THE SUFFOLK RIVER VALLEYS PROJECT: An assessment of the potential and character of the palaeoenvironmental and geoarchaeological resource of Suffolk river valleys affected by aggregate extraction

Funded by Aggregates Levy Sustainability Fund
Administered by English Heritage

Tom Hill, William Fletcher, Benjamin Gearey, Andy Howard and Clare Good

http://www.suffolk.gov.uk/Environment/Archaeology/MineralsAndArchaeology/SuffolkRiverValleysProject.htm

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THE SUFFOLK RIVER VALLEYS PROJECT: AN ASSESSMENT OF THE POTENTIAL AND CHARACTER OF THE PALAEOENVIRONMENTAL AND GEOARCHAEOLOGICAL RESOURCE OF SUFFOLK RIVER VALLEYS AFFECTED BY AGGREGATE EXTRACTION

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1 INTRODUCTION

This report documents the results of palaeoenvironmental assessments undertaken to reconstruct the development of Suffolk's main river valleys. The rivers Waveney, Little Ouse, Lark, Gipping and Black Bourn were all considered as sites with an abundance of archaeological history and yet lack supporting environmental knowledge. Generic models of alluvial development of such low gradient fluvial systems suggest that the build up of fine-grained sediment through overbank sedimentation has probably resulted in the burial of significant archaeological remains within valley floor environments (Howard & Macklin, 1999). Such sites were therefore deemed as having significant palaeoenvironmental potential.

The study of these valleys in particular was considered timely because of the direct impact of past, present and future aggregate extraction on the landscape and cultural heritage of Suffolk. Current research through the Aggregates Levy Sustainability Fund (ALSF; funded by English Heritage) in Suffolk is addressing the issues regarding the identification and quantification of the archaeological record in the minerals resource areas (Plouviez *et al*., 2007), but no provision had been made within the project for the characterisation and investigation of the palaeoenvironmental and geoarchaeological resource. When taking into account the abundance of aggregate extraction occurring in the lowlands of the county (see Figure 1), the potential threat posed to archaeological and environmental resources must be considered. With the core objective of the English Heritage funded scheme being to 'reduce the impact on the historic environment of aggregate extraction', a number of the ALSF priorities were identified as being directly related to the threats posed on the Suffolk lowlands:

- To contribute to 'developing the capacity to manage aggregate extraction landscapes in the future' through resource assessment
- To contribute to 'delivering to public and professional audiences the full benefits of knowledge gained through past work in advance of aggregates extraction' through outreach as well as popular and academic publications
- To contribute to 'promoting understanding of the conservation issues arising from the impacts of aggregates extraction on the historic environment' through the identification of areas of geoarchaeological significance worthy of preservation and conservation

In addition, English Heritage actively supports projects which will deliver against the headline objective of promoting environmentally friendly extraction and transport:

- To contribute to 'research to enhance the understanding of the scale and character of the historic environment in current or likely future aggregate producing areas in order to provide the baseline information necessary for effective future management' through the assessment and characterisation of sediments at threat through future aggregate extraction
- To provide 'support for the development of management and conservation strategies for the historic environment in current or likely future areas of aggregate production' which would aid in the development of future geoarchaeological prospection strategies

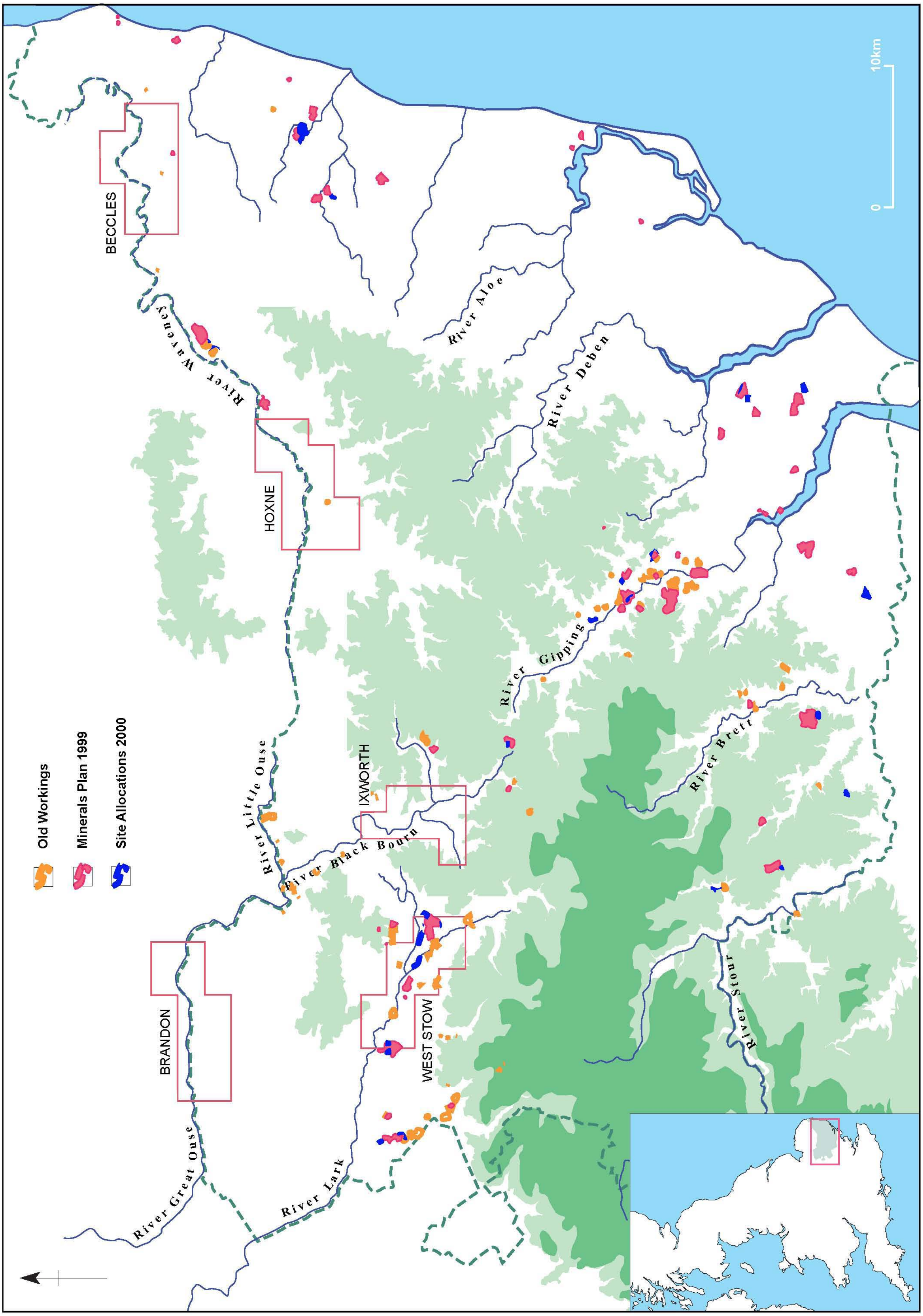


Figure 1: Map of Suffolk identifying the primary water courses, site locations chosen for assessment and the distribution of past and present aggregate sites within the county.

- To undertake 'the analysis and dissemination of important data from past work undertaken in response to aggregate extraction' through extensive literature reviews of both published and grey literature relating to the county

The Suffolk River Valleys Project subsequently developed through the identification of this major gap in knowledge. The project was therefore designed to:

- Provide baseline data addressing the geomorphological character of selected Suffolk valley floors and the potential of the landforms and sediments recorded within them for palaeoenvironmental reconstruction of the surrounding archaeological landscape.
- Provide an assessment of the potential for the preservation of archaeological remains within Suffolk valleys through an understanding of their geomorphological history.
- Review and collate both the grey and published palaeoenvironmental and archaeological literature into a single volume, chronologically ordered review. Initially it constitutes an unpublished grey report for distribution to key regional heritage managers (e.g. within Suffolk County Council, English Heritage and other organisations such as the Environment Agency). This includes an assessment of the importance of the results, recommendations for the future management of the resource and, if justified, proposals for publication. An end of project seminar is also to be organised for the identified stakeholders.

In addition, this project was linked directly to the 'Aggregate Landscape of Suffolk' project. Both projects had common goals and themes:

- To provide additional data, which is complementary to the project *The Aggregate Landscape of Suffolk: The Archaeological Resource* (PNUM 3987; Plouviez *et al*., 2007), and compatible with the aims of that project. This will enhance the themes identified in the research frameworks and enable the continued formulation of the regional research agenda.
- To use the findings of this study alongside the data provided by the Aggregate Landscape of Suffolk project to enhance the county HER. This will provide other heritage managers with information to assist them in the decision-making process associated with development activities.
- To provide a framework for the development of a closer working relationship between: Suffolk County Council, English Heritage, the University of Birmingham, and other stakeholder organisations such as the Environment Agency. Policies over the coming decades, such as the development of Catchment Flood Management Plans (CFMP's), changes to abstraction licences, and managed retreat, will have significant implications for the archaeology of the river valleys and coastal margins of Suffolk.

This project was co-ordinated by William Fletcher, for Suffolk's Archaeological Service, whilst the research was undertaken by the University of Birmingham, Institute of Archaeology and Antiquity, under the direction of Dr Benjamin R. Gearey, Dr Andy J. Howard, Dr Tom Hill, Keith Challis and Dr Emma Tetlow. In addition to core project staff, a steering group was established to oversee the project.

This consisted of senior members of Suffolk County Council Archaeological Service (Keith Wade, County Archaeologist, and Archaeological Officer Jude Plouviez), stakeholder partners Tom Cromwell and Dr Jane Sidell from English Heritage and Phil Catherall from the Environment Agency.

The original draft assessment report of the Suffolk River Valleys Project was submitted to English Heritage in March 2007. This report has been reproduced taking account of comments on this initial draft. A second phase of the Suffolk River Valleys Project was approved in response to the results obtained during the study (see section 9), and was commissioned in July 2007. The results of Phase 2 will be published separately upon completion (expected March 2008).

2 PREVIOUS STUDIES OF THE SUFFOLK RIVER VALLEYS

Alluvial landscapes provide valuable environments for human activity and settlement, but due to the continued expansion of transportation networks, settlement and mineral extraction, considerable pressure has been put on both cultural and environmental archaeological remains in these locations (Howard & Macklin, 1999). The large-scale land drainage and channelisation of valley floors that has taken place since the industrial revolution has had a significant impact on the fluvial stratigraphic archive and is likely to have had a subsequent impact on the preservation potential of archaeological and palaeoenvironmental archives in river valleys.

Low-energy river systems with cohesive channel banks typify the drainage network of Suffolk. They possess "low valley gradients (<2m km^{-1}), low-angle valley-side slopes, well-developed floodplains and transport predominantly fine-grained sediment" (Howard & Macklin, 1999, p534). Whilst the Late-glacial period was typified by variable discharge and the creation of multi-channel braided river systems, climatic amelioration during the early Holocene reduced discharge, promoted vegetation growth, and subsequently reduced the erosive potential of the river systems (Brown *et al*., 1994). The reduction in fluvial energy commonly resulted in the abandonment of secondary channels which would remain waterlogged and become infilled with organic deposits over time. In addition, the vertical accretion of thick sequences of both fine-grained alluvium and associated valley floor peat deposits occurred across the floodplains during the Holocene. High-quality *in-situ* multi-period cultural remains are subsequently commonly preserved within such sedimentary archives, and the extensive development of peat deposits in association with human occupation provides a valuable palaeoenvironmental and chronological record of landscape evolution.

Previous research into the palaeoenvironmental evolution of the Suffolk River Valleys is relatively limited, with pre-Holocene deposits receiving the most attention in recent years. This is primarily due to the importance of East Anglia to the Quaternary history of Britain, indicated by the identification of a number of stratigraphic type sites for Pleistocene climatic stages within the region (e.g. Cromerian, Anglian, Hoxnian, Ipswichian; Wymer, 1999). One such example is the recent excavations in pre-Anglian fluvial deposits around Pakefield on the east coast of Suffolk. Worked flints and a quantity of debitage, which are believed to correlate with the early Cromerian interglacial, were dated on the basis of regional fluvial correlations and glacial stratigraphy. Although not precisely dated, these finds are argued to represent the earliest evidence for human occupation north of the Alps (Parfitt *et al*., 2005). Such fundamentally important Palaeolithic discoveries are hence likely to have deflected palaeoenvironmental research away from the more abundant archives dating to the Holocene period.

The majority of valuable Holocene geoarchaeological and palaeoenvironmental evidence comes from small-scale work such as site evaluations (e.g. Hall, 2006; Hill *et al*., 2007a) or as specialist input within larger projects (e.g. Wiltshire, 1990). The potential for the survival and preservation of river valley deposits suitable for palaeoenvironmental assessment in Suffolk has been shown to be considerable through excavations at Scole in the Waveney Valley (Ashwin & Tester, *forthcoming*), at Brandon (Carr *et al*, 1988), along the River Lark (Hill, 2007) and along the River Gipping (Rose *et al*., 1980) for example. As a result, palaeoenvironmental work has subsequently become part of commercially funded investigations in the area.

A major desk-based literature review of previous archaeological and palaeoenvironmental research was undertaken as part of the Suffolk River Valleys Project, and can be found in Appendix I. Both published and unpublished ('grey') literature was reviewed to enable an assessment to be made regarding the current state of knowledge of the environmental history of the river valleys and to indicate areas of high and low potential. The results of the literature review enabled the identification of valley sites suitable for further study through the Suffolk River Valley Project.

3 RESEARCH METHODOLOGICAL OVERVIEW

The project was divided into two main stages: Stage 1 covered project set-up, desktop literature survey, GIS development, and topographical and geomorphological mapping through the utilisation of aerial photography and LiDAR data. The results of the first stage were then used to inform and guide Stage 2, which comprised the identification of sites within river valleys suitable for geoarchaeological and palaeoenvironmental assessment in order to lead to the formulation of a research agenda for the Suffolk rivers. Whilst a full breakdown of the tasks associated with each stage is provided in Fletcher *et al*. (2006), a summary of the task list is given below.

3.1 STAGE 1: DESKTOP ASSESSMENT OF RESOURCES AND PREVIOUS STUDY WITHIN THE AREA AND COMPILATION OF GIS

3.1.1 Stage 1 Tasks

Task 1: Creation of a project website

Task 2: Desk based literature survey of previous geoarchaeological, geomorphological and palaeoenvironmental investigations win Suffolk River Valleys

Task 3: Collation of existing geoarchaeological and palaeoenvironmental data into Geographical Information System (GIS) comprising aggregate, topographical, geological and archaeological data

Task 4: Assessment of study area evolution from the analysis of valley floor landform assemblages

3.2 STAGE 2: GEOARCHAEOLOGICAL SURVEY AND PALAEOENVIRONMENTAL ASSESSMENTS

3.2.1 Stage 2 Tasks

Task 5: Stratigraphic survey: identification and palaeoenvironmental assessment of organic sediments to determine the state of preservation and potential for environmental reconstruction, buried landsurfaces and associated archaeology

Task 6: Establishment of a chronological framework through radiocarbon dating

Task 7: Analysis of combined datasets to assess the distribution, preservation potential for cultural and environmental remains in the study area

Task 8: Development of a research agenda for the Suffolk River Valleys

Task 9: Dissemination and findings to stakeholders

Task 10: Archiving of GIS data

4 IDENTIFICATION OF STUDY AREAS

The Suffolk River Valleys have been and continue to be a major source of aggregates, with significant outgoing and current extraction occurring at Flixton on the River Waveney, and Fordham, Lackford, Cavenham and Worlington on the River Lark. In addition, the River Gipping is virtually exhausted of economically viable and accessible sand and gravel resources (Figure 1). Although much of the coastal lowlands are now protected through their inclusion within the Dedham Vale and Suffolk Coasts and Heaths ANOB's, renewed pressure has subsequently been applied to those areas not under similar Statutory Protection. Taking such factors into consideration, this project aimed to address the geoarchaeological and palaeoenvironmental development of the Rivers Waveney, Little Ouse, Lark, Gipping and Black Bourn and their tributaries. Site locations for palaeoenvironmental analysis therefore needed to be identified and assessed in order to meet the aims and objectives of the Suffolk River Valley Project (see Section 1). This section summarises the process through which suitable field locations were identified.

Taking into account the size of the County, five regions within Suffolk were to be chosen, thus concentrating the palaeoenvironmental investigations into smaller geographic areas. The sites were identified through collaboration with Suffolk County Council, utilising the current SMR data, whilst also assessing areas identified during the literature survey known to have limited previous palaeoenvironmental research (Appendix I). Site locations were required to be positioned proximal to areas that have been affected by past or present gravel extraction activity, or in areas threatened by the potential of future extraction. Much of the Waveney and Lark Valleys for example are under considerable pressure from the threat of gravel extraction activity, and have subsequently received considerable attention as part of the *Aggregate Landscape of Suffolk Project: the Archaeological Resource* (Plouviez *et al*., 2007; PNUM 3987). However, it was also necessary for the sites in question to contain sedimentary sequences to facilitate palaeoenvironmental investigation.

Due to the greater potential for peat accumulation and preservation in valley lowlands (and hence preservation of material suitable for palaeoenvironmental analysis), the identification of sites concentrated on the valley floodplains of the main drainage networks present within Suffolk. Such an approach, which targets organic-rich palaeochannels and other areas of organic accumulation, has proved successful in other river valleys of England, for example, the Trent (Knight & Howard, 2004). As a consequence, the valley lowlands surrounding Beccles, Brandon, Hengrave, Hoxne and Ixworth were identified as areas with palaeoenvironmental potential. A summary of each region is provided, reviewing the known palaeoenvironmental and archaeological history of the sites. The location of each site is identified in Figure 2. Unless cited otherwise, the majority of the archaeological information was obtained through the Suffolk County Council SMR.

4.1 BECCLES

Beccles is located on the southern valley side of the River Waveney (TM 642400 290600), which flows west-east towards Lowestoft and the North Sea. The River Waveney also marks the County boundary between Norfolk and Suffolk. The town centre is positioned on a topographic ridge that extends north into the River Waveney

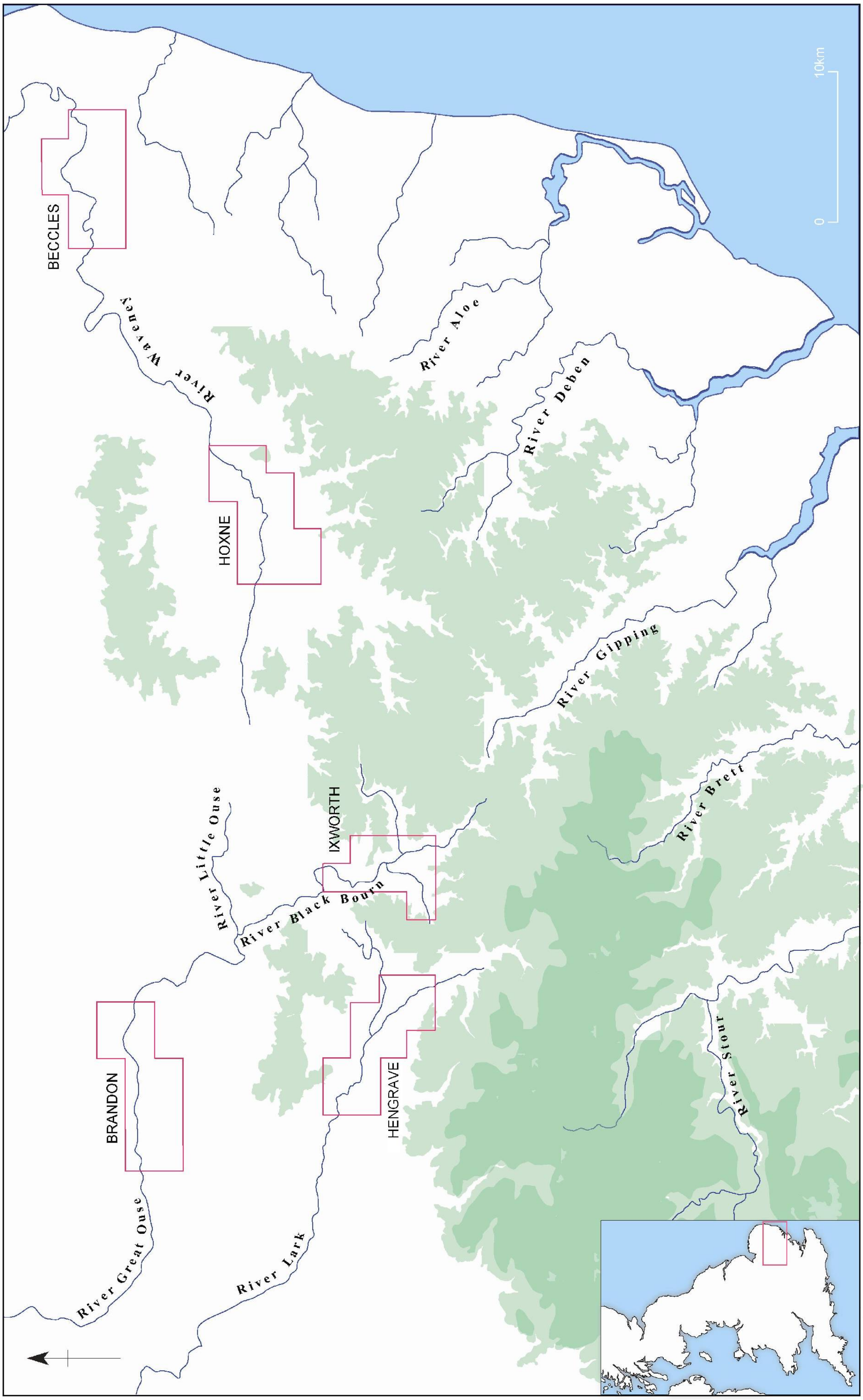


Figure 2: Map of Suffolk indicating primary water courses within the County. Site locations chosen for assessment as part of the Suffolk River Valleys Project are highlighted.

floodplain. The floodplain is up to 3 km wide and surrounds Beccles to the north, west and east. Small valley tributaries are present to the east and west of Beccles, flowing north from the higher ground into the River Waveney. A meander bend of the River Waveney also flows proximal to the western margin of the town. The drift geology comprises glaciofluvial drift and chalk till, providing a mix of acidic soils and slowly permeable loamy and clayey soils. The extensive width and length of the River Waveney, combined with the known presence of abundant gravel deposits underlying floodplain sequences (Alderton, 1983) makes the area vulnerable to aggregate extraction. This is confirmed by the abundance of active quarry sites to the west of Beccles, proximal to Flixton and Homersfield. The soils present along the River Waveney floodplain comprises deep peat sequences with associated clay horizons. An archaeological investigation proximal to the River Waveney during the re-alignment of its levees has revealed a sequence of floodplain peat deposits varying in thickness from 2.50 m to 7.00 m (Gearey *et al*., 2007). An outcrop of glaciofluvial drift is present within the floodplain to the north of Beccles: Boney's Island. In addition, along the floodplain to the northeast of Beccles, marine alluvium becomes abundant due to palaeo-tidal influences (Alderton, 1983).

