Final submitted report

ASSESSMENT REPORT: MIDDLE THAMES NORTHERN TRIBUTARIES

An ALSF Phase 2 Project

ENGLISH HERITAGE PROJECT NUMBER 3310

JANUARY 2007

archaeology & anthropology

University of Wales Lampeter

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Executive summary

This report presents the results of an Aggregates Levy Sustainability Fund Phase 2 Project concerned with the development of a Geographic Information System (GIS) based tool to assist with the research and curatorial management of the important archaeological and alluvial deposits located within the Middle Thames Northern Tributaries (MTNT). The pilot project was carried out by staff from the Department of Archaeology and Anthropology, University of Wales, Lampeter, Essex County Council Historic Environment Branch and Hertfordshire County Council Historic Environment Unit. The project was conceived and implemented within the context of: a history of intense pressure on the aggregate resource, particularly within the Lea Valley; potential threats leading from the identification of the Herts-Essex border as a growth area for development; proposed expansion of Stanstead Airport and future mineral extraction in the area. It was also undertaken in the light of the demonstrable importance of alluvial deposits in the river valleys for archaeological and palaeo-environmental material and research priorities set out in national and regional archaeological research frameworks.

The purpose of the pilot project was to determine whether the data sets that are available can produce robust geo-archaeological models and whether these can be translated into useful curatorial tools. For the pilot study, two areas were selected for detailed investigation focused on the River Lea to the South of Hoddesdon and north of the M25, and the River Ver at St Albans. Map regression was carried out to establish the impact of past mineral extraction and geological and archaeological information was collated and integrated within the GIS to allow the definition of geo-archaeological zones within the two areas. The success of the approach varied and was dependent on data availability, but it was shown to enable a nested framework of scales of investigation utilising a similar baseline of information. Finally, an Updated Project Design was prepared for the full MTNT area based on a hierachical deployment of approaches dependent on data availability.

INTRODUCTION

In 1994, following discussions with Roger Jacobi, the Hertfordshire County Archaeologist invited a steering committee to investigate the need for a project to aid the research and management of the important archaeological and alluvial deposits in the Middle Thames Northern Tributaries (**MTNT**) (Figure 1). Attention was focused on the Colne, the Lea and the Roding in response to the nature of past impact on the archaeological record (i.e. gravel extraction), the present day perceived threat to the deposits, the lack of co-ordinated management and mitigation strategies within the areas and the need for an assessment of the academic and research potential of these deposits.

Following these steering committee meetings, Hertfordshire and Essex County Councils commissioned MoLAS to produce a project outline in order that applications for funding could be made to the appropriate bodies. In addition, the National Rivers Authority (now Environment Agency) was approached with regard to help in-kind, such as access to data and computing facilities.

The Project Outline was submitted to English Heritage in late 1995 but put on hold for future consideration due to lack of funds in 1996. It was reconsidered in 1998, when comments were received from Sebastian Payne and Matthew Canti, the most substantive being the lack of input from an appropriately qualified geoarchaeologist.

To address this point, a meeting was held in late 1999 between Martin Bates (University of Wales, Lampeter), Stewart Bryant (Herts CC), Rosalind Niblett (St Albans District) and Peter Murphy (then EH Regional Advisor for Archaeological Science). It was determined that MB would provide technical and methodological input to a new Project Outline. This was to be for a staged project involving the examination of two pilot study areas. PM undertook to draft this new document, submitted to English Heritage as the project outline proposal in February 2003.

In 2002 the government established the Aggregates Levy Sustainability Fund (ALSF), to provide funds to tackle a wide range of problems in areas affected by the extraction of aggregates. As the MTNT project directly addressed this threat and a number of the aims of the fund this revised project design was submitted in December 2004, and ALSF funding for the pilot areas was granted.

For academic and management reasons this study is considered to have a ***very high regional priority.*** The MTNT has been highlighted as of special significance in the *Eastern Counties' Archaeological Research Framework* (Brown and Glazebrook, 2000, p47) and the project also fits well with ***The Historic Environment: A Force for Our Future*** (DCMS 2001) the government's response to ***Power of Place*** (EH 2000):

> *"For all organisations concerned with the historic environment, a solid evidence base is essential. For grant-givers such as English Heritage and the HLF, good quality research is vital to inform the direction of resources. For the Government and Local Authorities as legislators and regulators, evidence is crucial to the process both of framing policy and evaluating its impact" (DCMS, 2001, Paragraph 1.10)*

Following the successful completion of these pilot studies, consideration would be given to the implementation of this study (as appropriate) throughout the catchment area.

For the purpose of the study attention was originally focused on the archaeology of the (recently) active floodplain area of mainly Holocene date. A broad equivalency between the Holocene archaeology and fine-grained floodplain sequences (alluvium) are made. However, it was noted that this definition would also include elements of Late Upper Palaeolithic archaeology from the buried, basal gravels and resting on the interface between the gravels and overlying alluvium. Elements of older floodplains (terraces), associated with Palaeolithic material were initially excluded from our pilot survey as they have been investigated via the English Rivers Palaeolithic Project (ERPP) (Wessex Archaeology, 1996; Wymer, 1999). However, this project (ERPP) only examined the lower reaches of the Lea and parts of the Colne/Ver system furthermore it did not consider the relationship between the archaeological find spots and the sub-surface record in any detail. During the course of our trial project it was recognised that in order to formulate a geoarchaeological model for the region it would be necessary to consider not only the valley floor but also the valley sides and adjacent plateau surfaces. Consequently information on the older Pleistocene geologies were incorporated into the investigation. As a result it may be necessary to re-visit the issue of the Palaeolithic archaeological record prior to finalising the full, area-wide, MTNT project design.

1.1 Circumstances of project and regional development control issues

The study area of the Middle Thames Northern Tributaries (MTNT) has been subject to intense development since the mid 19th century. This is primarily due to its location immediately to the north of London and the characteristics of its landscape and drift geology. The latter includes a combination of relatively poor agricultural land on the London Clay soils and presence of extensive areas of glacial/fluvial gravels associated with past and present courses of the river Thames (Gibbard, 1994). The gravel deposits have therefore been heavily exploited since the mid 19th century as local sources of aggregate for development in North London and southern Herts and Essex.

As a consequence of the various studies undertaken in the region over the last 100 years it is widely assumed that the archaeological potential of alluvial sequences in the study area is generally very high for well-preserved remains for all periods and especially for prehistoric remains. However, much of our current understanding of this archaeological potential has been derived from archaeological sites found during gravel extraction before 1950. This includes in particular, the nationally important Mesolithic sites at Dobbs Weir and Rikoff's pit (Warren *et al*., 1934; Wymer, 1977) which were discovered during gravel extraction in the early 20th century. Framework reviews and characterisation of this area have not been undertaken however, although elements of this are now being addressed by projects such as the Colonisation of Britain by Modern Humans Project (Wessex Archaeology in progress).

It is currently difficult to accurately quantify the nature and extent of the threat to the historic environment resource of the study area because of the difficulty of identifying where the alluvial deposits which contain the sites with the highest archaeological potential are located. Without further information on the nature of the alluvial deposits (which is a key objective of this project) it is also difficult to quantify the nature and extent of the historic environment resource. A key objective of the pilot project was therefore to provide data on the location of alluvial deposits for the pilot areas and an indication of the nature of the archaeological and palaeo-environmental resource within these areas.

1.1.1 Current threats

The pilot study areas are located within the East of England Region for which the statutory regional planning guidance (Regional Spatial Strategy - RSS) is currently published for consultation and the Examination in Public for the RSS occurred in 2005. Within the context of the Sustainable Communities initiative of the Office of the Deputy Prime Minster (now the Department of Communities and Local Government) the M11 corridor area that straddles the Herts-Essex border has been identified as a growth area for development. The nature of this development, if it is approved, is difficult at this stage to quantify, but it is likely to be very substantial and include housing and industry together with associated infrastructure including roads and water/sewerage management plants and reservoirs. The proposals, which currently have a high likelihood of being approved, will potentially affect the Study Area of the river valleys in a number of ways:

- Small scale mineral extraction to supply aggregates for road and housing development (often now seen as a more significance threat to the buried archaeology due to the piecemeal nature of such sites).
- Flood alleviation drainage and reservoirs.
- Roads.
- Dewatering of waterlogged deposits.
- Housing.
- Industrial and commercial development.
- Leisure development (e.g. golf courses, parks and other green spaces, sport stadia).
- Pipelines for utilities such as water, sewerage and cables.
- Sustainable energy production such as wind farms.

In addition to the general growth along the M11 corridor the Government has, in recent years, been considering the future of air transport. As part of this the expansion of Stansted Airport, located on the Essex side of the M11, has been proposed. This expansion will present additional pressures within the area, and consequently an increasing demand for aggregate.

New roads and pipelines for utilities will be constructed to accommodate the new housing and other infrastructure resulting from the decisions of the RSS examination in public. However, current and predicted growth in population and traffic will require new infrastructure regardless of this new development pressure. A bypass for north Harlow, Sawbridgeworth and Little Hadham will almost certainly be developed into an advance planning stage in the next 5 years. These – and other likely schemes, will inevitable cross the many river valleys that lie within the study areas, impacting on alluvial deposits and historic environment resources through the removal of aggregates to support such initiatives.

Mineral planning applications are presently relatively few in number and generally have long a gestation before submission of planning application and take a long while to be implemented. They are also invariably very complex in terms of mitigation via conditions and S106 agreements and are always controversial in terms of public reaction. Hertfordshire and Essex County Councils currently provide the statutory Mineral Planning Authority function for the counties. Their primary duties are to produce the Mineral Local Plan and to control minerals development in accordance with the Local Plan, Planning Law and Government Minerals Planning Guidance. This also includes the restoration of old mineral workings to new uses.

