this area. This suggests that there has been lateral incision, which might explain the apparent absence of 3rd Terrace Deposits. Further upstream in the Cam valley, there are 3rd Terrace fragments mapped as far south as Littlebury. The 3rd Terrace in the Rhee valley is confined to a narrow strip of material mapped at Barrington.

1.2.4.5 4th Terrace Deposits

The Cambridge and Huntingdon Sheets recognise a 4th Terrace, which below Cambridge is fragmented, but to the east stretches for c.8km from Little Wilbraham (Penning and Jukes-Browne 1881) to Stow-cum-Quy and Barnwell. The 4th Terrace surface has been mapped as a relatively elevated feature, described in the literature as older than the 3rd Terrace (Figure 1.2.4-4). North of the River Cam, fragments of 4th Terrace are mapped from Castle Hill to Huntingdon Road (Marr and King 1932, Marr 1920, Marr and King 1928) and from Impington and Histon to Willingham beyond the Oakington Gap.

The 4th Terrace surface occurs at a variety of disjunct heights that clearly cannot belong to the same aggradation. The surface stretching from Little Wilbraham to Stow-cum-Quy has a gradient of c.1.4m km\(^{-1}\) and apparently grades into the 2nd Terrace of the River Cam in central Cambridge. The patch of deposits at Barnwell does not fit this profile and is closer in height to the 3rd Terrace surface. The fragments of 4th Terrace north of Castle Hill are considerably higher than the 3rd Terrace surface, and appear to represent an entirely separate profile with a gradient of c.1.6m km\(^{-1}\). Lastly, north of the Oakington Gap near Willingham, there are patches of 4th Terrace that form another separate profile, also higher than the 3rd Terrace, with a gradient of c.0.6m km\(^{-1}\). The discordances of the 4th Terrace on the Cambridge Sheet provides strong evidence for the argument against the continued use of morphostratigraphy for the classification of these deposits (Section 1.4.7.2).
1.2.4.6 Glacial, Plateau, Head and Taele Gravels

The Cambridge Sheet shows Head Gravels that are even more elevated than the 4th Terrace surface, and are presumed to represent the most ancient courses of the Cam system (Figure 1.2.4-5), although the term ‘Head’ suggests a partly subaerial or colluvial origin. A patch of Head Gravel stretching from the Observatory to Girton has been named the ‘Observatory Gravels’. It has been suggested that part of the sequence at the Traveller’s Rest Pit could be Anglian in age (Marr 1920, Marr 1926, Marr 1938, Marr and King 1928, White 1932), and there is a striking downstream correlation of the gradient of the ‘Observatory Gravels’ with that of the 4th Terrace near Willingham (Figure 1.2.4-4). Elsewhere, Taele, Glacial and Plateau Gravels, which may in part be equivalent to the Head Gravels of the Cambridge Sheet, occur at a range of elevations. Taele Gravels occupy a relatively elevated position above the terraces of the present Cam drainage system and are not intimately associated with them. The Taele Gravels at Thriplow occur at widely varying heights (20-60m OD) and have been interpreted as detrital fan material accumulating over a potentially wide span of time (Sparks 1957). Elsewhere, deposits mapped in this way variously cap elevated hills, form areas of neutral relief and are associated with valleys. Near Six Mile Bottom spreads of Head Gravel and Taele Gravel occur at an elevation considerably higher than the 4th Terrace at Little Wilbraham.

Glacial and Plateau Gravels are mapped capping hills and on valley sides at various heights, and are only occasionally mapped with a clear stratigraphic relationship to the Boulder Clay (till) of the Lowestoft Formation. At Over, Glacial Gravel is mapped overlying till, and the Glacial Gravel at Whittlesford has been associated with Anglian glacial deposits occupying a buried ‘tunnel valley’ known to exist in the upper Cam valley (White 1932, Baker 1977). The Head Gravel at Hare Park (c.50-60m OD) has yielded Middle Pleistocene flint artefacts, and appears to record the course of a headwater valley. It has a similar elevation to the Taele Gravels and Glacial Gravels of the Gog Magog Hills. These fragmentary deposits are mapped capping two parallel lines of hills that run southeast from the Gog Magog Hills, parallel to the valley of the River Granta. At least some of these Gravels appear to overlie and therefore post-date the till, but the wide variety of elevations represented (45-75m OD) makes their interpretation somewhat difficult. However, it is likely that together they represent ancient intersecting headwater valleys of dip-slope streams draining southeast; the opposite direction to northwest draining scarp-slope streams that currently dominate the landscape. Glacial Gravel is also mapped east of Pampisford in two elongated spreads (c.30-50m OD) on the southern flank of the Granta valley. These have a gradient similar to the more elevated adjacent gravels of the Gog Magog Hills. Only the Glacial Gravels at Hadstock (60-70m OD) are clearly overlain by
till. In contrast, the elevated (c.110m OD) Plateau Gravel of Rivey Hill, Linton, clearly overlies the till.

**1.2.4.7 Boulder Clay (till)**

The Boulder Clay (till) mapped across the study area is all presumed to belong to the Lowestoft Formation of Anglian age (Figure 1.2.4-6). For the most part this material comprises a massive blue-grey clay with fragments of Chalk, flint and a variety of exotic pebbles. The till occurs in two separate spreads; one associated with the Western Plateau and the other occurring on the Chalk Uplands. As a result the till forms elevated ramparts along the southeast and northwest sides of the River Cam-Rhee valley; a till capped ridge also extends into the valley at Haslingfield. A large part of the study area is without till, and this suggests that a considerable amount of downcutting and down-wastage must have occurred since its emplacement. In contrast, till occurs at lower elevations immediately adjacent to the course of the River Great Ouse to the west near Offord Cluny. Till beneath the Western Plateau reaches 50m in thickness, and is known to occupy a southwest-northeast aligned buried channel-form, named the Hatley Channel (Edmonds & Dinham, 1965). At Over, till caps a low ridge apparently aligned with an ancient course of the River Cam. On the Chalk Uplands, till at Heydon, Hadstock and Balsham reaches 25m in thickness and covers the crest and dip-slope of the degraded escarpment, although less elevated spreads of till on the scarp slope do occur, for example at Pepperton Hill. Baker (1977) described a complex of Anglian glacial deposits including outwash sands, glacio-lacustrine deposits and several till units in the Upper Cam valley in the south of the study area (see Figure 1.3.2-2). Given this evidence, it seems likely that the apparently featureless spreads of Boulder Clay (till) mapped by the BGS mask a wealth of internal complexity.

**1.3 Previous Quaternary Research in the Cambridge District**

**1.3.1 19th Century Geology of the Cambridge District**

**1.3.1.1 Prof. Adam Sedgwick**

Throughout the 19th Century, geological theory evolved from diluvial (biblical flood) philosophies towards something resembling modern geology. This was in great measure due to the efforts of Prof. Adam Sedgwick, who first divided the drift deposits near Cambridge into the (Boulder) Clay of the Western Plateau, Coarse Gravel with erratics capping the Chalk hills at Wandlebury and Harston, and Fine Flint Gravel of the river valleys, covered by bog-earth (Peat) and Alluvium in the fens. This tripartite division can be dated from various notes, and from papers presented by Sedgwick in 1844 and 1845. It is clear that the theological idea of a great deluge was difficult to escape, and Sedgwick
(1861) refers to the ‘diluvial drift’ of Cambridge and the Fenland. The situation was compounded by the discovery of marine shells in the March Gravels some 40km to the north of Cambridge, and this caused Seeley (1866) to follow Sedgwick’s tripartite scheme and perpetuate the idea of a great marine submergence across the area.

1.3.1.2 Division of drift deposits

Sedgwick’s basic division of the drift deposits became widely accepted as a sound precept, although increasingly without diluvial connotations (Bonney 1875). Penning (1875) began to differentiate high-level gravel of the hilltops, less elevated gravels and loams indicating past courses of the River Cam, and recent valley gravels. This was the first time that different gravel terraces had been identified, and ultimately led to the establishment of the terrace stratigraphy employed by the BGS a century later. In 1876 A. J. Jukes-Browne wrote The Sedgwick Prize Essay (published 1878) entitled ‘The Post Tertiary Deposits of Cambridgeshire’ in which he outlined the physical features of the district, described the Quaternary glacial and fluvial deposits and attempted correlations with similar deposits elsewhere in East Anglia. He refined Penning’s classification further, identifying Boulder Clay, Glacial Gravel, Hill Gravel and various terraces of Valley Gravel belonging to both the ancient and present river system. A year later, S. B. J. Skertchly (1877) wrote his famous Memoir of the geology of the Fenland, adding the Marine March Gravels to the list of deposits recognised by Jukes-Browne, and proposing the view, unpopular at the time, that Boulder Clay was formed beneath land-ice. In 1881 Penning and Jukes-Browne published their own Memoir on the Geology of the Neighbourhood of Cambridge, which also identified Boulder Clay and associated Glacial Gravels, ancient river gravels, higher gravel terraces, present river gravels, and Peat and Alluvium. Associated with this memoir, the original geological survey of the Cambridge District, which was made by F. J. Bennett, A. J. Jukes-Browne, H. W. Penning, S. B. J. Skertchly and H. B. Woodward, used this nomenclature and was published between 1881 and 1883 as a series of Quarter Sheet maps. cf. Skertchly 1877

1.3.2 20th Century Geology of the Cambridge District

1.3.2.1 Fearnsides and Rastall

Previous studies had widely interpreted glacial deposits as ice-rafted debris deposited as a result of high sea levels during a single glacial event (cf. Penning and Jukes-Browne 1881). This monoglacial hypothesis resulted in all ancient and present river gravels being referred to as ‘post-glacial’. In addition, following the recognition of river terraces at different heights within the valley gravels, attempts were made to distinguish the terraces using local names. In 1904, W. G. Fearnsides in Marr and Shipley’s Natural History of Cambridgeshire broadly followed the Penning and Jukes-Browne model describing Glacial
Gravel, Boulder Clay, Plateau Gravels, gravels of the ancient river system, and gravels of the present river system. The latter were separated into three terraces; the highest & oldest or Barnwell Series, the Intermediate Gravels of Chesterton and Newnham, and the Lowest Terrace, Alluvium and Peat. Similarly, Rastall (1909) identified gravels of the ancient river system, gravels of the Highest Terrace (the Barnwell and Barrington Gravel), gravels of the Intermediate Terrace (the Shelford and Cambridge Series) and gravels of the Lowest Terrace (the River Cam Gravel).

1.3.2.2 Prof. McKenny-Hughes

In a brave attempt at regional correlation, McKenny-Hughes (1916) at the end of his life opted for his own tripartite division of East Anglian deposits, partly based on the existing nomenclature. This comprised the identification of an Argilliferous (loam bearing) Series, the 'Barringtonian', representing deposits of a temperate elevated land surface, overlain by a Saxiferous (boulder bearing) Series, including boulder clays of the 'Cromerian', derived from ice rafting of material during the marine submergence of the land in glacial times, and an Arenaceous (terrace gravel) Series, the 'Barnwellian', formed on an elevated land surface during a cold, but not glacial climate. Despite the elegant simplicity of this concept, it quickly became clear that it was not supported by the facts; for example, excavations at Barnwell and Barrington both proved to have a mixture of temperate and cold-stage deposits.

1.3.2.3 J. E. Marr

Research by J. E. Marr on deposits in the Cambridge District, provided much-needed detail from various important exposures. Marr (1920) believed that gravels assigned to the ancient river system by Penning and Jukes-Browne were in part contemporaneous with those of the present river system, which themselves represented various accumulations over a wide span of time. In particular, Marr recognised a fundamental flaw in the morphostratigraphical sequence of terraces proposed by Penning and Jukes-Browne. He noted that deposits of different types and ages occurred in various combinations beneath the same terrace surface, and that in the absence of continuous sections it was impossible to determine the exact stratigraphic relationship between abutting deposits. In order to redress this deficiency, Marr attempted correlations based on biostratigraphy, archaeology and sedimentology; the very cornerstones of modern Quaternary science. Sadly, various previously held beliefs combined with incomplete data and sporadic exposures led him to a number of surprising conclusions.

Marr (1920) identified the *Corbicula*-bearing Lower Barnwell Village Beds, part of the Barnwell Terrace, as the oldest deposits of the River Cam system. He noted that other temperate taxa were often found in association with *Corbicula*, and envisaged that
temperate gravels had formed in a river valley with a base only a few metres higher than the present River Cam aggrading towards the ‘marine’ March Gravels in Fenland. Marr placed the Observatory Gravels, described from the Traveller’s Rest Pit, stratigraphically above the Lower Barnwell Village Beds. In contrast, these gravels had been regarded as belonging to the ancient river system by Penning and Jukes-Browne. Marr was convinced that the Observatory Gravels, which contained an impressive array of flint implements, represented deposits of a tributary that had largely escaped a subsequent period of erosion in the main valley. Following this erosive episode, Marr believed that the Upper Barnwell Village Beds, mostly forming the surface of the Barnwell Terrace and part of the Intermediate Terrace, had been deposited. In other places he held that they overlay the Lower Barnwell Village Beds, and elsewhere rested on bedrock. These gravels did not contain *Corbicula*, and fossils where present, indicated cool or cold conditions. Finally, the youngest gravels recognised by Marr were the Higher Downing Site and Barnwell Station Gravels, broadly equivalent to parts of the Intermediate Terrace and the Lowest Terrace of the River Cam. The arctic flora from the pit at Barnwell Station (TL 4705 5968) (Marr and Gardner, 1916), convinced Marr that following a further episode of erosion these gravels had been deposited in a cold climate, prior to the on-set of alluvial deposition in more recent times.

Subsequently, Marr (1926) developed an alternative theory whereby the oldest event recorded in the Cambridge District was a marine inundation bringing ice-rafted debris represented on the hills by Boulder Clay and in the valleys by a basal boulder bed derived from the former. Within the valleys Marr then envisaged the aggradation of temperate gravels, followed by the deposition of ‘mid-glacial gravels’. Finally, Marr believed there had been a further glacial phase bringing a second Boulder Clay to the area. This is noteworthy, since it is the first time that a multi-glacial hypothesis had been proposed in the region. From a modern perspective Marr’s thinking in 1926 is difficult to fathom. He combines adventurous attempts at sea level and climatic reconstruction with hypothetical diagrammatic cross-sections of the Cam valley, which seem impossible to substantiate. However, Marr’s contribution to the detailed understanding of the Cambridge District should not be underestimated.

### 1.3.2.4 Saffron Walden Sheet 205

Marr’s stratigraphic models were not widely adopted, and when the Pleistocene deposits of the Cam valley were re-mapped by H. G. Dines and F. H. Edmunds prior to 1931, they used Rastall’s revised version of the Penning and Jukes-Browne model. This identified Glacial Gravel, Plateau Gravel, Boulder Clay, Taele Gravel, and valley deposits including the ‘Highest’ or 3rd Terrace, the ‘Lowest and Intermediate’ or 1–2nd Terraces, Alluvium and Peat (Figure 1.3.2-1 & Figure 1.3.2-3). The resulting Saffron Walden Sheet 205, and the
Saffron Walden Memoir by H. J. Osbourne White (1932) also necessarily embraced these divisions. It is important to note that at this time, White clearly attributed the Boulder Clay and Glacial Gravel to terrestrial ice sheets rather than to ice-rafted debris.

1.3.2.5 Further geological investigations

Renewed geological survey work was carried out in the Cambridge District between 1936 and 1939 by E. E. L. Dixon, S. E. Hollingworth, J. H. Taylor, and J. R. Earp under the direction of C. H. Dinham. Following the war, survey work was resumed in 1947 by S. C. A. Holmes and was completed in 1953 with the assistance of B. C. Worsam under the direction of F. H. Edmunds. Soon after, the evolution of relief in the Cam valley had been studied by B. W. Sparks (1957) who had identified a series of ‘terrace’ surfaces (330ft, 230ft, 180ft, 130ft & the low plain) that he attributed to marine peneplanation. Within the low plain he recognised The Barnwell or High Terrace, The Newnham or Intermediate Terrace, and the Barnwell Station or Low Terrace, closely following Rastall’s scheme.

At this time there was great uncertainty about the nature of the Boulder Clay in the district. Baden-Powell (1948) recognised two glaciations in East Anglia, and West and Donner (1956) believed that they could identify two separate Boulder Clays; one of Lowestoft (Anglian or Elsterian) age on the Western Plateau, and the other of Gipping (‘Wolstonian’ or Saalian) age on the Chalk Uplands. Sparks, cautious at first, subsequently became convinced by this multi-glacial hypothesis and referred to it repeatedly in later works. During the gestation of the Cambridge Sheet and Memoir, investigations at Histon Road (TL 4438 6110) by Hollingworth et al. (1950), Walker (1953) and Sparks and West (1959) helped to assign deposits of the 3rd Terrace to the Ipswichian (Eemian) interglacial. This ongoing work led Hey and Perrin (1960) to recognise Boulder Clay (Lowestoft and Gipping), high-level gravels (post-Gipping late glacial drift) including Tæle Gravel, Glacial Gravel and Observatory Gravels, and valley deposits including the Cam High Terrace (3rd Terrace) (Eemian or Ipswichian interglacial), Valley Gravel (1st and 2nd Terraces) (Devensian or Weichselian), and Fen Deposits (post-glacial). In addition, plant material from the arctic bed of the 1st Terrace at Barnwell Station gave a Late Devensian (Late Weichselian) radiocarbon date of 19,500 ±650 BP (Godwin and Willis, 1964). By 1965, Sparks and West had developed a Pleistocene chronology, which incorporated three glacial events (Anglian (Elsterian), Gipping (Wolstonian/Saalian) and Devensian (Weichselian), and provided a convenient framework for the description of drift deposits in the Cambridge area.

1.3.2.6 Cambridge Sheet 188
The Cambridge Sheet 188 was published in 1965, and the accompanying Memoir by Worssam and Taylor was published in 1969. These works adopted the chronology of Sparks and West (1965) and presented a unified morphostratigraphic terrace framework largely derived and adapted from that used by Dines and Edmunds (1932). Apart from recognising Boulder Clay and Glacial Gravel (Anglian and Gipping), the term Head Gravel was used to refer to various elevated pebbly deposits including the 'Observatory Gravels' (assigned to the Gipping), which had formerly been categorised as high-level gravels of the ancient river system. In addition, the valley deposits were divided into a 'staircase' of four terraces (4th Terrace, 3rd Terrace, 2nd Terrace and 1st Terrace) spanning the Ipswichian (Eemian) interglacial, and the Devensian (Weichselian) glacial, with Alluvium and Peat assigned to the Flandrian or post-glacial (Figure 1.3.2-1).

1.3.2.7 Baker and the upper Cam valley

The Quaternary Stratigraphy of the upper Cam valley was investigated in some detail by Baker (1977). Much of this work centred on glacial deposits which cap the Chalk Uplands and occupy deeply incised ‘tunnel valleys’) aligned north-south along the present Cam-Stort valley south of Whittlesford, in the southern part of the greater study area. Baker concluded that a complex Anglian sequence was preserved comprising various tills, outwash gravels and sands, and glacio-lacustrine deposits. He identified two superimposed and deeply incised buried channels, the first filled by till and the second containing glacial lake sediments (Figure 1.3.2-2). In addition, Baker identified a third minor buried channel containing interglacial deposits near North Hall, Essex (TL 5240 3030) correlated with the Hoxnian stage on the basis of their pollen biostratigraphy and their stratigraphic position directly on till. This important site occurs in a similar stratigraphic position to a temperate kettle-hole in-filling recorded nearby at Tye Green, Stansted Airport (TL 5380 2380), also correlated with the Hoxnian stage (Boreham and Gibbard 1999). Younger deposits of the upper Cam valley appear to be hard to separate, and Baker grouped all deposits from the ‘Wolstonian’ to Devensian as valley gravels and periglacially derived diamictons, partly overlain by Flandrian deposits.

1.3.2.8 Gao and the River Great Ouse

Cunhai Gao (1997) investigated the sedimentology and stratigraphy of deposits in the valley of the River Great Ouse, on the northern and western edges of the greater study area. Gao recognised a single Anglian glaciation, which produced till, outwash gravels and glacio-lacustrine sediments, many filling deep buried channel-forms aligned north-south along the present course of the Ouse valley between Sandy and Huntingdon (Figure 1.3.2-2). He also noted the presence of temperate kettle-hole lake deposits directly overlying till at Hitchin, correlated with the Hoxnian interglacial on the basis of pollen biostratigraphy.
Deposits of ‘Wolstonian’ age appear to be represented in the Ouse valley by fragmentary gravel terraces at Fen Drayton and Cold Harbour Farm, which were laid down following a phase of fluvial incision. Gao correlated temperate deposits at Woolpack Farm, Galley Hill (TL 2993 6840), with the Ipswichian on the basis of biostratigraphic evidence from pollen, macrofossils, molluscs, beetles and vertebrate remains (Gao et al, 2000). In addition, Gao described temperate deposits from part of the former Cam valley at Manning’s Farm, Willingham (TL 3958 6940), which he also correlated with the Ipswichian interglacial on the basis of pollen biostratigraphy.

In the main Ouse valley, gravel terraces (BGS 3rd Terrace) at Fenstanton and Longstanton are taken to represent subsequent Early Devensian (MIS 5d to 4) deposition. These deposits have been truncated by an incisional event, followed by renewed gravel aggradation represented by the Hemingford Terrace (BGS undifferentiated 1st and 2nd Terrace), which at Earith, just outside the greater study area, have been shown to contain evidence for a temperate treeless event similar to the Upton Warren Interstadial (Bell 1969, 1970, Coope 2000). Middle Devensian (MIS 3) deposits from the Ivel valley at Sandy contained plant macrofossils and beetle remains indicating arctic conditions, and yielded radiocarbon ages between 29,250 and 34,055 years B.P (Gao et al. 1998). The Late Devensian (MIS 2) of the lower River Great Ouse valley is represented by cold stage gravel deposits at St. Ives which have produced radiocarbon dates in the range 18,000 to 10,000 years B.P. Distinct climatic amelioration appears to have taken place in the Ouse valley during the Windermere Interstadial around 14,000 years B.P. with the development of birch woodland (Gao 1997). The Loch Lomond Stadial (11,000 to 10,000 years B.P.) produced renewed periglacial activity and gravelly deposits recorded at Holywell (Gao 1997), before the stabilisation of the River Great Ouse and the deposition of alluvial deposits throughout the Flandrian.

1.4 Quaternary Stratigraphy

1.4.1 Introduction

Lithostratigraphy is the primary tool, used to investigate and understand geological history. The correlation and classification of Quaternary deposits is important because it forms the basis for understanding the stratigraphic relationship of sediments and the existence of past climate systems. The subdivision of terrestrial Quaternary deposits of the British Isles into Pleistocene and Holocene Epochs has been long-established, although the subdivision of the Pleistocene into Lower, Middle and Upper has not been formally proposed. Informally, the base of the Upper Pleistocene is drawn between the boundary of MIS 6 and 5e in deep-sea cores. In Britain, there is general agreement that MIS 5e corresponds broadly with the Ipswichian (Figure 1.1.2-2).
1.4.2 Correlation of British terrestrial Quaternary deposits

A correlation of British Quaternary deposits was undertaken by Mitchell et al. (1973), who divided the post-Anglian Stages into the Hoxnian (interglacial), ‘Wolstonian’ (glacial), Ipswichian (interglacial), Devensian (glacial) and Flandrian (post glacial). However, soon after the publication of that report, strong evidence from marine oxygen isotope stratigraphy, as a proxy for global ice volume, began to indicate a far greater potential complexity in the terrestrial record than had previously been realised (Shackleton and Opdyke 1973). The deep-sea oxygen isotope record revealed ‘missing’ interglacial events within the ‘Wolstonian’ interval, and a great deal of complexity within individual climatic cycles. The situation was compounded by mounting evidence against the existence of the ‘Wolstonian’ Gipping glaciation as envisaged by B. W. Sparks (Bristow and Cox 1973) and the discovery that the type locality of the ‘Wolstonian’ was in fact Anglian in age (Perrin et al. 1979, Sumbler 1983, Rose 1987). However, the name ‘Wolstonian’ has been retained in this study as a convenient way to refer to the interval between the Hoxnian and Ipswichian Stages, although the author is fully aware of the arguments against such a decision.

It is widely believed that the glacial deposits of East Anglia, with the principal exception of a small area of till at Hunstanton and outwash gravels at Tottenhill (Gibbard et al. 1992), can all be attributed to a single Anglian (MIS 12) glacial event. It should be noted that Hamblin, Moorlock and Rose (2000) have recently suggested a more complex and controversial stratigraphy for East Anglia with glaciations in each of MIS 16, 12, 10, 6 and 2. It is clear that the stratigraphic framework developed by Mitchell et al. (1973) was difficult to apply to sediments older than the Ipswichian stage outside East Anglia and the east Midlands. These authors recognised many of the limitations of their scheme, which was largely based on the climatic interpretation of diachronous, variable and potentially recurrent plant assemblages within interglacial stages throughout the Quaternary.

The revised correlation of British Quaternary deposits edited by Bowen (1999) attempted to refine the stratigraphy of Mitchell et al. (1973) using new geochronological methods including Uranium-series (U-Th) dating, thermoluminescence (TL), optically stimulated luminescence (OSL), electron spin resonance (ESR), cosmogenic chlorine-36 exposure dating, and amino acid dating.

These geochronological methods are all capable of producing anomalous results, especially in the absence of independent calibration. It is important to pursue a sound geochronology because this will ultimately provide a better basis for chronostratigraphy. This is particularly significant because fragmented terrestrial sequences are so hard to correlate with the global marine oxygen isotope signal. This may be exacerbated by the fact that Marine Isotope Stage boundaries are drawn at the mid-point of the transition, whereas
the equivalent terrestrial stage boundaries may exhibit considerable lead and lag. Despite these problems, there have been some advances in the correlation of terrestrial sedimentation, climatic signals from ice cores, and the marine oxygen isotope record, and a greater understanding of the importance of orbital frequencies (Milankovitch cycles) at 21,000 (precession), 41,000 (obliquity) and 100,000 (eccentricity) year intervals that appear to force changes in the earth's climatic systems and depositional environments (Ruddiman 1987, Imbrie et al. 1992, 1993, Björk et al. 1998). The close temporal relationship between the extent of former ice sheets and climate has been used to support the climatostratigraphic division of the Quaternary. However, most of geological time is not divided on a climatostratigraphic basis, and the climatic connotations of informal terms such as interglacial, interstadial and stadial, are not without ambiguity. Great misunderstandings have been generated by the failure to distinguish between lithostratigraphic, biostratigraphic and climatostratigraphic divisions, and the uncritical adoption of geochronology in chronostratigraphy (Bowen 1999).

The stratigraphic approach of both Mitchell et al. (1973) and Bowen (1999) was firstly to describe, define and interpret Quaternary deposits, secondly to correlate these with each other by any available means, and thirdly to classify the deposits using chronostratigraphy. Both of these works comprise regional sections by different authors, often with rather dissimilar, and sometimes conflicting ideas. Spatial variation of lithology within individual deposits is often quite large, but the integrity of whole stratigraphic units and their relationship with other distinct bodies or packages of sediment is the principal tool for correlation within terrestrial and shallow marine sequences.

The principal lithostratigraphic unit used by Bowen (1999) is the formation, which may be subdivided into various members with distinct properties. Numerous lithostratigraphic formations, subdivided into members have been proposed across the whole of Britain, offering the potential for the depositional history of geographically distant places to be correlated. McMillan and Hamblin (2000) proposed that, for mapping purposes, a lithostratigraphic framework comprising various groups of formations should be used. South of the Devensian ice limit for southern England these include the Southern British Glacigenic Group, to which the Lowestoft Formation belongs, and The Ouse-Nene Group including the Cam Valley and Ouse Valley Formations (see Figure 13.1.6-1).

The author contributed a number of lithostratigraphic units from the Cambridge District to Bowen's Quaternary correlation, and Table 1.4.2-1 shows a summary of the lithostratigraphic units recognised in the Cambridge District in that volume. It is important to note that these lithostratigraphic units will form the basis of the system of correlation used throughout this study. However, lithostratigraphic divisions have been applied across Britain by different workers in a variety of ways that have often made correlations
problematic. In addition, there are some serious internal inconsistencies within Bowen’s compendium that compounds these issues. Leaving these problems aside, Bowen further proposes that the correlation of lithostratigraphic units is possible with deep-sea oxygen isotope stratigraphy, certainly at formation level, and probably at member level, using geochronological techniques. Wherever possible, lithostratigraphic members have been defined from a type locality or stratotype (holostratotype). Often these key localities are not available today, and supplementary exposures (parastratotypes) are used to augment their description. The use of lithologic or genetic terms in the naming of lithostratigraphic members, such as the ‘Observatory Gravels’, is to be avoided, although some historical names have been retained because no suitable replacements are as yet available (Salvador 1994). Lithological descriptors are permissible for sediment units of lower status.

The approach adopted by the author in this study has been to add a lower tier of local stratigraphic nomenclature to that proposed in Bowen (1999) to assist correlation (see Section 2.3). This methodology was developed to deal with the particular difficulties caused by the large volume of data in the study area. This has the advantage that it overcomes many of the problems of scale and status, which have caused difficulties in Bowen’s (1999) correlation of British Quaternary deposits.

1.4.3 Marine Oxygen Isotope Stratigraphy

The correlation of deep-sea oxygen isotope chronology to terrestrial sequences has developed as an important basis for a stratigraphic framework in British terrestrial Quaternary research over the last 25 years (Sutcliffe 1975, Bowen et al. 1989, Bridgland et al. 1991, Bridgland 1994, Sutcliffe 1995, Green et al. 1996). Although the start of the Flandrian is clearly not synchronous with the MIS (Marine Isotope Stage) 1/2 boundary (Termination 1), it is generally accepted that the Flandrian (Holocene) Stage lies within MIS 1 (N. J. Shackleton, pers. com. 2001). In addition, MIS 2 to 5d all fall within the Devensian (Weichselian), and MIS 5e represents the Ipswichian (Eemian) interglacial (Figure 1.1.2-2). It is also widely accepted that MIS 12 represents the Anglian (Elsterian) glaciation responsible for the deposition of the Lowestoft Formation till over large areas of East Anglia (Bowen et al. 1986). Problems have arisen in the recognition of MIS 6 to 11 within the terrestrial record. This period of time apparently includes three interglacial (MIS 7, 9 and 11) and three glacial (MIS 6, 8 and 10) stages. The traditional viewpoint would be that if the Anglian is MIS 12, then the Hoxnian interglacial, which immediately succeeds it, should be MIS 11. Following this line of reasoning, the time period covered by MIS 6 to 10 should be equivalent to the ‘Wolstonian’ interval. In addition, there is considerable complexity indicated by the marine oxygen isotope curve within individual stages. Thus MIS 5, 7, 9 and possibly 11 all contain repeated climatic fluctuations in which episodes of temperate (interglacial) warming appear to be followed by short cool stadials and less-
marked interstadial intervals. Only the truly temperate episodes appear to be represented in northwest Europe in climatostratigraphic terms by forested interglacial stages (de Beaulieu et al. 2001) sensu Turner & West (1968).

1.4.4 Amino Acid Geochronology

The time-dependant epimerization of the amino acid L-isoleucine to D-alloisoleucine has been used as a method for estimating ages for marine and non-marine molluscs in Britain (Bowen et al. 1985, Bowen and Sykes 1988, Bowen et al. 1989, Miller and Brigham-Grette 1989, Bowen 1991). Some degree of variation in epimerization rates has been detected between marine molluscs and terrestrial molluscs, between various molluscan taxa, and even between different parts of some bivalve shells (J. Hollin pers. com.). There is also the possibility of differential geochemistry from shells of similar age. Many of these variations are now relatively well understood, and taxa that epimerize at ‘slow’ rates are now widely employed for amino acid geochronology (Miller and Mangerud, 1985). There is a clear correlation between the Marine Oxygen Isotope Stages and the D-alloisoleucine to L-isoleucine (D/L) ratios from molluscs found in deposits in southern England with independent means of dating (Bowen, 1999). Figure 1.4.4-1 shows the relationship between D/L amino acid ratios of non-marine molluscs with ‘slow’ epimerization rates and Marine Oxygen Isotope Stages in Southern England, using data in Bowen (1999). This relationship can therefore be used to estimate an age from any D/L ratio (see Appendix 5).

A number of apparently anomalous D/L ratios, particularly from samples analysed in the early days of the technique, have caused some workers to point out that aminostratigraphy is a relative and not an absolute dating technique, and to caution against the indiscriminate use of any relative geochronology as a chronostratigraphic tool.

Four main post-Anglian (MIS 12) interglacial events, correlated with MIS 5e, 7, 9 and 11 have been identified from D/L ratios in southern England. However, temperate shells from Oakley Park pit at Hoxne, Norfolk, the stratotype of the Hoxnian interglacial Stage give D/L ratios (~0.24) equivalent to MIS 9 (Bowen 1991, Bowen 1999). This is unexpected since the deposits at Hoxne appear to directly overlie Anglian (MIS 12) glacial deposits (Singer et. al 1993, Gosling 2001). In contrast, shells from other sites previously correlated with the Hoxnian on the basis of biostratigraphy, such as Swanscombe, Barnham and the Nar valley, give D/L ratios (~0.3) equivalent to MIS 11 (Bowen and Sykes 1994, Ashton et. al 1994, Bowen et al. 1989, Ventris 1996). This is awkward since the type section at Hoxne gives its name to an interglacial Stage widely accepted to be immediately post-Anglian, and therefore belonging to MIS 11. Something of an impasse has been reached in the solution of these problems. Recent comparisons of mammal assemblages (Schreve 2001a) firmly correlate Hoxne with other MIS 11 sites including Swanscombe, and not MIS 9 sites. Recent Uranium-series and ESR age estimates from
Hoxne also support correlation with MIS 11 (Rowe, Atkinson and Turner 1999, Grün and Schwarz 2000).

Amino acid geochronology has also revealed complexity within a group of sites previously correlated with the Ipswichian (MIS 5e) on the basis of pollen biostratigraphy. Classic sites at Bobbitshole (Coope 1974), the stratotype of the Ipswichian (Mitchell et al. 1973), and Trafalgar Square (Gibbard 1994) give D/L ratios (~0.1) equivalent to MIS 5e (Bowen et al. 1989). However, within the Thames valley, a number of sites originally attributed to the last interglacial including Aveley (Cooper 1972, Holyoak 1983, Preece 1995, Preece, 1999) and Stanton Harcourt (Briggs et al. 1985) have produced D/L ratios (~0.16) equivalent to MIS 7 (Bridgland 1994). The biostratigraphy and complex lithostratigraphy at these sites has produced polarised views (Gibbard 1994, Bridgland 1994) about the confidence and value placed in a correlation with MIS 7, as opposed to MIS 5e. In order to resolve these problems, research has re-focused on biostratigraphical tools, such as molluscan and vertebrate analyses, potentially capable of differentiating vegetationally similar interglacials, and on the development of absolute dating methods such as Uranium series and luminescence techniques.

1.4.5 Luminescence Dating Techniques

Luminescence dating techniques essentially date the latest exposure of mineral grains to light. They are based on the principle that naturally occurring ionizing radiation will cause electrons to build up over time within defects (or traps) within the crystal lattice of minerals such as quartz or feldspar. The accumulation of trapped electrons is assumed to be proportional to the amount of time elapsed since a 'zeroing' event, such as heating (burning) or exposure to sunlight (bleaching), took place. Exposure of these minerals to an external energy source, causes electrons accumulated in traps to be released as light (luminescence) which can be measured. There is considerable theoretical complexity surrounding the physics of electron traps and their response to heat (thermoluminescence) and light (optically stimulated luminescence) (Bailey 2001).

The original application of thermoluminescence (TL) dating to sediments rich in quartz and feldspar met with varying degrees of success (Wintle, 1974, 1975). In the past TL dating has been applied to the Devensian, for example, to correlate the sediments from the Chelford Interstadial with MIS 5c (Rendell et al. 1991). Although it has been generally considered that TL dating of sediments may be reliable back to between 50 and 150 ka BP, beyond this date the increasing inaccuracies caused by the onset of saturation seriously limit its usefulness (Aitken 1985, 1990). The main problem associated with this technique is incomplete zeroing of the TL signal at the time of deposition, leading to large residual signals (Wintle and Huntley 1982, Huntley et al. 1985, Godfrey-Smith et al. 1988).
The discovery that it was possible to stimulate luminescence using excitation by light (OSL) was a great breakthrough (Huntley et al. 1985). The optical dating of sediments has the advantage that luminescence emission is stimulated by the same form of energy that originally 'zeroed' the minerals. Both quartz and feldspar have been used in OSL age determinations, although quartz has various inherent advantages, since it is usually ubiquitous in sand-grade sediments (Smith et al. 1990), has a much simpler chemistry and simpler luminescence characteristics than feldspar, and is more easily 'zeroed' (bleached) (Godfrey-Smith et al. 1988). In addition, quartz unlike feldspar is not subject to 'anomalous fading' in which electron traps behave unpredictably; something that cannot be easily corrected for (Wintle, 1973, Visocekas, 1985). The only disadvantage of quartz is that the signal saturates sooner, and thus the potential dateable age range is greater than for feldspar (Wintle, 1997). Where dose rates of environmental radiation are low, OSL presents the possibility of extending a rigorous absolute geochronology back to at least 300 ka BP (pers. com. E. J. Rhodes, 2001). This potentially enables the separation of the biostratigraphically similar temperate events at MIS 5e and 7. For example, interglacial sediments at Deeping St. James (Keen et al. 1999) have been correlated with MIS 5e on the basis of OSL age estimates.

The recent development of single-aliquot OSL techniques has further extended the potential dating range (Duller 1991, Murray and Wintle 2000). In addition, these techniques allow for the rigorous checking of dates by producing several age estimates, compared with single age estimate of the traditional multiple-aliquot techniques. It is therefore possible to assess the consistency of age estimates produced with respect to sediment variability, and to routinely check for incomplete zeroing of the signal at the time of deposition (Li 1994, Clarke et al. 1999).

1.4.6 Biostratigraphy

1.4.6.1 Pollen

The recognition of regional vegetational successions within interglacial stages using pollen analysis has traditionally been used as an important tool in the correlation of deposits throughout the Quaternary. Interglacials have frequently been differentiated on the relative importance of different vegetational substages (pre-temperate I, early-temperate II, late-temperate III, post-temperate IV) and on the basis of the timing and composition of the appearance and expansion of different woodland taxa (Turner and West 1968, West 1980). Indeed, pollen analysis has often been applied as if it were a chronostratigraphic, rather than a biostratigraphic tool. It is also acknowledged that pollen assemblages may be diachronous (time transgressive), regionally variable and that local vegetation and taphonomic factors can greatly affect pollen assemblages (Bowen, 1999, Tzedakis et al.
2001), although these factors are notoriously difficult to quantify. Mitchell et al. (1973) recognised two interglacial stages, the Hoxnian and the Ipswichian, between the Anglian and the Flandrian on the basis of pollen analysis. However, there is strong evidence from Europe that the vegetational successions of interglacial forest events in MIS 11 and MIS 9 are both rather alike and that similarly the successions of MIS 7 and MIS 5e may be difficult to differentiate (Tzedakis et al., 2001). The possibility of past confusion between similar interglacial events quite clearly exists, since traditional British chronostratigraphy has relied heavily upon pollen as a principal biostratigraphic marker. A further aspect of concern is the multiple episodes of warming (for example MIS 5a, 5c, 5e, 7a, 7c, 7e, 9a, 9c, 9e, 11a, 11c) indicated by the marine oxygen isotope curve within individual stages (Figure 1.1.2-2) and their expression in the pollen signal (Tzedakis et al., 2001). The possibility of temperate treeless events, not clearly represented within the Quaternary pollen record, has been mooted by some workers (D. C. Schreve pers. com. 2001), although there remains little substantial evidence in support of such episodes. In general, it appears that these weaker interstadial events (for example MIS 5c and 5a) are represented in northwest Europe by boreal, rather than temperate forest (Andersen 1961, 1965). Despite these criticisms, pollen analysis still has an important part to play in palaeoenvironmental reconstruction and biostratigraphic correlation.

1.4.6.2 Plant macrofossils

In contrast to pollen, plant macrofossil assemblages tend to record conditions local to the site of deposition, quite often without a significant regional or catchment signal. The diversity and detail of taxonomic division possible from these remains, compared to pollen, makes plant macrofossils ideal for precise palaeoenvironmental reconstructions. They may also offer a type of biostratigraphic control unavailable from pollen analysis. For example, megaspores of the water fern *Azolla filiculoides* occur in Britain in some Middle Pleistocene temperate stages, but are unknown in the Late Pleistocene (MIS 5e) (M. Field pers. com.). In addition, fruit of the Montpellier maple *Acer monspessulanum* are thought only to occur abundantly in the Ipswichian (MIS 5e) (West 1957, 1980). Plant macrofossil assemblages tend to reveal the assemblage of habitats, both edaphic and aquatic, prevailing at the time of deposition, and are particularly useful when used in combination with other biostratigraphic indicators.

1.4.6.3 Molluscs

In a similar fashion to plant macrofossils, molluscan remains tend to record local environments, rather than a regional signal. Setting aside marine and estuarine molluscs, which represent a somewhat special case, terrestrial and freshwater molluscan remains frequently allow the interpretation of a mosaic of vegetation types and environments, from
which a clear picture of habitat and palaeoclimate can be built up. In addition, certain taxa and assemblages have been used as biostratigraphic markers; for example, the presence of the bivalve *Corbicula fluminalis* in post-Anglian deposits is taken as an indicator of the temperate intervals in MIS 11, 9 and 7. However, *Corbicula* appears to be absent in MIS 5e (Keen 1990, Preece 1995, Meijer and Preece 2000, Keen 2001). Evidence to support this hypothesis has been adduced from amino acid geochronology of *Corbicula* and other shells. Similarly, the gastropod *Belgrandia marginata* is thought by Keen (2001) to be present in MIS 11, 9 and 5e, but absent in MIS 7, although this is disputed by Meijer and Preece (2000). In combination with other biostratigraphic indicators, molluscs have great potential for the differentiation of the post-Anglian temperate episodes.

1.4.6.4 Beetles

Beetle remains, like plant macrofossils and molluscs tend to represent relatively local conditions. Coleoptera occupy a wide range of terrestrial and aquatic environments and are sensitive to climatic conditions. This makes them an invaluable palaeoenvironmental tool, which is enhanced by the ability to calculate mutual climatic ranges (MCRs) from a fossil assemblage (Coope 1986). As the identification of fossil specimens with extant species has progressed, so too have the possibilities for palaeoenvironmental reconstruction. The occurrence of distinct assemblages of beetles in combination with other biostratigraphic markers has formed the basis of a useful method for separating interglacial events (Coope, 2001). An early-temperate Ipswichian (MIS 5e) coleopteran assemblage comprising *Bembidion* spp. and *Onthophagus* spp. has been identified. This includes *Onthophagus massai* and an unknown species of *Drepanocerus*, both of which may be of stratigraphic significance. In contrast, a late-temperate group of beetles dominated by *Aphodius* spp., with *Oxytelus* (=*Anotylus*) gibbulus, *Stomodes* gyrosicollis and *Donacia* semicuprea has been assigned to MIS 7 (Coope, 2001). However, the beetle assemblages of the late-temperate Ipswichian are poorly known, and there is clearly the possibility of confusion between the beetle faunas of the late-temperate parts of the two temperate stages (G. R. Coope, pers. com. 2001).

1.4.6.5 Vertebrates

Vertebrate, and particularly mammal remains have frequently been the most conspicuous fossils recovered from excavations. The biostratigraphic significance of vertebrate remains became apparent with the identification of the ‘*Hippopotamus* fauna’ of the Ipswichian (MIS 5e) (Stuart 1982, Sutcliffe 1995), and its differentiation from an earlier mammoth/horse fauna. The stratigraphic and palaeoenvironmental significance of these fossils was often blurred by the combination of bones and teeth from two or more stratigraphic units exposed in a single pit. More recently, it has been suggested that each of
the post-Anglian temperate events (MIS 11, 9, 7 and 5e) can be differentiated from their vertebrate faunas (Schreve 2001a), and that evidence for considerable climatic complexity may exist within each marine oxygen isotope stage (Schreve 2001b). In addition, remains of the water vole *Arvicola* have biostratigraphical importance. Throughout the Middle and Late Pleistocene, several quantifiable evolutionary trends are apparent in the size, height and thickness of enamel in *Arvicola* molars, so that fossil material can be correlated with known specimens on the basis of morphology (von Koenigswald and van Kolfschoten 1996).

**1.4.7 Fluvial Terrace Stratigraphy**

**1.4.7.1 Introduction**

Quaternary fluvial aggradations in southern England are usually preserved on valley sides and as remnants on interfluves, and are traditionally separated on the basis of altitude (Gibbard 1994). These deposits are usually considered the result of successive incisions into the valley floor followed by the accumulation of fluvial sediments. This ‘cut-and-fill’ model of fluvial aggradation is widely recognised (Fisk 1944, Smith 1949, Quinn 1957). A consecutive series of incisional and aggradational cycles creates a succession of increasingly younger deposits down the valley side. Maddy & Bridgland (2000) have suggested a model of river terrace systems for southern England, whereby climate-driven terrace formation is set against a background of progressive uplift. The surfaces preserved on top of these deposits form a series of ‘steps’ or ‘stairs’ separated by steeper slopes that can be mapped as geomorphological landforms, and are thought to represent former valley floor surfaces (Cotton 1940, Leopold et al. 1964, Howard et al. 1968). It is these surfaces, termed ‘terraces’, that have traditionally been used to identify and map Quaternary fluvial sediments. Terrace surfaces usually have a downstream gradient that is frequently different from that of the modern floodplain, and their increasing fragmentation with altitude strongly suggests increasing antiquity (Howard et al. 1968).

**1.4.7.2 Problems of Morphostratigraphy**

The traditional approach to terrace stratigraphy, termed morphostratigraphy, used the classification and correlation of terrace surfaces based on altitude. This is the system widely used by the BGS to classify fluvial deposits of the Cambridge Sheet 188 and Saffron Walden Sheet 205 (Figures 1.2.3-1 and 1.3.2-1). It is clear that the development of morphostratigraphic sequences has often met with considerable problems because periglacial processes have invariably modified the terrace surfaces. Moreover, morphostratigraphy has also frequently ignored the often internally complex nature of the deposits underlying the terrace surfaces. Gibbard (1994) observed that this approach relied on the terraces remaining in the same order throughout the valley. Where they do not, for
example in the Lower Thames (Gibbard 1994), or in the case of the 4th Terrace of the Cam system (see Section 1.2.4.5), the system breaks down and causes great difficulty during interpretation of the deposits. This has led to morphostratigraphy being rejected in favour of a lithostratigraphic approach (Bridgland 1988, Gibbard 1985, Gibbard 1988, Bowen 1978). A comparison of the BGS morphostratigraphic interpretation of deposits on the Cambridge Sheet 188 (Figure 1.3.2-1) and the lithostratigraphic interpretation by Gao (1997) of deposits in the River Great Ouse valley (Figure 1.3.2-2) amply demonstrates these issues.

1.4.7.3 Lithostratigraphy

Lithostratigraphy uses conventional geological techniques to identify lithostratigraphic units beneath terrace surfaces, which are formally defined from stratotype localities (Hedberg 1976, Salvador 1994). Lithostratigraphic units may be correlated with each other on the basis of lithofacies and other data. Where appropriate, biostratigraphy and geochronology are then used to provide independent age control, resulting in an internally consistent and rigorous stratigraphic scheme (Gibbard 1994). This is principally the approach adopted by Bowen (1999) in an attempt to correlate British terrestrial Quaternary deposits.

Despite this modern and apparently rigorous endeavour, many workers have found themselves in contention over the interpretation and relative importance of various lines of evidence adduced to support lithostratigraphic conclusions. This is exemplified by the disagreement between Bridgland (1994) and Gibbard (1985, 1994) over the correlation of sequences in the Thames valley (Figure 1.4.7-1). Not only do these workers have different views on the lithostratigraphic division of the Thames units into formations and members, but they have fundamentally different opinions about the correlation and geochronology of the deposits. Bridgland (1994) believed that the Thames deposits represented the best British terrestrial Quaternary sequence, with a ‘staircase’ of gravels containing temperate deposits attributable to MIS 11, 9, 7 and 5e on the basis of biostratigraphy and amino acid geochronology. Gibbard (1994) however, urged caution in the application of relative dating techniques as a substitute for sound sequence stratigraphy, and identified only two temperate events, the Hoxnian and Ipswichian, in a model similar to that outlined by Mitchell et al. (1973). This example highlights the importance of adopting a flexible and broad-based approach to modern lithostratigraphy. While firmly entrenched prejudices and opinions are difficult to change in the face of new and sometimes contradictory evidence, the adoption of new paradigms can be an equally perilous pursuit.
They growled a response and went on digging. For some time there was no noise but the grating sound of the spades discharging their freight of mould and gravel.

*THE ADVENTURES OF TOM SAWYER*
*Mark Twain (Samuel Langhorne Clemens)*
Chapter 2 Contents

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2.1 Introduction

2.1.1 Introduction to the Methods

The research activities undertaken during this project have included the collection of geological, stratigraphic and palaeontological data from three main sources; literature searches and museum visits, fieldwork, and laboratory analyses. As a consequence of this work, databases for each main data type have been created, and investigation into appropriate software capable of two- and three-dimensional geological data representation has been made. In addition, broader issues concerning the development of the landscape in the Cambridge District over the Pleistocene in relation to different bedrock types and overlying deposits have been considered.

2.2 Information Sources

2.2.1 Literature searches and postal campaigns

Libraries visited to obtain papers and reports include those of the Department of Geography, Department of Earth Sciences, Department of Plant Sciences, Department of Archaeology, Scientific Periodicals Library and University Library (University of Cambridge), Cambridge City Library and British Geological Survey Library. A number of on-line services such as the Cambridge University Library Service and BIDS that have been useful for searching for references. A wide range of data has been obtained in this way, including stratigraphic, geological and palaeontological information. The author also undertook several postal campaigns aimed at obtaining stratigraphic and geological data from surveyors, civil engineers and various other organisations and individuals in the form of borehole and trial pit records from technical reports. A list of a hundred respondents was built up, giving rise to the acquisition of many hundreds of separate borehole and trial pit records.

2.2.2 Museum Visits

The Quaternary Museum, Department of Geography, and the Sedgwick Museum, Department of Earth Sciences (University of Cambridge), have provided palaeontological data from various records and specimen collections. These include large and small
mammal faunas, herpetological and fish faunas, molluscan faunas, plant macrofossils and blocks of sediment.

2.3 Desk Studies

2.3.1 Cartographic Methods

Cartographic evidence has been of particular interest, since maps often represent a particular interpretation of the available data, rather than a dispassionate account of the data itself. The Ordnance Survey, British Geological Survey, and Soil Survey maps of the Cambridge District provide a wealth of information about the structure and function of a complex landscape rich in features of geological interest. In the following chapters, for each of the ten 10km squares in the greater study area, the author has reproduced an extract from the Ordnance Survey 1:50,000 Landranger series showing which monads (one kilometre squares) contain geological data (boreholes, trial pit records, published geological sections). In addition, an extract from the relevant BGS geological map has also been included.

For the central study area, the author has reproduced extracts from the Ordnance Survey 1:25,000 Pathfinder series showing the location of individual geological data points, for each of the twenty 5km squares included. A separate plan of the labelled points and the geological sections drawn between them has also been provided. Where points are numerous, an extract from the relevant Ordnance Survey 1:10,000 map has been used to show details of data coverage within each monad. Extracts of the BGS geological map for each 5km square have also been included. In addition, the topographic data from the Ordnance Survey 1:25,000 Pathfinder maps has been used to create digital elevation models (DEMs), upon which the geological maps have been draped. These isometric (bird-eye view) images allow the relationship between Quaternary deposits and relief to be more clearly seen.

The data from each of the geological sections has been reproduced in a two-fold style; the actual borehole logs are printed on transparencies and overlie the author’s interpretation of the geology, presented as a ‘cartoon’ interpolation of the data. By inserting a sheet of plain paper beneath each transparency, the original data can be easily compared to the interpretation beneath. The stratigraphic relationship of different bodies of sediment shown in these geological sections is the primary tool for lithostratigraphic interpretation. A key to the lithological symbols used in these sections appears in Figure 2.3.1-1

2.3.2 Stratigraphic Methods

A method was needed to deal with the particular difficulties caused by the large volume of data. The approach adopted by the author has been to add a lower tier of local stratigraphic nomenclature to that outlined in Bowen (1999) (see Table 1.4.2-1) to assist
correlation. The various Quaternary deposits from each geological section have been described, where possible in detail, and the stratigraphic relationship of various sediments has been investigated. Where a particularly characteristic or well-developed sequence has been found, the author has proposed an informal name for that local stratigraphic unit using a *local stratotype* location. The informal name comprises a local geographical name and a lithological description of the sediment unit; for example ‘Grantchester Gravel’. This is intended by the author as a higher level of stratigraphic division than the term ‘bed’.

In practice, local stratotypes have been chosen to represent local stratigraphic units relating to discrete outcrops within an area. As a consequence, local stratotypes tend to be spaced at least 1-2km apart, avoiding unnecessary proliferation. A large number of local stratigraphic units have been identified in this way, and their altitudinal and lithological characteristics are summarised in various tables and figures. The local stratotypes and stratigraphic units are extremely useful tools for correlation purposes, but are not intended for regional recognition. It is clear that many local stratigraphic units may be correlated with each other on the grounds of altitude, lithology, biostratigraphy or stratigraphic position. Local stratigraphic units are grouped within formally named lithostratigraphic members, belonging to particular geological formations; for example ‘Jesus Green Member, Cam Valley Formation’. A single particularly representative stratotype section may be chosen to represent the lithostratigraphic member. This approach is advantageous in that it transcends the problems of scale and status, which caused difficulties in Bowen’s (1999) correlation of British Quaternary deposits, and is amenable to future changes of interpretation.

In some cases, sediments have already been given formal or informal names (*cf.* Bowen 1999), and the author has reviewed the naming and stratotype locations of these, and has proposed changes where appropriate. In addition, the lithostratigraphic members and the local sediment units that they comprise have been correlated with chronostratigraphic divisions of the Quaternary timescale, on the basis of stratigraphic position, biostratigraphy, and geochronology. The author has then attempted correlation of the stratigraphic model developed here, with sequences elsewhere in southern England.

### 2.3.3 Databases

Three main databases (stratigraphic, physical and palaeontological) have been created as a result of the data acquisition efforts detailed above. The stratigraphic database contains upwards of 5000 individual records of borehole, trial pit and other stratigraphic records gathered from a myriad of sources throughout the project. The physical database is essentially a collection of smaller data sets including analytical data from laboratory analyses including clast lithological analyses, loss-on-ignition, magnetic susceptibility and particle size distribution. These data have been used to interpret environments of deposition and to correlate deposits from different sites. The palaeontological database
includes information from published records, museum collections, laboratory analyses of plant and animal remains, and the results of pollen analysis. The faunal and floral inventory created for each site gives a profile of the vegetation, environment, climate and possible age of the deposits.

The collection, cataloguing and processing of large amounts of data has been made easier by recent advances in personal computer technology. The three databases outlined above require relatively sophisticated combination and interpretation to provide a balanced and defensible set of conclusions. The author has made considerable efforts to find and test appropriate software capable of data analyses, and of two- and three-dimensional stratigraphic data representation (Boreham, 1998).

2.4 Fieldwork and Site Visits

2.4.1 Introduction

Data acquisition from fieldwork has entailed visits to building sites, developments, sewer repairs, gravel pits and temporary excavations to obtain engineering reports containing borehole or trial pit records. Building developments and repairs to the infrastructure of Cambridge have constantly provided opportunities to collect samples and geological information. Every development, through necessity, has boreholes and trial pits associated with it. These have formed a prolific source of stratigraphic data throughout the study period.

With direct observation of geological sections it has often been possible to make measurements and take samples from the exposed deposits for subsequent laboratory analyses. More than three hundred sediment samples have been collected in this way. About a hundred boreholes and trial pits have carried out during this project, which have yielded stratigraphic data, and many samples for laboratory analyses.

2.4.2 Description of Geological Sections

Sections available in the field were logged and described by the author. These descriptions comprised both vertical and three-dimensional geometry of the sediments, including characteristics such as lithology, thickness, colour, contact with adjacent units, fossil content and sedimentary structures, which were recorded before the sediments were sampled. Where possible, exposures were photographed to augment written records. Sediments with internally similar lithologies and structures were described as single sedimentary units at a variety of scales. The description of these sedimentary elements included the nature of lower and upper bounding surfaces, the thickness and lateral extent of the sediments, and the internal and external geometry of the units.
Lithofacies codes (Table 2.4.2-1) were also applied to the sediments where possible (Miall, 1977, Postma 1990). Facies models are used to classify and interpret fluvial sediments, which are characterised by a wide range of channel morphologies, particle size distributions, sedimentary structures, bedforms and lithological geometries, at a variety of scales (Miall, 1977). The most important aspects of facies analysis are the types of mesoscale geomorphic elements, such as channels and bars, and the assemblage of different lithofacies units. Miall (1985) recognised typical architectural elements related to the lithofacies assemblage (Table 2.4.2-1) and different fluvial styles characterised by the degree of braiding and channel sinuosity.

2.4.3 Boreholes

Boreholes were often undertaken to investigate sites where satisfactory exposures were not readily available. Borings were mostly put down using hand augers, although a motorised power auger was used where ground conditions were difficult. The lithology of sediments recovered from each borehole was carefully logged, and where suitable cores could not be obtained, material was ‘spot’ sampled in the field.

2.4.4 Sampling of Sediments

Following the description of geological sections, samples of sediment were usually taken for various laboratory analyses. Three types of sample were obtained from the sections; large bulk samples (5-10kg) for clast lithology analysis were taken from sediments with a coarse component (mostly gravels and sands), bulk samples (2-5kg, although exceptionally 10kg) of fine-grained materials for palaeontological analysis, and small samples (10-50g) for pollen and physical analyses. Small samples for pollen and physical analyses were also frequently collected from fine-grained sediments in sections and from core material collected from boreholes.

2.4.5 Palaeocurrent analysis

Where possible, palaeocurrent directions were measured from cross-bedded fluvial sediments using a compass clinometer. Sections were cut 90° to the exposed face in order to determine the true dip. Measurements of dip and inclination were recorded from the surface of cross-bedding planes, which are taken to represent the down-current direction at the time of deposition. Although at least 20 palaeocurrent measurements are ideally required, in practice many of the sediments were insufficiently exposed to permit this.

2.4.6 Levelling

The geological sections and boreholes investigated were levelled to obtain their heights above Ordnance Datum, Newlyn (OD.). Where possible Ordnance Survey bench marks
were used as reference points from which to construct levelling transects, although temporary bench marks were often made by marking stable objects during surveying.

2.5 Laboratory Analyses

2.5.1 Introduction

The stratigraphic position, physical size and nature of the samples collected from field sites has governed which laboratory analyses are appropriate. In many cases it has only been possible to collect, at best, several bulk samples from exposed sections in excavations due to the confined and dangerous working conditions. In these situations, representative samples of the main stratigraphic units have been taken. Occasionally, opportunities for closely spaced sampling from exposed sections have arisen. In these cases, discrete and bulk samples have been taken together to allow a greater variety of analyses to be carried out. Finally, samples originating from boreholes have tended to be small and closely spaced, and there has often been little possibility for procuring bulk samples in this situation.

Bulk samples of gravel and sand present perhaps the least opportunity for laboratory analyses, although particle size and clast lithological analyses can be applied to them. More than seventy samples of gravel-rich sediments have been analysed in this way, and clast lithological analysis has proved to be a useful tool in distinguishing between otherwise superficially similar coarse-grained sediments. Some bulk samples, especially those of fine-grained deposits, have yielded mammal remains, molluscs, beetle fragments and plant macro-fossils. Sub-samples of bulk samples have also been subjected to the analyses described below, although the stratigraphic control is often poor. In a number of key localities, boreholes have provided sequences of between twenty and forty contiguous samples. These samples have been subjected to a rigorous suite of physical analyses including loss-on-ignition, magnetic susceptibility, laser particle size analysis, and pollen analysis. In these situations, it has been possible to discover a great deal about the depositional history of the sediments.

2.5.2 Clast Lithological Analysis

Spatial and temporal variations in the supply of particular lithologies can lead to characteristic pebble assemblages which can frequently be used as a lithostratigraphic tool for the correlation of gravel units (Gibbard 1985). The choice of pebble sizes used for clast lithological analysis must be appropriate for the sediments under investigation and be compatible with previous analyses if comparisons are to be made (Bridgland 1986). In general, workers have favoured analysis of clasts in various size classes within the range 8-32mm (Hey 1986, Green et al. 1982, Gibbard 1985). Ideally, analysis of at least 300
clasts from a small size class, for example 11.2-16mm or 16-32mm, would give the most reliable results. The small rivers of the Cam system rarely carry and deposit pebbles of this size. As a result in this study clast lithological analysis has been carried out on pebbles in the smaller 8-11.2mm size class, as well as the 11.2-16mm and 16-32mm size ranges. In the neighbouring River Great Ouse system, Gao (1997) primarily used 11.2-16mm and 16-32mm size fractions, adding data from the 8-11.2mm fraction if necessary.

Most bulk samples taken for clast lithological analysis weighed c.5kg. Clay-rich samples were dissociated using 4% w/v sodium pyrophosphate solution and warm water prior to sieving. Samples were washed through a stack of 500mm diameter steel sieves with mesh sizes of 32, 16, 11.2 and 8mm. The clasts retained in each sieve were carefully washed, and dried in an oven at 105 °C. Pebble counting was undertaken on a well-lit white plastic tray and sorted by hand using a magnifying lens and low-power stereo microscope when necessary. Critical determinations were carried out using fresh faces obtained by splitting pebbles using a hammer and anvil. Clasts were tested for carbonate content using 7% hydrochloric acid. Identifications were routinely checked using a small reference collection. A number of problematic clasts were kindly identified by P. L. Gibbard. The author attempted to count a minimum of 300 pebbles for each sample, but where this was not possible the deficiency is indicated with an asterisk after the site name.

Table 2.5.2-1 shows the lithological groups determined during pebble counting, their potential sources and durability in fluvial transport. Chalk bedrock is clearly identified as an important source of chalk clasts, and also of angular flint derived from shattered nodular flint. Small numbers of rounded patinated flints are likely to come from Tertiary strata that overlie the Chalk. Much of the material grouped as local lithologies is derived from various Lower Cretaceous and Jurassic strata that occur within 20km of Cambridge. However, the majority of these do not actually outcrop in the Cam catchment, and it must be presumed that they are in fact derived from the Lowestoft Formation till. Although the same provenance is generally assumed for exotic lithologies, the Cambridge Greensand and Lower Greensand are also known to contain a variety of exotic pebbles (Chatwin 1961, Nicholls 1947, Wells and Gossling 1947, Hawkes 1951). *Rhaxella* Chert is also generally thought to be derived from Lowestoft Formation till, having been transported from the outcrop of the Calcareous Grit in the Lower Corallian, Yorkshire, by ice sheets (Wilson 1938, Bridgland 1980).

A summary of clast lithological analyses carried out by the author is presented in Appendix 1, together with data from the BGS mineral assessment reports, and analyses by Gao (1997) and Norris (1962). The location of the points from which these samples were taken is shown in Figure 2.5.2-1. Where possible, the grading of gravel from each deposit has been included, and is summarised using a scheme of grade classes (I-VI) determined
from the percentage of clasts greater than 16mm diameter (Figure 2.5.2-2). The detailed clast lithology data has been simplified into the four lithological groups (Chalk, Flint, Local and Exotic) identified in Table 2.5.2-1. Appendix 1 includes the relative abundance of different lithological groups and their abundance in each sample. The relative abundance of these lithological groups is also shown in Figure 2.5.2-2. It is clear that the majority of samples are flint dominated and of medium to fine grade. Samples not following this trend are conspicuous and may be of use for lithostratigraphic correlation.

2.5.3 Loss-on-ignition analysis

Samples of fine-grained sediments were analysed for loss-on-ignition in order to determine their organic, carbonate and silicate content (Bengtsson and Enell 1986). Samples (1-2 cm$^3$) were placed in pre-weighed porcelain crucibles and re-weighed, so that wet bulk density (g cm$^{-3}$) could be calculated. Samples were oven-dried at 105°C for 6 hours to remove water, and re-weighed so that the field water content could be calculated. The samples were heated to 550°C for 6 hours in a muffle furnace, allowed to cool and weighed. The loss of mass on ignition at 550°C is taken to represent the complete oxidation of organic carbon (carbohydrates and elemental carbon) to carbon dioxide and water vapour, and is expressed as a percentage of the dry weight. The samples were then heated to 950°C for 6 hours, allowed to cool and weighed again. The loss of mass on ignition at 950°C is taken to represent the oxidation of calcium carbonate to calcium oxide and carbon dioxide. Calcium oxide remains in the sample so that the lost mass is entirely the result of carbon dioxide. The mass of carbon dioxide may be converted to the mass of calcium carbonate originally in the sample, and this is expressed as a percentage of the dry weight. The percentage silicate residue may also be calculated from this analysis.

A summary of loss-on-ignition analyses carried out by the author is presented in Appendix 2, together with magnetic susceptibility data. The location of points from which these samples were taken is shown in Figure 2.5.3-1. Appendix 2 includes the compositional groups and their abundance in each sample. The relative abundance of these compositional groups is shown in Figure 2.5.3-2. Apart from a few organic-rich peats, the samples are largely inorganic sediments ranging from silicate-dominated to carbonate-dominated sediments. These compositional differences reflect diverse low-energy depositional environments, and may be of limited use for lithostratigraphic correlation.

2.5.4 Magnetic susceptibility analysis

Samples of fine-grained sediments (c.10g) for magnetic susceptibility analysis were dried, lightly ground and passed through a 2mm sieve. Each sample was placed in a pre-weighed 10cm$^3$ plastic pot, and re-weighed. The low frequency volume susceptibility of each sample was determined using a dual frequency well sensor attached to a Bartington
Instruments MS2 magnetic susceptibility meter and a personal computer. The mass specific magnetic susceptibility of each sample was then calculated. A summary of magnetic susceptibility is presented in Appendix 2. The relationship between percentage silicate residue and magnetic susceptibility is shown in Figure 2.5.3-2. The majority of samples have low magnetic susceptibilities (<1.0 SI units x10^-8 (m^3kg^-1)). Samples with high proportions of silicate are dominated by non-magnetic mineral such as quartz and feldspar, while those dominated by carbonate are frequently diamagnetic, giving very low or negative values. A small number of samples containin magnet minerals and present higher susceptibility values (>1.0 SI units x10^-8 (m^3kg^-1)), although this does not clearly correlate with an elevated silicate content. This indicates a different provenance for the mineral assemblage, and could be of use for lithostratigraphic correlation.

2.5.5 Particle size analysis

Samples of fine-grained sediments (5-10g) were prepared for particle size analysis by disaggregating them with 4% sodium pyrophosphate. The residues were analysed using the Malvern Mastersizer X laser particle sizer, housed in the Department of Geography, University of Cambridge. The laser particle sizer can resolve particles in the range 2000µm (sand) to 0.1µm (clay). The sizer uses two lenses with overlapping ranges; a 1000mm focal length lens (2000µm to 4µm) and a reverse fourier 45mm focal length lens (80µm to 0.1µm). Each sample is presented in the form of an aqueous slurry which is mixed in a stirred water bath and pumped through a windowed cell through which the laser beam is aimed. Particles obscuring the laser beam cause it to refract and scatter onto a detector array. These signals are sent to a personal computer where they are interpreted as particle size information. Data from the two lenses are blended by an algorithm to create the particle size analysis (2000µm to 0.1µm).

A summary of particle size analyses is presented in Appendix 3, which has been simplified into six categories. The samples exhibit different degrees of sorting, and many have the majority of their particle size distribution within the silt and clay fractions, although some samples contain significant amounts of sand. These differences in particle size characterise various depositional environments, and could be of limited use for lithostratigraphic correlation.

2.5.6 Palynological analysis

Samples for pollen analysis were prepared using the standard method of the Quaternary Palaeoenvironments Group, Department of Geography, University of Cambridge (adapted from Bennett et al. 1990). The sediments were sub-sampled with a 1cm³ brass volumetric sampler (1 or 2 cm³ each), and an exotic ‘spike’ of Lycopodium spores was added to allow the calculation of fossil pollen concentration. Pollen samples were treated with hot
(c.90°C) 7% hydrochloric acid to remove carbonate, and hot 10% sodium hydroxide to extract humic acids, before being sieved at 180μm to screen off larger particles. If necessary, the samples were treated with hot 4% sodium pyrophosphate (hexametaphosphate) to disassociate clays, and washed until no further humic acids and suspended clay could be removed. The samples were acidified with 7% hydrochloric acid before treatment with hot 60% hydrofluoric acid (2 to 8 hours) to remove silicate minerals. This step was repeated for very minerogenic samples. The samples were then treated with hot 7% hydrochloric acid for 30 minutes to remove colloidal silicates and silicofluorides. Following this, the organic residues were acetylated using Erdtmans reagent (9:1 acetic anhydride:concentrated sulphuric acid) and washed in glacial acetic acid to remove soluble cellulose acetate. The pollen residues were stained with aqueous safranin, dehydrated in tertiary butyl alcohol (TBA) and stored in 2,000c/s silicone fluid before mounting on microscope slides.

Prepared pollen slides were counted using a high-power binocular microscope with 10x oculars and a x40 objective. The slides were traversed at regular intervals and pollen grains were identified using pollen atlases and keys (Faegri and Iversen 1989, and Moore, Webb and Collinson, 1991), and the pollen reference collection housed in the Quaternary Palaeoenvironments Group, Department of Geography, University of Cambridge. Plant nomenclature follows Stace (1997) and pollen-type conventions follow the suggestions of Bennett et al (1994). Critical determinations were made using an oil-immersion objective at x950 magnification. Although a count of 300 pollen grains is generally considered the statistically acceptable minimum, some residues produced insufficient slides to make this possible. Where this was not possible, the deficiency is indicated with an asterisk after the site name. In some cases, pollen concentrations were so low that even counts of 100 were not achieved. This is indicated by a two asterisk suffix, in contrast to completely barren samples, which are marked as such.

The pollen data has been presented as percentages of total land pollen and spores. A summary of pollen analyses is presented in Appendix 4. The location of points from which samples were taken for pollen analysis is shown in Figure 2.5.3-1. Appendix 4 shows summarised pollen assemblages, with taxa arranged in order of abundance and percentages of principal tree taxa given in brackets. Pollen of grass (Poaceae) and herbs, and trees such as pine (Pinus) and birch (Betula) dominate the assemblages. A small number of samples with significant arboreal elements contained in excess of 50,000 grains per cm³. A large number of samples contained low concentrations of pollen (<5000 grains per cm³) typical of grassland environments. Pollen diagrams show the relative frequencies of trees and shrubs, herbs, lower plants and obligate aquatics. Where possible, the pollen diagrams
have been divided into pollen assemblage zones. Lithology columns are shown using simplified symbols from the system developed by Troels-Smith (1957).

2.5.7 Plant macrofossil analysis

Bulk samples (1-5 kg) for plant macrofossil analysis generally were washed through sieves with mesh apertures of 2mm, 1mm, 500μm and 250μm. Clayey samples were soaked overnight in 4% sodium pyrophosphate before sieving. The use of strong water jets during sieving was avoided to help preserve fragile remains such as leaves. The residue in the 2mm sieve was visually scanned for any identifiable plant macroscopic remains, and other residues were examined under a low-power binocular microscope. Fragments of all identifiable macrofossils such as leaves, seeds, fruits, achenes, capsules and nuts were carefully picked using a fine paint brush or forceps. Specimens were preserved with a glycerine, formaldehyde and ethanol solution. Plant macrofossils were identified by comparison with modern taxa using the reference collection of Quaternary Palaeoenvironments Group, Department of Geography, University of Cambridge. The nomenclature used follows Flora Europeae CUP Vols. 1-5 (1964-1980).

2.5.8 Mollusc analysis

Bulk samples (1-5 kg) for mollusc analysis were weighed, and washed across sieves with mesh apertures of 2mm, 1mm, 500μm and 250μm. The residues were air-dried and examined under a low-power binocular microscope. All the shells and shell apices were picked from the residues. Nomenclature for British non-marine Mollusca follows Kerney (1976) as far as possible.

2.5.9 Beetle analysis

Bulk sediment samples (c.5kg) for beetle analysis were disaggregated in water, before being washed across sieves with mesh apertures of 2mm, 1mm, 500μm and 250μm. For some samples a floatation technique using liquid paraffin was also employed. The sieved residues were examined under a low-power binocular microscope. Most of the beetles were identified to species level. The nomenclature and taxonomy as far as possible follow (Lucht, 1987).

2.5.10 Vertebrate analysis

Bulk sediment samples c.10 kg for vertebrate analysis were washed across 500mm diameter sieves with mesh sizes of 2mm, 1mm, 500 and 250μm. Very clayey samples were air-dried and then soaked in dilute (7%) hydrogen peroxide prior to sieving. A low-power binocular microscope was used to examine the residues.
2.5.11 Dating Methods

2.5.11.1 Optically Stimulated Luminescence Dating

Four samples were analysed for OSL dating; one (Babraham Road Park and Ride Site - Lab No. Shfd99113) by Mark Bateman, Sheffield Centre for International Drylands Research, and three (Woolpack Farm - Lab No. WP010502 30-60cm, Histon Road Allotments - Lab No. HRA F5 380-430cm, and Abington Hall - Lab No. TWI Hi 30-90cm) by Becky Briant, Godwin Laboratory, Cambridge (Briant 2002, in prep.). The Babraham Road sample was collected using an opaque tube, and was not exposed to sunlight during sampling or transport to the laboratory. The Woolpack Farm sample was a large cohesive silt block collected by Cunhai Gao and the author, and archived in the Quaternary Palaeoenvironments Group, Department of Geography, University of Cambridge. Large blocks of sediment were collected by the author from Histon Road Allotments and Abington Hall.

In the laboratory the outside layers of the sediment blocks were removed in darkroom conditions. The concentration of potassium, thorium and uranium, the main contributors of environmental radiation to sedimentary quartz, were determined using ICP. For the Babraham Road sample this was undertaken at XRAL Laboratories, Don Mills, Ontario, Canada, and for the other samples it was carried out by Becquerel Laboratories, New South Wales, Australia. The conversion of elemental concentrations to give effective dose rates was achieved using the coefficients given by Aitken (1998). The contribution to the dose from cosmic sources was calculated using the data of Prescott and Hutton (1994). The dose rate was attenuated for grain size and palaeomoeisture content using the measured water content ±5%. The samples were prepared under darkroom conditions to extract and clean quartz (Bateman and Catt 1996). For the Babraham Road and Woolpack Farm samples, a particle size range of 90-125μm was used which yielded c.3cm³ of prepared material. The Histon Road Allotments and Abington Hall samples were poorer in quartz, and consequently a particle size range of 90-180μm was used which gave 1-2 cm³ of prepared material.

OSL measurements were carried out using a Risø reader fitted with a filtered 150W halogen lamp. The samples were dosed with a calibrated ⁹⁰strontium beta source. The Babraham Road sample was preheated to 260°C for ten seconds prior to OSL measurement to remove unstable signal generated by laboratory irradiations. The three samples analysed by Becky Briant were preheated to 160°C, 200°C and 250°C to investigate any dependence on preheat temperature (Figure 2.5.11-1). The samples from Woolpack Farm and Abington Hall showed no preheat dependence. The sample from Histon Road Allotments exhibited some dependence on preheat temperature and did not giving a good 'preheat
plateau' suggesting that the data obtained may not be wholly reliable (A. Wintle pers. com.).

To enable a laboratory-based assessment of whether the sample had been fully zeroed (bleached) at deposition, multiple palaeodose ($D_p$) determinations were made. The palaeodose ($D_p$) was calculated using the single aliquot regeneration method (Murray and Wintle 2000) whereby a growth curve is fitted to the dose data and the palaeodose ($D_p$) interpolated from it. For the Babraham Road sample, five regeneration dose points were used, with the fourth and fifth points repeated to check for any sensitivity changes during the course of measurement. The remaining three samples were checked for sensitivity changes using seven regeneration dose points, with the sixth and seventh points repeated. Only determinations with a recycling ratio within ±10% of unity were considered reliable. In addition, samples from Woolpack Farm, Histon Road Allotments and Abington Hall were checked for recuperation and the quality of the fitted curve.

The parameters set out in Clarke et al. 1999 and Li 1994 were used to assess whether samples were properly zeroed at the time of deposition. For each sample, the palaeodose ($D_p$) for each aliquot has been plotted against the natural OSL (Figure 2.5.11-2). If there is a correlation between high luminescence and high palaeodose values, then it is assumed that the sample was poorly bleached prior to burial. It can be speculated that the variation in palaeodoses not related to partial bleaching from individual aliquots may be taken to indicate intrinsic luminescence problems with the sedimentary quartz, suggested by poor recycling for certain aliquots. If partial bleaching is detected, a minimum age estimate may be calculated by using the y-intercept where the natural OSL is zero (Li 1994).

All the OSL measurements exhibited distinct growth in OSL response with dose, although reproducibility was not perfect within individual aliquots giving a range of palaeodose ($D_p$) values. The final single aliquot regeneration palaeodose for samples from Babraham Road and Woolpack Farm was calculated as a mean (weighted according to variance) derived from repeated measurements showing no evidence of partial bleaching. The palaeodose for the Abington Hall sample was also calculated in this way, although the measurements showed possible weak partial bleaching. The sample from Histon Road Allotments appeared to be partially bleached (Figure 2.5.1-2), so that a minimum age estimate was calculated by using the y-intercept method (Li 1994). The calculated age is quoted in absolute years from the present day with one sigma confidence intervals (Table 2.5.11-1). This error incorporates systematic uncertainties within the dosimetry data, uncertainties with the palaeomosture content and errors associated with the mean palaeodose ($D_p$) determination.

2.5.11.2 Amino Acid Geochronology
Fossil mollusc shells for amino acid dating were selected from twelve key sites in the Cambridge District both from residues sieved by the author and a variety of specimens in the Sedgwick Museum with the help of R. C. Preece. Taxa known to epimerize at ‘slow’ rates, such as *Valvata*, *Bithynia*, and *Trichia*, were selected for these analyses. Great care was taken to choose only well-preserved specimens showing no signs of reworking. Where possible, at each site four specimens of a single taxon were chosen. At some sites this was feasible for two or three taxa. In some cases, the target taxa were unavailable, and other ‘slow’ epimerizers, such as *Arianta* and *Pupilla*, were selected instead. The fossil mollusc shells were submitted to Charles P. Hart, at the Center for Geochronological Research, INSTAAR, University of Colorado, USA, for amino acid ratio analyses. The shells were prepared to produce total acid hydrolysates of the preserved amino acids. Cation exchange chemistry in a High Precision Liquid Chromatograph was then used to measure the ratio of D-alloisoleucine to L-Isoleucine following the method of Miller and Brigham-Grette (1989). Where possible, multiple analyses were made on each shell. The chromatograms produced by these analyses were carefully examined, and the mean ratio of D-alloisoleucine to L-Isoleucine (D/L), standard deviations and numbers of replicate analyses have been reported for all the samples (Appendix 5). In addition, for selected samples the actual quantities of several additional amino acids were calculated and used as a means of judging the consistency between analytical runs on a single shell preparation. Amino acid concentrations are measured on total hydrolysate preparations and appear to exhibit a reduction with increasing D/L ratio and therefore sample age.

The lowest D/L ratios obtained were from *Trichia* at Barrington (0.082) and *Bithynia* at Woolpack Farm (0.085), whilst the highest ratio, (0.25 *Pupilla*) was from the Traveller’s Rest Pit. Using Bowen’s (1999) correlation between the Marine Oxygen Isotope Stages and the D/L ratios from southern England (Figure 1.5.4-1), these ratios approximate to MIS 5a/c and MIS 9/10 respectively. One striking feature of the amino acid data is the great variability represented within each site. This is amply demonstrated by analyses from Barnwell Abbey where the lowest D/L ratio was 0.130 (*Valvata*) and the highest was 0.217 (*Bithynia*). These data equate to MIS 5e/6 and MIS 8/9. Since the molluscs from Barnwell Abbey were from a museum collection, there can be no absolute certainty that the shells had not been mixed with other specimens at some indeterminate point. However, a similarly wide variation in D/L ratios from Histon Road material collected and sieved by the author strongly suggests that this is a real phenomenon, and not an artefact of the sample selection. The possibility that geochemical variation between specimens might account for these difference should also be considered.

Other surprising features of this data are the relatively high D/L ratios (0.134 to 0.150) obtained from *Valvata* at Barnwell Station. This site was previously dated to 19,500 ±650
BP (MIS 2) by radiocarbon dating (Godwin and Willis, 1964), and therefore might be expected to produce D/L ratios in the region of 0.01. Instead, these ratios correlate broadly with MIS 6/7. There is clearly a chance that the samples were confused with those from the nearby Barnwell Abbey site during curation, but also the intriguing possibility that deposits of this age were exposed at Barnwell Station, but never recognised. Also noteworthy are the range of D/L ratios (0.085 to 0.178) from Bithynia at Woolpack Farm, a site correlated with the Ipswichian (MIS 5e) on the basis of biostratigraphy (Gao et al. 2000). These ratios approximate to MIS 5a/c and MIS 6/7. During consideration of these data, one must constantly bear in mind the status of aminostratigraphy as a relative and not an absolute dating technique, and so temper interpretations with caution.

2.5.11.3 Radiocarbon dating

The author discovered very little material during this study to which radiometric dating could have been applied. During the selection of molluscs for amino acid dating it became clear that fauna from the important site at Sidgwick Avenue might contain a significant proportion of reworked elements (R. C. Preece, pers. com. 2001). The author concluded that amino acid determinations from the site could be unreliable. An important feature of the Sidgwick Avenue site was the discovery of a bison skull from a silty unit beneath the gravel and sand beds (Lambert, Pearson and Sparks 1962). The bison skull is preserved in the Sedgwick Museum, and the author investigated the possibility of applying radiocarbon dating to this specimen. It appeared that there were several conceivable outcomes of this venture. Firstly, there was the possibility that the bison skull was older than the limit of the radiocarbon method (>c.50 ka BP). An ‘infinite’ radiocarbon date would still provide a useful geochronological marker, giving the deposits a minimum age of Early Devensian (MIS 4). A second possibility was a radiocarbon date of 15-25 ka BP within the Late Devensian (MIS 2), making the deposits of similar age to those at Barnwell Station (Godwin and Willis, 1964). The third and most likely outcome was of a date in the range 25-50 ka BP, which would superficially suggest correlation with the Middle Devensian. However, even minute amounts of contamination by modern carbon could produce this result from a sample of otherwise infinite age.