Archaeological discoveries within the Beccles region have concentrated along the floodplain (e.g. Barsham Marshes, Beccles Common and around Boney's Island) and along the outcrop of glaciofluvial drift that extends north into the floodplain. Historical maps suggests this sediment ridge was the original location of Beccles when the settlement was first established, from which it has developed and expanded into its present status. A Palaeolithic hand-axe was dredged from the River Waveney floodplain at Lotmans Carr, *c*.1.50 km northeast of Beccles. During the excavation for the development of the A416, Neolithic flint and a flint chopping tool was discovered on Beccles Common. A Neolithic flint axe was also discovered under peat on the Waveney floodplain north of Dole's Covert. An Iron Age Fort/settlement may have been present on Boney's Island, although this possibility requires further investigation. Roman metalwork has been found on Barsham Hill. A horde of Saxon coins were also found proximal to the River Waveney on Barsham Marshes, *c*. 2 km west of Beccles. The Beccles region is therefore known to contain an archaeological record that spans much of the historic and pre-historic periods.

4.2 BRANDON

Brandon is located on the western margin of the Brecklands in northwest Suffolk, where the River Little Ouse flows into the fenlands (TL 578400 28610). To the east, the River Little Ouse is steeply incised into the Brecklands and consequently its floodplain is very narrow until its emergence into Hockwold Fen. Considerable spatial variation exists relating to the soils of the Brecklands and are reflected in differences in acidity, alkalinity and moisture content. Soils range from shallow, highly calcareous deposits to leached acid soils (Lambley, 1994; Sussams, 1996). To the west of the Brecklands, the low-lying and flat topography has encouraged the development of thick sequences of fen peat proximal to the Little Ouse, whilst the floodplain and fens are composed of a mix of minerogenic and peat units. In addition, there is an abundance of inland sand dune deposits around the Hockwold Fens. Less than 10 km west of Brandon, marine alluvium is present within the Fenlands as a result of Holocene sea-level influences penetrating inland from the north. Historical maps suggest that initial settlement in Brandon occurred immediately west of the

Brecklands where the valley of the Little Ouse narrows due to subsurface geology. It has subsequently developed to incorporate much of the surrounding floodplain to the south of the Little Ouse.

Due to the narrow nature of the Little Ouse floodplains within the Brecklands, the majority of archaeological discoveries have been from the valley side. However, at Little Lodge Farm on the Breckland valley floor, 53 Palaeolithic hand-axes were discovered. In addition, at Stanton Downham, located on the floodplain and southern valley side of the Little Ouse, an abundance of Medieval and Saxon finds have been recorded. At Medieval sites such as Downham Hall, vessel fragments and 'The Square Plantation' have been identified. A Saxon brooch has also been found, along with a bronze escutcheon, and Ipswich sherds at Sycamore House.

A Bronze Age spearhead was discovered near the Little Ouse on the floodplain immediately northeast of Brandon. A spearhead and bronze rapier, also dating to the Bronze Age were found near the Little Ouse *c*. 2 km west of Brandon. To the west of Brandon and *c*. 0.50 km north of Fenhouse Heath, a number of barrows ring ditches of unknown age have been discovered, varying in diameter from 20-45 m. Similar to Stanton Downham however, the majority of finds date to the Roman and Medieval – Saxon periods. Within the region proximal to Brandon Town, a Medieval ferry is believed to have connected the north and southern margins of the Little Ouse floodplain. In addition, the remains of a Medieval chapel were discovered to the north of the Brandon House Hotel, on the northern floodplain of the Little Ouse.

4.3 HENGRAVE

The study area incorporating Hengrave lies northwest of Bury St Edmunds, located along a *c*. 10 km stretch of the River Lark (TL 582500 268700). The valley floor is narrow, although generally increases in size downstream from *c*. 0.20 km to *c*. 1 km width. The surrounding valley catchment has a subsurface geology of predominantly glaciofluvial drift, overlain by well-drained sandy calcareous soils. The Lark Valley has received considerable attention through aggregate extraction over recent years, second only to the Gipping Valley in which aggregate supplies have been almost wholly exhausted. This is reflected through the presence of numerous former derelict quarry sites as well as sites which have active aggregate extraction licenses (see Figure 1). As a consequence, the geoarchaeological and palaeoenvironmental potential of the valley lowlands in and around Hengrave were deemed to be of particular interest. The valley floor comprises river alluvium within the upper catchment, whilst beyond West Stow (north of Hengrave), thick sequences of fen peat is in abundance. Hunt *et al.* (1991) identified Late Devensian and Holocene river activity within the Lark Valley between West Stow and Lackford. Early to Mid Holocene gravel sedimentation was replaced by organic mud and peat deposition in the Late Holocene, reflecting a reduction in fluvial energy during the Holocene. A number of smaller streams/rivers also enter the River Lark within the study area. One such tributary flows west from Great Livermere, converging with the River Lark at West Stow. Another flows north from the direction of Barrow and enters the River Lark near Icklingham.

Palaeolithic, Mesolithic and Neolithic archaeology has been found in the West Stow region, along with evidence for Iron Age, Romano-British and Medieval occupations

(West, 1989). The archaeology therefore suggests that the regions proximal to Hengrave are likely to have experienced occupation throughout much of the pre-historic and historic periods. There is an abundance of archaeological sites around Hengrave and to the south around Fornham All Saints. Just west of West Stow, prehistoric finds such as worked flints, pottery sherds and exposed wooden piles have been identified in the Lackford Quarry region. On the floodplain immediately south of West Stow, two Palaeolithic hand-axes were discovered. Further north at Icklingham, Palaeolithic flakes have been identified in a ditch within the church, whilst a Neolithic leaf arrowhead and a Bronze Age plain square sectioned socketed axe was discovered to the northeast. A Neolithic cursus is also located immediately east of Hengrave whilst Bronze Age ditch and crop markings are evident directly opposite Fornham All Saints to the south. Iron Age pottery sherds and Roman coins have also been found near Lackford. To the north of Lackford, on the northern valley side, a substantial Roman Villa was present, with at least three Roman age stone coffins located on the floodplain to the south. In addition, floodplain finds dating to the Romano-British and Medieval have also been recorded in the region. On the eastern valley side of the River Lark is Fornham Park, associated with the Medieval Fornham Hall. Medieval pill box was also identified in close proximity to this site. Two possible Saxon settlement sites have been identified proximal to Lackford. An abundance of medieval material has also been recorded in the Icklingham region.

4.4 HOXNE

Hoxne is a small village located in north Suffolk on the southern valley side of the River Waveney (TM 61800 277300). The River Dove and a number of smaller tributaries drain the uplands to the south, converging with the River Waveney to the west of Hoxne. The topography of the surrounding landscape is controlled by the rivers in the immediate vicinity of Hoxne, with the floodplain of the River Waveney to the north, the River Dove valley to the west and smaller tributary valleys to the south. The village is surrounded by slightly permeable calcareous soils, whilst the floodplain of the River Waveney is composed of a mix of fen peat and river alluvium overlying basal gravels. In the River Dove valley, a similar stratigraphic archive is present, with alluvium overlying peat and basal gravels. To the west of Hoxne, excavations undertaken on the Waveney Valley floodplain during highway improvements at Scole identified a palaeochannel rich in organic sediments (Ashwin & Tester, *forthcoming*). Biogenic sedimentation occurred within the palaeochannel from the early Bronze Age, confirming the palaeoenvironmental potential in this area.

Hoxne is most famous for its association with the discovery of Palaeolithic flint industries dating to the early post-Anglian period. Due to the abundance of Quaternary deposits in which such Palaeolithic artefacts were found, the interglacial period that followed the Anglian glaciation was named the Hoxnian. A Palaeolithic hand-axe for example was discovered on the Waveney floodplain near Park Farm, east of Hoxne. Archaeology dating from the Mesolithic period onwards is also present in the region. The majority of finds were discovered along the floodplain of the River Waveney and River Dove, as well as along the hill sides and hill tops of the surrounding valleys. Dredging of the River Waveney also produced a quantity of Roman Pottery near Scole. Medieval pottery shards were discovered near Oakley, west of Hoxne, whilst historical maps suggest a medieval bridge over the river was located nearby. Medieval brickworks, kilns and drying sheds were also found *c*. 0.6 km southwest of Hoxne.

4.5 IXWORTH

The village of Ixworth is located on the eastern floodplain of the River Black Bourn, approximately 10 km northeast of Bury St Edmunds (TL593400 270300). The Black Bourn, in turn, flows north into the River Little Ouse which runs along the western Suffolk – Norfolk County border. The valley floors are narrow when compared to those of the River Waveney, varying in width from *c*. 0.25 km to 0.50 km. The surrounding catchments surface geology is primarily composed of chalk, chalk till, and glaciofluvial drift and till. Deep fen peat soils are present along the floodplain of Pakenham Fen to the west, whilst sandy and peaty soils are found on the valley floor of Black Bourn proximal to Ixworth.

In contrast to most of the other study sites within Suffolk, previous archaeological discoveries outside the village of Ixworth are relatively sparse. This may be due to the majority of settlements and human activity being concentrated towards the Brecklands, southeast Suffolk and along main drainage networks during the pre-historic and early historic periods. The dense woodland and clayey soils within central Suffolk may have discouraged settlement, limiting access to the region via the valley floodplains until the historic period. Roman finds increase in abundance towards the Black Bourn due to the presence of a major Roman settlement at Ixworth. Immediately south of the village and on the western valley side of the Black Bourn, a Roman settlement has been discovered. Directly opposite, on the eastern valley side, a Roman Villa was found. There is also evidence of medieval occupation, indicative of continued settlement of the site after the decline of the Romano-British Empire.

5 SITE LOCATION METHODOLOGY

Once regions had been chosen for palaeoenvironmental assessment, specific site locations needed to be identified that were suitable for in-depth field and laboratory analysis. It should be stated that even upon completion of the literature review, due to the significant lack of previous geoarchaeological and palaeoenvironmental work undertaken, very little was known about the depth or character of the sedimentary archives present in specific areas of the county. A number of resources were therefore utilised in order to identify sites deemed as being potentially suitable for further research (below). Access permission was considered important considering the relatively short timeframe of the project. Reliable and easily approachable landowner targets were required. Suffolk County Council Archaeology Service was able to supply some contact information, as part of their commitment using information held for the purpose of providing countryside and archaeological advice. This included landowners such as the County Farm Estates, the Suffolk Wildlife Trust, other conservation organisations, and single owner estates and holdings. The Suffolk branch of the Farming and Wildlife Advisory Group were also consulted with regards to access, because of the extensive knowledge of the individual advisors and their county-wide scope. Table 1 provides a breakdown of all resource criteria and their relevance to each region under consideration.

5.1 AGGREGATES HISTORY

As part of the commitment to the core ALSF objectives, combined with the aims of the project design relating the Suffolk River Valleys Project to the extraction of aggregates in Suffolk, the areas were selected based on the proximity of such extraction sites. The type of aggregates and extractive industries in the region are varied, and in the past have include turbarys on the coast, marl (a chalky-clay used for fertiliser), crag (a sand and shell based material used as a field dressing) brick earth, clay, and flints. More recently this has included larger scale aggregates quarries, focusing on chalk, sand and gravel. Using information provided by the *Aggregates Landscape of Suffolk Project* (PNUM 3987) current permission and active quarries were plotted alongside sites previously targeted for extraction. Targets were identified close to these areas, but not so close so that palaeoenvironmental deposits could have become significantly disturbed or adversely affected by water table fluctuation and draw down. Areas of previous past extraction were plotted by the Aggregates landscape project using map regression analysis, through which the focus of the industry on river valley locations is clear (see Figure 1).

5.2 HISTORIC ENVIRONMENT RECORD (HER) DATA

In order to allow an understanding of past settlement, land use and exploitation of the floodplain, terraces and adjacent areas of each valley, the Suffolk County Council Sites and Monuments Records (SMR) was provided as MapInfo MIF files and incorporated into the project GIS (being developed as part of the Suffolk River Valleys Project). The SMR provided information relating to the spatial distribution and diversity of archaeological finds throughout Suffolk. The SMR data includes fully mapped sites and excavations, in addition to locations of field walking and isolated spot finds. A brief summary of the archaeology is also included within the SMR, which enables the identification of single-phase and multi-phase occupation sites within Suffolk. If a location was found to have a) an abundance of archaeological finds, and/or b) archaeological evidence suggesting multi-phase occupation, the site in question would be considered to have considerable geoarchaeological and palaeoenvironmental potential.

The Suffolk County Council also provided a number of GIS 'layers' that proved useful to the identification of suitable organic deposits. Surface soil and bedrock geology data was available for the whole of Suffolk, which suggested the presence of peatlands within specific valley lowlands, whilst also assisting in identifying valley catchments with a relative lack of surface organic material. In addition, the location of parish boundaries through the chosen valley lowlands provided valuable evidence for channel migration and palaeochannel preservation. Parish boundaries, officially recognised in the Anglo-Saxon period (but commonly in use long before this period), frequently utilised river channels for boundary demarcation. Through comparisons between parish boundaries, modern maps and aerial photographs, the parish boundaries were occasionally found to not follow the route of the contemporary river channel. Instead, the boundary would follow a different route along the valley floor, before rejoining with the contemporary river channel further downstream (see Figure 3). This was therefore inferred as a potential indicator of a former river channel and hence may preserve organic deposits suitable for analysis.

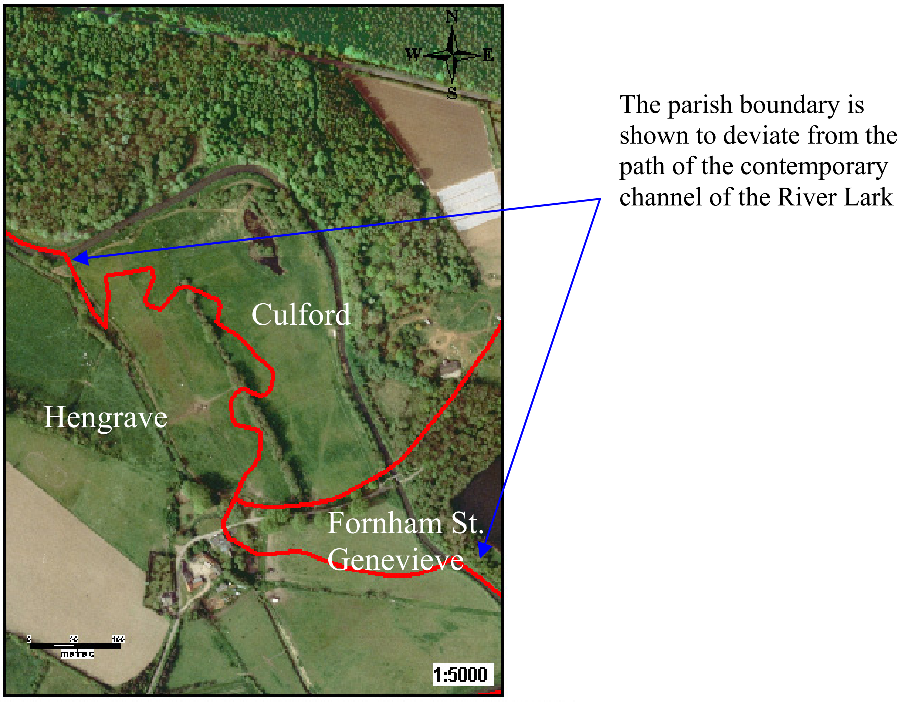


Figure 3: Parish boundaries of Hengrave, Culford and Fornham St. Genevieve shown in red, running through the Lark Valley. Site located *c.* 0.5 km northeast of the village of Hengrave, Suffolk (TL 829505 691752).

5.2 AERIAL PHOTOGRAPH ACQUISITION AND ANALYSIS

Aerial photographs were also utilised in order to identify visual topographic features that may suggest the preservation of peat deposits. The aerial photographs, supplied by Suffolk County Council, included vertical photographs taken from two separate decades (from the 1940's as well as photographs taken in 1999). Subtle changes in vegetation type and colour present on aerial photographs, for example, could suggest variations in the underlying soil type and moisture content; a common indicator for the presence of palaeochannels (Baker, 2003; see Figure 4). Comparisons were also made between aerial photographs taken in the 1940's and in 1999 to identify palaeochannels and other significant landscape features that were not visible on the later prints because they had had been destroyed by ploughing, gravel extraction or other forms of development (see Figure 5).

Figure 4: Example of surface colour variation evident on aerial photographs, suggesting the possible location of a palaeochannel, located *c*. 0.75 km northwest of Fornham All Saints, Suffolk (TL 583424 268323).

5.3 LIDAR ACQUISITION AND ANALYSIS

Once the five site research locations within Suffolk had been identified, an application for airborne laser altimetry (LiDAR) data was granted by project partners the Environment Agency as part of their contribution to this research project. An aircraft mounted laser projects a coherent beam of light to the ground surface, and the travel times to and from the ground surface are used to calculate the distance from the laser to the reflecting object (Challis, 2006). The topographic information can then be analysed and interpreted to identify potential palaeochannel site locations (see Figure 6). The resulting data was supplied as 2 m spatial resolution elevation product and provided as ArcGIS ASCII grid files, which were converted to ArcGIS raster grid format. Although LiDAR analysis was initially undertaken within ArcGIS, it is intended that the data will eventually be converted into a MapInfo compatible format for inclusion within the Suffolk Rivers Valleys Project GIS. A LiDAR Digital Surface Model (DSM) was created for each study area, which was examined to identify significant landscape features, such as palaeochannels and terraces.

Figure 5: Comparison of **a)** 1940's aerial photograph with **b)** 1999 aerial photograph to identify man-made channelisation of the River Little Ouse, south of Hockwold cum Wilton (TL 573040 286760). Parish boundaries are highlighted with red dashed lines.

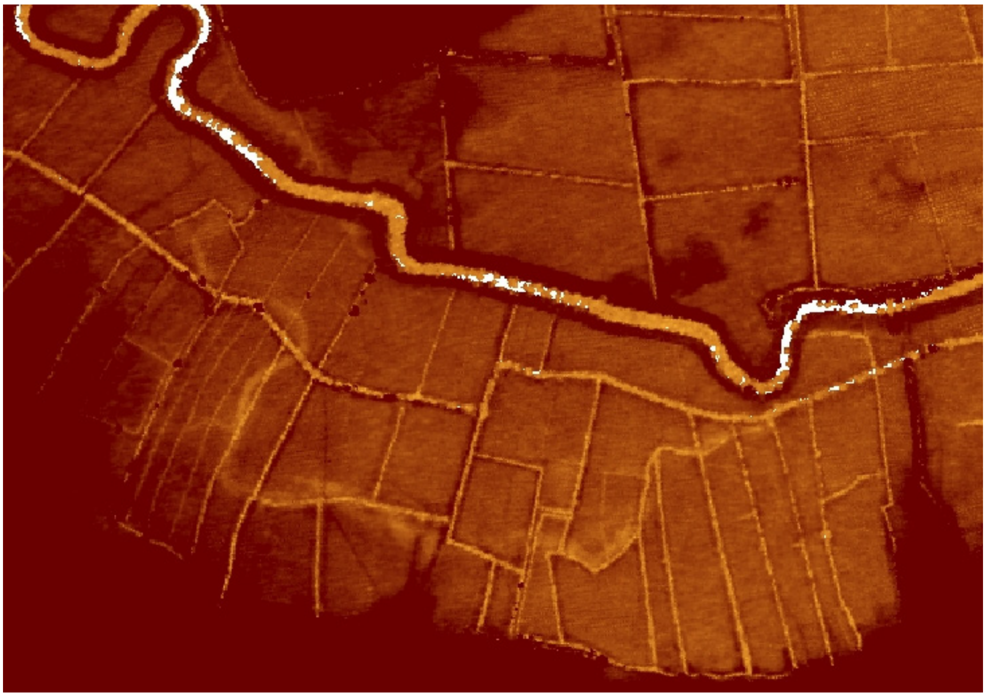


Figure 6: Example of LiDAR tile identifying a potential palaeochannel on the River Waveney floodplain, to the north of Shipmeadow (TM 637714 290888; LiDAR data © Environment Agency).

Site Location	River	AP coverage		LiDAR	Previous palaeoenvironmental Work	Aggregates History	Typical archaeology from the river valley	Access
		B & W	Colour					
Beccles	Waveney	✓ (1945 series)	✓ (1999 series)	✓	1) Beccles Iron Age post alignment, on site coring and master sequence taken in April 2006, just prior to the beginning of the SRV Project 2) Palaeoenvironmental assessment of Waveney Valley, focused to the east between Lowestoft and Great Yarmouth (Alderton, 1983)	1) C19 Sand quarrying from Beccles Common, and Worlingham, with in 1.5 m of the site 2) In Norfolk large quarries worked between 1940 –45 existed at Broome Common Broome, and Ditchingham (7 – 10 km) 3) Flixton quarry Nr Bungay, is one of the largest active quarries in Suffolk (*c*. 12 km)	1) Well preserved Iron Age timber post alignment from floodplain at Beccles, and possible Roman post alignment at Barsham Marshes 2) Multi-period settlement from Flixton quarry, from rare Neolithic Long barrow type monument to IA/RB fields systems	1) Beccles Town Council land 2) Private Land owner
Brandon	Little Ouse	✓ (1945 series)	✓ (1999 series)	✓	1) Sequences were taken as part of the excavation of the middle Saxon settlement at Staunch Meadow, Brandon, due to be published in 2008 2) Fenland Project (Martin pers. Comm) identified extensive fen peat sequences and archaeological sites in the Little Ouse	1) Peat and gravel extracted prior to the extension of the Lignacite works in Brandon *c* 1.5 km to the East 2) Extensive Gravel extraction from Nunnery Lakes in the Little Ouse at Thetford and Barnham (*c*. 10km east 3) Historic Flint Mining From Neolithic to C19 4) Chalk extracted for lime kilns from valley sides from C18 and C19	1) Staunch Meadow - Saxon village with church and burial ground 2) Extensive riverside IA/RB settlement 3) Deposited Metal work from river, e.g. double edges Saxon sword, IA and RB votive figurines	1) Brandon Hall Estate, access approved by Mr Giles de Lotbiniere

Table 1: Summary of resources utilised in order to identify sites deemed as being potentially suitable for further research, providing a breakdown of these criteria and their relevance to each region under consideration.