Almost all minerals planning applications, by their nature, have significant historic environment implications. The historic environment services of Herts and Essex CC are therefore consulted at an early stage in the development process and usually form an important part of the development control ongoing negotiation process. The will usually include at least one phase of predetermination assessment and S106 negotiations as well as one or more conditions. However, historic environment considerations are invariably only one of many planning considerations and are usually amongst the most straightforward to deal with for the development control officer. The historic environment advice to the applicant and their agent and ongoing negotiations are therefore usually handled directly by the historic environment advisor. The development control officer will have regular briefings on the historic environment issues will usually only become involved in negations if they become difficult or have implication beyond the historic environment

The Hertfordshire Mineral Local Plan is currently the subject of a Public Inquiry to determine the next phase of large-scale mineral extraction to accommodate the project demand. The plan is due to last until 2015.

In Essex, the existing Minerals Local Plan, Adopted First Review, was published in 1996. This stated that the landbank of sand and gravel, as at the start of 1995, was sufficient for over 11 years production at the apportionment level detailed in the Plan. To meet this level, the Plan identifies a number of ‘Preferred Sites’ where it was considered that there would be least environmental damage. However, demand is forecast to continue to rising. The Essex Minerals Local Plan is also under review. At present the Minerals Local Plan Second Review: First Deposit Draft (2003) has been prepared. This document will form the basis of the new Minerals and Waste Development Framework. This First Deposit Draft identifies three preferred areas for sand and gravel extraction (Schedule 1).

The Minerals Local Plan: Second Review, First Deposit Draft (December 2003) details the provision of resources needed to meet the regional requirement of land won aggregates set out by the East of England Regional planning Panel in 2003. This identifies a shortfall in the resource and suggests that this could be met by granting planning permission to two preferred sites, through ‘windfall’ sites (agricultural reservoirs, borrow pits etc) and areas where aggregate is mixed with the silica sand resource.

Recent experience from Herts and Essex has shown that small-scale mineral extraction – outside of area designation in minerals local plans – has had significant impact ion the historic environment. Most of this mineral extraction has been in association with road developments. In Hertfordshire six large 'borrow pits' all effecting archaeological sites were excavated in 1993 along the route of the A41 Kings Langley and Berkhamsted Bypasses and recently, a planning application for mineral extraction for the A10 Wadesmill bypass Plashes Farm in east Herts, had a significant impact on Roman and medieval archaeology.

These recent examples provided evidence that the new roads that will be constructed as part of the development, which takes place within the study area, will probably lead to the exploitation of small locally available sources of aggregate. The remaining sources of aggregate within the river valleys are therefore likely to come under threat of extraction.

The Essex Minerals Local Plan Second Review: First Deposit Draft also acknowledges the significant contribution that these 'windfall' sites make to the landbank. Indeed between 1992 and 2001 the planning permission for agricultural reservoirs and borrow pits contributed some 3.19 million tonnes. The current proposals for the local plan therefore include the contribution of such 'windfall' sites in the landbank calculations. Areas of aggregate close to development sites are therefore likely to be exploited, presenting a threat to the historic environment in those areas.

1.2 Study region

For the purpose of this study the MTNT area selected is bounded to the west by the Colne/Ver and to the east by the Roding (Figure 1), however a broader definition of the area (perhaps for inclusion in an expanded project) would extend from the Goring Gap upstream of Reading to the Mar Dyke in Essex. The region contains the important Thames tributary of the Lea as well as other smaller north bank tributaries such as the Fleet. Within the area the effective archaeological management of the historic environment resource is presently hindered by three main factors:

- The MTNT run through Hertfordshire, Buckinghamshire, Surrey, Essex, Bedfordshire and Greater London. Thus the archaeological curatorial role is devolved to five counties, a district archaeologist (St Albans) and English Heritage in Greater London, with archaeological responsibility restricted to their administrative area (in this case usually defined by the rivers in question). The result is that different approaches and priorities may be assigned to essentially the same deposits depending on county boundaries and different administrative regions.

- The archaeological data that is available for the MTNT is similarly distributed over six HERs and one UAD. Although results from the increasing number of evaluations and excavations are held by the appropriate HER, this does not easily facilitate intra- or inter- valley archaeological and environmental synthesis and thus the formulation of academic research frameworks and priorities. Without these structures, strategies for the evaluation and management of the archaeological resource will remain variable and uncoordinated.

- HERs do not include borehole or palaeoecological data, although the Urban Archaeological Database for St Albans does contain information on valley peats.

For the pilot study two areas have been selected for detailed investigation (Figures 1 - 3). These are:

1. Two 10km tracts of land focused on the River Lea to the south of Hoddesdon and north of the M25 (Figure 2)

2. One 10km square centred on the River Ver at St. Albans (Figure 3).

In both cases the focus of the investigation began with the valley bottom area of the recent floodplain and associated deposits, i.e. the area dominated by alluvium as mapped by the British Geological Survey. However, during the course of the investigation it became clear that in order to contextualise the valley bottom investigation the incorporation of valley side and plateau surface borehole and mapped data was necessary.

Today, the one organisation whose remit covers the whole of this area is the Environment Agency (EA), where the study region falls within the EA's 'Thames Region'. The MTNT project may provide relevant information to the EA and further the EA's involvement in conserving important valley deposits in other areas of the country and contribute to the development of its policies on archaeology.

1.3 Research context

The rivers of the MTNT project contain sequences containing a variety of forms of archaeology ranging from the Palaeolithic to the Industrial period and potentially feed many research agendas. Of particular importance are those relating to the prehistoric period. The English Heritage publication *Exploring our Past* (1991) identified three main themes for Palaeolithic research — physical evolution, cultural development and global colonisation. More recently a working party of the Prehistoric Society has defined three main strands for a national Palaeolithic and Mesolithic Research Framework (English Heritage/Prehistoric Society 1999):

- Identification of research themes and priorities
- Development of specific projects of immediate relevance
- Education and dissemination initiatives

While regularly under review, and subject to changing emphasis in light of new discoveries and research directions, among the core themes are issues relating to colonisation and recolonisation, settlement patterns and histories and social organisation and belief systems.

The main resource for addressing these themes is lithic and faunal/floral archaeological evidence. Undisturbed horizons have been rightly highlighted (Roe 1980; English

Heritage 1991) as of particular significance for their stratigraphic and chronological integrity, and their fascinating glimpses into short-lived episodes of activity. Disturbed and transported material (such as predominates in fluvial contexts) has, in contrast, often been downgraded in its potential significance, to the extent that some would regard such material as being of insufficient significance to merit any protection or research in advance of destruction. However, besides avoiding the risk of writing off large quantities of the finite resource just because we don't yet know what to do with it (cf. Chippindale 1989), the study of such material in fact *complements* the evidence from undisturbed sites by bringing a different chronological and spatial perspective to bear. Collections of transported artefacts represent a time and space-averaged sample, giving a more representative view of lithic production and diversity than the evidence from a few square metres representing one afternoon in the distant past. Such evidence may in fact be of more value in documenting and explaining general patterns of material cultural change, since it is less vulnerable to local heterogeneity caused by, for instance, specific tasks or raw material availability.

Besides the direct evidence of human activity, such as artefacts and cut-marked faunal remains, associated biological evidence plays a central role. It can be used to:

- Reconstruct the palaeo-climate and local environmental context of human activity

- Date the sedimentary context of any archaeological evidence

- Identify the depositional and post-depositional processes of sedimentary contexts

Even where direct archaeological evidence is absent, the study of biological evidence has a major contribution to make to Palaeolithic and Mesolithic research. As mapping and lithostratigraphic correlations of depositional units are developed in a region, accurate dating of even a few key units can provide foundations to tie in the whole sequence, and its contained archaeological horizons, with the wider national and global frameworks. Dating will most likely be achieved from the study of biological evidence — pollen, large vertebrates, molluscs or small vertebrates — from archaeologically sterile deposits. Thus a central aspect of the Palaeolithic archaeological agenda in any region has to be the discovery and study of such deposits.

In summary, the following key points can be made concerning how national Palaeolithic/Mesolithic research goals can be addressed:

- The main evidence is lithic artefacts and dietary faunal remains

- It is essential to know the stratigraphic context of such material

- Evidence from *both* undisturbed primary context *and* disturbed secondary context sites is significant

- The interpretive potential of any archaeological material depends upon understanding of depositional and post-depositional processes that have affected it

- Dating is essential to document the degree and spatial scale of contemporary variability, and the trajectories of cultural stasis and change through the changing climatic framework of the Pleistocene

- Biological palaeo-environmental evidence plays a fundamental role in Palaeolithic research, even on sites without artefacts, by contributing to the construction of chrono-, climato- and litho-stratigraphic frameworks

For the later periods regional research priorities are set out in ***Research and Archaeology: A Framework for the Eastern Counties 2. Research Agenda and Strategy*** (Brown and Glazebrook, eds. 2000). This agenda and strategy includes both Essex and Hertfordshire, along with Suffolk, Norfolk and Cambridgeshire. The two pilot study areas contain a wide range of remains, both in terms of type and chronological scope, and a significant potential resource (that is, remains which are likely to be present). The archaeological background to the study areas is set out in section 3.1 (below).

The regional research agenda and strategy is, in general, structured chronologically and sets out gaps in knowledge, the potential of the resource, research themes/projects. Given the range of remains in the two study areas the resource has the potential to take forward a number of the themes, selective examples of which are listed below:

- 'Identification of monument classes' (investigation of monuments of unknown date, e.g. cropmarks); there are a number of these within the pilot study areas.

- Historic Landscape Characterisation; this is being taken forward in the two counties. There is, perhaps, potential for the integration of this and the MTNT results

- Origins and development of the agrarian economy

- Settlement patterns and field systems

- Urban development / the impact of towns on the countryside

- Industry surveys

- Navigable rivers, canals, railways and ports

1.4 Integration/collaboration with other projects

Other on-going research projects that compliment the MTNT project are those directed towards similar goals within the region such as the Lea Valley Project recently completed by MoLAS (project 3282 MAIN Mapping the sub-surface drift geology of Greater London gravel extraction areas).