Ultimately, practical rather than theoretical considerations also determined the viability of the project. The state of bone preservation is a crucial factor in the success of protein extraction from which the radiocarbon determination is made. Protein is the only component of modern bone that contains nitrogen, and collagen is known to represent c.90% of bone nitrogen. The amount of collagen remaining in bone samples can therefore be estimated by comparing the percent nitrogen (%N) to modern values. Modern cow bone contains c.5% nitrogen. The author (with the kind permission of M. Dorling, Sedgwick Museum) removed small samples of bone from the underside of the bison skull and
submitted them to the Godwin Laboratory, University of Cambridge (J. Rolfe and M. Hall) for nitrogen analysis. Initial results showed that the specimen contained 2-3% nitrogen suggesting that it was well-preserved for a bone of this antiquity. On the basis of these results, F. Petchey, University of Waikato, New Zealand, suggested that there was a very good chance of obtaining a radiometric date from the specimen. The author cut four bone plugs from the base of the specimen. These were submitted to University of Waikato, New Zealand, for radiocarbon dating.

Further bulk %N values were obtained from two bone plugs (3.29% and 2.83% nitrogen) indicating that c.60% of the original protein remained, and suggesting that the bone was very well preserved. It appears that the bison skull was originally conserved using a mixture of polyvinyl acetal (‘Alvar’) and toluene (C. Forbes pers. com., 2001). Therefore, a pre-treatment process was adopted to take into account the possibility of this contamination and prepare the samples for analysis. The bone samples were cleaned and ground, and then refluxed for 2 days in each of a chloroform/ethanol mixture, acetone and distilled water, to remove polyvinyl acetal and toluene residues. The samples were then decalcified in 2% hydrochloric acid at 4°C for 4 days, and rinsed with distilled water to remove hydroxyapatite, secondary carbonates, some acid-insoluble fractions such as collagen breakdown products, and some humic contaminants. This process yielded acid insoluble collagen, which was then gelatinised by heating the sample in weakly acidified water at 90°C for 4 hours to produce crude gelatin. Finally, the gelatin was freeze-dried prior to analyses which showed that it contained 17.9% Nitrogen and 41.5% Carbon. These values are typical for well-preserved bone samples. A sample of the gelatin was submitted for AMS dating (University of Waikato, New Zealand) and was given the laboratory identifier Wk-9388.

Analysis of the gelatin for stable isotopes to check for fractionation was undertaken by University of Waikato, New Zealand. Any changes in the ratio of $^{13}$C to $^{12}$C are used to calculate the likely depletion of $^{14}$C, the resulting over-estimate of age, and therefore the degree of fractionation correction required. Fractionation occurs particularly in terrestrial (C3) plants, and in animals feeding on these plants incorporate depleted levels of $^{13}$C and $^{14}$C into their bone collagen. The bison skull gelatin yielded a $^{13}$C value of 19.9%o which falls within the expected range of values for terrestrial herbivores (van Klinken, 1999).

The conventional age calculated for the gelatin sample (Wk-9388) derived from AMS measurement was 37,746±420 years BP. The date quoted is given as uncalibrated radiocarbon years before present (1950), and was calculated on the Libby half-life of 5568±30 years (Stuiver and Polach, 1977) with correction for isotopic fractionation applied. This radiocarbon date indicates a Middle Devensian age for the Sidgwick Avenue bison skull and therefore also presumably the Sidgwick Avenue Gravel. There remains the
possibility that this date simply represents an infinitely old radiocarbon sample
contaminated by modern carbon. Such contamination would have to represent 1.2% of the
sample mass to achieve the same age determination. This is a relatively large amount of
contamination, and the author believes that the careful curation, sampling and preparation
procedures preclude the possibility of this being a spurious date. The calibration of
radiocarbon years into calendar years for dates >24 ka BP is fraught with difficulty (van
der Plicht, 2000; Bard, 2001). There is some evidence to believe that radiocarbon dates of
c.37,500 years BP might equate to calendar dates of c.50,000 years BP which falls on the
boundary of the Early and Middle Devensian.
Chapter 3

10km Square TL 220/560

Offord Cluny and Papworth Everard

Buckingham:
....by intelligence
And proofs as clear as founts in July, when
We see each grain of gravel -I do know them
To be corrupt and treasonous.

HENRY THE EIGHTH
William Shakespeare
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3.4.1 Synopsis
Chapter 3

10km Square TL 220/560

Offord Cluny and Papworth Everard

3.1 10km Square TL 220/560

3.1.1 Synopsis

This ten-kilometre square is a northwestern extension of the greater study area, and has been included because an important site at Woolpack Farm straddles the boundary with this and the neighbouring 10km Square TL 230/560. It contains 8 monads with data (Figure 3.1.1-1) all located within the 5km Square TL 225/565, which falls within the central study area. The square includes the villages of Offord Cluny and Great Paxton to the west, the outskirts of Brampton and Godmanchester to the north, Graveley and Papworth Everard to the south and Hilton to the east. The valley of the River Great Ouse runs along the western and northern margins of the square with an elevation of c.5-15m OD. A plateau with an elevation of c.55-65m OD dominates the centre.

3.1.2 Drainage

The drainage of this area is generally towards the River Great Ouse, which flows north and then east along the edge of the square. A number of tributaries dissect the plateau area, the most notable of which is the Gallow Brook to the southwest, and the West Brook, which flows northeast from Papworth Everard towards Hilton.

3.1.3 Bedrock geology

The bedrock geology comprises Jurassic Oxford Clay and Ampthill Clay broadly dipping towards the southeast (Figure 3.1.3-1).

3.1.4 Quaternary geology

The Quaternary geology mapped by the BGS (Figure 3.1.3-1) comprises Boulder Clay (till) on the plateau area, a patch of ‘Taele Gravel’ near Papworth St. Agnes, and various 3rd Terrace Deposits, undifferentiated 2nd and 1st Terrace Deposits and Alluvium associated with the Ouse valley.
3.2 5km Square TL 225/65 Hilton

3.2.1 Synopsis

This five-kilometre square contains 8 monads with 33 points (Figures 3.2.1-1 & 3.2.1-2). The area includes the village of Hilton to the southeast, the outskirts of Godmanchester to the northwest, and parts of the parishes of Hemingford and Hemingford Abbots to the north. The area includes a site at Galley Hill investigated by Gao (1997) and Gao et al. (2000), known as Woolpack Farm, and the A14 road, which provides a significant number of data points.

3.2.2 Drainage and relief

This square comprises a plateau area to the west at c.50m OD, that is drained by the West Brook, which flows northeast towards the relatively low-lying area (5-10m OD) adjacent to the River Great Ouse near Galley Hill in the northeast of the square.

3.2.3 Geology

The bedrock geology largely comprises Oxford Clay overlain by Elsworth Rock and Ampthill Clay in the area south of Hilton. These beds broadly dip towards the southeast (Figures 3.2.3-1 & 3.2.3-2). The Quaternary geology comprises Boulder Clay (till) on the plateau area and in a small area near Hilton. Undifferentiated 2nd and 1st Terrace Deposits and Alluvium associated with the Ouse valley are mapped at 5-10m OD near Galley Hill in the northeast of the square.

3.2.4 Geological Logs and Sections

3.2.4.1 Synopsis

The 33 points were all from secondary sources. They comprise 12 records from the British Geological Survey Mineral Assessment Report (Gatliff 1981), 13 records from the Highways Agency archives, 1 record from the Huntingdon Memoir (Edmonds & Dinham, 1965), 1 record from Cambridge (1964) and 6 from Gao (1997) and Gao et al. (2000). Boreholes marked on the geology map were not available from the BGS.

3.2.4.2 Geological Section 25/65.1

This section (Figure 3.2.4-1) follows the line of the A14 road for 3km from New Farm to Galley Hill. It provides a detailed record of the drift geology from the edge of the plateau area onto the undifferentiated 2nd and 1st Terrace Deposits and Alluvium of the Ouse valley (Figures 3.2.3-1 & 3.2.3-2).
West of New Farm, bedrock Oxford Clay is recorded at c.18m OD at point 70/1 beneath several metres of Made Ground. As the slope descends towards New Farm, point 69 records sandy clay overlying bedrock at c.15m OD, although 1m of chalky diamict overlying bedrock is recorded at point 67/1. Nearby, at point B65 topsoil is recorded overlying bedrock, and at point 64 at Rectory Farm, bedrock Oxford Clay is also recorded beneath topsoil at c.10m OD at the edge of the River Ouse floodplain. Between Rectory Farm and Gore Tree Farm 3m of gravel and sand overlie bedrock Oxford Clay at c.3m OD (points 63 to 62). It is proposed that this gravel unit is formally named the Gore Tree Farm Gravel, with the stratotype at 26NE9 (TL 2876 6942). The gravel unit is overlain by 2m of silty sandy clay and clay with gravel. This appears to be alluvium associated with the Longmarsh Brook. Southeast of Gore Tree Farm the bedrock rises slightly to c.4m OD, and the gravel unit is incised by a channel containing 2m of sandy silty clay (points 26NE16 to 60). This channel is clearly marked on the geology map (Figure 3.2.3-1). It is proposed that this silty clay unit is formally named the Longmarsh Brook Silty Clay, with the stratotype at 26NE15 (TL 2965 6910). To the southeast at Galley Hill, points 26NE14 and 59 record 2m of sand and gravel beneath 1m of sandy silty clay.

3.2.4.3 Geological Section 25/65.2

This 2km-long section (Figure 3.2.4-1) runs eastwards from New Farm towards the outskirts of Hemingford (67/1 to 26NE10). The section traverses the junction between the plateau area and the valley of the River Ouse. The diamict at New Farm (67/1) is described above. Down slope, points B65 and 66 record bedrock Oxford Clay at c.12m OD overlain by topsoil. In the vicinity of Douglas Farm points 64/1 and 26NE20 record 3m of gravel and sand on bedrock at c.2m OD overlain by 2m of sandy silty clay. The silty clay unit is probably alluvium associated with the Longmarsh Brook. In contrast, point 26NE10 nearer the River Great Ouse on the outskirts of Hemingford records 7m of gravel and sand, with little alluvial cover.

3.2.4.4 Geological Section 25/65.3

This 3km-long section runs roughly southwest-northeast from Debden Farm (26NE8) to New Farm (67/1) (Figure 3.2.4-2). Debden Farm is located on a spur of the plateau area at c.42m OD. Point 26NE8 records c.18m of chalky diamict overlying bedrock Oxford Clay at c.24m OD). It is proposed that this unit is formally named the Debden Farm Diamict, with the stratotype at 26NE8 (TL 2550 6798). Two kilometres to the east, point 26NE5 records c.5m of diamict overlying bedrock at c.26m OD. The diamict at New Farm (67/1) is described above. This appears to be at a considerably lower elevation than the main body of diamict to the south, and may represent part of a solifluction lobe.
3.2.4.5 Geological Section 25/65.4

This 2km-long section is aligned southwest-northeast from Linton’s Farm (26NE12) through Gao’s site at Woolpack Farm (WF4 to WF3-1) to Galley Hill (points 59 and 26NE14) (Figure 3.2.4-2). The point near Linton’s Farm (26NE12) at c.8m OD records 2m of gravel and sand on bedrock Oxford Clay at c.5m OD. The gravel unit is overlain by 1m of sandy clay and topsoil.

At Woolpack Farm quarry Gao (1997) and Gao et al. (2000) describe a basal gravel and sand unit (not figured in their geological sections) seen in contact with bedrock Oxford Clay at c.2m OD, which they formally named the Fen Drayton (Gravel) Member (see Section 4.2.4.2). This is overlain by 1m of pebbly organic sandy silty clay (WF4 to WF2) described by Gao as an organic ‘diamicton’ and formally named by him as the Woolpack Farm Beds with the stratotype in the middle of Woolpack Farm pit at (TL 2993 6840). Clast lithological analysis shows that the unit is dominated by flint, with a significant local component, and a low frequency (c.2%) of chalk clasts (Appendix 1). The palaeocurrent directions from a small number of cross-bedded sands within this unit give a mean vector of 47° (NE), and a mean dip of 19°. Confusingly, this unit and the surrounding gravels are erroneously referred to as the ‘Woolpack Farm Member’ in Bowen (1999). Above this silty unit, Gao describes a 4m thick gravel and sand unit which he formally names the Hemingford (Gravel) Member, with a stratotype also located in the centre of Woolpack Farm pit at (TL 2993 6840). This unit also contains sands and silts of apparently local extent which Gao names the Linton’s Farm Beds, although they do not actually occur at Linton’s Farm (data point 26NE12). Palaeocurrent measurements from this unit showed a mean vector of 115° (SE), and a mean dip of 23°. Cut into the Hemingford (Gravel) Member, Gao describes a second gravel and sand unit 2m thick that he formally names the St. Ives (Gravel) Member with a stratotype also apparently located in the centre of Woolpack Farm pit at (TL 2993 6840). The separation of these gravel units is impossible from borehole logs and very difficult in field sections. Gao suggests that the upper St. Ives (Gravel) Member contains significantly more chalk clasts (c.26%) than the underlying Hemingford (Gravel) Member (c.3%) (see Appendix 1.1) and has a palaeocurrent vector of 46° (NE), and a mean dip of 23°. Whilst the author is reluctant to accept stratigraphic divisions that cannot be clearly demonstrated in the field, Gao makes a clear case for the existence of the St. Ives (Gravel) Member elsewhere in this part of the Ouse valley. Finally, these gravel units are overlain by 1m of contorted sandy clay.

The Fen Drayton (Gravel) Member, Woolpack Farm Beds, Hemingford (Gravel) Member and St. Ives (Gravel) Member were all given the same stratotype at (TL 2993 6840) in the centre of the Woolpack Farm pit by Gao et al. (2000). This is problematic in that no
geological section was ever seen by Gao in this exact location. The remedy suggested by the author is to assign these formally named units revised stratotypes based on the appropriate sections published by Gao et al. (2000). This means that the revised stratotype of the Woolpack Farm Beds is at point WF4 (TL 2987 6826) and that the revised stratotype of the Hemingford Member is at point WF2 (TL 2984 6835). The revised stratotype location for the St. Ives (Gravel) Member is at point WF3 and the revised stratotype location for the Fen Drayton (Gravel) Member is at point 34/1, both located in the 5km Square 230/65 (see Section 4.2.4.2). The limited lateral extent and confused naming of the Linton’s Farm Beds at the base of the Hemingford Member leads the author to suggest that this particular unit should not be promulgated for stratigraphic purposes.

The geological section described by Cambridge (1964) (data point C1964) records a similar sequence, but with 1m of gravel and sand beneath the organic sandy silty clay. Further north at Galley Hill, points 59 and 26NE14 record 2m of gravel and sand on bedrock at c.3m OD overlain by 1m of silty clay.

3.3 Site Description 5km Square TL 225/65

3.3.1 Woolpack Farm

3.3.1.1 Introduction

Excavations in the vicinity of Woolpack Farm were first described by Cambridge (1964, 1965) and Forbes and Cambridge (1967). These authors described numerous bones, shells and wood fragments from a now disused pit at Woolpack Farm and from several other quarries in the area, including the West End pit, which is located in the neighbouring 5km Square 230/65 (Chapter 4). There is some uncertainty about the exact provenance of some of this material, in particular that described by Preece and Ventris (1983). Gao (1997) and Gao et al. (2000) provide a detailed account of the stratigraphy and fossil assemblages recovered from the Woolpack Farm pit (see Section 3.2.4.5).

3.3.1.2 Environments of deposition

The basal gravels of the Fen Drayton (Gravel) Member are thought to have been deposited as a braided stream deposit (Gao 1997) and (Gao et al. 2000). The organic sandy silty clay or ‘diamicton’ of the Woolpack Farm Beds appears to have been deposited under low-energy fluvial backswamp conditions, and has subsequently been disturbed, most probably by large mammals. Gao et al. (2000) observe that at the present day margins of some African rivers animals may churn the sediment reducing it to a mixture of sand, gravel, silt, shells, dung and bones (a diamict). There is also a possibility that part of this sediment might represent a cohesive debris flow. The gravel and sand facies of the
Hemingford and St. Ives Members have been interpreted as a braided river deposit. The sands and silts of the Linton’s Farm Beds at the base of the Hemingford Member are thought to represent overbank fines or pool deposits in abandoned channels.

3.3.1.3 Pollen and plant macrofossils

The author carried out pollen analysis of samples from the organic sandy silty clay of the Woolpack Farm Beds (Gao 1997 and Gao et al. 2000) (Figure 3.3.1-1). The pollen assemblage is characterised by frequencies of *Pinus* (pine) 25%, *Poaceae* (grass) 30%, and small but significant proportions of *Corylus* (hazel) and *Quercus* (oak). This is interpreted as a floodplain environment with mixed oak woodland some distance away on dry ground above the valley floor. Plant macrofossils recovered from the sediment included a range of temperate trees and shrubs including *Corylus*, *Acer monspessulanum* (Montpellier maple), *Acer campestre* (field maple), *Fraxinus excelsior* (ash), *Pinus sylvestris*, *Quercus* sp., *Cornus sanguinea* (dogwood), *Crataegus* sp. (hawthorn), *Prunus spinosa* (sloe), *Rubus fruticosus* agg. (bramble) and *Sambucus nigra/racemosa* (elder). *Acer monspessulanum* is not native in Britain today, and is confined to central and southern Europe. Remains from a range of herbaceous, woodland and aquatic taxa were also recovered. The presence of abundant *Acer* remains and the temperate nature of the pollen and plant macrofossil assemblages was interpreted by Gao (1997) and Gao et al. (2000) as evidence that the Woolpack Farm Beds should be assigned to the early temperate part of the Ipswichian (MIS 5e) interglacial (Substage Ip II).

3.3.1.4 Molluscs

A rich mollusc fauna was also recovered from the Woolpack Farm Beds. The majority of taxa were aquatic indicating a slow-moving, well-oxygenated river with some marginal vegetation. The gastropod *Belgrandia marginata* recovered from these samples is not present in Britain today, and indicates a somewhat warmer climate than at present. A hint of salinity is suggested by the presence of *Pseudamnicola confusa* which today lives close to the tidal limit in estuaries on the East Coast. Floodplain and riverside taxa dominated the land fauna, with inhabitants of grassland and marshy areas well represented. For taphonomic reasons, snails of scrub and woodland habitats were less abundant. A degree of continentality in the climate is indicated by the presence of several taxa restricted to central Europe and southern Sweden. According to Keen (1990, 2001) and Preece (1995) the occurrence of *Belgrandia marginata* and the absence of *Corbicula fluminalis*, despite the presence of suitable flowing water conditions indicated by *Pisidium* spp., indicate an Ipswichian (MIS 5e) age for these sediments.
3.3.1.5 Beetles

Coleopteran analysis of samples from the Woolpack Farm Beds yielded beetle species from a range of habitats including still water with aquatic vegetation, well oxygenated running water, grassy riparian and meadow habitats and bare sandy ground. A large number of dung beetles (for example *Onthophagus* spp. and *Aphodius* spp.), were recovered from the samples indicating the presence of large mammals. The presence of mature deciduous trees is also indicated by bark burrowing scolytid beetles. Taken together, the beetle fauna is one of warm temperate conditions, with most of the non-British species living today in south and central Europe. In particular, the dung beetles of the Scarabaeidae suggest that mean July temperatures must have been close to 21 °C. This suite of exotic dung beetles is very similar to those from other Ipswichian sites including the stratotype at Bobbitshole (Coope 1974).

3.3.1.6 Vertebrates

Analysis of vertebrate remains was also undertaken from samples from the Woolpack Farm Beds. A number of the mammals present such as *Dama dama* (fallow deer) and *Palaeoloxodon antiquus* (straight-tusked elephant) indicate temperate woodland habitats, and the remains of fish such as *Esox lucius* (pike) and *Perea fluviatilis* (perch) are typical of a temperate lowland river. The faunal assemblage of *Palaeoloxodon antiquus*, *Dama dama*, *Cervus elaphus* (red deer), *Canis lupus* (wolf) and *Ursus arctos* (brown bear) represents the major elements of the ‘hippopotamus fauna’ associated with the Ipswichian Stage (Stuart 1982, Sutcliffe 1995). The absence of *Hippopotamus amphibius* (hippopotamus) at this site has been attributed to the ‘inadequacy of excavation’ within the Woolpack Farm pit. Even without *Hippopotamus* the faunal assemblage from the Woolpack Farm Beds is thought to be sufficiently different to the *Mammuthus trogontherii-primigenius/Equus ferus* fauna correlated with MIS 7, to be regarded as Ipswichian (MIS 5e) in age.

3.3.1.7 Dating

Optically stimulated luminescence (OSL) dating of quartz from sample WP010502 (data point WF5) gave an age of 121.04 ka BP ±22.33 for the organic diamict unit (Table 2.5.11-1). This appears to indicate a correlation with MIS 5e. In contrast, amino acid racemization analyses for *Bithynia tentaculata* shells from the same unit (Appendix 5) gave D/L ratios of 0.085, 0.146, 0.160 and 0.178. The lowest of these ratios equates to an Early Devensian (MIS 5a/c) age, whilst the three higher ratios correlate with the later part of the ‘Wolstonian’ interval (MIS 6/7). Two plausible reasons for this apparent age distribution are that it either represents a deposit of late ‘Wolstonian’ age reworked in Early Devensian times, or that
Chapter 3  10km Square TL 220/560  
Offord Cluny and Papworth Everard

periglacial or other processes have combined deposits of two different ages within this organic diamict. Neither of these interpretations explain why molluscs of Ipswichian age were not found in a deposit clearly correlated with MIS 5e on the basis of faunal and floral assemblages, and OSL age estimates. Given the mixed amino acid signal from this site, the best that can be achieved is a minimum age estimate for the last phase of deposition based on the lowest D/L ratio. In this case that would be the Early Devensian (MIS 5a/c), which is not wholly incompatible with the Ipswichian (MIS 5e) age indicated from other lines of evidence. The implication is that a significant amount of deposits from the later part of the ‘Wolstonian’ interval must have been available locally to provide the reworked molluscs. The fact that the molluscs selected were well-preserved specimens showing no signs of reworking indicates that the shells could not have travelled far.

3.3.1.8 Conclusions

It is clear from the molluscan, floral and coleopteran assemblages that the organic diamict (sandy silty clay) of the Woolpack Farm Beds was deposited during an interglacial period, most probably the early temperate part of the Ipswichian (MIS 5e). This conclusion is supported by the OSL dating of quartz from the organic silty diamict. Amino acid racemization analyses for Bithynia shells from this unit gave a mixed signal, suggesting a minimum age of Early Devensian (MIS 5a/c), but with apparent significant reworking from older deposits from the later part of the ‘Wolstonian’ interval.

3.4 Correlation of Stratigraphic Units

5km Square TL 225/565

3.4.1 Synopsis

Figure 3.4.1-1 and Table 3.4.1-1 show details of the 5 local stratigraphic units proposed for the 5km Square 225/565. Most of these units occupy positions on the floor of the Great Ouse valley. The Debden Farm Diamict is the exception in that it is a relatively thick unit occupying a ridge that is part of a high plateau area. Table 3.4.1-2 and Figure 3.4.1-2 show the chronological and stratigraphic relationships of these units and their correlation with lithostratigraphic members and formations. Figure 3.4.1-3 presents an idealised geological section through the area showing the relationships of the various lithostratigraphic members. The Debden Farm Diamict is correlated with the Barrington Works Member of the Lowestoft Formation and is interpreted as Anglian (MIS12) till. The other stratigraphic units belong to the Ouse Valley Formation (see Table 1.4.2-1). The Fen Drayton (Gravel) Member (see Section 4.2.4.2) forms a basal gravel unit probably dating from the later part of the ‘Wolstonian’ interval (MIS 6/7) overlain by the Woolpack Farm Beds.
The Woolpack Farm Beds at point WF4 become the stratotype for the Woolpack Farm Member, which is interpreted as a temperate silty fluvial diamict of Ipswichian (MIS5e) age. There is a clear erosional contact between the diamict and the overlying Hemingford Gravel, which at point WF2 becomes the stratotype for the Hemingford Member, and is correlated with the Gore Tree Farm Gravel. However, there is also a strong possibility of confusion with the overlying St. Ives Member. These gravels are interpreted as Middle to Late Devensian (MIS 2/3) braidplain deposits of the River Great Ouse. The Longmarsh Brook Silty Clay partly overlies these gravels, and is correlated with the Ouse Member. It is interpreted as Flandrian alluvium of the River Great Ouse floodplain.

There is clearly a large interval of time not represented by sediments between the Anglian Stage (MIS 12) and the later part of the ‘Wolstonian’ interval (MIS 6/7). It appears that the Woolpack Farm Beds represent only a short period of temperate deposition, and that much of the interglacial and subsequent Early Devensian (MIS 5a/d & 4) may be missing. The Hemingford and St. Ives Members are taken to represent Middle to Late Devensian braidplain deposition. The Flandrian Ouse Member has no stratotype assigned to it (Bowen 1999), and partly overlies these older units, occupying channels and undulations cut into their surfaces.
Chapter 4

10km Square TL 230/560

Fenstanton and Swavesey

Looking-glass river
Smooth it glides upon its travel,
Here a wimple, there a gleam-
O the clean gravel!
O the smooth stream!

A CHILD'S GARDEN OF VERSES
Robert Louis Stevenson
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4.1 10km Square TL 230/560

4.1.1 Synopsis
This ten-kilometre square is located at the northwest corner of the main study area and contains 37 monads with data in three of the 5km Squares (Figure 4.1.1-1). The area includes the villages of Fenstanton and Elsworth to the west, Fen Drayton, Over and Willingham to the north and Longstanton, Bar Hill, and Madingley to the east. The valley of the River Great Ouse runs along northern margin of the square with an elevation of c.5m OD and to the south there is a plateau area with an elevation of c.55-65m.

4.1.2 Drainage
The drainage of this area is generally towards the River Great Ouse, which flows eastwards along the northern edge of the square. Several small tributaries dissect the plateau area, draining into two low-lying areas, thought to be thermokarst depressions (Boreham 1996a), before flowing north through narrow outlets into the main valley of the Ouse.

4.1.3 Bedrock geology
The bedrock geology comprises Jurassic Oxford Clay, Ampthill Clay and Kimmeridge Clay overlain by Cretaceous Lower Greensand, Gault Clay and Chalk broadly dipping towards the southeast (Figure 4.1.3-1).

4.1.4 Quaternary geology
The Quaternary geology mapped by the BGS (Figure 4.1.3-1) comprises Boulder Clay (till) on the plateau area to the south, and on a low ridge near Over where it associated with patches of ‘Glacial Gravel’. Small areas of 4th Terrace Deposits are mapped near Longstanton and Cold Harbour Farm, Willingham. Larger areas of 3rd Terrace Deposits are mapped between Fenstanton and Fen Drayton, and between Longstanton and Willingham. Patches of undifferentiated 2nd and 1st Terrace Deposits are mapped at the
edge of the Ouse valley and spreads of Alluvium occur in the main valley and in two low-lying depressions south of Fen Drayton and Over.

### 4.2 5km Square TL 230/65 Fenstanton

#### 4.2.1 Synopsis

This five-kilometre square contains 16 monads with 56 points (Figures 4.2.1-1 & 4.2.1-2). The area includes the villages of Fenstanton and Fen Drayton to the north, Conington at the centre, and Boxworth to the southeast. The area includes the part of the site known as Woolpack Farm investigated by Gao (1997) and Gao et al. (2000), and the A14 road, which provides a significant number of data points.

#### 4.2.2 Drainage and relief

This square comprises the edge of the plateau area to the south at c.40m OD, drained by several small streams. The valley of the River Great Ouse (5-10m OD) runs along the northern edge of the square from Galley Hill in the west to Low Fen and Far Fen in the east. South of Fen Drayton there is a low-lying depression that drains north into the Ouse valley.

#### 4.2.3 Geology

The bedrock geology largely comprises Oxford Clay, Elsworth Rock and Ampthill Clay overlain by Kimmeridge Clay in the area near Boxworth. These beds broadly dip towards the southeast (Figures 4.2.3-1 & 4.2.3-2). The Quaternary geology comprises Boulder Clay (till) on the edge of the plateau area and 3rd Terrace Deposits at Fenstanton, Fen Drayton and Conington. Undifferentiated 2nd and 1st Terrace Deposits are mapped east of Galley Hill and south of Fen Drayton.

#### 4.2.4 Geological Logs and Sections

##### 4.2.4.1 Synopsis

The 56 points were all from secondary sources and comprise 29 records from the British Geological Survey Mineral Assessment Report (Gatliff 1981), 24 records from the Highways Agency archives, 2 records from the Huntingdon Memoir (Edmonds & Dinham, 1965), and 1 record from Gao (1997) and Gao et al. (2000).

##### 4.2.4.2 Geological Section 30/65.1

This section (Figure 4.2.4-1) follows the line of the A14 road for 6km from Galley Hill to Friesland Farm. It provides a detailed record of the drift geology from the undifferentiated 2nd and 1st Terrace Deposits at Galley Hill, to the 3rd Terrace Deposits at Fenstanton and the Alluvium of the low-lying depression south of Fen Drayton.
At Galley Hill crossroads, several points (36NW40, 36NW39, 55, B54) record 3m of gravel and sand overlying bedrock Oxford Clay at c.3m OD. It is proposed that this gravel unit is formally named the **Galley Hill Gravel**, with the stratotype at 36NW39 (TL 3036 6889). To the east, point 36NW38 records clay with gravel overlying the gravel unit, and at point 53 near Manor Farm 2m of sandy clay with pebbles overlies 1m of gravel and sand on bedrock Oxford Clay at 5m OD. This sandy clay unit appears to be alluvium associated with the West Brook/Hall Green Brook, and it is proposed that it is formally named the **Manor Farm Sandy Clay**, with the stratotype at point 53 (TL 3058 6878). Further to the east, point 51 records a similar stratigraphy, and at B50 and 36NW36 1m of sandy clay overlies 3m of clayey gravel on bedrock at 2m OD. Alluvium is marked at this point in the valley of the West Brook on the geology map (Figure 4.2.3-1).

At Oxholme Farm, Fenstanton, four points (36NW35, 36NW34, B47, 46) record the transition to a somewhat different sequence at the edge of the 3rd Terrace Deposits. Point B47 records 1m of sandy clay overlying 3m of gravel and sand, which in turn overlies 1m of sandy silty clay on bedrock at c.2m OD. This silty clay unit appears to be in a very similar stratigraphic position to the interglacial Woolpack Farm Beds defined by Gao (1997) and Gao et al. (2000) from the pit at Woolpack Farm (see Section 3.2.4.5). In contrast, the adjacent point B47 records 1m of clayey gravel and sand overlying 2m of silt, overlying 3m of gravel and sand on bedrock Oxford Clay at c.2m OD. Point 36NW34 records 3m of organic silty clay with shells covered with topsoil with a surface height of c.10 m OD. Nearby, point 46 also records organic silty clay with shells overlain by a gravel unit and 1m of sandy clay.

To the east at Model Farm, Fenstanton, points 36NW33, 36NW32, 43/1 and 43 record a similar sequence to that at point 46 (Oxholme Farm), except that the ground surface is at c.12m OD. Point 36NW15 records the full thickness of these deposits with 2m of clayey gravel and sand overlying 5m of organic silty clay on bedrock Oxford Clay at c.3m OD. It is proposed that this silty clay unit is formally named the **Model Farm Silty Clay**, with the stratotype at 36NW15 (TL 3179 6816). Further east, points 36NW29 and B39 record 5m of clayey gravel and sand on bedrock at c.3m OD. It appears that this gravel occupies a channel-form incised into the underlying silt unit. Gao (1997) recognised this gravel unit and named it the Fenstanton (Gravel) Member with an approximate stratotype location of TL 3200 6800. It is proposed that this gravel unit is formally named the **Fenstanton Gravel**, with a revised stratotype at 36NW29 (TL 3210 6800).

Further along the A14 road near The Bungalows, Fen Drayton, several points record the silty clay unit previously described from Oxholme Farm and Model Farm. Point 35 shows that the silty clay is overlain by 3m of clayey sand and gravel, while points 36NW27 and 34/1 record the unit to be a organic silt with shells 1m thick. This silt unit is underlain by
2m of clayey gravel and sand on bedrock Ampthill Clay at c.6m OD. Gao (1997) formally named the gravel unit beneath the interglacial silts at Woolpack Farm the Fen Drayton (Gravel) Member, defined from a stratotype at TL 320 680 in a borehole section along the A14 road that approximates to the section under discussion here. Unfortunately, none of the points near the grid reference given by Gao (near Model Farm) exhibit a gravel unit beneath the silt. Four points in this section (B47, 34/1, 36NW27, 36NW16) clearly show the basal gravel unit, and the author suggests that point 34/1 (TL 3275 6772) should be defined as the revised stratotype for the Fen Drayton Gravel.

To the east, point 36NW16 records 6m of clayey gravel and sand overlying 3m of organic silt with shells, in turn overlying 1m of gravel and sand on bedrock Oxford Clay at c.2m OD. The edge of the 3rd Terrace Deposits is marked at point 34 by Ampthill Clay outcropping near the surface beneath topsoil at c. 12m OD.

Further east, point 33 records 1m of sandy silty clay overlying gravel and sand on the floor of the low-lying depression south of Fen Drayton, while point B32 records 2m of clayey gravel and sand overlying bedrock Ampthill Clay in a similar position. The remaining points (31, 29, 29/1, 28) record Ampthill Clay close to the surface beneath topsoil on the ascending slope towards Friesland Farm. Only point 29 records sandy clay above the bedrock.

4.2.4.3 Geological Section 30/65.2

This 2.5km-long section (Figure 4.2.4-2) runs northwards from the Woolpack Farm pit, across Galley Hill crossroad towards Cullum Farm on the outskirts of Hemingford (WF3 to 36NW5). Point WF3 records 3m of gravel and sand on bedrock Oxford Clay at c.3m OD. Gao et al. (2000) named the upper part of this gravel unit the St. Ives (Gravel) Member, and separated it from the underlying Hemingford (Gravel) Member on the basis of clast lithology. The original stratotype for the St. Ives (Gravel) Member was defined from an arbitrary location in the centre of Woolpack Farm pit (Gao 1997). The author therefore proposes that the St. Ives Gravel should be given a revised stratotype at point WF3 (TL 3003 6841). As observed in Section 3.2.4.5, it is not possible to separate the St. Ives Gravel and Hemingford Gravel using borehole logs and very difficult to distinguish them in field sections. Nevertheless, Gao (1997) has presented strong evidence for the existence of the St. Ives Gravel elsewhere in the Ouse valley.

Further north towards Galley Hill crossroads point 57 records 1m of Made Ground over gravel, probably marking the position of a back-filled pit. Points 36NW10 and B56 record 1m of sandy clay with pebbles overlying 1m of sand and gravel on bedrock at c.4m OD. The gravel and sand at points 36NW39, 36NW40 and B54, 55 At Galley Hill, points near Galley Hill has been described above. Further north near Stepping Stone Bridge point 36NW3 shows 1m of sandy clay overlying sand and gravel on bedrock at c.1m OD. A
similar sequence is recorded at point 36NW1 where 5m of gravel and sand overlies bedrock at 0m OD, and at Cullum Farm, point 36NW5 records 7m of gravel and sand on bedrock Oxford Clay at −1m OD. It is proposed that this gravel unit is formally named the **Cullum Farm Gravel**, with the stratotype at 36NW5 (TL 3063 6997).

**4.2.4.4 Geological Section 30/65.3**

This 2km-long section runs roughly south-north from Hilton Road (36NW14) through Manor Farm to Lower Road (36NW4) (Figure 4.2.4-2). Point 36NW14 is located near the edge of the spread of undifferentiated 2nd and 1st Terrace Deposits and records 1m of sandy clay overlying 3m of gravel and sand on bedrock at c.3m OD. Further north near Manor Farm point 51 also records sandy clay over gravel, but at Hall Green Farm point 36NW11, only 2m of clayey gravel and sand on bedrock Oxford Clay at c.3m OD are recorded. Point 36NW4 on Lower Road shows 1m of sandy clay overlying 2m of clayey gravel and sand on bedrock at c.3m OD.

**4.2.4.5 Geological Section 30/65.4**

This 2km-long section is aligned roughly south-north from Model Farm, Fenstanton, (B41 to 36NW30) through Church Farm (36NW12) to Fen Lane (36NW6) (Figure 4.2.4-3). Point B41 records 1m of sandy clay overlying 1m of clayey gravel and sand on bedrock Oxford Clay at c.8m OD. This sequence contrasts markedly with that at 36NW29 and B39 which record 5m of clayey gravel and sand on bedrock at c.3m OD, in a channel-form incised into underlying sediments. Evidence of this can be seen at point 36NW30 where gravel overlies 4.5m of silty clay, which in turn overlies a clayey gravel and sand on bedrock at c.6m OD. Further north at Church Farm, point 36NW12 records 2m of clayey gravel and sand on bedrock at c.8m OD. Beyond the edge of the 3rd Terrace Deposits, point 36NW6 at Fen Lane on the floodplain of the River Great Ouse shows 3m of sandy clay overlying 2m of clayey gravel and sand on bedrock Oxford Clay at c.0m OD. The sandy clay unit is probably alluvium, and it is proposed that it is formally named the **Fen Lane Sandy Clay**, with the stratotype at 36NW6 (TL 3269 6966).

**4.2.4.6 Geological Section 30/65.5**

This 3km-long section is aligned southwest-northeast from The Bungalows, Fen Drayton, (36NW16) through Fen Drayton village (36NW13) to Low Fen and Far Fen (36NW7 to 36NW9) on the floodplain of the River Great Ouse (Figure 4.2.4-3). Point 36NW16 records 7m of gravel and sand overlying 3m of organic sandy silty clay with shells, in turn overlying 1m of gravel and sand on bedrock at c.1m OD. This 10m long sequence represents the full thickness of the 3rd Terrace Deposits in this area. To the northeast in Fen Drayton village, point 36NW13 records 6m of clayey gravel and sand overlying bedrock at c.2m OD. On the edge of Low Fen, point 36NW7 records 1m of
sandy clay overlying 3m of gravel and sand on bedrock at c.1m OD. The sandy clay unit is probably alluvium, and present at point 36NW8 in Far Fen where it overlies 2m of gravel and sand on bedrock at c.2m OD. Further north, point 36NW9 records 1m of sandy clay overlying 5m of clayey gravel and sand on bedrock Oxford Clay at c.-2m OD.

4.2.4.7 Geological Section 30/65.6

This 2.5km-long section is aligned southwest-northeast from New Bams Farm (36NW19) to the low-lying depression south of Fen Drayton near St. John’s College Farm (36NW17) (Figure 4.2.4-4). The point near New Barn’s Farm (36NW19) is located in an area mapped as 3rd Terrace Deposits, and shows 1m of sandy clay overlying 1m of clayey gravel and sand on bedrock Ampthill Clay at c.9m OD. To the northeast at point B32 on the A14 road 1.5m of gravel overlie bedrock at c.6m OD. South of St. John’s College Farm point 36NW18 records sandy clay over 1m of clayey gravel on bedrock Ampthill Clay at c.4m OD in an area mapped as undifferentiated 2nd and 1st Terrace Deposits. Further north, at the edge of the low-lying depression point 36NW17 records 1m of sandy clay overlying 1m of clayey gravel on bedrock Oxford Clay at c.3m OD.

4.3 5km Square TL 235/65 Swavesey

4.3.1 Synopsis

This five-kilometre square contains 14 monads with 99 points (Figures 4.3.1-1 & 4.3.1-2). The area includes the village of Swavesey to the west, Longstanton to the east, and the outskirts of Over to the north and Willingham to the northeast. The area includes a short stretch of the A14 road and the site known as Manning’s Farm investigated by Gao (1997) which provides the majority of points in this square. Figure 4.3.1-3 shows the detailed distribution of points in monad 239/69.

4.3.2 Drainage and relief

This square comprises a low-lying depression (c.5 OD) known as Cow Fen at its centre surrounded by low hills to the south at 15-20m OD, and confined to the east and west by low ridges at 5-10m OD, and by low hills (c.15 OD) to the north. Cow Fen drains into Mow Fen in the floodplain of the River Great Ouse through a narrow outlet west of Over.

4.3.3 Geology

The bedrock geology largely comprises Ampthill Clay, overlain by Kimmeridge Clay in the area south of Longstanton. These beds broadly dip towards the southeast (Figures 4.3.3-1 & 4.3.3-2). The Quaternary geology comprises Boulder Clay (till) and Glacial Gravel on the low hills south of Over, and small patches of 4th Terrace Deposits are mapped at Cold Harbour Farm, Willingham, and at Longstanton. A spread of 3rd Terrace
deposits occupy the ridge that runs south-north between Longstanton and Willingham, and undifferentiated 2nd and 1st Terrace Deposits are mapped at Church End, Swavesey. Alluvium at c.5m OD is mapped in the Ouse valley at Mow Fen and in Cow Fen east of Swavesey.

4.3.4 Geological Logs and Sections

The 99 points were all from secondary sources and comprise 9 records from the British Geological Survey Mineral Assessment Report (Gatliff 1981), 9 records from the Highways Agency archives, 2 records from the Huntingdon Memoir (Edmonds & Dinham, 1965) and 79 records from Gao (1997).

4.3.4.1 Geological Section 35/65.1

This section (Figure 4.3.4-1) runs west-east from Mow Fen, through Over End and Cold Harbour Farm, to Willingham village. It provides a record of the drift geology from the Alluvium of the floodplain in the Ouse valley, the Boulder Clay (till) and Glacial Gravel at Over, and various Terrace Deposits at Willingham.

At Mow Fen, point 36NE1 records 1m of silty clay overlying 3m of gravel and sand on bedrock Oxford Clay at c.1m OD. It is proposed that this gravel unit is formally named the **Mow Fen Gravel**, with the stratotype at 36NE1 (TL 3601 6980). To the east at Over End, point 36NE3 is located on a low ridge at c.13m OD. It records 2m of clayey gravel and sand overlying 12m of chalky pebbly diamict on bedrock Ampthill Clay at c.-1m OD. It is proposed that the gravel unit here is formally named the **Over End Gravel**, with the stratotype at 36NE3 (TL 3762 6968). This is problematic in that Gao (1997) chose to name sediments in the nearby borehole CH1 (see Section 4.3.4.3) the ‘Cold Harbour Farm Member’. The sequence at CH1 is a poorly developed analogue of many points at Manning’s Farm which present better potential stratotypes and is ill-placed to provide an unambiguous distinction between deposits of the BGS 4th and 3rd Terraces. The author will therefore not use the name ‘Cold Harbour Farm Member’ in the sense defined by Gao (1997) for correlative purposes. To the east in Willingham village, excavations in 1964 for a trench at Willingham Pumping Station revealed 3m of gravel and sand overlying 2.5m of sandy silty clay with pebbles on bedrock Ampthill Clay at c.1m OD. It is proposed that the gravel unit is formally named the **Willingham Gravel**, with the stratotype at point WPS (TL 3990 6998). These deposits yielded several fragments of bone, which will be discussed below. This point is adjacent
to a patch of deposits attributed by the BGS to the 2nd Terrace, although the elevation and nature of the deposits is very similar to the nearby 3rd Terrace Deposits at Manning’s Farm.

4.3.4.2 Geological Section 35/65.2

This 5km-long section (Figure 4.3.4-2) runs roughly east-west from Church End, Swavesey (36NE2) through Cow Fen and Hill Farm to Manning’s Farm, Willingham (36NE7). It provides a record of the drift geology from the undifferentiated 2nd and 1st Terrace Deposits at Church End, the Alluvium of the Cow Fen depression, the Boulder Clay (till) and Glacial Gravel at Hill Farm, and various Terrace Deposits at Manning’s Farm.

Data point 36NE2 records 2.5m of clayey gravel and sand on bedrock Ampthill Clay at c.1m OD. It is proposed that this unit is formally named the Church End Gravel, with the stratotype at 36NE2 (TL 3570 6930). To the southeast in Cow Fen, point 36NE5 records 2m of sandy clay on bedrock at c.1m OD. This sandy clay unit is probably alluvium, and it is proposed that it is formally named the Cow Fen Sandy Clay, with the stratotype at 36NE5 (TL 3693 6877). Further into Cow Fen point 36NE8 records sandy clay overlying 1.5m of clayey gravel on bedrock at c.2m OD. To the northeast at Hill Farm the land rises to form a low ridge at c.17m OD. Point 36NE6 records 1m of sandy clay overlying 1m of gravel and sand, in turn overlying 18m of diamict with chalk fragments. It appears that the diamict here occupies a deeply incised channel-form that runs northwest towards point 36NE3 at Over End. It is proposed that this unit is formally named the Hill Farm Diamict, with the stratotype at 36NE6 (TL 3838 6904).

Further to the east at Manning’s Farm, adjacent to a patch of 4th Terrace Deposits mapped by the BGS, point MNB4 records 1.5m of flinty gravel and sand. However, point MNB1 nearby records 1m of sandy clay described by Gao (1997) as ‘loessic silt’ overlying 1m of chalky diamict. Downslope, point MNB43 records only 0.5m of clay with gravel on bedrock Ampthill Clay at c.10m OD, and point MNB44 shows a complex sequence with 1m of clay with gravel overlying gravel interbedded with silty clay on bedrock at c.9m OD. Point MNB45 records clay with gravel over gravel and sand. These records coincide with the edge of the 3rd Terrace mapped by the BGS. To the east, point 36NE7 records 2m of sandy clay over 0.5m of gravel and sand on bedrock Ampthill Clay at c.5m OD.

4.3.4.3 Geological Section 35/65.3

This 1km-long section runs northwest-southeast from Cold Harbour Farm (36NE4 and CH1) through various points at Manning’s Farm (MNB7-2 to MNB65) (Figure 4.3.4-3). Point 36NE4 records 2.5m of clayey gravel and sand overlying bedrock at c.11m OD. Downslope, point CH1 shows 2m of gravel and sand, on 0.5m of silty clay, in turn overlying gravel and sand. Both of these points fall within a patch of deposits mapped by
the BGS as 4th Terrace, but in this section they appear superficially contiguous with the 7m sequence of flint dominated gravel and sand on bedrock at c.3m OD recorded at point MNB7-2 mapped by the BGS as 3rd Terrace. It is for this reason that the author considers the stratotype proposed by Gao (1997) for the ‘Cold Harbour Farm Member’ at CH1 unsound (see Section 4.3.4.1). Point MNB18 merely records clay with gravel, and MNB20 shows clay with gravel over silty clay. However, point MNB19 records a complex sequence with 1m of clay with gravel over gravel and sand interbedded with silty clay. Point MNB70 records clay with gravel over gravel and sand, but nearby point MNB59 records bedrock Ampthill Clay near the surface at c.7m OD beneath clay with gravel. Point MNB56 records clay with gravel over 1m of gravel and sand, and point MNB58 records 1m of clay with gravel over gravel on bedrock Ampthill Clay at c.5m OD. Point MNB65 records gravel and sand near the surface.

4.3.4.4 Geological Section 35/65.4

This 1km-long section runs northwest-southeast from Cold Harbour Farm (CH3) through various points at Manning’s Farm (MNB7 to MNB68) (Figure 4.3.4-3). Point CH3 records clay with gravel over gravel and sand. Downslope, point MNB7 shows clay with gravel over bedrock Ampthill Clay near the surface at c.9m OD and point MNB71 merely records clay with gravel. In contrast, point MNB21 records clay with gravel on 3m of silty clay overlying 2m of gravel and sand, in turn overlying 1m of chalky diamict. The base of this borehole is at c.1m OD although bedrock was not encountered. Point MNB21 is crucial in that it establishes the presence of a gravel unit beneath the silty clay, but overlying diamict. It is proposed that this gravel unit is formally named the Manning’s Farm Gravel, and that the diamict unit is formally named the Manning’s Farm Diamict, both with the stratotype at MNB21 (TL 3958 6940). Points between MNB37 and MNBP34 record various combinations of clay with gravel overlying gravel and sand, and silty clay. However, point MNBP1 shows 2m of flint dominated gravel and sand overlying 2m of silty clay, in turn overlying 2m of gravel and sand. This tripartite sequence can be clearly identified beneath the 3rd Terrace surface in other sections at Manning’s Farm. Points MNB69 and MNB61 record clay with gravel overlying gravel and sand, but point MNB68 records clay with gravel on bedrock Ampthill Clay at c.7m OD.

4.3.4.5 Geological Section 35/65.5

This 1km-long section runs northwest-southeast from Cold Harbour Farm (CH2) through various points at Manning’s Farm (MNB6 to MNB26) (Figure 4.3.4-3). Point CH2 records diamict overlying bedrock Ampthill Clay at c.11m OD. To the southeast, points MNB6 and MNBP2 record bedrock Ampthill Clay close to the surface at c.9m OD.
beneath various deposits described as diamict, sandy clay and flint dominated gravel, and point MNB12 shows 1m of diamict on bedrock at c.8m OD. In contrast, point MNB11 records 1m of clay with gravel on 1m of gravel and sand overlying 3m of silty clay, in turn overlying 1m of chalky diamict. The adjacent point MNB41 records a similar sequence, but with 3m of silty clay overlying gravel and sand at c.2m OD. Other points in the section record a similar sequence, most notable of which is MNB29 showing 1m of clay with gravel on gravel and sand overlying 4m of silty clay, in turn overlying gravel and sand at c.1m OD. Several other points in this section (MNB28, MNB27, MNB26) also contact the gravel unit beneath the silty clay.

4.3.4.6 Geological Section 35/65.6

This 1km-long section runs southwest-northeast through Manning’s Farm (MNBP3 to MNB19) to Willingham Village (WPS) (Figure 4.3.4-4). Point MNBP3 records 1m of clay with gravel overlying bedrock Ampthill Clay at c.11m OD. To the north, points MNB2 and MNB1 record 1m of sandy clay described by Gao (1997) as ‘loessic silt’ overlying 1m of diamict. Downslope, MNB23 shows 2m of clay with gravel overlying bedrock Ampthill Clay at c.8m OD. In contrast, point MNB22 records 1m of clay with gravel on gravel and sand overlying 5m of silty clay, in turn overlying 1m of gravel and sand, overlying diamict at c.-1m OD. This sequence of silty clay was investigated in detail by Gao (1997) from the adjacent point MNB54, which records 4.5m of silty clay over gravel and sand. The author carried out pollen analysis (Figures 4.4.1-1 and 4.4.1-2) on the silty clay sequence from MNB54. Gao (1997) named the silty clay unit the Manning’s Farm Beds with a stratotype at TL 3998 6925. This is the position of the farm buildings themselves, rather than a stratotype log; the author proposes here that MNB54 (TL 3952 6926) should be the revised stratotype for the Manning’s Farm Beds. Point MNB8 also records gravel and sand beneath silty clay, but point MNB21 shows clay with gravel on 3m of silty clay overlying 2m of gravel and sand, in turn overlying 1m of chalky diamict. Points MNB37 and MNB19 record a tripartite sequence of gravel on silty clay overlying gravel and sand. Further to the north, point WPS records 3m of gravel and sand overlying 2.5m of sandy silty clay with pebbles on bedrock Ampthill Clay at c.1m OD. This section shows the correlation between the deposits at WPS mapped as 2nd Terrace by the BGS and the various 3rd Terrace Deposits at Manning’s Farm.

4.3.4.7 Geological Section 35/65.7

This 3km-long section runs north-south from Longstanton (36NE9) through Hatton Farm (HFtrench) and various points at Manning’s Farm (MNB44 to MNB59) (Figure 4.3.4-4). Point 36NE9 records 6m of gravel and sand on bedrock Ampthill Clay at c.1m OD, beneath 1m of sandy clay. To the northwest at Hatton Farm, point HFtrench records
2m of gravel and sand over 3m of silty clay. Gao (1997) named this unit the 'Longstanton (Gravel) Member' with the stratotype at Hatton Farm (TL 396 673). The author believes that for correlation purposes a more prudent approach would be to name the gravel unit the Longstanton Gravel with a stratotype at 36NE9 (TL 3981 6702) and to name the silty clay unit at Hatton Farm, the Hatton Farm Silty Clay with a stratotype at HFtrench (TL 3960 6740). To the north, a group of points record the deposits at Manning’s Farm. MNB44 shows clay with gravel over gravel and silty clay on bedrock Ampthill Clay at c.8m OD. Nearby, points MNB46, MNB48 and MNB51 record sandy clay over gravel and sand. However, MNB53 and MNB 52 show 1m of silty clay overlying gravel and sand. Several other points in the section record a similar sequence, most notably MNB57 which has 1m of clay with gravel on gravel and sand overlying 2m of silty clay, in turn overlying gravel and sand at c.3m OD. Bedrock Ampthill Clay is recorded near the surface at c.7m OD beneath clay with gravel at point MNB59.

4.3.4.8 Geological Section 35/65.8

This 2km-long section runs northwest-southeast along the line of the A14 road from point 27 to point 19 (Figure 4.3.4-5). Points 27 and 26 record topsoil on bedrock Ampthill Clay at c.18m OD. To the southeast near Trinity Foot bedrock Ampthill Clay is again near the surface at c.13m OD. However at point 21, 1m of clay with gravel overlies bedrock at c.14m OD. Downslope, a similar thickness of clay with gravel was recorded from points 20 and 19 on bedrock Ampthill Clay.

4.3.4.9 Other Data Points

At Bar Farm, point HD34/1 records 2m of gravel and sand overlying bedrock Ampthill Clay at c.11m OD. Nearby, point HD34/2 records over 1m of gravel and sand on bedrock at a similar elevation. Gravel is not recorded at either location on the geology map. It is proposed that this gravel unit is formally named the Bar Farm Gravel, with the stratotype at HD34/1 (TL 3880 6540).

4.4 Site Description 5km Square TL 235/56

4.4.1 Manning’s Farm, Willingham

4.4.1.1 Introduction

Deposits at Willingham were first brought to the attention of the scientific community when an excavation for a trench at Willingham Pumping Station in 1964 (point WPS) revealed 3m of gravel and sand overlying 2.5m of sandy silty clay with pebbles. This unit was initially interpreted as a ‘Boulder Clay’ (Gao 1997), although various bones were subsequently collected from these deposits. Cunhai Gao and the author originally
prospected at Manning's Farm in 1994 in the hope of locating similar deposits and establishing the relationship between the 4th and 3rd Terraces mapped by the BGS. With the help and encouragement of the farmer Mr R. Manning, 70 boreholes were put down across the farm. These boreholes succeeded in locating a 4.5m-long sequence of silty clays (point MNB54), on which the author carried out pollen analysis (see Section 4.3.4.6).

4.4.1.2 Environments of deposition

The diamict (Manning's Farm Diamict) identified at the base of the sequence at Manning's Farm may be an in situ remnant occupying a channel-form similar to that identified at Over End and Hill Farm. The river that deposited the overlying basal gravel (Manning's Farm Gravel) appears to have deeply incised both the diamict and bedrock alike, showing that it post-dates the emplacement of the diamict. Gao (1997) describes the silty clays of the Manning's Farm Beds as lake deposits occupying an asymmetrical basin whose formation he attributes to periglacial thermokarst activity. The author is in fundamental disagreement with this interpretation of the Manning's Farm Beds. It is much more likely that these deposits represent lateral fluvial accretion and overbank deposits of a low-energy river channel. Their apparent confinement to a 'basin' is due to their subsequent removal by the incision of a braided stream, which deposited the upper gravel (Willingham Gravel).

4.4.1.3 Pollen

The author carried out eighteen pollen analyses from the 4.5m sequence of silty clays of the Manning Farm Beds at point MNB54 (Gao 1997) (Figures 4.4.1-1 and 4.4.1-2). In general, the pollen assemblage is characterised by frequencies of Poaceae (grass) between 40% and 60%, Pinus (pine) 40% and relatively high proportions of Corylus (hazel) and Quercus (oak), and Carpinus (hornbeam) towards the top of the sequence. Gao (1997) cites the high proportion of grass pollen as evidence of local flooding and grazing by large mammals. Gao recognised four pollen assemblage biozones representing a vegetational succession through the sequence and tentatively correlated them with pollen zones Ip I to IV of the Ipswichian interglacial (MIS 5e). If this interpretation is correct, the sequence represents one of the most complete pollen sequences for the Ipswichian in southern England. Gao considers that correlation with MIS 7 cannot be completely ruled out. The author is inclined to agree with the Ipswichian interpretation and envisages the environment of deposition as a broad grassy floodplain with mixed oak woodland on dry ground above the valley floor.

4.4.1.4 Molluscs & Beetles

According to Gao (1997), Keen and Coope's personal communications (1995) of preliminary molluscan and coleopteran analyses of samples of silty clay from Manning’s
Farm confirmed the temperate nature of the deposits, but gave no particular clues to their age.

4.4.1.5 Vertebrates

Bones were recovered from the trench excavated at Willingham Pumping Station in 1964 (Gao 1997). The lower jaw and tusk fragments of *Palaeoloxodon antiquus* (straight-tusked elephant) were found *in situ* from the sandy silty clay unit (Manning’s Farm Beds) and indicate a temperate woodland habitat. A scapula attributed to *Coelodonta antiquitatis* (rhinoceros) was recovered *in situ* from the gravel and sand unit (Willingham Gravel) overlying the silty clay, and remains of *Equus, Bison* and *Cervus elephas* were also collected.

4.4.1.6 Conclusions

It is clear from these analyses that the Manning’s Farm Beds were deposited during a substantial part of an interglacial period, most probably the Ipswichian (MIS 5e). The absence of independent dating of these deposits suggests that this correlation must be treated with a degree of caution.

4.5 5km Square TL 35/60 Bar Hill

4.5.1 Synopsis

This five-kilometre square contains 7 monads with 24 points (Figures 4.5.1-1 & 4.5.1-2). The area includes the villages of Lolworth and Bar Hill to the north, Dry Drayton at the centre, and Madingly to the southeast. The A14 road provides a significant number of points in this square.

4.5.2 Drainage and relief

This square comprises the edge of the plateau area to the south at 60-70m OD, drained by several small streams including the Callow Brook. These streams are all tributaries of the River Great Ouse. The northern edge of the square from is relatively low-lying (c.15m OD).

4.5.3 Geology

The bedrock geology largely comprises Ampthill Clay, Kimmeridge Clay, Lower Greensand and Gault Clay overlain by Lower Chalk in the area near Madingly. These beds broadly dip towards the southeast (Figures 4.5.3-1 & 4.5.3-2). The Quaternary geology comprises Boulder Clay (till) on the plateau area.
4.5.4 Geological Logs and Sections

4.5.4.1 Synopsis

The 24 points were all from secondary sources comprising 20 records from the Highways Agency archive and 4 from the British Geological Survey Well Catalogue Series (Matthews and Harvey, 1965).

4.5.4.2 Geological Section 35/60.1

This section (Figure 4.5.4-1) follows the line of the A14 road for 3.5km from Hill Farm Cottages (point 18) past Bar Hill to Hacker’s Fruit Farm (point 187/141). It provides a detailed record of the geology across a range of bedrock strata (Figures 4.5.3-1 & 4.5.3-2).

Between Hill Farm Cottages and Lolworth Spring, several points (18, 17 and 16/1) record bedrock Ampthill Clay at between c.16m and c.19m OD beneath topsoil. Further east near Bar Hill, point 16 records clayey gravel and sand over bedrock Kimmeridge Clay at c.21m OD. Kimmeridge Clay is also recorded near the surface at point 15, and beneath 1m of Made Ground at point B11. However, point A604/10 records 2m of sandy clay possibly derived from the adjacent Lower Greensand outcrop overlying bedrock Kimmeridge Clay at c.17m OD. Nearby, point A604/9/1 shows clay with gravel overlying 1m of gravel and sand, in turn overlying 1m of silty clay with sandy pockets on bedrock Lower Greensand at c.16m OD. It is possible that this is a fluvial deposit, rather than soliflucted material derived directly from the Lower Greensand outcrop. Points A604/9 to 187/141 at Hacker’s Fruit Farm record bedrock Gault Clay near the surface at elevations between 16m and 19m OD.

4.5.4.3 Geological Section 35/60.2

This 4.5km-long section (Figure 4.5.4-2) runs roughly south-north from Hacker’s Fruit Farm, through Dry Drayton to Madingley village (A604/6 to b5035). Points A604/6 and A604/7 record bedrock Gault Clay near the surface at c.18m. Point 187/120 (Dry Drayton) shows bedrock Gault Clay at c.22m OD, while point 187/113 near Short Nursery Plantation, Madingley, shows bedrock Gault Clay at c.24m OD. In contrast, point 187/144 near Madingley Hall records 12m of diamict on bedrock Gault Clay at c.33m OD. In Madingley village points a5032, b5035 and b5033 record the edge of this diamict unit on bedrock Gault Clay at c.31m OD. It is proposed that this unit is formally named Madingley Diamict, with the stratotype at 187/144 (TL 3910 6030).
4.6 Correlation of Stratigraphic Units

5km Squares TL 230/565, TL 235/65 and TL 235/60

4.6.1 Synopsis

Figure 4.6.1-1 and Table 4.6.1-1 show details of the 22 local stratigraphic units proposed for the 5km Squares TL 230/565, TL 235/65 and TL 235/60. Most of these units occupy positions on the valley floor or valley side. Several units occupy relatively elevated positions on ridges above the valley of the River Great Ouse, and the Madingley Diamict occupies a ridge that is part of a high plateau area. Table 4.6.1-2 and Figure 4.6.1-2 show the chronological and stratigraphic relationships of these units and their correlation with lithostratigraphic members and formations. Figure 4.6.1-3 presents an idealised geological section through the area showing the relationships of the various lithostratigraphic members.

The Hill Farm Diamict, Manning’s Farm Diamict and Madingley Diamict are correlated with the Barrington Works Member of the Lowestoft Formation and are interpreted as Anglian (MIS 12) till. The position of the Barrington Works Member on both the high plateau area and occupying incised buried channel-forms should be noted. The other stratigraphic units belong to the Ouse Valley Formation (see Table 1.4.2-1). The Cold Harbour Farm Gravel at point 36NE4 becomes the stratotype for the Cold Harbour Farm Member and is correlated with the Over End Gravel. These elevated gravels directly overlie chalky diamict of the Barrington Works Member. They are interpreted as fluvial deposits of an ancient and now much-dissected river system belonging to the early part of the ‘Wolstonian’ interval (MIS 9/10) or possibly Late Anglian (MIS 12). In contrast the Fen Drayton Gravel at point 34/1, becomes the stratotype of the Fen Drayton Member, and occupies a buried channel clearly beneath the temperate fines of the Woolpack Farm Member. It is correlated with the Manning’s Farm Gravel and is interpreted as braidplain deposits of the River Great Ouse dating from the later part of the ‘Wolstonian’ interval (MIS 6/7).

The Model Farm Silty Clay, Manning’s Farm Beds and Hatton Farm Silty Clay are correlated with the Woolpack Farm Member, and interpreted as Ipswichian (MIS 5e) and Early Devensian (MIS 5a/d) partly temperate fluvial fine-grade deposits. The overlying Fenstanton Gravel at point 36NE29 becomes the stratotype for the Fenstanton Member and shows a clear erosional contact with the underlying fines. It is correlated with the Willingham Gravel and the Longstanton Gravel, and interpreted as elevated braidplain gravels of the River Great Ouse of probable Early Devensian (MIS 4) age. The St. Ives Member/Hemingford Member is incised into the Fenstanton Member, and interpreted as
Middle to Late Devensian (MIS 2/3) braidplain deposits of the River Great Ouse. They are correlated with the Galley Hill Gravel, St. Ives Gravel, Cullum Farm Gravel, Mow Fen Gravel, Church End Gravel, and the somewhat elevated Bar Farm Gravel attributed to tributary deposition. These gravels are partly overlain by the Manor Farm Sandy Clay, Fen Lane Sandy Clay and Cow Fen Sandy Clay, which are correlated with the Ouse Member, and interpreted as Flandrian (MIS 1) alluvium of the River Great Ouse floodplain.

A degree of uncertainty exists about the exact age of the Cold Harbour Farm Member, although it clearly post-dates the emplacement of the Barrington Works (till) Member. There is also apparently a significant interval of time not represented between the early and later parts of the ‘Wolstonian’ interval. The Fen Drayton Member, Woolpack Farm Member, Fenstanton Member, Hemingford Member and Ouse Member form a discrete package of sediments with an internally consistent chronology that can be observed at various locations within this 10km square, and in the neighbouring 5km Square 225/65.
Chapter 5

10km Square TL 240/560

Histon and Cottenham

What saith the river to the rushes grey,
Rushes sadly bending,
River slowly wending?
Who can tell the whispered things they say?
Youth, and prime, and life, and time,
For ever, ever fled away!

AEOLIAN HARP.
William Allingham
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Histon and Cottenham

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5.1 10km Square TL 240/560

5.1.1 Synopsis

This ten-kilometre square is located at the northern edge of the main study area and contains 57 monads with data (Figure 5.1.1-1). The area includes the villages of Oakington and Girton to the west, Waterbeach, Milton and Horningsea to the east, Girton, Histon and part of Cambridge to the south, and Cottenham near the centre. The valley of the River Cam (c. 5m OD) runs south to north across the southeast corner of the square. Much of the square is relatively low lying (c. 5-15m OD) and of subdued relief, although the land rises towards the southwest reaching c. 35m OD near Madingley.

5.1.2 Drainage

The drainage of this area is generally northwards towards the River Great Ouse, which flows west-east just beyond the northern boundary of the square. Although the River Cam flows across the southeast corner of the square, tributaries of the River Great Ouse drain the majority of the area.

5.1.3 Bedrock geology

The bedrock geology comprises Jurassic Ampthill Clay and Kimmeridge Clay, overlain by Cretaceous Lower Greensand, Gault Clay and Lower Chalk. These beds dip broadly towards the southeast (Figure 5.1.3-1), although there is some evidence for a monoclinic disturbance in the region between Cottenham and Landbeach.

5.1.4 Quaternary geology

The Quaternary geology mapped by the BGS (Figure 5.1.3-1) comprises two areas of 'Observatory Gravels' south of Girton and various patches of 4th Terrace Deposits between Cambridge and Oakington. In addition, a broad spread of 3rd Terrace Deposits has been mapped from northern Cambridge through Histon and Oakington to Willingham in the north. A similar but distinct spread of 2nd Terrace Deposits can be identified stretching...
from Cambridge through Milton, to beyond Landbeach. 1st Terrace Deposits and Alluvium are recorded along the Cam floodplain.

5.2 5km Square TL 240/565 Rampton

5.2.1 Synopsis

This five-kilometre square contains 13 monads with 19 points (Figures 5.2.1-1 & 5.2.1-2). The area includes the village of Rampton at the centre, Cottenham to the east, part of Longstanton to the west, Oakington and Westwick to the southwest and part of Willingham to the northwest.

5.2.2 Drainage and relief

Drainage of this area is generally towards the northeast. The Beck Brook and Reynolds Ditch unite near Rampton to feed an artificial watercourse, the New Cut, that runs across the low-lying (c.3m OD) Little and Great North Fen, and in turn feeds Cottenham Lode. Smithey Fen Engine Drain and Catch Water Drain also intercept water in this area. These watercourses are all tributaries of the River Great Ouse, whose valley runs c.2km further north. Cottenham village occupies a low ridge (c.12m OD) above the surrounding fen, and a small area south of Oakington Barracks reaches c.15m OD.

5.2.3 Geology

The bedrock geology comprises Ampthill Clay and Kimmeridge Clay overlain by Lower Greensand and Gault Clay broadly dipping towards the southeast (Figures 5.2.3-1 & 5.2.3-2). The Quaternary geology comprises 4th and 3rd Terrace Deposits at c.10-15m OD near Longstanton and Willingham and various fragments of 2nd Terrace Deposits at lower elevations north of Westwick and in Great North Fen. Patches of Alluvium are mapped south of Rampton and in Great North Fen.

5.2.4 Geological Logs and Sections

5.2.4.1 Synopsis

The 19 points were all from secondary sources. These include 16 records from the British Geological Survey Mineral Assessment Report (Dixon 1980), one record from the British Geological Survey Well Catalogue Series (Matthews and Harvey, 1965), and 2 records from Gao (1997).
5.2.4.2 Geological Section 40/65.1

This section (Figure 5.2.4-1) runs roughly 5km north-south from Willingham (46NW2) through Oakington barracks to Westwick (46NW7). It provides a record of the drift geology of the 3rd and 4th Terrace Deposits (Figures 5.2.3-1 & 5.2.3-2).

Data point 46NW2 near the disused windmill at Willingham is located on ground mapped by the BGS as 2nd Terrace Deposits. It shows 1m of sandy clay overlying 1.5m of gravel and sand on bedrock Ampthill Clay at c.3m OD. A kilometre to the south point 46NW2 near West Field, Willingham, records 6m of gravel and sand on bedrock at c.1m OD. This appears to represent part of a buried channel beneath the 3rd Terrace surface that should be compared with the geological sections described from Manning’s Farm, Willingham (see Section 4.4.1). It is proposed that this gravel unit is formally named the West Field Gravel, with the stratotype at point 46NW2 (TL 4010 6900).

North of New Farm, point 46NW3 records 2m of gravel and sand on bedrock Ampthill Clay at c.6m OD, and to the south, point 46NW4 shows sandy clay overlying 2m of gravel and sand containing a 0.5m thick bed of silty clay. In the vicinity of Nether Grove, points HFpond and HFbh record sandy clay overlying gravel and sand 1.5m thick. Point 46NW5 records 4m of gravel and sand overlying 1m of silty clay, in turn overlying 1m of gravel and sand on bedrock Kimmeridge Clay at c.2m OD. At Oakington Barracks point 46NW17 shows 1m of Made Ground on 6m of gravel and sand, overlying silty clay on bedrock at c.2m OD. This appears to mark the position of a buried channel beneath what is mapped as the 4th Terrace surface. It is proposed that this gravel unit is formally named the Oakington Barracks Gravel, with the stratotype at point 46NW17 (TL 4075 6657).

Nearby, point 46NW16 records 2m of gravel and sand overlying 1.5m of silty clay on bedrock Kimmeridge clay at c.5m OD. Further south, point 46NW6 shows 0.5m of sandy clay overlying 2m of gravel and sand on bedrock at c.6m OD. At Westwick, point 46NW7 records 1m of clay with gravel overlying silty clay on bedrock at c.11m OD.

5.2.4.3 Geological Section 40/65.2

This 5km-long section (Figure 5.2.4-2) runs southwest-northeast from Oakington (46NW6) towards Great North Fen (46NW13). North of Oakington, point 46NW6 records 0.5m of sandy clay overlying 2m of gravel and sand on bedrock Kimmeridge Clay at c.6m OD in an area mapped as 3rd Terrace Deposits. Nearby, point 46NW8 shows sandy clay on 2m of gravel and sand overlying 1m of silty clay, in turn overlying 3m of gravel and sand on bedrock at c.2m OD. This is presumably part of the same buried channel identified at Oakington Barracks to the northwest (see Section 5.2.4.2). A kilometre to the northeast,
point 46NW9 at Westwick Field shows 2m of Made Ground on bedrock at 4m OD. This probably represents the location of a past pit or excavation possibly working the 2nd Terrace Deposits mapped here by the BGS. At North Fen Farm, point 46NW10 records 1m of gravelly clay overlying gravel and sand on bedrock at c.2m OD, and the BGS map this area as a broad spread of Alluvium. It is proposed that this unit is formally named the **North Fen Farm Gravelly Clay**, with the stratotype at point 46NW10 (TL 4319 6739). In Great North Fen, point 46NW12 shows bedrock Kimmeridge Clay near the surface at c.2m OD beneath 1m of fen edge soil and at point 46NW13 silty clay overlies 1m of gravel and sand on bedrock at c.1m OD.

5.2.4.4 Geological Section 40/65.3

This 2km-long section (Figure 5.2.4-2) runs northwest-southeast from Iram Farm (46NW11) into Great North Fen (46NW13). At Iram Farm, point 46NW11 records 1.5m of sandy clay overlying 1m of gravel and sand with clay bands on bedrock Kimmeridge Clay at c.1m OD. It is proposed that the gravel unit is formally named the **Iram Farm Gravel**, with the stratotype at point 46NW11 (TL 4358 6985). To the east in Great North Fen, point 46NW14 shows 1m of grey/organic silty clay on bedrock at c.1m OD. This area is shown as Alluvium on the BGS map. It is proposed that this silty clay unit is formally named the **Great North Fen Silty Clay**, with the stratotype at point 46NW14 (TL 4473 6941). Nearby, point 46NW13 records silty clay overlies 1m of gravel and sand on bedrock at c.1m OD.

5.3 5km Square TL 240/560 Girton

5.3.1 Synopsis

This five-kilometre square contains 21 monads with 352 points (Figures 5.3.1-1 & 5.3.1-2). The area includes the village of Oakington to the north, Histon and Impington to the east, Cambridge to the south, Madingley to the southwest and Girton near the centre. The area includes the M11 and A14 Roads and important sites investigated by the author at Histon Road Allotments and Christ’s Sports Ground, which provide a large number of points in this square. Figure 5.3.1-3 shows the detailed distribution of points in monad 244/61 containing the site at Histon Road Allotments and Figure 5.3.1-4 shows the distribution of points in monad 243/60 containing the site at Christ’s Sports Ground.

5.3.2 Drainage and relief

The drainage of the square is generally towards the north. The Washpit Brook and Beck Brook are tributaries of the River Great Ouse some 8km to the north, and drain a relatively low-lying (c.10-20m OD) clay catchment. The River Cam runs to the south and
east of the square, but only land in the eastern part of the square drains towards it. The highest land in the square (c.35m OD) is at the extreme southwest near Madingley.

5.3.3 Geology

The bedrock geology comprises Jurassic Kimmeridge Clay overlain by Lower Greensand, Gault Clay and Lower Chalk broadly dipping towards the southeast (Figures 5.3.3-1 & 5.3.3-2). The Quaternary geology comprises several broad spreads of ‘Observatory Gravels’ (c.20-25m OD) near Girton, 3rd Terrace Deposits 10-15m OD) near Histon running south-north across the square, and fragments of 4th Terrace Deposits at c.15-20m OD. Small patches of Alluvium and 2nd Terrace Deposits are also mapped between Histon and Oakington.

5.3.4 Geological Logs and Sections

5.3.4.1 Synopsis

The 352 points comprise 91 collected by the author, 29 from the British Geological Survey Mineral Assessment Report (Dixon 1980), 9 from the British Geological Survey Well Catalogue Series (Matthews and Harvey, 1965), 23 from the Cambridge Memoir (Worssam and Taylor, 1969), 50 from various contractors’ reports, and 121 from the Highways Agency archives. In addition at Histon Road, 10 records were gleaned from Hollingworth et al. (1950), 9 records came from Walker (1953) and two records came from Sparks and West (1959). At Christ’s Sports Ground, 8 records came from Marr and King (1932).

5.3.4.2 Geological Section 40/60.1

This 5.5km-long section (Figure 5.3.4-1) runs west-east along the line of the A14 and A428 Roads from Trinity Cottages at Madingley (point b5034) through Girton village to a point east of Impington Farm (a5113). It provides a detailed record of the ‘Observatory Gravels’ and 3rd Terrace Deposits in this area.

Data point b5034 at Trinity Cottages records 1m of chalky diamict overlying 2m of sandy clay on bedrock Gault Clay at c.29m OD. A diamict is also recorded overlying bedrock at points a5037 and a5038 lower down the slope. This material is certainly reworked from the outcrop of Boulder Clay (till) mapped by the BGS at Madingley to the southwest. South of Bulls Close, points a5039 to b5058 record bedrock Gault Clay near the surface beneath sandy clay and topsoil. In the valley floor of the Washpit Brook, point b5061 shows 2m of silty clay with pebbles overlying bedrock at c.9m OD. This presumably represents Flandrian alluvium from this stream. On the eastern side of the valley, points b6053 to b5073 show bedrock close to the surface (c.14m OD) beneath
topsoil. However, point b5069 records 2m of silty clay with pebbles on Gault Clay at c.12m OD.

To the east near Girton College, the land rises steeply to points b5075a and a5075, which record 1m of clay with gravel and gravel and sand on bedrock at c.19m OD. Across the top of the ridge (c.21m OD) between Girton College and Girton village, points b5076a to b5079 record 4.5m of gravel and sand on bedrock Gault Clay at c.17m OD, in an area mapped as ‘Observatory Gravels’ by the BGS. However, point b5077b shows a relatively thick sequence with 6m of gravel and sand overlying 2m of silty clay, in turn overlying 5m of clayey gravel and sand on bedrock at c.9m OD. The depth and confined nature of this channel-form is similar in many ways to the deep channels filled with glacio-lacustrine sediments that occur near Whittlesford in the Cam valley (see Section 11.3). It is proposed that the upper gravel unit here is formally named the **Girton College Gravel**, the silty clay unit is formally named the **Girton Village Silty Clay**, and that the lower gravel unit is named the **Girton Village Gravel**, all with a stratotype at point b5077b (TL 4238 6141).

To the east, points b5081 to b5091 record Gault Clay bedrock near the surface beneath topsoil. Near Woodhouse Farm, point b5093 shows 1m of silty clay with gravel, and nearby point 46SW143 records clay with gravel over 6m of gravel and sand containing a bed of organic laminated silty clay. The gravel unit rests on bedrock Gault Clay at c.5m OD. It is proposed that this unit is formally named the **Woodhouse Farm Gravel** with the stratotype at point 46SW143 (TL 4370 6157). It is clear that there is a considerable bedrock channel beneath the 3rd Terrace Deposits that can be traced for a kilometre along the line of the A14 Road. Points from b5095 to b5105 record 1m of clay with gravel overlying gravel and sand 5m thick on bedrock at c.6m OD. To the east, beyond the Histon Road junction, points a5109 to a5113 appear to record the edge of the bedrock channel. Point 46SW145 records sandy clay overlying 2m of gravel and sand on bedrock at c.10m OD.

### 5.3.4.3 Geological Section 40/60.2

This 5km-long section (Figure 5.3.4-2) runs northwest-southeast along the line of the A14 and M11 Roads from Catch Hall (point A604/3) to the valley of the Washpit Brook (point 195) south of Girton. Point A604/3 records sandy clay, and gravel and sand on bedrock Gault Clay at c.17m OD, and nearby, point A604/2 shows 1m of clay with gravel. Near Catch Hall in the valley of the Beck Brook point A604/1 records 1m of Made Ground on bedrock at c.13m OD. To the southeast near Grange Farm, points 218 to 214 record 2m of sandy silty clay on bedrock at 12-13m OD. Interestingly, at point 216 1.5m of diamict is recorded beneath silty clay resting on bedrock at c.12m OD. This material is several kilometres from the nearest Boulder Clay (till) mapped by the BGS, and may in fact...
represent a diamict derived from periglacial activity. This interpretation is perhaps strengthened by the presence of clay with gravel at point b114 and to the southeast (points 213 to b112). At point b112, 4m of clay with gravel are recorded resting on bedrock Gault Clay at c.11m OD. Since it seems likely that the sandy silty clay, diamict and clay with gravel are all facies of the same unit, it is proposed that the clay with gravel is formally named the **Grange Farm Gravelly Clay** with the stratotype at point b112 (TL 4115 6158). To the southeast of the A428 Road into the valley of the Washpit Brook, points 210 to 195 record bedrock Gault Clay near the surface beneath clay with gravel and topsoil.

### 5.3.4.4 Geological Section 40/60.3

This 4km-long section (Figure 5.3.4-3) runs roughly northwest-southeast along the line of the Huntingdon Road from the junction of the M11 motorway (188/237) to point 196HR opposite the offices of NIAB (National Institute for Agricultural Botany). Point 188/237 records bedrock Gault Clay near the surface beneath topsoil at c.15m OD. To the east, point 211 records clay with gravel and point b112 shows 4m of clay with gravel on bedrock Gault Clay at c.11m OD. In the valley of the Washpit Brook, points 210 to b5068 record only clay with gravel and topsoil on bedrock Gault Clay. Upslope at Girton College point CD87/2 shows 3m of gravel and sand not touching bedrock at c.19m OD. To the southeast at Trinity Farm, points TrFmN and TrFmS show 1m of clay with gravel on bedrock at c.21m OD. A similar situation is shown by points CRC3 to 189HR on Huntingdon Road, but opposite NIAB (points trenchB to 196HR) bedrock Gault Clay is near the surface beneath topsoil at c.22m OD.

### 5.3.4.5 Geological Section 40/60.4

This 5km-long section (Figure 5.3.4-4) runs north-south from Oakington (46SW134) through Girton village to Girton College (46SW135). It provides a detailed record of the 3rd Terrace Deposits and ‘Observatory Gravels’ across this square. Point 46SW134 at Oakington records 1m of sandy clay overlying 8m of olive/grey silty clay with sand, in turn overlying 1m of diamict on bedrock Gault Clay at c.-3m OD. This represents a substantial buried channel beneath the 3rd Terrace Deposits. The silty clay unit is interesting in that it is similar to that described from the site at Histon Road Allotments. The presence of a diamict on the floor of the channel-form at c.-3m OD is intriguing, since the nearest Boulder Clay (till) mapped by the BGS is about 4km to the west at c.30m OD. It is proposed that the silty clay unit is formally named the **Oakington Silty Clay** with the stratotype at point 46SW134 (TL 4189 6473). To the south, points CD119/1 to 46SW163 record clay with gravel, and gravel and sand on bedrock at 8-9m OD at the edge of the 3rd Terrace. Nearby at Camboro Farm, points 46SW160 to 46SW169 show only topsoil over bedrock Gault
Clay at 9-11m OD. At Red House Farm, points G11 to G8 record clay with gravel overlying 1m of silty clay, in turn overlying 4m of gravel and sand on bedrock at 11-12m OD. The sequence at point G2 is well developed, and it is proposed that the gravel unit is formally named the **Red House Farm Gravel** with the stratotype at point G2 (TL 4228 6252). To the south in Girton village, points CD88/1 to CD88/2 record 1m of gravel and sand, overlain in part by clay with gravel, resting on bedrock at 18-19m OD. In contrast, points b5085 to 188/272 show Gault Clay bedrock close to the surface beneath topsoil on the slope rising towards Howe Farm. Point CD87/2 shows 3m of gravel and sand, and to the south point 46SW135 records 2m of gravel and sand on bedrock at c.21m OD. It is proposed that this gravel unit is formally named the **Howe Farm Gravel** with the stratotype at point 46SW135 (TL 4256 6041).