Site Location	River	AP coverage		LiDAR	Previous palaeoenvironmental Work	Aggregates History	Typical archaeology from the river valley	Access
Hengrave	Lark	✓ (1945 series)	✓ (1999 series)	✓	1) Fen peat overlying early to mid-Holocene gravels identified within the Lark Valley by Hunt *et al*. (1991) 2) No other previous palaeoenvironmental studies were identified during assessment of grey and published literature	1) Site chosen was ear marked for extraction under permissions granted in the 1960's. Work never undertaken 2) Extensive quarrying at West Stow and Lackford Bridge, part excavated c. 1960, now part of Country Park and County Wildlife site	1) Cursus monument, with causewayed enclosure and related monuments from on first terrace gravel adjacent to the site 2) IA/Saxon settlement excavated at West Stow and Lackford Bridge prior to gravel extraction 3) Long history of finds recorded from the Lark, Human skull, bones, metal work etc	1) Mill Farm, access approved by Mr Philip Aitken 2) St Edmundsbury District Council
Hoxne	Dove	✓ (1945 series)	✓ (1999 series)	✓	1) Palaeoenvironmental work undertaken on gravel deposits relating to the pre- and early Anglian glacial sequences 2) Palaeochannel identified during excavations for A143 Scole bypass, (Ashwin and Tester, *forthcoming*)	1) Hoxne brick works - using brick earth quarried locally (less than 1 km) 2) Sand excavated from Stuston common *c*. C18 and C19, and gravel from Broome Common (*c*. 3 km west) 3) Mendham Marshes – Large gravel quarry from Waveney (*c*. 7km to the east)	1) Palaeolithic finds 2) Human skulls and other metal work from dredging 3) Preserved timbers from Scole bypass 4) Possible hurdle trackway site from Lower Dove valley	1) Oakly Park Estate, access approved by Mr David Lewis
Ixworth	Black Bourne	✓ (1945 series)	✓ (1999 series)	✓	1) Sequence taken from Mickle Mere during A143 improvements, unpublished 2) No other previous palaeoenvironmental studies were identified during assessment of grey and published literature	1) Extensive gravel quarrying from Grimstone end *c*. 1950 (300 m to the south) 2) Large chalk quarry (*c*. 1.5 km east), also site of geological importance as one of the only studied regional chalk sequences 3) Gravel pits from Black Bourne at Ixworth Thorpe (*c*. 2.5 km north west)	1) Grimston end produced important multi-period site including ring ditches, a barrow and several Roman and Saxon pottery kilns, mainly excavated by Basil Brown 2) Small Roman town, bridge crossing and associated Roman Villa estate from Ixworth, adjacent to site	1) Private Land owner 2) Suffolk Wildlife Trust

Table 1 (cont'd): Summary of resources utilised in order to identify sites deemed as being potentially suitable for further research, providing a breakdown of these criteria and their relevance to each region under consideration.

6 SITE LOCATIONS

Through the analysis of the Suffolk SMR, GIS, aerial photography and LiDAR data, specific field locations within the five chosen areas were identified. A summary of each site location is provided (see also Table 1), along with the reasons why each location was deemed to be suitable for palaeoenvironmental assessment.

6.1 BECCLES

Shortly after the Suffolk River Valleys Project was commissioned, a major archaeological site was discovered *c.* 1 km north of Beccles during the re-development of the River Waveney flood defences (TM 642355 291900). The initial excavations identified a sequence of vertical oak posts within a thick peat sequence, and preliminary analysis suggested a Bronze Age or Iron Age origin. The feature, believed to a trackway or post alignment. As a consequence, this location was regarded of significant palaeoenvironmental potential, and hence suitable for consideration as part of the Suffolk River Valleys Project.

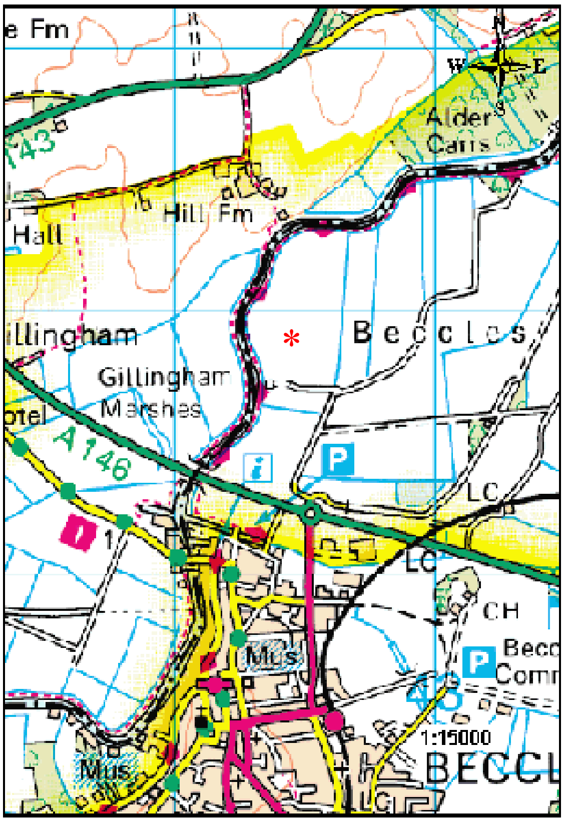


Figure 7: OS Map and Aerial photograph of area surrounding Beccles trackway, with site location indicated by * (TM 642736 291986).

A 10 km stretch of the River Waveney floodplain surrounding Beccles was also assessed for alternative sites. However, the combination of LiDAR, aerial photography and GIS data suggested that the River Waveney has predominantly remained stable along this reach for much of the Holocene. Few palaeochannels could be identified using LiDAR with the exception of a potential infilled channel feature north of Shipmeadow, *c*. 4 km west of Beccles (TM 637714 290888; see Figure 6). In addition, parish boundaries do not deviate from the present watercourse and few field boundary patterns suggested any anomlaies which might suggest the location of palaeochannels. It is hypothesised that, along this section of the River Waveney at least, the predominant feature has been significant vertical and lateral accumulation of floodplain peats. Under these circumstances, organic accumulation would have occurred in a 'backswamp' floodplain setting, where high water tables (relative to the palaeo-land surface) would have encouraged vegetation establishment and *in-situ* organic accumulation. This is further supported by previous study in the Waveney Valley which suggested that the contemporary channel has not experienced significant lateral migration for most of the Holocene period (Alderton, 1983).

The presence of the archaeological remains at Beccles (Figure 7) made this location an obvious target for the project. Initial stratigraphic investigation undertaken as part of the flood defence site assessment had identified up to *c*. 7 m of peat surrounding the post alignment, although the thickness of peat decreased to *c*. 2.50 m with distance south (Gearey *et al*., 2007). The site therefore provided an extensive sedimentary archive. In addition, it was regarded that significant synergy between the palaeoenvironmental and archaeological investigations was possible.

6.2 BRANDON

Brandon, located between the upland Brecklands to the east and the Fenlands to the west, was selected for detailed study, taking into account the abundance of archaeological finds found throughout the region. The steep valley sides along the River Little Ouse within the Brecklands limited channel migration and subsequent palaeochannel development. Research therefore concentrated on the lowlands immediately west of Brandon. As at Beccles, very little evidence was present for river migration and subsequent palaeochannel development, suggesting overall channel stability and sedimentation through vertical accretion. One potential palaeochannel was identified *c*. 5 km west of Brandon Town Centre, south of Hockwold cum Wilton (TL 573040 286760; Figure 5). At this location, the parish boundary was seen to deviate away from the contemporary River Little Ouse, and LiDAR data identified a substantial topographic anomaly (commonly indicative of an infilled channel).

Collaboration with Suffolk County Council however, identified this as a feature of artificial realignment of the river in the last *c*. 30 yrs. This was confirmed through comparisons between aerial photographs taken in 1940's with those from 1999. As a result, it seemed unlikely that deposits of significant palaeoenvironmental potential would be preserved here. However, results from the survey indicated possible palaeochannel features *c*. 1.40 km west of Brandon, in the grounds of Brandon Hall (TL 576949 286751; Figure 8). The LiDAR data identified the presence of topographic hollows running broadly east-west along the floodplain (Figure 9a and b), interpreted as possible former palaeochannels of the River Little Ouse. A concentration of archaeological finds to the west of Brandon Hall had also previously been discovered through field walking and this location was selected for further palaeoenvironmental analysis.

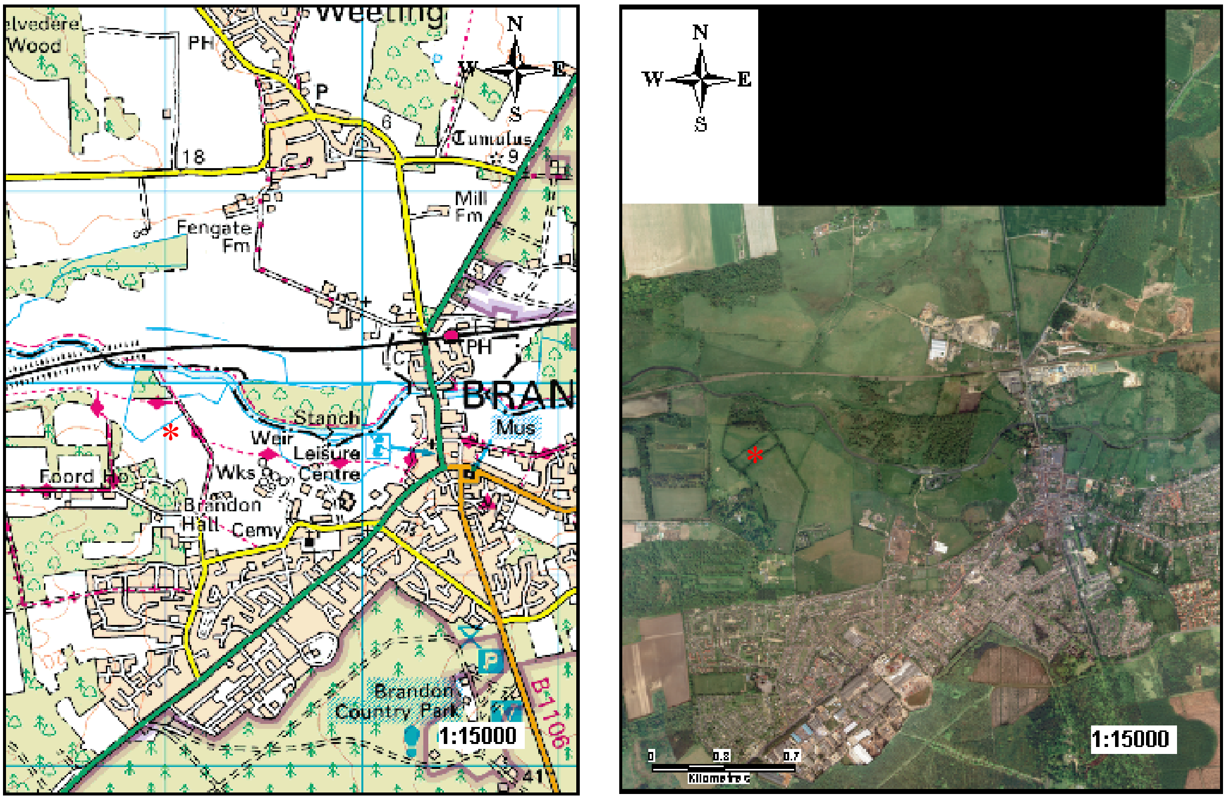
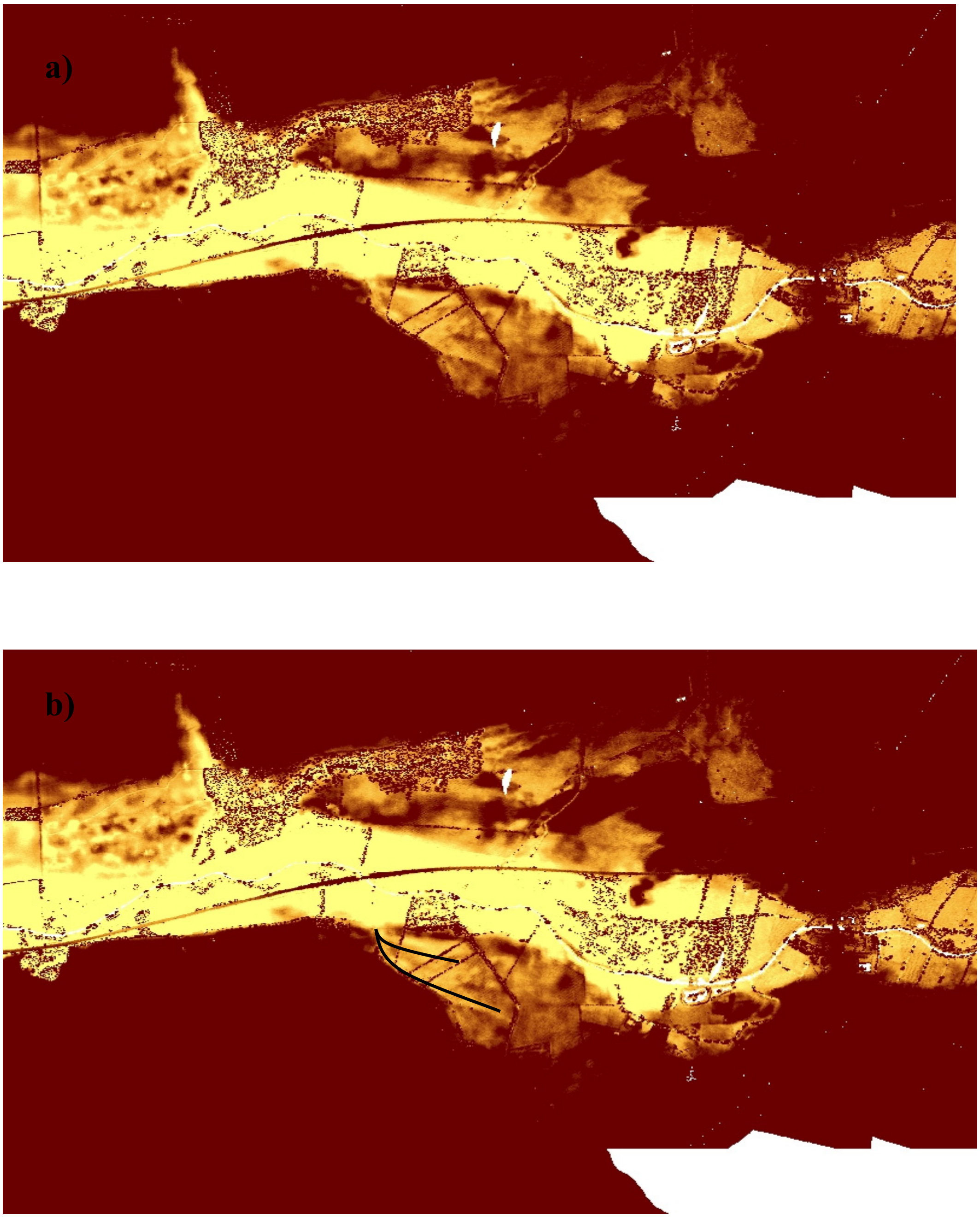


Figure 8: OS Map and Aerial photograph of area surrounding Brandon site, with the site location indicated by * (TL 576949 286751).



<u>Figure 9a:</u> LiDAR data for the region proximal to Brandon and **b:** highlighting the potential palaeochannel locations (LiDAR data © Environment Agency).

6.3 HENGRAVE

The identification of Hengrave as a site suitable for further palaeoenvironmental analysis related to the abundance of regional archaeological evidence and the lack of environmental research undertaken in this region. The desk-based assessment of the area suggested that there was more evidence for channel migration and palaeochannel preservation within the floodplains of the River Lark than was apparent at Beccles and Brandon (above). On the floodplain *c.* 1 km southeast of Hengrave for example, aerial photographs revealed variations in vegetation and surface sediments suggesting the presence of a substantial palaeochannel feature (TL 583424 268323; see Figure 4), whilst field boundary locations identified other potential palaeochannel features further north proximal to Flempton (1 km northeast of Hengrave). Meander cut-offs and potential palaeochannels were also present on the River Lark floodplain. Immediately east of Hengrave, the parish boundaries separating Hengrave, Culford and Fornham St Genevieve dissect the western River Lark floodplain (TL 829505 691752; see Figure 3). Further LiDAR interrogation identified subtle topographic variations that correlated with the location of the parish boundaries, again suggesting the location of a palaeochannel. The proximity of a Neolithic cursus, *c.* 0.40 km south of the site provided further archaeological rationale for the investigation of this location. In addition, ground investigations by the landowner, Mr Aitkens, had identified up to 4 m of peat overlying gravels. Consequently, this location was chosen as suitable for further investigation in the Hengrave area (Figure 10).

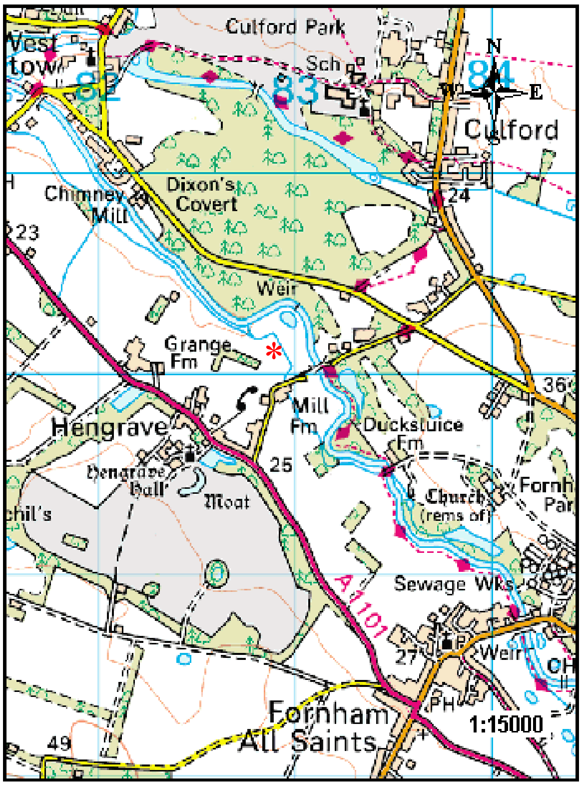


Figure 10: OS Map and Aerial photograph of area surrounding Hengrave site, with the site location indicated by * (TL 829505 691752).

6.4 HOXNE

At Hoxne, the confluence of River Dove into the River Waveney provided two separate floodplain areas suitable for palaeoenvironmental consideration. The River Waveney floodplain, up to *c.* 0.75 km wide proximal to Hoxne, contains a fen peat sequence capped by minerogenic overbank deposits. LiDAR analysis provided limited evidence for channel migration and palaeochannel development along much of the Waveney floodplain, suggesting channel stability and vertical sediment accretion occurred during much of the valley's depositional history. One potential palaeochannel however, *c.* 3 km west of Hoxne was identified on the southern River Waveney floodplain using LiDAR. Whilst this was initially considered as a potential site for further investigation, another palaeochannel (or potentially part of the same palaeochannel) had previously been identified during ground investigation works for the Scole A143 highway improvements (TM 614730 278460; Ashwin & Tester, *forthcoming*). Radiocarbon dating of the peat preserved within the palaeochannel identified that meander cut-off and *in-situ* biogenic sedimentation had commenced by the Early Bronze Age and ceased by the Saxon times. Palynological analysis had also been undertaken on the 1.30 m peat sequence (Wiltshire, *forthcoming*). Consequently, to prevent the potential duplication of research, the site was not deemed suitable for further assessment. No further sites along this section of the River Waveney floodplain were identified as having palaeoenvironmental potential.

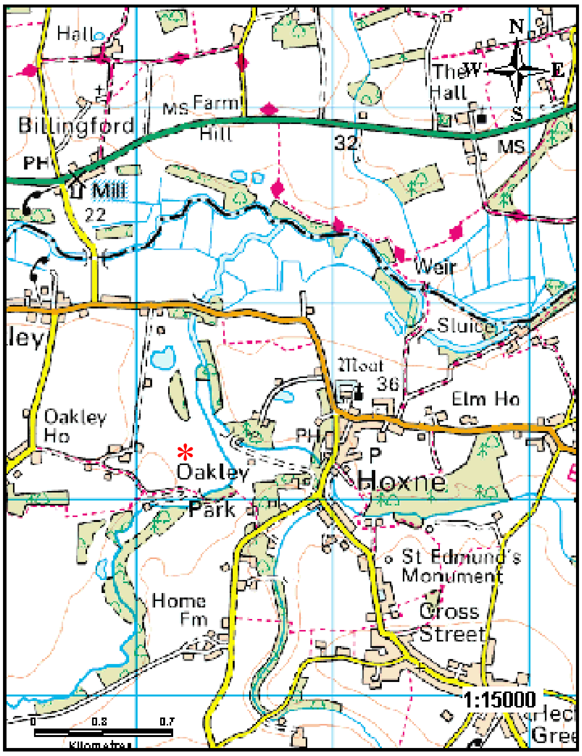


Figure 11: OS Map and Aerial photograph of area surrounding Hoxne site, with the site location indicated by * (TM 617381 277145).

The floodplain deposits of the River Dove provided the second potential palaeoenvironmental archive for the area. Soil records identified the presence of river alluvium underlain by fen peat along much of the River's course, whilst analysis of the LiDAR and SMR suggested a number of palaeochannels were present. Although smaller in scale to the palaeochannel proximal to Scole, the potential remained for *in-situ* organic sedimentation and preservation. Sites proximal to the Waveney Valley were deemed of greater value to those further upstream, due to the possibility for correlation with other Waveney palaeoenvironmental archives. As a consequence, one such site was identified on the River Dove, *c*. 0.50 km west of Hoxne and located proximal to where the valley converges with the Waveney Valley (TM 617381 277145; Figure 11). LiDAR analysis suggested the presence of topographic hollows on the western floodplain of the River Dove, confirming this location as suitable for further palaeoenvironmental analysis.