Other projects in which relevant information is likely to be provided include Predictive modelling of multi-period geoarchaeological resources at a river confluence (Project Number 3357). Through the lifetime of the current project discussion has taken place with team members on other projects through informal discussion and through briefings undertaken at meetings such as that held at Peterborough focusing on ALSF Palaeolithic orientated projects.

2.0 AIMS AND OBJECTIVES

The purpose of this pilot project was to determine a) whether the data sets available can produce robust models and b) can these be translated into useful curatorial tools.

The objectives of this pilot project were defined to:

- Map areas of destroyed and extant alluvial deposits within the study area (**OBJECTIVE 1**).

- Determine the distribution of borehole data and, (if the data are adequate), use them to generate deposit models for selected areas (**OBJECTIVE 2**).

- Map the locations of non-archaeological palaeoecological studies (**OBJECTIVE 3**).

- Map all known archaeological sites and finds (**OBJECTIVE 4**).

- Classify the deposits in terms of temporal and spatial characteristics (**OBJECTIVE 5**).

- Identify areas of high archaeological potential for all periods (**OBJECTIVE 6**).

- Identify areas with very little data (**OBJECTIVE 7**).

- Map the differing degree and nature of threat to the alluvial deposits (**OBJECTIVE 8**).

- Produce a costed Project Design for further work (**OBJECTIVE 9**).

2.1 Project objectives: Curatorial

The short, medium and long-term threat to the historic environment of the river valleys within the study area is considerable (as outlined in section 1.1.1, above) and is probably as high as any comparably-sized area of England. It is recognised that prior to this project there was very little easily available information on the nature and extent of the potential/predicted historic environment resource within the river valleys even though it is considered highly likely that important remains exist – some of which are likely to be of national significance. Given the diverse range of threats identified, the proper management of the historic environment resource is therefore almost impossible to achieve with the current range of available information. The archaeological curatorial teams, who provide advice to local planning authorities and other agencies, can only react to known and identifiable threats and make decisions based on very crude predictive modelling. The overall aim of the project is therefore to provide information (including models) within/against which archaeological data from the regions may be articulated or examined to enable the better management of the historic environment resource by improving the decision making process in response to development threats and undertaking proactive management plans for the long-term conservation of the resource.

The overall concept of the project is to demonstrate how a GIS resource for the study area can (a) present and synthesise information about the local superficial geology and geoarchaeology, both factual (i.e. borehole records) and interpretative (lithological and geological models), (b) present and synthesise information about the local SMR/HER data (c) summarise the mineral extraction history, (d) identify zones of varying geoarchaeological characteristics that links geoarchaeological factors to archaeological spatial patterning and (e) predict areas of varying archaeological potential and importance.

2.2 Project Objectives: Academic

Considerable interest in valley floodplain archaeology has been shown by the academic community in recent years, in particular issues related to the mechanisms responsible for changes in human activity as well as understanding human/environment interactions have been the focus of attention. Indeed as long ago as 1992 Macklin and Needham noted:

> "*Holocene alluvial sequences are arguably unique in the way that they integrate and record environmental change (natural and anthropogenic) over a wide range of spatial and temporal scales…....This important environmental and cultural resource should be protected for the benefit of future generations of archaeologists and earth scientists*" (Macklin and Needham, 1992, 20).

More recently Macklin *et al*. (p.11, 2003) have been able to state

> *"The last 10 years has seen considerable progress in UK Holocene alluvial archaeology, which now constitutes an established and well-respected sub-discipline of environment change and earth system science"*

Whilst this statement is particularly true at a national level in the UK some areas have seen greater investigation and study than others. For example considerable work has taken place in the Upper/Middle Thames (Robinson and Lambrick, 1984), the Humber wetlands (Van de Noort, 2004) and the Fen Basin (see examples in French, 2003) others have been less well served. This is particularly true of the MTNT, which have in the distant and recent past produced archaeological and palaeoenvironmental evidence of exceptional quality but which has failed to elicit the interest of academics in recent years.

This evidence has already contributed to elucidating some of the academic objectives outlined in *'Exploring Our Past'* (English Heritage, 1991, 35-6) which places emphasis on the value of undisturbed occupation areas and well-preserved biological remains. Further commitment on the part of EH to promoting under-studied and vulnerable areas such as alluvial and colluvial zones was reiterated *in 'Exploring Our Past 1998: Implementation Plan'* (English Heritage, 1998, section 2.4).

Consequently key academic questions include:

- Can we use the sequences present for high resolution palaeoenvironmental reconstruction?

- To what extent can we identify patterns of human activity that are related to changes in floodplain ecology and operation?

- How can we use a knowledge of floodplain stratigraphic architecture to predict the location of archaeological sites buried beneath the alluvium?

- To what extent can we identify a distinctive ‘floodplain archaeology’?

3.0 PROJECT CONTEXT
3.1 Archaeological

Important archaeological remains are partially described from many of the valleys to the north of the Thames (Warren *et al*., 1934) and a wide range of archaeological material, in different sedimentary contexts, has been described. Considerable archaeological and palaeo-environmental remains have been described with alluvial and peat deposits within the valleys. These generally have high potential for the survival of organic artefacts and ecofacts. Examples in the Colne include the rich late Upper Palaeolithic and Mesolithic sites such as the *in situ* Late Glacial and Early Mesolithic site at Three Ways Wharf, Uxbridge (Lewis, 1991: Lewis *et al.,* 1992) (Plate 1) and the Mesolithic sites described by Lacaille (Lacaille, 1961, 1963) which illustrate the potential of this area. Lower down the valley the successive Neolithic and late Bronze Age sites at Runnymede Bridge (Needham, 1991, 2000) amply demonstrate the possibilities of preservation for the later prehistoric periods, while the recently examined sediments at Bedfont Court (part of the currently on-going Heathrow Terminal 5 project) demonstrate the complexity of the preserved fluvial sequences (John Lewis, pers. com. June 2006).

Elsewhere rich palaeo-environmental sites are known such as the fills of pingos at Boxmoor, Berkhamsted (Murphy, unpublished a; Wiltshire unpublished) where calcareous marls and peats of Late Devensian-mid Flandrian date occur. Palynological and macrofossil assessment from this site indicates the presence of a near-complete vegetational record from late glacial dwarf shrub and arctic/alpine steppe vegetation through to the development of mixed deciduous woodland.

In the Lea valley the Mesolithic sites at Broxbourne are well known (Warren *et al,* 1934), and Dr. Roger Jacobi (pers.comm.) has emphasised their national significance. The later prehistoric potential of the deposits is illustrated by HER references to "crannogs", which are perhaps analogous to the Bronze Age timber trackways, which have been discovered in east London (Meddens, 1996) (Plate 2). There is also a concentration of remarkable Bronze Age metalwork from the lower reaches of the Lea and Roding (Couchman, 1980, figs 16-17; Brown, 1996, 26).

Sites containing tufa (see below and Plates 3 and 4) have been listed from the region by Evans (1972) and are often associated with buried soils, and, sometimes Mesolithic artefacts. For example in the Gage Valley (a tributary of the Colne) at the Grove Estate, Watford, alluvial and colluvial sequences have produced excellent artefactual and palaeoenvironmental data from the Mesolithic to at least the Bronze Age (Le Quesne, 2001).

These key sites demonstrate the importance of the alluvial deposits of the MTNT,for archaeological and palaeo-environmental material of early prehistoric date. However, because these sites with the highest potential are covered with alluvium (Plates 1 and 5) they are by their nature difficult to identify from the standard non-invasive archaeological surveying techniques such as aerial photography, fieldwalking and geophysical survey. It is therefore not possible to quantify the resource within the study areas as easily as in areas where alluvial deposits are not present; archaeological sites in these areas are more visible and mappable through the use of non-invasive techniques such as field-walking and aerial photographic survey.

The river valleys of the MTNT also contain extensive evidence for later prehistoric Roman and medieval occupation. In particular, the Ver Valley has Late Iron Age and Roman remains of international significance, including the late Iron Age *oppidum* and *Verulamium* Roman city (Niblett and Thompson, 2005). The Lea valley also has evidence for Late Bronze Age archaeology including a probably high status site at Turnford where evidence for bronze manufacturing and imports has been identified. Recently excavated sites also include late Iron Age/ Roman settlement at MAFF site and a late Bronze Age settlement at Hoddesdon.

Wooden structures of later periods are known to occur within alluvial sediments in this area, but due to lack of resources they have not been recorded to modern standards (*e.g.* the so-called 'timber tower' of 1st century AD date at *Verulamium*: Niblett 1999, 409). The floodplain of the River Ver, adjacent to the Roman *Verulamium* and Medieval St Albans, is plainly an area of special significance for these later periods.

The key points to emerge from this are:

- A wide variety of ages of material occur within the floodplain areas.

- Many different sedimentary contexts are associated with the sites that indicate occupation or utilisation of the locations under different environments conditions.

- Exceptional preservation of organic remains is frequently noted.

- Nationally important sites exist within the sequences.

- Many sites are only identified during quarrying, as a consequence of other extractive industries, and they are therefore under threat from a wide variety of activities.

3.2 Geology

The geological history of the region is influenced by the bedrock geology and the Middle Pleistocene history of drainage changes associated with major glaciation in the region during the Anglian cold stage (Gibbard, 1977, 1979, 1985).

Bedrock geology (Figure 4, 5 and 6) consists of chalk of the Cretaceous period and Palaeogene sediments infilling the London Basin. The chalk trends SW to NE through the study area forming the northern margin of the London Basin (a synclinal structure with the axis of the syncline running through the London conurbation). This means that the chalk dips to the southeast through both study areas.