### 5.3.4.6 Geological Section 40/60.5

This 5.5km-long section (Figure 5.3.4-5) runs roughly west-east from Catch Hall (A604/2) to Histon village (46SW147). It provides a record of the 3rd Terrace Deposits in this area. Point A604/2 at Catch Hall records 1m of clay with gravel on bedrock at c.15m OD. Downslope towards Camboro Farm, points 188/200 to 46SW160 show Gault Clay bedrock near the surface beneath topsoil. Points 46SW163 and 46SW137 record clay with gravel near the surface beneath topsoil. Points 46SW163 and 46SW137 record clay with gravel over 2m of gravel and sand on bedrock at c.5m OD at the edge of the 3rd Terrace. Nearby at Girton Crossing, point 46SW138 records 6m of gravel and sand overlying 6m of silty clay, in turn overlying 4m of chalky diamict with limestone and igneous pebbles. Bedrock was not reached, although the base of the borehole was at c.-6m OD. The silty clay unit at this point shows obvious similarities with that at the Histon Road site, and the diamict flooring a deeply buried channel is identical to that previously described. It is proposed that the gravel unit is formally named the **Girton Crossing Gravel**, that the silty clay unit is named the **Girton Crossing Silty Clay**, and that the diamict unit is named the **Girton Crossing Diamict**, all with the stratotype at point 46SW138 (TL 4277 6388). To the northeast, point 46SW139 shows 2m of gravel and sand on bedrock at c.8m OD, and in Histon village point 46SW162 records bedrock Gault Clay near the surface beneath topsoil at c.10m OD. To the east, point CD112/5 shows 3m of gravel and sand in a northward extension of the 3rd Terrace, and point 46SW147 records 1m of clay with gravel on bedrock at c.10m OD.

### 5.3.4.7 Geological Section 40/60.6

This 3km-long section (Figure 5.3.4-6) runs roughly west-east from Red House Farm (188/28) to Impington village (188/34). It provides a record across the ‘Observatory Gravels’, 4th Terrace Deposits and 3rd Terrace Deposits in this area. Point 188/28 shows
1m of unknown drift on bedrock Gault Clay at c.18m OD. Nearby at Red House Farm, points G12 to G7 record clay with gravel over silty clay, and gravel and sand on bedrock at 11-12m OD in an area mapped by the BGS as the ‘Observatory Gravels’. Adjacent to Red House Farm, points CD88/3 and GirCh show 3m of gravel and sand not touching bedrock at c.15m OD. To the east at Bower’s Farm, point 46SW141 records 3m of gravel and sand on bedrock at c.11m OD, and point CD107/6 also shows gravel in an area mapped as 4th Terrace Deposits. At Park Farm in an area mapped as 3rd Terrace Deposits, points HS.3 to HS.4 record 3m of clay with gravel overlying 4m of silty clay not touching bedrock at c.4m OD. In contrast, point HS.2 shows 1m of silty clay overlying 1m of gravel and sand on bedrock Gault Clay at c.9m OD. To the east in Impington village, point CD112/1 records 6m of gravel and sand on bedrock at c.5m OD, and nearby point 46SW157 shows 8m of gravel and sand on bedrock at c.6m OD. It is proposed that this gravel unit is formally named the Impington Village Gravel with the stratotype at point 46SW157 (TL 4390 6308). Point IBS to the east also records gravel and sand, although point 188/34 records bedrock Gault Clay near the surface beneath topsoil at c.12m OD despite being located in an area mapped as 4th Terrace Deposits by the BGS.

5.3.4.8 Geological Section 40/60.7

This 5.5km-long section (Figure 5.3.4-7) runs roughly north-south from Girton Crossing (46SW138) to Christ’s Sports Ground (BH1). It provides a record of the 3rd Terrace Deposits and 4th Terrace Deposits in this area. Point 46SW138 at Girton Crossing, records 6m of gravel and sand overlying 6m of silty clay, in turn overlying 4m of diamict not touching bedrock at c.-6m OD. To the southwest near Park Farm, point 46SW140 records 6m of silty clay overlying 1m of gravel and sand on bedrock at c.5m OD. Nearby, points HS.1 and HS.3 show 3m of clay with gravel overlying 5m of silty clay. However, point HS.5 shows 2m of sandy clay overlying 2m of gravel and sand. Further south, point 46SW142 records 8m of gravel and sand on bedrock Gault Clay at c.3m OD. Near Woodhouse Farm, point b5094 shows 1m of clay with gravel and point 46SW143 records clay with gravel overlying 6m of gravel and sand containing abed of organic laminated silty clay on bedrock at c.5m OD. In contrast, to the south points CD111/5 and CD111/4 show 1m of silty clay. In an area mapped by the BGS as 4th Terrace Deposits, points e16 and 188/329 show 3m of gravel and sand on bedrock at c.15m OD. Gravel is also recorded at 19-20m OD near NIAB at points TPA and BH21. On Christ’s Sports Ground points BH18 to BH1 show 1m of clay with gravel on bedrock Gault Clay at 18-19m OD.
5.3.4.9 Geological Section 40/60.8

This 4km-long section (Figure 5.3.4-8) runs roughly west-east from the M11 motorway (point 196) across NIAB on Huntingdon Road to Histon Road Allotments (HRTP1). It provides a record through the ‘Observatory Gravels’, 4th Terrace Deposits and 3rd Terrace Deposits in this area. Point 196 records bedrock Gault Clay near the surface at c.12m OD near the M11 motorway in the valley of the Washpit Brook. To the east, point 46SW135 records 2m of gravel and sand on bedrock at c.21m OD. Nearby at Trinity Farm, points TrFmN and TrFmS show 1m of clay with gravel on bedrock at c.21m OD. A similar situation is shown by points CRC3 to CRC1 near NIAB. However, points BH17 and BH13 record 2m of clay with gravel overlying bedrock at c.18m OD, although point BH15 and BH14 show much thinner gravelly deposits with bedrock near the surface at c.20m OD. Gravel is also recorded at 19-20m OD at point TPA, and points e16 and 188/329 show 3m of gravel and sand on bedrock at c.15m OD. To the east at Histon Road Allotments, point B-1959 (a borehole made by Sparks and West, 1959) records 1m of gravel and sand overlying 6m of silty clay, in turn overlying gravel not touching bedrock at c.5m OD. The silty clay unit at this site has produced temperate plant macrofossils, pollen and molluscs (Hollingworth et al. (1950), Walker (1953), Sparks and West, (1959)) and is formally named as the Histon Road (Silty Clay) Member in Bowen (1999). The stratotype location given by Bowen (1999) is not precise, and it is proposed that point B-1959 (TL 4438 6110) should be the revised stratotype for this unit. It is also proposed that the gravel unit underlying the silty clay is formally named the Histon Road Gravel, with a stratotype also at point B-1959. The generalised sequence shown by points A-1959 to HRTP1 is a sandy clay over 2m of gravel and sand overlying 4m of silty clay, in turn overlying gravel and sand 1m thick. To the west of the site the sequence thins as the surface of the Gault Clay bedrock rises to c.10m OD at point HRTP1.

5.3.4.10 Geological Section 40/60.9

This 5.5km-long section (Figure 5.3.4-9) runs roughly north-south from Histon (46SW162) through Impington and Histon Road Allotments to the Aldi Site on Histon Road (ALDIH). In Histon village, point 46SW162 records bedrock Gault Clay near the surface beneath topsoil at the edge of the 3rd Terrace. To the south, points CD107/7 shows 2m of gravel and sand, and point CD112/4 records 7m of gravel and sand not touching bedrock at c.3m OD. Nearby, point CD112/3 records 4m of gravel and sand. A similar situation is apparent at point 46SW157, where 8m of gravel and sand rest on bedrock at
c.6m OD. From these data it is clear that a substantial gravel filled buried channel is present beneath the 3rd Terrace near Histon village.

In Impington village, point CD112/2 shows 1m of silty clay on bedrock Gault Clay at c.11m OD and nearby points CD107/3 and CD107/4 record 1m of silty clay overlying 2m of gravel and sand. To the south at Millfield Farm, point a5106b shows 2m of gravel and sand on bedrock at c.13m OD. This area is slightly more elevated than the surrounding terrace surface and has been mapped as 4th Terrace Deposits by the BGS. Point a5106a near Impington Farm records 1m of clay with gravel overlying a similar thickness of gravel and sand on bedrock at c.11m OD. To the south, points a5106 to a5107a record 1m of clay with gravel overlying 5m of gravel and sand on bedrock at 6-7m OD. From this evidence, it appears that there is a gravel filled bedrock channel-form in this area. To the south at Histon Road Allotments, points A-1953 to I-1953 (taken from a geological section described by Walker, 1953) show 2m of gravel and sand overlying 3m of silty clay. The presence of a buried channel at this site is confirmed by point A-1959 (Sparks and West, 1959), which records 1m of gravel and sand overlying 6m of silty clay, in turn overlying gravel not touching bedrock at c.5m OD. Further south, point PSc1 records sandy clay overlying 1m of silty clay on bedrock at c.13m. Nearby, points PSc2 and PSc3 show sandy clay and silty clay 3m thick, although points LHCi and LHCii record bedrock Gault Clay near the surface beneath gravel and Made Ground at c.15m OD. At the Aldi development site on Histon Road, points ALDITP4 to ALDIH showed sandy clay 1m thick overlying Gault Clay bedrock at 18-19m OD.

5.3.4.11 Geological Section 40/60.10

This 1km-long section (Figure 5.3.4-10) runs roughly southwest-northeast from Huntingdon Road (189HR) across NIAB (e16). It provides a detailed record at the edge of the 4th Terrace Deposits. Point 189HR records bedrock Gault Clay near the surface beneath topsoil at c.22m OD. To the northeast at NIAB points BH20 to BH18 shows 1m of clay with gravel on bedrock at c.19m OD. Nearby, points BH21 and TPA show gravel and sand near the surface beneath topsoil, and points 188/329 and e16 shows 3m of gravel and sand on bedrock at c.15m OD.

5.3.4.12 Geological Section 40/60.11

This 1km-long section (Figure 5.3.4-10) runs roughly southwest-northeast from Huntingdon Road (177HR) across NIAB (e16). Points 177HR and NIAB2 record bedrock Gault Clay near the surface beneath topsoil and Made Ground at c.21m OD. To the northeast near NIAB and Christ's Sports Ground point BH9 shows 1m of clay with gravel on bedrock at c.18m OD. In contrast, point BH11 shows a similar thickness of silty clay,
and at point BH12 3m of yellow, white and laminated silty clay overlie gravel and sand not touching bedrock at c.16m OD. Nearby, points BH11 and BH2 show gravel and sand near the surface beneath topsoil, although point 46SW144 records 2m of clay with gravel overlying gravel on bedrock at c.17m OD. Further northeast, points 188/329 and e16 shows 3m of gravel and sand on bedrock at c.15m OD.

5.3.4.13 Geological Section 40/60.12

This 1km-long section (Figure 5.3.4-10) runs roughly southwest-northeast from Huntingdon Road (196HR) across Christ's Sports Ground (BH3). Point 196HR records bedrock Gault Clay near the surface beneath topsoil at c.22m OD. To the northeast at Christ's Sports Ground points BH1 and BH4 show 2m of clay with gravel on bedrock at c.17m OD. In contrast, point BH7 records bedrock close to the surface beneath clay with gravel at c.19m OD, and nearby point PF1B shows 2m gravel and sand on bedrock at c.16m OD. Marr and King (1932) described a geological section from this, and other points nearby. This gravel unit was formally named the Huntingdon Road (Gravel) Member in Bowen (1999). The stratotype location in Bowen (1999) is not precise, and it is proposed that point PF1B (TL 4372 6031) should be the revised stratotype for this unit. Points BH6 and BH5 record 1m of silty clay overlying gravel and sand, and points PF1C and PF1E show 2m of gravel and sand not touching bedrock at c.16m OD. To the northeast, point BH3 records gravel and sand at the surface beneath topsoil.

5.3.4.14 Geological Section 40/60.13

This 1km-long section (Figure 5.3.4-11) runs roughly west-east across the Histon Road Allotments site. It provides a detailed record of the 3rd Terrace Deposits in this area. Points A-1959 to BHA show sandy clay over 3.5m of gravel and sand overlying 5m of silty clay, in turn overlying 1m of gravel and sand on bedrock at 5-7m OD. This section incorporates data from a geological section (A-1950 to J-1950) described by Hollingworth et al. (1950). It seems clear that gravel filled channels have been cut into the surface of the silty clay unit, so that in some places the silty clay is rather thin, but elsewhere it is thicker and reaches the surface.

5.3.4.15 Geological Section 40/60.14

This 1km-long section (Figure 5.3.4-11) runs roughly south-north across the Histon Road Allotments site. This section (points X6 to CD111/1) shows a similar sequence to that described in 40/60.13. It is clear that the bedrock surface rises to the north so that at point F1, sandy clay overlies 1m of gravel and sand on Gault Clay at c.10m OD. At this point the silty clay unit appears to be completely cut away by the overlying gravel unit.
5.3.4.16 Geological Section 40/60.15

This 1km-long section (Figure 5.3.4-11) runs roughly south-north across the Histon Road Allotments site (points BHA to CD111/1). It appears that the edge of the bedrock channel filled by these deposits is located to the north, and that the surface of the silty clay unit has been incised by overlying gravel unit.

5.3.4.17 Geological Section 40/60.16

This 5.5km-long section (Figure 5.3.4-12) runs roughly north-south from north of Burgoynes Farm (46SW147) through Impington and Histon Road Allotments to the Aldi Site on Histon Road (ALDIH). It provides a record through the 4th Terrace Deposits and 3rd Terrace Deposits in this area. North of Burgoynes Farm, point 46SW147 shows 1m of clay with gravel overlying bedrock Gault Clay at c.10m OD in an area mapped by the BGS as 3rd Terrace. In contrast at Burgoynes Farm, points 46SW146 and CD107/8 record 2m of silty clay on bedrock at c.11m OD in an area mapped as 4th Terrace. To the south, point 188/34 shows bedrock Gault Clay close to the surface beneath topsoil at c.12m OD.

Further south at the edge of another patch of 4th Terrace Deposits near Impington village, points 46SW1 to 46SW2 record 1m of sandy clay on bedrock at c.14m OD. From point a5106b at Millfield Farm, the section follows the same line as described in Section 5.3.4.10.

5.4 Site Descriptions 5km Square TL 240/560

5.4.1 Histon Road Allotments

5.4.1.1 Introduction

In 1938 'shelly calcareous organic mud' was recovered from a 6m deep sewer trench dug along the Histon Road (Hollingworth et al., 1950) on a surface mapped by the BGS as belonging to the 3rd Terrace of the River Cam. The '1938 sample' yielded plant macrofossils, pollen and molluscs of a clearly interglacial character. In the winter of 1938-39, a trench connecting a pumping station to the main sewer was dug at right angles to the Histon Road, and the geological sections revealed were carefully recorded by Hollingworth et al. (1950) and are referred to herein as points A-1950 to I-1950. Samples from the connecting trench also yielded interglacial molluscs, plant macrofossils and vertebrate material. In 1949 a sewer trench was again opened on Histon Road some 150m north of the 1938 trench, and Hollingworth et al. (1950) collected a sample of 'sepia-coloured calcareous organic mud' from a depth of 5m. This material was successfully analysed for
pollen and is referred to as the ‘1949 sample’. Walker (1953) followed the excavation of the new sewer trench northwards and described a section, here referred to as points A-1953 to I-1953. Samples from this trench also yielded plant macrofossils, pollen and molluscs indicating interglacial conditions. Interest in these interglacial sediments led Sparks and West, (1959) to sink a borehole, referred to here as B-1959, in a field (now allotment land) close to both sewer trenches (see Section 5.3.4.9 ). These workers also recovered plant macrofossils, pollen and molluscs from the deposits, and carried out quite detailed analyses that led to various palaeoenvironmental reconstructions.

In 1996 the author was fortunate in being able to examine geological sections and procure samples from sewer trenches (points FI to F1 in particular) made during the development of part of the Histon Road Allotments site. The author was also able to put down a borehole (point BHA) to recover a continuous series of samples for various analyses. In addition, the developer kindly provided borehole and trial pit records from the adjacent area.

5.4.1.2 Environments of deposition

The relatively thin basal gravel unit at Histon Road Allotments appear to be confined to hollows and pockets in the bedrock surface. The author suggests that it may represent a ‘lag’ gravel left by an incising fluvial system. The down-cutting, which created a 5m deep channel-form at the site presumably occurred towards the end of a glacial period, since there was no appreciable gravel aggradation before the onset of interglacial sedimentation. The silty clay unit apparently represents overbank and channel deposition by a moderately-sized river, at first in fully temperate conditions and later in a cool temperate grassland environment. The overlying gravel unit has an erosional base channelled into the surface of the silty clay unit, and is thought to have been deposited by a braided stream under cold conditions.

5.4.1.3 Physical analyses and particle size distribution

The sequence of silty clay at point BHA was subjected to detailed physical and particle size analyses (Figures 5.4.1-1 and 5.4.1-2). The silty clay sequence at BHA was for the most part moderately rich in calcium carbonate (40-50%) and contained 5% organic material (Figure 5.4.1-1); significant quantities of detrital carbonate might be expected given the Chalk dominated catchment upstream. The amount of silicate residue was moderately high (40-50%) indicating in-wash from soils in the catchment. It is worth noting a small increase (c.60%) in silicate residue between 370 and 420cm accompanied by a corresponding decrease in calcium carbonate. More striking is the increase in silicate residue (up to c.80%) that occurs towards the top of the sequence (c.100cm). This clearly
indicates a marked increase in clastic silicate input to the fluvial system, possibly as a consequence of increased discharge. Given this pattern in the silicate residue, the magnetic susceptibility data is somewhat surprising. Much of the sequence (90 to 410 cm) has rather low magnetic susceptibility (0.1 to 0.5 SI units x 10^-8 (m^3 kg^-1)) which shows no response to the increase in silicate residue at the top of the core. This would suggest that the silicate clastics are largely composed of quartz and feldspathic material, rather than ferro-magnetic minerals. In contrast, the basal part of the core (below 410 cm) showed rather high magnetic susceptibility readings (0.6 to 4.1 SI units x 10^-8 (m^3 kg^-1)) completely unrelated to the proportion of silicate residue. It is clear that a source of ferro-magnetic minerals available to the river system in the basal part of the core was reduced abruptly above 410 cm.

The particle size distribution diagram for this sequence (Figure 5.4.1-2) also shows an abrupt change at 410 cm. At this point, the bimodal distribution of the underlying fine silts with a modal size of 7.5 Phi units (c. 6 μm) and medium sands with a modal size of 2 Phi units (c. 250 μm) is punctuated by a unit of coarse sand (< -0.5 Phi, > c. 1.4 μm). This may represent a higher energy fluvial event that may have caused an erosional horizon in the sequence. Above 410 cm, the coarser component becomes increasingly fine-grained, so that at 320 cm its modal size is 4.5 Phi units (c. 44 μm). This trend is interrupted by two episodes (380 & 350 cm) where the fine silt fraction (9 Phi, 2 μm) becomes more important. At 280 cm the sequence is again punctuated by a unit of coarse sand (0.5 Phi, c. 707 μm) before returning to a relatively uniform bimodal particle size distribution comprising fine silts with a modal size of 7.5 Phi units (c. 6 μm) and fine sand with a modal size of 3.5 Phi units (c. 88 μm) between 240 cm and 170 cm. Above 170 cm, coarser sandy in-wash (0.5 Phi, c. 707 μm) returns, probably indicating higher energy fluvial conditions.

During the excavation of sewer trenches across the site, the author arranged to have bulk samples of silty clay taken from known depths whenever possible. These large samples, 0.5 m across and with a volume of 100 litres, have been subjected to physical and particle size analyses (Appendices 3 and 4) to provide additional broad stratigraphic control. The silty clay from the bulk samples was moderately rich in calcium carbonate (50-70%), contained 6% organic material, and the amount of silicate residue was moderately high (30-50%). This material was similar in character to that from BHA. The magnetic susceptibility varied from 0.2 to 1.2 SI units x 10^-8 (m^3 kg^-1) and it is clear that samples from the base of the sequence (at or below 7.25 m OD) had the highest magnetic susceptibility readings (> 0.6 SI units x 10^-8 (m^3 kg^-1)). This accords with the pattern observed from BHA. The particle size distribution data for the bulk samples (Appendix 3) show silts and fine sands with modal sizes between 2.0 and 9.0 Phi (250 to 2 μm), many
with bimodal distributions. Several samples have elevated amounts of medium sand (0.0 to 2.0 Phi) indicating higher energy fluvial conditions. Taken as a whole, these particle size distributions are comparable to those from BHA (Figure 5.4.1-2).

### 5.4.1.4 Pollen analyses

Hollingworth, Allison and Godwin (1950) first carried out pollen analyses of the silty clay unit from the Histon Road site. Table 5.4.1-1 shows the pollen data from their Table II, recalculated as the percentage of land pollen and spores, rather than as the percentage of tree pollen. Material from a 6m deep sewer trench along Histon Road, known as the ‘1938 sample’, showed a pollen assemblage rich in *Quercus* (oak) (c.44%), and *Pinus* (pine) (c.36%), with subordinate *Carpinus* (hornbeam) (c.4%) and *Corylus* (hazel) (c.3%) and low frequencies of herbs. It was this clear mixed oak woodland signal, similar to Substage Ip II, that raised interest in these interglacial deposits. The exact location of this sample is not known, but it must have been close to point A-1950. Hollingworth et al. reported that a sample of ‘sepia mud’ from the pumping station sewer trench at a depth of 550cm (c.7.0m OD), probably point J-1950, ‘failed to reveal pollen’. In 1949, a sewer trench was again opened on Histon Road to the north of the pumping station where Hollingworth et al. procured several samples of ‘sepia mud’ from a depth of c.490cm (c.7.9m OD). These ‘1949 samples’ yielded pollen assemblages dominated by *Pinus* (28-48%), with *Carpinus* (9-12%), *Corylus* (3-18%), and significant frequencies of herbs (27-41%), including Poaceae (grass) (5-13%) (Table 5.4.1-1). These samples unequivocally represent interglacial material, although with much less oak pollen than the 1938 sample. Hollingworth et al. also reported that the calcareous muds from above these samples were very poor in pollen. The samples were probably taken near point I-1953, from the same sewer trench later investigated by Walker (1953). Hollingworth et al correlated these samples with the Ipswichian (MIS 5e) interglacial (Substages Ip II to III).

Walker (1953) produced the first pollen diagram from Histon Road (Figure 5.4.1-3). The author has recalculated the pollen data as the percentage of land pollen and spores, rather than as the percentage of tree pollen only. The sequence of samples analysed for pollen was taken from point I-1953. The pollen assemblages of the basal ‘sepia muds’ (460-540cm) is dominated by *Carpinus* (19-27%), with *Corylus* (11-14%) and *Pinus* (8-18%). Herb pollen is also important (35-45%), with Poaceae reaching (c.20%). In contrast, the pollen assemblages from the upper muds (260-360cm) are dominated by *Pinus* (up to 80%), with a little *Picea* (spruce) (c.3%), and with herb pollen making up most of the remaining sum. Steel girders supporting the trench prevented Walker (1953) sampling the intervening sediments. It is clear that the lower part of the Walker’s pollen diagram represents woodland of an interglacial character growing in the river catchment,
whereas the upper part of the sequence has an altogether more boreal aspect. Walker correlated the temperate part of his diagram with the Ipswichian (MIS 5e) interglacial (Substage Ip III).

Sparks and West (1959) sought to produce a more complete pollen diagram from the sediments at Histon Road by analysing material from a borehole (B-1959) close to the sewer trenches investigated by Hollingworth et al. (1950) and Walker (1953). Figure 5.4.1-4 shows the Sparks and West pollen diagram for trees and shrubs, and Figure 5.4.1-5 shows the frequencies of herbs and lower plants. The author has recalculated the pollen data as the percentage of land pollen and spores, rather than as the percentage of tree pollen only. Although 5m of silty clay produced countable pollen, it is notable that the basal part of the sequence (610-700cm) was found to be barren. The pollen assemblages of the ‘brown silty marl’ (510-600cm) is dominated by Poaceae (15-35%) with Carpinus (c. 10%), Corylus (5-10%), Quercus (c.5%), and Pinus (3-12%). This material is clearly of interglacial (Substages Ip II to III).character, although the high frequencies of herbs and Poaceae indicate the importance of local vegetation in the pollen signal. An abrupt change in the pollen assemblages at 500cm is marked in the sediments by a stony layer, although Sparks and West believed that it represented ‘no great unconformity’.

The pollen assemblages from the overlying silty marl (300-490cm) is dominated by herb pollen (50-85%), and particularly that of Poaceae (15-50%). The curve for Pinus increases from c.10% to a peak of 46% at 310cm accompanied by c.5% Betula (birch) above a band of silty sand at 350cm. These assemblages indicate an open boreal grassland and floodplain environment, with trees restricted to birch scrub and increasing stands of pine. The organic silty marl above this (160-300cm) is also dominated by herb pollen (65-80%), with Poaceae attaining 15-40%. There is some indication of a vegetational succession with Salix (willow) reaching c.5% at 290cm, followed by a peak in Betula (c.15%) at 260cm, and a rise in Corylus (c.15%) above 240cm. This is accompanied by low frequencies of Quercus (c.2%) and a falling Pinus curve (5-30%). Sparks and West (1959) dismissed this pattern as reworking of earlier sediments, rather than evidence of climatically driven vegetational change. Whilst the author accepts the possibility of reworking, this explanation requires that interglacial sediments with a particular pollen assemblage, possibly some 5m lower in the sequence, were exclusively exposed and eroded. In addition, the reworking hypothesis does not explain the apparent vegetational succession, and the complete absence of reworked material in the underlying herb dominated silty clay (310-490cm). On balance, the author concludes that the upper part of the sequence investigated by Sparks and West (1959) represents a climatic amelioration, although the Salix and Betula pollen might originate from dwarf species rather than trees. In addition,
the presence of *Corylus* type pollen may represent *Myrica gale* (bog myrtle) rather than *Corylus* itself.

In an attempt to correlate sediments across the Histon Road Allotments site, the author carried out pollen analysis of samples from borehole BHA. This point was located some 200m to the east of the Sparks and West borehole (B-1959) and the sewer trenches investigated by Hollingworth *et al.* (1950) and Walker (1953). Figure 5.4.1-6 shows the pollen diagram from borehole BHA for trees and shrubs, and Figure 5.4.1-7 shows the frequencies of herbs and lower plants. The pollen assemblage of the basal silty clay (420-500cm) is dominated by Poaceae (42-65%) with *Carpinus* (up to 5%) and *Corylus* (up to 5%), and low frequencies (c.2%) of *Quercus* and *Alnus* (alder). The frequency of *Pinus* varied from 5% to 25%. Although these sediments contain thermophilous arboreal pollen, it is by no means clear that they represent deposition during an interglacial. The total frequency of arboreal pollen excluding *Pinus* does not exceed 10%, and this appears rather low when compared with the interglacial portions of the other Histon Road pollen diagrams. It is conceivable that this thermophilous signal merely represents temperate woodland largely obscured by a strong local input of herbs and Poaceae on the river floodplain, although it might equally be interpreted as the reworking of temperate pollen. A bed of coarse sand abruptly terminates the weak thermophilous signal at 410cm. The pollen assemblage of the silty clay above this point (300-410cm) is dominated by Poaceae (55-65%) and other herbs, with a rising *Pinus* curve (5% to 15%) and low frequencies of *Betula* (c.2%). This is interpreted as an open grassland and floodplain environment, with boreal pine and birch scrub. It is worth noting the small peak of *Salix* (c.2%) at 320cm and the similarly small peak in *Corylus* (c.2%) at 290cm, although these frequencies are too low for any rigorous interpretation. A further bed of coarse sand punctuates the sequence at 280cm. The silt and sand above this (100-300cm) is dominated by herb pollen (60-85%), with Poaceae reaching 50-80%. However, the *Pinus* curve reaches a peak at 245cm (c.27%) before falling away towards the top of the core, with *Betula* (up to 3%) present at low frequencies. Notably, these sediments also contain pollen of *Picea* (2% to 8%). These assemblages are interpreted as a grassland and floodplain environment with birch scrub and stands of pine and spruce. Boreal forest with spruce is widely considered characteristic of the Chelford interstadial, dated to MIS 5c by Rendell *et al.* (1991).

The author also carried out pollen analysis of bulk samples taken from the sewer trenches (points F11 to F1) excavated across the Histon Road Allotment site during 1996. These data are shown in Table 5.4.1-2 (F11 to F10b) and Table 5.4.1-3 (F6a to X). It is clear that the pollen assemblages vary with depth, and fall into the various pollen assemblages identified above. The sample from 510-650cm at point F6a is notable in that
its pollen assemblage is dominated by *Carpinus* (c.25%), with subordinate amounts of *Poaceae* (c.22%), *Pinus* (c.10%), *Betula* (c.9%) and (*Quercus* (5%). It is the deepest sample, and the only one to be truly dominated by arboreal taxa representing late interglacial Substage III. Samples slightly higher in the sequence tend to have a strong arboreal signal, but are dominated by *Poaceae*. At point F11/10 the pollen from 475-525cm and 425-475cm, was dominated by *Poaceae*, with subordinate amounts of pine, hornbeam, hazel, ash and oak. A similar assemblage was obtained from 480-530cm at point F10a, and a thermophilous signal was also obtained from three samples taken from point F5 at 380-430cm. Higher in the sequence, the samples are generally dominated by *Poaceae* and herbs, with pine, birch and traces of thermophilous pollen, attributable to post-temperate Substage IV. Other samples are dominated by *Poaceae* with pine and occasionally spruce. Material from point F4 at 310-360cm produced an assemblage with *Poaceae*, c.12% *Pinus* and c.6% *Picea*. The boreal woodland signal from these sediments may allow correlation with the upper part of the BHA sequence, which also contained significant amounts of spruce pollen.

**5.4.1.5 Plant macrofossils**

The ‘1938 sample’ from a 6m deep sewer trench along Histon Road (near point A-1950) was analysed for plant macrofossils by Hollingworth, Allison and Godwin (1950). It yielded an assemblage dominated by aquatic and riparian herbs, but with some trees and shrubs including *Carpinus betulus* (hornbeam), *Cornus sanguinea* (dogwood), *Crataegus monogyna* (hawthorn), *Rosa* sp. (rose) and *Rubus cf. fruticosus* (bramble). Other samples from the pumping station sewer trench (near J-1950) added *cf. Acer* sp. (maple), *Sambucus nigra* (elder) and *Solanum dulcamara* (nightshade) to the list. Hollingworth et al. highlighted the significance of *Naias marina*, *N. minor* and *N. flexilis* from the sediments, and commented of the generally southern and Atlantic aspect of the assemblage. Walker (1953) analysed both the basal ‘sepia muds’ and the upper muds from the sewer trench on Histon Road (point I-1953), the former being richer in organic remains. Aquatic and riparian herbs also dominated the assemblage, and included many of the tree and shrubs taxa listed by Hollingworth et al. Notable differences are the addition of *Quercus* (oak) wood, and the absence of *Naias* spp. Walker concluded that the remains indicated extensive woodland with large clearings and marshes along the borders of streams.

Sparks and West (1959) carried out a more systematic analysis of plant macrofossils from their core (borehole B-1959), resulting in a detailed data set (their Table III) from approximately 200-700cm depth. The assemblage comprises a broad diversity of herbs and aquatic plants, and several arboreal taxa including *Carpinus betulus*, *Cornus sanguinea*, *Sambucus nigra* and *Solanum dulcamara*. Remains of *Naias* spp. were
apparently absent from these deposits. Sparks and West (1959) placed the herb taxa present into five ‘ecological groupings’ to aid palaeoenvironmental interpretation. They observed a transition from plants with a northern limit of distribution in the south of Scandinavia at the base of the core (430-630cm) to those that currently occur throughout Scandinavia at the top of the core (250-300cm). In addition, fragments of mosses recovered from the upper part of the sequence suggest a relatively cool temperate climate. Moreover, Sparks and West identified a succession of environments from the plant macrofossil assemblages, with marshland (at c.600cm) slowly becoming wetter towards stream conditions at 500cm, followed by a further alternation of marsh and stream environments at the top of the core (c.300cm). Several herbs, including *Apium graveolens* (fool’s watercress) and *Plantago maritima* (sea plantain) are suggestive of nearby maritime conditions, although there is no other corroborative evidence for this allusion.

5.4.1.6 Molluscs

Hollingworth, Allison and Godwin (1950) submitted samples from the main lithological units exposed in the pumping station sewer trench (near J-1950), and a sample from the Histon Road trench (the 1938 sample near Point A-1950) to A. S. Kennard for molluscan analyses. Kennard produced comprehensive analyses showing a diverse assemblage of aquatic, marshland and grassland taxa (Table 5.4.1-4). Indeed, Hollingworth *et al.* showed that these data inferred changing environments, with aquatic taxa dominant at the base of the sequence (c.480cm) and grassland taxa becoming more abundant towards the top (390cm and above) indicating different facets of a floodplain environment. In general, the climatic conditions indicated by these molluscan analyses were interpreted by Hollingworth *et al.* as ‘warm and possibly dry’, with a reduction in southern forms up the sequence. The most striking feature of these analyses is the occurrence of *Corbicula fluminalis* in a band (Bed E) at 300-370cm depth. It is important to realise that the occurrence of this taxon is exclusive to Bed E; it was not found in any of the other samples analysed (270-520cm). Hollingworth *et al.* conclude that ‘the *Corbicula* horizon represents an environment that did not persist for long’ at the Histon Road site. It is generally considered that *Corbicula fluminalis* requires flowing water habitats and temperate conditions for successful colonisation, and that where these occur it may become very abundant. However, the absence of *Corbicula* elsewhere in the Histon Road sequence implies a scarcity of suitable conditions at or upstream of the site. Elsewhere, the occurrence of *Corbicula fluminalis* and absence of *Belgrandia marginata* in sediments has been correlated with MIS 7, rather than MIS 5e (Keen, 1990, 2001, and Preece, 1995).

Walker (1953) submitted samples of the mud (300-450cm) and the sands and gravels (150-200cm) to B. W. Sparks for mollusc identification. Sparks pointed out the broad
similarity of this assemblage containing aquatic, marshland and grassland taxa to that described from Histon Road by Hollingworth et al. to other interglacial deposits in the Cambridge District. He noted the absence in these samples of several taxa including Corbicula fluminalis and Belgrandia marginata that might be regarded as indicating conditions warmer than today. The small sample from the mud yielded too few specimens to give a reliable indication of climate, but the sample from the sand and gravel unit indicated conditions similar to those in Scandinavia at the present day. Sparks and West (1959) carried out a systematic analysis of molluscs from their core (borehole B-1959) (Table 5.4.1-4). Their analyses cover the range 160-750cm depth (their Table II). Below c.500cm molluscs that today reach to the south of Scandinavia or are confined to mainland Europe are present in the fauna. Above this point such sensitive taxa are absent, and those that currently survive throughout Scandinavia and the Arctic Circle dominate. The mollusc data identifies a succession of environments similar to that identified from the plant macrofossil assemblages. Fluvial conditions at c.750cm depth become drier and progress towards grassland at 650cm, with a reversion to marshland at c.600cm which slowly becomes wetter towards stream conditions at 500cm, followed by a further alternation of marsh and stream environments at the top of the core (c.300cm). These variations are what might be expected from deposits representing a floodplain environment. It is worth noting that woodland or scrub further from the floodplain is indicated by Carychium tridentatum and Clausilia spp., which occur between 580-640cm. The absence of Corbicula fluminalis from this entire sequence is a curious phenomenon, given the abundance in Bed E (300-370cm) described by Hollingworth et al.

Mollusca recovered from the bulk samples taken from the sewer trenches (points F11 and F2) excavated across the Histon Road Allotment site during 1996 were analysed by R. C. Preece and are shown in comparison to mollusc assemblages identified in Hollingworth et al. (1950) and Sparks and West (1959) (Table 5.4.1-4). Although less diverse, the assemblages from F11 and F2 indicate a range of floodplain environments similar to those deduced from the classic works described above. The temperate nature of the assemblage is confirmed by the presence of Valvata cristata, Bithynia tentaculata, Azeca goodalli and Ena montana, amongst others. It is also worth noting that neither Corbicula fluminalis or Belgrandia marginata were found in these samples.

5.4.1.7 Beetles

Coleopteran analysis of six bulk samples taken from the sewer trenches (points F11, F10a, F6a, F5i, F5ii, F3/2) were undertaken by A. Dixon (Table 5.4.1-5). The samples from points F11 and F10a were found to be barren. The beetle assemblages of samples F6a, F5i, F5ii, suggest a temperate maritime climate with mild winters, and summer
temperatures 1-2 °C warmer than the Cambridge district today. This climatic regime is reminiscent of present day northern central Europe. In contrast, the beetle assemblage of sample F3/2 suggests a climate with summer temperatures perhaps 1-2 °C cooler than today, and rather like that of northern England (A. Dixon, pers. com.). This fauna is clearly interglacial in nature, quite unlike those from early Ipswichian sites such as Bobbitshole (Coope 1974) and Trafalgar Square (Franks et al 1958). The Staphylinid *Oxytelus (=Anotylus) gibbulus*, is thought to be of particular stratigraphic significance, and has been associated with many British sites correlated with MIS 7. The Ipswichian (MIS 5e) site at Shropham, Norfolk, contains plentiful *Oxytelus (=Anotylus) gibbulus* in cooler conditions at the end of this interglacial (G. R. Coope, pers. com.). Unfortunately, it appears that the coleopteran evidence offers no clear guide to the dating of these sediments.

Taken as a whole, the beetles indicate the environment of deposition to be that of a moderately-sized eutrophic river, swift in places with reed-beds bordering the channel, and fringed by fen and wetland meadow. Very little woodland is indicated, although there is a strong signal from beetles of grassland and riparian herbs. Faster flowing water is indicated by the riffle beetles *Elmis* spp. and *Oulimnius tuberculatus*, and the caseless caddisfly *Hydropsyche pellucidula*. Well-vegetated eutrophic still or slowly moving aquatic habitats are indicated by *Ochthebius minimus* and other members of the Hydraenidae. Such environments may have been partly represented by stagnant pools on the floodplain indicated by *Helophorus* sp., and providing riparian habitats for ground beetles such as *Bembidion clarki*. Extensive reedbeds and wet meadow are indicated by reed beetles *Donacia* spp., other Chrysomelid leaf beetles and weevils *Notaris* spp. There is perhaps some evidence for local wet woodland, but very little for extensive tree cover. However, there is a strong signal from Scarabeid dung beetles such as *Aphodius* spp. and *Heptaulacus* spp. that suggests the presence of large grazing animals. This interpretation is also supported by the presence of Staphylinid beetles such as *Anotylus* (=*Oxytelus*) and *Platystethus*.

5.4.1.8 Vertebrates

Hollingworth, Allison and Godwin (1950) recovered vertebrate remains from sediments exposed in the pumping station sewer trench (near J-1950). These were associated with gravel lenses at c.480 cm depth, at the top of their mottled light and dark organic mud (Beds D1-2). These remains comprised bones of *Palaeoloxodon antiquus* (straight-tusked elephant), *Dama dama* (fallow deer), *Cervus elaphus* (red deer), *Bos* sp. (aurochs) and an indeterminate rhinoceros. Of these, *Bos* and *Cervus* bones were described as having a mud matrix adhering to them and thus came from bed D2, while the remains of elephant and red deer with a buff silt matrix came slightly higher in the section, near the *Corbicula*
bearing Bed E (300-370cm). Examination of material recovered from the same trench and conserved at the Sedgwick Museum, revealed various bones labelled as *Equus ferus* (horse), *Cervus elaphus*, and remains of an indeterminate elephant (D. C. Schreve, pers. com.). Hollingworth *et al.* also record vole teeth from Beds D1-F2 (400-580cm), although no further information was provided and these specimens have not been relocated in a recent search for the material (D. C. Schreve, pers. com.). In addition, a complete humerus of *Dama dama* was discovered by Adrian Lister in the collections of the British Geological Survey Museum, excavated in 1939 (No. SEH419). The specimen was described as ‘chocolate-brown’ in colour, similar to the rest of the assemblage, and with a fine grey-brown sediment adhering (Lister, 1981). A sediment sample taken from the bone was analysed from for pollen, but proved to be barren (Lister, 1981).

Analyses for vertebrate remains from four bulk samples (F11, F11/10, F6, F2) taken from the sewer trenches excavated across the Histon Road Allotment site during 1996 were undertaken by Danielle Schreve. Overall, the yield of fossil material from the bulk samples was poor and consisted mainly of small (<5mm) indeterminable fragments. The most commonly preserved mammalian material tended to be the more robust elements, such as incisor fragments and caudal vertebrae of Microtinae sp. (indeterminate vole), Cricetidae sp. (indeterminate vole or lemming) and *Sorex araneus* (common shrew). Rolling and degradation are apparent on some of the small mammal postcranial material and on the single molar of *Arvicola terrestris cantiana* (water vole). However, the presence of fragile fish scales of *Perca fluviatilis* (perch), and of *Esox lucius* (pike) teeth, and *Gasterosteus aculeatus* (three-spined stickleback) spines implies that at least some of the material was not transported any great distance since its deposition. Bones of *Anura* sp. (undetermined frog or toad) and other indeterminate elements of the herpetofauna were also recovered. The author also recovered a well-preserved lower cheek tooth of *Equus ferus* from bulk sample F11 (450-500cm).

Aquatic habitats are indicated by the water vole, which frequents the well-vegetated banks of rivers and lakes with still or slow-flowing water (Corbet and Harris, 1991). This is also reflected by the fish assemblage, since pike and perch are most commonly found today in the mid to lower reaches of rivers, overgrown backwaters and ponds with overhanging vegetation. The presence of pike implies winter water temperatures of not less than 5°C (Wheeler, 1969). The three-spined stickleback is widespread in all waters in Britain, including in coastal and estuarine situations, although in freshwater, it is least common in stagnant, densely weeded areas (Wheeler, 1969). The large mammal assemblage suggests a mosaic of vegetational conditions. The occurrence of *Dama dama* and *Palaeoloxodon antiquus* is indicative of deciduous wooded environments, whereas the
presence of *Equus ferus* implies that more open habitats also existed in the vicinity of the river. Today, *Sorex araneus* (common shrew) is found in a wide range of habitats, especially with low vegetation cover, and is most abundant in thick grass, bushy scrub and deciduous woodland (Corbet and Harris 1991).

The presence of *Dama dama* and *Palaeoloxodon antiquus* taken with *Cervus elaphus* represents some of the major elements of the ‘hippopotamus fauna’ associated with the Ipswichian (MIS 5e) (Stuart 1982, Sutcliffe 1995). Despite the lack of *H. amphibius*, this faunal assemblage appears to be substantially different to the *Mammuthus trogontherii-primigenius/Equus ferus* fauna correlated with MIS 7. Bridgland and Schreve (2001) believed this mammal assemblage, taken with the presence of the bivalve *Corbicula fluminalis* suggests a correlation with MIS 9. The presence of horse certainly conflicts with an Ipswichian (MIS 5e) interpretation of the fauna. Horse is believed to have been absent from the British Isles for a very extensive period, from some point during the immediately pre-Ipswichian cold-climate episode (MIS 6) until the Middle Devensian (MIS 3) (Sutcliffe, 1995; Currant and Jacobi, 1997, in press). Horse is unknown from any site of unequivocal Last Interglacial age (MIS 5e) anywhere in the UK and it is equally absent from sediments attributable to the later parts of OIS 5, such as in the Gower Caves (Currant and Jacobi, 2001). The horse tooth from Histon Road is from a robust animal of large size, typical of Middle Pleistocene contexts in Europe, rather than those from MIS 6 and Devensian deposits (D. C. Schreve, pers. com.).

### 5.4.1.9 Dating

Optically stimulated luminescence (OSL) dating of quartz from the silty clay unit at point F5 gave a minimum age estimate of 121.55 ka BP ±20.08 (Table 2.5.11-1). This appears to indicate a correlation with MIS 5e. Amino acid racemization analyses for *Bithynia tentaculata* and *Trichia* sp. shells from the same unit at point F11 gave D/L ratios of 0.128, 0.129, 0.156, 0.170, 0.173, 0.189, 0.203 and 0.208 (Appendix 5). An unpublished amino acid analysis for *Bithynia tentaculata* collected from the borehole (point B-1959) put down by Sparks and West (1959) gave a D/L ratio of 0.123 (J. Hollin pers. com.). Although the lowest of these ratios equate to an Ipswichian (MIS 5e) age, the remainder indicate dates from the later (MIS 6/7) and middle (MIS 7/8) parts of the ‘Wolstonian’ interval. This mixed amino acid signal means that a minimum age estimate for the last phase of deposition based on the lowest D/L ratios is the Ipswichian stage (MIS 5e), suggesting significant reworking of ‘Wolstonian’ deposits from local sources. If this is the case, then it might potentially explain the presence of at least some other faunal elements incompatible with an Ipswichian interpretation.
5.4.1.10 Conclusions

It is clear that the deposits beneath the Histon Road Allotment site occupy a buried channel-form, and that they consist of a tripartite sequence; a basal gravel and sand, a silty clay unit, and an upper gravel and sand unit. The floral, molluscan, and coleopteran assemblages from the silty clays of the Histon Road Member clearly show a change from warm late temperate to cooler post-temperate conditions and record a variety of floodplain environments. It appears that this is a record of the end of an interglacial period, most probably the Ipswichian (MIS 5e). These conclusions are supported by the OSL dating of quartz from the silty clay unit. Amino acid racemization analyses for *Bithynia* and *Trichia* shells from the same unit gave a mixed signal, suggesting a minimum age of Ipswichian, but with large-scale reworking from deposits belonging to the later and middle parts of the ‘Wolstonian’ interval. There is also evidence for an interval with boreal forest with spruce, which may correlate with the Chelford interstadial (MIS 5c). There is clear evidence from Swan’s Pit, Milton Road (see Section 8.6.1), that earlier sediments of this age are present within the same channel-form as those at Histon Road Allotments. This may partly explain the conflicting evidence concerning the biostratigraphy of these sediments, particularly with regard to the vertebrate assemblage and the presence of the mollusc *Corbicula fluminalis*.

5.4.2 Christ’s Sports Ground

5.4.2.1 Introduction

Marr (1920) first described a deposit that he termed ‘clay-with-race’ from a trench at Oxford Road on the north side of Huntingdon Road, Cambridge (see Section 8.3.3). Marr (1926) traced this material northwest along Huntingdon Road to Christ’s Sports Ground. Marr and King (1932) later opened sections at this site, which exposed ‘clay-with-race’ and a shell bearing silty clay (‘loamy band within sand’) overlying gravel and sand mapped by the BGS as 4th Terrace Deposits. The exact stratigraphic relationship of the ‘clay-with-race’, the sand with loam, the overlying gravelly slopewash and the underlying gravel and sand at this site is complex, and was shown by Marr and King (1932) in two sections (their Figures 1 and 2) equivalent to points PF1A to PF1E and PF2A to PF2C. In 1995, the author put down a series of boreholes (points BH1 to BH7) roughly parallel to the first section excavated by Marr and King (Section 5.3.4.13). This revealed clay with gravel (equivalent to Marr’s clay-with-race) and silty clay overlying gravel and sand exactly as formerly described. It appears that the silty clay unit occupies a channel-form at the edge of the spread of gravel and sand, which has been partly covered by clay with gravel soliflucted from the Huntingdon Road ridge to the southwest. The channel was investigated
by sinking further boreholes (BH9-BH12) along the northwest boundary of Christ’s Sports Ground and land owned by NIAB (see Section 5.3.4.10). These revealed a well developed channel containing 3m of silty clay with shells at BH12. Further boreholes made to the north (BH13 to BH22) failed to locate a similar thickness of material. Marr and King interpreted the ‘clay-with race’ and shell bearing silty clay as being younger than the ‘Observatory Gravels’ exposed in the Traveller’s Rest Pit to the south of Huntingdon Road.

5.4.2.2 Environments of deposition

The basal gravel and sand unit at Christ’s Sports Ground is thought to have been deposited by a braided stream under cold conditions. Marr and King (1932) conclude that their clay-with-race unit may have been formed by various processes at different times, including ‘the washing down of weathered Gault [Clay]’ in the Flandrian. The author believes these ‘various processes’ to be largely periglacial in nature, and to have been in synchronous operation with the deposition of the shell bearing silty clay. It appears that minor fluvial incision formed a marginal channel between the braid plain and the valley side, which subsequently filled with low-energy overbank or backswamp deposits on a grassy floodplain. There is a little evidence for some climatic amelioration during this period, but it is presumed that conditions were essentially cold.

5.4.2.3 Physical analyses and particle size distribution

The sequence of silty clay at point BH12 was subjected to detailed physical and particle size analyses (Figures 5.4.2-1 and 5.4.2-2). The sequence of silty clay at BH12 showed a clear transition from calcium carbonate-rich (60-80%) sediments at the base (260-345cm) to silicate dominated (70-90%) material towards the top (110-160cm). This clearly shows a marked increase in clastic silicate input to the fluvial system, probably as colluvial in-wash from the catchment. The silty clay contained c.3% organic material throughout the sequence. It is curious that the entire sequence has a rather low magnetic susceptibility (0.1 to 1.1 SI units x10^-8 (m^3 kg^-1)) which shows no response to the steadily increasing proportion of silicate residue towards the top of the core. The proportion of ferro-magnetic minerals relative to quartz and feldspars in the silicate clastics must be rather low.

The particle size distribution diagram for this sequence (Figure 5.4.2-2) shows a broadly bimodal distribution comprising fine silts with a modal size of 7.5 Phi units (c.6μm) and fine sand and coarse silt with a modal size of 3-4 Phi units (125-63μm). In general the sand fraction of this sequence fines upwards from 345cm to 210cm. This pattern is punctuated by in-wash of coarse sand (0.5 Phi, c.707μm) at 220cm and 190cm,
indicating higher energy fluvial conditions. Above 190cm deposition of coarse silt fining upward continues to the top of the core.

5.4.2.3 Pollen analyses

The author carried out pollen analysis of samples from borehole BH12 (Table 5.4.2-1). These counts generally yielded low concentrations of palynomorphs, which were dominated by Poaceae (grass). A sample from 330cm depth showed an assemblage dominated by *Pinus* (pine) (33%) and grass, with herbs and the notable presence of *Alnus* (alder). Taken together, the analyses suggest a grassy floodplain under cold and possibly harsh pre-temperate climatic conditions, with perhaps a short interlude of amelioration where pine and alder became established locally.

5.4.3.4 Molluscs

Marr and King (1932) recovered a limited assemblage of molluscs from a 'loamy sand' at point PF1D (their point X). These comprised a mixture of dry grassland species such as *Pupilla muscorum* and various marshland taxa, but no truly aquatic types. Marr and King offer no further interpretation of this fauna, although it is clear that contains no thermophilous elements. Mollusca recovered from samples taken from the borehole BH12 were analysed by R. C. Preece. The limited assemblage was similar to that recorded by Marr and King (1932), with *Pupilla muscorum*, *Trichia hispida* other grassland species.

5.4.3.5 Dating

Amino acid racemization analyses for *Trichia* sp. shells from point PF1D gave D/L ratios of 0.196, 0.235 and 0.238 (Appendix 5). The lowest of these ratios equates to the middle of the ‘Wolstonian’ interval (MIS7/8), and the others suggest an age early in the ‘Wolstonian’ (MIS 9). This mixed amino acid signal means that a minimum age estimate for the last phase of deposition based on the lowest D/L ratios is in the middle of the ‘Wolstonian’ (MIS7/8). However, the apparent age distribution of these well-preserved molluscs suggests reworking of older deposits from local sources.

5.4.3.5 Conclusions

It is clear that these 4th Terrace Deposits are older than those known from the 3rd Terrace at Histon Road, but younger than the more elevated ‘Observatory Gravels’. This places them within the ‘Wolstonian’ interval. This conclusion is supported by the amino acid racemization analyses for *Trichia* shells from the ‘clay-with race’, which gave a mixed signal, suggesting a minimum age in the middle of the ‘Wolstonian’ interval (MIS 7/8), but with apparent reworking from earlier deposits. The faunal and floral evidence suggest that these deposits are essentially from a cold periglacial environment.
5.5 5km Square TL 245/560 Milton

5.5.1 Synopsis

This five-kilometre square contains 23 monads with 321 points (Figures 5.5.1-1 & 5.5.1-2). The area includes part of Impington to the west, parts of Landbeach and Waterbeach to the northeast, Homingsea to the east, Fen Ditton to the southwest, Chesterton and north Cambridge to the southwest and Milton at the centre. The square also includes the A14 Motorway, which provides a large number of records.

5.5.2 Drainage and relief

The River Cam flows across the square from the south to the northeast (<5m OD) and is joined by a number of small drains in the vicinity of Cambridge and Milton. The northern part of the square (c.10m OD) drains north towards the valley of the River Great Ouse some 6km distant. The most elevated land (c.15m OD) is near Fen Ditton in the southeast.

5.5.3 Geology

The bedrock geology comprises Gault Clay and Lower Chalk broadly dipping towards the southeast (Figures 5.5.3-1 & 5.5.3-2). The area of Lower Chalk in the southeast of the square has a slightly higher elevation, and it appears that the River Cam flows southwest-northeast along the junction of the two bedrock types. The Quaternary geology comprises two broad bands of deposits running south to north across the square; one in the west near Impington mapped as 3rd Terrace Deposits and the other running across the centre of the square mapped as 2nd Terrace Deposits. In addition, several patches of 4th Terrace Deposits are shown between Impington and Milton and near Fen Ditton. Alluvium is mapped on the floodplain of the River Cam, which is flanked to the west by a band of 1st Terrace Deposits. Various fragments of 1st and 2nd Terrace Deposits are also shown near Homingsea.

5.5.4 Geological Logs and Sections

5.5.4.1 Synopsis

The 321 points comprise 19 collected by the author and 302 from secondary sources. These consist of 2 records from the Geological Survey Well Catalogue Series (Matthews and Harvey, 1965), 16 from the Cambridge Memoir (Worssam and Taylor, 1969), 26 from the British Geological Survey Mineral Assessment Report (Dixon 1980), 92 from the Highways Agency archives, 47 from contractors’ reports from the North Cambridge Sewer...
5.5.4.3 Geological Section 45/60.1

This 5km section (Figure 5.5.4-1) runs roughly west-east from Impington Hall Farm (point CD35/1) to the River Cam near Clayhithe (point 46SE109). It provides details of the relationship between various Terrace Deposits mapped by the BGS in the area north of Milton.

Data point CD35/1 at Impington Hall Farm records 1m of clay with gravel on bedrock Gault Clay at c.12m OD, while nearby point 46SE94 shows 1m of yellow/green silty clay overlying gravel and sand on bedrock at c.10m OD. This material is mapped by the BGS as deposits belonging to the 3rd Terrace. A kilometre to the northeast at Bedlam Farm, point CD107/5 records 1m of gravel and sand with a base not touching bedrock at c.9.5m OD. The BGS map shows patches of 4th Terrace Deposits near Bedlam Farm. The elevation of this gravel unit is rather similar to the deposits near Impington Hall Farm. It is proposed that this gravel unit is formally named the **Bedlam Farm Gravel** with the stratotype at point CD107/5 (4650 6400). At Walnut Farm, Waterbeach, point 46SE100 records 1m of sandy clay overlying 2m of gravel and sand on bedrock at c.3m. To the east at Hall Farm, point 46SE101 shows sandy clay overlying 3m of gravel and sand on bedrock at c.1m OD. These deposits clearly represent the 2nd Terrace mapped by the BGS. It is proposed that this gravel unit is formally named the **Hall Farm Gravel** with the stratotype at point 46SE101 (4874 6462). To the east on the floodplain of the River Cam near Clayhithe, point 46SE109 shows 3m of organic silty clay overlying including a bed of peat overlying 1m of gravel and sand on bedrock Gault Clay at c.-2m OD. This basal gravel probably represents the late Devensian course of the River Cam, overlain by Flandrian fen and alluvial deposits. It is proposed that this silty clay unit is formally named the **Clayhithe Silty Clay** with the stratotype at point 46SE109 (4991 6452).

5.5.4.4 Geological Section 45/60.2

This 5km-long section (Figure 5.5.4-2) is aligned west-east between Impington Hall Farm (CD35/1) and Eye Hall Farm, Clayhithe (46SE11). It provides further insight into the relationship between various Terrace Deposits mapped by the BGS in the area north of Milton. Point CD35/1 at Impington Hall Farm records 1m of clay with gravel on bedrock Gault Clay at c.12m OD, while nearby point 46SE94 shows 1m of yellow/green silty clay overlying gravel and sand on bedrock at c.10m OD. To the east at Sun Close Farm, point MBH32 shows Made Ground overlying 1m of gravel and sand on bedrock at c.9m OD.
Nearby, point 46SE188 shows 2.5m of marly sandy clay overlying gravel and sand on bedrock at c.8m OD. Patches of 3rd and 4th Terrace Deposits are mapped in this area by the BGS, although the sediments described all appear to have similar elevations. To the east at Rectory Farm, point CD116/5 shows 2m of gravel and sand on bedrock at c.6m OD and 46SE99 shows a similar thickness of gravel on bedrock at c.5m OD. These deposits are mapped as belonging to the 2nd Terrace by the BGS. It is proposed that this gravel unit is formally named the **Rectory Farm Gravel** with the stratotype at point CD116/5 (4750 6340). To the east near the River Cam, point 46SE108 records silty clay overlying lm of gravel and sand on bedrock Gault Clay at c.2m OD. This point falls within the strip of 1st Terrace Deposits mapped by the BGS. The sequence from point 46SE109 to the north has been projected on to the section to indicate the stratigraphy beneath the River Cam floodplain. At Eye Hall Farm, point 46SE111 records bedrock Chalk close to the surface at c.5m OD beneath topsoil, indicating the abrupt change in bedrock type to the east of the River Cam.

### 5.5.4.4 Geological Section 45/60.3

This 5km-long section (Figure 5.5.4-3) runs roughly west-east from Impington Hall Farm (CD35/1), through Milton village to Horningsea village (HS13). Point CD35/1 at Impington Hall Farm records lm of clay with gravel on bedrock Gault Clay at c.12m OD. To the east, point MW7 shows 2m of clay with gravel on bedrock at c.10m OD. At an archaeological site at MiltX the author recorded clay with gravel overlying 1.5m of cryoturbated gravel and sand with clay diapirs. It appears that the depth of cryoturbation in this area has resulted in the incorporation of bedrock Gault Clay into the overlying fluvial gravels resulting in a diamictic admixture recorded by these points as clay with gravel. This is also seen at Milton Landfill Site, where points MBH21 and MW3 show 2m of contorted clay with gravel. In contrast, point MBH22 records clay with gravel overlying 1m of gravel and sand on bedrock at c.9m OD. Much of this disturbed material is mapped as bedrock Gault Clay by the BGS and is at a similar elevation to deposits mapped as belonging to the 3rd Terrace. Near Milton village, points MYTP5 to MYTP7 record sandy clay, clay with gravel, and gravel and sand on bedrock Gault Clay at c.5m OD. This appears to represent the edge of the 2nd Terrace mapped by the BGS. At Milton Country Park, point CD116/3 records 5m of gravel and sand with a base not touching bedrock at c.1m OD. Thin bands of silty clay are recorded within this gravel at points MCPA and MCPC, but at point MCPPH1 9m of gravel and sand is recorded with a base not touching bedrock at c.-3m OD. Such an exceptional thickness of deposits is not recorded beneath the 2nd Terrace surface elsewhere in this square. It is proposed that this gravel unit is formally named the **Milton Country Park Gravel** with the stratotype at point MCPPH1.
To the east, point 46SE102 shows silty clay overlying 3m of gravel and sand on bedrock at c. 1m OD.

On the floodplain of the River Cam point MSWD3 records 1m of silt with shells overlying a similar thickness of clay with peat and gravel and sand on bedrock at c. 1m OD. Nearby, point MSWD1 shows 2m of organic silty clay with shells overlying gravel, peat and clay with peat not touching bedrock at c. 0m OD. Near Horningsea, the author recorded 2m of peat and clay with peat on bedrock Gault Clay at c. 2m OD at point HS17. These silty and peaty deposits must represent deposition by the River Cam during the Flandrian. A series of closely spaced boreholes (HS16 to HS13) carried out by the author through Horningsea village reveal units of gravel and sand, and silty clay 2m thick overlying bedrock at 6-7m OD. It appears that these deposits represent the edge of the 2nd Terrace Deposits. Some of this material, particularly that from HS8 to HS13, had been disturbed by past mining of the Cambridge Greensand.

5.5.4.5 Geological Section 45/60.4

This 5.5km-long section (Figure 5.5.4-4) runs roughly west-east along the line of the A14 Road from Kings Hedges (a5115) through Milton and the River Cam to Fen Ditton (a5199). In the vicinity of Kings Hedges, points a5115 to 46SE8 generally show 2m of sandy silty clay with lenses of gravel on bedrock Gault Clay at c. 1.1m OD. In several places the silty clay is replaced by 2m of clayey gravel and sand with bands of clay (for example point b5124). The exact stratigraphic relationship between these units is not clear, although it appears that the gravel may underlie the silty clay. These points are within the area mapped by the BGS as 3rd Terrace Deposits. To the east, points a5133 to a5138 record 1m of clay with gravel, at a5135 overlying gravel and sand. Near Milton Landfill Site, point MBH3 shows 1.5m of Made Ground over 1m of sandy clay and clay with gravel, in turn overlying 2m of gravel and sand on bedrock at c. 7m OD. This must be near the edge of the 3rd Terrace. Point MBH5 records only clay with gravel on bedrock at c. 9m OD and point MBH7 shows bedrock Gault Clay at a similar elevation beneath 2m of Made Ground in an area that was once presumably worked for aggregate. Points a5140 and e16 show 1m of gravel and sand on bedrock at c. 7m OD, and point MBH8 records 3m of clay with gravel beneath 2m of Made Ground. To the east, points a5140 to a5157 show clay with gravel overlying 3m of gravel and sand on a channelled bedrock surface at 3-6m OD. This material clearly belongs to the 2nd Terrace of the BGS.

A similar pattern continues from Milton towards the River Cam (points a5158 to a5168) with 4m of gravel and sand recorded resting on an undulating bedrock surface at elevations between 3 and 6m OD. Points a5162 to a5168 fall within the narrow strip at the edge of the River Cam floodplain mapped by the BGS as belonging to the 1st Terrace. At the edge
of the floodplain north of Fen Ditton, point b5171c shows 1m of clay with peat overlying gravel and sand on bedrock at c.2m OD. In contrast, beneath the River Cam point b5170 shows 6m of peat with shells overlying 3m of gravel and sand on bedrock at c.-5m OD. Nearby points (for example b5171d) show a comparable thickness of peat, but point a5174 shows 2m of gravel and sand overlying bedrock Gault Clay at c.2m OD. It is proposed that the peat unit here is formally named the **Fen Ditton Peat**, and that the underlying gravel unit is formally named as the **Fen Ditton Gravel**, both with a stratotype at point b5170 (4835 6162). On the east side of the River Cam the ground surface rises steeply away from the river, and points a5176 to a5185 record bedrock Chalk close to the surface beneath topsoil at elevations c.11m OD. East of the B1047 Homingsea Road, point a5187 shows clay with gravel overlying gravel and sand, and point a5188 records 0.5m of chalky gravel and sand on bedrock Chalk at c.11m OD. It is interesting to note that this material occurs at a similar elevation to that attributed to the 3rd Terrace at Kings Hedges. To the east, points a5189 to a5197 record sandy clay and clay with gravel 1m thick overlying bedrock at heights between 10m and 12m OD. Point a5199 shows bedrock Chalk near the surface beneath topsoil at c.9m OD.

### 5.5.4.6 Geological Section 45/60.5

This 4.5km-long section (Figure 5.5.4-5) runs roughly west-east from Kings Hedges (e1) to Fen Ditton (46SE117). Between Kings Hedges and Chesterton points e1 and NCMD1 record Made Ground overlying 1m of gravel and sand, in turn overlying 2m of sandy silty clay on bedrock Gault Clay at c.9m OD. It is proposed that the gravel unit is formally named the **Kings Hedges Gravel** and that the silty clay unit is formally named the **Kings Hedges Silty Clay** with the stratotype for both at point NCMD1 (4511 6097). To the east, point b5123 records 2m of gravel and sand on bedrock at c.11m OD. These points fall within an area mapped as 3rd Terrace Deposits by the BGS. At Cambridge Science Park point LR1 shows 1m of silty clay overlying a comparable thickness of gravel and sand on bedrock at c.8m OD and nearby at 46SE130 a similar sequence rests on bedrock at c.10m OD. Between the Science Park and Milton Sewage Works points TF1 to MSWD27 record an apparently complex stratigraphy within the 2nd Terrace Deposits. Points TF1 and TF2 show sandy clay overlying silty clay, in turn overlying gravel and sand on bedrock at c.7m OD. In contrast, points e7 and NCMD7 record 1m of gravel and sand overlying 2m of silty clay on bedrock at c.5m OD, while point MSWD30 shows sandy clay overlying 2m of gravel and sand. Nearby, points D3 and MSWD27 show 3m of gravel and sand overlying bedrock at c.4m OD. At the edge of the River Cam’s floodplain, point a5168b shows Made Ground overlying 1m of peat on bedrock at c.1m OD. In the centre of the floodplain, point 46SE105 records a complex sequence.
comprising 1m of sandy clay overlying, 1.5m of silty clay, in turn overlying 2m of peat
and clayey peat over 3m of gravel and sand on bedrock Gault Clay at c. -3m OD. Point e24
shows a similar sequence on bedrock at c. -2m OD. At Fen Ditton on the east side of the
River Cam the land rises steeply away from the river, and points 46SE114, CD37/2 and
46SE117 show bedrock Chalk close to the surface beneath topsoil at elevations c. 13m OD.

5.5.4.7 Geological Section 45/60.6

This 5km-long section (Figure 5.5.4-6) runs roughly south-north from Chesterton
(CD115/3ii) through Arbury and Milton Landfill Site to Bedlam Farm (CD107/5). In
Chesterton, point CD115/3ii records 2m of gravel and sand not reaching bedrock at c. 10m
OD. To the north at Arbury, points ARE4 and CD111/3 show 2m of gravel and sand
overlying 2m of marly silty clay, in turn overlying gravel and sand not touching bedrock at
c.7m OD. In contrast, point e17 shows 5m of gravel and sand, but point ARE1 records
3m of gravel and sand overlying 2.5m of sandy silty clay. Point ARE3 shows a complex
sequence with 2.5m of gravel and sand overlying 2m of silty clay, in turn overlying 1.5m
of gravel and sand overlying silty clay not reaching bedrock at c.5m OD. Nearby, points
NCMD2 and e2 record 1m of Made Ground over 5m of gravel and sand, in turn overlying
2m of silty clay on bedrock Gault Clay at c.6m OD. However, points e13 and CD111/2
show 7m of gravel and sand with a base at 5-6m OD. It is proposed that the gravel unit is
formally named the Arbury Gravel and that the silty clay unit is formally named the
Arbury Silty Clay with the stratotype for both at point NCMD2 (4542 6077). Near
Kings Hedges, points e3 and NCMD3 record Made Ground over 2.5m of gravel and sand,
in turn overlying 1m of silty clay on bedrock at c.8m OD. Further north near the A14
Road, point 46SE11 show sandy clay overlying 1m of gravel and sand on bedrock at 10-
11m OD, but point a5133 shows only 1m of clay with gravel. The points between
Chesterton and Kings Hedges traverse an area mapped by the BGS as 3rd Terrace Deposits.
It is clear that these sediments occupy a channel-form, and that they have a similar
stratigraphy to those described from the Histon Road Allotment site (Section 5.4.1).

At Milton Landfill site (point Milt13) the author observed sandy clay overlying hugely
cryoturbated gravel and sand with clay diapirs 0.5m thick on bedrock Gault Clay at c.9m
OD. Much of the gravel in this vicinity appears to have been disturbed in this fashion, and
nearby point MW8 shows 2.5m of contorted clay with gravel. Points MBH42 and MiltX
record sandy clay over cryoturbated gravel, and point MW7 shows 2m of clay with gravel
on bedrock at c.10m OD. To the north, points MBH37 and MBH32 show gravel and sand
1m thick on bedrock at c.9m OD and point MBH38 records a similar thickness of clay with
gravel. At Sun Close Farm, point 46SE188 records 2.5m of sandy clay overlying gravel
and sand on bedrock at c.8m OD, and at Bedlam Farm point CD107/5 shows 1m of gravel
and sand. These sediments occur at the edge of the spread of 3rd Terrace Deposits mapped by the BGS and are largely at a similar elevation to them.

5.5.4.8 Geological Section 45/60.7

This 5.5km-long section (Figure 5.5.4-7) runs roughly south-north from Chesterton (D15) through Cambridge Science Park and Milton Landfill Site to Bedlam Farm (CD107/5). The first part of the section runs along the line of the North Cambridge Sewer, and many of these points originate from vibro-coring where the nature of the superficial deposits is unknown, although the depth of the rockhead is recorded. Points D15 to D7 record 3m of gravel and sand on an undulating rockhead at between 2m and 5m OD, overlain by varying thicknesses of topsoil and Made Ground. All of these points fall within a broad spread mapped by the BGS as 2nd Terrace Deposits. On Milton Road, points e6 and NCMD6 show 1m of gravel and sand overlying 1m of silty clay on bedrock at c.7m OD. Samples of the silty clay from a temporary exposure near this location were found to contain temperate pollen assemblages (P. L. Gibbard, pers. com.). To the northeast near Cambridge Science Park, point MR1 showed 2m of Made Ground overlying 1.5m of gravel and sand on bedrock at c.5m OD, and at point e7 1m of gravel and sand overlies 1.5m of silty clay.

Similarly, point MR3 shows 3m of gravel and sand on bedrock at c.5m OD, and NCMD7 records 1m of gravel and sand overlying 1.5m of silty clay. Point TF2 shows sandy clay overlying 1m of silty clay, in turn overlying gravel and sand on bedrock at c.7m OD. Points TF3 to e54.4 record 1m of sandy clay overlying 2m of gravel and sand, in turn overlying a bed of silty clay over gravel and sand 2m thick with a base on bedrock at 4-6m OD. These sediments apparently correspond to a tongue of 3rd Terrace Deposits mapped by the BGS extending northeast from the main spread.

Near the A14 Road, points a5138 to MBH5 record gravel and sand and clay with gravel 1m thick on bedrock at 8-9m OD. However, point e54.3 records 3m of gravel and sand on bedrock at c.6m OD. Across Milton Landfill Site points MBH2 to MW6 show either 2m of clay with gravel, or clay with gravel overlying 1m of contorted gravel and sand. The rockhead across this area is remarkably consistent at 8-9m OD. At Sun Close Farm, point 46SE188 records 2.5m of sandy clay overlying gravel and sand on bedrock at c.8m OD, and at Bedlam Farm point CD107/5 shows 1m of gravel and sand. These sediments occur in an area mapped by the BGS as bedrock Gault Clay at the edge of the spread of 3rd Terrace Deposits.
5.5.4.9 Geological Section 45/60.8

This 5.5km-long section (Figure 5.5.4-8) runs roughly southwest-northeast from Chesterton (CD115/3ii) through Milton Sewage Works and Milton village to Walnut Farm, Landbeach (46SE100). Much of this section runs within the band of 2nd Terrace Deposits mapped by the BGS. In Chesterton, point CD115/3ii records 2m of gravel and sand not reaching bedrock at c.10m OD. Gravel and sand is also recorded at point MR and at CD115/2 where it is 4m thick with the base not reaching bedrock at c.6m OD. It is proposed that this gravel unit is formally named the Chesterton Gravel with the stratotype for at point CD115/2 (4640 6050). Nearby, point CD115/5 shows 1m of clay with gravel overlying 1.5m of gravel and sand. The next part of this section runs along the line of the North Cambridge Sewer where several points are derived from vibro-coring, which records only the depth of the rockhead. Points 342 to RD3 show 4m of gravel and sand on an undulating bedrock surface at between 6m and 7m OD. To the north, points D3 to 46SE98 record 3m of gravel and sand on bedrock at 4-5m OD. At Milton Sewage Works, point NCMD8 shows 1m of gravel and sand over silty clay on bedrock at c.6m OD. Near the A14 Road, points a5152 to e54.1 show 3m of gravel and sand on bedrock at 5-6m OD. West of Benet Farm, point MBH12 shows 1.5m of clay with gravel, and point MBH14 has 5m of Made Ground over 1m of gravel and sand on bedrock at c.7m OD. In Milton village points MYTP5 to MYTP3 show gravel 1.5m thick on bedrock at c.6m OD partly overlain by sandy clay and clay with gravel. Point CD116/5 at Rectory Farm records 2m of gravel and sand on bedrock at a similar elevation, and at Walnut Farm, Landbeach, point 46SE100 shows sandy clay overlying 2m of gravel and sand on bedrock Gault Clay at c.3m OD.

5.5.4.10 Geological Section 45/60.9

This 4.5km-long section (Figure 5.5.4-9) runs roughly south-north from Chesterton (46SE189) through Milton Sewage Works and Milton County Park to Walnut Farm, Landbeach (46SE100). This section runs parallel to Geological Section 45/60.8 and is entirely within the band of 2nd Terrace Deposits mapped by the BGS. In Chesterton, point 46SE189 records Made Ground over gravel on bedrock Gault Clay at c.6m OD. To the north at Milton Sewage Works, points MSWD28 to 46SE152 show sandy clay overlying 2.5m of gravel and sand on bedrock at 4-5m OD. Near the A14 Road, point a5159a shows a band of silty clay in 5m of gravel and sand on bedrock at c.2.5m OD, but nearby at 46SE120 4m of gravel and sand overlie bedrock at c.5m OD. However, points a5159 to MCPD show 5m of gravel and sand on bedrock at 2-3m OD. Points MCPA and MCPC at Milton Country Park record bands of silty clay within the gravel. In Milton village, point...
188/241 shows 6m of gravel and sand on bedrock at c.0m OD and nearby at CD116/4 4m of gravel and sand on bedrock at c.2m OD are recorded. This is clearly a substantial channel-form beneath the 2nd Terrace surface. To the north at Rectory Farm, point 46SE99 shows 2m of gravel and sand on bedrock at c.5m OD, and at Walnut Farm, Landbeach, point 46SE100 shows sandy clay overlying 2m of gravel and sand on bedrock Gault Clay at c.3m OD.

5.5.4.11 Geological Section 45/60.10

This 4.5km-long section (Figure 5.5.4-10) runs roughly southwest-northeast from the River Cam near Fen Ditton (a5168b) through Baits Bite Lock and Horningsea to Eye Hall Farm (46SE111). This section traverses the narrow strip of 1st Terrace Deposits mapped by the BGS at the edge of the River Cam floodplain south of Milton. Point a5168b at the edge of the floodplain of the River Cam near Fen Ditton records 1m of Made Ground overlying 1m of peat on bedrock Gault Clay at c.1m OD. To the north, points MSWD20 to a5163 show 1m of sandy clay overlying gravel and sand 2m thick on bedrock at 3-4m OD. Near the A14 Road, point b5164 shows 1m of clay with gravel on bedrock at c.4m OD, and point b5165a shows bedrock Gault Clay beneath 2m of Made Ground. Point b5167 records Made Ground over 1m of sand and gravel on bedrock at c.2m OD. To the north, points MSWD12 to MSWD11 show silty clay overlying 1m of gravel and sand on bedrock at 3-4m OD at the edge of the River Cam floodplain. At Baits Bite Lock, point MSWD7 shows 1m of silty clay overlying 1.5m of gravel and sand on bedrock at c.2m OD. Nearby, point CD128/1 records 3m of unknown drift on bedrock at c.0m OD and point e63 shows 2m of gravel and sand on bedrock at a comparable elevation. Point MSWD5 shows 1m of silty clay overlying 2m of gravel and sand on bedrock at c.2m OD, and near the River Cam point MSWD1 records 2m of silty clay overlying gravel and 1m of peat and clayey peat not touching bedrock at c.0m OD. To the northeast near Horningsea, point HS17 shows 1.5m of peat and clay with peat on bedrock at c.2m OD. North of Horningsea village, point JP3 shows gravel on bedrock at c.5m OD and point JP4 has bedrock Gault Clay near the surface beneath topsoil. Between Horningsea and Clayhithe, points 46SE106 and 46SE107 show 2m of gravel and sand on bedrock at c.2m OD occupying a small valley leading from Quy Fen to the east. In contrast, at Eye Hall Farm point 46SE111 shows bedrock Chalk near the surface at c.5m OD beneath topsoil.

5.6 Site Description 5km Square TL 245/ 560

5.6.1 Milton Road

5.6.1.1 Synopsis
In 1987 P. L. Gibbard collected samples of silty clay from c.3m depth (c.7m OD) from a temporary exposure on a building site near point NCMD6 on Milton Road (see Section 5.5.4.8). Subsequent pollen analysis of these samples revealed a partly temperate character. Table 5.6.1-1 shows the percentage pollen data from the Milton Road site. Samples 2 and 3 have a pollen assemblage dominated by herbs, particularly Cyperaceae (sedges) and Apiaceae (cow parsley), but with Corylus (hazel) (11-13%), Carpinus (hornbeam) (c.10%), Quercus (oak) (4-5%), Pinus (pine) (3-4%), and small amounts (1-3%) of Acer (maple) pollen. This is clearly an early temperate signal, similar in many ways to that from the Histon Road Allotments site (Section 5.4.1). The pollen assemblages of samples 4 and 5 were also dominated by Cyperaceae and other herbs, but yielded lower frequencies of arboreal pollen including Pinus (1-5%), Betula (birch) (3-5%) and Salix (willow) (2-3%). This appears to be a more boreal signal with few of the temperate components present in the other samples. In contrast, the pollen assemblages of samples 8 and P are dominated by arboreal pollen, with Pinus (19-40%), Quercus (12-15%), Corylus (1-10%), Betula (2-4%) and Salix (2-3%), and Acer c.6%. The presence of a mixed oak woodland signal with Acer, and material containing Carpinus led P. L. Gibbard to correlate these sediments with the Ipswichian (MIS 5e) (Substage Ip II). (P. L. Gibbard pers. com.). This is an important observation since the silty clay at point NCMD6 lies beneath the 2nd Terrace surface mapped by the BGS, rather than the 3rd Terrace, as at Histon Road. In this location, it appears that the interglacial silty clay may have been partly removed, and is now overlain by younger Devensian gravels of the 2nd Terrace.

### 5.7 Correlation of Stratigraphic Units

**5km Squares TL 240/565, TL 240/560 and TL 245/560**

#### 5.7.1 Synopsis

Figure 5.7.1-1 and Table 5.7.1-1 show details of the 32 local stratigraphic units proposed for the three 5km Squares TL 240/565, TL 240/560 and TL 245/560. In this low-lying square many of the units occupy positions on the valley floor or valley sides. Only the Howe Farm Gravel and the Girton College Gravel form a significant ridge in the area. The silty clay unit beneath the 3rd Terrace surface is particularly striking, and the buried Girton Crossing Diamict is also worthy of note. Table 5.7.1-2 and Figure 5.7.1-2 show the chronological and stratigraphic relationships of these units and their correlation with lithostratigraphic members and formations. Figure 5.7.1-3 presents an idealised geological section through the area showing the relationships of the various lithostratigraphic members. The Girton Crossing Diamict is correlated with the Barrington Works Member...
of the Lowestoft Formation and is interpreted as Anglian (MIS12) till. The Girton Village Silty Clay and Girton Village Gravel occupy a deeply incised channel-form and are correlated with the Whittlesford Station Member of the Lowestoft Formation (see Section 11.4.1). These deposits are interpreted as Anglian (MIS12) glacio-lacustrine and fluvioglacial outwash deposits (P. Friend pers. com., 2000). The other stratigraphic units described belong to the Ouse Valley and Cam Valley Formations (see Table 1.4.2-1).

The Girton College Gravel and Howe Farm Gravel are correlated with the Observatory Member of the Cam Valley Formation, and are interpreted as braidplain deposits of the proto-Cam belonging to the early part of the ‘Wolstonian’ interval (MIS 9/10) or possibly the Late Anglian (MIS 12). The Observatory Member overlies deposits of the Whittlesford Station Member. It is also clearly separate from the neighbouring Huntingdon Road Gravel, which at point PF1B becomes the stratotype for the Huntingdon Road Member of the Cam Valley Formation, and is correlated with the Red House Farm Gravel. These deposits are interpreted as braidplain deposits of the River Cam that are younger than the Observatory Member, and probably date from the middle of the ‘Wolstonian’ interval (MIS 7/8). At a considerably lower elevation and occupying an incised channel-form beneath temperate silty clay, the Impington Village Gravel at point 46SW157 becomes the stratotype for the Impington Village Member of the Cam Valley Formation. It is correlated with the Histon Road Gravel and Bedlam Farm Gravel, and is interpreted as braidplain deposits of the River Cam dating from the later part of the ‘Wolstonian’ interval (MIS 6/7). Directly overlying this unit, the Histon Road Silty Clay at point B-1959 becomes the stratotype for the Histon Road Member of the Cam Valley Formation, correlated with the Oakington Silty Clay, Girton Crossing Silty Clay, Kings Hedges Silty Clay and Arbury Silty Clay. This unit is interpreted as temperate silty overbank and backswamp deposits of the River Cam, of probable Ipswichian (MIS 5e) and Early Devensian (MIS 5a-5d) age. Overlying and cut into the Histon Road Member, the Arbury Gravel at point NCMD2 becomes the stratotype for the Arbury Member of the Cam Valley Formation. It is correlated with the Oakington Barracks Gravel, the Woodhouse Farm Gravel and the Girton Crossing Gravel and interpreted as Early Devensian (MIS 4) braidplain deposits of the River Cam. In the Ouse valley, the West Field Gravel is correlated with the Fenstanton Member of the Ouse Valley Formation, and also interpreted as Early Devensian (MIS 4) braidplain deposits of the River Ouse.