6.5 IXWORTH

Although Roman archaeology dominates Ixworth area, Palaeolithic and Neolithic artefacts have also been discovered immediately south at Pakenham Fen. The narrow nature of the valley of the River Black Bourn restricts the potential for channel migration and palaeochannel preservation along much of its course. To the north, downstream of Ixworth, however, the floodplain widens to *c*. 0.50 km, and LiDAR data suggested the location of a number of topographic depressions indicative of potential palaeochannel features. Whilst these were initially identified as having palaeoenvironmental potential, on closer inspection it was apparent that the features were still used as small-scale drainage channels. Immediately south of Ixworth, a small *c*. 0.30 km wide floodplain is present called Mickle Mere (TL 593767 269749). This is located between a Roman Fort on the western valley side and Roman Villa to the east, whilst the Palaeolithic and Neolithic archaeological sites at Pakenham Fen are located *c*. 0.50 km south. Previous studies in Mickle Mere had identified an organic-rich stratigraphic archive with an overlying minerogenic unit which was suggested as reflecting enhanced hillslope erosion resulting from agricultural activity commencing *c*. 1,290 ± 100 BP (AD600, HAR-5936; Murphy & Wiltshire, 1989). No clear palaeochannel features were identified through the interpretation of the LiDAR data, but this was a consequence of standing water present on the surface of Mickle Mere during data collection (preventing a clear signal being recorded). Further south, upstream of the River Black Bourn, the valley floor narrows further preventing the potential for lateral channel migration or significant floodplain development. Consequently, due to the lack of palaeoenvironmental information for the region around Ixworth, combined with the abundance of Roman archaeology immediately east and west, Mickle Mere was identified as the most suitable for further assessment (Figure 12).

Figure 12: OS Map and Aerial photograph of area surrounding Ixworth site, with the site location indicated by * (TL 593767 269749).

7 FIELDWORK RESULTS

Fieldwork was carried out at all five sites over a period of two weeks during July and August 2006. The fieldwork results for each location will be summarised first, after which the results of palaeoenvironmental assessments are presented. Coring surveys were undertaken at each site to provide an initial assessment as to whether the chosen sites did indeed contain sedimentary archives of significant palaeoenvironmental value. Cores were extracted using a manual gouge 'Eijkelcamp' corer. Coring at each site location continued until either bedrock or basal gravels were encountered (typically 3-4 m depth). A stratigraphic summary of all sedimentary cores extracted during the initial site assessments is provided In Appendix II. A generalised summary of the stratigraphic archive encountered during fieldwork is provided for each site assessment. The descriptions indicate the spatial and temporal variation in sedimentology present within each site. In addition, a stratigraphic profile, deemed to be representative of each location's deposits, is also included. If material of palaeoenvironmental value was identified (organic-rich deposits), a sample core was extracted at a location where the deposits were regarded as 'typical' of the site's stratigraphic archive. The sample core was taken using a Russian corer, and was extracted in 1 m length sections. The sediment was then transferred into plastic guttering, wrapped and returned for palaeoenvironmental analysis to the laboratories at the University of Birmingham.

7.1 BECCLES

Fieldwork at the Beccles site on the River Waveney floodplain (TM 642355 291900) coincided with the excavations of a wetland site undertaken by Birmingham Archaeo-Environmental (Gearey *et al*., 2007), with access permission granted by Halcro BESL and Suffolk County Council. Whilst coring was undertaken as part of this project, additional coring proximal to the excavation was also carried out. As a consequence, a total of 46 cores were extracted on the River Waveney floodplain and assessed for palaeoenvironmental potential. The location of each core is provided in Figure 13. Levelling of all core locations indicated that the surface elevation of the Waveney Valley varied in altitude from *c*. -0.10 m O.D. to -0.50 m O.D.

7.1.1 Stratigraphic Survey

A coring transect containing seven cores was excavated running east from the trackway excavation (Cores 1-7). Three further coring transects were excavated running approximately north-south parallel to the flood embankment of the River Waveney, each containing between 10 and 16 cores. In addition, two further cores were taken from the archaeological trench (Cores 44 and 45) to assess the subsurface stratigraphy at this location (see Figure 13). The initial coring strategy intended to take cores at roughly 20 m intervals surrounding the excavation site. For the first of these transects however, running proximal to the embankment, the interval was reduced at 10 m intervals to provide an initial assessment of the stratigraphic archive. With distance north, it became clear that the stratigraphy changed considerably, which resulted in the coring resolution being maintained at 10 m intervals in the northern section of the site. Elsewhere, the coring resolution returned to *c*. 20 m intervals.

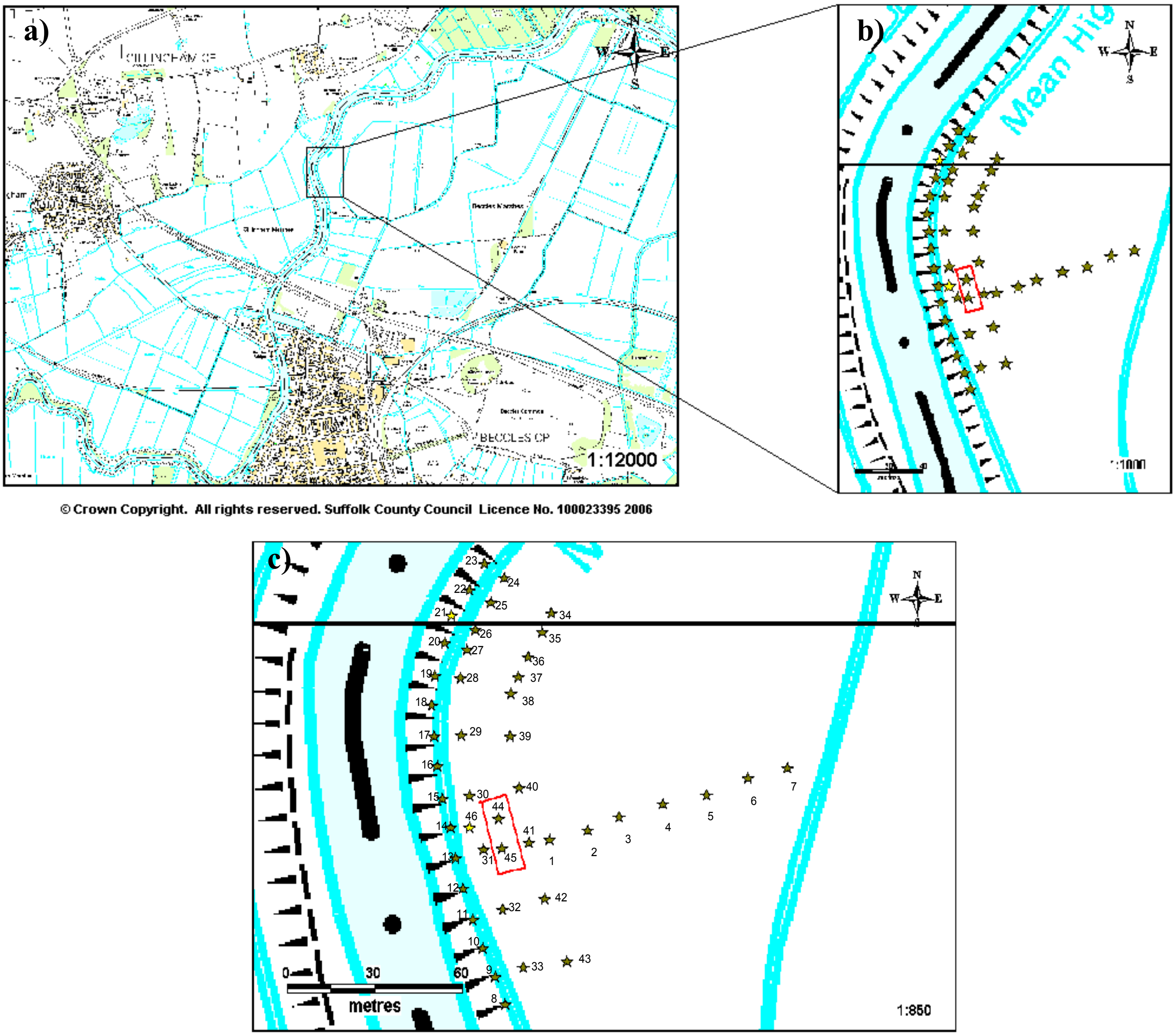


Figure 13a: location map of River Waveney floodplain north of Beccles, **b:** core locations and **c:** core numbers for reference to stratigraphic summary provided in Appendix II. Red rectangle indicates approximate location of archaeological excavation. Sample core locations highlighted by yellow stars.

The cores extracted from the east, west, south and immediately north of the trackway excavation contained very similar stratigraphic sequences. In addition, the two cores extracted from within the excavation site also corresponded with the surrounding sequence. Although there was some variation relating to unit thickness and colour present through the archive, the stratigraphy can be summarised as follows:

	Depth	
Unit 1	0.00-0.90 m	Dark grey-brown herbaceous well humified slightly silty PEAT
Unit 2	0.90-1.00 m	Light grey organic rich SILT
Unit 3	1.00-1.90 m	Dark grey-brown herbaceous humified slightly silty PEAT
Unit 4	1.90-4.50 m	Dark red-brown herbaceous humified PEAT with wood fragments
Unit 5	4.50-5.50 m	Dark brown-black very well humified PEAT
Unit 6	> 5.50 m	SANDS and GRAVELS

Although not commonly extracted due to the level of saturation within the core, basal sands and gravels were commonly identified at a depth of between 5.50 m and 6.00 m (Unit 6). A thin sandy peat horizon was occasionally found overlying the sands and gravels, although it was more common to encounter a dark brown or black very well humified peat (Unit 5). This was overlain by herbaceous red-brown/black well-humified peat with wood fragments in varying abundance (Unit 4). The wood-rich unit was, in turn, overlain by a dark grey-brown slightly silty herbaceous humified peat (Unit 3). A thin organic-rich silt unit was then encountered, commonly only 0.10m thick, although up to 0.30 m is recorded in places (Unit 2). The cores were all capped by a dark grey-brown herbaceous well humified slightly silty peat (Unit 1). All stratigraphic boundaries except those relating to the thin silt unit were found to be very gradational. The organic-rich silt unit however, was seen to have relatively sharp upper and lower boundaries.

To the north of the study area, the upper *c*. 1.0 m of the sedimentary sequence became more silt-rich, trending into grey-brown/blue-grey organic-rich silts and clays. The upper peat (Unit 1) appeared to thin northwards, being replaced by the minerogenic unit, which is possibly related to the thin organic-rich silt unit that was commonly encountered at *c*. 0.90 m depth (Unit 2). With distance north, the minerogenic unit increased in thickness, resulting in the surface of the underlying peat (Unit 3) being encountered at greater depths within the cores. Core 23, located furthest north, contained 4.90 m of silts and clays without the underlying peat surface being encountered.

Due to the considerable variation in the stratigraphic archive found with distance north on the River Waveney floodplain, two cores were extracted for palaeoenvironmental assessment. One core was taken proximal to the excavation where the stratigraphy was typified by brown well-humified peat (Core 46). This core is subsequently referred to as Beccles Core 1. A second core was taken further north at the original location of Core 21 where the stratigraphy consisted of organic-rich silts and clays overlying peat (referred to as Beccles Core 2).

7.2 BRANDON

Fieldwork was undertaken at the Brandon site located within the grounds of Brandon Hall, on the floodplain of the River Little Ouse (TL 576949 286751). Access permission to the chosen site location was granted by Mr Giles de Lotbiniere. The coring strategy had been previously prepared to account for the topographic anomalies identified by LiDAR on the valley floor (see Figure 9). In addition, a topographic depression running approximately east west was visible which correlated with one such an anomaly identified by the LiDAR data. A total of seven cores were extracted and assessed for palaeoenvironmental potential. The location of each core is provided in Figure 14. Levelling of all core locations indicated that the surface elevation of the lowlands proximal to the River Little Ouse varied in altitude from *c*. 3.60 m O.D. to 3.90 m O.D.

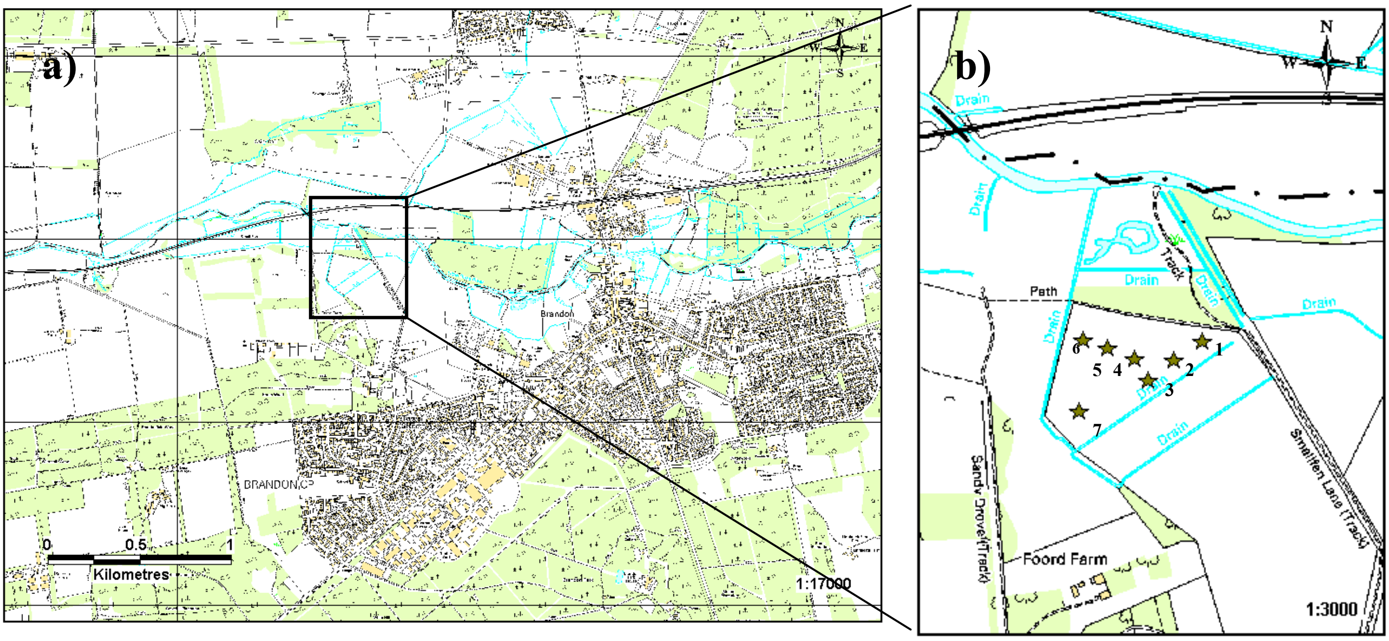


Figure 14a: location map of River Little Ouse floodplain to the west of Brandon, **b:** core locations and numbers. Stratigraphic summary provided in Appendix II.

7.2.1 Stratigraphic Survey

Cores 1 to 6 were separated at approximately 10 m intervals within the field location to fully assess the variations in topography identified by LiDAR and during fieldwork. Core 7 was to be located *c*. 30 m further south proximal to where a second topographic anomaly had previously been identified by LiDAR. The anomaly however turned out to be a small depression infilled with standing water and was interpreted on-site as possibly man-made in origin. Core 7 was subsequently taken immediately north of this feature.

A stratigraphic summary of the Brandon cores can be found in Appendix I. The majority of cores encountered a *c*. 2.0 m thick sequence of yellow-brown sands with varying abundances of disarticulated shell fragments and occasional humic mottling. Below *c*. 2.0 m, saturation of the sediment by the local water table resulted in further sample extraction being unsuccessful. Visual assessment of the cores suggested the sands were relatively well sorted with an overall coarsening of grain size with depth. In addition, the abundance of shell fragments increased with depth, although the high level of disarticulation prevented on-site identification. Organic deposits were only encountered in Cores 5 and 6. A thin layer of very well humified sandy peat was present at a depth of *c*. 0.60 m (*c*. 3 m O.D.), varying in thickness from 0.10-0.30 m and was interbedded within the yellow-brown sands. The sedimentary sequence from Core 5 is summarised below:

Depth	
0.00-0.60 m	Dark brown organic fine SAND
0.60-0.90 m	Dark brown-black sandy PEAT
0.90-1.60 m	Yellow-brown medium SAND
1.60-2.30 m	Orange-yellow coarse SAND with occasional shell and flint fragments

The relatively shallow stratigraphic archive encountered, combined with the overall absence of organic-rich sediments within the deposits, suggested the Brandon site did not contain sediments of significant palaeoenvironmental value. This was further supported by the discovery of a Victorian porcelain pottery fragment (identification K. Krawiec, *pers. comm.*) within the yellow-brown sands in Core 2 at a depth of *c.* 0.70 m (*c.* 3.20 m O.D.) which indicates sediment accumulation in the past few hundred years. The inability to extract sediments to a depth greater than *c.* 2.0 m by manual coring also restricted the assessment of spatial and temporal variation in the sedimentary archive of the region.

The location of the thin sand-rich peat layer within two of the survey cores correlated with a LiDAR anomaly identified during the initial site assessment. Soil survey records identified wind-blown sand deposits to the northwest of Brandon (around the Hockwold Fens) as well as throughout the Brecklands to the east (Bateman & Godby, 2004). Whilst it was therefore initially suggested that the LiDAR anomalies for the site were relict palaeochannels of the River Little Ouse, the inorganic deposits encountered are likely to have developed through predominantly sub-aerial rather than fluvial processes. Biogenic sedimentation commonly occurs within dune slacks located in between dune ridges, where the local water table is close to, or at the sediment surface (Carter, 1991). As a consequence, a period of relative stability of the dune slack environment would have encouraged vegetation colonisation, expansion and subsequent *in-situ* organic sedimentation (Packham & Willis, 1997). The thin sand-rich peat unit is likely to have developed as a consequence of such biogenic sedimentation within a dune slack. The subsequent burial by wind-blown sand and post-depositional decomposition and compaction of the organics would have then lowered the surface altitude to create the topographic anomaly identified during LiDAR analysis. Due to the limited spatial extent of the organic unit, combined with the likely very late Holocene age of the deposits, it was concluded that the value of further palaeoenvironmental analysis at the site was limited and no further samples were collected.

7.3 HENGRAVE

Fieldwork occurred on the floodplain of the River Lark proximal to Hengrave (TL 829505 691752), with access permission to the chosen site granted by Mr Philip Aitken of Mill Farm. The coring strategy had been designed to investigate the parish boundary and LiDAR data which suggested a palaeochannel feature running through the contemporary floodplain of the River Lark (see Figure 3). A total of six cores were extracted and assessed for palaeoenvironmental potential. The location of each core is provided in Figure 15. Levelling of all core locations indicated that the surface elevation of the floodplain proximal to the River Lark varied in altitude from *c.* 20.20 m O.D. to 20.85 m O.D.

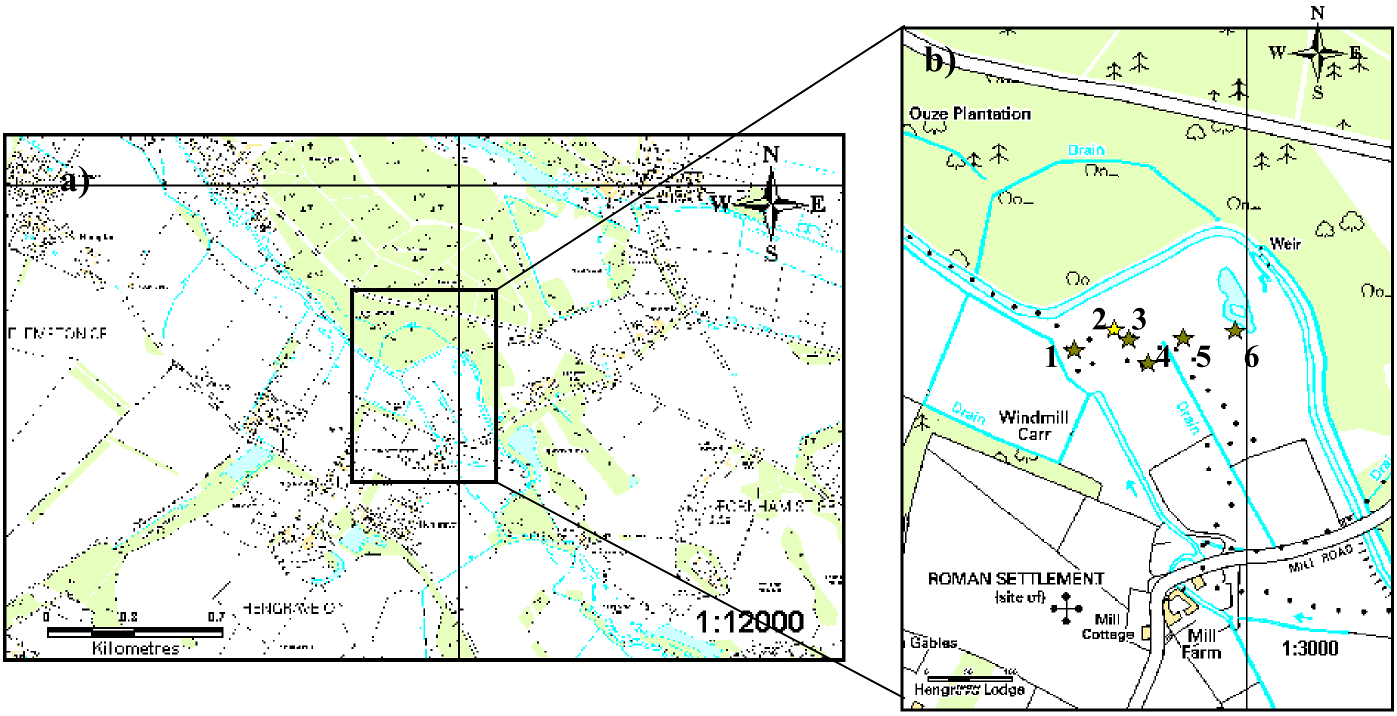


Figure 15a: location map of River Lark floodplain to the east of Hengrave, **b:** core locations and numbers, with parish boundary indicated by dotted line running through the floodplain. Sample core location highlighted by yellow star. Stratigraphic summary provided in Appendix II.