Younger sediments of the Palaeogene consist of a thin outcrop of the Thanet Sand Formation and Lambeth Group with more extensive spreads of Thames Group sediments (London Clay) to the south.

Key factors of importance relating to the bedrock geologies are:

- the calcareous properties of the chalk enhance preservation of vertebrate, mollusc and ostracod remains in sediments derived from the chalk.

- the free draining properties of chalk dominated sediments and bedrock enhance the leaching of material from the sediments.

- the impervious nature of some elements of the Palaeogene sequence (i.e. London Clay) resulting in the developments of higher water-tables and the potential waterlogged deposits to preserve plant remains, insects etc.

Pleistocene sequences (Table 1, Figure 7) are dominated by fluvial deposits of the pre-diversion Thames and post-diversion tributaries on the north bank of the Thames as well as glacial deposits associated with ice sheets and ice dammed lakes (Figure 8).

Prior to 470,000 years ago drainage through the area was dominated by a major river system draining from the Reading direction through the Vale of St. Albans and eastwards towards the Suffolk/Essex coast (Gibbard, 1985, 1994). This river (an ancestral Thames) deposited a series of sand and gravel bodies known collectively as the Kesgrave Formation/Sands and Gravels (Table 1). These deposits formed as part of a former floodplains turned into river terraces by downcutting and uplift along the line of the former river. Glaciation during the Anglian period around 470,000 B.P. (Table 1) resulted in the advance of ice to the Vale of St. Albans and as far south as Hornchurch in Essex. This ice effectively dammed the former course of the river, created a series of ice dammed lakes in the vicinity of Watford and through a complex sequence of manoeuvres pushed the Thames into its current southerly location (Gibbard, 1985). Following ice retreat deposition of sands and gravels within the main Thames and newly formed tributary valleys such as the Lea commenced and terrace formation followed through time.

Thus in both study areas extensive suites of sands and gravels (Kesgrave Sands and Gravels) are present that are overlain by till from the Anglian ice. Post Anglian activity has been more extensively recorded and preserved in the Lea system where a number of river terraces composed of sands and gravels are preserved.

The most recent phase of sand and gravel deposition and terracing occurred in the late Pleistocene between 10 and 30ka B.P. and has resulted in the creation of the modern floodplain in the Holocene and the underlying late Devensian river gravels. Minor changes in sedimentation patterns within the Holocene floodplain are well attested to in the valley and demonstrate the complexity of the sequences associated with the last 10,000 years of human history in the valley. Sediments present within the alluvium typically consist of clay-silts and sands with occasional beds of peat. These are particularly well represented in the sequences around Broxbourne (Warren *et al*., 1934). In addition to the typical alluvial sediments a number of sites in Buckinghamshire and Hertfordshire are associated with tufa. These have been described by Lacaille (1961, 1963) and Evans (1972) and all have a high potential for palaeoenvironmental reconstruction. A similar tufa site at Solesbridge, Chorleywood, in the Chess valley, included a buried soil with mollusc assemblages pointing to damp floodplain woodland of probable 'Atlantic' date (Murphy, unpublished b). Sites of this type are often associated with buried soils and, sometimes, Mesolithic artefacts.

More recently, in the Gade valley at the Grove Estate, Watford, alluvial and colluvial sequences have produced excellent artefactual and palaeoenvironmental data from the Mesolithic to at least the Bronze Age (Le Quesne, 2001). A basal organic unit of early-mid Holocene date was overlain by tufaceous deposits, and then by alluvial and colluvial silts. Assessment of plant and animal macrofossils and pollen indicates good potential for environmental reconstruction, and assemblages of charred crop remains and animal bone will provide palaeo-economic data

4.0 METHODS AND COLLECTION OF THE DATA

4.1 Project areas

4.1.1 The Lea Valley (Figure 2)

The first pilot area of 50 km^2 runs along the valley of the River Lea, which runs north-south, forming the border between Hertfordshire and Essex. In terms of development history, the Hertfordshire side of the valley has largely been developed for housing and the Essex side for mineral extraction, mostly now water bodies. The area is bordered to the south by the M25 and also includes the A10 trunk road.

The historic environment potential is primarily related to the potential of early prehistoric archaeology and palaeo-environmental remains occurring within peat and other alluvium. The remains are therefore thought to comprise fragments of sequences of Flandrian, riverside landscapes.

4.1.2 The Ver Valley (Figure 3)

The second square area of 24 km^2 includes the lower Ver valley, which joins the River Colne 2 km south of the pilot area. It includes a 7km length of the Ver valley and most of the city of St Albans. However, unlike, the Lea valley pilot area, a much higher proportion of the Ver valley has been relatively unaffected by development. There has however been extensive mineral extraction at the south of the pilot area.

The historic environment of this pilot area is relatively well understood due fieldwork and publication since the 1930s. Key more recent studies are Niblett (1999) and Niblett and Thompson (2005).

The potential of the river valley area in which the project is focused, mainly consists of late Prehistoric, Roman and early medieval remains. The river runs though Roman city of *Verulamium* and the extensive late Iron Age *oppidum*. There is also evidence that the Ver river was used as a place for ritual deposition in the late Iron Age and Roman periods (Niblett, 1999) and waterlogged, organic deposit dating to the late Iron Age and Roman periods are known from where the Ver passes alongside the Roman city.

4.2 Data

There exists a diverse body of data relevant to the project held by a number of different organisations. Data sources used in this project include information on the sub-surface stratigraphy, known archaeology and landuse histories. The main data sources included:

- **Geological** compiled by the British Geological Survey This information formed the basis of the mapping component of the project, and was readily available, either in paper or digital form (see Figures 5, 6, 9 and 10).

- **Borehole, test-pit and site investigation** data held by the British Geological Survey. Although far from complete, the coverage of records held by the BGS is extensive (Figures 11 – 13). Although there are problems of correlating borehole information, these data are potentially extremely important in assessing the nature and extent of alluvial deposits.

- **Ordnance Survey maps.** Information from successive editions of the local 1:50,000 and 1:25,000 and previous imperial editions supplied information on quarrying history in the region (Figures 14 and 15).

- **County Historic Environment Records**. The data held in these is obviously vital to any attempt to understand the archaeology of the Middle Thames Northern Tributaries. Both are computerised and readily accessible (Figures 16 and 17).

- **The Urban Archaeological Data-base** for St Albans District.

- **Data from the English Rivers Palaeolithic Survey** included in the final reports of the English Heritage-funded project summarised by Wymer (1999) and the **Upper Palaeolithic and Mesolithic Database for England** (PAMELA) currently under construction by Wessex Archaeology (a draft version of the relevant section of the database was consulted).

- **Planning, highways and minerals department reports** held by local government departments. The data held by these bodies was potentially crucial in mapping the extent of large-scale destruction by road schemes, redevelopment and mineral extraction. These bodies old information concerning future developments and proposals (e.g. Local and Mineral Plans). The quantity and accessibility of this information was very variable and close co-operation between county archaeologists and their planning colleagues was helpful in this respect.

- **Unpublished information** held by archaeological units. This included site monitoring, test-pit observations, borehole logs *etc*., which were held by the units but may not necessarily have been included on the HERs.

- **Hydrogeological data** held by organisations such as the Environment Agency and the water companies relating to the MTNT and the alluvial deposits of the flood-plains.

- **Academic palaeoecological studies** carried out by non-archaeological bodies. A number of known palaeoecological and sedimentological studies have been carried out by students at various non-archaeological university departments on the sequences in the MTNT.

The data-sets were examined in this pilot project were therefore potentially very large, although their exact size, quality and accessibility was unclear to start with.

4.3 Geological information, mapping and data archive

Geological information is available in a number of forms that include written observations, borehole records, maps produced by regional survey (BGS) etc. In most cases this information reports evidence gathered at a point in space through observations of exposures, test pits, boreholes etc. This point specific data can then be extrapolated across space through the production of maps. For archaeological purposes reference to BGS maps is often the first 'port of call' for information on the nature of either the bedrock or superficial sediments. However these maps, particular the superficial maps, only represent those deposits immediately beneath the topsoil and rarely indicate anything about the complex of sediments forming the sub-surface stratigraphy. In order to gather information on sub-surface stratigraphic complexity the archaeologist will be expected to read and assimilate often complex geological histories for the area.

Attempts at alternative mapping procedures that categorise the nature of the sub-surface record have not been attempted in this country but examples are now standard in other parts of Europe, for example within the Low countries (Baeteman, 2005; Weerts *et al*., 2005). In the absence of such maps it falls to the geoarchaeological specialist to synthesis the geological history and attempt to model the sub-surface stratigraphy for the archaeological perspective.

The data available to a geoarchaeologist has been listed (4.2 above) and can be integrated together to produce a ground model for the region. Similar ground models are now being developed for engineering geology (Culshaw, 2005). While for many practitioners this model is generated through exposure and familiarity within specific regions for others models are created using borehole data that may best be stored and articulated within electronic medium such as suites of software specifically designed for storing geological information. Regional projects are now becoming increasingly common where the objectives of the projects are to store and model geological data for archaeological objectives and the success of such projects depends on the successful integration of a range of surface and sub-surface data sets (e.g. the MoLAS run Lower Lea Valley Mapping Project). In particular for those areas where detailed investigations are to be undertaken the creation of a database of sub-surface information is a necessary precursor to analysis and integration of information in a ground model and its subsequent use as a management tool (Bates, 2000, 2003). Archiving and modelling geotechnical data within an archaeological framework required consideration not only of the geological data but also of the aims and objectives of the archaeological end-user. A wide variety of software packages are available for archiving and displaying sub-surface stratigraphic data. These were originally developed either for the geotechnical industry or for oil/gas prospecting. Fundamental differences exist in the data storage set-ups between packages developed for these two end-users.