In the Cam valley at a lower elevation, the Hall Farm Gravel, the Rectory Farm Gravel, the Milton Country Park Gravel and the Chesterton Gravel are all correlated with the Sidgwick Avenue Member of the Cam Valley Formation. This is interpreted as Middle to Late Devensian (MIS 2/3) braidplain deposits of the River Cam. In the Ouse valley, the
Iram Farm Gravel is correlated with the Fenstanton Member of the Ouse Valley Formation, and interpreted as Middle to Late Devensian (MIS 2/3) braidplain deposits of the River Ouse. In the Cam valley, the Fen Ditton Gravel is correlated with the Midsummer Common Member of the Cam Valley Formation and is interpreted as Late Devensian (Late Glacial) (MIS 2) Gravels of the River Cam. The Clayhithe Silty Clay and the Fen Ditton Peat are correlated with the Jesus Green Member of the Cam Valley Formation, and in the Ouse valley, the Fen Farm Gravelly Clay and the Great North Fen Silty Clay are correlated with the Ouse Member of the Ouse Valley Formation. These units are interpreted as Flandrian (MIS 1) alluvium and fen deposits of their respective river systems. The Grange Farm Gravelly Clay is correlated with the High Cross Member of the Cam Valley Formation. These variable deposits probably represent reworked solifluction material derived from periglacial activity in the ‘Wolstonian’ interval and the Devensian.

The sediments described here appear to represent a sequence stretching from the Anglian (MIS 12) through the ‘Wolstonian’ and Devensian to the Flandrian. The exact age of many of the older units is debatable, and they probably represent at best a fragmentary record of this time period.
Chapter 6

10km Square TL 250/560

Bottisham and Burwell

It seems to float ever, for ever,
Upon that many-winding river,
Between mountains, woods, abysses,
A paradise of wildernesses!

ASIA: FROM PROMETHEUS UNBOUND
Percy Bysshe Shelley
Chapter 6 Contents

10km Square TL 250/560 Bottisham and Burwell

6.1 10km Square TL 250/560

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5km Square TL 250/560

6.3.1 Synopsis
Chapter 6

10km Square TL 250/560

Bottisham and Burwell

6.1 10km Square TL 250/560

6.1.1 Synopsis

This ten-kilometre square is located at the northeast edge of the main study area and contains 11 monads with data (Figure 6.1.1-1). The area includes the villages of Upware to the north, Burwell to the east, Swaffham Bulbeck, Bottisham, and Stow cum Quy to the south, Waterbeach, Clayhithe and Horningsea to the west, and Reach and Swaffham Prior near the centre. The River Cam runs southwest to northeast across low lying fenland (<5m OD) in the northwest part of the square, and part of Adventurers’ Fen is below Ordnance Datum. Several canalised tributary streams including Bottisham Lode, Swaffham Bulbeck Lode, Reach Lode and Burwell Lode drain northwest towards the River Cam from Chalk springs at the edge of the fenland area. The area rises towards the southeast reaching c.50m OD near Four Mile Stable Farm.

6.1.2 Drainage

The drainage of tributaries fed by Chalk springs at the fen edge in this area is generally towards the River Cam in the northwest. There are minor dry valley systems developed on the higher land to the southeast. Most of the watercourses in this square run in raised embankments above the level of the surrounding fenland, and many have been straightened or run in completely artificial courses.

6.1.3 Bedrock geology

The bedrock geology comprises Lower Greensand, Gault Clay, and Lower and Middle Chalk broadly dipping towards the southeast (Figure 6.1.3-1). A small anticlinal structure near Upware brings the Jurassic West Walton Beds (Upware Limestone) to the surface. The axis of the flexure is aligned parallel to the regional strike (southwest-northeast) and can be traced along with minor synclinal folding on each side as far south as Horningsea.
6.1.4 Quaternary geology

The Quaternary geology mapped by the BGS (Figure 6.1.3-1) comprises ‘Head Gravel’ and 3rd Terrace Deposits on the higher land near Four Mile Stable Farm, and 4th and 3rd Terrace Deposits near Stow cum Quy. At the southern and western edge of the fenland area, and in other minor locations the BGS map 2nd and 1st Terrace Deposits. Alluvium is shown along the floodplain of the River Cam, and Peat is mapped across the low lying area and along the past courses of minor streams rising from Chalk springs at the fen edge.

6.2 5km Square TL 250/560 Bottisham

6.2.1 Synopsis

This five-kilometre square contains 11 monads with 24 points (Figures 6.2.1-1 & 6.2.1-2). The area includes the village of Clayhithe to the northwest, Bottisham and Stow cum Quy to the south, Lode at the centre and part of the parish of Homingsea to the west.

6.2.2 Drainage and relief

The River Cam (<5m OD) runs southwest to northeast through the extreme northwest corner of this square near Clayhithe. A large part of this square is low lying fenland drained by numerous dykes and ditches. The artificial watercourses of Quy Water and Bottisham Lode carry water across the area from Chalk springs at the fen edge. To the south and east the land rises to c.15m OD.

6.2.3 Geology

The bedrock geology comprises Gault Clay and Lower Chalk broadly dipping towards the southeast (Figures 6.2.3-1 & 6.2.3-2). There is some evidence of minor folding in these strata in the area east of Clayhithe, perhaps associated with the anticlinal axis at Upware to the northeast. The Quaternary geology comprises an area of 4th and 3rd Terrace Deposits mapped by the BGS at Stow cum Quy, and a spread of 2nd and 1st Terrace Deposits south and east of Clayhithe. Alluvium is confined to the floodplain of the River Cam, and Flandrian Peat marks the original course of Quy Water across the area.

6.2.4 Geological Logs and Sections

6.2.4.1 Synopsis

The 24 points are all from secondary sources and comprise 12 from the BGS Mineral Assessment Report for Ely and Cambridge (Clayton 1981), 4 from the British Geological Survey Well Catalogue Series (Matthews and Harvey, 1965), 3 from the Cambridge Memoir (Worssam and Taylor, 1969), 1 from the Highways Agency archives, 2 from
personal observations by Horningsea farmer John Pickard (JP1-2) and 2 from boreholes for a reservoir (BH3-4) on his land.

6.2.4.2 Geological Section 50/60.1

This 4km-long section (Figure 6.2.4-1) is aligned southwest-northeast from Horningsea (BH3) to Bottisham Fen (56SW14), and runs across 2nd and 1st Terrace deposits Mapped by the BGS. At John Pickard’s reservoir at Horningsea, point BH4 records 1m of gravel and sand on bedrock at c.2m OD and point BH3 shows 1m of sandy clay overlying gravel and sand on bedrock Gault Clay at a similar elevation. To the northeast in Stow cum Quy Fen, point 56SWE2 records 2m of gravel and sand on bedrock Chalk at c.1.5m OD. Nearby, point 56SWE1 shows 1m of gravel and sand on bedrock at c.1m OD and point 56SW10 records 2m of gravel and sand on bedrock Chalk at c.-1m OD. It is proposed that this gravel unit is formally named the Stow cum Quy Fen Gravel, with the stratotype at point 56SWE2 (TL 5068 6304). Further northeast in North White Fen, point 56SW11 records 1m of gravel and sand overlying 1m of silty clay on bedrock Chalk at c.0.5m OD. At Jack of Clubs Farm, point CD121/1 records Made Ground over 1m of gravel and sand on bedrock Gault Clay at c.1m OD and close by point 56SW17 showed 1.5m of drift on bedrock at a similar elevation. To the northeast, Made Ground over 1m of gravel and sand on bedrock was recorded at point CD121/2, and at point 56SW18 bedrock Gault Clay was recorded beneath 1m of unknown drift. Point 56SW14 in Bottisham Fen records 1m of peat overlying gravel and sand on bedrock Gault Clay at c.0m OD. It is proposed that this peat unit is formally named the Bottisham Fen Peat with the stratotype at point 56SW14 (TL 5341 6466).

6.2.4.3 Geological Section 50/60.2

This 4km-long section (Figure 6.2.4-2) is aligned southwest-northeast from Horningsea (JP2) to Bottisham Fen (56SW14). Point JP2 records gravel and sand overlying bedrock at c.3.5m OD and point JP1 shows 1m of gravel and on bedrock Gault Clay at c.2.5m OD. To the northeast in Stow cum Quy Fen, point 56SWE3 records 1m of gravel and sand on bedrock Chalk at c.2m OD. In North White Fen, point 56SW12 records peat and silty clay overlying 1m of gravel and sand overlying on bedrock Chalk at c.0.5m OD. Point 56SW11 records 1m of gravel and sand overlying 1m of silty clay on bedrock Chalk at a similar elevation. From point CD121/1 at Jack of Clubs Farm this geological section runs along the same line as that described in Section 6.2.4.2.

6.2.4.4 Geological Section 50/60.3

This 5.5km section (Figure 6.2.4-3) runs northwest-southeast from Clayhithe Farm (188/73) to Newmarket Road between Stow cum Quy and Bottisham (56SW15). It
provides details of the 2nd and 1st Terrace deposits at Stow cum Quy Fen and of the 4th and 3rd Terrace Deposits near Stow cum Quy village. Point 188/73 at Clayhithe Farm records bedrock Gault Clay at the surface at c.5m OD. Nearby, point CD37/3 shows 1m of clay with gravel on bedrock at c.4m OD. To the southeast in Stow cum Quy Fen, point 56SWE1 shows 1m of gravel and sand on bedrock at c.1m OD. Point 56SW2 records 2m of gravel and sand on bedrock Chalk at c.2m OD and points 56SW9 and 56SWE3 both record gravel and sand on bedrock Chalk at a similar elevation. Further to the southeast, point 188/185 near Spring Plantation north of Stow cum Quy shows bedrock Chalk close to the surface beneath topsoil. Southeast of Stow cum Quy near The Bury, point 56SW13 records 2m of gravel and sand on bedrock Chalk at c.16m OD. On the A1303 Newmarket Road, point 56SW15 shows gravel and sand on bedrock at a similar elevation. Although this point falls within a patch of 3rd Terrace Deposits mapped adjacent to the area of 4th Terrace Deposits at Stow cum Quy, based on these data there seems to be little grounds for differentiation.

6.2.4.5 Geological Section 50/60.4

This 2km-long section (Figure 6.2.4-4) runs west-east through the ridge capped by 4th Terrace Deposits at Stow cum Quy. Point a5233 shows 1m of gravel and sand on bedrock Chalk at c.12m OD. Nearby, point 188/101 records 3m of gravel and sand on bedrock at a similar elevation. To the east, point 188/103 records 4m of gravel and sand on bedrock Chalk at c.13m OD. It is proposed that this gravel unit is formally named the Stow cum Quy Village Gravel, with the stratotype at point 188/103 (TL 5200 6000). Further east, near The Bury, point 56SW13 records 2m of gravel and sand on bedrock Chalk at c.16m OD. On the A1303 Newmarket Road, point 56SW15 shows gravel and sand on bedrock at a similar elevation.

6.3 Correlation of Stratigraphic Units

5km Square TL 250/560

6.3.1 Synopsis

Figure 6.3.1-1 and Table 6.3.1-1 show details of the 3 local stratigraphic units proposed for the 5km Square 250/560. The Bottisham Fen Peat and Stow cum Quy Fen Gravel are close to 0m OD in the fenland area, and contrast markedly with the Stow cum Quy Village Gravel which occupies a ridge (c.20m OD) at the fen edge. In the fenland, it is often difficult to identify the discrete terraces mapped by the BGS, and the sections presented above show continuous spreads of gravel and various heights between −1m OD and 4m OD. Table 6.3.1-2 and Figure 6.3.1-2 show the chronological and stratigraphic
relationships of these units and their correlation with lithostratigraphic members and formations. Figure 6.3.1-3 presents an idealised geological section through the area showing the relationships of the various lithostratigraphic members. The three stratigraphic members recognised fall within the Cam Valley Formation (see Table 1.4.2-1). The Stow cum Quy Village Gravel is correlated with the Little Wilbraham Member of the Cam Valley Formation. These sediments are interpreted as braidplain deposits of an ancient River Cam tributary of Early Devensian (MIS 4) or possibly ‘Wolstonian’ age. At a much lower elevation, the Stow cum Quy Fen Gravel is correlated with the Sidgwick Avenue Member and interpreted as Middle to Late Devensian (MIS 2/3) braidplain deposits of a tributary of the River Cam. The Bottisham Fen Peat is correlated with the Jesus Green Member and interpreted as Flandrian (MIS 1) fen deposits.

There is clearly uncertainty about the antiquity of the Little Wilbraham Member, and parts of the Sidgwick Avenue Member here may also be of composite age. It seems likely that large intervals of time are not represented by the deposits. This suggests that significant amounts of erosion and periods of non-deposition may punctuate the sequence.
Chapter 7

10km Square TL 230/550

Bourn and Comberton

Over the broad, the shallow, rapid stream,
The alder, a vast hollow trunk, and ribb'd -
All mossy green with mosses manifold,
And ferns still waving in the river-breeze.

A BECK IN WINTER.
Samuel Taylor Coleridge
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10km Square TL 230/550

Bourn and Comberton

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Chapter 7

10km Square TL 230/550

Bourn and Comberton

7.1 10km Square TL 230/550

7.1.1 Synopsis

This ten-kilometre square is located at the western edge of the main study area. The author has restricted his attention to two of the 5km Squares which contain 13 monads with data in (Figure 7.1.1-1). The ten-kilometre square includes the villages of Caxton, Bourn and Longstowe to the west, Caldecote, Kingston and Hardwick to the north, Comberton and Harlton to the east, Barrington, Orwell and Arrington to the south, and the Eversdens at the centre. The valley of the Bourn Brook is the main line of drainage running west-east through the centre of the square dissecting a plateau area to the north and west. The southern part of the square drains south toward the valley of the River Rhee. This drainage pattern has produced two west-east trending interfluves reaching c. 70-80m OD, with the floor of the Bourn Brook valley at c. 20m OD.

7.1.2 Drainage

The central part of this area drains eastwards through the valley of the Bourn Brook from Caxton and Bourn towards Comberton and the River Cam. Several small tributaries of the River Great Ouse dissect the plateau area near Hardwick on the extreme northeast edge of the square. To the south, a tributary of the River Rhee drains towards the east near Arrington and Orwell.

7.1.3 Bedrock geology

The bedrock geology comprises Jurassic Kimmeridge Clay overlain by Cretaceous Lower Greensand, Gault Clay and Chalk broadly dipping towards the southeast (Figure 7.1.3-1). It is interesting to note that Lower Greensand outcrops at c. 10-15m OD beneath the drift-filled Hatley Channel (Woodland 1942, Sparks 1957, Edmonds and Dinham 1965) to the southwest of Caldecote.
7.1.4 Quaternary geology

The Quaternary geology mapped by the BGS (Figure 7.1.3-1) comprises Boulder Clay (till) on the plateau area to the north and west, and on a ridge between Arrington and Harlton. Beneath the plateau, the Boulder Clay (till) is known to occupy the southwest-northeast aligned Hatley Channel (Woodland 1942, Sparks 1957, Edmonds and Dinham 1965) where it reaches c.30m thickness. Small areas of 3rd Terrace Deposits are mapped near Comberton, Toft and Kingston. Larger areas of Undifferentiated 1st and 2nd Terrace Deposits associated with the Bourn Brook are mapped south of Comberton, and near Bourn, Caldecote and Kingston there are areas assigned to the 1st Terrace. Alluvium is confined to the floor of the Bourn Brook valley.

7.2 5km Square TL 235/55 Comberton

7.2.1 Synopsis

This five-kilometre square contains 9 monads with 39 points (Figures 7.2.1-1 & 7.2.1-2). The area includes the villages of Hardwick to the north, and Toft and Comberton to the south. The area includes a short stretch of the A428 road, which provides the majority of points in this square.

7.2.2 Drainage and relief

This square comprises the edge of the plateau area to the north and west at c.30-60m OD. The drainage is principally towards the east, although near Hardwick several small streams drain north towards the valley of the River Great Ouse. The valley of the Bourn Brook (20-30m OD) runs along the southern edge of the square towards the River Cam to the east, and a tributary, the Tit Brook drains the area around Comberton. North of Comberton the plateau is also dissected by the headwaters of the Bin Brook, which flows east to join the River Cam in Cambridge.

7.2.3 Geology

The bedrock geology comprises Lower Greensand overlain by Gault Clay and Lower Chalk. These beds dip broadly towards the southeast (Figures 7.2.3-1 & 7.2.3-2). The Quaternary geology comprises Boulder Clay (till) on the plateau area and 3rd Terrace Deposits at Comberton and Toft. Undifferentiated 2nd and 1st Terrace Deposits are also mapped in the Bourn Brook valley, and Alluvium is mapped on the valley floor.
7.2.4 Geological Logs and Sections

7.2.4.1 Synopsis

Secondary sources accounted for 38 of the 39 points which comprise 30 records from the Highways Agency archives, 7 records from the Huntingdon and Biggleswade Memoir (Edmonds and Dinham 1965) and 1 record from the British Geological Survey Well Catalogue Series (Matthews and Harvey, 1965). The author collected data from a single point (CVP) during work carried out at Comberton Village Pond.

7.2.4.2 Geological Section 35/55.1

This section (Figure 7.2.4-1) runs roughly southwest-northeast from Toft (HD68/3) through Asplins Farm to Hardwick (HD68/8). It provides a record of the drift geology from the buried Hatley Channel (Woodland 1942, Sparks 1957, Edmonds and Dinham 1965) and the plateau area near Hardwick. The section entirely consists of chalky diamict overlying Gault Clay bedrock (Figures 7.2.3-1 & 7.2.3-2).

At Toft, point HD68/3 records 18m of chalky diamict overlying bedrock Gault Clay at c.12m OD. It is proposed that this diamict unit is formally named the **Toft Diamict**, with the stratotype at HD68/3 (TL 3590 5620). This rockhead appears to represent the northeastern extension of the Hatley Channel, which may be clearly identified southwest of Caldecote in Figure 7.1.3-1. The elevation of the ground surface at this point (c.30m OD) suggests considerable incision by the Bourn Brook when compared to the plateau surface at 60-70m OD elsewhere. To the northeast at Asplins Farm, point HD68/4 records 26m of chalky diamict overlying bedrock at c.17m OD. This point must still be within the confines of the Hatley Channel. To the north point HD68/9 near Hardwick Church records 27m of chalky diamict overlying bedrock Gault Clay at c.39m OD. Further north, point HD68/8 records 28m of chalky diamict over bedrock at 36m OD. It is clear that although part of the plateau area, these two points lie outside, and probably to the north of the buried channel. However, the exact course of the Hatley Channel to the northeast of Toft is somewhat difficult to determine. It is proposed that this diamict unit is formally named the **Hardwick Diamict**, with the stratotype at HD68/8 (TL 3720 5940).

7.2.4.3 Geological Section 35/55.2

This section (Figure 7.2.4-2) runs roughly west-east along the line of the A428 road from Hardwick (HD68/8) through Red House Farm to beyond Highfield Farm, Madingley (a5031). It provides a record of the drift geology at the edge of the plateau. This section comprises chalky diamict overlying Gault Clay or Chalk bedrock. Point HD68/8 records 28m of diamict over bedrock Gault Clay at 36m OD. To the east near Red House Farm, a
number of points (a5001 to a5010) record the presence of chalky diamict at or within a few metres of the land surface at c.40-63m OD. However, point 187/112 shows 27m of chalky diamict overlying Chalk bedrock at c.42m OD. The height of the rockhead near Highfield Farm is somewhat variable with point b5021 recording bedrock Chalk beneath 21m of chalky diamict at c.41m OD and point HD68/10 recording 27m of chalky diamict on bedrock at c.36m OD. The land surface rapidly descends at the edge of the plateau, so that point a5029 shows 3m of chalky diamict on bedrock Chalk at c.43m OD. Thin chalky diamict is present over bedrock at points a5030c to a5030, and at a5031 Chalk reaches the surface beneath topsoil.

7.2.4.4 Other Data Points

Data point CVP was collected by the author at Comberton Village Pond, and comprises a combined log and borehole. It records more 2m of gravel and sand with silty bands beneath topsoil, with a land surface of c.25m OD. It is proposed that this gravel unit is formally named the **Comberton Gravel**, with the stratotype at CVP (TL 3810 5630).

7.3 5km Square TL 235/50 Harlton

7.3.1 Synopsis

This five-kilometre square contains 4 monads with 15 points (Figures 7.3.1-1 & 7.3.1-2). The area includes the Eversdens, Harlton, Orwell and part of Barrington to the south.

7.3.2 Drainage and relief

This square has the valley of the Bourn Brook running west-east along its northern edge and the valley of the River Rhee to the south. The two valleys are separated by c.40-70m OD west-east trending ridge.

7.3.3 Geology

The bedrock geology largely comprises Gault Clay, overlain by Lower Chalk beneath the west-east trending ridge south of Harlton. These beds broadly dip towards the southeast (Figures 7.3.3-1 & 7.3.3-2). The Quaternary geology comprises Boulder Clay (till) capping the ridge, and undifferentiated 2nd and 1st Terrace Deposits and Alluvium in the Bourn Brook valley.

7.3.4 Geological Logs and Sections

7.3.4.1 Synopsis

The 15 points were from secondary sources and comprise 2 records from the Huntingdon and Biggleswade Memoir (Edmonds and Dinham 1965), 8 records gleaned
from Sparks (1952), 3 records from Norris (1962), and 2 records from Hoare and Connell (1981).

7.3.4.2 Geological Section 35/50.1

This section (Figure 7.3.4-1) runs west-east from Orwell Hill (HD67/3), to the Barrington Works HD 67/4. It provides a record of the drift geology through the ridge and comprises chalky diamict overlying bedrock Chalk.

At Orwell Hill, West and Donner (1956) described chalky diamict exposed in a ditch section at c.70m OD elevation (data point HD67/3). To the east, Hoare and Connell (1981) described sections exposing 13m of chalky diamict overlying bedrock chalk at c.56m OD in the excavations at Barrington Works. West and Donner (1956) also described chalky diamict (HD67/4) at the edge of excavations at Barrington Works. This chalky diamict unit has been formally named the Barrington Works (Diamict) Member (Bowen 1999), although the stratotype location given appears to be in the centre of the pit, rather than at a specific log. Since the original intention was clearly to use one of the logs described by Hoare and Connell (1981) as the stratotype, the author suggests that the revised stratotype for the Barrington Works (Diamict) Member should be HoareA at TL 3890 5150.

7.3.4.3 Geological Section 35/50.2

This section (Figure 7.3.4-1) runs west-east through part of the Barrington Works pit. It provides a record of the detailed drift geology through the system of dry valleys at the edge of the ridge.

Sparks (1952) described sections at Barrington Works cut into a series of small dry valleys that he named (west to east) D, C, B and A. At that time no chalky diamict was exposed, and Sparks studied the deposits filling the dry valleys. Norris (1962) was able to observe the same valleys after the sections had been cut back by a further c.100m to reveal chalky diamict on the interfluves. All these sections were destroyed as the face was further cut back to give show the chalky diamict sections described by Hoare and Connell (1981).

Data point NorrisD shows 6m of chalky diamict on bedrock Chalk at c.56m OD on the western interfluve of valley D. Points SparksD to SparksA show the deposits filling the dry valleys and the bare interfluves for the four dry valleys D to A described by Sparks (1952). The deposits filling the dry valleys may be summarised as comprising 3m of clay with gravel (Sparks’ Bed 2) overlying 3m of white chalk putty containing chalk clasts (Sparks’ Bed 1) on frost shattered bedrock Chalk at c.44m OD. On the interfluves, bedrock Chalk was observed close to the ground surface at c.50m OD. It is proposed that these deposits are formally named the Barrington Works Dry Valley Beds, with the stratotype at SparksC (TL 3940 5112).
7.4 Site Description 5km Square TL 235/50

7.4.1 Barrington Works, Barrington

7.4.1.1 Introduction

The dry valley deposits described in detail from Eastwood’s Pit, Barrington Works were analysed for their mollusc fauna by Sparks (1952). The clay with gravel and underlying chalk putty were thought to have quite different origins, although Sparks’ stratigraphic interpretations are now clearly open to question. Norris (1962) described further exposures of dry valley fillings and exposures of chalky diamict not seen by Sparks. Much of his discussion concerns the debate over the identification of Gipping and Lowestoft tills that had preoccupied West and Donner (1956). Norris’ description of two chalky diamict units, the later apparently partly overlying the chalk putty of the dry valleys further fuelled a somewhat tenuous stratigraphic interpretation based on that developed by Sparks a decade earlier. Hoare and Connell (1981) examined new exposures of chalky diamict and reviewed the previous evidence. They argued that there was only evidence for one chalky diamict unit, which they attributed to the Anglian glaciation (contra Norris 1962) and that the dry valley deposits clearly post-dated this chalky diamict, with a soliflucted chalky diamict giving the impression of stratigraphic complexity in the dry valley systems.

7.4.1.2 Environments of deposition

The chalky till (Barrington Works Diamict) is thought to have been lodged beneath Anglian ice advancing towards the south (Hoare and Connell, 1981). It appears likely that there was a considerable interval of time between the deposition of the chalky diamict and the formation of the dry valleys and their contained deposits (the Barrington Works Dry Valley Beds). The numerous chalk pellets in the chalk putty unit suggest the widespread destruction of Chalk bedrock by periglacial processes. Solifluction processes within the active layer of permafrost are known to transport the regolith downslope. Cold conditions are also indicated by the contained mollusc fauna. Although there is little direct evidence, it appears that this deposit is probably Late Devensian (Late Glacial) in age. The overlying clay with gravel unit seems represent an early Flandrian soil and subsequent colluvial slopewash. The mollusc fauna indicates a mixture of grassland and woodland at that time. Both units are principally terrestrial deposits with little evidence of stream action.

7.4.1.3 Molluscs & Pollen

Sparks (1952) analysed the molluscan fauna of the chalky putty unit and the overlying clay with gravel. He determined that the fauna of the chalk putty indicated climatic conditions similar to those in northern Scandinavia or perhaps central Europe today,
although there was a lack of distinctly southern taxa. Similar deposits further downslope (SparksE) contained a comparable assemblage, but with indicators of damper conditions. According to Norris (1962), ‘only a few extremely rare and badly preserved pollen grains were present’ in the chalk putty unit. In contrast, the clay with gravel unit, thought partly to be a palaeosol, contained a Flandrian mollusc fauna, with elements indicating both open ground and woodland and a climate at least as warm as that today. Sparks argued that the absence of *Helix aspersa* and various other taxa indicated an early Flandrian (Atlantic) date.

### 7.4.1.4 Conclusions

The chalky rubble unit of Barrington Works Dry Valley Beds at this site appears to be a Late Devensian (Late Glacial) solifluction deposit, and the overlying clay with gravel unit seems to represent soil and colluvial slopewash of Flandrian age.

### 7.5 Correlation of Stratigraphic Units

#### 5km Squares TL 235/55 and TL 235/50

#### 7.5.1 Synopsis

Figure 7.5.1-1 and Table 7.5.1-1 show details of the 5 local stratigraphic units proposed for the 5km Squares TL 235/55 and TL 235/50. Three of these units are chalky diamicts occupying valley side, plateau and ridge positions. The Comberton Gravel is mapped as part of the 3rd Terrace of the Bourn Brook. The Barrington Works Dry Valley Beds are not recognised on the BGS map, although analogous deposits may be very widespread in similar valley side situations throughout the area. Table 7.5.1-2 and Figure 7.5.1-2 show the chronological and stratigraphic relationships of these units and their correlation with lithostratigraphic members and formations. Figure 7.5.1-3 presents an idealised geological section through the area showing the relationships of the various lithostratigraphic members. The Barrington Works Diamict at point HoareA becomes the stratotype of the Barrington Works Member of the Lowestoft Formation, and is correlated with the Toft Diamict and the Hardwick Diamict. These deposits are interpreted as Anglian (MIS12) till. The exact stratigraphic position of the Comberton Gravel is unclear, and may it represent Early Devensian (MIS 4) or ‘Wolstonian’ fluvial deposition of the proto-Bourn Brook, or even Anglian outwash. The Barrington Works Dry Valley Beds are interpreted as Late Devensian (Late Glacial) (MIS 2) and Flandrian (MIS 1) dry valley deposits, and are therefore correlated with the Midsummer Common Member and Jesus Green Member of the Cam Valley Formation respectively (see Table 1.4.2-1).

There appears to be a large interval of time not represented by sediments between the Anglian and Flandrian Stages. This suggests that significant periods of erosion and non-deposition intersperse the sequence. The Comberton Gravel might partly represent this
interval, but there is great uncertainty about its exact age, which makes correlation very difficult.
Chapter 8

10km Square TL 240/550

Cambridge

...go closer, hold the land; feel partly no more than grains of sand,
We stand to lose all time, a thousand answers there in your hand,
Next to your deeper fears, we stand, surrounded by a million years.

ROUNDABOUT
Jon Anderson
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Chapter 8

10km Square TL 240/550

Cambridge

8.1 10km Square TL 240/550

8.1.1 Synopsis

This ten-kilometre square is located at the centre of the main study area and contains 83 monads with data (Figure 8.1.1-1). The area includes much of the City of Cambridge to the north, and also covers the villages of Coton, Barton and Haslingfield to the west, Harston, Hauxton, Great and Little Shelford and Stapleford to the south, Wandlebury, Cherry Hinton and Teversham to the east, and Grantchester and Trumpington near the centre. In the south of the square, the River Cam joins the River Granta before flowing northwest to meet the River Rhee and the Bourn Brook. From this point, the valley of the River Cam (5-10m OD) runs southwest to northeast through Cambridge. Relatively high spurs of land (c.60m OD) fringe the square to the northwest near Coton and to the southwest near Haslingfield, and to the east, the area around Wandlebury and the Gog Magog Hills reaches c.70m OD. However, much of the square is occupied by the valleys of various streams and is relatively low-lying (c.10-20m OD).

8.1.2 Drainage

The drainage of this area is generally towards the north through the River Cam system. The extreme northwest of the square near Madingley Hill drains north towards the River Great Ouse. The southern part of the square is characterised by a series of confluent streams. The River Cam flows north to join the westward flowing River Granta south of Stapleford, before continuing northwest to join the River Rhee flowing northeast and the eastward flowing Bourn Brook south of Grantchester. The River Cam continues northeast towards Cambridge and is joined by Hobson’s Brook, Bin Brook and Coldham’s Brook, all of which carry Chalk spring water.

8.1.3 Bedrock geology

The bedrock geology comprises Cretaceous Gault Clay, Lower Chalk and Middle Chalk. These beds dip broadly towards the southeast (Figure 8.1.3-1), although there is
some evidence for minor folding in the area around Wandlebury (Worssam and Taylor 1969, and White, 1932)

8.1.4 Quaternary geology

The Quaternary geology mapped by the BGS (Figure 8.1.3-1) comprises areas of Boulder Clay (till) capping the highest spurs of land in the northwest near Coton and in the southwest near Haslingfield. In addition, an area of ‘Observatory Gravels’ is mapped near the Observatory, Cambridge, patches of ‘Glacial Gravels’ are shown capping the Gog Magog Hills, and there are various patches of 4th Terrace Deposits in Cambridge and to the north of Teversham. A disjointed spread of 3rd Terrace Deposits can be traced from Little Shelford and Stapleford in the south, through Trumpington to Cambridge in the north, and a smaller area of 3rd Terrace Deposits is also mapped at Grantchester. A distinct spread of 2nd Terrace Deposits can also be identified stretching from Great Shelford along the valley of Hobson’s Brook through Cambridge to Chesterton in the north. Further south, near Hauxton, Harston and Stapleford undifferentiated 1st and 2nd Terrace deposits are mapped at the edge of the current floodplain, which is occupied by Alluvium. 1st Terrace Deposits are only identified at the edge of the Cam floodplain in Cambridge.

8.2 5km Square TL 240/555

Coton, Grantchester & West Cambridge

8.2.1 Synopsis

This five-kilometre square contains 22 monads with 993 points (Figures 8.2.1-1 & 8.2.1-2). The area includes the villages of Coton to the northwest, Barton to the southwest, Grantchester and Trumpington to the southeast, and the western part Cambridge City to the northeast. Figures 8.2.1-3 to 8.2.1-8 show the detailed distribution of points in six monads at the edge of Cambridge. The area includes the M11 Motorway and a large number of development sites in Cambridge City, which provide a great deal of data points. An auger survey of the West Cambridge site by Dr C. L. Forbes supplies the largest number of points in this square.

8.2.2 Drainage and relief

Drainage of this area is generally towards the River Cam, which flows northwards across the east of the square. A small area at the northern edge of this square drains north towards the River Great Ouse. The Bin Brook (10-20m OD) drains the area between Coton and Barton in the west of this square, and is confluent with the River Cam near The Backs, Cambridge. Hobson’s Brook is also confluent with the River Cam in this square,
although its valley is located within the five-kilometre squares 45/55 and 45/50. Generally, the square is low lying (5-20m OD), although the highest areas are the spurs reaching c.60m OD near Coton. It is also worth noting the northwest-southeast trending ridge of land (c.25m OD) which forms Castle Hill and on which Cambridge Observatory is located.

**8.2.3 Geology**

The bedrock geology comprises Gault Clay overlain by Lower Chalk broadly dipping towards the southeast (Figures 8.2.3-1 & 8.2.3-2). The Quaternary geology comprises Boulder Clay (till) capping the higher spurs of land near Coton, ‘Observatory Gravels’ at the Observatory, Cambridge, and various patches of 4th Terrace Deposits. In addition, 3rd Terrace Deposits are mapped as a strip north of Barton stretching east towards Grantchester, and at Trumpington in the southeast and Chesterton in the northwest. Patches of 2nd Terrace Deposits are shown in west and central Cambridge, and to the south of Newnham, and strips 1st Terrace deposits are mapped adjacent to the Alluvium of the River Cam floodplain.

**8.2.4 Geological Logs and Sections**

**8.2.4.1 Synopsis**

The author collected 154 of the 993 points from this square. The secondary sources comprised 53 records from the British Geological Survey Mineral Assessment Report (Dixon 1980), 7 from the British Geological Survey Well Catalogue Series (Sayer and Harvey, 1965) and (Matthews and Harvey, 1965), 23 from the Cambridge Memoir (Worssam and Taylor, 1969) and 19 from the Saffron Walden Memoir (White, 1932). The Highways Agency Archives provided 78 records, and various contractors reports contributed 210 records including 28 from the North Cambridge Sewer. Dr C. L. Forbes kindly provided 8 records from his observations in central Cambridge, and 433 points from an auger survey on the West Cambridge site. In addition, 1 record at Oxford Road (point OxRd) came from Marr (1926), 5 records at the Traveller’s Rest Pit (points TRP to TRPA1) came from Marr (1919), and 2 records at Sidgwick Avenue (points SWAA and SWAB) came from Lambert, Pearson and Sparks (1963).

**8.2.4.2 Geological Section 40/55.1**

This section (Figure 8.2.4-1) runs 4km north-south from Madingley Hill (45NW116) through Coton to a point north of Barton (45NW121). It provides a record of the drift geology of the spurs of higher land capped by till. Point 45NW116 on the north side of Madingley Hill near the American Cemetery shows 1m of chalky diamict on bedrock Chalk at c.36m OD. On the top of Madingley Hill, near Madingley Hill Farm, points 45NW137,
HC and CD82/3 record 25m of chalky diamict on bedrock Chalk at 32–34 m OD. Close by at Coton Court, point 188/190 shows 29m of chalky diamict on bedrock Gault Clay at c.29m OD. It appears that this represents a buried bedrock channel-form beneath the centre of the Madingley Hill ridge. It is proposed that this diamict unit is formally named the Madingley Hill Diamict, with the stratotype at point 188/190 (TL 4040 5930). To the south, point 45NW9 records 16m of chalky diamict on bedrock at c.36m OD, and at point CD82/2 4m of chalky diamict overlies 1.5m of chalky gravel and sand, which in turn overlies 10m of chalky diamict on bedrock at c.37m OD. This gravel unit probably represents sub-glacial drainage within the Anglian ice sheet. It is proposed that this gravel unit is formally named the Madingley Hill Gravel, with the stratotype at point CD82/2 (TL 4050 5910).

West of Coton village, point 45NW10 shows 3.5m of chalky diamict on bedrock at c.36m OD, and point 45NW11 records bedrock Chalk near the surface beneath topsoil at c.33m OD. Point 187/10 at Whitwell Farm shows 8m of Made Ground on bedrock Chalk at c.24m OD. This disturbance may be due to the past mining of phosphatic nodules from the Cambridge Greensand in this area. Nearby, points 45NW12 and 45NW13 record bedrock Chalk near the surface beneath topsoil. Close to Highfield Farm, point 45NW14 also records bedrock Chalk near the surface at c.39m OD, but point 45NW15 shows 5m of chalky diamict on bedrock Chalk at c.40m OD. Near the top of the ridge, point CD82/1 records 17m of chalky diamict on bedrock Chalk at 33m OD, and point 45NW16 shows 14m of chalky diamict on bedrock at c.37m OD. There also appears to be a buried bedrock channel-form beneath the centre of this ridge. It is proposed that this diamict unit is formally named the Highfield Farm Diamict, with the stratotype at point CD82/1 (TL 4020 5740). Downslope towards Barton village, point 45NW121 records bedrock Chalk close to the surface beneath topsoil at c.27m OD.

8.2.4.3 Geological Section 40/55.2

This 5.5km-long section (Figure 8.2.4-2) runs north-south along the line of the M11 Motorway from near the Pheasant Plantation, north of the A1303 Madingley Road (point 194) past High Cross and Dumpling Farm near the A603 Barton Road to a point southwest of Grantchester village (sb53). It provides a detailed record of the drift geology to the east of the spurs of higher land capped by till, and of the strip of 3rd Terrace deposits near Grantchester. Points 194 to 192 near the Pheasant Plantation show bedrock Gault Clay near the surface beneath topsoil at c.14m OD. To the south, point 190 shows clay with gravel on bedrock at c.17m OD and near the A1303 Madingley Road, points 189 and b101 record clay with gravel on bedrock at c.21m OD, forming a low ridge. Nearby, point 188 shows Made Ground over bedrock at a similar elevation, and points 187 and 186 show
clay with gravel on bedrock Gault Clay at c.20m OD. Adjacent to the British Antarctic Survey building, point 185 shows bedrock Gault Clay near the surface at c.20m OD, and point 184 records bedrock Chalk at the surface at a similar elevation. To the south, points 183 and 182 both show bedrock Gault Clay near the surface beneath topsoil. At the edge of the High Cross site, point b100 shows 2m of topsoil (probably dumped) overlying 0.5m of clay with gravel on bedrock at c.14m OD. In contrast, points 181 to 179 record 1.5m of diamict on bedrock at c.15m OD. This material is probably the product of solifluction from diamict on higher slopes at Madingley Hill to the west. It is proposed that this diamict unit is formally named the **High Cross Diamict**, with the stratotype at point 179 (TL 4200 5837). To the south, points 178 to 173 show bedrock Gault Clay close to the surface at elevations between 15m and 18m OD.

In the valley of the Bin Brook, point b97 records 1m of clay with gravel on bedrock at c.14m OD, and nearby points 172 to 169 show 1m of topsoil on bedrock Gault Clay at a similar elevation. It is worth noting that in this area the BGS map (Figures 8.2.3-1 & 8.2.3.2) indicate a small patch of 2nd Terrace Deposits. To the south, point 168 shows 1.5m of diamict on bedrock at c.12m OD, and point 167 records clay with gravel overlying 2m of diamict on bedrock at c.13m OD. Nearby at Dumpling Farm, points b95 and 164 record a similar thickness of diamict, although points 205/318 and b96 show bedrock near the surface beneath topsoil. It is proposed that this diamict unit is formally named the **Dumpling Farm Diamict**, with the stratotype at point 167 (TL 4188 5718). Near Haggis Farm and the A603 Barton Road, points 163 to b93 show clay with gravel over Bedrock at c.16m OD. However, point 162 records 2m of diamict on bedrock Gault Clay at c.16m OD. To the south, a low ridge rises so that point 161 records bedrock Chalk beneath 0.5m of topsoil at c.20m OD. Point 160 records topsoil over clay with gravel, in turn overlying 1m of gravel and sand on bedrock chalk at c.20m OD. Nearby, point 158 shows clay with gravel on bedrock at a similar elevation, although downslope, points 156 and 155 record 1m of clay with gravel overlying silty clay on bedrock Gault Clay at c.17m OD. However, point 338 records only bedrock Gault Clay near the surface at c.19m OD. In contrast, to the west of Grantchester village point 337 records topsoil over 1m of sandy silty clay overlying 1m of gravel and sand, in turn overlying 3m of diamict on bedrock at c.15m OD. These deposits occur at the edge of the 3rd Terrace mapped by the BGS. It is proposed that the diamict unit here is formally named the **Grantchester Diamict**, with the stratotype at point 337 (TL 4210 5584).

Nearby, point b89 shows 2m of clay with gravel overlying 1m of diamict on bedrock at c.17m OD and point sb55 records 1m of clay with gravel overlying 2m of gravel and sand, in turn overlying diamict on bedrock at c.16m OD. In contrast, point b232 shows 4m of
sandy silty clay on bedrock at c.16m OD. A similar sequence is also recorded at point 336, although other points nearby show a more complex stratigraphy. It is proposed that this silty clay unit is formally named the **Grantchester Silty Clay**, with the stratotype at point b232 (TL 4215 5572). Point b88 shows clay with gravel overlying diamict and point sb54 reveals a composite sequence comprising 1m of clay with gravel overlying 1m of gravel and sand, in turn overlying silty clay and 2m of diamict on bedrock Gault Clay at c.14m OD. The 3rd Terrace surface forming this low ridge at Grantchester is clearly underlain by a buried channel-form in the bedrock. To the south, point 335 shows 2m of silty clay over bedrock Chalk at c.19m OD, and point 334 shows 1m of silty clay overlying 2m of gravel and sand on bedrock Gault Clay at c.18m OD. Downslope, point 332 records sandy clay over clay with gravel on bedrock Chalk at c.18m OD, and points 330 and 331 show bedrock Chalk close to the surface beneath topsoil. Points 330 and b231 show topsoil over bedrock Gault Clay at c.15m OD, and point SW18/2 records bedrock near the surface at c.13m OD. In the valley of the Bourn Brook point sb53 records 2m of diamict overlying bedrock Gault Clay at c.12m OD. It is proposed that this diamict unit is formally named the **Bourn Brook Diamict** with a stratotype at point sb53 (TL 4250 5502).

**8.2.4.4 Geological Section 40/55.3**

This 5.5km-long section (Figure 8.2.4-3) runs roughly north-south from the Traveller’s Rest Pit (TRPM) through the West Cambridge site near the Cavendish Laboratory to the M11 Motorway south of Grantchester (SW18/2). At the now graded Traveller’s Rest Pit at the top of a low ridge, point TRPM shows 5m of gravel and sand overlying bedrock Gault Clay at c.20m OD. A separate exposure described by Marr (1919) at point TRPB records 4m of gravel and sand, the upper part contorted and with ice wedges, overlying bedrock at c.21.5m OD. Nearby at the Cambridge Observatory, points CD87/1 to e52 record 4m of Gravel and sand on bedrock Gault Clay at c.21m OD. Point e48 records a similar thickness of gravel and sand overlying bedrock Chalk at this elevation. South of the A1303 Madingley Road, archaeological excavations at the site of the new Microsoft development allowed the author to collect detailed information across the valley of the small stream known as the Willows Brook. The sequence revealed by points 11/1 to 9/1 can be summarised as silty clay 1m thick overlying a basal gravel and sand unit also 1m thick on bedrock at 14-15m OD. It is proposed that the gravel unit here is formally named the **Willows Brook Gravel**, with the stratotype at point 11/1 (TL 4318 5920). A low bedrock ridge (c.16m OD) covered by clay with gravel is revealed by points 6/1 and 6/3, and downslope near the Cavendish Laboratory points 5/1 to mc record bedrock Gault Clay near the surface. However, point HRBH2 shows 3.5m of Made Ground (an embankment) over 1m of diamict. On the floor and southern flank of a second small valley, points
45NW180 to WFRB record 2m of sandy clay with pebbles on bedrock at 11-13m OD. It is proposed that this sandy clay unit is formally named the **Cavendish Laboratory Sandy Clay**, with the stratotype at point 45NW180 (TL 4321 5869). In contrast, downslope from the top of the next small ridge (c.15m OD) points 45NW179 to 78 show only bedrock Gault Clay at the surface beneath topsoil.

Further south near Stone Bridge where the A603 Barton Road crosses the Bin Brook at Newnham, point 45NW182 records 0.5m of sandy clay over gravel and sand on bedrock at c.9m OD. Towards Grantchester to the south, points SW18/20 to SW18/2 summarise a section originally described by Penning and Jukes-Browne (1881) and reproduced by White (1932). Points SW18/20 to SW18/17 record bedrock Gault Clay near the surface of the rising ground on the southern flank of the valley of the Bin Brook. Points SW18/16 to SW18/13 show a ridge (c.19m OD) formed by bedrock Chalk near the surface, and points SW18/12 and SW18/11 record Gault Clay at the surface in a small valley near Lacies Farm. A second ridge capped by 2m of gravel and sand on bedrock Chalk at c.17m OD (points SW18/9 to SW18/7) is shown west of Grantchester village. Downslope into the valley of the Bourn Brook, points 150 to SW18/2 record bedrock Chalk and Gault Clay close to the surface. However, point sb53 near the M11 Motorway records 2m of diamict overlying bedrock Gault Clay at c.12m OD.

**8.2.4.5 Geological Section 40/55.4**

This 5.5km-long section (Figure 8.2.4-4) runs roughly north-south from the Aldi Site on Histon Road (ALDIM) through the University Library, the Sidgwick Site and Newnham to Trumpington (45NW6). Point ALDIM at the Aldi Site shows Made Ground over 0.5m of sandy silty clay on bedrock Gault Clay at c.18m OD. Many points associated with the North Cambridge Sewer were collected using a vibro-coring technique, which provides only the depth to the bedrock surface rather than any details of the superficial deposits. This is the case with points ch14 to ch11122 where 3m of unknown deposits are recorded overlying bedrock at 16-18m OD. However, point c14 shows 2m of silty clay in this area, suggesting a small buried bedrock channel-form at the top of this low ridge. To the south, points a12, e51 and CSsewer show bedrock Gault Clay near the surface at c.19m OD beneath Made Ground and topsoil, while near New Hall, points NH and CD53/4 record bedrock Chalk close to the surface at a similar elevation. In contrast, point CD53/5 at New Hall records 2m of gravel and sand on bedrock Chalk at c.18m OD. It is proposed that this gravel unit is formally named the **New Hall Gravel**, with the stratotype at point CD53/5 (TL 4415 5945). Downslope, point CD106/10 shows 1m of clay with gravel on bedrock Gault Clay at c.14m OD and point a15 on the A603 Madingley Road shows 1m of Made Ground on bedrock at c.11m OD. To the south adjacent to
Grange Road, points B1 and CNIS1 show 1m of clay with gravel on bedrock at c.8m OD. At the University Library and Sidgwick Site, points ULT1 to L&C8 record 1m of clay with gravel over 2m of gravel and sand on bedrock at 6-7m OD in an area mapped by the BGS as 2nd Terrace. At the Sidgwick Avenue site described by Lambert, Pearson and Sparks (1963), point SWAA records 4.5m of gravel and sand containing silt bands, and overlying white calcareous silty clay on bedrock Gault Clay at c.4m OD. These deposits yielded a bison skull, molluscs and plant macrofossils generally indicating a cool climate. This gravel unit has been formally named the Sidgwick Avenue Member (Bowen, 1999). However, for correlation purposes the author will refer to this unit as the Sidgwick Avenue Gravel, with the stratotype at point SWAA (TL 4418 5801).

At Newnham College points SA1 to NCTP1 show gravel and sand near the surface, and in Newnham point Sumf shows Made Ground over 1m of gravel and sand on bedrock at c.7m OD, and point 45NW184 shows clay with gravel over 1.5m of gravel and sand on bedrock at c.6m OD. To the south on the floodplain of the River Cam on Grantchester Meadows, points GM1 to GM6 record 4m of shelly silty clay, overlying 1.5m of gravel and sand on bedrock Gault Clay at c.3m OD. The silty clay unit presumably represents Flandrian alluvial deposition, and it is proposed that it is formally named the Grantchester Meadows Silty Clay with a stratotype at point GM1 (TL 4409 5685). Further to the south on a low ridge northeast of Trumpington Hall, points 45NW2 and 45NW4 record 2m of silty clay on bedrock Chalk at c. 13m OD. Nearby, point 45NW5 shows 2m of gravel and sand overlying 1.5m of silty clay, in turn overlying 1m of gravel and sand on bedrock at c.12m OD. Point 45NW6 shows a similar but thinner sequence on bedrock at c.13m OD.

**8.2.4.6 Geological Section 40/55.5**

This 5.5km-long section (Figure 8.2.4-5) runs roughly west-east from Clare Farm, Barton (45NW122) through Grantchester to Trumpington (45NE65). At Clare Farm, point 45NW122 shows bedrock Chalk near the surface beneath topsoil at c.24m OD and nearby, point 45NW145 shows bedrock Gault Clay close to the surface at c.23m OD. Both these points are within a patch mapped as 3rd Terrace Deposits by the BGS. Near Trinity Foot Kennels point 45NW142 shows bedrock Chalk near the surface also at c.23m OD. To the east near the M11 Motorway at Grantchester within another patch of 3rd Terrace Deposits, point 337 records 1m of silty clay overlying 1m of gravel and sand, in turn overlying 3m of diamict. Point sb54 reveals a complex sequence comprising 1m of clay with gravel overlying 1m of gravel and sand, in turn overlying silty clay and 2m of diamict on bedrock Gault Clay at c.14m OD. Point 154 shows clay with gravel overlying 2m of silty clay on bedrock at c.17m OD, and point b88 shows clay with gravel overlying diamict on bedrock.
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at a similar elevation. Nearby, point sb55 shows 1m of clay with gravel overlying 2m of gravel and sand over diamict on bedrock also at c.17m OD. In contrast, point 153 records 1.5m of gravel and sand overlying 3m of silty clay on bedrock Gault Clay at c.14m OD, and point 152 shows 4m of gravel and sand. The edge of the deposits is clearly marked at point 151 where bedrock Chalk is close to the surface beneath clay with gravel at c.19m OD. Points 149 to 145 all show bedrock Chalk close to the surface at 17-19m OD. To the northeast, the floodplain of the River Cam has been projected on to the Geological Section 40/55.4 from Grantchester Meadows downstream. On the east side of the valley of the River Cam at Trumpington Hall, point 45MW9 shows 1m of silty clay on bedrock Gault Clay at c.11m OD. Nearby, point 45NW3 records 6m of silty clay with a base not touching bedrock at c.8m OD. It is proposed that this silty clay unit is formally named the **Trumpington Hall Silty Clay** with a stratotype at point 45NW3 (TL 4425 5563). These points fall at the edge of an area mapped by the BGS as 2nd Terrace Deposits. Further east near Trumpington, point 45NW4 shows 2m of silty clay on bedrock Chalk at c.13m OD, and point 45NW1 records 0.5m of sandy clay on bedrock at c.15m OD. East of Trumpington Road on the top of a low ridge, point 45NE65 shows bedrock Chalk close to the surface beneath topsoil at c.15m OD.

8.2.4.7 Geological Section 40/55.6

This 5km-long section (Figure 8.2.4-6) runs roughly southwest-northeast from the M11 Motorway (SW18/2) at Grantchester to the New Museums Site (Forb12) in central Cambridge. Near the M11 Motorway, point SW18/2 records bedrock Gault Clay close to the surface at c.12m OD, and nearby point sb53 shows 2m of diamict overlying bedrock Gault Clay at a similar elevation. South of Grantchester, points 148 and b86 show a low ridge underlain by bedrock Chalk near the surface beneath topsoil at 18-19m OD. West of Grantchester Church, a pit just within the bounds of the 3rd Terrace mapped by the BGS (point SW96/1) originally described by Mrs McKenny-Hughes (1888), and mentioned in White (1932) showed 2.5m of gravel and sand containing organic bands with shells resting on bedrock Chalk at c.14.5m OD. Material from this pit yielded abundant vertebrate remains, and also numerous molluscs, which were re-examined by Kennard and Woodward (1922), Marr (1920) and by Sparks (1963, 1964) who concluded that they represented interglacial conditions. It is proposed that this gravel unit is formally named the **Grantchester Gravel** with a stratotype at point SW96/1 (TL 4295 5545). To the northeast on the floodplain of the River Cam, points GM2 to GM6 record 4m of presumably Flandrian shelly silty clay, overlying 1.5m of gravel and sand on bedrock Gault Clay at c.3m OD. In Newnham, point 45NW184 shows clay with gravel over 1.5m of gravel and sand on bedrock at c.6m OD and point Sumf shows Made Ground over 1m
of gravel and sand on bedrock at c.7m OD. Points NR2 and NR3 record gravel and sand beneath Made Ground on bedrock Gault Clay at c.6m OD, and at the edge of the River Cam floodplain point NR1 shows 1m of silty clay beneath Made Ground on bedrock at c.5m OD.

Boreholes by the author on Sheep's Green reveal 2m of silty clay on bedrock at c.4m OD at point Sheepsl, and silty clay over gravel at point Sheeps2. Point Coel by the River Cam on Coe Fen showed clay with gravel over 3.5m of presumably Flandrian silty clay, in turn overlying 2.5m of gravel and sand on bedrock at c.-1m OD. It is proposed that the silty clay unit here is formally named the Coe Fen Silty Clay, and that the gravel unit is formally named the Coe Fen Gravel, both with a stratotype at point Coel (TL 4472 5778). At the eastern edge of the floodplain near the Mill Pool, point SILV2 records 1m of silty clay on bedrock at c.4m OD. However, in a strip mapped by the BGS as 1st Terrace Deposits, point 45NW130 in Mill Lane shows 2m of clay with gravel on bedrock at c.8m OD, and point SILV1 in Trumpington Street records 2m of Made Ground over 2m of gravel and sand on bedrock at c.4m OD. In comparison, points Forb4 to Forb12 on the 2nd Terrace at the New Museums Site in the centre of Cambridge show 5m of gravel and sand on bedrock Gault Clay at c.5m OD. It is proposed that this gravel unit is formally named the New Museums Site Gravel with a stratotype at point Forb12 (TL 4498 5824).

8.2.4.8 Geological Section 40/55.7

This 5.5km-long section (Figure 8.2.4-7) runs roughly southwest-northeast from Barton (205/126) to beyond Castle Hill, Cambridge (point c12). Point 205/126 near the A603 road southwest of Barton village shows bedrock Gault Clay near the surface at c.17m OD. Bedrock Gault Clay is also close to the surface at point 45NW140 (c.18m OD), but near College Farm point 45NW144 showed 1.5m of gravel and sand on bedrock at a similar elevation. Nearby, point 45NW141 recorded bedrock close to the surface at c.20m OD. It is proposed that the gravel unit here is formally named the College Farm Gravel with a stratotype at point 45NW144 (TL 4113 5536). To the northeast, points 45NW142 and 205/117 record bedrock Chalk beneath a low ridge at c.23m OD. Near the M11 Motorway, points b90 to b93 show clay with gravel overlying bedrock Gault Clay at 15-16m OD, and point 45NW139 recorded bedrock at the surface at a similar elevation. To the northeast in the valley of the Bin Brook at Newnham, point 45NW182 records 0.5m of sandy clay over gravel and sand on bedrock at c.9m OD, and west of Grange Road points 55 to 40 show 1m of clay with gravel adjacent to this stream. However, points 33 to 11 record bedrock close to the surface at 9-10m OD, although point 12 shows gravel marking the edge of the 2nd Terrace Deposits. Near Robinson College, point CHND shows white silty clay over 1m of gravel and sand on bedrock at c.9m OD and points RCSC1 to RCSC3
show 2m of gravel and sand on bedrock at c.8m OD. It is notable that the BGS maps only bedrock Gault Clay at these locations. To the northeast at Grange Road, point 65GRd shows bedrock near the surface at c.10m OD, and point CNIS1 records 1.5m of clay with gravel on bedrock at c.8.5m OD. At Lucy Cavendish College, points LCLc to LCD record 1m of clay with gravel, with silty clay at the base on bedrock at 9-10m OD, and on Castle Hill, points CH1sewer and CH2sewer show 3m of Made Ground on bedrock Chalk at 18-19m OD. Point CH2sewer records gravel beneath the Made Ground. In contrast at Victoria Road, point 12 shows 1m of topsoil on bedrock Gault Clay at c.13m OD.

8.2.4.9 Geological Section 40/55.8

This 5.5km-long section (Figure 8.2.4-8) runs roughly southwest-northeast from west of Haggis Farm (45NW121) to the Aldi site on Histon Road, Cambridge (ALDIM). Point 45NW121 west of Haggis Farm records bedrock Chalk close to the surface beneath topsoil at c.27m OD. South of the Wheat Cases on Grantchester Road, points SpFd and 45NW148 show bedrock Gault Clay near the surface at 17-18m OD, and at the M11 Motorway points 171 and 172 record 1m of topsoil over bedrock at c.13m OD. At the edge of the West Cambridge Site points jh to ii show bedrock Gault Clay close to the surface at 12-15m OD. At the top of a low ridge point if records 1m of sandy clay. Although points hg and hv show bedrock near the surface at c.16m OD, points hm to HRBH1 record 1m of sandy clay on the floor of the small valley near the Cavendish Laboratory. Points mf to mj show the low ridge to the north to be underlain by bedrock at c.14m OD, and at Bulstrode Gardens points BG1 and BG2 show the floor of the Willows Brook to have 1m of sandy clay on bedrock Gault Clay at c.11m OD. Near Churchill College at a house formally named Black Gable, point CD107/1 shows 1m of clayey gravel and sand, with a base not on bedrock at c.17m OD. Marr (1926) mentions a valve of Corbicula fluminalis from this location. It is proposed that the gravel unit here is formally named the Churchill College Gravel with a stratotype at point CD107/1 (TL 4380 5940). On Huntingdon Road point PLG shows Made Ground over 1m of clay with gravel on bedrock Gault Clay at c.17m OD. Near the Aldi site on Histon Road, point 188/78 shows bedrock Gault Clay near the surface at c.18m OD and nearby point e49 shows bedrock Chalk close to the surface at a similar elevation. Points ADIC to ALDIB show bedrock Gault Clay close to the surface at c.19m OD beneath Made Ground, but points ALDITP5 and ALDIM record 1m of sandy silty clay on bedrock at c.18m OD.

8.2.4.10 Geological Section 40/55.9

This 4.5km-long section (Figure 8.2.4-9) runs roughly southwest-northeast from south of Whitwell Farm, Coton (45NW13) to Huntingdon Road, Cambridge (trenchA). Point
45NW13 south of Whitwell Farm shows bedrock Chalk near the surface at c.31m OD, and to the northeast near Coton village, point 45NW119 records bedrock Gault Clay close to the surface at c.21m OD. Near the M11 Motorway and High Cross, point 183 to point g record bedrock Gault Clay close to the surface beneath topsoil at 19-21m OD. Only point g showed sandy clay at the surface. At the Bullard Laboratories on the low ridge near the Cambridge Observatory, point Bull/B shows gravel and sand at c.20m OD and point Bull/D shows 2.5m of gravel and sand on bedrock Gault Clay at a similar elevation. The author recorded 4m of gravel and sand at point Bull/C, and some 3m of gravel and sand at point Bull/A. The base of the observed section in this gravel unit was at c.18m OD. Close by, point 45NW115 also shows 3m of gravel and sand with a base not touching bedrock at c.17m OD. It is proposed that this gravel unit is formally named the Bullard Laboratory Gravel, with a stratotype at point Bull/C (TL 4303 5952). At the Observatory, point CBH shows 3m of gravel and sand on bedrock Gault Clay at c.21m OD, and point MS3 records 1m of gravel and sand on bedrock at c.23m OD. Points MS2 and MS1 shows 3m of gravel and sand on bedrock Gault Clay at 21-22m OD and point UnivFm, near the University Farm, shows 3.5m of gravel and sand on bedrock Chalk at a similar elevation. Similarly, point CD53/3 records 4m of gravel and sand on bedrock Chalk at c.20m OD. This section through the ‘Observatory Gravels’ of the BGS shows an undulating base to the deposits, suggestive of two separate bedrock channel-forms; one beneath the Bullard Laboratories reaching down to c.17m OD, and a second beneath the University Farm separated from each other by a bedrock ridge. Point trenchA on Huntingdon Road records only sandy clay beneath Made Ground, although neighbouring points show bedrock Gault Clay within 2m of the surface.

8.2.4.11 Geological Section 40/55.10

This 5.5km-long section (Figure 8.2.4-10) runs roughly west-east from near Whitwell Farm, Coton (45NW11) to the New Museums Site, central Cambridge (45NW128). Point 45NW11 near Whitwell Farm shows bedrock Chalk near the surface at c.32m OD, and point 45NW119 records bedrock Gault Clay close to the surface at c.21m OD. Near the M11 motorway, point 179 records 1m of diamict on bedrock at c.15m OD. On the boundary of the West Cambridge Site points fp to 82 show bedrock Gault Clay close to the surface beneath topsoil at 11-14m OD. Point 72 shows 1m of sandy clay with gravel, but points 79 and 78 record bedrock near the surface at c.11m OD. Nearer to Bin Brook, points 69 to 44 show 1m of clay with gravel, although point 62 records bedrock close to the surface at c.10m OD. At the edge of the 2nd Terrace mapped by the BGS, points 43a to 37 show 1m of sand and gravel. At the Sidgwick Site, points L&C4 to L&CT1 record 1m of clay with gravel over 2m of gravel and sand on bedrock at c.6m, and at Sidgwick
Avenue points L&C8 and SWAA record 4.5m of gravel and sand on bedrock Gault Clay at c.4m OD. Nearby, point CA1 shows Made Ground over 1m of gravel and sand. On the floodplain of the River Cam, point QG1 shows 3m of Made Ground over gravel and sand at c.4m OD and in Silver Street point CD120/1 shows Made Ground over 1m of silty clay on bedrock at c.4m OD. To the northeast on the New Museum Site in an area mapped as 2nd Terrace deposits points Forbl1 and Forb9 show 5m of gravel and sand on bedrock at c.5m OD. In central Cambridge point LYE1 shows 3m of Made Ground over 3m of gravel and sand at c.4m OD, and point 45NW128 records 4.5m of gravel and sand on bedrock a comparable elevation.

**8.2.4.12 Geological Section 40/55.11**

This 5km-long section (Figure 8.2.4-11) runs roughly west-east parallel to Geological Section 40/55.10 from Coton village (Coton 1) to near the Market Square, central Cambridge (45NW128). In Coton village points Coton 1 and 188/197 show bedrock Chalk near the surface at c.30m OD, and point 45NW120 records bedrock Chalk close to the surface at c.25m OD. Near the M11 Motorway and High Cross, points 183 to dp show bedrock Gault Clay near the surface at 17-20m OD, although point de shows sandy clay at the surface. Point ds also shows sandy clay, but points gj and gp record bedrock near the surface at c.15.5m OD. Nearer to the Cavendish Laboratory on the floor of a small valley, points gr to lz show sandy clay 1.5m thick. Point 45NW180 records 1.5m of sandy clay with pebbles on bedrock at 11m OD, and point WFRTPE shows sandy clay over 1m of gravel and sand on bedrock at c.12m OD. In contrast, points ma and mb record bedrock near the surface at c.12m OD, and point WFRTPN shows 1m of gravel and sand on bedrock at a similar elevation. At Robinson College points RCSC1 to RCSC3 show 2m of gravel and sand on bedrock at c.8m OD, and at the University Library point ULT2 to point ClarCY record 2.5m of gravel and sand on bedrock at c.6m OD. At The Backs on the floodplain of the River Cam, point 45NW131 records 3.5m of unknown deposits over 0.5m of gravel and sand on bedrock at c.2.5m OD, and at point ClarC at Clare College, 5m of gravel and sand overlies bedrock at c.4m OD. At Kings Parade and Peas Hill, points KP to PeasH show Made Ground 2m thick over 2m of gravel and sand on bedrock at c.7m OD. It is notable that point PH2 had sandy clay beneath the gravel and sand at c.7m OD. At the Market Square the author recorded 3m of Made Ground over gravel and sand and at Wheeler Street, point WheSt showed 3m of Flandrian peat overlying gravel and sand at c.7m OD. Elsewhere, points Cd114/2, KLPU6 and 45NW128 record 5m of gravel and sand on bedrock Gault Clay at c.5m OD.
8.2.4.13 Geological Section 40/55.12

This 4km-long section (Figure 8.2.4-12) runs roughly west-east from the M11 Motorway near High Cross (b101) to near the Market Square, central Cambridge (45NW128). Near the M11 Motorway, points b101 and b103 show 1m of clay with gravel on bedrock Gault Clay at c.21m OD, and points b104 and b105a record bedrock near the surface at a similar elevation. Along the line of the A1303 Madingley Road, points ad to be show bedrock at the surface at 19-20m OD. Archaeological excavations at the site of the new Microsoft development south of Madingley Road, allowed the author to collect detailed information across the Willows Brook valley. Points l/1 to 12/3 reveal silty clay 1m thick overlying a basal gravel and sand unit on bedrock at 15-18m OD. To the east near Bulstrode Gardens, points Bulst to CHPub show Made Ground over 1m of clay with gravel on bedrock at 11-12m OD. Further along Madingley Road, point a15 shows 1m of Made Ground on bedrock Gault Clay at c.11m OD, and at Lucy Cavendish College points LCLa to Lca show 1m of clay with gravel on bedrock at 11-12m OD. On Queens Road, point CNIS2 shows 1m of clay with gravel on bedrock at c.8.5m OD and point B2 records bedrock close to the surface at c.9.5m OD. On the edge of the River Cam floodplain at St. Johns College, point SJ1a records 1m of clay with gravel on bedrock at c.7m OD, and points e41 to SJ6c record a complex sequence with 2m of Made Ground over clay with gravel, overlying 2m of silty clay, in turn overlying 2m of peat and clay with peat, over 2m of gravel and sand on bedrock Gault Clay at c.-2m OD. Sparks and West (1965) published a detailed geological section from the boreholes at St. Johns College. It is proposed that the silty clay, peat and gravel units in this location be formally named the St. Johns College Silty Clay, St. Johns College Peat, and St. Johns College Gravel, with the stratotype at point SJ6a (TL 4463 5888). To the east near Bridge Street, point 45NW151 records 4m of sand and gravel overlying 1.5m of silty clay on bedrock at c.2.5m OD. In the centre of Cambridge, points SID1 to 45NW128 show 4m of gravel and sand on bedrock Gault Clay at 4.5m to 5.5m OD.

8.2.4.14 Geological Section 40/55.13

This 4km-long section (Figure 8.2.4-13) runs roughly northwest-southeast from the Traveller’s Rest Pit (TRP1) to the floodplain of the River Cam near Newnham (45NW186). Marr (1919) described exposures at the Traveller’s Rest Pit at the top of a low ridge reaching c.26m OD. Points TRP1 to TRPA show 5.5m of gravel and sand, the upper part contorted and with ice wedges, on bedrock Gault Clay at 19.5-22m OD. The gravel here has been named the Observatory Member in Bowen (1999), but for correlation purposes the author will refer to these gravels as the Traveller’s Rest Gravel with a
revised stratotype at point TRPA (TL 4313 5975). Nearby, point MS3 shows over 1m of gravel and sand on bedrock at c.23m OD, and points MS2 and MS1 show 3m of gravel and sand on bedrock Gault Clay at 21-22m OD. Downslope at Bulstrode Gardens, points Bulst to CHPub show Made Ground over 1m of clay with gravel on bedrock at 11-12m OD. To the east points ca to cf record bedrock Gault Clay near the surface at c.12m OD. At the new Mathematics building on Clarkson Road, points CMTP2 to CMTP8 show 1.5m of clay with gravel on bedrock at c.10m OD, although points ch and cj show bedrock close to the surface at c.11m OD. Near Grange Road, point 65GRd shows bedrock near the surface at c.10m OD, and points CNIS1 and B1 shows 1.5m of clay with gravel on bedrock at c.8.5m OD. In contrast, in the valley of the Bin Brook points BF1 to BF3 show 1m of peat over gravel on bedrock at c.5.5m OD. At Clare College, point ClarCa to ClarCY record Made Ground over gravel and clay with gravel. On the floodplain of the River Cam, point QG2 shows 1m of Made Ground over 4m of silty clay with a base not touching bedrock at c.2m OD. To the south, point QG1 shows 3m of Made Ground over gravel and sand at c.4m OD, and points Sheeps1 and Sheeps2 at the edge of the floodplain show silty clay on bedrock at c.4m OD. By the River Cam at Newnham, point 45NW185 shows 2m of silty clay over gravel and sand on bedrock at c.3m OD and point 45NW186 records 4.5m of presumably Flandrian silty clay overlying peat and 1m of gravel and sand on bedrock Gault Clay at c.-1m OD. It is proposed that the silty clay unit is formally named the **Newnham Silty Clay** with the stratotype at point 45NW186 (TL 4475 5728).

8.2.4.15 Geological Section 40/55.14

This 3.5km-long section (Figure 8.2.4-14) runs roughly northwest-southeast from the Traveller’s Rest Pit (TRP1) to the New Museums Site in central Cambridge (point Forb12). Points TRP1 to TRPA1 described by Marr (1919) show 5.5m of gravel and sand on bedrock Gault Clay at 19.5-22m OD. Thin clay with gravel overlies the gravel and sand at point TRPA1, and at point CD53/2 4m of gravel and sand overlies bedrock Chalk at c.21m OD. Nearby, point FSTP2 shows bedrock Chalk near the surface beneath Made Ground at c.22m OD, and point FSTP1 records sandy clay near the surface. Downslope near Churchill College, point CD107/1 shows 1m of gravel and sand with a base not touching bedrock at c.17m OD. Point CD106/10 shows 1m of clay with gravel on bedrock Chalk at c.14m OD. Near Lucy Cavendish College, points LCn to Lca show 1m of clay with gravel, occasionally underlain by silty clay on bedrock at 12-14m OD. On Queens Road, point CNIS2 shows 1m of clay with gravel on bedrock at c.8.5m OD and point B2 records bedrock close to the surface at c.9.5m OD. At St. Johns College, point SJ1a records 1m of clay with gravel on bedrock at c.7m OD. Near Garret Hostel Bridge on The Backs, point CD120/2 records 6m of presumably Flandrian silty clay on bedrock at c.-1m
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OD. In contrast, points GH2 and GH4 show 3m of Made Ground over 1m of silty clay overlying 1.5m of peat, in turn overlying gravel and sand on bedrock at c.0m OD.
However, point e24 reveals 4.5m of silty clay overlying 7m of gravel and sand on bedrock Gault Clay at c.-6m OD. This clearly shows the buried bedrock channel-form beneath the River Cam at this location. It is proposed that the silty clay and gravel units here are formally named the Garret Hostel Bridge Silty Clay and the Garret Hostel Bridge Gravel with a stratotype for both at point e25 (TL 4453 5850). To the east, point ClarC at Clare College shows 5m of gravel and sand on bedrock at c.4m OD. Point KingP in King’s Parade shows only 1.5m of Made Ground, but at the New Museums Site points Forbl1 to Forbl2 show 5m of gravel and sand on bedrock Gault Clay at c.5m OD.

8.2.4.16 Geological Section 40/55.15

This 3.5km-long section (Figure 8.2.4-15) runs roughly northwest-southeast along Huntingdon Road (trenchA) to the New Museums Site in central Cambridge (Forb4). On Huntingdon Road, point trenchA shows Made Ground over sandy clay, while nearby point 45NW176 shows 1.5m of clay with gravel on bedrock Gault Clay at c.19m OD. Point trenchC shows 1m of Made Ground on bedrock at a similar elevation. Further along Huntingdon Road, a section described by Marr (1926) (point OxRd) shows 1m of Made Ground over clay with gravel (clay with race) overlying 1m of gravel and sand on bedrock at c.17m OD. It is proposed that the gravel unit here is formally named the Oxford Road Gravel with a stratotype at point OxRd (TL 4383 5982). Nearby, point PLG shows Made Ground over 1m of clay with gravel on bedrock Gault Clay at c.17m OD. Near New Hall, points NH1 and CD53/4 show bedrock Chalk close to the surface at c.18.5m OD beneath Made Ground, but at point STA bedrock Gault Clay is close to the surface at a similar elevation. On Castle Hill, point CH1sewer shows 3m of Made Ground on bedrock Chalk at c.19m OD, and point CH2sewer records gravel beneath the Made Ground on bedrock Chalk at c.18m OD. At Shire Hall, Castle Hill, point CD106/9 records 4m of gravel and sand on bedrock Chalk at c.15.5m OD. It is proposed that the gravel unit here is formally named the Shire Hall Gravel with the stratotype at point CD106/9 (TL 4452 5923).

Downslope, the author recorded 3m of gravel and sand with a base not reaching bedrock at c.11m OD at point MCh. Since this deposit is considerably lower than the gravel at Shire Hall, it is proposed that this gravel unit is formally named the Castle Hill Gravel with the stratotype at point MCh (TL 4452 5915).

Further down Castle Hill, point CH3sewer records Made Ground over gravel and sand on bedrock Gault Clay at c.12m OD, and point CH4sewer shows 2m of Made Ground on bedrock Gault Clay at c.9m OD. At the foot of the hill on Chesterton Lane, point ChesL shows only 2.5m of Made Ground. Near Magdalene Bridge next to the River Cam at
Quayside, points QS1 to QS2 shows Made Ground over 3m thick over 3m of peat and silty clay overlying 2m of gravel and sand on bedrock Gault Clay at 1-3m OD. In contrast, point Forb6 records 2.5m of gravel and sand with a base not touching bedrock at c.5.5m OD, and at Thompson’s Lane (point THOM) 2.5m of Made Ground overlies 1m of gravel and sand on bedrock at c.5m OD. To the south near Bridge Street, point 45NW151 records 4m of sand and gravel overlying 1.5m of silty clay on bedrock at c.2.5m OD. Towards the centre of Cambridge, points CD120/9 to 45NW129 show 4m of Made Ground over gravel and sand on bedrock Gault Clay at c.5m OD. Sections at the Senate House (SenHo) and Kings Parade (KP) both revealed Made Ground, with gravel reached at c.8m OD at the latter site. Points PH2 to SPL showed 2m of Made Ground over 2m of gravel and sand on bedrock at c.7m OD. As noted in 40/55.11, point PH2 had sandy clay beneath the gravel and sand. However, point FIW shows 2m of Made Ground over 2m of gravel and sand at c.5m OD, and points Forb11 and Forb4 on the New Museums Site record 5m of gravel and sand on bedrock Gault Clay at the same elevation.

8.2.4.17 Geological Section 40/55.16

This 2km-long section (Figure 8.2.4-16) runs roughly northwest-southeast from the Aldi site on Histon Road (ALDITP7) through Castle Hill to the centre of Cambridge (45NW128). Points ALDITP7 to ch13 on Histon Road show bedrock Gault Clay close to the surface at 18-19m OD. On Victoria Road, point ch10 shows 2m of unknown drift on bedrock at c.14m OD and point CNIS6 records Made Ground over 1.5m of clay with gravel on bedrock at the same elevation. Nearby, point b6 shows bedrock Gault Clay at c.16m OD. At the foot of Castle Hill near Chesterton Lane, point 45NW156 records 2.5m of Made Ground over 4m of gravel and sand on bedrock at c.8.5m OD. It is proposed that this gravel is formally named the Chesterton Lane Gravel with a stratotype at point 45NW156 (TL 4470 5920). Also near Chesterton Lane, point CNIS4 shows bedrock close to the surface beneath Made Ground at c.10m OD, and by the River Cam point e46 shows bedrock close to the surface at c.5m OD. On the south side of the river, points CD120/3 to LPaSt on Lower Park Street show the floodplain of the River Cam underlain by a bedrock channel-form filled with mostly Flandrian sediments. In general the sequence here comprises 1m of Made Ground over 4m of silty clay overlying 3m of peat and clayey peat, in turn overlying 3m of gravel and sand on bedrock at −2 to 2m OD. The edge of the floodplain can be identified at Park Street (point PaSt) where Made Ground overlies bedrock at c.6m OD. Points RCS1 and RCS2 show 3m of Made Ground over gravel and sand, and point Forb7 records 2.5m of gravel and sand with a base not touching bedrock at c.7.5m OD. On Sidney Street point SID1 shows 1m of Made Ground over 3m of gravel and sand, and point KLPX records 4m of Made Ground over gravel on bedrock at c.5m OD.
OD. To the south, point Forb8 shows 3m of gravel and sand on bedrock at c.6m OD and point 45NW128 shows 4.5m of gravel and sand on bedrock Gault Clay at c.5m OD.

8.2.4.18 Geological Section 40/55.17

This 2km-long section (Figure 8.2.4-16) runs west-east from the Bullard Laboratory near Cambridge Observatory (Bull/D) to Victoria Road, Chesterton (ch673). At the Bullard Laboratory, point Bull/D shows 2.5m of gravel and sand on bedrock Gault Clay at c.20m OD, and points Bull/C and Bull/A show 4m of gravel and sand with a base not touching bedrock at c.18m OD. Nearby, point 45NW115 also shows 3m of gravel and sand with a base not touching bedrock at c.17m OD. At the Observatory, point CBH shows 3m of gravel and sand on bedrock Gault Clay at c.21m OD. Point MS3 records over 1m of gravel and sand on bedrock at c.23m OD, and point MS2 shows 2m of gravel and sand on bedrock Gault Clay at c.22m OD. At point FSTP2, bedrock Chalk occurs near the surface beneath Made Ground at c.22m OD, and point FSTP1 records sandy clay near the surface. To the east on Huntingdon Road, point PLG shows Made Ground over 1m of clay with gravel on bedrock Gault Clay at c.17m OD. Near Histon Road, points CSsewer to 45NW117 show Made Ground over bedrock at c.19m OD, although point ch11 shows 2m of unknown drift on bedrock at c.17m OD. On Victoria Road, point ch10 shows 2m of unknown drift on bedrock at c.14m OD and point CNIS6 records Made Ground over 1.5m of clay with gravel on bedrock at the same elevation. Nearby, point b6 shows bedrock Gault Clay at c.16m OD. Downslope, point ch3101 records 4m of unknown drift on bedrock at c.11.5m OD, and points ch9 and c12 show bedrock beneath topsoil at 13-14m OD. In contrast, point a11 shows 4m of silty clay on bedrock at c.9m OD and point ch7 shows 2m of gravel and sand on bedrock Gault Clay at c.11m OD. These points are at the edge of a patch of 3rd Terrace Deposits mapped by the BGS. Nearby, points ch674 and ch673 show 6m of unknown drift on bedrock at c.7m OD. There is clearly a considerable thickness of deposits beneath this terrace surface accompanied by an incised bedrock surface.

8.3 Site Descriptions 5km Square TL 240/55

8.3.1 Traveller’s Rest Pit

8.3.1.1 Introduction

The gravels on the low ridge between the Cambridge Observatory and Girton Village (see Section 5.3.4) have been mapped by the BGS as ‘Observatory Gravels’. Penning and Jukes-Browne (1881) observed that at the Observatory the gravel appeared to banked against a bedrock ridge, but that further north it seemed to occupy a bedrock channel-form
in the Gault Clay. Penning and Jukes-Browne (1881) believed that these gravels represented the ancient course of a stream that flowed northward from Whittlesford (see Section 11.3.4). Marr (1917, 1920 and 1926) and Marr and King (1928) considered the ‘Observatory Gravels’ at the Traveller’s Rest Pit to be fluvial, although later, Marr and King (1932) and Sparks and West (1965) concluded that they might represent glacial outwash deposits. Marr (1920) described 6m high sections, named here as the Traveller’s Rest Gravel, at the Traveller’s Rest Pit (points TRPA and TRPB) comprising 3m of basal horizontally bedded ‘evenly-bedded’ gravels, overlain by 2m of cryoturbated ‘unevenly-bedded’ gravels and sandy loam, in turn overlain by 0.5m of horizontally bedded ‘upper evenly-bedded’ gravels, and capped by ‘soil and warp’ or ‘rubble drift’ (see Section 8.2.4.14). A little to the east (point TRPA1), Marr and King (1928) observed 1m of blue clay with flints between the cryoturbated ‘unevenly-bedded’ gravel and the ‘upper evenly-bedded’ gravel units. The exact nature of this material and its similarity to Boulder Clay (till) has been the subject of much discussion (Marr and King, 1928). Ice wedges were observed to penetrate the lower two gravel units, but were truncated by the upper horizontally bedded gravel.

A variety of erratic pebbles with exotic lithologies were described from the lower gravel (Rastall and Romanes, 1909), and Marr (1920) commented on the unusually large number of boulders 30cm diameter present in the deposit. Marr (1920) also described a number of worked flints attributed to human activity. Cold climatic conditions are indicated by the mollusc fauna (Kennard and Woodward in Marr and King, 1928), and periglacial conditions are suggested by the cryoturbated gravels and ice wedges described by Marr (1920) and Paterson (1940). Worssam and Taylor (1969) tentatively suggested that the ‘Observatory Gravels’ dated from the end of the Gipping Glaciation on the basis of their elevation and lack of glacial disturbance. Their thinking was influenced by the stratigraphic ideas prevailing at that time, and a modern interpretation of their ideas would be that these deposits might date from the end of the Anglian Glaciation (MIS12).

8.3.1.2 Environments of deposition

The basal horizontally bedded ‘evenly-bedded’ gravels probably represent deposition by a braided stream under cold conditions. It is possible that this was an outwash stream, although there is no clear evidence for this. The author believes that the overlying cryoturbated ‘unevenly-bedded’ gravels and sandy loam represent a continuation of these conditions, with pools forming on the braidplain surface. It is clear that the surface of the braidplain was sub-aerially exposed to cold conditions for some time, causing cryoturbation and ice wedge formation. The boundary between the two gravel ‘series’ must therefore be an artificial one, merely representing the depth of periglacial activity in
the permafrost active layer. Such harsh conditions must also have caused mass movement of material on the valley sides, and it seems likely that the blue clay with gravel overlying the ‘unevenly-bedded’ gravels represents solifluction deposits near the edge of the braidplain. The horizontally bedded ‘upper evenly-bedded’ gravels clearly overlie the clay with gravel and truncate the ice wedges and involutions in the ‘unevenly-bedded’ gravels, marking a return to fluvial conditions.

8.3.1.3 Molluscs

Marr (1920) described two specimens of *Pupilla muscorum*, recovered from sandy concretions, apparently from ice wedge infillings within the ‘unevenly-bedded’ gravels. Kennard and Woodward in Marr (1926) describe specimens of *Trichia hispida, Pupilla muscorum* and *Planorbis planorbis* from the ‘upper gravels’, and Kennard and Woodward in Marr and King (1928) in addition record *Lymnaea truncatulata, Columella columella* and *Succinea oblonga* from the ‘lower bed’. Taken as a whole this limited assemblage indicates cold conditions with dry grassland, marshland and pools with aquatic vegetation. Marr and King (1932) argued that the terrestrial taxa could have been washed into temporary pools, in the manner they had observed shells accumulate in tundra-like conditions on the Malaspina Glacier floodplain, Greenland.