7.3.1 Stratigraphic Summary

A core transect was excavated across the River Lark floodplain approximately east-west. Cores were positioned adjacent to the location of the parish boundary, believed to be representative of a palaeochannel. Topographic depressions were also identified during fieldwork and were believed to relate to the location of the relict channel feature. A stratigraphic summary of the cores is provided in Appendix II. The thickness of the stratigraphic sequence varied from *c*. 2.20 m to 3.70 m before gravels were encountered and further coring was not possible. Although there was considerable spatial variation between cores, the stratigraphic archive was typified by silty peat, with thin interbedded minerogenic horizons. The silt-rich peat horizons were commonly found to immediately overlie the basal gravels. The peat units varied in organic content and humification. In addition, occasional shell fragments were evident. The minerogenic horizons varied from silts to fine sands and rarely exceeded a thickness of a few centimetres. The minerogenic horizons were also found to commonly have relatively sharp upper and lower unit boundaries. Organic-rich fine sands and silts tend to cap the sedimentary sequence. Core 6, located away from the route of the parish boundary, also contained organic-rich sediments. This sequence however was interpreted as being deposits that have accumulated in response to the gradual infilling of a shallow (possibly manmade) pond located immediately north of the core location (see Figure 15b). A stratigraphic summary of Core 2, deemed broadly representative of the site's stratigraphic archive, is provided below:

Depth	
0.00-0.24 m	Dark brown very well humified PEAT, occasional sand and silt
0.24-0.60 m	Grey-brown herbaceous very well humified silty PEAT
0.60-1.00 m	Dark brown/red-brown herbaceous humified PEAT with occasional wood
1.00-1.51 m	Dark brown/grey-brown herbaceous well humified silty PEAT
1.51-1.64 m	Dark grey-brown herbaceous very well humified slightly sandy PEAT
1.64-2.00 m	Dark grey-brown herbaceous well humified sandy PEAT with occasional sand horizons
2.00-3.00 m	Dark brown/grey-brown very herbaceous humified slightly silty PEAT with occasional wood fragments.

It seems likely that the accumulation of peat at this location occurred in response to the gradual infilling of a former channel, whilst the thin minerogenic units may reflect ephemeral flooding of the channel in response to periods of increased river discharge. The organic-rich fine sands and silts capping much of the site is interpreted as recent floodplain deposition. A sample core was recovered at the location of Core 2.

7.4 HOXNE

Fieldwork was undertaken within the grounds of Oakley Park to the west of Hoxne on the floodplain of the River Dove (TM 617381 277145). Access permission to the chosen site location was granted by Mr David Lewis of Oakley Park. The coring strategy had been previously prepared to account for the results obtained through the interpretation of both surface soil GIS data and a topographic anomaly identified by LiDAR on the valley floor. The feature had also been found to correlate with the location of the parish boundary separating Hoxne from Brome & Oakley. It was therefore assumed that the LiDAR feature was a relict palaeochannel used for parish boundary demarcation. A total of eleven cores were extracted and assessed for palaeoenvironmental potential. The location of each core is provided in Figure 16. Levelling of all core locations indicated that the surface elevation of the lowlands proximal to the River Dove varied in altitude from *c*. 22.10 m O.D. to 23.50 m O.D.

7.4.1 Stratigraphic Summary

A core transect was implemented that traversed the River Dove floodplain approximately east-west. Cores were positioned proximal to the location of the parish boundary and also where visual topographic depressions were identified during fieldwork. A stratigraphic summary of the cores is provided in Appendix II. The stratigraphic sequence was generally found to only be *c*. 0.50 m thick before gravels were encountered and further sample extraction was not possible. The sedimentary archive was typified by fine orange-brown sands increasing in grain size with depth. Occasional gravel of flint was also found, increasing in abundance with depth. In contrast, Core 10 contained a *c*. 3.70 m thick sequence consisting of black well-humified silty peat overlain by dark brown silty sands. This core location however was positioned *c*. 100 m east from the assumed palaeochannel identified through LiDAR and GIS data analysis. Further discussions with Mr Lewis indicated that the area in question used to contain man-made pond which had been previously infilled.

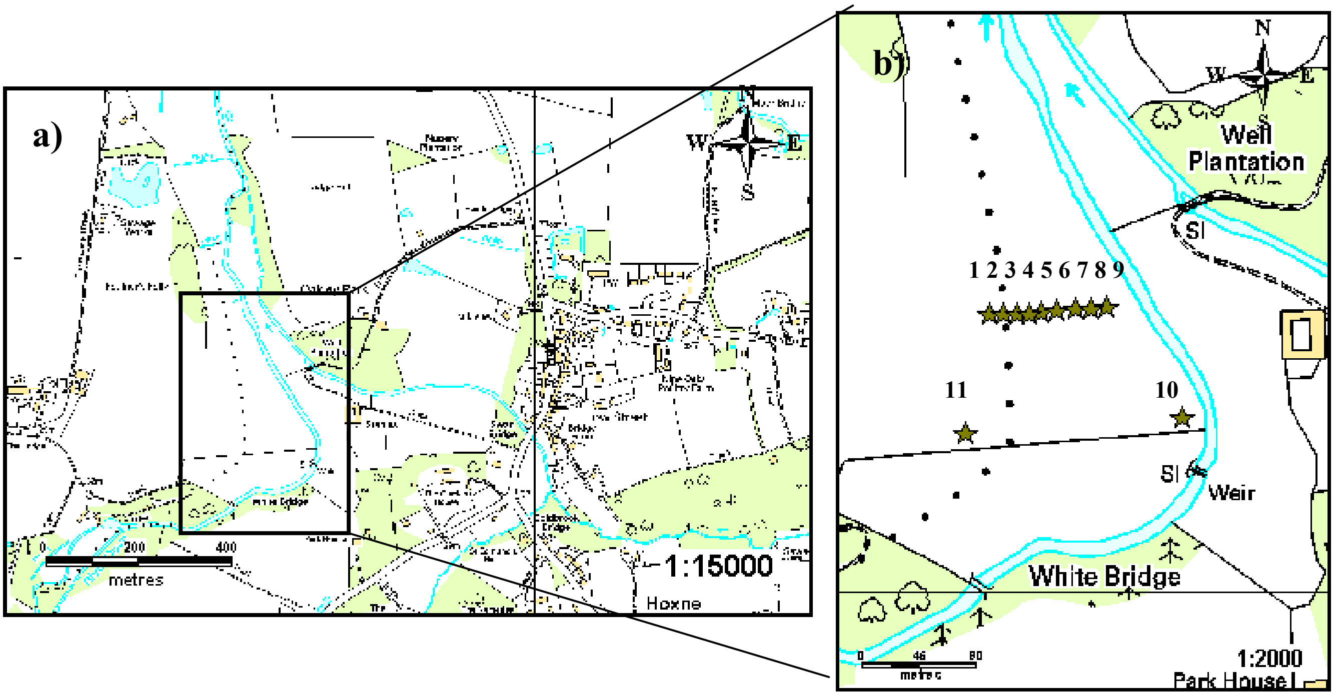


Figure 16a: location map of River Dove floodplain to the west of Hoxne, **b:** core locations and numbers, with parish boundary indicated by dotted line running approximately north-south through the floodplain. Stratigraphic summary provided in Appendix II.

Evidence for a former palaeochannel identified by both LiDAR and parish boundary data was therefore unsuccessful. The basal gravels known to underlie the region are only *c*. 0.50 m below the surface throughout the site location, overlain by agricultural topsoil. There was an absence of organic-rich deposits typical of relict water courses and the stratigraphic archive available therefore yielded little potential information regarding the palaeoenvironmental history of the region. It was concluded that no palaeoenvironmental potential was evident within the stratigraphic archive. As a consequence, no sample core was taken for palaeoenvironmental assessment.

7.5 IXWORTH

Fieldwork took place on the floodplain of the River Black Bourn immediately south of Ixworth within Mickle Mere (TL 593767 269749). Access permission to the Mere was granted through Suffolk Wildlife Trust. Although it was not possible to identify potential relict palaeochannels through the analysis of LiDAR data (waterlogging of the surface of the Mere prevented a clear signal return), the deposits known to be present, combined with the local archaeological record, encouraged further analysis. A total of six cores were extracted and assessed for palaeoenvironmental potential. The location of each core is provided in Figure 17. Levelling of all core locations indicated that the surface elevation of the floodplain next to the River Black Bourn varied in altitude from *c*. 27.10 m O.D. to 27.50 m O.D.

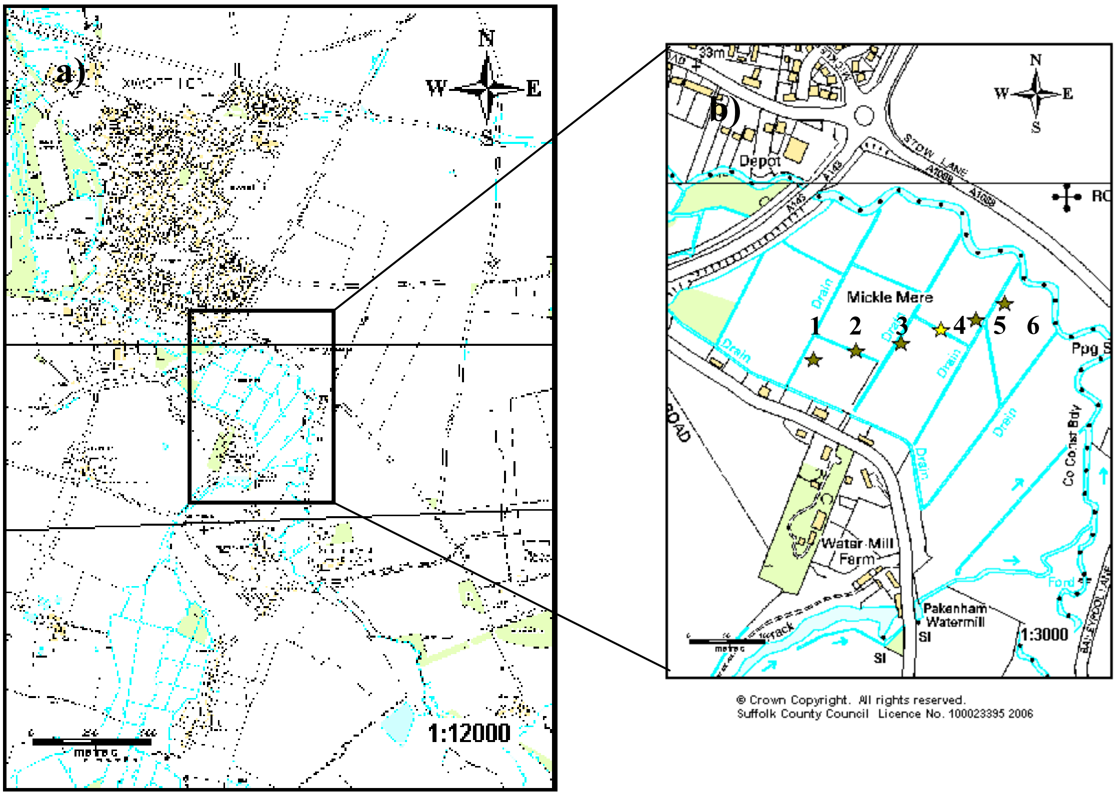


Figure 17a: location map of River Black Bourne floodplain to the south of Ixworth, **b:** core locations and numbers. Sample core location highlighted by yellow star. Stratigraphic summary provided in Appendix II.

7.5.1 Stratigraphic Summary

A core transect was excavated across the River Black Bourne floodplain approximately east-west. The waterlevels in the Mere have been artificially managed for conservation purposes since the construction of the A143 bypass to the north. At the time of fieldwork, the mere had been drained which enabled access across the whole of the site. A stratigraphic summary of the cores is provided in Appendix II. The thickness of the stratigraphic sequence varied from *c*. 2.50 m to 3.50 m. Although there was considerable spatial variation between cores, the stratigraphic archive was typified by interbedded layers of peat, with varying abundances of minerogenics within. In addition, occasional sand and silty-sand horizons are interbedded within the organic-rich deposits. The peat is capped by an organic-rich silt layer averaging *c*. 0.50 m thickness across the site.

A summary of Core 3 is provided below to infer the general stratigraphic archive encountered during fieldwork:

Depth	
0.00-0.10 m	Yellow-brown organic right sandy SILT
0.10-0.45 m	Light grey clayey SILT with iron mottling
0.45-0.80 m	Dark brown herbaceous very well humified PEAT
0.80-1.70 m	Dark brown well humified silty PEAT
1.70-1.85 m	Light grey fine SAND horizon
1.85-1.90 m	Dark brown slightly silty PEAT
1.90-2.00 m	Grey-brown organic fine SAND horizon
2.00-2.50 m	Dark brown humified herbaceous PEAT with occasional silt-rich horizons within
2.50-2.60 m	Grey SAND

Upon review of the sequences encountered during the Mickle Mere fieldwork, Core 4 was chosen as a core location in which the sedimentary sequence encountered typified the sequence present within the floodplain of the River Black Bourn and a core was recovered from this location.

8 PALAEOENVIRONMENTAL RESULTS

Due to the absence of stratigraphic archives with palaeoenvironmental potential at Brandon and Hoxne, only three of the five original sites were carried forward for multi-proxy palaeoenvironmental assessment: Beccles, Hengrave & Ixworth.

During the initial design of the Suffolk River Valleys Project, the relative lack of previous geoarchaeological and palaeoenvironmental investigations undertaken in the county meant that the sedimentary archives present within the Suffolk lowlands were a largely unknown quantity. As a consequence, the primary aim of the study was to undertake a *qualitative* assessment of the sedimentary archive available. Consultation between Birmingham Archaeo-Environmental, Suffolk County Council and English Heritage during the project design stage resulted in the development of a programme of limited palaeoenvironmental assessments. This was intended to allow the 'identification and palaeoenvironmental assessment of organic sediments and to determine the state of preservation and potential for environmental reconstruction' (see Section 3.2).

8.1 PALAEOENVIRONMENTAL TECHNIQUES

Depending on the precise nature of the deposits, beetle, pollen and diatom assessments were carried out on sub-samples from the cores. A description of methodologies is provided within Appendix III, whilst a summary of all palaeoenvironmental results is provided in Appendix IV.

Coleoptera assessments were undertaken on all sedimentary sequences sampled during fieldwork. Full analyses would commonly require *c.* 10 litre samples to obtain sufficient faunal assemblages to enable reliable palaeoenvironmental interpretations (Kenward *et al.,* 1980). For this reason, combined with the qualitative nature of this project (see above), core samples were required to be 'bulked' to provide adequate assessment sampling quantities, averaging *c.* 0.40 m in thickness. Pollen assessments were undertaken on three of the four cores taken as part of the project (Beccles Core 1, Hengrave and Ixworth). In the case of Beccles Core 2 however, the identification of blue-grey silts and clays believed to be of estuarine origin, deemed the deposits to be less suitable for a palynological study. Diatom analysis was therefore chosen due to its successful application to similar coastal lowland environments (Hill *et al*., 2007b). Diatom analysis of the thin organic-rich silt unit within Beccles Core 1 (see section 7.1.1) was also carried out due to the possible influence of estuarine conditions on the unit's development. Each of the assessments were supported through the application of a radiocarbon dating strategy to provide chronological control. This strategy was developed through collaboration with the English Heritage scientific dating team, with dating concentrating on stratigraphic boundaries within each core sequence. Single AMS radiocarbon measurements were undertaken on plant macrofossil remains taken from the chosen sedimentary horizons.

8.2 BECCLES CORE 1

Beccles Core 1 was taken from a *c*. 6 m thick sequence of peat present adjacent to the Beccles trackway archaeological excavation. Levelling of Beccles Core 1 positioned the ground surface altitude at -0.415 m O.D. A summary of the stratigraphy of Beccles Core 1 is provided to assist the palaeoenvironmental assessment:

Depth	
0.00-0.20 m	Dark brown herbaceous very well humified silty PEAT
0.20-0.85 m	Medium brown very well humified silty PEAT
0.85-1.00 m	Grey-brown organic rich SILT
1.00-1.16 m	Dark grey-brown very well humified silty PEAT
1.16-2.00 m	Red-brown very well humified PEAT with occasional wooden fragments
2.00-4.84 m	Dark red-brown herbaceous very well humified woody PEAT
4.84-5.00 m	Dark brown herbaceous very well humified PEAT
5.00-5.25 m	Dark red-brown herbaceous very well humified PEAT
5.25-5.35 m	Dark brown herbaceous very well humified PEAT
5.35-5.45 m	Dark grey-brown organic-rich sandy SILT

8.2.1 Pollen Assessment Results

Pollen concentrations and preservation was found to be highly variable in the samples from Beccles Core 1 (Figure 18), with evidence of a general deterioration in pollen preservation and associated reduction in concentration towards the top of the sequence. For this reason, pollen counts are very low above *c*. 2.90 m depth in particular, and although the data are presented as percentages, these data should be regarded with caution and any interpretation must be very tentative.

The basal zone (BCC1) is dominated by *Pinus sylvestris* (Scots' pine), with few other taxa in any quantity other than Cyperaceae (sedges) and Pteropsida (ferns). Pine must have been growing on the floodplain itself at this time, with ferns and sedges on slightly damper soils near to the sampling site. BCC2 opens with a marked decline in Pinus and concomitant rise in *Alnus glutinosa* (alder) and other trees including *Quercus* (oak)*, Corylus* (hazel)*, Salix* (willow) and *Tilia* (lime). Poaceae (wild grasses) also increases whilst Cyperaceae (sedge) declines steadily across the zone and Pteropsida remain well represented. This zone therefore reflects both local and extra-local vegetation change, with alder, willow and perhaps oak replacing pine on the floodplain and with lime, hazel and oak becoming established in the wider landscape on drier soils. The Poaceae curve is likely to reflect local wetland grasses such as *Phragmites* (common reed), with few other herbs recorded at this time.

The final zone BCC3 sees an abrupt fall in *Tilia* and steady reductions in other trees and shrubs including *Alnus*, *Corylus* and *Pinus*. *Salix* and *Betula* are the only woody taxa to increase at this time. Herbs including Poaceae and Cyperaceae increase with other indicators of open ground including Lactuceae (dandelion-type plants), *Galium*-type (bed straws) and towards the top of the zone, *Plantago lanceolata* (ribwort plantain) and *Rumex* (docks). *Sparganium emersum*-type (bur-reeds) also displays a steady increase. The data would therefore appear to reflect a general opening up of the woodland canopy both on the floodplain and on drier soils. The increase in bur reeds,

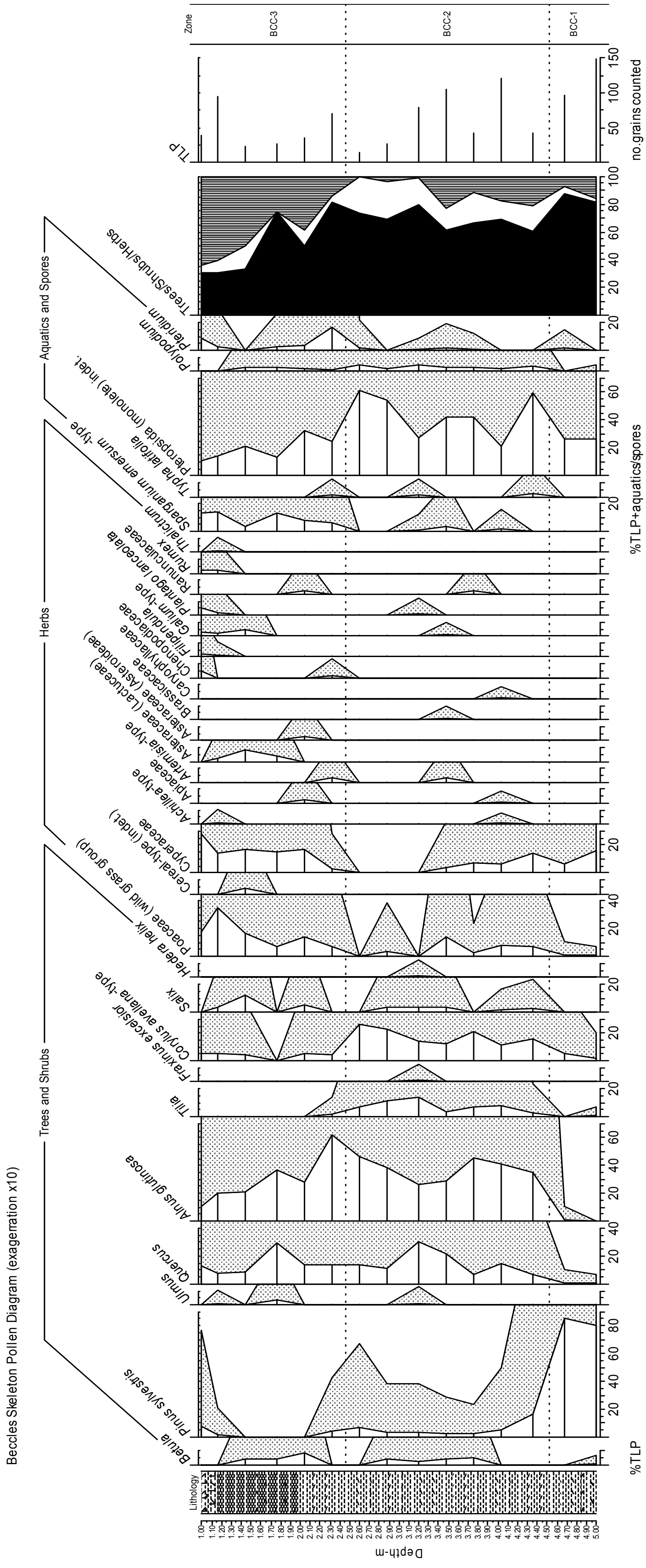


Figure 18: Beccles Core 1 Pollen Diagram

sedges and willow may suggest that locally conditions had become wetter, favouring the expansion of willow over alder. The disappearance of lime and falls in the other arboreal components alongside rising grasses and other herbs suggest significant changes on the dryland, with lime dominated woodland being replaced by open grassland.

8.2.2 Beetle Assessment Results

Two bulk samples were assessed for beetle remains from within the core. The bulk samples were taken from towards the centre of the core (2.00-2.60 m depth) within dark red-brown herbaceous well-humified woody peat, and from towards the base of the core (4.80-5.40 m depth) within dark brown to red-brown herbaceous very well-humified peat.

A restricted assemblage of well-preserved and identifiable coleopteran remains was recovered from 2.00-2.60 m. Species included *Pterostichus spp., Trogophloeus spp., Philonthus spp.* and *Aphodius spp*., but species abundance never exceeded 1-2 individuals. Consequently, the limited nature of this assemblage prevented any palaeoenvironmental interpretation. In addition, the sample from 4.80-5.40 m depth contained no coleopteran remains.

8.2.3 Diatom Assessment Results

Due to the limited presence of minerogenic sediments within the core stratigraphy (preventing frustule preservation), diatom analysis was restricted to the organic-rich silt horizon present at 0.85-1.00 m depth. Two samples were taken and processed for diatom assessment; 0.88 m and 0.96 m depth

At 0.88 m depth, diatom abundance was relatively low and the frustules were commonly disarticulated. The species *Diploneis interrupta* almost wholly dominated the diatom assemblage encountered during the initial assessment. Fragments of species including *Diploneis bombus*, *Rhophalodia gibba*, *Nitzschia navicularis*, *Paralia sulcata* and *Nitzschia punctata* were also present. The dominance of *Diploneis interrupta* may be a consequence of preferential diatom preservation, as diatoms composed of weaker biogenic silica may have been destroyed. However, the overall abundance of *Diploneis interrupta* is an indicator to the influence of intertidal conditions on the development of the sedimentary unit. The aerophilous nature of *Diploneis interrupta*, supported by the presence of *Diploneis bombus*, suggests deposition occurred on the coastal zone proximal to an upper tidal flat or saltmarsh.