Most data usable to archaeologists and suitable for use in geological models contains a number of attributes:

1. spatial information (xyz co-ordinates) [necessary]

2. variation in lithology by depth (i.e. disposition of layers in ground) [necessary]

3. interpretation of lithology in terms of environments of deposition [sometimes present]

4. ascriptions of lithologies to local, region, national and international stratigraphic systems (e.g. the Taplow Terrace, Goodwood-Slindon Raised Beach [occasionally present]

In order to incorporate the data the software chosen for this pilot study needed to enable:

- unconstrained entry of lithostratigraphic data

- input of ancillary data such as core photographs, laboratory test data and age estimates (not undertaken here due to the absence of suitable data but possible during future project works)

- interactive analysis to display cross-section, fence diagram and topographic surface modelling.

- allow integration of stratigraphic information

Furthermore data storage formats within the selected software should allow easy export of information to other software systems.

The viability of modelling sub-surface alluvial deposits within the context of the Middle Thames Northern Tributaries was consequently considered to depend on:

- the software package chosen

- the distribution of data within the valley bottom areas, and

- the quality of the data.

Optimal strategies and software systems for archiving alluvial geotechnical information and data interrogation have previously been reviewed for English Heritage (Bates, 2000) and these include Rockworks 98/2002, TerraStation II and GSYS. More recently it has been acknowledged that a successful modelling system should also allow the sub-surface investigation to be integrated with data derived from the Sites and Monuments Record via GIS systems such as those now in use by Hertfordshire and Essex Councils. Consequently a key task in this project was the consideration of the methods and approaches towards integrating the data sets, and their format.

The software selected for use in the project was the Rockworks software. Rockworks 2004 was used to initially store the data; this was upgraded in the later stages of the project to Rockworks 2006. Lithology data was loaded into the Rockworks software and subsequently exported via Excel to the ArcGIS. Upgrading to the Rockworks 2006 software now permits data to also be exported to an Access Database.

5.0 GIS

5.1 Introduction

The MTNT GIS is the prime medium through which the project will present its results to the 'end users' such as the HER and development control teams in the local authorities. GIS has also been used to address specific project objectives and provide information for incorporation into project as a whole.

The structure of the GIS was outlined in broad terms at the start of the project; this data structure has necessarily evolved as the project results came in. One of the key decisions in considering the GIS design was the software to be used. The project area includes two counties, each with their own HER and one district with an Urban Archaeological Database (UAD); the results of the project had to be accessible to the respective HERs and development control teams.

It was decided to utilise ESRI GIS products, with the results of the project being presented as a series of individual shape files which could be used in all current versions of ArcView/ArcGIS. Background data was inputted into attribute field which are an integral part of the shape file rather than as an external linked database. Experience has shown that problems can arise when linking between GIS and external data, for example through the accidental re-location or deletion of one of the elements which results in the loss of links that subsequently need to be reconstructed or the software for one part of the work is upgraded (e.g. Access) resulting in compatibility problems.

The shape files which comprise the GIS can be queried both by their attributes using SQL queries and spatially, for example proximity to known archaeological sites/finds. There are a number of pre-set spatial queries available in ArcView/GIs. Spatial queries allow comparison with other datasets, such as the HER, geology maps, site plans and aerial photographs. In the more up-to date versions of the software it is also possible to combine the two.

In Essex spatial data is ultimately stored in the ViewEssex data repository which allows the Council to share its many layers of geographic information across departments. The View Essex team has provided a number of guidance documents for the creation and archiving of geographical information which have been utilised through the MTNT project.

Discussions took place during the course of the project on methods to incorporate the data into the HERs. It was however considered that this was not going to be effective as HER databases are not structured to deal with geological, geo-archaeological and predictive data. The data from this pilot project will be deposited with the HERs, along with supporting documentation.

5.2 Map Regression

The pilot areas, particularly the Lea Valley have been subject to intense pressure from the mid 19th century onwards, particularly the aggregate resource which has been utilised in development in Greater London, Hertfordshire and Essex (Figure 14). A large proportion of archaeological knowledge of the area has been obtained through work associated with this extraction. It has illustrated that there is generally high potential for multi-period remains to be present within surviving alluvial deposits. Objective 1 of this pilot project was therefore to map areas of destroyed and extant alluvial deposits within the study area

The extents of alluvial deposits have been taken to be as mapped by the BGS. In order to establish those areas where these deposits have been destroyed by extraction map regression was carried out. These utilised readily available editions of the Ordnance Survey mapping and areas of extraction digitised (generally at a scale of 1:10,000).

Editions consulted included:

- 1st Edition, 1876 (digital)
- 2nd Edition 1898 (digital)
- 3rd Edition 1915-24 (digital)
- Revised Edition 1936-47 (digital)
- 1952 Edition (Record Offices)
- 1980s Editions (Record Offices)
- Modern Ordnance Survey Mapping 10K and 2.5K (digital)

It should be noted that the results of the map regression should not be considered to be the definitive extents of extraction. In some cases there are significant time lags between editions during which extraction and infilling could have taken place. Active aggregate extraction sites are also difficult to map, the limits of excavation are more difficult to discern than those of, for example, cliff faces in chalk quarries.

For each of the editions identified above the extents of extraction were digitised. Where possible this used 1:10,000 OS mapping as a base, however in some cases digital versions of earlier editions were used, due to the dramatic changes in the landscape. Each edition has its own shape file with (where possible) the following attributes:

- Type
- Comments
- Source Scale
- Digitised Scale
- Digitised by

- Area (m2)

The shape files have also been merged in order to illustrate the maximum (known) extents of extraction (Figure 14). Data on the extents of the extraction was extracted in order to provide information on resource loss (see Section 6.1.4 and Table 6) by geo-archaeological zone.

5.3 Boreholes

Borehole data, from the BGS archives has been obtained as part of the project. This was primarily used to create deposit models and better understand the nature of the geological development of the study areas.

As the borehole data was primarily to be used to display and archive sub-surface stratigraphic data Rockworks software was utilised by the Lampeter team. The borehole data was inputted into an Access database and then exported to Rockworks. The data was also exported as Excel spreadsheets to be used by the ECC team to create a (point) shape file.

The process of creating the borehole shape file which retained the relevant attribute data proved time consuming as the GIS and Rockworks required the data in slightly different formats. The Rockworks data requires a row per lithostratigraphical unit, for example:

Bore	Depth-1	Depth-2	Lithology
TL11 SE27	0	0.1	Made Ground
TL11 SE27	0.1	1.3	Clay
TL11 SE27	1.3	3.3	Gravel

However if inputted directly into the GIS without amendment this would result in there being a point per unit in each borehole (the above example would create four points). The data was therefore ‘swivelled’ so that there was a single row for each borehole, creating a single point with the relevant attributes appended.

The borehole shape file has the following attributes:

- Borehole number
- Name
- Easting
- Northing
- Elevation

- Total Depth
- Company
- Date
- Record Type
- Source data location
- Top depth_1 (Depth of the top of the 1st unit)
- Basedep_1 (Depth of the base of the 1st unit)
- Lith_1 (Lithology of 1st unit)
- Desc_1 (description of 1st Unit)

The underlined data is entered for each unit within a borehole, distinguished by a numerical suffix

Thus when the identify command is utilised within the GIS a 'log', showing the background information and the identified units from top to bottom is displayed. Data can be selected by either spatial or attribute queries (or a combination of the two) and exported.

5.4 Zones

Following the integration of geological and archaeological information (provided by the respective HERs) consideration was given to the development of a meaningful method of presenting the data, a process outlined in section 6.1.3. This process resulted in the creation of a number of zones within the Lea Valley Pilot area. These zones were digitised and attribute data appended.

The following fields are incorporated into the zone shape file:

- Zone
- Total area of the zone
- Area lost to extraction
- Percent of area lost
- Number of boreholes
- Geomorphological characteristics

- Sediment characteristics
- Superficial geology
- Superficial geology description
- Bedrock geology
- Bedrock description
- Sequence of deposits likely to be present
- Age range of sediments
- Number of known Palaeolithic sites/finds (at the time of complication)
- As above Mesolithic
- As above Neolithic
- As above Bronze Age
- As above Prehistoric (un-defined)
- As above Iron Age
- As above Roman
- As above Saxon
- As above Medieval
- As above Post Medieval
- As above Modern
- As above Unknown period (e.g. cropmarks)
- Key research questions
- Investigative strategies

5.5 Data Catalogue and Metadata

In order to ensure that the above described elements of the MTNT GIS are straightforward to use a data catalogue has been prepared for each of the projects' shape files. The data catalogue contains a short summary explaining what the dataset represents, 'health warnings' (information on the limitations of the data or issues which need to be considered when using it), tables detailing fieldnames, an explanation and the source data.

Metadata for ESRI shape files has been created through ArcCatalog (part of the ArcGIS 8 package). This metadata can be stored alongside the data source as a XML file. The metadata profile is that of the FGDC (Federal Geographic Data Committee) standard established in the USA. In addition to this ViewEssex metadata documentation has also been compiled and included within the data catalogue. This has been designed to meet the NGDF data standards.

6.0 RESULTS
6.1 The Lea Valley
6.1.1 Distribution of data

The mapped bedrock and superficial geology has been derived from the BGS mapping within the area and is illustrated in Figures 5 and 9. Borehole data has also been obtained from the BGS archive and the distribution of the data is shown in Figure 11 and 12. The pattern described by the borehole data is clearly skewed towards two particular areas of the study catchment:

- The M25 corridor to the south and

- The Hoddesdon conurbation to the north

For the remainder of the study area the distribution of data is low and skewed towards hot spots within the region. Plotting the numbers of boreholes against the total area (in km^2) of individual zones (see below) (Figure 19) also illustrates a broad similarity in distributions, i.e. those zones that are largest typically contain greater quantities of borehole records. However in some cases the number of records for a relatively small zone is very high, e.g. zone XIX.