8.3.1.4 Vertebrates

Marr (1920) described an astragalus of *Cervus elephus* (red deer), a vertebra of *Rhinoceros* sp. (rhinoceros) and two teeth of *Equus ferus* (horse) from these deposits. It is not clear which part of the sequence these remains came from, and appears that vertebrate remains were not abundant at this site. Further, it is difficult to deduce much environmental or stratigraphic information from such a limited collection.

8.3.1.5 Dating

Amino acid racemization analyses for *Pupilla muscorum* from the upper gravels (Appendix 5) gave a D/L ratio of 0.250. This equates to an age in the early part of the ‘Wolstonian’ (MIS 9/10) interval. Attention must be drawn to the fact that this is only a single value, and that a range of D/L ratios have been obtained from well-preserved shells from assemblages at other sites. This is the highest and therefore oldest D/L ratio obtained in the study, and confirms the relative antiquity of the Traveller’s Rest Gravels.

8.3.1.6 Conclusions

It appears that on the basis of amino acid racemization analyses the upper gravels have an age early in ‘Wolstonian’ (MIS 9/10) interval. This confirms the relative stratigraphic position of the Traveller’s Rest Gravel as older and more elevated than the neighbouring
Huntingdon Road Gravel at Christ's Sports Ground (see Section 5.4.2), but younger than the Anglian (MIS 12) glacial deposits which it overlies at Girton Village (see Section 5.3.4.2).

8.3.2 Black Gable, Storeys Way

8.3.2.1 Synopsis

Marr (1926) described 1m of clayey gravel from a property formerly known as Black Gable on Storeys Way (point CD107/1), close to Churchill College. Marr was of the opinion that this gravel was continuous with that at the Traveller's Rest Pit, a kilometre to the northwest, believing it to be 'equivalent to the lowest evenly-bedded gravel of that pit'. However, the BGS map shows a patch of 4th Terrace Deposits at this location, entirely separate from the ‘Observatory Gravels’ to the west. This would make it equivalent to the Huntingdon Road Gravel at Christ’s Sports Ground. Marr records that W. B. R. King obtained a specimen of *Corbicula fluminalis* (identified by Kennard and Woodward) from this deposit, although no description of its condition is given.

8.3.3 Oxford Road

8.3.3.1 Synopsis

Marr (1926) described a 3m high section showing gravel and sand and ‘clay with race’, perhaps better described as clay with gravel, from a trench opposite 83 Oxford Road. The gravel and sand reached 2m thick, but Marr’s section shows it as being disturbed, perhaps cryoturbated, and mixed with the ‘clay with race’. Marr was at pains to point out that the ‘clay with race’ was not simply puddled Gault Clay, but represented a definite deposit. Marr states that a tusk of *Sus* (pig) came from a depth of 2m in the trench, but that shells provided by a workman had been brought in from elsewhere. This section represents a valuable record of deposits mapped by the BGS as belonging to the 4th Terrace, and is presumably equivalent to the Huntingdon Road Gravel at Christ’s Sports Ground (see Section 5.4.2).

8.3.4 Sidgwick Avenue

8.3.4.1 Introduction

Lambert, Pearson and Sparks (1962) described two geological sections in gravel from excavations for new lecture rooms at Sidgwick Avenue on an area mapped by the BGS as 2nd Terrace Deposits. Point SWAA records 4.5m of gravel and sand with silt bands containing molluscs and a bison skull overlying white calcareous silty clay on bedrock Gault Clay at c.4m OD (see Section 8.2.4.5 & Figure 8.2.4-4). Nearby point SWAB
shows a similar section with closely bedded fine sand and silt containing plant debris and molluscs at the base. Both the plant macrofossils and molluscs from these deposits indicate cool to cold climatic conditions, although occasional southern species of mollusc are present.

8.3.4.2 Environments of deposition

The gravel and sand at the Sidgwick Avenue site was probably deposited by a braided stream under cool to cold conditions. The beds of intercalated silty clay must represent overbank sedimentation or deposition in pools on the surface of the braidplain. The surrounding area must have been dominated by dry grassland with well-drained calcareous soils.

8.3.4.3 Pollen and Plant macrofossils

Although pollen analysis of the silt at point SWAB was attempted by Lambert et al. they stated that no usable data were obtained. The author located the original pollen slide prepared at that time from the Quaternary Museum, Department of Geography, University of Cambridge and attempted to re-count it. In addition, the author analysed two samples of silt from the top and base of the bison skull preserved in the Sedgwick Museum (Appendix 4). The re-count of the original slide yielded only a low concentration of palynomorphs, dominated by Poaceae (grass), but with Pinus (pine) (8%) and herbs. The silt from the top of the bison skull yielded a similar pollen assemblage with Poaceae (grass), herbs, Pinus and Picea (spruce). In contrast, the sample from the base of the skull was dominated by Poaceae (grass), with Betula (birch) (17%) and Pinus (11%) and herbs. These analyses suggest a grassy floodplain under a pre-temperate cool to cold climate, perhaps with scattered pine trees, and birch scrub in favourable locations. However, it is possible that the birch pollen here represents dwarf birch (B. nana) rather than tree birch (B. pendula).

Samples from the organic beds exposed at point SWAB were analysed for plant macrofossils by C. A. Lambert. These yielded an assemblage dominated by herbs from a variety of habitats, including steppe, damp grassland and riparian taxa, aquatics, calcicoles, halophytes and arctic-alpine species. The only arboreal remains were of Salix (willow), although it was not possible to determine whether these represented dwarf species rather than trees. The relative abundance of aquatic and land plants found today near estuaries and the sea, for example Suaeda maritima (annual seablite) and Armeria maritima (sea pink), raise interesting questions concerning the proximity of the tidal limit. Since the mollusc assemblage shows no indication of salinity, it appears that the presence of these halophiles must reflect edaphic factors, perhaps related to climate, rather than any real maritime influence. Several taxa with southern distributions were also discovered,
although the possibility that they had been reworked from earlier deposits could not be excluded. Lambert envisaged the plant assemblage indicating well-drained calcareous soils, and marshland and shallow water environments, with the constantly shifting channels of a braided stream providing spreads of bare gravel and sand.

Analyses of bryophyte remains by J. H. Dickson revealed taxa from fens, calcareous streams, dunes, rocks, grassland and damp habitats such as the roots of willow.

**8.3.4.4 Molluscs**

Sparks recovered molluscs from the sediments exposed at SWAA and SWAB, and from outside and inside the bison skull. The close correspondence of the mollusc assemblage within the bison skull to that in the surrounding deposit clearly indicates that it has not been reworked from earlier deposits. Sparks commented on ‘certain puzzling features’ of the mollusc fauna as a whole. Although the environment is interpreted as being cool or cold, with many of the mollusc taxa tolerating present conditions at or near the Arctic Circle in Scandinavia, certain taxa such as *Belgrandia marginata*, and possibly *Vertigo angustior*, might be regarded as indicating conditions as warm or warmer than today. Sparks considered the possibility that these specimens had been reworked from earlier deposits, but thought this unlikely due to the fragile nature of the shells. Other elements of the assemblage, such as *Valvata cristata* and *Bithynia tentaculata* suggest cool, rather than cold conditions, and *Clausilia* sp. and *Carychium tridentatum* hint at the presence of woody scrub nearby. Indeed, it is interesting to note that the faunal list from this site is not greatly dissimilar to that from the interglacial site at Woolpack Farm (Gao et al., 2000) (see Section 3.3.1). The assemblage has a preponderance of dry grassland taxa (for example *Pupilla muscorum*), with species of marshland and pools, and of slow well-oxygenated moving water and aquatic vegetation. The plant macrofossils indicate that this is not an interglacial deposit, although it might perhaps be regarded as interstadial in nature. Despite the number of halophytes recorded in the plant macrofossil list, the mollusc assemblage shows no sign of salinity.

**8.3.4.5 Beetles**

Coleopteran analysis of samples from the Sidgwick Avenue Site by R. G. Pearson yielded a small number of beetle species from habitats including plant communities dominated by sedges, and taxa restricted to coastal areas at the present day. A reassessment of Pearson’s faunal list by G. R. Coope (pers. com.) suggests that it is in fact similar to many Middle Devensian interstadial assemblages.
8.3.4.6 Vertebrates

The bison skull identified by Dr C. L. Forbes from this site was similar to others from Quaternary deposits of the Cambridge District. The ‘post-orbital constriction’ of the skull was measured and compared to data from skulls of *Bison priscus* and *B. bonasus*. As a result of this analysis it was tentatively concluded that the Sidgwick Avenue specimen belonged to *B. priscus*. A fragment of *Hippopotamus amphibius* tooth, a bone of *Equus ferus* (horse) and a fragment of *Bison* bone were also recovered from the site, although they are not mentioned by Lambert, Pearson and Sparks (1962). It seems likely that hippopotamus tooth was reworked from earlier deposits given the wealth of evidence that this is not a truly temperate deposit, and there remains some uncertainty about the exact stratigraphic provenance of the horse bone, which may have come from the overlying gravels.

8.3.4.6 Dating

The uncalibrated radiocarbon (AMS) age calculated for bone from the bison skull was 37,746±420 years BP (Wk-9388). This suggests a Middle Devensian age for the Sidgwick Avenue Gravel. Uncertainties about the possibility of contamination by modern carbon, and problems with calibration into calendar years mean that the deposits could easily date from c.50,000 years BP, at the boundary of the Early and Middle Devensian (MIS 3/4).

8.3.4.7 Conclusions

It appears that the deposits from this site may represent interstadial conditions. Lambert *et al.* concluded that these deposits were later than the interglacial sediments at Histon Road (Hollingworth *et al.*, 1950), Walker (1953), Sparks and West, (1959) (see Section 5.4.1), but earlier than the Late Devensian glacial deposits at Barnwell Station (Chandler (1921), Bell and Dickson (1971)) (see Section 8.6.7). In modern terms this would place the Sidgwick Avenue deposits somewhere within the Middle Devensian (MIS 3). The radiocarbon date from the bison skull certainly substantiates the view that these deposits are of Middle Devensian age. It is also interesting to note the apparent reworking of plant macrofossils, molluscs and vertebrate remains at this site.

8.3.5 Grantchester

8.3.5.1 Introduction

A 3m high section in gravel and sand exposed in coprolite mining at Grantchester, mapped by the BGS as 3rd Terrace (point SW96/1) was originally described by Mrs McKenny-Hughes (1888) (see Section 8.2.4.7). It comprised 2m of ‘chalky gravel and marl with pans of peaty silt and bands full of land and freshwater shells’, overlain by soil
and decalcified gravel. The deposit yielded various vertebrate remains and a list of molluscs that was revised by Kennard and Woodward (1922 and in Marr, 1920), presumably from re-examination of material in the Sedgwick Museum. Sparks (1964) was lucky enough to discover hitherto undescribed mollusc specimens and sediment blocks from this site collected by Henry Keeping in 1881 in the Sedgwick Museum. Analysis of a small sediment block led Sparks to remark that it was the ‘richest lump of shelly sediment I have ever examined’ yielding some 14,000 specimens, and when combined with existing data, it provided records of 90 taxa from the site.

8.3.5.2 Environments of deposition

The gravel and sand containing beds of organic silty clay at Grantchester were evidently deposited in a fluvial environment. A geological section drawn by Mrs McKenny-Hughes (1888) clearly shows the sediment filling minor channels, and she comments that the deposits seem ‘to indicate the shifting channels of a river wandering over a tolerably wide area’. Sparks (1964) concludes that ‘the Grantchester deposit was laid down by the Cam itself and not in any minor tributaries or marshes on its floodplain’. The position of this site on a distal part of a fragment of 3rd Terrace does not easily lend itself to this conclusion. The relative abundance of gravel and sand in the deposit indicates episodes of higher energy, and the apparently shifting channels are not what one might expect from a stable low-energy temperate stream in a well-vegetated catchment. The author suggests that these apparent contradictions might in part be explained if the deposits represent those at the confluence of an earlier course of the Bourn Brook with the River Cam. The mollusc fauna indicates a temperate climate, with at least some woodland in the catchment. Despite this, pollen, mollusc and vertebrate evidence show that open grassland environments were an important part of the landscape.

8.3.5.3 Pollen

Pollen analysis from several samples of silty clay from SW96/1, was undertaken by C. A. Lambert, but the results the assemblage was considered to be distorted by excessively weathered and reworked elements. The author also attempted pollen analyses from two blocks of sediment from the site preserved in the Sedgwick Museum (Appendix 4). One sample proved to be barren, whilst the other yielded a low concentration of palynomorphs dominated by Poaceae (grass).

8.3.5.4 Molluscs

Sparks (1964) considered Mrs McKenny-Hughes (1888) list of molluscs as revised by Kennard and Woodward (1922) and in Marr (1920) with his own analyses of material from the Keeping Collection. The interglacial nature of the assemblage is clear, with Azeca
menkeana, Ena montana, and Clausilia pumilla all indicating warm, and perhaps continental conditions. Woodland habitats are indicated by these taxa, and by Clausilia sp. and Carychium tridentatum, although Sparks calculates that this group comprises only 11-14% of the land assemblage. Marshland and open ground taxa dominate the land molluscs, with snails of dry grassland (for example Pupilla muscorum) forming 27-33% of the total. The majority of freshwater molluscs were determined to be characteristic of moving water environments, although some indicate marshland and pools. The absence of Belgrandia marginata and Corbicula fluminalis from these deposits, despite the presence of suitable flowing water conditions indicated by Pisidium spp., is a notable feature of this assemblage. Considerable stratigraphic significance has been attached to the relative presence or absence of these two species (Keen, 1990 and Preece, 1995), although they are not universally present in British temperate stages. Sparks believed firmly that this assemblage represented the last interglacial. In a comparison of the mollusc faunas at Ipswichian sites in southeast England (Sparks, 1964) he aggregated data from Grantchester, Barnwell Abbey (see Sections 8.3.5 and 8.6.2) and Trumpington Railway Cutting (see Section 8.9.1), saying ‘These three [sites] are so obviously in the same terrace as the Histon Road deposit and so near each other that there can be little doubt that they belong to the same period’. It is worth noting that Belgrandia marginata and Corbicula fluminalis, although absent from Grantchester and Trumpington Railway Cutting, are both present at Barnwell Abbey.

8.3.5.5 Vertebrates

Mrs McKenny-Hughes (1888) recorded vertebrate remains recovered from the deposits at Grantchester, and White (1932) lists those attributed to the site from a collection in the Sedgwick Museum. Mammals represented include many believed to favour grassland habitats such as Crocuta crocuta (spotted hyena), Equus ferus (horse), Panthera leo (lion), Bos primigenius (aurochs), Bison priscus (bison) and Megaloceros giganteus (giant deer). In addition, the author found teeth of Mammuthus primigenius (mammoth) to be relatively abundant in the Sedgwick Museum. This assemblage appears to resemble the Mammuthus trogontherii-primigenius/Equus ferus fauna correlated with MIS 7. Remains of Cervus elaphus (red deer), Canis lupus (wolf) and Ursus arctos (brown bear) which are elements of the ‘hippopotamus fauna’ associated with the Ipswichian Stage (MIS 5e) (Stuart 1982, Sutcliffe 1995) are also present, although Hippopotamus amphibius (hippopotamus), Palaeoloxodon antiquus (straight-tusked elephant) and Dama dama (fallow deer) are plainly absent. This confuses the potentially invaluable stratigraphic information from these remains to a degree, although the author considers it likely that bones from a variety of
strata in the Grantchester pit may have been collected and combined to give this chimeric signal.

### 8.3.5.6 Dating

Amino acid racemization analyses for *Valvata piscinalis* shells from the silty clay unit at point SW96/1 gave D/L ratios of 0.147, 0.160, 0.191, and 0.202 (Appendix 5). The lowest pair of these ratios equate to an age in the later part of the ‘Wolstonian’ interval (MIS 6/7) age, whilst the other two indicate dates within the middle part of the ‘Wolstonian’ interval (MIS 7/8). This mixed amino acid signal means that a minimum age estimate for the last phase of deposition based on the lowest D/L ratios is within the later part of the ‘Wolstonian’ interval (MIS 6/7). Given the nature of the molluscan and vertebrate fauna, the author concludes that this deposit correlates with a temperate part of MIS 7. The apparent age distribution of these well-preserved shells suggests reworking of older deposits from locally exposed sources dating from the middle of the ‘Wolstonian’ interval.

### 8.3.5.7 Conclusions

Sparks (1964) correlated the Grantchester deposits with the Ipswichian (MIS 5e). There is relatively strong biostratigraphic evidence that this deposit was laid down during a temperate part of MIS 7. This interpretation is supported by the amino acid racemization analyses for *Valvata* shells, which suggest an age at the end of the ‘Wolstonian’ (MIS 6/7) interval. However, there is some evidence for the reworking of material from older deposits.

### 8.4 Correlation of Stratigraphic Units

#### 5km Square TL 240/55

### 8.4.1 Synopsis

Figure 8.4.1-1 and Table 8.4.1-1 show details of the 32 stratigraphic units proposed for the 5km Square 240/55. Terrace deposits of the River Cam are relatively abundant in this square and this is reflected in the large number of stratigraphic units occupying valley floor and valley side positions. In contrast, the Madingley Hill Diamict and Highfield Farm Diamict form ridges to the west, and to the north of the square the Traveller’s Rest Gravel, the Bullard Laboratory Gravel and the Shire Hall Gravel occupy a low ridge aligned southeast-northwest along Huntingdon Road.

Table 8.4.1-2 and Figure 8.4.1-2 show the chronological and stratigraphic relationships of these units and their correlation with lithostratigraphic members and formations. Figure 8.4.1-3 presents an idealised geological section through the area showing the relationships
of the various lithostratigraphic members. The Madingley Hill Diamict, Madingley Hill Gravel and Highfield Farm Diamict are correlated with the Barrington Works Member of the Lowestoft Formation, and are interpreted as till and associated outwash deposits of Anglian (MIS 12) age (Table 1.4.2-1). The High Cross Diamict at point 179 becomes the stratotype of the High Cross Member of the Cam Valley Formation, and is correlated with the Dumpling Farm Diamict, Grantchester Diamict and Bourn Brook Diamict. These variable deposits probably represent reworked solifluction material derived from periglacial activity in both the ‘Wolstonian’ interval and the Devensian.

The Traveller’s Rest Gravel at point TRPA becomes the stratotype of the Observatory Member of the Cam Valley Formation and is correlated with the Bullard Laboratory Gravel. These gravels are interpreted as braidplain deposits of the proto-Cam belonging to the early part of the ‘Wolstonian’ interval (MIS 9/10). The New Hall Gravel, Churchill College Gravel, Oxford Road Gravel and Shire Hall Gravel are correlated with the Huntingdon Road Member of the Cam Valley Formation, and are interpreted as elevated braidplain deposits of the River Cam dating from the middle of the ‘Wolstonian’ interval (MIS 7/8). The Grantchester Gravel at point SW96/1 becomes the stratotype of the Grantchester Member of the Cam Valley Formation, and is correlated with the Grantchester Silty Clay. These deposits are interpreted as gravels and interglacial fines of the River Cam and Bourn Brook dating from the later part of the ‘Wolstonian’ interval (MIS 6/7). The Trumpington Hall Silty Clay is correlated with the Histon Road Member of the Cam Valley Formation. It is interpreted as Ipswichian and Early Devensian (MIS 5a/e) interglacial and cold stage fines of the River Cam. The College Farm Gravel and Castle Hill Gravel are correlated with the Arbury Member of the Cam Valley Formation, and interpreted as Early Devensian (MIS 4) gravels of the River Cam and Bourn Brook. The Sidgwick Avenue Gravel at point SWAA becomes the stratotype of the Sidgwick Avenue Member of the Cam Valley Formation, and is correlated with the New Museums Site Gravel and the Chesterton Lane Gravel. These deposits are interpreted as Middle to Late Devensian Braidplain deposits of the River Cam. The Willows Brook Gravel, Coe Fen Gravel, St. Johns College Gravel and Garret Hostel Bridge Gravel are correlated with the Midsummer Common Member of the Cam Valley Formation. These deposits are interpreted as Late Devensian (Late Glacial) Gravels of the River Cam and its tributaries. The Cavendish Laboratory Sandy clay, Grantchester Meadows Silty Clay, Coe Fen Silty Clay, St Johns College Silty Clay, Newnham Silty Clay, Garret Hostel Bridge Silty Clay, and St. Johns College Peat are all correlated with the Jesus Green Member of the Cam Valley Formation. These deposits are interpreted as Flandrian alluvium and fen deposits of the River Cam and its tributaries.
The sediments described above appear to represent a sequence stretching from the Anglian (MIS12) through the ‘Wolstonian’ and Devensian to the Flandrian. The exact age of the older units is uncertain, and the record is unlikely to be continuous or complete.

**8.5 5km Square TL 245/55 East Cambridge**

**8.5.1 Synopsis**

This five-kilometre square contains 21 monads with 989 points (Figures 8.5.1-1 & 8.5.1-2). The area includes the villages of Teversham and Cherry Hinton to the east, and a large area of central, eastern and southern parts of Cambridge City in the western part of the square. Figures 8.5.1-3 to 8.5.1-7 show the detailed distribution of points in six monads at the edge of Cambridge. The area includes a large number of development sites in Cambridge City, which provide a great deal of data points.

**8.5.2 Drainage**

Drainage of this area is generally towards the north, and the River Cam flows southwest to northeast across the northwest corner of the square. An area at the eastern edge of the square drains east towards Quy Water, a tributary of the River Cam that flows north to join it at Bottisham Lock. The low-lying (c.9m OD) catchment of the Cherry Hinton Brook/Coldham’s Brook system is fed by chalk springs and seepage lines and drains the area between Cherry Hinton and Coldham’s Common in the centre of this square. It is confluent with the River Cam near Stourbridge Common in the north. Hobson’s Brook also flows across the southwest corner of this square, although it is confluent with the River Cam in five-kilometre square 40/55 and rises from chalk springs to the south in five-kilometre square 45/50. Generally, the square is low lying (5-15m OD), although Lime Kiln Hill reaches c.55m OD to the southeast.

**8.5.3 Geology**

The bedrock geology comprises Gault Clay overlain by Lower and Middle Chalk broadly dipping towards the southeast (Figures 8.5.3-1 & 8.5.3-2). The Quaternary geology (Figures 8.5.3-1 & 8.5.3-2) comprises several patches of 4th Terrace Deposits near Cambridge Airport in the northeast of the square, and an area of 3rd Terrace Deposits which stretches north from Homerton College to Barnwell in the west of the square. Spreads of 2nd Terrace Deposits are mapped to the west in the valley of Hobson’s Brook, through central Cambridge and to the north in New Chesterton. Thin strips of 1st Terrace deposits are mapped adjacent to the Alluvium of the River Cam floodplain at Midsummer Common and Barnwell Station.
8.5.4 Geological Logs and Sections

8.5.4.1 Synopsis

The author collected 211 of the 988 points from this square. The secondary sources comprised 30 records from the British Geological Survey Mineral Assessment Report (Dixon 1980), 24 from the British Geological Survey Well Catalogue Series (Sayer and Harvey, 1965) and (Matthews and Harvey, 1965), 20 from the Cambridge Memoir (Worssam and Taylor, 1969) and 6 from the Saffron Walden Memoir (White, 1932). The Highways Agency Archives provided 5 records, and various contractors reports contributed 676 records including a large number associated with the North Cambridge Sewer, and developments at Lion Yard, Parkside Pool, Riverside, Homerton College and the Comet site on Newmarket Road. Dr C. L. Forbes kindly provided 6 records from his observations in central Cambridge. In addition, 2 records from the Downing Site (points DSWELL and DSTrench) came from Marr (1920), 5 records at Barnwell Station (points BSE to BSSE) came from McKenny-Hughes (1888), McKenny-Hughes (1916), Marr and Gardner (1916) and Chandler (1921), 1 record at Barnwell Abbey (point BWA) came from Mrs McKenny-Hughes (1888) and McKenny-Hughes (1916), 1 record at Sedley Taylor Road (point SedT) came from Marr and King (1928), and 1 record from the Botanic Garden (BotGdn) came from Marr (1926).

8.5.4.2 Geological Section 45/55.1

This 5.5km-long section (Figure 8.5.4-1) runs roughly north-south from the site of Swan’s Pit, Milton Road, New Chesterton (point CD115/3i) through central Cambridge (Lion Yard and Pembroke College), Newtown, the Botanic Gardens and Homerton College to Addenbrookes Hospital (point 45NE70). It provides a record of the geology across the floodplain of the River Cam at Jesus Green, and from the 2nd and 3rd Terrace Deposits in south and central Cambridge. Point CD115/3i at the site of Swan’s Pit, Milton Road, New Chesterton (now Cambridge City football ground) shows 2m of gravel and sand with a base not reaching bedrock at c.8m OD. This locality is known to have yielded vertebrate and molluscan remains (Reed, 1897, Rastall 1913, Marr 1920). To the south at Victoria Road, point c8 shows 3m of Made Ground, presumably representing old gravel pits, over 2m of silty clay and 5m of gravel and sand on bedrock Gault Clay at c.-2m OD. Point rsa9 on Chesterton Road records 1m of Made Ground over gravel and a bed of silty clay, in turn overlying 8m of gravel and sand on bedrock at c.-2m OD. These points show the presence of a buried bedrock channel-form beneath the 2nd Terrace surface adjacent to the floodplain of the River Cam. Just across the river at Jesus Green, points JesGm1 and e14 show 1m of topsoil over 2m of silty clay overlying 2m of presumably Flandrian peat,
in turn overlying 3m of gravel and sand with a base not reaching bedrock at c. -3m OD. It is proposed that the silty unit here is formally named the **Jesus Green Silty Clay**, that the peat unit is named the **Jesus Green Peat**, and that the gravel unit is named the **Jesus Green Gravel**, all with a stratotype at point e14 (TL 4520 5930). Nearby, point JesGrn2 records a similar sequence, but with bedrock Gault Clay at c.0m OD beneath the gravel unit. This indicates the presence of a second buried channel-form beneath the floodplain of the River Cam. To the south, points JLS3 to HOBS2 record Made Ground 3m thick overlying 1m of silty clay, in turn overlying 2.5m of gravel and sand on bedrock at c.4m OD. This area of 2nd Terrace Deposits has clearly been extensively worked for aggregates in the past. Points HOBS1 to LYRDBH16 through the centre of Cambridge also show Made Ground 3m thick over gravel and sand which reaches 3m in thickness where it has not been worked, on bedrock Gault Clay at 6-7m OD.

At Pembroke College, points PemBH1 to PemTP4 show Made Ground over gravel and sand 2m thick on bedrock at 7-8m OD. The gravel unit at this location contained a bed of clay with gravel diamict 0.5m thick interpreted by the author as a mass flow deposit, indicating the proximity of the valley side. To the south at Trumpington Street, points AHSMBH5 to Trump5 record 2m of Made Ground over gravel and sand 6m thick (point Browns). These deposits occupied a buried bedrock channel-form with a base below 4m OD. It is proposed that the gravel unit here is formally named the **Trumpington Street Gravel** with a stratotype at point Browns (TL 4506 5782). In contrast, point Holst14 showed Made Ground over 0.5m of clay with gravel on bedrock at c.10m OD. Points Holst13 to FMBHi show 2m of clay with gravel, sandy clay and silty clay overlying gravel and sand 2.5m thick occupying a second smaller channel with a base at c.7m OD. Point 45NE102 records a basal silty clay unit in the bottom of this feature. At the Botanic Gardens, point 45NE99 shows 4m of gravel and sand on bedrock at c.8m OD, although nearby, point SW93/1 records 2m of gravel and sand on bedrock at c.10m OD. It is proposed that the gravel unit here is formally named the **Botanic Gardens Gravel** with a stratotype at point 45NE99 (TL 4526 5722). Points SB-c to SB-d show 2m of gravel and sand overlying 1m of silty clay with a base not reaching bedrock at c.8m OD. On Trumpington Road, point 45NE104 records 1m of gravel and sand overlying 2m of silty clay on bedrock Gault Clay at c.6m OD. This appears to represent a third manifestation of a bedrock channel-form beneath the 2nd Terrace surface in this area. It is proposed that the silty clay unit here is formally named the **Trumpington Road Silty Clay** with a stratotype at point 45NE104 (TL 4527 5696). To the south, point SW93/2 shows 2m of gravel and sand on bedrock Chalk at c.10m OD. At Homerton College, points HCT1 to HCT4 show bedrock near the surface beneath silty clay at c.13m OD, but nearby at point
45NE90, 2.5m of gravel and sand is recorded on bedrock Chalk at c.13m OD. Gravel and sand is also recorded at a similar elevation at Sedley Taylor Road (point SedT). This was the ‘Agricultural Show’ site from which Marr and King (1928) described a limited molluscan fauna. To the south at Addenbrookes Hospital, points NH2 to NH1 show 0.5m of sandy clay on bedrock at c.17m OD, and at point 45NE70 bedrock Chalk is recorded close to the surface beneath topsoil at c.21m OD.

8.5.4.3 Geological Section 45/55.2

This 5.5km-long section (Figure 8.5.4-2) runs roughly north-south from Chesterton Road (point ch3) through central Cambridge (Parkers Piece and Regent Street), Newtown, the Botanic Gardens and Homerton College to Netherhall Farm (point 205/19). It provides a record of the geology across the floodplain of the River Cam at Midsummer Common, and from the 2nd and 3rd Terrace Deposits in south and central Cambridge. Point ch3 on Chesterton Road, shows 1m of gravel and sand on bedrock Gault Clay at c.6.5m OD, and nearby point a7 records 1m of clay with gravel on bedrock at a similar elevation. Near the river, point FSGCB2 shows Made Ground over 7m of gravel and sand on bedrock at c.-3m OD, while on Midsummer Common points FSGCB1 and e31b show 2m of Made Ground over 3m of peat and clay with peat, in turn overlying 5m of sand and gravel on bedrock at c.-5m OD. It is proposed that the peat unit here is formally named the Midsummer Common Peat and that the gravel unit is named the Midsummer Common Gravel, both with a stratotype at point e31a (TL 4545 5920). Nearby, point e31b shows Made Ground over sandy clay overlying 7.5m of gravel and sand on bedrock at c.-4m OD. This is clearly the buried bedrock channel-form identified beneath the floodplain of the River Cam in 45/55.1. On Butt Green near Maid’s Causeway, point MCBH7 shows Made Ground over 1m of gravel and sand on bedrock at c.4m OD and nearby point Holst23 records 1m of sandy clay on bedrock at a similar elevation. Point B1 shows 3m of unknown drift deposits on bedrock at c.4m OD, but point B1A records 5m of unknown deposits on bedrock at c.1.5m OD. This obviously represents a small buried bedrock channel-form beneath the 1st Terrace surface, although unfortunately the vibrocoring equipment used at these points does not record the nature of the drift deposits encountered. On Maid’s Causeway, point MCBH8 shows 2m of Made Ground over sandy clay and 1m of gravel and sand on bedrock at c.5m OD, and in New Square points Holst24 and Holst25 record clay with gravel over gravel and sand on bedrock at c.7m OD. The deposits of this area are mapped as belonging to the 3rd Terrace by the BGS. Nearby, point Holst 26 shows 0.5m of clay with gravel on bedrock at c.9m OD. Near Parkside College, points Holst27 to PSCCBii show Made Ground over gravel and sand 2m thick on bedrock at c.10.5m OD. A silty clay unit was recorded above the gravel at Holst27.
On Parkers Piece, points ParkP5 to ParkP1 show 1m of sandy silty clay overlying gravel and sand. This is an area mapped by the BGS as bedrock Gault Clay between the 3rd and 2nd Terraces. On Regent Street, points DCG to RegSt1 show 3m of Made Ground on bedrock at c.9m OD. Pollen analysis of an organic silty clay deposit revealed at the bottom of a trench at point RegSt5 showed a late Flandrian pollen assemblage suggesting that it was in fact a medieval ditch in-filling, rather than part of the Pleistocene sequence. Near the Catholic Church, points RegSt2 to CCrch2 showed Made Ground over gravel and sand 1.5m thick on bedrock at c.9m OD. Point CCrch1 showed 1m of silty clay overlying the gravel unit. In Newtown, point CorSt showed Made Ground over 2m of gravel and sand on bedrock also at c.9m OD in an area mapped as 2nd Terrace. Further south in the Botanic Gardens, point 188/75 records 5m of unknown drift deposits on bedrock Gault Clay at c.8km OD, while point 45NE45 near Hills Road shows 4.5m of gravel and sand on bedrock Chalk at c.10m OD. It is proposed that this gravel unit is formally named the **Hills Road Gravel** with a stratotype at point 45NE45 (TL 4570 5720). Point SB-i shows silty clay overlying gravel and sand, and point Bave/CRd records Made Ground over 2m of silty clay with a base not touching bedrock at c.12m OD. Near the junction of Hills Road and Cherry Hinton Road point 45NE27 shows Made Ground over sandy clay overlying 2.5m of gravel and sand, in turn overlying a silty clay unit on bedrock at c.11.5m OD, and point SW94/2 records 3m of gravel and sand with base not reaching bedrock at c.14m OD. To the south at Homerton College, points SIC12 to SIC14 show 3m of gravel and sand on bedrock Chalk at c.13m OD. These deposits are mapped as part of the 3rd Terrace by the BGS. It is proposed that this gravel unit is formally named the **Homerton College Gravel** with a stratotype at point SIC12 (TL 4612 5661). To the east near Blinco Grove, point 45NE67 showed bedrock Chalk close to the surface at c.14m OD, and near Wulfstan Way, points WW1 to WW5 record bedrock Chalk near the surface at c.9m OD in a low-lying area which drains north towards Coldham’s Common. Point 205/19 at Netherhall Farm shows bedrock Chalk near the surface beneath topsoil at c.18m OD.

### 8.5.4.4 Geological Section 45/55.3

This 5.5km-long section (Figure 8.5.4-3) runs roughly northwest-southeast from Chesterton High Street (point CD115/3) through Barnwell and Romsey Town to Lime Kiln Hill (point 205/536). It provides a record of the geology across the floodplain of the River Cam at Elizabeth Way Bridge, and from the 2nd and 3rd Terrace Deposits east Cambridge. Point CD115/3 shows 2m of gravel and sand on bedrock Gault Clay at c.6m OD, but point 912 records 5m of unknown drift deposits on bedrock at c.4m OD. Point a5 on Haig Road shows Made Ground over clay with gravel overlying 3m of gravel and sand on bedrock at
On Elizabeth Way, points CheB6 to 122 record 1m of clay with gravel or silty clay over gravel and sand 1m thick on bedrock at 3-4m OD. In contrast on the floodplain of the River Cam, point CheB4 shows Made Ground over 2.5m of presumably Flandrian peat overlying 4.5m of gravel and sand on bedrock at c.-3m OD. Nearby, points LGA12 and g6 show Made Ground over 3m of silty clay overlying 3m of gravel and sand on bedrock at -0.5 to -1.5m OD, and point TTP7 shows 1m of silty clay overlying 4m of peat and clay with peat, in turn overlying gravel and sand on bedrock at c.-1.5m OD. Point e27e shows Made Ground over 3m of silty clay overlying 4m of gravel and sand on bedrock at c.-3m OD and point CheB1 shows 5m of peat and clay with peat overlying 2.5m of gravel and sand on bedrock at a similar elevation. These deposits clearly fill a bedrock channel-form similar to that identified beneath the River Cam in 45/55.1 and 45/55.2. This reaches its deepest at point e27a where Made Ground overlies 3.5m of silty clay on 3.5m of peat, in turn overlying 3m of gravel and sand on bedrock Gault Clay at c.-6m OD. It is proposed that the silty unit here is formally named the Elizabeth Way Silty Clay, and that the peat unit is named the Elizabeth Way Peat, and that the gravel unit is named the Elizabeth Way Gravel, all with a stratotype at point e27a (TL 4610 5910).

Points TPP11 to B26 record Made Ground over silty clay and peat, overlying 1m of gravel and sand on bedrock at -1 to 0m OD. At the edge of the floodplain, point LGA3 shows 1m of clay with gravel over silty clay and 1m of peat on bedrock at c.4m OD. Point KLPU3 records 3m of gravel and sand on bedrock at c.7m OD and nearby LGA9 shows 1m of clay with gravel and bedrock at c.8m OD. Further upslope, point LGA4 records silty clay over bedrock at c.8m OD and points LGA8 and TTP1 record bedrock at 9-10m OD beneath Made Ground. However, points LGA13 and LGA14 show Made Ground over gravel and sand 7m thick, including a bed of silt, resting on bedrock Gault Clay at c.3m OD. It is proposed that this gravel unit is named the East Road Gravel with a stratotype at point LGA13 (TL 4615 5883). It is clear that this represents a buried bedrock channel-form beneath the 3rd Terrace surface. Close by, points OccBH2 to OccBH3 record Made Ground over gravel and sand and a basal silt on bedrock at c.9m OD. Point OccTP1 records 5m of Made Ground overlying bedrock. On New Street, point CD109/2 shows topsoil over 1m of silty clay overlying 3.5m of gravel and sand with a base not reaching bedrock at c.11m OD. This is the site of the Rodney Brewery from which a rich collection of temperate molluscs was made (McKenny-Hughes 1916). To the south, points Gwyd and 188/24 show 4m of gravel and sand on bedrock Gault Clay at c.9m OD. Near Mill Road, points 188/227 and 45NE74 show 4.5m of gravel and sand on bedrock Chalk at c.10m OD, and nearby at point Kinema 1.5m of silty clay was recorded over 2m of gravel and sand on bedrock at c.12m OD. It is proposed that this gravel unit is named the Mill
Road Gravel with a stratotype at point 188/227 (TL 4620 5790). At Mill Road Bridge, point 45NE47 shows 1.5m of gravel and sand on bedrock at c.14m OD. This appears to be close to the edge of the 3rd Terrace, although points Argyll to RT2 in Romsey Town show 1m of gravel or clay with gravel on bedrock at c.13m OD. Near Perne Road on the floor of the low-lying area that drains north towards Coldham’s Common, points CC3 and PR3 show bedrock Chalk close to the surface at c.9m OD. Near Cherry Hinton Road, point 205/22 shows bedrock Chalk near the surface at c.11m OD and at point 205/538 bedrock Chalk is close to the surface at c.12m OD. At Lime Kiln Hill, point 205/536 records bedrock Chalk beneath topsoil at c.21m OD.

8.5.4.5 Geological Section 45/55.4

This 5.5km-long section (Figure 8.5.4-4) runs roughly northwest-southeast from Chesterton High Street (point CD 115/3) through Barnwell and Romsey Town to Cherry Hinton (point 45/NE61). It provides a record of the geology across the floodplain of the River Cam at Riverside, and from the 2nd and 3rd Terrace Deposits in that area. Point CD115/3 shows 2m of gravel and sand on bedrock Gault Clay at c.6m OD, and point d17 records Made Ground over 3m of gravel and sand on bedrock at c.3.5m OD. Points 9101 to cr1 were all drilled with vibrocoring equipment and therefore show only the depth of drift to the bedrock. In general they show 3m of unknown drift on bedrock at c.5m OD. Point d19 records Made Ground over 2.5m of unknown drift deposits on bedrock at c.4m OD. Points 10111 to 10114 were also carried out with a vibrocore rig and record 5m of unknown drift deposits on bedrock at 2-3m OD. Near St. Andrews Road, points b15 and b16 show 2m of silty clay on bedrock at 2-3m OD, and point 10115 shows 3m of unknown drift on bedrock at c.2m OD. To the southeast on the floodplain of the River Cam, points r11 and d20 shows Made Ground over silty clay overlying 2m of gravel and sand on bedrock at c.1m OD. Point e29e shows Made Ground over 1m of silty clay overlying 2m of peat, in turn overlying 1.5m of gravel and sand on bedrock at c.-2m OD. Nearby, point e29d records a similar sequence with Made Ground over sandy clay overlying 3m of peat, in turn overlying 4.5m of gravel and sand on bedrock at c.-5m OD. The edge of the floodplain is shown at point e29c where Made Ground overlies silty clay over 2m of peat on bedrock at c.1m OD. Point e29b shows Made Ground over 2m of gravel and sand on bedrock at c.3m OD and point e29a shows 2m of Made Ground on bedrock at c.5m OD.

At the top of a short steep incline, the River Lane development site (formerly Cambridge Gas Works) occupies a finger of 3rd Terrace Deposits mapped along Newmarket Road. Points RDtrench to RLDU show Made Ground over gravel and sand 3m thick on bedrock at 8-10m OD. It is proposed that this gravel unit is named the River Lane Gravel with a
stratotype at point RDtrench (TL 4645 5913). Point 188/222 records bedrock Chalk close to the surface at c.12m OD to the southeast of the site, and it is important to note that deposits here tend to rest on bedrock Chalk rather than Gault Clay. Point AFH on Newmarket Road shows Made Ground over bedrock Chalk at c.10.5m OD, and at Coral Park Trading Estate, Barnwell, points CD36/2 to 188/74 record bedrock Chalk near the surface beneath topsoil at 9-10.5m OD. To the southeast at Vinery Road, Romsey Town, points Vinery1 and Vinery2 show bedrock Chalk close to the surface at 9-10m OD. On Coldham’s Lane, point 45NE124 shows 2m of sandy clay on bedrock at c.7m OD, and point CC2 records bedrock Chalk beneath topsoil at a similar elevation. These points are located at the northern exit of the low-lying area centred on Perne Road, which drains northwards towards Coldham’s Common. It is proposed that this sandy clay unit is named the Coldham’s Lane Sandy Clay with a stratotype at point 45NE124 (TL 4740 5810). South of Coldham’s Lane in an area of disused Chalk pits, points 45NE80 to CD54/4 show bedrock Chalk close to the surface at 9-10m OD. Point CD54/5 shows that an area now restored as a landfill site once had 1m of clay with gravel overlying Chalk bedrock at c.11m OD, and point 188/88 beneath the railway records Chalk bedrock beneath topsoil at c.15m OD. In the valley of Cherry Hinton Brook, point BH201 shows bedrock at c.8m OD, but points BH202 and BH203 record 2m of silty clay with pebbles on bedrock at c.6m OD. It is proposed that this silty clay unit is named the Cherry Hinton Silty Clay with a stratotype at point BH203 (TL 4819 5684). Further to the southeast, point 45NE61 shows bedrock Chalk beneath topsoil at c.16m OD.

8.5.4.6 Geological Section 45/55.5

This 5km-long section (Figure 8.5.4-5) runs roughly west-east from Chesterton High Street (CD115/3) through Coldham’s Common and Cambridge Airport to Teversham and Quy Waters (point APWa). Point CD115/3 shows 2m of gravel and sand on bedrock Gault Clay at c.6m OD. Nearby, points 894 to 895 were drilled with vibrocoring equipment and only record the thickness of drift deposits and the elevation of the rockhead. Point 984 shows 3m of unknown drift on bedrock at c.5m OD and point 895 shows 5m of unknown drift on bedrock at c.3.5m OD. South of Chesterton High Street, points b10 and CNIS10 show Made Ground over 2m of clay with gravel overlying silty clay, in turn overlying 1m of gravel and sand on bedrock at c.3m OD. Point HG records gravel near the surface beneath Made Ground, and points b11 and CNIS11 show 3m of gravel and sand on bedrock at 2.5-3.5m OD. Point b13 records Made Ground over 3.5m of silty clay on bedrock at c.1.5m OD and point CNIS12 shows 4m of gravel and sand on bedrock at a similar elevation. Southeast of the river at the site of the old Pumping Station, point CL10 showed 5.5m of Made Ground on bedrock Gault Clay at c.1.5m OD, but nearby points
CL12 and CL3 recorded 5m of Made Ground over 5m of silty clay and clay with gravel on bedrock at −1 to −3m OD. On the same site, point e39.2 shows Made Ground over 2m of clay with gravel overlying 3m of gravel and sand on bedrock at c.−3m OD. Point CL11 records 6m of unknown drift on bedrock at c.0m OD and point CL4 shows Made Ground over 4m of sandy silty clay overlying 3m of gravel and sand on bedrock at c.−0.5m OD. It is clear that a buried bedrock channel-form exists beneath this site, presumably equivalent to that identified beneath the floodplain of the River Cam in other sections. Points e26 and CL7 record Made Ground over 1m of silty clay on bedrock at c.4m OD and upslope point CL5 and CLS show bedrock Gault Clay close to the surface at c.7m OD and c.10m OD respectively. The presence of a deep pit at point CL1 is shown by the presence of 12m of Made Ground.

At the Comet development site on Newmarket Road, point COMTP1 recorded Made Ground over sandy clay, overlying 1m of silty clay on bedrock Chalk at c.9m OD. Elsewhere on the Comet site, points COMTP11 to COMTP14 show bedrock Chalk close to the surface beneath Made Ground at c.10m OD. Point CD36/5 southeast of Newmarket Road showed bedrock close to the surface at a comparable elevation. On Coldham’s Common, points CCSP3 and CCSP4 both show bedrock Chalk beneath topsoil at c.5m OD, and close by point 45NE9 records bedrock Gault Clay near the surface at a similar height. This low-lying area drains north towards the River Cam. At Barnwell Road, points 45NE2 and BWR show bedrock Chalk near the surface at c.11m OD. However, point 45NE1 records 3.5m of unknown drift on bedrock close by. At Airport Way, Teversham, point 188/228 records bedrock close to the surface beneath topsoil at c.8.5m OD, and nearby point APWTP5 shows bedrock Chalk at c.9.5m OD. Excavations for the current alignment of Airport Way revealed topsoil over 1.5m of sandy clay with a base not reaching bedrock at c.8m OD at point APWTP4, although bedrock was exposed near the surface (c.10m OD) at point APWTP3 nearby. It is proposed that this sandy clay unit is named the Teversham Sandy Clay with a stratotype at point APWTP4 (TL 4964 5896). Points APWe and APWb showed topsoil over clay with gravel and bedrock at c.11m OD and upslope, point APWTP showed clay with gravel on bedrock at c.13m OD. Near Quy Waters at the top of the slope, point APWTP1 showed bedrock Chalk at c.14m OD, but a pit dug at the authors’ request at APWa showed 1m of gravel and sand on bedrock Chalk at c.12.5m OD. It is proposed that this gravel unit is named the Quy Waters Gravel with a stratotype at point APWa (TL 4990 5925).

8.5.4.7 Geological Section 45/55.6

This 5km-long section (Figure 8.5.4-6) runs roughly west-east from Chesterton High Street (CD115/3) through Cambridge Cemetery and Greenhouse Farm to the A14 Road
Point CD115/3 shows 2m of gravel and sand on bedrock Gault Clay at c.6m OD, and point 984a shows 5m of unknown drift on bedrock at c.3.5m OD. South of Chesterton High Street, points b10 and CNIS10 show Made Ground over 2m of clay with gravel over silty clay, in turn overlying 1m of gravel and sand on bedrock at c.3m OD. Point HG records gravel near the surface beneath Made Ground, and points b11 and b12 show 3m of gravel and sand on bedrock at 1.5-2.5m OD. Point CNIS13 records Made Ground over 3.5m of clay with gravel on bedrock at c.1m OD. The geology across the floodplain of the River Cam has been projected from elsewhere. At Garlic Row, point CD36/4 records bedrock Chalk at the surface at c. 10m OD. At Newmarket Road bridge points NR1 to NR4 show 2m of clay with gravel on bedrock Gault Clay at elevations between 7.5 and 5.5m OD. Point NR6 records 1m of clay with gravel over gravel and sand on bedrock at c.5m OD. It is unclear whether these deposits relate to the River Cam or its tributary Coldham’s Brook. It is proposed that this clay with gravel unit is named the Newmarket Road Gravelly Clay with a stratotype at point NR2 (TL 4707 5943).

Further along Newmarket Road, point CD106/6 at the site of the Elfleda House Pit (Marr, 1917, Marr, 1920) shows 1m of silty clay beneath Made Ground, but in contrast point 45NE122 nearby shows gravel and sand on bedrock Chalk at c.11m OD. Point CD106/7 records 2m of silty clay overlying gravel and sand with a base not touching bedrock at c.11m OD. Close by at the Cambridge Cemetery, points NRC1 to NRC2 show 2.5m of silty clay overlying gravel and sand on bedrock at 12-13m OD. This area is mapped by the BGS as 4th Terrace Deposits. It is proposed that this silty clay unit is named the Cemetery Silty Clay with a stratotype at point NRC1 (TL 4815 5940). Further east at the Marshalls industrial site, points NWTP3 to NWBH1 record similar deposits with 2m of silty clay overlying gravel and sand 1.5m thick on bedrock Chalk at 13-15m OD. To the east at Greenhouse Farm, excavation for a Park and Ride site revealed silty clay 1m thick, in places overlying gravel and sand. Point 45NE71 also at Greenhouse Farm, shows 11m of Made Ground. Near Black House, points 188/317 and 188/232 show bedrock Chalk close to the surface at c.10m OD, but on High Ditch road, point a5204 shows topsoil over sandy clay on gravel. At the A14 Road, points b5201a to b5200 record sandy clay 2m thick on bedrock Chalk at 8-9m OD. It is proposed that this sandy clay unit is named the Black House Sandy Clay with a stratotype at point b5200 (TL 4996 5996).

8.5.4.8 Geological Section 45/55.7

This 3km-long section (Figure 8.5.4-7) runs roughly west-east along the line of Chesterton Road, New Chesterton, from Albert Street (point a14) to Scotland Road (point 783). The section crosses the spread of 2nd Terrace Deposits mapped by the BGS. Point a14 near Albert Street records 1m of silty clay overlying gravel and sand on bedrock Gault
Cambridge Clay at c.6.5m OD. Nearby, points rsa11 and m3 show Made Ground over 2m of gravel and sand on bedrock at c.6m OD, but at point m2 Made Ground is recorded over 1m of sand and gravel overlying 0.5m of silty clay, in turn overlying 4m of gravel and sand, overlying 8m of silty clay with a base not touching bedrock at c.-7m OD. It is proposed that the lower gravel unit here is formally named the Victoria Road Gravel, and that the underlying silty clay unit is named the Victoria Road Silty Clay, both with a stratotype at point m2 (TL 4517 5942). In contrast, point rsa10 shows 4m of gravel and sand on bedrock at c.3m OD, but point tunnel(j) shows 11m of unknown drift resting on bedrock at c.-3m OD. Near Victoria Road, points CNIS7 and b7 show Made Ground over 1m of silty clay overlying gravel and sand 6m thick, and point m1a records gravel over 1m of silty clay overlying 10m of gravel and sand, in turn overlying 2m of silty clay with a base not touching bedrock at c.-7m OD. These points clearly record a complex of deep, steep-sided buried channel-forms incised into bedrock beneath Chesterton Road. Point rsa13 shows Made Ground over 5m of gravel and sand on bedrock at c.2m OD, but points tunnel(e) and 344 record unknown drift on bedrock at 1-3m OD, and points tunnel(a) and 343 show unknown drift on bedrock at c.-3m OD and 2m OD respectively. Close by, points rsa4 to m4 record Made Ground over gravel and sand 5m thick on bedrock at 1-3m OD, and points tunnel(a) and 343 show unknown drift on bedrock at c.-3m OD and 2m OD respectively. Point rsa7 shows Made Ground over 4m of gravel and sand on bedrock at c.3m OD and point c7 records 3m of gravel and sand on bedrock at c.4.5m OD. At point 342, 2m of unknown drift overlie bedrock at c.6m OD, and at point a9 2m of silty clay overlie bedrock at a similar elevation. Near Springfield Road, point 341 records 4m of Made Ground on bedrock at c.4m OD, but point MLM1 shows 1m of gravel and sand on bedrock at c.6.5m OD. This marks the position of a bedrock ‘high’ that appears to mark the eastern edge of the first complex of channels in this section.

Point a7 shows 1.5m of clay with gravel on bedrock at c.6m OD and point ch3 shows 1m of gravel and sand on bedrock at a similar elevation. Near George Street, point c6 records 1.5m of silty clay on bedrock at c.6m OD and point j4 shows 1m of Made Ground over 1.5m of gravel and sand on bedrock at c.5m OD. Nearby, point a8 records 1.5m of silty clay overlying 3m of gravel and sand on bedrock at c.3.5m OD, and points j3 and c5 show a similar sequence on bedrock at 4.5 to 5m OD. It is proposed that the upper silty clay unit here is formally named the New Chesterton Silty Clay with a stratotype at point c5 (TL 4564 5961). In contrast, point CNIS8 shows Made Ground over 9m of gravel and sand with a base not touching bedrock at -2m OD, and although point rsa3 records 5.5m of gravel and sand on bedrock at c.1m OD, point b8 again shows 9m of gravel and sand with a base not reaching bedrock at -2m OD. Near De Freville Avenue, points j1 and ch2 record 6m of gravel and sand on bedrock at 1.5 to 2.5m OD, and point
cpt4 shows 13m of unknown drift not reaching bedrock at c.-4.5m OD. The nature of these deposits is revealed at point g2 where 8m of gravel and sand overlies 3m of silty clay, which in turn overlies 2m of gravel and sand on bedrock at c.-6m OD. It appears that these deposits represent a second complex of steep-sided bedrock channel-forms exist beneath the eastern end of Chesterton Road. Points j2 and rsa2 record 6m of gravel and sand on bedrock at 1.5 to 2.5m OD, and point c4 shows 5m of gravel and sand overlying 1m of silty clay, in turn overlying 1m of gravel and sand on bedrock at c.0m OD. Near Hawthorn Way, points g1 and g3 show 9m of gravel and sand, and point g4 records 12m of gravel and sand on bedrock at c.-4m OD. Near Milton Road, points a6 to ch1 record 3m of gravel and sand on bedrock at c.5m OD, and point 915 shows 6m of unknown drift on bedrock at c.3m OD. Points obtained using vibrocoring equipment dominate the remaining part of this section. This technique merely records the thickness of drift deposits and the depth of the rockhead. Along Chesterton High Street, points 913 to 9101 show unknown drift 5m thick on bedrock at c.4m OD. Point d17 shows that this material is probably gravel and sand, and nearby points 895 to 894 also show 5m of drift deposits resting on bedrock at c.3.5m OD. Near Scotland Road, points 893 to 784 record 3m of unknown drift deposits on bedrock Gault Clay at 5-6m OD.

8.5.4.9 Geological Section 45/55.8

This 5km-long section (Figure 8.5.4-8) runs roughly southwest-northeast from Sidney Sussex College, King Street, (point SSCBH2) through Midsummer Common and Barnwell Station to Ditton Fields (point 45NE36). At Sidney Sussex College, points SSCBH2 and SCCBH1 show Made Ground over 2m of silty clay overlying 3m of gravel and sand on bedrock Gault Clay at c.4m OD. Nearby, points SSCBH3 and HOBS2 show Made Ground over 1.5m of gravel and sand on bedrock at 5-6m OD, although points SSCBH4 and SCCBH5 show silty clay 2m thick of overlying 2.5m of gravel and sand on bedrock Gault Clay at c.4m OD. On Jesus Lane, point CD115/1 records 9m of gravel and sand with a base not reaching bedrock at c.0m OD. Near Jesus College, points JLS2 to e32.2 show Made Ground over clay with gravel 1m thick overlying 2m of gravel and sand, in turn overlying 4m of silty clay, over 2m of gravel and sand on bedrock at c.-1m OD. The author was able to investigate this sequence in more detail during archaeological investigations at Jesus College (points JC A and JC B) and sewer works in Jesus Lane. It is clear that these sediments occupy a buried bedrock channel-form, and it tempting to note the similarity of this feature to the channel-forms described from Chesterton Road. It is proposed that the upper gravel unit here is formally named the **Jesus College Gravel**, that the lower silty clay unit is named the Jesus Lane Silty Clay, and that the lower gravel unit is named the Jesus Lane Gravel, all with a with a stratotype at point JLS5 (TL 4523...
5880). In King Street, point AFBH1 shows Made Ground over silty clay overlying 1m of gravel and sand on bedrock at c.4m OD, point AFHBH2 shows Made Ground directly on bedrock at c.5.5m OD, while point AFHBH3 records 2.5m of gravel and sand overlying silty clay, in turn overlying gravel on bedrock at c.4.5m OD. At the Four Lamps roundabout, point 4Lamps also records Made Ground only, although nearby point MCBH8 shows 3m of Made Ground over silty clay and 1m of gravel and sand on bedrock at c.4.5m OD.

On Butt Green, point Holst23 shows Made Ground over 1m of clay with gravel on bedrock at c.4m OD. In contrast, point B1A shows 5m of unknown drift deposits on bedrock at c.1.5m OD. Many of the points across Butt Green and Midsummer Common are from boreholes carried out with vibrocoring equipment. This technique yields only the thickness of drift deposits and the elevation of the bedrock surface. Points B2B to B12 show 3m of unknown drift on bedrock at 3-4m OD, although point MCBH6 recorded 1m of clay with gravel on bedrock at c.5m OD. Closer to the floodplain of the River Cam, point MCBH4 shows 1m of silty clay over 3m of peat overlying 1m of gravel and sand on bedrock at c.0m OD, and points B15 to B17 show 5m of unknown drift deposits on bedrock at a similar elevation. It appears that this represents part of a channel beneath the floodplain. Point MCBH3 records Made Ground over 1m of silty clay overlying 1.5m of peat and clayey peat, in turn overlying 1.5m of gravel and sand on bedrock at c.2m OD. Likewise, points B18 to B21 show 4m of unknown drift deposits on bedrock at c.2m OD. Points MCBH2 records Made Ground over 1m of peat overlying gravel on bedrock at c.3m OD, and points B22 to B24 show 3m of unknown drift on bedrock at the same elevation. Point MCBH1 shows 4m of Made Ground over 1m of peat overlying 1.5m of gravel and sand on bedrock at c.0m OD. Nearby, points TTP11, TTP3 and CheB2 show Made Ground over peat and clay with peat 4m thick overlying 1.5m of gravel and sand on bedrock at c.-1.5m OD. Point LGA2 shows Made Ground over 2m of silty clay overlying 1.5m of peat in turn overlying 1m of gravel and sand on bedrock at c.-1.5m OD and point B26 records 5m of unknown drift on bedrock at c.0m OD. However, point e27a records 4m of silty clay overlying 3m of peat, in turn overlying 2m of gravel and sand on bedrock at c.-6m OD. This buried channel-form in the bedrock is clearly similar to those described from beneath the Cam floodplain from other sections in the square.

To the north, point 1(a2) shows 7m of unknown drift deposits on bedrock at c.-2m OD and CheB1 shows Made Ground over 5.5m of peat and clay with peat overlying 2.5m of gravel and sand on bedrock at c.-3m OD. Point TTP12 shows 5m of peat overlying 1m of gravel and sand at c.-1m OD and point g7 shows 4m of silty clay overlying peat, in turn overlying 2m of gravel and sand on bedrock at c.-2m OD. On Elizabeth Way, points
LGA11 to g5 record Made Ground over silty clay 3m thick overlying gravel and sand 3m thick on bedrock at 0 to –2m OD. In contrast, point TTP8 records 2.5m of peat overlying 3m of gravel and sand on bedrock at c.-2m OD. Close by, points 122 and 121 show 2m of unknown drift on bedrock at c.3m OD, and point e21 shows Made Ground over gravel at a similar elevation. South of St. Andrews Road, point b18 shows Made Ground on bedrock at c.3m OD, and point CNIS18 shows Made Ground over clay with gravel on bedrock at the same height. Points 1115 to 10115 record 3m of unknown drift deposits on bedrock at 1.5 to 2m OD, while point RLB6 shows 1m of silty clay over gravel and sand, and point CNIS17 shows Made Ground over 2m of clay with gravel overlying 1m of gravel and sand on bedrock at c.1m OD. At Logan’s Way, points r11 and d20 record Made Ground over silty clay overlying 2m of gravel and sand on bedrock at c.1m OD, and point b23 shows 3m of gravel and sand on bedrock at a similar elevation. In contrast, point e29e records 1.5m of silty clay over 2m of peat, in turn overlying 1.5m of gravel and sand on bedrock at c.-1m OD. Closer to the River Cam, point h4 shows 3m of silty clay over gravel on bedrock at c.0.5m OD, and point a3 records silty clay over 2.5m of peat and clay with peat, in turn overlying 2m of gravel and sand on bedrock at c.-1m OD. Points 11123 and 11124 show 4.5m of unknown drift deposits on bedrock at c.0m OD, and point h3 shows 1.5m of silty clay over 1.5m of peat and clay with peat, in turn overlying 2m of gravel and sand on bedrock at c.-1m OD. Point d22 shows Made Ground over 2m of silty clay overlying 2.5m of peat on bedrock at c.-1m OD, and point 11125 shows 6m of unknown drift on bedrock at c.-2m OD.

On the southeast side of the river at Riverside, points b26 to r12 show Made Ground over silty clay 2m thick on bedrock at 3-4m OD, and point 11126 records 3.5m of unknown drift on bedrock at c.0.5m OD. At the site of the old Pumping Station, point d23 shows Made Ground over 1m of silty clay overlying 2m of gravel and sand on bedrock at c.1m OD, and points CL2 to e39.1 show Made Ground 6m thick on bedrock at 0-1m OD. Point CL4 shows 1.5m of clay with gravel overlying 2m of silty clay, in turn overlying 2m of gravel and sand on bedrock at c.-0.5m OD. Points e26 and e26.3 show Made Ground over silty clay on bedrock at c.4m OD. However, point e39.3 records Made Ground over 3m of clay with gravel overlying 2m of silty clay, in turn overlying 2m of gravel and sand on bedrock at c.-2m OD. This is clearly equivalent to the buried channel-form that exists beneath the floodplain of the River Cam elsewhere. Upslope, point e26.2 records silty clay on bedrock Gault Clay at c.7m OD and point Stanley at Stanley Road shows 0.5m of gravel and sand on bedrock Chalk at c.10m OD. At Garlic Row, point CD36/4 also shows bedrock Chalk at c.10m OD and near Barnwell Station point CD36/6 records bedrock at the same elevation. At the site of Barnwell Station, points BSSE to BSE show 1.5m of gravel
and sand, incorporating a bed of silt with plant remains, resting on bedrock Gault Clay at c.8m OD. The rich arctic plant macrofossils from the 1st Terrace Deposits exposed in the pit at Barnwell Station have been studied by a succession of workers (McKenny Hughes 1888, McKenny-Hughes 1916, Marr and Gardner 1916 and Chandler 1921, Coope 1968). In addition, plant material from these deposits has been radiocarbon dated to 19,500 ±650 years BP (Godwin and Willis 1964). It is proposed that the gravel unit here is formally named the Barnwell Station Gravel with a stratotype at point BSSE (TL 4705 5968). Across the valley of Coldham’s Brook, point DW shows 3m of silty clay with a base not touching bedrock at c.6m OD, although nearby point CD37/1 shows bedrock Chalk near the surface at c.9m OD. At Ronald Rolfe Court, point 188/223 records bedrock chalk close to the surface at c.6m OD, and at the edge of the Ditton Fields estate, point 45NE36 records bedrock Chalk at c.7m OD beneath 1m of topsoil.

8.5.4.10 Geological Section 45/55.9

This 4km-long section (Figure 8.5.4-9) runs roughly southwest-northeast from Lion Yard (point LYRDBH12) through Maid’s Causeway and Newmarket Road to Ditton Fields (point 45NE36). At Lion Yard, central Cambridge, points LYRDBH12 shows Made Ground over gravel and sand on bedrock Gault Clay at c.6m OD, and point Forb10 records 3m of gravel and sand on bedrock at c7m OD. It is proposed that the gravel unit here is formally named the Lion Yard Gravel with a stratotype at point Forb10 (TL 4504 5830). Nearby, point LYRDBH13 shows 4m of Made Ground on bedrock at c.6m OD, point LYRDBH14 shows Made Ground over gravel on bedrock at c.8m OD and point LYRDBH15 records Made Ground directly on bedrock at c.9.5m OD. To the east in the grounds of Emmanuel College, point ECBH1 shows Made Ground over 4m of silty clay on bedrock at c.6m OD. It is proposed that the silty clay unit here is formally named the Emmanuel College Silty Clay with a stratotype at point ECBH1 (TL 4525 5837). Point ECBH2 records Made Ground over silty clay on bedrock at c.8.5m OD, but point ECBH3 shows only Made Ground on bedrock at c.7m OD. At the junction of Elm Street and Emmanuel Road, point ElmSt. records 2m of Made Ground over gravel on bedrock at c.7.5m OD, and in New Square point Holst25 shows Made Ground over clay with gravel overlying 1.5m of gravel and sand on bedrock at c.7m OD. At Fair Street, point FairSt. ‘B’ records bedrock Gault Clay near the surface beneath Made Ground at c.9.5m OD. Further east, point KLP1 shows Made Ground over 1m of silty clay on bedrock at c.9m OD and on Maid’s Causeway, point Sewer’C’ shows gravel on bedrock at c.12m OD. In contrast, point CD35/4 shows 1.5m of gravel and sand overlying 3m of silty clay on bedrock at c.8m OD, and point e36 shows Made Ground over 3m of gravel and sand on bedrock at c.8.5m OD. It is proposed that this silty clay unit is formally named the Maid’s
Causeway Silty Clay with a stratotype at point CD35/4 (TL 4580 5880). Point Sewer’Ci’ shows 3m of Made Ground over gravel on bedrock at c.10m OD, and point Sewer’D’ records Made Ground over 1.5m of gravel and sand overlying 2m of silty clay, in turn overlying gravel and sand with a base not reaching bedrock at c.9m OD. These points appear to record a small buried bedrock channel-form beneath the 3rd Terrace surface in this area. To the east, points CENAii to CENBi show 1.5m of gravel and sand with silt beds on bedrock at 12-13m OD. Points Sewer’E’ and Sewer’F’ record several metres of Made Ground, although point Sewer’G’ shows 1m of gravel and sand on bedrock at c.12m OD.

At Elizabeth Way roundabout, point LGA13 records Made Ground over 7m of gravel and sand (incorporating a bed of silt) on bedrock at c.3m OD. This buried channel-form is remarkably similar to those observed to the north beneath Chesterton Road in 45/55.7. Nearby, point Ocl shows Made Ground over 1m of gravel and sand overlying 1m of silty clay on bedrock at c.8m OD. At Barnwell Abbey, point BWA records topsoil over gravel overlying 1.5m of silty clay, in turn overlying 1m of gravel and sand on bedrock Gault Clay at c.8m OD. Deposits from a pit at this site yielded vertebrate remains and a rich assemblage of temperate molluscs (Mrs McKenny-Hughes 1888, McKenny-Hughes 1916). It is proposed that the silty clay unit here is formally named the Barnwell Abbey Silty Clay with a stratotype at point BWA (TL 4624 5894). To the east, point KLPOBAP shows 3m of gravel and sand on bedrock Chalk at c.10m OD. At the River Lane development site (formerly Cambridge Gas Works) on Newmarket Road, points RLDZ to RLDDD show Made Ground over gravel and sand 3m thick on bedrock at 8-10m OD. Some points show appreciable thicknesses of Made Ground, in some cases marking backfilled pits 7m deep. To the northeast at the Comet development site on Newmarket Road, points COMTP15 to COMTP16 show bedrock Chalk close to the surface beneath Made Ground at c.10m OD. However, point COMBH2 recorded Made Ground over sandy clay on bedrock Chalk at c.9m OD. Point CD36/3 on Coldham’s Common showed bedrock Chalk close to the surface at c.9m OD. At Newmarket Road bridge (near Barnwell Station) point NR4 shows up 2m of clay with gravel on bedrock Gault Clay at 5.5m OD, point NR5 shows 1m of gravel and sand on bedrock at c.7m OD, and point NR6 records 1m of clay with gravel over gravel and sand on bedrock at c.5m OD. The relationship of these deposits to those from the Barnwell Station site is not entirely clear. Across the valley of Coldham’s Brook, point DW shows 3m of silty clay with a base not touching bedrock at c.6m OD, although nearby point CD37/1 shows bedrock Chalk near the surface at c.9m OD. At Ronald Rolfe Court, point 188/223 records bedrock chalk close to the
surface at c.6m OD, and at the edge of the Ditton Fields estate, point 45NE36 records
bedrock Chalk at c.7m OD beneath 1m of topsoil.

**8.5.4.11 Geological Section 45/55.10**

This 4.5km-long section (Figure 8.5.4-10) runs roughly southwest-northeast from
Pembroke College (point PemTP5) through East Road and Coldham’s Common to Ditton
Lane (point DLBH2). At Pembroke College, points PemTP5 to PemTP3 show Made
Ground over gravel and sand 2m thick on bedrock Gault Clay at 7-8m OD. The gravel and
sand here incorporated a diamicton unit 0.5m thick, thought to represent a mass flow
deposit. On the Downing Site, point DSWELL shows 1m of silty clay overlying 3.5m of
gravel and sand on bedrock at c.6m OD, and point DSTrench records silty clay overlying
2.5m of gravel and sand. These exposures were described by Marr (1920) who recovered
a mollusc assemblage from silty bands within the gravel. At point G.opp, 1.5m of Made
Ground overlies clay with gravel over gravel with sand on bedrock at c.8.5m OD, and near
St. Andrews Street points St.A1 and RCCTP1 show Made Ground over 1m of gravel and
sand. Point RCCBH1 shows Made Ground over 2.5m of gravel and sand on bedrock at
c.7m OD, point RCCTP4 shows Made Ground over clay with gravel, and gravel and sand
on bedrock at c.8m OD, and point RCCTP2 shows Made Ground over gravel overlying
1m of silty clay. On Parker’s Piece, points ParkP3 and ParkP4 show silty clay over gravel
and sand, and near Prospect Row, point Holst29 Made Ground overlies 1m of silty clay on
1m of gravel and sand. Nearby, point DoverSt. shows 2m of silty clay, but points Holst20
and MGBH1 record 3m of Made Ground. Point MGBH2 shows Made Ground over 1m
of silty clay on bedrock at c.10m OD, and near Burleigh Street point Holst21 shows Made
Ground over 2m of silty clay overlying gravel and sand.

On the east side of East Road, points BH9 and ER1 show 2m of gravel and sand on
bedrock at c.9m OD. Points BH10 to ER3 record Made Ground over clay with gravel
overlying 2m of gravel and sand. This area was an old pit, and the original ground surface
here must have once been considerably higher. In contrast, point KLPLL records gravel
on bedrock at c.12m OD, but at point CD109/2, the site of the Rodney Brewery, topsoil
overlies 1m of silty clay on gravel and sand 3.5m thick. McKenny-Hughes (1916)
collected an assemblage of temperate molluscs from this site. To the northeast at
Occupation Road, point OccBH4 shows Made Ground over gravel overlying 1.5m of silty
clay on bedrock at c.8m OD, and points OccTP2 and OccBH3 show several metres of
Made Ground. Trenches at New Street (points NewSt.C to NewSt.A) showed Made
Ground over gravel and sand 2m thick, and point CD109/4 records 5m of gravel and sand
on bedrock Gault Clay at c.8m OD. On Coldham’s Common, point e37 shows bedrock
Chalk near the surface at c.11m OD, and points CD36/2 to 188/15 record bedrock Chalk
beneath topsoil at c.9m OD. Point CC1 shows bedrock Chalk near the surface at c.7m OD, and points CCSP5 to 45NE9 record Made Ground over bedrock at 5-6m OD. It is interesting to note that Gault Clay bedrock reaches the surface beneath a covering of Lower Chalk at point 45NE9. On Newmarket Road, point CD106/6 at the site of the Elfleda House Pit (Marr, 1917, Marr, 1920) shows 1m of silty clay beneath Made Ground, but nearby point 45NE122 shows gravel and sand on bedrock Chalk at c.11m OD. Point CD106/7 records 2m of silty clay overlying gravel and sand with a base not touching bedrock at c.11m OD in an area is mapped by the BGS as belonging to the 4th Terrace. Close to the Cambridge Cemetery, point NRC1 shows 1m of silty clay overlying 1m of gravel and sand on bedrock at 12m OD, point NRC4 shows 1m of silty clay on bedrock at c.14m OD, and point NRCC records 1.5m of silty clay. On Ditton Lane, point DLBH1 shows sandy clay on bedrock at c.12.5m OD and point DLBH2 shows silty clay on bedrock Chalk at c.7.5m OD.

8.5.4.12 Geological Section 45/55.11

This 5km-long section (Figure 8.5.4-11) runs roughly southwest-northeast from Newtown (point 45NE3) through Barnwell and Coldham’s Common to Cambridge Cemetery (point DLBH6). At the Department of Engineering, point 45NE3 shows Made Ground over 2m of gravel and sand on bedrock Gault Clay at c.5.5m OD. At Brookside, point Holst13 shows 2m of silty clay overlying 1.5m of gravel and sand on bedrock at c.7.5m OD, and point Holst14 shows Made Ground over 1m of clay with gravel on bedrock at c.9m OD. Near Lensfield Road, point Holst15 records 2m of clay with gravel over gravel and sand, and at the Scott Polar Institute, point Scott1 records Made Ground over gravel overlying 1.5m of silty clay, in turn overlying 1m of gravel and sand on bedrock at c.9m OD. Near the Catholic Church, point CChrch1 shows Made Ground over 1.5m of gravel and sand, and at points CChrch2 and Holst 16 2m of silty clay overlies gravel and sand on bedrock at a similar elevation. In contrast at point Perse, 3m of gravel and sand rest on bedrock at c.9m OD. To the north on Parker’s Piece, point Holst17 shows clay with gravel over 1.5m of gravel and sand on bedrock at c.10m OD, and point 45NE101 shows 2m of silty clay on bedrock at a similar elevation.

At the site of Parkside Pool, points Donk3 to PSP2ii show gravel and sand 2m thick interbedded with silty clay reaching 1m thick, resting on bedrock at 10-12m OD. The bedrock here showed the junction of the Lower Chalk with the Gault Clay, including a band of Cambridge Greensand. On Mill Road, point MRPO shows sandy clay overlying 2m of gravel and sand on bedrock Chalk at 10.5m OD. To the north, point KLPU4 shows gravel on bedrock Gault Clay at c.12m OD, and at Anglia University, points SASTP1 to SASTP2 show Made Ground over 2m of gravel and sand with beds of silty clay on
bedrock at c.10.5m OD. In contrast near Barnwell Cemetery, point CMWBH3 records 2.5m of gravel and sand overlying 3m of silty clay on bedrock at c.8.5m OD, and point CMWBH2 shows 6m of gravel and sand on bedrock at c.8m OD. Near Gwydir Street, point 188/124 shows 4m of gravel and sand on bedrock at c.9m OD and point KLPKK records Made Ground over 3m of gravel and sand on bedrock Gault Clay at c.10m OD. On Coldham’s Common, points 45NE31 and e33 show bedrock Chalk near the surface at c.9m OD. To the east at Barnwell road, points 45NE1 and BWR show bedrock close to the surface at c.11m OD, but point 45NE2 records 4m of unknown drift on bedrock Chalk at c.8m OD. At the Cambridge Cemetery on Newmarket Road, points NRCA to NRC3 show 2m of silty clay on bedrock Chalk at c.13m OD, and point NRCB records 1.5m of gravel and sand on bedrock at c.13.5m OD. Nearby, points DLBH4 and NWBH3 record 1m of sandy clay on bedrock at c.13m OD. Downslope, point DLBH5 shows sandy clay on bedrock at c.12m OD and point DLBH6 shows sandy clay on bedrock Chalk at c.9m OD.

8.5.4.13 Geological Section 45/55.12

This 5km-long section (Figure 8.5.4-12) runs roughly southwest-northeast from Brooklands Avenue (point 45NE103) through Romsey Town and Coldham’s Common to Marshalls industrial site (point NWBH2). Near Chaucer Road, point 45NE103 shows 1m of silty clay on bedrock Gault Clay at c.7.5m OD. At Brooklands Avenue, point 45NE104 shows 1m of gravel and sand overlying 2m of silty clay on bedrock at c.6m OD. Point SB-f in the Botanic Gardens shows 1m of gravel and sand, and points BA10 to BA1 record gravel and sand sometimes overlying silty clay. Point 45NE45 in the Botanic Gardens shows 4m of gravel and sand on bedrock Chalk at c.10m OD. Close by, points Fpig and Kett1 show Made Ground over silty clay overlying gravel and sand on bedrock at c.11.5m OD, and point Kett2 shows Made Ground over silty clay on bedrock at the same height. Near Tenison Road, points TenRd and ORS-A show Made Ground over gravel and sand, but point ORS-B records 1m of silty clay overlying gravel and sand with a base not reaching bedrock at c.13m OD. Near Mill Road Bridge, point 45NE47 shows 1.5m of gravel and sand on bedrock at c.14m OD. In Romsey Town, a trench at St. Philips Road (point StPhilip) showed Made Ground over 1.5m of gravel and sand on bedrock at 13m OD. At Thoday Street point Thod shows Made Ground over gravel and sand, and point Thod2 shows 1m of clay with gravel on bedrock Chalk at c.13m OD. Nearby at Ross Street, points Ross2 to Ross record bedrock Chalk close to the surface at c.11m OD, and points Vinery1 and Vinery2 show bedrock Chalk near the surface at c.10m and c.9m OD respectively. Near Coldham’s Lane, point 45NE124 shows 2m of sandy clay on bedrock at c.7m OD, and on Coldham’s Common point 45NE32 shows bedrock Chalk near the
surface at c.8.5m OD. To the northeast at the Marshalls industrial site, points NWTP2 to NWTP1 record 2m of silty clay overlying gravel and sand 1.5m thick on bedrock Chalk at 13.5-14m OD. Point NWBH6 shows Made Ground over silt and gravel on bedrock at c.14m OD, and point NWBH4 records gravel and sand on bedrock at c.15m OD. Nearby, point NWBH2 shows 1m of sandy clay overlying 2m of gravel and sand on bedrock Chalk at c.12m OD.

8.5.4.14 Geological Section 45/55.13

This 5.5km-long section (Figure 8.5.4-13) runs roughly southwest-northeast from Douglas House (point DougA) through Romsey Town and Coldham’s Lane to Quy Waters (point APWa). At Douglas House, point DougA records Made Ground over gravel and sand, and point DougB shows 2m of gravel and sand on bedrock chalk at c.10.5m OD. To the northeast at Homerton College, points SIC5 to SIC12 show 2.5m of gravel and sand on bedrock at c.13m OD. Near Cherry Hinton Road, point CHR1 shows 2m of gravel and sand overlying silty clay with a base not reaching bedrock at c.13m OD, and point CHR2 records sandy clay over 2m of gravel and sand overlying 1.5m of silty clay on bedrock at c.12m OD. To the north near Cambridge Railway Station, point CHR3 shows Made Ground over gravel overlying 3.5m of silty clay. It is proposed that the silty clay unit here is formally named the Cambridge Station Silty Clay with a stratotype at point CHR3 (TL 4631 5703). Nearby, point CHR4 shows 1m of sandy clay overlying 1m of gravel and sand, in turn overlying 1m of silty clay on bedrock at c.14m OD. In contrast, point CD109/1 shows 5m of gravel and sand with a base not touching bedrock at c.12m OD. In Romsey Town, point Argyll shows Made Ground over gravel and sand, and points RT1 to RT3 shows Made Ground over 1m of gravel and sand and clay with gravel on bedrock at c.13m OD. Near Coleridge Road, points Coll to Col2 record bedrock Chalk near the surface at c.14m OD, and on Mill Road, point MRSewer2 shows Made Ground over 1m of clay with gravel on bedrock at c.11m OD. Downslope near Madras Road, point 45NE34 shows bedrock Chalk near the surface at c.10m OD, and at point Madras, 2m of Made Ground rests directly on bedrock Chalk. Close by, point Vinery3 shows sandy clay on bedrock at c.9m OD, and point CD36/1 shows bedrock close to the surface at c.10m OD. South of Coldham’s Lane in an area of disused Chalk pits, points 188/89 and 45NE80 also show bedrock Chalk close to the surface at 9-10m OD. To the northeast at Airport Way, Teversham, point 188/228 records bedrock close to the surface beneath topsoil at c.8.5m OD, and nearby point APWTP5 shows bedrock Chalk at c.9.5m OD. Point APWTP4 showed 1.5m of sandy clay, and bedrock was exposed near the surface at c.10m OD at point APWTP3 nearby. Points APWa and APWb showed topsoil over clay with gravel and bedrock at c.11m OD and upslope, point APWTP2 showed clay with gravel on
bedrock at c.13m OD. Near Quy Waters at the top of the slope, point APWTP1 showed bedrock Chalk at c.14m OD, but point APWa showed 1m of gravel and sand on bedrock Chalk at c.12.5m OD.

**8.5.4.15 Geological Section 45/55.14**

This 5.5km-long section (Figure 8.5.4-14) runs roughly southwest-northeast from Addenbrookes Hospital (point GE1) through Cherry Hinton to Quy Waters (point APWa). At Addenbrookes Hospital, points GE1 and NH3 record 1m of gravel and sand on bedrock Chalk at c.16m OD. It is proposed that the gravel unit here is formally named the **Addenbrookes Hospital Gravel** with a stratotype at point GE1 (TL 4657 5507).

Close by, point NH4 shows gravel on bedrock at c.17.5m OD and points GE4 and NH2 record sandy clay on bedrock at c.17m OD. To the northeast near Wulfstan Way, points WW6 to WW3 record bedrock Chalk near the surface at c.9m OD, and point WW2 shows sandy clay on bedrock at a similar elevation. Nearby, points W-Sewer to GW5 also show Chalk bedrock close to the surface at c.9m OD on the floor of a low-lying area that drains north towards Coldham’s Common. Point 205/16 shows Made Ground over bedrock at c.10m OD and to the north point 205/22 shows bedrock chalk near the surface at c.10.5m OD. In the valley of Cherry Hinton Brook, points BH207 and BH204 record 1m of silty clay on bedrock at c.7m OD, although point BH201 shows bedrock Chalk close to the surface at c.8m OD. At Airport Way, Teversham, point 188/228 records bedrock close to the surface beneath topsoil at c.8.5m OD, and nearby point APWTP5 shows bedrock Chalk at c.9.5m OD. Point APWTP4 showed 1.5m of sandy clay, and bedrock was exposed near the surface at c.10m OD at point APWTP3 nearby. Points APWc and APWb showed topsoil over clay with gravel on bedrock at c.11m OD and upslope, point APWTP2 showed clay with gravel on bedrock at c.13m OD. Near Quy Waters at the top of the slope, point APWTP1 showed bedrock Chalk at c.14m OD, but point APWa showed 1m of gravel and sand on bedrock Chalk at c.12.5m OD.