Diatom abundance was slightly higher at 0.96 m depth than encountered at 0.88 m. As a consequence, there was also a higher overall diversity in diatom species. However, as with 0.88 m, *Diploneis interrupta* dominated. Species including *Diploneis ovalis*, *Nitzschia navicularis*, *Cyclotella striata* and *Nitzschia punctata* were also encountered, whilst the common fragmented nature of the frustules restricted the identification of disarticulated *Navicula spp*., *Pinnularia spp*. and *Cymbella spp*. The majority of identifiable species thrive in brackish water sedimentary environments, whilst the abundance of *Diploneis interrupta* confirms deposition is likely to have occurred within an intertidal estuarine setting.

8.2.4 Radiocarbon Dating

A total of nine plant macrofossil samples were submitted for radiocarbon dating from the base of key stratigraphic units present within the core profile. However, only eight samples were successfully dated due to insufficient carbon being available within the sample submitted from 4.92 m depth. In stratigraphic sequence the samples were:

- GrA-33477 (unidentified plant remains) from the base (5.34 m) of a dark brown herbaceous very well humified peat, from near to the base of the sequence.
- GrA-33476 (*Alnus glutinosa*, stem) from the centre (3.50 m) of a dark red-brown herbaceous very well humified peat.
- SUERC-12037 (unidentified bark fragment) from the top (2.02 m) of a dark red-brown herbaceous very well humified peat
- GrA-33475 (*Alnus glutinosa*, stem) from the base (1.99 m) of a red-brown herbaceous very well humified peat.
- The two samples (SUERC-12036 & GrA-33473) from the top (1.18 m) of a red-brown herbaceous very well humified peat (unidentified wood & Poaceae fragments and internode) are not statistically consistent (T'=20.1; ν=1; T'(5%)=3.8; Ward and Wilson 1978) and represent material of different ages.
- SUERC-12035 (Poaceae fragments) from the base (1.15 m) of a dark grey-brown very well humified silty peat, thought to have been deposited prior to the start of inter-tidal estuarine conditions.
- GrA-33472 (*Alnus glutinosa*, small wood fragment) from the base (0.99 m) of a dark grey-brown organic-rich silt, thought to have been deposited under inter-tidal estuarine conditions.
- GrA-33471 (*Alnus glutinosa*, small wood fragment) from the base (0.84 m) of a dark grey-brown well humified silty peat.

Figure 19 shows that the results are not in a stratigraphic sequence. The basal date GrA-33477 correlates with the pollen evidence in showing that the onset of organic accumulation started in the early Holocene. However, the measurements in the upper 3.50 m of the core do not provide a robust chronological framework, and display a number of inversions.

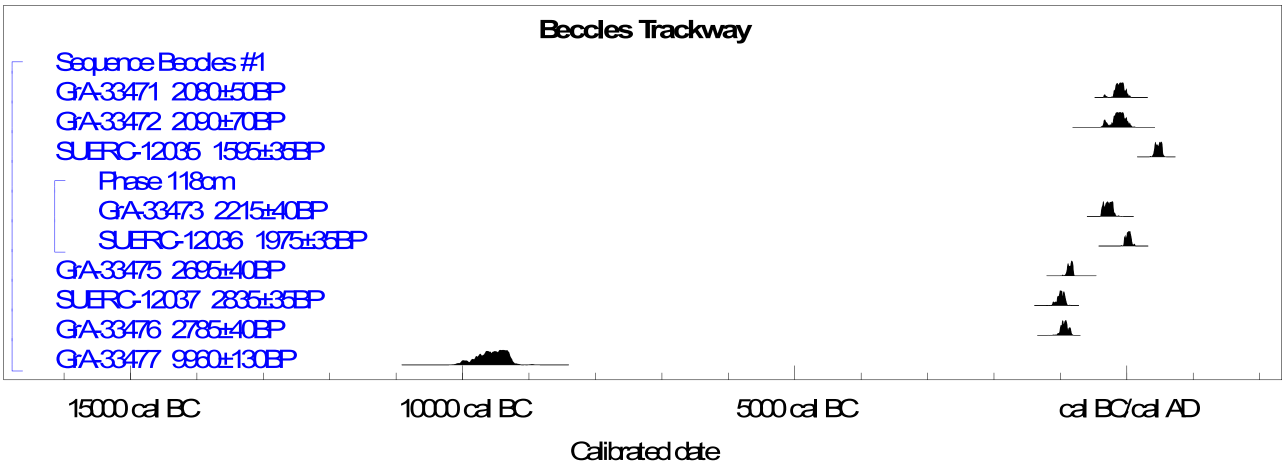


Figure 19: Probability distributions of dates from Beccles Trackway (Beccles Core 1). Each distribution represents the relative probability that an event occurred at a particular time. These distributions are the result of simple radiocarbon calibration (Stuiver and Reimer 1993).

8.3 BECCLES CORE 2

Beccles Core 2 was located *c*. 80 m north of Beccles Core 1 where the stratigraphy was typified by *c*. 3 m of grey-brown to blue-grey clays and silts overlying *c*. 2 m of red-brown peat. The surface of the core was levelled to -0.083 m O.D. The distinct spatial shift in stratigraphy justified the second core being taken, but due to the cohesive nature of the minerogenic sediments, it was not possible to undertaken sedimentary sampling using a Russian corer (as used for Beccles Core 1). As a consequence, an Eijkelcamp gouge corer had to be used. Due to the gouge corer having an 'open' sampling chamber, every effort was made to reduce the potential threat of sediment contamination during coring. A summary of the stratigraphy of Core 2 is provided to assist palaeoenvironmental assessment:

Depth	
0.00-0.16 m	Unsampled in core
0.16-0.89 m	Blue-grey (with organic and iron mottling) clayey silt
0.89-0.96 m	Grey-brown organic rich rooty silt
0.96-1.35 m	Blue grey (with org and iron mottling) clayey silt
1.35-1.56 m	Grey-brown organic-rich silt
1.56-1.74 m	Blue-grey (org mottling) clayey silt
1.74-2.23 m	Grey-brown organic rich silt
2.23-2.51 m	Blue-grey (org. mottling) clayey silt
2.51-2.55 m	Grey-brown organic rich silt
2.55-2.58 m	Blue-grey (org. mottling) clayey silt
2.58-2.76 m	Grey-brown organic rich silt
2.76-2.84 m	Blue-grey (org. mottling) clayey silt
2.84-3.74 m	Dark brown herbaceous well humified silty peat, becoming red-brown with depth
3.74-3.88 m	Wood horizon

8.3.1 Beetle Assessment Results

Two bulk samples were assessed for beetle remains from within the core. One bulk sample was taken from towards the base of the core within dark brown herbaceous well-humified silty peat (3.20-3.80 m depth). A second bulk sample was taken from towards the centre of the core (2.00-2.30 m depth) within grey-brown organic-rich silts and blue grey clayey silts.

The sample from 3.20-3.80 m provided a small but well-preserved and interpretable beetle assemblage. Species included *Elaphrus cupreus*, *Pterostichus spp*., aquatic *Cercyon spp*. and *Hydrothassa glabra*. The insect remains from this sample suggest well vegetated, standing water surrounded by grassland. The carabid, *Elaphrus cupreus,* is found at the muddy margins of standing waters in reedy swamps and bogs (Lindroth 1974). The aquatic members of the hydrophilid family, *Cercyon* spp., are a found amongst wet, decaying organic material at the margins of standing and slow moving waters (Hansen 1987).

At 2.00-2.30 m, a restricted assemblage of well-preserved and identifiable coleopteran remains was recovered. Species included *Helophorus spp*., *Stenus spp*. and *Aleocharinae* (gen. & spp. indet). In addition, species counts rarely exceeded 1-2 individuals. As a consequence, the limited nature of this assemblage precluding any interpretation.

8.3.2 Diatom Assessment Results

The interbedded layers of organic-rich silts and blue-grey silts and clays were suggested to be stratigraphic evidence for the influence of relative sea-level change on the lowland evolution of the Waveney Valley. As a consequence, a total of nine samples were assessed for diatoms. Each sample was located at the lower stratigraphic boundary between the organic-rich silts and the clayey silts.

Of the nine samples assessed for diatoms, two samples contained very low species abundance and diversity. As a consequence, reliable palaeoenvironmental information could not be obtained from 2.50 m depth and 2.57 m depth. In addition, a count of only 110 frustules could be made for the sample at 1.55 m depth. The diatom frustules from within these samples may have experienced post-depositional biogenic silica dissolution as a consequence of fluctuations in the region's water table. Enhanced redox conditions within lowland archives have been shown to precipitate iron oxides that influence diatom preservation (Mayer *et al*., 1991). However, the diatom assemblage from 1.55 m depth, combined with the remaining six samples in which 200+ diatom valves were counted, are suitable for palaeoenvironmental interpretation. Figure 20 summarises the diatom species present within Beccles Core 2. A summary of the diatom assemblages encountered within each sample assessed is provided within Appendix IV. Diatom ecological groups are shown as a percentage of Total Diatom Valves (% TDV) according to the ecological classification scheme of Vos & deWolf (1993).

2.83 m Dominant species: *Nitzschia navicularis*, *Cocconeis placentula*, *Paralia sulcata*, *Epithemia turgida*.
Marine brackish epipelon species contribute *c*. 31% TDV, with *Nitzschia navicularis* dominating. Marine-brackish aerophilous species such as *Diploneis ovalis* and *Diploneis interrupta* are also present in relative abundance (12.6% TDV). There is also however strong influence from brackish-fresh and fresh-brackish epiphytic species (26% TDV combined), whilst fresh epiphytic species (*Epithemia turgida* dominating) contribute 11.5% TDV.

Sample 2.83 m was located at the base of a blue-grey clayey silt that immediately overlies fen peat. Although the overall dominance of marine brackish epipelon and aerophilous species initially suggests sedimentation in an upper mudflat intertidal environment, the influence of brackish-fresh and fresh-brackish and fresh epiphytic species underlines the maintained influence of freshwater conditions. Consequently, classification according to Vos & deWolf (1993) suggests deposition may have occurred within pools on the supratidal salt marsh

2.75 m Dominant species*: Epithemia turgida*, *Cocconeis placentula*, *Epithemia Zebra*.
Brackish-fresh (13.5% TDV), fresh-brackish (17.6% TDV) and fresh (24% TDV) epiphytic species dominate, with *Cocconeis placentula*, *Gomphonema constrictum* and *Epithemia turgida* contributing respectively. Marine-brackish epipelon species also contribute.

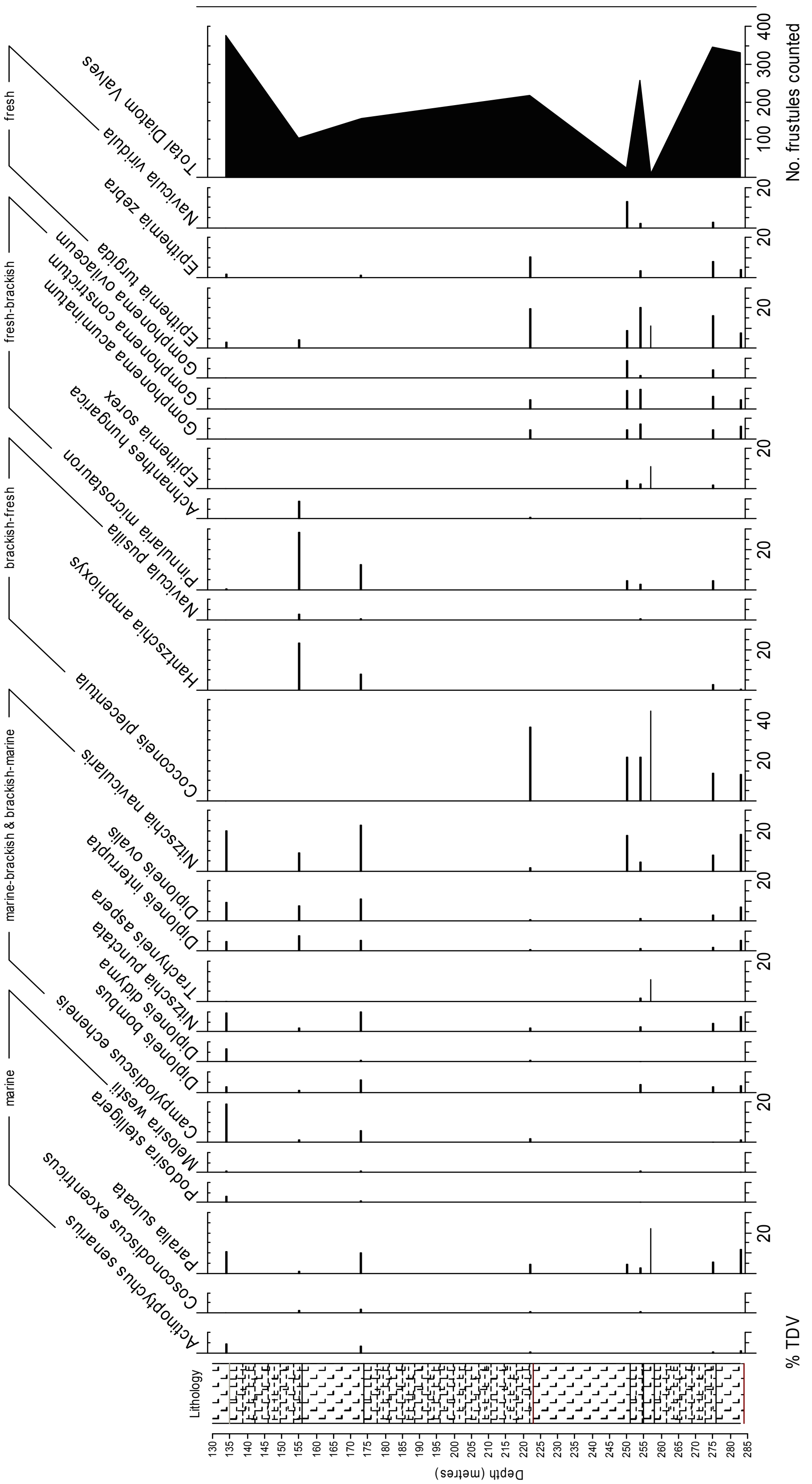


Figure 20: Summary of the diatom assemblages encountered within Beccles Core 2. Diatom species are expressed as a percentage of TDV.

There is a distinct increase in the influence of diatom species that thrive in environments with lower salinity levels when compared to the underlying assemblage. This in turn is supported by the enhanced organic content within the sedimentary unit, indicative of deposition at a higher altitude on the salt marsh. However, based on Vos & deWolf (1993), deposition is still occurring in pools within the salt marsh, as this depositional environment is the highest altitudinal zone relative to tidal level available within the classification scheme.

2.57 m Very low diatom abundance was present within this sample. Consequently no reliable palaeoenvironmental interpretations were possible. Based on sedimentology alone, it is suggested that a shift from the deposition of the underlying organic-rich silt to blue-grey clays and silts is indicative of a positive sea-level tendency. The abundance of organic matter within estuarine deposits commonly decreases with distance down the tidal frame (Hill, 2006). If deposition occurred at a lower altitude on the tidal frame, marine encroachment may have caused the shift in the depositional environment

2.54 m Dominant species: *Cocconeis placentula*, *Epithemia turgida*, *Gomphonema constrictum*.
As with 2.75 m depth, brackish-fresh, fresh-brackish and fresh epiphytic species dominate, with *Cocconeis placentula*, *Gomphonema constrictum* and *Epithemia turgida* dominating the respective contributions. The influence of Marine planktonic and tychoplanktonic species remains low, indicating the restricted input from tidal influence.

Deposition of the organic-rich silt continued to occur within pools on a salt marsh, similar to samples 2.83 m and 2.75 m. If deposition of the underlying sample at 2.57 m depth had occurred further down the tidal frame, it is likely that a negative sea-level tendency resulted in enhanced freshwater terrestrial sedimentation within the coastal lowlands. This would have consequently encouraging the development of diatom assemblages representative of such supratidal conditions.

2.50 m Very low diatom abundance was present within this sample. Consequently, as with sample 2.57 m, no reliable palaeoenvironmental interpretations were possible. It is however suggested that a shift from the deposition of the underlying organic-rich silt to blue-grey clays and silts is once again indicative of a positive sea-level tendency.

2.22 m Dominant species: *Cocconeis placentula, Epithemia turgida, Epithemia sorex*.
Brackish-fresh epiphytic species (*Cocconeis placentula)* and fresh epiphytic species (*Epithemia turgida* and *Epithemia sorex*) dominate the assemblage. Less than 15% TDV are diatom species requiring marine, marine-brackish or brackish water conditions to survive.

The low abundance of saline-tolerant species, combined with the lack of planktonic and aerophilous species within the assemblage, is indicative of the restricted influence of tidal conditions on the sedimentary environment at the time of deposition. It is therefore proposed that deposition is occurring within the supratidal area, within pools on saltmarshes (in accordance with Vos & deWolf, 1993). It is once again suggested however, that if deposition of the underlying blue-grey clays and silts did occur in conditions of enhances marine influence, a negative sea-level tendency has been observed to return to supratidal depositional conditions.

1.73 m Dominant species: *Nitzschia navicularis*, *Diploneis ovalis*, *Paralia sulcata*, *Nitzschia punctata*.
Marine-brackish epipelon species dominate (42% TDV), with contributions from *Nitzschia navicularis*, *Diploneis didyma* and *Diploneis bombus*. Marine plankton species (e.g. *Paralia sulcata*) are much more influential (15.4% TDV) when compared to the underlying assemblage. Marine-brackish and brackish-marine aerophilous species, including *Diploneis ovalis* and *Hantzschia amphioxys* respectively, are also influential within the diatom archive.

The domination of marine-brackish epipelon species, combined with the influence of saline-tolerant aerophilous species indicates sedimentation has occurred lower down the tidal frame when compared to the underlying assemblage. This is also supported by the comparable reduction in organic content within the unit. Although the diatom species present suggests deposition may have occurred on intertidal mud flats, according to Vos & deWolf (1993) the maintained presence of brackish-fresh aerophilous species indicates deposition slightly higher up the tidal frame, on saltmarshes around Mean High Water (MHW). This however indicates a positive sea-level tendency when compared to the underlying diatom assemblage, resulting in the enhanced influence of estuarine conditions within the depositional environment.

1.55 m Dominant species: *Pinnularia microstauron*, *Hantzschia amphioxys*, *Nitzschia navicularis*.
Brackish-fresh aerophilous species dominate the assemblage, contributing *c*. 57% TDV. *Pinnularia microstauron* and *Hantzschia amphioxys* dominate this group. Whilst marine-brackish epipelon species such as *Nitzschia navicularis* and marine-brackish aerophilous species including *Diploneis interrupta* and *Diploneis ovalis* are also present, their abundance is relatively low. Very low populations of marine planktonic and tychoplanktonic species are also evident within the assemblage.

Although a count of 200 diatom valves could not be achieved for this assemblage, tentative conclusions can be made regarding the palaeoenvironmental conditions present at the time of deposition. Based on the influence of marine-brackish epipelon and aerophilous species, combined with the overall dominance of brackish-fresh aerophilous species, deposition is suggested to have occurred in the supratidal zone, on salmarshes *above* MHW. This would therefore indicate a negative sea-level tendency has occurred in relation to the underlying depositional environment.

1.34 m Dominant species: *Nitzschia navicularis, Campylodiscus echeneis, Paralia sulcata, Nitzschia punctata*.
Marine-brackish epipelon species such as *Nitzschia navicularis* and *Campylodiscus echeneis* dominate the diatom assemblage, contributing c. 54% TDV. Marine planktonic species (e.g. *Paralia sulcata*) contribute 17% TDV, whilst marine-brackish aerophilous species including *Diploneis interrupta* and *Diploneis ovalis* contribute 14% TDV.

The overall dominance of marine-brackish epipelon species, supported by the enhanced influence of marine planktonic and aerophilous species, would suggest deposition continued on the supratidal area, but lower down the tidal frame on a salt marsh around Mean High Water (MHW). A positive sea-level tendency is therefore indicated due to the enhanced influence of marine environmental conditions on the diatom assemblage.

8.3.3 Radiocarbon Dating Results

Samples for radiocarbon dating were taken at the same depths as those taken for diatom assessment. Dating would therefore provide a chronological framework for the changing influence of relative sea level on the lowlands of the Waveney Valley. As a consequence, plant macrofossil samples from each of the nine horizons were submitted for radiocarbon dating. However, only five of the nine submitted samples were successfully dated. Samples taken from 1.55 m, 1.73 m, 2.57 m and 2.75 m depth were not dated due to insufficient carbon yield. This was probably due to the highly minerogenic nature of the sedimentary sequence which consequently meant that plant macrofossil remains were fairly restricted within the core. In stratigraphic sequence the samples were:

- GrA-35067 (unidentified plant remains) from the base (2.83 m) of a blue-grey clayey silt, thought to have been deposited in an inter-tidal estuarine environment, and located immediately above freshwater peat deposits.
- GrA-33479 (monocot stem – modern cal AD 1956-1957) from the base (2.54 m) of a grey-brown organic-rich silt, thought to have been deposited under inter-tidal estuarine conditions.
- SUERC-12039 (herbaceous stems) from the base (2.50 m) of a blue-grey clayey silt, assumed to have been deposited in an inter-tidal estuarine environment.
- GrA-35050 (unidentified plant fragments) from the base (2.22 m) of a grey-brown organic-rich silt, thought to have been deposited in an inter-tidal estuarine environment.
- SUERC-12038 (Poaceae fragment) from the base (1.34 m) of a blue-grey clayey silt, assumed to have been deposited in an inter-tidal estuarine environment.

The results shown in Figure 21 suggest that an intact sequence does not survive, although the two modern results might be explained by the use of an Eijkelcamp corer in the minerogenic rich sediments.