The density of the SMR/HER data is shown in Figure 16.

The significance of the distribution of the data, in particular the borehole data, is in relation to our ability to use the borehole data to significantly improve on the current conceptual model for sequence development at the regional scale.

6.1.2 Nature of the mapped superficial geology

The superficial geology (or drift that includes both man-made and natural sediments lying close to the earths surface that have accumulated in the recent past (last 2 million years) has been mapped as surface expressions of the underlying sequences by the BGS and this has been the base mapping data for the region (Figure 9). In all cases our work uses the mapped lithostratigraphic units as provided by the BGS that reflect the presumed origin of the sediments combined with the characteristics of the sediments in the near surface zone (note however that within the geological database both lithology and stratigraphy are stored (Figure 20). It is only rarely that consideration of the deeper parts of the drift or superficial geology have been integrated into the BGS system. No primary interpretations of the sequences from sediment cores/test pits/exposures etc. have been undertaken here and our geoarchaeological perspective has been obtained using commonly applicable principles of geomorphology/sedimentology coupled with the interpreted stratigraphy to make inferences about the geoarchaeological framework and significance.

Sediments and stratigraphy within the region can be broadly divided into 3 categories (Figure 8; Table 2):

1. Sequences associated with the pre-diversion Thames and the Anglian glaciation.

2. Sequences associated with the post-Anglian course of the river (remnants of former floodplains) now forming terraces along the valley margins.

3. Sequences lying within the valley bottom consisting of floodplain alluvium (still accumulating) over older late Pleistocene sands and gravels.

6.1.3 Zone model

The principal approach to integrating the geological and archaeological information in a meaningful way that can allow the contained archaeological resource to be interpreted has been through the development of a geoarchaeological model linking surface and sub-surface sequences, processes of both depositional and post-depositional character and site use/artefact discard/post-depositional behaviour. In order to achieve this interlinked approach a number of factors need to be considered:

1. Site/sequence production factors. How was the site/sequence produced in the first place, what geological framework was responsible for site/sequence production.

2. Temporal factors. How was the geological framework controlling site/sequence production modified through time, i.e. is it correct to assume that all temporal episodes are equally likely to produce sites/sequences for preservation?

3. Site/sequence preservation factors. What are the post-depositional factors operating on the site/sequence that lead to preservation or destruction of the site/sequence and how do these vary through time?

The broad stratigraphic framework has been produced from the BGS mapping and academic study of the patterns of change during the Pleistocene and Holocene (e.g. Gibbard, 1985). Such models represent the baseline data for the region and are illustrated in Figures 7 and 8. This framework model enables a series of associated depositional environment types to be inferred that reflect geomorphological evolution and post-depositional factors that dictate the way in which archaeological material preserves (Table 2). Consequently prediction may be made regarding the geoarchaeological operation of the region at a variety of scales (Figures 21 and 22).

Adopting this approach to the data, coupled with the insight provided by the borehole information it is now possible to consider subdivision of the area on the basis of geoarchaeological criteria. It should be remembered that much of the BGS mapping relies on near surface observations and consequently deeper buried elements (e.g. elements of buried Pleistocene terraces) will not appear through the BGS maps and without the reader having a detailed understanding of the map, approaches and regional geology the presence of important areas of sub-surface archaeology might be missed. Here we have used the borehole data held in the Rockworks database to supplement the information derived from the geological mapping and more fully understand the nature of the subsurface stratigraphy (Figures 23-25). On the basis of this approach nineteen discrete zones have been identified throughout the Lea study region. These have been identified on the basis of:

1. The mapped BGS superficial geology

2. The position of the zones within the geomorphological framework

3. The potential nature of sequences in transition zones between units mapped by the BGS (i.e. those areas in which sediments from 2 adjacent mapped zones may be intermittently distributed).

The individual characteristics of each zone are summarised in Appendix I and Table 3.

6.1.4 Impact of past mineral extraction

The impact of quarrying has varied across the region and this is illustrated in Figures 14 and 26. Summary statistics are provided in Table 4.

The evidence clearly indicates that significant loss of resource has occurred in zone II where 38% of the total area has been lost through quarrying. Reduced loss is noted in zones I, III, VI and XIV and XIX. The distribution of the major quarrying activity has been clearly focused on the valley base zone in this region (see contrast with Ver Valley study area) and consequently the major impact within the area is likely to have been on Holocene aged sequences. By contrast the later Pleistocene sediments of the valley sides and the Middle Pleistocene sediments of the Plateau areas appear to have been only minimally impacted or have suffered no impact.

6.1.5 Distribution of sites of archaeological and palaeoenvironmental importance

The mapped distribution of archaeological sites by period (as recorded in the SMR/HER) is shown in Figures 27 – 38 and summarised in Figure 39. The grouped results are shown in Figures 40 (Prehistoric) and 41 (Historic and Unknown). This distribution is also shown by geoarchaeological zones in Tables 6 and 7.

Density of site types per zone have also been calculated (Table 8). These results are illustrated graphically in Figures 42 to 47. From these results it is clear that the density of Prehistoric sites represent a skewed distribution across the zones (Figure 42) when compared to the distribution of Historic/Unknown sites (Figure 43). Unsurprisingly the density of Prehistoric sites across the study region is in all cases lower than those for more recent sites (Figure 44). Broken down into the constituent parts of the record it is clear from the results of the Prehistoric survey (Figure 45) that the highest density of all sites in this category are to be found on the valley side/margins group and not the valley base or plateau area groups. This contrasts with the picture from the Historic/Unknown data that appears to indicate a rather more evenly distributed picture (Figures 46 and 47).

Very few sites of palaeoenvironmental importance were noted during the survey. While significant sites do occur many others probably exist but have not been identified.

6.1.6 Deposit modelling: Hoddesdon area

Because of the uneven distribution of the borehole data across the Lea Valley study area it has proved difficult to develop region wide geological models using the borehole data. However, sufficient information on particular areas have enabled an attempt to be made to illustrate the potential of the approach for future investigations.

The Hoddesdon area lies at the northern end of the study area (Figure 48) and is associated with a considerable quantity of borehole data. Of the borehole data available for the entire study area Figure 49 illustrates the numbers of boreholes containing records of alluvium (A) and peat (B). This again illustrates the significant density of data and presence of peat within the region.

Evidence from the boreholes (Figure 50) indicates a relatively simple succession of alluvium (containing peat) overlying gravels intermittently across the area. However, modelling through the Rockworks software clearly indicates a pattern exists in which two small, but significant steps in the gravel surface heights may be seen across the study area. Most significantly peat is seen to overlie the lowermost step (Step 1) but abut and thin out against step 2 (Figure 50). This distribution is also readily apparent in Figure 51 that illustrates the distribution of boreholes with peat that clearly surround the topographic gravel high (A). A similar pattern is shown in Figure 52. The pattern indicated in the borehole data and the mapped gravel surface topography clearly suggests a gravel promontory into the wetland. If present during prehistory such a promontory is likely to be the focus of human activity and forms a target for future investigation should development occur in the region. The presence of one such feature in the landscape (where borehole densities were sufficient to pick up the feature) may indicate that others may also occur in the vicinity but remain invisible at the present time due to inadequate data coverage.

The borehole evidence also has additional benefit when modelled through the Rockworks as depth slicing of the stratigraphic model (Figure 53) can provide projections across horizontal space of sequences likely to be encountered if bulk excavation were to proceed to such depths. This is of particular importance in development control procedures.

6.1.7 Objectives of the trial

6.1.7.1 Objective 1. *Map areas of destroyed and extant alluvial deposits within the study area*

The distribution of sequences impacted on by quarrying activity in the past has been achieved (Figure 14). Furthermore direct quantification of the impact of quarrying in terms of total area of alluvium, total area impacted and % of area of alluvium impacted has been calculated (Table 4). This has principally been linked to those zones identified in the valley bottom (zones I, II, III, VI, XIX). This information indicates that within the Lea Valley study area the most significant impact of quarrying has been on the relatively recent sequences associated with the late Devensian and the Holocene (i.e. late Upper Palaeolithic through later Prehistoric to recent). Only minimal quarrying impact has been noted on the older sediments associated with the Lower, Middle and Upper Pleistocene sediments found along the valley sides and plateau areas.

6.1.7.2 Objective 2. *Determine the distribution of borehole data and, (if the data are adequate), use them to generate deposit models for selected areas*

Borehole data is unevenly distributed across the study area (Figures 11 and 12) and while the combined borehole and mapped BGS data has allowed a regional framework for sequence development and geoarchaeological evolution of the region to be developed detailed deposit models, at site specific scales, have been difficult to generate with the exception of the example from Hoddesdon described above (Figures 48 – 53).

However despite the inability of the borehole data to provide adequate densities of information for full 3-D modelling of the region the borehole information has been suitable for:

- Confirming the regional stratigraphic models derived from the BGS mapping and previous regional studies.

- Refining our understanding of the detailed nature of the stratigraphy in order to develop the geoarchaeological zones described here.

- Provide information suitable for developing the geoarchaeological model used to underpin the zone system.

- To model, in discrete locations, more detailed sub-surface stratigraphies and to illustrate the potential for more widespread modelling should data densities ever become suitable.

6.1.7.3 Objective 3. *Map the locations of non-archaeological palaeoecological studies*

Very few non-archaeological palaeoecological studies were encountered in the project.

6.1.7.4 Objective 4. *Map all known archaeological sites and finds*

The location of archaeological sites and finds, as mapped by the HERs, along with draft data from PAMELA, was loaded into ArcGIS and the data spatially queried against the extents of the geoarchaeological zones. The numbers of sites/monuments, by period, has been incorporated into the attributes of base geoarchaeological zones

(Figures 27 – 38). It should be noted therefore that the archaeological data represents the position at a fixed point in time (early 2006) when the data was entered in the shapefiles and that additional information may be available as HERs are continually updated.