**8.5.4.16 Geological Section 45/55.15**

This 4km-long section (Figure 8.5.4-15) runs roughly southwest-northeast from Netherhall Farm (point 45NE70) to Cherry Hinton (point ea32). Near Worts Causeway, point 45NE70 shows bedrock Chalk close to the surface beneath topsoil at c.21m OD and at Netherhall Farm, point 205/19 shows bedrock Chalk near the surface at c.18m OD. Likewise, to the northeast at Lime Kiln Hill, point 205/536 shows Chalk at the surface at c.21m OD, and point 45NE61 shows bedrock Chalk close to the surface at c.16.5m OD. At Cherry Hinton, points BH108 to BH101 also record Chalk near the surface, but points BH40 and ea36 show 1m of silty clay on bedrock at 12-12.5m OD. Point ea38 shows 3m
of Made Ground over bedrock Chalk, but silty clay is again recorded over Chalk at point ea35. Point ea37 shows Chalk bedrock near the surface at c.14m OD, but point ea39 shows sandy clay over 1m of silty clay on bedrock at c.11.5m OD. Points ea34 and ea32 also show 1m of silty clay on bedrock, although point ea33 shows Chalk near the surface at c.13.5m OD. It seems likely that these carbonate-rich silty clay deposits may be tufaceous in origin, since they occur adjacent to the outcrop of the Totternhoe Stone in the Lower Chalk, which commonly gives rise to spring and seepage lines.

8.5.4.17 Geological Section 45/55.16

This 4.5km-long section (Figure 8.5.4-16) runs roughly north-south from the A14 Road (point b5200) to Cherry Hinton (point BH111). Near the A14 Road, points b5200 to b5201a record 2m of sandy clay on bedrock Chalk at 6-7m OD, and point b5204 shows sandy clay over gravel and sand. Near Quy Waters, point APWa showed 1m of gravel and sand on bedrock Chalk at c.12.5m OD, but point APWTP1 showed bedrock Chalk at c.14m OD. Point APWTP2 showed clay with gravel on bedrock at c.13m OD, and downslope points APWc and APWb showed topsoil over clay with gravel and bedrock at c.11m OD. Point APWTP3 showed bedrock Chalk close to the surface at c.10m OD, and point APWTP4 recorded 1.5m of sandy clay. Near Airport Way Teversham, point APWTP5 shows bedrock Chalk at c.9.5m OD, and point 188/109 records bedrock close to the surface beneath topsoil at c.10m OD. To the south at Cherry Hinton, points ea28 to ea36 show 1m of silty clay on bedrock at 12-13m OD. Point ea38 shows 3m of Made Ground over bedrock Chalk, and bedrock Chalk is recorded near the surface at points 205/168 and BH103. Point BH40 shows 1m of silty clay on bedrock at c.13m OD, and points BH107 and BH110 show bedrock chalk close to the surface at 15-16m OD. On Fulbourn Road, point BH111 shows topsoil over 0.5m of silty clay on bedrock chalk at c.18m OD.

8.5.4.18 Geological Section 45/55.17

This 5.5km-long section (Figure 8.5.4-17) runs roughly northwest-southeast from New Chesterton (point CD110/1) through Newmarket Road and Coldham’s Common to Fulbourn Hospital (point 205/29). Near Green’s Road, New Chesterton, point CD110/1 shows 2m of gravel and sand with a base not reaching bedrock at c.9.5m OD. On Victoria Road, point c11 records Made Ground over 1m of gravel and sand overlying 2m of silty clay, in turn overlying 1m of gravel and sand on bedrock Gault Clay at c.7m OD. Some of the points in this section were collected using vibrocoring equipment, and these records only the thickness of drift deposits and the elevation of the bedrock surface. Point ch672 shows 7m of unknown drift deposits on bedrock at c.6m OD, and point c10 shows Made
Ground over 3m of gravel and sand overlying 4m of silty clay on bedrock at c.4m OD. Close by, point ch63 shows 3m of gravel and sand overlying 7m of silty clay on bedrock at c.0.5m OD. Points ch464 and ch462 show 8.5m of unknown drift deposits on bedrock at c.3m OD, and point c9a records Made Ground over 2m of silty clay overlying 2m of gravel and sand on bedrock at c.6.5m OD. It is clear that these data show the presence of a steep-sided bedrock channel-form beneath the surface of the 3rd Terrace mapped by the BGS. At point ch461, 6m of unknown drift rests on bedrock at c.5m OD, but nearby point a10 shows Made Ground over 6m of gravel and sand overlying 7m of silty clay with a base not reaching bedrock at c.-4.5m OD. Similarly, point ch5 records 7.5m of gravel and sand overlying 6m of silty clay with a base not touching bedrock at a comparable elevation.

Near Chesterton Road, point m1a shows Made Ground over gravel overlying 1m of silty clay, in turn overlying 10m of gravel and sand, over 2m of silty clay with a base not reaching bedrock at c.-7m OD. Point b7 shows Made Ground over 1.5m of silty clay overlying 5.5m of gravel and sand, and point tunnel(e) records 11m of unknown drift on bedrock at c.-3m OD. Point CNIS7 shows Made Ground over 1.5m of silty clay overlying 6m of gravel and sand, and point rsa13 shows Made Ground over 5m of gravel and sand on bedrock at c.2m OD. Nearby, point rsa6 shows Made Ground over 3.5m of gravel and sand on bedrock at c.3m OD, and point rsa8 records Made Ground over 1m of gravel and sand on bedrock at c.5m OD.

The lateral continuation of this north-south trending buried channel beneath the current floodplain of the River Cam can be plainly seen at point GE2 near Victoria Bridge on Jesus Green where 3m of Flandrian silty clay and 1m of peat, overlies 6m of gravel and sand, which in turn crucially overlies 1m of clay with gravel and 3m of silty clay with a base not reaching bedrock at c.-9m OD. On Midsummer Common, points GE1 records 3.5m of silty clay overlying 1m of peat, in turn overlying 2m of gravel and sand on bedrock at c.-2m OD. Close by at point FSGCB1, 2m of Made Ground overlies 3m of peat and clay with peat, in turn overlying 5m of gravel and sand on bedrock at c.-5m OD, and at point FSGCB2 Made Ground overlies 7m of gravel and sand on bedrock at c.-3m OD. Near Elizabeth Way Bridge, point e27e records Made Ground over 3m of silty clay overlying 4m of gravel and sand on bedrock at c.-3.5m OD, and point LGA5 shows clay with gravel over 3m of peat overlying 4m of gravel and sand on bedrock at a similar elevation. Close by, point CheB1 shows Made Ground over 5.5m of peat and clay with peat overlying 2.5m of gravel and sand on bedrock at c.-3m OD, and point 1(a2) shows 7m of unknown drift deposits on bedrock at c.-2m OD. Point a1 shows silty clay overlying 3m of peat, in turn overlying 4m of gravel and sand on bedrock at c.-2m OD, and point g7 records 4m of silty clay over peat overlying 2m of gravel and sand on bedrock at a comparable elevation.
Point g9 shows 2.5m of silty clay overlying 2m of gravel and sand on bedrock at c.-1m OD, and point c22 shows Made Ground over 3m of clay with peat overlying 3m of gravel and sand on bedrock at c.-3m OD. In contrast at Riverside, point RLB1 records 2m of Made Ground resting directly on bedrock Gault Clay at c.5m OD.

At the crest of a sharp slope, the River Lane development site (formerly Cambridge Gas Works) occupies an area of 3rd Terrace Deposits mapped along Newmarket Road. Points RDCB to RLDX show Made Ground over gravel and sand 2.5m thick on bedrock Gault Clay at 8-9m OD. Points RLDS to RLDDD show extensive areas of Made Ground 7m thick. Point AFH on Newmarket Road shows Made Ground over bedrock Chalk at c.10.5m OD, and at Coral Park Trading Estate, Barnwell, points CD36/2 to e34 record bedrock Chalk near the surface beneath topsoil at 9-10.5m OD. On Coldham’s Common, points 45NE33 to 45NE32 show bedrock Chalk close to the surface beneath topsoil at c.8.5m OD. To the southeast at Cherry Hinton, point ea19 records 2m of silty clay on bedrock at c.10m OD, and points ea36 to ea35 show silty clay 1.5m thick on bedrock at 12-13m OD. It is proposed that the silty clay here is formally named the Fulbourn Hospital Silty Clay with a stratotype at point ea19 (TL 4937 5692). Point ea37 shows bedrock Chalk close to the surface at c.13.5m OD, and point ea39 records 1m of sandy clay over 1m of silty clay on bedrock at c.11.5m OD. Points 205/168 and BH103 show bedrock Chalk close to the surface at c.14m OD, and point BH40 shows 1m of silty clay on bedrock at c.12.5m OD. Point BH104 shows bedrock Chalk close to the surface at c.13.5m OD, and at Fulbourn Hospital, point 205/29 shows Chalk close to the surface at c.19.5m OD.

8.5.4.19 Geological Section 45/55.18

This 5km-long section (Figure 8.5.4-18) runs roughly north-south from Chesterton High Street (CD115/3) through the Grafton Centre and Cambridge Railway Station to Homerton College and Sedley Taylor Road (SedT). Point CD115/3 shows 2m of gravel and sand on bedrock Gault Clay at c.6m OD, and point 914 shows 4.5m of unknown drift on bedrock at c.4m OD. Close by, point b9 shows Made Ground over 2m of gravel and sand on bedrock at c.4m OD, and point 913 and 915 record 6m of unknown drift on bedrock at 2m OD and 3m OD respectively. Point ch1 shows 3m of gravel and sand on bedrock at c.4.5m OD. To the south, the geology across the floodplain of the River Cam has been projected onto this section from elsewhere. South of the River Cam on Midsummer Common, points B22 to B19 show 4m of Made Ground on bedrock at 2-3m OD. On the abrupt slope marking the edge of the floodplain, point Pars’ A’ records silty clay over gravel and sand, and on Parsonage Street point e35 shows Made Ground over 3m of gravel and sand on bedrock at c.8.5m OD. On Maid’s Causeway, point CD35/4
shows 1.5m of gravel and sand overlying 3m of silty clay on bedrock at c.8m OD. In contrast, point Sewer’Ci’ shows 2m of Made Ground over gravel on bedrock at c.10m OD. To the south at Fitzroy Street near the Grafton Centre, point KLP2 shows Made Ground over 1m of silty clay on bedrock at c.11m OD, and points CWC’A’ to CWC’D’ shows Made Ground over gravel and bedrock at c.11.5m OD.

Near Brandon Place, point Holst28 records Made Ground over 1m of silty clay overlying 1m of gravel on bedrock at c.10.5m OD, and on Prospect Row, point Holst29 shows Made Ground over silty clay on gravel and sand. On East Road, point Holst19 shows a similar sequence with 1m of silty clay overlying 2m of gravel and sand with a base not reaching bedrock at c.10m OD, and point Forbl at the junction of Mill Road and East Road records 2m of gravel and sand. On the northeast corner of Parker’s Piece, point Holst18 shows 1.5m of silty clay overlying 3m of gravel and sand on bedrock Gault Clay at c.8m OD, and close by point PP1 shows Made Ground over 1.5m of sandy clay overlying gravel on bedrock at a similar elevation. At the site of Parkside Pool, points Donk5 to PSP4i show gravel and sand 2m thick with interbedded silty clay 1m thick, resting on bedrock at 10-12m OD. The bedrock at this location showed the junction of the Lower Chalk with the Gault Clay, including a band of Cambridge Greensand. To the south at Fenner’s Sport Ground, points HRATP1 to HRATP3 show 2m of silty clay on bedrock Gault Clay at c.10.5m OD. Near Tenison Road, points TenRd and ORS-A show Made Ground over gravel and sand, but point ORS-C records 1m of silty clay overlying gravel and sand with a base not reaching bedrock at c.13m OD. Near Cambridge Railway Station, point 188/81 shows 6m of unknown drift deposits on bedrock Gault Clay at c.10.5m OD, point 45NE69 records 4m of gravel and sand on bedrock Chalk at c.11m OD. Further south, point 205/539 shows 4m of unknown drift deposits on bedrock at c.11m OD, and near Hills Road point 45NE27 shows Made Ground on sandy clay overlying 2.5m of gravel and sand, in turn overlying silty clay on bedrock at a comparable height. Near Cherry Hinton Road, point SW94/2 records 3m of gravel and sand, and at Homerton College, points SIC12 to SIC4 show 3m of gravel and sand on bedrock at c.13m OD. Close by, points HCT10 to HCT17 show silty clay over lying gravel and sand, and 1m of gravel and sand with a base not touching bedrock at c.14m OD is recorded at Sedley Taylor Road (point SedT).

8.6 Site Descriptions 5km Square TL 245/55

8.6.1 Swan’s Pit, Milton Road

8.6.1.1 Introduction
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The gravel pits in 2nd Terrace Deposits at the junction of Milton Road and Victoria Road at New Chesterton, were first described by Reed (1897). The excavations opened in 'sandy brick-earth' and gravel were quite extensive and stretched for 500m northeast along the northern edge of Milton Road. Rastall (1913) also described the locality and recorded its name as Swan’s Pit. The pit was also known to Marr (1917, 1920), and Worssam and Taylor (1969) were still able to observe the 2m high banks of the old pit. Later development on the site included Cambridge City Football Ground. Worssam and Taylor (1969) appear uncertain about the exact location of individual pits at this site, but the author will treat this complex of pits as a single locality; point CD115/3i (Figure 8.5.4-1).

Although the stratigraphy at this point appears deceptively simple, it is clear that a complex of deep buried bedrock channel-forms aligned north-south run through the area of the former Swan’s Pit. The stratigraphic confusion in the area around the eastern end of Victoria Road is further highlighted in Section 8.5.4.18 (Figure 8.5.4-17) where nested channels seem to cut into each other. It appears that there might at least be two sedimentary couplets distinguishable in this area; an upper gravel and silty clay, and a lower gravel and silty clay confined to the buried channels.
8.6.1.2 Environments of deposition

The upper gravels worked at Swan’s pit probably represent deposition by a braided stream under cold conditions. The vertebrate evidence from this deposit certainly suggests cool or cold open grassland conditions. Marr (1920) observed that deposits in this area formed ‘an extensive alluvial tract’ and thought that some material might be of lacustrine origin. He was presumably referring to the buff loam containing *Corbicula* exposed in the base of the pit. Since *Corbicula* requires flowing water habitats and temperate conditions, it appears that this fluvial deposit may represent channel accretion or possibly overbank fines.

8.6.1.3 Pollen

The author attempted pollen analysis from a sample of silty clay from the site preserved in the Sedgwick Museum (Appendix 4). The pollen assemblage yielded a relatively low concentration of palynomorphs dominated by Poaceae (grass), but with *Betula* (birch) (27%), and *Corylus* (hazel) (20%) and herbs. This clearly thermophilous signal might be correlated with beginning of an interglacial period (Substage II).

8.6.1.4 Molluscs

The occurrence of *Corbicula fluminalis* in buff sandy loams at the base of Swan’s Pit suggest that these deposits were laid down in temperate, rather than the cool or cold conditions suggested by the vertebrate remains. It is interesting to note that *Corbicula* was recorded from Histon Road at a similar elevation by (Hollingworth et al., 1950). The absence of other evidence from the site makes further interpretation difficult. At many sites, the occurrence of *Corbicula fluminalis* and absence of *Belgrandia marginata* has been correlated with MIS 7 (Keen, 1990, 2001 and Preece, 1995). Prof. McKenny-Hughes also noted the thermophilous bivalve *Unio littoralis* from Swan’s Pit.

8.6.1.5 Vertebrates

Worssam and Taylor (1969) include Reed’s (1897) list of vertebrate remains from this site including bones of *Megaceros giganteus* (giant deer) and teeth of *Mammuthus primigenius* (mammoth), *Coelodonta antiquitatis* (woolly rhinoceros) and *Equus ferus* (horse). Taken together, this fauna suggests cool or cold open grassland conditions, and resembles the *Mammuthus trogontherii-primigenius/Equus ferus* fauna correlated with MIS 7 (Stuart 1982, Sutcliffe 1995). Teeth of *Hippopotamus amphibius* are also reported from the site, and although Marr (1920) records that its occurrence was mentioned by Prof. McKenny-Hughes to F. R. C. Reed, no specimen has been located. Obviously, the
juxtaposition of a thermophilous creature like hippopotamus with a generally cool fauna is problematic, although the presence in the same pit of sediments deposited under warmer conditions, indicated by the presence of *Corbicula*, perhaps helps the case. The coexistence of *Corbicula* and hippopotamus creates its own biostratigraphic difficulties, and if taken at face value would indicate a ‘Cromerian’ age! It is of course possible that hippopotamus remains were reworked from earlier deposits nearby, or occupied a separate channel higher in the sequence. Bridgland and Schreve (2001) correlate this site with MIS 7 on the basis of the vertebrate fauna and presence of *Corbicula*.

### 8.6.1.6 Dating

Amino acid racemization analyses for *Arianta arbustorum* from the silty clay unit at Swan’s Pit gave a D/L ratios of 0.194 (Appendix 5). This equates to an age in the middle of the ‘Wolstonian’ interval (MIS 7/8). Attention must be drawn to the fact that this is only a single value, and that a range of D/L ratios have been obtained from well-preserved shells from assemblages at other sites. This date does appear to correlate well with molluscan and vertebrate evidence.

### 8.6.1.7 Conclusions

The absence of detailed historical descriptions of the sections hampers correlation and introduces a large degree of uncertainty about the provenance of mollusc and vertebrate remains. Marr (1920) is at least some help in this respect, observing that the ‘rich mammalian fauna’ came chiefly from the beds in the upper parts of the pit, whereas shells of *Corbicula* came from the buff coloured loams not often exposed at the base of the pit. It is tempting to refer these observations to the upper gravel and silty clay couplet. It is clear that the upper gravels exposed in the pit were deposited in a cool or cold climate, and that the underlying silty clay loams were laid down under less energetic and more temperate conditions. Certainly pollen analysis of shelly sediment from the Sedgwick Museum, confirms the temperate aspect of the vegetation. The vertebrate and molluscan biostratigraphic evidence points to a correlation with MIS 7, and this interpretation is supported by the amino acid racemization analyses for *Arianta* which gave an age in the middle of the ‘Wolstonian’ (MIS 7/8) interval.

### 8.6.2 Barnwell Abbey

#### 8.6.2.1 Introduction

The gravel pits in 3rd Terrace Deposits at the Barnwell Abbey site originally extended for some 400m west-east along the south side of the River Cam between Walnut Tree Avenue (now Elizabeth Way) and Ferry Lane (now River Lane). Descriptions of the various sections, and lists of plants, vertebrates and molluscs are given by Brodie (1844), Seeley
(1866), Jukes-Browne (1878), Penning and Jukes-Browne (1881), McKenny-Hughes (1916), Mrs McKenny-Hughes (1888), and Marr (1920, 1922). The gravel in these pits appears to have been 2.5m to 6m thick, resting on bedrock Gault Clay to the north near the river, and banked against a ridge of Lower Chalk to the south near Newmarket Road. Seeley (1866) described ‘pipes’ and ‘walls’ extending through the full thickness of the gravel, which are strongly reminiscent of frost cracks and ice wedge development, and sections figured by Mrs McKenny-Hughes (1888) and Prof. McKenny-Hughes (1916) show involutions 1m below the ground surface. Seeley (1866) also noted that the remains of plants, vertebrates and molluscs all came from a single silty marl bed 1m-thick above gravel near the base of the pit. In contrast, Mrs McKenny-Hughes observed that molluscs including *Corbicula* were distributed sporadically within lenticular masses and pockets throughout the section. This is clearly at odds with Marr (1920) who believed that *Corbicula* came only from the basal silty beds that were infrequently exposed. Worssam and Taylor (1969) suggest that Mrs McKenny-Hughes may have over-emphasised the variability of the deposits, and point to her apparently erroneous correlation of this site with deposits from Barnwell Station. Despite the apparent complexity, the author will treat this pit as a single locality; point BWA (Section 8.5.4.11 & Figure 8.5.4-10).

8.6.2.2 Environments of deposition

There is some evidence that the lowest gravels in the Barnwell Abbey pit represent deposition by a braided stream under cold conditions. Deposition in pools and abandoned channels on the braidplain surface probably account for marly deposits containing *Chara* and willow leaves. The overlying silty clays with shells probably represent deposition of overbank fines or possibly channel accretion in temperate conditions. The overlying gravel is thought to have been deposited by a braided stream under cold conditions, but has been cryoturbated during a period of subaerial exposure.

8.6.2.3 Pollen and Plant macrofossils

The author analysed five samples of silty clay from sediment blocks preserved in the Sedgwick Museum (Appendix 4). Three of these were barren, but the remaining two yielded relatively low concentrations of palynomorphs, dominated by Poaceae (grass), but with *Pinus* (pine) (7-25%) and herbs. These analyses suggest a grassy floodplain environment with scattered pine trees under a pre-temperate cool to cold climate. Mrs McKenny-Hughes (1888) recorded spores and stems of the alga *Chara* from a bed near the base of the gravel, and from the same location, Clement Reid identified twigs and leaves of *Salix* (*cf.* repens). The creeping willow is a low growing boreal shrub capable of tolerating
relatively harsh conditions, and it seems that a cool or cold climate may have existed during the deposition of the lowest beds in the pit.

8.6.2.4 Molluscs

Worssam and Taylor (1969) provide a list of molluscs from Barnwell Abbey, which agrees with Sparks (1964) aggregated data from Grantchester (see Section 8.3.5), Barnwell Abbey and Trumpington Railway Cutting (see Section 8.9.1), and is broadly similar to those made by Mrs McKenny-Hughes (1888), and by Kennard and Woodward in Marr (1920). It includes specimens from collections made by Prof. McKenny Hughes, Rev. E. S. Dewick, B. B. Woodward and A. G. Davis. The interglacial nature of the assemblage is clear, with *Azeca menkeana*, *Ena montana*, and *Clausilia bidentata* indicating woodland habitats in warm, and perhaps continental conditions. Marshland and open ground taxa are present, but are dominated by freshwater molluscs characteristic of moving water environments, but with some indicating marshland and pools. Both warmth-loving *Belgrandia marginata* and *Corbicula fluminalis* are recorded from these deposits, and this combination has been taken as a biostratigraphic indicator of an age older than the Ipswichian (MIS 5e) or MIS 7 (Keen, 1990, 2001 and Preece, 1995). The possibility that these taxa occur together as a result of reworking cannot be discounted. In contrast, Sparks (1964) firmly believed that this mollusc assemblage represented the last interglacial, and that similar deposits at Grantchester, and Trumpington were ‘so obviously in the same terrace as the Histon Road deposit and so near each other that there can be little doubt that they belong to the same period’. It should perhaps be noted that neither *Corbicula* or *Belgrandia* have been found at Grantchester (see Section 8.3.5).

8.6.2.5 Vertebrates

Worssam and Taylor (1969) give a list of vertebrate remains from Barnwell Abbey including *Bos primigenius* (aurochs), *Bison priscus* (bison), *Coelodonta antiquitatis* (woolly rhinoceros), *Equus ferus* (horse), and *Palaeoloxodon antiquus* (forest elephant). The list from Mrs McKenny-Hughes (1888) adds *Megaloceros giganteus* (giant deer), *Cervus elephas* (red deer), *Rangifer [Cervus] tarandus* (reindeer), *Mammuthus primigenius* (mammoth), *Panthera leo* (lion), *Crocuta crocuta* (spotted hyena), *Hippopotamus amphibius* (hippopotamus), *Ursus arctos* (brown bear), *Meles meles* (badger), and *Arvicola* sp. (a vole).

The vertebrates from Barnwell Abbey appear to represent an eclectic mixture of both temperate and cold adapted taxa. The faunal assemblage of *Hippopotamus amphibius*, *Palaeoloxodon antiquus*, *Cervus elaphus*, and *Ursus arctos* (brown bear) are the main elements of the ‘hippopotamus fauna’ associated with the Ipswichian (MIS 5e) (Stuart
1982, Sutcliffe 1995). Conversely, the *Mammuthus trogontherii-primigenius/Equus ferus* fauna is correlated with MIS 7. It appears that the assemblage at Barnwell Abbey contains both of these elements.

Temperate woodland habitats are indicated by the presence of *Cervus elephas* (red deer), *Meles meles* (badger) and *Palaeoloxodon antiquus* (straight-tusked elephant), while taxa such as *Crocuta crocuta* (spotted hyena), *Panthera leo* (lion), *Bos primigenius* (aurochs), *Bison priscus* (bison) and *Megaloceros giganteus* (giant deer) are thought to prefer grassland areas. Evidence of temperate riparian and aquatic habitats is provided by the presence of *Hippopotamus amphibius* (hippopotamus). Cool or cold grassland habitats are suggested by *Mammuthus primigenius* (mammoth), *Coelodonta antiquitatis* (woolly rhinoceros), *Equus ferus* (horse), and *Rangifer [Cervus] tarandus* (reindeer). From the vertebrate evidence it seems that the deposits at Barnwell Abbey represent at least one temperate and one cool episode, and although it is impossible to determine the exact stratigraphic provenance of each fauna, it seems likely that the 'hippopotamus fauna' was associated with the silty clays containing temperate molluscs. An added complication of this explanation is the apparent co-existence of *Corbicula* and hippopotamus, which causes biostratigraphic problems. Bridgland and Schreve (2001) correlated these deposits with MIS 9 on the basis of the vertebrate assemblage and the presence of *Corbicula*.

### 8.6.2.6 Dating

Amino acid racemization analyses for *Bithynia tentaculata* and *Valvata piscinalis* shells from the silty clay unit at point BWA gave D/L ratios of 0.130, 0.149, 0.171, 0.177, 0.189, 0.214, 0.216 and 0.217 (Appendix 5). The lowest of these ratios equate to an Ipswichian (MIS 5e) age, whilst the remainder indicate ages in the middle (MIS 7/8) and early (MIS 8/9) parts of the ‘Wolstonian’ interval. This mixed amino acid signal means that a minimum age estimate for the last phase of deposition based on the lowest D/L ratios is the Ipswichian (MIS 5e). The apparent age distribution of these well-preserved shells suggests either major reworking of older ‘Wolstonian’ deposits from local sources, or a mixture of stratigraphic horizons preserved at a single site.

### 8.6.2.7 Conclusions

Although there is a clear stratigraphic sequence at this site, the exact relationship between this and most of the vertebrate and molluscan remains is unclear. At least one warm and one cool episode are indicated by the vertebrate data, and the lowest gravel unit is thought to have been laid down under cool conditions. Superficial similarities between the temperate vertebrate fauna here, and that correlated with the Ipswichian (MIS 5e) at Cardo’s Pit, Barrington (Section 10.3.1) are striking, although the fauna at Grantchester
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(Section 8.3.5) also has a mixed signal. Other biostratigraphic tools are also confounded, with hippopotamus, *Corbicula* and *Belgrandia* all apparently occurring from the same strata. In contrast, Sparks (1964) firmly believed that the mollusc assemblage here represented the last interglacial. Amino acid racemization analyses for *Bithynia* and *Valvata* shells gave an Ipswichian (MIS 5e) age for the last deposition event, but indicated strong elements from both the later (MIS 7/8) and early (MIS 8/9) parts of the ‘Wolstonian’ interval. The chimeric signal from molluscan and vertebrate faunas at this site, only serves to emphasise the complex and possibly reworked nature of the sediments.

### 8.6.3 Downing Site

#### 8.6.3.1 Introduction

Marr (1920) described a section (point DStrench) exposed in military trenches dug during the First World War, and also a log from a well (point DSWELL) which he had sunk nearby to re-expose the deposits (Section 8.5.4.11 & Figure 8.5.4-10). The two exposures were rather similar, and the latter showed 5m of gravel and sand with beds of silty clay loam, contorted at the top and resting on bedrock Gault Clay.

#### 8.6.3.2 Environments of deposition

The gravels of the Downing Site probably represent deposition by a braided stream in a grassland environment under cool or cold conditions. Sedimentation in pools and marshy abandoned channels on the braidplain surface probably account for silty deposits containing mollusc remains. The upper part of the gravels here, have been cryoturbated during a period of subaerial exposure.

#### 8.6.3.4 Pollen

The author analysed two samples of silty marl from a borehole at the Downing Site Garage (point G.gar) (Appendix 4). One sample at 130cm depth yielded relatively low concentrations of palynomorphs, dominated by Poaceae (grass), with herbs, and the second at 90cm depth gave a similar assemblage but with low frequencies of *Salix* (willow) and *Corylus* (hazel). These analyses suggest a grassy floodplain environment with scattered scrub in favourable locations under a cool climate.

#### 8.6.3.3 Molluscs

A restricted assemblage was obtained by Marr from two silt bands exposed in the military trench sections. This included species of grassland (particularly *Pupilla muscorum*), marshes, floodplains, and a number of aquatic taxa suggesting flowing water. A single valve of *Corbicula fluminalis* was also discovered, and on this basis the lower silt band was correlated with the deposits containing *Corbicula* at Barnwell Abbey (Marr
Analysis of the upper silt band exposed in the well log gave a similar signal dominated by grassland taxa. It seems certain that the valve of *Corbicula* from this location was re-worked from nearby deposits, given the generally cool aspect of the remaining taxa.

### 8.6.3.4 Conclusions

The occurrence of a single valve of *Corbicula fluminalis* within the loam at this site was used by Marr to correlate these deposits with those at Barnwell Abbey. From a modern perspective, this seems a rather unwise judgement, and correlation with the deposits at Sidgwick Avenue (see Section 8.3.4) dating to within the Middle Devensian (MIS 3) seems more likely. It should be noted that Bridgland and Schreve (2001) correlate this site with MIS 7, presumably on the ‘presence’ of the single *Corbicula* valve.

### 8.6.4 Rodney Brewery

#### 8.6.4.1 Synopsis

Prof. McKenny-Hughes (1916) described a 4m section in gravel from the Rodney Brewery, East Road, (point CD109/2) exposed in 1908 (Section 8.5.4.10 & Figure 8.5.4-9). Near the top of the gravel, he observed a sandy loam unit with shells, overlain by a gravel bed interrupted by structures that might today be interpreted as frost cracks. Kennard and Woodward in Marr (1920) list molluscs obtained from the silty clay unit at this site. These include *Ena montana* indicating temperate woodland, taxa of grassland and marshes, and freshwater molluscs characteristic of moving water environments. In addition, *Corbicula fluminalis* was recorded from these deposits, and its presence without *Belgrandia marginata* has been taken as a biostratigraphic indicator of a date older than the Ipswichian (MIS 5e) (Keen, 1990, 2001 and Preece, 1995). Kennard and Woodward clearly believed this mollusc assemblage to be a subset of that known from the nearby Barnwell Abbey pit, and confidently correlate the two sites.

Amino acid racemization analyses for *Bithynia tentaculata* shells from the silty clay unit at point CD109/2 taken from the Sedgwick Museum gave D/L ratios of 0.105, 0.167, 0.181 and 0.184 (Appendix 5). The lowest of these ratios equate to an Ipswichian (MIS 5e) age, whilst the remainder indicate an age in the later part of the ‘Wolstonian’ interval (MIS 7/8). This mixed amino acid signal means that a minimum age estimate for the last phase of deposition based on the lowest D/L ratios is the Ipswichian (MIS 5e). The mixed age distribution of these well-preserved shells is comparable to that observed from Barnwell Abbey and suggests either reworking of older deposits from the later part of the ‘Wolstonian’ interval, or a mixture of different aged deposits at a single site.
8.6.5 Sedley Taylor Road

8.6.5.1 Synopsis

Marr and King (1928) reported deposits thrown up from a sewer trench (point SedT) in Sedley Taylor Road, near the site of an Agricultural Show, on what is mapped as a patch of 3rd Terrace Deposits. The material from the site is described as a ‘gravelly loam with much chalky material’ containing mollusc shells. However, Kennard and Woodward’s report in Marr and King (1928) gives only two taxa; *Pupilla muscorum* and *Oxyloma [Succinea] pfeifferi*, from this site. The former is taken to represent grassland and the latter to indicate marshland conditions, on or close to a river braidplain. Unfortunately, very little can be said about the age of these deposits from such limited data.

8.6.6 Botanic Gardens

8.6.6.1 Introduction

Marr (1926) described a 3m high section through gravels and loams of the 2nd Terrace from a pit at the western edge of the Botanic Gardens exposed in 1922. The section (points BotGdn, SW93/2 and SW93/3) showed interbedded gravels and loams containing shells and plant remains overlain by bedded gravel to the west, and apparently truncated by a unit of sandy loam to the east. This unit was reported to have yielded molluscan and vertebrate remains, including an astragalus of hippopotamus reported by Marr (1920).

8.6.6.2 Environments of deposition

The deposits at the Botanic Garden probably represent deposition by a braided stream in a grassland environment under cool or cold conditions. Deposition in pools and marshy abandoned channels on the braidplain surface probably explain the lower interbedded silt and gravel deposits containing plant and mollusc remains, whilst overbank sedimentation probably accounts for the overlying sandy loam.

8.6.6.3 Plant macrofossils

Marr (1926) states that a ‘chocolate-coloured laminated bed’ yielding shells from the lower interbedded silt and gravel deposits was analysed for plant remains by M. E. J. Chandler. Unfortunately, only a single nutlet of *Carex* (sedge) was recovered from this deposit.

8.6.6.4 Molluscs

Kennard and Woodward in Marr (1926) report a list of molluscs from the Botanic Garden Pit, presumably from the upper sandy loam, although their provenance is not categorically stated. This includes a majority of freshwater molluscs characteristic of
moving water environments, although some indicate pools, marshes and grassland. There is little in the assemblage to indicate warm conditions, although Kennard and Woodward tentatively correlate this deposit with that at Barnwell Abbey.

**8.6.6.5 Vertebrates**

Marr (1926) recorded vertebrate remains recovered from pits at the Botanic Gardens. The mammals represented include *Equus ferus* (horse), *Bos primigenius* (aurochs) or *Bison priscus* (bison), *Cervus* sp. (deer), and *Hippopotamus amphibius* (hippopotamus). It is difficult to interpret such a limited assemblage, although there are clearly taxa here that favour grassland habitats. It is entirely possible that the *Hippopotamus* astragalus could have been reworked from earlier deposits, or taken from a different unit to the other specimens. Bridgland and Schreve (2001) assign these deposits to MIS 5e on the basis of *Hippopotamus* and the absence of *Corbicula*.

**8.6.6.6 Dating**

Amino acid racemization analyses for *Valvata piscinalis* shells from the upper sandy clay unit at the Botanic Garden Pit gave D/L ratios of 0.144 and 0.158 (Appendix 5). These ratios equate to an age in the later part of the ‘Wolstonian’ interval (MIS 6/7). It is worth noting that only two analyses were undertaken, and that this might be insufficient to detect the variation in D/L ratios observed at other sites.

**8.6.6.7 Conclusions**

Kennard and Woodward in Marr (1926) tentatively correlated the Botanic Garden deposit with that at Barnwell Abbey on the basis of the molluscan assemblage, even though no truly temperate taxa were represented. Bridgland and Schreve (2001) suggested a correlation with the Ipswichian (MIS 5e), on the basis on the presence of *Hippopotamus*. On balance, the evidence suggests deposition in cool or cold conditions, and the position of these sediments in the 2nd Terrace shows an obvious similarity with the deposits at Sidgwick Avenue (see Section 8.3.4) thought to date from the Middle Devensian (MIS 3). Amino acid racemization analyses for *Valvata* shells gave an age in the later part of the ‘Wolstonian’ (MIS 6/7) interval; an interpretation also compatible with the limited floral and faunal evidence. The presence of reworked *Hippopotamus* (MIS 5e) and reworked *Valvata* (MIS 6/7) would tend to suggest a Devensian age for these deposits, although the lack of evidence limits the depth of discussion.
8.6.7 Barnwell Station

8.6.7.1 Introduction

Mrs McKenny-Hughes (1888) first described the brick pit at Barnwell Station (points BSE to BSSE), which exposed 4m of gravel and loam with plant remains channelled into bedrock Gault Clay and Chalk (Figure 8.5.4-8). The deposits yielded both molluscs and vertebrate remains. Mrs McKenny-Hughes correlated the deposits at this site with those at Barnwell Abbey a kilometre to the southwest. The confusion is to some extent understandable in that both sites showed superficially similar sections through the gravel capped ridge on the southeast bank of the River Cam. It is only with the benefit of greater stratigraphic knowledge and radiocarbon dating that Worssam and Taylor (1969) suggested that Mrs McKenny-Hughes was mistaken. Amino acid racemization analyses for Valvata shells surprisingly gave an age within the later part of the ‘Wolstonian’ interval (MIS 6/7) for these deposits. This may be result of a mistake during curation, or it may show that older deposits are also present at the site, partially confirming Mrs McKenny-Hughes correlation with Barnwell Abbey. It might also indicate significant reworking of older shells in the Late Devensian.

Marr and Gardner (1916) visited an enlarged pit and described new sections, recording plant, mollusc and vertebrate remains indicative of a cool climate. Analysis of the plant macrofossils was carried out by Clement Reid, and Kennard and Woodward listed the molluscs (both in Marr 1920). Chandler (1921) described further sections at the site, and made a detailed study of the plant macrofossils, and Coope (1968) identified beetle remains indicating an arctic environment. Plant material from the site was dated to 19,500 ±650 BP by radiocarbon dating (Godwin and Willis, 1964), and Bell and Dickson (1971) reappraised the identifications of Chandler (1921).

8.6.7.2 Environments of deposition

The deposits exposed at Barnwell Station probably represent deposition by a braided stream in a grassland environment under cold conditions. Overbank deposition, and sedimentation within inactive channels and marshy pools on the braidplain surface are likely to account for the silt beds containing plant and mollusc remains.

8.6.7.3 Plant macrofossils

Clement Reid began analysis of the plant remains from the site, but died before he could complete the task. Further detailed analysis was carried out by Chandler (1921) on Reid’s specimens. He identified different categories of plants such as the ‘arctic-alpine’ group
including *Betula nana* (dwarf birch), various species of *Salix* (willow), and various tundra species, plants with a wide distribution in wetlands, marshes and meadows, plants with a southern distribution including *Naias marina* and *Carpinus betulus* (hornbeam), chalk-loving plants, and a small number of halophiles. This latter 'estuarine' group probably reflects local soil conditions, rather than the proximity of the tidal limit at this time. The presence of the temperate woodland tree hornbeam seems out of place in this assemblage, and the author believes that several of the southern taxa may be reworked from nearby interglacial deposits. The similarity of this arctic flora to others known at that time from such diverse sites as the Lea Valley and Hoxne is also discussed by Chandler (1921). It is perhaps not surprising that the floral list also superficially resembles that from the site at Sidgwick Avenue (Lambert, Pearson and Sparks (1962). Bell and Dickson (1971) reappraised the identifications made by Chandler, 1921), and although various non-British taxa were removed from the assemblage, others replaced them.

### 8.6.7.4 Molluscs

The lists produced by Mrs McKenny-Hughes (1888) and Marr (1920) are not substantially different from each other and comprise taxa of moving water environments, floodplains, marshes and grassland. There are no thermophilous elements represented in the assemblages, and it seems likely that they indicate cool or cold conditions.

### 8.6.7.5 Vertebrates

Mrs McKenny-Hughes (1888) recorded vertebrate remains from the deposits at Barnwell Station, and lists *Cervus elaphus* (red deer), *Mammuthus primigenius* (mammoth), *Equus ferus* (horse), and *Coelodonta antiquitatis* (woolly rhinoceros). Marr (1920) added *Rangifer* [*Cervus*] *tarandus* (reindeer) to this list, commenting that it was fairly abundant. This assemblage suggests cool or cold open grassland conditions, and superficially resembles the *Mammuthus trogontherii-primigenius/Equus ferus* fauna correlated with MIS 7 (Stuart 1982, Sutcliffe 1995). It is important to note that a similar vertebrate fauna indicative of arctic conditions also prevailed close to the last glacial maximum (MIS 2) (Currant and Jacobi 2001).

### 8.6.7.6 Beetles

Coleopteran analysis by Coope (1968) of specimens originally collected by Chandler 1921 yielded twenty one alpine and tundra beetle taxa. Environments indicated by the beetle assemblage include well-drained sandy and gravelly bare ground, riparian habitats, marshy vegetation and some standing water. In addition, Coope (1968) makes an important distinction between cold treeless 'full glacial' habitats of the arctic tundra, and cool temperate treeless 'interstadial' environments from sites like Upton Warren (Coope,
Shotton & Strachan, 1961). Coope (2000) suggests that summer temperatures of c. 10°C and winter temperatures of c. -20°C are indicated by the ‘full glacial’ fauna at Barnwell Station and a group of other British Devensian sites

8.6.7.7 Dating

Amino acid racemization analyses for *Valvata piscinalis* shells from point BSE gave D/L ratios of 0.134, 0.146 and 0.150 (Appendix 5). These equate to an age in the later part of the ‘Wolstonian’ interval (MIS 6/7). This is a problematic result since much of the evidence from other sources suggests that the deposits at this site are from full glacial conditions in the Late Devensian (MIS 2). There are three obvious possibilities to explain this discrepancy. One possibility is that there was confusion between this site and the nearby Barnwell Abbey pit at some stage during the curation process in the Sedgwick Museum. The second possibility is that deposits from the later part of the ‘Wolstonian’ interval were exposed at Barnwell Station, but remained unrecognised, except perhaps for the original observations by Mrs McKenny Hughes. Thirdly, there is the possibility that shells from older deposits have been reworked into the Late Devensian sediments. Unfortunately, there is no way to resolve this problem within the scope of this project.

8.6.7.8 Conclusions

It seems clear from many lines of evidence that the fluvial deposits at this site were laid down under ‘full glacial’ arctic conditions, which prevailed close to the late glacial maximum in the Late Devensian (MIS 2). The value of the Barnwell Station site is that it provides a much-needed reference point in terms of age, climate, environments of deposition and elevation of deposits, against which other sediments in the area may be compared. The author believes that the reworked plant macrofossils identified at this site are of significance, since it repeats a pattern observed at other sites in this study.

8.6.8 Jesus College and Jesus Lane

8.6.8.1 Introduction

McKenny-Hughes (1916) recorded a 9m deep section in a drainage trench (point CD115/1) revealing gravel and sand overlain by Made Ground in Jesus Lane outside the gates of Jesus College. A tusk of *Mammuthus primigenius* was recovered from these deposits, and Marr and Gardner (1916) suggested a correlation with the deposits at Barnwell Station. The author was able to observe various sewer excavations along Jesus Lane (points JLS1 to JLS6), and was invited to record sections (points JCA and JCB) at an archaeological investigation, referred to here as the Jesus College Archaeological Site, where gravel and sand was observed to overlie a marly silty clay unit. The author put
down a hand auger borehole at point JCA to ascertain the thickness of this silty clay, and to procure samples for further analysis (Figure 8.5.4-8).

**8.6.8.2 Environments of deposition**

The gravels exposed at Jesus College and Jesus Lane probably represent deposition by a braided stream in a grassland environment under cold conditions. The silty clay unit is interpreted as low-energy channel sedimentation, or possibly overbank deposition on the braidplain surface.

**8.6.8.3 Physical analyses and particle size distribution**

The sequence of marly silty clay at point JCA was subjected to detailed physical and particle size analyses (Figures 8.6.8-1 and 8.6.8-2). The silty clay sequence at JCA was moderately rich in calcium carbonate (40-60%) and contained 2% organic material (Figure 8.6.8-1). Large amounts of detrital carbonate are not unexpected within a Chalk dominated catchment. The amount of silicate residue was moderately high (40-50%) indicating inwash from soils in the catchment. The silt bed at 365cm comprised 70% silicate accompanied by a corresponding decrease in calcium carbonate. The sequence has a rather low magnetic susceptibility (0.1 to 0.25 SI units x 10^8 (m^3 kg^-1)) suggesting that the silicate clastics are largely composed of quartz and feldspathic material, rather than ferromagnetic minerals.

The particle size distribution diagram for this sequence (Figure 8.6.8-2) shows a bimodal distribution of fine silts with a modal size of 7.5 Phi units (c.6μm) and coarse silts with a modal size of 4.5 Phi units (c.44μm). Towards the top of the sequence, the coarser part of this bimodal distribution has a modal size of 5 Phi units (c.31μm). There is some evidence for in-wash of medium sand at c.0 Phi units (c.1000μm) at 220cm and at 0.5 Phi (>c.707μm) at 255cm and 300cm, from higher energy fluvial events.

During the excavation of sewer trenches on Jesus Lane, the author took bulk samples of silty clay from 400cm and 450cm depth at point JLS5, and this material had similar physical characteristics to the sequence at point JCA.

**8.6.8.4 Pollen analyses**

The author carried out pollen analysis on samples of marly silty clay from borehole JCA. Figure 8.6.8-3 shows the pollen diagram from borehole JCA. The pollen assemblage of the basal silty clay (240-320cm) is dominated by Poaceae (grass) (20-50%) with Cyperaceae (sedges) (up to 20%), Pinus (pine) (up to 40%), monolete pteropsid spores (ferns) (up to 15%) and low frequencies (c.2%) of Quercus (oak), Alnus (alder), Picea (spruce), Corylus (hazel), Salix (willow), and Betula (birch). At the top of the
sequence, Betula becomes more important rising to c.15%, and is accompanied by a peak in Pteridium (bracken) spores, although Poaceae and Pinus remain important. These assemblages are interpreted as a grassland and floodplain environment with boreal birch scrub and stands of pine (Substage IV). Pollen of Typha latifolia (reedmace) and Sparganium (bur-reed) show that these emergent aquatics grew nearby. The low frequencies of temperate pollen might represent local reworking of interglacial sediments or long distance transport, although the Corylus type pollen may represent Myrica gale (bog myrtle) rather than Corylus (hazel) itself. Equally, the Salix and Betula pollen might originate from dwarf species rather than trees. In addition, the presence of Picea pollen might be taken as an indication that some spruce was growing within the catchment.

8.6.8.5 Vertebrates

A tusk of Mammutthus primigenius was recovered from the 9m deep section in a drainage trench in Jesus Lane (point CD115/1) described by McKenny-Hughes (1916). Little can be concluded from this find, other than it tends to suggest cool rather than temperate conditions for at least some part of these sediments.

8.6.8.6 Conclusions

These deposits appear to occupy a north-south trending buried bedrock channel-form similar to the one described from Swan's Pit (see Section 8.6.1) to the north. It is clear from the physical, pollen and vertebrate evidence that these deposits represent fluvial accumulation in cool or cold conditions. The sediments yielded few clues to their age, although correlation with other sequences might conceivably place them within the Early Devensian (MIS 5a/d).

8.7 Correlation of Stratigraphic Units

5km Square TL 245/55

8.7.1 Synopsis

Figure 8.7.1-1 and Table 8.7.1-1 show details of the 38 stratigraphic units proposed for the 5km Square 245/55. The majority of deposits in this square are on the valley floor and valley sides, although many of the 3rd Terrace Deposits such as the Homerton College Gravel, Mill Road Gravel, and Barnwell Abbey Silty Clay occupy positions on low ridges.

Table 8.7.1-2 and Figure 8.7.1-2 show the chronological and stratigraphic relationships of these units and their correlation with lithostratigraphic members and formations. Figure 8.7.1-3 presents an idealised geological section through the area showing the relationships
of the various lithostratigraphic members (Table 1.4.2-1). The Newmarket Road Gravelly Clay is correlated with the High Cross Member of the Cam Valley Formation, and is interpreted as reworked solifluction material derived from periglacial activity in the ‘Wolstonian’ interval and the Devensian.

The Jesus Lane Gravel is correlated with the Impington Village Member of the Cam Valley Formation, and is interpreted as gravels of the River Cam belonging to the later part of the ‘Wolstonian’ interval (MIS 6/7). The Barnwell Abbey Silty Clay becomes the stratotype of the Barnwell Abbey Member of the Cam Valley Formation. It is correlated with the Victoria Road Silty Clay, Jesus Lane Silty Clay, Maid’s Causeway Silty Clay, Trumpington Road Silty Clay and Cambridge Station Silty Clay. These deposits are also correlated with the Histon Road Member, and are interpreted as Ipswichian and Early Devensian (MIS 5a/e) temperate and cold stage fines of the River Cam. The Victoria Road Gravel, River Lane Gravel, East Road Gravel, Mill Road Gravel, Homerton College Gravel, Hills Road Gravel, Addenbrookes Hospital Gravel, Jesus College Gravel and Trumpington Street Gravel are all correlated with the Arbury Member of the Cam Valley Formation. These units are difficult to separate and are interpreted as Early Devensian (MIS 4) gravels of the River Cam. The Quy Waters Gravel is correlated with the Little Wilbraham Member of the Cam Valley Formation, and interpreted as Early Devensian (MIS 4) gravels of an ancient tributary of the River Cam system. It is conceivable that parts of these deposits also belong to the later part of the ‘Wolstonian’ interval (MIS 6/7).

The Barnwell Station Gravel becomes the stratotype of the Barnwell Station Member of the Cam Valley Formation, and is correlated with the Lion Yard Gravel and Botanic Gardens Gravel. These deposits are also correlated with the Sidgwick Avenue Member, and are interpreted as Middle to Late Devensian (MIS 2/3) braidplain deposits of the River Cam. The Emmanuel College Silty Clay becomes the stratotype of the Emmanuel College Member of the Cam Valley Formation, and is correlated with the New Chesterton Silty Clay and Cemetery Silty Clay. These sediments are also correlated with the Barnwell Station Member and Sidgwick Avenue Member, and appear to represent cold stage overbank fines of Middle to Late Devensian (MIS 2/3) age. The Midsummer Common Gravel becomes the stratotype of the Midsummer Common Member of the Cam Valley Formation, and is correlated with the Jesus Green Gravel and Elizabeth Way Gravel. These deposits are interpreted as Late Devensian (Late Glacial) (MIS 2) Gravels of the River Cam. The Jesus Green Silty Clay becomes the stratotype of the Jesus Green Member of the Cam Valley Formation, and is correlated with the Coldham’s Lane Sandy Clay, Black House Sandy Clay, Fulbourn Hospital Silty Clay, Teversham Sandy Clay, Elizabeth Way Silty Clay, Cherry Hinton Silty Clay, Jesus Green Peat, Midsummer
Common Peat and Elizabeth Way Peat. These deposits are interpreted as Flandrian alluvium and fen deposits of the River Cam and its tributaries.

The sediments described above represent a sequence stretching from the later part of the ‘Wolstonian’ interval, through the Devensian to the Flandrian. Older sediments appear to be absent, and there appears to be considerable complexity within the record, making precise correlation difficult.

8.8 5km Square TL 240/550 Harston and Haslingfield

8.8.1 Synopsis

This five-kilometre square contains 19 monads with 242 points (Figures 8.8.1-1 & 8.8.1-2). The area includes the village of Trumpington to the northeast, Hauxton and Harston to the south, and Haslingfield to the west. The area includes the M11 Motorway, which provides a large number of points in this square.

8.8.2 Drainage

The drainage of the square is generally towards the north. The northwestward flowing River Cam meets the northeastward flowing River Rhee north of Hauxton. From this confluence the river flows northeast, and is joined by the eastward flowing Bourn Brook at Byron’s Pool. The highest land in the square (c.65m OD) is at Chapel Hill south of Haslingfield, and a low ridge at St. Margaret’s Mount, south of Hauxton reaches c.40m OD. The remainder of the square is relatively low-lying (c.10-20m OD).

8.8.3 Geology

The bedrock geology comprises Cretaceous Gault Clay overlain by Lower and Middle Chalk broadly dipping towards the southeast (Figures 8.8.3-1 & 8.8.3-2). The Quaternary geology (Figures 8.8.3-1 & 8.8.3-2) comprises an area of Boulder Clay (till) at Chapel Hill (c.50-65m OD) south of Haslingfield, and a patch of 3rd Terrace Deposits (c.15-20m OD) to the northeast near Trumpington. Spreads of Undifferentiated 1st and 2nd Terrace Deposits are mapped along the valleys of the River Cam, River Rhee and Bourn Brook, and a curious excursion of this terrace is mapped between Harston and Haslingfield. Alluvium is confined to the river floodplains.

8.8.4 Geological Logs and Sections

8.8.4.1 Synopsis

The 242 points comprise 66 collected by the author, 16 from the British Geological Survey Well Catalogue Series (Sayer and Harvey, 1965), 3 from the Saffron Walden
Memoir (White, 1932), 2 from contractors’ reports, and 155 from the Highways Agency archives. One record mentioned by White (1932) at Trumpington Railway Cutting was originally described by Kennard and Woodward (1922), and Marr (1926).

8.8.4.2 Geological Section 40/50.1

This 5.5km-long section (Figure 8.8.4-1) runs roughly northwest-southeast along the line of and parallel to the M11 Motorway from the valley of the Bourn Brook south of Grantchester (point 329) through the junction with the A10 Road and Hauxton to Clunch Pit Hill (point 91). It provides a detailed record of the undifferentiated 1st and 2nd Terrace Deposits adjacent to the floodplain of the River Cam in this area.

Data point 329 in the valley of the Bourn Brook records 1m of sandy clay on bedrock Gault Clay at c. 12m OD. Downslope, point sb51 shows clay with gravel over diamict, and point 328 shows 1m of sandy clay on bedrock at c.10m OD. Similar diamict units have been recorded on valley-side locations in 5km square 40/55. On the floor of the Bourn Brook valley, point b230 records 5.5m of silty clay overlying sand and gravel on bedrock at c.3m OD. In contrast, point b228 shows 1m of clay with gravel on bedrock at c.9m OD, although point b224 shows 3m of silty clay on bedrock at c.6m OD. It appears that this represents a buried bedrock channel-form filled with Flandrian sediments beneath the floodplain of the Bourn Brook. It is proposed that the silty clay unit here is formally named the Bourn Brook Silty Clay, with a stratotype at point b230 (TL 4263 5475).

Close by, point b226 shows 1m of clay with gravel on bedrock at c.8m OD, and points 327 to 325 show 2m of gravel and sand on bedrock at a similar elevation. The edge of this patch of undifferentiated 1st and 2nd Terrace Deposits is marked at point sb40 where clay with gravel overlies gravel and sand. On the floodplain of the River Cam near Lingey Fen, point 320 shows 1m of clay with peat overlying 2m of gravel and sand on bedrock at c.5m OD. Nearby, points sb29 to b219 record silty clay overlying peat and clay with peat 3m thick, in turn overlying 3m of gravel and sand on bedrock at 4 to 5m OD. This seems to be a buried bedrock channel-form beneath the floodplain of the River Cam, similar to that beneath the Bourn Brook to the north, and recorded downstream beneath the River Cam in 5km square 40/55. At the edge of the floodplain, point 318 shows 2m of gravel and sand on bedrock Gault Clay at c.7m OD and point 317 shows gravel on bedrock Chalk at c.10m OD. Although the BGS map this area as bedrock Gault Clay, points 132 to 130 record 2m of gravel and sand on bedrock Gault Clay at c.10m OD. On the rising slope to the southeast near Shepherd’s Cottage, points b74 to 128 show bedrock Chalk close to the surface beneath topsoil. Bedrock Gault Clay briefly reaches the surface at point 127, and on the floor of a small valley point 126 shows 1m of sandy clay on bedrock Chalk at c.12m OD.
Across a narrow interfluve occupied by the A10 Road, points 126 to 123 show bedrock Chalk close to the surface. However, points b60 to 119 record 2m of gravel and sand on bedrock Chalk at 12 to 13m OD, in an area mapped as undifferentiated 1st and 2nd Terrace Deposits. It is proposed that this gravel unit is formally named the **Hauxton Mill Gravel** with a stratotype at point 119 (TL 4422 5266). On the floodplain of the River Cam near University Arms Farm, Hauxton, points b8a to 114 record 1.5m of silty clay overlying 2m of peat, in turn overlying 1m of gravel and sand on bedrock Chalk at c.9m OD. The buried channel-form beneath the floodplain of the River Cam at Hauxton is in many respects a microcosm of that already described downstream at Lingey Fen. The smaller size of this feature at Hauxton might be attributed to its position upstream of the confluence of the River Cam with the River Rhee. It is proposed that the peat unit here is formally named the **University Arms Farm Peat** and that the underlying gravel unit is formally named the **University Arms Farm Gravel**, both with a stratotype at point 114 (TL 4433 5233). Nearby, points b56 and b54a show 0.5m of silty clay overlying gravel and sand on bedrock at c.10m OD, and point 110 shows gravel on bedrock at a similar elevation. Points b53 to 108 record 2m of gravel and sand on bedrock at 11 to 13m OD. These points are in an area mapped by the BGS as undifferentiated 1st and 2nd Terrace Deposits. It is proposed that this gravel unit is formally named the **Hauxton Village Gravel** with a stratotype at point b53 (TL 4439 5198). In contrast, a break in slope at point b46 shows bedrock Chalk close to the surface at c.14m OD beneath silty clay. Near the Shelford Road, points b48 to b42 show 1.5m of gravel and sand on bedrock at c.13m OD. This spread of gravel appears to be at a similar elevation to the Hauxton Mill Gravel to the north. At the edge of the gravel spread, point 103 shows sandy clay over gravel, and point 102 shows sandy clay on bedrock at c.13m OD. Upslope, points 101 to 95 show topsoil and sandy clay over bedrock Chalk near the surface. Close to Clunch Pit Hill, points 94 to 91 record 0.5m of sandy clay on bedrock Chalk at 19m OD.

### 8.8.4.3 Geological Section 40/50.2

This 5.5km-long section (Figure 8.8.4-2) stretches roughly northwest-southeast along the line of and parallel to the M11 Motorway. It runs from the valley of the Bourn Brook south of Grantchester (point 144) through the junction with the A10 Road and Hauxton to Clunch Pit Hill (point 91). It provides a detailed record of the undifferentiated 1st and 2nd Terrace Deposits adjacent to the floodplain of the River Cam in this area.

Data points 144 and 143 in the valley of the Bourn Brook record bedrock Chalk close to the surface beneath topsoil at c.16m and c.12m OD respectively. In contrast, at Lingey Fen near Byron’s Pool close to the confluence of the Bourn Brook and the River Cam, points b84 to b82 show 3m of silt clay overlying 5m of peat and clay with peat, in turn overlying
gravel and sand 1.5m thick on bedrock Gault Clay at 1 to 2m OD. Point 141 shows silty clay over 4m of clay with peat on bedrock at c.3.5m OD, and points b80, 140 and 139 record 1m of silty clay overlying 4m of peat and clay with peat, in turn overlying 3.5m of gravel and sand on bedrock at 1 to 2m OD. It is proposed that the peat here is formally named the Lingey Fen Peat, and that the underlying gravel is formally named the Lingey Fen Gravel, both with a stratotype at point 140 (TL 4330 5470). To the south, points 138 and 137 show 1m of silty clay over 1m of peat and clay with peat, overlying 1.5m of gravel and sand on bedrock c.4.5m OD. Nearby at the edge of the floodplain, points 136 and b76 show silty clay overlying 4m of peat and clay with peat, in turn overlying 1.5m of gravel and sand on bedrock at c.3.5m OD. It is clear that these presumably Flandrian deposits occupy a buried bedrock channel-form similar to that identified upstream in 40/50.1. Near Shepherd’s Cottage in an area mapped by the BGS as bedrock Gault Clay, points 135 and 134 to 314 record 2m of gravel and sand on bedrock at 8 to 9m OD. It is proposed that the gravel here is formally named the Shepherd’s Cottage Gravel with a stratotype at point 134 (TL 4328 5412). Point sb22 marks the position of an old pit, where 1.5m of Made Ground overlies clay with gravel on bedrock Gault Clay at c.9.5m OD. Upslope, points b216 to b210 record bedrock Chalk close to the surface beneath topsoil and sandy clay. Near the A10 Road (Cambridge Road), point 310 records sandy clay over 0.5m of silty clay overlying gravel on bedrock Chalk at c.17.5m OD. These sediments are at a similar elevation to those mapped as 3rd Terrace Deposits and recorded in Geological Sections 40/50.5 and 40/50.6. It is proposed that the silty clay here is formally named the Cambridge Road Silty Clay with a stratotype at point 310 (TL 4332 5383).

To the southeast, points 309a to 308 show 1m of gravel and sand on bedrock at c.13m OD. In contrast, point 307 shows bedrock Chalk close to the surface at c.14m OD. On the floodplain of the River Cam at Hauxton, point b205 shows 1m of silty clay overlying 4.5m of peat and clay with peat on bedrock at c.6m OD. Nearby, points b204 and sb19 record 1m of silty clay overlying 3m of peat, in turn overlying gravel and sand on bedrock at 7 to 8m OD. At the edge of the floodplain near the University Arms Farm, point 303 shows silty clay overlying gravel, and points sb17 and 305 show 1m of gravel and sand on bedrock at 10 to 11m OD. The buried channel-form beneath the floodplain of the River Cam here appears to be a smaller version of that seen downstream at Lingey Fen. Near the Shelford Road, points b208 to 108 record 2m of gravel and sand on bedrock at 11 to 12m OD. These points are in an area mapped by the BGS as undifferentiated 1st and 2nd Terrace Deposits. In contrast, a break in slope at point b46 shows bedrock Chalk close to the surface at c.14m OD beneath silty clay. Points b48 to b42 show 1.5m of gravel and sand
on bedrock at c.13m OD. This spread of gravel appears to be at a higher elevation, and therefore possibly older that that identified nearer the University Arms Farm. At the edge of the gravel spread, point 103 shows sandy clay over gravel, and point 102 shows sandy clay on bedrock at c.13m OD. Upslope, points 101 to 95 show topsoil and sandy clay over bedrock Chalk near the surface. Close to Clunch Pit Hill, points 94 to 91 record 0.5m of sandy clay on bedrock Chalk at 19m OD.

**8.8.4.4 Geological Section 40/50.3**

This 5.5km-long section (Figure 8.8.4-3) runs roughly northwest-southeast from Spring Hall Farm north of Haslingfield (point 205/38), through Haslingfield village and Harston to Hill Farm (205/503). At Spring Hall Farm, point 205/38 shows bedrock Gault Clay close to the surface beneath topsoil at c.17m OD. To the east, point 205/342 records 1m of unknown drift on bedrock at c.23m OD, and in Haslingfield village, point 205/308 shows Gault Clay at the surface, while point 205/335 shows bedrock Chalk close to the surface, both at c.22m OD. Near the edge of the floodplain of the River Rhee, point 205/37 shows Gault Clay close to the surface at c.13.5m OD. The section through the Rhee floodplain has been projected from sections upstream and downstream. At Harston Mill, point 205/356 shows bedrock Chalk close to the surface beneath topsoil at c.12m OD at the edge of an area mapped by the BGS as undifferentiated 1st and 2nd Terrace Deposits. In Harston village, point 205/506 shows 3m of unknown drift on bedrock Gault Clay at c.9m OD, and point 205/32 records 9m of unknown drift on bedrock at c.5m OD. It appears that there is a buried bedrock channel-form beneath Harston, although the exact nature of the deposits, assumed here to be gravel, is not known. At Hill Farm, point 205/503 shows bedrock Chalk close to the surface beneath topsoil at c.28m OD.

**8.8.4.5 Geological Section 40/50.4**

This 5km-long section (Figure 8.8.4-4) runs roughly northwest-southeast from Spring Hall Farm north of Haslingfield (point 205/38), through Rectory Farm, Hauxton, to the M11 Motorway near the Shelford Road (205/112). At Spring Hall Farm, point 205/38 shows bedrock Gault Clay close to the surface beneath topsoil at c.17m OD, and to the east, point 205/342 records 1m of unknown drift on bedrock at c.23m OD. The section through the Rhee floodplain has been projected from sections upstream and downstream. The author carried out a series of boreholes to investigate the low ridge on which Rectory Farm is located. To the west, points RFBH13 to RFBH1 showed sandy clay sometimes overlying a gravel unit on bedrock Chalk at between 16 and 19m OD. To the east, point RFBH2 showed sandy clay over 0.5m of silty clay, in turn overlying gravel and sand not reaching bedrock at c.18m OD. The deposits near the top of this ridge appear to be of a
superficially similar nature and elevation to those recorded at point 310 in Geological Section 40/50.2. It is proposed that the silty material here is formally named the **Rectory Farm Silty Clay** with a stratotype at point RFBH2 (TL 4283 5211). Downslope, points RFBH3 and RFBH4 show sandy clay over bedrock at 16 to 18m OD, and point RFBH5 records gravel and sand with a base not reaching gravel at c.14.5m OD. At the foot of the hill near the A10 Road, point RFBH7 shows 1m of silty clay overlying gravel on bedrock Chalk at c.12.5m OD, point RFBH8 shows 1.5m of gravel and sand, and point RFBH9 records silty clay near the surface at c.12m OD. This appears to represent the edge of a spread of undifferentiated 1st and 2nd Terrace Deposits mapped by the BGS. Much of the gravel at Hauxton has been worked out in a series of disused pits. Close to the M11 Motorway and the railway, points b201 to 104 record 0.5m of sandy clay overlying 1m of gravel and sand on bedrock at c.13m OD. Near the Shelford Road, points 205/112 and 205/113 show the edge of the gravel, where bedrock Chalk is close to the surface at between 14 and 16m OD.

### 8.8.4.6 Geological Section 40/50.5

This 5.5km-long section (Figure 8.8.4-5) runs roughly west-east from Spring Hall Farm north of Haslingfield (point 205/38), through Cantelupe Farm and Trumpington to a point southeast of Glebe Farm (205/84). At Spring Hall Farm, point 205/38 shows bedrock Gault Clay close to the surface beneath topsoil at c.17m OD, and to the east, point 205/342 records 1m of unknown drift on bedrock at c.23m OD. Near Cantelupe Farm, point 205/35 shows bedrock Gault Clay close to the surface at c.13m OD. On the floodplain of the River Cam, points b221 to b223 record silty clay overlying 3m of clay with peat, in turn overlying 2m of gravel and sand on bedrock at c.4m OD. Close by, points b77 to 138 record a similar sequence, with 1.5m of silty clay overlying 3m of peat and clay with peat, in turn overlying 2m of gravel and sand on bedrock at 3 to 4m OD. At Byron’s Pool, Point SW101/1 shows 0.5m of silty clay overlying 1m of gravel and sand. At the site of the new Waitrose supermarket on the site of the PBI, Trumpington, archaeological excavations (points A/A to A4/4) revealed sandy clay overlying gravel and sand 1m thick with a base not reaching bedrock at c.16m OD. This is part of the spread of 3rd Terrace Deposits mapped by the BGS at Trumpington. Point SW93/4 recorded 3.5m of gravel and sand with a base not reaching bedrock at c.14m OD exposed in a railway cutting. The site at Trumpington Railway Cutting was originally described by Kennard and Woodward (1922), and Marr (1926), and yielded a mollusc assemblage. It is proposed that the gravel here is formally named the **Trumpington Railway Cutting Gravel** with a stratotype at point SW93/4 (TL 4475 5445). To the south near Glebe Farm, point CSRR1 showed 2m of silty clay overlying 1m of gravel and sand on bedrock chalk at
c.16m OD, and point CSRR2 showed 1m of silty clay on bedrock at c.17m OD. It is proposed that this silty clay unit is formally named the **Glebe Farm Silty Clay** with a stratotype at point CSRR1 (TL 4458 5401). Further south, point 205/84 records bedrock Chalk close to the surface beneath topsoil at c.15m OD.

### 8.8.4.7 Geological Section 40/50.6

This 5.5km-long section (Figure 8.8.4-6) runs roughly west-east from Harston village (205/32) to the PBI at Trumpington (A/F). In Harston village, point 205/32 records 9m of unknown drift on bedrock Gault Clay at c.5m OD in an area mapped by the BGS as undifferentiated 1st and 2nd Terrace Deposits. These sediments have been assumed to be gravel and sand for the purposes of this section. To the north, point 205/116 shows bedrock Chalk close to the surface at c.14m OD in an area also shown on the geology map as river deposits. Near the A10 Road at Rectory Farm, Hauxton, point RFHB6 shows 1m of silty clay over gravel on bedrock at c.13m OD, and point RFBH8 shows gravel and sand at the surface. Close to the works at Hauxton Mill, point 205/341 records 3m of unknown drift, assumed here to be gravel and sand, resting on bedrock Gault Clay at c.8.5m OD. The section through the Cam floodplain here has been projected from sections upstream and downstream. At the top of a steep rise near the M11 Motorway, point 124 shows bedrock Chalk close to the surface at c.18m OD. In contrast, point 310 records sandy clay over 0.5m of silty clay overlying gravel on bedrock Chalk at c.17.5m OD. Nearby at points b210 and b212 bedrock Chalk is close to the surface at c.17m OD. At the site of the new Waitrose supermarket at the PBI, Trumpington, archaeological excavations at points B2/1 to B1/2 showed sandy clay overlying gravel and sand. At one location (point B3/1) the gravel and sand was 1m thick and overlay a silty clay unit, and elsewhere on the site (points B1/11 and B1/12) the silty clay reached the ground surface. Trenches to the north (points A5/3 to A/F) revealed sandy clay overlying gravel and sand 1m thick with a base not reaching bedrock at c.16m OD.

### 8.9 Site Descriptions 5km Square TL 240/550

#### 8.9.1 Trumpington Railway Cutting

##### 8.9.1.1 Introduction

Sections in gravel and sand exposed in a railway cutting were originally described by Kennard and Woodward (1922), and Marr (1926), and a list of molluscs from the site was included in the Saffron Walden Memoir (point SW93/4) by White (1932).
8.9.1.2 Environments of deposition

The 3.5m of ‘fine to medium, sandy and chalky gravel’ exposed in the railway cutting were presumably deposited by a braided river system under generally cool or cold conditions. The presence of marshland and pools on the surface of the braidplain is clearly shown by the mollusc fauna. There is some evidence of more temperate conditions, presumably accompanied by a less energetic flow regime. It appears that either such conditions did not persist for long, or the evidence for them has been largely removed.

8.9.1.3 Molluscs

Kennard and Woodward (1922) recovered molluscs from two distinct but similar horizons 2.4m and 3.4m below the surface. The combined assemblage comprised a curious mixture of dry grassland species such as *Pupilla muscorum*, taxa of marshlands, floodplains and stagnant pools, aquatic types indicating slow flowing well oxygenated conditions, and snails of temperate woodland habitats, indicated by *Ena montana*, and *Clausilia* sp. The thermophilous elements in this assemblage led Sparks (1964) to correlate this site with Grantchester (see Section 8.3.5) and Barnwell Abbey (see Section 8.6.2). The part of this assemblage with temperate associations is rather small, and several other important thermophilous taxa are absent, including *Azeca menkeana*. In addition, *Belgrandia marginata* and *Corbicula fluminalis* were not recovered from these deposits, despite the presence of suitable flowing water conditions indicated by *Pisidium* spp. The absence of these stratigraphically important taxa is certainly a feature shared with the deposits at Grantchester. The overall signal from the molluscan data is difficult to interpret, but there is evidence for a slow flowing river with a marshy floodplain and pools in a grassland environment. Assuming that the thermophilous elements are not reworked, there is also evidence for some temperate woodland within the catchment.

8.9.1.4 Conclusions

Sparks (1964) concluded with confidence that the deposits at this site should be grouped with those at Grantchester and Barnwell Abbey on the basis of their position in the 3rd Terrace and the temperate nature of the mollusc faunas, and could be correlated with the Ipswichian (MIS 5e). Certainly, the relative elevation of these deposits above the Flandrian floodplain suggests that they might in part date from at least the early Devensian (MIS 5a-d). The possibility that these might be rather older sediments dating from the later part of the ‘Wolstonian’ interval (MIS 7) should also be considered.
8.10 5km Square TL 245/550 Great Shelford

8.10.1 Synopsis

This five-kilometre square contains 21 monads with 656 points (Figures 8.10.1-1 & 8.10.1-2). The area includes parts of Cambridge and Trumpington to the north, Wandlebury to the east, part of Sawston to the south, Little Shelford to the west, and the villages of Great Shelford and Stapleford near the centre. Figures 8.10.1-3 and 8.10.1-4 show the detailed distribution of points in two monads north of Great Shelford, where an archaeological investigation at the site of a proposed golf course provided a large number of data points.

8.10.2 Drainage

The River Cam flows across the square from the south to the southwest (15-20m OD) and is joined at Great Shelford by the River Granta, which flows from the east. North of Great Shelford, Chalk springs at Granham's Road and Nine Wells feed Hobson's Brook (Hobson's Conduit), which flows north towards Cambridge (c.12m OD). The most elevated land (c.74m OD) is at Wandlebury in the east of the square, and several low ridges (Fox Hill, Clarke's Hill, White Hill) extend west and north from this point. Near Sawston, the land rises to c.30m OD on the interfluve between the Cam and Granta valleys.

8.10.3 Geology

The bedrock geology comprises Lower and Middle Chalk broadly dipping towards the southeast (Figures 8.10.3-1 & 8.10.3-2). There is some evidence for a minor flexure or monoclinic disturbance in the Chalk in the vicinity of Wandlebury and the Gog Magog Hills. The Quaternary geology (Figures 8.10.3-1 & 8.10.3-2) comprises 'Glacial Gravel' capping the hills around Wandlebury. In addition, several patches of 3rd Terrace Deposits are mapped between Stapleford and Trumpington, and spreads of 2nd Terrace Deposits are shown flanking the river floodplains. It is important to note the strip of 2nd Terrace mapped along the valley of Hobson's Brook. This has been interpreted as a Devensian course occupied by the River Cam prior to its diversion westwards towards Hauxton (White 1932). Alluvium is mapped along the floodplains of the River Cam and River Granta.

8.10.4 Geological Logs and Sections

8.10.4.1 Synopsis

The 656 points comprise 617 collected by the author. These include 573 from an archaeological investigation at the site of a proposed golf course north of Great Shelford,
18 from an archaeological investigation at the Babraham Road Park and Ride site, 23 from investigations at Wandlebury, and 3 from a trench at Black Barn, Stapleford. Secondary sources accounted for 39 sites including 23 records from the Geological Survey Well Catalogue Series (Sayer and Harvey, 1965), 7 from the Saffron Walden Memoir (White, 1932), 2 from the Highways Agency archives and 9 from various contractors’ reports.

8.10.4.2 Geological Section 45/50.1

This 5.5km section (Figure 8.10.4-1) runs roughly north-south from the valley of Hobson’s Brook near Trumpington (point CSRR6) through Nine Wells, Granham’s Farm and Great Shelford to Rectory Farm, south of Little Shelford (point 205/163). Point CSRR6 in the valley of Hobson’s Brook records bedrock Chalk beneath topsoil close to the surface at 14m OD, in an area mapped as Undifferentiated 1st and 2nd Terrace Deposits by the BGS. To the south near the springheads at Nine Wells, points 1/7 and 1/6 also show bedrock Chalk close to the surface at a similar elevation, but point 1/5 records sandy clay over gravel and sand. Points 1/4 to 1/2 show sandy clay overlying bedrock Chalk at c. 14m OD, and point 1/1 shows bedrock Chalk close to the surface at this elevation. Upslope, points 3/3 to 5/1 also show bedrock close to the surface between 14.5m and 16.5m OD. Close by, points 7/4 to 8/1 record gravel and sand on bedrock at c. 16.5m OD, although points 9/1 and 12/1 show bedrock close to the surface beneath topsoil at a comparable elevation. However, points 14/3 to 14/4 record 0.5m of gravel and sand with a base not reaching bedrock at c.15.5m OD. Points 14/3 to 14/1 show sandy clay overlying gravel and sand at the same elevation. This material is not recognised on the geology map (Figure 8.10.3-1). Nearby, points 20/1 to 29/2 show sandy clay 1m thick on bedrock Chalk at c.16m OD. Point 29/3 shows bedrock Chalk close to the surface, but points 29/2 to 29/12 show gravel and sand on bedrock at 15.5 to 16m OD. Near Granham’s Farm, points 95/9 to 95/12 record silty clay overlying gravel and sand with a base not touching bedrock at c.15m OD. Close by, points 94/6 to 94/1 show 1.5m of silty clay with a base not reaching bedrock at c.14m OD. It is proposed that the silty clay unit here is formally named the Granham’s Farm Silty Clay with the stratotype at point 94/6 (TL 4627 5300). Point 96/6 shows 1m of gravel and sand with a base at c.15m OD. It is proposed that this gravel unit is formally named the Granham’s Farm Gravel with the stratotype at point 96/6 (TL 4630 5289). In Great Shelford, point 205/76 records 3m of unknown drift on bedrock at c.15m OD and nearby point SW92/4 shows 0.5m of clay with gravel overlying 2.5m of gravel and sand on bedrock at c.14m OD. These points are in an area mapped as 3rd Terrace Deposits by the BGS. It is proposed that the gravel unit here is formally named the Great Shelford Gravel with the stratotype at point SW92/4 (TL 4650 5218). To the south, point 205/140 records 0.5m of clay with gravel overlying 2m
of gravel and sand on bedrock at c.16m OD, in an area mapped as 2nd Terrace Deposits. The deposits in the floodplain of the River Granta and River Cam valley have been projected on to this section from data downstream in 5km Square 40/50. Near Rectory Farm, Little Shelford, point 205/163 shows 5m of unknown drift overlying bedrock Chalk at c.12m OD.

8.10.4.3 Geological Section 45/50.2

This 5km-long section (Figure 8.10.4-2) is aligned southwest-northeast and runs from the M11 Motorway at Well Head Plantation, Little Shelford (point 89) through Stapleford to point 205/226 on Babraham Road. Point 89 on the M11 Motorway at Well Head Plantation, Little Shelford records bedrock Chalk close to the surface at c.20m OD, and point 90 shows sandy clay overlying bedrock at a slightly lower elevation. Downslope near Sainsfoins Farm, point 205/368 shows bedrock Chalk close to the surface at c.15m OD. The deposits in the floodplain of the River Granta and River Cam valley have been projected on to this section from data downstream in 5km Square 40/50. To the northeast, point 205/140 records 0.5m of clay with gravel overlying 2m of gravel and sand on bedrock at c.16m OD, and in Stapleford point SW99/1 shows clay with gravel over 2.5m of gravel and sand with a base not reaching bedrock at c.14.5m OD. It is proposed that this gravel unit is formally named the Stapleford Gravel with the stratotype at point SW99/1 (TL 4715 5210). Upslope, point 205/548 on Fox hill records bedrock Chalk close to the surface beneath topsoil at c.48.5m OD, and at the foot of the Gog Magog Hills on Babraham Road, points 205/549 and 205/226 show bedrock Chalk at c.36m OD.

8.10.4.4 Geological Section 45/50.3

This 4km-long section (Figure 8.10.4-3) runs roughly southwest-northeast from Stapleford (205/82), through Wandlebury to Bishop’s Farm (205/196). Point 205/82 at Stapleford records bedrock Chalk close to the surface at c.33m OD. On Little Trees Hill, now known as Magog Down, points MA and MB each record 1m of gravel and sand with bases at c.69m and c.71m OD respectively. It is proposed that the gravel unit here is formally named the Magog Down Gravel with the stratotype at point MB (TL 4888 5292). Near Wandlebury, point WA shows bedrock chalk close to the surface at c.70m OD, but point WB shows 1m of gravel and sand on bedrock at c.72m OD. In the centre of Wandlebury Ring, point WP records bedrock Chalk near the surface at 74m OD. To the north on the Gog Magog Hills, point WC shows 1m of gravel and sand on bedrock at c.71m OD and point SW80/1 records 1m of topsoil over 3m of gravel and sand with a base not touching bedrock at c.69m OD. These deposits are mapped by the BGS as ‘Glacial Gravel’, and were formally named as the Wandlebury Member in Bowen (1999). The
stratotype location given appears to be an arbitrary location on the north east edge of Wandlebury Ring, and the author proposes a revised stratotype for this gravel nearby at point SW80/1 (TL 4928 5385). The name **Gog Magog Gravel** has been chosen for this unit, which may also serve as the stratotype of the Wandlebury Member. Downslope at Bishop’s Farm, point 205/196 shows bedrock chalk close to the surface at c.50m OD.

**8.10.4.5 Geological Section 45/50.4**

This 5.5km-long section (Figure 8.10.4-4) runs roughly north-south from Bishop’s Farm (205/196 ) across the Gog Magog Hills to a point east of Stapleford in the Granta valley (205/599). At Bishop’s Farm, point 205/196 shows bedrock chalk close to the surface at c.50m OD. Upslope, point WH shows bedrock close to the surface at c.65m OD, and at Telegraph Clump points WG and WI show 0.5m of gravel and sand at c.72m OD. Close by, points WL and WQ record gravel and sand near the surface at a lower level (68-69m OD), and point WJ shows gravel and sand on bedrock at c.69.5m OD. Adjacent to this, point WM shows bedrock Chalk close to the surface at c.70m OD. To the south near Round Clump, point WK shows bedrock Chalk close to the surface at 65m OD, and points WS and WR show gravel and sand near the surface at c.57m OD. Near Magog Farm, point 205/509 shows bedrock Chalk close to the surface at c.45m OD, and point MF on Babraham Road shows 1m of clay with gravel over gravel and sand on bedrock at c.39m OD. Closer to the River Granta, point 205/599 shows bedrock Chalk close to the surface beneath topsoil at c.26m OD.

**8.10.4.6 Geological Section 45/50.5**

This 4km-long section (Figure 8.10.4-5) runs roughly west-east from Shelford Road, Trumpington (point CSRR3A) through the Babraham Road Park and Ride site to Heath Farm (205/74). Point CSRR3A records 3m of silty clay overlying bedrock Chalk at c.11m OD. It is proposed that the silty clay here is formally named the **Shelford Road Silty Clay** with the stratotype at point CSRR3A (TL 4507 5420). Close by, point CSRR3 shows only 0.5m of silty clay on bedrock at c.14m OD, but further east point CSRR4 shows 2.5m of silty clay over 1m of gravel and sand on bedrock at c.10.5m OD. Near Hobson’s Brook, point CSRR5A shows 2.5m of gravel and sand on bedrock at c.10m OD, and point CSRR5 shows 1m of silty clay overlying 2m of gravel and sand on bedrock Chalk at c.9.5m OD. These sediments are in an area mapped as 2nd Terrace Deposits by the BGS, although they bear a superficial similarity to those at Glebe Farm, Trumpington (5km Square 40/50). It is proposed that this gravel is formally named the **Hobson’s Brook Gravel** with the stratotype at point CSRR5A (TL 4544 5453). In contrast, point CSRR6 shows bedrock Chalk close to the surface at c.14m OD.
To the east at the archaeological investigation at Babraham Road Park and Ride site near
Newbury Farm, points BRA to BRQ showed a complex sequence of sediments 2.5m thick
on bedrock Chalk at 17.5m OD. In general the sequence here comprises topsoil over sandy
clay overlying chalk putty 1m thick, in places overlain by gravel. The chalk putty overlies
a silty clay unit 1m thick interpreted as a Late Devensian (Late Glacial) lake deposit. It is
proposed that this silty clay unit is formally named the Babraham Road Silty Clay with
the stratotype at point BRF (TL 4768 5462). Close by at point BRO, 1m of silty clay
containing Flandrian molluscs occupied a saucer-like depression in the surface of the Late
Devensian deposits. Although initially interpreted as a pool or pond by the archaeologists,
this material contained only terrestrial molluscs of marshland and dry grassland (R.
Meyrick, pers. com. 2000). At Caius Farm, point 205/230 showed bedrock Chalk close to
the surface at c.22m OD and upslope on Babraham Road, points 205/226 and 205/549 also
show bedrock close to the surface at c.36m OD. At Heath Farm, point 205/74 records
bedrock Chalk near the surface beneath topsoil at c.50m OD.