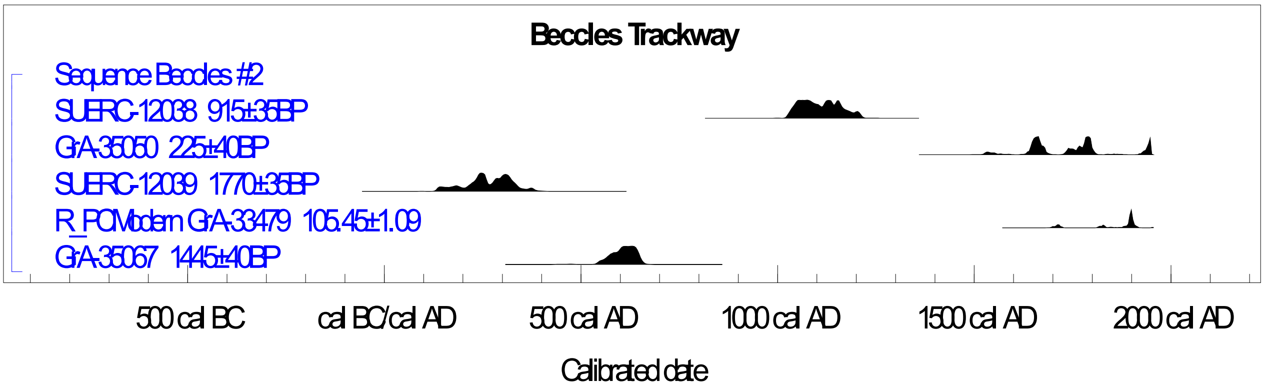


Figure 21: Probability distributions of dates from Beccles Trackway (Beccles Core 2). Each distribution represents the relative probability that an event occurred at a particular time. These distributions are the result of simple radiocarbon calibration (Stuiver and Reimer 1993).

8.4 HENGRAVE

The sample core for Hengrave was located within the study area where the stratigraphy was typified by silty peat with occasional minerogenic horizons within the organic deposits. Fieldwork had confirmed the presence of a palaeochannel previously identified through the desk-based assessment of the study area. The surface of the core was levelled to 20.608 m O.D. A summary of the stratigraphy of the Hengrave sample core is provided to assist palaeoenvironmental assessment:

Depth	
0.00-0.24 m	Dark brown very well humified peat, occasional sand and silt
0.24-0.60 m	Grey-brown herbaceous very well humified silty peat
0.60-1.00 m	Dark brown/red-brown herbaceous humified peat with occasional wood
1.00-1.51 m	Dark brown/grey-brown herbaceous well humified silty peat
1.51-1.64 m	Dark grey-brown herbaceous very well humified slightly sandy peat
1.64-2.00 m	Dark grey-brown herbaceous well humified sandy peat with occasional sand horizons
2.00-3.00 m	Dark brown/grey-brown very herbaceous humified slightly silty peat with occasional wood fragments.
3.00-3.75 m	Grey-brown silty sand with organic mottling (*unsampled as Russian corer could not penetrate minerogenic sediments*)

8.4.1 Pollen Assessment Results

Pollen concentrations were assessed as moderate-good for most samples from this sequence, although counts for the samples at depths 2.40 m and 2.64 m are low due to poor preservation (Figure 22). Poaceae and Cyperaceae dominate HEN1 with a range of other herbs including Lactuceae, Brassicaceae (cabbage family), *Cerealia*-type (cereals) and *Plantago lanceolata* recorded. Arboreal taxa are very low. The data therefore reflect an open, damp grassland landscape, with evidence for the cultivation of cereals. Few trees can have been present in the near vicinity of the sampling site, although some alder is possible on damper soils of the floodplain.

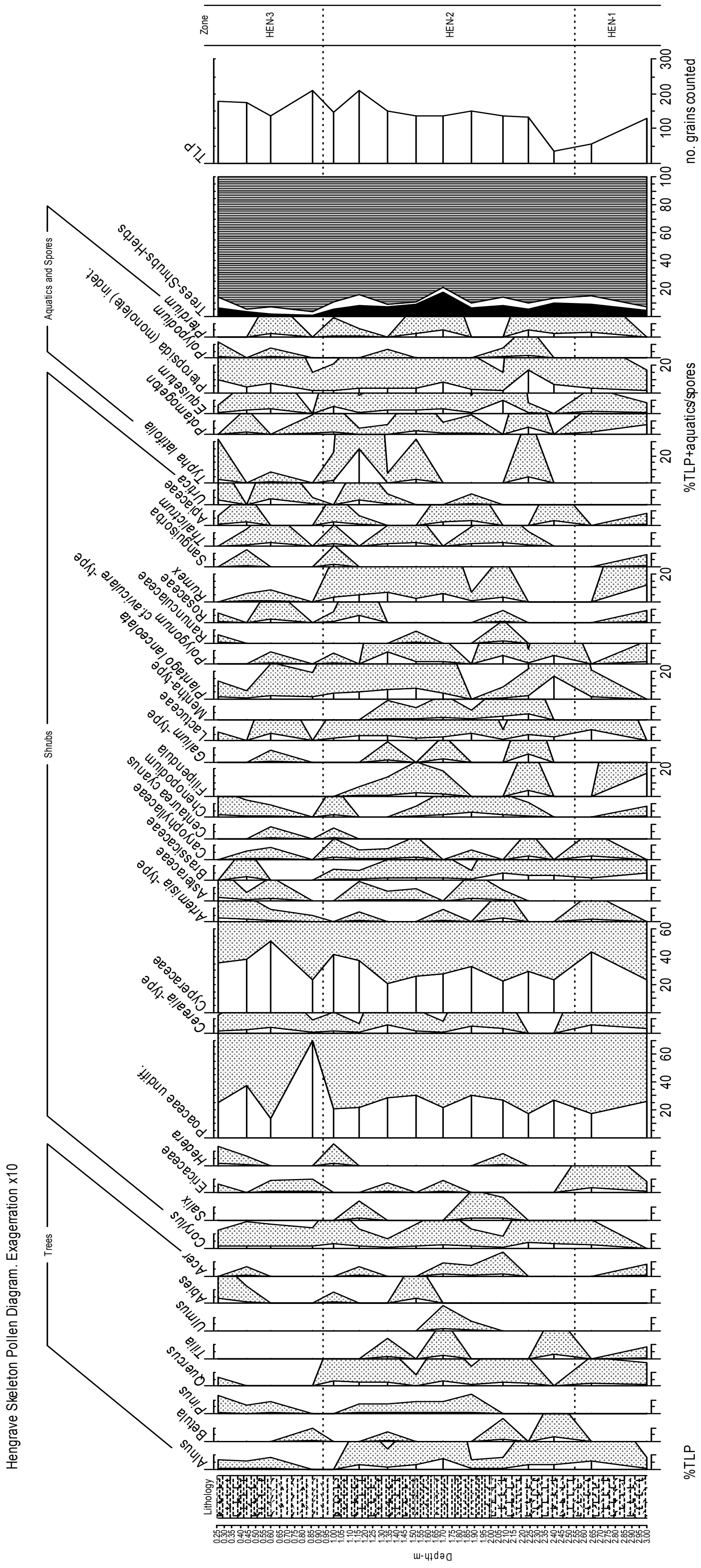


Figure 22: Hengrave Pollen Diagram

Changes at the opening of the subsequent zone (HEN2) are fairly subtle, consisting of increases in *Plantago* and other herbs including *Chenopodium* (fat hen), *Filipendula* (meadow sweet), *Rumex*, *Urtica* (nettles), *Polygonum* cf. *aviculare* type (knott weed etc.) and *Cerealia*-type. The impression is of an open agricultural landscape with an expansion in arable plots and associated weed floras (eg. mugwort and fat hen), as well as herbs suggesting a range of other semi-natural vegetation communities such as tall herbs (meadowsweet and the carrot family) and disturbed grassy places (knotweed), pasture/meadow (ribwort plantain, dandelions, meadow-rue, docks and nettles). Vegetation on damper soils near to the sampling site and probably also on the edge of the floodplain included sedges, *Equisetum* (horsetails), *Typha latifolia* (reedmace), which expands towards the top of the zone, whilst aquatic vegetation is evidenced by *Potamogeton* (pondweeds). As with the previous zone, no substantial woodland cover is indicated, with perhaps some alder and scattered oak-hazel scrub possible.

The final zone, HEN3, is mainly defined on the basis of the virtual disappearance of tree and shrub taxa from the record, with only *Corylus* recorded as a continuous curve at very low percentages. Changes in the ground flora consist of an initial spike in Poacaeae, followed by reductions in *Rumex*, *Polygonum* cf. *aviculare*-type and *Filipendula*. Other herbs including *Plantago* and Lactuceae remain well represented, whilst there are slight increases in *Artemisia*-type (mugwort) and *Urtica*. The spectra therefore indicate the demise of any remaining woodland communities in the pollen source area at this time, with hazel the only woody component that might have persisted after the opening of the zone. This as well as the changes in the representation of herbaceous taxa is probably a reflection of a shift in the nature of the local agricultural regime at this time.

8.4.2 Beetle Assessment Results

Three bulk samples were assessed for beetle remains from within the core. One bulk sample was taken from towards the base of the core within dark brown to grey-brown herbaceous humified silty peat (2.60-3.00 m depth). A second bulk sample was taken from within a dark grey-brown sandy peat (1.40-1.80 m depth) and a third from within the dark brown to red-brown herbaceous humified peat encountered towards the surface of the stratigraphic archive (0.60-1.00 m depth).

The beetle assemblage from 2.60-3.00 m depth is primarily composed of aquatic and hygrophilous beetle taxa. This suggests a pool or stream filled with slow moving water fringed by tall reed swamp was present at the time of deposition. For example, *Hydrobius fuscipes* and *Chaetarthria seminulum,* are both found with standing stagnant waters. *Hydrobius fuscipes* is a distinctly aquatic taxa found at the margins of standing water amongst dense vegetation (Hansen 1987), whilst *Chaetarthria seminulum* prefers the muddy periphery of standing water, particularly in bogs and Fens (Friday 1988). A further indicator of Fen-type vegetation is the chrysomelid, *Plateumaris braccata*, a monophagous taxa exclusively associated with the common reed (*Phragmites australis*; Menzies and Cox 1996). Vegetation in the wider environment is also suggested by the presence of the Curculionid, *Apion* spp., a family of weevils associated with a variety of plants commonly found in both meadows and disturbed ground such as vetches and mallows (Koch 1992).

In sample 1.40-1.80 m, whilst the beetle assemblage is similar to that encountered in the previous sample, the conditions at Hengrave appear to have become drier over time. Aquatic taxa are absent and are replaced by the Hydraenidae, a family of hygrophilous taxa associated with muddy, ephemeral pools (Hansen, 1987). The chrysomelid *Plateumaris braccata*, which feeds exclusively upon the common reed, increases in abundance (Menzies and Cox 1996), which suggesting the spread of tall herb fen across the site. A single specimen of the Scarabaeidae (dung beetle) family was also recovered from this sample; *Geotrupes* spp. (the 'Dor' beetle) is found amongst the dung of large herbivores (Jessop, 1986).

During the deposition of sample 0.60-1.00 m, wetter conditions appear to have returned to the site. Distinct aquatic species such as the hydrophilid *Hydrobius fuscipes*, and the dytiscid Noterus spp., were recovered which are both found in standing, stagnant water (Nilsson and Holmen 1995). In addition, in contrast to its relative abundance in the underlying sample (1.40-1.80 m), The Hydraenidae is found in lower abundances suggesting the reduction in more ephemeral, muddy pool environments. Vegetation at the site has also changed subtly, with a decrease in beetle assemblages indicative of tall reed environments, only to be replaced by species associated with lower growing and aquatic vegetation. The chrysomelid *Plateumaris sericea*, is found on sedges (*Carex* spp.), water-lily (*Nuphar* spp.) and yellow flag (*Iris pseudocorus*; Menzies and Cox 1996). Increased numbers of the curculionid, *Apion* spp., suggest drier grassland close by.

8.4.3 Radiocarbon Dating Results

Nine plant macrofossil samples were submitted for radiocarbon dating from the Hengrave core. Each sample was located at the base of a key stratigraphic unit present within the core. In stratigraphic sequence the samples were:

- SUERC-12031 (unidentified plant stems) from the base (2.99 m) of a herbaceous well humified slightly silty peat.
- GrA-33482 (Poaceae fragment) from (2.56 m) within a herbaceous well humified slightly silty peat.
- SUERC-12030 (Poaceae fragment) from (2.32 m) within a herbaceous well humified slightly silty peat.
- GrA-35054 (Poaceae stems) from the base (1.99 m) of a herbaceous well humified sandy peat.
- SUERC-12030 (Unidentified plant remains cf. seed/flower head) from the base (1.63m) of a herbaceous well humified slightly sandy peat.
- GrA-33481 (Poaceae stems and internode) from the base (1.50 m) of a herbaceous well humified silty peat.
- SUERC-12028 (Poaceae fragments) from the base (0.99 m) of a herbaceous humified peat.
- GrA-35051 (Poaceae fragment) from the base (0.59 m) of a herbaceous well humified silty peat.
- SUERC-12027 (Poaceae fragment) from the top (0.26 m) of a herbaceous well humified silty peat.

Figure 23 shows that the results are not in a stratigraphic sequence and as such do not provide a chronological framework for either answering the objectives of the dating programme or for interpreting the palaeoenvironmental work.

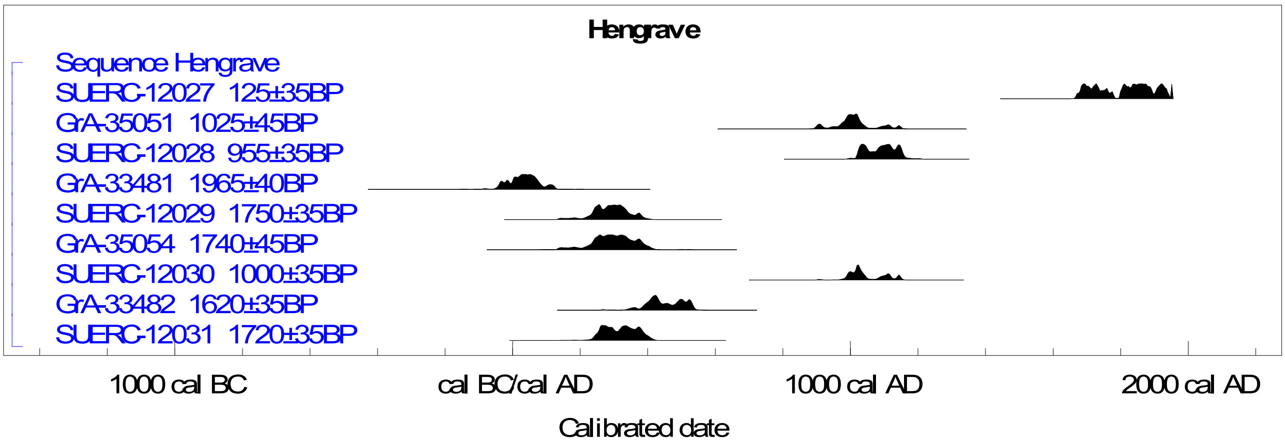


Figure 23: Probability distributions of dates from Hengrave. Each distribution represents the relative probability that an event occurred at a particular time. These distributions are the result of simple radiocarbon calibration (Stuiver and Reimer 1993).

8.5 IXWORTH

The sample core for Ixworth was located within Mickle Mere where the stratigraphy was typified by interbedded layers of peat, with varying abundances of minerogenics within. The surface of the core was levelled to 27.126 m O.D. A summary of the stratigraphy of the Ixworth sample core is provided to assist palaeoenvironmental assessment:

Depth	
0.00-0.50 m	Unsampled (light grey slightly gravely silt)
0.50-0.57 m	Same as above
0.57-0.87 m	Dark brown very well humified peat with occasional herbaceous remains
0.87-1.38 m	Dark brown/grey-brown herbaceous well humified silty peat
1.38-1.41 m	Light grey-brown organic rich sand horizon
1.41-1.50 m	Dark brown very well humified slightly silty peat
1.50-2.50 m	Dark brown herbaceous very well humified peat, occasional wood fragments
2.50-2.64 m	Grey-brown slightly gravely organic silt
2.64-3.45 m	Dark brown herbaceous well humified woody peat
3.45-3.50 m	Grey silty sand

8.5.1 Pollen Assessment Results

Both pollen concentration and preservation were assessed as good-moderate for this sequence (Figure 24). The basal zone (IX1) records a peak in *Betula* with lower values for *Pinus*, *Salix* and *Quercus*. Cyperaceae is well represented with other herbs including Poaceae, *Thalictrum* (meadowrue), *Plantago lanceolata* and *Saxifraga* spp. (saxifrages etc.) The impression is therefore of an open birch-willow scrub dominated environment, with herbs such as sedges, meadowrue, ribwort plantain and saxifrage suggesting disturbed/skeletal soils.

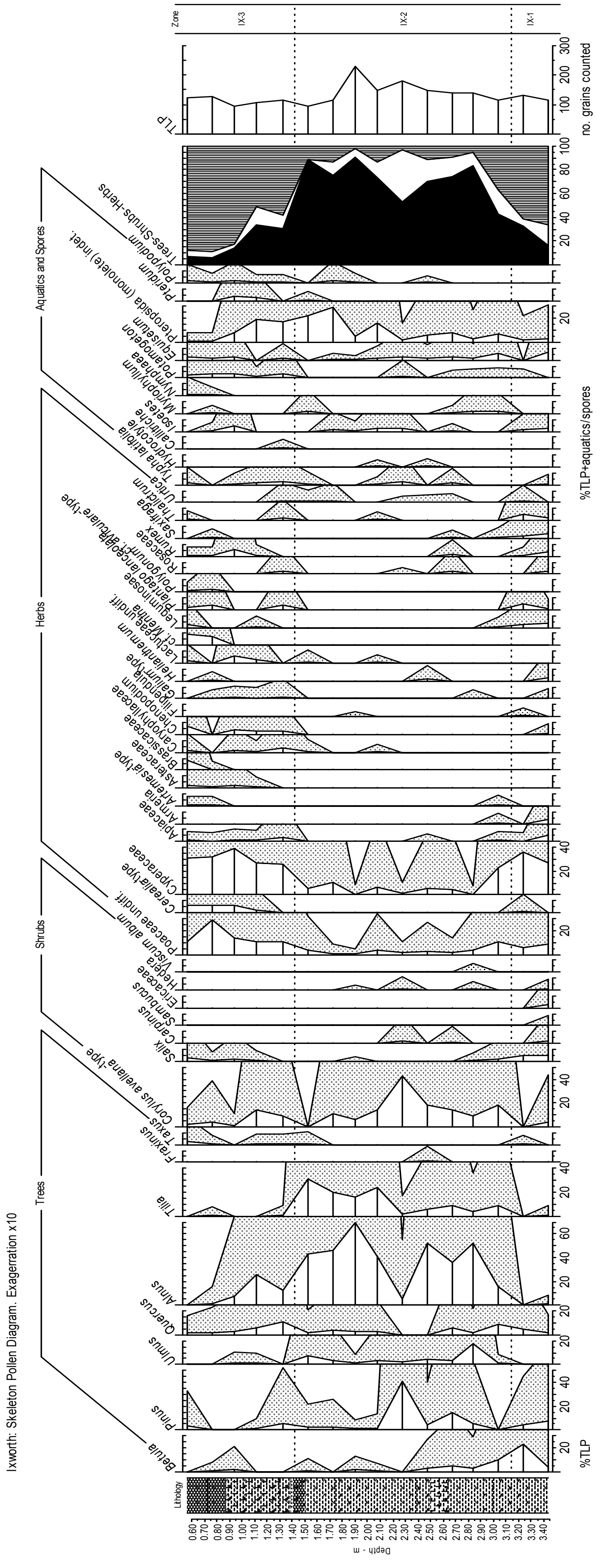


Figure 24: Ixworth Pollen Diagram

IX2 is marked by a reduction in *Betula* and *Salix* and increases in the other arboreal taxa including *Alnus, Ulmus, Tilia* and *Corylus*. *Pinus* also increases to a marked peak at 2.28 m prior to falling to low values. Indicators of open habitats are reduced and in the case of certain of the herbs in the previous zone, disappear from the record. Other than Poaceae and Cyperaceae, herbs tend to be recorded in low and sporadic quantities in IX2, whilst Pteropsida rises towards the top of the zone. The pollen spectra reflect the development of alder carr on and around the wetter soils of the sampling site and the spread of mixed woodland in the wider landscape. Lime and hazel appear to have been the major components of the tree/shrub cover, with oak and elm less significant. Birch was clearly out competed following the spread of the other trees, but pine appears to have remained present on some areas of the floodplain, and even expanded perhaps as a result of a dry phase which favored this tree over alder. This was clearly a relatively brief event, as pine is subsequently reduced whilst alder re-expands. The nature of the understorey on the drier soils beyond the floodplain is unclear, but it seems probable that the canopy was closed with few clearings or naturally open areas away from those where high soil moisture favored wetland vegetation. Is possible that some of the Poaceae derive from dryland communities rather than wetland grasses on the floodplain, but it is likely that the pollen spectra are biased towards on-site vegetation in any case with ferns and sedges probably forming the alder carr understorey.

The final zone IX4 is marked by an abrupt decline in *Tilia* with *Alnus* and *Ulmus* also reduced at this time. Other trees including *Corylus* and *Quercus* initially display small increases but subsequently decline across the zone. Marked rises in Poaceae and Cyperaceae are accompanied by the record of other herbs such as Lactuceae, Apiaceae (carrot family), Asteraceae undiff. (thistles etc.), Caryophyllaceae (the pink family), *Chenopodium* with *Cerealia*-type and *Plantago lanceolata* towards the top of the zone. These events can be interpreted as indicating a significant opening up of the lime woodland followed some point after this by disturbance to the alder carr on and around the sampling site. The initial enhanced values for hazel and oak are probably a result of the increased representation of extra-local vegetation following the reduction in alder rather than an actual areal expansion of these taxa. The subsequent drops in all the arboreal components and the rise in *Cerealia*-type and indicators of disturbed habitats and grassy places towards the top of the diagram reflect the demise of much of the woodland on both dry and wetland soils as a result of the expansion of arable cultivation.

8.5.2 Beetle Assessment Results

Three bulk samples were assessed for beetle remains from within the Mickle Mere core. One bulk sample was taken from towards the base of the core within dark brown herbaceous well humified woody peat (2.70-3.10 m depth). A second bulk sample was taken from within the dark brown well humified peat with occasional wood fragments (1.90-2.30 m depth) and a third from within the dark brown herbaceous well humified peat encountered towards the surface of the stratigraphic archive (0.50-0.90 m depth).

Upon assessment of the basal sample (2.70-3.10 m), only a single beetle sclerite was recovered from this sample. As a consequence, beetle preservation was very poor and precluded any palaeoenvironmental interpretation.