6.1.7.5 Objective 5. *Classify the deposits in terms of temporal and spatial characteristics*

This has been achieved through the development of the geoarchaeological model and the subdivision of the region into a series of geoarchaeological zones (see Table 3; Appendix I).

6.1.7.6 Objective 6. *Identify areas of high archaeological potential for all periods*

Although the integrated HER archive and the geoarchaeological approach to zonation of the landscape have provided us with clear evidence regarding the distribution of known sites and sequences defining areas of high archaeological potential remains problematic. In part this is a function of the unknown (see 6.1.7.7. below) as well as difficulties in defining potential within the conceptual framework of the archaeological record. Potential can be defined as 'the inherent capacity for coming into being' and the use of terms such as 'Areas of (High) Archaeological Potential' are used within the planning framework to identify areas where it is **known** that buried archaeology is likely to survive. Here we use potential within a different reference framework where 'Areas of (High/Low) Archaeological Potential' are only partially based on what is known about the buried archaeology but also what may be present, where such information is derived from knowledge derived from studies elsewhere. The degree to which the known and the suspected contribute to the assessment of potential vary by time period and commonly for older time periods (associated with the Palaeolithic and Mesolithic for example where sites are commonly associated with primarily geological sediments as opposed to anthropogenic sediments) the suspected will be weighted more importantly than the known. Consequently we note:

- Using the known evidence for the Prehistoric period (Figure 45) that the highest density of all sites in this category are to be found on the valley side/margins group and not the valley base or plateau area groups. This may be a reflection of the real distribution of prehistoric archaeological sites but is more likely to reflect distribution of investigations in the past.

- Although few sites have been recorded from the valley base those present, particular those of Mesolithic date, are Nationally important. Because of the scarcity of investigations in the valley floor are it is not possible to ascertain whether this is a real pattern however, recent experience on Phase 2 of the Channel Tunnel Rail Link (including the Thames River Crossing) suggests that when extensive tracts of wetland are investigated away from natural topographic highs little evidence of human activity is forthcoming.

- Floodplain marginal situations (i.e. zones IV-VI) have been shown elsewhere to be of considerable importance and are therefore of High Archaeological Potential.

6.1.7.7 ***Objective 7.*** *Identify areas with very little data*

Areas of the study region can now be identified that currently have little or no archaeological data attached to them. For the Prehistoric period these equate to zones XI, XII, XIII, XV, XVI, XVII, XVIII and XIX. It should also be noted that those zones in which Prehistoric archaeology is present is typically low. In the case of Historic and Unknown archaeology only zones XV, XVII and XVIII are devoid of archaeology. In the case of Historic and Unknown archaeology site numbers are considerably higher in many cases than for the Prehistoric results.

Although it is beyond the scope of this project to consider the reasons for the presence of zones with very little data it is important that they are considered when attempting to derive development control strategies from the type of information presented here. For example, the presence of areas with little data may be a function of patterns of collector activity where little activity in a given region (or activity of only one particular kind) may result in no finds being reported. However, if it is known that intensive collector activity has occurred in a given region then the absence of evidence becomes a much more likely scenario.

6.1.7.8 Objective 8. *Map the differing degree and nature of threat to the alluvial deposits*

Within the alluvial zones of the study area the significant loss of resource has occurred in zone II where 38% of the total area has been lost through quarrying while reduced loss is noted in zones I, III, VI and XIV and XIX. The loss has been achieved through major quarrying activity clearly focused on the valley base zone. In the future in combination with the major extraction sites other, small-scale, mineral extraction sites are likely to have significant impact on the historic environment. However, it is likely that the impact of flood alleviation drainage and reservoirs may become increasingly important with respect to those zones of the valley already significantly impacted by extraction.

6.1.7.9 ***Objective 9.*** *Produce a costed Research Design for further work*

See accompanying UPD.

6.2 The Ver Valley
6.2.1 Distribution of data

The mapped bedrock and superficial geology has been derived from the BGS mapping within the area and is illustrated in Figures 6 and 10. Borehole data has also been obtained from the BGS archive and the distribution of the data is shown in Figure 13. The pattern described by the borehole data is clearly skewed towards the

M25 corridor in the south with the majority of the data in this sector. Elsewhere much of the data is rather evenly spread across the study region. Significantly only small quantities of data are available for the valley bottom areas of any of the main water courses through the study region. This contrasts strongly with the case of the Lea previously discussed.

6.2.2 Nature of the mapped superficial geology

The superficial geology (or drift that includes both man-made and natural sediments lying close to the earths surface that have accumulated in the recent past (last 2 million years) has been mapped as surface expressions of the underlying sequences by the BGS and this has been the base mapping data for the region (Figure 10). In all cases our work uses the mapped lithostratigraphic units as provided by the BGS that reflect the presumed origin of the sediments combined with the characteristics of the sediments in the near surface zone. It is only rare that consideration of the deeper parts of the drift or superficial geology have been integrated into this system. No primary interpretations of the sequences from sediment cores/test pits/exposures etc. have been undertaken here and our geoarchaeological perspective has been obtained using commonly applicable principles of geomorphology/sedimentology coupled with the interpreted stratigraphy to make inferences about the geoarchaeological framework and significance.

Sediments and stratigraphy within the region can be broadly divided into 4 categories (Figures 6, 10 and 54; Table 9):

1. Sequences associated with the residual deposits of the Clay-with-flints

2. Sequences associated with the pre-diversion Thames

3. Sequences associated with the Anglian glaciation and drainage modification.

4. Sequences associated with the post-Anglian river.

6.2.3 Ground model

The principal approach to integrating the geological and archaeological information in a meaningful way that can allow the contained archaeological resource to be interpreted has been through the development of a geoarchaeological model linking surface and sub-surface sequences, processes of both depositional and post-depositional character and site use/artefact discard/post-depositional behaviour. In order to achieve this interlinked approach a number of factors need to be considered:

1. Site production factors. How was the site produced in the first place, what geological framework was responsible for site production.

2. Temporal factors. How was the geological framework controlling site production modified through time, i.e. is it correct to assume that all temporal episodes are equally likely to produce sites for preservation?

3. Site preservation factors. What are the post-depositional factors operating on the site that lead to preservation or destruction of the site and how do these vary through time?

The broad stratigraphic framework has been produced from the BGS mapping and academic study of the patterns of change during the Pleistocene and Holocene (e.g. Gibbard, 1985). Such models represent the baseline data for the region and is illustrated in Table 9. This framework model enables a series of associated depositional environment types to be inferred that link to geomorphological evolutionary factors and post-depositional factors that dictate elements of the archaeological preservation issues (Table 9). Consequently prediction may be made regarding the geoarchaeological operation of the region at a variety of scales.

Within this region however, borehole data is considerably more limited than has proved the case in the Lea Valley study area with regards to refining the observations made from the BGS mapped information. Because the distribution of boreholes (Figure 13) reflects a more general distribution than in the Lea and where focus of attention is apparent the majority of the boreholes appear to be associated with the Lowestoft and Kesgrave Formations it has not been possible here to enhance the subdivision of the region beyond that currently provided by the BGS mapping and the inferences derived from a geoarchaeological knowledge of the sequences. As a result no zones of archaeological potential have been examined and at present it is not possible to achieve the levels of data investigation that has been possible in the Lea area.

6.2.4 Impact of past mineral extraction

The impact of quarrying has varied across the region and this is illustrated in Figure 15. The majority of the quarrying activity has been outside the confines of the river valleys of either the Ver or the Colne and within those areas dominated by the older sequences of the Lowestoft and Kesgrave Formations. This contrasts with the situation in the Lea Valley where the focus of extraction is centred on the valley floor

6.2.5 Distribution of sites of archaeological and palaeoenvironmental importance

The mapped distribution of archaeological sites by period as illustrated in the HER and the HHER has been compared with that of the bedrock/superficial geology and the areas of extraction. The distribution of selected sites relative to the distribution of quarrying patterns is shown in Figure 54. Very few sites of palaeoenvironmental importance were noted during the survey.

6.2.6 Objectives of the trial

6.2.7.1 Objective 1. Map areas of destroyed and extant alluvial deposits within the study area

The distribution of sequences impacted on by quarrying activity in the past has been achieved (Figure 15). Direct quantification of the impact of quarrying in terms of total area impacted, has not been calculated although such figures could be surmised from the information stored in the GIS. Quarrying has principally been linked to those associated with the older sediments of the Lowestoft and Kesgrave Formations. This information indicates that within the Ver Valley study area the most significant impact of quarrying has been on the relatively older sequences associated with the Middle Pleistocene sequences (i.e. Lower Palaeolithic). Only minimal quarrying impact has been noted on the younger sediments associated with the Middle and Upper Pleistocene and Holocene sediments found along the valley sides and bases.

6.2.7.2 Objective 2. Determine the distribution of borehole data and, (if the data are adequate), use them to generate deposit models for selected areas

Borehole data is relatively evenly distributed across the study area (Figure 13). However, this has not significantly enhanced our understanding of the key elements associated with the river valley sequences and in particular the development of the floodplain beyond that currently possible to deduce from a knowledge of the BGS maps and geoarchaeological frameworks and consequently it has been difficult to develop detailed deposit models, at regional or site specific scales.

However despite the inability of the borehole data to provide adequate densities of information for 3-D modelling of the region the borehole information has been suitable for:

- Confirming the regional stratigraphic models derived from the BGS mapping and previous regional studies

- To illustrate the potential for modelling should sufficient information become available in the future?

6.2.7.3 Objective 3. Map the locations of non-archaeological palaeoecological studies

Very few non-archaeological palaeoecological studies were encountered in the project.