8.10.4.7 Geological Section 45/50.6

This 4.5km-long section (Figure 8.10.4-6) runs roughly northwest-southeast from
Hobson’s Brook near Trumpington (CSRR5) through Nine Wells and Granham’s Farm to
Stapleford (205/598). In the valley of Hobson’s Brook near Trumpington, point CSRR5
shows 1m of silty clay overlying 2m of gravel and sand on bedrock Chalk at c.19.5m OD.
To the southeast near Nine Wells, points 6/3 to 6/7 record topsoil with occasional sandy
clay on bedrock Chalk at 15.5 to 16.5m OD. However, points 6/8 and 6/9 show 1m of
gavel and sand not reaching bedrock at c.16.5m OD. Nearby, points 6/10 to 7/10 show
bedrock Chalk close to the surface at c.17m OD. Upslope, points 7/12 to 11/8 record
gravel and sand on bedrock at 18-19m OD, and points 11/9 to 11/12 show bedrock close to
the surface at c.19m OD. Points 13/1 and 13/2 show sandy clay on bedrock, and points
13/3 and 13/4 show gravel on bedrock at a similar elevation. Points 13/5 and 13/6 show
bedrock Chalk close to the surface at c.19m OD, but points 13/7 to 15/5 show sandy clay
on bedrock at c.19.5m OD. Close by, points 17/1 to 18/9 record bedrock Chalk close to
the surface beneath topsoil at c.19.5m OD. Closer to Granham’s Road, points 18/10 to
48/9 show sandy clay and gravel on bedrock at 19-19.5m OD. North of Granham’s Farm,
points 54/6 to 51/6 also record sandy clay and gravel on bedrock at c.18m OD. An
interesting archaeological feature was revealed at point 51/6 where 0.5m of sandy clay was
seen to overlie clay with peat, with a base at c.18m OD. This was interpreted by the
archaeologists as a pre-Roman artificial well or pool. From a geological point of view, this
indicates the thickness of sandy colluvial slopewash deposits that can form in temperate
conditions over just two thousand years. To the southeast, points 51/4 to 53/12 show
bedrock Chalk close to the surface at 19 to 19.5m OD and point 55/6 shows sandy clay on bedrock at a similar elevation. Near Stapleford Church, point SW99/1 records clay with gravel overlying 2.5m of gravel and sand with a base not reaching bedrock at c.14.5m OD in an area mapped as 3rd Terrace Deposits. To the south, point 205/598 records 3m of unknown drift deposits on bedrock Chalk at c.15m OD.

8.10.4.8 Geological Section 45/50.7

This 4.5km-long section (Figure 8.10.4-7) runs roughly west-east from Great Shelford (SW92/5) to a point east of Stapleford in the Granta valley (205/599). Near De Freville Farm and the railway at Great Shelford, point SW92/5 shows 3m of gravel and sand overlying bedrock Chalk at c.15m OD, and close by point 205/73 records Made Ground over 2m of unknown drift on bedrock at c.16.5m OD. It is proposed that the gravel unit here is formally named the De Freville Farm Gravel with the stratotype at point SW92/5 (TL 4590 5255). Further east in Great Shelford village, point 205/76 shows 3m of unknown drift on bedrock at c.15m OD and point SW92/4 shows 0.5m of clay with gravel overlying 3m of gravel and sand on bedrock at 14m OD. Near Stapleford Church, point SW99/1 records clay with gravel overlying 2.5m of gravel and sand with a base not reaching bedrock at c.14.5m OD. At Greenhedge Farm, point 205/575 shows 2m of Made Ground on bedrock at c.20m OD at the edge of what must be an old pit. Upslope, point 205/82 shows bedrock Chalk beneath topsoil at c.33m OD, and closer to the River Granta, point 205/599 shows bedrock Chalk close to the surface beneath topsoil at c.26m OD.

8.10.4.9 Geological Section 45/50.8

This 4.5km-long section (Figure 8.10.4-8) runs roughly west-east parallel to 45/50.7 from Rectory Farm, Great Shelford (205/79) through Stapleford and Black Barn to a point east of Stapleford in the Granta valley (205/599). Near Rectory Farm, Great Shelford, point 205/79 records 2m of unknown drift deposits on bedrock Chalk at c.13m OD. Close by, points SW92/2 and SW92/3 show 2.5m of gravel and sand with a base not reaching bedrock at 12-13m OD. Point 205/114 shows 3m of gravel and sand on bedrock at c.12m OD. It is proposed that the gravel unit here is formally named the Rectory Farm Gravel with the stratotype at point 205/114 (TL 4604 5193). In Great Shelford village, point 205/140 records 0.5m of clay with gravel overlying 2m of gravel and sand on bedrock at c.16m OD, and in Stapleford point 205/598 shows 3m of unknown drift deposits on bedrock at c.15m OD. To the east at Black Barn, point BlkBmn1 shows sandy clay overlying 1m of clay with gravel on bedrock at c.18.5m OD and point BlkBmn2 shows 1m of gravel and sand at a similar elevation. It is proposed that this gravel unit is formally
named the **Black Barn Gravel** with the stratotype at point BlkBn3 (TL 4876 5151). Near by, point 205/523 shows 3m of unknown drift on bedrock Chalk at c.16m OD, and to the northeast, point 205/599 shows bedrock Chalk close to the surface beneath topsoil at c.26m OD.

### 8.10.4.10 Geological Section 45/50.9

This 3.5km-long section (Figure 8.10.4-9) runs roughly southwest-northeast from near De Freville Farm, Great Shelford (SW92/5) along Granham’s Road and through White Hill to the Babraham Road Park and Ride site near Newbury Farm (BRM). Point SW92/5 near De Freville Farm, Great Shelford, shows 3m of gravel and sand overlying bedrock Chalk at c.15m OD. To the northeast near the Granham’s Road railway crossing, points 95/12 to 95/1 show 0.5m of silty clay overlying 1m of gravel and sand with a base not touching bedrock at c.15m OD. Close by, points 29/12 and 29/10 record gravel on bedrock Chalk at c.15.5m OD, and north of Granham’s Farm points 28/1 to 23/7 record bedrock close to the surface beneath topsoil at 16-18m OD. Points 23/5 to 23/1 show sandy clay 1m thick on bedrock Chalk at 18-19m OD, and upslope at 19-23m OD points 48/6 to 48/22 show gravel and sand overlying a chalk putty comprising chalk pellets in a finer matrix. The thickness of the chalk putty was hard to judge in the field, although it seems to represent a mantle of solifluction material particularly associated with steeper chalk slopes. Further along Granham’s Road, points 58/1 to 58/12 show 0.5m of sandy clay, occasionally overlying gravel on chalk putty at 25-31m OD. Point SW113/1 records bedrock Chalk close to the surface beneath 0.5m of topsoil at c.30m OD. Near the top of White Hill (34-39m OD), points 69/1 to 75/10 also show bedrock Chalk close to the surface beneath topsoil with no trace of chalk putty, although point 75/12 at the summit shows sandy clay overlying bedrock Chalk at c.40m OD. On the northeast flank of White Hill, points 75/9 to 75/3 show bedrock close to the surface at 39-36m OD, and points 75/2 and 75/1 show sandy clay on bedrock at c.36m OD. At the foot of White Hill at the Babraham Road Park and Ride Site near Newbury Farm, point BRP records sandy clay overlying 1.5m of chalky gravel and sand on bedrock Chalk at c.18m OD. Close by, points BRH to BRM show a complex sequence of sediments 2.5m thick comprising sandy clay overlying gravel and chalk putty resting on bedrock Chalk at 27.5m OD.

### 8.10.4.11 Geological Section 45/50.10

This 3.5km-long section (Figure 8.10.4-10) runs roughly parallel to 45/50.9 southwest-northeast from Great Shelford (SW92/4) through Clarke’s Hill to Caius Farm, Babraham Road (205/230). In Great Shelford, point SW92/4 shows 0.5m of clay with gravel overlying 2.5m of gravel and sand on bedrock at c.14m OD, and point 205/76 records 3m
of unknown drift on bedrock at c.15m OD. At the foot of Clarke’s Hill, points 55/7 to 56/2 record 1m of sandy clay overlying bedrock Chalk at 19-24m OD. Upslope, points 67/11 to 67/1 show sandy clay, in places overlying chalk putty and elsewhere resting on Chalk bedrock at elevations between 29m and 38m OD. Near the top of Clarke’s Hill, points 73/1 to 73/9 record chaotically bedded cobbles with a base not reaching bedrock at c.44m OD) overlain by 1m of gravel and sand. The deposits sampled at point 73/2 were remarkable not only for the relatively large clasts they contained, but also for the conspicuous presence of various clasts of exotic lithologies (see 8.11.2 ). It is proposed that the gravel unit here is formally named the **Clarke’s Hill Gravel** with the stratotype at point 73/2 (TL 4712 5349). In contrast on the northeast flank of Clarke’s Hill, points 74/7 to 79/7 record sandy clay overlying bedrock Chalk at 45-42m OD. Downslope, points 79/8 to 79/16 also show sandy clay overlying bedrock, and points 79/17 to 85/1 show bedrock Chalk close to the surface beneath topsoil at 36-33m OD. To the northeast at Caius Farm on Babraham Road, point 205/230 records bedrock Chalk close to the surface at c.22m OD.

**8.10.4.12 Geological Section 45/50.11**

This 3km-long section (Figure 8.10.4-11) follows a slightly erratic course roughly northwest-southeast from Babraham Road (205/226) through Wandlebury to Wormwood Hill (205/509). On Babraham Road, points 205/226 and 205/549 show bedrock Chalk close to the surface beneath topsoil at c.36m OD. At Heath Farm, point 205/74 also records bedrock Chalk close to the surface at c.50m OD. However, point SW80/1 shows 1m of topsoil overlying 3m of gravel and sand with a base not touching bedrock at c.69m OD. Close to Telegraph Clump, point WD shows 1.5m of gravel and sand on bedrock Chalk at c.71m OD, and point WF shows 2m of gravel and sand on bedrock at c.69m OD. Nearby, point WE shows bedrock Chalk close to the surface at c.72m OD, and at Wandlebury points 205/81 and WO also record bedrock close to the surface. Downslope, point WN shows bedrock Chalk near the surface at 67m OD, and point WT shows gravel on bedrock at a similar elevation. At the foot of Wormwood Hill, point 205/509 records bedrock Chalk close to the surface beneath topsoil at c.45m OD.

**8.11 Site Descriptions 5km Square TL 245/550**

**8.11.1 Babraham Road Park and Ride Site**

**Synopsis**

In September 1998 the author was invited to an archaeological investigation at the Babraham Road Park and Ride site near Newbury Farm (points BRA to BRQ). Topsoil
had been cleared from the site, and trenches had been cut into material superficially resembling bedrock Chalk. Closer investigation revealed that this was actually a unit of chalk putty 1m thick composed of chalk pellets in a finer carbonate matrix, the surface in places incised by gravel filled scours. This chalky solifluction material could easily have been mistaken for the disturbed surface of the Chalk bedrock had it not been for the fact that it was clearly underlain by a unit of carbonate-rich silty clay 1m thick containing tubules and oospores of the alga *Chara*, indicating deposition in aquatic conditions. Pollen analysis of the silty clay unit at point BRF (Table 8.11.1-1) shows the assemblages to be dominated by herbs (75%) including Poaceae (grass) (37.5%), Asteraceae (Cardueae/Asteroideae) (Daisies) (12.5%) and Caryophyllaceae (Pinks) (12.5%). Only *Betula* (birch) (12.5%) represents tree pollen, and the aquatic habitat is confirmed by the presence of *Nuphar* (yellow waterlily) pollen (12.5%). This limited pollen assemblage is interpreted as representing open grassland, perhaps with birch scrub, surrounding a pool or lake. However, the *Betula* pollen might originate from dwarf species rather than from trees. Other pollen analyses from the silty clay unit at point BRPitl were dominated by grass, and point BRL was barren. An OSL date on the silty clay from point BRF gave an age of 14,200 ± 2,300 years BP indicating a Late Glacial, and possibly Windermere Interstadial (Allerød) age for these sediments. The overlying chalk putty might therefore originate from intense periglacial activity during the Loch Lomond Stadial (Younger Dryas) c.11,000 to 10,000 years BP.

### 8.11.2 Clarke’s Hill

#### 8.11.2.1 Introduction

A trench cut for an archaeological investigation near the crest of Clarke’s Hill, Great Shelford, (TL 4712 5349) at c.45.3m OD exposed a matrix supported medium to fine grade gravel with indistinct inclined bedding 1.4m thick, overlying a unit of chaotically bedded clast supported cobbles at points 73/1 to 73/9.

#### 8.11.2.2 Clast size

A bulk sample taken by the author from the cobble unit contained 57 clasts between 50mm and 280mm in length, with the majority (66.7%) in the 64-128mm size class (Table 8.11.2-1). The largest clast, a boulder of Jurassic fossiliferous limestone 280mm long, weighed 12.5kg. In contrast, the overlying gravel unit contained very few large clasts (1.9%) in the 16-32mm size range (Appendix 1.5). Figure 8.11.2-1 shows a comparison of clast size for the cobble unit and overlying gravel from point 73/2. The significance of the coarse grade of these cobbles is highlighted by the fact that no pebbles >64mm were encountered in any other samples analysed by the author during this project, or indeed by
the British Geological Survey Mineral Assessment Reports within the study area. It is clear that the clast size distributions represent deposition in two very different depositional regimes. The cobble unit must represent a high-energy depositional environment, whilst the overlying gravel is typical of deposition by a small stream.

8.11.2.3 Clast Lithology

The clasts recovered from the cobble unit, were washed, measured and identified by the author (Table 8.11.2-1). To facilitate identification, Dr C. V. Jeans, Department of Earth Sciences, University of Cambridge, kindly sectioned some clasts with a rotary diamond saw. It is notable that in contrast to the majority of other gravel samples analysed by the author, many of the limestone clasts were clearly derived from the Carboniferous Limestone, rather than local Jurassic sources. In addition, other far-travelled cobbles composed of easily distinguishable granite, schist, Millstone Grit and Whin Sill dolerite were identified. This resulted in a large (c.50%) exotic component, with c.40% local lithologies and c.10% chalk and flint. Conversely, the overlying gravel contained 1.9% exotics, 18% local lithologies, 21.4% flint and 58.7% chalk. The two samples clearly have thoroughly different clast lithologies and the provenance of each must be markedly different. The large exotic component of the cobble unit is interpreted as being glacial or derived from glacial sources, whilst the large chalk component of the overlying gravel strongly suggests it is derived from a relatively small stream draining a catchment dominated by Chalk bedrock.

8.11.2.4 Conclusions

The coarse grade of the cobbles and the large exotic component of the clasts suggests a high-energy sub-glacial or pro-glacial environment of deposition. In contrast, the overlying predominantly medium-grade flint and chalk gravel unit appears to have been laid down by a relatively small stream draining a catchment dominated by Chalk bedrock. The elevated position of these deposits and the obvious glacial derivation of the cobbles strongly suggest an Anglian (MIS 12) age for these deposits.

8.12 Correlation of Stratigraphic Units

5km Squares TL 245/50 and TL 240/50

8.12.1 Synopsis

Figure 8.12.1-1 and Table 8.12.1-1 show details of the 25 stratigraphic units proposed for the 5km Squares 240/50 and 245/50. The valleys of rivers Rhee, Cam and Granta are
confluent in this square, and this is reflected in the large number of stratigraphic units occupying valley floor and valley side positions. In contrast, the Rectory Farm Silty Clay and Trumpington Railway Cutting Gravel occupy low ridges, and to the east the Magog Down Gravel and Gog Magog Gravel cap the higher land. The Clarke’s Hill Gravel is also worthy of note due to the relatively large clasts of exotic lithologies that it contains.

Table 8.12.1-2 and Figure 8.12.1-2 show the chronological and stratigraphic relationships of these units and their correlation with lithostratigraphic members and formations. Figure 8.12.1-3 presents an idealised geological section through the area showing the relationships of the various lithostratigraphic members (Table 1.4.2-1). The Gog Magog Gravel becomes the stratotype of the Wandlebury Member of the Lowestoft Formation. It is correlated with the Magog Down Gravel and the Clarke’s Hill Gravel. These sediments are interpreted as high-level headwater stream deposits of probable Anglian age, and the Clarke’s Hill Gravel also clearly contains a component of glacial outwash.

The Granham’s Farm Gravel, Great Shelford Gravel, Stapleford Gravel, Hobson’s Brook Gravel, De Freville Farm Gravel, Rectory Farm Gravel, Black Barn Gravel, and Trumpington Railway Cutting Gravel are correlated with the Impington Village Member of the Cam Valley Formation. The Cambridge Road Silty Clay, Rectory Farm Silty Clay, and Glebe Farm Silty Clay are correlated with the Grantchester Member of the Cam Valley Formation. These members are correlated with each other and are interpreted as elevated gravels and fines of the River Cam system belonging to the later part of the ‘Wolstonian’ interval (MIS6/7). The Granham’s Farm Silty Clay and Shelford Road Silty Clay are correlated with the Histon Road Member of the Cam Valley Formation, and are interpreted as Ipswichian to Early Devensian (MIS 5a/e) temperate and cold stage fines of the River Cam. The Hauxton Village Gravel, Shepherd’s Cottage Gravel and Hauxton Mill Gravel are correlated with the Sidgwick Avenue Member of the Cam Valley Formation. These deposits are interpreted as Middle to Late Devensian (MIS 2/3) braidplain deposits of the River Cam system. The University Arms Farm Gravel, Lingey Fen Gravel and Babraham Road Silty Clay are correlated with the Midsummer Common Member of the Cam Valley Formation. The Babraham Road Silty Clay is interpreted as Late Devensian (Late Glacial) (MIS 2) thaw lake deposits, while the remaining units are interpreted as Late Devensian (Late Glacial) (MIS 2) gravels of the River Cam. The Bourn Brook Silty Clay, University Arms Farm Peat and Lingey Fen Peat are correlated with the Jesus Green Member of the Cam Valley Formation, and are interpreted as Flandrian (MIS 1) alluvium and fen deposits of the River Cam and its tributaries.
These deposits represent material of probable Anglian age separated by a considerable gap from younger deposits stretching from the later part of the ‘Wolstonian’ interval, through the Devensian to the Flandrian. There appears to be appreciable complexity within part of the sequence, making the exact relationship between units difficult to determine.
Chapter 9

10km Square TL 250/550

Fulbourn and Balsham

Where the pools are bright and deep,
Where the trout lies asleep,
Up the river and over the lea,
That's the way for Billy and me.

A BOY'S SONG
James Hogg
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9.1 10km Square TL 250/50

9.1.1 Synopsis
This ten-kilometre square is located at the eastern edge of the main study area and contains 31 monads with data (Figure 9.1.1-1). The area includes the villages of Fulbourn to the west, Great and Little Wilbraham to the north, Babraham to the southwest and Balsham to the southeast. There is a low-lying area of fen in the northwest of the square at 10m OD. The area gradually rises towards the south and east reaching c.50m near Hare Park in the northeast, and c.60m at Meggs Hill to the southwest. The land near Balsham in the south east corner reaches c.120m OD. In contrast, Babraham in the southwest corner of the square is situated in the Granta valley at c.25m OD.

9.1.2 Drainage
The drainage of this area is generally towards the northwest. There is an extensive system of dry valleys and a number of Chalk springs, some of which feed tributaries of Quy Water which drains the low-lying area known as Little Wilbraham Fen near Fulbourn. The River Granta at Babraham flows northwest, and joins the River Cam and River Rhee, before turning northeast through Cambridge.

9.1.3 Bedrock geology
The bedrock geology comprises Lower, Middle and Upper Chalk broadly dipping towards the southeast (Figure 9.1.3-1).

9.1.4 Quaternary geology
The Quaternary geology mapped by the BGS (Figure 9.1.3-1) comprises Boulder Clay (till) on the higher ground near Balsham, various high-level ‘Taele’, ‘Glacial’ and ‘Head Gravels’ near Hare Park, Six Mile Bottom, Great Wilbraham Hall Farm, and to the southwest at Worsted Lodge and Meggs Hill. In addition, there is a spread of 4th Terrace Deposits at Little Wilbraham leading northwest towards Quy Mill. There is also a complex
area of 2nd and 1st Terrace Deposits and Peat in the low-lying depression north and east of Fulbourn. In the Granta valley near Babraham, 3rd Terrace Deposits and undifferentiated 2nd and 1st Terrace Deposits, and Alluvium are recorded.

9.2 5km Square TL 250/55 Fulbourn

9.2.1 Synopsis

This five-kilometre square contains 15 monads with 75 points (Figures 9.2.1-1 & 9.2.1-2). The area includes the villages of Fulbourn to the south, Teversham to the west, Little Wilbraham and Great Wilbraham to the east and Stow-cum-Quy to the north. The area includes the A14 and A1303 roads. The A14 provides a significant number of points in this square.

9.2.2 Drainage and relief

This square is dominated by a low-lying area of fen to the north and east of Fulbourn at 10m OD. This depression known variously as Little Wilbraham Fen and Fulbourn Fen, and is drained by Quy Water and its tributaries Caudle Ditch and the Little Wilbraham River which are fed by a number of perennial springs in the Chalk at c.15m OD. Several dry valley systems (including the Fulbourn Valley) also drain into this area from the south and east where the land rises c.50m OD. Little Wilbraham Fen is confined to the north by a northwest-southeast trending ridge capped by gravel. Water drains northwards from the low-lying area through a narrow gap in the ridge at Quy Mill.

9.2.3 Geology

The bedrock geology comprises Lower and Middle Chalk underlain by Gault Clay broadly dipping towards the southeast (Figures 9.2.3-1 & 9.2.3-2). The Quaternary geology (Figures 9.2.3-1 & 9.2.3-2) comprises a ridge of 4th Terrace Deposits at c.20m OD running across the north of the square. Little Wilbraham Fen is mapped as containing both 2nd and 1st Terrace Deposits and Peat between 8 and 10m OD.

9.2.4 Geological Logs and Sections

9.2.4.1 Synopsis

The 75 points comprise 10 records (FNRA-J) collected by the author and 65 records from secondary sources. These include 21 from the British Geological Survey Well Catalogue Series (Matthews and Harvey, 1965, Sayer and Harvey, 1965), two from the Cambridge Memoir (Worssam and Taylor, 1969), 13 from various civil engineers archives and 29 from the Highways Agency archives.
9.2.4.2 Geological Section 50/55.1

This section (Figure 9.2.4-1) follows an early proposed line of the A14 road for 2km from Quy Water Farm to Church Farm in Stow-cum-Quy. It provides a detailed record of the drift geology across the narrow outlet of Little Wilbraham Fen the bounding ridge of 4th Terrace Deposits (Figures 9.2.3-1 & 9.2.3-2).

North of Quy Water Farm, bedrock Chalk is recorded at c.7m OD beneath topsoil at b5203. A low ridge at c.10m OD (a5205 to a5208) is capped by 1m of brown, chalky pebbly sandy clay. As the slope descends towards Quy Mill, points a5209 and a5210 record 1m of clayey sand and gravel, apparently overlying sandy clay with pebbles. At point a5211 clayey sand and gravel is recorded overlying bedrock Chalk at c.7m. It is proposed that this gravel unit is formally named the Quy Water Farm Gravel, with the stratotype at a5211 (TL 5063 5974).

Near Quy Mill at the bottom of the narrow outlet, point a5212 records Chalk at c.5m OD near the surface beneath topsoil. The valley is more typically floored by 2m of soft peat overlying bedrock Chalk. At points b5215 and b5217 the surface of the peat is at c.5m OD, but to the east the peat surface is at c.7m OD. The peat is underlain at point b5221 by a sand and gravel, and at point b5219 the material is a sandy clay with peat. It is proposed that this peat unit is formally named the Quy Mill Peat, with the stratotype at b5215 (TL 5083 5969). The west-facing slopes of the valley (a5224 to b5226) have topsoil in places overlying buff chalky sandy clay with pebbles rising c.13m OD. Further up the slope points b5227 to a5231 record 2m of brown, often clayey gravel and sand. At point b5227 the gravel overlies bedrock Chalk at c.14m OD. This gravel spread is mapped as 4th Terrace Deposits on the geology map, and rises to c.17m OD (Figure 9.2.3-1). It is proposed that this gravel unit is formally named the Church Farm Gravel, with the stratotype at a5230 (TL 5140 5980).

9.2.4.3 Geological Section 50/55.2

This 3km-long section (Figure 9.2.4-1) runs south-north from Great Wilbraham, through Little Wilbraham to a point near the A14 road (188/286 to TA27). The section traverses the relatively low-lying area between Great Wilbraham and Little Wilbraham (188/286 to 188/294), and records only topsoil overlying bedrock Chalk. However, point CD106/4 north of Little Wilbraham Church records 3m of gravel and sand overlying bedrock Chalk at c.17m OD. This area of gravel rises to 20m OD and is mapped as 4th Terrace Deposits on the geology map (Figure 9.2.3-1). This gravel unit has been formally named the Little Wilbraham Gravel, with the stratotype at CD106/4 (TL 5460 5870) by the author in Bowen (1999). The final point in the section (TA27) records 3m of silty
clay with pebbles overlying bedrock Chalk at c.12m OD. The geology map shows no drift deposits near this location, and the derivation of this material remains unclear.

9.2.4.4 Geological Section 50/55.3

This 2km-long section runs roughly southeast-northwest from Fulbourn (205/28) to Manor Farm, Teversham (188/108) (Figure 9.2.4-2). The points in Fulbourn village at c.11m OD (205/28 and 205/176) record only topsoil overlying bedrock Chalk. The section crosses a broad depression between Fulbourn and Teversham that appears devoid of deposits on the geology map (Figure 9.2.3-1). Point TA30 adjacent to Fernleigh Farm in the middle of the depression records 2m of sandy clay with pebbles overlying bedrock Chalk at c.6m OD. Nearby, points ea48 to ea42 record 1m of white/brown mottled sandy silty clay overlying bedrock Chalk at c.8m OD. It seems likely that these are facies variations within the same deposit filling the floor of the depression. It is proposed that this sandy clay unit is formally named the **Fernleigh Farm Sandy Clay**, with the stratotype at TA30 (TL 5061 5728). Further north at Manor Farm (188/108), 1m of topsoil is recorded overlying bedrock Chalk.

9.2.4.5 Geological Section 50/55.4

This 3km-long section is aligned southeast-northwest from Fleam Dyke (205/91) through Fulbourn Nature Reserve, near Mill Gardens Cottage (FNRA to FNRJ) to Station Road, Fulbourn (205/95) (Figure 9.2.4-2). The point near Fleam Dyke (205/91) at c.30m OD records only topsoil overlying bedrock Chalk. The section crosses the broad depression into which the Fulbourn Valley drains. The geology map (Figure 9.2.4-2) indicates Peat and 1st-2nd Terrace Deposits in this area. A series of boreholes and ditch sections made by the author (FNRA to FNRJ) reveal this to be accurate. At the edge of the depression point FNRA recorded topsoil and sandy clay overlying Chalk bedrock. Nearby, points FNRB and FNRC at c.13m OD show peat overlying sandy clay. Further north points FNRD to FNRH record peat overlying 1m of chalky silty gravel and sand. It is proposed that this gravel unit is formally named the **Mill Gardens Gravel**, with the stratotype at FNRF (TL 5321 5588). Thin peat overlying sandy clay is also recorded at FNRI, but at FNRJ topsoil and sandy clay overlies gravel and sand. In contrast, at Station Road, Fulbourn points 205/565 and 205/95 record only topsoil overlying bedrock Chalk.

9.3 5km Square TL 250/550 Babraham

9.3.1 Synopsis

This five-kilometre square contains 16 monads with 91 points (Figures 9.3.1-1 & 9.3.1-2). The area includes the village of Babraham to the southwest, and part of the
Parish of Little Abington to the southeast and Fulbourn to the north. The area includes the A1307 and the A11 roads, the latter providing the majority of records.

9.3.2 Drainage and relief
The northern part of the square is dominated by a dry valley system, the Fulbourn Valley, which rises from c.15m OD towards two parallel lines of hills that run northwest-southeast across the square (Figure 9.3.1-1). A smaller dry valley system extends south of Worsted Lodge towards the valley of the River Granta near Babraham at c.25m OD. To the southeast beyond Worsted Lodge and the A11 road, the land rises to c.90m OD. The River Granta at Babraham represents the only perennial drainage in this square. However, minor spring and seepage lines in the Chalk allow seasonal flow to enter the dry valley systems.

9.3.3 Geology
The bedrock geology comprises Lower and Middle Chalk broadly dipping towards the southeast (Figures 9.3.3-1 & 9.3.3-2). The Quaternary geology (Figures 9.3.3-1 & 9.3.3-2) comprises a patch of Boulder Clay (till) on the highest ground (c.90m OD) at Gunner’s Hall, and at the Claypit Plantation on the A11 road south of Worsted Lodge. ‘Taele Gravel’ at c.50m OD and ‘Glacial gravel’ at c.60m OD are mapped capping the two parallel lines of hills which run northwest-southeast across the area. In the Granta valley near Babraham, 3rd Terrace Deposits and undifferentiated 2nd and 1st Terrace Deposits, and Alluvium are recorded.

9.3.4 Geological Logs and Sections
9.3.4.1 Synopsis
The 91 points are all from secondary sources and comprise 20 from the British Geological Survey Well Catalogue Series (Sayer and Harvey, 1965), one from the Saffron Walden Memoir (White, 1932) and 70 from the Highways Agency archives.

9.3.4.2 Geological Section 50/50.1
This section (Figure 9.3.4-1) follows the line of the A11 road for 5km from the Four Went Ways to Worsted Lodge and then northeast to Beech Tree Cottages. It provides a detailed record of the drift geology across an area located between two parallel lines of gravel-topped hills to the northwest and higher land to the southeast. The geology map records few drift deposits along the line of the A11 road. In the vicinity of Four Went Ways, several points (for example bh28b) record 1m of gravel and sand overlying bedrock Chalk at c.33m OD.

For the next kilometre (bh31 to bh37) there is only topsoil recorded covering bedrock Chalk, and little evidence for the patches of Boulder Clay (till) north of Four Went Ways,
which appear on the geology map. Near the Claypit Plantation tp38 and tp40 each record 1m of red/orange/brown sandy clay with pebbles, while between these points bh39 at c.43m OD records 3m of gravel and sand overlying bedrock Chalk. It is proposed that this gravel unit is formally named the **Claypit Plantation Gravel**, with the stratotype at bh39 (TL 5260 5124). A patch of Boulder Clay (till) is mapped at this location together with an adjacent and apparently overlying spread of ‘Glacial Gravel’ to the east. It seems probable that the sandy clay represents slope-wash or sediments associated with the gravel in bh39 rather than the indicated till.

The next kilometre of section (bh41 to tp55) records only topsoil over Chalk bedrock, despite the proximity of a patch of ‘Taele Gravel’ mapped some 300m to the northwest. As the line of section descends the southwest flank of the Fulbourn Valley towards Charterhouse Plantation from c.40m to c.32m OD, various deposits overlying bedrock Chalk become evident. These are characterised at bh57 by 1m of chalky gravel and sand at c.40m OD overlying bedrock Chalk, while nearby bh56 records 1m of sandy clay. It is proposed that this gravel unit is formally named the **Heath Plantation Gravel**, with the stratotype at bh57 (TL 5354 5271). At a lower elevation, tp59 to tp60 record sandy clay with pebbles. At the bottom of the Fulbourn Valley bh62 records 1m of sandy clay with pebbles overlying bedrock Chalk. These deposits presumably derive from the past development of the Fulbourn Valley drainage system. It is proposed that this sandy clay unit is formally named the **Charterhouse Plantation Sandy Clay**, with the stratotype at bh62 (TL 5386 5308).

In contrast, the northeastern flank of the Fulbourn Valley has only topsoil covering Chalk bedrock (tp66 to tp68). The final kilometre of this section (bh71b to tp82) falls toward Beech Tree Cottages from c.41m to c.35m OD and records chalky sandy clay overlying Chalk bedrock at bh71b, tp75, tp79 and bh81.

### 9.3.4.3 Geological Section 50/50.2

This 1km-long section (Figure 9.3.4-2) follows the northwest-southeast line of the Balsham Road from New Shardelowes Farm across the A11 road and Charterhouse Plantation (205/233 to bh72). With the exception of the sandy clay already described above, only topsoil covering Chalk bedrock is recorded. This apparent paucity of drift deposits on the northeastern flank of the Fulbourn Valley agrees with the observations made in Section 9.3.4.2 (tp66 to tp68).

### 9.3.4.4 Geological Section 50/50.3

This 2km-long section is aligned roughly northwest-southeast between Valley Farm and the A11 road at Worsted Lodge (Figure 9.3.4-2). It is notable that drift is apparently
absent even on the floor of this arm of the Fulbourn Valley and that only topsoil overlies bedrock Chalk. An overgrown pit at c.52m OD (SW84/6) described in the Saffron Walden Memoir records 2m of chalky gravel and sand. Bedrock Chalk is not recorded here, so the total thickness of gravel is unknown. It is proposed that this gravel unit is formally named the **Worsted Lodge Gravel**, with the stratotype at SW84/6 (TL 5278 5250). A spread of ‘Taele Gravel’ is mapped at this location capping the elongate hill northwest of Worsted Lodge.

**9.3.4.5 Geological Section 50/50.4**

This 2km-long section runs roughly west-east from Babraham Hall to the Four Went Ways (Figure 9.3.4-2). Although the geological map indicates that point 205/352 should be located on undifferentiated 2nd and 1st Terrace Deposits of the River Granta, none are recorded. Bedrock Chalk is also recorded from point 205/355 near the A1307 road, but at point tp30 north of the Four Went Ways there is 0.5m of sandy clay. The gravel at point bh28b is described above, but nearby at c.33m OD point bh29 records 1m of gravel and sand. It is proposed that this gravel unit is formally named the **Four Went Ways Gravel**, with the stratotype at bh29 (TL 5231 5001). There are no drift deposits marked on the map in this location, but this gravel is probably part of the adjacent patch of 3rd Terrace Deposits shown to the west in Figure 9.3.3-1.

**9.4 Correlation of Stratigraphic Units**

**5km Squares TL 250/55 and TL 250/50**

**9.4.1 Synopsis**

Figure 9.4.1-1 and Table 9.4.1-1 show details of the 11 stratigraphic units proposed for the 5km Squares 250/55 and 250/50. These units occupy different positions in the landscape at a variety of elevations. The Worsted Lodge Gravel occupies a high-level ridge between the valley of the River Granta and the Fulbourn Valley, and several of the other units occupy lower ridges above the level of the current valley systems. The remainder of the members occupy valley floor positions or valley side positions and consist of gravels, sandy clays and peat, many of which are not recognised by the BGS.

Table 9.4.1-2 and Figure 9.4.1-2 show the chronological and stratigraphic relationships of these units and their correlation with lithostratigraphic members and formations. Figure 9.4.1-3 presents an idealised geological section through the area showing the relationships of the various lithostratigraphic members (Table 1.4.2-1). The Worsted Lodge Gravel is correlated with the Wandlebury Member of the Lowestoft Formation, and is interpreted as
elevated headwater stream deposits and possibly glacial outwash of probable Anglian (MIS 12) age.

The Little Wilbraham Gravel becomes the stratotype of the Little Wilbraham Member of the Cam Valley Formation, and is correlated with the Church Farm Gravel. These deposits are interpreted as gravels of a large, but now extinct tributary of the River Cam system dating from the Early Devensian (MIS 4) or possibly the later part of the ‘Wolstonian’ interval. The Four Went Ways Gravel is correlated with the Arbury Member of the Cam Valley Formation, and interpreted as Early Devensian (MIS 4) gravels of the River Granta. The Quy Water Farm Gravel, Claypit Plantation Gravel and Heath Plantation Gravel are correlated with the Sidgwick Avenue Member of the Cam Valley Formation. These deposits are interpreted as Middle to Late Devensian (MIS 2/3) gravels of various elevated tributaries of the River Cam system. The Mill Gardens Gravel is correlated with the Midsummer Common Member of the Cam Valley Formation, and is interpreted as Late Devensian (Late Glacial) (MIS 2) gravels of the Fulbourn Valley. The Fernleigh Farm Sandy Clay, Charterhouse Plantation Sandy Clay, and Quy Mill Peat are correlated with the Jesus Green Member of the Cam Valley Formation, and are interpreted as Flandrian (MIS 1) slope wash, alluvium and fen deposits of various tributaries of the River Cam.

The oldest deposits represented are of probable Anglian age, although there is a considerable gap between these, and a sequence stretching from the Early Devensian to the Flandrian. The fragmentary nature of the deposits makes the precise relationship between units difficult to determine.
Chapter 10

10km Square TL $^{230/540}$

Royston and Melbourn

*Speak to me of summers, and of long winters, longer than time can remember,*
*And the setting up of other roads to travel on in old-accustomed ways,*
*I still remember the talk by the water, and the proud sons and daughters that,*
*Knew the knowledge of the land, and spoke to me in sweet-accustomed ways.*

*STARSHIP TROOPER*
*Jon Anderson*
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10.1 10km Square TL 230/540

10.1.1 Synopsis

This ten-kilometre square is located at the southwest edge of the main study area. The author has restricted attention to a single 5km Square which contain only 3 monads with data (Figure 10.1.1-1). The ten-kilometre square includes the villages of Barrington, Shepreth, Meldreth and Melbourn to the east, the town of Royston to the south, Croydon, Abington Pigotts and Litlington to the west, and Bassingbourn, Kneesworth and Whaddon at the centre. The valley of the River Rhee (c.20m OD) is the main line of drainage running west-east through the northern part of the square. There is an area of elevated relief (c.90-100m OD) to the south and east of Royston, and northwest of Croydon the land rises to c.80m OD.

10.1.2 Drainage

This entire square is part of the River Rhee catchment. Several small tributaries drain the more elevated areas to the north and south, although there are extensive dry valley systems developed in the south of the square near Royston.

10.1.3 Bedrock geology

The bedrock geology comprises Gault Clay overlain by Lower and Middle Chalk broadly dipping towards the southeast (Figure 10.1.3-1).

10.1.4 Quaternary geology

The Quaternary geology mapped by the BGS (Figure 10.1.3-1) comprises Boulder Clay (till) on the elevated area near Croydon to the northwest, and on a ridge and valley side east of Royston. Broad patches of ‘Taele Gravel’ are mapped on the floor and sides of a valley near Noon’s Folly Farm, east of Royston, and small patches of 3rd Terrace Deposits are mapped near Barrington. Undifferentiated 1st and 2nd Terrace Deposits are also mapped.
between Barrington and Shepreth in the northeast of the square. Alluvium is confined to the floor of the River Rhee valley and its tributaries.

**10.2 5km Square TL 235/35 Meldreth**

**10.2.1 Synopsis**

This five-kilometre square contains 3 monads with 14 points (Figures 10.2.1-1 & 10.2.1-2). The area includes the village of Barrington to the northeast, and Shepreth and Meldreth to the east and south. The majority of points in this square are from boreholes made by the author. The area includes at Barrington the site known as Cardo’s Pit, sections from which were described by Mrs McKenny-Hughes (1888), Prof. McKenny-Hughes (1911, 1916), and Sparks (1952).

**10.2.2 Drainage and relief**

This square comprises the broad valley of the River Rhee c.15-20m OD. The drainage is principally towards the east, although several small tributaries including the River Mel and River Shep, drain the higher areas to the north and south.

**10.2.3 Geology**

The bedrock geology comprises Gault Clay overlain by Lower Chalk. These beds dip broadly towards the southeast (Figures 10.2.3-1 & 10.2.3-2). The Quaternary geology comprises small patches of 3rd Terrace Deposits north of the River Rhee at Barrington, and an area of Undifferentiated 1st and 2nd Terrace Deposits between Barrington and Shepreth. Alluvium is confined to the floor of the River Rhee valley and its tributaries.

**10.2.4 Geological Logs and Sections**

**10.2.4.1 Synopsis**

Secondary sources accounted for 4 of the 14 points which comprise a record (C1948) from Cardo’s Pit visited by the Geological Congress of 1948 (Sparks 1952), a further record (C1916) from Cardo’s Pit described by Prof. McKenny-Hughes (1916), and a record (C1911) from the eastern part of Cardo’s Pit (Prof. McKenny-Hughes1911). A record from an earlier pit (W1888) north of Barrington windmill (Mrs McKenny-Hughes1888) has also been included. The remaining 10 records are from boreholes put down by the author in an attempt to understand the relationships of the various deposits in this area.
10.2.4.2 Geological Section 35/45.1

This section (Figure 10.2.4-1) runs roughly northwest-southeast from an area east of Trinity Farm and north of Bleak House (BBH9) through Riverside Meadows (BBH6) to Willer’s Mill, Shepreth (WM1). It provides a detailed record of the drift geology through the area south of Bleak House, formerly known as Cardo’s Pit. The section crosses a patch of 3rd Terrace Deposits, Alluvium of the River Rhee and an area of Undifferentiated 1st and 2nd Terrace Deposits (Figures 10.2.3-1 & 10.2.3-2).

North of Bleak House, points BBH9 to BBH7 record bedrock Chalk, partly consisting of Cambridge Greensand, beneath topsoil close to the ground surface at c.22m OD. However, point BBH4 shows 1m of grey/white marly silty clay, and point BBH3 records 2m of a similar material overlying Chalk bedrock at c.19m OD. Further downslope, point BBH2 records 1m of buff silty sand clay overlying 1m of white marly silty clay with bone fragments, in turn overlying gravel and sand at c.17m OD. Unfortunately, the author’s attempt to extract pollen from the lower silty clay was not successful (Table 10.3.1-1). To the south, BBH1 recorded a similar sequence with 0.5m of sandy clay overlying 1m of marly silty clay, in turn overlying gravel and sand on Gault Clay bedrock at c.16m OD. On the floor of the River Rhee valley at Riverside Meadows, point BBH6 records silty clay over gravel and sand. This in turn overlies 1m of peat, and 3.5m of silty clay with peat and shells, on 0.5m of gravel and sand at c.10m OD. It appears that these detrital peaty deposits represent Flandrian fluvial accumulation and apparently occupy a buried channel beneath a alluvial spread. It is proposed that this organic unit is formally named the Riverside Meadows Peat, with the stratotype at BBH6 (TL 3854 4896). Adjacent to Riverside Meadows, there is a small but marked rise to the south, which in morphostratigraphic terms might be taken as a terrace surface, although no Terrace Deposits are marked of the BGS map geology. In this location point BBH5 shows 0.5m of gravel and sand overlying a organic silty clay, in turn overlying gravel on bedrock Chalk at c.15m OD. A sample of silty clay from 95cm depth was analysed for pollen (Table 10.3.1-1) and yielded a assemblage dominated by grass and herbs, with low frequencies of tree pollen. At Willer’s Mill, Shepreth a trial excavation for a fox enclosure was further investigated using a hand auger. Point WM1 shows 1m of gravel and sand overlying bedrock Chalk at c.16m OD. Anecdotal evidence suggests that 2-3m of gravel and sand have in the past been exposed elsewhere in Shepreth village. It is proposed that this gravel unit is formally named the Shepreth Gravel, with the stratotype at WM1 (TL 3940 4820).
10.2.4.3 Geological Section 35/45.2

This section (Figure 10.2.4-1) runs roughly southwest-northeast across the site of the former Cardo’s Pit, south of Bleak House. It provides a record of the drift geology through this patch of 3rd Terrace Deposits.

Data point C1948 records 1m of chalk clay with gravel on gravel and sand, in turn overlying 1m of sandy silty clay and gravel and sand on bedrock Chalk at c. 18m OD. In contrast, point C1916 in the same pit shows 5m of sandy silty clay (the upper 2m thought to be reworked Chalk) overlying 1m of fossiliferous clayey gravel and sand on bedrock Chalk at c. 14m OD. This material and similar deposits from pits east of Barrington have often been referred to as the Barrington Beds (Fisher, 1879), and were formally named the Barrington Village Beds in Bowen (1999) (Section 11.2.4.2). It is proposed that the silty clay unit at this location is formally named the Cardo’s Pit Silty Clay, with the stratotype at C1916 (TL 3826 4914). To the east point BBH2 records 1m of buff, and silty sand clay overlying 1m of grey, white and marly silty clay with bone fragments, in turn overlying gravel and sand at c. 17m OD. Point C1911 shows 3m of sandy silty clay with shells and bones with a pebble bed at the base overlying bedrock Chalk at c. 14m OD, and point W1888 records 2m of sandy silty clay ‘loam’ on bedrock Chalk at c. 16m OD.

10.3 Site Description 5km Square TL 35/45

10.3.1 Cardo’s Pit, Barrington

10.3.1.1 Introduction

Fisher (1879) first described the fossiliferous deposits at Barrington from a pit east of the village. Sections of similar deposits (W1888) were subsequently exposed in coprolite workings west of Barrington village at a location north of the windmill (Mrs McKenny-Hughes 1888). It appears that this was the precursor of what was to become Cardo’s Pit, a complex of excavations that eventually covered a considerable area. The Barrington Beds were described as exceptionally rich in mammalian remains, with small pieces of bone occurring throughout. However, it was the basal gravel that yielded the most numerous and best preserved bones. The superb section from Cardo’s Pit (C1916) described by Prof. McKenny-Hughes (1916) records 1m of clayey gravel rich in mammal remains, beneath 5m of silty clay. Molluscs were also obtained from the deposits, although like many of the bones there was often some confusion over exactly which bed (and sometimes which location) they were derived. A section cleaned for the Geological Congress of 1948 revealed only the upper silty clay unit, and yielded no mammalian material (Sparks 1952).
10.3.1.2 Environments of deposition

The basal bone bearing gravels of the Barrington Beds are remarkably similar to the organic sandy silty clay or ‘diamicton’ described by (Gao 1997) and (Gao et al. 2000) from Woolpack Farm (Section 3.3.1). This material appears to have been laid down under low-energy fluvial conditions, and has probably been disturbed by large mammals thus incorporating gravel, shells, and bones into the deposit. The overlying silty clay unit was presumably deposited as overbank fines, although the climate at this time may have been cooler.

10.3.1.3 Pollen

Gibbard & Stuart (1975) carried out pollen analyses of silt scraped from two hippopotamus teeth and a rhinoceros jaw from the Sedgwick Museum collection. Despite poor preservation, sufficient pollen was counted to enable a palaeoenvironmental reconstruction. The pollen assemblage was characterised by high frequencies (c.90%) of grass and herbs. Tree and shrub pollen was represented by *Quercus* (oak), *Pinus* (pine), *Corylus* (hazel), *Salix* (willow) and several other taxa including *Acer* (maple), *Alnus* (alder) and *Ulmus* (elm). A similar assemblage was reported by Turner (1975) from silt also scraped from a hippopotamus tooth. This is interpreted as a treeless floodplain environment grazed by large mammals, with mixed oak woodland at some distance on higher ground. Gibbard & Stuart (1975) assign their analyses to the early part of the Ipswichian (MIS 5e) interglacial (Substage Ip II), whilst Turner (1975) tentatively suggests Substage Ip III.

The author has also undertaken pollen analyses on a number of specimens of silt from the Sedgwick Museum collection, and from samples recovered from borehole BBH2 (and BBH5). The results of these analyses are shown in Table 10.3.1-1. Sadly, the samples of silty clay from BBH2 contained very few palynomorphs, and with pollen concentrations of <1000 grains per cubic centimetre of sediment, they must be regarded as barren. The specimens of silt from the Sedgwick Museum show pollen assemblages dominated by grass and herbs. Tree and shrub pollen is represented by low frequencies of *Pinus, Betula* (birch), *Corylus, Salix* and *Juniperus* (juniper). It is notable that the specimen of silt from the basal bone bearing beds gave 33% *Pinus*. The silty clay from BBH5 yielded an assemblage dominated by grass and herbs, with low frequencies of *Quercus* (oak), *Pinus* (pine), *Salix* (willow) and *Alnus* (alder). This is in broad agreement with the analyses by Gibbard & Stuart (1975), although many of the temperate elements of mixed oak woodland identified by them are missing. The author believes that these assemblages must represent an open grassland environment with some local carr vegetation and shrubby woodland at
some distance from the river. There are few temperate elements in the flora, suggesting generally cool climatic conditions.

10.3.1.4 Molluscs

Mrs McKenny-Hughes (1881) and Prof. McKenny-Hughes (1911) list various molluscs recovered from the Barrington Beds and conclude that they represent ‘continental conditions’. It is certainly true that no particularly thermophilous taxa are recorded. Most of the taxa are aquatic indicating a slow-moving, well oxygenated river with some fringing vegetation. The limited land fauna was represented by marshland and riverside species, and snails of scrub and woodland habitats were rare. Sparks (1952) also records molluscs recovered from Cardo’s Pit (C1948), and opines that the assemblage could have ‘withstood the rigours’ of a Scandinavian climate. The interpretation of habitat is similar to that from the McKenny-Hughes’ fauna, although land snails are better represented, with more grassland species. Kennard and Woodward in Marr (1920) also describe a similar mollusc fauna from the Barrington Beds derived from the washing of large quantities of material. The most notable discovery made by these workers were fragments of *Corbicula fluminalis* and *Unio* sp. from the basal bone bearing gravel. These taxa indicate conditions warmer than the ‘continental’ and ‘Scandinavian’ climates indicated elsewhere. Indeed, the absence of *Corbicula fluminalis* in the other assemblages is notable since appropriate habitats are indicated by the presence of *Pisidium* spp. The fact that only three fragments of *Corbicula fluminalis* were recovered from such a large volume of material raises the question of whether these specimens were reworked from an earlier deposit. However, a collection of molluscs made by C. E. Gray from the very basal part of the Barrington deposits yielded pristine specimens of *Corbicula*, together with other aquatic taxa including *Bithynia tentaculata*. The presence of this taxon has been taken to indicate a MIS 7 age at other sites (Keen, 1990 and Preece, 1995).

10.3.1.5 Vertebrates

Gibbard & Stuart (1975) re-examined the large collection of Barrington vertebrate material in the Sedgwick Museum, Cambridge, and smaller collections in the British Museum (Natural History) and the Geological Survey Museum, London. They concluded that the diverse assemblage reflected the variety of available habitats in the vicinity of the river. Fisher (1879) suggested that the assemblage is a mixture of washed-in material and stranded carcasses. Temperate woodland habitats are indicated by the presence of *Dama dama* (fallow deer), *Cervus elephas* (red deer), *Meles meles* (badger) and *Palaeoloxodon antiquus* (straight-tusked elephant). Conversely, taxa such as *Crocuta crocuta* (spotted hyena), *Panthera leo* (lion), *Bos primigenius* (aurochs), *Bison priscus* (bison) and
Megaloceros giganteus (giant deer) are believed to favour grassland areas. Evidence of riparian and aquatic habitats is provided by the presence of *Hippopotamus amphibius* (hippopotamus) and the water vole *Arvicola terrestris*.

The faunal assemblage of *Hippopotamus amphibius*, *Palaeoloxodon antiquus*, *Dama dama*, *Cervus elaphus*, *Canis lupus* (wolf) and *Ursus arctos* (brown bear) characterises the ‘hippopotamus fauna’ associated with the Ipswichian Stage (Stuart 1982, Sutcliffe 1995). Since the *Mammuthus trogontherii-primigenius/Equus ferns* fauna correlated with MIS 7 is significantly different to the assemblage from the Barrington Beds, it appears that this fauna may be confidently correlated with the Ipswichian (MIS 5e). Bridgland and Schreve (2001) also assign these deposits to MIS 5e on the basis of hippopotamus and the absence of *Corbicula*. Mrs McKenny-Hughes (1881) and Fisher (1979) refer to *Mammuthus primigenius* and *Equus ferns* as coming from the Barrington Beds. Indeed the author has found teeth of *Equus ferns* in the Sedgwick Museum attributed to Barrington. However, Prof. McKenny-Hughes (1916) believed that this confusion arose because contemporaneous pits near Barrington, but south of the River Rhee, opened in undifferentiated 1st and 2nd Terrace Deposits also yielded bones. It is clear that there can be no certainty about the stratigraphic provenance of these specimens, and that they do not represent a significant part of the assemblage.

### 10.3.1.6 Dating

Two distinct collections of shells were available from the Sedgwick Museum for amino acid dating. Amino acid racemization analyses for *Trichia* spp. shells associated with hippopotamus gave D/L ratios of 0.082, 0.138, 0.154 and 0.203 (Appendix 5). The lowest of these ratios equates to an Early Devensian (MIS 5a/c) age, whilst the others indicate dates in the later (MIS 6/7) and middle (MIS 7/8) parts of the ‘Wolstonian’ interval. This mixed amino acid signal means that a minimum age estimate for the last phase of deposition based on the lowest D/L ratios is the Early Devensian (MIS 5a/c). This is not entirely incompatible with the Ipswichian (MIS 5e) age suggested by the floral and faunal assemblages. However, it does not explain why shells of Ipswichian age were not found. In addition, the apparent age distribution of these well-preserved shells suggests reworking of older ‘Wolstonian’ deposits from nearby deposits.

Amino acid racemization analyses for *Bithynia tentaculata* shells from the C. E. Gray collection associated with a basal bed containing *Corbicula* gave D/L ratios of 0.173, 0.208 and 0.233 (Appendix 5). These equate to ages in the later part (MIS 7), in the middle (MIS 8) and in the early part (MIS 8/9) of the ‘Wolstonian’ interval. This mixed amino acid signal means that a minimum age estimate for the last phase of deposition based on the
lowest D/L ratios is within the later part of the ‘Wolstonian’ interval (MIS 7). Again there appear to be a significant amount of reworking in these deposits.

The implication of these two sets of amino acid ratios is that at Barrington there is a lower deposit of late ‘Wolstonian’ age incorporating earlier reworked material, overlain by Ipswichian and Early Devensian deposits, themselves containing significant reworked elements.

**10.3.1.7 Conclusions**

Although there has been debate about the stratigraphic position of the Barrington Beds (Sparks 1952, Norris 1962) it is clear that most authors believe they represent an interglacial, probably the Ipswichian (MIS 5e) followed by an episode of cooler climatic conditions. Evidence from amino acid racemization analyses suggest that locally there is a basal *Corbicula* bearing deposit dating from the end of the ‘Wolstonian’ (MIS 7) interval, overlain by Ipswichian (MIS 5e) and Early Devensian deposits. All of these deposits appear to contain significant quantities of reworked material.

**10.4 Correlation of Stratigraphic Units**

**5km Square TL 235/45**

**10.4.1 Synopsis**

Figure 10.4.1-1 and Table 10.4.1-1 show details of the 3 stratigraphic units proposed for the 5km Square 235/45. The Cardo’s Pit Silty Clay is the local equivalent of the Barrington Beds described by Fisher (1879) from a pit to the east of Barrington village in 3rd Terrace Deposits (see 10km Square TL 240/40). The Shepreth Gravel characterises a broad spread of fluvial deposits beneath the undifferentiated 1st and 2nd Terrace surface that apparently extends up the Rhee valley no farther than Shepreth itself. Beneath the present floodplain of the River Rhee there is a buried channel filled by the Flandrian Riverside Meadows Peat.

Table 10.4.1-2 and Figure 10.4.1-2 show the chronological and stratigraphic relationships of these units and their correlation with lithostratigraphic members and formations. Figure 10.4.1-3 presents an idealised geological section through the area showing the relationships of the various lithostratigraphic members (Table 1.4.2-1). The Cardo’s Pit Silty Clay is correlated with the Barrington Village Member of the Cam Valley Formation and interpreted as Ipswichian to Early Devensian (MIS 5a/e) deposits of the River Rhee. The Shepreth Gravel is correlated with the Sidgwick Avenue Member of the Cam Valley Formation, and is interpreted as Middle to Late Devensian (MIS 2/3) deposits.
of the River Rhee. The Riverside Meadows Peat is correlated with the Jesus Green Member of the Cam Valley Formation, and is interpreted as Flandrian (MIS 1) alluvial and fen deposits of the River Rhee.

This sequence of deposits probably spans the Ipswichian, Devensian and Flandrian, but is unlikely to be complete. It appears that older deposits, such as ancient elevated and high-level gravels, and Anglian till of the Lowestoft Formation are not represented in this part of the Rhee valley.
...as if the dragon's teeth had been sown
broadcast, and had yielded fruit equally on hill and plain, on rock, in
gravel, and alluvial mud, under the bright sky of the South and under the
clouds of the North...

A TALE OF TWO CITIES
Charles Dickens
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11.1 10km Square TL 240/540

Fowlmere and Sawston

11.1.1 Synopsis

This ten-kilometre square is located at the southern edge of the main study area and contains 46 monads with data (Figure 11.1.1-1). The area includes the villages of Barrington, Whittlesford and Sawston to the north, Pampisford, Duxford, and Ickleton to the east, Foxton, Fowlmere and Flint Cross to the west, Fleydon and Chrishall to the south, and Thriplow near the centre. The valley of the River Cam (c.20-25m OD) runs south to north across the eastern part of the square, and the valley of the River Rhee runs across the extreme northwest corner. The area rises towards the south and west reaching c.135m OD near Heydon and Chrishall in the south.

11.1.2 Drainage

The drainage of this area is generally towards the north. There is an extensive system of dry valleys and a number of Chalk springs, some of which feed tributaries of the River Rhee and River Cam. Adjacent to these springs are several poorly drained low-lying areas, such as Fowlmere RSPB Reserve (Fowlmere watercress beds). The River Rhee at Barrington flows northeast, and joins the River Cam and River Granta, before continuing northeast through Cambridge.

11.1.3 Bedrock geology

The bedrock geology comprises Gault Clay, overlain by Lower, Middle and Upper Chalk broadly dipping towards the southeast (Figure 11.1.3-1).

11.1.4 Quaternary geology

The Quaternary geology mapped by the BGS (Figure 11.1.3-1) comprises Boulder Clay (till) on the higher ground near Heydon and Chrishall and at a lower elevation west of Ickleton. South of Thriplow, ‘Taele Gravels’ are mapped forming a broad spread stretching to the southwest, and are also marked at various other locations in the Rhee and Cam.
valleys. Between Duxford and Whittlesford, two areas of ‘Glacial Gravel’ are shown, and small patches of 3rd Terrace Deposits are mapped near Barrington and south of Sawston. In addition, Undifferentiated 2nd and 1st Terrace Deposits and Alluvium are recorded along both the Rhee and Cam valleys.

11.2 5km Square TL 240/545 Fowlmere

11.2.1 Synopsis

This five-kilometre square contains 10 monads with 31 points (Figures 11.2.1-1 & 11.2.1-2). The area includes the villages of Barrington and Newton to the north, Thriplow and Fowlmere to the south and Foxton to the west. It contains an important site at Barrington, from which Fisher (1879) collected numerous mammalian remains.

11.2.2 Drainage and relief

The valley of the River Rhee (c.15m OD) runs across the northwest corner of the square, and several tributaries fed by perennial springs in the Chalk drain north towards it. There are several dry valley systems in the more elevated area (c.30-25m OD) south of Thriplow. To the north, west of Newton, Rowley’s Hill rises to c.50m OD and south of Foxton, West Hill and Chalk Hill (c.35m OD) are aligned in a similar southwest-northeast direction.

11.2.3 Geology

The bedrock geology comprises Lower and Middle Chalk underlain by Gault Clay broadly dipping towards the southeast (Figures 11.2.3-1 & 11.2.3-2). The Quaternary geology comprises ‘Taele Gravels’ at c.35m OD near Thriplow and at c.22m OD near Fowlmere. A small patch of gravel is marked capping Rowley’s Hill. There is also a small patch of 3rd Terrace Deposits (c.18m OD) mapped at Barrington. The valley of the River Rhee contains a broad spread of Undifferentiated 2nd and 1st Terrace Deposits at c.13-18m OD. Alluvium is confined to the valley floor, and is also mapped at Fowlmere Reserve.

11.2.4 Geological Logs and Sections

11.2.4.1 Synopsis

The 31 points comprise 1 record (FMR) collected by the author and 30 records from secondary sources. These include 26 from the British Geological Survey Well Catalogue Series (Sayer and Harvey, 1965), 1 from the Saffron Walden Memoir (White, 1932), and 3 taken from Fisher (1879).
11.2.4.2 Geological Section 40/45.1

This section (Figure 11.2.4-1) runs roughly north-south between Barrington (Fisher3) through Foxton to Fowlmere Reserve (FMR). It provides a record of the drift geology from the 3rd Terrace and Undifferentiated 1st and 2nd Terrace Deposits of the Rhee valley.

The section in a pit (points Fisher1 to Fisher3) at the eastern end of Barrington village described by Fisher (1879) has long been famous for the mammalian remains that it furnished. Point Fisher2 proves the greatest thickness of deposits, showing 0.5m of fine gravel and sand overlying 5m of silty clay with pebbles. The basal part of this unit was particularly rich in cobbles and bones, overlying bedrock Gault Clay at c.12m OD. The deposits exposed here and at Cardo’s Pit (Section 10.3.1) at the western end of the village became known as the Barrington Beds. The deposits from Fisher’s sections are named in Bowen (1999) as the Barrington Village (Silty Clay) Member. The stratotype location given by Bowen (TL 4040 4980) is slightly different to that used here, and the author proposes a revised stratotype at Fisher2 (TL 4030 4980). The position of the River Rhee is marked on the section, with heights of rockhead and land surface projected from elsewhere. At Foxton, point SW90/1 records clay with gravel overlying 1m of chalky gravel and sand. The presence of drift deposits reaching 3m in thickness is recorded in Foxton village by points 205/337, 205/319 and 205/27. Unfortunately, these boreholes did not record the nature of the superficial deposits encountered, although the author has assumed that this was largely gravel. It is proposed that the gravel unit here is formally named the Foxton Gravel, with the stratotype at SW90/1 (TL 4060 4530). Bedrock Chalk is recorded close to the surface at point 205/350, and a similar situation is evident near Field Farm (205/412). A borehole by the author at Fowlmere Reserve showed 1m of clay with peat overlying gravel and sand on bedrock at c.19m OD. It appears that this organic material is of Flandrian age and has accumulated beneath reed-swamp that has grown up where Chalk springs issue into a poorly drained and relatively low-lying area of ground, which has a narrow outlet to the north. It is proposed that this organic unit is formally named the Fowlmere Reserve Peat, with the stratotype at FMR (TL 4060 4530).

11.2.4.3 Geological Section 40/45.2

This 4km-long section (Figure 11.2.4-2) runs southwest-northeast from Fowlmere Reserve (FMR) through Fowlmere village to Thriplow Farm (205/256). The section traverses the undulating edge of the Middle Chalk outcrop with which a number of springs and low-lying areas are associated. Point FMR shows organic deposits overlying gravel on
bedrock Chalk. To the east, points 205/434 and 205/459 record bedrock Chalk at the surface, but at 205/568 a borehole records 3m of drift on bedrock at c.22m OD. In Thriplow village, points 205/347 to 205/386 also record bedrock Chalk near the surface. At Thriplow Farm point 205/256 shows 8m of drift on bedrock at 16m OD. Sadly, there is no record of the character of the drift deposits discovered at these locations, and the BGS map shows only bedrock. Given the location of this superficial material in hollows near springheads, it would not be surprising if these deposits were tufaceous in nature.

11.3 5km Square TL 245/45 Sawston

11.3.1 Synopsis

This five-kilometre square contains 22 monads with 148 points (Figures 11.3.1-1 & 11.3.1-2). The area includes the village of Sawston to the north, Pampisford to the east, Duxford and Hinxton to the south and Whittlesford at the centre. The area also includes the M11 Motorway, which provides a large number of points in this square.

11.3.2 Drainage and relief

The valley of the River Cam (c.20-25m OD) runs from south to north through this square. There are several small tributaries draining into the River Cam, and north of the Imperial War Museum, chalk springs at Little and Great Nine Wells give rise to the Hoffer Brook, which flows north towards the River Rhee. The interfluve south of Whittlesford reached c.35m OD. There are also several small dry valleys on the higher ground (c.60-70m OD) in the south of the area.

11.3.3 Geology

The bedrock geology comprises Lower and Middle Chalk broadly dipping towards the southeast (Figure 11.3.3-1 & 11.3.3-2). The Quaternary geology shows an area of ‘Taele Gravel’ at c.30m OD near Stanmoor Hall, west of Whittlesford, a smaller patch south of Duxford, and two patches of ‘Glacial Gravel’ at c.35m OD between Whittlesford and Duxford. South of Sawston, there is an area mapped as 3rd Terrace Deposits, and Undifferentiated 1st and 2nd Terrace Deposits, and Alluvium are shown along the Cam valley. A small area of Alluvium is also marked north of the Imperial War Museum.
11.3.4 Geological Logs and Sections

11.3.4.1 Synopsis

The 148 points are all from secondary sources and comprise 55 from the British Geological Survey Well Catalogue Series (Sayer and Harvey, 1965), 10 from the Saffron Walden Memoir (White, 1932) and 83 from the Highways Agency archives.

11.3.4.2 Geological Section 45/45.1a

This section (Figure 11.3.4-1) follows the line of the M11 Motorway for 3km from the north of the square to the area west of Hill Farm, Whittlesford. It provides a detailed record of the drift geology across the edge of an area of ‘Taele Gravel’ near Stanmoor Hall and through a patch of ‘Glacial Gravel’ in the vicinity of Hill Farm.

Although points sb4 and sb5 record bedrock Chalk near the surface at c.21m OD, points 88, 87 and 86 show 1m of chalky sandy clay on bedrock. Further downslope, point b36 records sandy clay and point b37 has bedrock near the surface. In the bottom of a small valley west of Ley Grove Cottages, point b38 shows 2m of sandy silty clay on bedrock and point b39 records 1m of silty clay overlying 1m of clayey gravel on bedrock Chalk at c.17m OD. It is proposed that the silty clay unit is formally named the **Ley Grove Silty Clay**, with the stratotype at point b38 (TL 4528 4970).

On the southern side of the valley (points 85 to 82) there is only topsoil recorded covering occasional sparse sandy clay over bedrock Chalk. In the valley east of Foster’s Farm, point 81 records 2m of gravel and sand overlying 2m of sandy silty clay on bedrock at c.21m OD. On the valley floor, points 78 and 80 record 2m of chalky gravel and sand, and at point 77 there is 2m of chalky sandy clay on bedrock at c.16m OD. Further south, point 76 records sandy clay overlying 3m of clayey gravel and sand on bedrock at c.17m OD. Some 3m of gravel and sand is also recorded at point 75, and point 74 shows 2m of sandy clay on bedrock Chalk at c.21m OD. The various deposits in this valley at different heights suggest that they might be derived from different processes operating at different times. It is proposed that the gravel unit filling the valley is formally named the **Foster’s Farm Gravel**, with the stratotype at point 76 (TL 4568 4889).

At the top of the next interfluve near Stanmoor Hall on the Newton Road, points b32 to 72 record 3m of sandy clay on bedrock at c.26m OD. These points are adjacent to a patch of ‘Taele Gravel’ shown on the BGS map. It is proposed that this sandy clay unit is formally named the **Stanmoor Hall Sandy Clay**, with the stratotype at point b31 (TL 4574 4856). To the south at point 71, bedrock Chalk is close to the surface at c.29m OD. The floor of the next small valley west of Middle Moor (points 69 to 65) has 2m of sandy...
clay on bedrock at c.24m OD. It is proposed that this sandy clay unit is formally named the **Middle Moor Sandy Clay**, with the stratotype at point 69 (TL 4582 4825).

To the south, point 64 shows sandy clay on bedrock Chalk at c.30m OD. The points that traverse the hill northwest of Hill Farm (points 63 to 56) record a buried channel filled by sandy silty clay, gravel and sand and diamict, in an area mapped by the BGS as ‘Glacial Gravel’. Bedrock is not encountered in most of the boreholes, but the depth of the channel is indicated at point b29a where 1m of sandy clay overlies 11m of chalky silty clay, which in turn overlies 1m of gravel and sand on bedrock at c.23m OD. It is proposed that this silty clay unit is formally named the **Hill Farm Silty Clay**, with the stratotype at point b29a (TL 4610 4742). An adjacent borehole, point 61, encountered 5m of sandy clay overlying 1m of chalky diamict at c.28m OD. It is proposed that this diamict unit is formally named the **Hill Farm Diamict**, with the stratotype at point 61 (TL 4606 4748). Elsewhere, clayey gravel overlies the silty sandy clay unit. This is evident at point 62 where 3m of gravel and sand overlies 3m of silty clay, and at point 57a where 3.5m of gravel and sand overlies bedrock Chalk at c.34m OD. At point 56, 1m of sandy clay overlies bedrock at c.32m OD.

11.3.4.3 Geological Section 45/45.1b

This geological section (11.3.4-2) also follows the line of the M11, and provides a detailed record of the drift geology across an area west of Duxford, mapped as bedrock Chalk. South of Hill Farm, the M11 Motorway crosses a broad dry valley. Points 56 to 39 record 1m of sandy clay on bedrock Chalk at c.30-35m OD. To the south, points b14 to 32 cross a spur of Pepperton Hill to the west of Duxford. The land here rises to c.57m OD, but bedrock Chalk is close to the surface covered by only sandy clay or topsoil.

11.3.4.4 Geological Section 45/45.2

This 4km-long section (Figure 11.3.4-3) crosses the River Cam valley west-east from the M11 Motorway (point 82) to Sawston (point 205/171). Point 82 records bedrock Chalk at the surface at c.26m OD, and in the valley east of Foster’s Farm, point 81 records 2m of gravel and sand overlying 2m of sandy silty clay on bedrock at c.21m OD. South of Ley Grove Cottages point 205/300 shows 11m of drift on bedrock at c.5m OD. This is in an area mapped as Undifferentiated 1st and 2nd Terrace Deposits, but unfortunately the nature of the deposits is not recorded. Points 205/96b to 205/171 all record bedrock Chalk at the surface in Sawston village.

11.3.4.5 Geological Section 45/45.3

This 4km-long section also crosses the River Cam valley (Figure 11.3.4-4). The section runs from the M11 near Whittlesford (point 71) to Sawston (point 205/171). Points 71 and
205/367 record bedrock Chalk close to the surface beneath topsoil. However, points 205/370 and 205/302 north of Whittlesford record 3m of drift on bedrock at c.17m OD. Across the Cam valley near the Paper Mill, point 205/96a records 3m of Made Ground on bedrock at c.16m OD. Near Sawston, point 205/72 shows 3m of drift deposits on bedrock Chalk at c.19m OD. Points 205/303 to 205/171 all record bedrock Chalk at the surface in Sawston village.

11.3.4.6 Geological Section 45/45.4

This 3.5km-long section crosses the River Cam valley (Figure 11.3.4-5) from the M11 (b29a), through Whittlesford to Sawston (point 205/307). Point b29a records 1m of sandy clay overlying 11m of chalky silty clay, in turn overlying 1m of gravel and sand on bedrock at c.23m OD. These deposits occupy a buried channel described in Geological Section 45/45.1a. In contrast, at point 205/327 bedrock Chalk is recorded near the surface at c.28m OD. There are several records from Whittlesford village (205/241 to 205/60) that show varying thicknesses of drift, although its nature is revealed only at SW 114/1 where 4m of gravel and sand overlies bedrock at c.20m OD. It is proposed that this gravel unit is formally named the Whittlesford Village Gravel, with the stratotype at point SW 114/1 (TL 4715 4810). At Whittlesford Mill, point 205/529 records 9m of drift on bedrock Chalk at c.12m OD. Across the River Cam valley at the Tannery point 205/11 shows 3m of Made Ground on bedrock at c.20m OD, and at point 205/55, there is 2m of drift on bedrock at 22m OD. In Sawston village, points 205/71 and 205/307 show bedrock Chalk close to the surface beneath topsoil.

11.3.4.7 Geological Section 45/45.5

This 3km-long section (Figure 11.3.4-6) runs west-east from the Imperial War Museum (point 205/312), through Hill Farm to Whittlesford (point 205/327). On the A505 road southwest of the Imperial War Museum, point 205/312 records bedrock Chalk close to the surface beneath topsoil at c.35m OD. To the northeast, point 205/25 shows 1m of gravel and sand on bedrock at c.28m OD. It is proposed that this gravel unit is formally named the Imperial War Museum Gravel, with the stratotype at point 205/25 (TL 4590 4620). Beneath the M11 Motorway, points b28 and 53 show sandy clay on bedrock at c.30m OD. At Hill Farm where the land rises to c.38m OD, point 205/581 suggests 32m of gravel and sand on bedrock Chalk at c.6m OD. This is clearly part of the same buried channel described above, and coincides with the patch of ‘Glacial Gravel’ shown on the BGS map. It is proposed that this gravel unit is formally named the Hill Farm Gravel, with the
stratotype at point 205/581 (TL 4660 4700). To the north, point 205/327 records bedrock Chalk close to the surface at c.28m OD beneath topsoil.

11.3.4.8 Geological Section 45/45.6

This 1.5km-long section (Figure 11.3.4-7) runs northwest-southeast from the area near Whittlesford Station (205/100) to Duxford Mill (point 205/345). North of the A505 road, point 205/100 records 1m of gravel and sand on bedrock Chalk at c.20m OD. To the south, point SW77/3 shows 9m of gravel and sand on bedrock at c.21m OD, and point 205/321 records 4m of gravel on bedrock at c.25m OD. This is clearly the edge of the buried channel identified above, and coincides with the patch of ‘Glacial Gravel’ mapped by the BGS. To the southeast, point 205/522 records 5m of drift on bedrock at c.19m OD. It is not clear whether this material is part of the buried channel, or associated with the Undifferentiated 1st and 2nd Terrace Deposits mapped nearby. At Duxford Mill, point 205/345 records 1m of drift overlying bedrock Chalk at c.22m OD.

11.3.4.9 Geological Section 45/45.7

This 1.5km-long section (Figure 11.3.4-7) runs roughly west-east from the Tannery (point 205/70) to Pampisford village (point 205/61). At the edge of the River Cam valley, points 205/70 and 205/66 record 2m of drift on bedrock Chalk at c.20m OD. This area is mapped as Undifferentiated 1st and 2nd Terrace Deposits by the BGS. To the east, the rising ground through Pampisford village (205/65 to 205/61) shows bedrock Chalk close to the surface beneath topsoil.

11.3.4.10 Geological Section 45/45.8

This 1.5km-long section (Figure 11.3.4-8) runs northwest-southeast from Whittlesford (point 205/60) to the A505 road near Whittlesford Station (point SW77/4). It provides a section across the buried channel identified above. The rising ground from Whittlesford village (205/60 to 205/219) shows only drift and topsoil on bedrock Chalk. However, point 205/119 records 6m of silty sandy clay overlying 5m of clay with gravel, in turn overlying 13m of silty clay on bedrock at c.12m OD. It is proposed that this silty clay unit is formally named the Whittlesford Station Silty Clay, with the stratotype at point 205/119 (TL 4780 4765). To the south, point 205/296 records 26m of gravel and sand, and point 205/521 shows 18m of gravel and sand on bedrock Chalk at c.19m OD. The gravel is clearly shown to overlie the silty clay unit at point 205/120, where 8m of gravel and sand overlies 10m of silty clay on bedrock at c.11m OD. Nearby, point SW77/4 shows 7m of gravel and sand at a similar elevation.
11.3.4.11 Geological Section 45/45.9

This 1.5km-long section (Figure 11.3.4-9) runs northwest-southeast from Whittlesford (point 205/60) to the A505 road near Whittlesford Station (point SW77/4). It also provides a section across the buried channel identified above. In Whittlesford village (points 205/60 and 205/346) drift overlies bedrock Chalk. However, point SW77/2 records 6m gravel and sand. To the south, point 205/612 suggests 42m of gravel and sand, with a base not touching bedrock at c.-4m OD. It is proposed that this gravel unit is formally named the **Whittlesford Station Gravel**, with the stratotype at point 205/612 (TL 4800 4750).

Nearby, point 205/504 records 30m of gravel on bedrock Chalk at c.9m OD. The stratigraphic relationship of the gravel and the silty clay unit is clearly shown at point 205/120 where 8m of gravel and sand overlies 10m of silty clay on bedrock Chalk at c.11m OD. However, at point 205/86 33m of gravel and sand are recorded overlying bedrock at c.-7m OD. This contrasts markedly with the sequence recorded at point SW61/2, where 4m of chalky diamict material overlies 14m of silty clay on bedrock at c.9m OD. It is proposed that this diamict unit is formally named the **Whittlesford Station Diamict**, with the stratotype at point SW61/2 (TL 4841 4723). At point 205/309, 4m of gravel and sand is shown overlying 10m of silty clay on bedrock Chalk at c.9m OD.

11.3.4.12 Geological Section 45/45.10

This 1.5km-long section (Figure 11.3.4-10) runs roughly south-north from the M11 Motorway (point 33), through Duxford village to Duxford Mill (point 205/345). Apart from sandy clay at point 33 and 1m of drift recorded at 205/345, the descending slope through Duxford village shows only bedrock Chalk close to the surface beneath topsoil.

11.3.4.13 Geological Section 45/45.11

This 3km-long section (Figure 11.3.4-11) runs roughly west-east from the M11 Motorway (point 36), through Duxford village and across the valley of the River Cam to Hinxton village (point 205/513). The descending slope (points 36 to 205/349) through Duxford village shows only bedrock Chalk close to the surface beneath topsoil. At Duxford Works, point 205/344 records 1m of drift on bedrock at c.27m OD, and south of the Works near a patch of ‘Taele Gravel’, point SW 84/5 shows 2m of ‘rubbly’ gravel and sand. It is proposed that this gravel unit is formally named the **Duxford Works Gravel**, with the stratotype at point SW 84/5 (TL 4845 4518). Near the centre of the valley, point 205/500 records 9m of drift overlying bedrock at c.20m OD, and to the east near Hinxton Church, point 205/40 shows 6m of drift on bedrock Chalk at c.30m OD in a position elevated above the valley floor. Nearby, point 205/513 records bedrock Chalk near the surface at c.36m OD.
11.4 Correlation of Stratigraphic Units

5km Squares TL 240/540 and TL 245/545

11.4.1 Synopsis

Figure 11.4.1-1 and Table 11.4.1-1 show details of the 16 stratigraphic units proposed for the 5km Squares 240/540 and 245/545. The relatively thick gravel, silty clay and diamict units forming a ridge, but occupying a deep buried channel feature at Hill Farm and Whittlesford Station are particularly noteworthy. The Barrington Village Silty Clay is also a stratigraphically important unit. The remainder of the units occupy valley floor or valley side positions and consist of gravels, sandy clays and peat. Several of these are not recognised by the BGS.

Table 11.4.1-2 and Figure 11.4.1-2 show the chronological and stratigraphic relationships of these units and their correlation with lithostratigraphic members and formations. Figure 11.4.1-3 presents an idealised geological section through the area showing the relationships of the various lithostratigraphic members (Table 1.4.2-1). The Whittlesford Station Silty Clay becomes the stratotype for the Whittlesford Station Member of the Lowestoft Formation, and is correlated with the Hill Farm Silty Clay, and the Stanmoor Hall Sandy Clay. These deposits are interpreted as glacio-lacustrine deposits of Anglian (MIS 12) age. The Hill Farm Diamict, the Whittlesford Station Diamict, the Whittlesford Station Gravel and the Hill Farm Gravel are correlated with the Barrington Works Member of the Lowestoft Formation. These units are interpreted as glacial till and outwash gravels of Anglian (MIS 12) age.

The Barrington Village Silty Clay becomes the stratotype of the Barrington Village Member of the Cam Valley Formation. It is correlated with the Cardo’s Pit Silty Clay in the neighbouring 5km Square 235/545, and is interpreted as Ipswichian to Early Devensian (MIS 5 a/e) interglacial and cold stage fines of the River Rhee.

The Foxton Gravel, Foster’s Farm Gravel, Whittlesford Village Gravel, Imperial War Museum Gravel and Duxford Works Gravel are correlated with the Sidgwick Avenue Member of the Cam Valley Formation. These units are interpreted as Middle to Late Devensian (MIS 2/3) deposits of the River Rhee, River Cam and their tributaries. The Fowlmere Reserve Peat, Ley Grove Silty Clay and Middle Moor Sandy Clay are correlated with the Jesus Green Member of the Cam Valley Formation, and are interpreted as Flandrian (MIS 1) alluvial, colluvial and fen deposits of various Cam valley tributaries.
There appears to be a complex of Anglian deposits preserved in the deep channel at Hill Farm and Whittlesford Station. Younger deposits spanning the Ipswichian, Devensian and Flandrian are also represented in the sequence, although material of intermediate age has not been identified.
I saw the heavens break and all the world go down to sleep
And rocks on mossy banks drip acid rain from craggy steeps
Saw golden angels kiss the dawn
Wish you goodbye 'til further on.

FURTHER ON
Ian Anderson
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12.3 Site Description 5km Square TL 250/45

12.3.1 Abington Hall

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12.4 Correlation of Stratigraphic Units

12.4.1 Synopsis
Chapter 12

10km Square TL 250/540

Great Chesterford and Linton

12.1 10km Square TL 250/540

12.1.1 Synopsis

This ten-kilometre square is located at the southeast edge of the main study area and contains 15 monads with data entirely within the five-kilometre square TL 250/545 (Figure 12.1.1-1). The area includes the villages of Pampisford, Little and Great Abington and Hildersham to the north, Great and Little Chesterford to the west, Bartlow to the east, Ashdon and Little Walden to the south, and Linton and Hadstock near the centre. The valley of the River Granta (c.30-50m OD) runs southeast to northwest across the north of the square, and the valley of the River Cam (c.35-40m OD) runs south to north across the southwest corner of the square. The area rises towards the south and east reaching c.110m OD north of Linton and c.115m OD near Ashdon in the south where it forms a plateau.