At 1.90-2.30 m depth, coleopteran remains were present that were well-preserved and identifiable. However, the species abundance and diversity was found to be restricted, with only the Staphylinidae *Lathrobium* spp. present. As a consequence, the limited nature of this assemblage also precluded any interpretation.

A restricted assemblage of well-preserved and identifiable coleopteran remains was also recovered from 0.50-0.90 m depth. Coleopteran abundance and diversity was greater than the underlying assemblages, with species such as the Staphylinidae *Stenuus* spp. and the Curculionidae *Apion* spp. encountered. However, once again the limited nature of this assemblage prevented any palaoenvironmental interpretations from being achieved.

8.5.3 Radiocarbon Dating Results

Nine plant macrofossil samples were submitted for radiocarbon dating from the Ixworth core. However, only eight samples were successfully dated. A radiocarbon sample from 0.56 m depth could not be dated due to an insufficient carbon yield. In stratigraphic sequence the samples were:

- GrA-33483 (*Alnus glutinosa*, stem) from the base (3.44 m) of a well humified peat which is underlain by silty sands.
- SUERC-12026 (*Alnus glutinosa*, wood fragment) from the base (2.63 m) of an organic silt unit which is underlain by well humified peat.
- GrA-33485 (*Alnus glutinosa*, stem) from the base (2.49 m) of a well humified peat which is underlain by an organic silt.
- SUERC-12025 (unidentified wood fragments) from the base (1.49 m) of a well humified slightly silty peat which is underlain by herbaceous well humified peat.
- GrA-35056 (Poaceae fragment) from the base (1.40 m) of a light grey-brown organic sand, which overlies a dark brown well humified peat.
- SUERC-12021 (Poaceae fragment) from the base (1.37 m) of a dark brown very well humified silty peat which is underlain by an organic-rich horizon.
- GrA-350555 (unidentified seed) from the base (0.86 m) of a dark brown very well humified peat which is underlain by a silty peat.

The basal date of 9660–9250 cal BC (GrA-33483) correlates with the pollen evidence in suggesting that organic sedimentation started in the early Holocene at the site (Figure 25). The other results do not support the pollen evidence in suggesting an intact Holocene palaeoenvironmental sequence, and a chronological framework therefore cannot be provided for the upper part of the sequence.

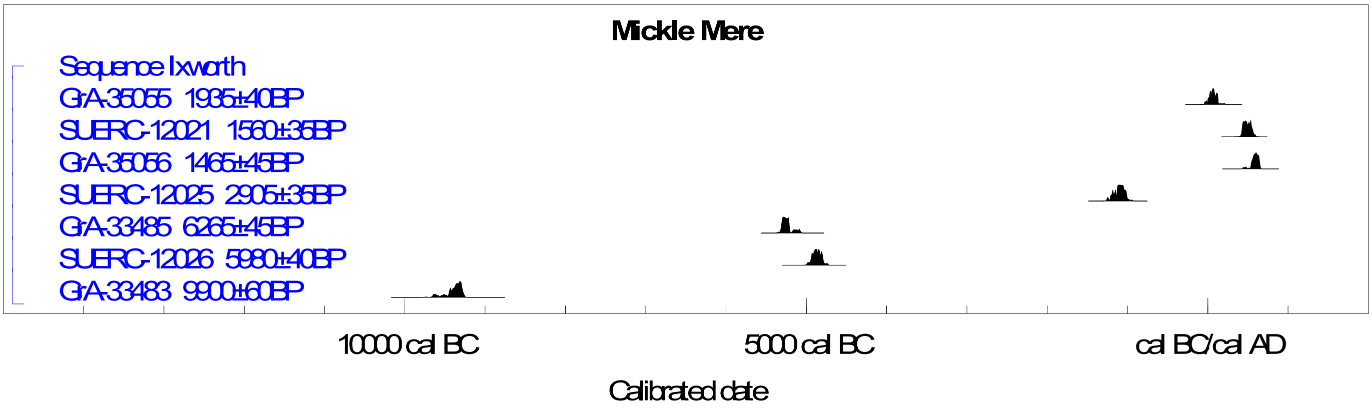


Figure 25: Probability distributions of dates from Mickle Mere (Ixworth). Each distribution represents the relative probability that an event occurred at a particular time. These distributions are the result of simple radiocarbon calibration (Stuiver and Reimer 1993).

9 INTERPRETATIONS

Despite the problems connected to radiocarbon dating of the deposits, the biostratigraphies at Hengrave and Ixworth do not suggest obvious unconformities; the pollen curves from both diagrams make ecological sense, with no evidence for any form of significant disturbance to the sequences of sediment deposition. Indeed, despite the poorer preservation of pollen at Beccles, the biostratigraphy at this site is also apparently conformable. The diatom spectra from both Beccles Core 1 and 2 also support this conclusion. These observations are not intended to suggest that the sedimentary processes at these sites are anything less than complex, as the radiocarbon results clearly illustrate, but if anything serve to highlight the potential problems associated with palaeoenvironmental study of such deposits.

Some features of the deposits may go some way to explaining the anomalous dating results. The degree of humification of the organic remains was commonly high, often resulting in plant macrofossil remains preserved in relatively low abundance. Whilst this may explain the failure of a number of samples to provide sufficient material for successful radiocarbon dating, it does not account for the presence of inverted dates and modern age estimates from deep within some of the stratigraphic sequences. Sampling of Beccles Core 2 using a gouge corer may account for some such anomalous results, but a subsequent meeting with an English Heritage dating specialist (Dr Peter Marshall) established that sampling protocols applied during both fieldwork and laboratory analyses did not appear to be responsible for providing the erroneous radiocarbon results. A number of other factors may have contributed, with evidence from the archaeological excavations at Beccles meriting comment:

- The potential exists for vertical mixing and disturbance of the peat sequences through human and/or pastoral activity on the floodplain, with a number of the radiocarbon measurements from Beccles Core 1 providing dates of between 390 cal BC and 120 cal AD (encompassing the duration of post alignment construction and use; Gearey *et al.*, 2007).
- A number of the oak posts within the triple row post alignment were found to be heavily penetrated by *Phragmites* stems and roots, indicating the invasive and aggressive potential of such vegetation growth. This could potentially lead to vertical mixing and increase the subsequent potential for inverted dates (although it should be noted that the majority of plant macrofossil remains dated within the Beccles Core 1 sequence were wood fragments).

It is beyond the scope of this report to consider the precise reasons for the anomalous chronological frameworks achieved. From the curatorial perspective of Suffolk County Council, it was deemed essential to further investigate the reasons behind such chronological problems and determine if these might be a broader issue within the East Anglian region. As a consequence, English Heritage commissioned a second phase of the Suffolk River Valleys Project (Fletcher *et al*., 2007) to investigate the sedimentary sequences of Beccles, Hengrave and Ixworth further, with particular reference to the chronostratigraphy of each site. In summary, whilst the evidence from the environmental assessments support the stratigraphic integrity of the sampled sequences, the absence of detailed, radiocarbon dated pollen diagrams from Suffolk makes it difficult to establish even a relative chronology for the sequences. Despite these *caveats*, some general comments may be made.

9.1 BECCLES

The application of pollen, coleopteran and diatom analysis to the stratigraphic archives present within the River Waveney floodplain at Beccles yielded contrasting results. The very low pollen counts for the sequence preclude detailed discussion, with the associated lack of robust chronological control (see section 8.2.4) also hindering interpretation. In addition, coleopteran assemblages were almost wholly absent from the archive. It is therefore likely that either a) such material was present in low concentrations during *in-situ* organic accumulation or, b) post-depositional decomposition of the sedimentary archive has resulted in the destruction of any such material originally deposited. The latter may be more likely. Comparisons between the palaeoenvironmental assessments undertaken for this project and those undertaken during the archaeological excavation could prove useful for further investigation of the issues relating to proxy preservation at the site.

The majority of the proxy analysis applied to Beccles Core 1 concentrated on the deposits below *c*. 1.00 m depth. In contrast, the archaeological excavation incorporated much of the upper 1.00 m of the stratigraphic archive. Here, pollen and coleopteran were also carried out with pollen again poorly preserved but good preservation of coleoptera (Gearey *et al*., 2007). It is therefore inferred that post-depositional decomposition of the archive is responsible for the poor preservation of certain proxies within the sedimentary archive below *c*. 1.00 m depth. The level of the water table is likely to have remained at or close to the palaeo-landsurface during sedimentary accumulation within the Waveney Valley. Seasonal water table fluctuations would have encouraged the circulation of oxygen within the stratigraphic archive, resulting in the decomposition and humification of the deposits during *in-situ* biogenic sedimentation. This, in turn, would have encouraged the desiccation of the proxy records such as pollen grains and beetle remains from the archive. Such a theory is further supported by the level of humification present throughout much of the stratigraphic archive. Except for occasional wood fragments, much of Beccles Sample Core 1 was very well humified with few herbaceous remains. In addition, the results of coleopteran analysis from the upper *c*. 1.00 m undertaken as part of the post alignment excavation indicates relatively dry valley floor conditions prevailed prior to the abandonment of the trackway (Gearey *et al*., 2007).

A temporary shift in the depositional environment is shown to have occurred during the development of the thin organic-rich silt unit present within Beccles Core 1 (*c*. 0.85-1.00 m depth). Although present in relatively low abundances, diatom frustules typical of estuarine environments dominated the assemblages. It is therefore clear that a positive sea-level tendency resulted in estuarine inundation of the valley lowlands, shifting the depositional setting from predominantly terrestrial freshwater-influenced peatland environment to a tidally-influenced estuarine environment. Coleopteran analysis of the sediments immediately underlying this minerogenic horizon suggested the environment became wetter prior to deposition of the organic-rich silts. In addition, in Beccles Core 2, the beetle assemblages present within the peat unit underlying the *c*. 3.0 m thick clay and silt unit also indicated that prior to the onset of minerogenic sedimentation, deposition occurred within in a relatively shallow pool or slow moving stream fringed by aquatic and emergent vegetation. There is therefore evidence for an increase in surface wetness across the valley floor before the shift to minerogenic sedimentation took place. A rise in relative sea level is likely to be responsible, causing the local water tables to rise before the eventual estuarine inundation and subsequent sedimentation.

This study has identified the presence of a *c*. 5.50 m thick organic-rich archive in the Waveney Valley at Beccles. Based on the results of the stratigraphic and palaeoenvironmental assessments undertaken, some interpretations can be made regarding the nature of the depositional environment. Previous environmental studies within the Waveney Valley, combined with evidence obtained through historical records, suggest that the River Waveney has been relatively stable, maintaining its present route for much of the valley's depositional history (this would agree with ideas for the River Gipping; Rose et al., 1980). This is supported through the relative absence of palaeochannel features encountered during LiDAR analyses of the floodplain around Beccles. As a consequence, the majority of the sedimentary archive is likely to have accumulated within an anastomosing river system, experiencing vertical accretion through *in-situ* biogenic sedimentation and possibly limited avulsion. Whilst the vast majority of the archive is composed of peat, the presence of occasional silt-rich organic units would developed as a result of a combination of both *in-situ* organic accumulation and floodplain deposition during periods of elevated river discharge. Taking into account the low-lying nature of the Waveney Valley (close to 0 m O.D. at Beccles), the influence of sea-level change on the region's water table would have contributed significantly to the evolution of the valley floor. The rise in relative sea level since the last glacial maximum (LGM; *c*. 21,000yrs BP) would have resulted in high base levels relative to land surface, which would have subsequently maintained waterlogging of the valley floor. This in turn would have encouraged vegetation colonisation, establishment and expansion adjacent to the river channels. Although radiocarbon dating provided limited success, it is suggested that the basal date of 10,040-2,220 cal BC (GrA-33477) is reliable and hence suggests that such *in-situ* vertical accretion has continued throughout much of the Holocene.

Beccles Core 2 provided further palaeoenvironmental information and indicates the direct influence of relative sea level. Diatom analysis undertaken at the base of each layer of interbedded organic-rich silts and blue-grey clayey silts suggest that a) estuarine conditions were responsible for the development of the minerogenic unit within Beccles Core 2 and, b) fluctuations in the influence of relative sea level occurred during the development of the stratigraphic archive. Figure 26 indicates the variation in altitude of each sedimentary surface within the core, based on the interpretation of diatoms using Vos & deWolf (1993). The reconstruction estimates the position of palaeo-ground surface relative to the level of the tide at the time of deposition, and hence provides a qualitative indicator of positive or negative sea-level tendencies. Although not explained directly by Vos & deWolf (1993), it has been assumed in the study that, within the supratidal area, the interpreted sedimentary environment with the highest altitude relative to Mean Sea Level (MSL) is "pools within saltmarshes" (primarily due to the enhanced freshwater diatom influence), followed by "saltmarshes above MHW" and "saltmarshes around MHW". In Figure 26, higher palaeo-ground surfaces are indicated towards the right of the diagram whilst lower palaeo-ground surfaces are indicated towards the left.

			Supratidal		
Depth (m)	Altitude (m OD)	Sediment	Around MHW	Above MHW	Pools in SM
1.34	-1.423	clayey-silt			
1.55	-1.633	organic silt			
1.73	-1.813	clayey-silt			
2.22	-2.303	organic silt			
2.5	-2.583	clayey-silt		?	
2.54	-2.623	organic silt			
2.57	-2.653	clayey-silt		?	
2.75	-2.833	organic silt			
2.83	-2.913	clayey-silt			

Figure 26: Qualitative reconstruction of ground surface altitude relative to the palaeo-tidal frame from the diatom assemblages of Beccles Core 2.

In general, diatom assemblages from within the blue-grey clayey silts suggest deposition low down the tidal frame, proximal to MHW. In contrast, the diatoms preserved within the organic-rich silts suggest deposition further up the tidal frame within pools in the saltmarsh, probably closer to Highest Astronomical Tide (HAT). Although two of the clayey-silt samples had poor diatom preservation, in general, such deposits may reflect the supratidal zone on saltmarhes around MHW. Only the lower clayey silt sample (2.83 m depth) contained a diatom assemblage reflecting deposition occurring further up the tidal frame, and this may have been a consequence of the erosive contact boundary with the underlying fen peat unit. All four of the organic-rich units contained diatom assemblages suggesting deposition occurred at a higher altitude along the tidal frame, either within saltmarshes above MHW or within pools on the saltmarsh. It is therefore concluded that the five blue-grey clayey silt units each represent periods of positive sea-level tendency during which an increase in marine influence occurred on the coastal lowland. In contrast, these periods of enhanced estuarine sedimentation are separated by negative sea-level tendencies during which the organic-rich silt units were deposited. The episodic reductions in tidal influence resulted in enhanced in-situ organic sedimentation and the development of diatom assemblages indicative of sedimentation within the upper limits of the palaeo-tidal frame.

The application of multi-proxy analyses to the sedimentary archive has therefore confirmed the presence of estuarine conditions as far inland as Beccles. Positive and negative sea-level tendencies have been inferred through the diatom assemblages preserved within each of the nine minerogenic units. At this stage however, due to the absence of a reliable chronology, it is not possible to confirm whether such sea-level tendencies are indicators of marine transgressions or regressions resulting from changes in relative sea level within the Waveney Valley.

9.2 HENGRAVE

The assessment of LiDAR and historic records identified a potential palaeochannel, the presence of which was confirmed through fieldwork and subsequent palaeoenvirnmental analyses. Discussion of the Hengrave sequence is also hindered however by the lack of a robust chronology. However, pollen and beetle concentrations are adequate and preservation is good to moderate for most of the samples. Beetle assemblages from the base of the sequence indicate that deposition initially occurred in a fen-like environment, with relatively deep water, surrounded by dense, emergent vegetation (with an abundance of tall reed species). The evidence then suggests the establishment of drier conditions at the site, with muddy, seasonal pools and extensive swathes of tall reeds. This drier period however finally gave way to wetter conditions, with the return of pools of permanent, standing water on the valley floor. The pollen sequence reflects later Holocene environmental change as the vegetation in the pollen source area is clearly an open, agricultural landscape with very few trees and both arable and pastoral agriculture indicated. The suite of herb pollen in all three zones includes relatively high percentages of cereal-type pollen, as well as weeds of cereal plots and those suggesting grazed swards and disturbed habitats. The final zone (HEN3) would appear to reflect an intensification/change in the nature of local farming activity, leading to the demise of certain herb communities including knotweed, docks and tall herbs, and the expansion of taxa typical of heavily disturbed habitats such as nettles and mugwort. It might be speculated that the maintenance of a steady hazel curve in the context of an open, farmed landscape at this time suggests some form of woodland management.

9.3 IXWORTH

The application of pollen and coleopteran analysis to the sedimentary sequence taken from Mickle Mere, Ixworth, provided contrasting results. As with the other sequences under assessment, in-depth discussion and interpretation is hindered by the lack of a reliable chronology. Organic-rich deposits were encountered in all sedimentary cores extracted from the Mickle Mere site. This suggests that the development of the archive occurred through vertical accretion of the River Black Bourn floodplain, similar to the depositional environment encountered at Beccles. *In-situ* organic accumulation would have occurred in a waterlogged floodplain environment, with the thin horizons of minerogenic deposits resulting from floodplain deposition during periods of elevated river discharge and flooding. Due to the very low beetle species abundance and diversity evident within the samples assessed, little information on the floodplain development of Mickle Mere could be achieved through coleopteran analysis. The Ixworth pollen sequence would appear to reflect an almost complete Holocene sequence of environmental change. The basal zone reflects a very early Holocene landscape with open birch scrub prior to the subsequent expansion of the main tree taxa recorded in IX-2. Alder carr dominated the floodplain with wetter, more open areas probable whilst the dryland tree communities consisted of lime and hazel. Whilst elm and oak appear to have been less significant, it is possible that this is in part a result of a taphonomic bias towards local on-site vegetation. However, the good representation of lime, usually an under-represented taxon, might suggest that this is not the case. Likewise, the paucity of herbaceous taxa indicative of understorey vegetation in the wider landscape might also be a result of taphonomic factors, but it appears likely that the canopy was generally closed and dense. There is no clear evidence for human disturbance to the vegetation until the final zone, when what appears to have been an abrupt and landscape-scale clearance of lime woodland seems to have been followed shortly after by the clearance of other components of the arboreal vegetation. Initially, the pollen spectra suggest predominantly pastoral activity (dandelions, docks) in the vicinity of the sampling site but with the relatively high values for cereal pollen subsequently indicating arable agriculture, presumably relatively close to the sampling site. By the close of the diagram, then, an open, agricultural landscape with few trees other than perhaps oak and hazel present is inferred.

The Ixworth diagram suggests that following the growth of birch scrub during the earlier Holocene, the migration of trees led to the development of lime dominated woodland, at least on the better-drained, base-rich soils. It is also possible that lime was growing on 'poorer' soils as well. Alder probably formed dense carr on the more stable river floodplains, as is the case for many other English lowland river systems at this time (eg. Gearey & Lillie, 1999). Other trees such as hazel, oak and elm were components of the woodland, with exact species composition no doubt dependent on local edaphic conditions. At Ixworth, pine was also present on the floodplain and apparently expanded at one stage perhaps as a result of dry conditions. The woodland appears to have been dense with few natural openings; lime woodland tends to create deep shade, although the precise structure of the vegetation in the wider landscape is difficult to establish on the basis of these data.

Perhaps curiously, there is no evidence for a clear Neolithic 'elm decline' in the Ixworth diagram. The reduction in elm at the opening of the final zone is concomitant with an abrupt decline in lime, and may reflect this event, although similar 'lime declines' are recorded in other diagrams from eastern England during the early-Middle Bronze Age. The lime decline at Scole in Suffolk appears to be equally abrupt and is probably a result of human activity during this period (Wiltshire, *forthcoming*) which also led to the spread of open grassland. There is evidence that lime was virtually eliminated from the uplands adjacent to the Fenland within what may have been only a few hundred years (Waller, 1994) whilst pollen diagrams from other areas of lowland England also display a similarly rapid decline in lime during the Bronze Age-Iron Age (eg. Grieg, 1982).

The impression is of both arable and pastoral farming activity during IX-3. The relatively high values for Cereal-type pollen suggest that cultivation was taking place reasonably close to the sampling site. Again, the absence of secure dating control makes further comment difficult but it seems likely on stratigraphic grounds that this dates to the later Holocene period.

10 CONCLUSIONS

Very little palaeoenvironmental research had been undertaken within Suffolk previously, with the Holocene period receiving the least attention. Through reviewing both published and unpublished (grey) literature relating to the Suffolk, it was clear that the current state of knowledge regarding the environmental history of the river valleys was poor. Five study areas were identified as containing significant palaeoenvironmental potential: Beccles, Brandon, Hengrave, Hoxne and Ixworth. Fieldwork subsequently confirmed that whilst Brandon and Hoxne were less promising, Beccles, Hengrave and Ixworth contained sedimentary archives worthy of further multi-proxy palaeoenvironmental analysis. Representative sedimentary sequences were extracted from each of the three sites and assessed using various proxy analytical techniques. The palaeoenvironmental assessments were supported through the application of radiocarbon dating to each archive.

In general terms, this project has shown that specific locations in the river valleys of Suffolk proximal to areas susceptible to the threat of gravel extraction contain archives of high palaeoenvironmental and archaeological potential. Although the project focussed on specific valley floor locations within Suffolk, stratigraphic archives of considerable palaeoenvironmental potential are also known to be present throughout the river valleys of the County. There is therefore considerable scope for further work based on the initial results of the Suffolk River Valleys Project. The project has thus contributed significantly towards the English Heritage theme of understanding the 'character, scale and geographical distribution of potential impacts of gravel extraction in the historic environment' in the Suffolk lowlands. The project has also compiled an up-to-date literature survey in order to provide an archaeological context for geoarchaeological, geomorphological and palaeoenvironmental knowledge of the Suffolk river valleys (Appendix I). Throughout the literature review, all existing geoarchaeological and palaeoenvironmental data identified was also compiled onto a GIS database to complement the Suffolk County Council SMR.

However, in light of problems encountered with chronology and the dating strategy applied during the project, combined with subsequent discussions with the English Heritage Dating team (Dr P. Marshall), it has been concluded that it is necessary to reconsider the future direction of the project. Discussions will continue between Suffolk County Council and English Heritage in order to utilise the information obtained through the project thus far. A second phase to the Suffolk River Valleys Project has been commissioned by English Heritage. The principal aims of this second phase will be to revisit the three most palaeoenvironmentally promising sites investigated during Phase 1 of the Suffolk River Valleys Project (Beccles, Hengrave and Ixworth). In addition, in close collaboration with the dating team at English Heritage, a sampling and dating methodology will be applied to new sample cores from each site to rigorously assess the standard framework normally applied to such palaeoenvironmental studies.

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