6.2.7.4 Objective 4. Map all known archaeological sites and finds

The location of known archaeological sites and finds have been obtained from the HER, supplemented by draft data from PaMELA . These have been loaded into ArcGIS and their distribution compared with the geological data, as illustrated on Figure 54. As noted previously HER data is continually updated. Should geoarchaeological zones be assigned to this study area at a later date up to date HER/UAD data should be obtained to be incorporation into the zone attributes as per the Lea.

6.2.7.5 Objective 5. Classify the deposits in terms of temporal and spatial characteristics

This has only partially been achieved through the application of geoarchaeological principles linked to the baseline BGS mapping, full subdivision similar to that attempted in the Lea Valley study area has not been possible.

6.2.7.6 Objective 6. Identify areas of high archaeological potential for all periods

Areas of high archaeological cannot easily be defined from the level of the data coverage and our inability to construct local geoarchaeological zones. However, a number of points may be made:

1. The majority of the superficial deposits within the region (Figure 9) are ascribed to the Kesgrave and Lowestoft Formations. Traditionally neither have produced archaeological remains however, the recent discoveries of Lower Palaeolithic archaeology in contemporary sediments at Pakefield (Parfitt *et al*., 2005) demonstrate the possibility that artefacts may exist within these deposits (Table 10).

2. On the basis of the evidence from elsewhere in the Colne drainage basin Mesolithic archaeology has traditionally been associated with the tufa and peat sequences of the valley floor (Lacaille, 1961, 1963) however recent work in the Gage Valley has demonstrated that Mesolithic archaeology does occur in valley marginal situations and on the valley sides.

6.2.7.7 Objective 7. Identify areas with very little data

The data gathering exercise indicated that although data was relatively evenly distributed across the region (Figure 13) this was at low densities and insufficiently dense for creating geoarchaeological zones of the type created for the Lea Valley study area.

6.2.7.8 Objective 8. Map the differing degree and nature of threat to the alluvial deposits

On the basis of the distribution of quarrying activity (Figure 15) it appears that relatively little impact has been made on the floodplain floor by major quarrying and consequently preservation of the prehistoric archaeological record associated with these deposits is likely to be high. Conversely impact on older deposits (Kesgrave Formation) has been higher, given the current revision in the age of the earliest occupation of Britain (Parfitt *et al*., 2005) this may indicate that sediments with some archaeological potential have been significantly impacted by quarrying on the plateau and upper valley sides.

6.2.7.9 Objective 9. Produce a costed Research Design for further work

See accompanying UPD.

7 DISCUSSION AND ASSESSMENT OF SUCESS

The approach adopted in an attempt to provide a framework for curatorial management of the archaeological resource from a geoarchaeological perspective has provided new baseline information for incorporation of information as layers in GIS programmes. Furthermore it has provided the end user, as well as those charged with constructing the system, with a framework (geoarchaeological) in which to think about the archaeology of the region and its distribution. The approach adopted has at its core a working hypothesis that elements of the archaeological record (in terms of both site location as well as site preservation and modification) are, in part, a function of natural factors such as topography and geomorphology. As such viewing the archaeological resource within such a framework has significant advantages within the curatorial field in allowing predictions to be made regarding the nature and location of archaeological material within a predefined area. Defining potential within these sequences has been considered here however, in many cases it is likely that curatorial staff familiar with the ever changing nature of the archaeological record in their regions of responsibility are likely to be able to articulate better the question of potential when based upon the understanding of the geology and geoarchaeological record presented here coupled to patterns emerging through updated HER's and new discoveries.

The success of the approach has varied and has depended on the complexity of the perceived systems and the data available for investigation. Within the Lea Valley study area large quantities of borehole data were available for interrogation that have allowed significant progress to be made beyond that of the current BGS mapping and SMR/HER archive. Zoning of the region has been possible and this now allows a fresh approach to archaeological resource management throughout this part of the drainage basin. By contrast within the St. Albans area insufficient data was available to significantly enhance our understanding of the region beyond that mapped by the BGS. However, despite this it has been possible to consider the geoarchaeological implications of the base mapping data for archaeology providing additional insight into the archaeological resource of the region.

The success of the project is in many ways a reflection of its inter-disciplinary nature, drawing together diverse strands of information within a framework that has allowed the stratigraphic information to drive predictions regarding the archaeological resource. The approach also demonstrates the flexible nature of such strategies when attempting to deal with diverse data sets and differentially distributed data. Thus despite the paucity of data from the St. Albans area meaningful predictions have been made and demonstrate the suitability of a geoarchaeological approach to data management operating at a variety of scales. This is further emphasised by the Lea study where subdivision into a series of meaningful zones was achieved. However, even with this enhanced level of detail detailed deposit modelling at the scale of the sub-catchment (i.e. regional scale = 10km) was not possible. Local modelling at Hoddesdon was achieved and demonstrates the potential. The approach therefore enables a nested framework of scales of investigation utilising the same base line information in which interrogation may be undertaken at different scales dependant on data density. It should also be noted that scales of investigation will vary depending on the nature of the questions being asked by the researcher.

A number of key findings relating to methodology, against which future roll-out of the project methodology, needs to be judged, particularly where roll-out across the wider landscape of the entire MTNT area (Figure 1) is considered:

1. Confining the investigation to the valley bottom, or Holocene deposits, is impracticable due to the necessity to consider those deposits of Pleistocene age buried beneath the floodplain and the nature of valley side sediments as sources for material ending up within the valley bottom context.

2. In order to derive a geoarchaeological model for a given region full consideration of the totality of the superficial and bedrock geology is required. This will involve consideration of valley side and plateau archaeology of Palaeolithic nature contained in the ERPP.

3. Distribution and quantity of borehole data are the key factors in defining roll-out potential across the remainder of the MTNT region. The paucity of data from the river valley floors in the St.Albans area indicate the problems with generating meaningful geoarchaeological for certain regions.

8 POTENTIAL FOR FURTHER WORK

The potential for further work, and indeed the level of detail to which further work may be targeted, varies across the catchment area of the MTNT. Primary data sources available for key areas of the Colne (Figure 55), Lea (Figure 56) and Roding (Figure 57) are shown and indicated that for some areas of the MTNT catchment density of information appears suitable for further investigation and categorisation.

The diverse body of data relevant to the project has previously been identified (see Sections 4.0 and 6.0) and are expected to be similar in any future roll-out of the project across the broader area of the full MTNT. Here the full MTNT area is taken as the north bank tributaries of the Thames from the Goring Gap down to, and including, the Mar Dyke. The main data source previously used is the geological digital base mapping compiled by the British Geological Survey coupled to the borehole record archive held by the same organisation. This pilot study has demonstrated that where sufficient density of data is available significant enhancement of the geoarchaeological understanding of a region is possible using this combined information set. It is now known that the Environment Agency holds, and is gathering additional, borehole data from many sites although access to the data while possible is not always feasible.

Linked to the baseline geological data were the County Historic Environment Records that have provided the archaeological context. Beyond these data sets little other useful information was obtained with the exception of some additional sites from the PAMELA database, grey literature a limited number of academic publications.

On the basis of the experience from the pilot study it is clear that roll-out of the methodologies used in the pilot studies across the entire MTNT may be premature and that a hierarchical deployment of approaches may be suitable for the region depending on levels of data availability etc. There is also the question of study are size to consider. On the basis of the present study field areas of approximately 10x10km appear to represent ideal region sizes. Increased size of regions is likely to bring with it problems in data management (particular where very large numbers of boreholes (>700) are required to be manipulated within the software). Areas significantly smaller that 10km are unlikely to develop suitable, and spatially significant zones, at other than a site specific level. Here we favour continuity with the 10x10km study area. We also note that in line with the approach adopted during the trial project attention is focused not only on the floodplain floors but is extended to include all Quaternary sediments within the region. Consequently we can identify 3 levels of approach to the roll-out of the project across the full MTNT area:

1. Level 1 survey. This represents a base-line survey that provides a framework for the geoarchaeological interpretation of the full MTNT area but that stops short of full archive search of all borehole records. In order to achieve this baseline survey digital BGS mapping coverage would be required. The objectives of this baseline survey would be to map areas of extant superficial deposits within the study area (**OBJECTIVE 1 – part of**), determine the distribution of borehole data (**OBJECTIVE 2 – part of**), classify the deposits in terms of their likely temporal and spatial characteristics (**OBJECTIVE 5**) and provide a framework for future data collection.

2. Level 2 survey. This represents an intermediate level survey (of the kind undertaken in the Lea Valley Study area) where data is collated from the borehole archive and SMR/HER for selected 10km blocks of river valley systems and integrated into a series of geoarchaeological zones for incorporation into the GIS. Specifically this would be to map areas of destroyed and extant deposits within the study area (**OBJECTIVE 1**), determine the distribution of borehole data and, (if the data are adequate), use them to generate deposit models for selected areas (**OBJECTIVE 2**), map the locations of non-archaeological palaeoecological studies (**OBJECTIVE 3**), map all known archaeological sites and finds (**OBJECTIVE 4**), classify the deposits in terms of temporal and spatial characteristics (**OBJECTIVE 5**), identify areas of high archaeological potential for all periods (**OBJECTIVE 6**), identify areas with very little data (**OBJECTIVE 7**) and map the differing degree and nature of threat to the deposits (**OBJECTIVE 8**).

3. Level 3 survey. For those areas of river valleys surveyed at Level 2 that remain isolated from adjacent stretches of river valley only surveyed to Level 1 integration into a broader pattern of geomorphology and stratigraphy will have to remain at a general level. However for those blocks of river valley occupying adjacent space it is likely that the continuity of sequences (or not in some cases) is likely to require a possible additional level of zoning to accommodate long, down-valley trends in sequences.

Detailed proposals and scope of works are considered in the UPD.

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