12.1.2 Drainage

The drainage of this area is generally towards the northwest. There are extensive systems of dry valleys in both the River Granta and River Cam catchments, and a number of minor springs and seepage lines feed tributary streams such as the River Bourn north of Ashdon, which have dissected the plateau area.

12.1.3 Bedrock geology

The bedrock geology comprises Middle and Upper Chalk broadly dipping towards the southeast (Figure 12.1.3-1).

12.1.4 Quaternary geology

The Quaternary geology mapped by the BGS (Figure 12.1.3-1) comprises Boulder Clay (till) on the plateau near Hadstock and Ashdon, on the higher ground north of Linton, and at a lower elevations north of Abington and Hildersham. Near Hadstock, ‘Glacial Gravels’ are mapped protruding from beneath till, although elsewhere the stratigraphic relationship is not so clear. North of Hildersham and Abington, patches of ‘Glacial Gravel’ are shown to
overlie till, and between Abington and Pampisford two elongated patches of ‘Glacial Gravel’ occupy the valley side. Elsewhere, ‘Plateau Gravel’ overlying till caps hill tops as at Rivey Hill near Linton, or is mapped on valley sides as at Ashdon. There is also a patch of ‘Plateau Gravel’ on bedrock mapped east of Heavy Hill in the Cam valley. Patches of 3rd Terrace Deposits are mapped along the River Granta and Cam valleys, and Undifferentiated 2nd and 1st Terrace Deposits and Alluvium are recorded along the floodplains of both streams.

12.2 5km Square TL 250/45 Abington

12.2.1 Synopsis

This five-kilometre square contains 15 monads with 157 points (Figures 12.2.1-1 & 12.2.1-2). The area includes the villages of Little and Great Abington to the north, Hildersham to the east and part of the Parish of Pampisford to the west. The area includes a stretch of the A11 road and a site at Abington Hall investigated by the author, which together provide the majority of points in this square. Figure 12.2.1-3 shows the detailed distribution of points in monad 251,445.

12.2.2 Drainage and relief

The valley of the River Granta (c.25-30m OD) runs across the northern part of the square. Several dry valley systems flank the higher land to the north and the plateau area to the south (c.100m OD) although there are few tributary streams. Some of the dry valleys to the southwest are part of the River Cam catchment, and perennial springs in the Chalk at Home Farm near Pampisford Hall (c.25m OD) drain towards the River Cam.

12.2.3 Geology

The bedrock geology comprises Middle and Upper Chalk broadly dipping towards the southeast (Figures 12.2.3-1 & 12.2.3-2). The Quaternary geology comprises Boulder Clay (till) at c.100m OD on the plateau south of Abington Park Farm and at c.50-60m OD north of Little Abington and Hildersham. ‘Glacial Gravel’ is mapped in three different situations in this square. In the extreme southeast, ‘Glacial Gravel’ is shown beneath till, whilst north of Little Abington it is shown overlying till. Southwest of Great Abington ‘Glacial Gravel’ is mapped in two elongated patches on the valley side at a range of elevations from c.55m to c.30m OD. Patches of 3rd Terrace Deposits are mapped along the Granta valley downstream of Little Abington, and Undifferentiated 2nd and 1st Terrace Deposits and Alluvium are confined to the valley floor (c.25-30m OD).
12.2.4 Geological Logs and Sections

Synopsis

The 157 points comprise 14 records (twi/a to twi/vii) collected by the author and 143 records from secondary sources. These include 18 from the British Geological Survey Well Catalogue Series (Sayer and Harvey, 1965), 77 from Highways Agency archives, 47 from contractors' reports from The Welding Institute's Science Park development at Abington Hall and 1 from the Saffron Walden Memoir (White, 1932).

12.2.4.1 Geological Section 50/45.1a

This 3km-long section (Figure 12.2.4-1) runs roughly southwest-northeast along the A11 road from Field Farm (bh50) to a point east of Pampisford Hall (bh83). It provides a detailed record of the drift geology across the western edge of the plateau area.

Near Field Farm, points bh50 to bh59 record bedrock Chalk near the surface beneath topsoil and sandy clay. On the floor of a small dry valley south of the Round Plantation, points tp60 and bh61 show 3.5m of chalky sandy clay on bedrock Chalk at c.51m OD. It is proposed that this sandy clay unit is formally named the Round Plantation Sandy Clay, with the stratotype at bh61 (TL 5100 4601). Further to the north points bh62 to bh66 traverse a spur of the plateau and record bedrock Chalk close to the surface beneath topsoil. North of the Round Plantation, point tp67 records sandy clay overlying 1m of gravel and sand on bedrock at c.59m OD. This is close to a small patch of till mapped by the BGS. It is proposed that this gravel unit is formally named the Round Plantation Gravel, with the stratotype at tp67 (TL 5119 4664). The remaining points (bh68 to tp84) record sandy clay overlying bedrock on a slope that descends c.20m into the valley of the River Granta. The BGS map shows a patch of 'Glacial Gravel' on these lower slopes.

12.2.4.2 Geological Section 50/45.1b

This 2.5km-long section (Figure 12.2.4-2) runs roughly southwest-northeast along the A11 road from near the Round Plantation (bh77) through Lagden's Grove (bh3) and across the River Granta at Bourn Bridge (tp25). Part of this section has been described in Section 12.2.4.1. It provides a detailed record of the drift geology across a patch of 'Glacial Gravel', and Undifferentiated 1st and 2nd Terrace Deposits and Alluvium of the Granta valley.

North of the Round Plantation, points bh77 to tp84 record bedrock Chalk near the surface beneath topsoil and sandy clay. However, point tp85 shows sandy clay overlying 1m of chalk gravel and sand on bedrock at c.33m OD. Further downslope, points bh86 and tp87 show 2m of sandy clay on bedrock at c.32m OD. Nearby, point bh1 shows 4m of Made Ground (embankment) overlying 2m of chalky gravel and sand on bedrock Chalk at
c.32m OD. These various deposits occupy a channel-like depression observed nearby and are separated from deposits in the Granta valley proper, by a rampart of bedrock Chalk that rises near Lagden’s Grove to c.35m OD at points bh3 and bh3a. Further north near Bourn Bridge, points tp5 to rc16a record gravel and sand 4.5m thick on bedrock at c.26m OD. It is proposed that this gravel unit is formally named the **Bourn Bridge Gravel**, with the stratotype at bh12 (TL 5185 4907). On the valley floor, points bh17 and bh18 record 1.5m of silty clay with pebbles overlying 3m of gravel and sand on bedrock Chalk at c.21m OD. This material is mapped as Flandrian Alluvium by the BGS and it is proposed that this silty clay unit is formally named the **Bourn Bridge Silty Clay**, with the stratotype at bhl2 (TL 5185 4907). North of the River Granta, points tp19 and tp20 show 1m of gravel and sand on bedrock at c.26m OD. In contrast, point bh21 records bedrock Chalk near the surface beneath topsoil at c.31m OD. Close to the Four Went Ways, points rc22a and rc27a record 1m of gravel and sand over bedrock at c.31m OD. Nearby, points bh24 and tp25 show 3m of clay with gravel on bedrock Chalk at c.29m OD. These points are adjacent to a patch of 3rd Terrace Deposits mapped by the BGS.

### 12.2.4.3 Geological Section 50/45.2

This 1.5km-long section (Figure 12.2.4-3) runs west-east from Pampisford Hall (205/201) to The Welding Institute at Abington Hall (twi/g). The section crosses a patch of ‘Glacial Gravel’ and the Undifferentiated 1st and 2nd Terrace Deposits of the Granta valley. Point 205/201 north of Pampisford Hall records bedrock Chalk close to the surface beneath topsoil at c.31m OD. To the east, point tp6 shows gravel and sand over bedrock, and tp6a has Made Ground over 1m of sandy clay on bedrock Chalk at c.27m OD. To the northeast, points rc7a to tp9 record 3m of gravel and sand on bedrock at c.26m OD. This material apparently occupies a channel-like depression previously identified in 50/45.1, and is separated from deposits of the Granta valley by a rampart of Chalk bedrock rising to c.30m OD near the surface at point 205/525. It is proposed that this gravel unit is formally named the **Pampisford Hall Gravel**, with the stratotype at rc8a (TL 5161 4892). To the north near Lagden’s Grove, points bh11 to bh14 record 4m of gravel and sand on bedrock Chalk at c.27m OD. To the east, points TP44 and TP42 show 2m of gravel and sand overlying sandy silty clay.

On the edge of the Granta floodplain near The Welding Institute at Abington Hall, point twi/c shows sandy silty clay with pebbles overlying 1.5m of white laminated marly silty clay, in turn overlying 3.5m of chalky gravel and sand on bedrock at c.22m OD. It is proposed that this gravel unit is formally named the **Abington Hall Gravel**, with the stratotype at twi/c (TL 5238 4908). Points twi/e and twi/f also show white marly silty clay over gravel. The silty clay unit formed a shallow meandering channel flanked across the...
site, and was the subject of an extensive archaeological investigation which suggested that it was early to mid-Flandrian in age. Nearby, at the edge of the channel, point twi/d records 5m of gravel and sand. Point twi/g records a sandy clay overlying 3.5m of chalky gravel and sand, in turn overlying 3.5m of organic silty clay on gravel at c.21m OD. The silty clay unit at point twi/g has been investigated in detail by the author, and it is proposed that it is formally named the Abington Hall Silty Clay, with the stratotype at twi/g (TL 5242 4909).

12.2.4.4 Geological Section 50/45.3

This 1km-long section (Figure 12.2.4-3) runs roughly west-east from Lagden’s Grove (tp4) to The Welding Institute at Abington Hall (twi/hi). The section crosses a patch of ‘Glacial Gravel’ and Undifferentiated 1st and 2nd Terrace Deposits. Point tp4 records 1m of Made Ground over gravel on bedrock Chalk, and points bh2 and bh2a shows chalk close to the surface at c.35m OD beneath topsoil. At Lagden’s Grove, points TP54 and TP50 show 1m of gravel and sand on bedrock at c.34m OD. Nearby, point BH 9 records 4m of sand and gravel overlying 4m of silty clay on bedrock Chalk at c.27m OD. It is proposed that the gravel unit is formally named the Lagden’s Grove Gravel, and the silty clay unit is formally named the Lagden’s Grove Silty Clay, both with a stratotype at BH9 (TL 5199 4895). Downslope, points TP47 to TP45 record gravel and sand 3m thick. At the edge of the Granta floodplain, TP43 shows sandy clay over gravel, and BH8 records 1m of sandy clay overlying 3m of sand and gravel on bedrock Chalk at c.25m OD. Sandy clay over gravel is also recorded at points TP1 and twi/a. However, point TP41 records a and red mottled sandy silty clay bed within the gravel and sand unit. To the east near The Welding Institute at Abington Hall, excavations in the floor of an old pit at points twi/hi and twi/hii revealed gravel overlying 4m of silty clay, in turn overlying gravel at c.22m OD. The silty clay unit at point twi/hi has been investigated in detail by the author.

12.2.4.5 Geological Section 50/45.4

This 1km-long section (Figure 12.2.4-4) runs roughly west-east from Lagden’s Grove (tp4) to The Welding Institute at Abington Hall (twi/j). The section crosses a patch of ‘Glacial Gravel’ and Undifferentiated 1st and 2nd Terrace Deposits. Point tp4 records 1m of Made Ground over gravel on bedrock Chalk. Near Lagden’s Grove points TP4 to TP50 record 2m of gravel and sand beneath sandy clay and topsoil. Downslope, point TP57 shows a bed of mottled sandy silty clay within gravel, and points TP52 to TP2 record 2.5m of gravel and sand. Point TP51 shows 1m of gravel and sand on bedrock Chalk at c.28m OD. Nearby, point TP57 shows a bed of mottled sandy silty clay within the gravel. Near The Welding Institute at Abington Hall, excavations for a sports pitch at points twi/i and
twi/j revealed sandy silty clay overlying 1m of white/buff marly silty clay, in turn overlying 1.5m of chalky gravel and sand. The complexity of the sediments in these sections cannot be adequately described here. The marly silty clay unit appeared to occupy a shallow channel-form, which had in part been removed and replaced by medium to coarse gravel.

12.2.4.6 Geological Section 50/45.5

This 1km-long section (Figure 12.2.4-4) runs roughly west-east from Lagden’s Grove (tp4) to The Welding Institute at Abington Hall (TP64). Point tp4 records 1m of Made Ground over gravel on bedrock Chalk, and points bh2 and bh2a shows chalk close to the surface at c.35m OD beneath topsoil. However at Lagden’s Grove, points TP54 and TP50 show 1m of gravel and sand on bedrock at c.34m OD. Nearby, point BH 9 records 4m of sand and gravel overlying 4m of silty clay on bedrock Chalk at c.27m OD. Points TP3 records gravel and sand beneath sandy clay and topsoil, and downslope, points TP57 and TP58 show a bed of mottled sandy silty clay within gravel. On the floor of a small side-valley at the edge of the Granta floodplain, point twi/vii records sandy clay overlying 1m of chalky gravel on Chalk bedrock at c.28m OD, and point twi/vi shows 1m of sandy and silty clay in a similar situation. Near The Welding Institute at Abington Hall, point TP64 records sandy clay overlying 1.5m of gravel and sand, in turn overlying sandy silty clay at c.31m OD.

12.2.4.7 Geological Section 50/45.6

This 1km-long section (Figure 12.2.4-4) runs roughly northwest-southeast from Lagden’s Grove (bh14) to The Welding Institute at Abington Hall (TP67). The section crosses a patch of ‘Glacial Gravel’. Point bh14 records 2m of Made Ground overlying 3m of gravel and sand on bedrock Chalk at c.27m OD. Near Lagden’s Grove, points TP48 and TP47 record 2m of gravel and sand, and point BH 9 records 4m of sand and gravel overlying 4m of silty clay on bedrock Chalk at c.27m OD. Points TP49 to TP62 record 2m of gravel and sand beneath sandy clay and topsoil. On the floor of a small side-valley, points TP63 and BH12 show 1m of sandy clay overlying gravel and sand. At BH12 this unit is 2m thick and overlies bedrock Chalk at c.28m OD. Nearby, points TP66 records 1.5m of gravel and sand on bedrock at c.30m OD, and point TP67 shows sandy clay overlying gravel and sand on bedrock at c.33m OD.

12.2.4.8 Geological Section 50/45.7

This 1km-long section (Figure 12.2.4-5) runs roughly northwest-southeast from Lagden’s Grove (bh14) to The Welding Institute at Abington Hall (TP68). The first part of this geological section is described in Section 12.2.4.7. Nearby, points TP49 to TP62 record 2m of gravel and sand beneath sandy clay and topsoil. Point BH10 shows sandy
clay overlying 3m of gravel and sand on bedrock at c.30m OD, and adjacent to this point 
TP70 shows sandy clay over bedrock at c.32m OD. Further east, point TP65 records 2.5m 
of gravel and sand on bedrock at c.29m OD, and points TP71 to TP68 show over 1m of 
gravel on bedrock Chalk at c.32m OD.

12.2.4.9 Geological Section  50/45.8

This 1km-long section (Figure 12.2.4-5) runs roughly northwest-southeast from 
Lagden’s Grove (bh14) to The Welding Institute at Abington Hall (TP7). The first part of 
this geological section is described in Section 12.2.4.7. Nearby, points TP49 to TP4 record 
2m of gravel and sand beneath sandy clay and topsoil. Point TP69 shows 1m of gravel and 
sand on bedrock at c.34m OD, and adjacent to this point TP5 records 2m of gravel and sand 
on bedrock at c.32m OD. Further east, point TP65 records 2.5m of gravel and sand on 
bedrock at c.29m OD, and points TP71 to TP68 show over 1m of gravel on bedrock Chalk 
at c.32m OD. Point TP72 records gravel on bedrock at a similar elevation, and point TP6 
shows sandy clay over 1m of gravel and sand. Point TP73 shows only gravel over bedrock 
Chalk at c.33m, but to the east, BH11 records 2m of sandy clay overlying 1m of gravel and 
sand on bedrock at c.29m OD. Nearby, point TP74 records gravel and sand, and point TP7 
shows 1m of sandy clay with pebbles on gravel and sand at c.32m OD.

12.2.4.10 Geological Section  50/45.9

This 1km-long section (Figure 12.2.4-5) runs roughly south-north adjacent to The 
Welding Institute at Abington Hall. Point TP74 records 1m of gravel and sand, and point 
BH11 records 2m of sandy clay overlying 1m of gravel and sand on bedrock at c.29m OD. 
Nearby, TP75 and TP66 show 1m of gravel and sand on bedrock Chalk at c.31m OD. 
However, TP64 records sandy clay overlying 1.5m of gravel and sand, in turn overlying 
silty clay at c.31m OD. At the edge of the Granta floodplain, point twi/i shows sandy clay 
overlying 2m of chalky gravel and sand. Point twi/h records 1m of sandy clay overlying 
4m of gravel and sand, in turn overlying organic silty clay at c.24m OD. Excavations in the 
floor of an old pit at points twi/hi and twi/hii revealed gravel overlying 4m of silty clay, in 
turn overlying gravel at c.22m OD.

12.2.4.11 Geological Section  50/45.10

This 3km-long section (Figure 12.2.4-6) runs roughly south-north from Great Abington 
(205/527), through the Granta valley to the Sandpit Plantation, north of Little Abington 
(SW79/1). South of Great Abington, points 205/527 and 205/211 record bedrock Chalk 
close to the surface beneath topsoil. In the Granta valley, points 205/217 and 205/212 
record 7m of drift overlying bedrock Chalk at c.24m and c.27m OD respectively. 
Unfortunately, there is no record of the precise nature of these deposits. Through Little
Abington, points 205/214 to 205/552 record only bedrock Chalk beneath topsoil. At the Sandpit Plantation, point SW79/1 records 8m of gravel and sand with a base not on bedrock at c.67m OD. This point is located within a patch of 'Glacial Gravel' shown on the BGS map. It is proposed that this gravel unit is formally named the **Sandpit Plantation Gravel**, with the stratotype at SW79/1 (TL 5410 4998).

### 12.3 Site Description 5km Square TL 250/545

#### 12.3.1 Abington Hall

**12.3.1.1 Introduction**

In 1998 the author was invited by the County Archaeologist to inspect the site of The Welding Institute's Science Park development at Abington Hall prior to major building works. Topsoil had been removed from the archaeological site (near point twi/c) to reveal a shallow meandering palaeo-channel cut into the surrounding gravel and filled with pale marly silty clay. Mesolithic artefacts recovered from the channel suggested that it was of early to mid-Flandrian age. Adjacent to the archaeological site, an old gravel pit previously filled with refuse had been re-opened and deepened in preparation for an ornamental lake. This afforded excellent sections in the deposits including the Flandrian marly silty clays and the underlying gravel. At one location (twi/g) the author noted organic silts on the newly deepened floor of the pit beneath the gravel. An augered borehole was put down through these deposits proving 3.5m of silty clay resting on gravel. Closer examination of the pit floor revealed that the silty clay could be traced for at least 100m to the east. The author arranged to have two trenches (twi/hi and twi/hii) dug at the eastern end of the pit. Both excavations proved 4m of silty clay overlying gravel. To the south, excavations for a sports pitch exposed further sections (twi/i and twi/j), and as building works progressed further sections became available (twi/vi and twi/vii). The developer also kindly provided numerous borehole and trial pit records from the adjacent area.

**12.3.1.2 Environments of deposition**

The gravels at Abington Hall are thought to have been deposited by a braided stream within a confined valley system. In the field, the sequences of silty clay at points twi/g and twi/hi were clearly seen to be parts of the same channel fill sequence that had been truncated by the overlying gravel. It appears that these sediments represent the silting up of a river channel during a phase of climatic warming. The sequence at twi/hi appears to represent a slowly flowing fluvial environment fringed by reedbeds, wet woodland and open meadow with a cool temperate climate. The sequence at twi/g indicates slow-moving fluvial conditions with emergent vegetation, and nearby dry grassland and deciduous woodland in
fully temperate conditions. The Flandrian marly silty clay overlying the gravel at points twi/c and twi/e also appears to be a channel-filling abandoned by the river. The silty clay at points twi/i and twi/j may represent pool deposits within an abandoned channel on the braid plain. Many other similar silt beds within gravel are recorded across the site.

12.3.1.3 Physical analyses and particle size distribution

The sequences of silty clay at points twi/g and twi/hi were both subjected to detailed physical and particle size analyses (Figures 12.3.1-1 to 12.3.1-4). The silty clay sequence at twi/g (Figure 12.3.1-1) was very rich in calcium carbonate (70-90%) and contained 5-10% organic material. Such large amounts of detrital carbonate are not surprising given the Chalk dominated catchment upstream. The amount of silicate residue (10-25%) and magnetic susceptibility (0.5 to –0.3 SI units x10⁸ (m³kg⁻¹)) decreased towards the top. This suggests a reduction in the supply of clastic material, possibly due to the stabilisation of local soils. The particle size distribution diagram for this sequence (Figure 12.3.1-2) also indicates a change in the depositional environment from relatively well-sorted fine silts with a modal size of 7.5 Phi units (c.6μm) at the base, to poorly sorted coarse silts with a modal size of 5.5 Phi units (c.24μm) near the top. In contrast, the silty clay sequence from twi/hi (Figure 12.3.1-3) shows 50-70% calcium carbonate and c.5% organic material. In addition, the silicate residue (35-50%) and magnetic susceptibility (2.5 to 0.2 SI units x10⁸ (m³kg⁻¹)) values were much higher than for the twi/g sequence. Near the top of the section, there is some suggestion of silicate residue values decreasing and calcium carbonate values increasing. The particle size distribution diagram for the twi/hi sequence (Figure 12.3.1-4) shows a largely bimodal distribution of silts with peaks at 4.5 Phi units (c.45μm) and 7.5 Phi units (c.6μm). In general, the coarser silt fraction is dominant, but near the top of the sequence the finer silts become more important. It is interesting to note that this is exactly the particle size distribution seen at the base of the twi/g sequence.

12.3.1.4 Pollen and plant macrofossils

The author carried out pollen analysis of samples from the organic silty clay at points twi/g (Table 12.3.1-1), twi/hi (Table 12.3.1-2) and from various fine-grained sediments from other points (Table 12.3.1-3).

The base of the sequence at point twi/g (samples 725cm and 615cm) shows a pollen assemblage dominated Poaceae (grass) 34%, various herbs (c.35%), and subordinate amounts of Betula (birch) (c.15%) and Pinus (pine) (c.6%). However, the sample at 525cm shows a peak in Betula pollen (c.27%), an increasing amount of Pinus (c.37%) and the first appearance of mixed oak woodland (Quercus (oak), Ulmus (elm), Corylus (hazel)). Towards the top of the sequence, the samples at 445cm and 430cm show declining
frequencies of *Betula*, with high proportions of *Pinus* (c.63%). At the top of the sequence (sample 430cm), mixed oak woodland components become more established, with *Quercus* (c.7%) and *Ulmus* (c.3%). This sequence is interpreted as recording a vegetational succession from an open grassland habitat with birch and pine scrub to closed canopy woodland, within a fluvial environment. Such a change in the vegetation seems consistent with climatic warming at the beginning of an interglacial (Substage I to II).

Pollen analysis of samples from the sequence at twi/hi (Table 12.3.1-2) revealed an assemblage dominated by the pollen of *Poaceae* (grass) (c.47%) and various herbs (c.40%). The distribution of arboreal pollen in these samples is somewhat curious, since although the lowest and highest samples analysed (560cm and 410cm) show *Betula* and *Pinus* at low frequencies, the latter with *Salix* (willow), the intermediate samples (510cm and 460cm) record the presence of *Quercus* and other temperate trees. There is no clear succession in the sequence, and the overall impression is that these assemblages are the product of a river flowing through open grassland with birch and pine scrub. It is possible that the sporadic presence of mixed oak woodland elements represents fluctuating climatic conditions. It appears that on the basis of palynology, the top of the silty clay sequence from point twi/hi can be correlated with the base of the sequence from point twi/g.

Table 12.3.1-3 shows pollen analyses from a variety of fine-grained sediments from other points at Abington Hall. Adjacent to point twi/hi, a second trench (twi/hii) was dug to reveal the silty clay unit. The top of this silty clay at twi/hii was somewhat higher than that at twi/hi, and the sample at 310cm was taken to investigate whether this was a different part of the sequence. *Poaceae* (grass) (c.39%) and various herbs (c.30%) dominate the pollen assemblage, with subordinate amounts of *Betula*, *Pinus* and *Salix*. In many respects it is very similar to the top-most sample (410cm) from twi/hi. Likewise, it is interpreted as representing open grassland with birch and pine scrub. Excavations for a sports pitch exposed a complex series of coarse and fine fluvial sediments at points twi/i and twi/j. Samples 70cm and 300cm from twi/i and 130cm from twi/j all represent part of a fine-grained silty clay channel fill that could be traced for 50m across the floor of the pit. Their pollen assemblages are dominated by *Poaceae* (grass) (60-75%) with other herbs and *Pinus*. This is interpreted as representing river deposition in an principally treeless open grassland environment. Analysis of similar sediments exposed at point twi/vi yielded virtually no countable pollen. Unfortunately, the same was true for some of the sediment samples from the Flandrian marly silty clay exposed adjacent to the archaeological site; samples from 190cm at point twi/c, and 110cm at point twi/e were both barren. Low concentrations of pollen were recovered from 90cm at point twi/c, analysis of which suggests a grassland
environment with some birch woodland. This type of vegetation existed in the early Flandrian.

Plant macrofossils recovered from the sediment at twi/g and twi/hi were analysed by C. Turner (Table 12.3.1-4). A bulk sample from twi/g 400-420cm yielded a relatively diverse aquatic flora, including *Nais marina*, *Myriophyllum* spp. and *Alisma plantago-aquatica*, indicative of deposition in a still, or slowly moving pond or backwater in temperate conditions. The remains of terrestrial herbs including Chenopodiaceae, *Plantago* sp. and *Ranunculus* spp. were also found. Arboreal taxa were represented by a leaf of *Juniperus*, a fruit stone of *Prunus* and parts of *Salix* and *Betula*. However, it is not clear whether the remains of willow and birch indicate dwarf or shrub species. A range of environments ranging from shallow open water, exposed mud, emergent marginal vegetation and riparian herbs are indicated by the assemblage. In addition, there may have been scrub of juniper, birch and willow nearby. There is no direct evidence for the mixed oak woodland or pine shown by the pollen from this part of the sequence, although this may be due to the plant macrofossils recording the local, rather than catchment vegetation.

A bulk sample from twi/hi 500-540cm produced a restricted aquatic flora, suggestive of deposition in a shallow pond under cool conditions. The only arboreal taxa present were *Salix* and *Betula*, although the remains could be from either dwarf or shrub species. It is difficult to produce a terrestrial palaeoenvironmental interpretation from this assemblage, although it is possible that scattered willow and birch scrub occupied the local area.

12.3.1.5 Molluscs

Three bulk samples of sediment from Abington Hall were analysed for molluscs by R. C. Preece (Table 12.3.1-5). The sample from point twi/g (400-420cm) contained a limited predominantly aquatic fauna including *Bithynia* sp. and *Valvata cristata*, both indicative of fluvial sedimentation in warm conditions. The sample from point twi/hi (500-540cm) contained no warm elements, and was dominated by *Pisidium* spp. and *Valvata piscinalis* indicating fluvial sedimentation. The few terrestrial molluscs present in this sample are suggestive of grassland environments. The bulk sample from twi/i (300cm) was also dominated by aquatic taxa, and included *Planorbis obtusale* and *Anisus leucostoma*, which are often associated with stagnant floodplain pools. Thermophilous taxa were also absent from this sample.

12.3.1.6 Beetles

Coleopteran analysis of samples from a single bulk sample from twi/g (400-420cm), and eight bulk samples from twi/hi were undertaken by A. Dixon (Table 12.3.1-6). The bulk sample from twi/g yielded only a sparse beetle fauna indicating a temperate climate warmer
than today. The dung beetles Valgus hemipterus and Onthophagus sp. are taken to indicate
temperatures perhaps 3-4°C higher than the present, and notably V. hemipterus is known
from early Ipswichian (MIS 5e) deposits in Britain (Coope 2000). Still or slow-flowing
aquatic environments are indicated by the aquatic weevil Bagous, and the reed beetle
Donacia semi-cuprea is found on reed sweet-grass (Glyceria maxima). There are no beetles
of flowing water habitats in this sample. Dry, open grassland is suggested by the ground
beetle Calathus sp., and mature deciduous woodland is suggested by V. hemipterus, the
larvae of which develop in deciduous trees. The decaying dung of large mammals is
suggested by the dung beetle Onthophagus sp. and mould beetle Corticaria sp.

The bulk samples from twi/hi yielded a beetle fauna broadly comparable to that from
southern Sweden (c.61°N) today. However, the analogue is not an exact one, since the
assemblage contains eastern European and Asian elements such as the dung beetle Aegialia
kamschatica, and the rove beetle Tachinus caelatus, indicative of a cool temperate continental
somewhat arid climate with summer temperatures slightly lower than the present day
(c.15°C), but with very cold winters. In addition, there are montane elements in the fauna,
also suggestive of thermal extremes, such as the click beetle Zorochrus flavipes. The
overall assemblage shows a mixture of beetles whose ranges of distribution do not overlap
today. The stratigraphic relationship of twi/hi with the sediments at twi/g suggest that these
deposits represent the very early part of an interglacial, most probably the Ipswichian (MIS
5e). The aquatic environment indicated by the insect fauna is one of a still or slowly
flowing water body, with the aquatic weevil Bagous, the whirligig beetle Gyrinus opacus,
the reed beetle Donacia semi-cuprea and a number of caddisflies (Trichoptera). A. Dixon
interprets this assemblage as representing lacustrine conditions, although the author suspects
that it represents a low-energy fluvial environment. There is some evidence for relatively
shallow water with aquatic vegetation and reedbeds, fringed by wet woodland containing
willow, and expanses of open meadow. There are also some indicators of dry chalk
grassland, for example the ground beetle Bembidion quadrimaculatum.

12.3.1.7 Dating

Optically stimulated luminescence (OSL) dating of quartz from sample 30-90cm (data
point twi/hi) gave an age of 137.74 ±41.65 for the silty clay unit (Table 2.5.11-1). This
appears to indicate a correlation with the Ipswichian (MIS 5e). Amino acid racemization
analyses for Valvata shells from the silty clay unit at point twi/hi gave D/L ratios of 0.117
and 0.133 (Appendix 5). These ratios equate to an Ipswichian (MIS 5e) age. Attention
should be drawn to the fact that only two analyses were carried out from this site, and that
this might be insufficient to detect reworked material, which appears to be endemic to many
of the other sites in this study.
12.3.1.8 Conclusions

The floral, molluscan, and coleopteran assemblages from the silty clay unit at points twi/g and twi/hi clearly show a change from cool to warm conditions. It appears that these sediments record the beginning of an interglacial period; probably the Ipswichian (MIS 5e) based on optically stimulated luminescence (OSL) and amino acid racemization dating.

12.4 Correlation of Stratigraphic Units

5km Square TL 250/545

12.4.1 Synopsis

Figure 12.4.1-1 and Table 12.4.1-1 show details of the 10 stratigraphic units proposed for the 5km Square 250/545. These units occupy various positions in the landscape at a wide range of elevations. For example, the Sandpit Plantation Gravel is located high on the edge of the Granta valley at c.75m OD, but the Abington Hall Silty Clay occurs beneath the floor of the Granta valley at c.20m OD. It is clear that channels containing fine and coarse sediments have cut into one another bringing sediments representing similar depositional conditions but quite different ages into close juxtaposition.

Table 12.4.1-2 and Figure 12.4.1-2 show the chronological and stratigraphic relationships of these units and their correlation with lithostratigraphic members and formations. Figure 12.4.1-3 presents an idealised geological section through the area showing the relationships of the various lithostratigraphic members (Table 1.4.2-1). The Round Plantation Gravel and the Sandpit Plantation Gravel are correlated with the Wandlebury Member of the Lowestoft Formation. These deposits are interpreted as elevated headwater and glacial outwash gravels of Anglian (MIS 12) age.

The Abington Hall Silty Clay and Lagden’s Grove Silty Clay are correlated with the Barrington Village Member of the Cam Valley Formation and interpreted as Ipswichian to Early Devensian (MIS 5a/e) temperate and cold stage fines of the River Granta. The Lagden’s Grove Gravel is correlated with the Arbury Member of the Cam Valley Formation, and is interpreted as Early Devensian (MIS 4) gravels of the River Granta. The Bourn Bridge Gravel and Pampisford Hall Gravel are correlated with the Sidgwick Avenue Member of the Cam Valley Formation. These units are interpreted as Middle to Late Devensian (MIS 2/3) deposits of the River Granta. The Abington Hall Gravel is correlated with the Midsummer Common Member of the Cam Valley Formation, and is interpreted as Late Devensian (Late Glacial) (MIS 2) gravels of the River Granta. The Round Plantation
Sandy Clay and Bourn Bridge Silty Clay are correlated with the Jesus Green Member of the Cam Valley Formation. These are interpreted as Flandrian (MIS 1) colluvial and alluvial tributary deposits and alluvial deposits of the River Granta respectively.

The ancient high-level gravels in this square appear to be of Anglian age, whilst the deposits of the Granta valley apparently span the Ipswichian, Devensian and Flandrian. Material of intermediate age does not appear to be represented. The arrangement of these deposits in a series of nested channels in a valley-confined system inevitably means that the sequence is likely to incomplete.
Chapter 13

Discussion and Conclusions

Snakes are coiled upon the granite
Horsemen ride into the west
Moons are rising on the planet
Where the worst must suffer like the rest
Pears are ripe and peaches falling
Suns are setting in the east
Women wail and men are calling
To the god that’s in them and to the beast

RELAYER
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13.3 Stratigraphic Problems and Developments

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Chapter 13 Discussion and Conclusions

13.1 Correlation of Lithostratigraphy

13.1.1 Correlation within the Lower Ouse Valley
(10km Squares 20/60, 30/60 & 40/60)

In the lower Ouse valley the earliest Pleistocene deposit represented is the Barrington Works Member of the Lowestoft Formation, characterised by diamicts interpreted as glacial till of Anglian age (MIS12) (Figure 13.1.1-1). This material is apparently confined to the Western Plateau and to various buried channel-forms near Over. The remainder of the stratigraphic members fall within the Ouse Valley Formation. The oldest fluvial deposits recognised here are represented by the Cold Harbour Farm Member. These gravels are interpreted as high-level deposits of an ancient river system dating from the early part of the ‘Wolstonian’ interval (MIS 9/10) or possibly the Late Anglian (MIS 12). At a much lower elevation, the Fen Drayton Member frequently occupies incised buried channel forms within the Ouse valley. These gravels are interpreted as braidplain deposits belonging to the later parts of the ‘Wolstonian’ interval (MIS6/7). Directly overlying this is the Woolpack Farm Member, interpreted as Ipswichian (MIS5e) temperate deposits and cold-stage fluvial fines of Early Devensian (MIS 5a/d) age. Above this in a relatively elevated position, the Fenstanton Member is interpreted as Early Devensian (MIS 4) braidplain deposits. Cut into these older units, the Hemingford Member is represented by cold-stage gravels. It is interpreted as Middle to Late Devensian (MIS 3/2) braidplain deposits, and is difficult to distinguish from the overlying St. Ives Member, interpreted as Late Devensian and Late Glacial (MIS 2) braidplain sediments. The Ouse Member of the Ouse Valley Formation occupies the floodplain and oversteps several of the older members. It is interpreted as alluvial and fen deposits of Flandrian (MIS 1) age.

13.1.2 Correlation within the Lower Cam Valley
(10km Squares 40/60, 50/60, 30/50, 40/50 & 50/50)

The earliest Pleistocene deposit seen in the lower Cam valley is the Barrington Works Member of the Lowestoft Formation (Figure 13.1.2-1). This is represented by diamicts and gravels interpreted as glacial till and outwash of Anglian age (MIS12). This material occupies the Western Plateau area and is also present in a buried channel-form near Oakington. The Wandlebury Member of the Lowestoft Formation is present on hill-tops
southeast of Cambridge, and is interpreted as elevated headwater stream deposits and outwash of probable Anglian (MIS 12) age.

All the remaining stratigraphic members identified fall within the Cam Valley Formation. The oldest of these is represented by the Observatory Member. These gravels are interpreted as elevated deposits of an ancient river system dating from the early part of the ‘Wolstonian’ interval (MIS 9/10) or possibly the Late Anglian (MIS 12). Clearly separate from the Observatory Member, and at a lower elevation, the gravels of the Huntingdon Road Member are interpreted as braidplain deposits belonging to the middle of the ‘Wolstonian’ interval (MIS 7/8). At a considerably lower elevation than the Huntingdon Road Member, the gravels of the Impington Village Member often occupy incised channel-forms, and are interpreted as braidplain deposits dating from the later part of the ‘Wolstonian’ interval (MIS 6/7). Directly overlying this are the temperate and cold stage deposits of the Histon Road Member and Barnwell Abbey Member. These are interpreted as fluvial fines of Ipswichian (MIS 5e) and Early Devensian (MIS 5a/d) age. Above this in a relatively elevated position, the Arbrey Member is interpreted as Early Devensian (MIS 4) braidplain deposits. To the east, the gravels of the Little Wilbraham Member apparently represent braidplain deposits of an ancient River Cam tributary of Early Devensian (MIS 4) or possibly late ‘Wolstonian’ age. The cold-stage gravels of the Sidgwick Avenue Member are incised into the older units of the Cam valley. These are interpreted as Middle to Late Devensian (MIS 3/2) braidplain deposits. It is difficult to distinguish the Sidgwick Avenue Member from the Barnwell Station Member, which is interpreted as Late Devensian (MIS 2) braidplain sediments. Occupying an incised channel-form beneath the floodplain of the River Cam, gravels of the Midsummer Common Member are interpreted as Late Glacial (MIS 2) fluvial sediments. The Jesus Green Member of the Cam Valley Formation occupies the floodplain and is interpreted as alluvial and fen deposits of Flandrian (MIS 1) age. The diamicts of the High Cross Member are interpreted as periglacially disturbed material of uncertain age.

13.1.3 Correlation within the Middle Cam Valley

(10km Squares 30/40, 40/40 & 50/40)

The earliest Pleistocene deposits seen in the middle Cam valley belong to the Lowestoft Formation (Figure 13.1.3-1). The Barrington Works Member is represented by diamicts and gravels interpreted as glacial till and outwash of Anglian age (MIS 12). This material together with glacio-lacustrine fines of the Whittlesford Station Member occurs in a buried channel-form between Whittlesford and Duxford. The Wandlebury Member of the Lowestoft Formation is present on hill-tops southeast of Cambridge, and is interpreted as high-level headwater stream deposits and outwash of probable Anglian (MIS 12) age. All the other stratigraphic members identified fall within the Cam Valley Formation.
The oldest of these is represented by the Barrington Village Member, which occurs in both the Rhee and Granta valleys. These partly temperate deposits are interpreted as partly temperate fluvial fines of Ipswichian (MIS 5e) and Early Devensian (MIS 5a/d) age. Some gravels equivalent to the Impington Village Member dating from the later part of the ‘Wolstonian’ interval (MIS 6/7) occur beneath these deposits, but are poorly developed and hard to differentiate. Relatively elevated gravels assigned to the Arbury Member are also present, but rather rare and are interpreted as Early Devensian (MIS 4) braidplain deposits. Gravels of the Sidgwick Avenue Member are incised into the older units, and are interpreted as Middle to Late Devensian (MIS 3/2) braidplain deposits. The Midsummer Common Member occupies an incised channel-form beneath floodplain deposits. These gravels are interpreted as Late Glacial (MIS 2) fluvial sediments. The Jesus Green Member occupies the floodplain of the River Cam and its tributaries. It is interpreted as alluvial and fen deposits of Flandrian (MIS 1) age.

13.1.4 Correlation within the study area

13.1.4.1 Correlation between Ouse and Cam valleys

Lithostratigraphic members proposed for the three neighbouring parts of the main study area may be correlated with relative ease (Table 13.1.4-1). Thus within the Anglian Lowestoft Formation, tills of the Barrington Works Member are common to the lower Ouse, lower Cam and middle Cam valleys, whilst high-level deposits of the Wandlebury Member occur in the lower Cam and middle Cam, and the glacio-lacustrine sediments of the Whittlesford Station Member are apparently confined to the latter. Comparisons between the Ouse Valley and Cam Valley Formations are also possible, so that for example, the elevated fluvial deposits of the Cold Harbour Farm and Observatory Members dating from the early part of the ‘Wolstonian’ interval (MIS 9/10) may be correlated. This is of particular use where important Ipswichian (MIS 5e) interglacial units, such as those represented by the Woolpack Farm, Histon Road, Barnwell Abbey and Barrington Village Members can be directly related to each other. It is clear that the lower Cam valley has the greatest diversity of Quaternary deposits in the study area, suggesting that the preservation potential here must be relatively high.

13.1.4.2 Correlation with BGS mapping units

Having established a lithostratigraphic framework for the lower Ouse valley and the lower and middle Cam valley, it is possible to attempt a correlation with the morphostratigraphic mapping units used by the BGS (Table 13.1.4-2). In the lower Ouse valley this appears to be a relatively simple exercise with the 4th Terrace Deposits equivalent to the Cold Harbour Farm Member, the 3rd Terrace Deposits equivalent to the Fen Drayton, Woolpack Farm and Fenstanton Members, and the undifferentiated 1st and 2nd Terrace...
Deposits equivalent to the Hemingford and St. Ives Members. The situation in the Cam valley is complicated by the disjunct nature of the 4th Terrace. Thus, the Little Wilbraham and Arbury Members are correlated with the Early Devensian (MIS 4), although the former is assigned to the 4th Terrace, and the latter is assigned to the 3rd Terrace. These differences are essentially the product of the rigorous lithostratigraphy applied during this study.

13.1.4.3 Problems of correlation

Recently, Bridgland and Schreve (2001) published a stratigraphy for the Fenland rivers, including the River Cam, based on the concept that terrace formation is synchronous with long-term climatic fluctuations, and that individual terraces may be dated using a combination of biostratigraphic tools. Whilst this approach claims success within many other river systems including the Thames (see Section 1.4.7), its implementation within Fenland is fraught with difficulty. Firstly, there is an implicit reliance on morphostratigraphy, so that Marine Oxygen Isotope Stages are ‘counted back’ using terraces identified and numbered by BGS survey work. Secondly, there is an assumption that all Fenland Rivers (Welland, Nene, Ouse and Cam) have behaved in a similar fashion throughout the Pleistocene (cf Bridgland and Schreve 2001), although there is clear evidence to the contrary (R. M. Briant pers. com. 2001). Thirdly, much of the vertebrate and molluscan evidence cited has been used directly from publications with little reference to the stratigraphy of the sites involved. This has produced an array of spurious assumptions, so that for example, a single valve of Corbicula from the Downing Site is taken as evidence for a MIS 7 association, a single astragalus of hippopotamus from the Botanic Garden is used to determine a MIS 5e age, and the clearly mixed vertebrate assemblage at Barnwell Abbey, which includes hippopotamus and mammoth, is assigned to MIS 9. The differences between the Bridgland and Schreve stratigraphy (Figure 13.1.4-1) and that determined in this study for the Ouse (Figure 13.1.4-2) and the Cam (Figure 13.1.4-3) are clear to see. The Ouse valley stratigraphy should also be compared with that presented by Gao (1997) (Figure 1.3.2-2).

13.1.5 Correlation with regions bordering the study area

13.1.5.1 Middle and Upper Ouse and the Nene Valley

The lithostratigraphy developed in this study for the lower Ouse valley is not at variance with that of Bowen (1999) for the entire Ouse system (Table 13.1.5-1). In the Ouse and Nene alike, the Anglian (MIS 12) is represented by the Lowestoft Formation. The Cold Harbour Farm Member is equivalent to the Biddenham Member in the middle and upper Ouse and to the Orton Longueville Member of the Nene Valley Formation. These date from the early part of the ‘Wolstonian’ interval (MIS 9/10). The Spinney Pit at Biddenham has yielded a temperate molluscan fauna including Belgrandia, and archaeology from clayey
bands in gravels of the 3rd Terrace (Harding et al. 1991). Similarly, the Fen Drayton Member is correlated with the Stoke Goldington and Hartigans Pit Members of the middle and upper Ouse and to the Grendon Member of the Nene Valley Formation, all within the later part of Wolstonian’ interval (MIS 6/7). The Hartigans Pit at Stoke Goldington, yielded a temperate flora and fauna, which have produced a D/L ratio of 0.146 and have been dated to 167-208 ka BP by Uranium series (Green et al. 1996). In the lower Ouse, the Woolpack Farm Member is taken to represent both the Ipswichian and Early Devensian (MIS 5a/e). In the middle and upper Ouse the Ravenstone Member is taken to represent both the Ipswichian and Early Devensian (MIS 5a/e). In the middle and upper Ouse the Ravenstone Member is correlated with the Ipswichian (MIS 5e) and the Radwell and Felmersham Members are equivalent to the Early Devensian (MIS 5a/d). The Hartigans Pit also contained deposits (the Ravenstone Member) containing a cool flora and fauna, which have produced a D/L ratio of 0.121 (MIS 5e) (Green et al. 1996). Deposits formerly exposed in a pit at Radwell, also produced a cool flora and fauna, considered to be Early Devensian (Rogerson et al. 1992).

No equivalent Ipswichian and Early Devensian (MIS 4) deposits were identified by Bowen (1999) in the Nene valley, and this is also the case for the Fenstanton Member in the middle and upper Ouse valley and Nene valley. However, sites at Maxey (French 1982) and Deeping St. James (Keen et al. 1999) are also correlated with the Ipswichian (MIS 5e) on the basis of flora, fauna and OSL dating. The Middle to Late Devensian (MIS2/3) Hemingford and St. Ives Members do not have recognised equivalents in the middle and upper Ouse, although they are represented by the Ecton Member of the Nene Valley Formation.

13.1.5.2 Upper Cam Valley

The lithostratigraphy developed in this study for the lower and middle Cam valley is not exactly comparable with that presented by Bowen (1999) for the entire Cam system, largely because the latter implicitly followed the morphostratigraphic scheme used by the BGS (see 13.1.4.2). Bowen also includes detailed stratigraphy for the upper Cam valley derived from Baker (1977) (Table 13.1.5-2). The Lowestoft Formation of the upper Cam comprises six members representing glacial till, outwash and glacio-lacustrine deposits. Of these, the Barrington Works and Wandlebury Members are also recognised in the lower and middle Cam valley. The Whittlesford Station Member may be correlated with the Wicken Bonhunt and Newport Members in the upper Cam. Within the complex of deposits identified by Baker (1977), the North Hall Member of Hoxnian (MIS 11) age has no immediately obvious correlatives in the lower and middle Cam valley. Channel-fill sediments at North Hall yielded a pollen sequence correlated by Baker with the Hoxnian. The present study interprets the Observatory Member as belonging to the early part of the ‘Wolstonian’ interval (MIS 9/10) and places it within the Cam Valley Formation, rather than the Lowestoft Formation (contra Bowen, 1999). In the upper Cam valley, the
Bordeaux Pit Member is suggested in Bowen (1999) as a possible ‘Wolstonian’ (MIS 9/10) equivalent. The pit, near Bordeaux Farm, Great Chesterford, produced a cool mollusc and vertebrate fauna, providing little biostratigraphic information (Marr 1926, Sparks 1955). The Barnwell Abbey Member is interpreted here as Ipswichian (MIS 5e) rather than Devensian (MIS 2-4), and the Little Wilbraham Member is interpreted as Early Devensian (MIS 4) as opposed to Wolstonian (MIS 6/8) (contra Bowen, 1999).

13.1.6 Correlation in Southern England
The lithostratigraphic framework for the Ouse and Cam valleys may be compared to those determined for neighbouring areas of southern England (Bowen 1999). Table 13.1.6-1 shows a comparison of stratigraphies west-east across southern England from the Avon valley, through the Nene, the Ouse and Cam, East Anglia and the Southern North Sea. In the Avon valley, deposits at Strensham Court produced a temperate fauna and flora giving D/L ratios of 0.165 to 0.176 correlated with MIS 7 (Bowen et al. 1989, Rouffignac et al. 1995). At Eckington Railway Cutting, deposits with a temperate mollusc and vertebrate fauna, including *Hippopotamus* have produced D/L ratios of 0.116, and have been correlated with the Ipswichian (MIS 5e) (Keen & Bridgland 1986, Bowen et al. 1989). In East Anglia, sites at Brundon and Stutton (Wymer 1985) have been correlated with MIS 7 on the basis of geochronology, and mollusc and vertebrate faunas. However, the palaeobotany from the Stutton has been interpreted as Ipswichian (Sparks & West 1963). The stratotype of the Ipswichian at Bobbitshole (West 1957, Mitchell et al. 1973) has yielded a temperate flora and fauna, and D/L ratios of 0.09 (Bowen et al. 1989). In general, terrestrial post-Anglian sequences are defined at the formation level by major river systems. The inconsistent stratigraphic framework of Bowen (1999) is highlighted by the fact that many East Anglian sites have been elevated to formation status in their own right. Correlation would be facilitated if these sites had member status within a wider formation based on local river catchments.

Table 13.1.6-2 shows stratigraphies of neighbouring areas north-south from the Trent valley, through Fenland, the Ouse and Cam, Essex, the lower Thames and the Sussex coastal plain. In the Fenland basin, deposits of ‘Wolstonian’ to Ipswichian age have been referred to the March Formation. Sites at Somersham (West 1994), Wimblington and March (West et al. 1995) and at Wretton (Sparks and West 1970) all provide interglacial pollen sequences attributed to the Ipswichian (MIS 5e). Also in Fenland, complex Flandrian sequences have been referred to the Fenland Formation, rather than to members of river system formations draining into the fens. In Essex and the lower Thames, deposits at Purfleet and Aveley (Gibbard 1994, Bridgland 1994), have been attributed to MIS 7 mainly on the basis of D/L ratios of 0.148 (Bowen et al. 1989), although Gibbard (1994) used pollen biostratigraphy to correlate these sites with the Ipswichian (MIS 5e). Gibbard
also correlated deposits at the Uphall Pit, Ilford (Stuart 1976) with the Ipswichian, although Bridgland (1994) attributes them to MIS 7 on the basis of mollusc and vertebrate faunas. In the middle Thames, the deposits at Trafalgar Square have been confidently correlated with the Ipswichian on the basis of flora, fauna and D/L ratios of 0.11 (Gibbard 1985, 1994, Bowen et al. 1989). In the upper Thames, two temperate deposits are recognised from pits near Summertown-Radley. The Stanton Harcourt Bed (Briggs et al. 1985, Bridgland 1994) has been correlated with MIS 7 on the basis of the mollusc and vertebrate fauna, and D/L ratios of 0.153–0.174. A separate *Hippopotamus*-bearing bed correlated with the Ipswichian (MIS 5e) has also been recognised (Sandford 1924). Marsworth (Green et al. 1984, Murton et al. 2001) also appears to contain deposits of two separate temperate events, although the geochronology and biostratigraphy at the site do not agree.

The terrestrial Anglian deposits across much of southern England are represented by the Lowestoft Formation, although in eastern Norfolk the North Sea Drift Formation is also recognised, and to the west in the Trent and Avon valleys the Wolston Formation represents this glacial stage. The terrestrial pre-Anglian stratigraphy is in contrast relatively complex, comprising a variety of units of formation status relating to different ancient river systems. In Sussex, south of the Anglian ice limit, the West Sussex Coast Formation spans the pre-Anglian to Middle Devensian. The stratigraphy of the Southern North Sea is well developed, and characterised by numerous formations relating to alternating glacial and marine conditions.

McMillan and Hamblin (2000) proposed that for mapping purposes, Stratigraphic groups of formations south of the Devensian ice limit for southern England should be used (Figure 13.1.6-1). These include the pre-Anglian Dunwich Group, the Southern British Glacigenic Group, which includes the Lowestoft Formation, The Ouse-Nene Group including the Cam Valley and Ouse Valley Formations, and a number of non-glacigenic interfluve groups, not well represented in the study area. It should be noted that the Southern British Glacigenic group as envisaged by McMillan and Hamblin (2000) spans the pre-Anglian to later part of the ‘Wolstonian’ interval (MIS 6) as a consequence of a recently suggested complex and controversial stratigraphy for Norfolk (Hamblin, Moorlock and Rose 2000).

13.2 Pleistocene Fluvial Behaviour, Landscapes and Palaeoenvironments

13.2.1 Pre-Anglian Palaeogeography and drainage

There is little direct evidence to assist with palaeoenvironmental reconstructions from the study area in pre-Anglian (MIS >12) times. Most of what can be said relies upon evidence
from areas adjacent to the Cambridge District. It appears that during the early Middle Pleistocene, the Chalk escarpment was a more striking feature of the landscape, and may have outcropped some 10km to the northwest of its current position (Clayton 2000) and reached to c.120m OD. It is also clear that much of Fenland would have been at a considerably higher elevation (up to 60m OD) than today. Within the Cambridge District, only deposits beneath tills of the Barrington Works Member, and the gravels of the Wandlebury Member clearly have the potential to be of this age. The second of these may represent high-level headwater deposits from streams draining the dip slope of the Chalk escarpment. To the southeast of the study area, the Kesgrave Formation records the cold stage and temperate ‘Cromerian Complex’ courses of the River Thames and its tributaries (Rose et al. 1999), whilst to the west the Milton and Baginton Formations record pre-Anglian fluvial activity across the present-day Ouse, Nene and Avon catchments. To the north and northeast, quartz and quartzite-rich gravels of the Shouldham and Ingham Formations form an alignment suggesting an ancient course of drainage west-east across Fenland and through the present-day Lark, Little Ouse and Waveney catchments. This line of drainage is known as the Bytham River (Lewis, Rose and Davies 1999), considered by many as the major western tributary of the Pre-Anglian Thames system. This river would have breached the Chalk escarpment near Lakenheath, Suffolk, bringing pebbles from the Midlands into East Anglia. Gallois (1999) has presented evidence, refuted by Rose et al. (2000), that the pre-Anglian drainage of Fenland was through a breach of the Chalk escarpment to the north of Hunstanton, Norfolk, and that sediments attributed to the Bytham River are simply outwash of Anglian age. Unfortunately, little from the Cambridge District can help determine which of these opposing theories might be correct.

13.2.2 Anglian Glacial Events

Much of the detailed information concerning events within the Anglian Stage (MIS 12) comes from the Lowestoft Formation of the middle and upper Cam valley. The approach of the Anglian ice sheet appears to have been preceded by copious glacial outwash forming gravels of the Widdington Member. There is some evidence for oscillations during this glacial advance from the till and outwash complex of the Quendon Member. During this period, ice lodged against the Chalk escarpment, and outwash streams followed the courses of headwater valleys draining towards the southeast. Such deposits belong to the Wandlebury Member. There is also evidence from the lacustrine deposits of the Newport Member that large pro-glacial meltwater lakes formed at this time in front of the advancing ice. Once ice overrode the Chalk escarpment, till of the Barrington Works Member was laid down across interfluve areas in both the Ouse and Cam valleys. At Madingley Hill, the Barrington Works Member contains a well-developed bed of outwash gravel. However, along the main north-south Cam valley alignment, a deep ‘tunnel’ valley was carved into.
the bedrock by sub-glacial drainage. It is not clear whether this down cutting followed existing lines of drainage. Similar features are known from Stevenage, Hertfordshire, and from elsewhere in East Anglia. This incisional feature was subsequently filled by till of the Henham Member, perhaps during a pause in the advance of the Anglian ice sheet. Presumably following a re-activation of the ice, a second sub-glacial ‘tunnel’ valley was cut, partly superimposed on the first. This steep-sided channel was filled by glacio-lacustrine and outwash sediments of the Wicken Bonhunt Member. Similar buried channel forms containing glacial sediments can be traced in the middle Cam at Whittlesford Station, in the lower Cam at Girton Village, Girton Crossing, and in the lower Ouse at Hill Farm and Manning’s Farm. Together these form an important north-south drainage alignment through the Oakington Gap, a course that was inherited by post-Anglian streams.

Elsewhere in East Anglia, the Lowestoft Formation exhibits a similarly complex sequence. Equally complicated stratigraphy is seen in both the North Sea Drift Formation of east Norfolk and the Wolston Formation of the Midlands. The extent to which the Anglian ice sheet eroded the Chalk escarpment in the Cambridge District is by no means clear. It is widely considered that the advancing ice was responsible for excavating great quantities of Jurassic clay from the Fenland basin, and also overrode and effectively destroyed the East Anglian Chalk escarpment (Perrin et al. 1979, Clayton 2000). Debris from both of these sources clearly forms the majority of Lowestoft Formation till. The author believes post-Anglian periglacial destruction of these landforms to be an equally important part of the story. This has been amply demonstrated in Fenland by West (1991) and Burton (1976, 1987), and in the Cambridge District and elsewhere by Boreham (1996a, 1996b, 1998).

13.2.3 Hoxnian Palaeoenvironments

Very little detail is available for the Hoxnian Stage (MIS 11) from the Cambridge District, and most of the information must be gleaned from adjacent areas. It is clear that the retreat of the Anglian ice sheets left a hugely modified landscape of disrupted drainage and bare mineral soils. In the upper Cam valley, temperate lacustrine sediments of the North Hall Member (Baker 1977) record the first half of the Hoxnian, and a temperate kettle-hole in-filling at Tye Green, Stansted Airport (Boreham and Gibbard 1999) preserves sediment spanning much of the interglacial. To the southwest in Hertfordshire, sites at Hitchin (Boreham and Gibbard 1995) and Fishers Green (Gibbard and Aalto 1977) contain lake sediments from the first part of the Hoxnian. To the north, sequences at Woodston, Peterborough (Horton et al. 1992), and in the Nar valley (Ventris 1996) and Elveden (Ashton et al. 2000), Norfolk, have all been attributed to this interglacial. From these sites it is possible to surmise that pre-temperate scrub vegetation spread rapidly across the freshly exposed landscape, and was replaced by a succession of thermophilous early- and late-temperate woodland. It is believed that during this period, sea-level rose to c.20m OD
(Ventris 1996) and that rivers were characterised by low-energy meandering or anastomosing courses (Gibbard and Lewin 2002). These streams would have picked their way through the relict late-Anglian landscape without greatly modifying it. Further, the preservation potential of fluvial deposits from this stage is not particularly great given the high-energy fluvial activity of the succeeding ‘Wolstonian’ interval. It is presumed that the elevation of the Cambridge District at this time was mostly greater than 20m OD, since there is no discernible evidence of Hoxnian marine or estuarine deposits.

### 13.2.4 ‘Wolstonian’ Palaeoenvironments

Within the Cambridge District, deposits from the early part of the ‘Wolstonian’ interval (MIS 9/10) are preserved as elevated cold-stage fluvial aggradations in the lower Ouse (Cold Harbour Farm Member) and lower Cam (Observatory Member) valleys. These sediments appear to be intimately associated with the courses of Anglian ‘tunnel’ valleys, which must have heavily influenced drainage of the post-Anglian landscape. Thus, the course of the proto-Cam appears to have been northwards through the Oakington Gap. These high-energy braidplain deposits infer dry grassland under cold tundra-like conditions within the catchment. In the Nene, the gravels of the Orton Longueville Member seem to record similar conditions at this time, but there is little direct evidence in the Cambridge District for temperate deposits dating from the early part of the ‘Wolstonian’ interval (MIS 9), such as those ascribed to the Biddenham Member in the middle Ouse.

In the lower Cam valley, deposits belonging to the middle part of the ‘Wolstonian’ interval (MIS 7/8) are represented by the Huntingdon Road Member. These cold stage braided stream deposits are lower than, and occupy a distinct course from the Observatory Member of early ‘Wolstonian’ age. They record dry grassland and periglacial conditions within the catchment of the proto-Cam. Similar deposits have not been recognised in the lower Ouse and middle Cam valleys. During the middle part of the ‘Wolstonian’ interval there appears to have been significant downcutting and lateral movement of the river systems so that many sediments of the later part of the ‘Wolstonian’ interval occupy incised channel-forms at a considerably lower elevation than earlier deposits.

Sediments attributed to the later part of the ‘Wolstonian’ interval (MIS 6/7) are relatively widespread within the lower Ouse and lower Cam, and are also known to be present in the middle Cam. The Fen Drayton Member of the Ouse and the Impington Village Member of the Cam appear to record cold stage braided stream deposits from the later part of the ‘Wolstonian’ (MIS 6) interval, often confined to an incised channel-form. There is abundant evidence that these deposits also contain temperate material of MIS 7 age, which has become widely reworked and redeposited in later Ipswichian (MIS 5e) sediments. In the lower Cam, Swan’s Pit, Milton Road, supplies one of the few examples of in situ temperate sediments from the later part of the ‘Wolstonian’ interval within the Impington
Village Member. Elsewhere, for example at Histon Road and Barnwell Abbey, the deposits seem to contain a mixed biostratigraphic signal of MIS 7 and 5e. Exactly the same situation is evident at Woolpack Farm in the lower Ouse. In a more elevated tributary situation, the deposits of the Grantchester Member provide an excellent insight into the temperate environment in the later part of the ‘Wolstonian’ interval (MIS 7). Here the confluence of the proto-Bourn Brook and Cam produced an area of shifting channels in a floodplain surrounded by grassland with some broad-leaved temperate woodland in the catchment. Upstream at Barrington in the middle Cam, a basal unit beneath Ipswichian (MIS 5e) sediments is also correlated with a temperate episode in the later part of the ‘Wolstonian’ interval (MIS 7).

13.2.5 Ipswichian Palaeoenvironments

The majority of Ipswichian (MIS 5e) fluvial sediments are closely associated with units of late ‘Wolstonian’ age that occupy incisional channel-forms. Indeed, reworking of fossil material from earlier sediments appears to be a universal characteristic. In the early-temperate phase of the Ipswichian, the Ouse and Cam were low-energy meandering single-thread streams with grassy floodplains, and catchments with broad-leaved thermophilous woodland (Gibbard and Lewin 2002). In the late-temperate phase, there was an expansion of grassland and an increase in the supply of fine sediment, so that large expanses of floodplain filled the river valleys. Many sites in the Cambridge District record only a relatively short time interval within this interglacial. For example, Abington Hall in the middle Cam appears to show only pre-temperate and early-temperate sediments. However, the Barrington Village Member, Barnwell Station Member, and Woolpack Farm Member record fully temperate conditions, and the Histon Road Member comprises largely late-temperate and post-temperate sediments. In contrast, the deposits at Manning’s Farm in the lower Ouse valley appear to span both early- and late-temperate substages. It is thought that sea-level during this period was higher than that at the present day, although there is little direct evidence for marine influence in the Cambridge District, despite the deposits at Manning’s Farm in the lower Ouse being at 2-7m OD. However in Fenland, brackish and marine deposits attributed to the Ipswichian at Somersham (West 1994), Wimblington and March (West et al. 1995) and at Wretton (Sparks and West 1970), have been described at elevations ranging from −3m to 3m OD.

13.2.6 Devensian Palaeoenvironments

In the Cambridge District, the Early Devensian (MIS 5a/d & 4) is characterised by two quite different climatic and fluvial regimes. It appears that after the end of the Ipswichian Stage, the aggradation of fines continued in river valleys throughout MIS 5a/d to form broad tracts of floodplain. The climate was cool but not extremely cold, and the landscape was dominated by steppic grassland, with some scrubby boreal woodland developing in
the less severe substages. These sediments are well developed in the Histon Road and Woolpack Farm Members. Elsewhere in the British Isles, sediments thought to be of this age, for example at Chelford (Rendell et al 1991) and Brimpton (Bryant, Holyoak and Moseley 1983), show evidence of boreal forest often with *Picea* (spruce).

Subsequently, there was a moderate to severe incisional event followed by the aggradation of cold stage braidplain sediments in MIS 4 (*cf.* van Huissteden *et al.* 2001). These deposits are recognised as the Fenstanton Member in the lower Ouse and the Arbury Member in the Cam. Cold stage braidplain sediments of the Little Wilbraham Member form the course of an abandoned major eastern tributary of the Cam system, which was active at this time. However, it seems likely that the genesis of this river was much earlier, although there is little direct evidence available. The course of the Cam in the Early Devensian was apparently still northwards through the Oakington Gap, towards a confluence with the River Ouse north of Willingham.

The prelude to the Middle Devensian (MIS 3) was a major incisional event, which cut through many of the older units. This was followed by an aggradation of cold stage braidplain deposits. In the lower Ouse, sediments of the Hemingford Member unconformably overlie ‘Wolstonian’ and Ipswichian deposits, as at Woolpack Farm. This is also the case for the Sidgwick Avenue Member in central Cambridge and further upstream. However, to the north of the city there is clear evidence that the Cam avulsed to the east during the incisional phase and established an entirely new Middle Devensian course that did not pass through the Oakington Gap. The braidplain in this area is particularly well developed and arcs to the northwest near Cottenham, presumably to join the course of the River Ouse north of Willingham. At the Sidgwick Avenue site, basal fines record a grassy floodplain environment, with a cool to cold climate and scattered pine and birch scrub in the catchment. In central Cambridge, fines of the Emmanuel College Member fill a channel-form cut into the surface of the Sidgwick Member braidplain. These represent floodplain sediments laid down under a cool climate by a river with a catchment dominated by grassland. In the Ouse, fines within the Hemingford Terrace at Earith (Bell 1969, 1970, Coope 1997) and at Over (Coope, pers. com. 2001) contain evidence for a temperate treeless event similar to the Upton Warren Interstadial.

Deposits of the Late Devensian (MIS 2) are rather difficult to distinguish from Middle Devensian units, since both are represented by cold stage braidplain gravels. It is clear from the lower Ouse that the Late Devensian St. Ives Gravel fills an incisional feature partly cut into the Hemingford Member. Upstream of Cambridge, the Barnwell Station Member dated to 19,500 ±650 BP (Godwin and Willis, 1964) is equally difficult to differentiate from the Sidgwick Avenue Member and is often covered by Flandrian Alluvium. Downstream of Cambridge, it is clear that the Cam avulsed further to the northeast during
the Late Devensian incisional phase and formed an entirely separate braidplain course, taking a circuitous route into Fenland to the east of Stretham and Ely. In Fenland at around this time, West (1993) envisaged fluvial drainage impeded by a pro-glacial lake dammed by an ice sheet in the Wash.

In Late Glacial times, there was a further major incisional event, which established a single thread river morphology. These channel-forms are largely floored by cold stage deposits. In the lower Ouse these sediments, for example at Holywell (Gao 1997), may be included within the St. Ives Member, but in the Cam system gravels of the Late Glacial Midsummer Common Member are clearly separate from the older Barnwell Station Member. Marginal to the main river valleys, thaw lakes formed during the Devensian through periglacial processes, and at the Babraham Road Park and Ride site, laid down lacustrine sediments in Late Glacial times. In dry valleys and on interfluves, there appears to be ample evidence for the accumulation of Late Glacial solifluction deposits, such as the Barrington Works Dry Valley Beds.

13.2.7 Flandrian Palaeoenvironments

Detrital and fen peats and clayey peats of the early Flandrian are confined to the channel-forms incised in the Late Glacial. At this time the Ouse and Cam adopted a stable low-energy flow regime, as broad-leaved mixed oak woodland stabilised soils within the catchment. In Fenland, a marine transgression at 4000-5000 BP inundated early Flandrian peats and is marked by considerable thicknesses of intertidal fines belonging to the Barroway Drove Beds. At its maximum, this transgression may have affected the lower Ouse and Cam valleys. Following this, the accumulation of the Nordelph Peat marked a return to freshwater conditions, only briefly punctuated by second marine incursion at 2000-2600 BP (Willis 1961). In the Ouse and Cam, the later part of the Flandrian is characterised by localised lateral shifting of channels followed by the widespread deposition of overbank fines in a floodplain environment. In tributary valleys, this period is often represented by colluvial deposits. These changes in fluvial behaviour were largely driven by human activity including the felling of woodland and the spread of arable farming within the catchment. All of these Flandrian deposits are assigned to Ouse Member in the Ouse valley and the Jesus Green Member in the Cam valley (Figure 1.2.4-1).

13.3 Stratigraphic Problems and Developments

13.3.1 Lithostratigraphy

The lithostratigraphic division of Quaternary deposits based upon clearly discernible 'packages' of sediments recorded in the field, from borehole logs and from seismic studies forms the corner-stone of modern stratigraphic practice. However, lithostratigraphic units can only be assigned to their relative position in the stratigraphic sequence. In themselves,
they cannot provide any specific chronostratigraphic information. The climatostratigraphic division of the British Quaternary further compounds these issues in that there is an implicit expectation that glacial and interglacial deposits will form separate and clearly different sedimentary ‘packages’. Fortunately, this appears to be the case, although it clearly cannot be taken as a basis for correlation over wide geographical areas or within different environments of deposition. Langford (2002) has urged the Quaternary community to adopt a flexible approach to stratigraphic grouping.

The author has refined the lithostratigraphic method of Salvador (1994) in this study, by formally naming local stratotypes for local stratigraphic units (Section 2.3.2). This approach was developed in response to the large amount of data in the study area, and is amenable to future changes of interpretation. Each lithostratigraphic member may comprise a number of co-correlative local stratigraphic units. An advantage of this approach is that it transcends the problems of scale and status, which caused difficulties in Bowen’s (1999) correlation of British Quaternary deposits.

### 13.3.2 Geochronology

Whilst geochronological dating techniques should provide unimpeachable evidence to support chronostratigraphic correlation, in practice there are considerable hurdles to be overcome. The first and largest of these is the absence of a widely available and independently verifiable ‘clock’ against which other dating techniques can be compared and calibrated. The obvious choice for such a chronometer is isotopic radioactive decay, such as Uranium-Thorium dating (Ivanovich & Harmon, 1992). However, this technique has been troubled by post-depositional leaching of sediments, by the presence of ancient carbonate from Chalk catchments, and the need to assume a closed system. The problems are such that some workers have recently rejected U-Th dates in favour of biostratigraphic dating evidence (Murton et al. 2001). Radiocarbon dating is of course a well-established technique, and although theoretically limited to c.50 ka BP, problems with contamination by modern carbon and the calibration of radiocarbon years into calendar years make reliable dating beyond c.24 ka BP problematic (see 2.5.11.3). Luminescence dating, and in particular single-aliquot OSL dating of quartz (Duller 1991, Murray and Wintle 2000), seems to offer the possibility of a reliable absolute geochronology back to c.300 ka BP (pers. com. E. J. Rhodes, 2001) (see 2.5.11.1). However, it is a maturing technique, whose results some workers are perhaps understandably cautious about accepting unconditionally.

Amino acid geochronology (the time-dependant epimerisation of L-isoleucine to D-alloisoleucine in mollusc shells) is a relative, not an absolute dating technique, although it has been widely used in southern England with other dating methods to correlate deposits with Marine Oxygen Isotope Stages (Bowen 1999) (see 2.5.11.2). The results of this
study strongly suggest that amino acid determinations with a high degree of internal integrity from a single site, can exhibit a wide scatter of D/L ratios. Presumably, this pattern has been produced by the reworking of mollusc shells from one interglacial deposit to another, although the possibility of differential geochemistry cannot be entirely discounted. This causes serious problems for the interpretation of D/L ratios, since it is quite clear that if an insufficiently large number of shells are analysed, there is a great risk of entirely erroneous conclusions being reached. This is clearly an area that deserves greater attention, and research activity is currently being directed towards these issues (D. Maddy, pers. com. 2001). However at Marsworth, where a large number of D/L ratios agree, the results have been rejected in favour of biostratigraphic dating evidence (Murton et al. 2001).

13.3.3 Biostratigraphy

Given the problems associated with many aspects of geochronology, it is unsurprising that biostratigraphic techniques have remained vitally important to the chronostratigraphic interpretation of Quaternary sediments. Pollen analysis remains the principal tool for the correlation of deposits throughout the Quaternary. Recent work on long sequences in southern Europe (Tzedakis et al., 2001) provides important possibilities for biostratigraphic differentiation between interglacial stages, and a chronological framework against which Marine Oxygen Isotope Stages can be correlated. The application of pollen as a biostratigraphic tool in fragmentary sequences from southern England remains less secure (Thomas 2001). The apparent differentiation of post-Anglian temperate events (MIS 11, 9, 7 and 5e) in southern England using vertebrate assemblages (Schreve 2001a) is a considerable biostratigraphic achievement. However at some sites, age determinations based on vertebrate faunas conflict with those from geochronological dating methods, for example at Marsworth (Murton et al. 2001), and elsewhere conflict with other biostratigraphic indicators, for example at Barnwell Abbey and Histon Road (Bridgland and Schreve 2001). Using the Flandrian as an analogue, it appears that the environment of deposition and various taphonomic controls have major roles in influencing which sections of the vertebrate fauna are preserved (S. Payne pers. com. 2001). In addition, it is clear that during the Late Glacial there was quite marked regional patterning in the distribution of particular taxa (Currant and Jacobi 2001). Such considerations may also significantly affect the viability of vertebrates as biostratigraphic indicators in the later part of the Middle Pleistocene. Once uncertainties about the reworking of specimens are added to this, it becomes clear that a great deal of care is required to apply this type of biostratigraphy properly.

Distinct assemblages of beetles have formed the basis of a biostratigraphic method for separating interglacial events (Coope, 2001). An early-temperate Ipswichian (MIS 5e)
assemblage, from for example Woolpack Farm and Trafalgar Square (Gibbard 1994), and a late-temperate assemblage tentatively assigned to MIS 7 have been identified. However, late-temperate Ipswichian beetle assemblages are poorly known, and the possibility of confusion between the two temperate stages is apparent (G. R. Coope pers. com. 2001). This appears to be the situation at Histon Road Allotments. Molluscan biostratigraphy in post-Anglian deposits based on the presence or absence of *Corbicula fluminalis* and *Belgrandia marginata* is rather well developed, permitting differentiation of MIS 11, 9, 7 and 5e (Keen 1990, Preece 1995, Meijer and Preece 2000, Keen 2001). Evidence to support this comes from amino acid geochronology and biostratigraphic markers. If these key species are present together because of reworking, then there is the possibility for great confusion to be caused.

### 13.3.4 Chronostratigraphy and Comparison of Major Sites

The sediments investigated from sites of major importance identified in this study have been dated where possible on the basis of geochronology and biostratigraphy. The comparative ages of the sites considered in this way is shown in Figure 13.3.4-1. These range from the earliest ‘Wolstonian’ deposits of the Traveller’s Rest Pit, to the Late Glacial sediments of the Babraham Road Park and Ride site and Barrington Works. An important theme in this chronostratigraphic analysis is the apparent reworking of molluscs, vertebrates and plant macro-fossils, which appears to be endemic in the deposits. Thus, reworking of biostratigraphically important taxa such as *Hippopotamus, Corbicula* and *Belgrandia* has the potential to cause erroneous age determinations. However, it is possible to correlate a number of the sites in this study on the basis of similar faunal and floral assemblages and comparable geochronology. The relationship between geochronology, biostratigraphy and issues of reworking at these sites is shown in Table 13.3.4-1. Some sites, like Cardo’s Pit, Barrington, comprise sediments of clearly different ages, which exhibit a distinct lithostratigraphic relationship. At other sites, such as Barnwell Abbey, the detailed lithostratigraphy is unclear, although the biostratigraphic signal is clearly a mixed or chimeric one that must originate from deposits of more than one interglacial stage. Another variation, as at Grantchester, is where the majority of the biostratigraphic signal indicates a particular age, but certain minor elements appear incompatible, perhaps indicating later sedimentation or reworking from nearby. The problem of reworking is more evident where interglacial fauna and flora occur within cold stage sediments, as at Sidgwick Avenue and Barnwell Station. However, the greatest difficulty arises when biostratigraphically consistent interglacial sites such as Woolpack Farm produce amino acid ratios that suggest extensive reworking of older mollusc material, as considered below.
13.3.5 The Problem of Reworking

Work on amino acid geochronology in this study (see Appendix 5) suggests that in the Cambridge District, a large proportion of molluscs found within temperate deposits may have been reworked from previous interglacials. Even before this discovery, there was the realisation that reworking of molluscs might be problematic, since the thermophilous *Belgrandia marginata* had been discovered in Devensian sediments at the Sidgwick Avenue site (Lambert, Pearson and Sparks 1962). Indeed it was for this reason that the author concluded that amino acid determinations from that site might be unreliable (see 2.5.11.3).

Similar problems of reworking have also been documented at Somersham, Cambridgeshire, where temperate molluscs and ostracods were found in Devensian sediments (West *et al.* 1994). If these observations are correct, then not only are palaeoenvironmental interpretations based on the mollusc assemblages called into question, but their value as biostratigraphic indicators must also be doubted. The reworking of molluscs from one temperate deposit into another cannot be the result of high-energy cold stage fluvial activity, since the specimens used for amino acid analyses were carefully chosen for their pristine condition. Therefore, it seems that this reworking is the product of a low-energy process. It appears that deposits from previous interglacial stages must have been exposed immediately adjacent to temperate river channels, such that mud flows or blocks of silty clay containing shells became incorporated within the later deposits. A modern analogue of this situation has apparently often been observed on the floodplains of some African rivers (D. H. Keen pers. com.). It may be that smaller rivers such as the Cam and Ouse did not carry a sufficient volume of water during each intervening cold stage to entirely ‘flush’ old interglacial sediments from the system, thus increasing the possibility of subsequent temperate reworking.

A further worrying possibility is that if molluscs can be reworked in pristine condition from one interglacial to the next, then so might other fossil groups. Plant macrofossils exhibit a similar size range to molluscs, and therefore could be prime candidates for suspicion. The difficulty is that once beyond the reach of radiocarbon dating, it would be very hard to detect older interglacial material reworked into younger temperate deposits. The presence of *Carpinus* fruits reworked into the fully arctic sediments of the Barnwell Station Member (Chandler 1921), hints at the potential problems for this group. Of perhaps greater concern is the possibility that vertebrate material might also be reworked in this way. The biostratigraphic importance of this group is such that, for example, pristine horse teeth from sediments of late ‘Wolstonian’ (MIS 7) age became reworked into Ipswichian (MIS 5e) deposits, very great confusion and circularity of arguments could ensue. This is precisely the situation that may exist at Histon Road Allotments, Barnwell Abbey and other interglacial sites in the Cambridge District. Indeed, these problems of
reworking may have led Bridgland and Schreve (2001) to erroneously place Histon Road and Barnwell Abbey in MIS 9, largely on the basis of previously published vertebrate assemblages.

In contrast, the reworking of beetle remains appears to be a less serious concern, by virtue of the fact that they are very easily oxidised, and readily attacked by fungi and bacteria. It seems likely that if sediments from a previous interglacial were exposed on the banks of a river, any coleopteran remains would quickly degrade and become unrecognisable. This supposition is supported by the fact that there is a demonstrable paucity of reworked beetle remains in Pleistocene sediments (G. R. Coope, pers. com. 2001). Pollen grains may also be less susceptible to this type of reworking. It is easy to imagine silt-sized pollen grains being winnowed away as suspensive load in a river current leaving behind larger and denser fossil material. Pollen analysis of Devensian sediments at Somersham containing reworked molluscs and ostracods, contained only pre-Pleistocene trilete spores (West et al. 1994). However, if sediments are reworked in the form of mud balls or pellets, then pollen grains will certainly be incorporated within the final sediment. These facts must be considered when interpreting pollen assemblages from both temperate and cold-stage deposits.

13.4 Conclusions

The rigorous lithostratigraphic approach used in this study has provided an important framework for correlation, and may form the basis for future mapping of these deposits. In addition, the refinement of lithostratigraphic methods with an additional lower tier of local stratigraphic units is a technique that has proved to be an invaluable tool in this study, and could usefully be applied to Pleistocene deposits across much of southern England. This study has attempted correlation of both deposits from the Anglian glaciation, and the post-Anglian fluvial deposits of the Great Ouse and Cam systems within the Cambridge District. Lithostratigraphic units from the study area have also been correlated across southern England with relative ease. Correlations with European sequences are more difficult, since they rely on geochronological and biostratigraphic techniques that are still developing (cf. Tzedakis et al. 2001, Schreve and Thomas 2001).

The apparent absence of pre-Anglian sediments in the study area has made it difficult for the author to contribute to the debate about the Bytham River (cf. Gallois 1999, Smith & Rose 1997). In pre-Anglian times, the Chalk escarpment of the Chilterns was more pronounced, outcropping to the northwest of its current position, and Fenland was at a considerably higher elevation than today (cf. Clayton 2000). At that time, the main lines of drainage in the study area were subsequent streams flowing towards the northeast following the regional bedrock strike, and consequent streams flowing southeastwards,
draining the dip slope of the Chalk. The advance of Anglian ice across this area clearly had a major impact on the landscape and drainage, although the author believes that post-Anglian periglacial processes have also played a key role in producing the landscape we see today. The Ouse and Cam river systems initially developed in the early part of the ‘Wolstonian’ interval along lines of Anglian sub-glacial drainage. In each ‘Wolstonian’ and Devensian cold stage these streams adopted a high-energy braided channel morphology, characterised by lateral erosion, episodic incision, and the aggradation of gravels and sands. During these times, the rivers progressively extended their catchments and modified their courses. In contrast, temperate stages (MIS 7 and MIS 5e) brought relatively stable low-energy anastomosing or single thread channel morphologies, and resulted in the accretion of fines and organic sediments (cf. Gibbard and Lewin 2002).

Many different depositional environments have been identified from sediments of the Cambridge District including, subglacial, proglacial, tundra, scrub-tundra, steppic grassland, boreal forest and temperate woodland.

Throughout this study, the author has taken lithostratigraphy as the primary line of evidence for correlation, supported secondly by geochronology and thirdly by biostratigraphy. Recently, workers in some circumstances have promoted biostratigraphy above geochronology (cf. Murton et al. 2001). It is clear that without a fixed set of rules, it is possible to accept or reject different lines of evidence so that interpretations of chronostratigraphy become highly subjective, and prone to circular arguments. Where possible, absolute geochronological techniques including OSL and radiocarbon dating have been applied. Advances in the aminostratigraphy of this region have also proved invaluable for the correlation of deposits. This study has investigated many new deposits, and brought a much greater understanding of classic Cambridge Pleistocene sites and how they relate to each other. The problem of reworking seems to be endemic to smaller river systems like the Cam, and this has major implications for biostratigraphy, and particularly that of molluscan and vertebrate remains.
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